LONG-TERM MONITORING

OF THE

GREAT BARRIER REEF

Status Report

Number 3 1998

by

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Executive summary

The Great Barrier Reef World Heritage Area is of immense aesthetic value and great economic importance supporting tourism and fisheries worth more than $1 billion annually to the Australian economy. Information on status and natural variability of populations is essential for informed management of such an extensive area. The AIMS Long-term Monitoring Program is designed to provide information on key groups of organisms (particularly crown-of-thorns starfish, corals , algae, and reef fishes) on appropriate spatial scales over the length and breadth of the Great Barrier Reef Marine Park (GBRMP).

This report represents the synthesis of monitoring data collected over the last six years which required approximately 3600 person days at sea. The report provides the first integrated analysis of patterns of change in numbers of crown-of-thorns starfish, abundances of reef fishes and cover of benthic organisms over most of the Great Barrier Reef (GBR). New results are presented from 1996 to 1998 and these build on previously reported information. The results contained within this report are intended as a primary source of strategic information for the effective management of the GBR.

Broadscale manta tow surveys have now been carried out, over the length of the GBR in 11 latitudinal sectors, for a continuous period of 13 years (1985-1998) and have played a significant role in our increased understanding of the crown-of-thorns-starfish (COTS) phenomenon. The perimeters of 110 reefs were surveyed using manta tows in the 1996 field season, 74 reefs in 1997 and 108 reefs in 1998.

Intensive surveys on reefs in six sectors began in the 1993 field season. Coral and fish are surveyed annually on fixed sites within one habitat on each reef. Fifty-one reefs were surveyed in 1996, 45 in 1997 and 48 in 1998. For most reefs, these surveys have been conducted at least five times in six years and consequently there are now sufficient data to estimate temporal trends.

Major results are:

Crown-of-thorns-starfish

The percentage of reefs on the GBR with outbreaks of COTS is increasing. Active or Incipient Outbreaks were observed on 14.8% of the 108 reefs surveyed in 1998. This compares with 12.2% in 1997 and 10% in 1996. The highest recorded percentage of reefs with Active Outbreaks over the 13 years of surveys was 17.1% in 1987.

A similar pattern is seen in the overall density of COTS on the GBR. The overall number of COTS per tow recorded in 1998 was 0.23. This has increased from 1997 and 1996 when the numbers were 0.14 tow^{-1} and 0.11 tow^{-1} respectively. For comparison, the overall number of COTS tow^{-1} on the GBR during the last major COTS outbreak in 1989 was 0.87.

Details of their current distribution are as follows:

- The abundance of COTS is high in the Cooktown / Lizard Is. sector but did not increase greatly between 1996 and 1998.
- There is evidence of increases in COTS numbers in the Cairns and Innisfail sectors. This is consistent with a southward drift and supports the hypothesis that secondary outbreaks are caused by larvae being transported between reefs by the East Australian Current.
- COTS numbers increased greatly in the Swain Reefs in 1998, largely due to a dense population on Horseshoe Reef.
- There were no significant changes in COTS abundance within the other seven GBR sectors.

Coral Cover

The salient changes on the Great Barrier Reef over the last six years reflect the impact of cyclones and COTS on reef communities and their subsequent recovery from such disturbances. Key results found were:

- The highest mean values for cover of living coral on the perimeters of reefs were found in the Cape Grenville sector (43%) in 1996 and in the Pompey sector in 1997 (46%) and 1998 (43%). In recent years both of these sectors have been largely free from recorded COTS outbreaks or severe cyclone disturbances (Categories 3-5).
- Lowest values for reef-wide live coral cover were in the Cape Upstart and the Cairns sectors (18% each) in 1996, the Cape Upstart sector in 1997 (17%) and in the Cooktown / Lizard Is. sector (17%) in 1998. These sectors have been affected by both COTS and cyclones.
- Permanent survey sites on NE faces of reefs showed that cover of hard coral was highest in the mid-shelf region of the Townsville sector (47%) in 1996 and in the outer shelf region of the Cooktown / Lizard Is. sector in 1997 (43.7%) and 1998 (52.4%). These regions have been observed recovering from COTS and cyclone activity respectively.
- Coral cover on permanent survey sites was lowest in the mid-shelf region of the Cooktown / Lizard Is. sector in 1996 (18%), 1997 (14%) and 1998 (15%): an area where there is current COTS activity.
- Coral cover on the permanent survey sites increased over six years in inshore and outer shelf regions of the Cooktown / Lizard Is. sector, the mid-shelf and outer shelf regions of the Cairns and Townsville sectors and the Capricorn / Bunker sector.
- Coral cover on the permanent survey sites declined over six years in the inner region of the Swain sector. This was due to a COTS outbreak at Reef 22-088.

- Currently coral cover on the permanent survey sites is increasing in the outer shelf region of the Cooktown / Lizard Is. sector and in the Capricorn / Bunker sector. Both these regions have been recovering from storm disturbance.
- Currently coral cover on the permanent survey sites is declining in the inshore region of the Cairns sector, possibly due to COTS, and the mid-shelf regions of the Townsville and Whitsunday sectors, attributed to the influence of Cyclone Justin in March 1997.
- The recent wide spread coral bleaching occurred after most sampling in the 1998 field season was complete. The extent of mortality due to bleaching will be assessed by the 1999 surveys.

Reef fishes

While many groups of fishes showed significant long term and current trends in various regions, there were only a few instances where a majority of groups showed a consistent trend in a region:

- The majority of larger, more mobile fish taxa showed an increase in abundance over the six years of surveys in the Capricorn / Bunker sector. Several groups, such as surgeonfishes, butterfly fishes and wrasses, continue to do so. Coral cover has increased greatly in this region from very low levels in 1989; the fish assemblages may be changing as the coral communities recover.
- The majority of groups of reef fishes showed an increase in relative species richness over the time of the surveys in the outer shelf region of the Cooktown / Lizard Is. sector and the Capricorn / Bunker sector. These are both regions where coral cover has increased greatly over that time.
- The majority of groups of reef fishes showed a declining trend in relative species richness in the outer shelf region of the Whitsunday sector. This was not associated with significant trends in coral cover but may be related to the effects of Cyclone Justin.

1. Introduction

Background

The Australian Institute of Marine Science set up a long-term monitoring program for the Great Barrier Reef (GBR) in 1992 in conjunction with the Great Barrier Reef Marine Park Authority (GBRMPA). The program was based on some monitoring initiatives on smaller scales and represents the first concerted attempt to assess a range of ecological variables across most of the GBR. In 1993 the Long-Term Monitoring Program (LTMP) became a task in the Cooperative Research Centre for Ecologically Sustainable Use of the Great Barrier Reef.

Scope and limitations of the program

Coral reef monitoring concerns the detection of change. Coral reefs are always changing through natural processes such as recruitment, growth, mortality and disturbance by storms. A major function of the LTMP is to document status and to describe change in reef communities on the GBR. This information allows managers to place small scale, site specific changes in the context of the types of changes that are observed over much larger scales. This provides some perspective on the importance and significance of site specific status and change.

Specifically the objectives of the program are:

- to monitor the status and changes in distribution and abundance of reef biota on a large scale.
- to provide environmental managers with a context for assessing impacts of human activities within the Great Barrier Reef Marine Park and with a basis for managing the GBR for ecologically sustainable use.

The program addresses long-term regional change in benthic assemblages, reef fishes and crown-of-thorns starfish on coral reefs of the GBR. It does not address associated habitats: mangroves, seagrass beds and areas of soft substrate between reefs. Intensive sampling of benthic organisms and reef fishes is concentrated in one habitat: the NE face of each survey reef, but the perimeter of each reef is also surveyed by manta tow which gives a reef wide estimate of hard coral cover.

Structure of this report

This report presents an analysis of the changes that the Program has detected on the GBR since 1993. This contrasts with the first and second status reports (Oliver *et al* 1995, Sweatman 1997), which were primarily concerned with geographic patterns in the distribution of organisms. This report includes data collected between 1993 and 1998.

The format of the report has been modified to describe the changes at three scales: a large scale including most of the GBR, a regional scale by latitude (sector) and at the scale of individual reefs.

2. Methods

Program design

The AIMS Long-term Monitoring Program is designed to detect changes over time in reef communities at a regional scale. Regions in this context refer to the combinations of three positions across the shelf (inshore, mid-shelf, outer shelf) at six latitudes (sectors). Surveys by the Long-term Monitoring Program involve three "tasks": manta tow surveys for crown-of-thorns starfish (COTS) and reef-wide coral cover, surveys of sessile benthic organisms using video and visual counts of reef fishes. The data that are collected are listed in Table 2.1. A fourth task, routine water quality monitoring, was discontinued in 1995.

Table 2.1: Summary of Measurement Variables for each of the LTMP tasks

Task	Description	Variables Measured
Broadscale Surveys	Manta tow surveys around entire reef perimeter	Crown-of-thorns starfish counts; estimates of cover of hard and soft coral, dead coral, other incidental observations (e.g. coral bleaching, *Drupella*, giant clams, reef aesthetics)
Benthic Organisms	Video transects at selected sites in one reef habitat	Percent cover of all identifiable sessile benthic organisms
Fishes	Visual surveys of fish at selected sites in one reef habitat	Counts of most mobile and non-cryptic fish species (see Appendix C)

Selection of reefs

Initially, 52 "core" reefs were selected for annual survey. The reefs were widely distributed throughout the GBR and spanned variations in the composition of coral and fish communities (Done 1982, Williams 1982), which are known to be greater across the GBR than they are along its length.

The sample reefs were selected within six of the 11 cross-shelf sectors (Figure 2.1) that had been identified for manta-tow surveys for crown-of-thorns starfish (Bainbridge *et al*. 1994). Where possible, three or more reefs were selected in each of three zones of the continental shelf: inshore, mid-shelf and outer shelf, in each sector.

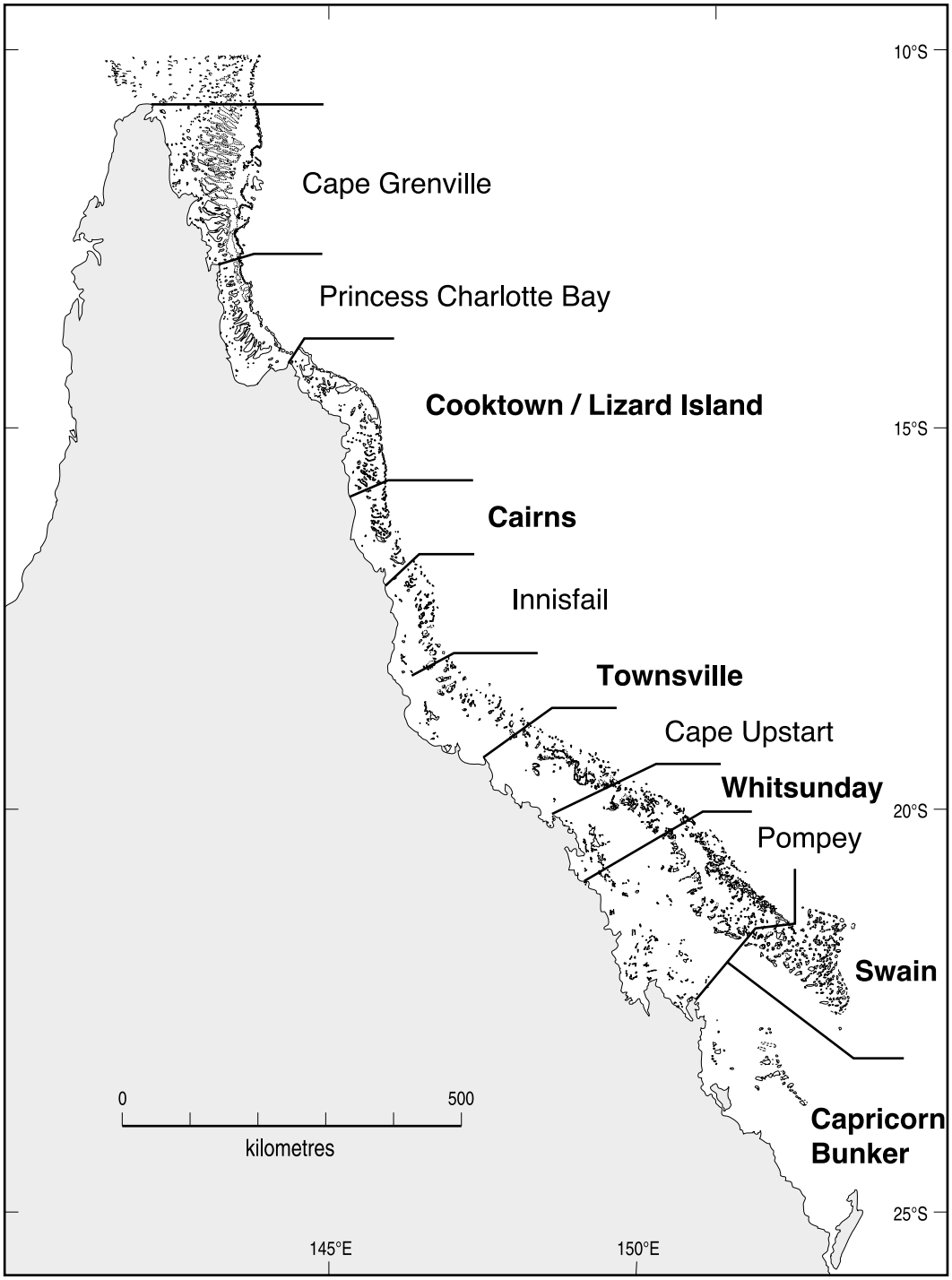


Figure 2.1 Map of the GBR showing the locations of latitudinal sectors. The six sectors where LTMP sites are located are shown in bold face type.

There are no inshore or mid-shelf reefs in the Capricorn/Bunker sector. The core survey reefs were chosen from the reefs within each shelf position for logistical and historical reasons. Because of the non-biological nature of the selection criteria, the survey reefs are likely to be representative of the reefs in each of the regions. The

number of core survey reefs has been reduced subsequently to 49 because some reefs could not be sampled reliably on a regular basis.

An additional 35 reefs from the 11 sectors are surveyed annually using manta tow only. Some of these reefs are surveyed every year (key reefs); others are surveyed every three years (cycle reefs). Maps and a full listing are given in Appendices A and B.

In addition to data from the LTMP, staff of the Cairns region of the Queensland Department of Environment and Heritage made video surveys of sites on the LTMP key manta tow reefs in the far northern GBR. These data are included in Section 6.

Sampling methods

The core survey reefs are sampled in two stages (Fig. 2.2). The entire perimeter of each reef is surveyed using manta tows. Fishes and benthic organisms are surveyed intensively at three sites in a habitat that is standardised across reefs. The sites are located in the first stretch of continuous reef (excluding vertical drop-offs) to be encountered when following the perimeter from the back reef zone in a clockwise direction towards the front reef. The sites are usually situated on the north east flank of the reef (Figure 2.2). Sites are separated by at least 50 m where possible. On small reefs, the sites may extend around the reef as far as the east or south east flanks.

There are five 50 m transects within each site. These are permanently marked with a star picket at each end and lengths of reinforcing rod at 10 m intervals. Transects run parallel to the reef crest at about 6-9 m depth (Fig. 2.2). Transects were initially laid in a haphazard manner with 10 - 40 m between transects.

Surveys are made each year between September and May. In this report, annual surveys are referred to by the year in which the field season ended: thus surveys made between October 1997 and May 1998 are referred to as 1998 surveys.

Fifty-one core reefs were sampled for fish and benthos in 1995-96, 45 reefs in 1996-97 and 48 in 1997-98 (Appendix B). In addition to the core reefs, 59 reefs were surveyed by manta tow alone in 1995-96, 29 in 1996-97, and 60 in 1997-98 (Appendix B).

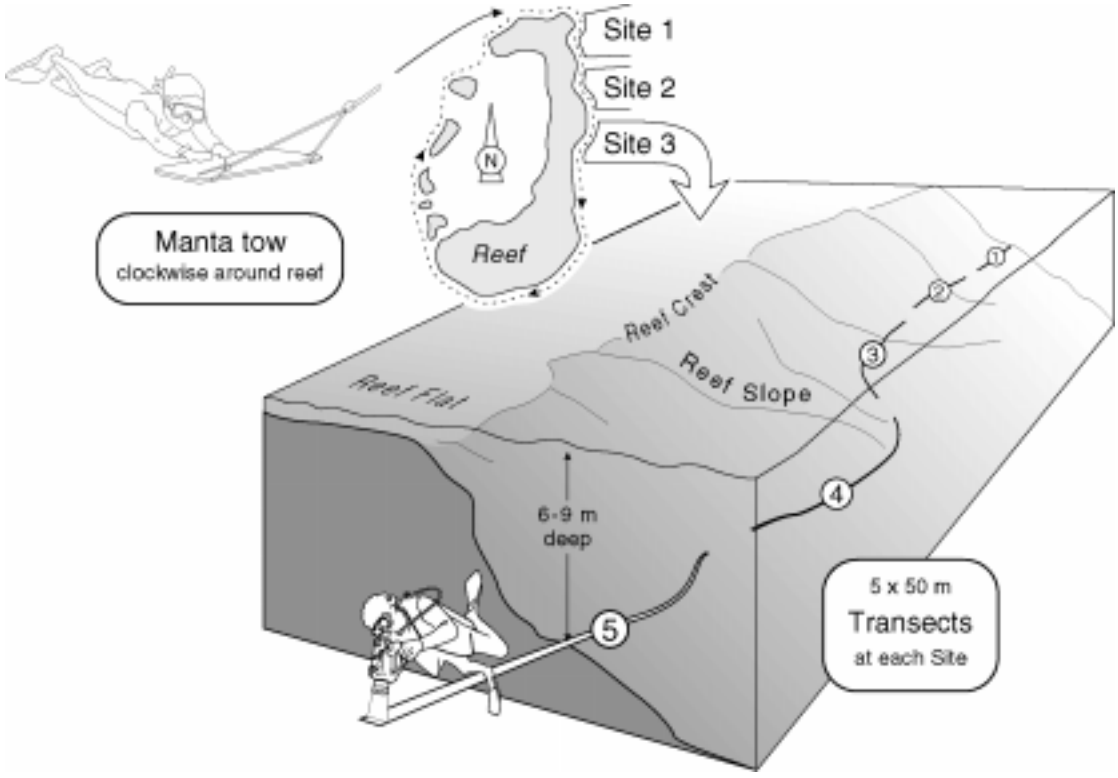


Figure 2.2: Schematic arrangement of sampling effort on a core survey reef

Quality control

It is important to maintain consistency in the way data are collected and processed, so that differences that appear over time reflect differences in the populations of reef organisms rather than changes in sampling. Each part of the program has quality control measures in place, but one general approach has been to produce a series of Standard Operating Procedures (SOPs, Table 2.2). These document the current methods of data collection and processing in considerable detail. They are reviewed at least every two years and updated as necessary. Current SOPs are available in electronic form via the AIMS web page (www.aims.gov.au).

Data storage and access

Data are entered using a number of purpose-designed data entry and checking programs. All data are held in an Oracle™ database at AIMS. The structure of the database is described in Baker and Coleman (in press).

Table 2.2: Titles of standard operating procedures and related documents	
Broadscale surveys	Bass DK and Miller IR (1996) Crown-of-thorns starfish and coral surveys using the manta tow and SCUBA search techniques. Standard Operating Procedure No. 1, AIMS, Townsville. 38 pp.
Fishes	Halford AR and Thompson AA (1996) Visual census surveys of reef fish. Standard Operating Procedure No. 3, AIMS, Townsville. 24 pp.
Benthos	Christie CA, Bass DK, Neale SJ, Osborne K and Oxley WG (1996) Surveys of sessile benthic communities using the video technique. Standard Operating Procedure No. 2, AIMS, Townsville. 42 pp.
Data handling	Baker VJ and Coleman G (in press) A guide to the Reef Monitoring database. Standard Operating Procedure No. 6, AIMS, Townsville.

Methods for individual tasks

Broadscale surveys

AIMS began broadscale surveys of the Great Barrier Reef in the mid-1980s. These surveys were incorporated into the LTMP in 1992. The primary objective of the broadscale surveys is to detect and monitor populations of crown-of-thorns starfish (COTS) on the Great Barrier Reef. Manta tow surveys also provide estimates of percent cover of soft corals and living and dead coral, allowing assessment of the impact of COTS outbreaks and other large-scale disturbances. This report presents coral cover and crown-of-thorns starfish data from 13 years of broadscale surveys on the GBR.

Sampling techniques

Broadscale surveys use the manta tow technique as described by Bass and Miller (1995) and English *et al*. (1997). At each reef, two teams work in opposite directions around the reef to survey about half the perimeter each. A team consists of a boat driver and an observer who is towed behind the boat on a manta board. At two-minute intervals the boat stops, allowing the observer to record the data for that tow (Table 2.3). Current practice differs from the documented method in that cover of soft coral is estimated in place of sand and rubble. This was instigated in the 1998 field season.

Table 2.3: Primary variables recorded every 2 minutes during a manta tow survey. See Bass and Miller (1996) for more details.

Variable	Data recorded	Categories
Number of COTS	number observed	actual counts
Size class of COTS	size class	A = juvenile (<25cm)
		B = adult (>25cm)
Presence of feeding scars	abundance categories	A = absent (0)
		P = present (1-10)
		C = common (>10)
Live coral	estimated cover categories (scale of 0-5)	0 = 0%
Dead coral		1- = >0-5%
Soft coral		1+ = >5-10%
		2- = >10-20%
		2+ = >20-30%
		3- = >30-40%
		3+ = >40-50%
		4- = >50-62.5%
		4+ = >62.5-75%
		5- = >75-87.5%
		5+ = >87.5-100%
Visibility	distance categories (scale of 1-4)	1 = <6m
		2 = 6-12m
		3 = 12-18m
		4 = >18m

Quality control

Quality control is in two stages. First, all observers are trained before participating in the broadscale surveys (see Bass and Miller 1995). Secondly, on each sampling trip, some reefs are surveyed by two observers following the same tow path to give a measure of the variability between observers. This is necessary because the precision

of observers varies continually (Moran and De'ath 1992). When observers show signs of bias (Miller and Müller 1997) they are retrained.

Data handling and analysis

Percent cover of living coral, dead coral and soft coral is calculated from the manta tow results by representing each cover category by the mid-point of its range. Coral cover, the number of COTS per reef and the average number of COTS per tow are used to assess the outbreak status of each reef (Fernandes 1991; Moran and De'ath 1992). There are four categories: Active Outbreak (AO); Incipient Outbreak (IO), Recovering (RE); or No recent Outbreak (NO). In concept, an Active Outbreak occurs when starfish densities reach levels where loss of coral tissue through starfish feeding is estimated to be faster than the growth of the coral. Definitions of outbreaks have evolved over the time that surveys have been made. Initially, reefs with active outbreaks were those where >40 COTS were recorded over the whole reef and >30% of coral was dead. Examination of manta tow data from reefs of all categories found that 90% of reefs with active outbreaks by these criteria supported >1500 COTS km^{-2} (Moran and De'ath 1992). This is approximately 0.22 COTS per two-minute tow. After consideration of the relative costs of Type I and Type II errors, the criterion for an Active Outbreak was revised upwards to 1.0 COTS per tow (Lassig and Engelhardt 1995, Engelhardt *et al*. 1997). This represents a starfish density that is highly likely to cause net decline in corals. In this report the criterion of 0.22 COTS per tow is referred to as "Incipient outbreak".

Reefs which fit the following criteria were chosen to estimate the regional trends:

- reefs must have been surveyed at least four times
- reefs must also have been surveyed within three years of both the start (1986) and the end (1998) of the surveys.

An exception was made in the case of the inshore region of the Cape Grenville sector where one reef which had only been surveyed three times was included to provide an adequate sample. At least three reefs from each region were required for the analysis.

Linear models were used to fit simple (quadratic) curves to the sequence of observations of median coral cover (reef-wide coral cover) and mean numbers of COTS per tow from each reef. The fitted values from these curves for individual reefs were then used to estimate regional means. A similar linear model was fitted to the regional means and then used to estimate the overall trend over time and the current trend for each region. See Appendix K for a more technical explanation.

Sessile benthos

Sampling Techniques

Benthic organisms were surveyed on the five marked transects within each site on the core reefs. A 25 cm wide swathe was recorded along each 50 m transect using a Hi-8 video camera held 25-30 cm above the substrate. Percent cover of corals and other benthic categories were estimated using a point sampling technique, in which approximately 200 systematically-dispersed points were sampled from each video transect. Details of the video survey and sampling techniques can be found in the SOP (Christie *et al*. 1996). Corals were identified to the greatest taxonomic detail achievable, but aggregated for analysis. Analysis concentrated on three major components of the benthic community: hard corals, soft corals and algae. The hard corals were then divided into the dominant families: Acroporidae, Faviidae, Pocilloporidae and Poritidae. The Acroporidae were further subdivided into *Montipora* spp., tabulate *Acropora* spp. and other *Acropora* spp. (see Table 2.4).

Table 2.4: Explanation of benthic categories

Major Benthic Group	
Hard Corals	Order Scleractinia
Soft Corals	Subclass Alcyonaria
Algae	Macro-algae and turf algae
Major Benthic Families	
Acroporidae	Family Acroporidae
Faviidae	Family Faviidae
Pocilloporidae	Family Pocilloporidae
Poritidae	Family Poritiidae
Acroporidae Groups	
Montipora	Genus *Montipora*
Acropora tabulate	Genus *Acropora* tabulate life-form
Acropora other	Genus *Acropora,* non-tabulate life-forms

Quality control

Quality control involves training new observers to use the video camera effectively in the field followed by initial training and an on-going program monitoring agreement between all observers when identifying organisms in the recordings. A

second on-going program checks field identifications against identifications in the recordings.

Data handling and analysis

For each category of benthic organisms, the mean values (based on the five transects) for percent cover at each site in each year were used to estimate temporal trends in cover of benthic organisms at each reef. Annual cover values were transformed using the empirical logit transformation prior to analysis (see Appendix K). A linear model was then used to fit a simple (quadratic) curve to the transformed annual values for percent cover. This model was then used to estimate the overall trend (over the six annual surveys) and current trend for each core survey reef.

Regional trends in percent cover over time were estimated using a similar procedure except that the linear model was fitted to transformed annual estimates of overall mean cover on each reef in the region. See Appendix K for a more technical explanation.

Reef fishes

Sampling technique

Fishes of 191 species (Appendix C) were counted on the five 50 m transects at three sites on each reef. Because the surveys span the annual recruitment season, 0+ individuals are excluded from counts. Initially, larger more mobile species were counted using transects 10 m wide and pomacentrids were counted using transects 2 m wide. These dimensions were too wide to give accurate counts in the low visibility that is often encountered at inshore reefs. Sampling time also became very long when large schools of planktivorous fishes were encountered which resulted in problems with dive times. Transect widths were reduced to 5 m and 1 m respectively prior to the third year of sampling (1995). A correction factor for change in transect dimensions was incorporated into the analysis (see Appendix K). Full details of the sampling method are given in the SOP (Halford and Thompson 1996).

Quality control

All observers cross calibrate their counts each year during training prior to the field season. Estimating the cut point for 0+ individuals is particularly important.

Counts are entered into a database at the end of each day's diving using specially written programs that trap simple errors. When data for all the transects on a reef have been entered, the new data are compared with counts from previous years using a linear model to check for unlikely values. This allows observers to check for misidentifications.

Data handling and analyses

Counts have been summed over the five transects, giving estimates of abundance from three sites in the one area of each reef. As in previous Status Reports (Oliver *et al*. 1995, Sweatman 1997), larger species have been grouped into families and pomacentrid fishes have been grouped into genera. This increases the power of the analyses, but complicates interpretation.

Abundances required correction to account for the change in transect width after two annual surveys. A correction factor, based on the change in intercepts of regression lines for data collected before and after the change in transect width, was incorporated into the analysis (see Appendix K).

Three reefs (Fitzroy, Reef 21-583 and Havannah Is.) were only sampled twice and were not included in temporal analyses.

To look at trends in abundance of fishes on individual reefs, the corrected abundances for the five transects in each site were summed and log transformed [ln(x + 1)] to reduce the influence of abundant taxa. A linear model was then used to fit a simple (quadratic) curve to the transformed annual estimates of abundance. This model was then used to estimate the overall trend (over the six annual surveys) and current trend for each core survey reef.

Regional trends in abundance over time were estimated using a similar procedure except that the linear model was fitted to transformed annual estimates of mean abundance per site for each reef in the region. See Appendix K for a technical explanation.

3. Reefs of the Great Barrier Reef: general trends

The notable changes on the Great Barrier Reef (GBR) over the last six years reflect the impact of cyclones and crown-of-thorns starfish (COTS) on reef communities, and the subsequent recovery of communities from such disturbances. The analyses of abundances of fishes and percent cover of benthic organisms on individual reefs (Section 2, Appendix K) estimate two types of trends: general trends over the six annual surveys, and current trends - those evident at the 1998 survey. Trends for the GBR can be summarised by considering the numbers of core survey reefs that show increasing, decreasing, or no significant trends in cover of hard coral and abundance of reef fishes.

The crown-of-thorns starfish, *Acanthaster planci*, is an important cause of coral mortality when populations build up to outbreak levels. AIMS staff have been monitoring starfish populations since 1986. The results of these surveys are summarised in Figure 3.1. Currently, there are high population levels of *A. planci* in the Cooktown /Lizard Is sector in the north, and in the Swains sector in the south. Note that the current high densities in these sectors are much lower than those observed in the central GBR in the last wave of outbreaks in the late 1980s (Fig. 3.1). The northern and southern reefs differ in that outbreaks in the north have been intermittent, while there have been some high density populations in the Swain sector since the earliest surveys (Fig. 3.1).

The period since 1993 has generally been one of low disturbance and net growth of coral on most of the GBR (Fig. 3.2). Reefs in two sectors go against the pattern: the proportion of reefs in the Cooktown /Lizard Is. and Swain sectors that have shown long-term decreases in coral cover is high relative to other sectors (Fig. 3.2). Both these sectors have reefs with COTS outbreaks (Fig. 3.1).

The Capricorn /Bunker reefs have shown a dramatic increase in coral cover (Fig. 3.2) representing recovery from a major decline in 1989, due to the physical removal of coral, probably by severe weather. A majority of reefs in the Townsville, Cairns and Cooktown / Lizard Is sectors also showed long term increases. The Cooktown / Lizard Is sector has both increases and decreases: while coral cover on inshore and mid-shelf reefs in the sector has declined due to COTS, coral cover on outer shelf reefs has been recovering from cyclone damage. A relatively low proportion of the reefs in two sectors: the Whitsunday and Swain reefs have shown a long term increase in coral cover; this low level of increases is probably an effect of Cyclone Justin in 1997.

The current trends show a slightly modified pattern: coral cover in the Capricorn/Bunker reefs continues to increase (Fig. 3.3), but there are obvious declines in the Townsville sector. This is partly due to cyclone damage after Cyclone Justin and partly because the Townsville sector was surveyed after mortality due to coral bleaching became evident in 1998.

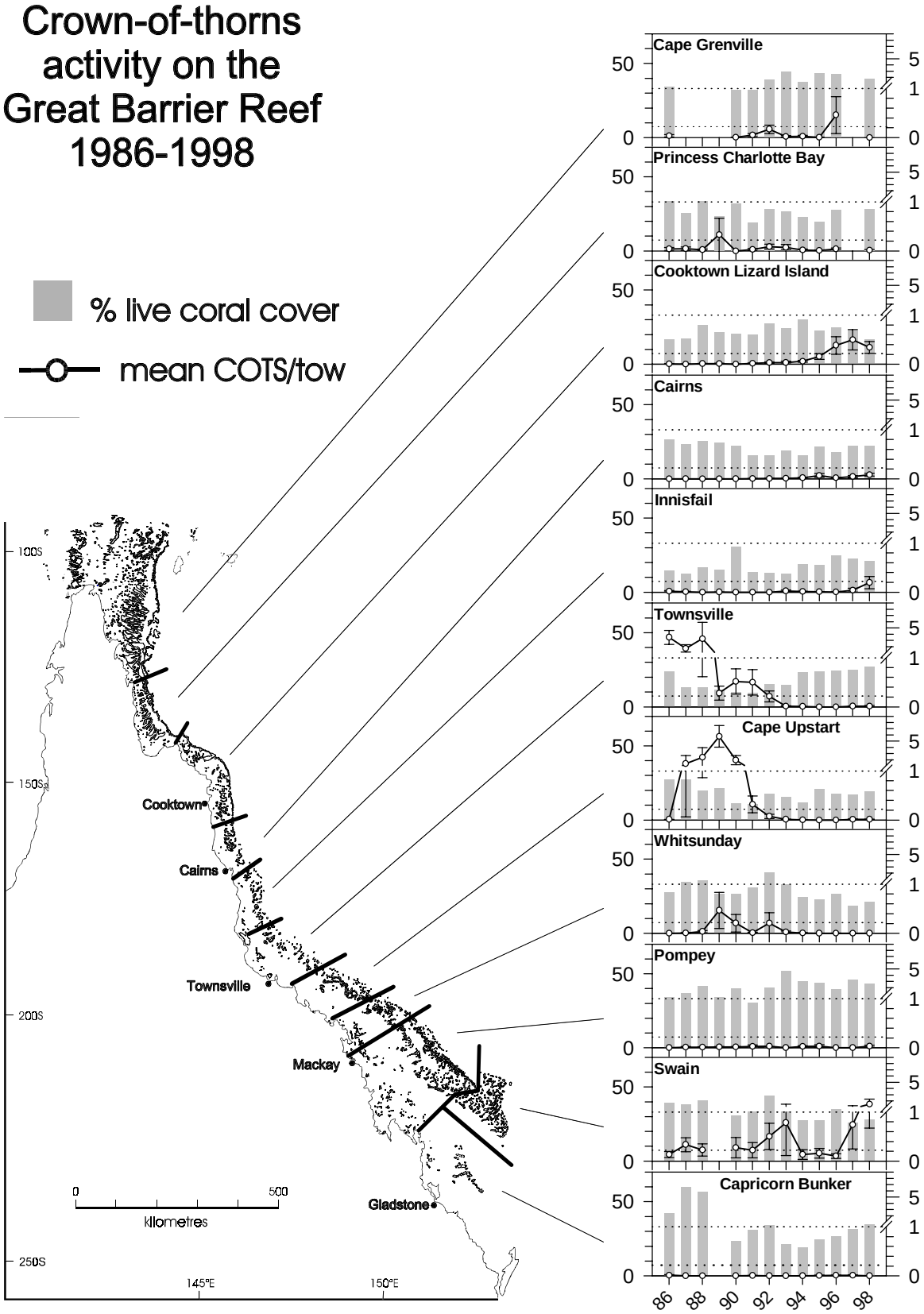


Figure 3.1 Summary of COTS populations and reef-wide coral cover on the GBR since 1986. Bar charts show mean live coral cover in each year (left hand axis); line plots show COTS abundances (mean COTS per tow $\pm$ SE) in each year (right hand axis). Lower dotted line = Incipient outbreak level (0.22 COTS per tow), upper dotted line = Active outbreak level (1.0 COTS per tow)

The outstanding feature of the overall trends in abundance of larger reef fishes is the large number of increases in the Capricorn /Bunker Sector (Fig. 3.4), presumably responding to the increase in habitat due to recovery of the coral communities. Current trends are similar (Fig. 3.5).

Explanation of summary plots

Appendices I and J show the results of analyses for long term trends and for current trends in benthic organisms and selected taxa of reef fishes on all the core survey reefs in six sectors. Data for some taxa on some reefs were insufficient for analysis, but where analysis was possible there were three possible outcomes: increase, decrease or no trend. The figures in this section summarise these trends.

Figures 3.2 and 3.3 summarise overall and current trends in hard coral by summing the reefs in each sector that showed each outcome and expressing this as a percentage of the number of reefs in the sector.

Figures 3.4 – 3.7 summarise overall and current trends in eight families of larger reef fishes and eight families of damselfishes. In these cases the figures give the sum of the occurrences of the taxa increasing, decreasing or showing no net trend on all the reefs in a sector. These sums are plotted as percentages of the total number of possible occurrences (number of survey reefs in a sector x number of taxa), less the number of cases where there were insufficient data. The number of cases where there were sufficient data for analysis and the total number of possible cases are given in parentheses beside the sector codes.

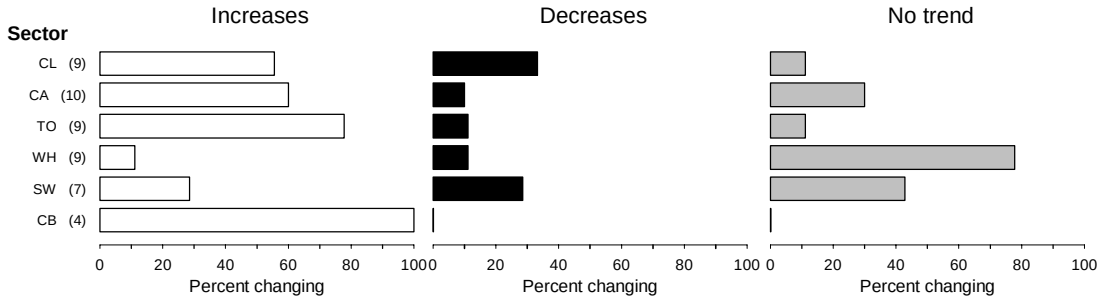


Figure 3.2: Overall trends in hard coral cover in the sectors over six years. Graphs show the percentage of core survey reefs in each sector showing increases, decreases or no trend in cover of hard coral. Numbers in parentheses are the numbers of survey reefs in each sector. CL = Cooktown /Lizard Is., CA = Cairns, TO = Townsville, WH = Whitsundays, SW= Swains, CB = Capricorn /Bunkers.

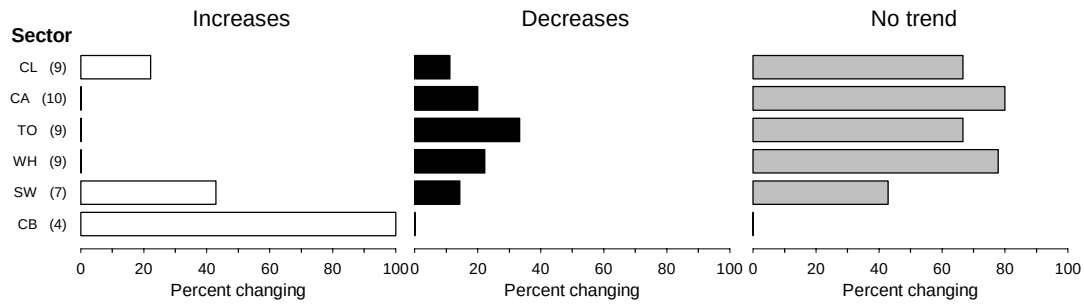


Figure 3.3: Trends in hard coral cover in the sectors at the 1998 survey. Graphs show the percentage of core survey reefs in each sector showing increases, decreases or no trend in cover of hard coral. Numbers in parentheses are the numbers of survey reefs in each sector. See Fig 3.2 for Sector codes.

The smaller, more site-attached, damselfishes show a different pattern. The greatest proportion of increases is in the Cooktown /Lizard Is and Capricorn /Bunker sectors. Coral cover has been increasing in the outer-shelf region of the Cooktown /Lizard Is sector and on the Capricorn /Bunker reefs. A notably small proportion of damselfish genera showed increasing trends and a large proportion of genera show decreasing trends in the Whitsunday and Swain sectors. This contrasts with the trends in larger fishes. Considerable changes coincided with Cyclone Justin (see Section 5). Current trends show a similar distribution (Fig. 3.7) except that there is a high proportion of taxa showing decreasing trends on the Capricorn /Bunker reefs. This reflects the die off of a large cohort of one species: *Pomacentrus coelestis* (see Section 4).

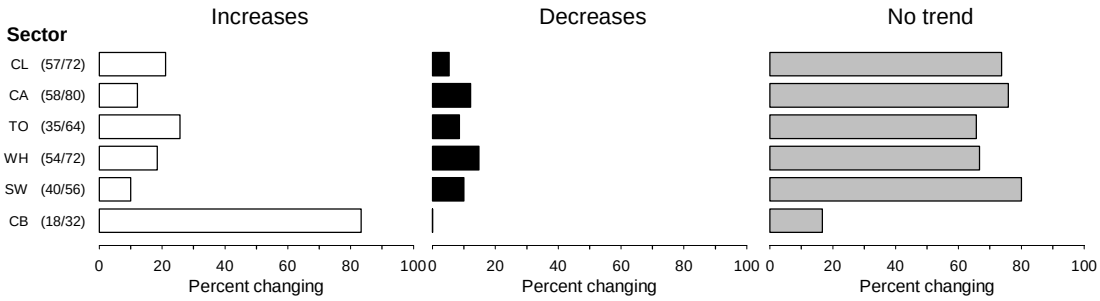


Figure 3.4: Overall trends in abundance of eight families of large mobile fishes in the sectors over six years. Graphs show the percentage of the sum of taxa occurring on each reef in each sector showing increases, decreases or no trend in abundance. Taxa that were not common enough to test were omitted. Numbers in parentheses are: (sums of the numbers of taxa on reefs in each sector that could be tested) / (total possible). See Fig 3.2 for Sector codes.

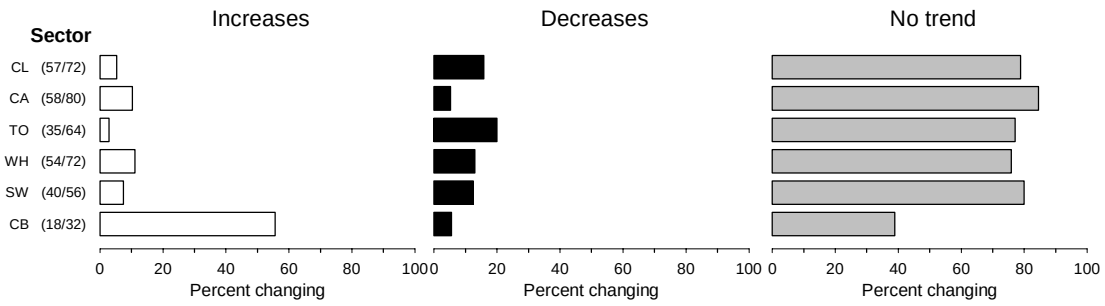


Figure 3.5: Trends in abundance of eight families of large mobile fishes in the sectors at the 1998 survey. Graphs show the percentage of the sum of taxa occurring on each reef in each sector showing increases, decreases or no trend in abundance. Taxa that were not common enough to test were omitted. Numbers in parentheses are: (sums of the numbers of taxa on reefs in each sector that could be tested) / (total possible). See Fig 3.2 for Sector codes.

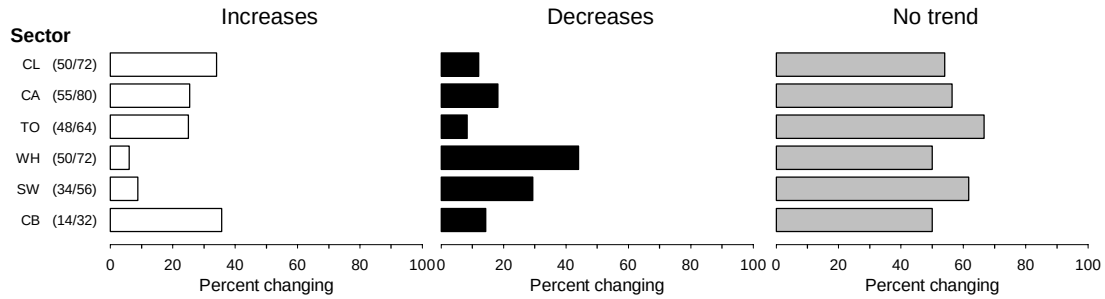


Figure 3.6: Overall trends in abundance of eight genera of damselfishes in the sectors over six years. Graphs show the percentage of the sum of taxa occurring on each reef in each sector showing increases, decreases or no trend in abundance.Taxa that were not common enough to test were omitted. Numbers in parentheses are: (sums of the numbers of taxa on reefs in each sector that could be tested) / (total possible). See Fig 3.2 for Sector codes.

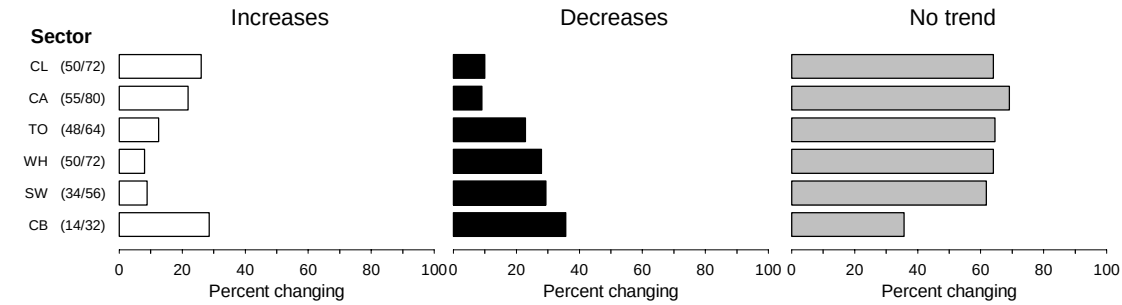


Figure 3.7: Trends in abundance of eight genera of damselfishes in the sectors at the 1998 survey. Graphs show the percentage of the sum of taxa occurring on each reef in each sector showing increases, decreases or no trend in abundance. Taxa that were not common enough to test were omitted. Numbers in parentheses are: (sums of the numbers of taxa on reefs in each sector that could be tested) / (total possible). See Fig 3.2 for Sector codes.

In summary, the outer region of the Cooktown/Lizard Is. sector and the Capricorn/Bunkers sector show obvious coral growth. The assemblages of reef fishes have also increased in number and diversity. Other regions of the Cooktown/Lizard Is. sector and the Cairns sector have lost coral due to predation by COTS. Fish numbers have also declined, presumably because of habitat losses. The Whitsunday reefs show restricted growth of corals and loss of small fishes coinciding with Cyclone Justin. Surveys of Reefs in the Townsville sector show loss of coral due to cyclones and bleaching. This is an incomplete picture of the extent of the bleaching because most sectors were surveyed before the bleaching developed fully in 1998.

4. Reefs of the Great Barrier Reef: regional status and trends

Introduction

The AIMS Long-term Monitoring Program is designed to provide estimates of regional status where the term "region" refers to each combination of sector (latitude) and position on the continental shelf (inshore, mid-shelf, outer shelf).

This section of the report considers status in terms of mean abundances or cover values for major groups, as well as the past and current trends in those values. These are presented sector by sector from north to south. Mean values for regions are given in Appendices E and F. Similar information about each survey reef is given in Section 5.

Analyses and their interpretation have been described in Section 2 and are given in detail in Appendix K.

Several facts need to be born in mind when reading the regional summaries:

1. The summaries draw on the three components of the LTMP and these differ in the areas of the individual reefs that are sampled and in the length of the time since surveys were started:

- Fishes and benthic organisms have been sampled on permanent sites on the NE faces of all the core sample reefs since 1995. Earlier surveys did not include all core reefs in each year.
- Regional species richness for fishes is based on the total numbers of prescribed species recorded on the permanent sites on each reef in each survey. This measure is only useful on a comparative basis. These data differ from the others in that only the last four years of surveys are included, see Section 2.
- The entire perimeters of most of the core reefs and of a large number of additional reefs have been surveyed using manta tows at varying intervals since the mid-1980s. Manta tows provide information on coral cover and population densities of crown-of-thorns starfish, *Acanthaster planci,* (COTS).

2. The statistical model (Appendix K) requires a sequence of observations from several reefs in each region; this condition was not always fulfilled. Some reefs that have been surveyed were not included because they have not been sampled frequently enough to identify trends. Similarly, some regions have been omitted because too few reefs within them had been surveyed adequately. The reefs that were included in the analyses are indicated in Appendix B, with a few exceptions that are mentioned in the text.

3. Estimates of the magnitude of changes that would have been detected - the statistical power of the tests - are given in Appendix K.
4. Percent cover refers the absolute value: the percent of the total substrate that is covered by a certain taxon.
5. Early in 1998, a significant proportion of corals began to bleach over large areas of the GBR. The Cooktown/Lizard Is. sector, the Swains and Capricorn-Bunker Reefs were surveyed late in 1997 and the Cairns sector was surveyed early in 1998 before the onset of major bleaching. This report does not provide a basis for assessing the full extent of the bleaching; the 1999 survey will reveal the extent of coral mortality.

Cape Grenville

Geography

In some areas in this sector, the outer shelf reefs form a wall which shelters the inner reefs from oceanic waves. The mid-shelf is characterised by large reefs and expanses of shallow shoals.

Reefs in this sector are visited opportunistically and are only surveyed by manta tow. The remoteness of this region means that few reefs have been sampled with sufficient frequency to estimate long-term trends.

Inshore reefs

COTS populations have been low on inshore reefs since surveys began. The current trend of increasing COTS populations is due to Curd Reef, which had an active outbreak in 1996, but it has not been surveyed since. The statistical model which fits the curve (Appendix K) does not work well with sparse and variable data such as these. There has been no significant regional trend in reef-wide coral cover though the current mean value (38%) is less than the long-term mean of 46% (Fig. 4.1).

Mid-shelf Reefs

Populations of COTS reached a peak in the early 1990s, gradually declining to well below outbreak levels (Fig. 4.1). This is due to Quoin Is and Sir Charles Hardy (1), both of which had incipient outbreak populations in 1991. No significant change in general coral cover was evident on the three survey reefs though cover is currently higher (42%) than the long-term average of 34% (Fig. 4.1).

Outer-shelf Reefs

The only COTS recorded in this region in any year were two observed on Lagoon Reef in 1998. Coral cover has remained stable at approximately 34% (Fig. 4.1).

Bleaching

Reefs in this sector were surveyed in March 1998. While there was some bleaching on all reefs, it was most evident on inshore reefs and declined across the shelf. On inshore reefs bleaching was extensive at 3-5 m but extended down to 9 m in places.

Summary

There have been COTS outbreaks in this sector in the past and in recent years, but the irregularity of sampling makes it hard to identify trends in starfish populations or coral cover.

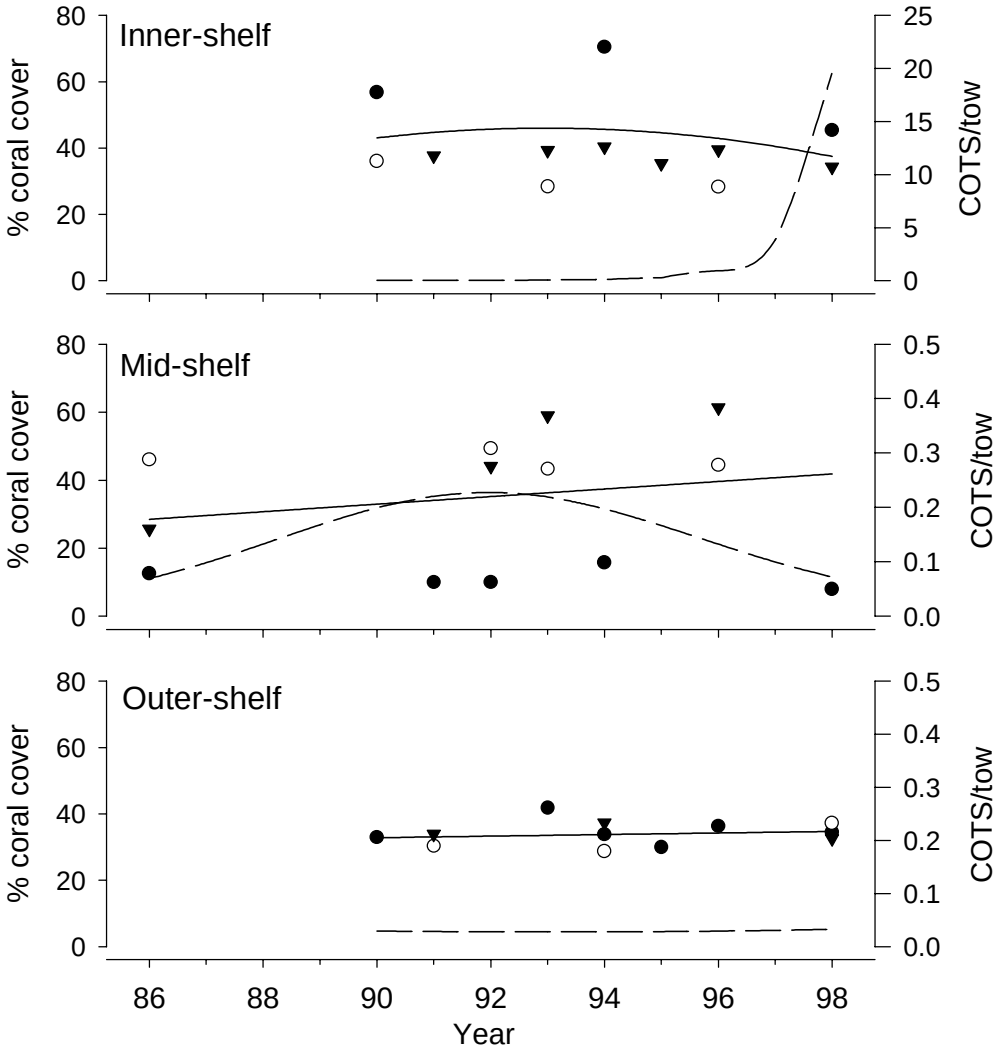


Figure 4.1: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Cape Grenville sector, classified by position on the continental shelf. Solid line represents the overall trend in coral cover; broken line represents the overall trend in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

Princess Charlotte Bay

Geography

The outer reefs in this sector form a substantial wall against the influences of the Coral Sea. The mid-shelf reefs are very large.

Inshore Reefs

COTS have been found sporadically on inshore reefs and mean densities peaked during the early 1990s. This was mainly due to Clack Reef, which had outbreak densities in 1989. COTS have been observed there in most surveys. Osborne Reef had an incipient outbreak population in 1993. Populations of COTS on the survey reefs in this region are currently low. The long-term reef-wide average cover of coral on inshore reefs has been 30% and this has not changed significantly. There is no consistent regional trend in coral cover at present: Pelican Is. is increasing, Osborne Reef is stable and there is a downward trend at Clack Reef (Fig. 4.2).

Mid-shelf reefs

Too few mid-shelf reefs have been sampled consistently through time to provide a basis for analysis.

Outer-shelf reefs

Large numbers of COTS were present on Rodda Reef in the mid-1980s, but no COTS were observed on outer-shelf reefs in this region during in 1998. No COTS have been observed on the other two reefs in any year. Coral cover in this region has increased since 1986 (Fig. 4.2); it is currently 27%.

Bleaching

This sector was surveyed in October 1997, before significant bleaching had developed anywhere on the GBR.

Summary

Only inshore and outer-shelf regions could be analysed. There are currently no significant COTS populations in either region. There is no consistent trend in coral cover on inshore reefs. Coral cover on outer-shelf reefs has increased.

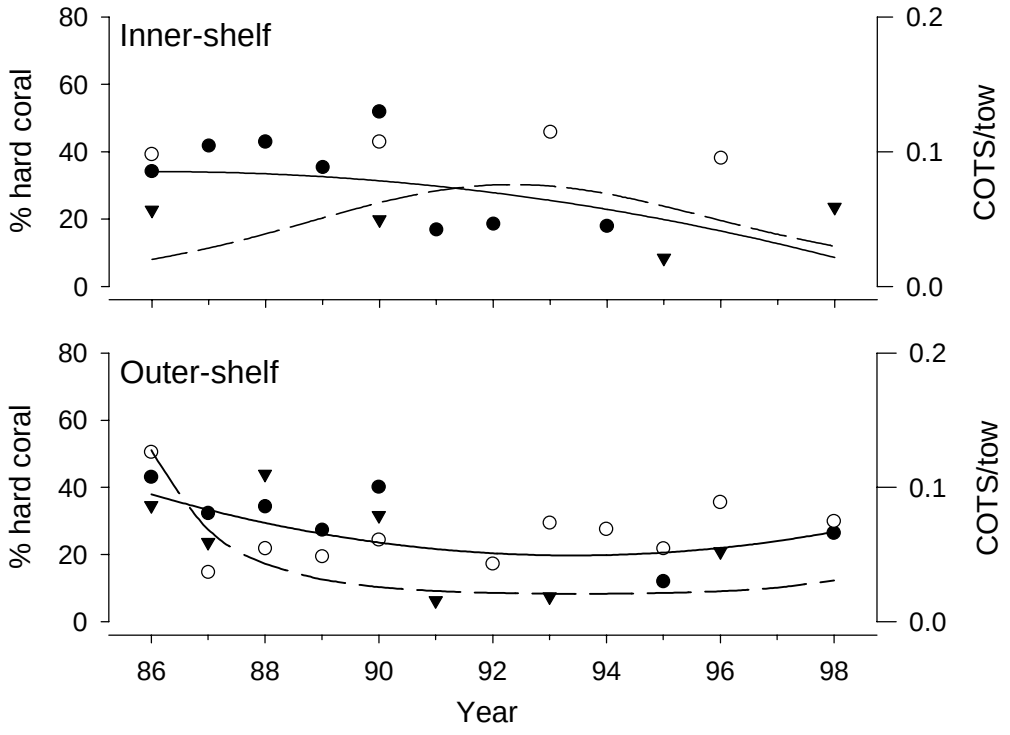


Figure 4.2: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Princess Charlotte Bay sector, classified by position on the continental shelf. Solid line represents the overall trend in coral cover; broken line represents the overall trend in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

Cooktown/Lizard Is Sector

Geography

The offshore reefs in this sector form a wall and represent a substantial barrier to influences from the Coral Sea, both in terms of wave energy and exchange of water.

Inshore Reefs

The number of COTS on inshore reefs has been increasing since the early 1990s. Two Isles Reef has an active outbreak while Boulder and Linnet Reefs have incipient outbreaks. Manta tow surveys of the entire reef perimeters of five reefs show that overall hard coral cover has increased in the region since surveys began in 1985 but is currently decreasing (Fig. 4.3). Reef-wide hard coral cover in the region is currently about 24% and is declining at approximately 3% per annum. The mean cover since 1985 is 32%.

Video transects from the permanent sites on three reefs show a slightly different picture. Cover of hard corals has increased marginally since 1991 to an average of 30% (Fig. 4.4).

Cover of soft corals (3%) is low and has declined slightly since surveys began. Cover of algae has not changed significantly and currently averages 49%.

On average, Acroporidae made up 9% of total cover of hard corals, while Faviidae, Poritidae and Pocilloporidae averaged about 4% each. 'Other' corals accounted for 6% of cover. There was no significant increase in the cover of any of these taxa in the last six years (Fig. 4.4).

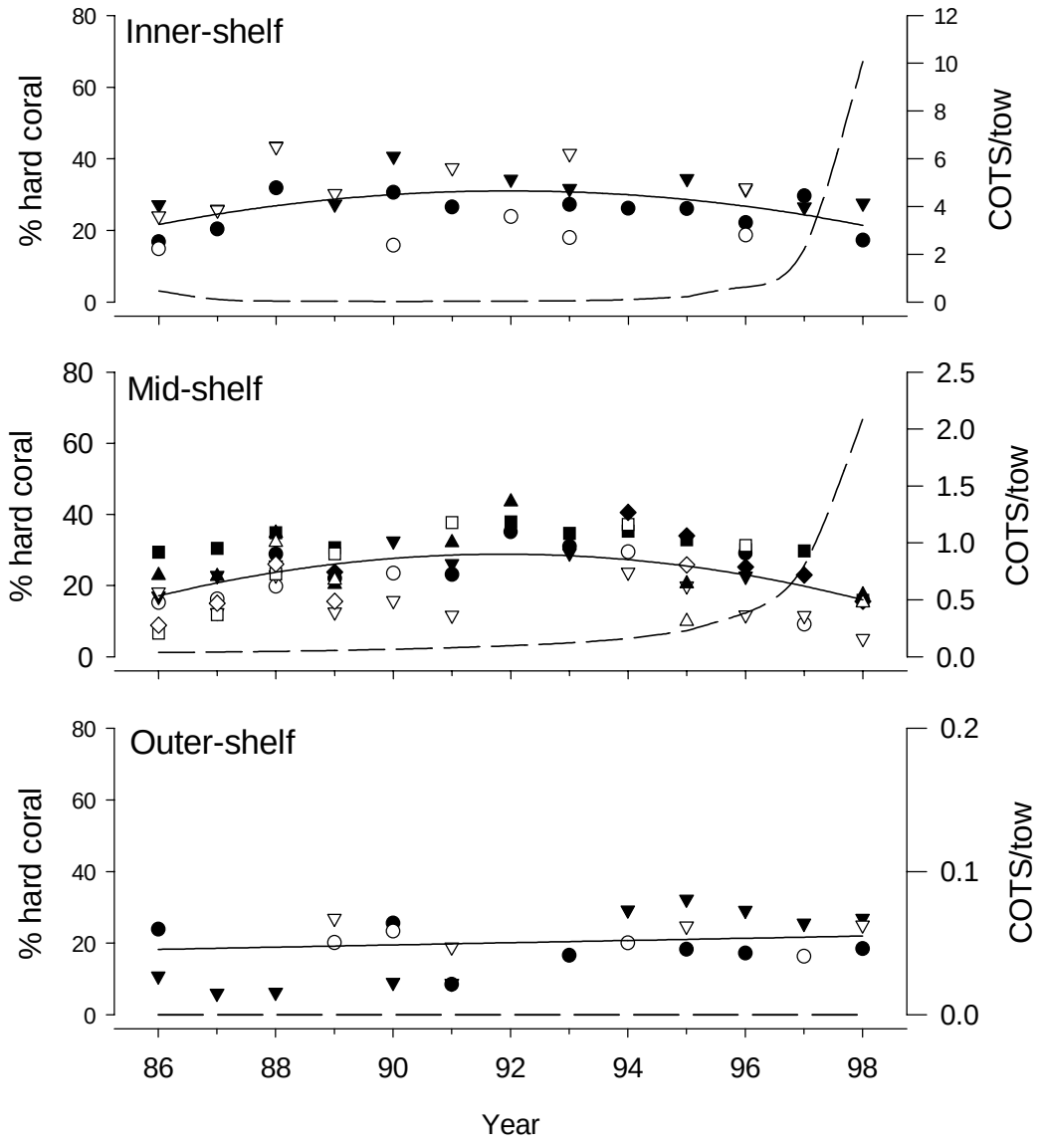


Figure 4.3: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Cooktown/Lizard Is. sector, classified by position on the continental shelf. Solid line represents overall trend in coral cover; broken line represents trends in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

There have been no significant declines in species richness in any of the categories of coral reef fishes (Fig. 4.5). The numbers of coral reef fishes in the family Serranidae has declined marginally on the three core inshore reefs since the first surveys (Fig. 4.5). Recently wrasses (Labridae) have decreased in numbers significantly but they have not shown a long-term trend. Two damselfish genera have increased in numbers over the period of surveys: *Amblyglyphidodon* continues to increase marginally (Fig. 4.5), while the genus *Pomacentrus* has increased markedly in numbers over the six years, but has been stable recently. This is principally due to *P. moluccensis*, but *P. coelestis* and *P. lepidogenys* have increased too.

Mid-Shelf Reefs

The numbers of COTS on mid-shelf reefs have been increasing since the early 1990s. The average level of COTS for the region is currently above incipient outbreak levels. Lizard Is. and MacKay Reefs have active outbreaks of COTS, while populations on MacGillivray, Startle and Swinger Reefs have incipient outbreak levels

Reef-wide coral cover increased in the late 1980s, peaked in the early 1990s and is currently declining (Fig. 4.3). It is currently about 16% compared with a long-term average of close to 29%. The present rate of decline is about 4% per annum, but this is accelerating due to COTS. Once again, the permanent sites on mid-shelf reefs give a slightly different picture. Cover of the major groups has not changed significantly over the last six years (Fig. 4.4); hard coral currently averages 15% cover, algae averages 55% while cover of soft corals is low at MacGillivray (5%) and North Direction (2%) Reefs, but is higher at Lizard Island (18%).

The hard coral assemblages on mid-shelf reefs were not dominated by any one family. On average, Poritidae (6%) and Faviidae (3%) were the most abundant hard corals, followed by Pocilloporidae and Acroporidae (1%). 'Other' corals accounted for 2% of total cover. While there was little change in the total proportion of space occupied by these taxa, there were some changes in composition within taxa. In the family Acroporidae, corymbose and digitate life-forms decreased significantly. These are favourite prey of *A. planci* (De'ath and Moran, 1998) and their decline may reflect increased numbers of COTS in the region. Cover of Pocilloporidae has also declined slightly.

One family of coral reef fishes, the Chaetodontidae, is currently declining in numbers on the permanent sites on mid-shelf reefs; this is reflected in species richness (Fig. 4.5). Several species in this family are coral feeders, so this may be a response to decline in coral cover due to *A. planci.* Among larger species the Lethrinidae have also increased marginally. The abundance and species richness of the genus *Pomacentrus* has increased since the first surveys, but abundance has declined recently. *Pomacentrus brachialis* and *P. moluccensis* increased in the first three visits but individual species do not show

consistent trends. The number of species in the genus *Chromis* has decreased marginally over the four years (Fig 4.5).

Outer-shelf Reefs

COTS have rarely been observed on outer-shelf reefs: only two individuals have been recorded in the surveys. There are anecdotal reports of outbreaks in this sector in the mid-1980s. Manta tows of the perimeters of six outer-shelf reefs show no clear pattern in reef-wide coral cover. While coral cover has increased on some reefs, it has declined or remained the same on other reefs over the same time period (Fig. 4.3). Mean coral cover is currently 22%, which is close to the long-term average of 20%.

Video transects on permanent sites on outer-shelf reefs show that cover of hard corals has increased, rising from an average of 12% in 1993 to 52% in 1998 (Fig. 4.4). A large cyclone ("Ivor", maximum category 3) passed about 100km north outside the Barrier Reef in March 1990 (Puotinen *et al*. 1997), which caused the low starting values for coral cover on the NE faces of these reefs. Cover of hard corals is currently increasing at a rate of 9% per year. There has been a decrease in the cover of algae over the same period, from an average of 40% to 10%. Cover of algae is currently decreasing at a rate of 7% per year. Cover of soft corals has not changed significantly during the surveys, averaging 7%.

Increases in cover of hard corals reflect increases in cover of tabulate *Acropora* spp. (Fig. 4.4), which have risen from practically zero in 1993 to an average of 20% in 1998. This accounts for about half of the total increase in hard coral cover. Cover of corymbose and digitate life-forms increased initially from an average of 0.4% in 1993, but has subsequently stabilised at approximately 9%. This is probably an artefact of the life-form classification: corymbose corals may be re-classified as tabulate corals when they grow large.

Cover of Pocilloporidae has increased from approximately 2% in 1993 to 10% in 1998. This accounts for about a quarter of the total increase in hard coral cover. Other coral taxa have low cover values (Appendix E).

Among reef fishes, the abundance of acanthurids has declined on outer-shelf reefs (Fig. 4.5). The majority of these feed on algae so the decline in numbers may be related to the significant increase in coral cover on these reefs and the associated decline in algal turf in the duration of the study. The abundant genus *Ctenochaetus* also declined; these are largely detritivores. Abundance of three genera of site-attached damselfishes is increasing on these reefs (Fig. 4.5), where the cover of hard corals has been increasing dramatically. Species richness of number of groups has increased, presumably related to the increase in coral cover and hence habitat complexity.

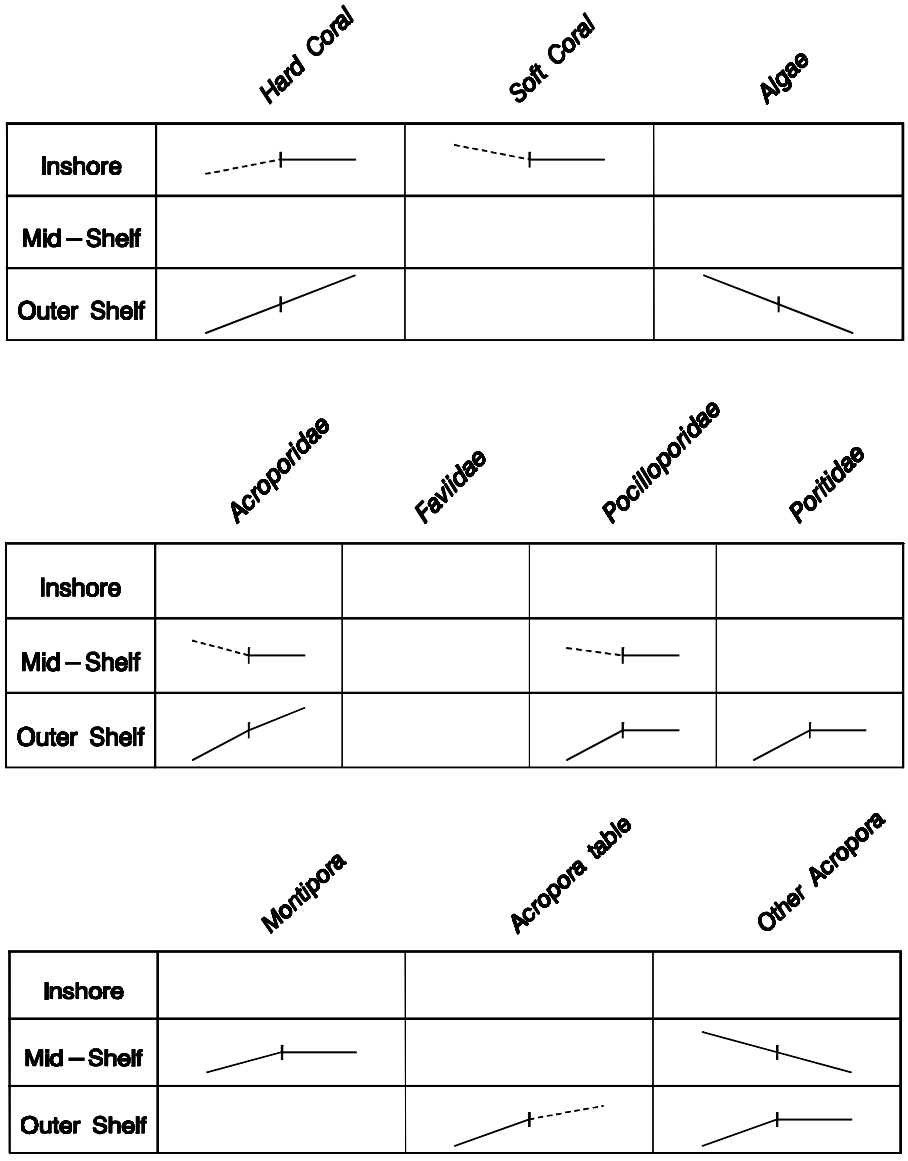


Figure 4.4: Trends in the cover of benthic organisms in the Cooktown/Lizard Is. sector, for reefs classified by position on the continental shelf. Symbols summarise trends in percent cover (per site) of the main groups of benthic organisms, principal families of hard corals and three groups within the Acroporidae. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over six years. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank.

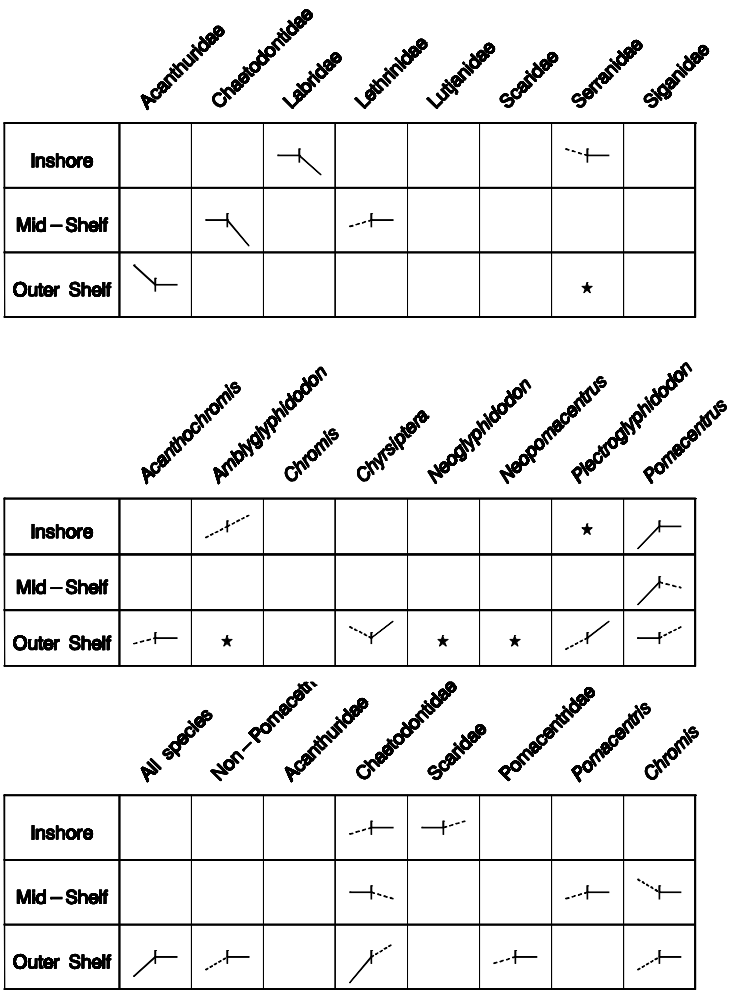


Figure 4.5: Trends in the abundance (top 2 plots) and in species richness (lower plot) of reef fishes in the Cooktown/ Lizard Is. sector for reefs classified by position on the continental shelf. Symbols summarise trends in abundance (mean number per site) of eight families of larger, more mobile species and of eight genera of site-attached damselfishes over six years. Trends in species richness for selected taxa based on numbers of species per reef over four years. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over the survey period. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank. A star (★) indicates that the data were insufficient to detect a trend with any certainty.

Bleaching

This sector was surveyed in October 1997, before the major bleaching was evident. No information is available.

Summary

Inshore and mid-shelf reefs in this sector are showing the influence of COTS, with declines in hard coral cover and in numbers of coral dependent fishes. Outer-shelf reefs have not been affected by COTS and show no significant change in overall levels of coral cover, though there has been a strong recovery of coral cover on the NE faces following Cyclone Ivor. Some changes in fish numbers may be associated with this increase in coral. Declines in other fish taxa have no evident explanation and these should be followed closely in future surveys.

Cairns Sector

Geography

Unlike the sector to the north, the outer reefs of this sector form less of a barrier, so mid-shelf reefs are likely to be exposed to more wave action and to more oceanic water from the Coral Sea. The coastal hinterland falls within the Wet Tropics and several large rivers drain into this sector.

Inshore Reefs

AIMS surveys had recorded few COTS on these reefs until low numbers were seen at Green Is. in 1994. Since then there has been a general increase and low numbers were present on all three reefs in 1998. Manta tows of reef perimeters show that the average cover of hard coral on inner-shelf reefs in the Cairns sector has changed little since 1986 (Fig. 4.6). The slight apparent increase in mean regional coral cover is mainly due to Fitzroy Is. and may be because extensive bleaching made hard corals very obvious on this reef at the 1998 survey.

Video surveys of permanent sites on these reefs showed that cover of hard coral has not changed over the six years, but is currently declining (Fig. 4 7). The average cover of hard coral in this region is 24% but varies among reefs, ranging from approximately 37% at Fitzroy Is. to about 6% at Green Is. It is declining at about 3% per annum. Declines generally correspond to increases in COTS populations. As cover of hard coral has declined, cover of algae has generally increased (Fig. 4.7). Cover of soft corals has been stable but is currently declining. It ranges from 19% at Fitzroy Is. to 2% at Green Is. (Fig. 4.7).

Among hard corals, the cover of Acroporidae is currently 5% and has been decreasing at an average rate of 4% per annum. Within this family, declines have occurred in both *Montipora* spp. and *Acropora* spp. (Fig. 4.7). Changes in cover have been less rapid in the Pocilloporidae. The Faviidae and Poritidae have increased over time but show no current trend (Fig. 4.7).

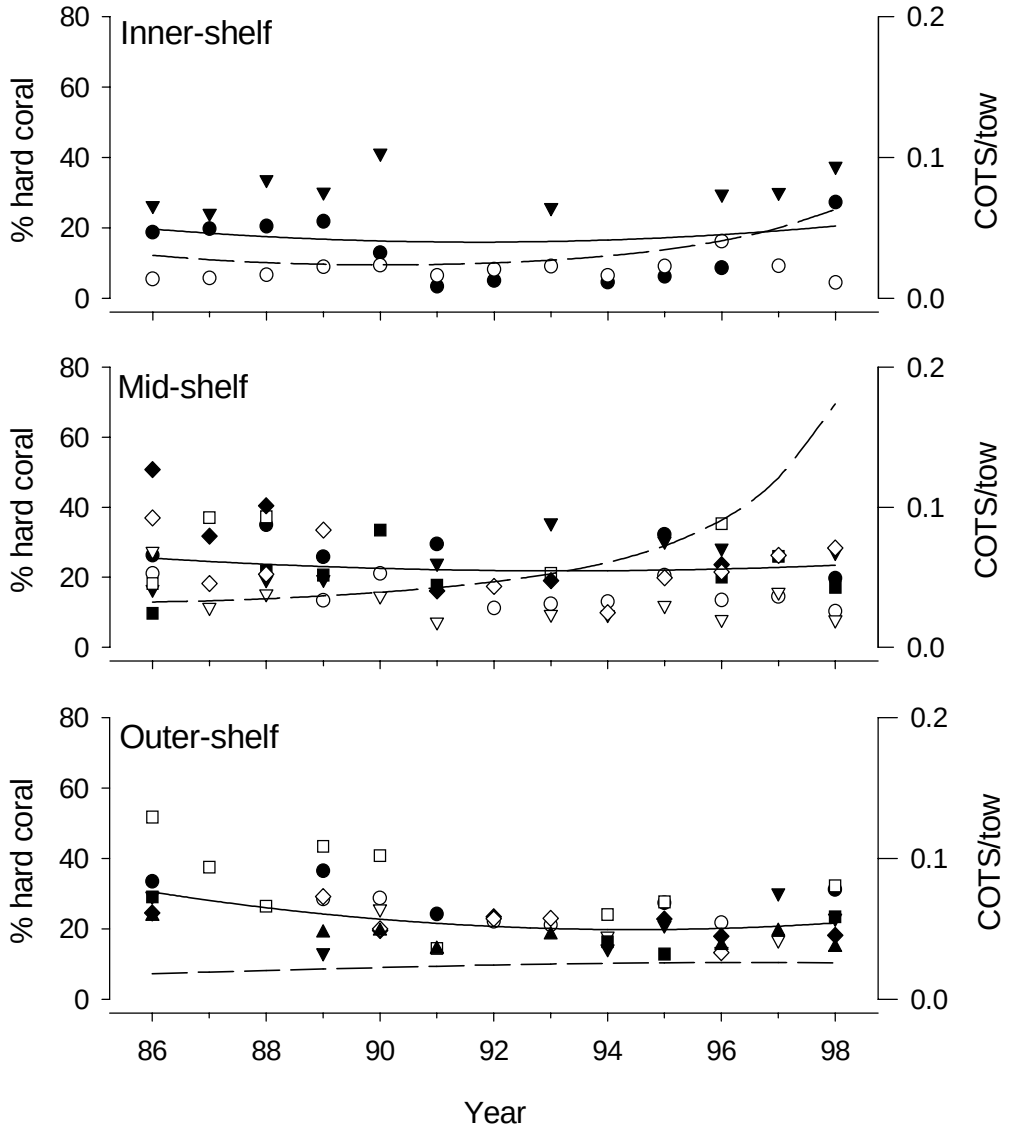


Figure 4.6: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Cairns sector classified by position on the shelf. Solid line represents the trend in coral cover; broken line represents the trend in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

Mean numbers of one family of reef fishes, the Labridae, has declined overall on the permanent sites on reefs in this region over the last six years, though numbers have been increasing recently (Fig. 4.8). The abundances of individual species show much variability from year to year and few consistent trends. Acanthuridae have declined and Scaridae have increased slightly. Among damselfishes, *Chrysiptera* spp. have increased marginally over the six years, while *Amblyglyphidodon* has not increased

significantly over the six years but currently shows an increasing trend. The numbers of individuals of *Pomacentrus* spp. have increased significantly over the six years and are now decreasing. This largely reflects changes in the population of *P. moluccensis*. In terms of species richness, only the genus *Chromis* has increased marginally (Fig. 4.8).

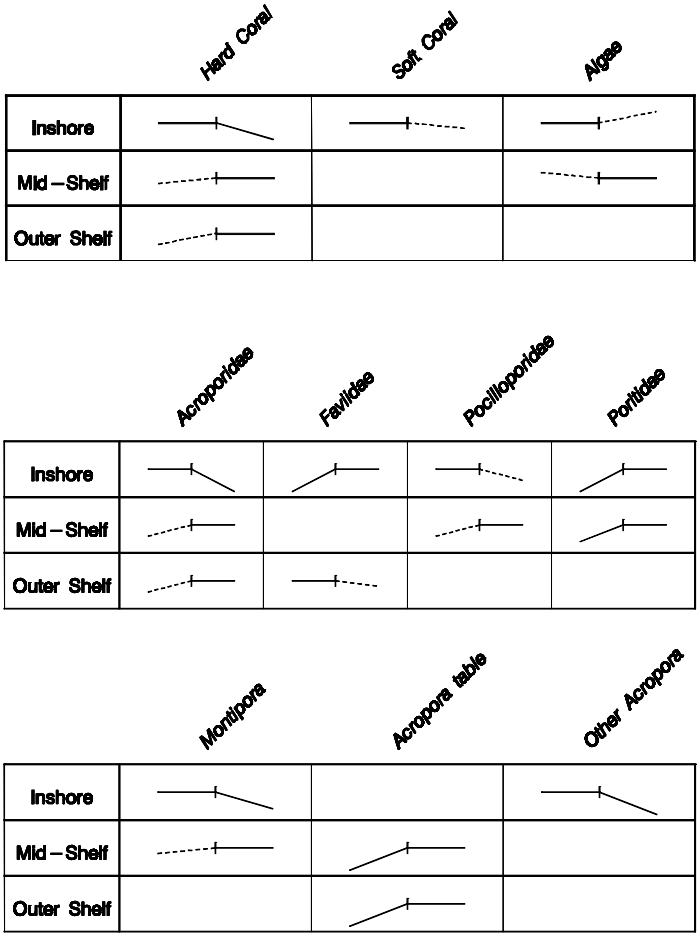


Figure 4.7: Trends in the cover of benthic organisms in the Cairns sector, for reefs classified by position on the continental shelf. Symbols summarise trends in percent cover (per site) of the main groups of benthic organisms, principal families of hard corals and three groups within the Acroporidae. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over six years. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank.

Mid-Shelf Reefs

A few COTS have been recorded in this region in most surveys and the overall mean density has been 0.04 COTS tow^{-1}. Populations are increasing: there have been higher numbers on Michaelmas Reef since 1993 and incipient outbreaks were detected at MacKay and Pickersgill Reefs in the most recent survey. There has been no clear pattern of change in coral cover in the region since manta tow surveys began in the mid-1980s: coral cover has increased on some mid-shelf reefs and declined on others resulting in no net change (Fig. 4.6). Current coral cover is 23% compared with the long-term average of 22%.

Intensive sampling of the permanent sites has found that cover of hard coral has increased marginally while cover of algae has decreased over the last six years (Fig. 4.7). Average cover of hard coral is currently 28% and cover of algae currently averages 39%. Cover of soft coral has shown no trends and now averages 14%, ranging from less than 4% at MacKay Reef to 31% at Michaelmas Reef.

The increase in hard coral cover on the permanent sites over the six years included most taxa (Fig. 4.7). Cover of Acroporidae increased to the current average of 11%. This was mainly due to tabulate *Acropora* spp., which increased from 0.3%in 1993 to more than 4% in 1998. Cover of *Montipora* spp. increased but remains low at an average of about 1%. Cover of Pocilloporidae (currently 4%) and Poritidae (2%) increased slightly during the initial years of the survey period. Cover of Faviidae (4%) did not change significantly. Cover of other coral taxa has also been stable (currently 3.5%).

Fish assemblages on mid-shelf reefs show no major trends: there was a marginal decrease in the number of Labridae and a marginal increase in numbers of *Pomacentrus* spp. (Fig. 4.8).

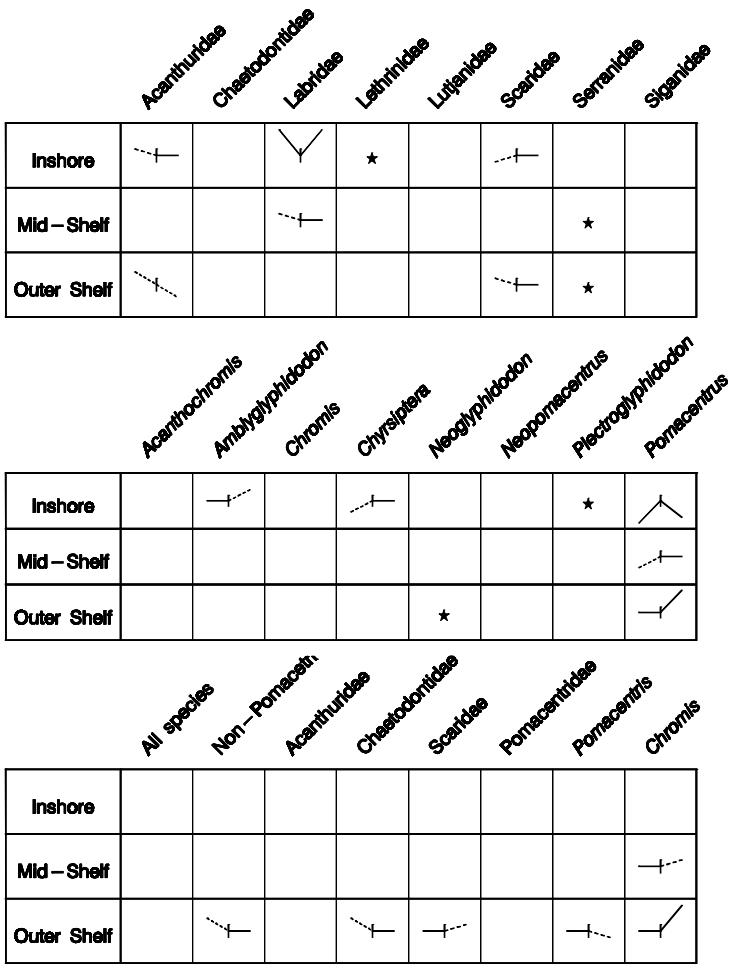


Figure 4.8: Trends in the abundance (top 2 plots) and in species richness (lower plot) of reef fishes in the Cairns sector for reefs classified by position on the continental shelf. Symbols summarise trends in abundance (mean number per site) of eight families of larger, more mobile species and of eight genera of site-attached damselfishes over six years. Trends in species richness for selected taxa based on numbers of species per reef over four years. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over the survey period. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines Where neither the general nor the current trends were significant, the cell was left blank. A star (★) indicates that the data were insufficient to detect a trend with any certainty.

Outer-shelf reefs

Few COTS have been recorded on these reefs in any survey and none was recorded in recent surveys. Broad scale surveys showed no significant change in reef-wide cover of hard coral since the mid-1980s (Fig. 4.6).

Hard coral cover on the permanent sites increased slightly over the last six years, averaging 21% in 1993 and 26% in 1998. This increase is small compared with the changes on outer-shelf reefs in nearby sectors and was largely due to tabulate *Acropora* spp. (Fig. 4.7) which increased from 0.2% cover in 1993 to 3% in 1998. Average cover of all Acroporidae is 15%. Other hard corals were stable: Pocilloporidae (currently 5%), Poritidae and Faviidae (2% each) and all others (0.5%) except that Faviidae currently show a slight decreasing trend (Fig. 4.7). Cover of soft corals showed no trend, with an average of 34%over the survey period.

Among reef fishes, Acanthuridae showed a marginally significant long-term decline in numbers, which is continuing (Fig. 4.8). Acanthuridae have declined in abundance in the Cooktown / Lizard Is sector to the north. Similar species were involved, though there was no coincident increase in coral cover in this sector as on outer-shelf reefs in the Cooktown / Lizard Is. sector. Parrotfishes (Scaridae) have declined over the last six years but show no current trend. *Pomacentrus* spp. currently show a significant increasing trend due to *Pomacentrus lepidogenys*, *P. bankanensis* and *P. philippinus*. Considering species richness, non-pomacentrids in general and Chaetodontidae in particular have declined over the last four years. Species richness of the genus *Chromis* has shown no long term trend but has increased strongly recently, the *Scaridae* show the same pattern less strongly and species richness of the genus *Pomacentrus* had been stable but has recently declined marginally (Fig. 4.8).

Bleaching

Reefs in this sector were surveyed in January 1998, before the major bleaching was evident.

Summary

Numbers of COTS are increasing on inshore and mid-shelf reefs. Intensive surveys show declining coral cover on fronts of inshore reefs but there is no evidence of reef-wide changes in coral cover. Coral cover in the Cairns sector is stable on inshore and mid-shelf reefs and increasing on outer-shelf reefs.

Innisfail

Geography

This sector resembles the Cairns sector in that the outer-shelf reefs do not form an impermeable barrier to oceanic influences and the adjacent coast receives a lot of rainfall.

Inshore reefs

There are no core reefs in the Innisfail sector, so reefs there are surveyed by manta tow only. No inshore reefs in the Innisfail sector have been surveyed adequately to allow identification of trends.

Mid-shelf reefs

Manta tows have shown little change in reef-wide coral cover since 1986 (Fig. 4.9). Hard corals cover about 19% of the substrate at present, while the long-term mean is approximately 16%. After an initial decrease in COTS numbers at the start of surveys, population levels have been low with sporadic sightings in some survey years. The recent increase in COTS is due to Scott Reef, which had an incipient outbreak population in 1998. The regional average starfish density was 0.47 COTS tow^{-1} in 1998, which is within incipient outbreak levels.

Outer-shelf Reefs

Coral cover on outer-shelf reefs has also changed little since 1986 (Fig. 4.9). Coral cover is approximately 23% compared with the long-term average of 18%. COTS populations have increased in recent years: all three reefs showed increases in the last survey year. In 1998, Wardle Reef had an incipient outbreak but the mean COTS density for the region was 0.14 COTS tow^{-1}, which is well below outbreak levels.

Bleaching

Reefs in this sector were surveyed in February 1998, before the major bleaching was evident.

Summary

Coral cover in this sector has been relatively stable and is currently slightly above the long-term average. COTS populations have been increasing in recent years, though this has yet to show up in reduced coral cover.

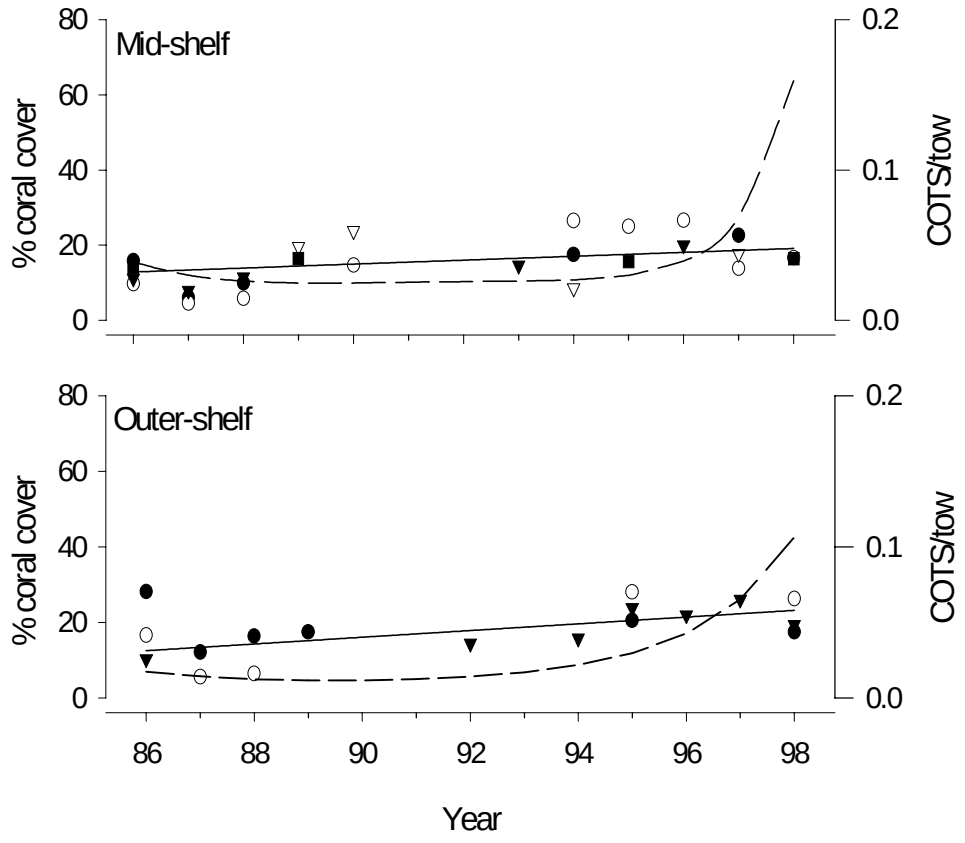


Figure 4.9: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Innisfail sector classified by position on the shelf. Solid line represents overall trend in coral cover; broken line represents trends in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

Townsville

Geography

The outer-shelf reefs in this sector do not exclude oceanic influences, but the GBR lagoon is wider near Townsville than it is further north. The Herbert River drains into the northern part of this sector, and the mouth of the Burdekin is just to the south. River plumes tend to be transported northwards by the prevailing winds.

Inshore reefs

Inshore reefs in the Townsville sector were not surveyed by manta tow often enough to allow analysis, but video surveys of the permanent sites on Pandora and Middle Reefs in the last six years show that the cover of algae has increased slightly (Fig. 4.10). Havannah Is has only been surveyed since 1997. Regional mean cover of hard coral is currently 39% and is declining at about 8% per annum on average, though this is largely due to Havannah Reef, where cover decreased from 44% in 1997 to 28% in 1998. This coincided with the occurrence of coral bleaching, which has affected reefs across the GBR. Because this reef has only been surveyed in the last two years it is not included in the data for Fig 4.11. The decline in cover of hard coral on inshore reefs has coincided with increases in cover of algae. Cover of soft corals has remained stable at approximately 14%.

Regionally, cover of *Montipora* spp. was increasing but declined from 5% in 1997 to 4% in 1998 (Fig. 4.10). There were significant decreases in coral cover at Pandora Reef, which has high cover of *Montipora* spp. and of taxa such as *Pachyseris speciosa*, *Leptoseris* spp. Cover of these species declined regionally from 11% in 1997 to 9% in 1998 while cover of Poritidae (13%) and Faviidae (3%) remained stable over the same period. Poritidae are an important part of the hard coral community at both Middle and Pandora Reefs.

The data on fish abundances is incomplete and has been omitted. The poor visibility on inshore reefs has meant that counts of larger fish species are often impractical and the resulting incomplete data cannot be analysed. Damselfishes have been counted in most years on Pandora and Middle Reefs, but the variable counts from two reefs do not allow reliable detection of trends.

Mid-shelf reefs

COTS populations were high in this region in the mid-1980s (about 4 COTS tow^{-1}: well above outbreak levels) but declined rapidly through the late 1980s. Average COTS densities in this region had dropped below outbreak levels by 1993. Populations currently show an increasing trend, though they remain well below outbreak levels (Fig. 4.11). Manta tows of the perimeters of six reefs (Appendix B) show that coral cover on mid-shelf reefs decreased during the initial years of survey then subsequently increased

(Fig. 4.11). Coral cover is currently 39% compared with a long-term average of just 11% and is increasing at 7% per annum.

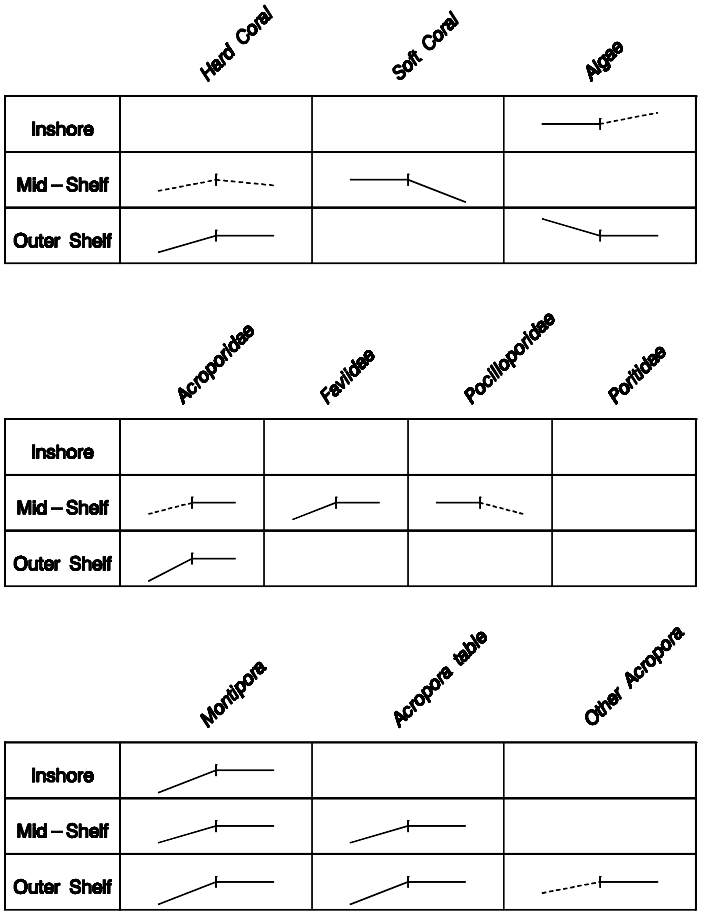


Figure 4.10: Trends in the cover of benthic organisms in the Townsville sector, for reefs classified by position on the continental shelf. Symbols summarise trends in percent cover (per site) of the main groups of benthic organisms, principal families of hard corals and three groups within the Acroporidae. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over six years. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank.

Video surveys of permanent sites began at a time when reefs were recovering from COTS predation, so cover of hard coral in this region has increased over the six years of surveys. This increase was particularly pronounced at Rib Reef, which increased in cover from 39% in 1994 to 69% cover in 1996 (see Section 5). Cyclone Justin caused a

decrease in regional coral cover in 1997. Cover of algae showed no consistent changes over the six year period, but has increased slightly recently. Cover of soft corals remained stable at a low average of less than 3% (Fig. 4.10).

Most of the dynamics of hard coral assemblages in this locality is due to changes in cover of tabulate *Acropora* spp., which initially increased from 0.6% in 1993 to 20% in 1996, then decreased to an average of 11% in 1998 (Fig. 4.10). Cover of *Montipora* spp. also increased over the six years.

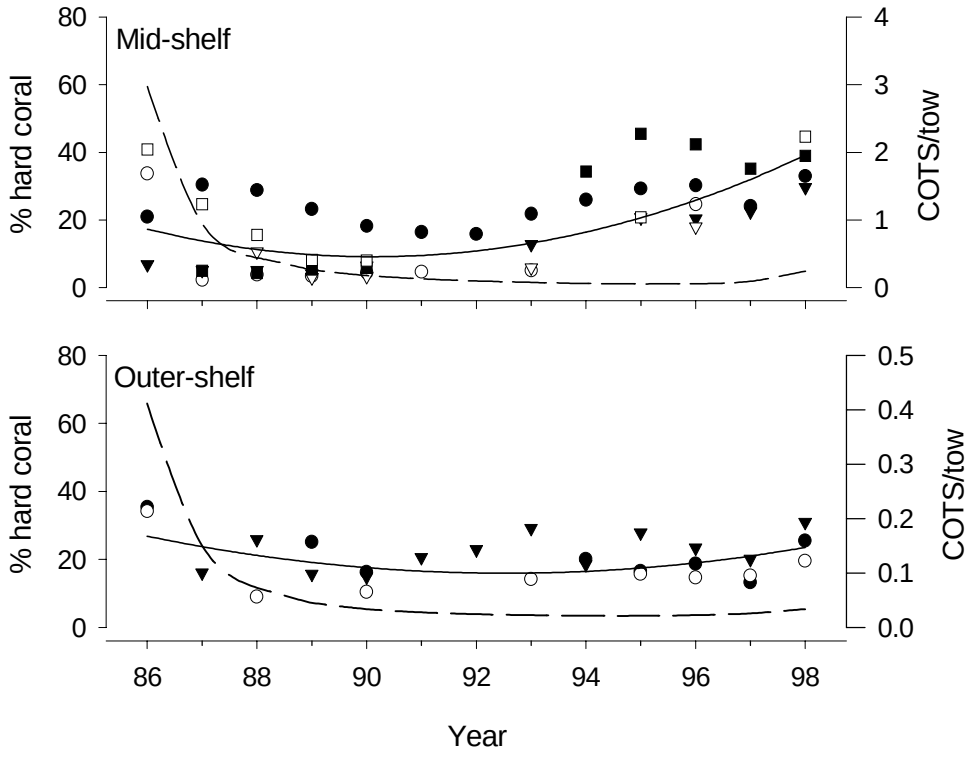


Figure 4.11: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Townsville sector. Solid line represents overall trend in coral cover; broken line represents trends in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

Faviidae increased over the six years while Acroporidae as a family increased only marginally. Pocilloporidae were stable in the long term but cover is currently decreasing.

Numbers of Labridae have also declined marginally on mid-shelf reefs in the last six years, though there is currently no net trend (Fig. 4.12). Numbers of lethrinids have increased slightly over six years but declined recently. The numbers of the damselfishes in the genus *Chromis* have increased: this is largely due to *C. atripectoralis*, a species that is associated with branching and corymbose corals.

The mean number of species in the genus *Pomacentrus* has decreased over the last four years, though there is currently no net trend (Fig. 4.12).

Outer-shelf reefs

As on mid-shelf reefs, numbers of COTS were high in the mid-1980s, due mainly to Dip Reef, which had an outbreak population in 1986. Numbers have declined subsequently, with only one COTS recorded on these reefs since 1990. Outer-shelf reefs show an initial decline in coral cover followed by recovery, similar to the pattern on mid-shelf reefs (Fig. 4.11). Coral cover is currently 24%.

Video data from the permanent sampling sites show that average cover of hard coral increased from 21% in 1993 to 34% in 1998 (Fig. 4.10). Cover of algae declined over the six years. Cover of Acroporidae increased over the six years, but a great portion of the change was due to cover of tabulate *Acropora* spp. increasing from 0% in 1993 to 4% in 1998. Faviidae (6%), Pocilloporidae (5%), Poritidae (3%) and other hard corals (2%) did not change significantly over the survey period. Cover of algae has declined from 41% in 1993 to 29% in 1998 and cover of soft corals has been stable at about 13%.

Of the reef fishes on outer-shelf reefs, scarids have increased significantly and serranids have increased slightly over the six years (Fig. 4.12). Acanthuridae have shown no trend overall but are currently increasing, while Labridae are decreasing marginally. There are no regional trends in species richness of the groups of fishes.

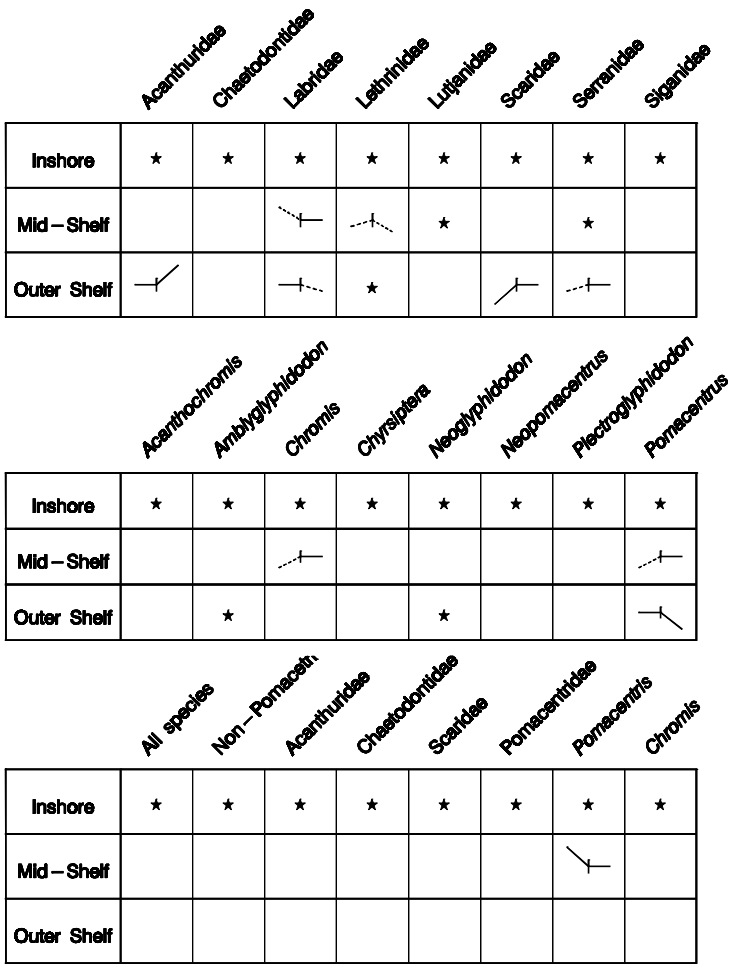


Figure 4.12: Trends in the abundance (top 2 plots) and in species richness (lower plot) of reef fishes in the Townsville sector for reefs classified by position on the continental shelf. Symbols summarise trends in abundance (mean number per site) of eight families of larger, more mobile species and of eight genera of site-attached damselfishes over six years. Trends in species richness for selected taxa based on numbers of species per reef over four years. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over the survey period. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank. A star (★) indicates that the data were insufficient to detect a trend with any certainty.

Bleaching

Bleaching was observed on all reefs, but was highest on inshore reefs where up to 75% of corals were affected. Middle Reef was extensively bleached. At Havannah Is. there was extensive bleaching of hard and soft corals and 10 - 20% percent of the reef was covered with dead standing corals (see Section 5).

Summary

Cover of hard coral had increased in this sector up until Cyclone Justin in March 1997. Though the cyclone only came within 500 km, it remained in the area for more than two weeks causing heavy swells and resuspending sediment. Some of the decline may also be due to COTS that are appearing in the sector following the southward drift of larvae in the East Australian Current (Reichelt *et al*. 1990. Moran *et al*. 1992). While changes in damselfish abundances can be explained by changes in the coral cover, other groups such as the Labridae are unlikely to respond in the same way. Their numbers will be followed closely in future surveys to see if they continue to decrease.

Cape Upstart

Geography

The reefs in the Cape Upstart sector do not form a significant barrier to oceanic influences and the tidal range is higher than in the sectors to the north.

The reefs in this sector are surveyed by manta tow only, often at intervals of more than a year. Only one inshore reef is surveyed, so regional trends could not be established.

Mid-shelf Reefs

There was a rapid build up of COTS on mid-shelf reefs during the initial years of survey peaking well above outbreak levels in 1989. Since then COTS numbers have dwindled to their current low levels. While coral cover declined in the late 1980s, it has since begun to recover (Fig. 4.13). Current mean coral cover is approximately 22% compared to a long-term average of 13%. Coral cover is increasing on these reefs at around 3% per annum.

Outer-shelf Reefs

Trends in coral cover have varied among the reefs in this region (Fig. 4.13), resulting in no significant regional trend. Small numbers of COTS have been recorded on these reefs at every survey, but populations have remained well below outbreak levels.

Summary

The mid-shelf reefs in this sector show a clear response to a wave of COTS outbreaks in the late 1980s which resulted in reduced hard coral cover. The coral has substantially recovered. Outer-shelf reefs did not suffer the COTS outbreaks and show no clear trends in coral cover.

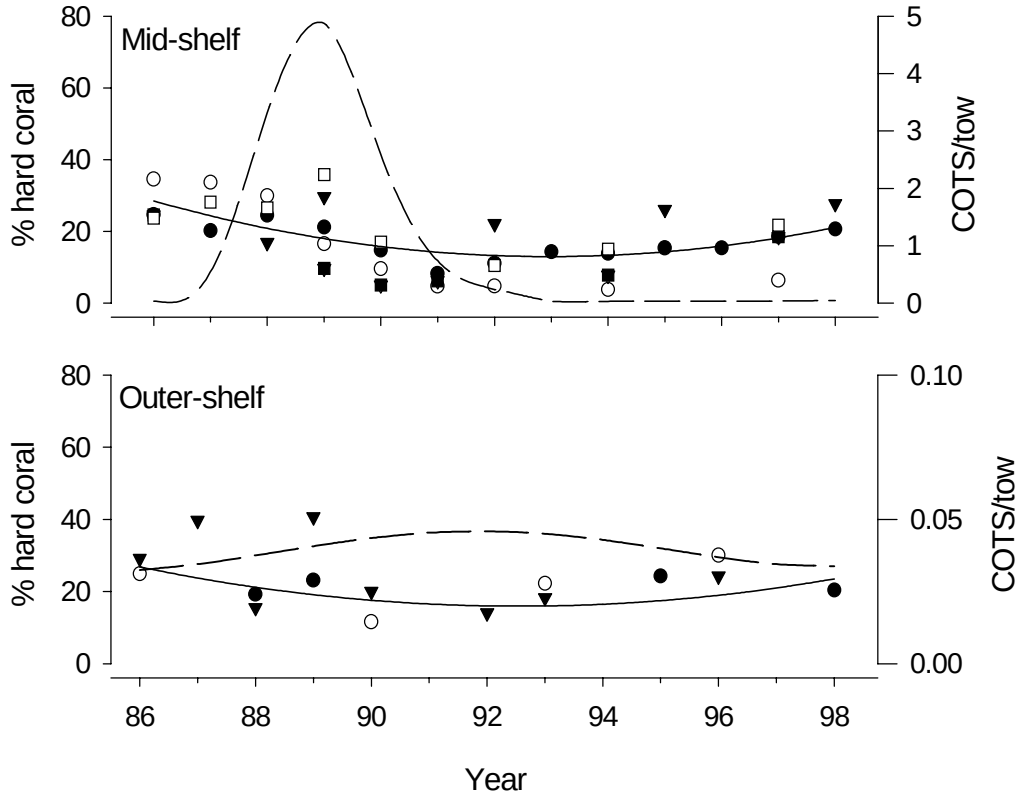


Figure 4.13: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Cape Upstart sector classified by position on the shelf. Solid line represents overall trend in coral cover; broken line represents trends in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

Whitsundays

Geography

The tidal range is high in this sector causing strong currents particularly at the southern outer reefs. Inshore reefs are associated with large continental islands and there are some very sheltered areas. The area is subject to plumes from the Fitzroy River to the south.

Inshore Reefs

Poor visibility has meant that inshore reefs in the Whitsundays sector have not been surveyed by manta tow often enough to allow analysis, but video surveys of the permanent sites in the last six years found no net trend in cover of hard coral which is currently about 28%. Cover of algae (31%) and soft corals (19%) did not change either (Fig. 4.14).

Community composition tends to vary among reefs: Border Is. has high cover of Poritidae (due to *Goniopora* spp.), while Hayman Is. has a higher cover of branching and bottlebrush *Acropora* spp. Cover of Faviidae has increased to 4% (Fig. 4.14), but community composition has otherwise been stable over the last six years comprising Acroporidae (6%), Poritidae (7%), and others (2%). Cover of Pocilloporidae is comparatively low, averaging less than 1%.

Among larger reef fishes, Labridae and Acanthuridae and Scaridae decreased in abundance over the six years of surveys (Fig. 4.16), though all three families show no current trend. The Lutjanidae have increased marginally in abundance over the six years, but are currently declining. There were no significant trends in abundances of damselfishes (Fig. 4.16). Species richness of all fish taxa combined has decreased marginally over the last four years, though none of the individual taxa showed a significant trend (Fig. 4.16).

Mid-shelf Reefs

Mean densities of COTS were higher during the late 1980s and early 1990s but have since declined to well below outbreak levels (Fig. 4.15). Manta tow surveys showed no consistent trends in reef-wide coral cover among the reefs in this region.

The video surveys of permanent sites over six years suggest that cover of hard coral has been generally stable during the initial surveys (Fig. 4.14). Following Cyclone Justin in 1997, the mean cover of hard coral decreased dramatically in the region from more than 40% to 24%. Cover of algae showed a corresponding increase over the six-year period. Cover of soft corals on reefs in the region is low (4%).

The overall decline in hard coral following Cyclone Justin affected most of the major coral taxa (Fig. 4.14). It was most pronounced in the Acroporidae due to large decreases

in cover of tabulate *Acropora* spp. From 1993 to 1996, mean cover of tabulate *Acropora* spp. in the region increased from an average of less than 1% in 1993 to 6% in 1996 then decreased to 0.3% following Cyclone Justin. The cyclone did not pass particularly close to this sector (Puotinen *et al*. 1997), but did cause an extended period of storm swells which battered the reefs and resuspended a lot of sediment. Other groups showed

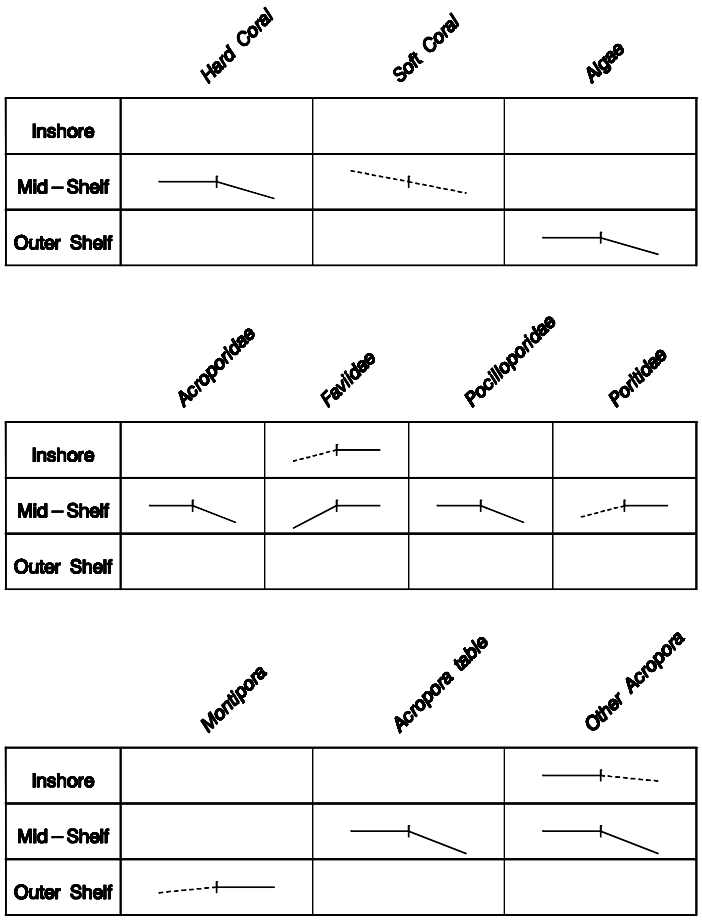


Figure 4.14: Trends in the cover of benthic organisms in the Whitsunday sector, for reefs classified by position on the continental shelf. Symbols summarise trends in percent cover (per site) of the main groups of benthic organisms, principal families of hard corals and three groups within the Acroporidae. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over six years. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank.

similar declines coinciding with Cyclone Justin: cover of digitate and corymbose *Acropora* spp. had averaged 3% cover and decreased to 1%, Pocilloporidae decreased from 4% to 2%, *Montipora* spp. declined from 7% to 5%. Cover of Faviidae increased over the six years though it declined in 1997 and is currently 6%.

There were some changes in fish abundance that coincided with the regional changes in coral cover associated with Cyclone Justin. Serranidae, particularly *Plectropomus leopardus*, have declined over the last six years with a drop in 1997 (Fig. 4.16). Chaetodontidae, principally the coral feeding species *Chaetodon rainfordi* (Myers 1991), declined in abundance and Acanthuridae, primarily *Naso tuberosus* and *N. unicornis* increased. The latter species feed on fleshy algae (Myers 1991). Among damselfishes, *Acanthochromis polyacanthus* has shown a general decline over the survey period, and members of the genus *Chromis*, particularly *C. nitida* and *C. atripectoralis,* have declined recently. These species are associated with *Acropora* spp. *Chrysiptera rollandi* and *C. talboti* both decreased in number in 1997 but have increased since (Fig. 4.16).

Over the four years there has been an increase in the species richness of coral reef fishes, both of all species considered together and of non-pomacentrid species (Fig. 4.16). The numbers of species of scarids and acanthurids have increased significantly (Fig. 4.16).

Outer-shelf reefs

Very few COTS have been recorded on reefs in this region; none was seen during the most recent surveys. Broadscale surveys found divergent patterns in reef-wide coral cover among the three outer-shelf reefs (Fig. 4.15). Mean coral cover (25%) is currently less than the long-term mean for the region (33%) but has not changed significantly since the beginning of surveys.

Based on video surveys of the permanent sites, average cover of hard coral on outer-shelf reefs in the Whitsunday sector is currently 27% and has shown no net trend (Fig. 4.14). Algae have averaged about 18% and also showed no change. Cover of soft corals (31%) is high compared with the previous groups; Hyde and Rebe Reefs are both dominated by soft corals. Within the hard corals, 11% of the cover was composed of Acroporidae but this varied considerably among reefs from an average of 24% at Reef 19-159 to 3% at Rebe Reef. Cover of corals in other families were all less than 2%. None increased significantly during the six years sampling (Fig. 4.14).

Among reef fishes, Acanthuridae have shown a recent decline on outer reefs (Fig. 4.16), mostly due to *Acanthurus nigrofuscus*. Three damselfish genera, *Acanthochromis polyacanthus*, *Neopomacentrus* (specifically *N. azysron*) and *Pomcacentrus* have also shown general declining trends over the six years. Several *Pomacentrus* spp. declined in abundance in the region, including the abundant *P. lepidogenys* and *P. moluccensis* as well as *P. bankanensis* and *P. wardi*. Overall species richness and species richness of a number of subgroups have been stable but currently show a declining trend (Fig. 4.16). There was no coincident change in coral cover (Fig. 4.14).

Bleaching

Little bleaching was observed in this sector. It was most extensive on the inshore and mid-shelf reefs, but was localised and species specific. The most commonly affected form was encrusting *Montipora* spp.

Summary

There are few trends in the inshore reefs in the Whitsundays, though the individual survey reefs are quite divergent in their assemblages. Mid-shelf reefs showed a decline in coral cover and in abundance of several taxa of fishes that coincided with Cyclone Justin. Abundance and species richness of several groups of fishes declined in the outer shelf region at the same time, but there was no clear change in coral cover, suggesting that the cyclone affected the fish directly rather than through habitat destruction.

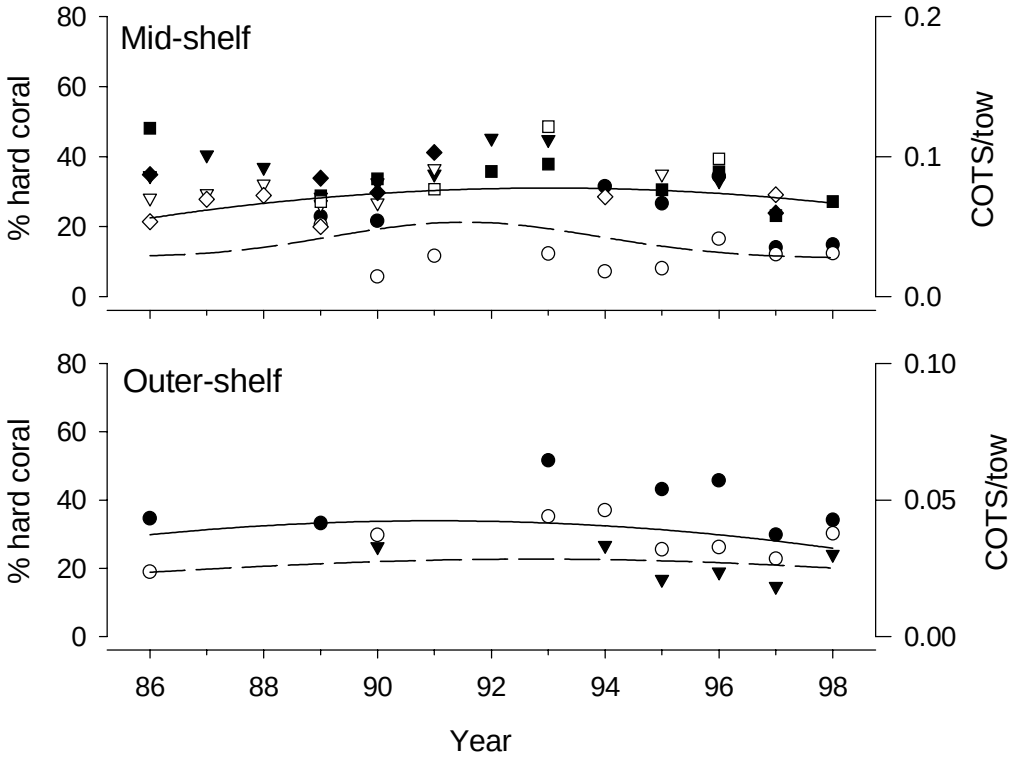


Figure 4.15: Reef-wide estimates of coral cover and of COTS density from manta tow surveys of reefs in the Whitsunday sector classified by position on the shelf. Solid line represents overall trend in coral cover; broken line represents trends in COTS densities. Different symbols represent annual mean coral cover on individual reefs.

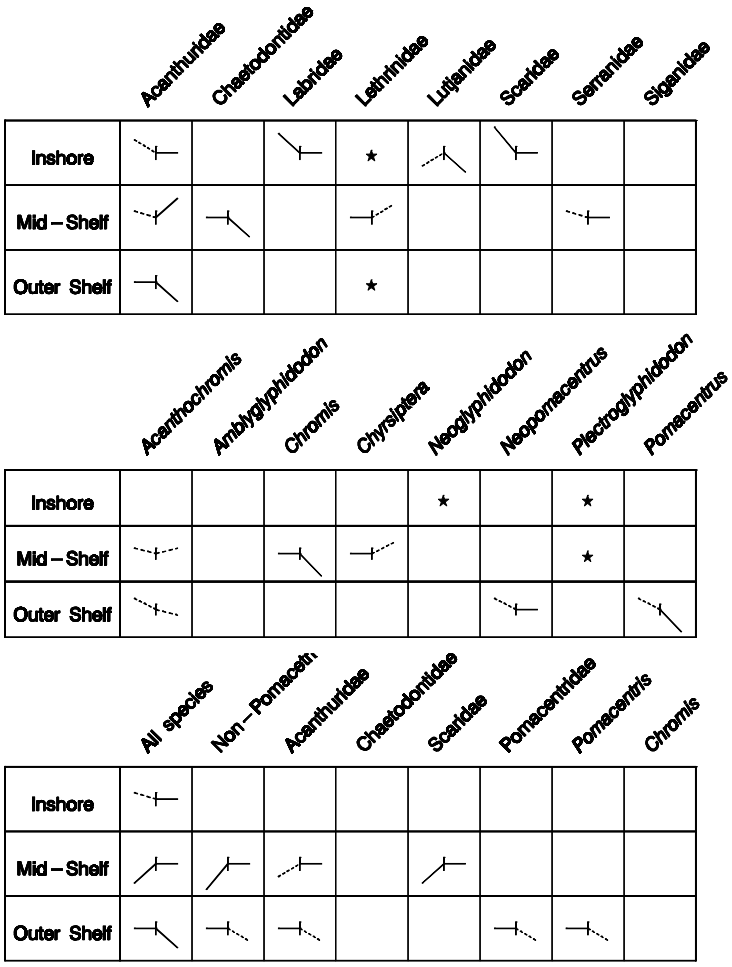


Figure 4.16: Trends in the abundance (top 2 plots) and in species richness (lower plot) of reef fishes in the Whitsunday sector for reefs classified by position on the continental shelf. Symbols summarise trends in abundance (mean number per site) of eight families of larger, more mobile species and of eight genera of site-attached damselfishes over six years. Trends in species richness for selected taxa based on numbers of species per reef over four years. The steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over the survey period. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends ($0.1 > p > 0.01$) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank. A star (★) indicates that the data were insufficient to detect a trend with any certainty.

5. Reefs of the Great Barrier Reef: status and trends

Explanation of the reef status pages

This section contains data on each reef surveyed in the 1998 field season. An aerial photograph of each reef shows the size and orientation of the reef, location of fixed transects and the manta tow path. Dotted lines indicate the manta tow path. Numbered dots correspond to tow number in Figure A. The solid line indicates the area covered by fixed transects. The physical geography of the reef is described below the aerial photograph. Reefs are ordered alphabetically within the sectors, with the core survey reefs first, followed by reefs that are only surveyed by manta tow. The sectors are presented in order from north to south .

Manta tow surveys

Figure A is a histogram showing coral cover categories recorded by observers for each two minute manta tow for 1998. This information provides an overview of the current status of a reef in terms of spatial distribution of coral cover and COTS around the perimeter.

Figure B provides an overview of the reef over the history of manta tow surveys. Median coral cover and the number of COTS per tow counted for each year are presented.

Benthic video surveys

Data on benthic organisms and fishes are also presented for the 48 core reefs where permanent monitoring sites are located. For benthic organisms, three figures (C, D, and E) describe the trends in percentage cover over time for the major benthic groups, for major benthic families and for groups within the family Acroporidae respectively. Each plot shows the distribution of mean cover based on survey sites and the fitted trend line. The significance level and direction of the trend is coded in the legend: a period (·) indicates no significant trend, a plus sign (+) indicates a significant positive trend and a minus sign (-) indicates a significant negative trend (see Appendices I and J). Symbols before the slash refer to the general trend over the six years; symbols after the slash refer to the trend at the 1998 survey, thus '·/-' would indicate that a taxon has shown no net trend over the six years, but there is currently a significant decreasing trend. '+/+' would indicate that a taxon had increased significantly over the six years and was continuing to do so.

A fourth figure (F) is included for reefs where significant bleaching occurred (Havannah Island, Middle and Pandora Reefs). The figure shows percentage cover of bleached and unbleached corals from 1997 and 1998.

Visual fish census surveys

Another four figures (G, H, I and J) on the facing page show the trends of fish abundance over time for reef fish groups where abundance is greater than 5 per site for at least one survey. The four plots show the scatter of mean fish abundance. Figures G and H show trends in the major reef fish families and Figures I and J show trends in the damselfish genera. The significance levels and direction of the trends are coded in the legend in the same way as those for the benthic video surveys.

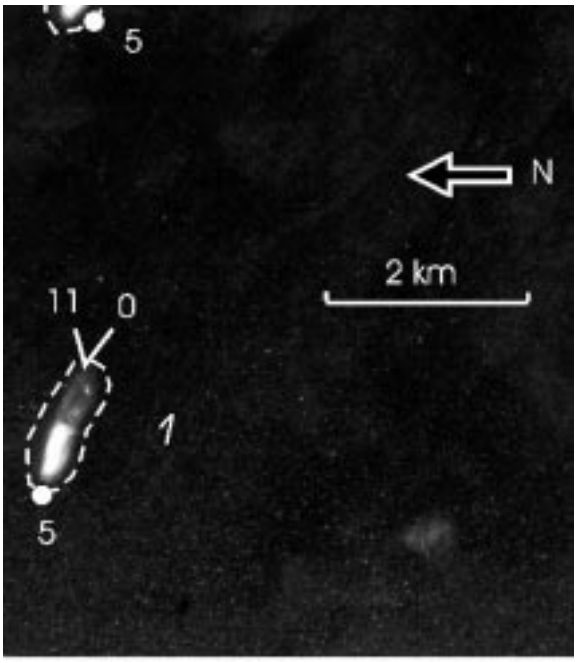
Written summary

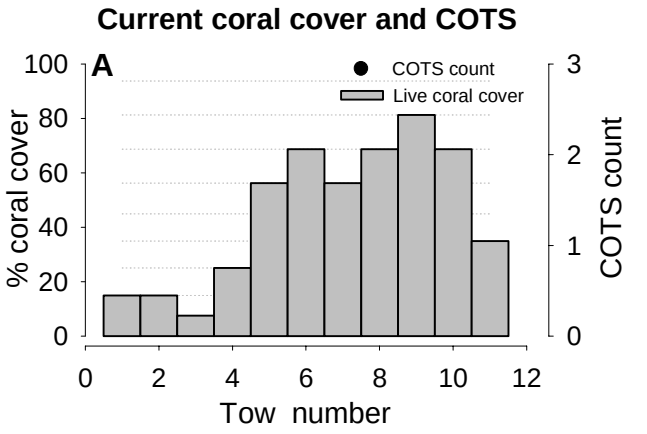
A summary of the status and trends is given for each reef.

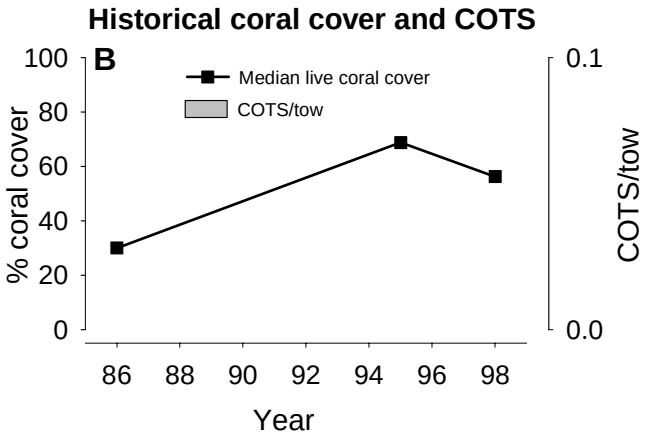
Cape Grenville
reef pages

Figure 5.1

Ashmore Banks (1)



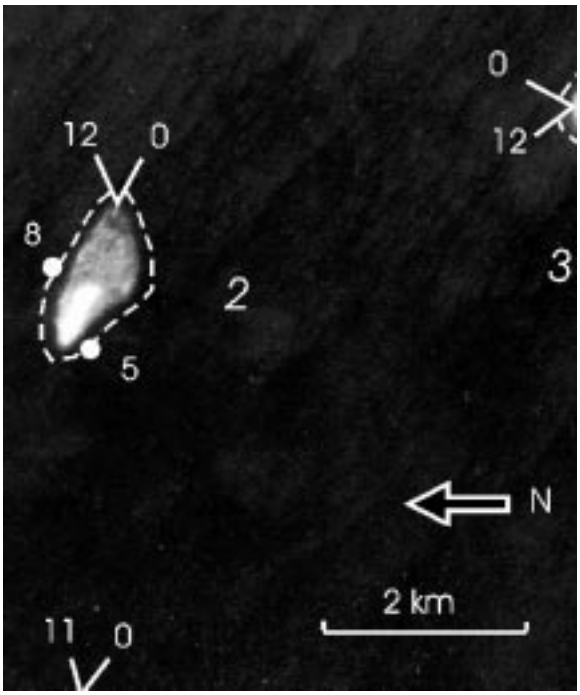


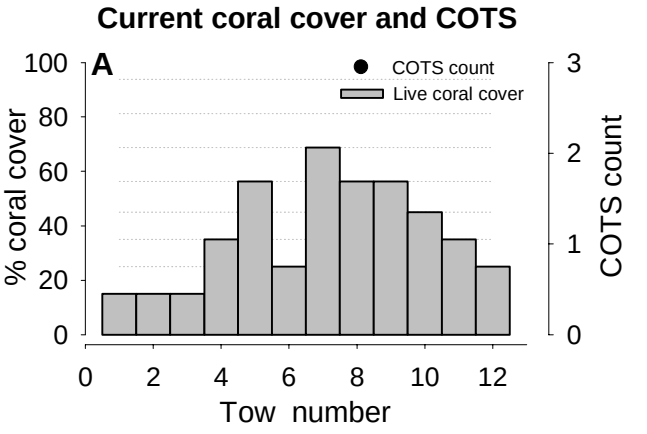


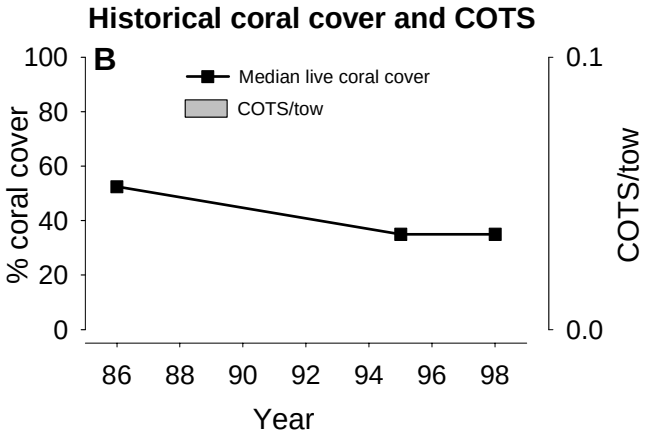
Ashmore Banks (1) (No. 11-237) is a middle shelf reef patches reef with an area of 1 sq.km. There is a sand cay on the western end. Last surveyed March 1998.

Figure 5.2

Ashmore Banks (2)



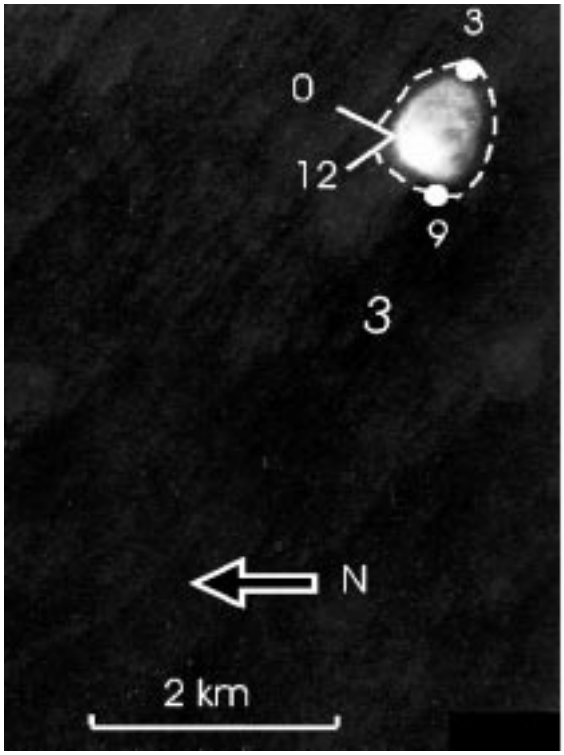


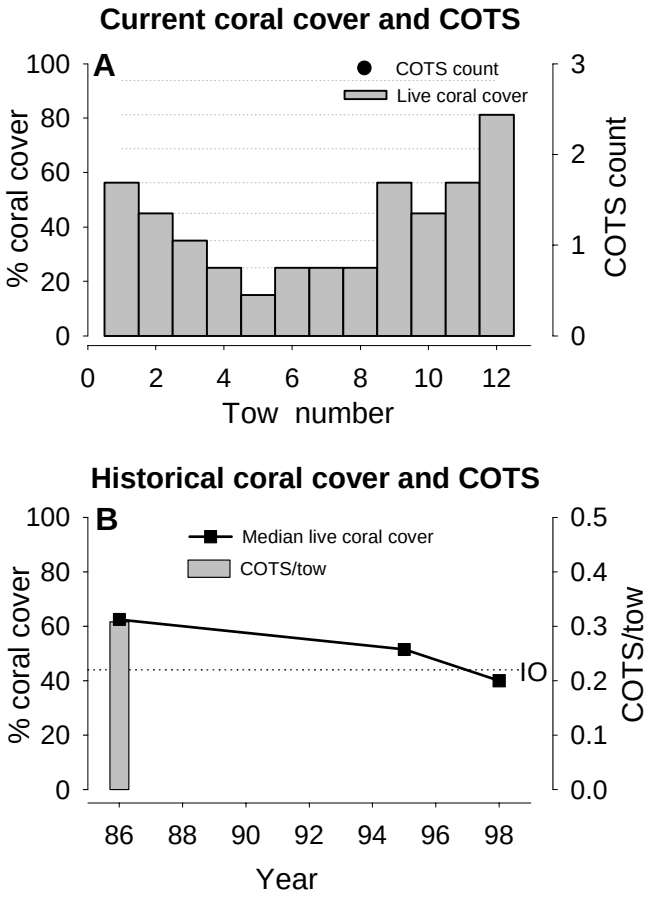


Ashmore Banks (2) (No. 11-237) is a middle shelf reef patches reef with an area of 1 sq.km. There is a sand cay on the western end. Last surveyed March 1998.

Figure 5.3

Ashmore Banks (3)





Ashmore Banks (3) (No. 11-237) is a middle shelf reef patches reef with an area of 1 sq.km. There is a sand cay on the western side. Last surveyed March 1998.

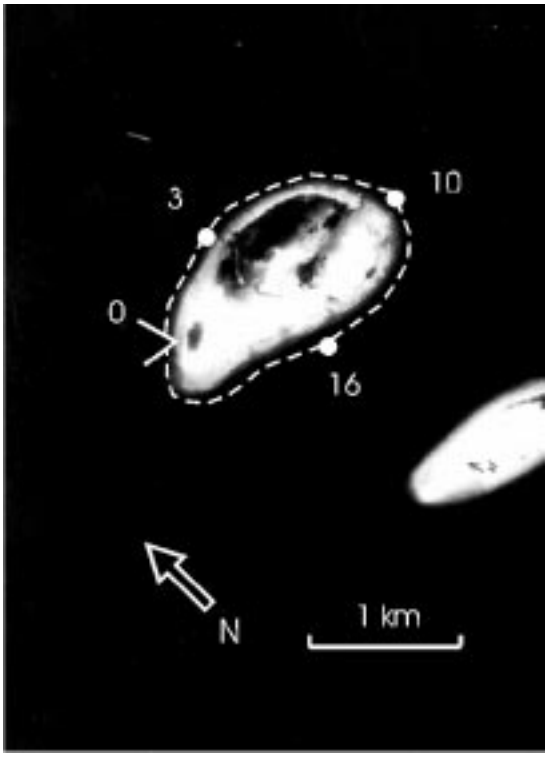
Ashmore Banks (1)
This reef has been surveyed three times since 1986. During this time coral cover increased between 1986 and 1995, it has since remained at a very high level. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

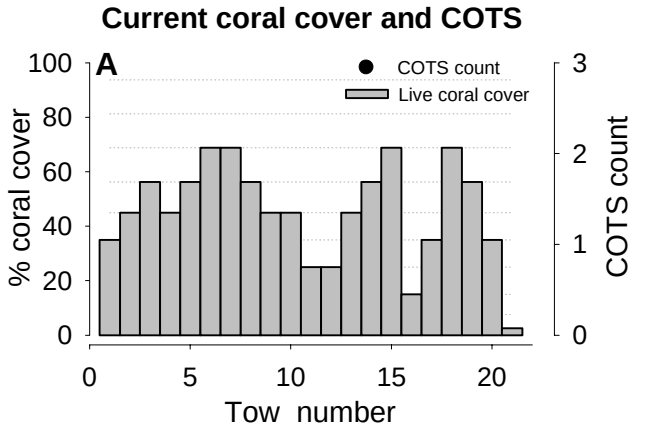
Ashmore Banks (2)
This reef has been surveyed three times since 1986. During this time there has been no appreciable change in coral cover, which remains high. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

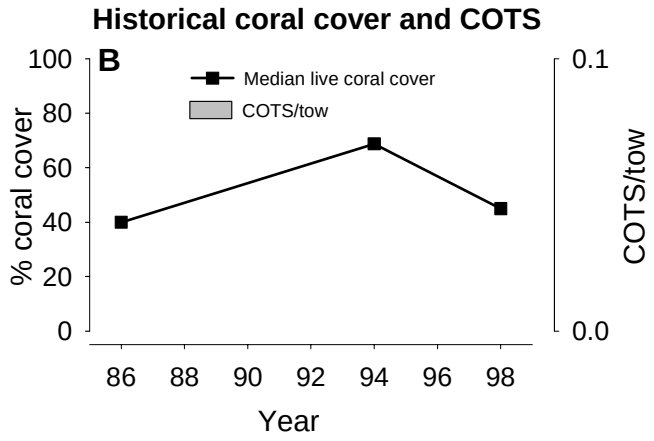
Ashmore Banks (3)
This reef has been surveyed three times since 1986. During this time there has been a gradual decline in coral cover on this reef. When first surveyed in 1986 the reef was classified as an Incipient Outbreak. Since this time coral cover has continued to decline to the present level which would still be considered high. This reef is currently classified as Recovering.

Figure 5.4

Bird Island



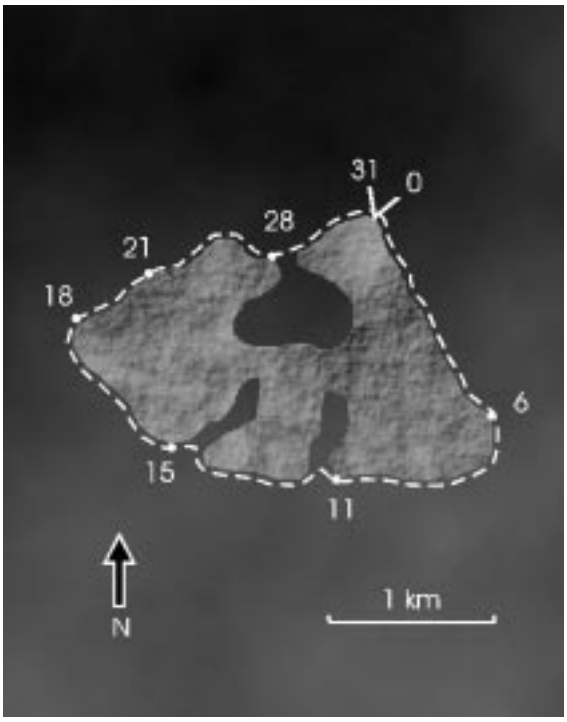


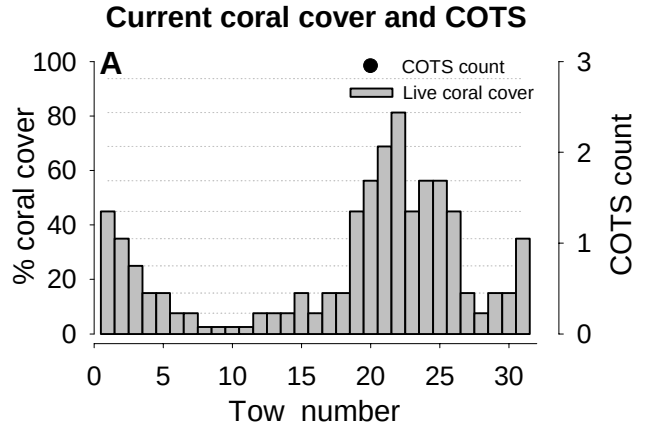


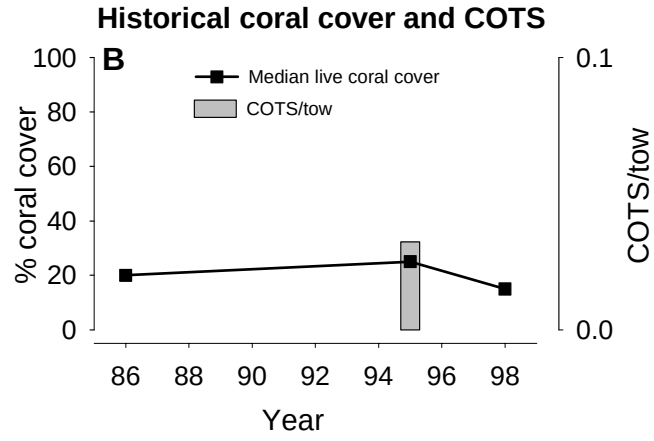
Bird Island (No. 11-167) is an inner shelf planar reef with an area of 1.2 sq.km. There is a low wooded island on the north-eastern side. Last surveyed March 1998.

Figure 5.5

Forty-Winks



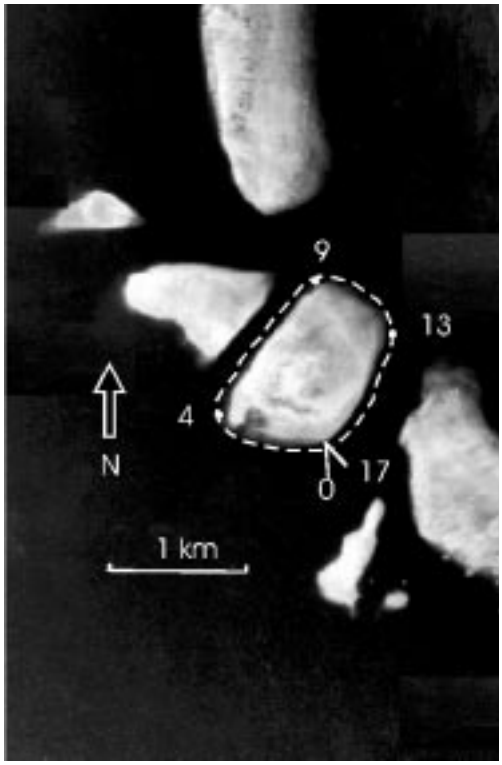


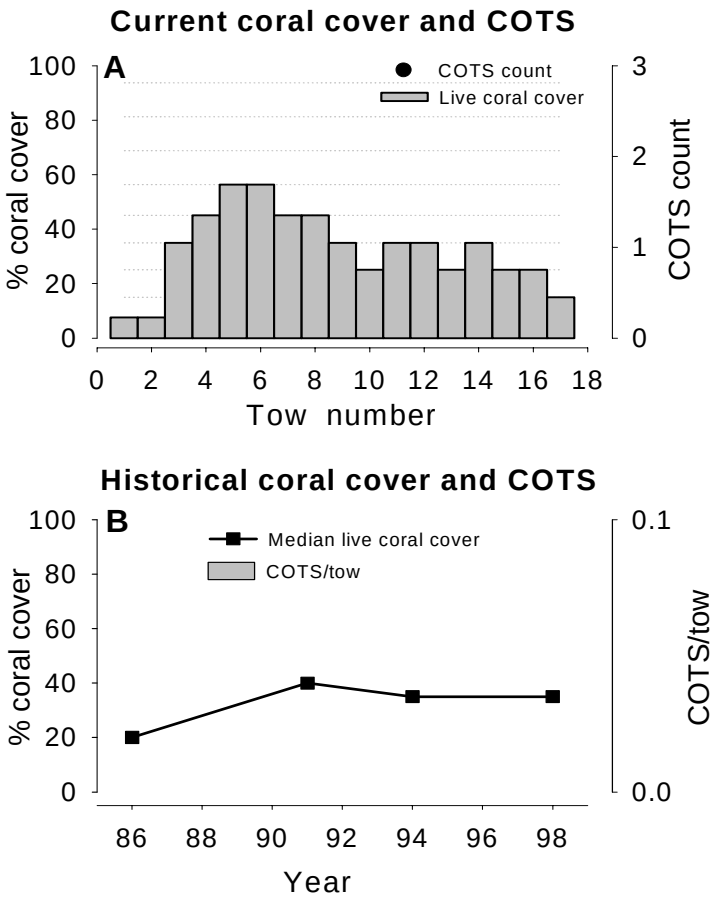


Forty-winks (No. 11-211) is a middle shelf lagoonal reef with an area of 3.1 sq.km. Last surveyed March 1998

Figure 5.6

Second Small





Second Small (No. 12-098) is an outer shelf planar reef with an area of 1.9 sq.km. Last surveyed March 1998.

Bird Island

This reef has only been surveyed three times since 1986. During this time there was an initial increase and subsequent decline in coral cover. The most recent decline may be attributable in part to cyclone Nathan, which influenced this area in March 1998, as well as low levels of coral bleaching observed at the time of survey. Coral cover remains high. No COTS have been recorded on this reef which is currently classified as Non-Outbreaking.

Forty-Winks

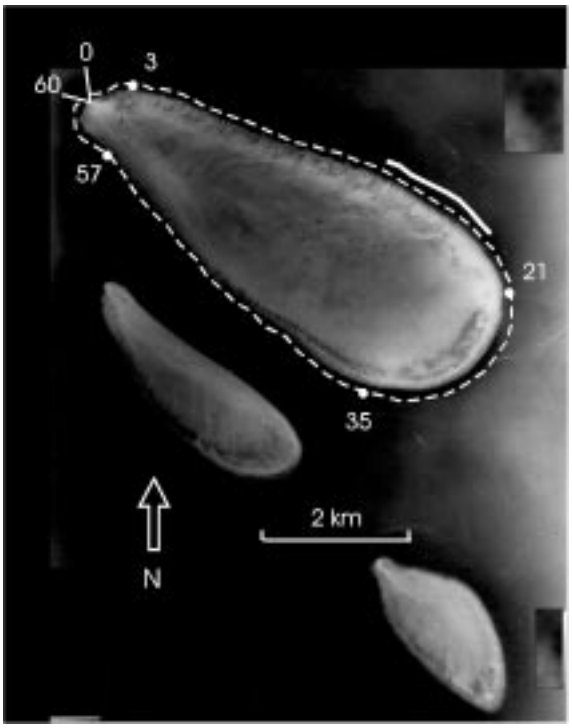
This reef has only been surveyed three times since 1986. During this time there has been no detectable change in coral cover which has remained moderate. Low levels of COTS have been recorded on this reef on one occasion but not in numbers that would be expected to cause significant coral mortality. This reef remains classified as Non-Outbreaking.

Second Small

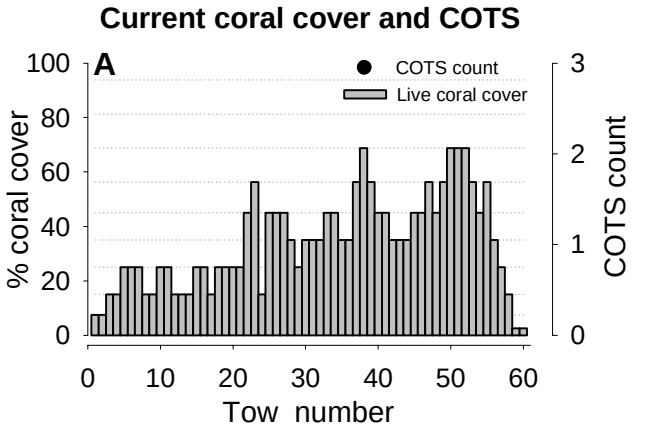
This reef has been surveyed four times since 1986. While there was an initial increase in coral cover between 1986 and 1991 there has been little appreciable change in coral cover since this time. Coral cover is currently high. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

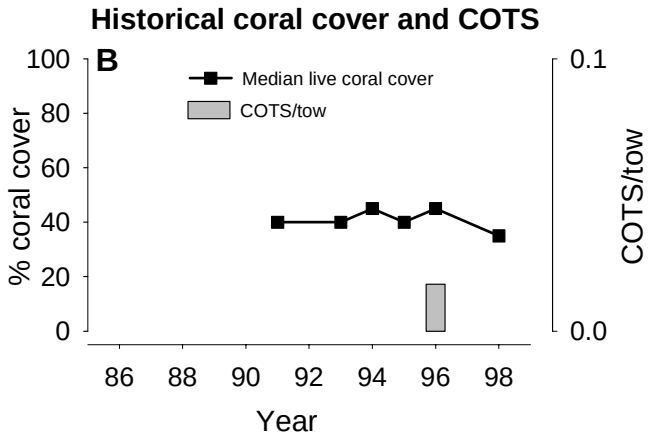
Figure 5.7

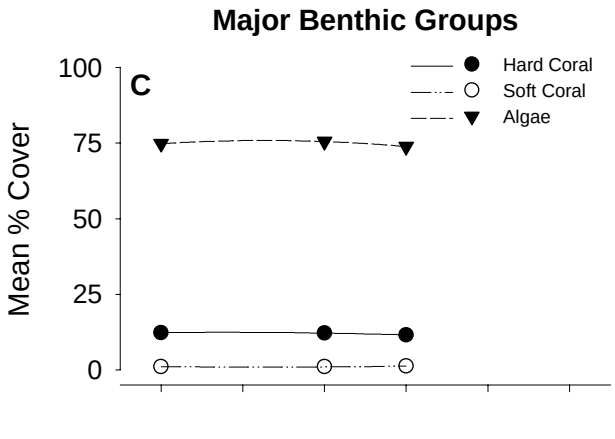
Kay

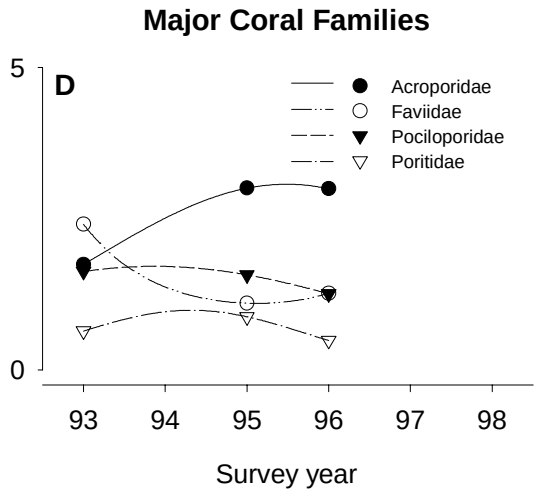


Kay (No. 12-010) is an inner shelf planar reef with an area of 7.5 sq.km. There is a vegetated sand cay on the western end. Last surveyed March 1998.









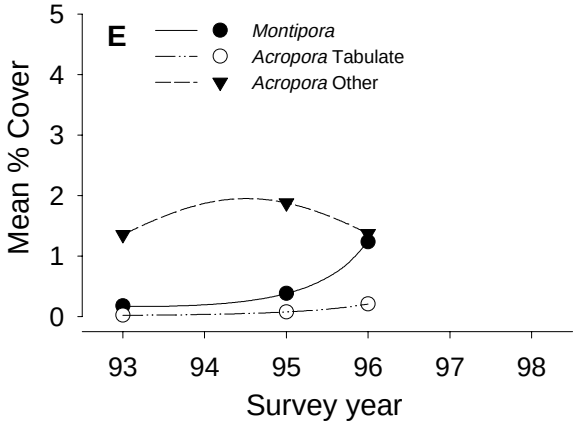
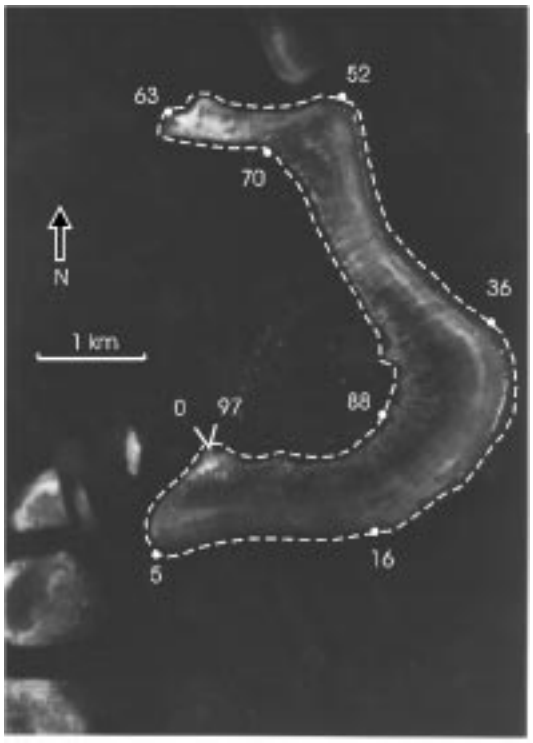
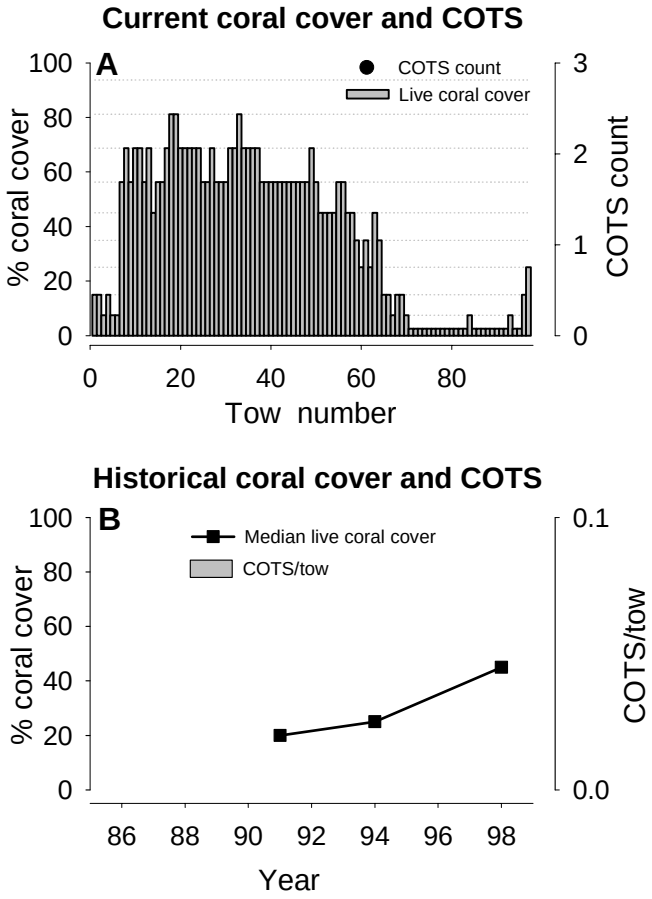


Figure 5.8



Log (2) (No. 12-107) is an outer shelf ribbon reef with an area of 10.6 sq.km. Last surveyed March 1998.

Log(2)



Kay

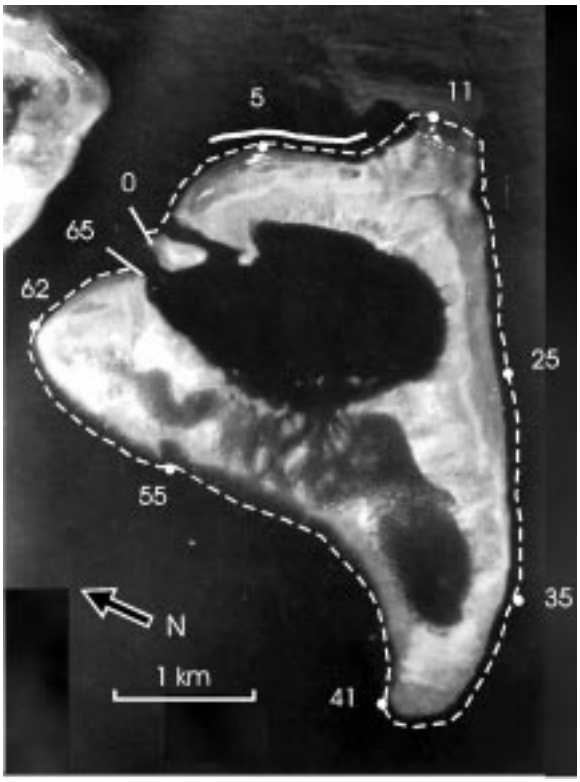
This reef has been surveyed by AIMS since 1991 using the manta tow technique. The reef has also been surveyed three times, using the AIMS video technique, by staff from the Cairns office of Queensland Department of Environment and Heritage (QDEH) and these data are also presented. The manta tow data show that coral cover at the reef level has remained stable at a high level since surveys began. The QDEH surveys show a contrasting picture of low stable coral cover for the years surveyed. This is attributed to the QDEH sites being located on the northern face of the reef where manta tow also recorded low hard coral cover. The detailed surveys reveal small shifts in cover within the major coral groups however, given the low percentage cover, these changes are not considered to be ecologically significant. It is noteworthy that an extremely high level of algae has been consistently recorded during the three years of QDEH surveys. High levels of brown algae were also noted during manta tow surveys. Low levels of COTS were recorded by manta tow in 1996, but not in sufficient numbers to cause significant coral mortality and the reef remains classified as Non-Outbreaking. Low levels of coral bleaching were also observed during the most recent manta tow survey.

Log (2)

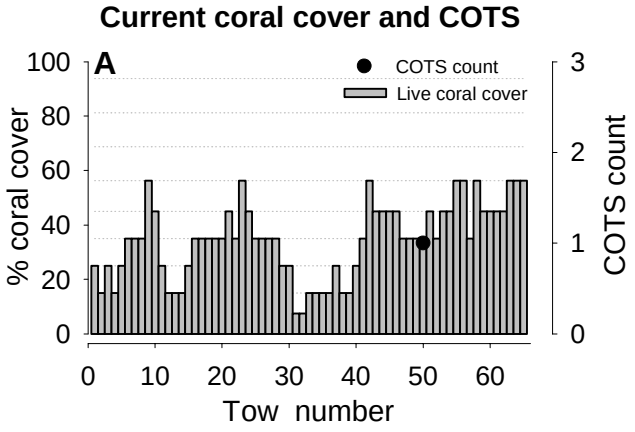
This reef has been surveyed three times since 1991. While there was little appreciable change in coral cover in the initial years of survey our most recent findings indicate an increase in coral cover to the current high level. No COTS have been recorded on this reef which is currently classified as Non-Outbreaking.

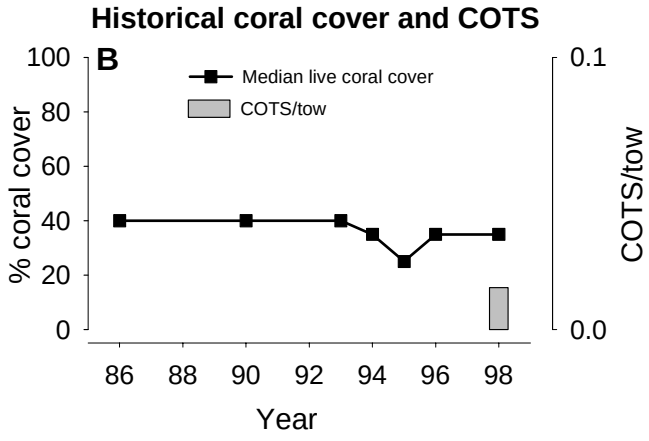
Figure 5.9

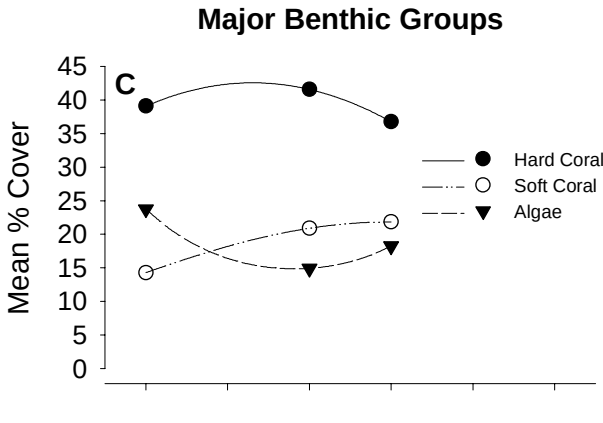
Lagoon

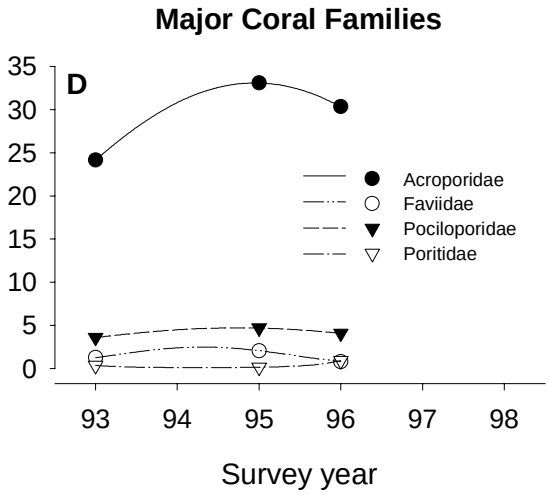


Lagoon (No. 12-061) is an outer shelf lagoonal reef with an area of 7.2 sq.km. Last surveyed March 1998.









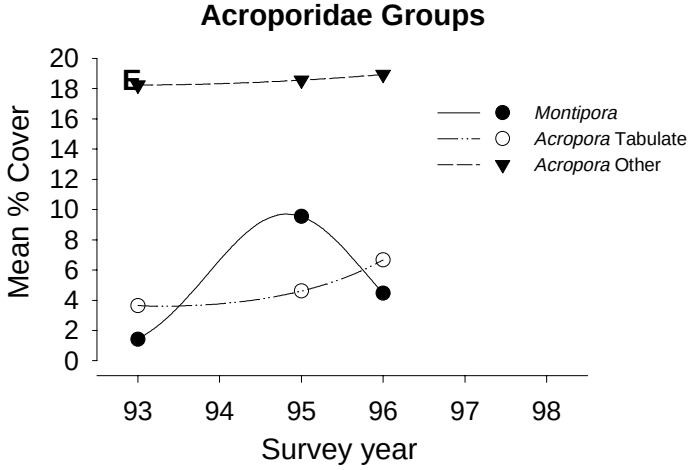
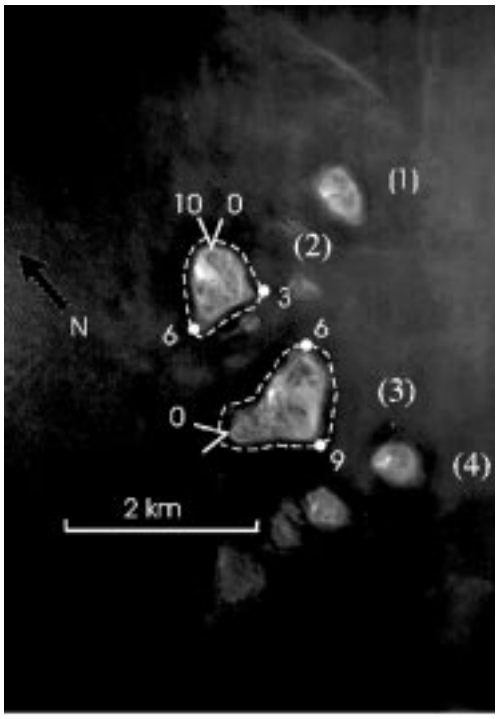
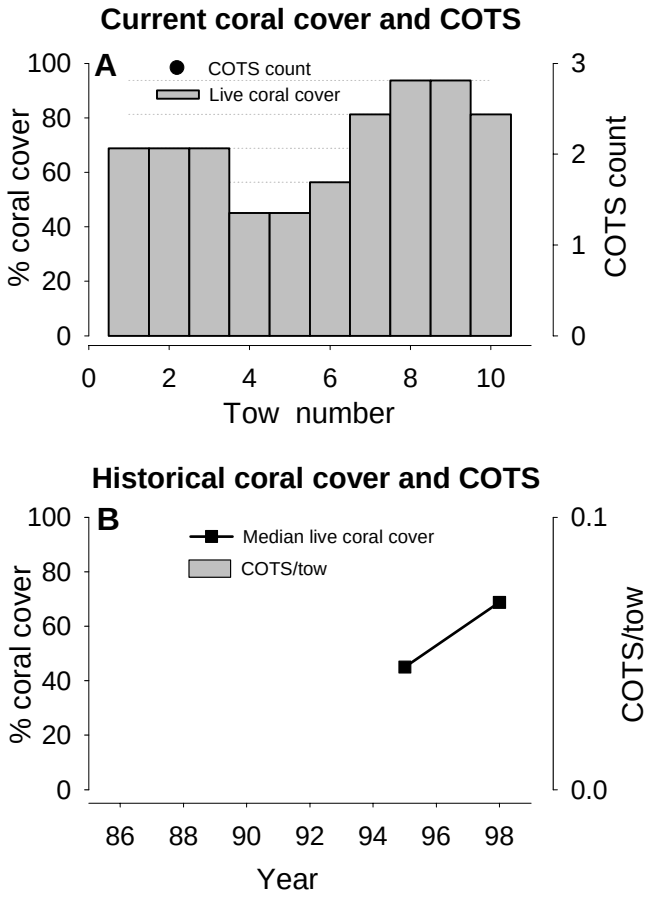


Figure 5.10

Middle Banks(2)





Middle Banks (2) (No. 11-222) is a small middle shelf submerged/patches reef. There is a sand cay on the western side. Last surveyed March 1998.

Lagoon

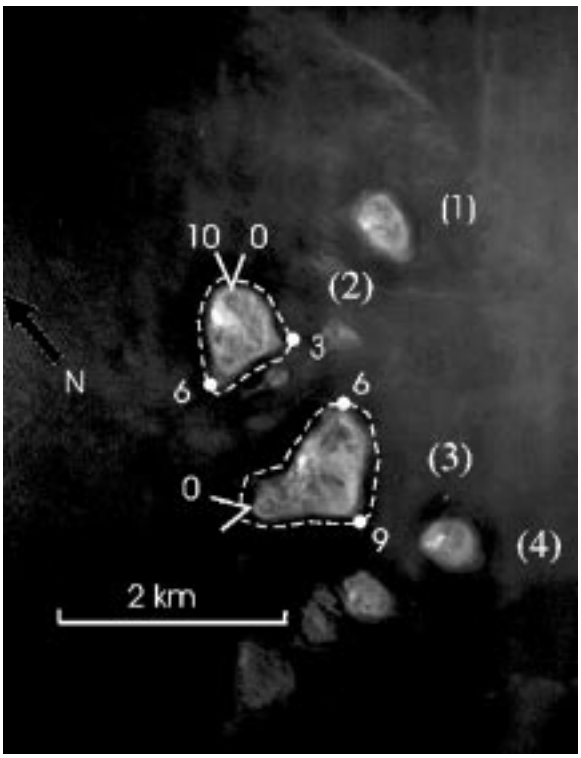
This reef has been surveyed by AIMS since 1986 using manta tow. The reef has also been surveyed using the AIMS video technique, by staff from the Cairns office of Queensland Department of Environment and Heritage (QDEH) and these data are also presented. The manta tow data show that there has been little appreciable change in coral cover since 1986 and it remains at a high level. The three years of data collected by QDEH support the manta tow surveys as they show a relatively stable high hard coral cover through to 1996 (36.8 %). The majority of the hard coral on the sites is made up of corals from the family Acroporidae (30.3% in 1996). Low levels of COTS were recorded during out most recent surveys but not in numbers that would be expected to cause significant coral mortality and the reef remains classified as Non-Outbreaking.

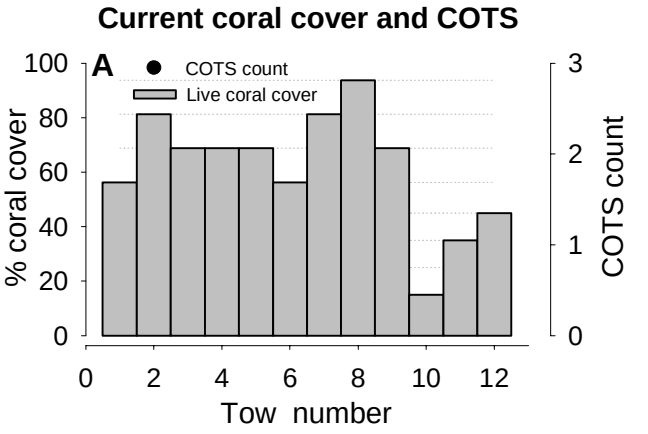
Middle Banks (2)

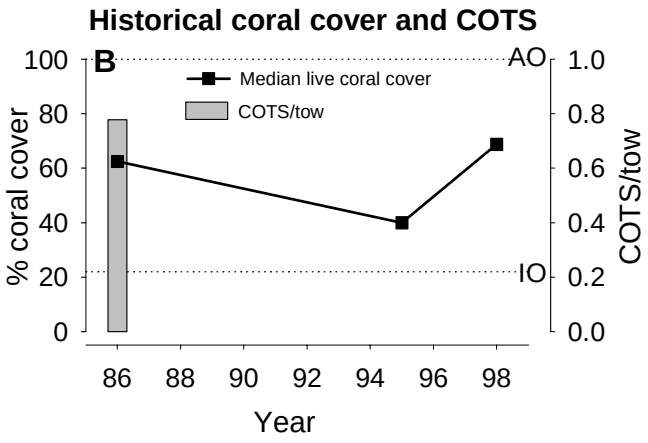
This reef has only been surveyed in 1995 and 1998. Between surveys there has been an appreciable increase in coral cover to its present very high level. No COTS have been recorded on this reefs and it is currently classified as Non-outbreaking.

Figure 5.11

Middle Banks(3)



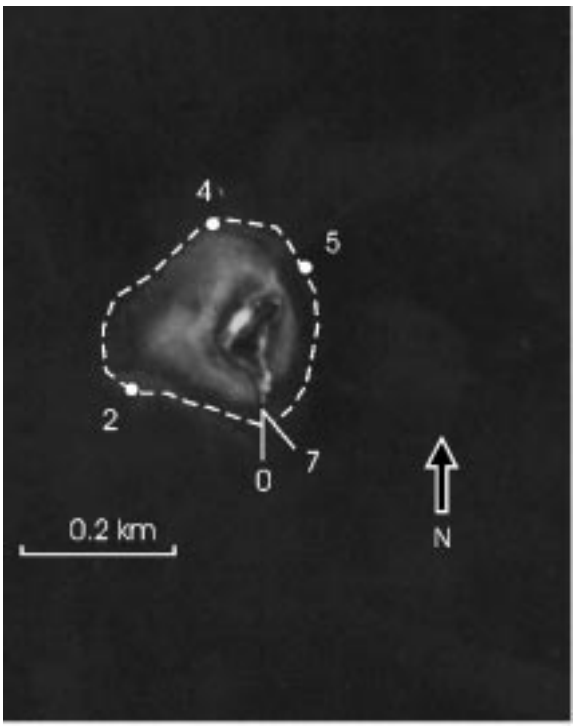


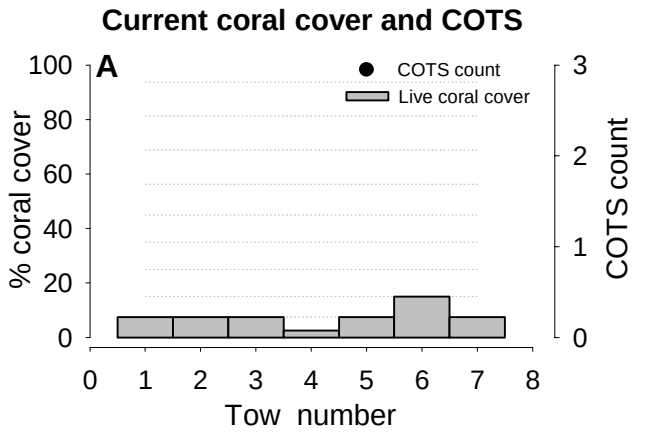


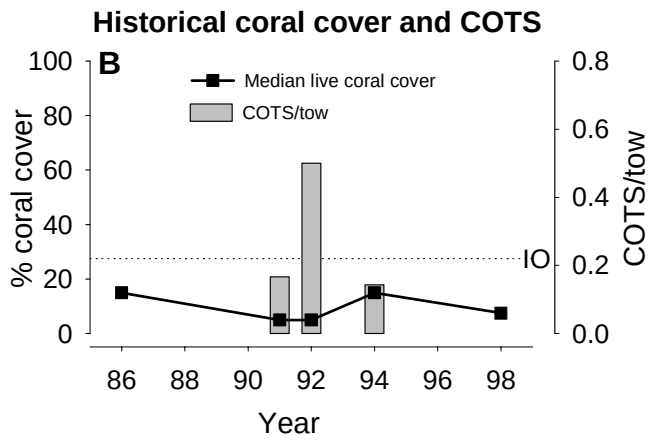
Middle Banks (3) (No. 11-222) is a small middle shelf submerged/patches reef. It has a sand cay on it's western end. Last surveyed March 1998.

Figure 5.12

Quoin Island



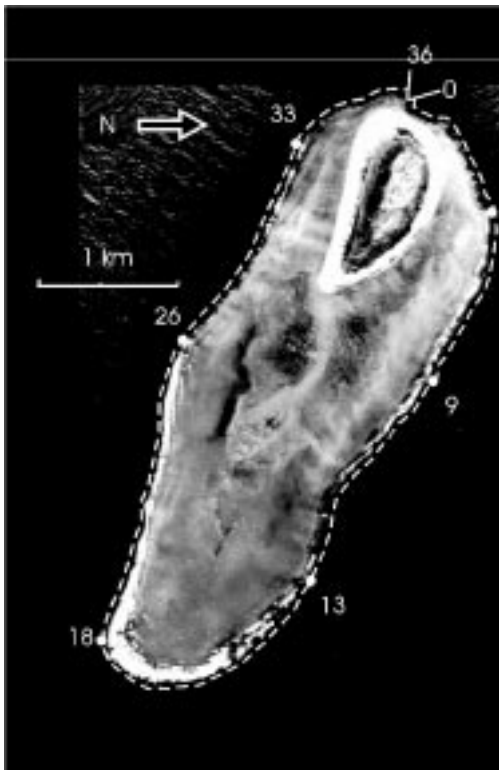


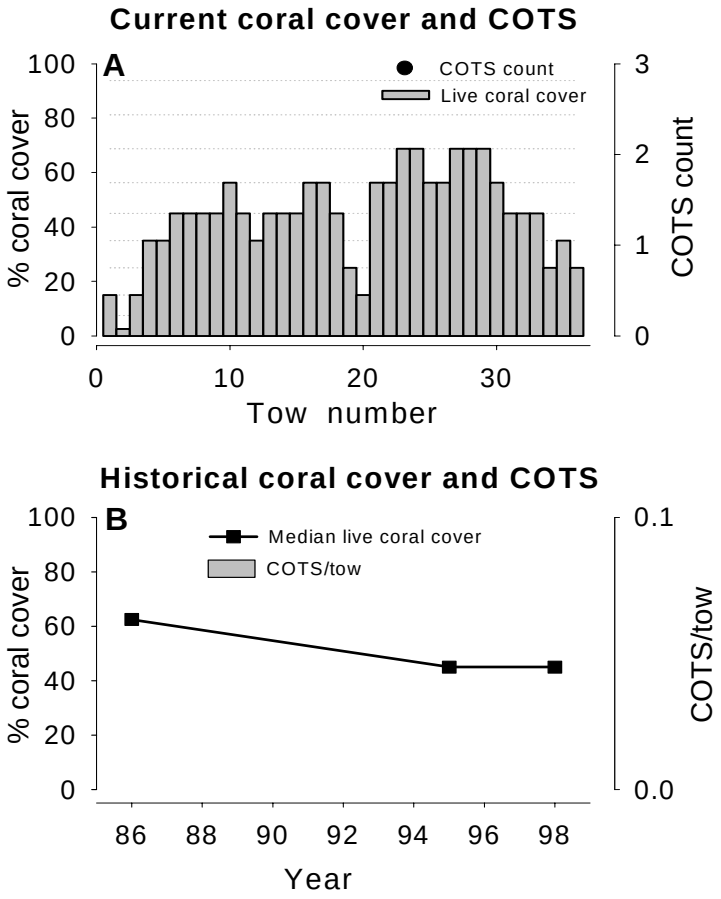


Quoin Is (No. 12-027) is a middle shelf fringing reef surrounding a high, wooded continental island, with an area of 0.01 sq.km. Last surveyed March 1998.

Figure 5.13

Raine Island





Raine Island (No. 11-243) is an outer shelf planar reef with an area of 1.9 sq.km. There is a vegetated sand cay on the western end. Last surveyed March 1998.

Middle Banks (3)

This reef has been surveyed three times since 1986. While there was little appreciable change in coral cover in the initial years of survey our most recent findings indicate an increase in coral cover to the current very high level. No COTS have been recorded on this reef which is currently classified as Non-Outbreaking.

Quoin Island

This reef has a relatively extensive history of survey since 1986. There has been little appreciable change in coral cover during this time, which has remained low. COTS have been observed on this reef to varying degrees on a number of survey years. While Quoin Island was classified as an Incipient Outbreak in 1992 it is currently classified as Non-Outbreaking.

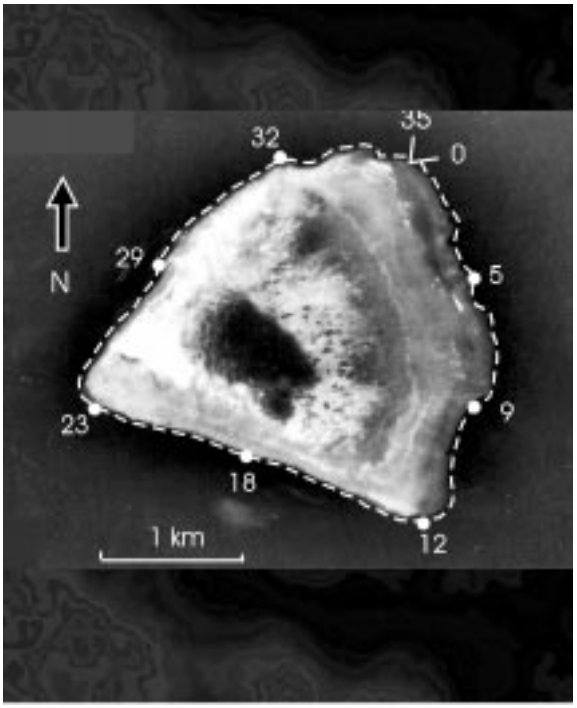
Raine Island

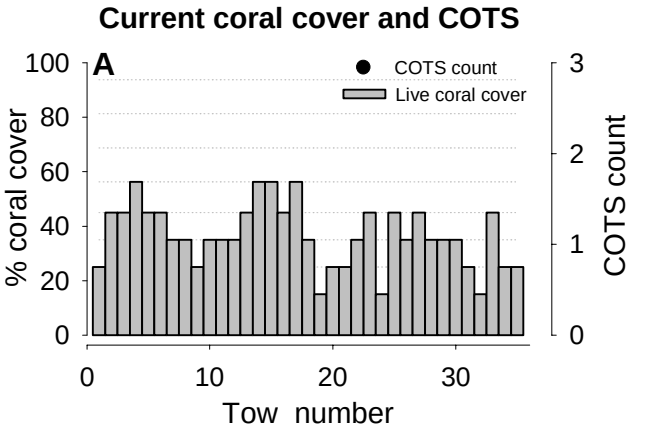
This reef has only been surveyed three times since 1986. Surveys indicate little appreciable change in coral cover over this time, which remains generally high. No COTS have been recorded from this reef which is currently classified as Non-Outbreaking.

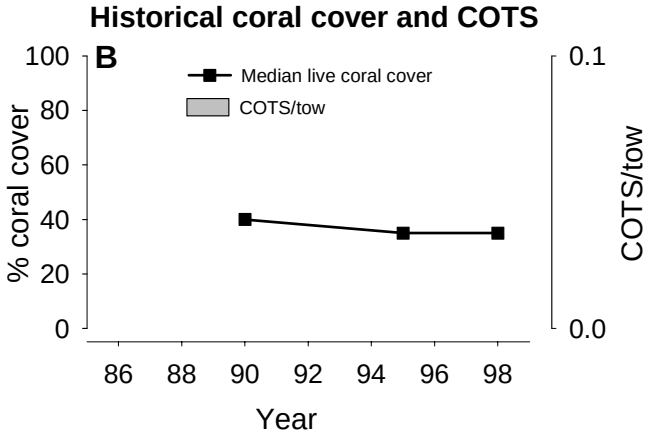
Princess Charlotte Bay
reef pages

Figure 5.14

Creech (a)



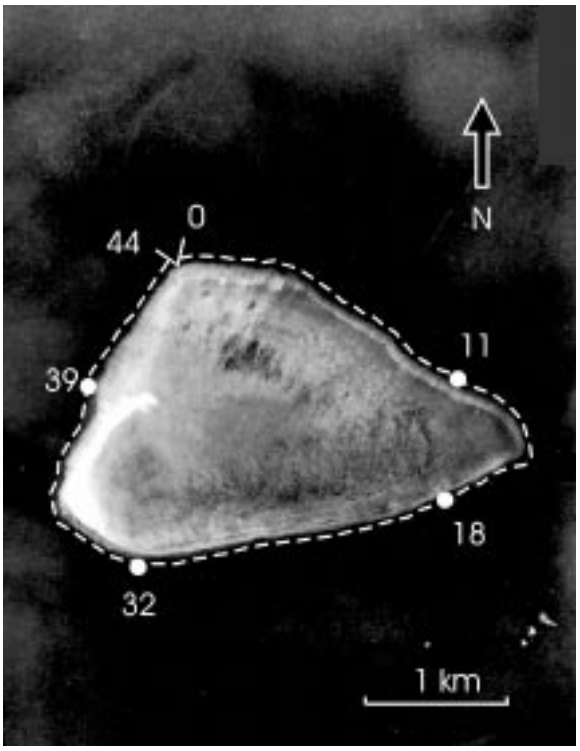


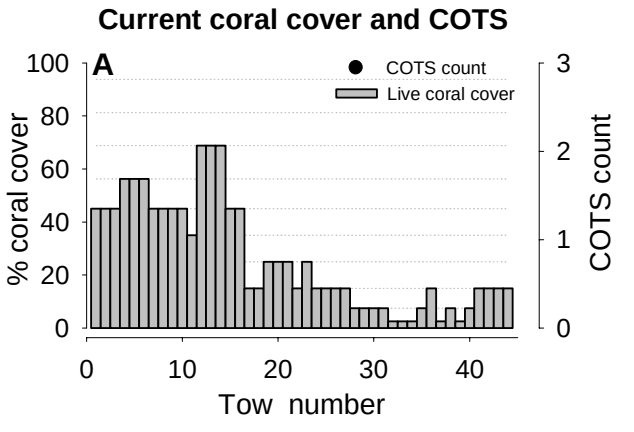


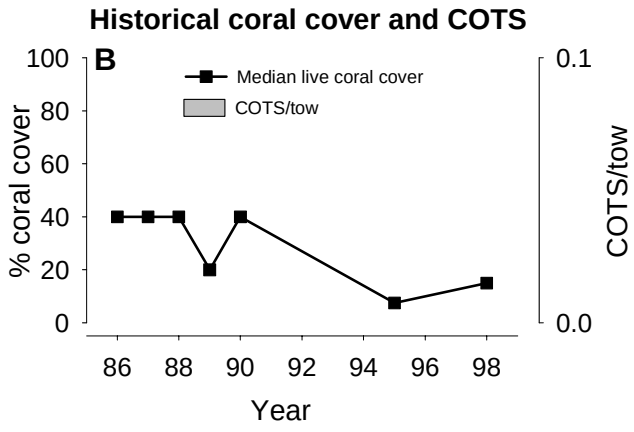
Creech (a) (No. 13-118) is an outer shelf patch reef with an area of 4.1 sq.km. There is a sand cay on the western side. Last surveyed October 1997.

Figure 5.15

Davie



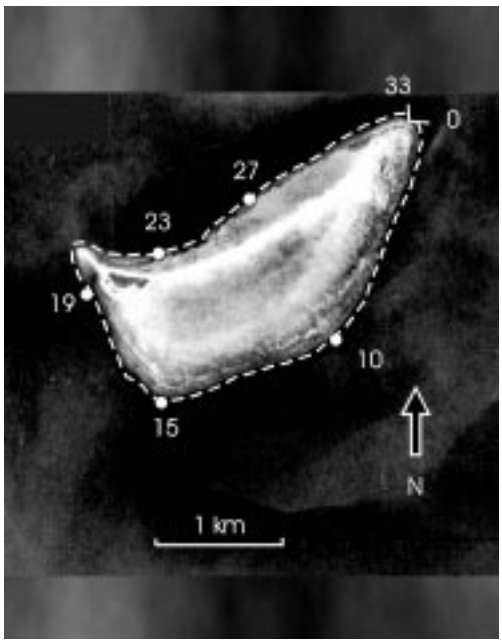


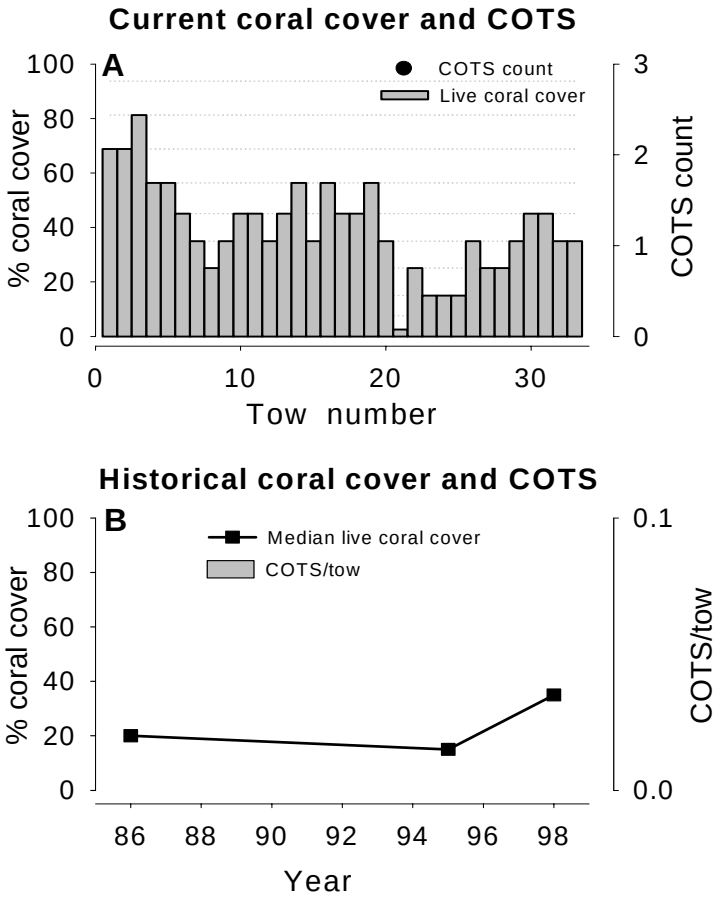


Davie (No. 13-130) is an outer shelf planar reef with an area of 5.6 sq.km. There is a sand cay on the western side. Last surveyed October 1997.

Figure 5.16

Fife Island





Fife Island (No. 13-081) is an inner shelf planar reef with an area of 4.39 sq.km. There is a vegetated sand cay on the western side. Last surveyed October 1997.

Creech (a)

This reef has been surveyed three times since 1990. During this time there has been little appreciable change in coral cover which has remained high. No COTS have been recorded on this reef which is currently classified as Non-Outbreaking.

Davie

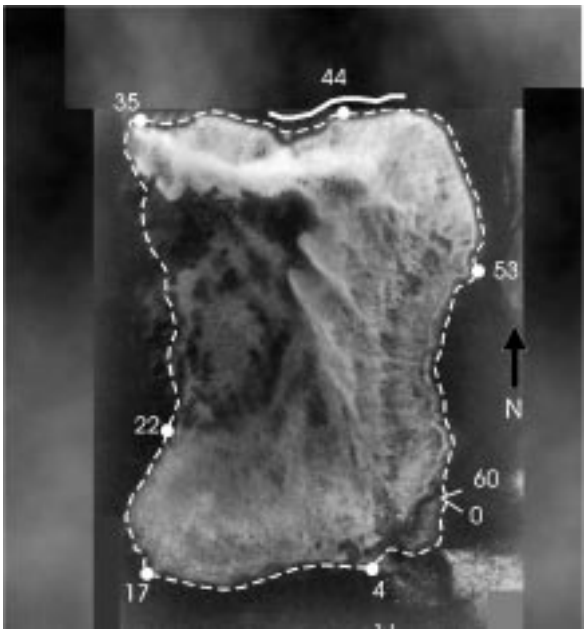
This reef has been surveyed since 1986. Coral cover remained high on this reef up until 1990, the next survey in 1995 showed there had been a marked decrease in coral cover. Coral cover now appears to be recovering (1998) future surveys will determine if this trend continues. While it is difficult to ascribe reasons for the drop in coral cover, Cyclone Ivor did impact this area in March 1991. COTS have not been observed on this reef over the period of survey. Davie Reef is currently classified as Non-Outbreaking.

Fife Island

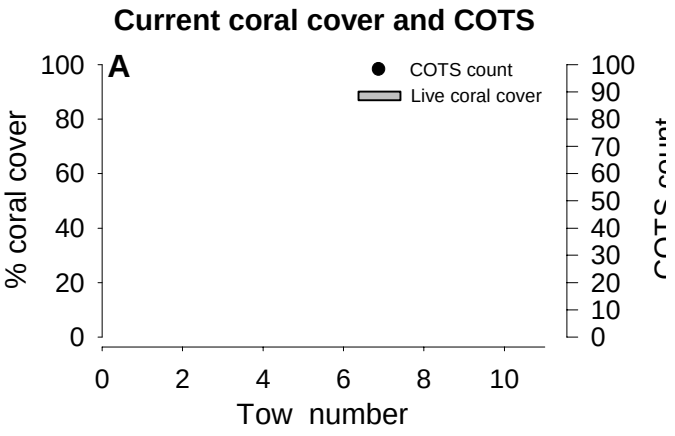
This reef has only been surveyed three times since 1986. There was little appreciable change in coral cover in the initial years of survey (1986 to 1995) our most recent findings indicate a trend of increasing coral cover to the current high level. No COTS have been recorded on this reef which is classified as Non-Outbreaking.

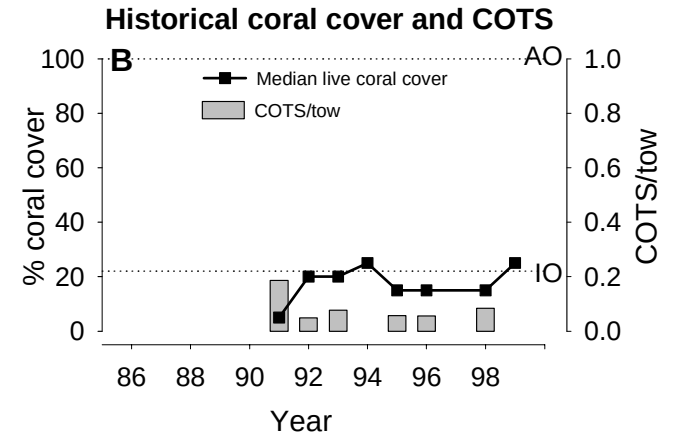
Figure 5.17

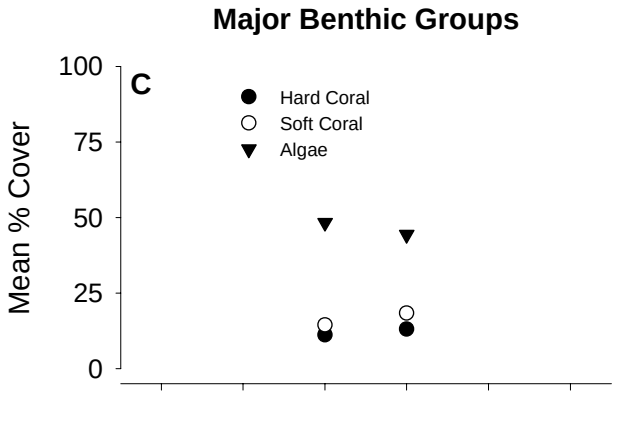
Reef No. 13-124

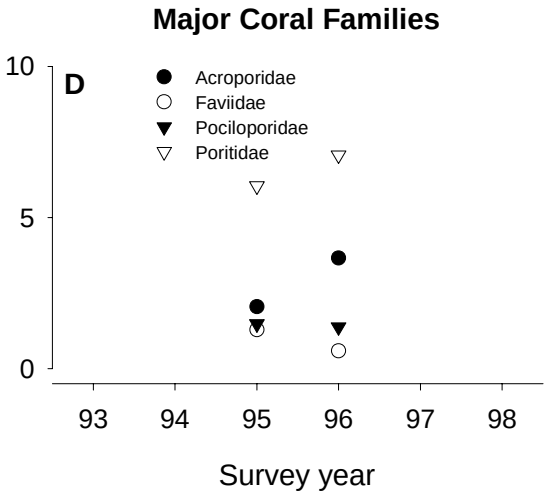


Reef No. 13-124 is a middle shelf crescentic reef with an area of 11.3 sq.km. Last surveyed October 1997.









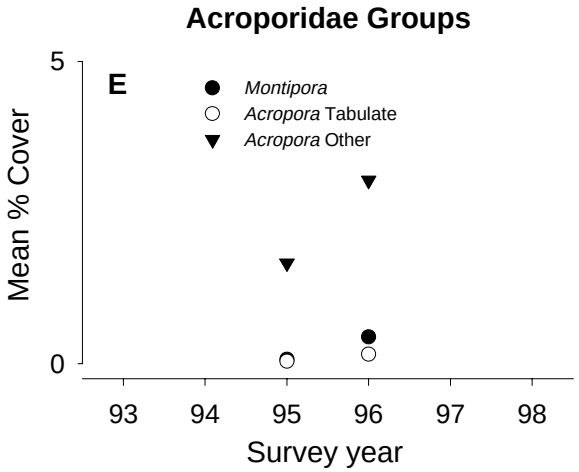
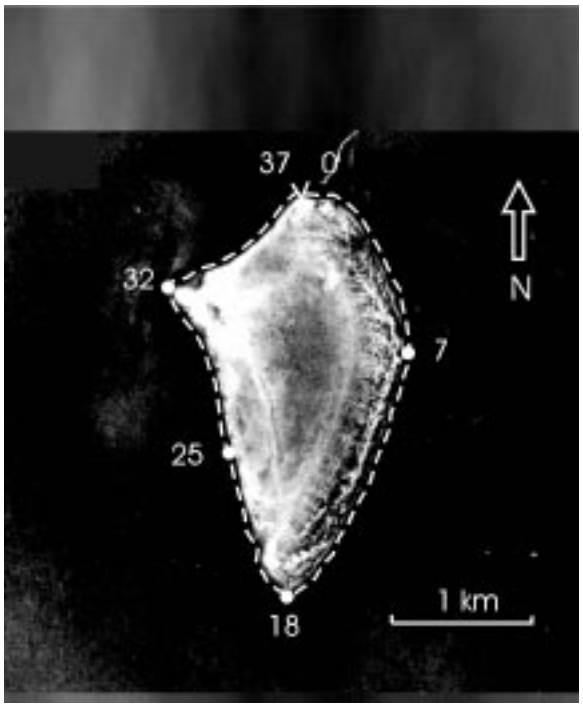
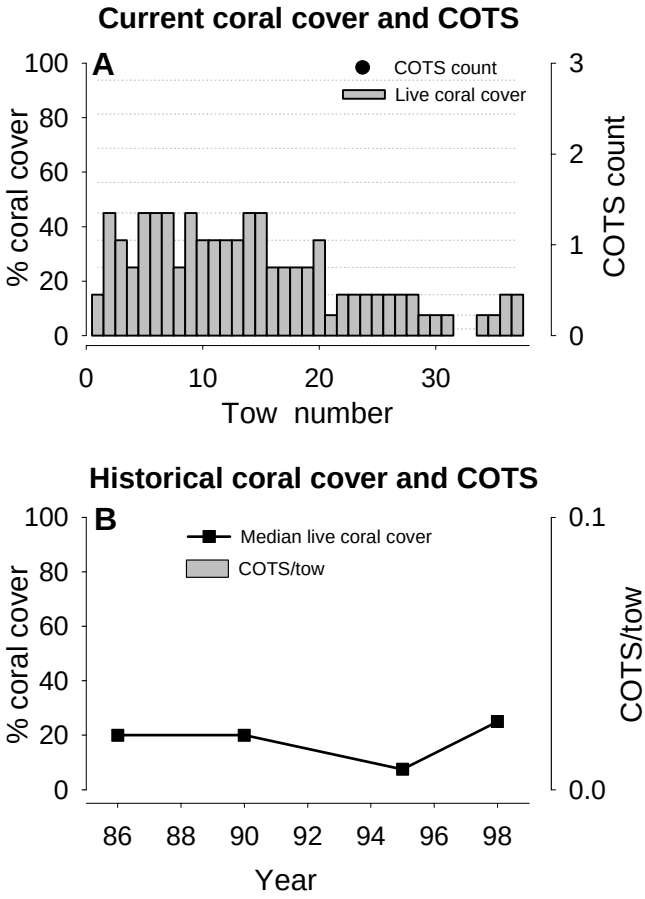


Figure 5.18

Pelican Island





Pelican Is (No. 13-107) is an inner shelf planar reef with an area of 3.8 sq.km. There is a vegetated sand cay on the western side. Last surveyed October 1997.

Reef No. 13-124

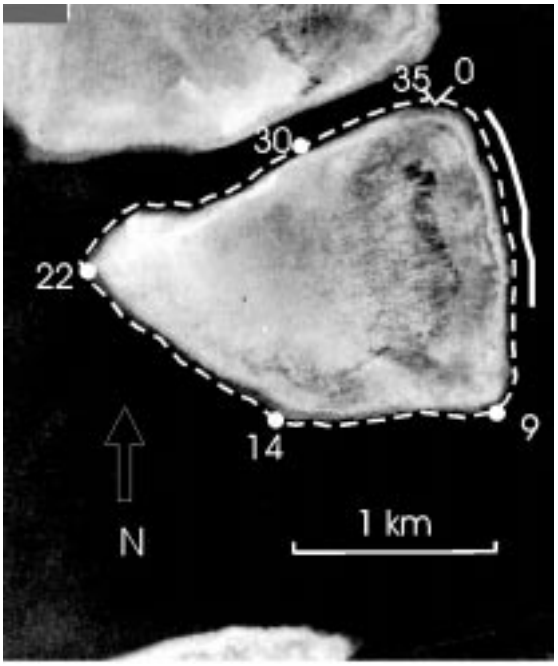
This reef has been surveyed by AIMS since 1991 using manta tow. The reef has also been surveyed twice, using the AIMS video technique, by staff from the Cairns office of Queensland Department of Environment and Heritage (QDEH) and these data are also presented. The manta tow data shows that COTS have been recorded on this reef in all surveys except 1994. In each case the COTS populations were generally below those that would be considered to cause significant coral mortality. Coral cover was initially low in 1991 and COTS were at near Incipient Outbreak levels. COTS numbers have subsequently declined and coral cover recovered to a moderate level where it has remained. The two QDEH surveys show similar stable but low-moderate hard coral cover with Poritidae dominating. A high cover of algae was also observed during both surveys. This reef remains classified as Non-Outbreaking.

Pelican Island

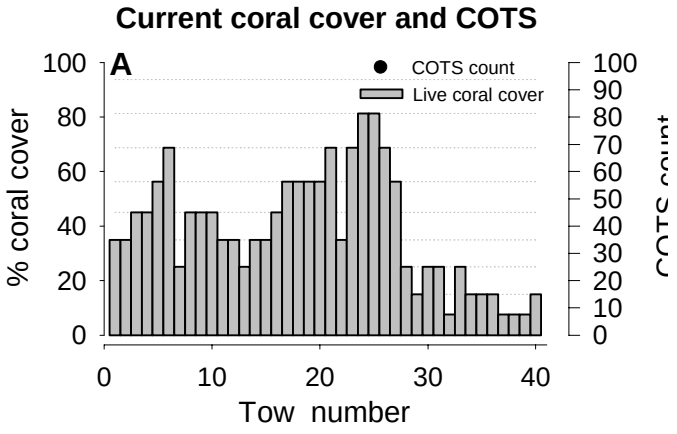
This reef has been surveyed four times since 1986. While there was little appreciable change in coral cover (remaining moderate) between 1986 and 1990, there was an apparent decrease in coral cover between 1990 and 1995. While it is difficult to ascribe reasons for the decline in coral cover, cyclone Nina did impact this area in December 1992. Since this time coral cover has recovered to its previously moderate levels. No COTS have been recorded on this reef which is currently classified as Non-Outbreaking.

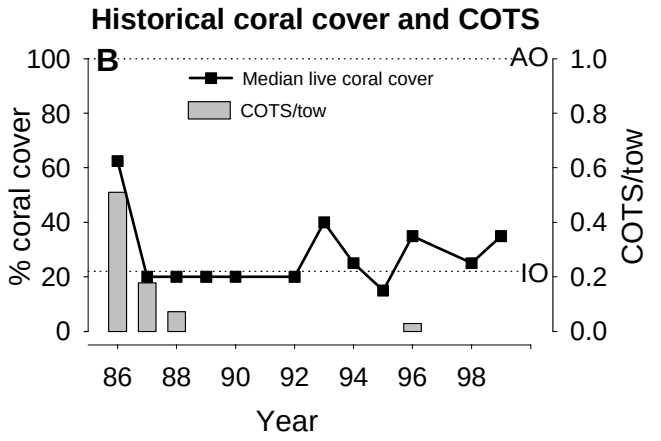
Figure 5.19

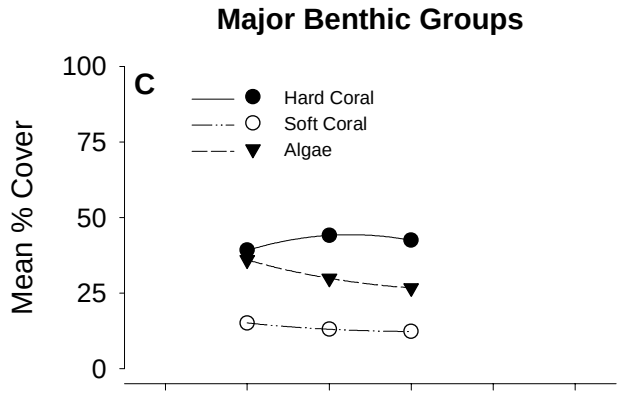
Rodda

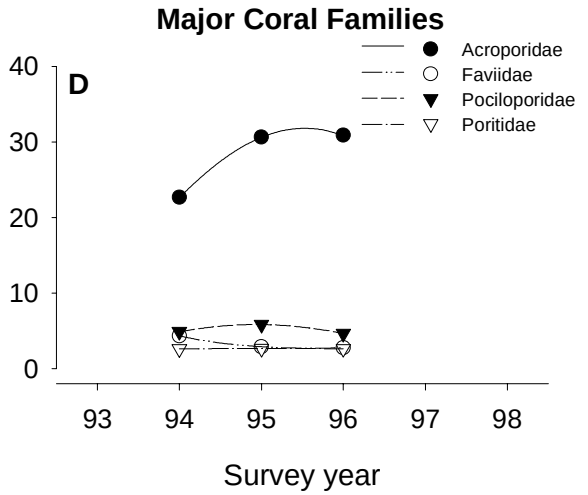


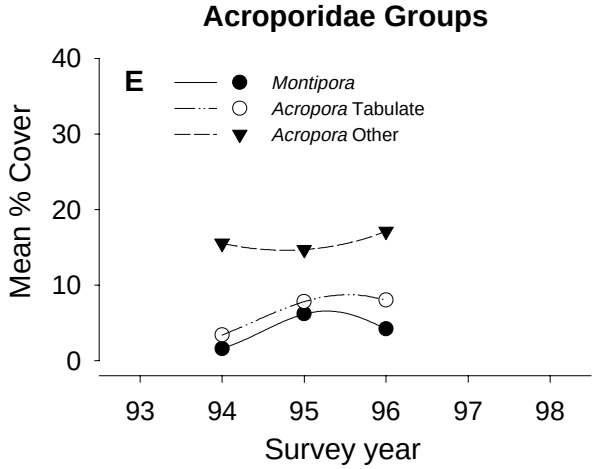
Rodda (No. 13-127) is an outer shelf planar reef with an area of 4.39 sq.km. Last surveyed October 1997.











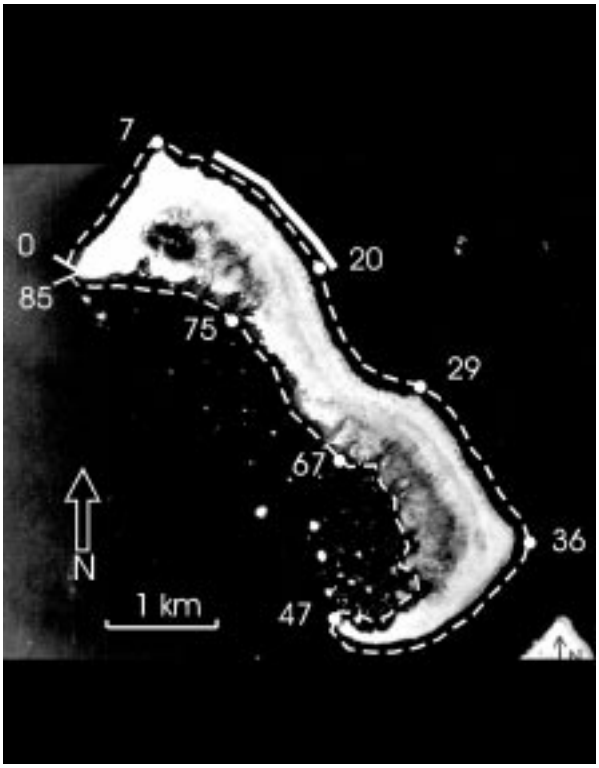
Rodda

This reef has an extensive history of manta tow survey by AIMS extending back to 1986. The reef has also been surveyed twice, using the AIMS video technique, by staff from the Cairns office of Queensland Department of Environment and Heritage (QDEH) and these data are presented. The manta tow data show that coral cover was initially very high on this reef then a large decline in coral cover occurred prior to the next survey. We attribute this to a relatively large population of COTS recorded during the first survey. Since 1993 there has been little appreciable change in coral cover though the trend would suggest a current increase. This is supported by the QDEH surveys which recorded high hard coral cover increasing slightly over the three years, with corals from the family Acroporidae responsible for the increase. Rodda reef was classified as having an Incipient Outbreak in 1986 and is currently classified as Recovering.

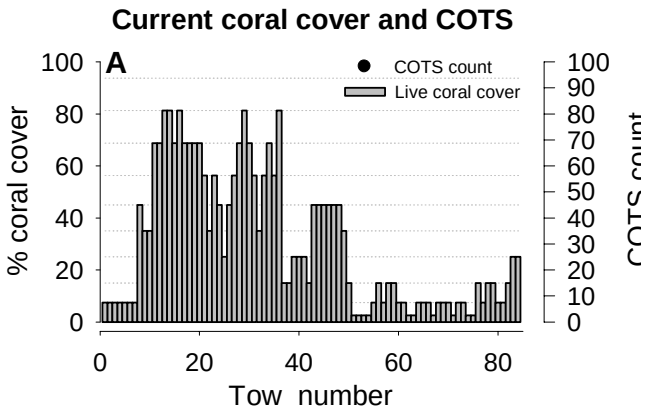
Cooktown/Lizard Island reef pages

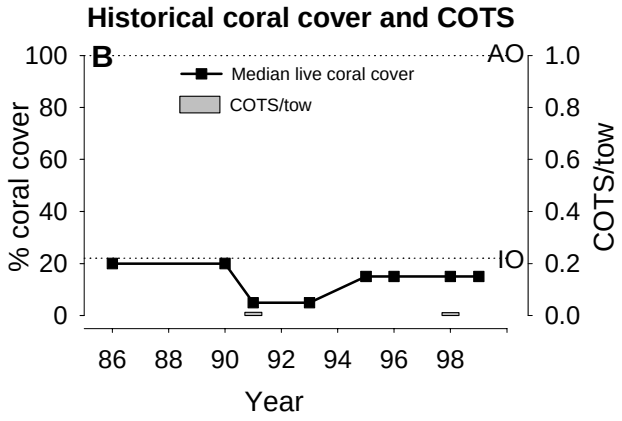
Figure 5.20

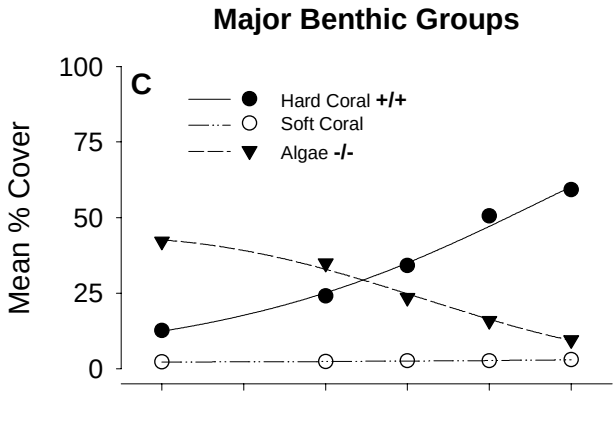
Carter

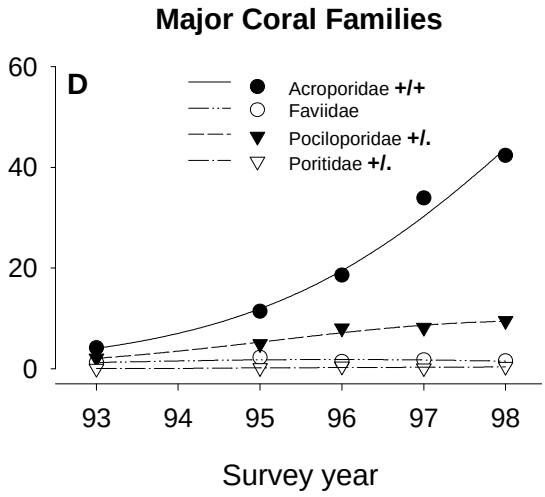


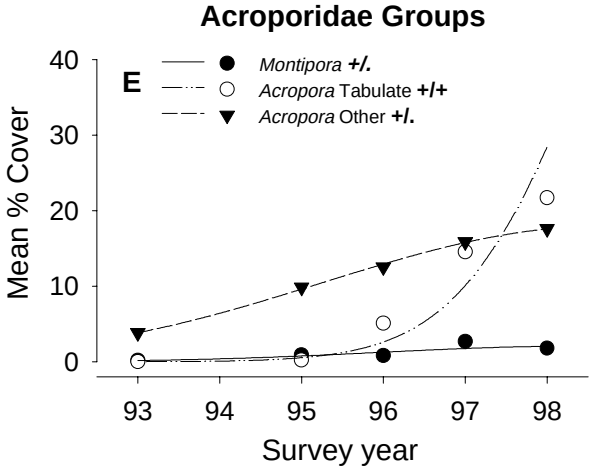
Carter (No. 14-137) is an outer shelf ribbon reef with an area of 13.7 sq.km. Last surveyed October 1997.

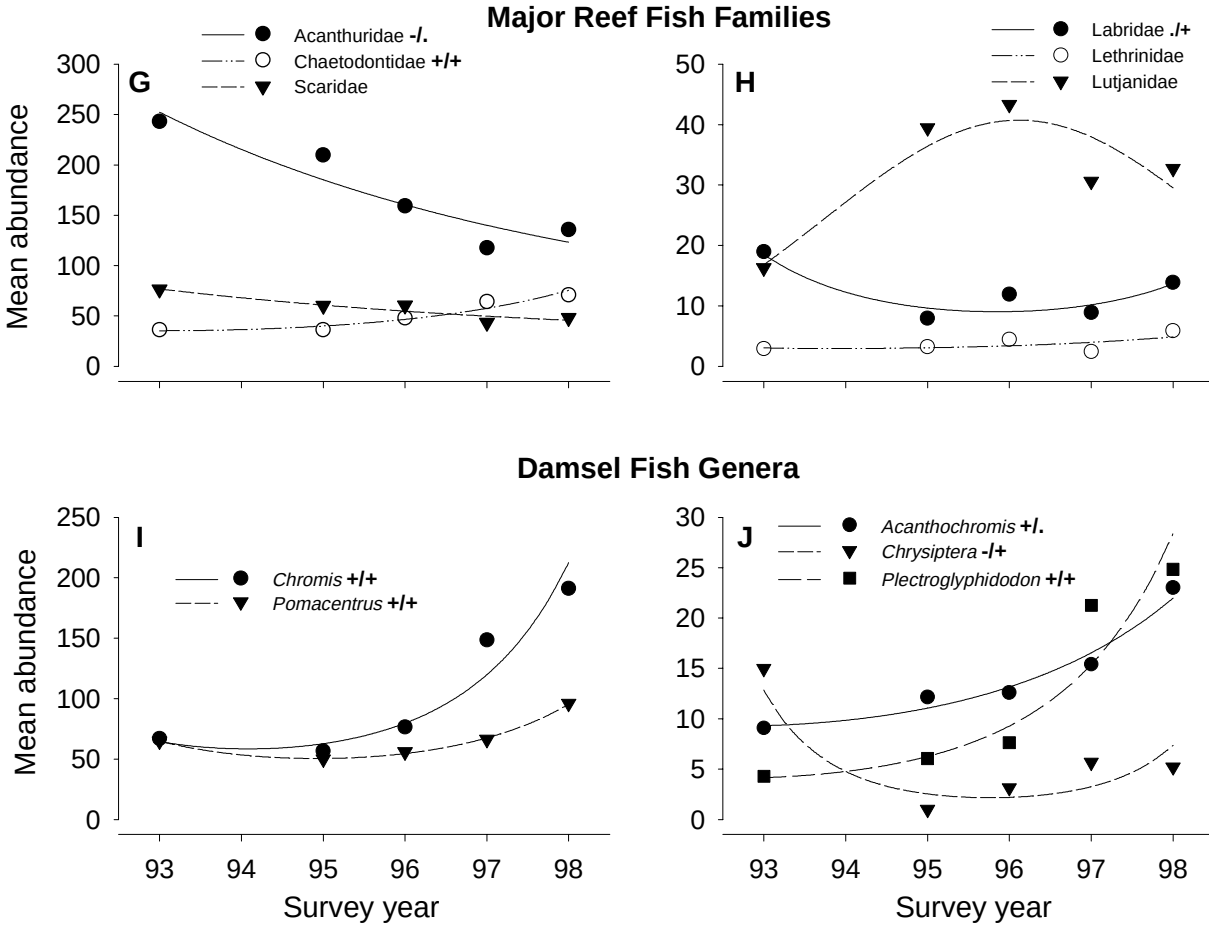












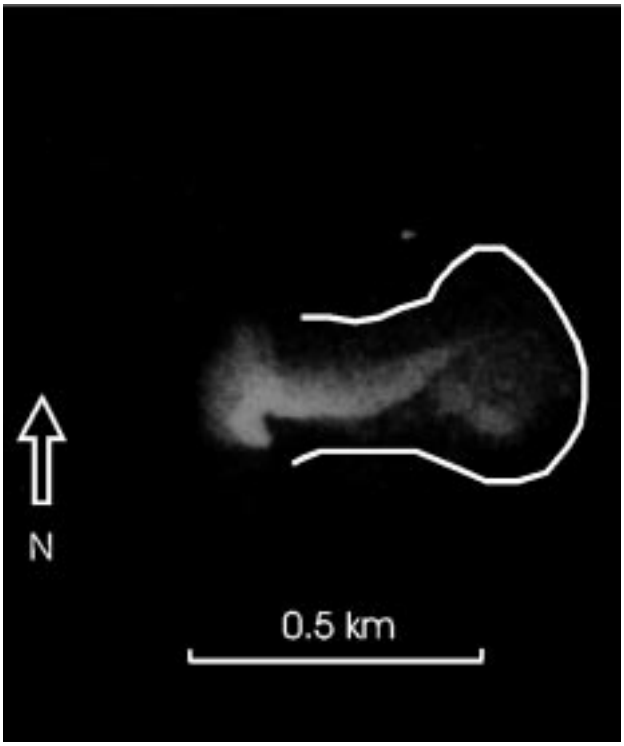
Carter Reef

This reef has a history of broadscale surveys from 1986. These surveys show that coral cover remained stable from1986 to 1990 before dropping appreciably in 1991. Whilst COTS were observed on the reef at this time their numbers were well below the level considered to cause significant coral mortality. Examination of other possible impacts between surveys leads to the most likely explanation that the decline in coral cover occurred as a result of the effects of Cyclone Ivor, which passed in vicinity of this reef in March 1990. Significant physical damage on the reef front was observed during surveys undertaken soon after the cyclone. Benthic video transects, conducted since 1993, in conjunction with continued broadscale surveys, show that coral cover is continuing to recover and is currently dominated by tabulate *Acropora* on the reef front. The percentage cover of coral increases rapidly on reefs dominated by tabulate *Acropora* and coral cover was recently recorded at 59% on the benthic video transects, up from 13.2% in 1993. Other major coral groups have also increased since surveys were initiated in 1993 but have not changed during the most recent survey interval.

With the increase in coral cover and resultant habitat complexity, the majority of fish taxa have increased in mean abundance since detailed surveys began in 1993. *Acanthochromis polyacanthus*, *Chromis* (*C. lepidogenys*, *C. margaritifer*, *C. ternatensis*, *C. weberi*), *Plectroglyphidodon* (*P. johnstonianus*, *P. dickii*), *Pomacentrus* (*P. lepidogenys*, *P. philippinus*), Chaetodontidae (numerous species) and to a lesser degree Labridae (*Hemigymnus fasciatus*, *Gomphosus varius*) all increased over the period of survey. The only fish group which has decreased are the Acanthuridae with decreases in the three common grazers, *Acanthurus nigrofuscus*, *Ctenocheatus* spp and *Zebrasoma scopas*. *Chrysiptera rex* decreased initially however abundance is currently increasing.

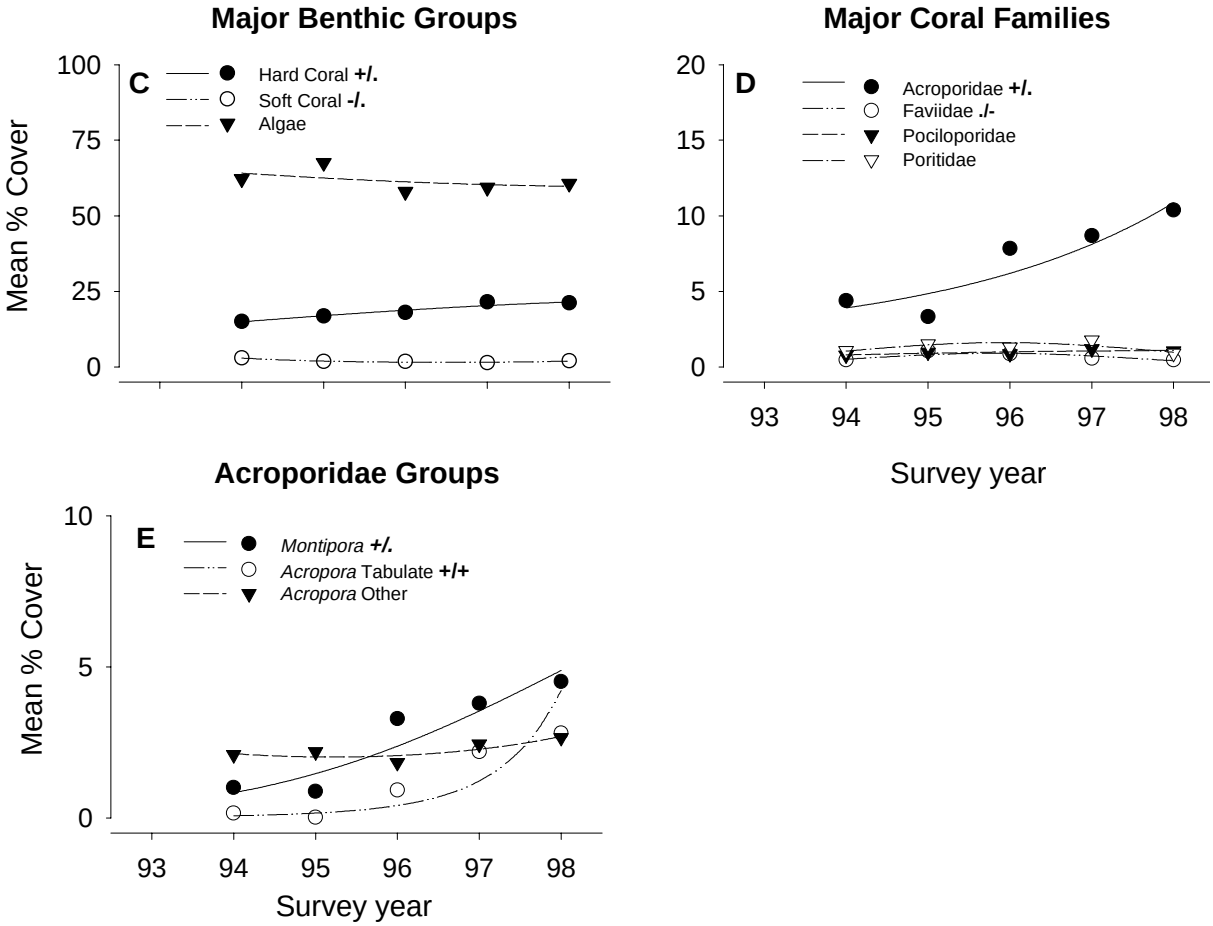
Figure 5.21

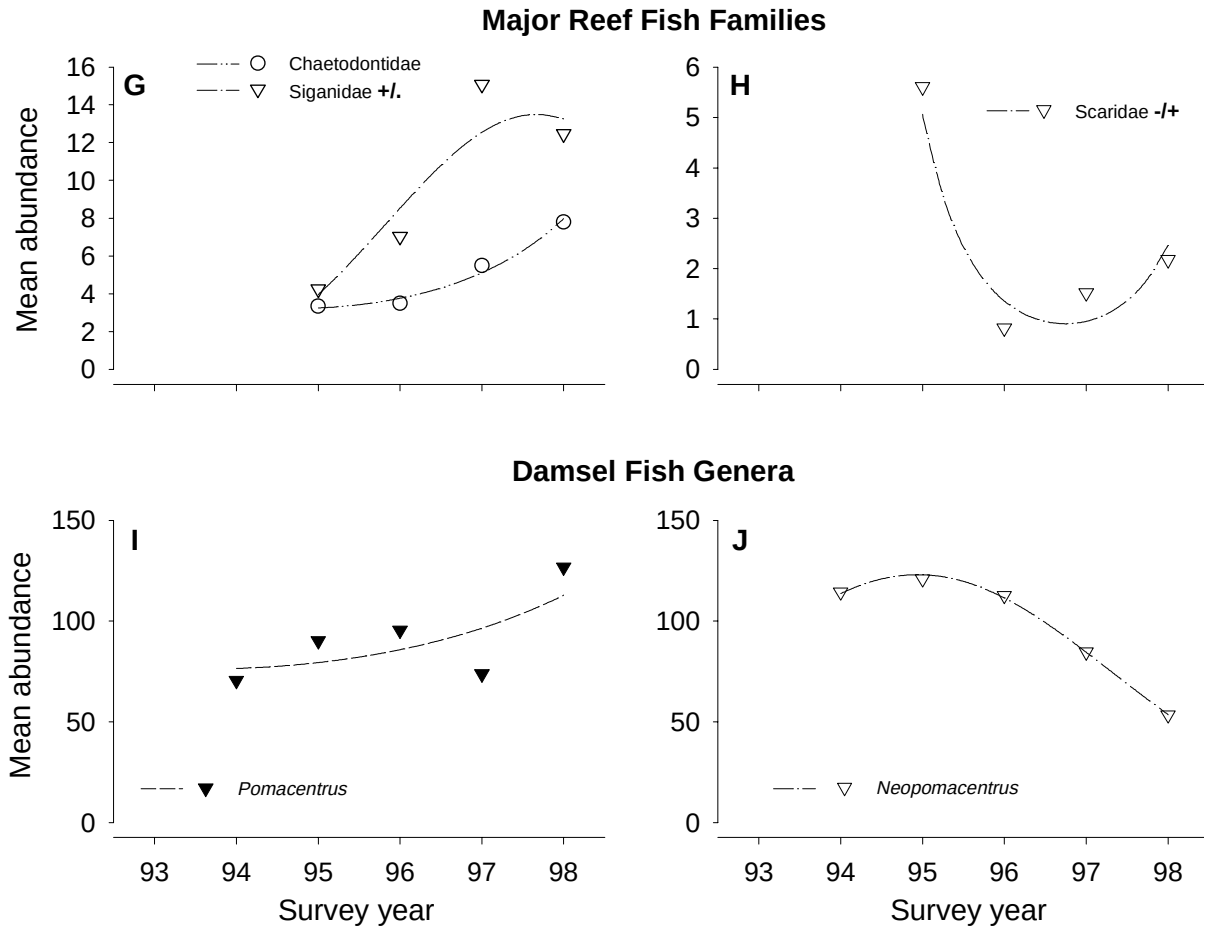
Decapolis



No manta tow surveys conducted on Decapolis Reef due to poor visibility

Decapolis (No. 14-131) is an inner shelf planar reef with an area of 0.4 sq.km. Last surveyed October 1997.





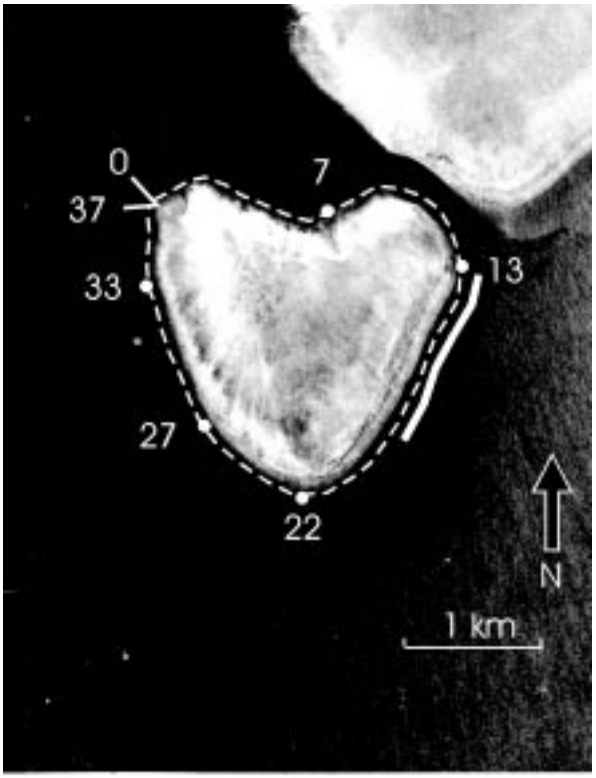
Decapolis

We do not manta tow this reef due to poor water clarity (typically <4m visibility). The aerial photo shows that the survey sites cover the majority of the perimeter of the reef. This reef has the highest percent cover of macro algae (36.3%) of all the reefs surveyed using video, with the first three transects of site one dominated by macro algae. Corals from the family Acroporidae are increasing in cover while other coral groups and soft coral remain stable at low levels of cover. There is a high diversity of hard coral on this reef and abundant gorgonians from the family Ellisellidae and Antipatharians (Black Coral).

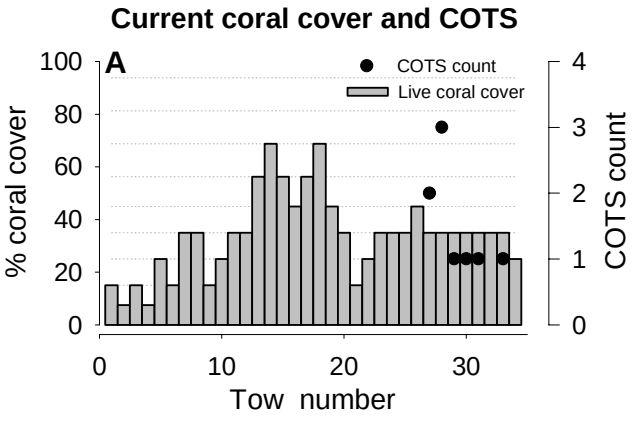
The reef fish community is particularly depauperate. Prevailing low visibility combined with low numbers necessitates cautious interpretation of the observed temporal trend for Scaridae. The increase in Siganidae between years 4 and 5 is due to *Siganus lineatus*.

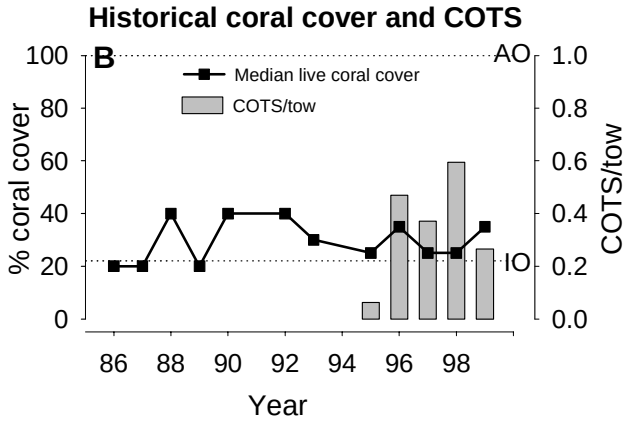
Figure 5.22

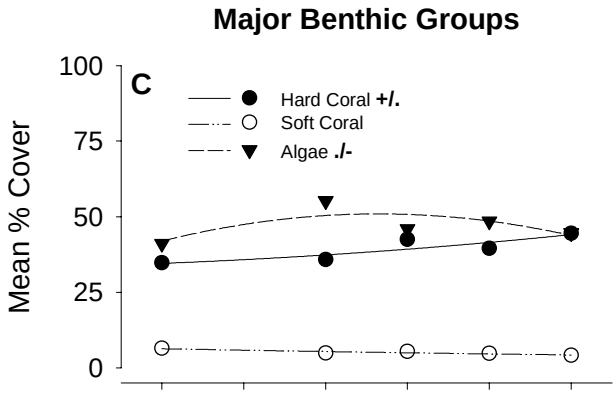
Linnet

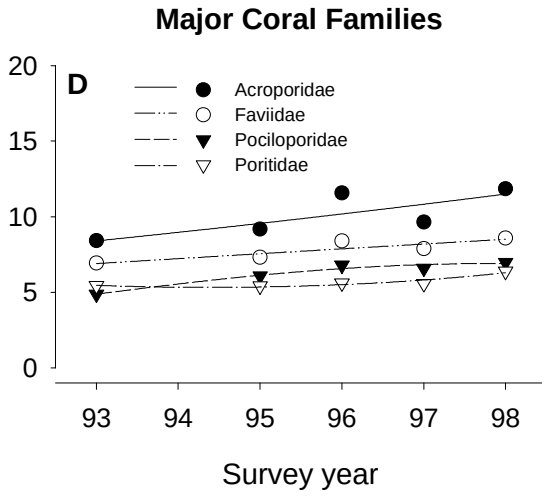


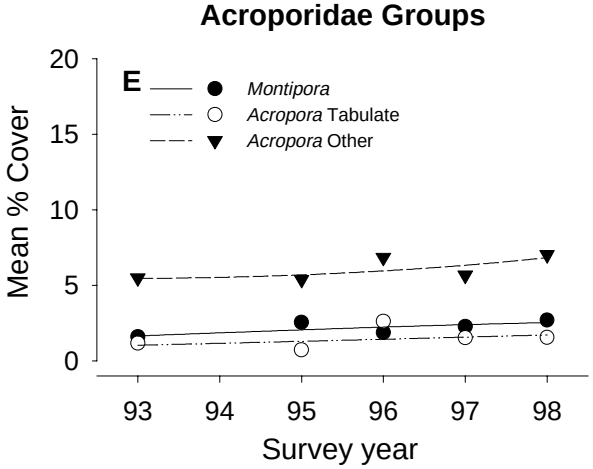
Linnet (No. 14-126) is an inner shelf planar reef with a sand cay on the north-western end. The reef has an area of 3.5 sq.km. Last surveyed October 1997.

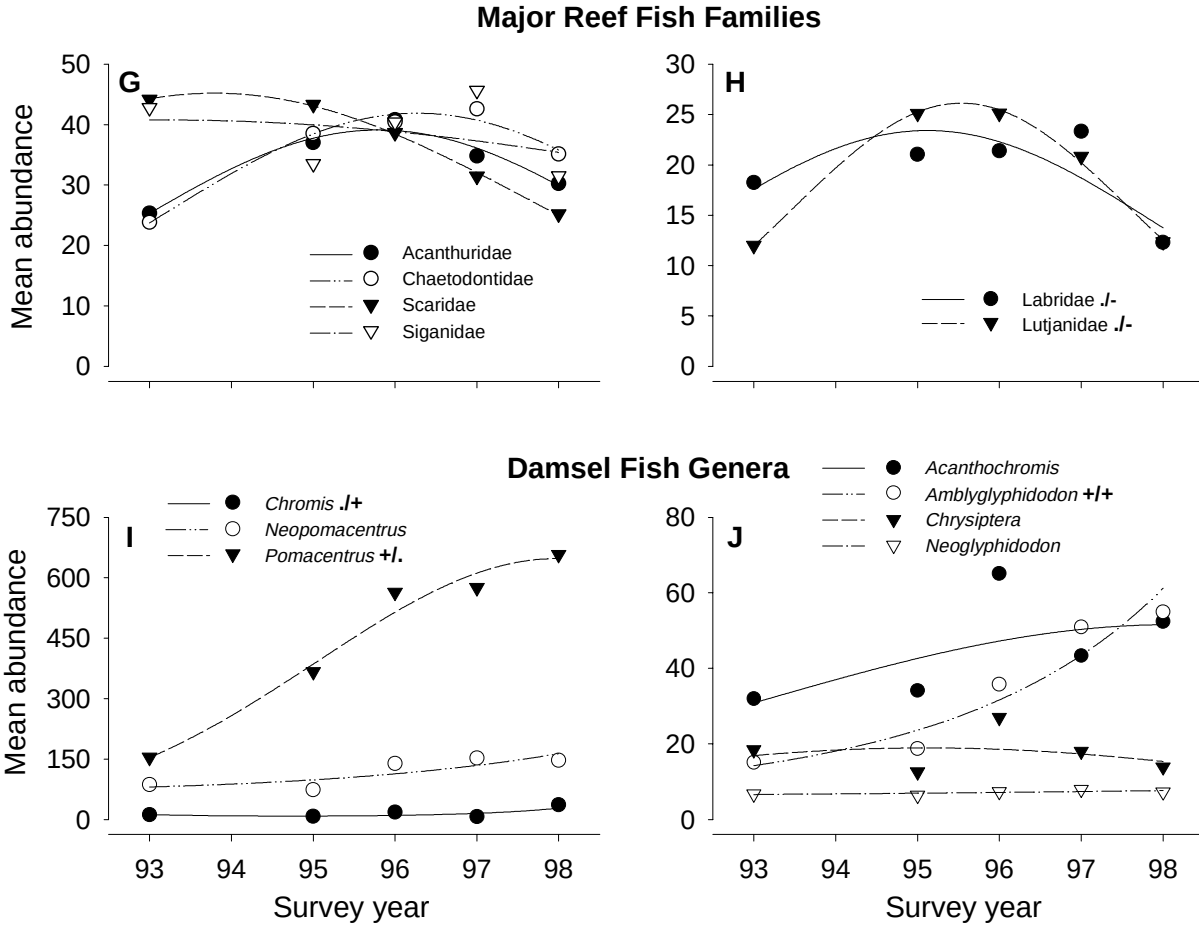












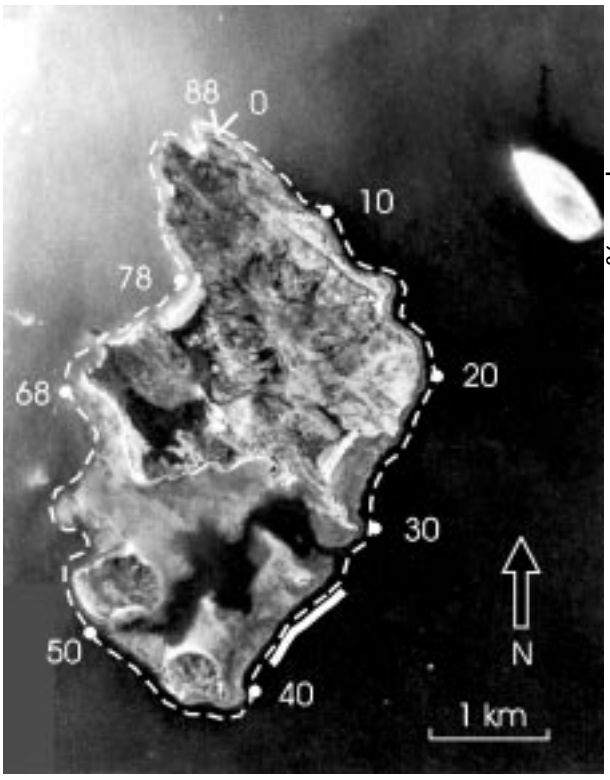
Linnet

This reef has an extensive history of survey beginning in 1986. Since this time there has been little appreciable change in coral cover which has remained moderate to high. Data recorded from the benthic transects show that coral cover is moderately high and stable at 44.5% which is an increase of 10% since surveys were initiated in 1993. This apparent contradiction reflects the more limited coverage of the video transects but also their increased sensitivity over the manta tow method. The relative abundance of Favids at this reef is high at 8.7%. A rise in COTS numbers has been recorded since 1995 and the reef was reclassified as an Incipient Outbreak in 1996. Subsequent surveys should determine the impact of increased COTS populations. Low level bleaching was also observed on the reef.

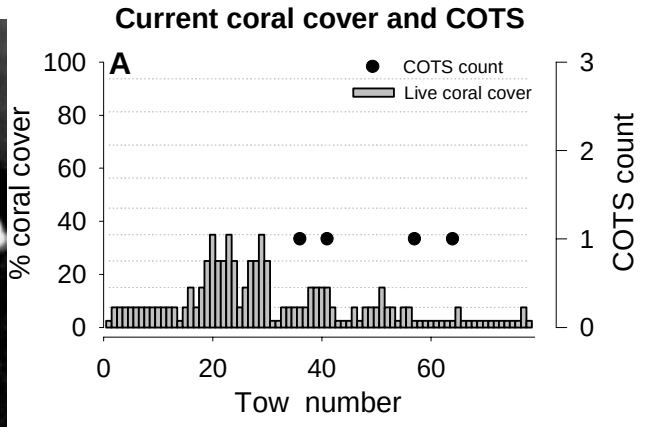
The moderately high coral cover is reflected in high abundances of many fish taxa. The increase in *Pomacentrus* numbers was largely due to the abundant *P. moluccensis* with *P. lepidogenys* and *P. brachialis* also increasing steadily. The increase in *Chromis* has been driven by one species (*C. atripectoralis*) with other less abundant species (*C.ternatensis* and *C. weberi*) also showing steady increases. *Amblyglyphidodon curacao* has also increased over the period of surveys. Populations of larger reef fishes have generally been stable with the exception that most of the common species of Labridae and Lutjanidae declined at the latest survey.

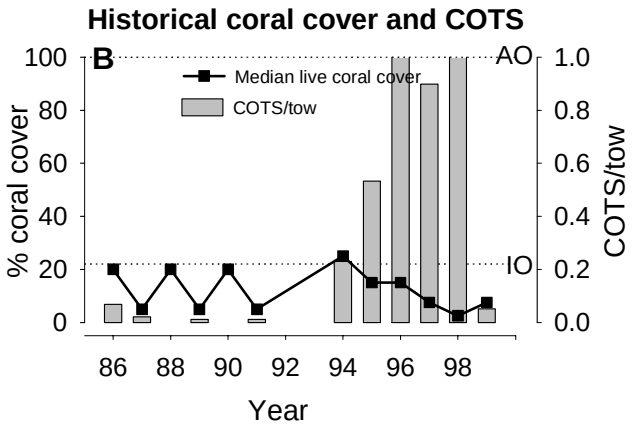
Figure 5.23

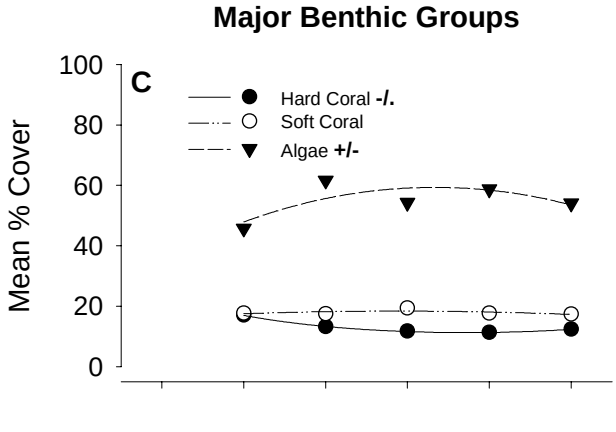
Lizard Island

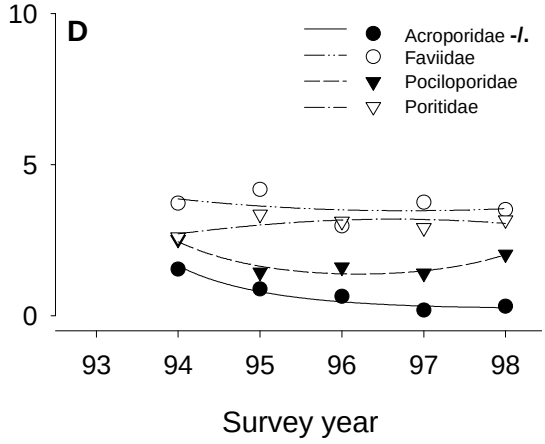


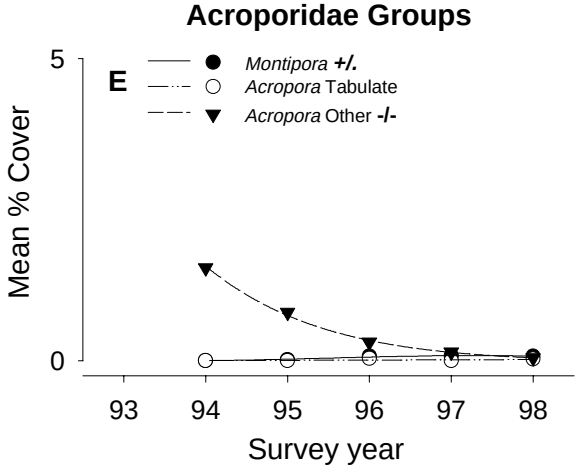
Lizard Island (No 14-116) is a middle shelf fringing reef surrounding four high continental islands. The reef has an area of 14.1 sq.km. Last surveyed October 1997.

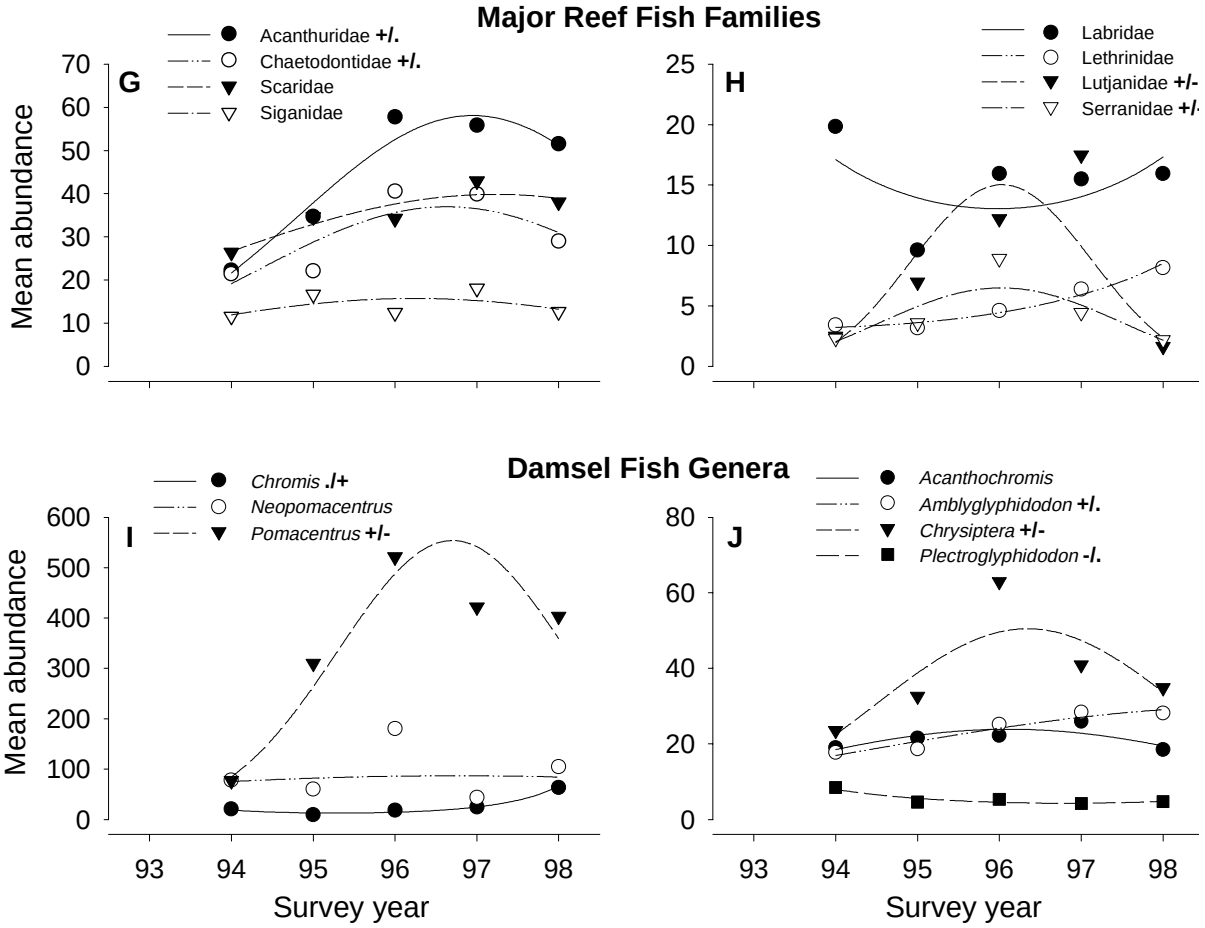












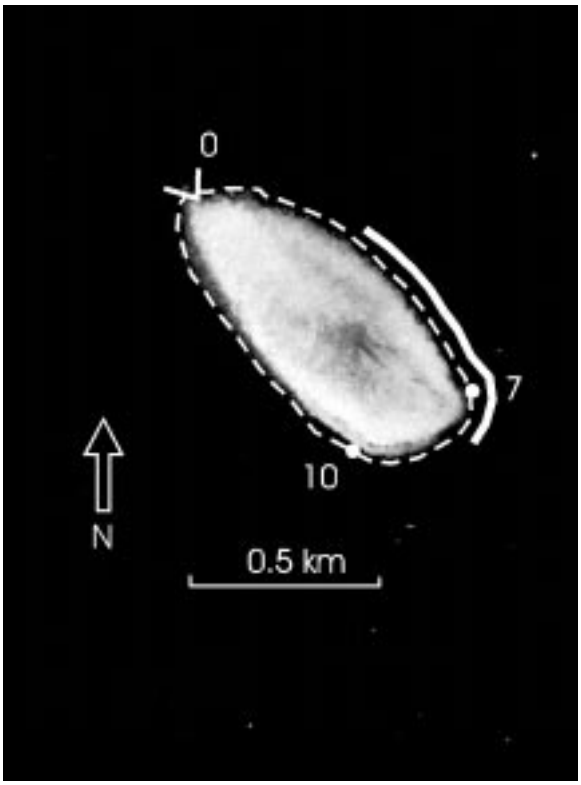
Lizard Island

This reef has been surveyed extensively since 1986. When first surveyed, Lizard Island Reef was considered to be recovering from COTS activity. However in 1994 a population of COTS was observed on the reef at Incipient Outbreak levels. The COTS population has continued to increase and the reef was classified as an Active COTS Outbreak in 1996 and 1998. Coral cover has steadily declined since 1994 and is currently extremely low (<10%) at the reef level. Detailed benthic surveys on transects in the south eastern area of the reef recorded hard coral cover of 13.1% during the most recent survey. COTS and moderate scarring were also observed on the sites during the latest survey.

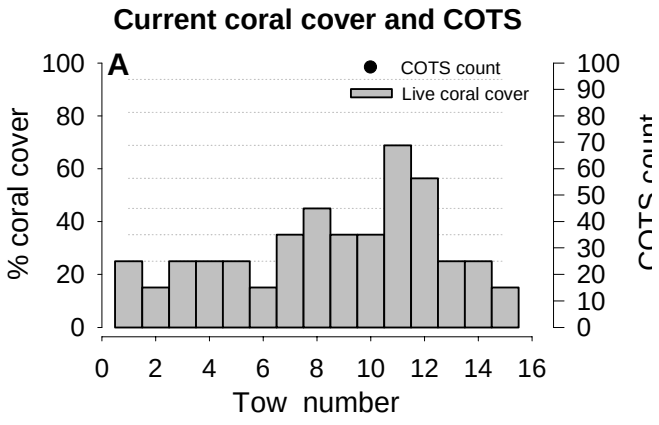
There has been a large increase in the common grazing Acanthurids (*Acanthurus nigrofuscus*, *Ctenochaetus* spp and *Zebrasoma scopas*). Given the low and decreasing coral cover it is interesting that a number of Chaetodontid species also showed general increases over the period although most declined in the last visit. The damsel fishes *Pomacentrus moluccensis* and *Chysiptera rollandi* also increased over the first three visits before declining to current abundances. Trends in Lutjanidae are due to incidental presence of schooling species (*L. gibbus* and *L. bohar*) in years 4 and 5 rather than general changes in abundance. The current increase in Chromis is due to a ten fold increase in *C.hromis weberi* in the last survey. Abundance of *Plectropomus leopardus* has been stable except for a high count in 1996.

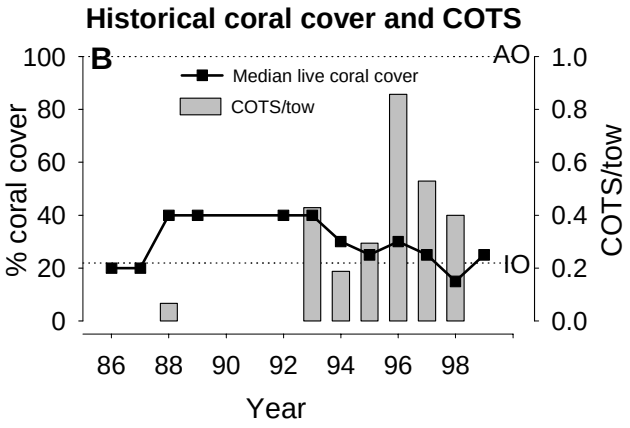
Figure 5.24

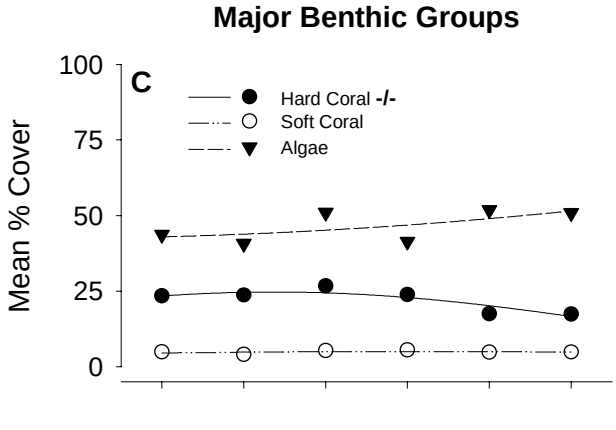
MacGillivray

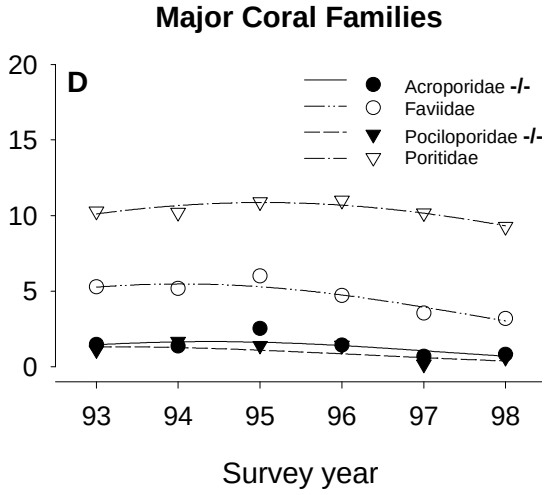


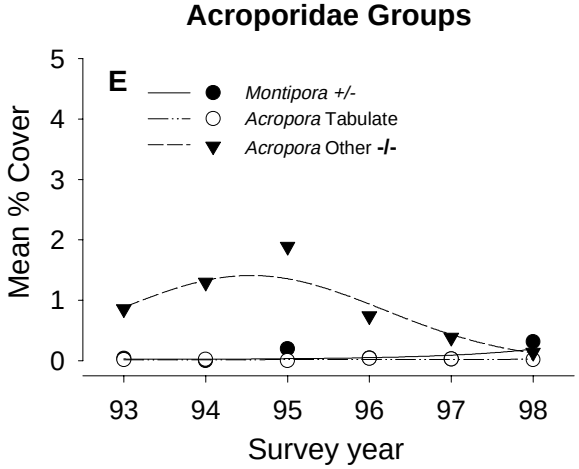
MacGillivray (No. 14-114) is a middle shelf planar reef with an area of 0.5 sq.km. There is a sand cay on the northern end. Last surveyed October 1997.

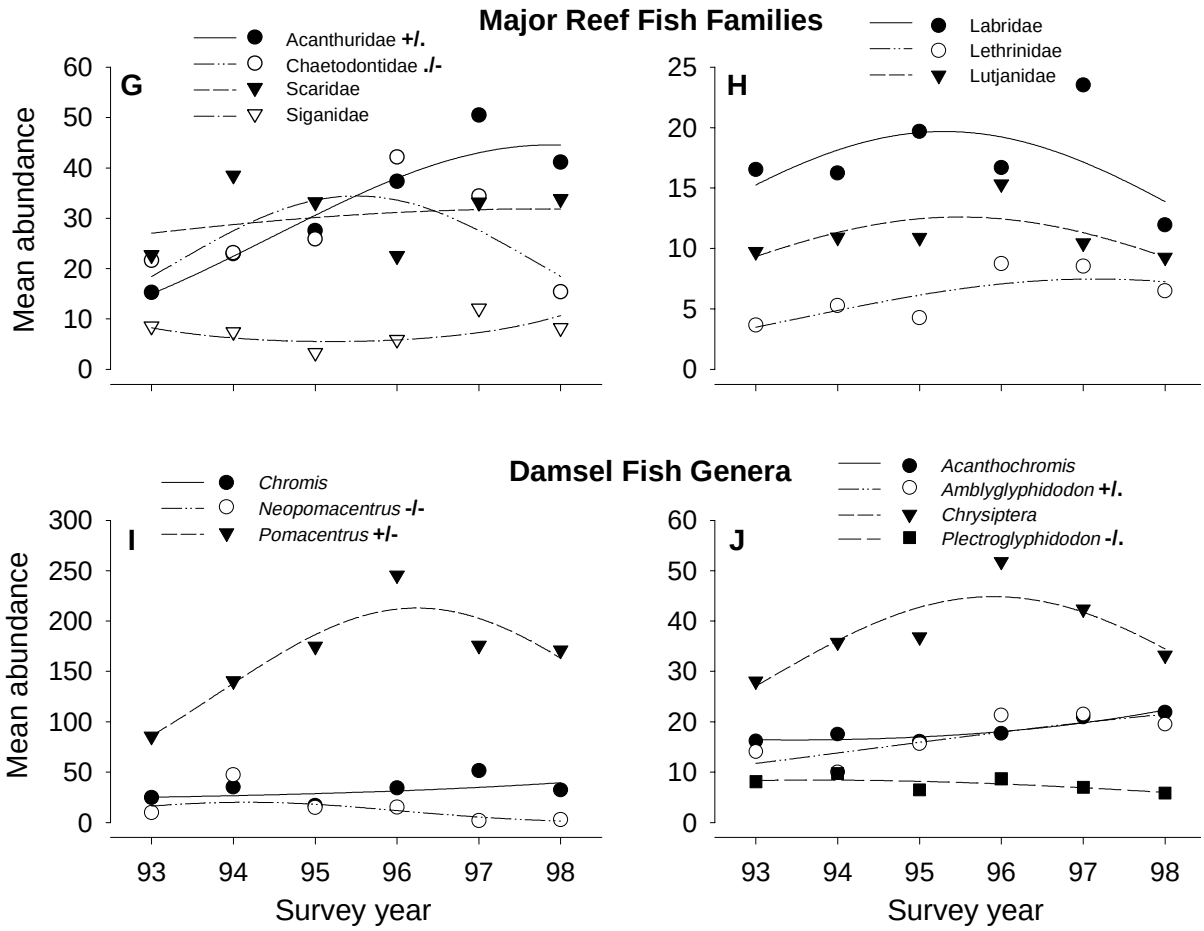












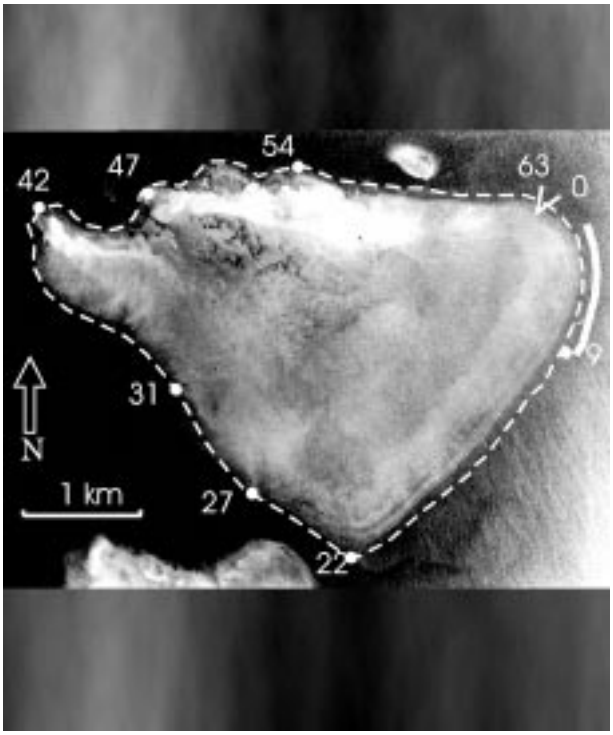
MacGillivray

This reef has been surveyed since 1986 when it was initially classified as recovering from previous COTS activity. Coral cover remained static at a high level through 1986 to 1994. In 1993 elevated COTS populations were recorded and the reef was reclassified as having an Incipient Outbreak . This reef remains classified as an Incipient Outbreak and both manta tow and detailed benthic surveys show that coral cover is currently in decline with cover on benthic video transects presently low at 17.4%. Low levels of bleaching were also observed. It is of note that approximately 20% of the transect area monitored on this reef is sand.

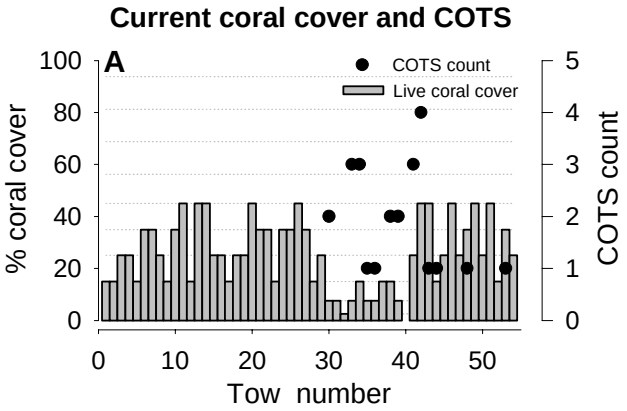
There has been a general increase in *Amblyglyphidodon curacao* and the Acanthurids, *Acanthurus nigrofuscus*, *Ctenocheatus* spp and *Zebrasoma scopas*. The common *Pomacentrus* species, *P. amboinensis*, *P. brachialis*, *P. lepidogenys* and *P. moluccensis* showed increases over the first four visits before stabilising or slightly declining. Individual counts of Chaetodontids have been variable though commonly low in the last two surveys. *Neopomacentrus azysron* has been declining over the period of survey.

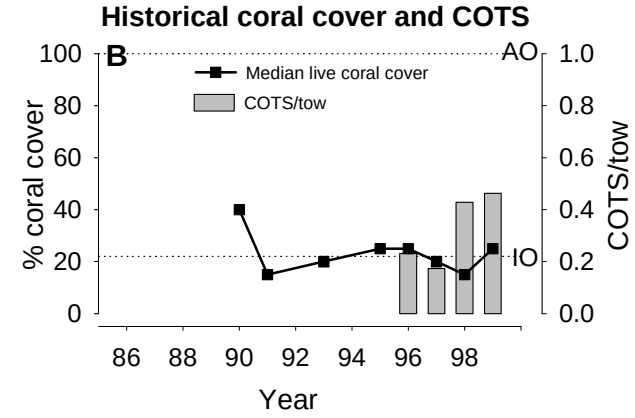
Figure 5.25

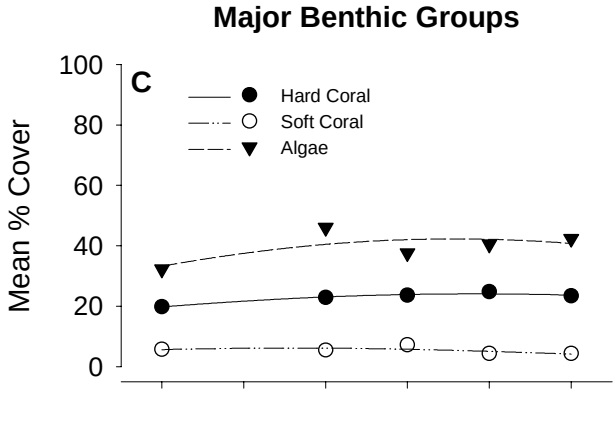
Martin

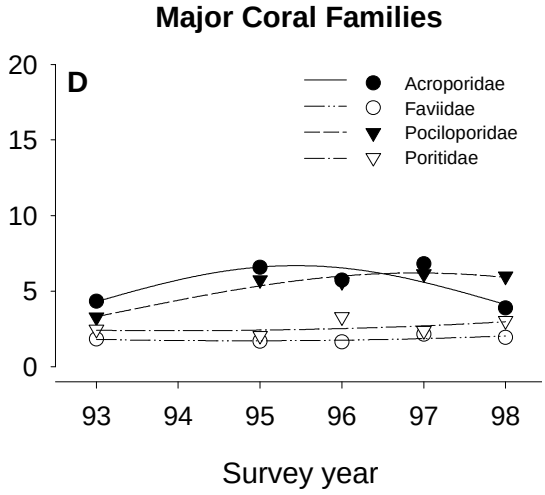


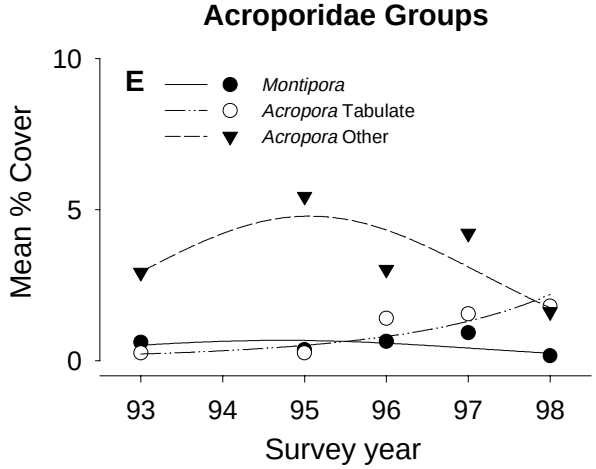
Martin (No. 14-123) is an inner shelf planar reef with an area of 10.1 sq.km. There is a sand cay on the north-western side. Last surveyed October 1997.

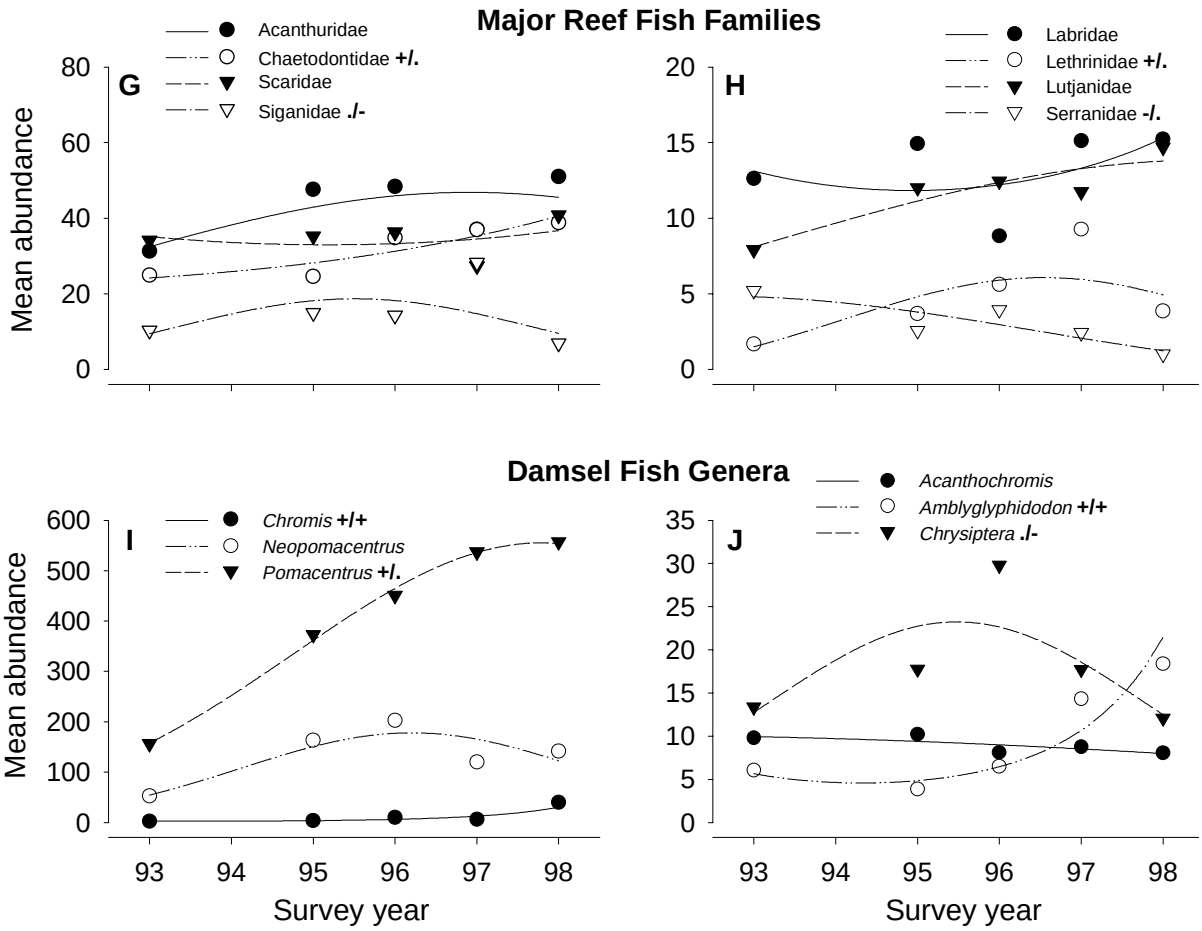










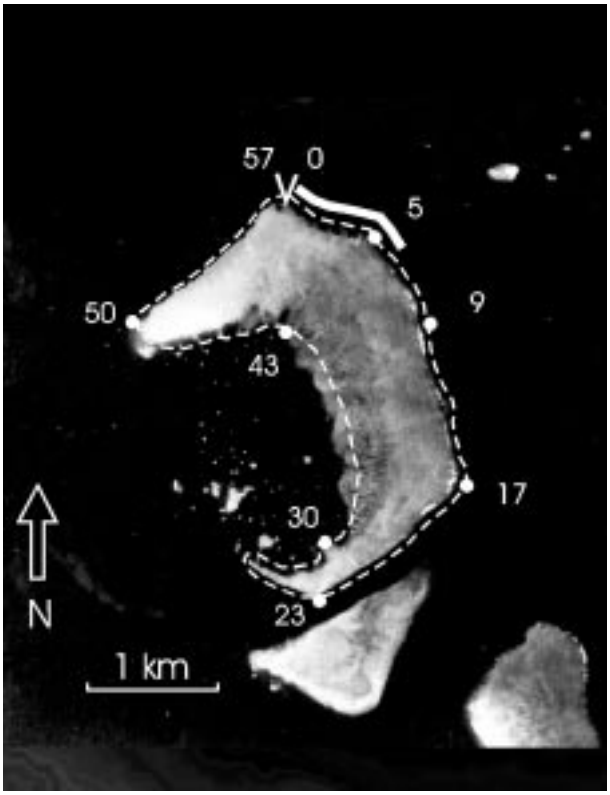


Martin

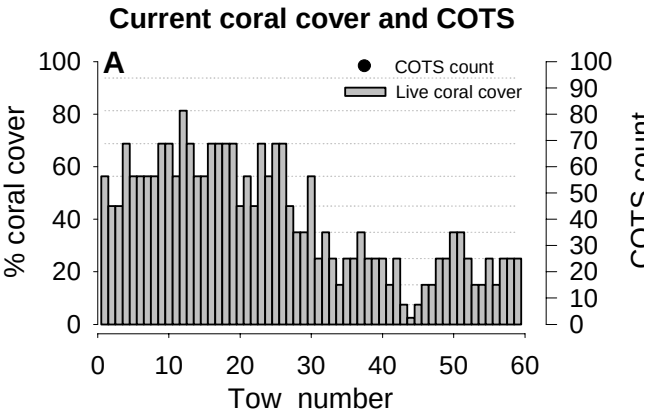
This reef has a history of broadscale survey extending back to 1990. Coral cover has not changed significantly on this reef over the survey period. COTS populations are currently increasing with the reef presently classified as having an Incipient Outbreak. Broadscale data suggest that coral cover is slowly declining while detailed transect surveys show moderate hard coral cover of 23.7%. It is noteworthy that COTS and *Drupella* were recorded on the sites during the most recent surveys and a decline in coral cover in this area seems likely.

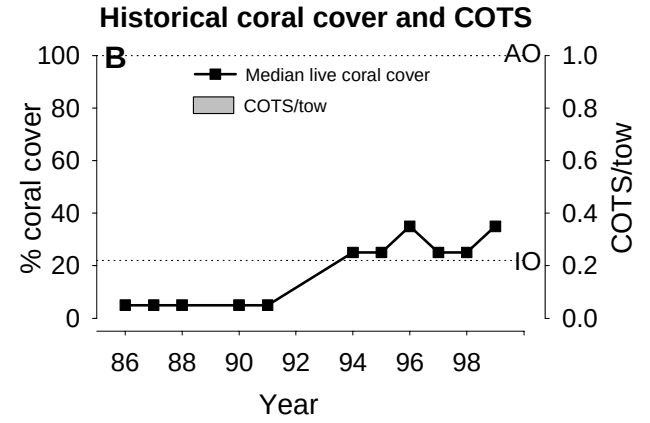
Pomacentrid fishes show trends similar to those observed on Linnet Reef with increases in *Amblyglyphidodon, Pomacentrus* and *Chromis* involving the same species. In contrast, numbers of *Chrysiptera rollandi* declined over the last three years. Among larger reef fish taxa, Chaetodontidae increased until 1997 (primarily *Chaetodon aureofasciatus*, *C. auriga*, and *C. rainfordi*) while the Serranid *Plectropomus leopardus* decreased. The trends in both Lethrinidae and Siganidae result from the incidental presence of schooling species rather than general changes in abundance.

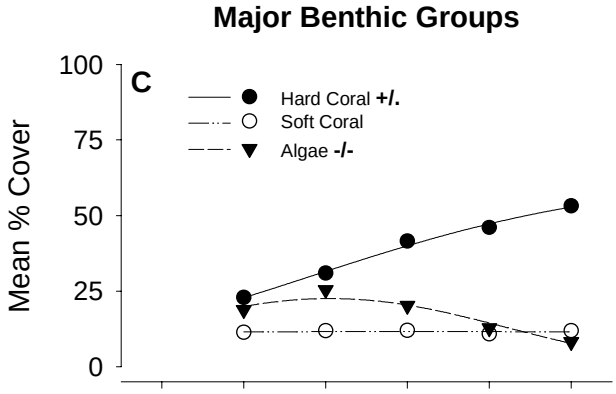
Figure 5.26 **No Name**

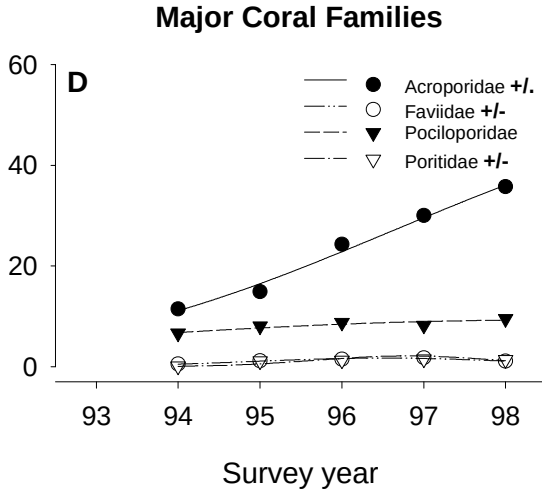


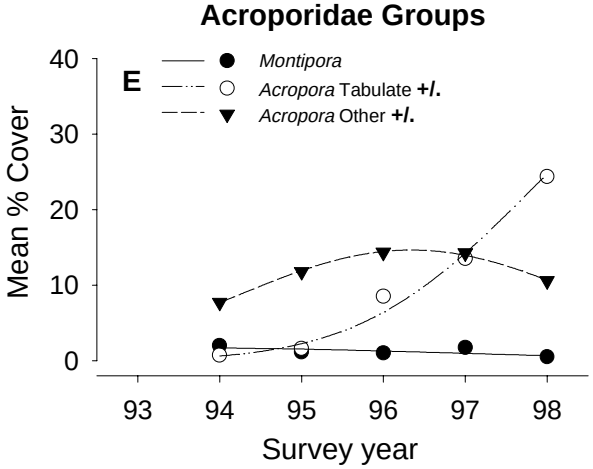
No Name (No. 14-139) is an outer shelf ribbon reef with an area of 7 sq.km. Last surveyed October 1997.

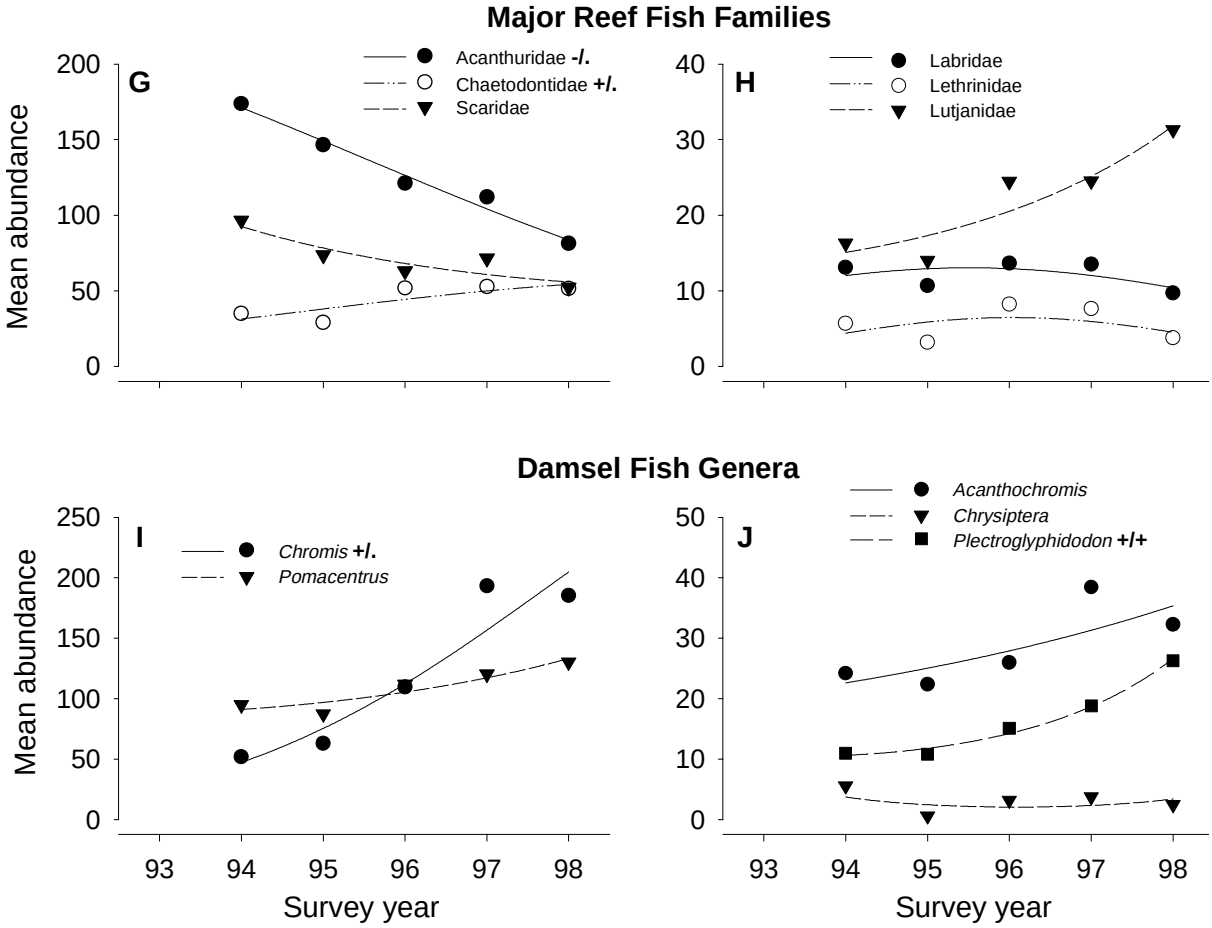












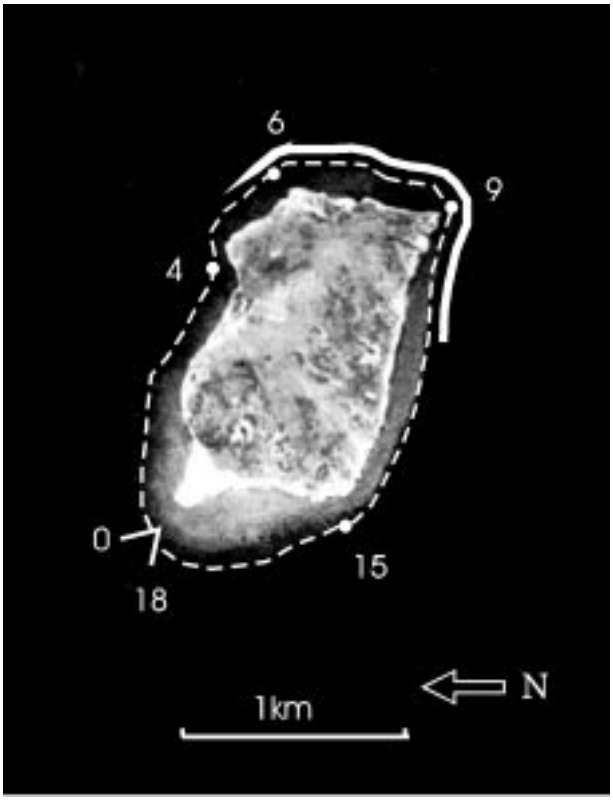
No Name

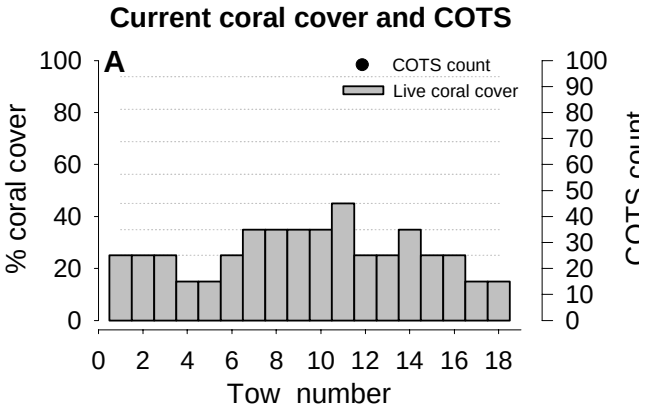
This reef has an extensive history of broadscale survey from 1986. No COTS have been recorded during this time. Coral cover was low through to surveys in 1991. Cyclone Ivor passed through the area in 1990 and caused significant physical damage. The next broadscale survey was conducted in 1994 and showed that average coral cover had increased to around 20-30%. This is supported by detailed benthic surveys which showed an average coral cover in 1994 of 23.1%. Since this time coral cover has steadily increased to 53.1% in 1998. This increase in coral cover has been due mostly to a large increase in tabulate *Acropora* tabulates. Other corals have also increased since 1994. It is notable though, that slight decreases were recorded during the last survey interval for the families Faviidae and Pocilloporidae. We suggest that this "apparent" decline may be due to overgrowth by *Acropora* tabulate which results in the tabulate coral being recorded during video analysis rather than the coral underneath.

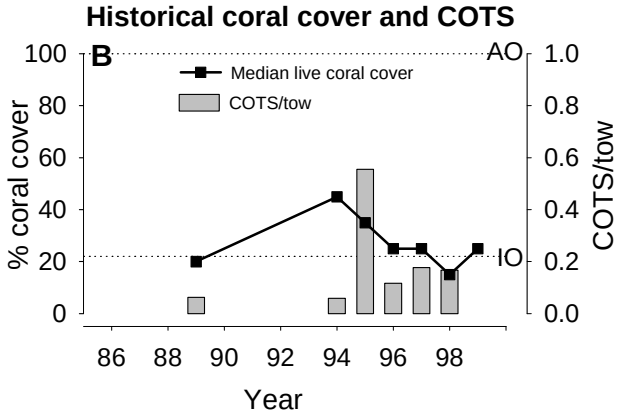
As with Carter Reef, there has been a general increase in the majority of fish taxon surveyed. P*lectroglyphidodon dickii* and *P. johnstonianus* have almost tripled over the period of surveys, as have the genus *Chromis* in which five of the seven species commonly present, have been steadily increasing. The contrast occurs in the Acanthuridae with steady declines in *Acanthurus nigrofuscus* and *Ctenochaetus* spp. and to a lesser degree declines within the Scaridae.

Figure 5.27

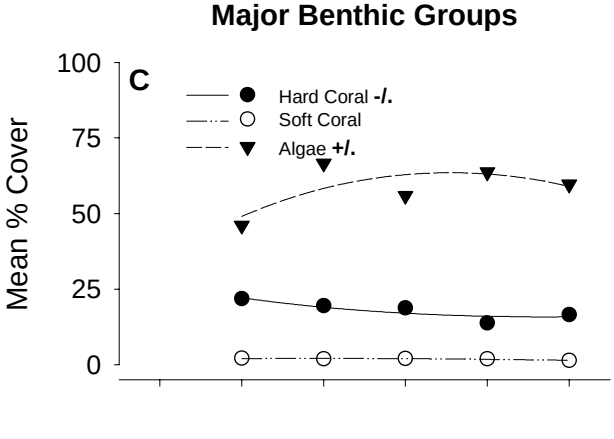
North Direction Island

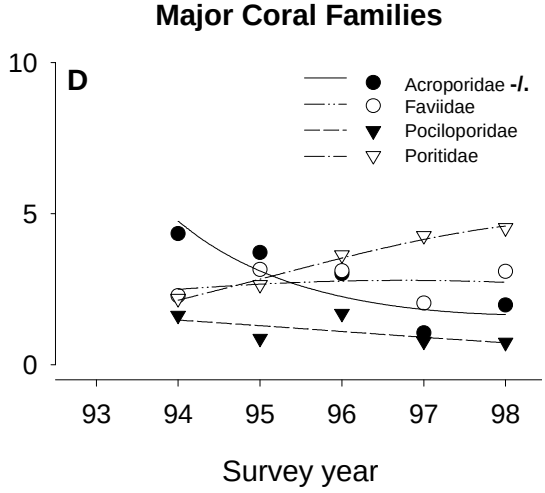


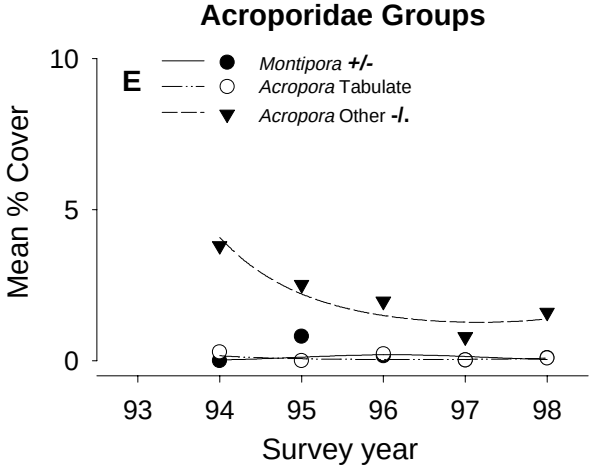


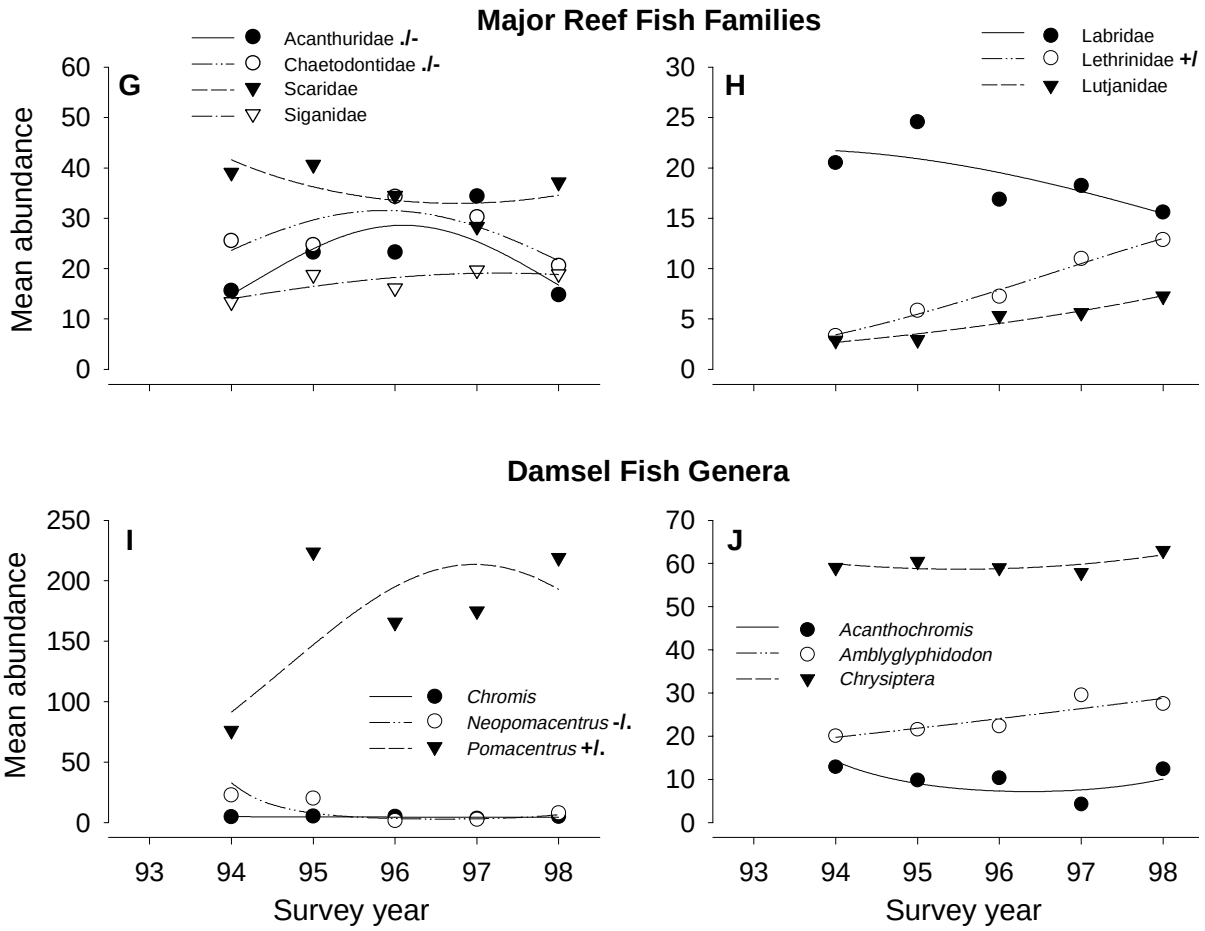


North Direction Island (No. 14-143) is a middle shelf fringing reef surrounding a high continental island. The reef has an area of 0.9 sq.km. Last surveyed October 1997.









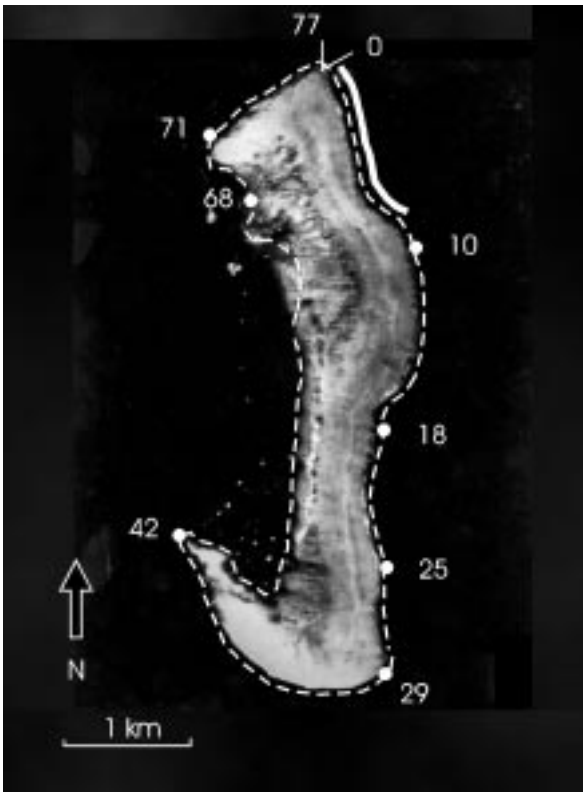
North Direction Island

This reef was initially surveyed in 1989 using broadscale surveys. The next survey was in 1994 with surveys conducted annually since this time. Coral cover increased appreciably between the 1989 and 1994 broadscale surveys but since then has steadily declined to moderately low levels. We attribute this decline to the impact of COTS which were observed on all surveys, and at Incipient Outbreak levels in 1995. The COTS numbers have since declined. Hard coral cover did not change over the last survey interval and it is currently 17% with a conversly high percent cover of algae. It is worth noting that high numbers of the corallivorous gastropod *Drupella* were observed during the most recent surveys.

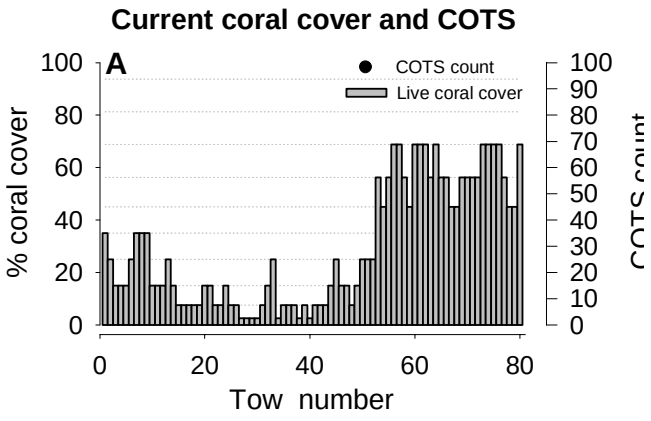
As with Lizard and MacGillivray Reefs the observed trend in *Pomacentrus* was due to increases over the first few surveys with a current stabilisation or decline in some species (notably *P. moluccensis).* Observed trends in *Neopomacentrus* and Serranidae are due to variable counts of *N. azysron* and *Plectropomus leopardus* rather than general changes in abundance. The current decline in Acanthurids reflects low counts for *A. nigrofuscus*, *Ctenocheatus* spp. and *Zebrasoma scopas* in the latest survey. Lethrinids, *Lethrinus atkinsoni* and *Monotaxis grandoculis*, have increased over the period of survey.

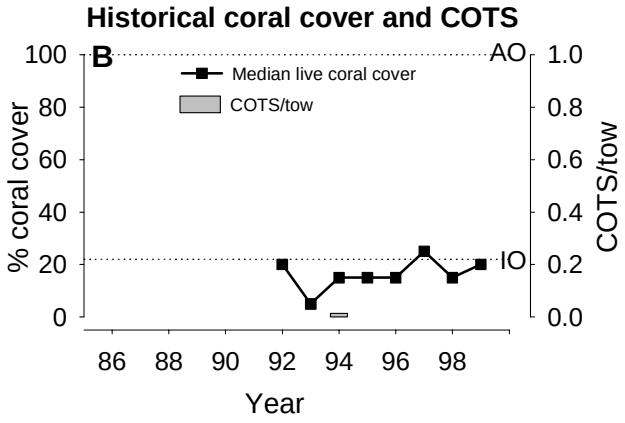
Figure 5.28

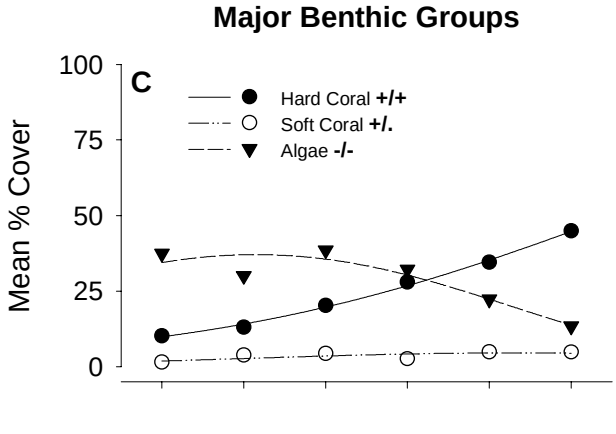
Yonge

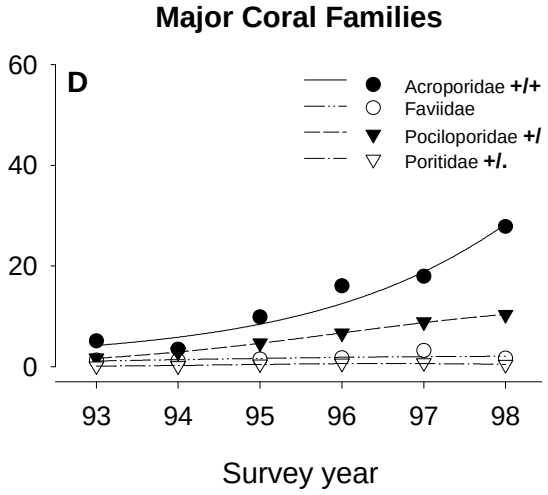


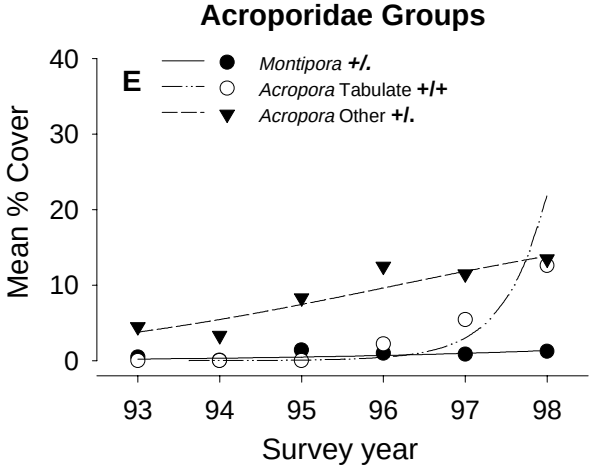
Yonge (No. 14-138) is an outer shelf ribbon reef with an area of 11.1 sq.km. Last surveyed October 1997.

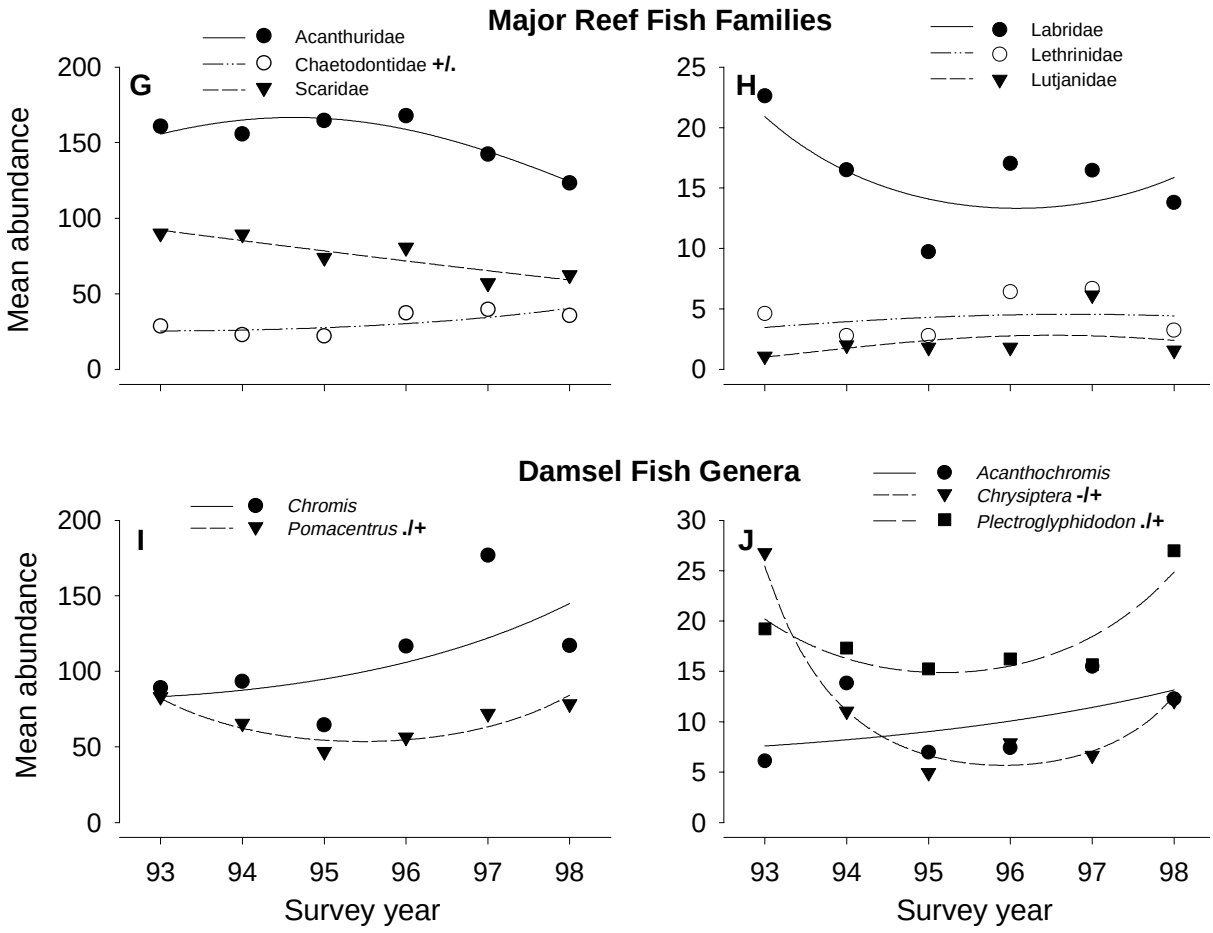












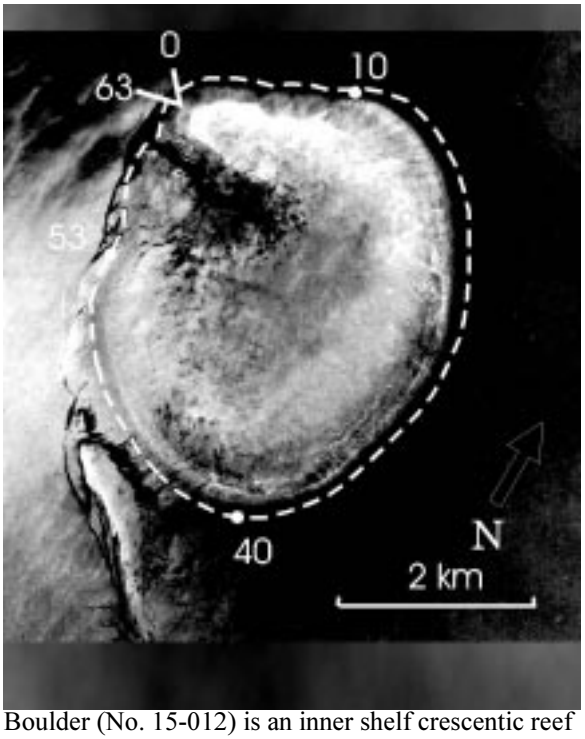
Yonge

This reef has been surveyed annually since 1992. COTS have only been observed on one occasion (1994) on this reef and their density was extremely low. Hard coral cover has steadily increased since 1993 (10.5%). It is thought that this reef is recovering from Cyclone Ivor (which passed through the area in 1990). Overall hard coral cover is currently moderately high at 44.9% with *Acropora* species dominating. Other corals have also increased since initial surveys but did not change during the most recent survey interval.

Although not as strong, trends in the reef fish community are consistent with those seen at Carter and No Name reefs. Numbers of Chaetodontids and *Chromis* have increased steadily in contrast to declines in Acanthurids and Scarids. Increases in *Plectroglyphidodon* spp. have lagged behind the other outer reefs. The increases occurred mainly in the last survey interval and included rises in *P. lacrymatus, P. dickii* and *P. johnstonianus*. Similarly, abundances of the *Pomacentrus* species, *P. lepidogenys, P. bankanensis* and *P. philippinus* have only increased since 1996. As with the other outer reefs in this sector, *Chrysiptera rex* decreased from 1993 to 1995 but is currently increasing.

Figure 5.29

Boulder



Boulder (No. 15-012) is an inner shelf crescentic reef with an area of 12.6 sq.km. Last surveyed October 1997.

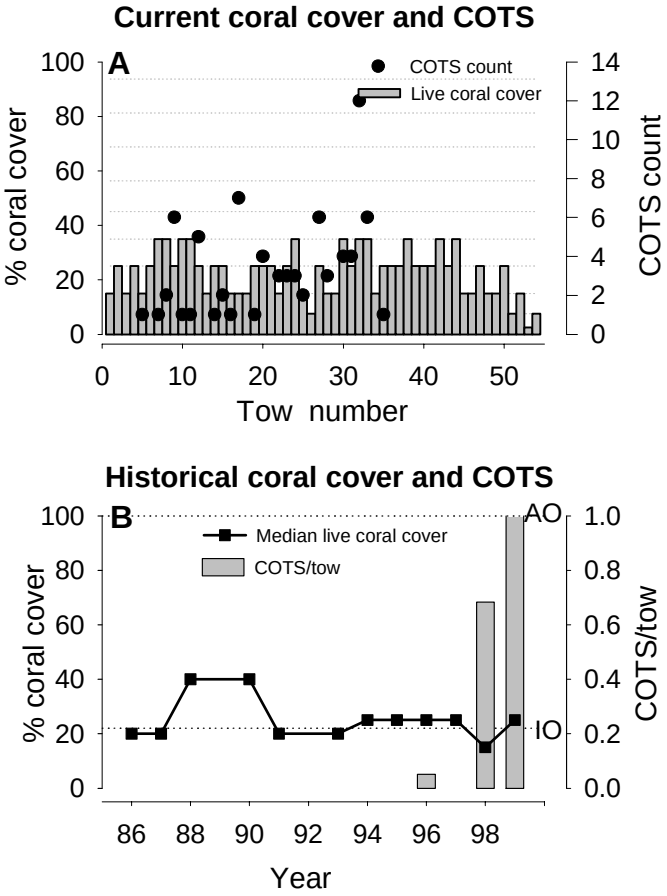
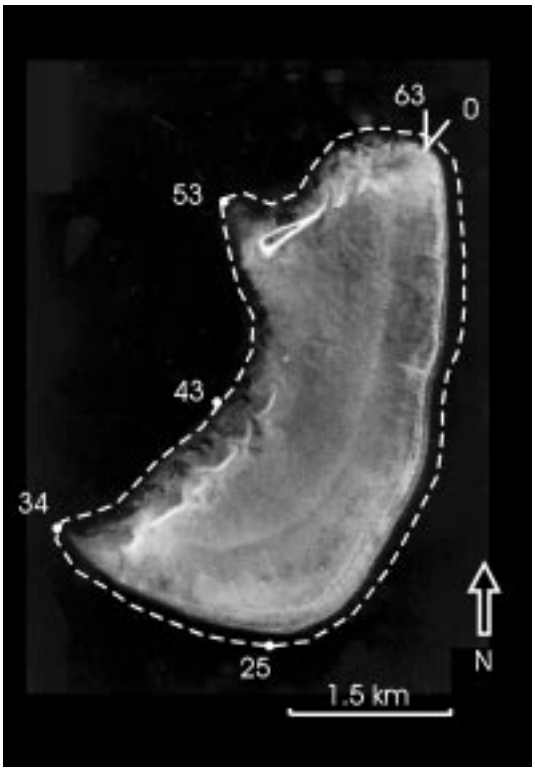


Figure 5.30

Eyrie



Eyrie (No. 14-118) is a middle shelf planar reef with an area of 12 sq.km. there is a vegetated sand cay on the north-western side. Last surveyed October 1997.

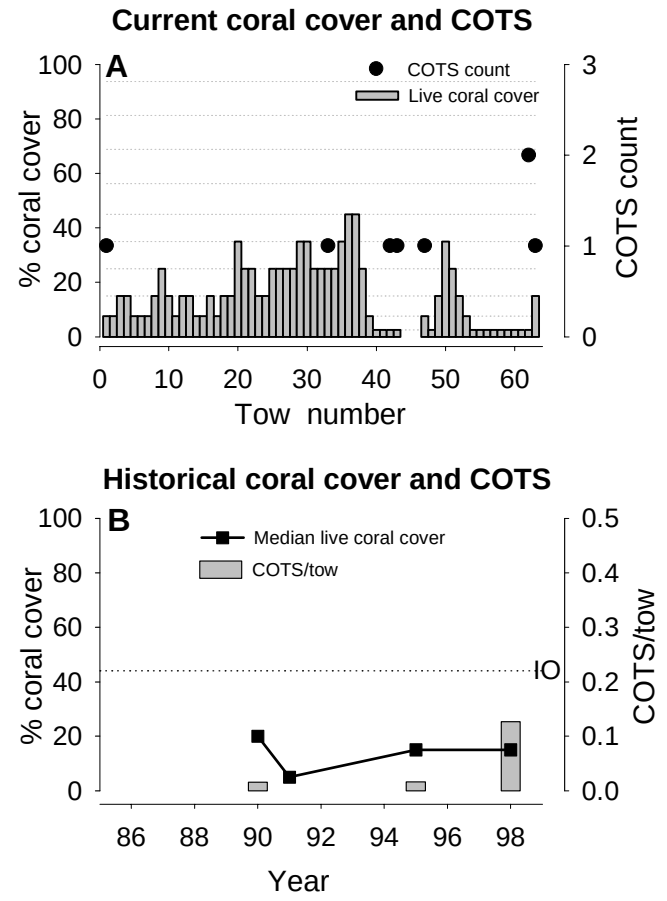
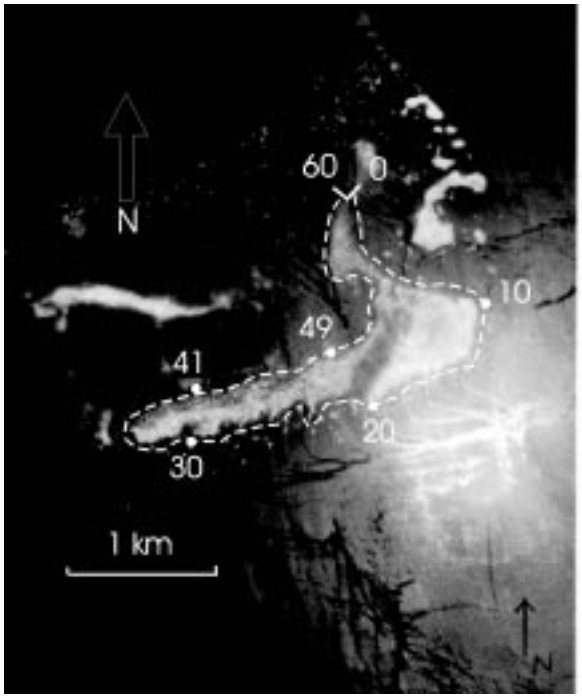
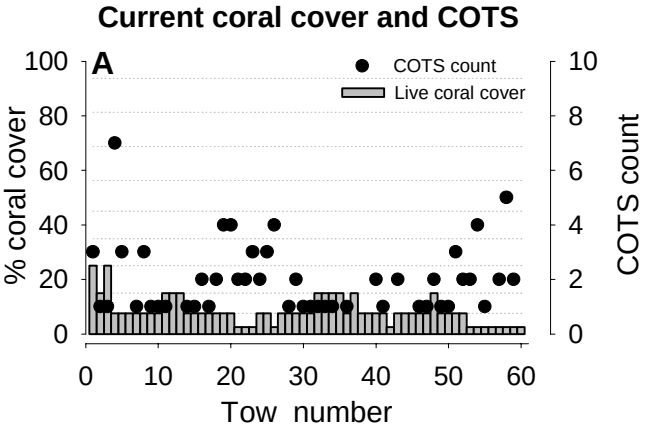
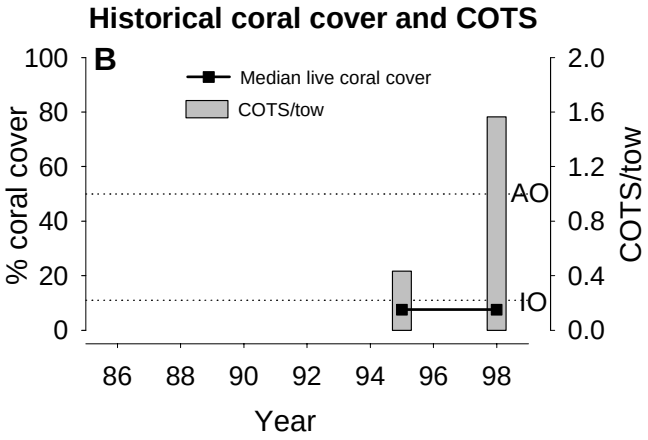


Figure 5.31

Mackay Reefs







Mackay Reefs (No. 15-024) is a middle shelf patch reef with an area of 25.9 sq.km. Last surveyed October 1997.

Boulder

This reef has been surveyed since 1986. Over this time coral cover initially increased, peaking around 1990 and then remained relatively stable at moderate levels until 1997. The current decline in coral cover coincides with an increase in COTS activity on this reef, and the reef is currently classified as an Incipient Outbreak.

Eyrie

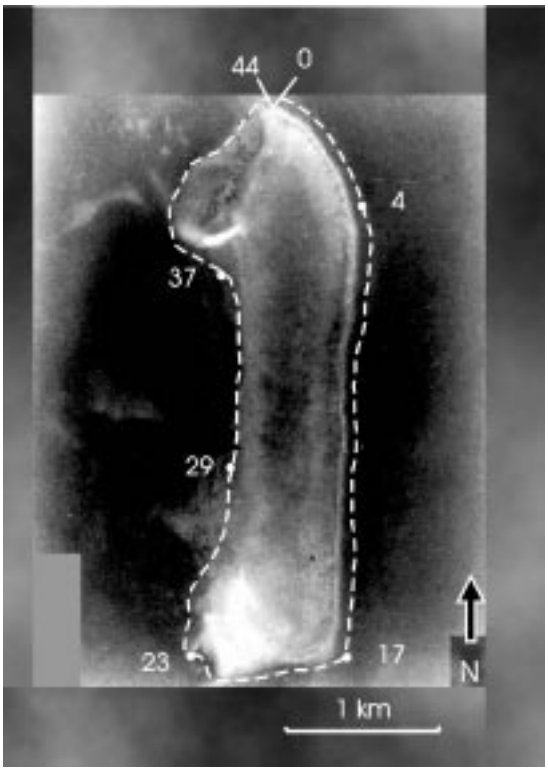
This reef has been surveyed four times since 1990. While coral cover decreased initially it is currently stable at a moderate level. Although COTS have been recorded on this reef during most years of survey, they have been in numbers below those that would be considered to cause significant coral mortality. This reef is currently classified as Non-Outbreaking.

Mackays

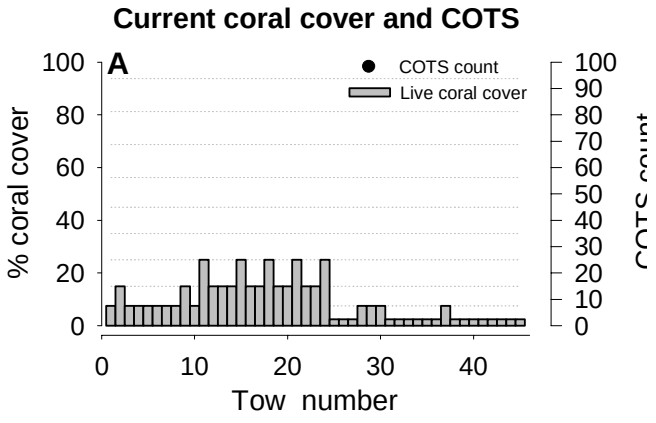
This reef has only been surveyed two times since 1986. During this time coral cover has not changed appreciably and remains low. While initially considered to be Non-Outbreaking this reef was classified as an Incipient Outbreak in 1995. Since this time COTS populations have continued to increase and the reef is currently classified as an Active Outbreak.

Figure 5.32

Reef No. 14-056



Reef No. 14056 is a middle shelf crescentic reef with an area of 7.8 sq.km. There is a sand cay on the north-western side. Last surveyed October 1997.



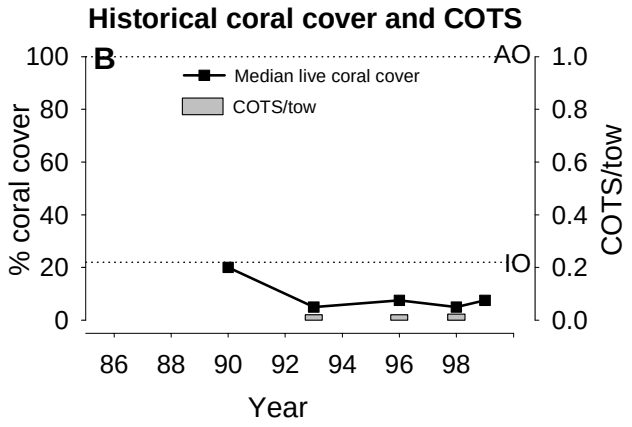
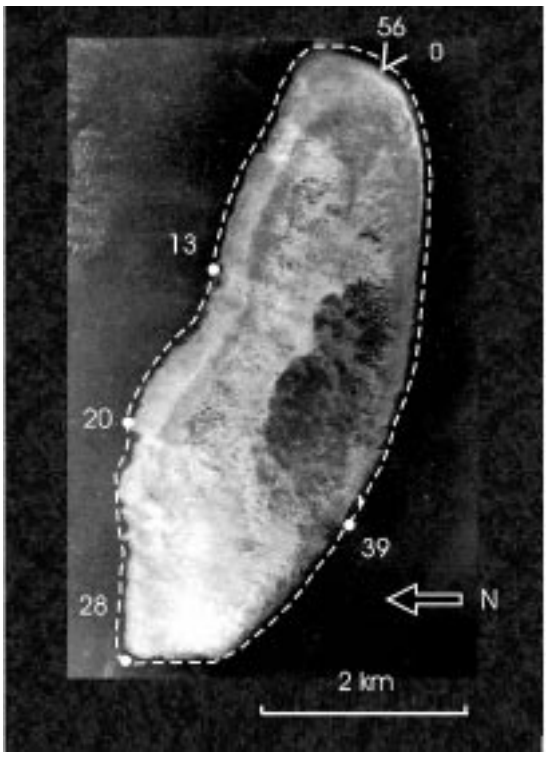
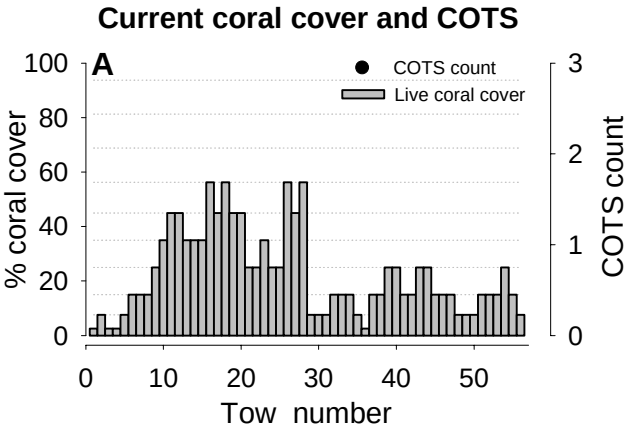


Figure 5.33

Reef No. 14-075



Reef No. 14075 is an outer shelf ribbon reef with an area of 8 sq.km. Last surveyed in October 1997.



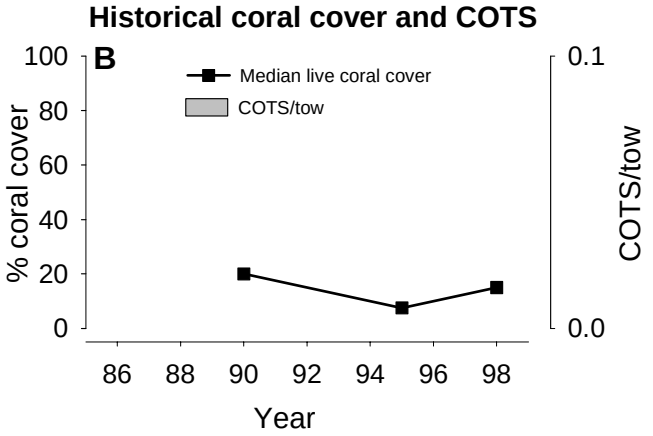
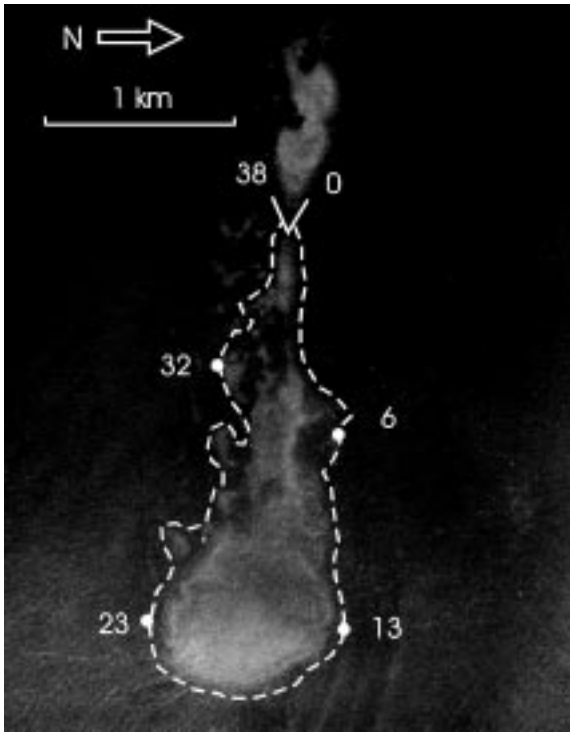
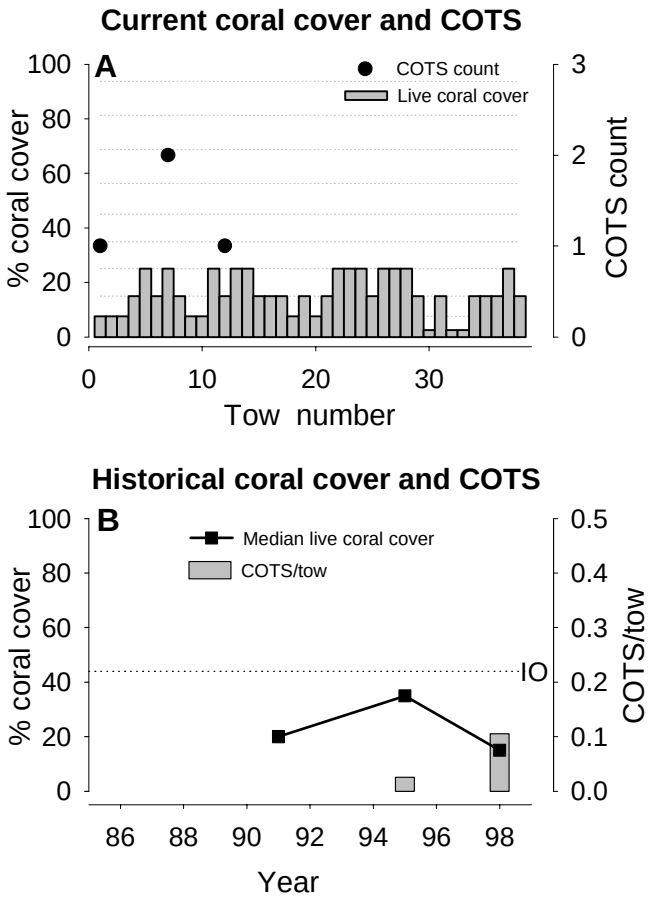


Figure 5.34

Reef No. 15-077



Reef No. 15077 is a middle shelf planar reef with an area of 6 sq.km. Last surveyed October 1997.



Reef No. 14-056

This reef has been surveyed four times since 1990. Initially coral cover was moderate before declining in subsequent years. Although COTS were recorded on this reef in all subsequent surveys they were well below the level considered to impact heavily on coral cover. However they may be considered a factor in the poor recovery of coral on this reef which is currently classified as Non-Outbreaking.

Reef No. 14-075

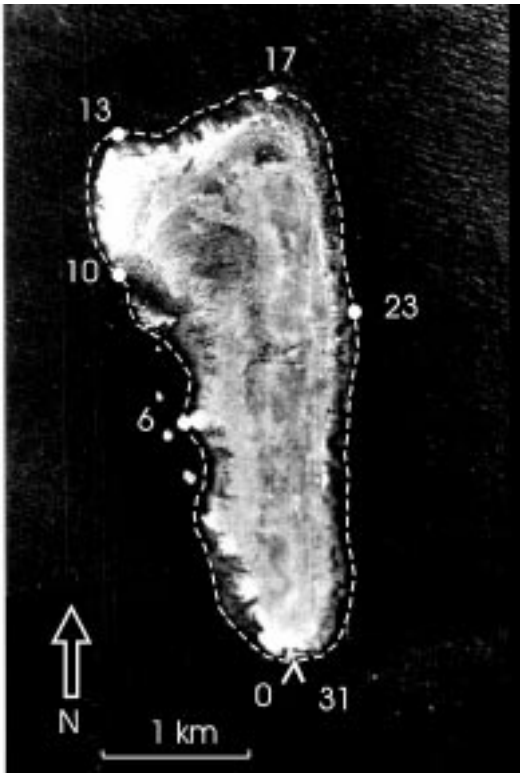
This reef has been surveyed three times since 1990. During this time coral cover declined between 1990 and 1995. The latest surveys indicate coral cover is increasing although the change would not be considered significant. No COTS have been recorded on this reef which is currently classified as Non-Outbreaking.

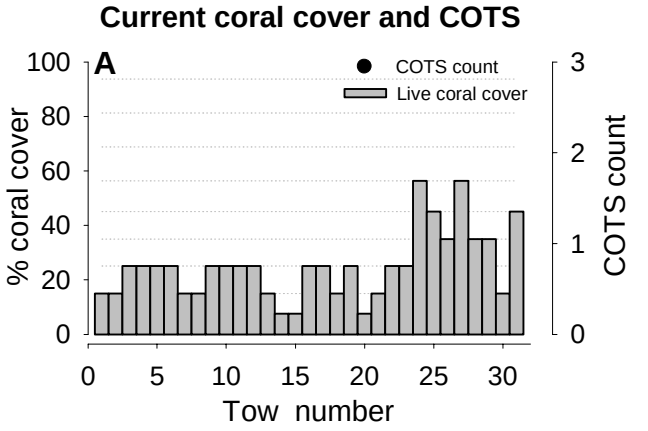
Reef No. 15-077

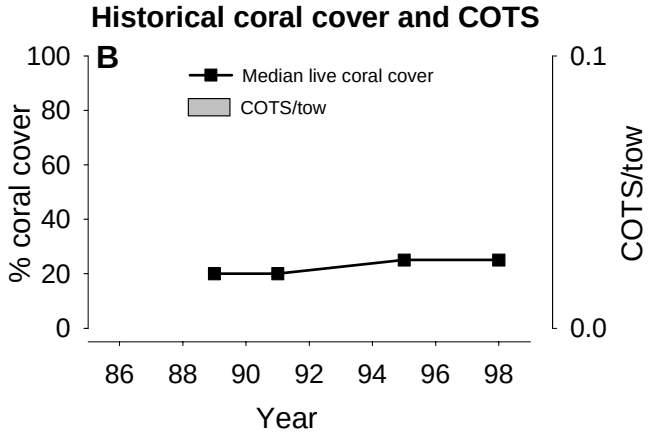
This reef has been surveyed three times since 1991. Coral cover remained relatively stable till 1995 and has subsequently declined. This decline coincides with increased COTS activity. COTS numbers are presently below those that would be considered to cause significant coral mortality and the reef is currently classified as Non-Outbreaking.

Figure 5.35

Ribbon No.1



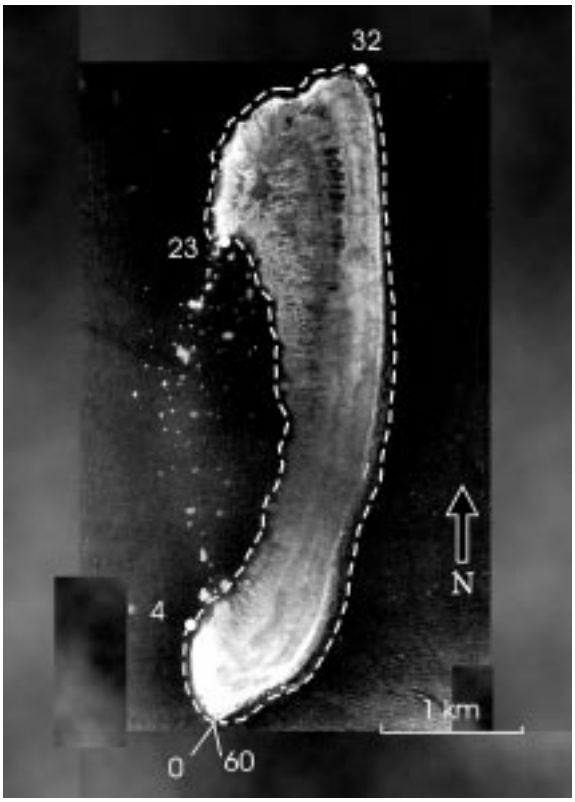


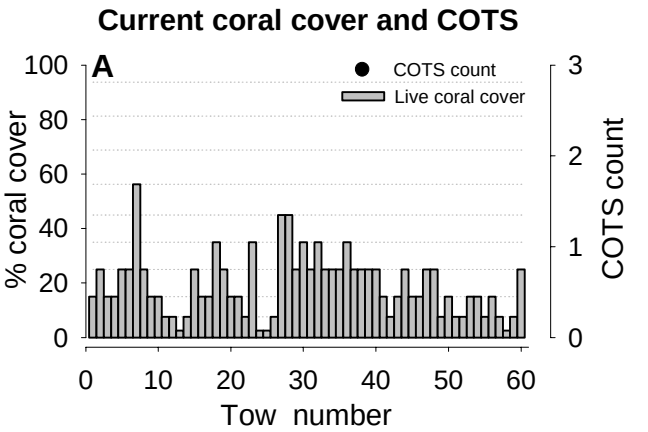


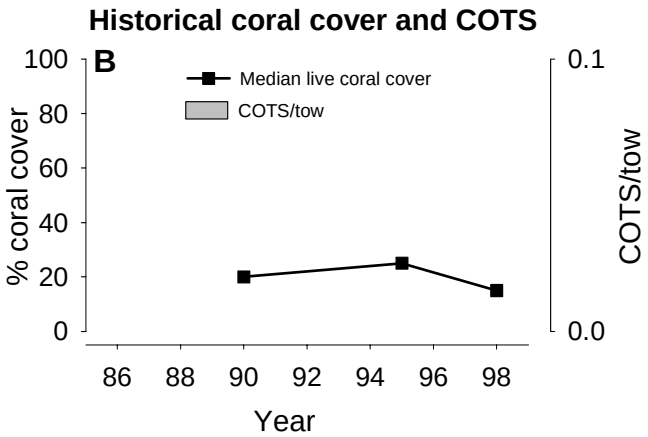
Ribbon No.1 (No. 15-080) is an outer shelf ribbon reef with an area of 3.3 sq.km. Last surveyed in October 1997.

Figure 5.36

Ribbon No.3



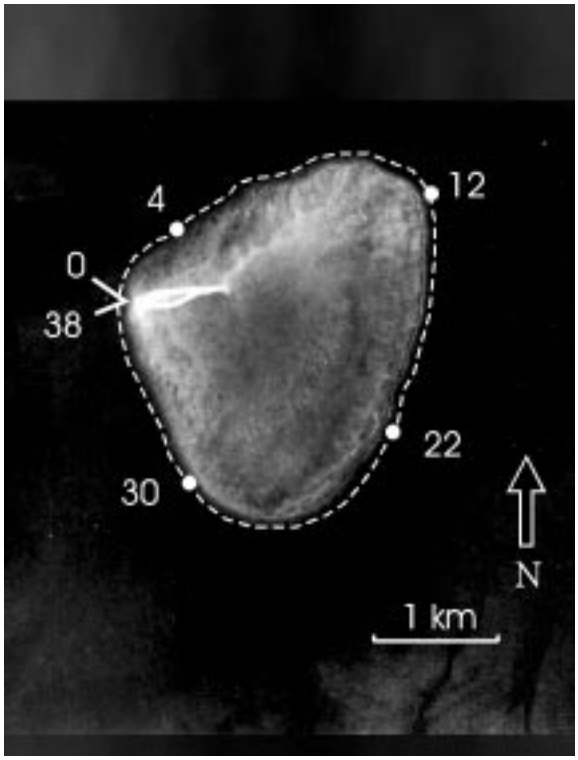




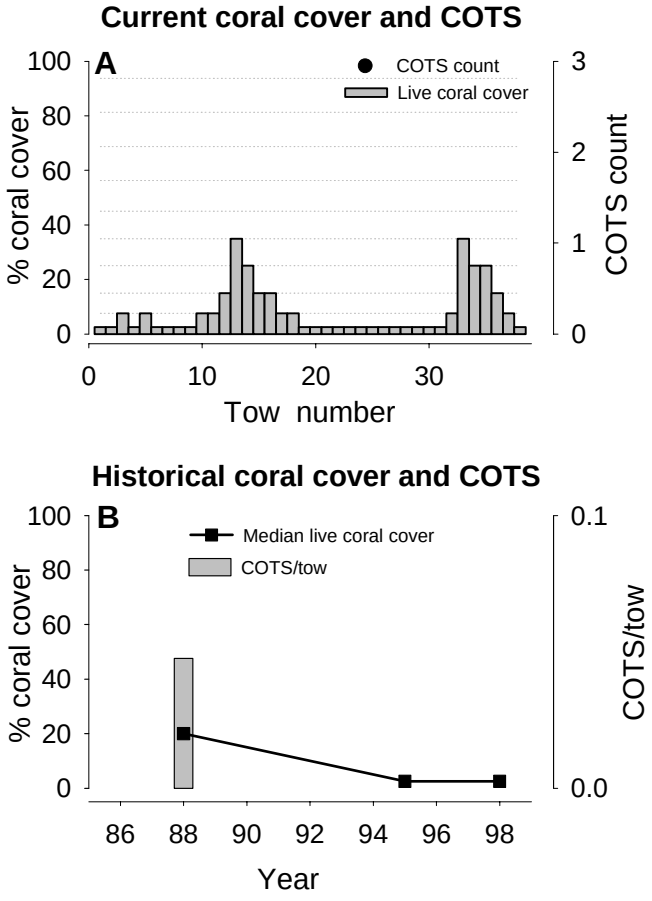
Ribbon No.3 (No. 15-050) is an outer shelf ribbon reef with an area of 11 sq.km. Last surveyed October 1997.

Figure 5.37

Stapleton Islet



Stapleton Islet (No. 14-054) is a middle shelf planar reef with an area of 4.8 sq.km. There is a vegetated sand cay on it the western side. Last surveyed October 1997.



Ribbon Reef No.1

This reef has been surveyed four times since 1989. Over this time there has been no appreciable change in coral cover which has remained at moderate levels. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

Ribbon Reef No.3

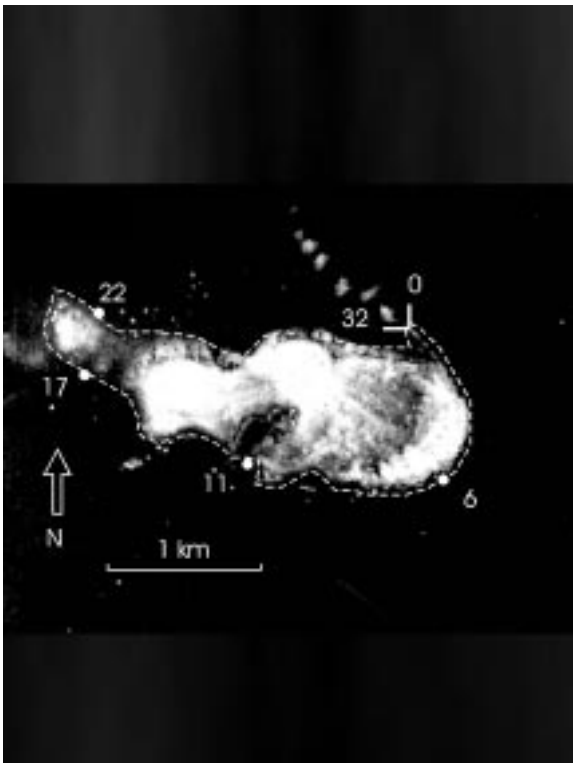
This reef has only been surveyed three times since 1990. During this time there has been no appreciable change in coral cover which has remained at moderate levels. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

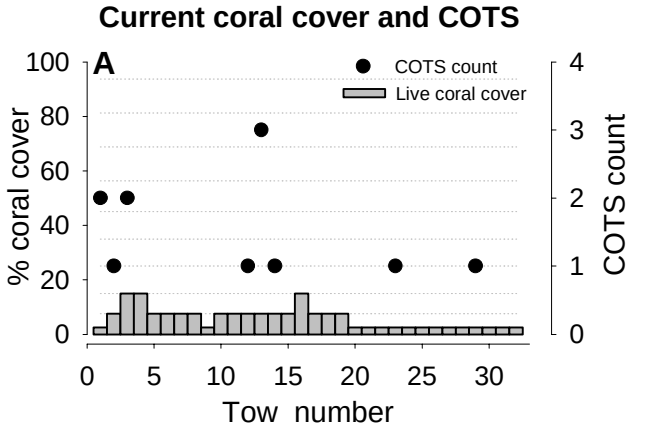
Stapleton Islet

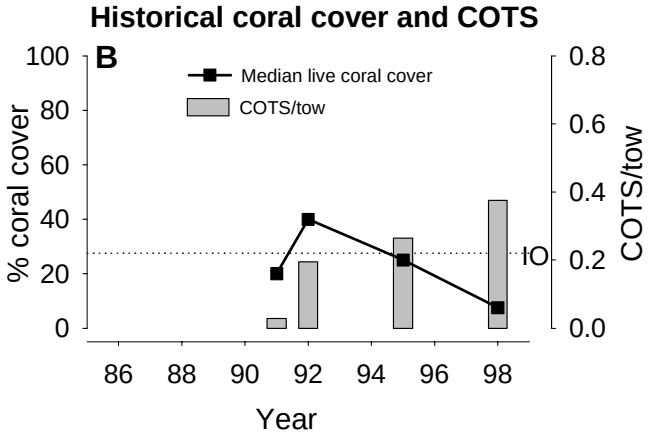
This reef has only been surveyed three times since 1988. After an initial decline to 1995 coral cover has remained low. COTS populations detected during the initial year of survey on this reef are most likely responsible for the observed decline in coral cover. Stapleton Islet is currently classified as Non-outbreaking.

Figure 5.38

Startle (East)



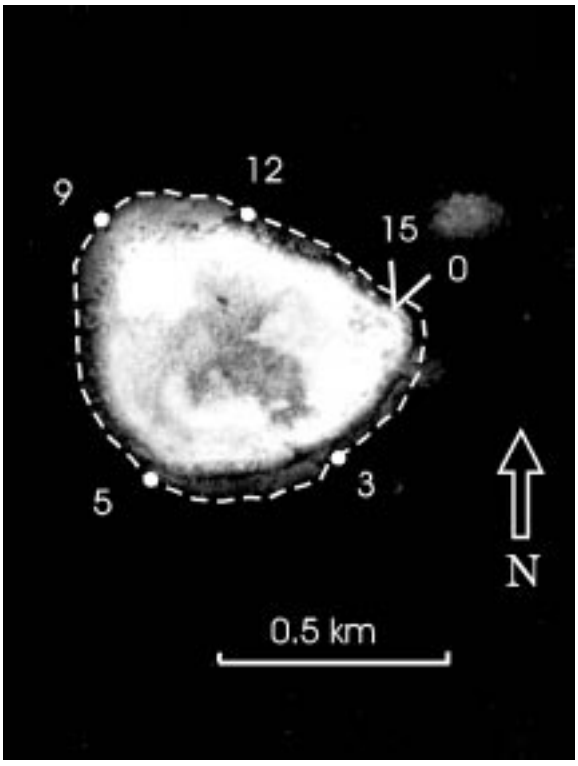


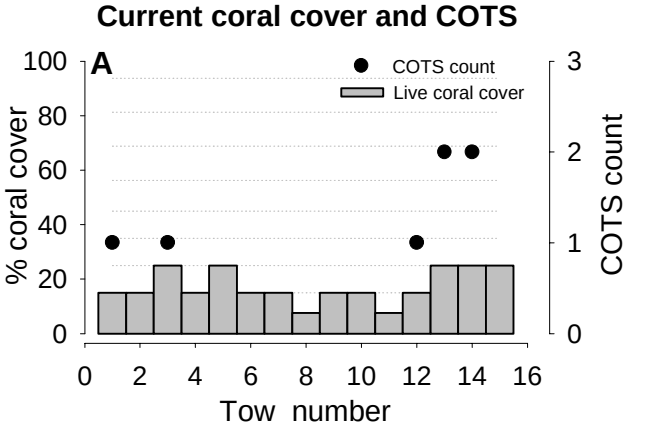


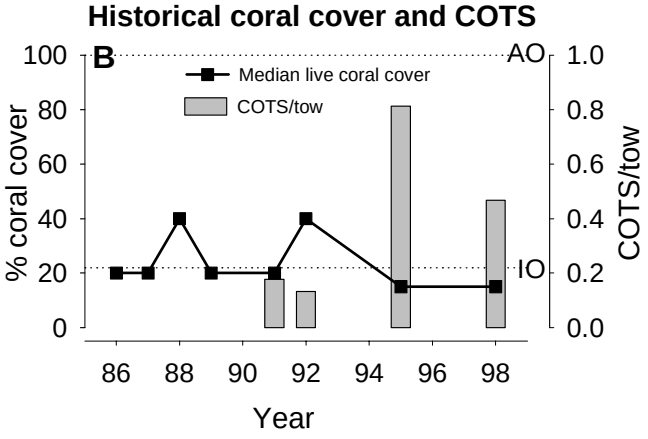
Startle (East) (No 15-028S2) is one of a series of middle shelf reef patches with an area of 11.3 sq.km.Last surveyed October 1997.

Figure 5.39

Swinger



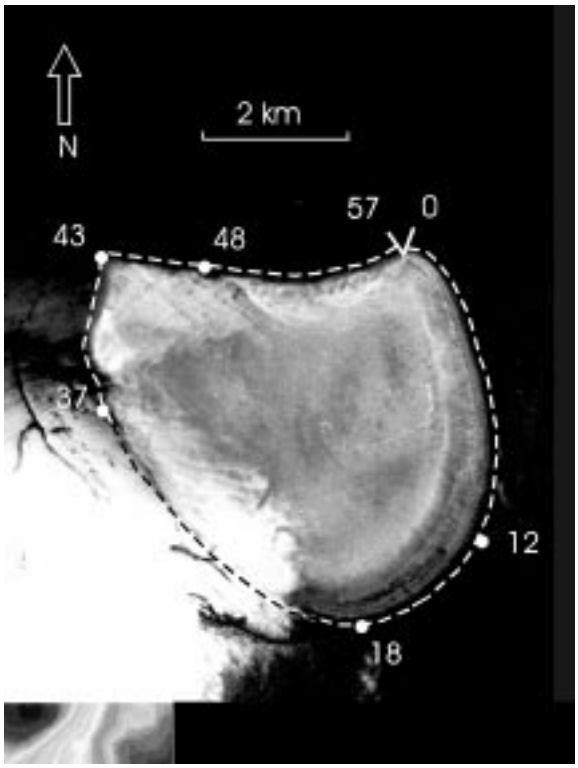




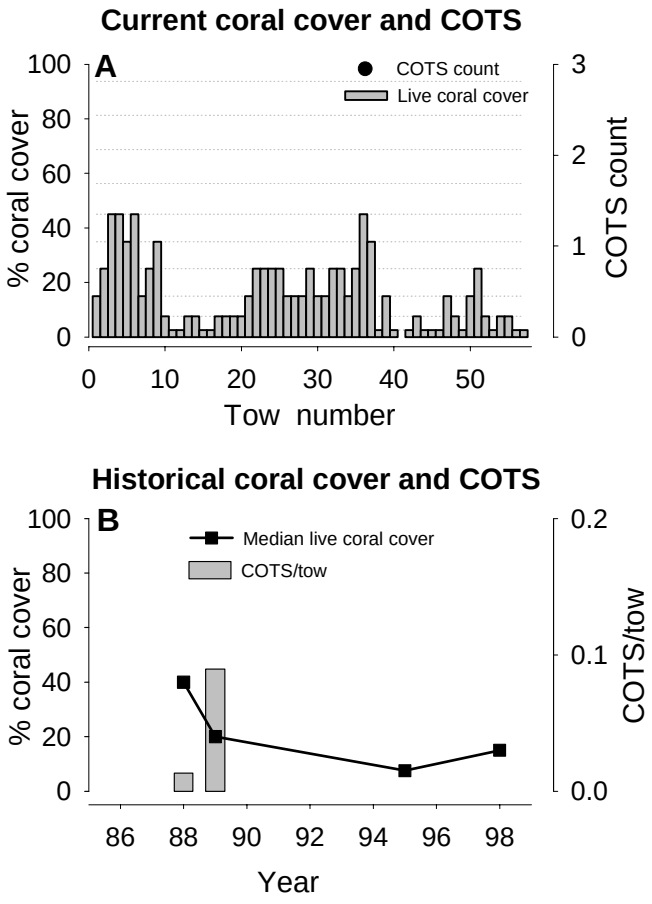
Swinger (No. 15-030) is a middle shelf planar reef with a sand cay on the north-western end. The reef has an area of 2.5 sq.km. Last surveyed October 1997.

Figure 5.40

Switzer



Switzer (No. 14-061) is a middle shelf planar reef with an area of 14.3 sq.km. Last surveyed in October 1997.



Startle (East)

This reef has been surveyed four times since 1991. Coral cover has declined since 1992, from a high level to the current low level. COTS are most likely responsible for the decline in coral cover, with COTS activity increasing over the same time period. This reef is currently classified as an Incipient Outbreak.

Swinger

This reef has an extensive history of survey since 1986. Coral cover exhibits an increasing trend up until 1992 then a subsequent decline which is attributed to COTS activity. COTS were initially observed on this reef in 1991 with numbers increasing up until 1995. Although latest surveys indicate a small decline in COTS numbers, they still remain in numbers considered to cause significant coral mortality. Swinger reef is currently classified as an Incipient Outbreak.

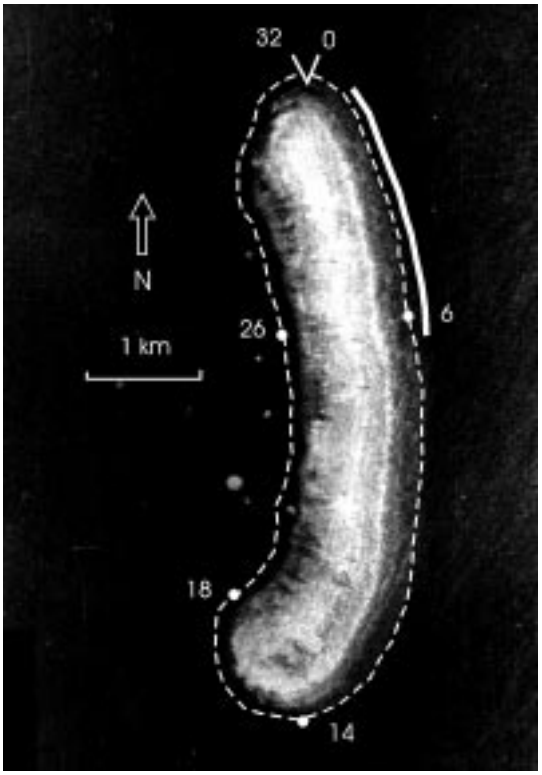
Switzer

This reef has been surveyed four times since 1988. During this time coral cover decreased between 1988 and 1995. While COTS were observed in 1988 and 1989 they were in numbers considered below those that would cause significant coral mortality. As the coral mortality occurred between surveys it is difficult to directly ascribe the decline in coral cover to COTS though they would be a likely agent. Switzer reef is currently classified as Non-Outbreaking.

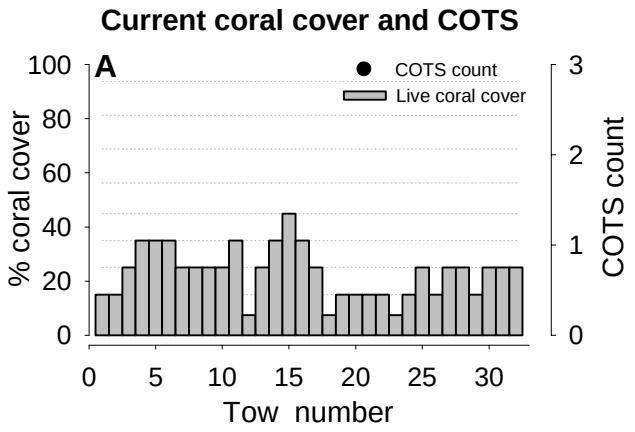
Cairns
reef pages

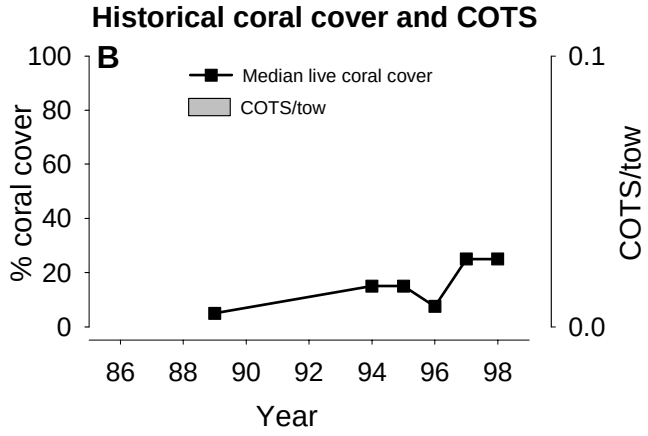
Figure 5.41

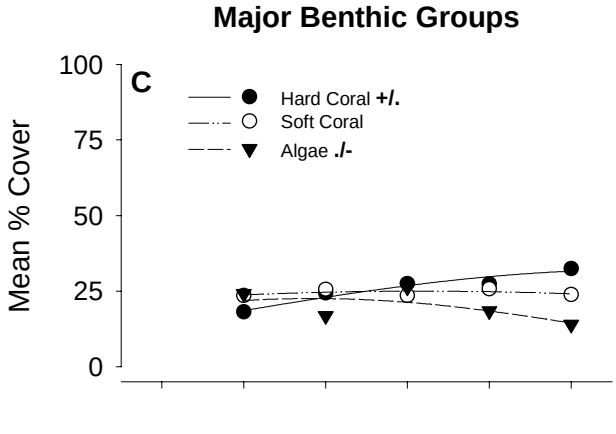
Agincourt No. 1

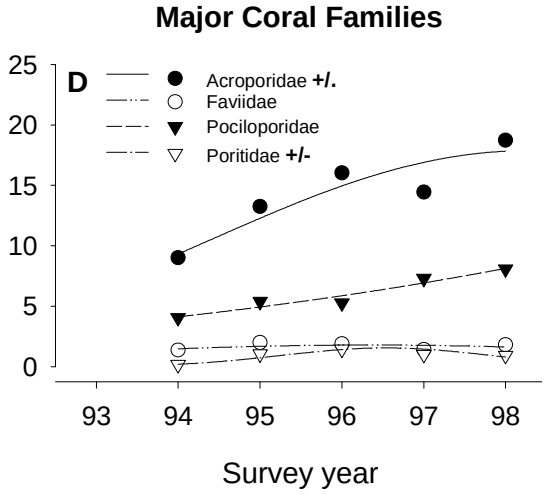


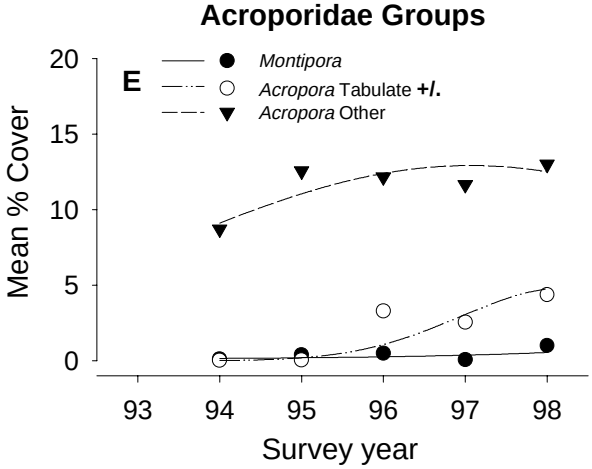
Agincourt No.1 (No. 15-099) is an outer shelf ribbon reef with an area of 5.1 sq.km. Last surveyed January 1998.

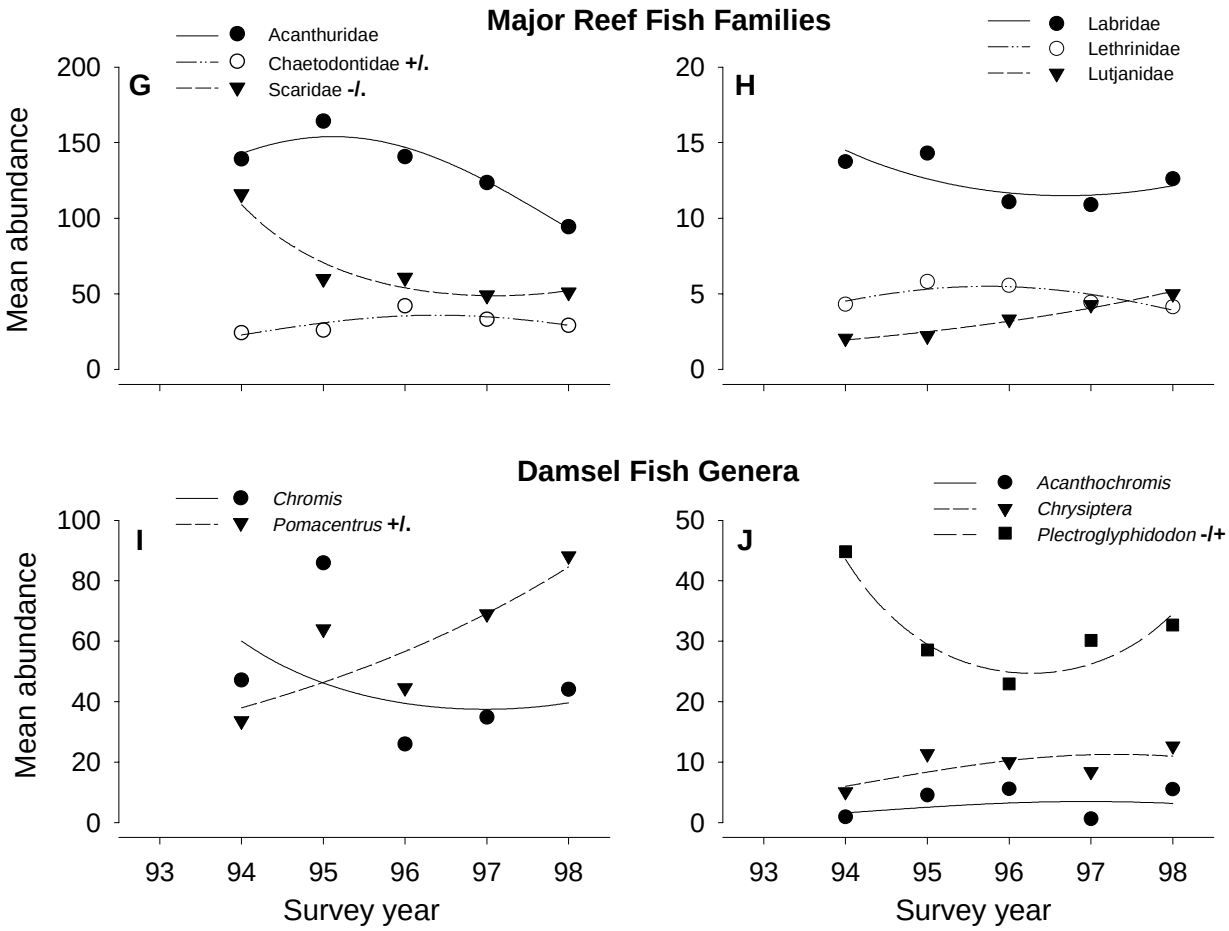












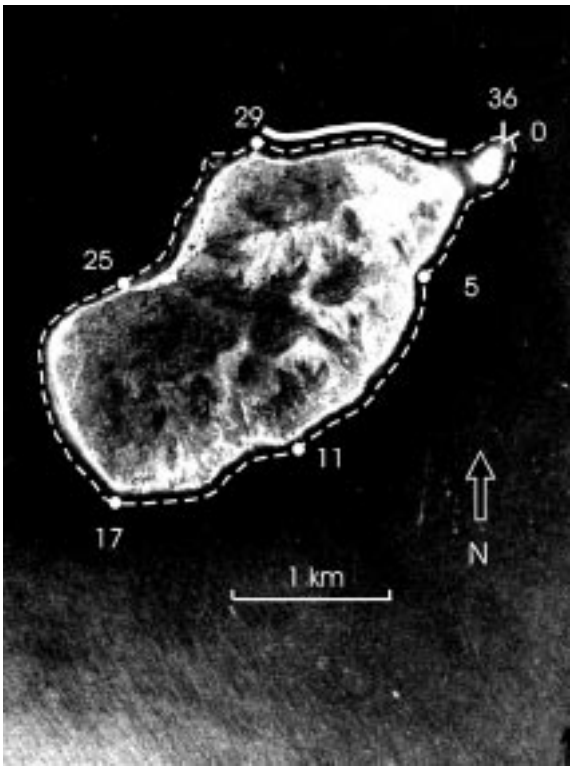
Agincourt No. 1

This reef was initially surveyed in 1989, using manta tow, then annually since 1994. Broadscale surveys have shown an average increase in coral cover over the duration of the surveys. This is supported by detailed benthic surveys which show that the percentage cover of hard coral on the sites at this reef has increased by 14.3% since the detailed surveys started in 1994. This has been due primarily to an increase in the percent cover of *Acropora* spp. Hard coral cover did not change in the last survey interval and is currently moderately high at 32.5%. The abundance of algae has decreased while soft coral abundance has remained constant. This reef has a high relative abundance of Isoporid *Acropora*. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking. Isolated bleaching events have been recorded on this reef.

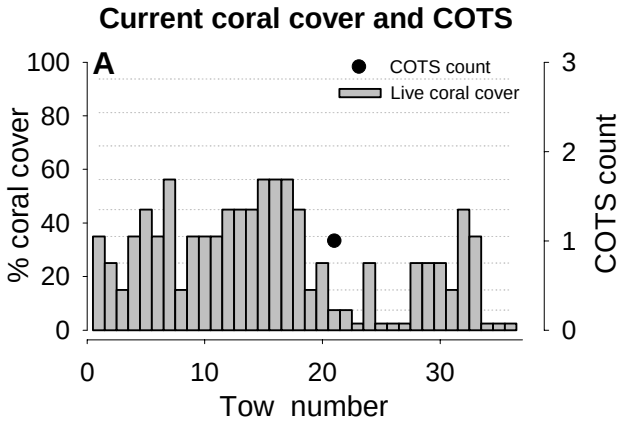
The increasing hard coral cover is reflected in general increases in Chaetodontidae, *Pomacentrus*, and currently *Plectroglyphidodon.* Chaetodontid increases are due to a number of species having peaks in abundance in 1996 or 1997 (*Chaetodon ulietensis*, *C. pelewensis*, *C. melannotus* and *C. kleinii*) and *C. trifascialis* which increased sharply in 1998. The increase in *Pomacentrus* is due to an increase of *P. lepidogenys*, and to a lesser degree *P. philippinus. Plectroglyphidodon* initially decreased due to decreases in *P. lacrymatus* to 1996. Since then, *P. dickii*, *P. johnstonianus* and *P. lacrymatus* have steadily increased. Scarid abundance has been stable across most species since 1995. The overall decreasing trend is a result of higher abundances of *S. chameleon, S. globiceps*, *S. niger*, *S. psittacus*, *S. sordidus*, and *S. spinus* in 1994.

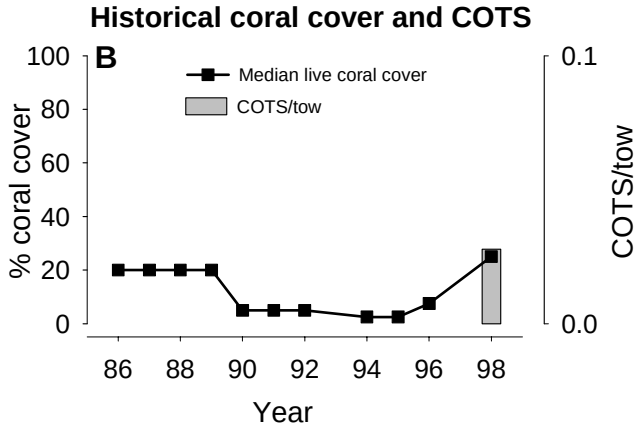
Figure 5.42

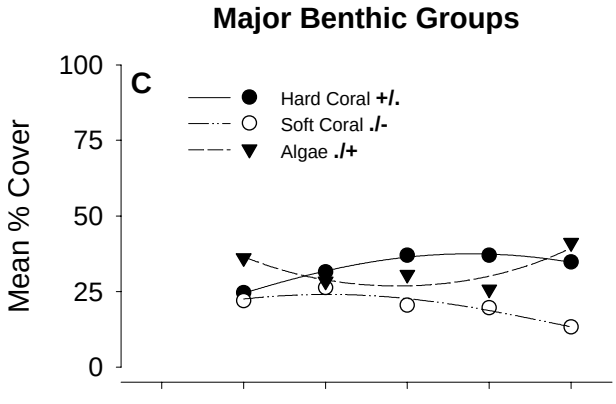
Fitzroy Island

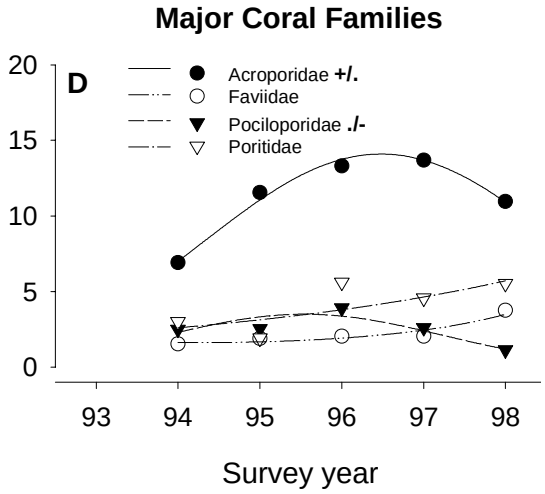


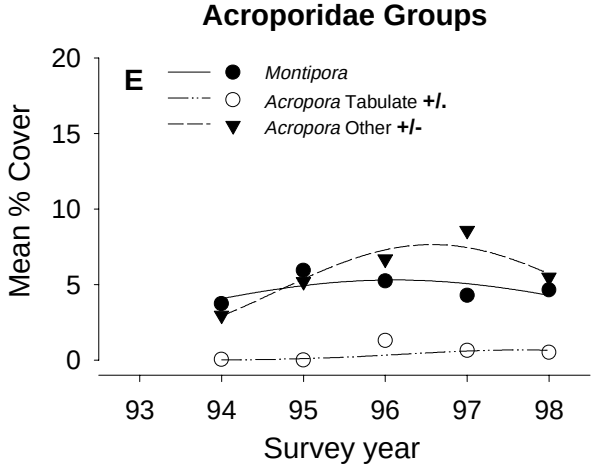
Fitzroy Is (No. 16-054) is an inner shelf fringing reef which surrounds a high continental island. The reef has an area of 0.2 sq.km. Last surveyed February 1998.

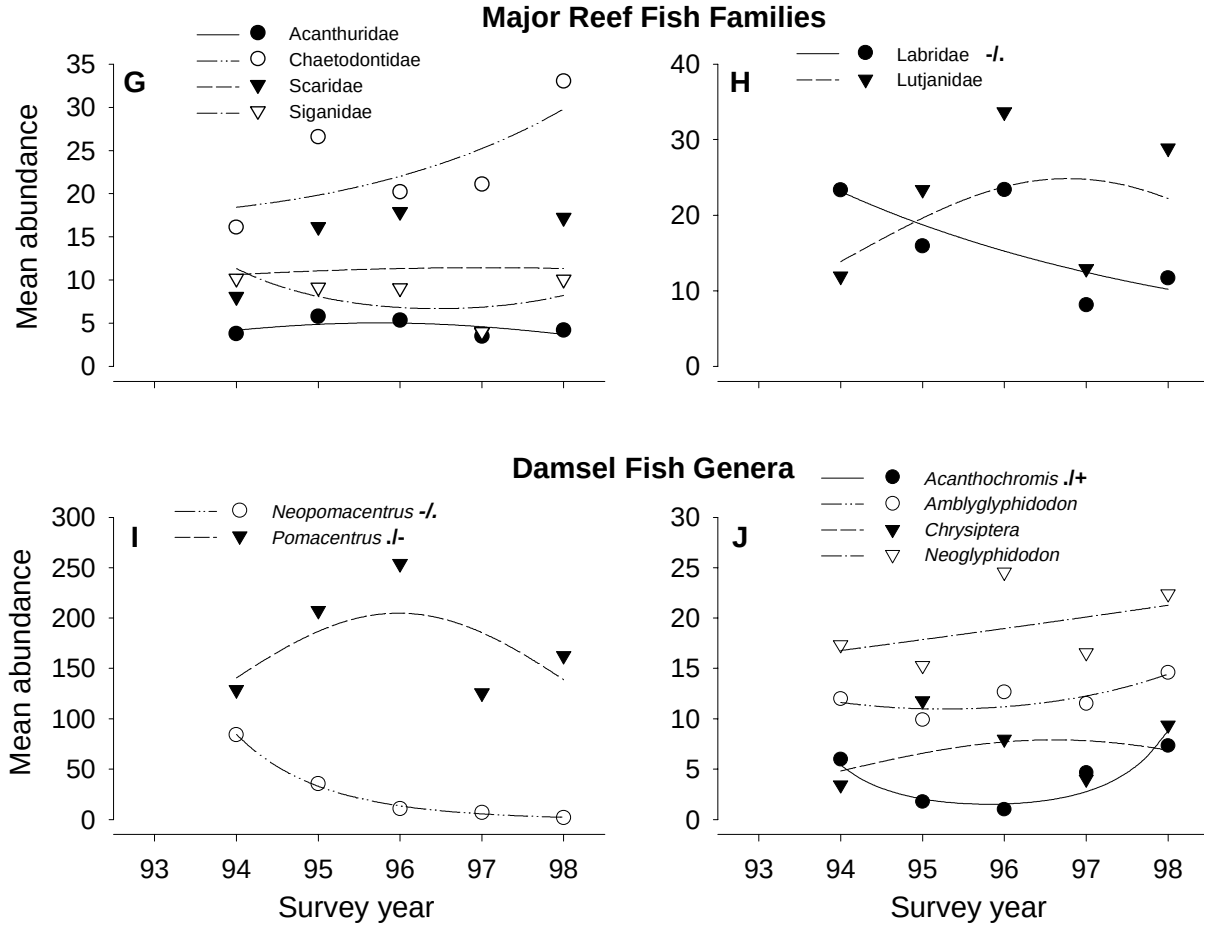












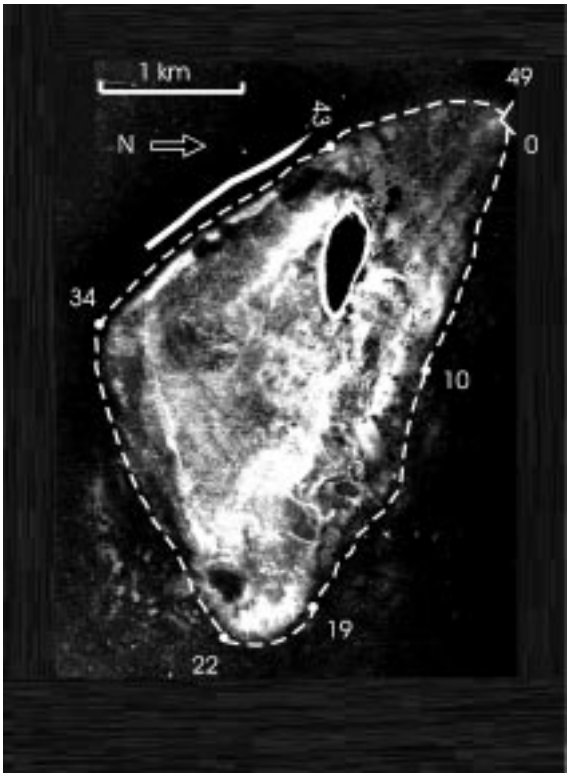
Fitzroy Island

This reef has been broadscale surveyed extensively since 1986. Coral cover decreased through to 1990, then remained at low levels until the last two surveys which show an increase in coral cover. This is supported by detailed benthic surveys begun in 1994, which reveal that the percentage cover of hard coral on the sites has increased by 10% since then and is currently moderately high at 34.7%. Soft corals and corals of the families Acroporidae and Pocilloporidae declined in the most recent survey. A large proportion of corals on this reef were bleached at the time of survey (1998). The longer term impact of this bleaching will become apparent in the next survey planned for January 1999. COTS were recorded during the most recent survey however the reef is currently classified as Non-Outbreaking.

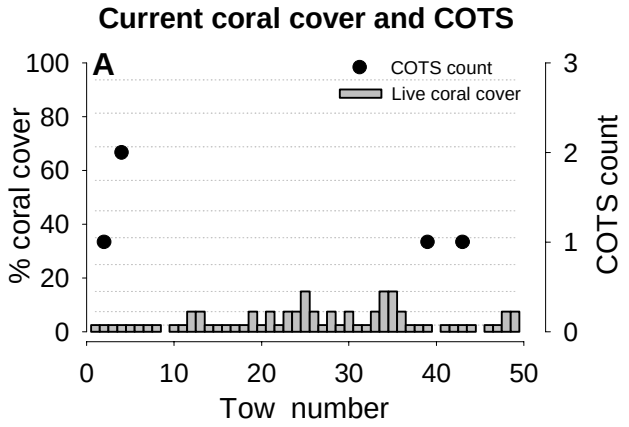
The fish community has been relatively stable since detailed surveys began in 1994, with the following exceptions. *Neopomacentrus* has declined strongly over the period of the surveys largely as a result of the two species *N. azysron* and *N. bankieri*. *Pomacentrus* has increased then declined as a result of a doubling of abundance of *P. moluccensis* to 1996 before a sharp reduction to initial densities. *Acanthochromis polyacanthus* is currently showing a slight increase. Labrid abundance estimates have been variable but generally declining, predominantly due to a decline in *Choerodon fasciatus*.

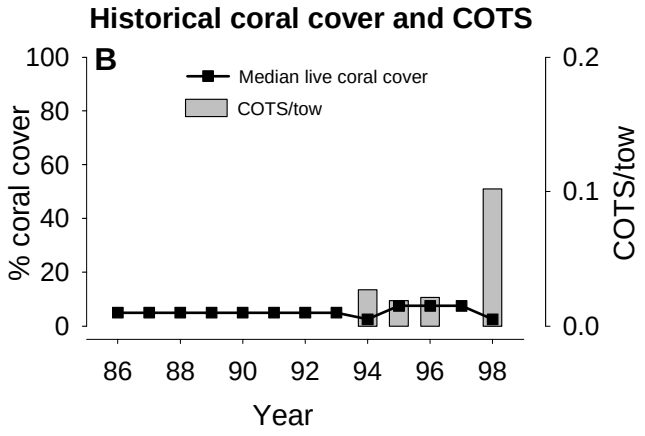
Figure 5.43

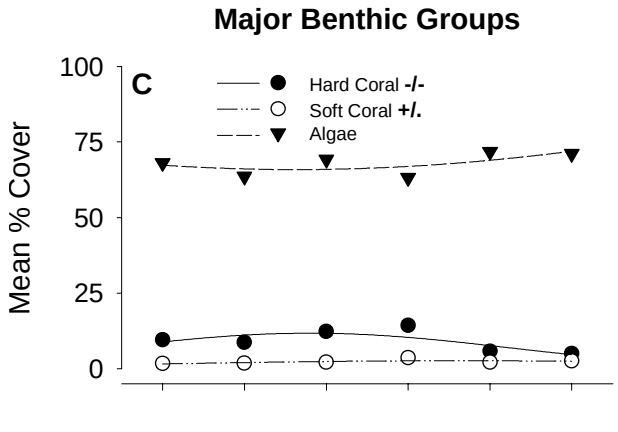
Green Island

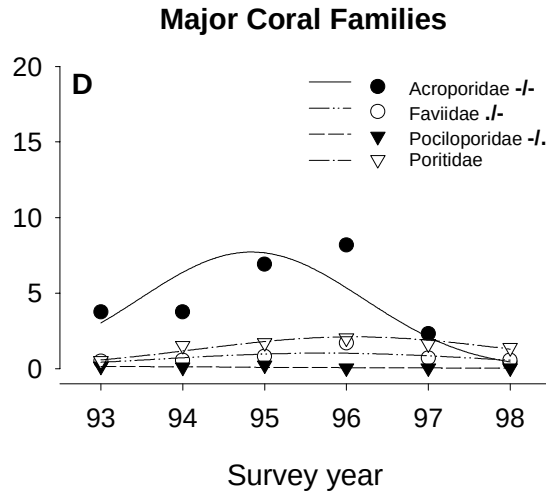


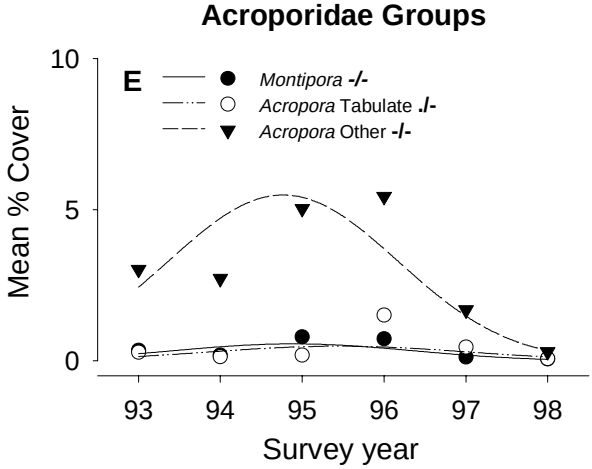
Green Is (No. 16-049) is an inner shelf planar reef with an area of 7.1 sq.km. There is a vegetated sand cay at the north-western end. Last surveyed February 1998.

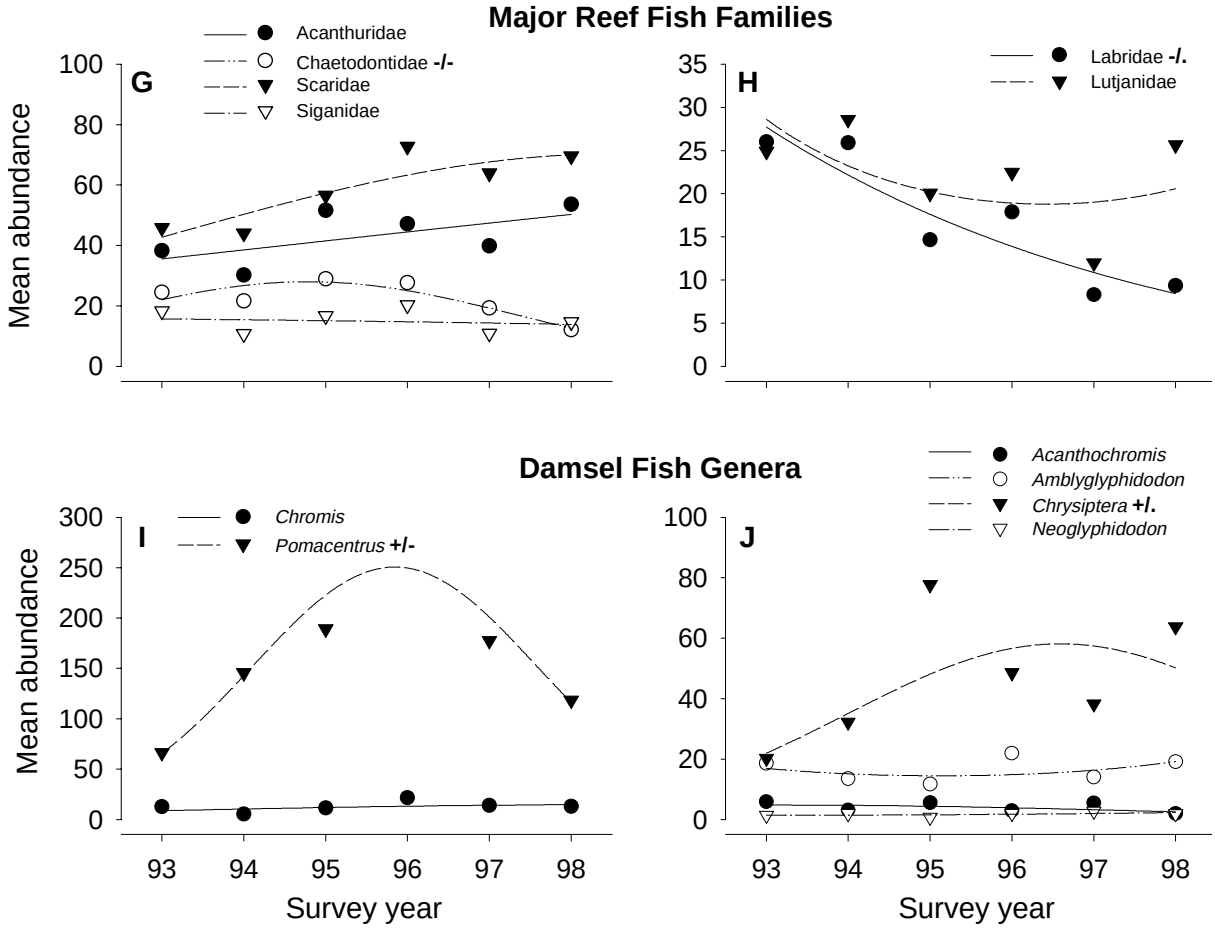












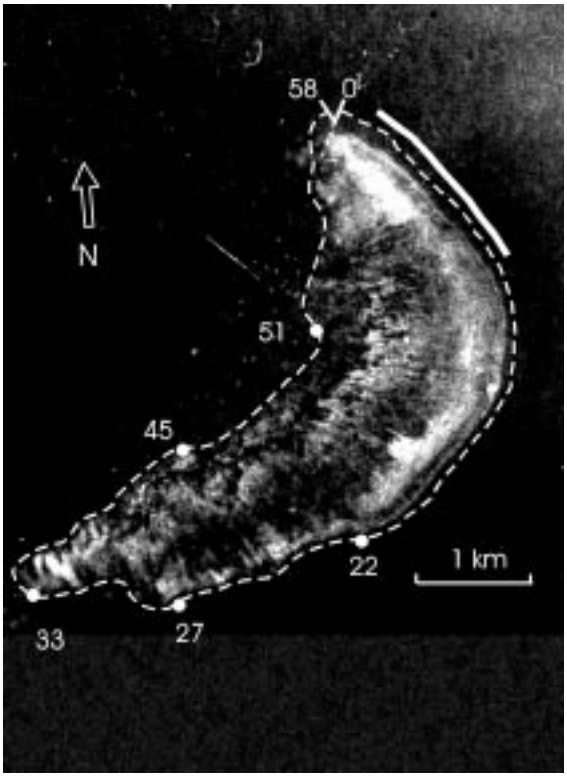
Green Island

This reef has been broadscale surveyed since 1986 when it was initially classified as Recovering from a previous COTS outbreak. Coral cover has remained very low since1986. An apparent small recovery in coral cover in 1995 and 1996 subsequently stalled as COTS numbers began to rise. Surveys in 1998 recorded the lowest value for coral cover on this reef since the commencement of broadscale surveys. Our detailed survey sites monitored since 1993, show that hard coral cover at this reef is the lowest recorded of all our survey sites on the GBR, with cover declining or stable in all coral groups. Although COTS populations on this reef are below what would be considered outbreak levels, resident COTS populations are clearly having an impact on coral cover. Green Island is currently classified as Recovering, however we have seen few signs of this in 12 years of continuous monitoring and the prognosis for recovery remains poor. Low levels of bleaching have also been recorded on this reef.

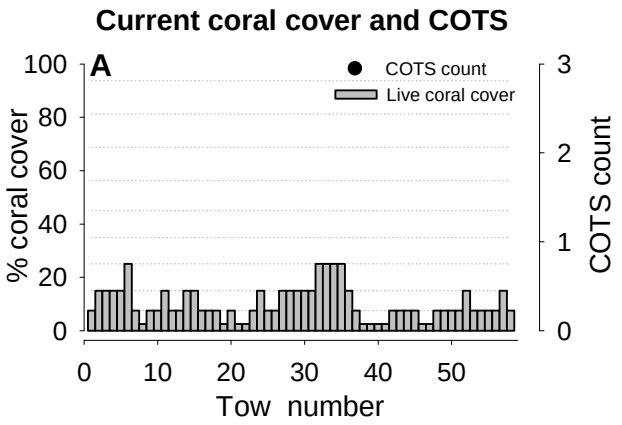
The decrease in coral cover and associated habitat is reflected in the decline of Chaetodontids. This trend is being driven mainly by *Chaetodon aureofasciatus*, *C. baronessa*, and *C. trifasciatus*. Labrids have been variable at species level but generally declining. *Pomacentrus* counts have been stable except for *P. moluccensis* which followed the pattern seen at many reefs of increasing until1996 before a current decline, this driving the observed trend in the genus.

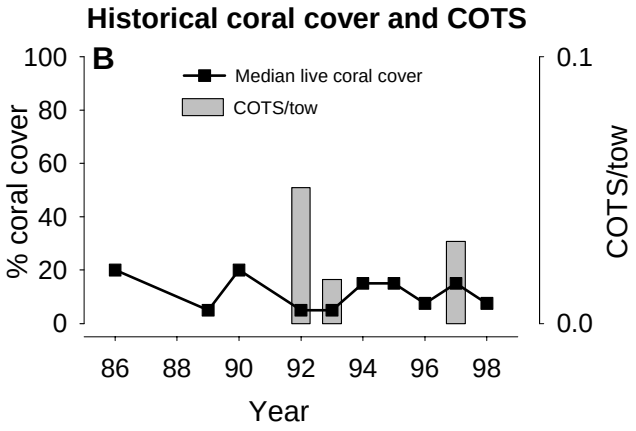
Figure 5.44

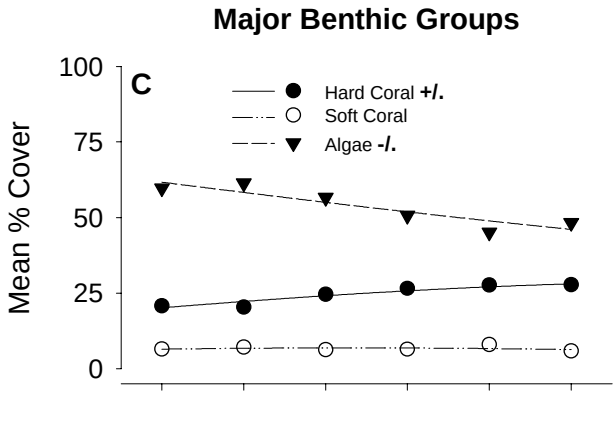
Hastings

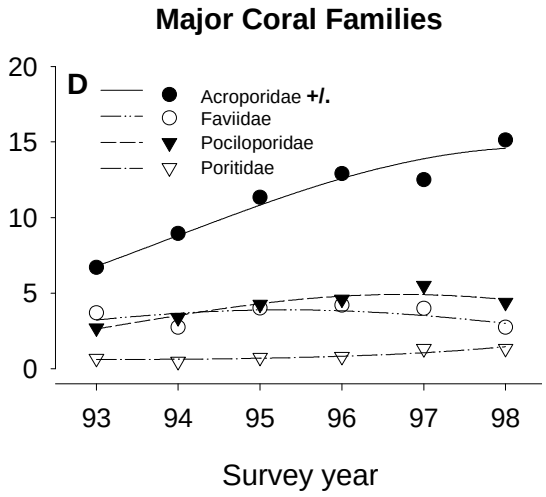


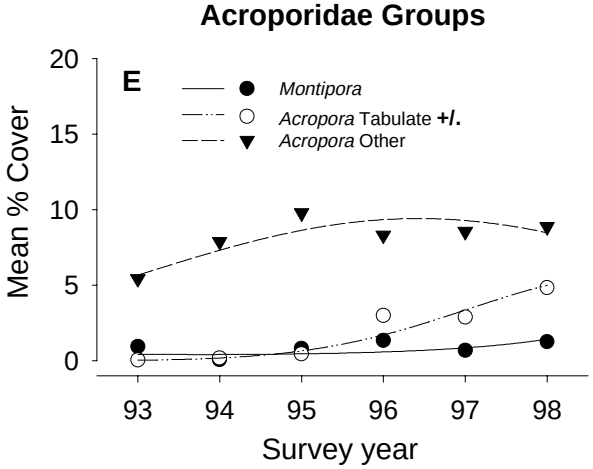
Hastings (No. 16-057) is a middle shelf crescentic reef with an area of 10.2 sq.km. Last surveyed January 1998.

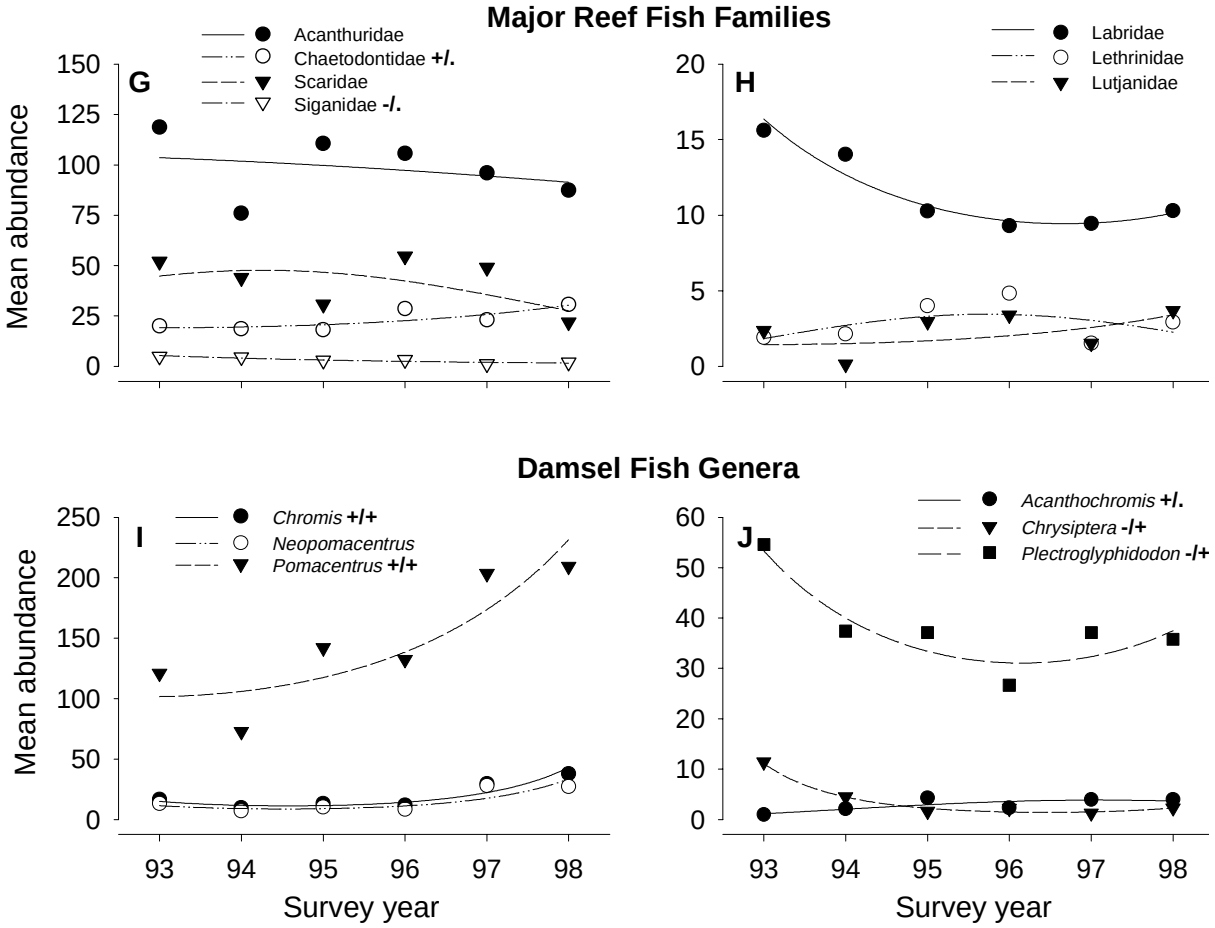












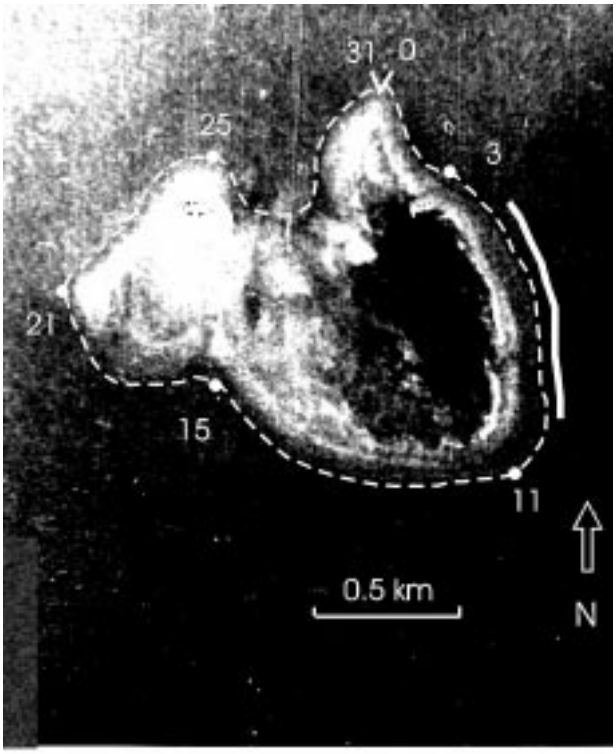
Hastings

This reef has been broadscale surveyed since 1986. Over this time coral cover has shown little change remaining at moderate levels. Detailed coral surveys, conducted since 1993, show hard coral cover has increased by 7% to 27.8% due to an increase in the percent cover of *Acropora* spp. The relative abundance of Isoporid *Acropora* is high on this reef. The cover of algae has decreased since surveys began while soft coral cover has remained low. This reef was originally classified as Recovering from COTS activity when first surveyed. Given the slow increase of coral cover, the reef remains classified as Recovering. Numbers of COTS detected periodically on this reef are lower than those considered to impact significantly on coral cover. There are isolated records of coral bleaching from this reef.

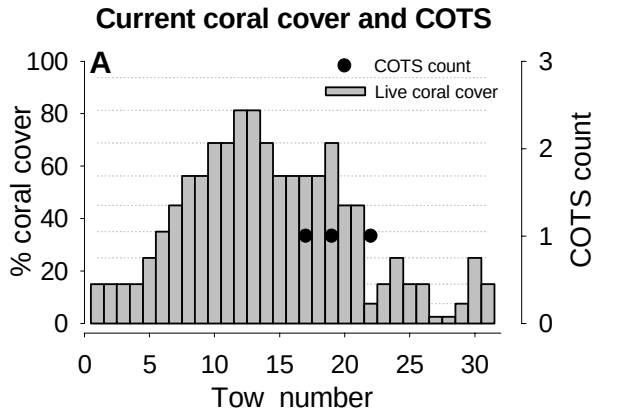
The larger reef fish have been very stable over the survey period. The increase in Chaetodontidae possibly reflects the increasing coral cover while decreases in Siganidae are more an artifact of variable counts of *Siganus corallinus* and *S. punctatus* rather than real trends. The Pomacentridae have been more dynamic. *Acanthochromis polyacanthus* has increased slightly over the period of survey. Both *Plectroglyphidodon lacrymatus* and *Chrysiptera rex* declined to relatively stable numbers after the first survey. There has been a general increase in *Chromis atripectoralis* and *C. lepidolepis.* The increase in *Pomacentrus* is due to a large influx of *P. lepidogenys* between the 1996 and 1997 surveys.

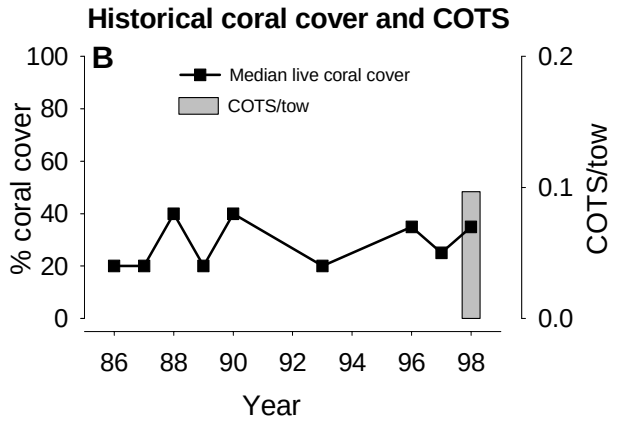
Figure 5.45

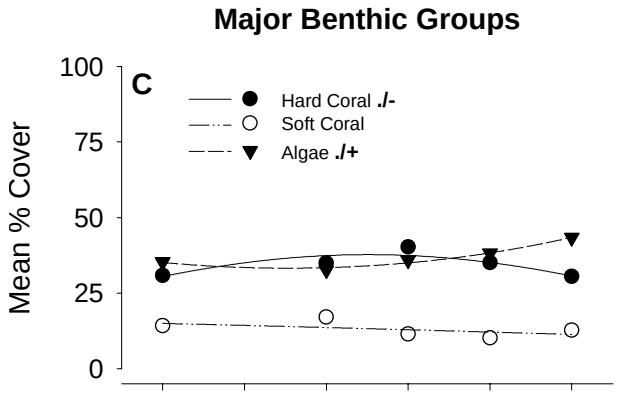
Low Islets

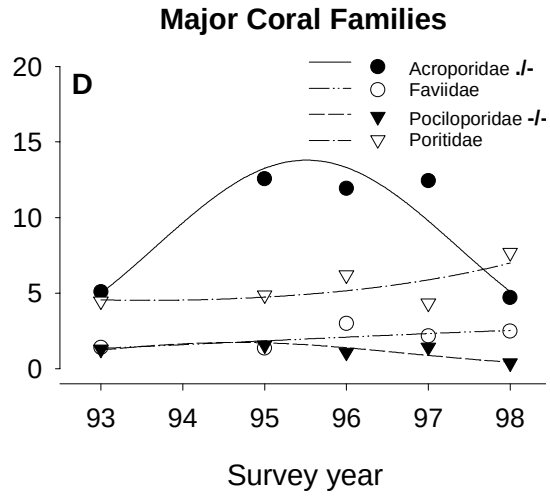


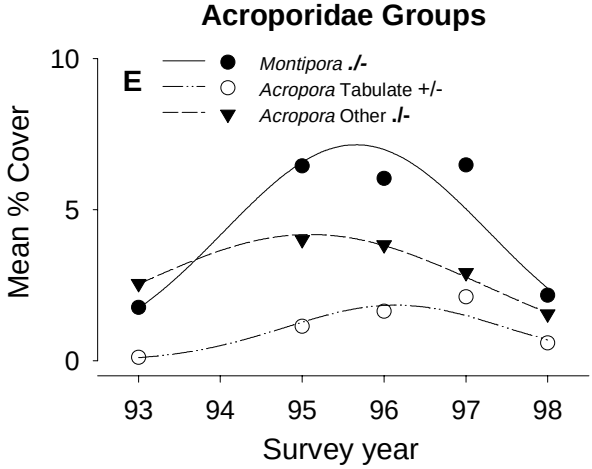
Low Islets (No. 16-028) is an inner shelf planar reef which surrounds two low wooded islets. The reef has an area of 2.3 sq.km. Last surveyed February 1998.

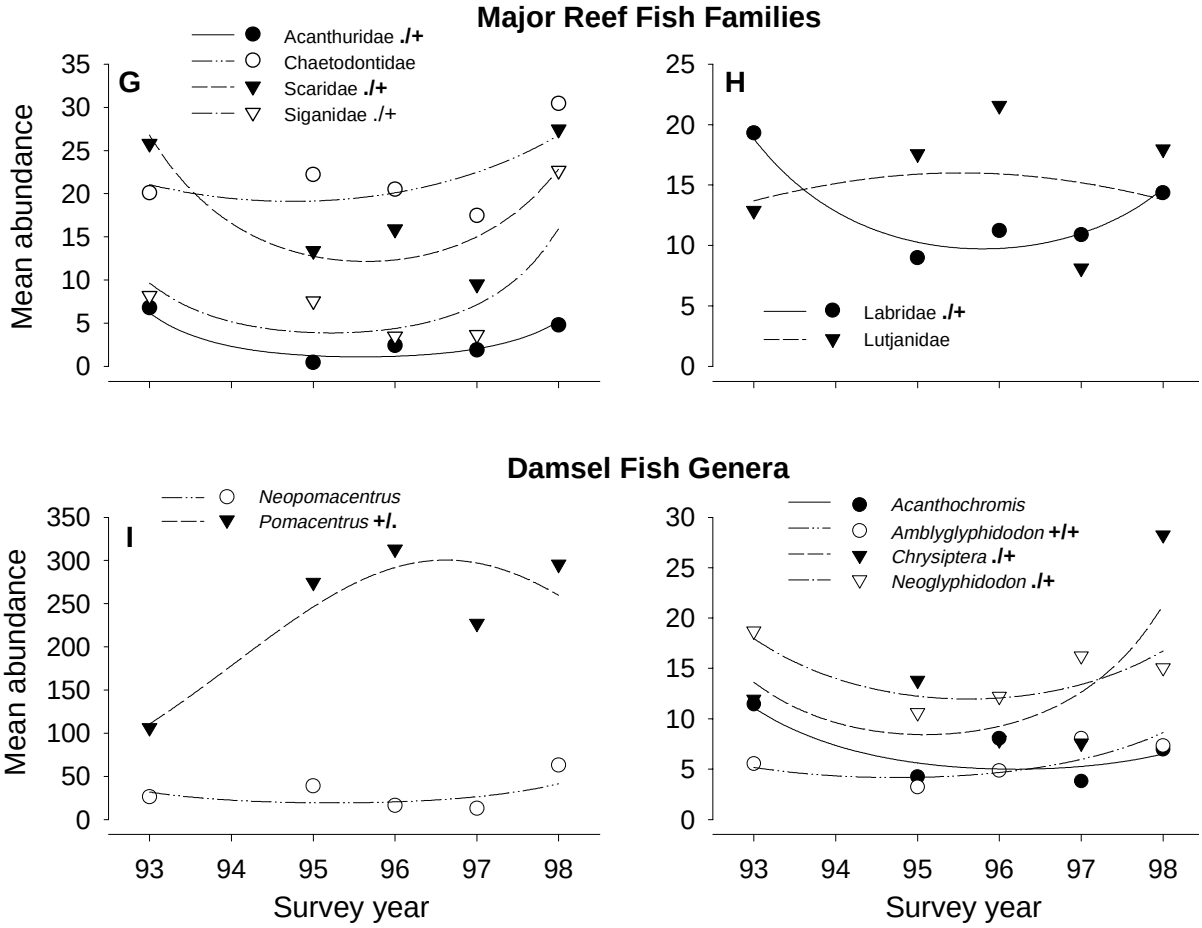












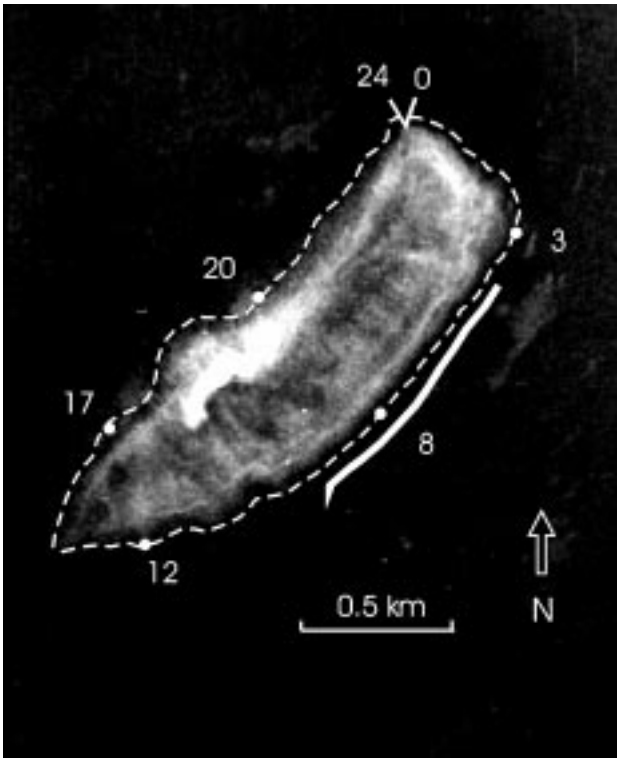
Low Islets

This reef has been broadscale surveyed since 1986. During this time there has been no clear trend in coral cover, which has remained at moderate to high levels. Detailed surveys, conducted since 1993, show that hard coral cover is declining or stable in all coral groups and is currently 31% overall. Corals of the family Acroporidae have declined significantly during the last two years. Approximately 12% of the area monitored is sand. COTS were recorded on this reef in 1998 for the first time since the commencement of broadscale surveys. COTS numbers are lower than those expected to cause significant coral mortality, hence the reef is classified as Non-Outbreaking. Low levels of coral bleaching were observed during the most recent survey.

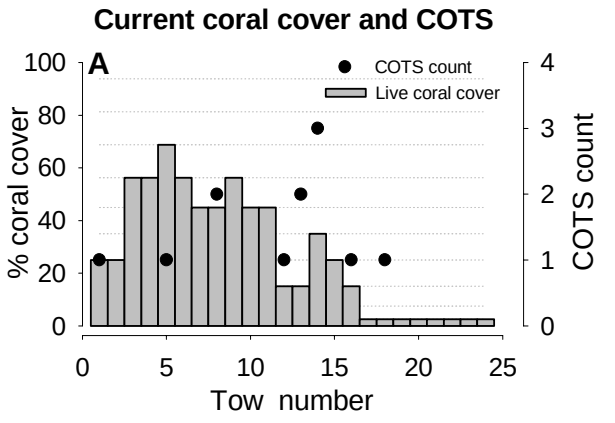
The majority of fish groups have been stable over the period of surveys although some groups have shown an increase in the last survey. This trend is most obvious in *Chrysiptera rollandi* (three fold increase) and *Siganus lineatus* (ten fold increase). The increase in *S. lineatus* will need verification in future surveys given the schooling nature of the species. Scarid abundance has remained stable with the apparent increase in 1998 due solely to high numbers of the highly mobile *Scarus rivulatus* on one site. *Pomacentrus*, show an overall increase which was driven by a strong increase in *P. moluccensis* until 1996 followed by stable to slightly declining numbers to present.

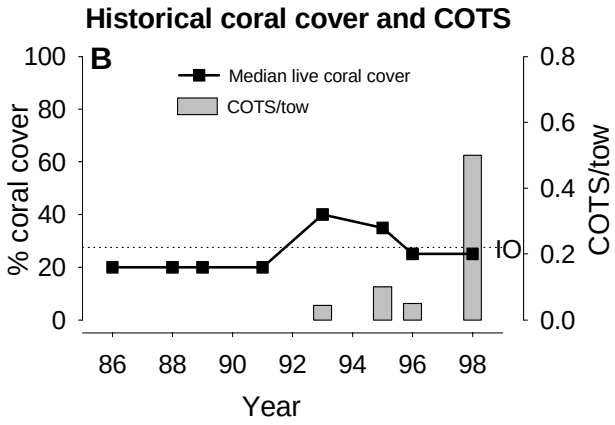
Figure 5.46

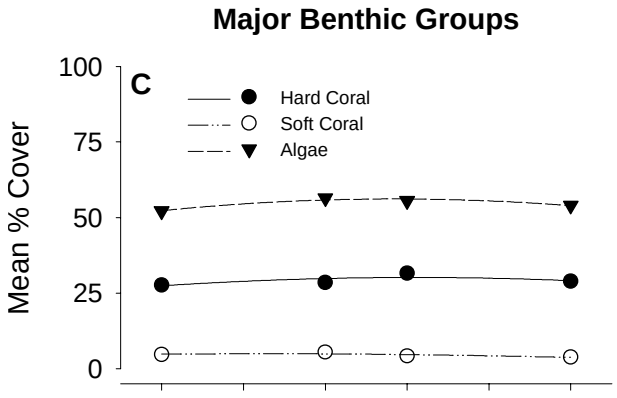
Mackay

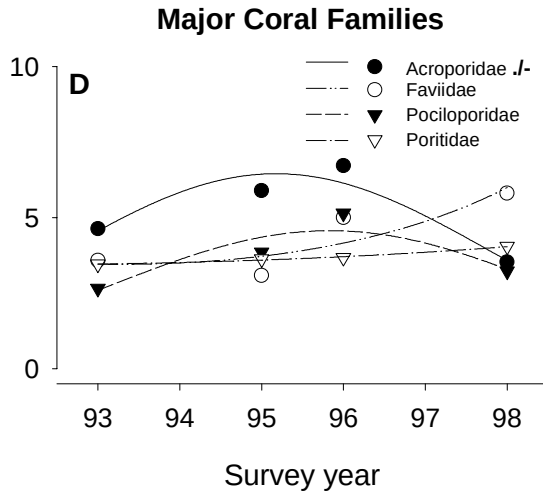


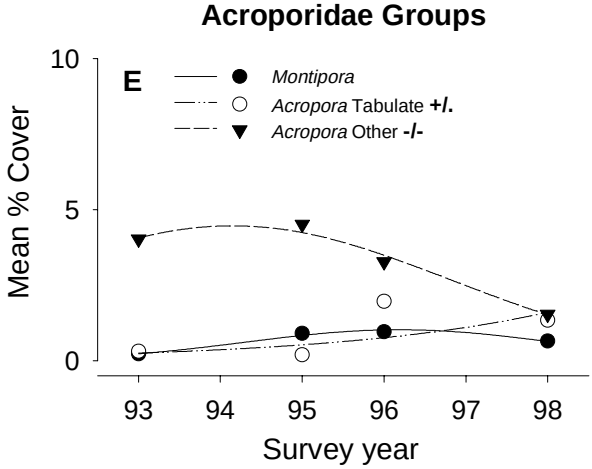
Mackay (No. 16-015) is a middle shelf planar reef with an area of 4.2 sq.km. A sand cay is located on the southern end. Last surveyed January 1998.

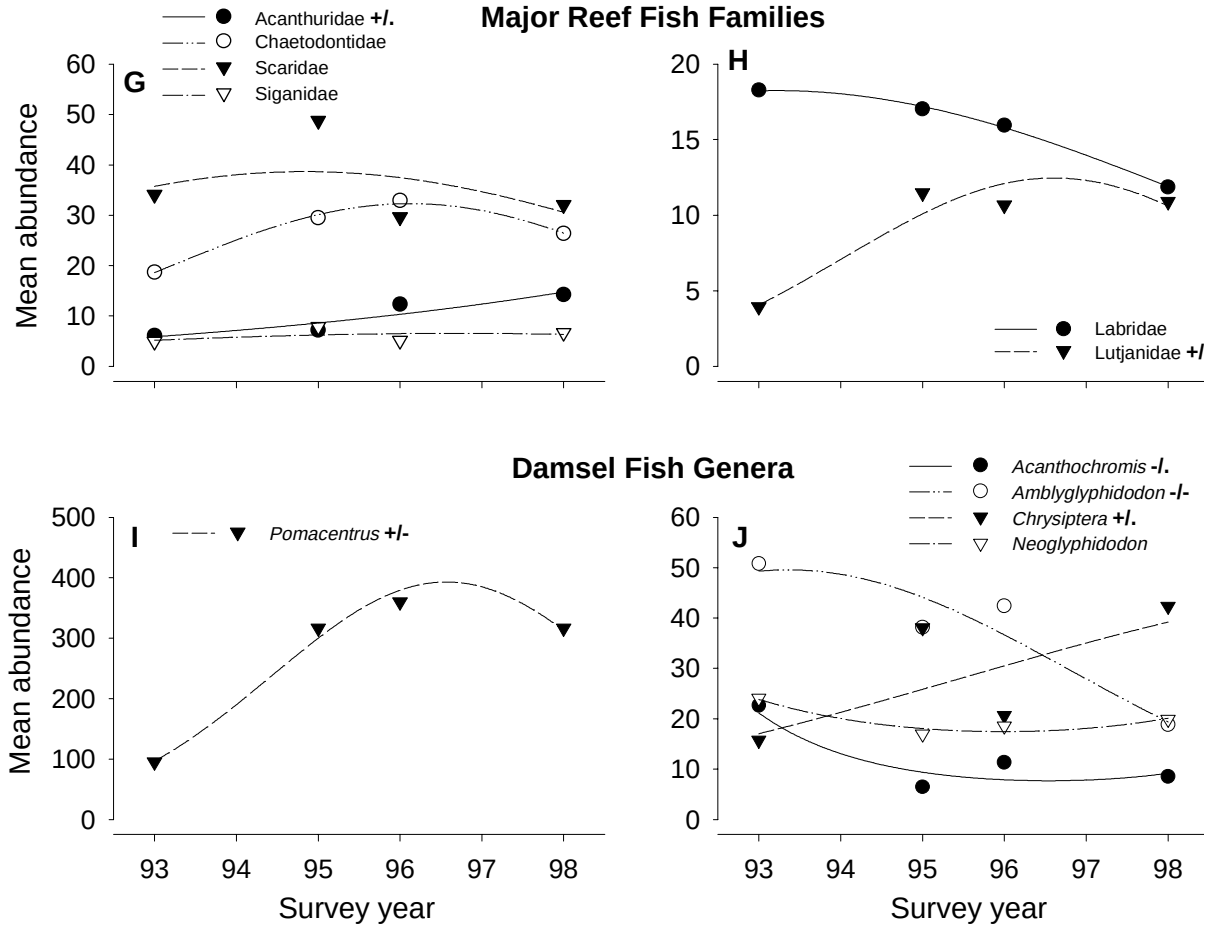












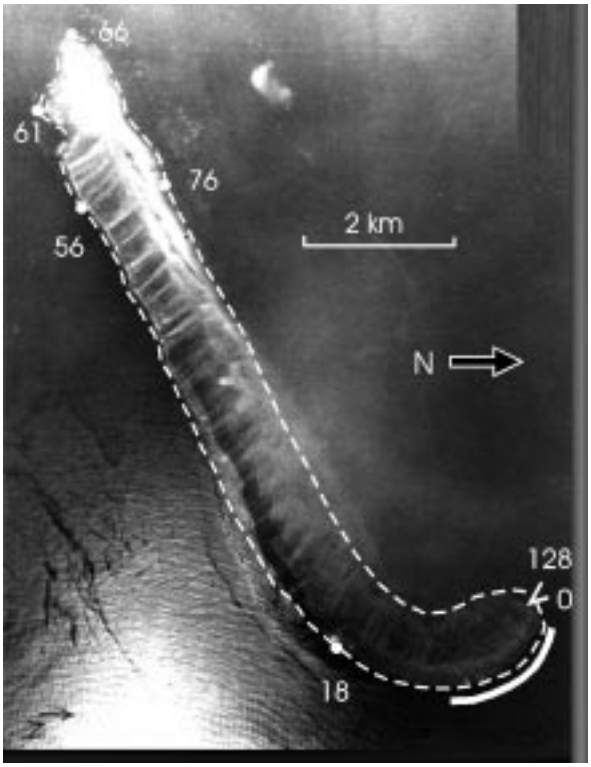
Mackay

This reef has an extensive history of broadscale survey since 1986. Coral cover remained constant over the first four survey periods then increased between 1991 and 1993, followed by declines to present day. COTS were recorded in low numbers in 1993 and have been recorded during all subsequent surveys. The most recent survey revealed relatively large numbers of COTS and a stabilisation in coral cover. This reef is currently classified as an Incipient Outbreak. Detailed benthic surveys began on this reef in 1993 and show that coral cover has only increased marginally on the transects since this time (2%) with a current level of 29%. This contrasts with the decline observed at the larger reef scale, using the manta tow method. Cover of algae and soft coral have remained fairly constant since 1993. There are isolated records of bleaching on this reef.

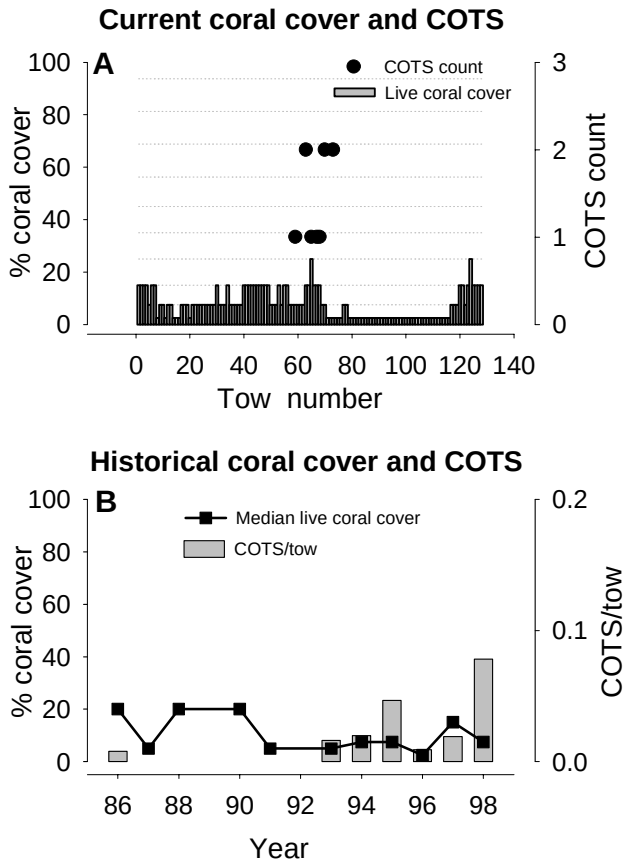
Abundances of large reef fish have been relatively stable over the period of detailed fish surveys. The only observed trends are a slight increases in *Ctenochaetus* spp.(Acanthuridae) and an increase in *Lutjanus lutjanus* (Lutjanidae) between 1993 and 1995. *Pomacentrus moluccensis* drives the observed trend for the genus *Pomacentrus*. This follows the same pattern observed on many reefs in the region of strong abundance increases until 1996 followed by a stabilisation. *Pomacentrus adelus* has also increased while *P. brachialis*, *P. grammorhynchus*, *P. lepidogenys*, and *P. wardi* have all decreased. *Amblyglyphidodon curacao* abundance has steadily decreased while *Acanthochromis polyacanthus* decreased between 1993 and 1995 then remained stable.

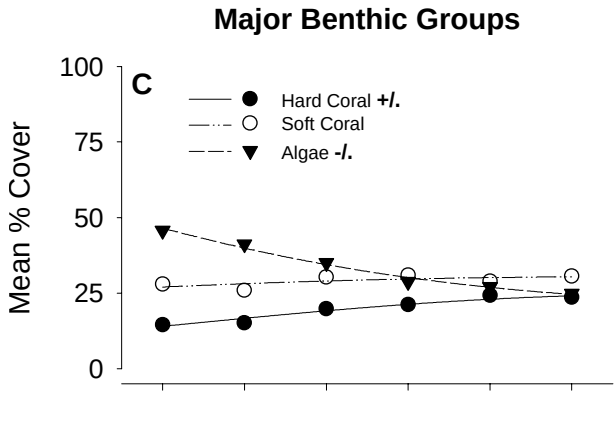
Figure 5.47

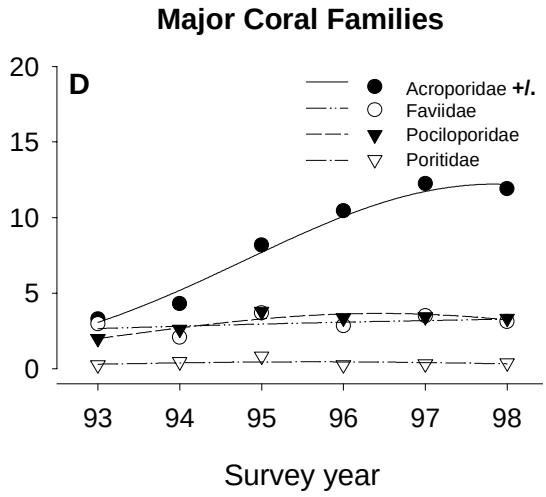
Michaelmas

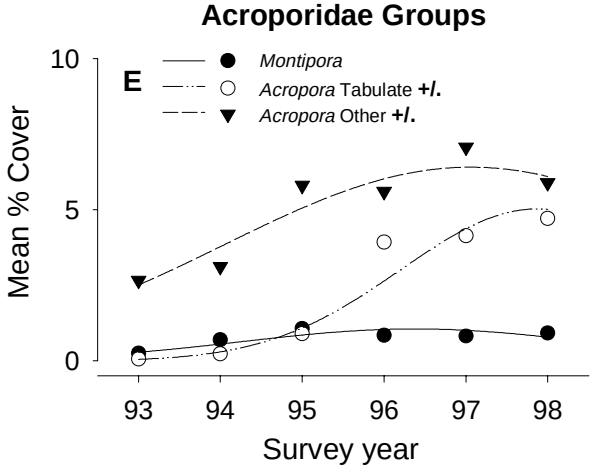


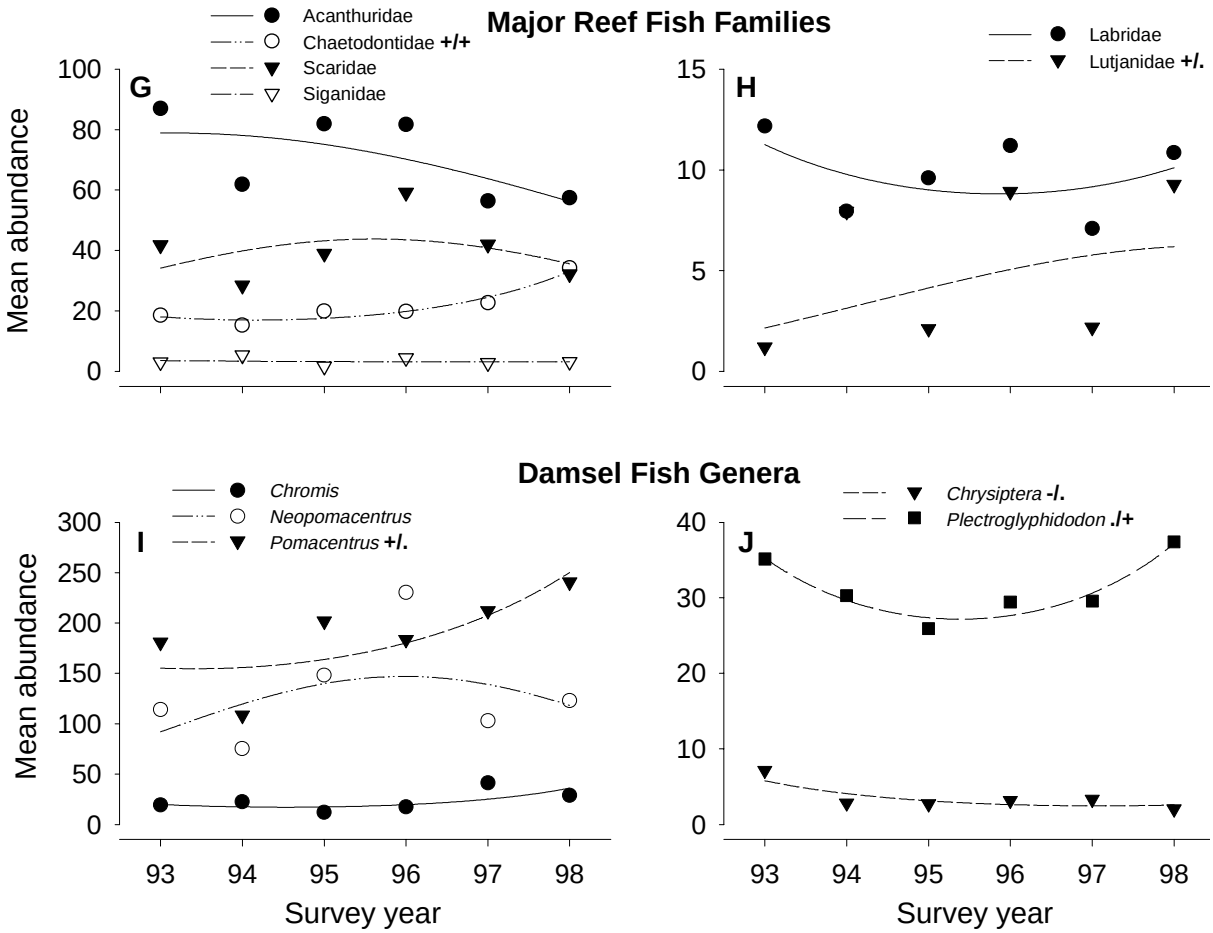
Michaelmas (No. 16-060) is a middle shelf crescentic reef with an area of 30 sq.km. There is a vegetated sand cay on the south-western end. Last surveyed January 1998.











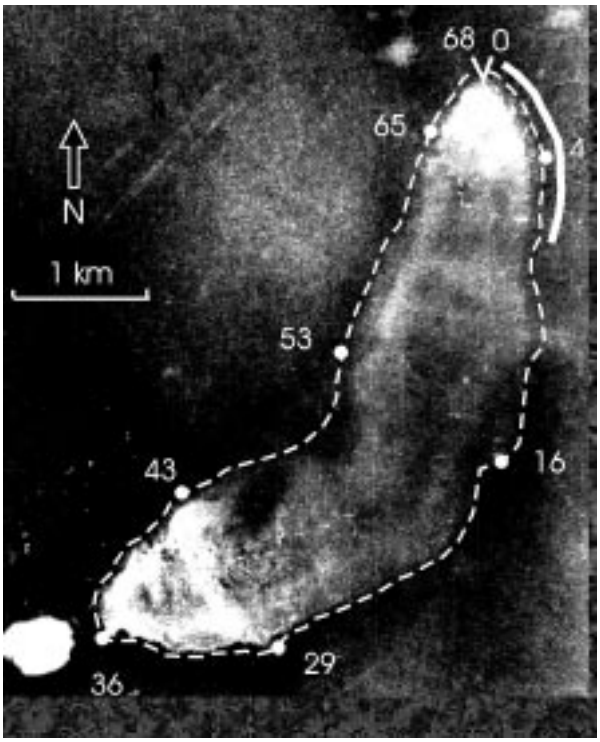
Michaelmas

This reef has an extensive history of broadscale survey since 1986. The coral cover shows an apparent decline from moderate to low levels in the initial years of survey and has remained generally low since this time. This situation is not reflected in the detailed coral surveys conducted since 1993 which show hard coral cover increasing by 8.7% due primarily to an increase in *Acropora* spp. Hard coral cover has not changed since 1997 and is currently moderately high on the sites at 27.8%. The cover of algae has decreased while soft coral cover has remained stable. This apparent contradiction between the manta tow and video transect methods is explained by the scale of each survey method. The aerial photo shows that the area of the detailed surveys covers only a small percentage of the total perimeter of the reef and so the increase in coral cover in the north eastern part of the reef is not reflective of changes in other areas of the reef. COTS populations observed on this reef have generally been observed on the south western corner of the reef while the coral on the survey sites remains unaffected. Low numbers of COTS have been observed in most years on this reef. Numbers are lower than normally considered causative of widespread coral mortality, however given the low coral cover we consider COTS are adversely affecting coral growth. Michaelmas reef is currently classified as Non-Outbreaking. There are isolated records of coral bleaching on this reef.

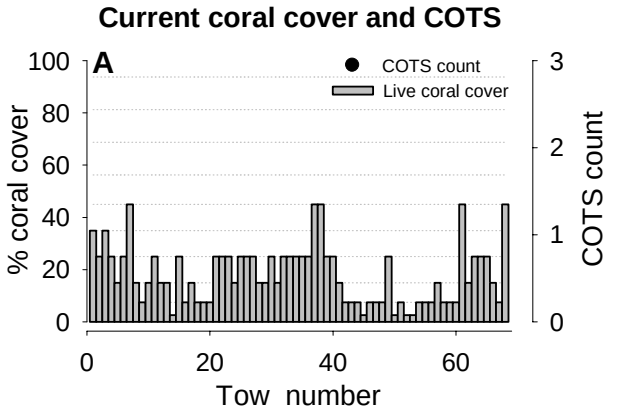
Increasing hard coral cover on the survey sites is reflected in increasing abundance of the Chaetodontids; *Chaetodon citrinellus*, *C. melannotus*, *C. pelewensis*, *C. trifascialis* and *C. trifasciatus*. The apparent increase in *Pomacentrus* abundance is more likely an artifact of variable counts of *P. lepidogenys*, rather than general increases, although *P. philippinus* and *P. bankanensis* show slight current increases. The decline in *Chrysiptera* stems from abundance being higher in the first survey with abundances of the dominant species *C. rex* stable over the last five years. Abundance of *Plectroglyphidodon lacrymatus* declined to 1995, but have been increasing steadily since then. The observed increase in Lutjanidae is an artifact of highly variable counts of *Lutjanus fulviflamma*, which appear sporadically on one site in high numbers.

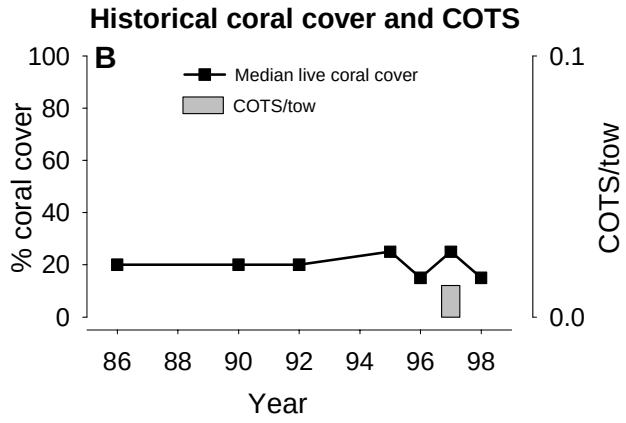
Figure 5.48

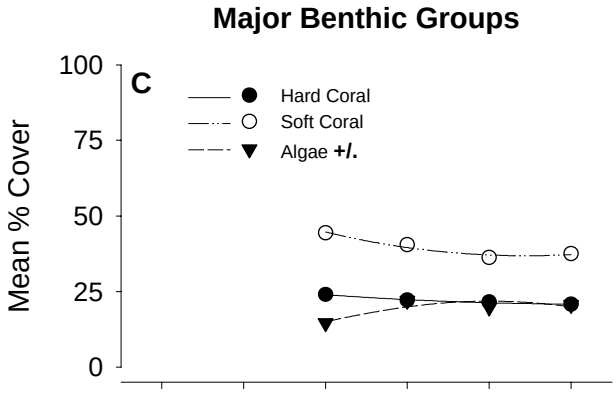
Opal (2)

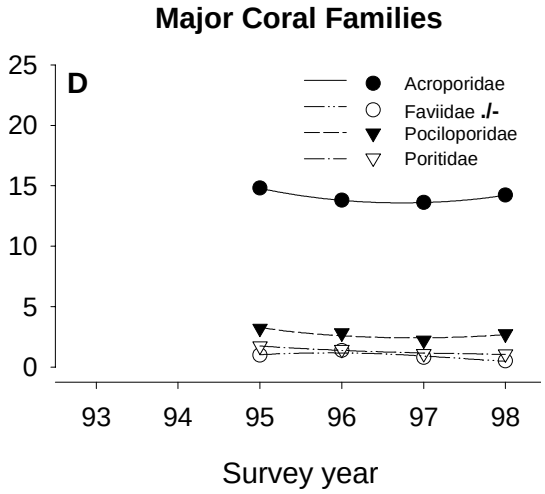


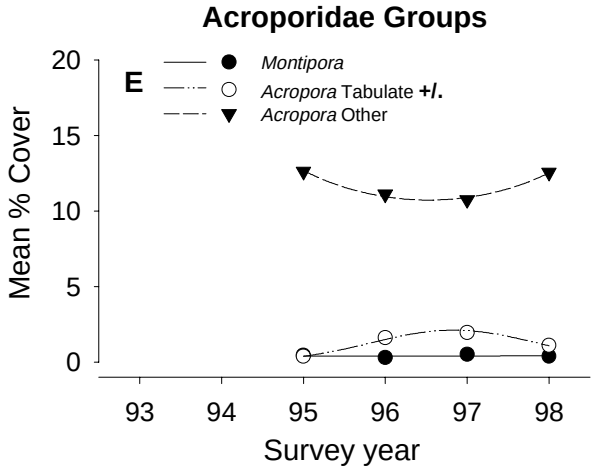
Opal (2) (No. 16-025) is an outer shelf crescentic reef with an area of 24.7 sq.km. Last surveyed January 1998.

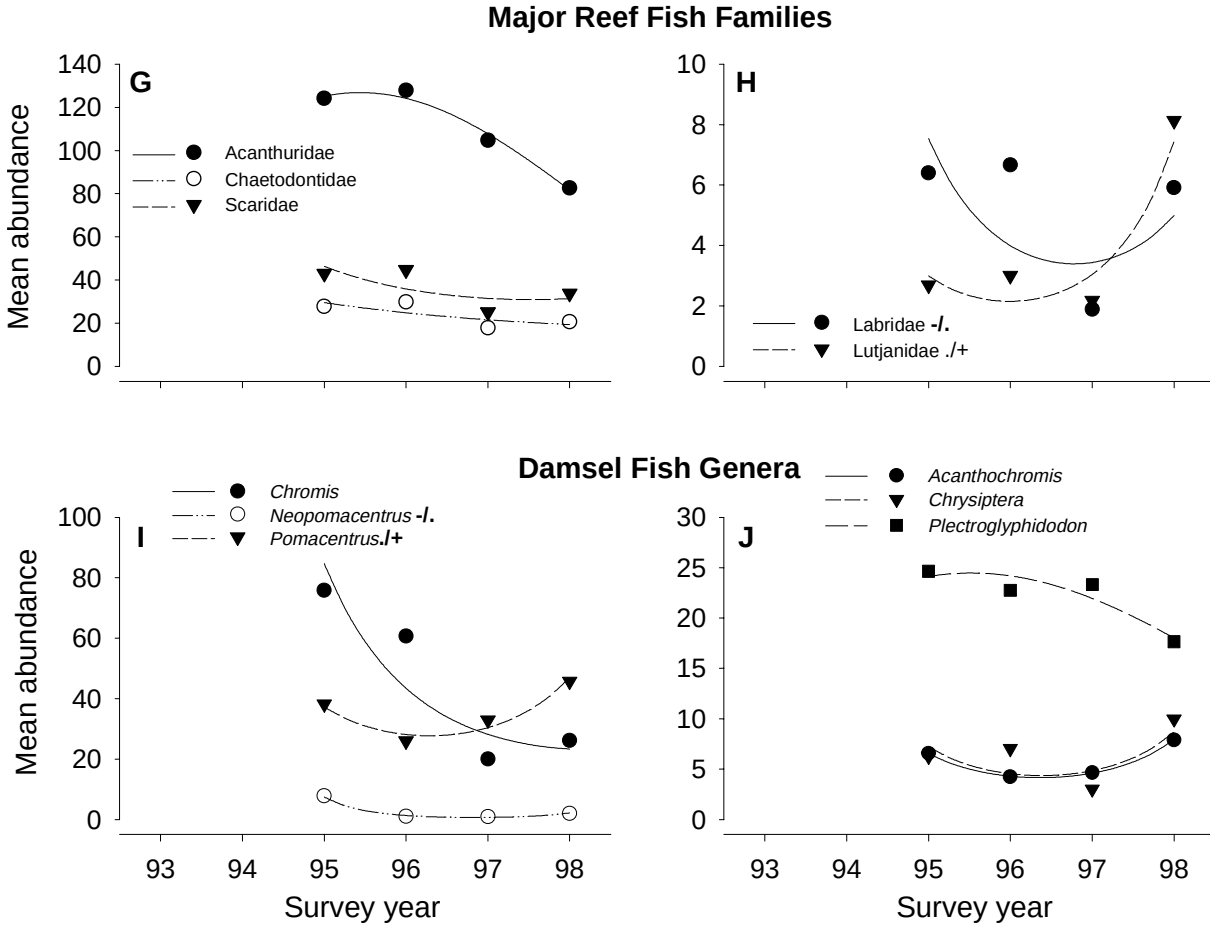












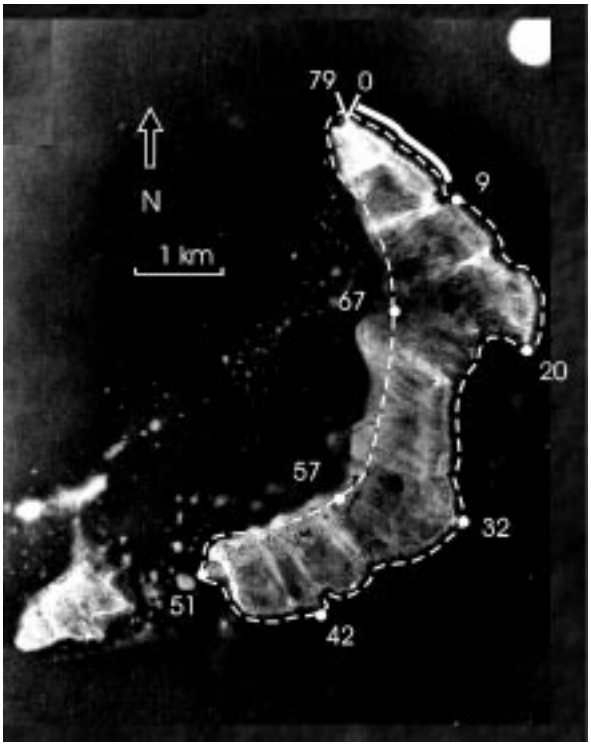
Opal (2)

Broadscale surveys have been undertaken on this reef six times since 1986. Surveys have shown no appreciable change in coral cover which remains at moderate levels. This is supported by detailed benthic surveys (since 1995) which show a stable hard coral cover of 20.7% with a high relative abundance of Isoporid *Acropora*. This reef is notable for a high percent cover of soft coral (37.7%) which has remained stable since detailed surveys began. This reef was initially classified as Recovering in 1986. Since this time COTS have only been seen in very small numbers and the reef remains classified as Recovering.

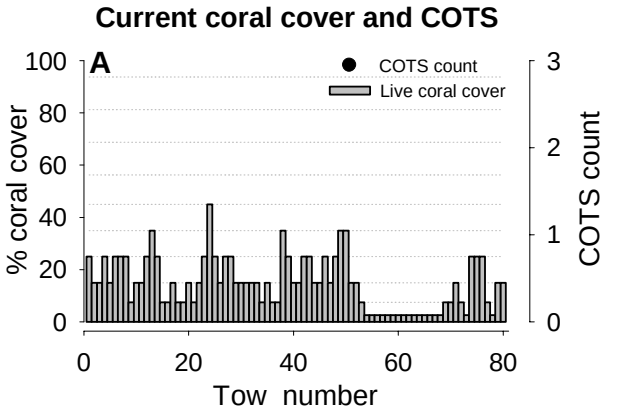
The fish community on Opal (2) has been relatively stable. The observed trend in Labridae is due to the absence of *Gomphosus varius* in 1997. Trends observed in *Neopomacentrus* and Lutjanidae are both due to intermittent inclusion of schooling species (*N. azysron* and *Lutjanus gibbus* respectively) in the counts rather than steady changes in abundance. The current increase in *Pomacentrus*, due mostly to an increase in *P. bankanensis*, is the most discernible change in the fish community. While not revealed statistically there has also been a decrease in Chaetodontids due to steady declines in two of the most numerate species *Chaetodon citrinellus* and *C. trifasciatus*. There has also been a decline (though not statistically significant) in *Chromis* as a result of a steady reduction in numbers of *C. atripectoralis* and *C. margaritifer*.

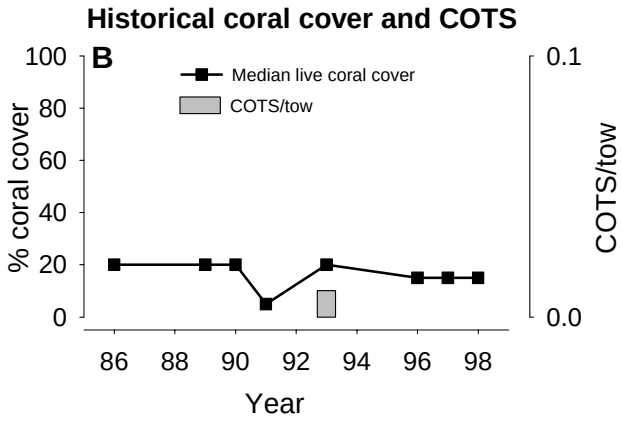
Figure 5.49

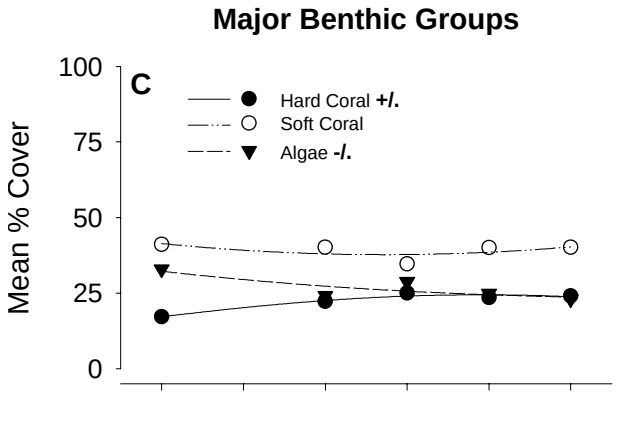
St. Crispin

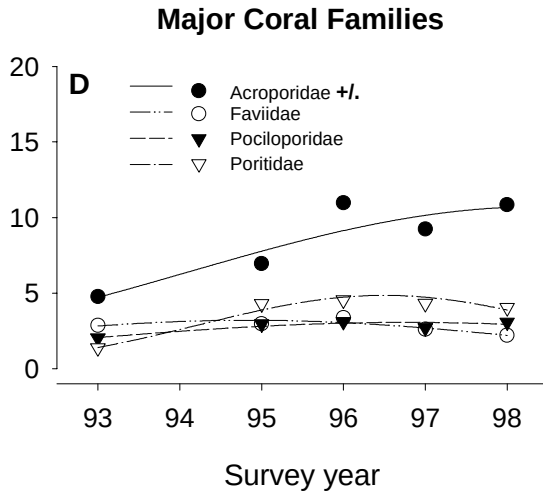


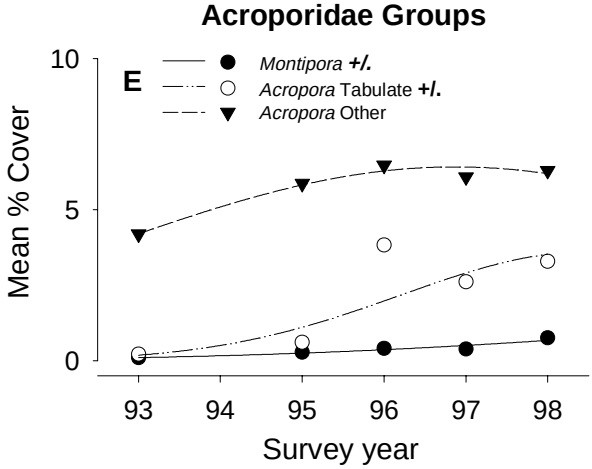
St. Crispin (No. 16-019) is an outer shelf crescentic reef with an area of 38.19 sq.km. Last surveyed January 1998.

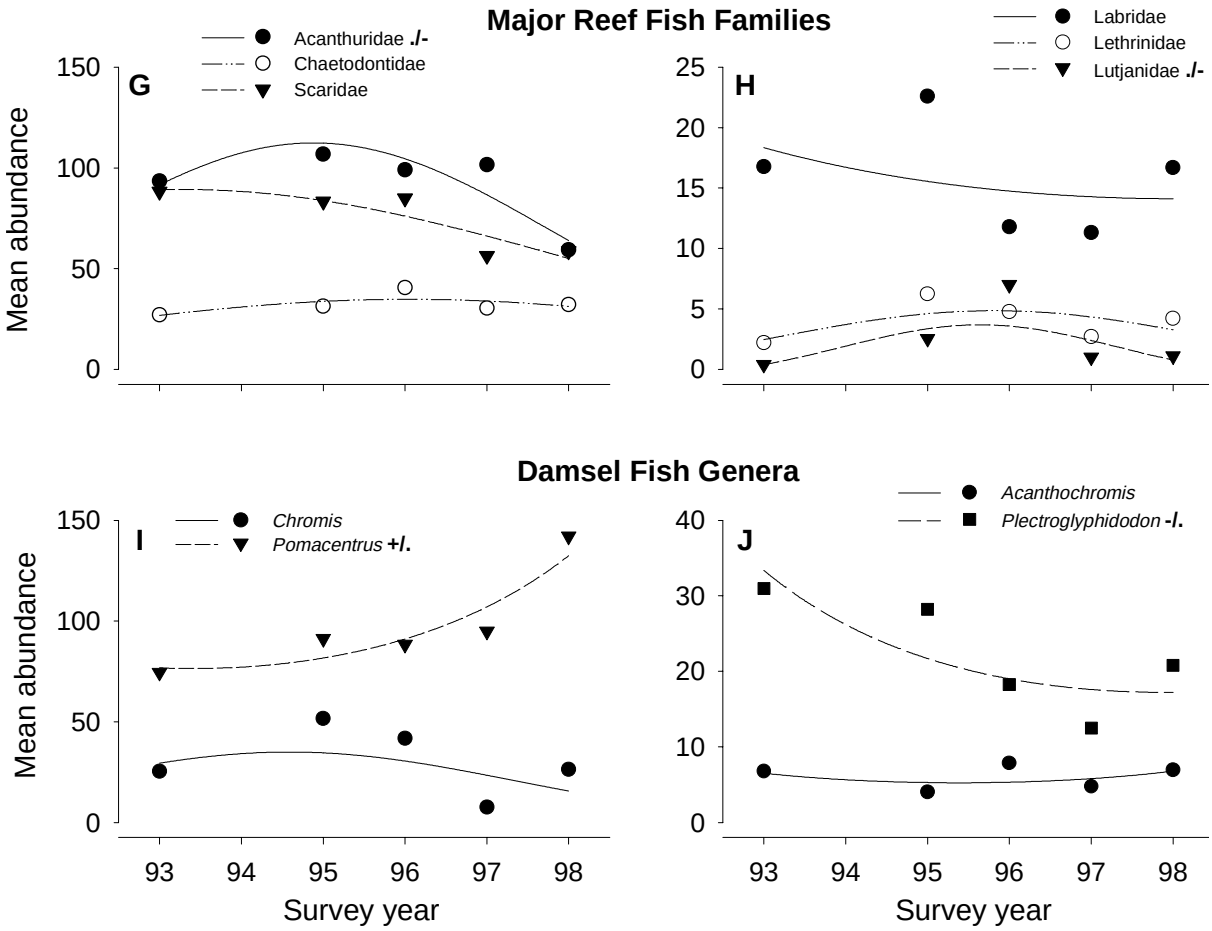












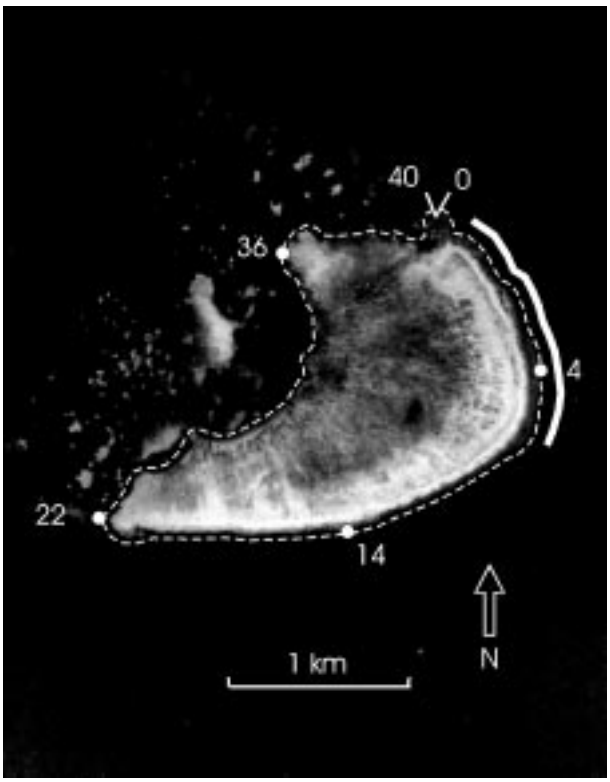
St. Crispin

This reef has been broadscale surveyed since 1986. Over this time coral cover has remained at moderate levels. Detailed benthic surveys show hard coral cover has increased by 6.8% since surveys began in 1994, to the current level of 24.1%. The increase is due primarily to *Acropora* spp. It is notable that the cover of soft corals is high and stable at 40.1%. COTS were observed in 1993 in numbers lower than those considered to cause significant coral mortality. The reef is currently classified as Non-Outbreaking. There are isolated records of coral bleaching from this reef.

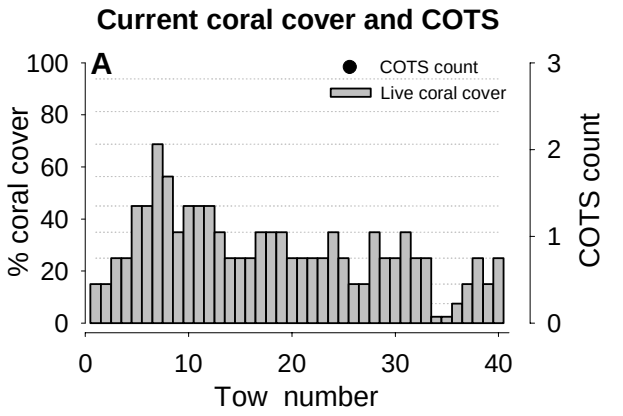
The majority of fish groups have been stable with some slight declines. The current decline in Acanthuridae is due to a general decline in *Ctenochaetus* spp., *Zebrasoma scopas* and *Z. veliferum*. *Plectroglyphidodon lacrymatus* drives the observed trend in the genus with declining abundance until 1997 then some subsequent recovery. The negative trend in Lutjanidae is a result of the inclusion of a large school of *Lutjanus gibbus* in 1996 with otherwise stable counts. The only group increasing is *Pomacentrus* due to an influx of *P. lepidogenys* between the 1997 and 1998 surveys.

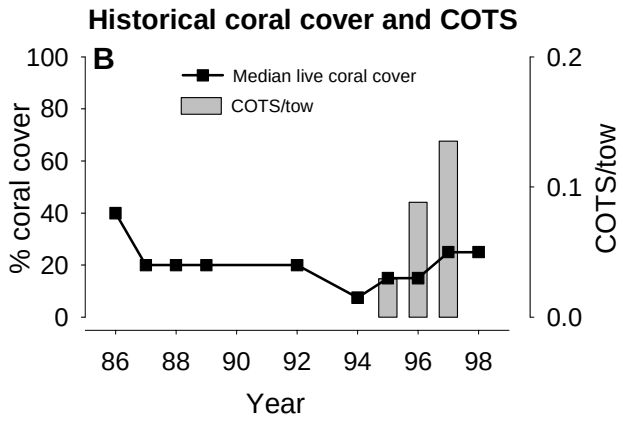
Figure 5.50

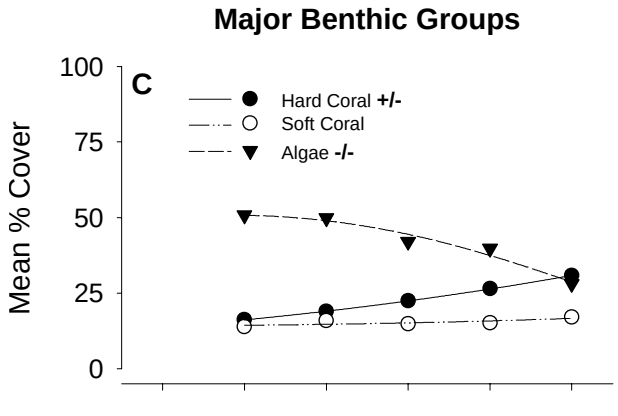
Thetford

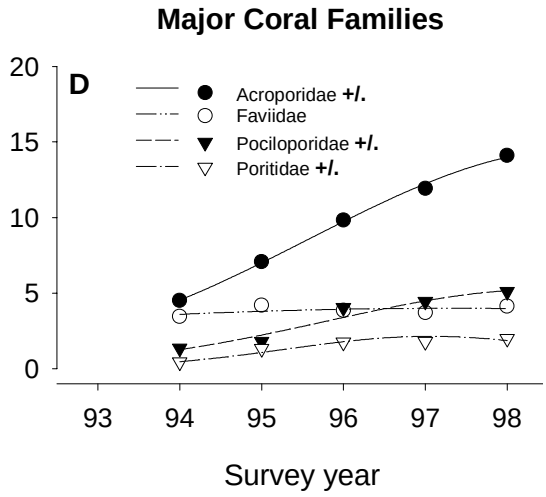


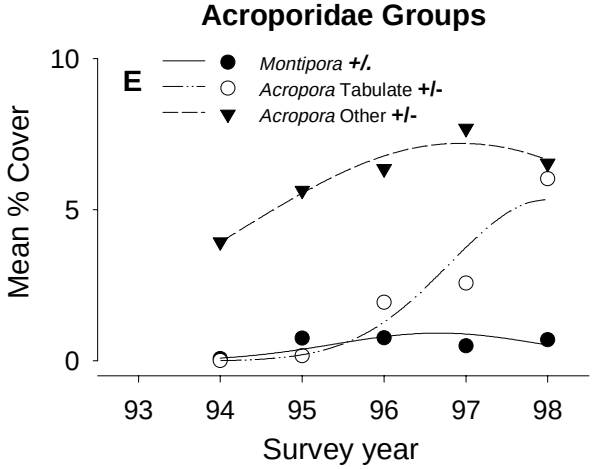
Thetford (No. 16-068) is a middle shelf crescentic reef with an area of 7.9 sq.km. Last surveyed February 1998.

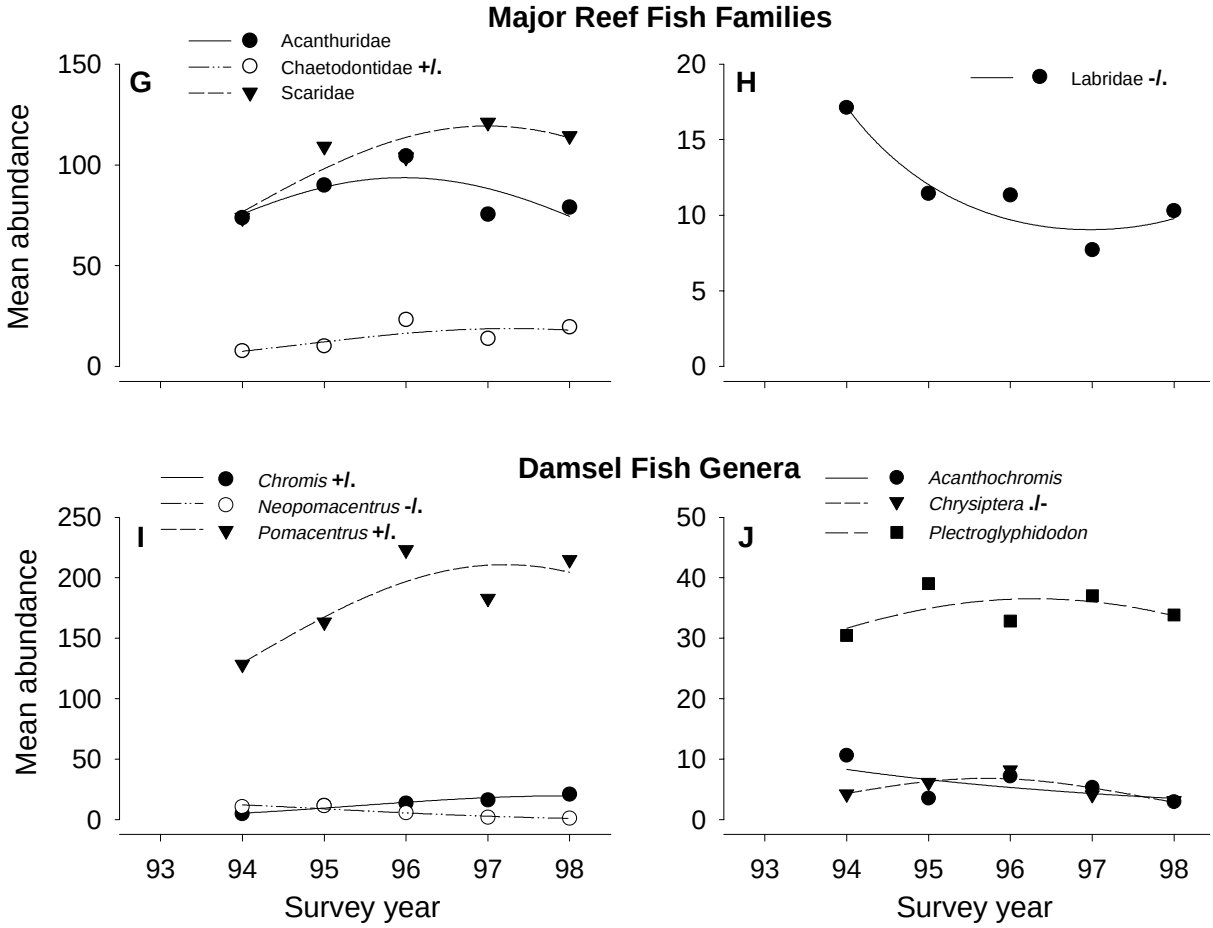










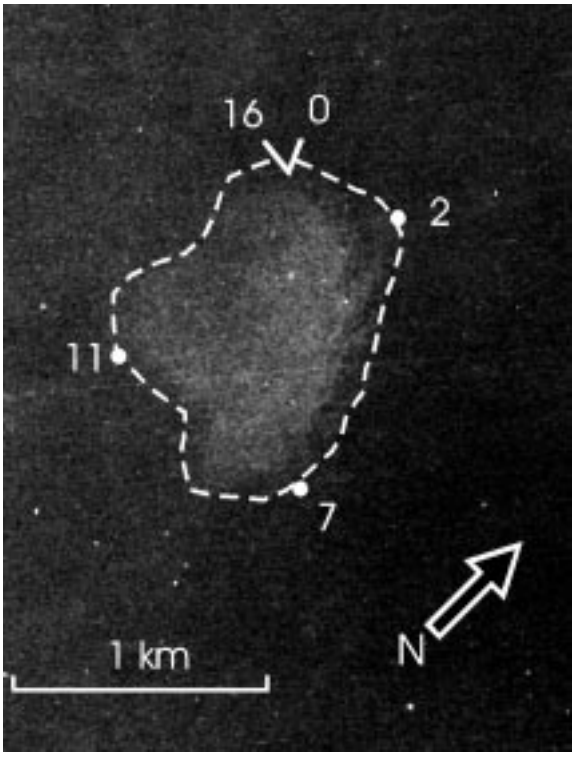


Thetford

This reef has been broadscale surveyed since 1986. These surveys showed a general decrease in hard coral cover through to 1994 followed by a gradual increase to the present moderate coral cover. This is supported by detailed benthic surveys from 1994 which show a 14.9% increase in percentage cover of hard coral over the last four years, due largely to an increase in the percent cover of *Acropora* spp. Hard coral cover is currently moderately high at 31.1%. Percent cover of algae has decreased since surveys began while soft coral cover has remained unchanged. COTS have been observed on this reef on a number of occasions with numbers too low to cause significant coral mortality. This reef is considered to be Recovering from COTS activity. There are isolated coral bleaching records from this reef.

The increase in coral cover is reflected in increases in the fish community. Both Chaetodontids (*Chaetodon citrinellus*, *C. trifasciatus*, and *C. trifascialis*) and *Chromis* (*C. atripectoralis*, *C. lepidolepis*, *C. margaritifer*, and *C. ternatensis)* have shown general increases with higher abundances currently than during the first two surveys. The increase in *Pomacentrus* is due to *P. lepidogenys* with other species remaining stable. Of the groups showing decreasing abundance; decreases in *Neopomacentrus* were due to *N. azysron*, the decrease in Labridae is due to higher counts for *Epibulus insidiator* and *Gomphosus varius* in the first survey. The current decrease of *Chrysiptera* is likely due to variation in the annual estimates rather than a significant change in abundance.

Figure 5.51



Euston (No. 16-063) is an outer shelf patch reef with an area of 0.7 sq.km. Last surveyed February 1998.

Euston

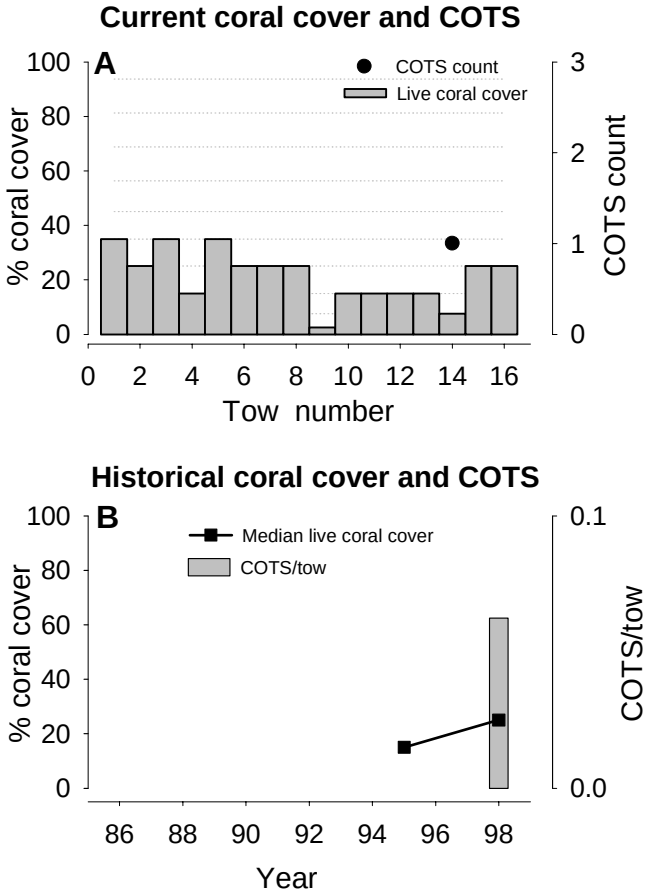
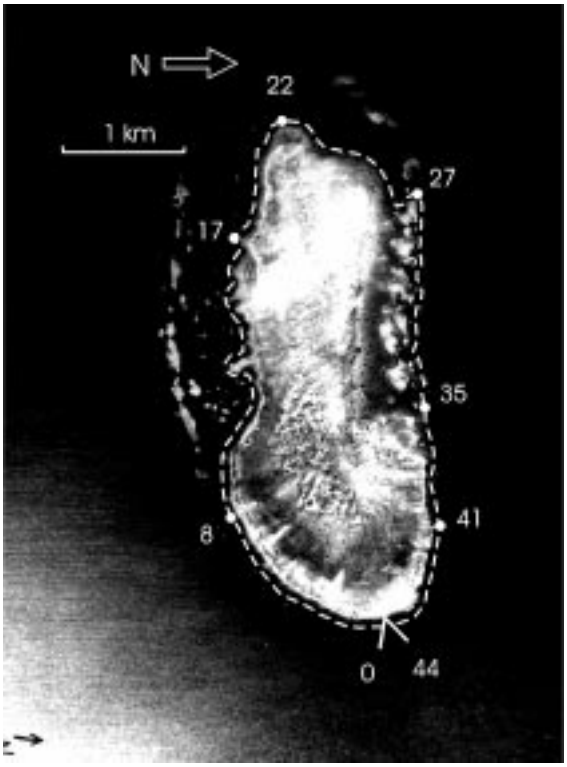


Figure 5.52



Evening (No. 15-095) is a middle shelf planar reef with an area of 8.8 sq.km. Last surveyed February 1998.

Evening

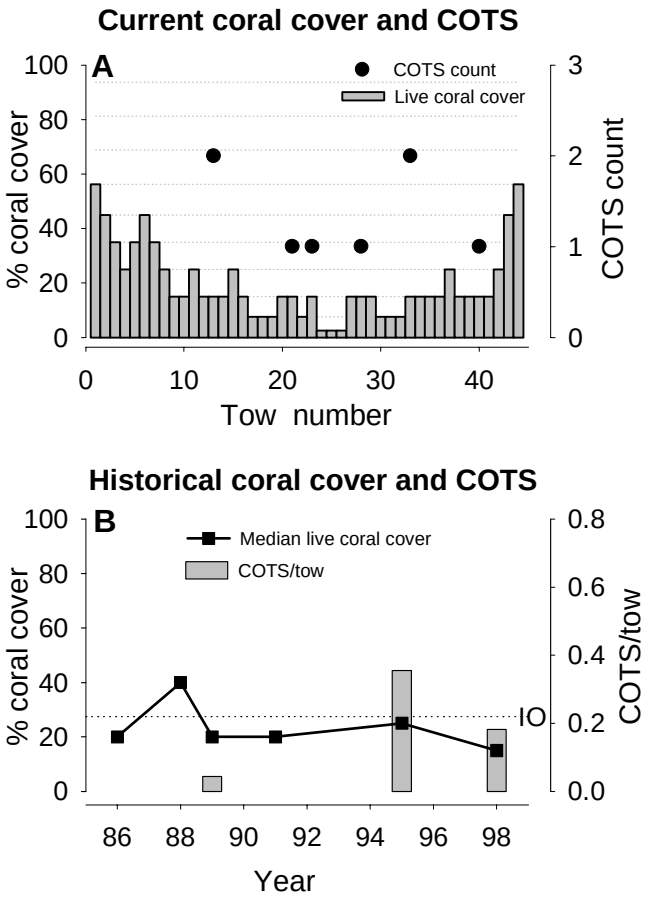
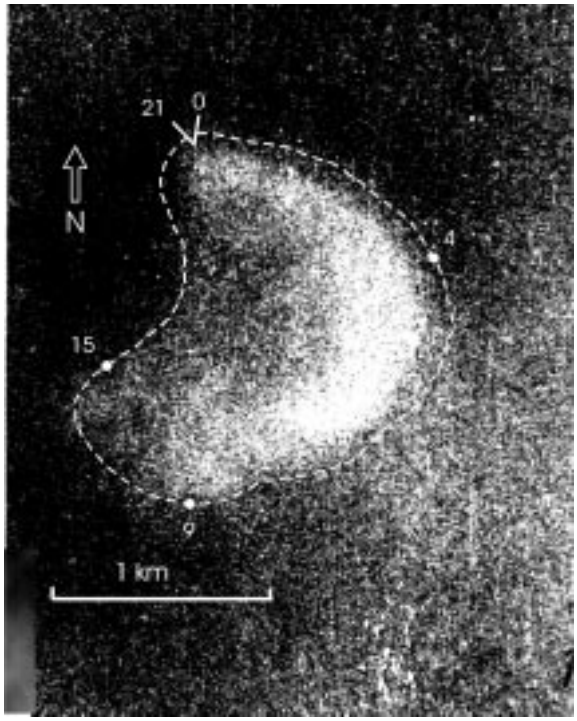
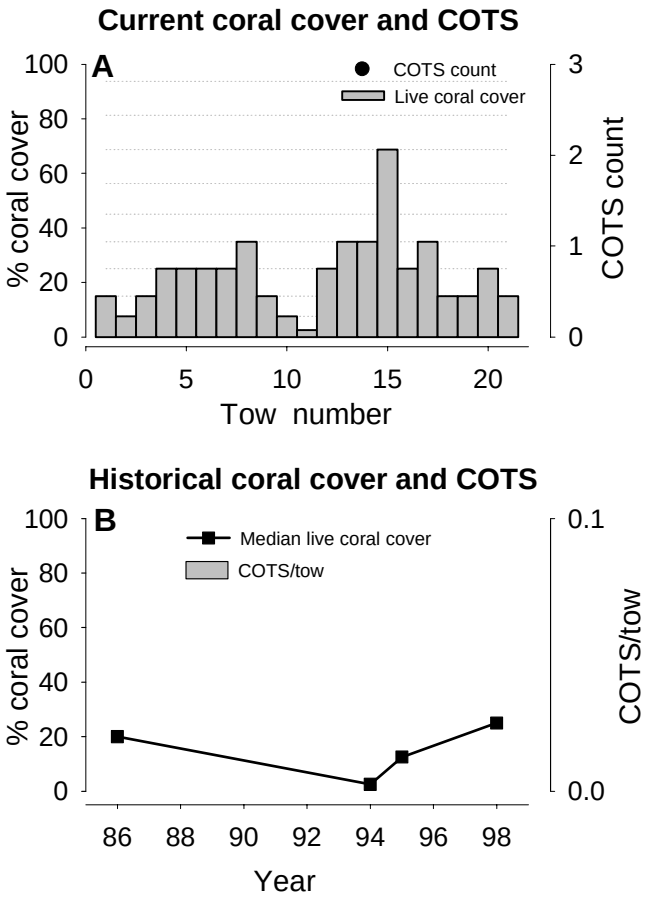


Figure 5.53 **Flynn**



Flynn (No. 16-065) is an outer shelf planar reef with an area of 2.2 sq.km. Last surveyed February 1998.



Euston

This reef has only been surveyed in 1995 and 1998. Over this time there has been no appreciable change in coral cover which remains at moderate levels. COTS were observed on this reef during our most recent surveys and were not in numbers high enough to impact on coral cover. Euston Reef is currently classified as Non-Outbreaking.

Evening

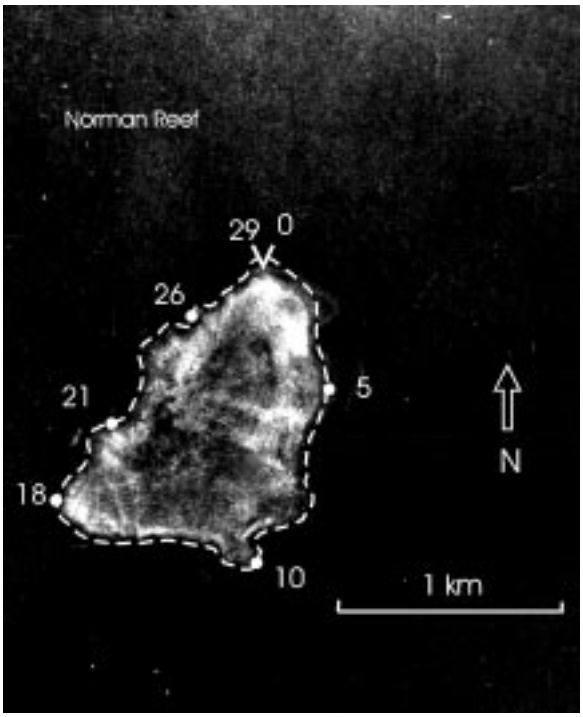
This reef has been surveyed on a regular basis since 1986. Over this time coral cover has generally remained at moderate levels. Initially the reef was classified as Recovering from COTS activity. Relatively large numbers of COTS were observed on this reef in 1995 when it was reclassified from Recovering to Incipient Outbreak. Our most recent surveys indicate a decline both in coral cover and COTS numbers. Evening Reef is currently classified as Recovering.

Flynn

This reef has been surveyed four times since 1986. Coral cover declined till 1995 before subsequently recovering to the present moderate levels. In the absence of COTS activity the reasons for this trend remain enigmatic. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

Figure 5.54

Norman



Norman (No. 16-030) is an outer shelf planar reef with an area of 4.3 sq.km. Last surveyed February 1998.

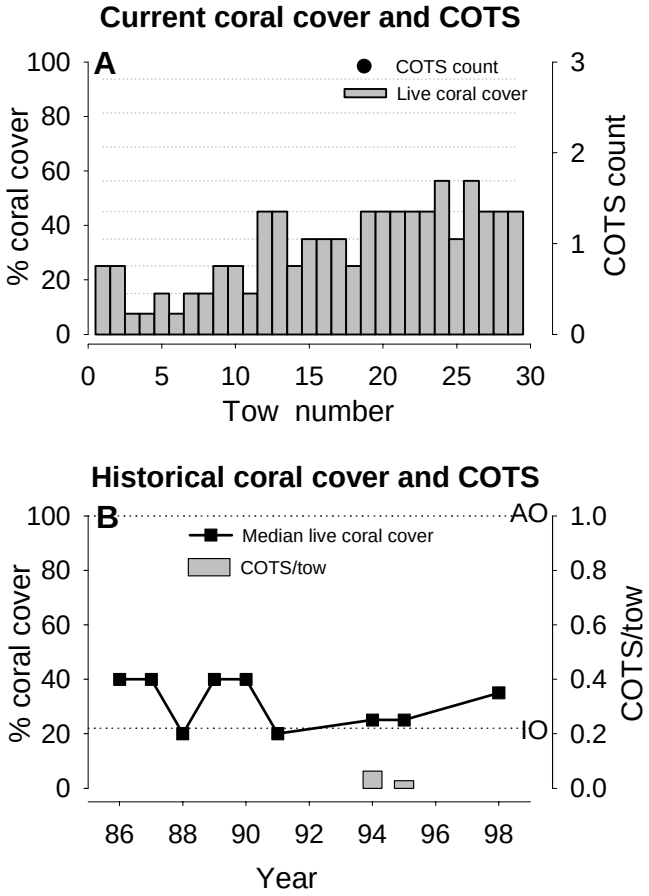
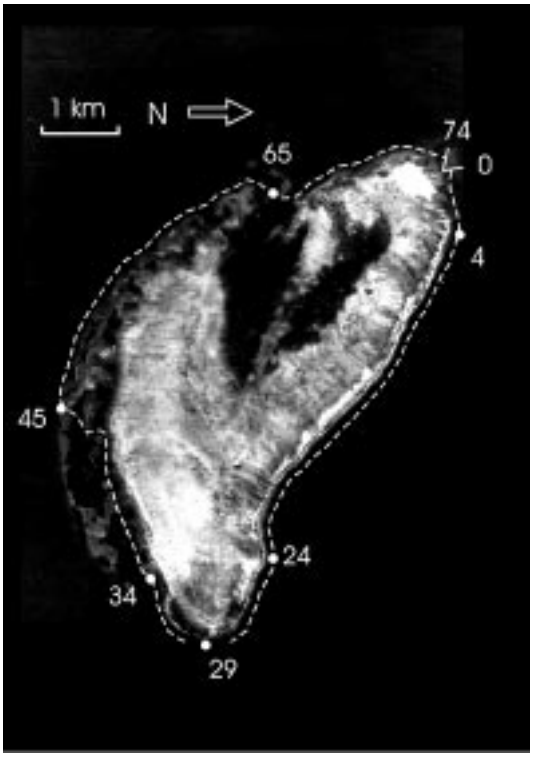


Figure 5.55

Pickersgill



Pickersgill (No. 15-093) is a middle shelf lagoonal reef with an area of 17 sq.km. There is a sand cay at the north-western end. Last surveyed February 1998.

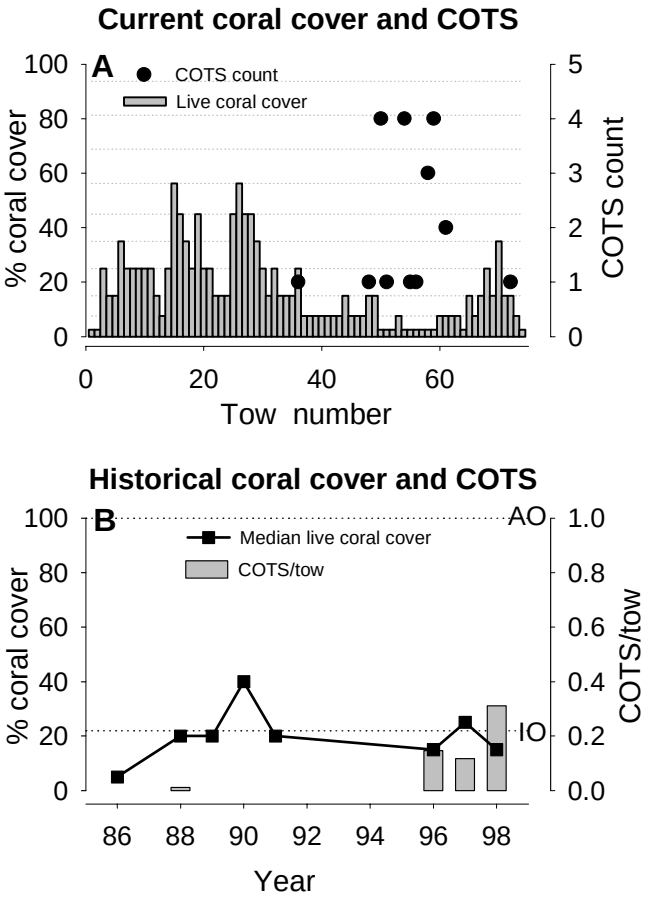
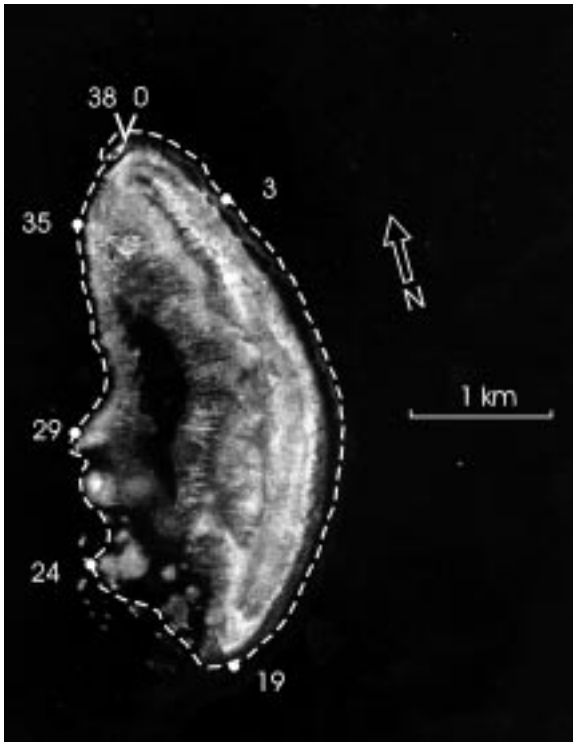
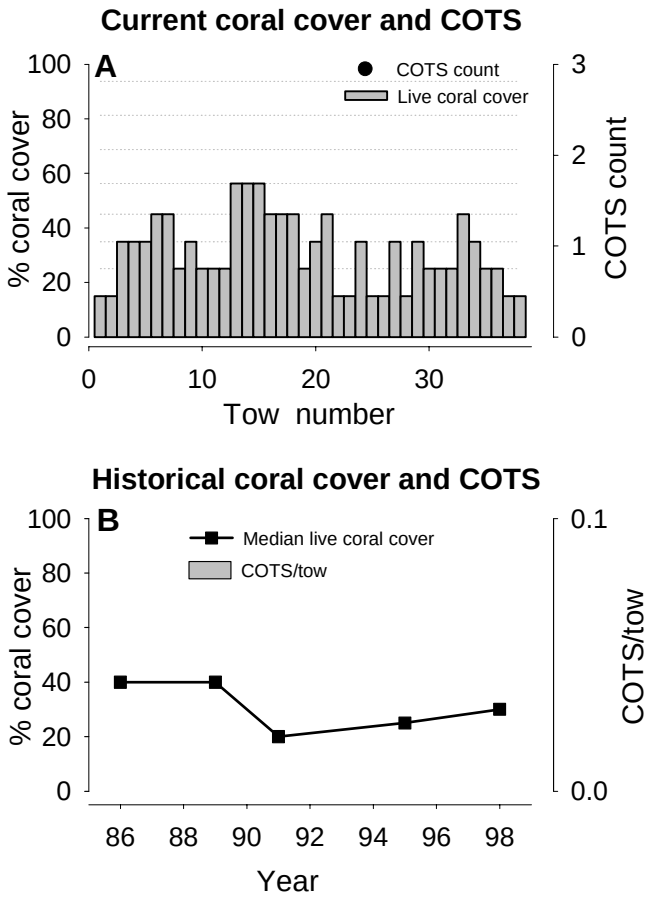


Figure 5.56 **Reef No. 15-092**



Reef No. 15-092 is an outer shelf ribbon reef with an area of 4.2 sq.km. Last surveyed February 1998.



Norman

This reef has an extensive history of manta tow survey since 1986. While coral cover was generally high in the initial years of survey it dropped to moderate levels by 1991. In the absence of COTS populations the reasons for this are somewhat enigmatic (though Cyclone Joy did impact reefs in this area during Dec 1991). Since 1991 coral cover has continued to recover to the current high level. Although small numbers of COTS have been seen on this reef on a number of occasions these have been in numbers too low to be considered to cause significant coral mortality. Coral cover increased between 1986 and 1995 where it has since remained at a very high level. Coral cover is presently high on this reef which is classified as Non-Outbreaking.

Pickersgill

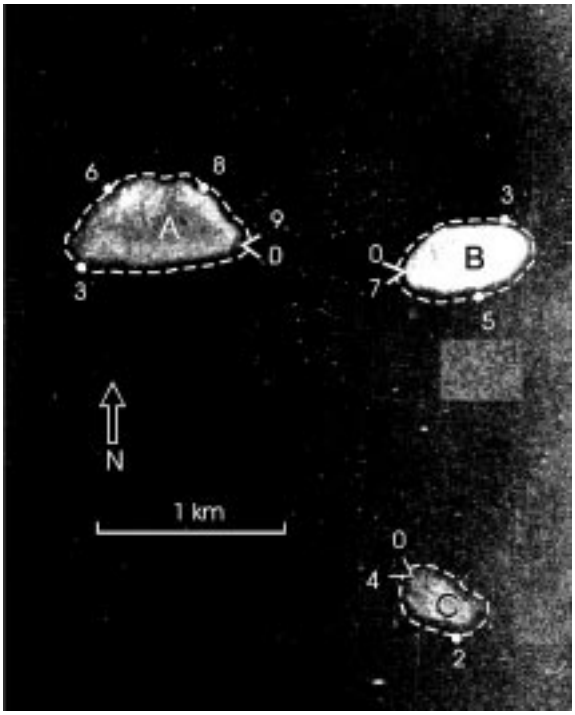
This reef has an extensive history of survey since 1986. Originally classified as recovering from COTS activity, coral cover increased on this reef (in the absence of COTS) up until 1990. Coral cover dropped appreciably on this reef in 1991 in the absence of COTS populations. The reasons for this are somewhat recondite (though Cyclone Joy did impact reefs in this area during Dec 1991). Since 1991 there has been little increase in coral cover on this reef while COTS numbers have continued to grow. This reef is currently classified as an Incipient Outbreak. Future surveys will determine trends in coral cover, which appears to be decreasing at the present time.

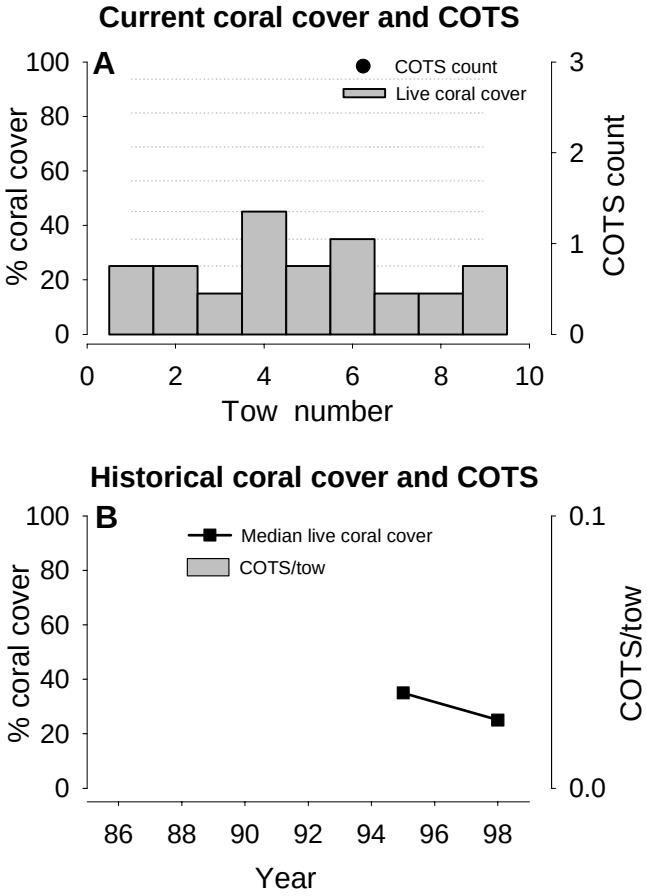
Reef No. 15-092

This reef has been surveyed five times since 1986. Coral cover has generally remained at moderate to high levels. An apparent drop (1989 to 1991) and subsequent recovery of coral (from 1991) occurred in the absence of any observed COTS activity. This reef is currently classified as Non-Outbreaking.

Figure 5.57

Reef No. 16-013 (a)

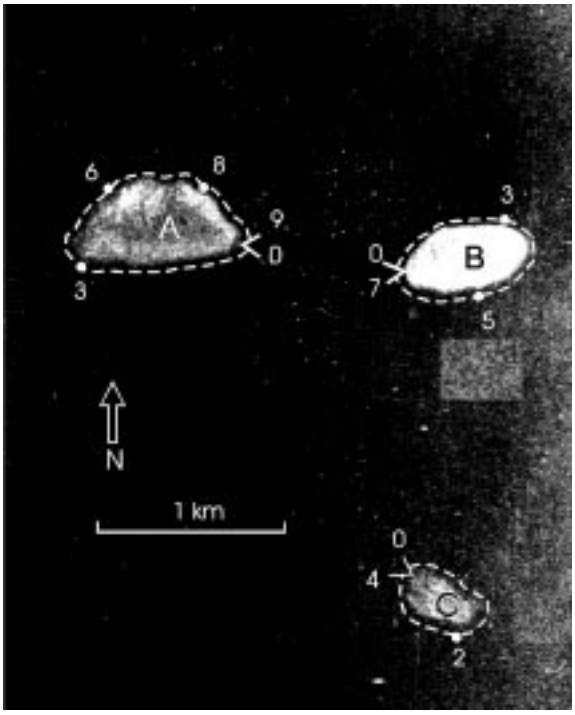


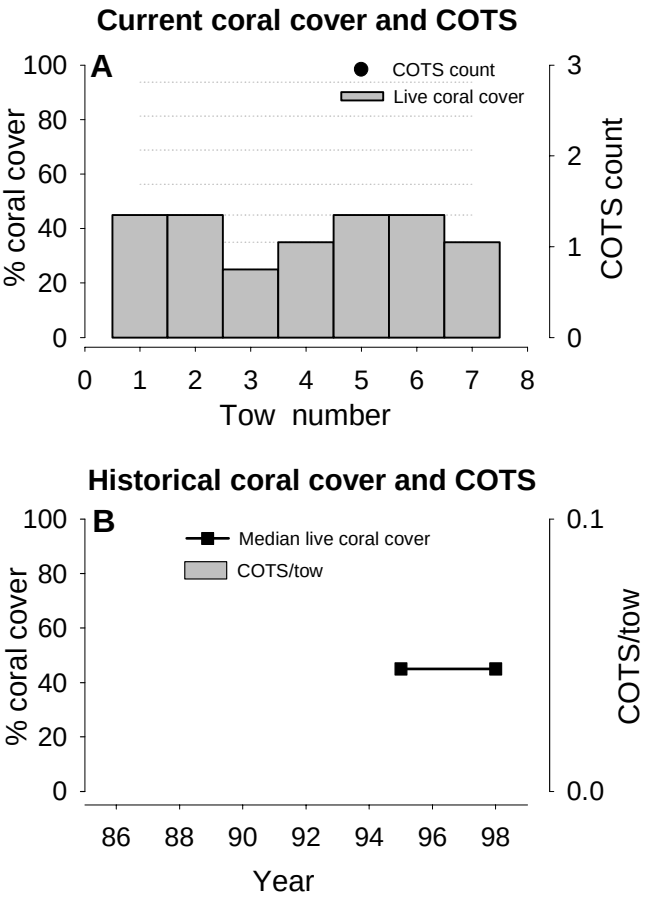


Reef No. 16-013 (a) is a middle shelf patch reef with an area of 0.4 sq.km. Last surveyed February 1998.

Figure 5.58

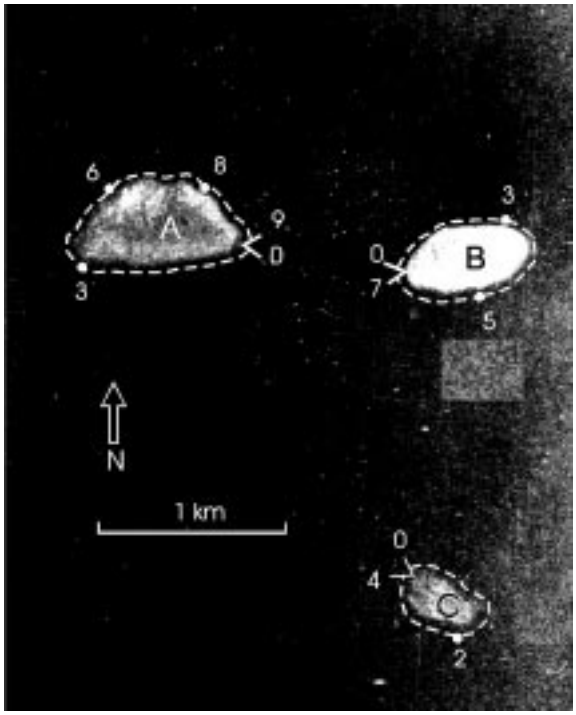
Reef No. 16-013 (b)



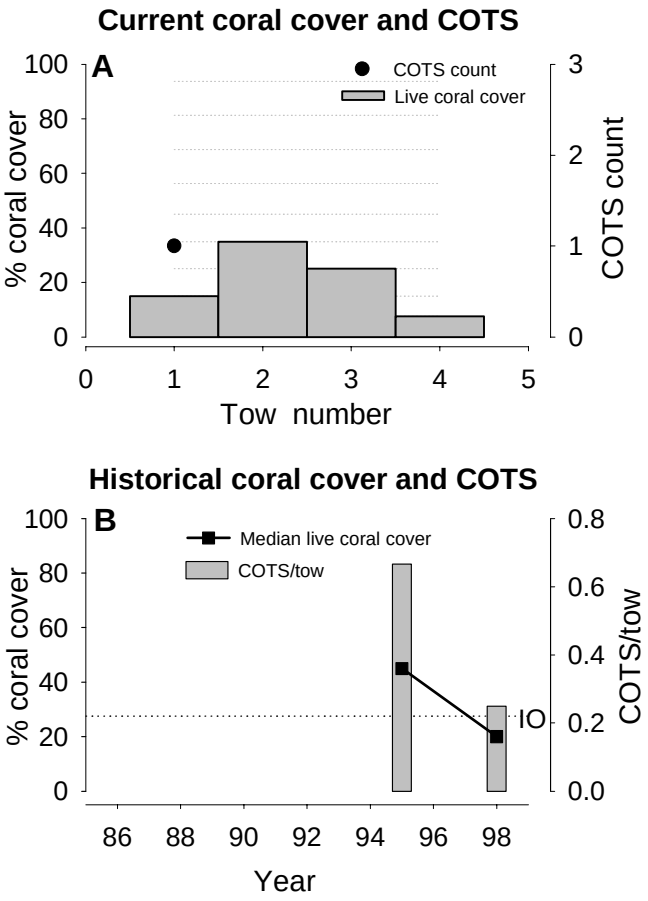


Reef No. 16-013 (b) is a middle shelf patch reef with an area of 0.2 sq.km. Last surveyed February 1998.

Figure 5.59 **Reef No. 16-013 (c)**



Reef No. 16-013 (c) is a middle shelf patch reef with an area of 0.2 sq.km. Last surveyed February 1998.



Reef No. 16-013 (a)

This reef has only been surveyed in 1995 and 1998. Over this time there has been no appreciable change in coral cover which is currently at moderate levels. No COTS have been observed on this reef and it is currently classified as Non-Outbreaking.

Reef No. 16-013 (b)

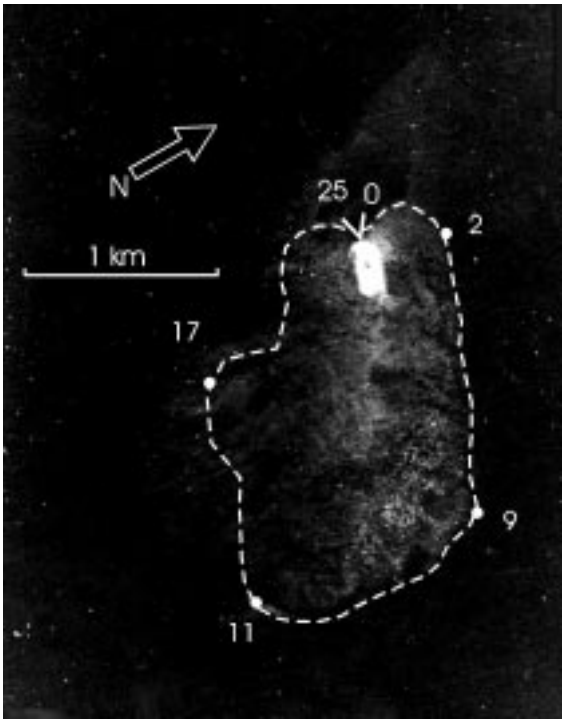
This reef has only been surveyed in 1995 and 1998. Over this time there has been no appreciable change in coral cover which is currently considered to be at a high level. No COTS have been observed on this reef and it is classified as Non-Outbreaking.

Reef No. 16-013 (c)

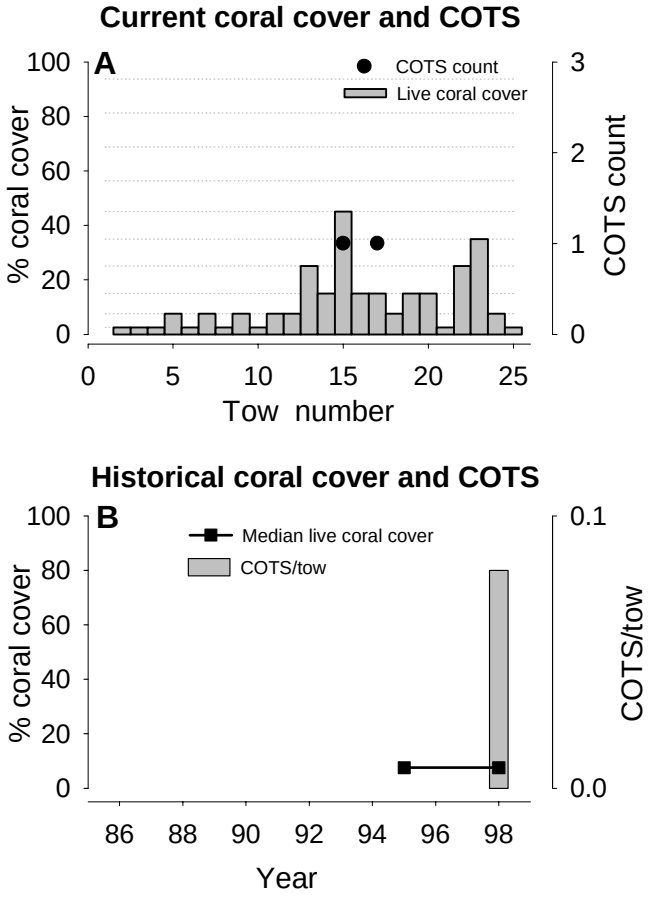
This reef has only been surveyed in 1995 and 1998. Initial surveys revealed a high COTS population on this reef and it was classified as an Incipient Outbreak. Recent surveys reveal COTS are still present in relatively high numbers on this reef and coral cover has declined to a moderate level from the previous high cover. Reef No 16-013 (c) is currently classified as an Incipient Outbreak.

Figure 5.60

Upolu Cay



Upolu Cay (No. 16-046) is a middle shelf planar reef with an area of 12.1 sq.km. There is vegetated sand cay the western side. Last surveyed February 1998.



Upolu Cay

This reef has only been surveyed in 1995 and 1998. Over this time there has been no appreciable change in coral cover which remains at low levels. Although COTS were observed on this reef during our most recent surveys they were not considered sufficently abundant to impact on coral cover. Upolo Cay is currently classified as Non-Outbreaking.

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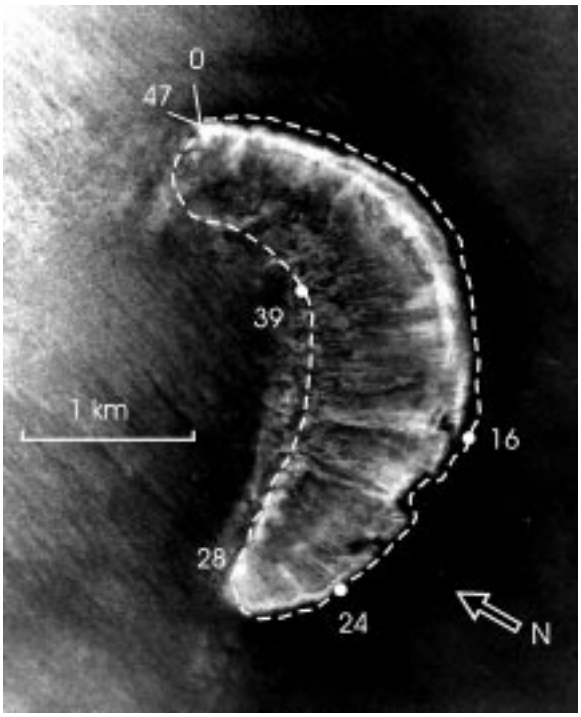
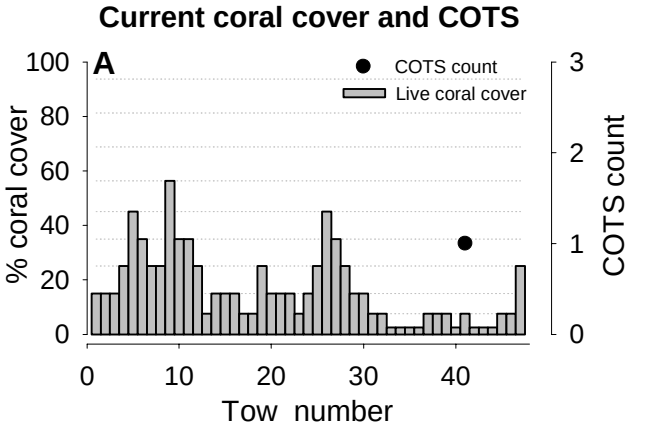
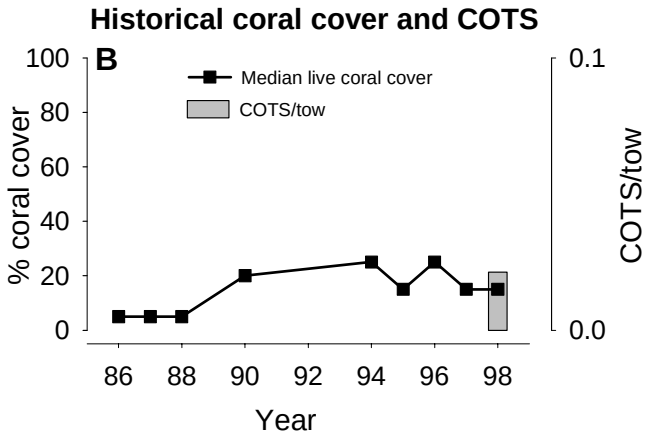
Innisfail
Reef Pages

Figure 5.61

Feather



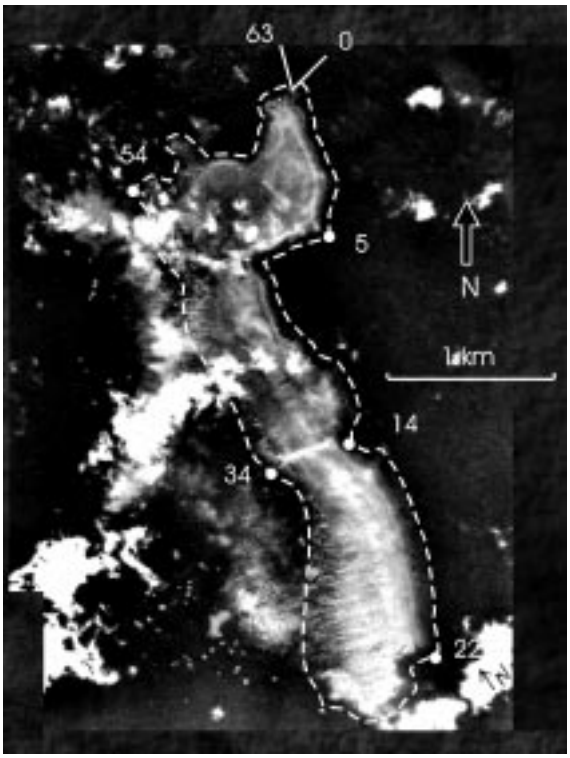


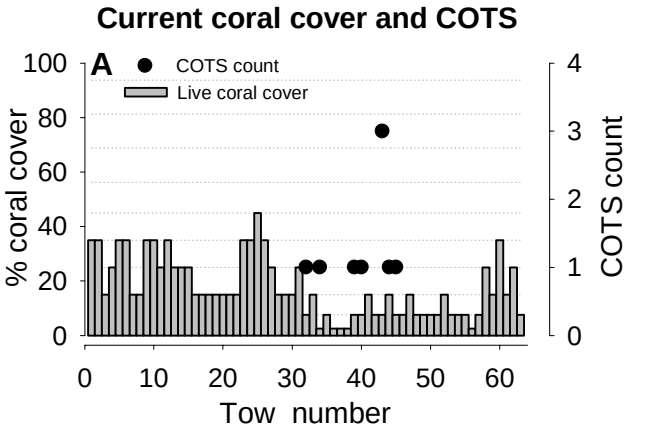


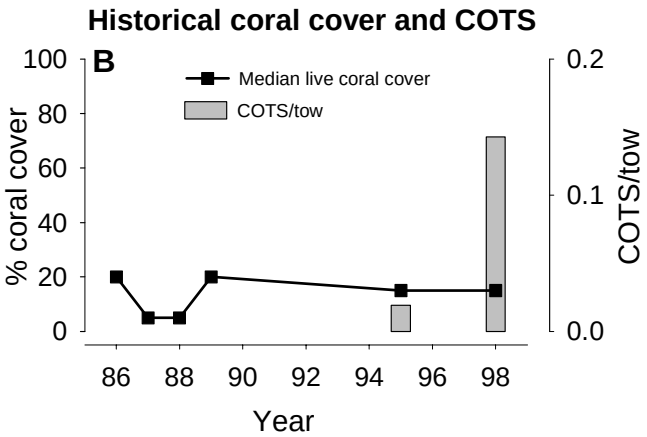
Feather (No. 17-034) is a middle shelf crescentic reef with an area of 14.1 sq.km. Last surveyed February 1998.

Figure 5.62

Noggin

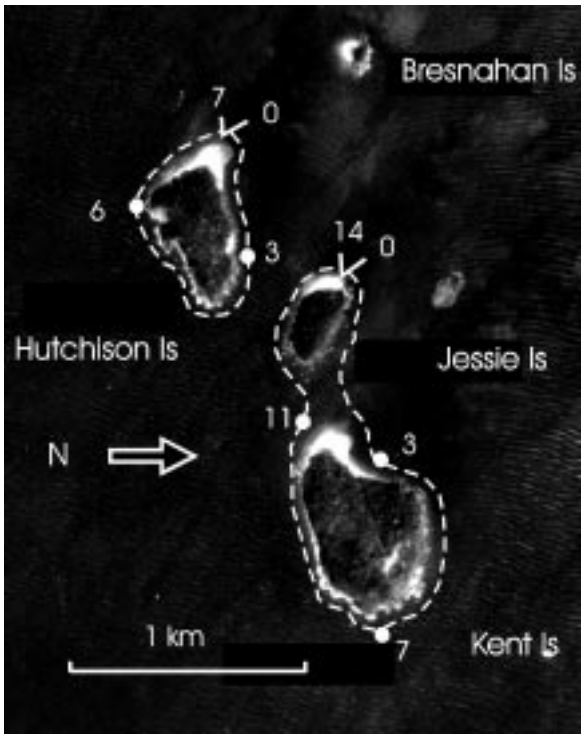


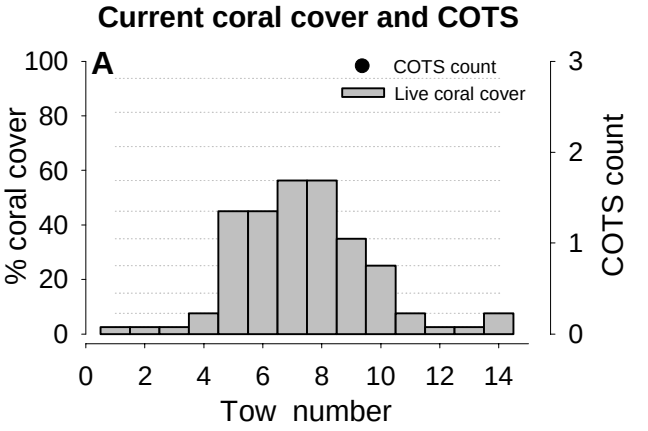


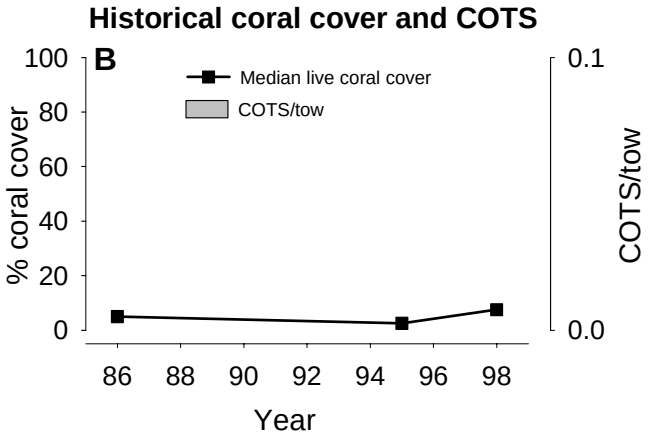


Noggin (No. 17-008) is an outer shelf crescentic reef with an area of 9.2 sq.km. Last surveyed February 1998.

Figure 5.63 **Jessie and Kent Islands**







Jessie and Kent Islands (No. 17-043) is an inner shelf fringing reef surrounding a high continental island. Last surveyed February 1998.

Feather

This reef has been surveyed extensively since 1986 when it was initially classified as Recovering from previous COTS activity. Since this time there has been a gradual increase in coral cover to the current moderate level. Although COTS were observed on this reef during our most recent survey, they are in numbers too low to be considered to impact significantly on live coral cover. The slow rate of increase in coral cover on this reef means it remains classified as Recovering, despite the last Active Outbreak being recorded on this reef in 1983.

Noggin

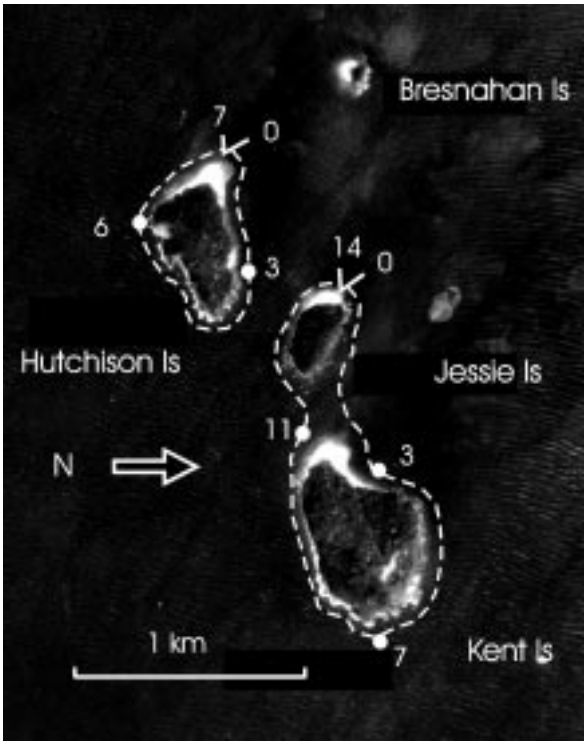
This reef has been surveyed intermittantly using manta tow six times since 1986. Coral cover has generally remained at a moderate level. Although coral cover declined slightly between 1987 and 1988 it has since recovered to the levels initially recorded on this reef. COTS have only been observed on this reef since 1995. While COTS remain at levels below those considered to cause significant coral mortality, recent surveys indicate COTS numbers may be increasing. Future surveys should determine if this trend continues. Noggin Reef is currently classified as Non-Outbreaking.

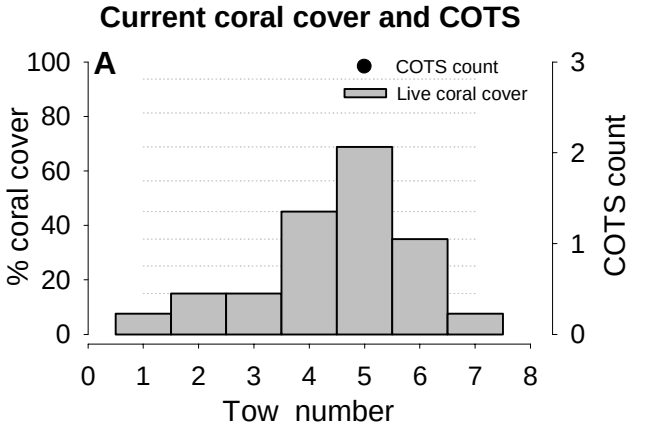
Jessie and Kent Islands

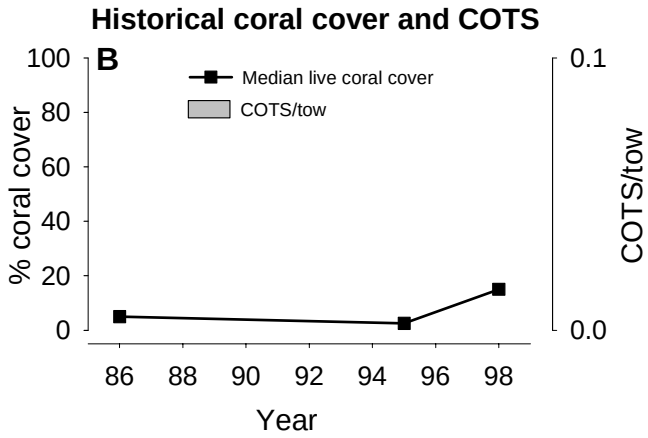
This reef has only been surveyed three times since 1986. Sampling suggests that there has been little change in coral cover and it remains at a low level. However, recent surveys indicate a trend of increasing coral cover. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

Figure 5.64

Hutchison Island



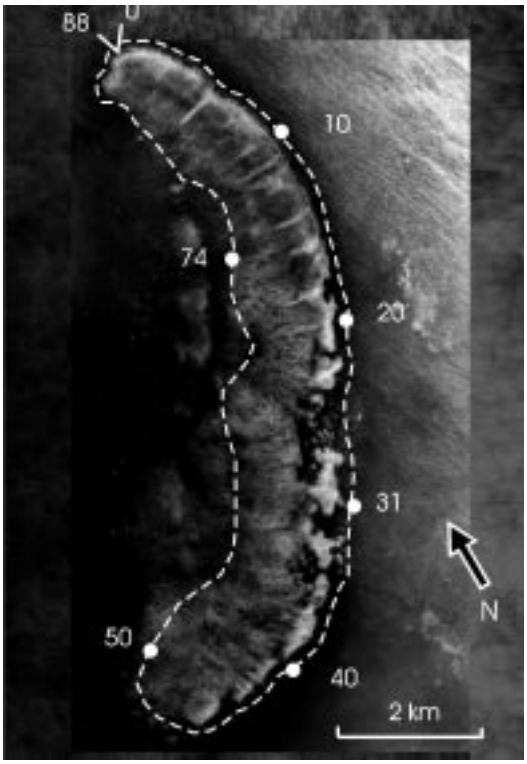


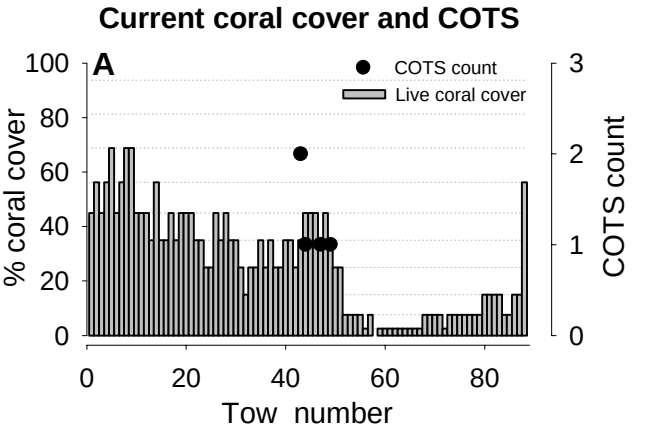


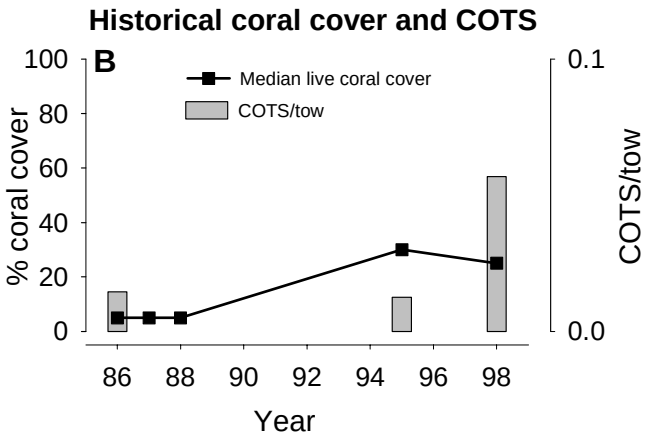
Hutchison Island (No. 17-043) is an inner shelf fringing reef with an area of 0.3 sq.km which surrounds a high wooded continental island. Last surveyed February 1998.

Figure 5.65

Potter (a)

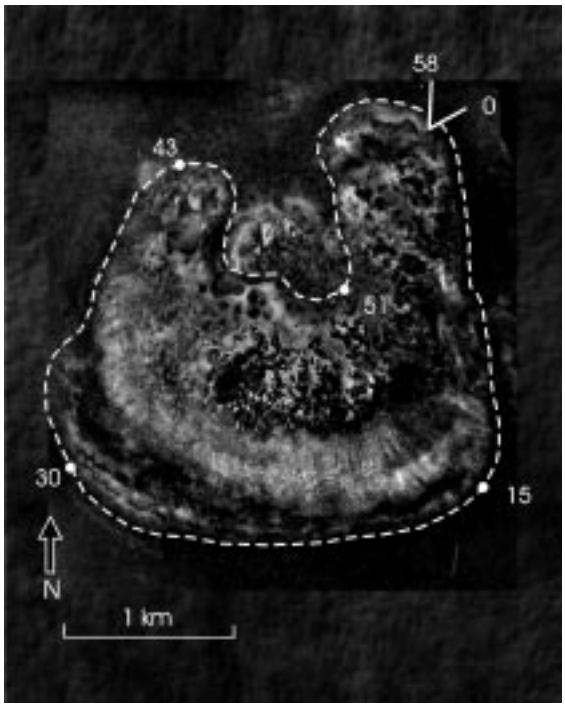




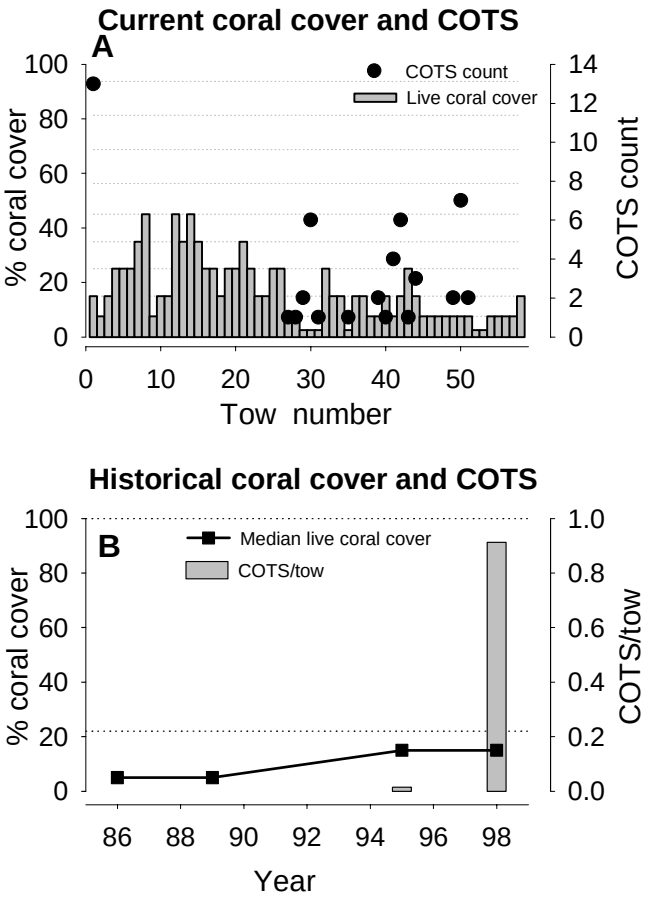


Potter (a) (No. 17-059) is an outer shelf submerged reef with an area of 15.7 sq.km. Last surveyed February 1998.

Figure 5.66 **Scott**



Scott (No. 17-004) is a middle shelf crescentic reef with an area of 16.7 sq.km. Last surveyed February 1998.



Hutchison Island

This reef has only been surveyed three times since 1986. The manta tow surveys show an appreciable increase in coral cover in recent years to a moderate level. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

Potter (a)

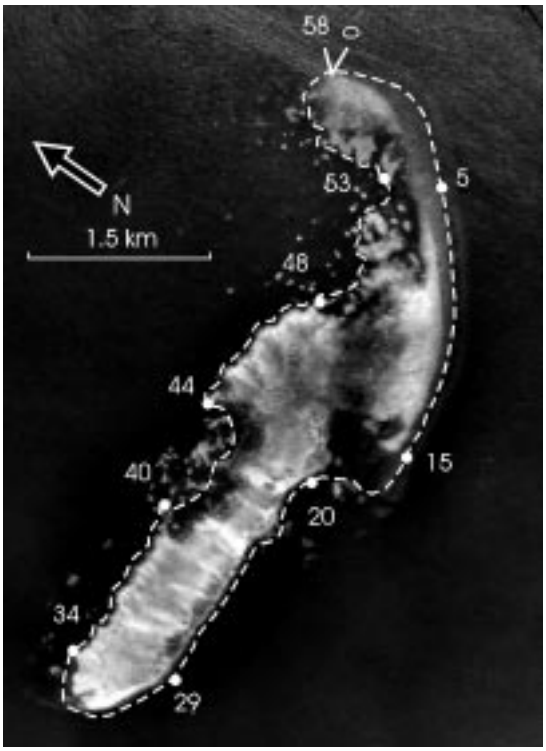
This reef has been surveyed five times since 1986. Surveys indicate a gradual increase in coral cover to the present moderate levels. COTS numbers on this reef appear to be on the rise, however they still remain in numbers too low to be considered to cause significant coral mortality. Potter (a) Reef is currently classified as Non-Outbreaking.

Scott

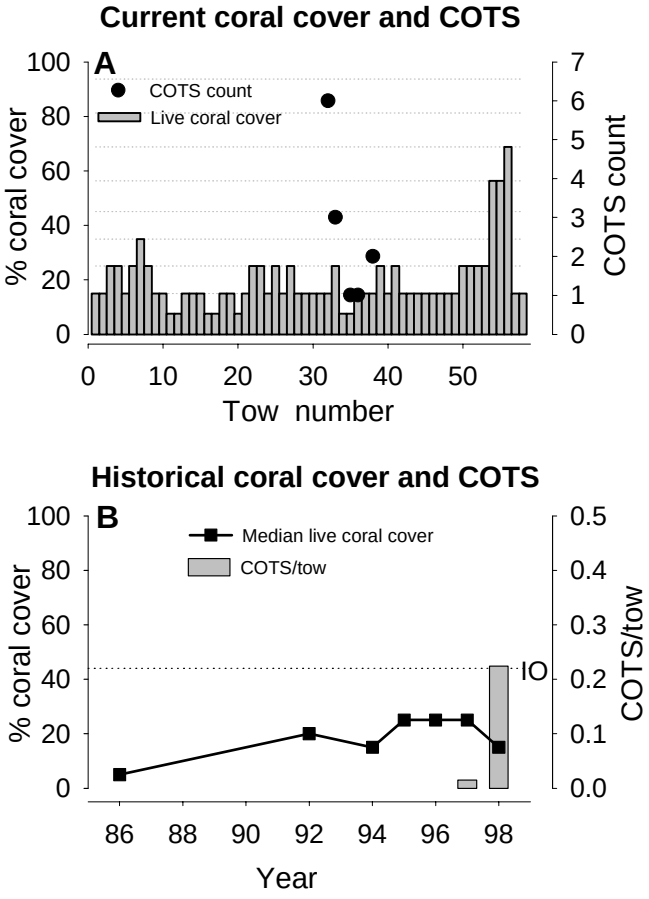
This reef has only been surveyed four times since 1986. Initially this reef was classified as Recovering from COTS activity recorded before the advent of broadscale surveys. Our data indicate a small but gradual recovery of coral cover to the present moderate level. Our most recent surveys suggest a dramatic rise in COTS numbers to a level expected to cause significant coral mortality and consequently Scott Reef is currently classified as an Incipient Outbreak and coral cover is expected to decline.

Figure 5.67

Wardle



Wardle (No. 17-032) is an outer shelf crescentic reef with an area of 11.8 sq.km. Last surveyed February 1998



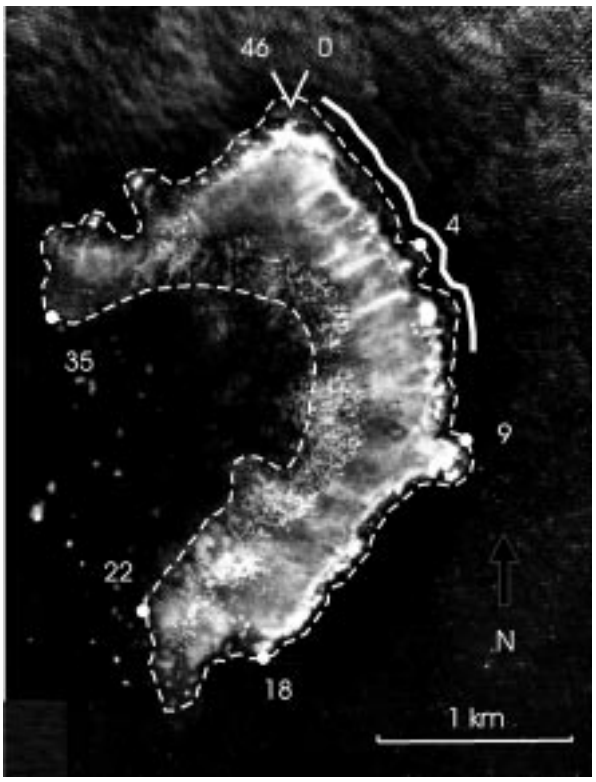
Wardle

This reef has been surveyed seven times since 1986. Initially this reef was classified as Recovering from COTS activity recorded prior to the advent of broadscale surveys. Our surveys indicate a small but gradual recovery of coral cover to the present moderate level. The most recent surveys reveal a dramatic rise in COTS numbers to a level expected to cause significant coral mortality. This is also reflected in coral cover estimates, which were lower in 1998. Wardle Reef is currently classified as an Incipient Outbreak.

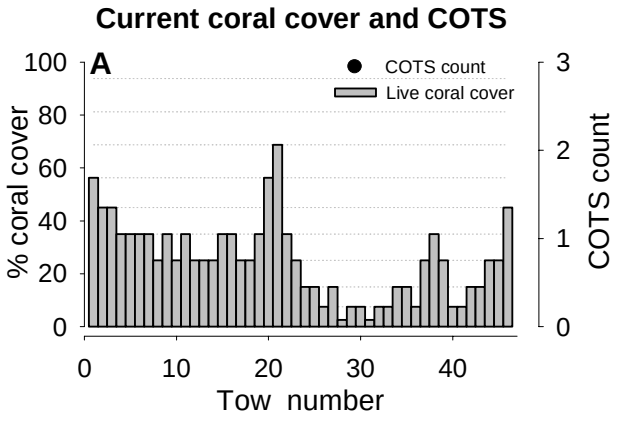
Townsville
reef pages

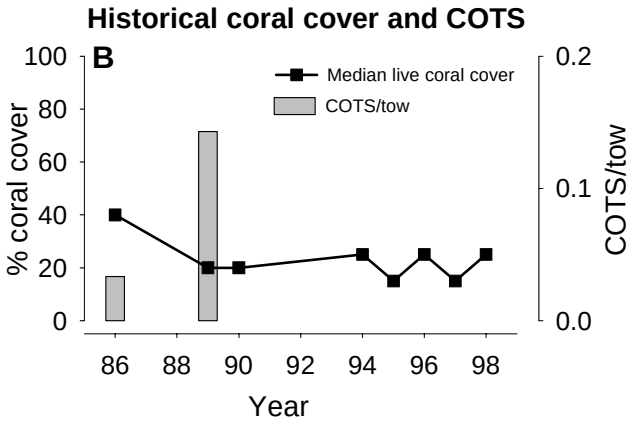
Figure 5.68

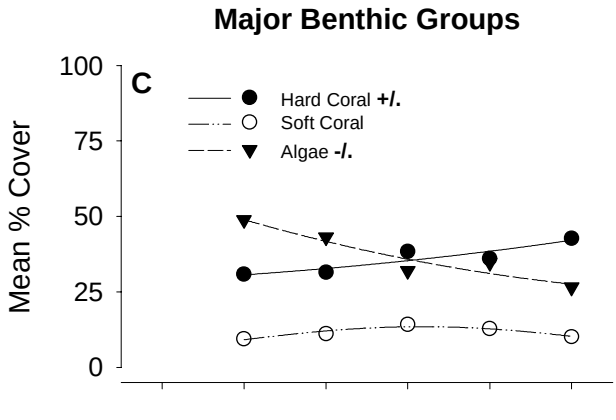
Chicken

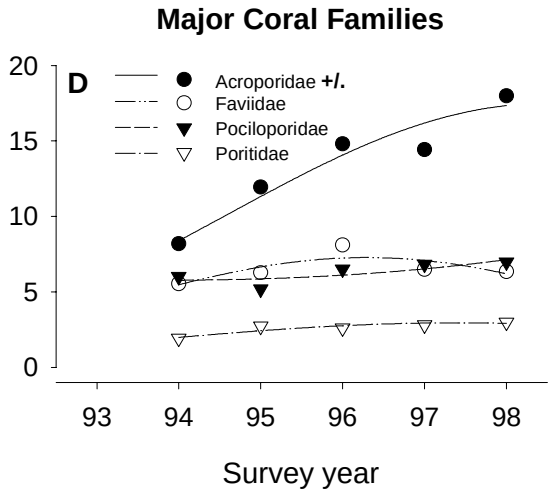


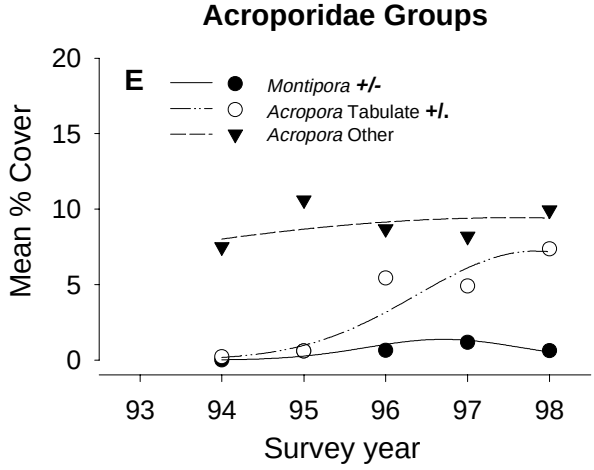
Chicken (No. 18-086) is an outer shelf crescentic reef with an area of 3.8 sq.km. Last surveyed May 1998.

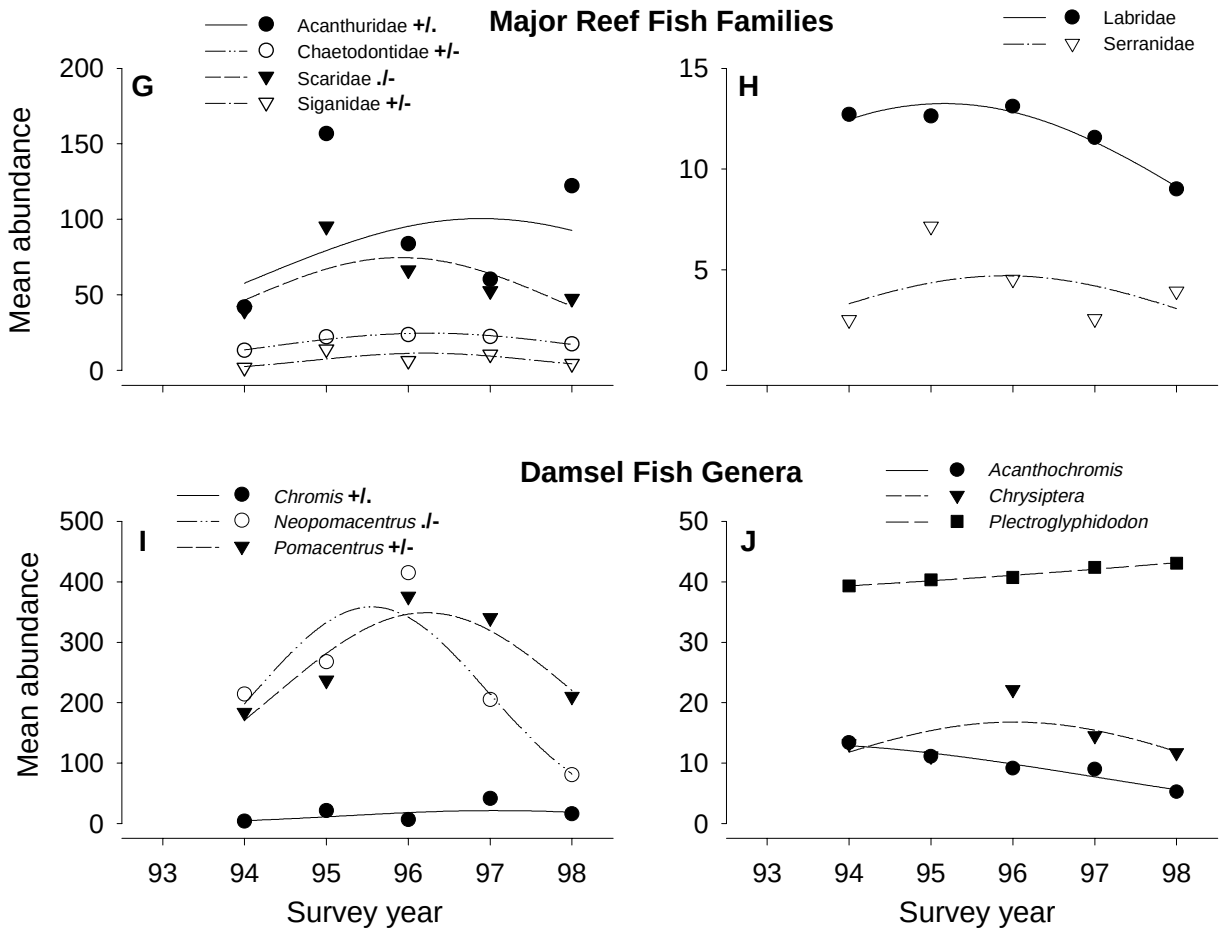












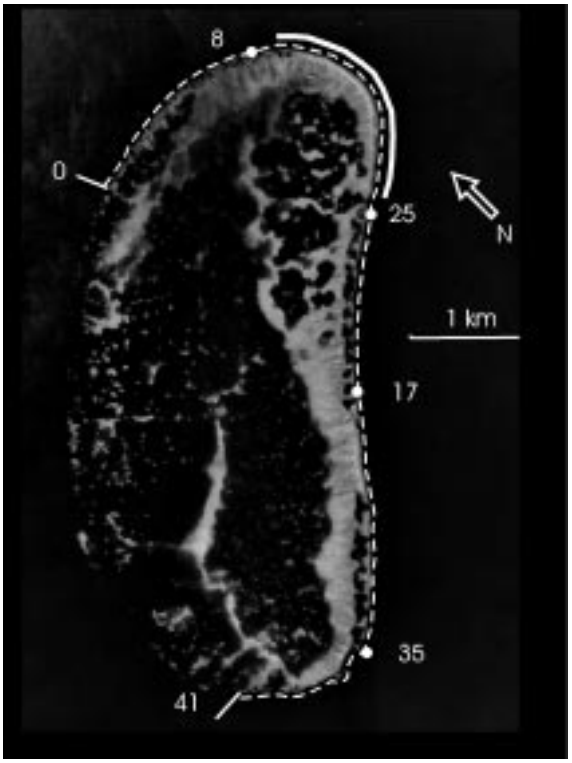
Chicken

This reef has been surveyed since 1986 using the manta tow technique. The initial survey indicated a high coral cover which then dropped to a moderate level in 1989, most likely as a result of COTS which were present in elevated numbers at this time. Since 1989 coral cover has remained stable at moderate levels up until the present time. Detailed coral surveys on the northeastern flank show that coral cover has increased by 11.8% since surveys began in 1993 and is currently moderately high at 42.7%. This reflects increases in tabulate and corymbose *Acropora* and to a lesser extent *Porites* spp. The abundance of *Pocillopora* spp. has remained relatively high. The cover of algae has declined since detailed surveys were initiated. No COTS have been recorded since 1989 and the reef is currently classified as Non-Outbreaking. Low levels of coral bleaching were recorded in 1998.

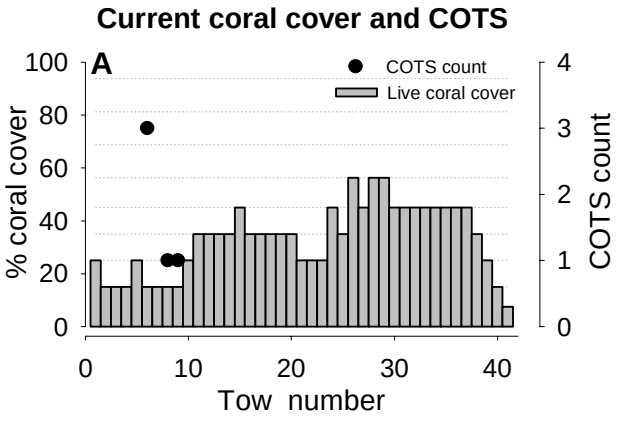
Major trends in the fish community follow the general pattern observed on many reefs, of increasing abundance to 1996 then a decline as seen in Chaetodontidae (*Chaetadon citrinellus*), *Neopomacentrus* (*N. azysron*) and *Pomacentrus* (*P. bankanensis*, and *P. lepidogenys*). The increase in Acanthuridae is due primarily to *A. nigrofuscus, Ctenochaetus* spp. and *Zebrasoma scopas*, all of which have had variable estimates of abundance. The observed trends in *Chromis*, Scaridae and Siganidae result from intermittent inclusion of schooling species (*C. weberi, Scarus globiceps* and *S. sordidus*, and *Siganus corallinus* respectively).

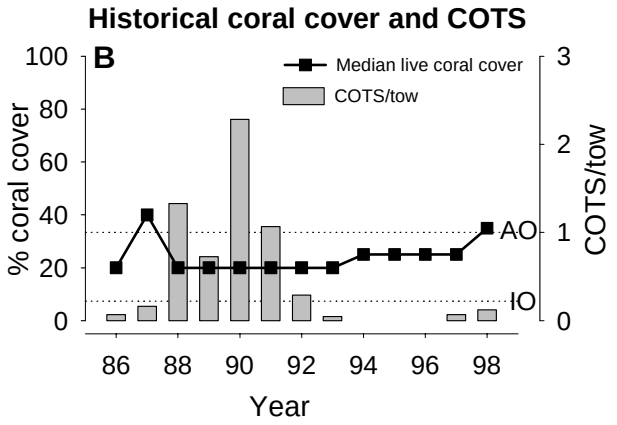
Figure 5.69

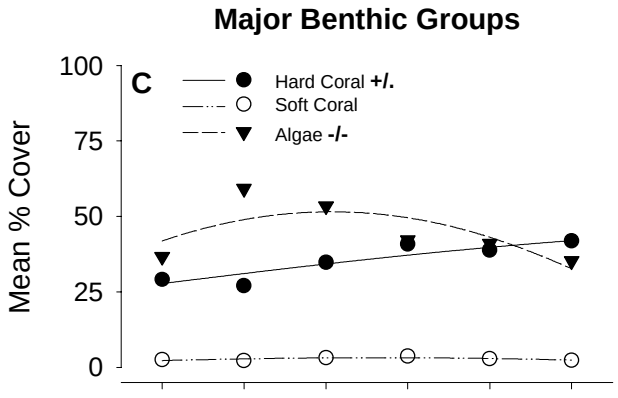
Davies

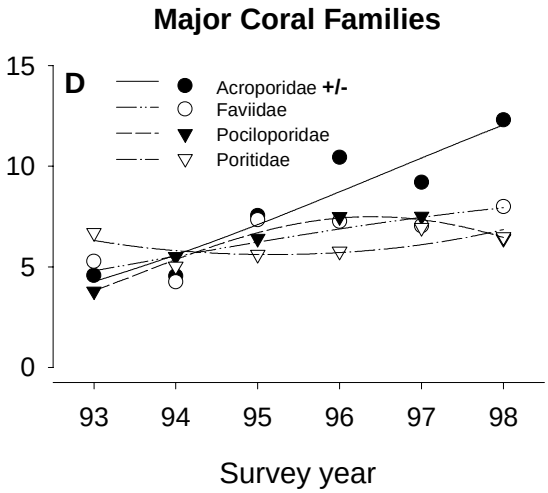


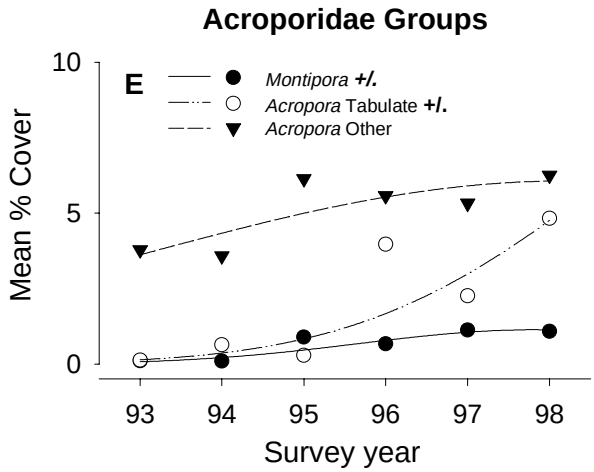
Davies (No. 18-096) is a middle shelf lagoonal reef with an area of 13.8 sq.km. Last surveyed May 1998.

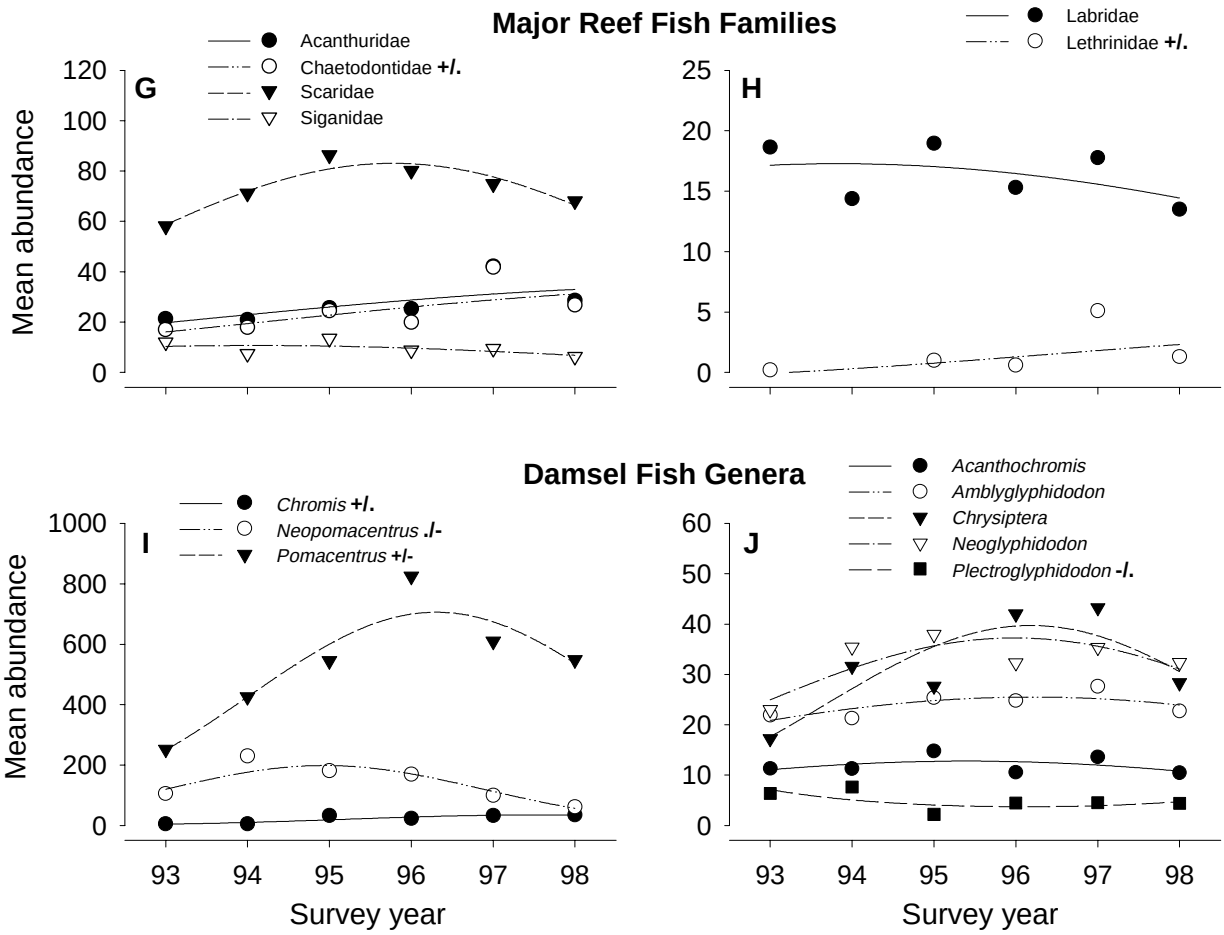












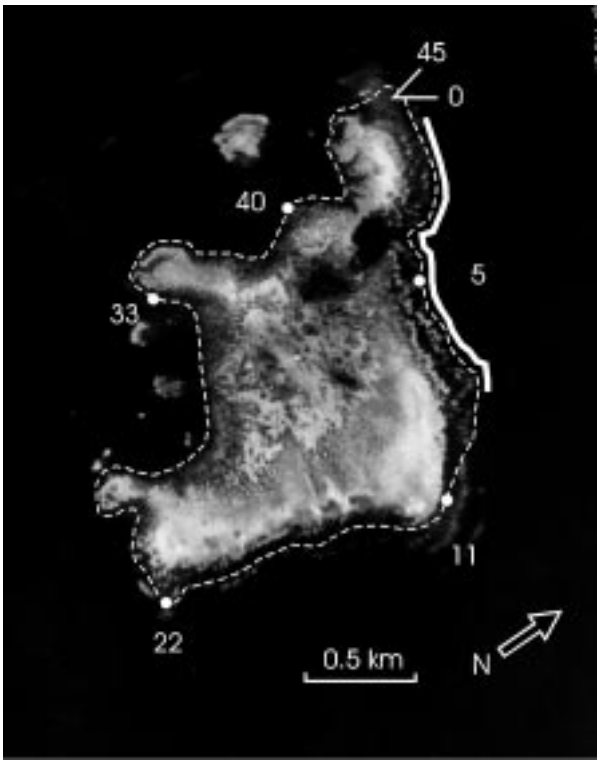
Davies

This reef has been surveyed annually since 1986 using manta tow. Initial surveys show increasing COTS densities. The reef was classified as an Active Outbreak from 1988 through to 1993 when it was reclassified as Recovering. However, the elevated COTS populations appeared to have had only a minimal effect on coral cover at the reef scale with cover largely unaffected. Recent surveys show an increase in coral cover to the present high level as well as a concomitant increase in COTS numbers. Detailed coral surveys since 1993 show that hard coral cover on this reef has increased by 12.6% through to 1998 and is currently moderately high at 41.9%. An observed decrease in tabulate *Acropora* spp. in 1997 is attributed to the effects of heavy wave action resulting from Cyclone Justin which was active in the region in February 1997. Acroporidae and Favidae have increased with other groups remaining stable. Low level bleaching was recorded in 1998. COTS are presently in numbers which are not causing significant coral mortality and this reef is currently classified as Recovering.

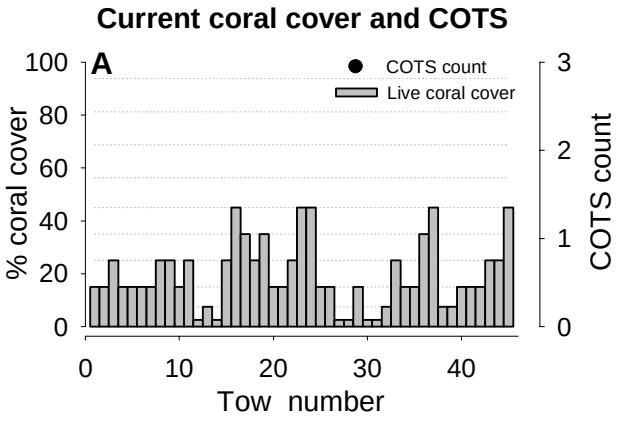
Increasing coral cover is reflected in the fish community with predominantly stable or increasing trends. Chaetodontids have shown a steady increase largely due to *Chaetodon baronessa*, *C. rainfordi*, and *C. trifasciatus*. The trend in *Chromis* was due to increases in *C. atripectoralis* between 1993 and 1994. *Pomacentrus moluccensis* and *P. lepidogenys* both increased strongly until 1996 before a period of slight decline. The increase in Lethrinidae is a result of high counts of *Lethrinus miniatus* in 1997. This species was noted to be very active in shallow reef areas in the region for several months following the passage of Cyclone Justin. The only group showing a statistical overall decline was *Plectroglyphidodon.*

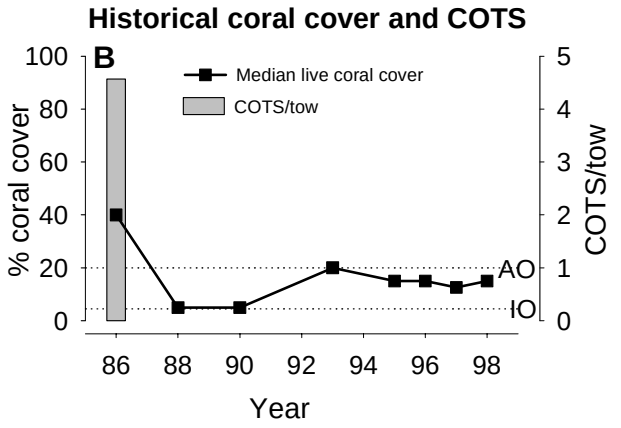
Figure 5.70

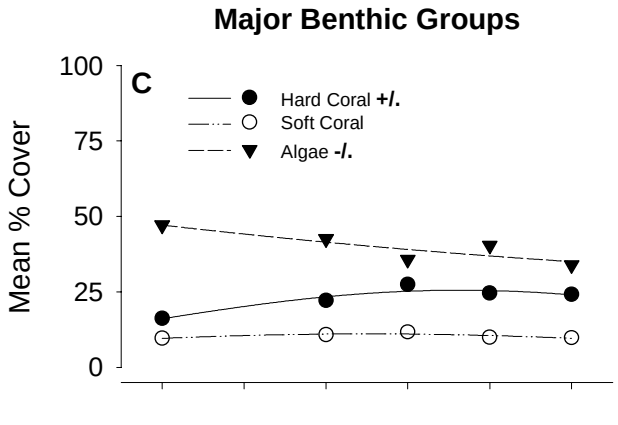
Dip

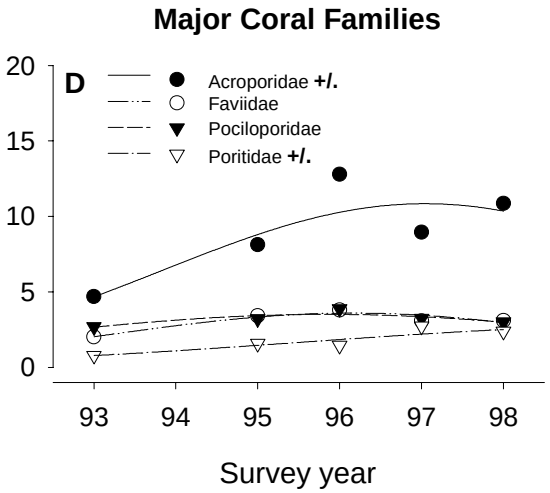


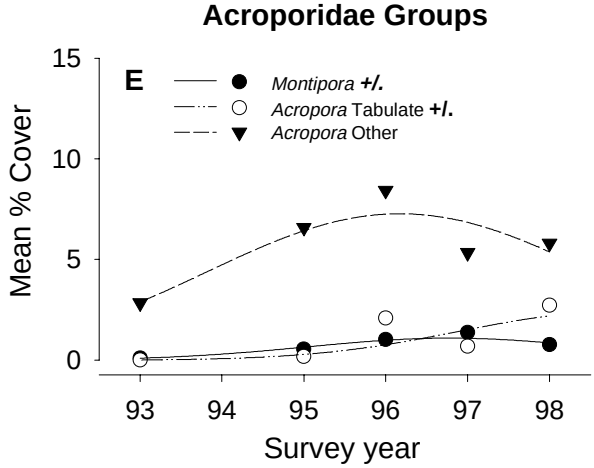
Dip (No. 18-039) is an outer shelf crescentic reef with an area of 5.6 sq.km. Last surveyed May 1998.

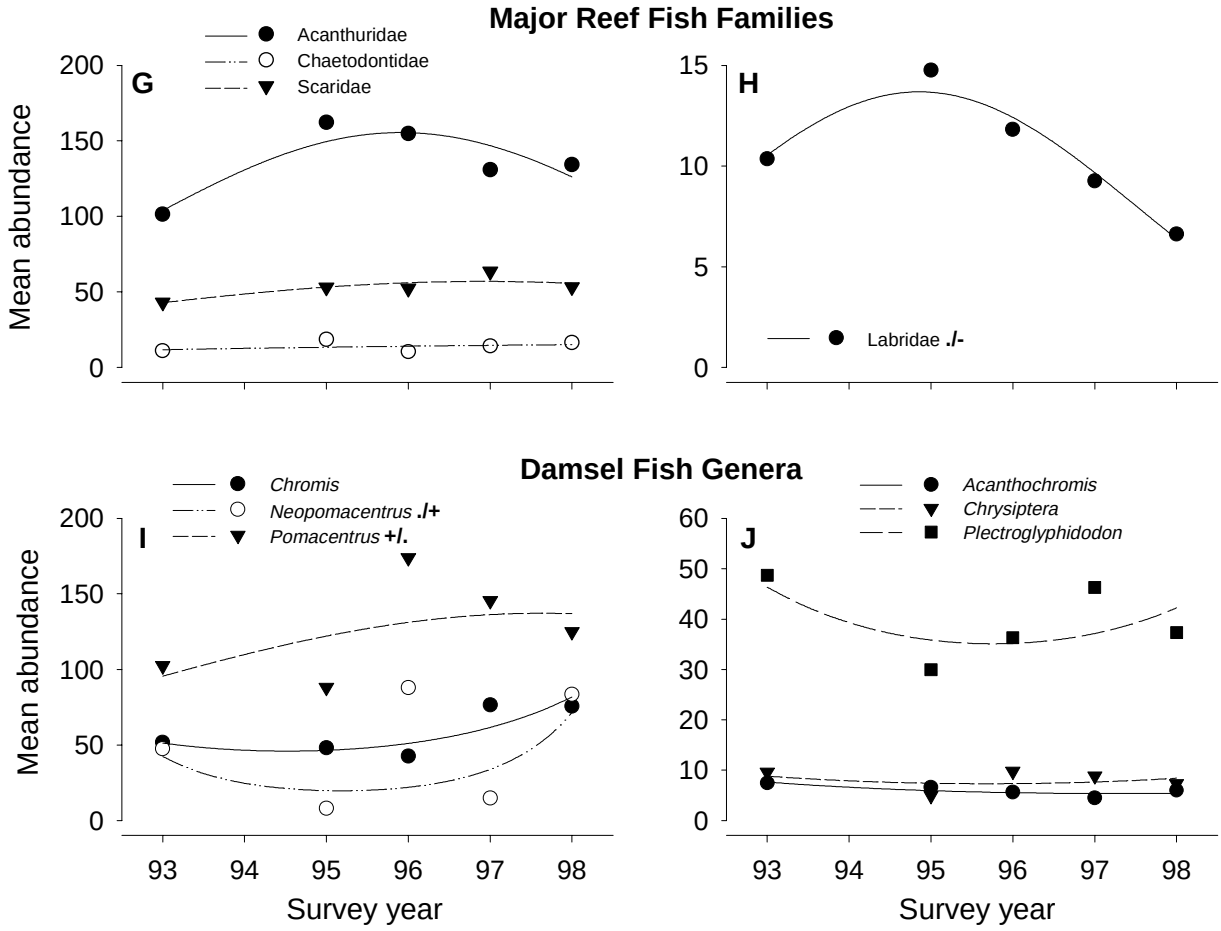












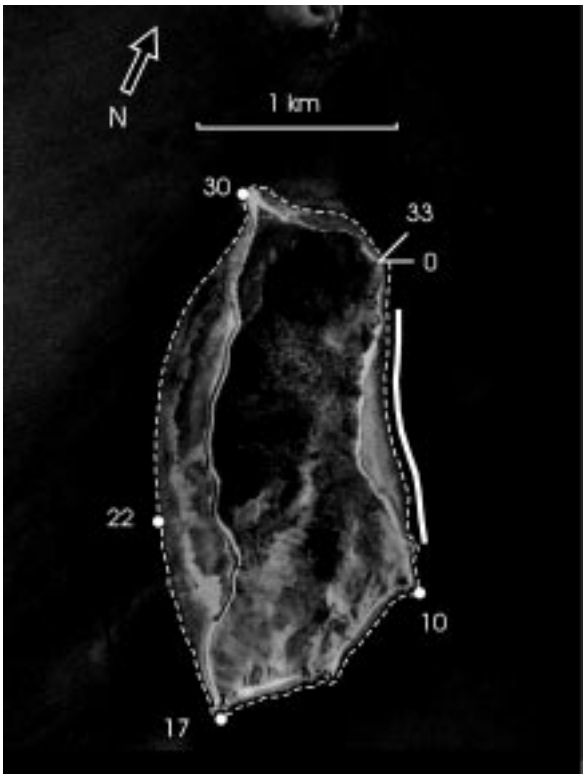
Dip

This reef has been surveyed since 1986 using the manta tow technique. Initial surveys revealed high COTS densities and the reef was consequently classified as an Active Outbreak. Coral cover declined dramatically in the initial years of survey before showing some recovery then stabilising from 1993. Detailed coral surveys, started in 1993, show that there has been a gradual increase in coral cover from 9% to the current level of 25.5% on the northern flank of the reef. The increase reflects increases in tabulate and corymbose *Acropora* and to a lesser extent *Montipora* spp. and Poritidae. The reef is still classified as Recovering from the earlier COTS outbreak. Low levels of coral bleaching were recorded during 1998.

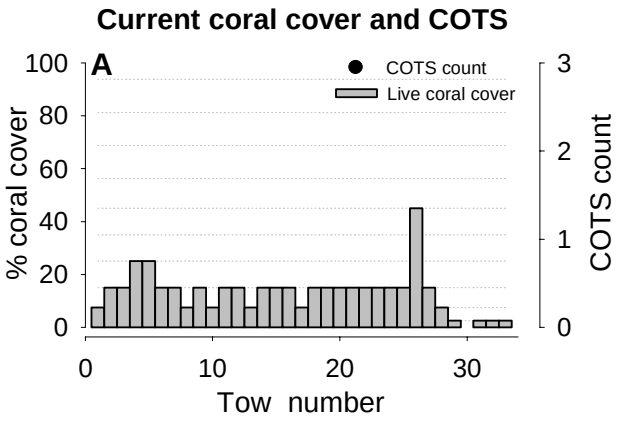
Pomacentrus lepidogenys dominates the observed trend in *Pomacentrus* with a large increase in abundance between the 1995 and 1996 surveys followed by a current decrease. The three most abundant species of Labridae (*Gomphosus varius*, *Halichoeres hortulanus* and *Hemigymnus fasciatus*) have been steadily declining since the 1995 survey. The observed trend in *Neopomacentrus* is due *to N. azysron,* however the variability in abundance estimates suggest caution in assigning an increase to this species.

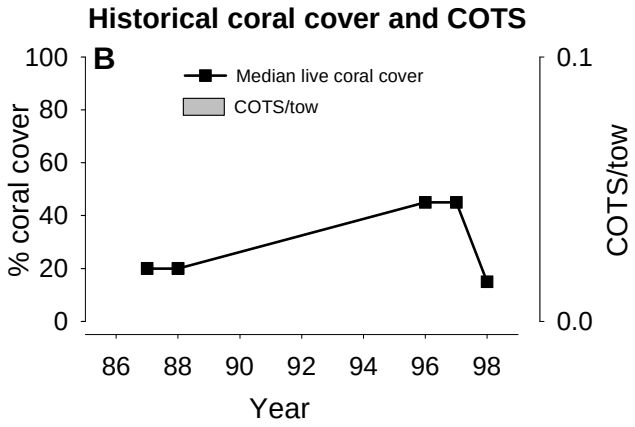
Figure 5.71

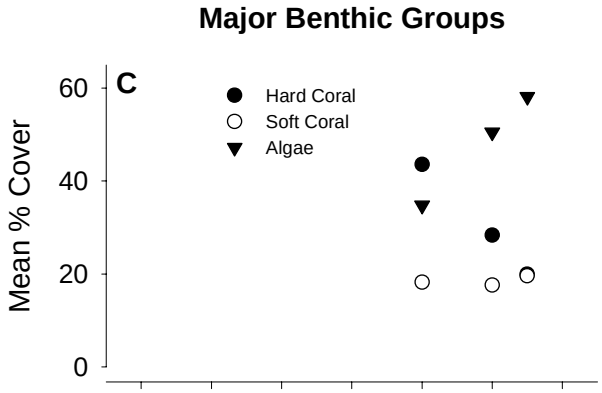
Havannah Island

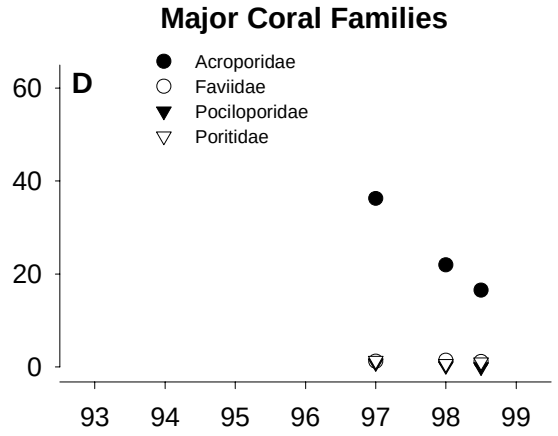


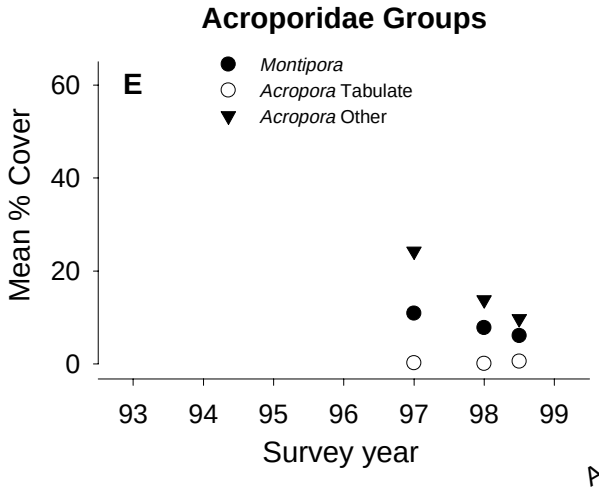
Havannah Island (No. 18-065) is an inner shelf fringing reef which surrounds a high continental island. The reef has an area of .3 sq.km. Last surveyed April 1998.

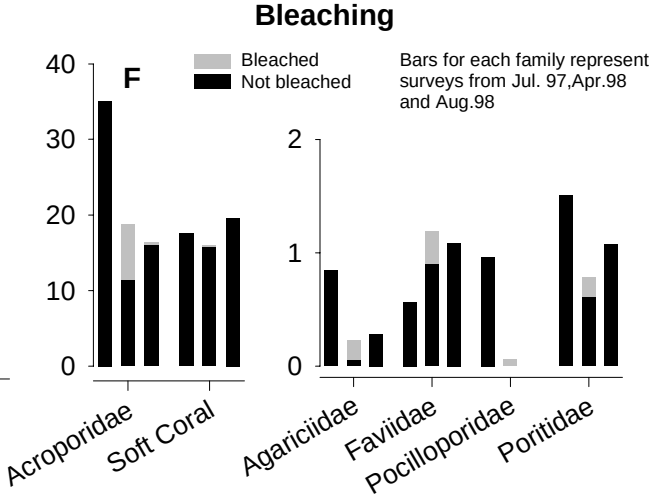


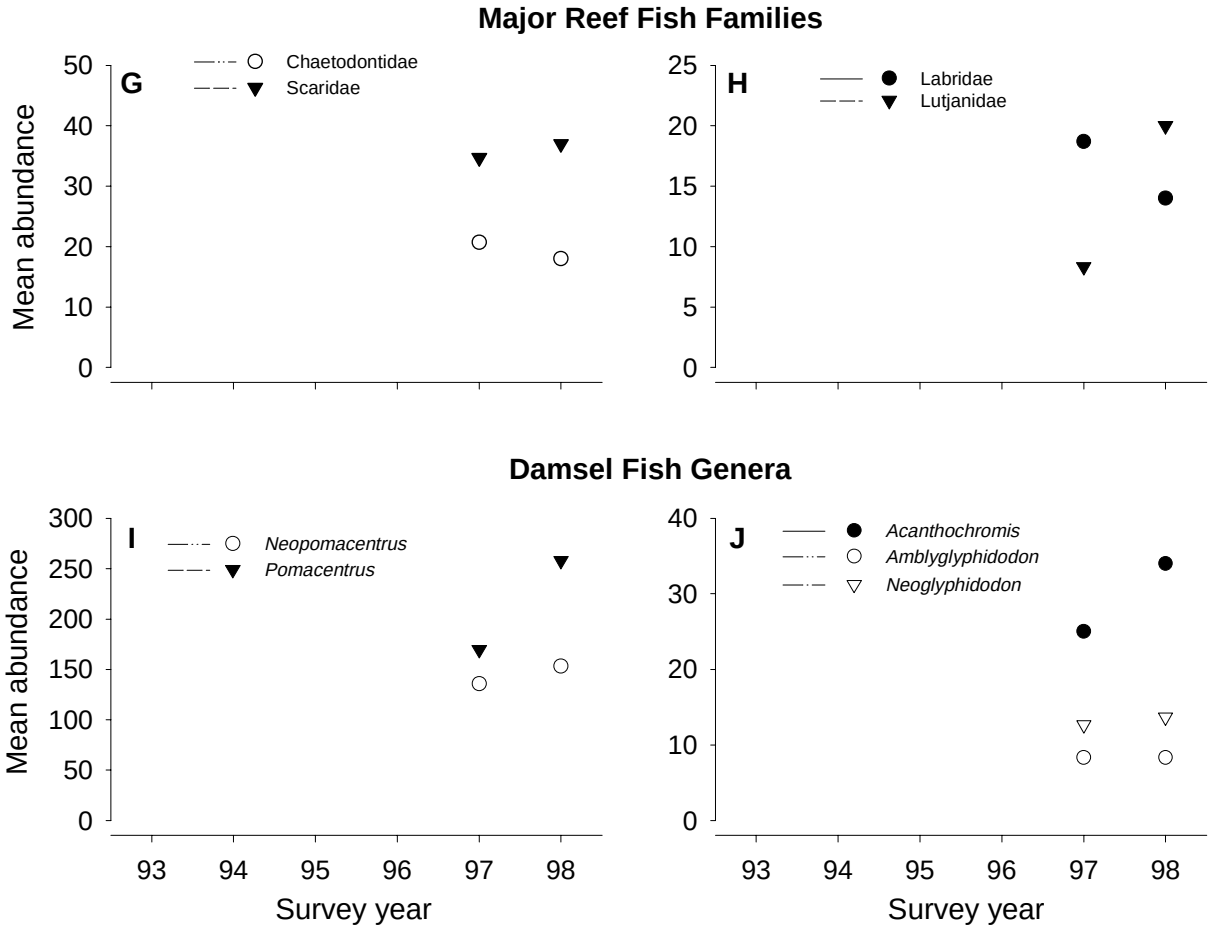












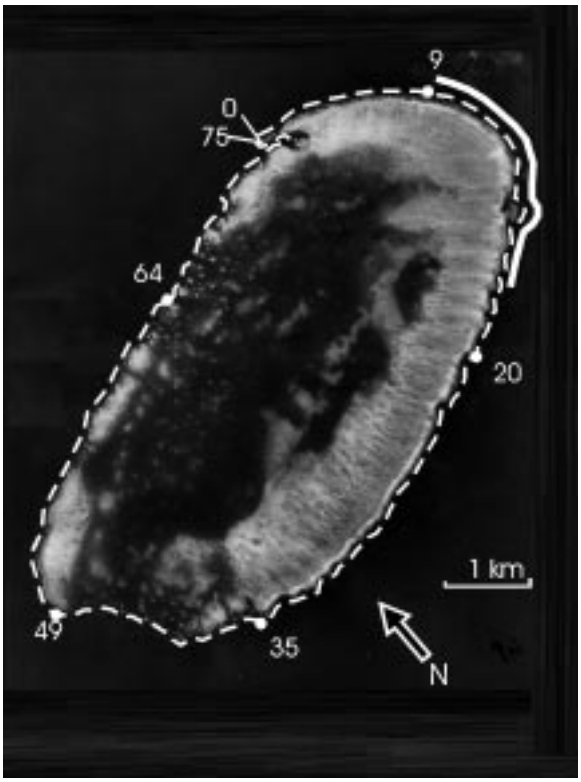
Havannah Island

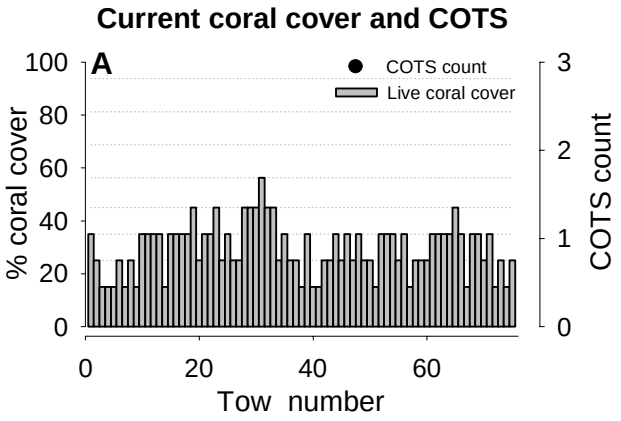
This reef has been surveyed five times since 1987 using manta tow. Coral cover increased between 1987 and 1997 then decreased dramatically in 1998. Detailed coral surveys show that hard coral cover declined from 43.6 % in 1997 to 28.3 % in May 1998. This reef was dominated by *Acropora* spp in 1997 (35% cover). By 1998, cover of *Acropora* had declined dramatically to 21.9%. The observed coral mortality is attributed to a failure of the corals to recover from a large scale bleaching event which occurred over the 1997/98 summer on the GBR. Extensive bleaching was observed on Havannah during surveys in May 1998. Consequently we decided to re-survey the reef in August 1998 to examine the effects of bleaching. By the time of re-survey *Acropora* cover had further declined to 16.1% with the dead *Acropora* densely colonized by turf and small non-fleshy macro algae. Corals of the family Pocilloporidae present in the 1997 survey were not recorded in August 1998: this is also attributed to the bleaching event. Very little soft coral was observed to be bleached during surveys and overall the cover has not changed, indicating that bleaching did not affect the dominant soft coral species on this reef (*Clavularia* sp. and *Briarium* spp.). No COTS have been recorded using manta tow on this reef and it is currently classified as Non-Outbreaking.

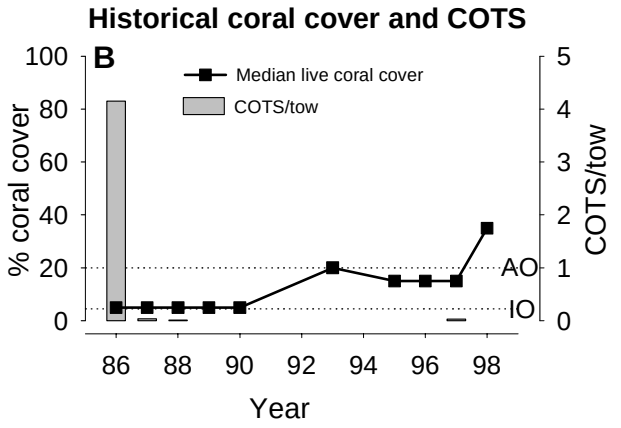
Two surveys is insufficient to assess changes in the fish community however no fish taxa appear to have markedly declined as a result of the bleaching induced coral mortality.

Figure 5.72

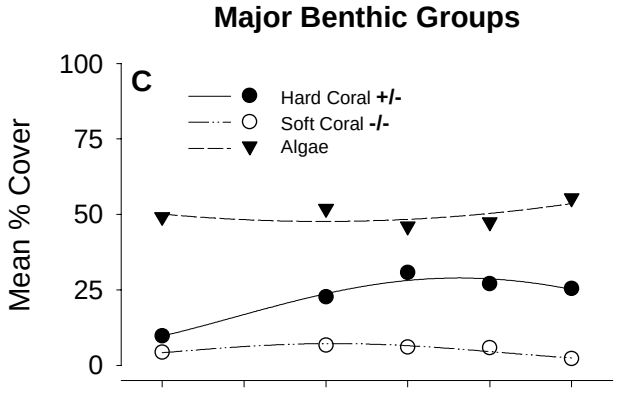
John Brewer

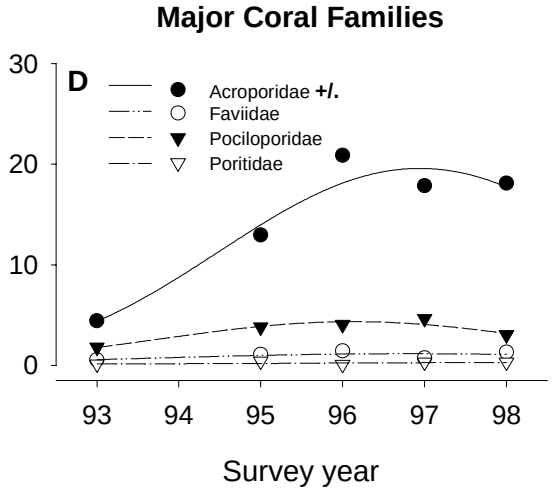


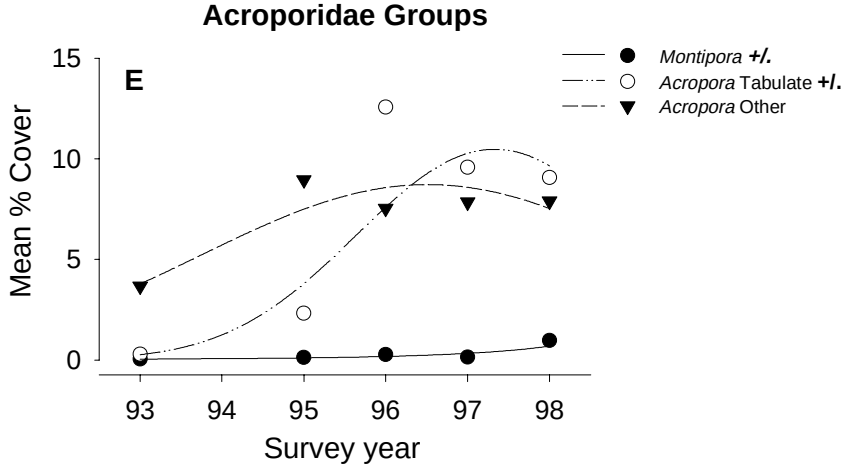


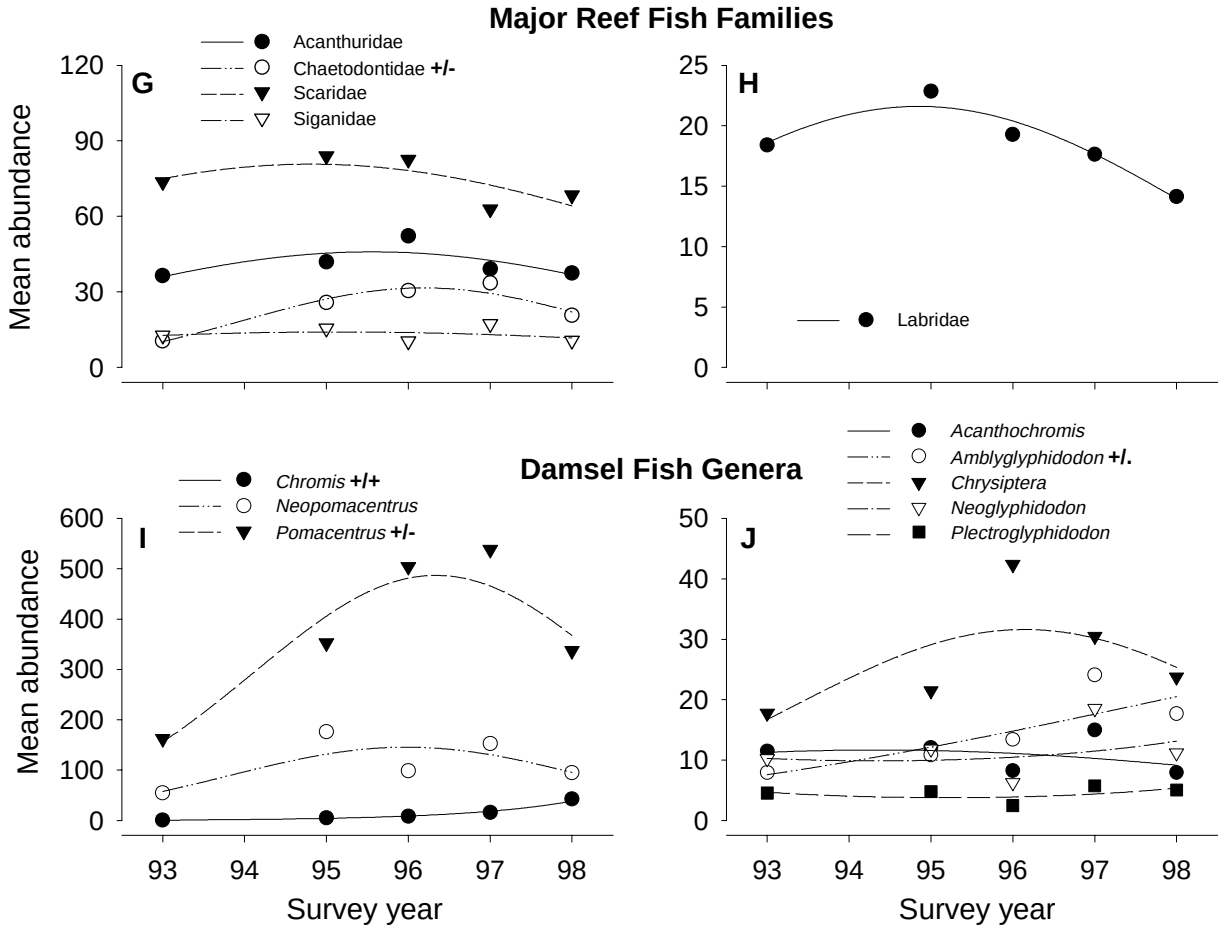


John Brewer (No. 18-075) is a middle shelf lagoonal reef with an area of 17.5 sq.km. Last surveyed April 1998.









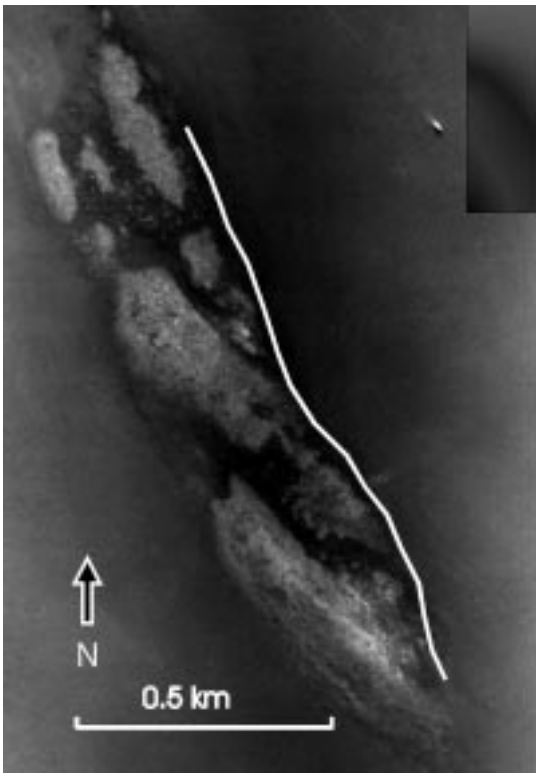
John Brewer

This reef has been surveyed since 1986 using manta tow. Previous surveys indicate that John Brewer was subject to extremely high COTS populations prior to 1986. This was confirmed in the initial year of survey when the reef was classified as an Active Outbreak. COTS populations subsequently declined and coral cover remained low through to 1990. When the reef was resurveyed in 1993, coral cover had increased to moderate levels. 1998 overall coral cover was at high levels. Detailed coral surveys since 1993 show that hard coral cover reached a maximum in 1996 then declined slightly in 1997 with the impact of Cyclone Justin resulting in a decline in tabulate *Acropora*. The cover of soft corals also declined from 6% to 2.34% in the last survey period. There has been a corresponding increase in algae. Low numbers of COTS were observed in 1997 and a low level of coral bleaching was recorded in 1998. The reef is currently classified as Recovering from an earlier COTS outbreak.

The general increase in coral cover to 1996 is reflected in the fish community with all groups stable or increasing over this period. *Amblyglyphidodon* (*A. curacao*), *Pomacentrus* (*P. moluccensis* and *P. lepidogenys*), and Chaetodontidae (*Chaetadon baronessa*, *C. rainfordi*, and *C. trifasciatus*) all increased to 1997 before a slight decline. *Chromis* continued to increase over the period of surveys largely due to *C. atripectoralis*.

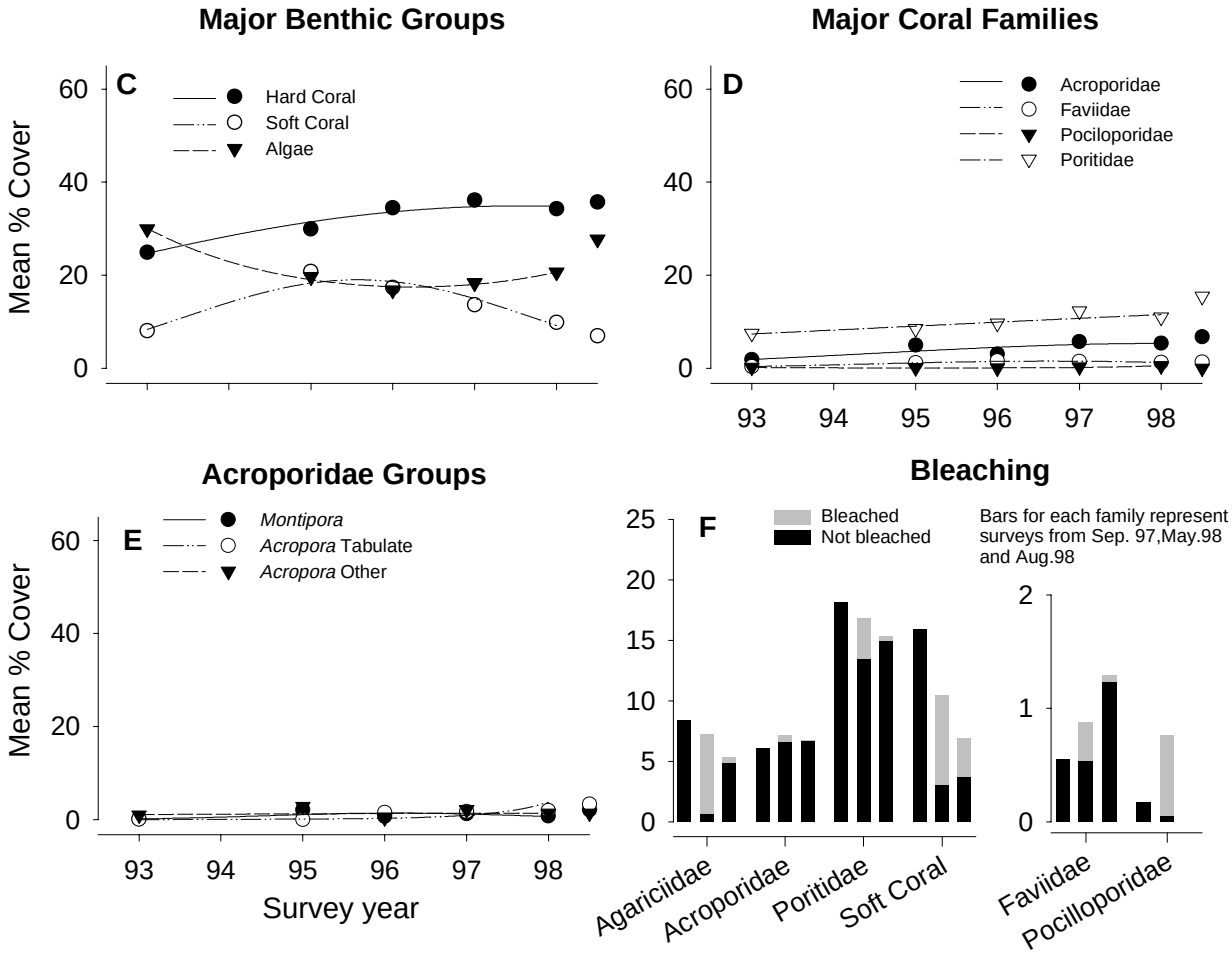
Figure 5.73

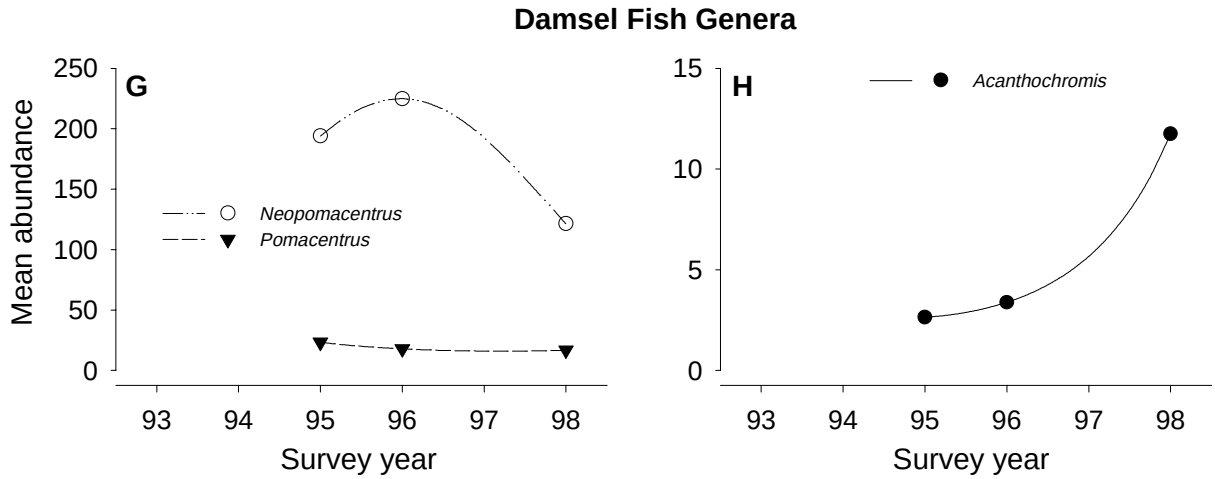
Middle



Middle (No. 19-011) is an inner shelf planar reef with an area of 1.2 sq.km. Last surveyed May 1998.

No manta tow surveys conducted at Middle Reef due to poor visibility





Middle

Fixed transects have been surveyed on this reef annually since 1993 (except 1994). Manta tow surveys are not conducted on this reef due to the poor water visibility. It is worth noting that the video surveys still produce the required quality footage even when visibility is 2 m or less. Coral cover has remained fairly constant since surveys began and was recorded at 34.2% in 1998.

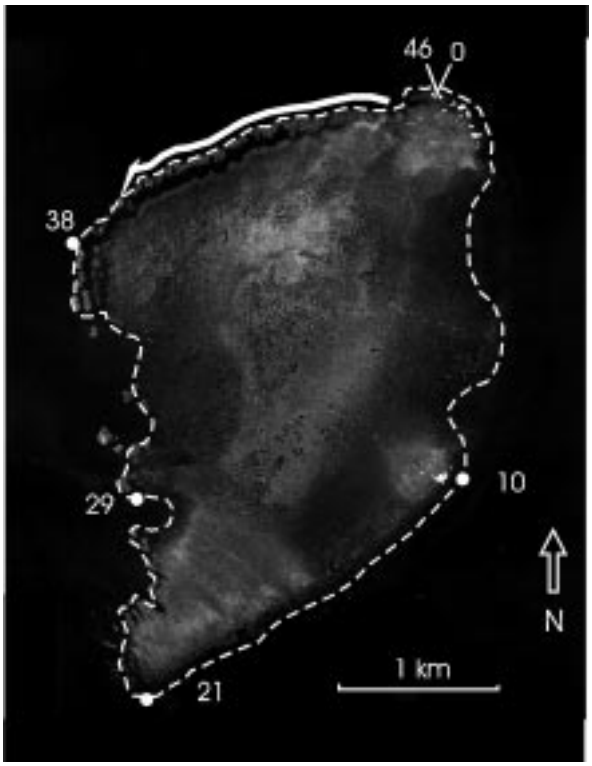
A significant bleaching event was observed during the 1998 surveys which affected both hard and soft corals on Middle Reef. Cover of the hard coral family Agariicidae decreased from 8.3% in 1996 to 7.2% in 1998. The majority of corals in the family Pocilloporidae were bleached. Relatively high cover of bleached soft corals (mostly *Sinularia* spp) were recorded.

As a result of the observed bleaching Middle Reef was resurveyed in August 1998. Overall hard coral cover remained stable over the surveys however caution in interpretation of the last survey is suggested as only three transects within each site were surveyed due to time constraints. Low levels of mortality were observed in the two dominant hard coral families, Agariciidae (5.2% cover) and Poritidae. The cover of Pocilloporidae decreased to below a detectable level. The percent cover of Acroporidae was unchanged from previous surveys. Soft coral cover had not recovered from the bleaching event, declining from 13.6% in 1997 to 6.9%.

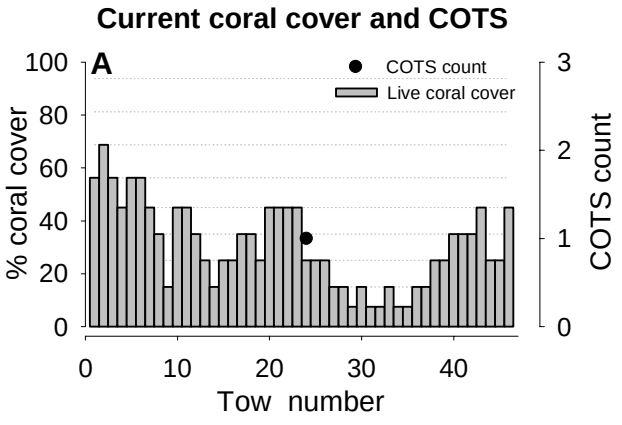
Large reef fish are not surveyed because of the poor visibility. The Pomacentrid community has low diversity with only three genera returning abundances suitable for analysis. The trends observed for *Acanthochromis polyacanthus* showed a strong increase from 1996 to 1998 and *Neopomacentrus bankieri* declined over the same period. These trends were not statistically significant as a result of the model specifications rather than magnitude of change.

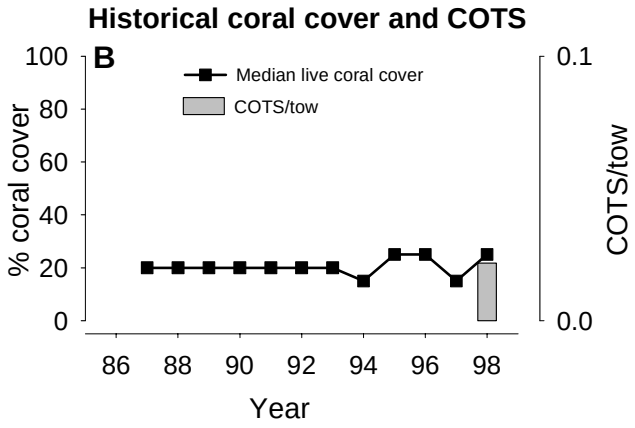
Figure 5.74

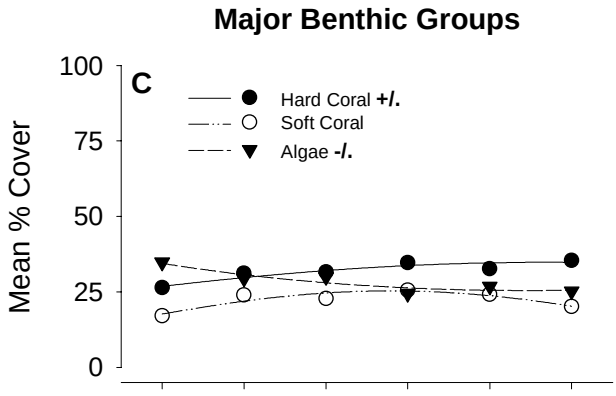
Myrmidon

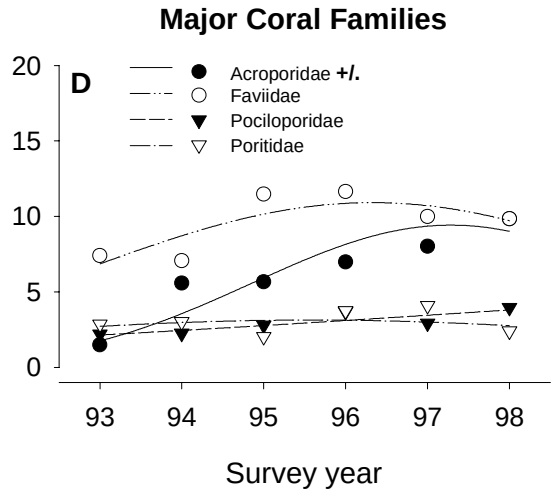


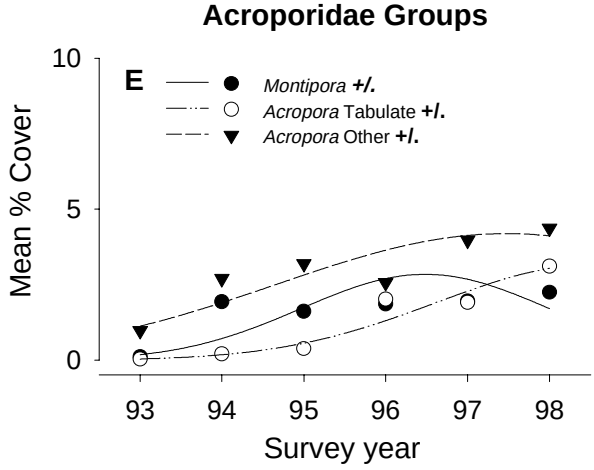
Myrmidon (No. 18-034) is an outer shelf planar reef with an area of 6.2 sq.km. Last surveyed May 1998.

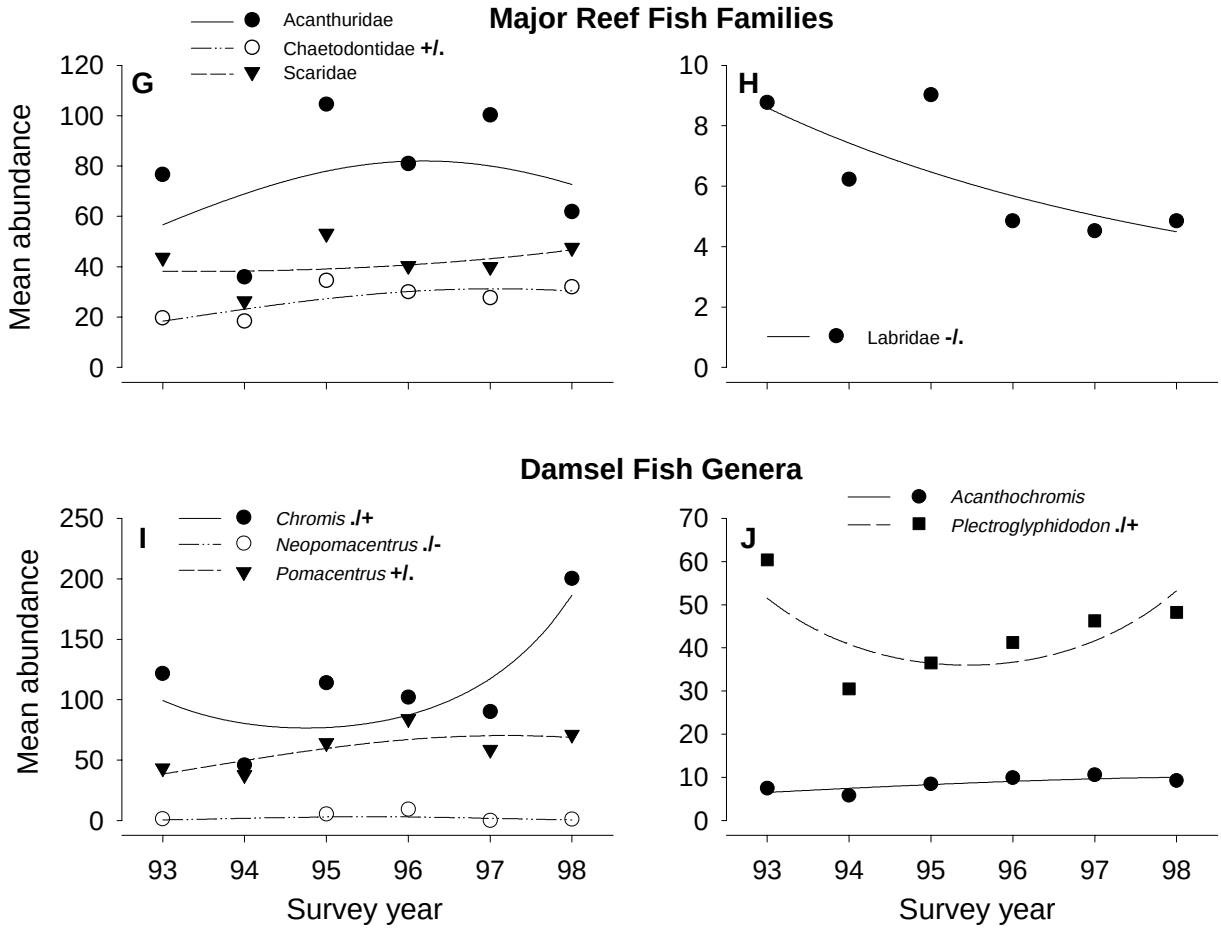












Myrmidon

This reef has been surveyed extensively since 1987 using manta tow. There has been little appreciable change in coral cover which has remained at moderate levels. Detailed coral surveys on the northern flank of the reef show that hard coral cover has increased by 9% since 1993, and is currently moderately high at 35.4%. This change is due to increases in the *Acropora* spp., Faviidae and *Montipora* spp. with other groups remaining stable. The abundance of Favids is relatively high at 10.35% and this includes some large colonies of *Diploastrea heliopora*. COTS were observed on our most recent surveys and these are the first observed on this reef in the twelve years of manta tow surveys. Their abundance is currently well below the level expected to cause significant coral mortality and consequently the reef is currently classified as Non-Outbreaking. Low level coral bleaching was also recorded in 1998.

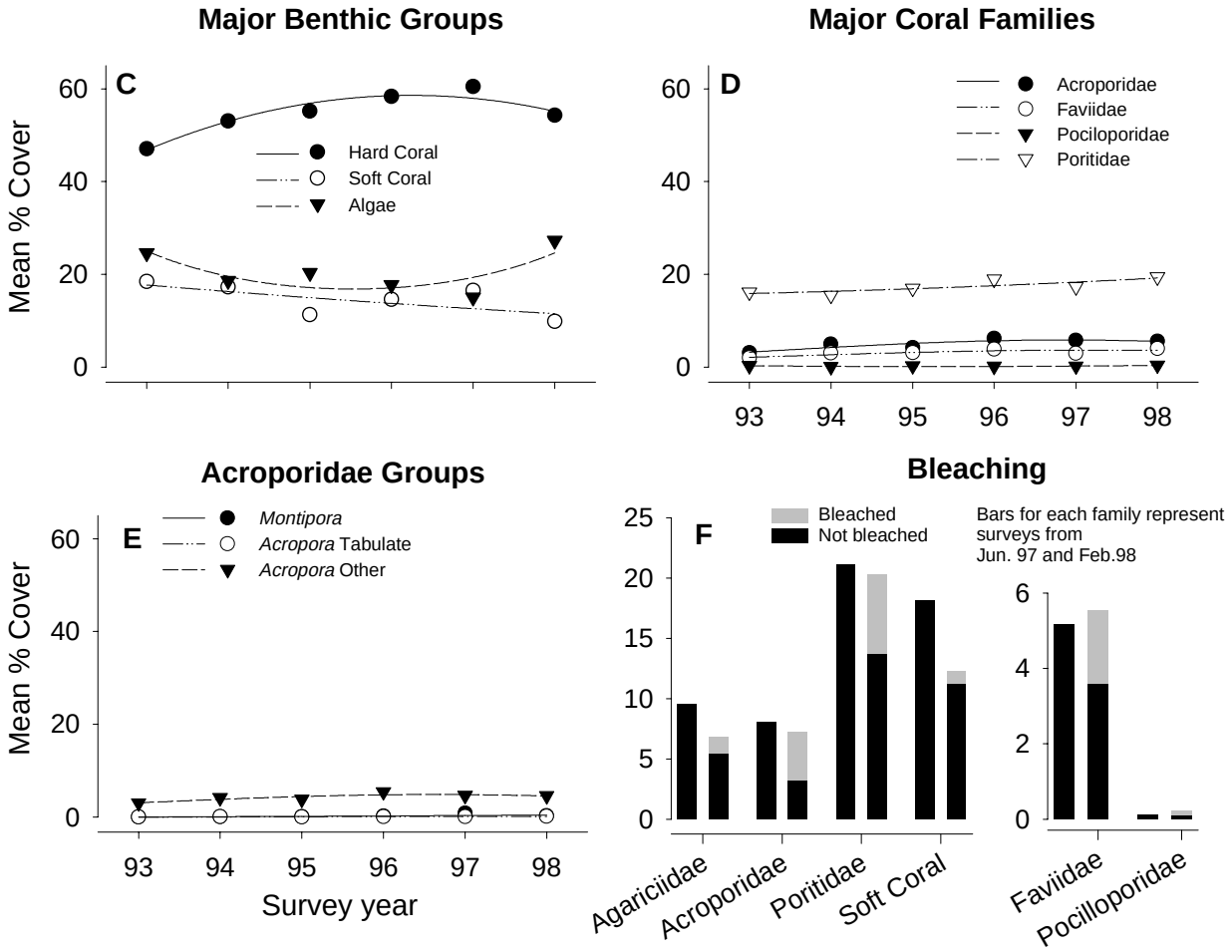
As with the benthic community most fish groups have increased or remained stable over the years of survey. Chaetodontidae show a general increase and although variable at the species level, *Chaetodon citrinellus*, *C. ornatissimus, C. pelewensis, C. trifasciatus* and *Forcipiger flavissimus*, have all increased. The increase in *Pomacentrus* is due to *P. lepidogenys,* which peaked in 1996. *Chromis* counts were stable for most species over the first five years with current increases in *Chromis atripes, C. iomelas, C. lepidolepis* and *C. margaritifer*. After a decline in *Plectroglyphidodon lacrymatus* between 1993 and 1994, *P. dickii, P. johnstonianus*, and *P. lacrymatus* have all been steadily increasing. The only group showing an overall decline are the Labridae and this was driven mostly by declining numbers of *Gomphosus varius* and *Halichoeres hortulanus*. The "apparent" decline in *Neopomacentrus* is more likely to have resulted from the periodic inclusion of small schools on the transects rather than real change.

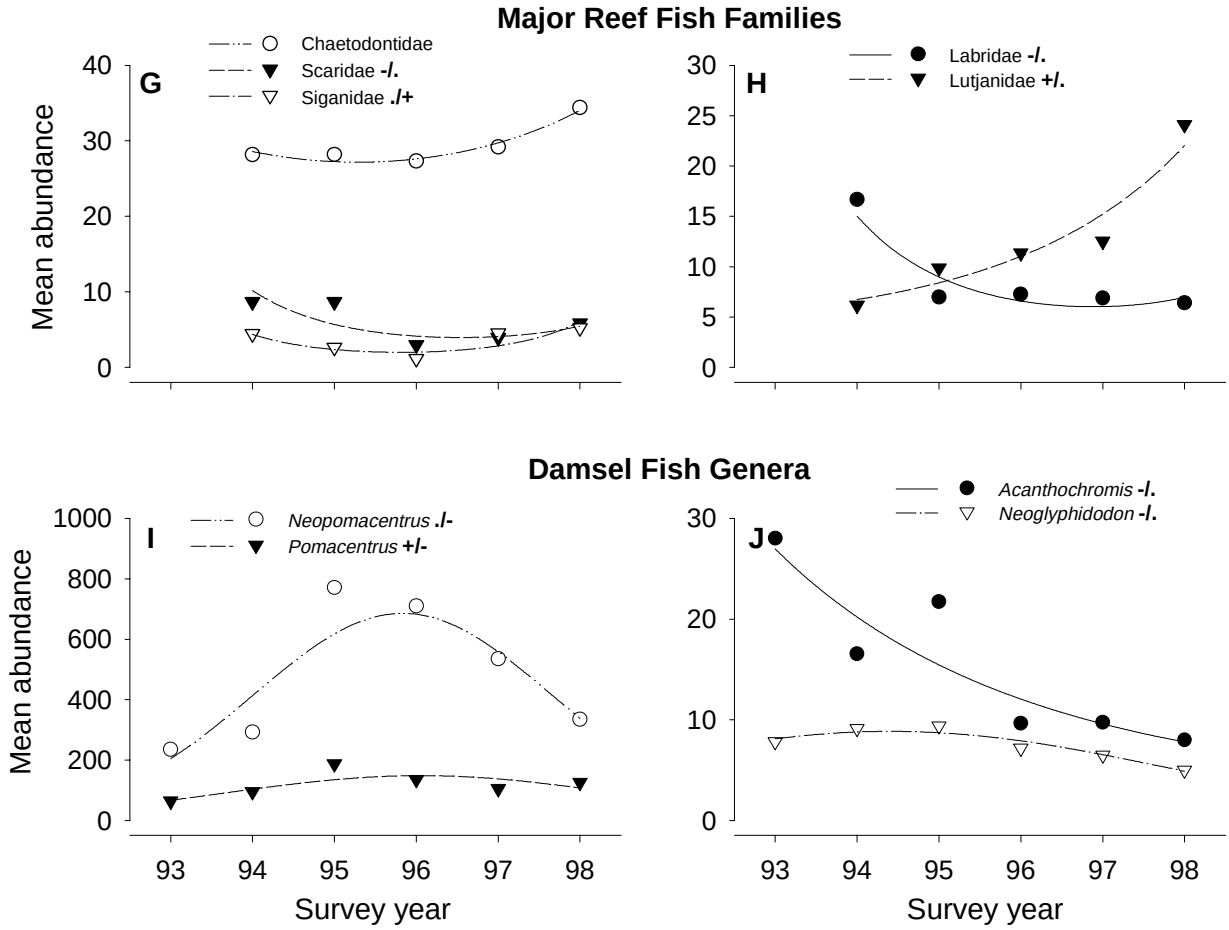
Figure 5.75

Pandora

Pandora (No. 18-051) is an inner shelf planar reef with an area of .6 sq.km. There is a shingle cay on the western side. Last surveyed February 1998.

No manta tow surveys conducted at Pandora Reef due to poor visibility





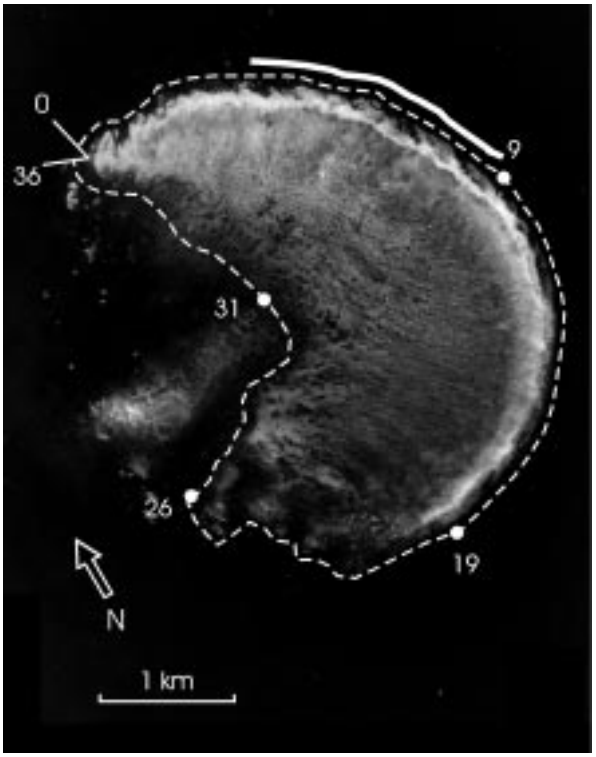
Pandora

This reef has been surveyed annually since 1993 using visual census for fish and benthic video transects. Manta tow surveys are not conducted on this reef due to poor water clarity. There have only been minor fluctuations in hard coral cover. When last surveyed, hard coral cover was high at 59.5%. Moderate bleaching was evident in all the abundant hard and soft coral families during the last survey in January 1998. The Townsville region experienced a major flood event in the second weekend in January and it has been reported by other AIMS scientists (Devantier, Fabricius pers. comm.) that four weeks after the floods, around 80% of the corals on Pandora were bleached to a depth of around 10 metres. Large scale mortality has subsequently occurred. Future surveys of Pandora Reef will provide detailed quantitative information on the effects of this bleaching event.

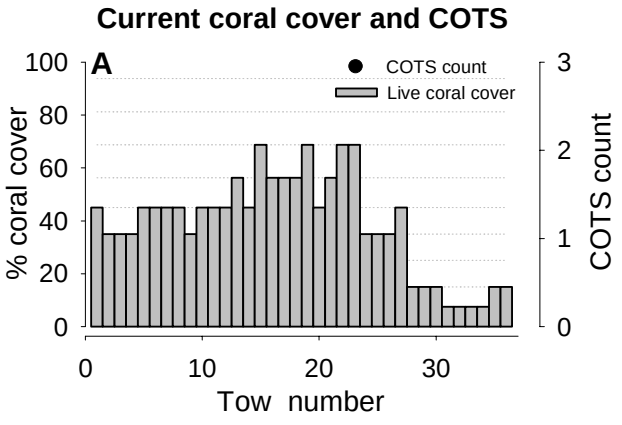
Visual census surveys indicate that the fish community is relatively depauperate albeit dynamic with only two of the groups analysed not showing some trend. In the case of Siganidae, Scaridae and Lutjanidae the observed trends are an artifact of the periodic inclusion of schools (*Siganus doliatus* and *S. lineatus, Scarus rivulatus*, and *Lutjanus carponotatus* respectively) rather than steady changes in abundance. *Acanthochromis polyacanthus* has shown a steady decline in abundance as has *Neoglyphidodon* (due mainly to *N. melas*). The trend in *Pomacentrus* is driven by *P. moluccensis* which increased strongly until 1995 before declining to a stable point in years 1997 and 1998. Other *Pomacentrus* species have remained stable. *Neopomacentrus bankieri* increased until 1996 before declining.

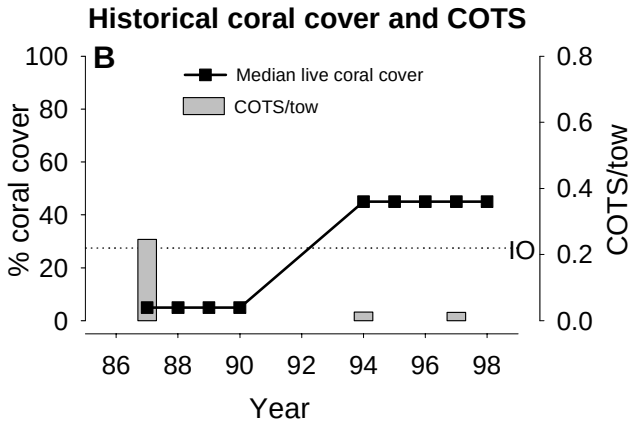
Figure 5.76

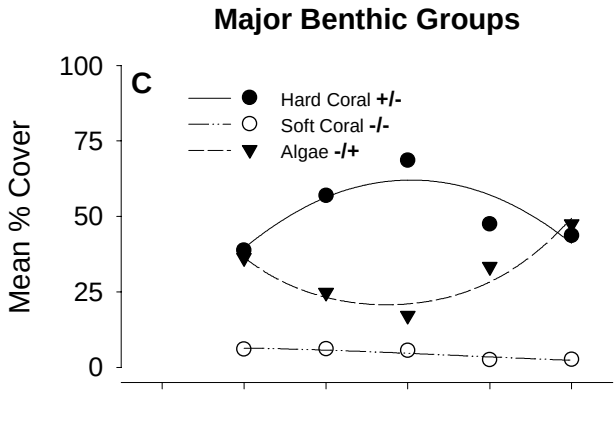
Rib

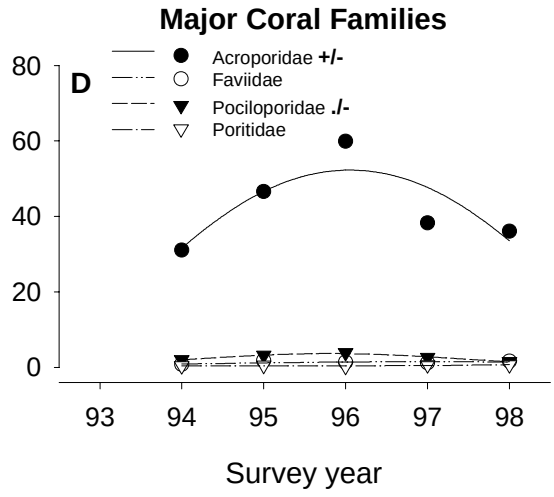


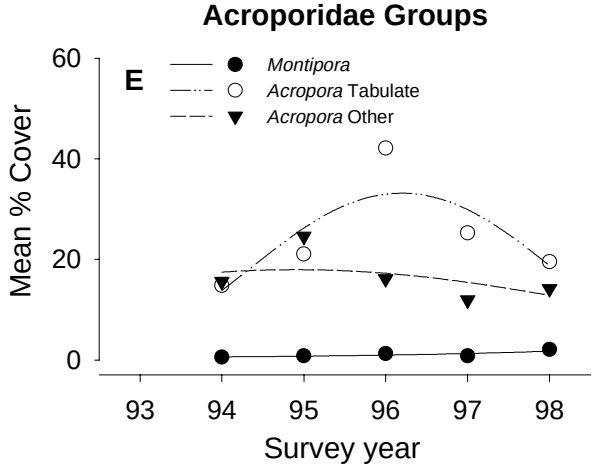
Rib (No. 18-032) is a middle shelf crescentic reef with an area of 5 sq.km. Last surveyed April 1998.

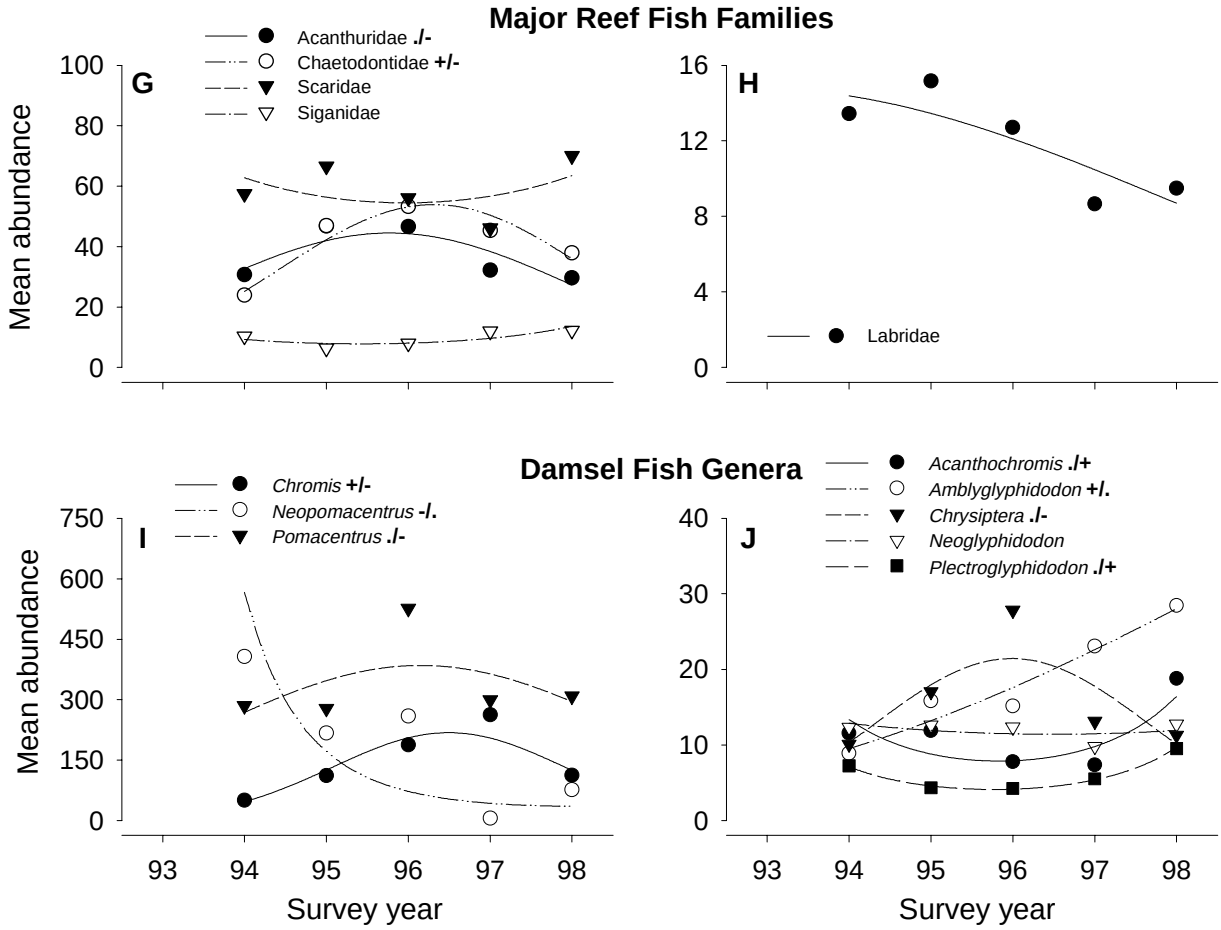












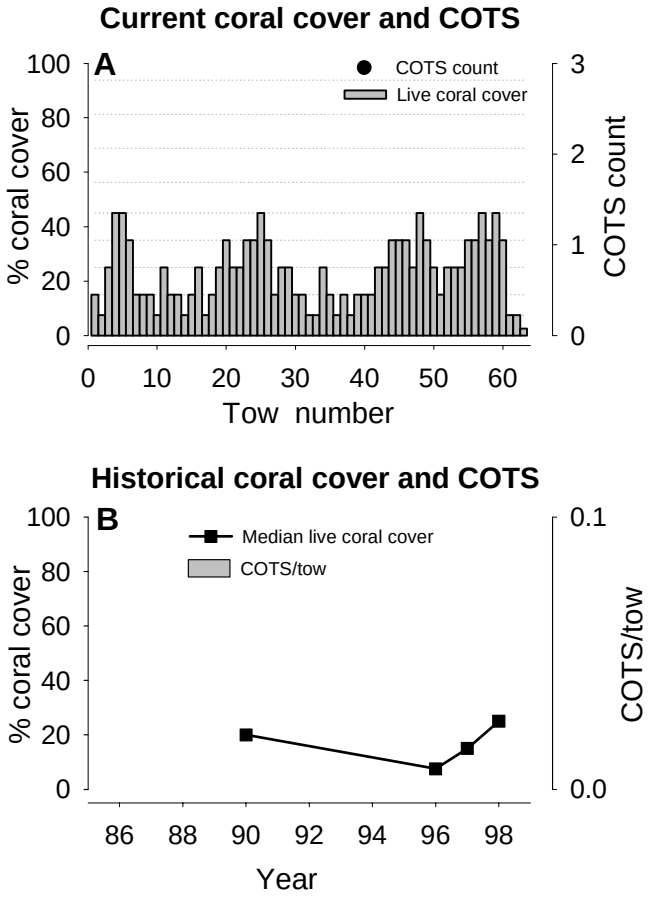
Rib

This reef has been surveyed using manta tow since 1987 using manta tow. Earlier studies indicate that Rib Reef had extremely high COTS populations prior to this time. Between 1990 and 1994 coral cover increased markedly on this reef and the cover has subsequently stabilised at the present high level. Detailed coral surveys since 1994 show that coral cover reached a maximum of 68% in 1996. A decrease in 1997 was is attributed to the impact of Cyclone Justin on tabulate *Acropora* spp. Hard coral cover is still moderately high at 43.8%. The *Acropora* community on this reef is diverse with tabulates dominant while branching and bottlebrush species are also relatively abundant. Soft coral cover has declined. Recently, low numbers of COTS have been observed, however, they are presently in numbers too low to cause significant coral mortality. Rib Reef is still classified as Recovering from the last historical outbreak of COTS. Low levels of coral bleaching were recorded in 1998.

The effects of Cyclone Justin on tabulate *Acropora* spp. may also be influencing the observed patterns in Chaetodontidae (*Chaetodon baronessa, C. plebeius, C. rainfordi*, and *C. trifascialis*), *Chrysiptera* (*Chrysiptera* rollandi), and *Pomacentrus* (*Pomacentrus lepidogenys* and *P. moluccensis*), all of which showed increases up until 1996 and subsequently declined. *Chromis* also increased initially then declined. *Amblyglyphidodon curacao* has steadily increased over the entire survey period. *Plectroglyphidodon lacrymatus* and *Acanthochromis polyacanthus* abundance were initially stable then increased.

Figure 5.77

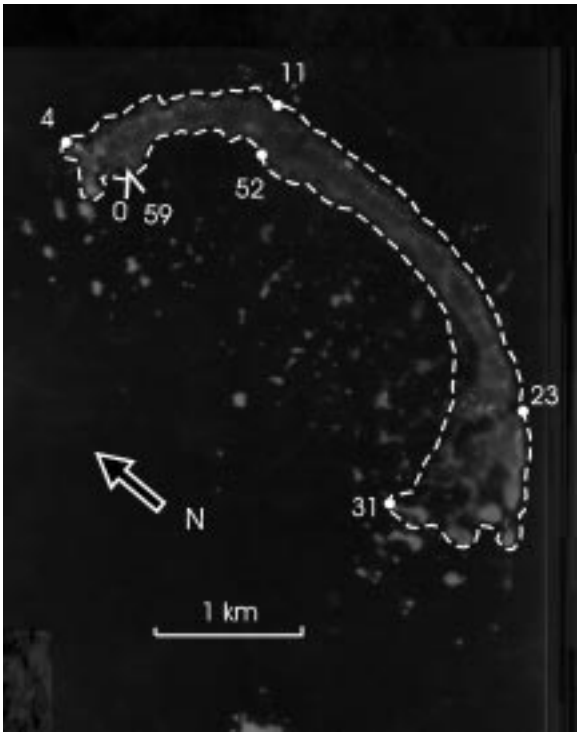
Fantome Island

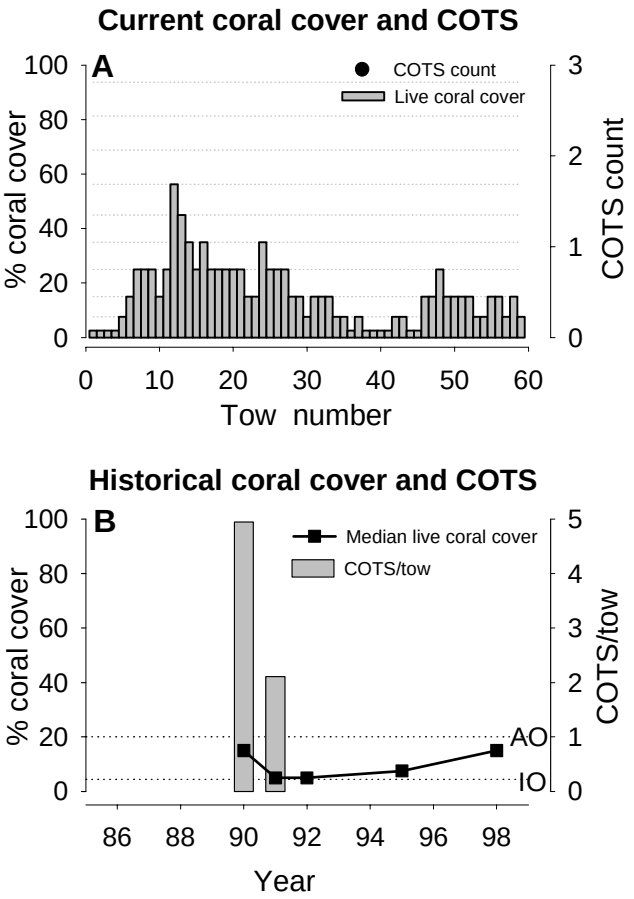


Fantome Island (No. 18-053) is an inner shelf fringing reef which surrounds a high continental island. The reef has an area of 1.9 sq.km. Last surveyed February 1998.

Figure 5.78

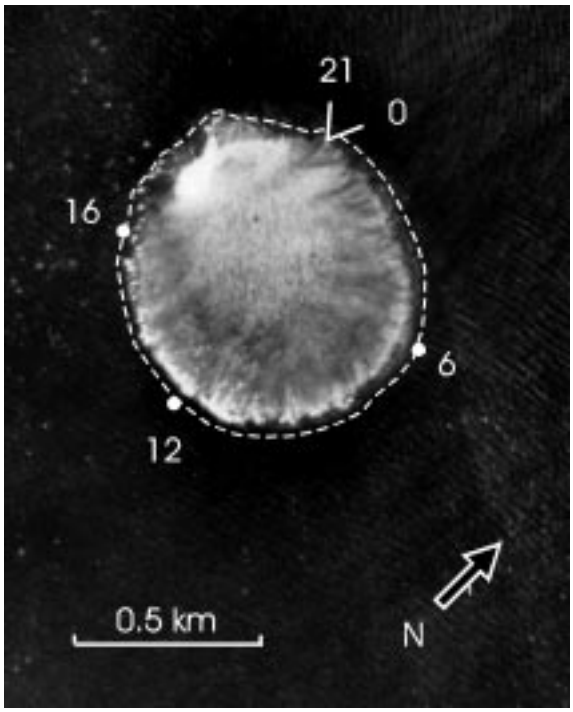
Reef No. 18-099



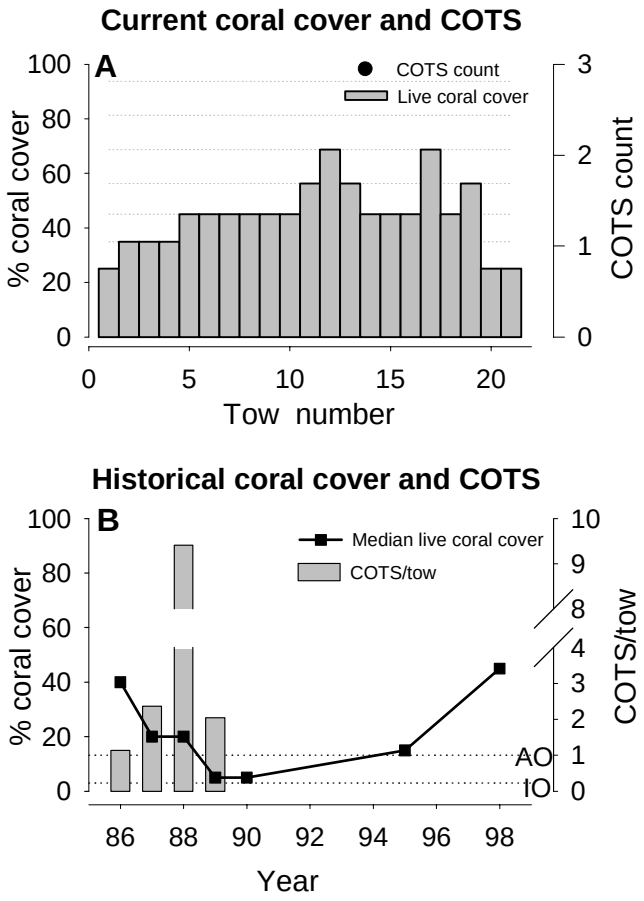


Reef No. 18-099 is a middle shelf crescentic reef with an area of 12.5 sq.km. Last surveyed May 1998.

Figure 5.79 **Wheeler**



Wheeler (No. 18-095) is a middle shelf planar reef with an area of 1.9 sq.km. There is a small sand cay on the western side. Last surveyed May 1998.



Fantome Island

This reef has been surveyed four times since 1990. While coral cover has remained generally low on this reef, there is some sign of an increase in coral cover during our most recent surveys. No COTS have been recorded and it is currently classified as Non-Outbreaking.

Reef No. 18-099

This reef has been surveyed five times since 1990. Initial surveys revealed extremely high COTS numbers and a low coral cover. Consequently it was classified as an Active Outbreak up until 1991. COTS subsequently declined and coral cover presently appears to be increasing on this reef. No COTS were seen on this reef during our most recent surveys. Coral cover is moderate and the reef is currently classified as Recovering.

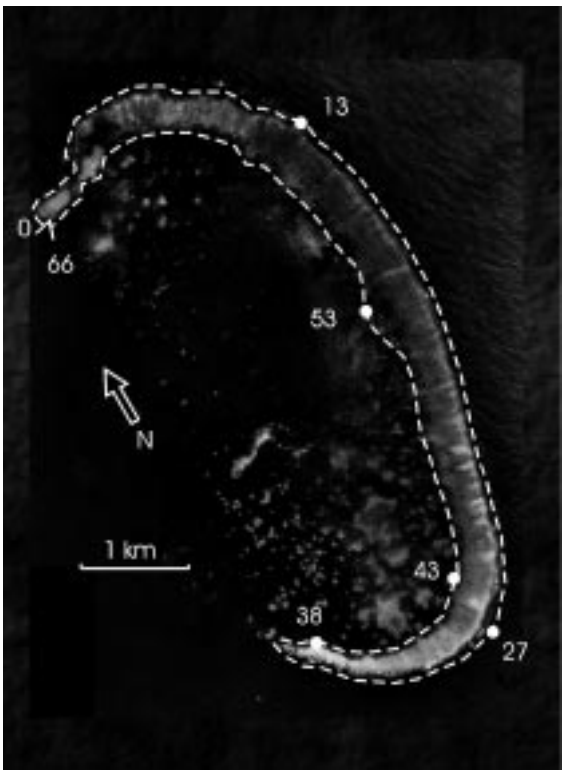
Wheeler

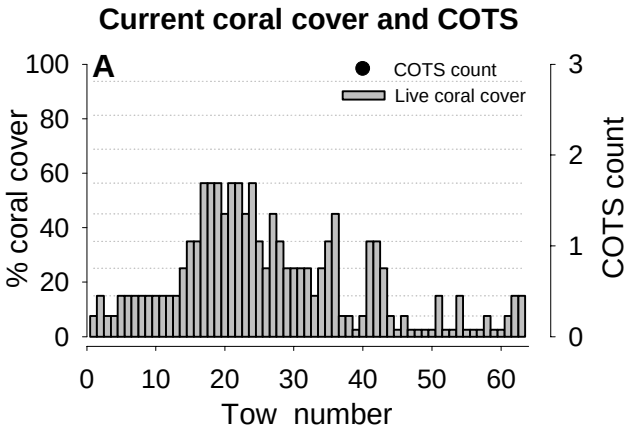
This reef has been surveyed extensively since 1986 when it was classified as an Active Outbreak. COTS numbers continued to increase on this reef until 1988, before declining. Coral cover declined from a high level in 1986 to a low level in 1989. Since then coral has recovered, particularly in the last few years, to approach the high levels originally recorded on this reef before the outbreak. The reef is currently classified as Recovering.

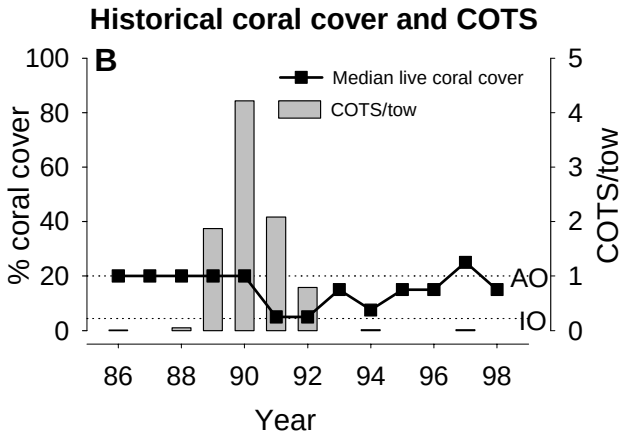
Cape Upstart
Reef Pages

Figure 5.80

Bowden



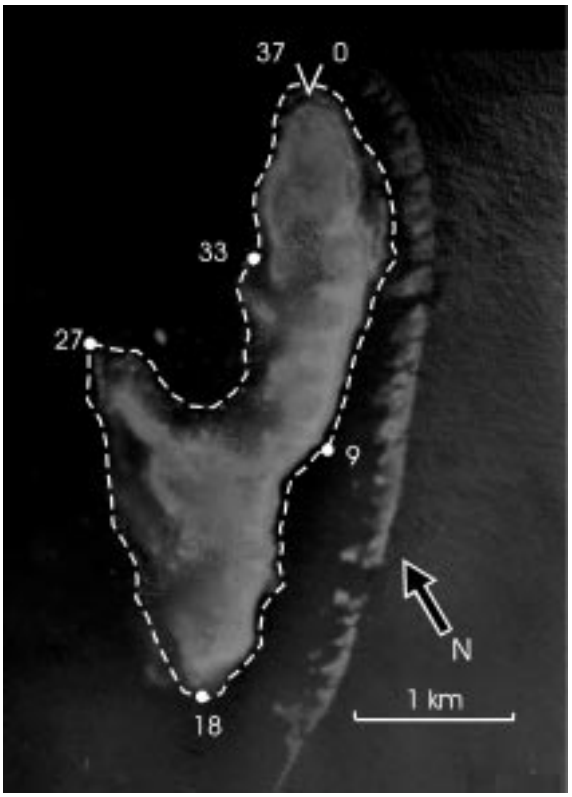


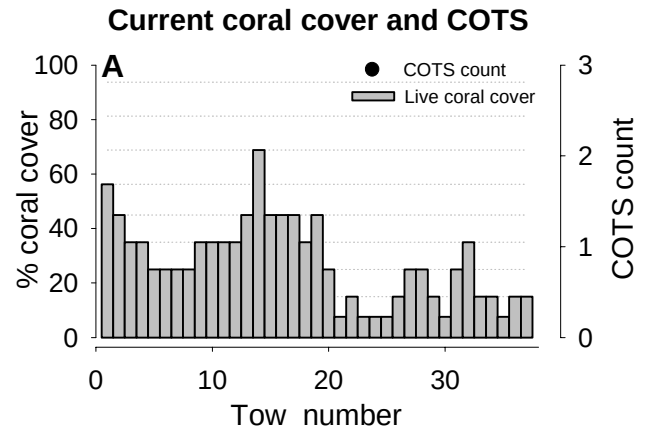


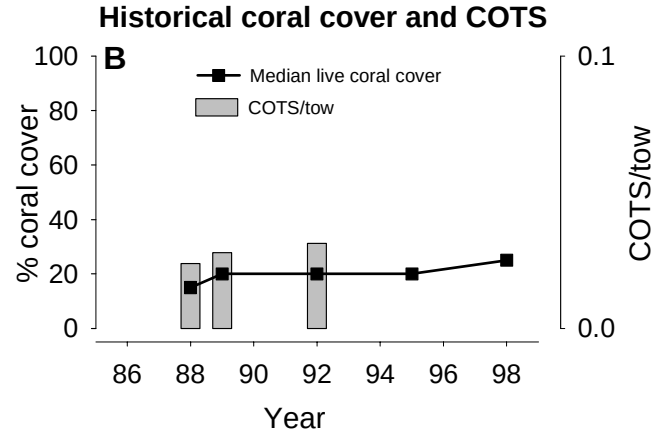
Bowden (No. 19-019) is a middle shelf crescentic reef with an area of 9.4 sq.km. Last surveyed May 1998.

Figure 5.81

Elizabeth



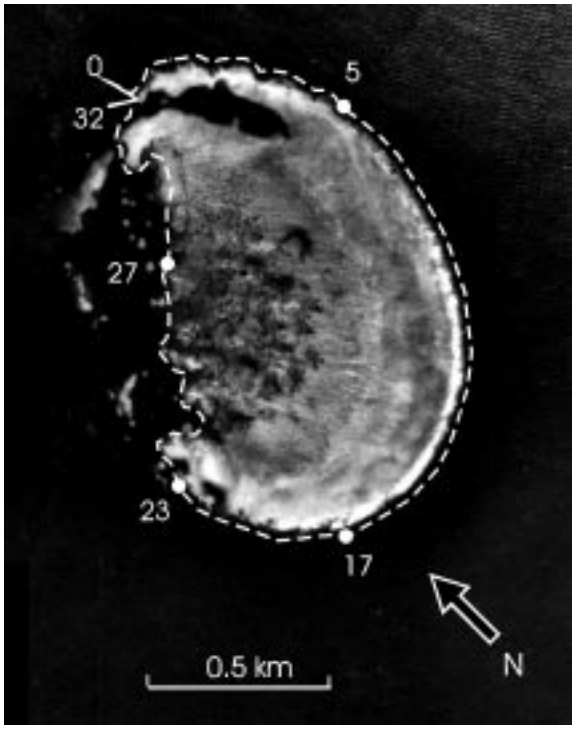




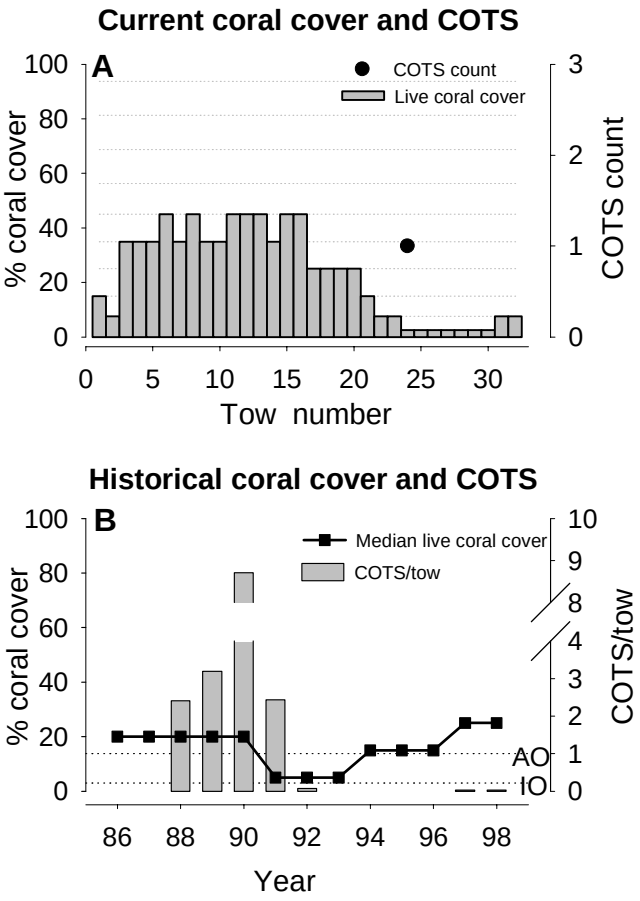
Elizabeth (No. 19-082) is a middle shelf crescentic reef with an area of 7.5 sq.km. Last surveyed April 1998.

Figure 5.82

Faith



Faith (No. 19-044) is a middle shelf crescentic reef with an area of 3.8 sq.km. Last surveyed April 1998.



Bowden

This reef has been surveyed extensively since 1986. During this time COTS populations initially rose spectacularly resulting in the reef being classified as an Active Outbreak from 1989 through to 1991. Coral cover decreased over this time. With the disappearance of large COTS numbers on this reef coral cover has subsequently begun to increase. Coral cover is currently at moderate levels and the reef is classified as Recovering.

Elizabeth

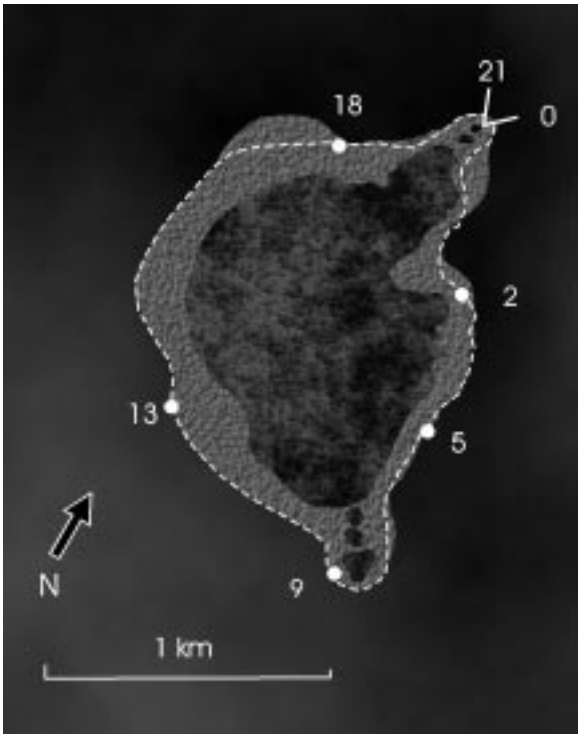
This reef has been surveyed five times since 1988. Although COTS were observed in the initial years of survey they were in numbers not considered large enough to cause significant coral mortality. Coral cover appears to have steadily increased over the period of sampling to the present moderate level. This reef is currently classified as Non-Outbreaking.

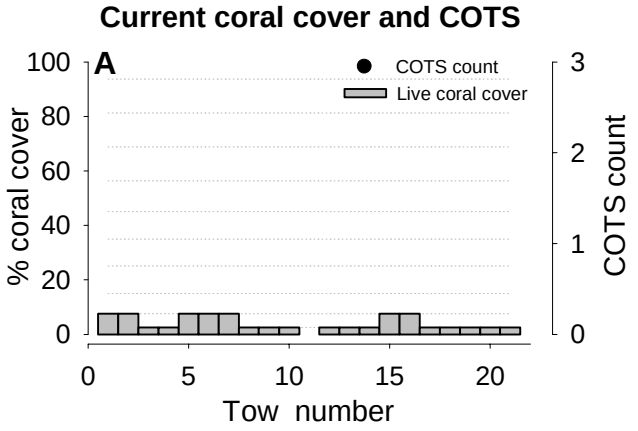
Faith

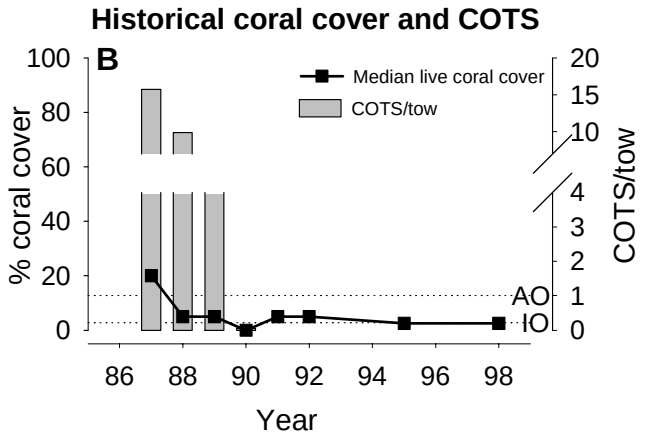
This reef has been surveyed extensively since 1986. COTS were not recorded until the third year of survey when they appeared in extremely high numbers. COTS populations subsequently increased, peaking in 1990 before declining. In line with the COTS outbreak, coral cover declined on this reef from moderate to low levels. Coral cover on this reef has increased with the disappearance of COTS during the nineties and is currently at the moderate levels recorded before the outbreak. Although COTS have been observed on this reef in recent surveys, they are not presently in numbers considered large enough to cause significant coral mortality and the reef is classified as Non-Outbreaking.

Figure 5.83

Holbourne Island



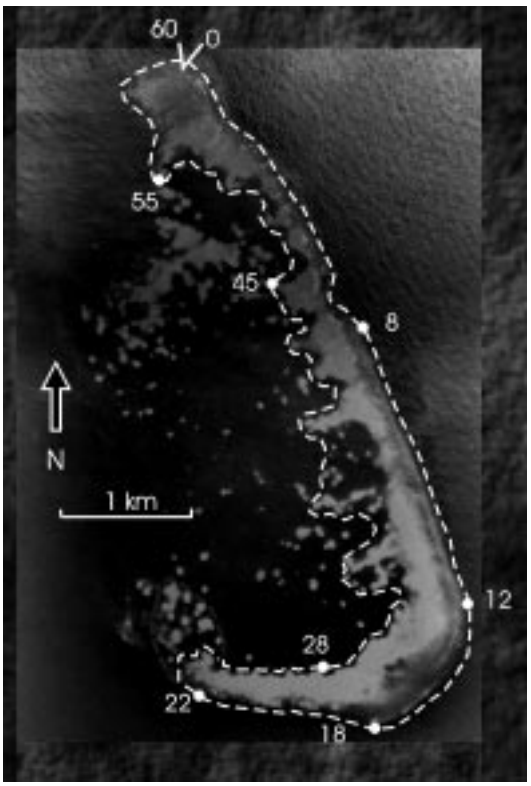


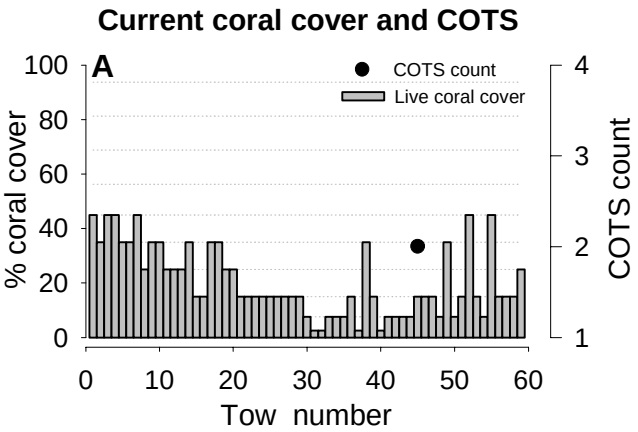


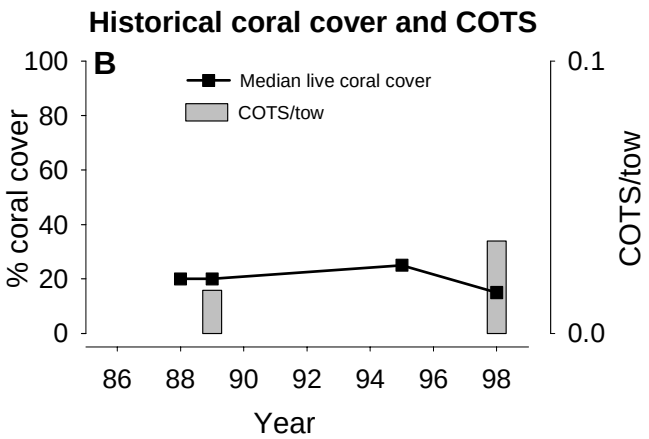
Holbourne Island (No. 19-103) is an inner shelf fringing reef surrounding a high continental island. The reef has an area of 1.2 sq.km. Last surveyed April 1998.

Figure 5.84

Jacqueline



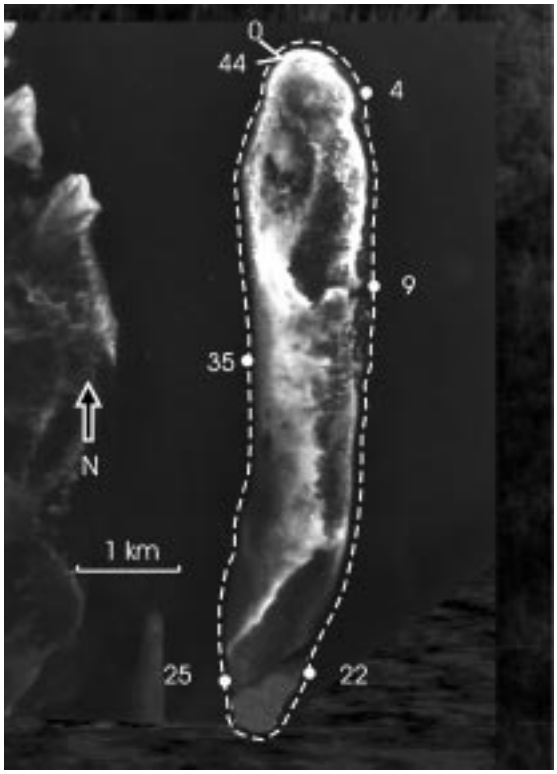




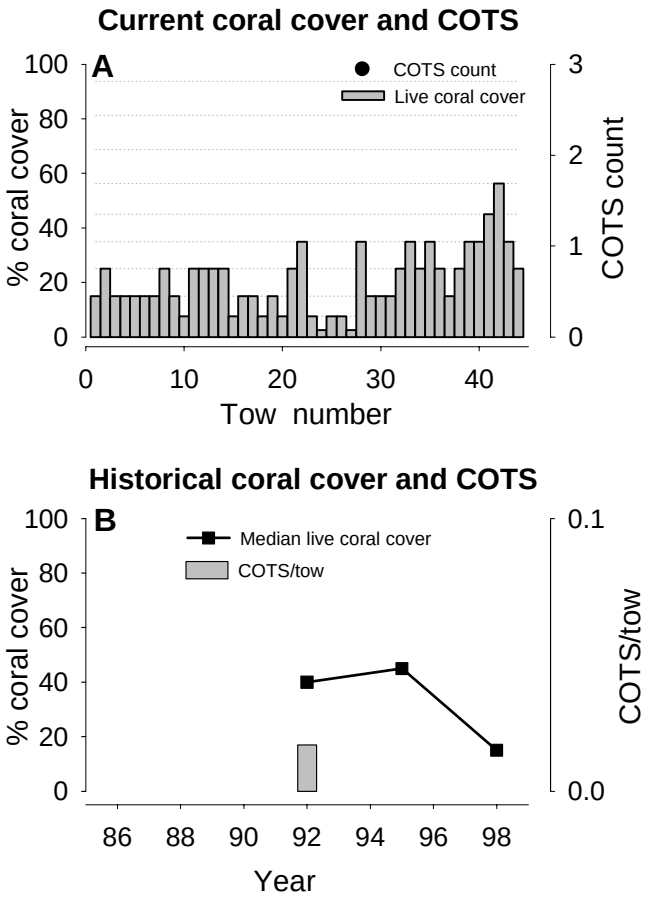
Jacqueline (No. 19-061) is an outer shelf crescentic reef with an area of 6.2 sq.km. Last surveyed April 1998.

Figure 5.85

Reef No. 19-098



Reef No. 19-098 is a middle shelf lagoonal reef with an area of 5 sq.km. Last surveyed April 1998.



Holbourne Island

This reef has been surveyed extensively since 1987. The initial year of survey revealed extremely high COTS populations and was classified as an Active Outbreak. COTS populations and coral cover subsequently declined on this reef. Coral cover has remained low since 1990 and shows few signs of recovery. Consequently, this reef remains classified as recovering from COTS.

Jacqueline

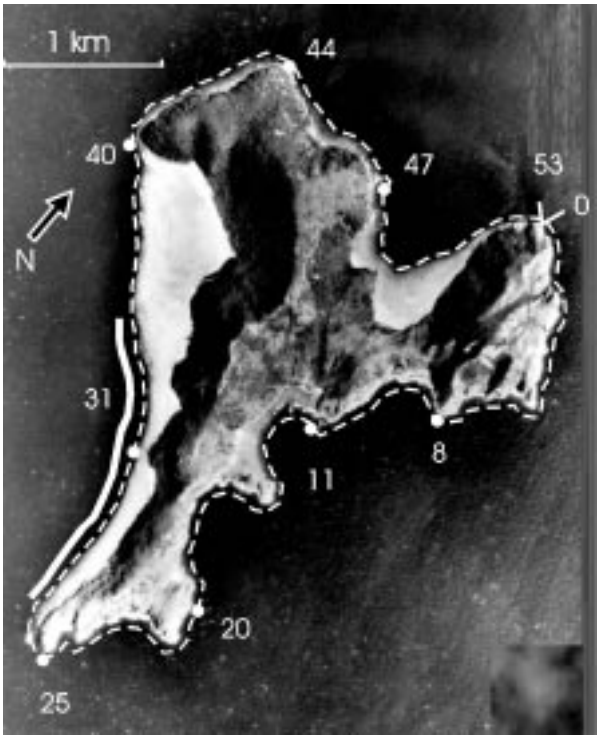
This reef has been surveyed four times since 1988. Although COTS were observed in the initial years of survey and again in 1998 they were in numbers not considered large enough to cause significant coral mortality. Coral cover appears to have remained stable at a moderate level over the period of sampling. This reef is currently classified as Non-Oubreaking.

Reef No. 19-098

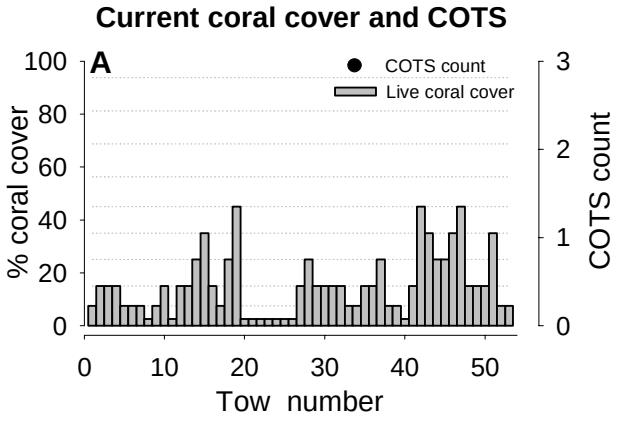
This reef has only been surveyed three times since 1992. Although COTS were observed on this reef in the initial year of survey they were observed in numbers too low to cause significant coral mortality. Interestingly, there was an appreciable drop in coral cover on this reef from a high level in 1995 to the present moderate level. This is probably a result of the effects of Cyclone Justin which influenced reefs in this area in March 1997. Reef 19-098 is currently classified as Non-Outbreaking.

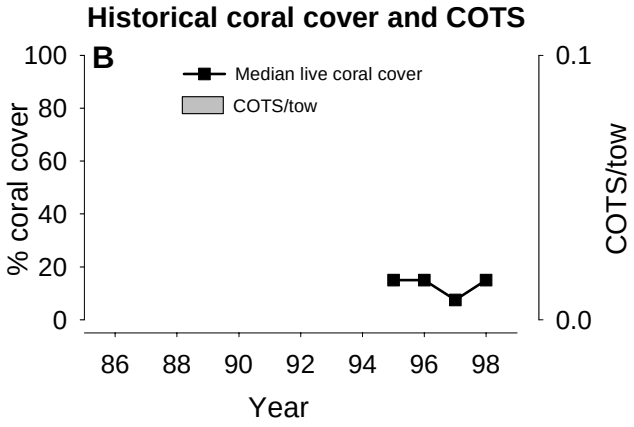
Whitsunday
reef pages

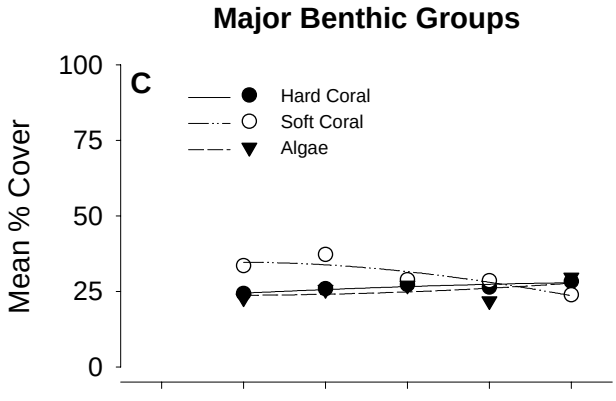
Figure 5.86 **Border Island**

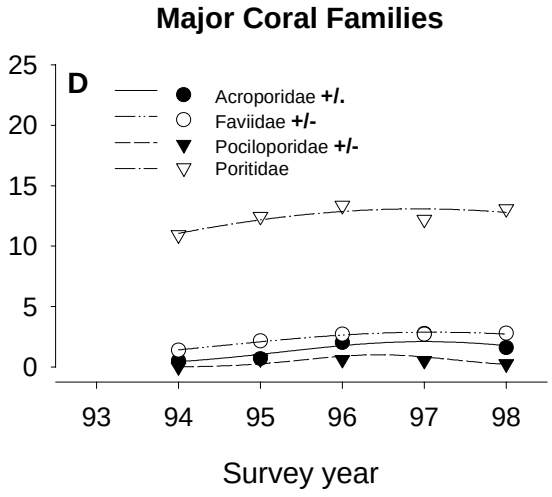


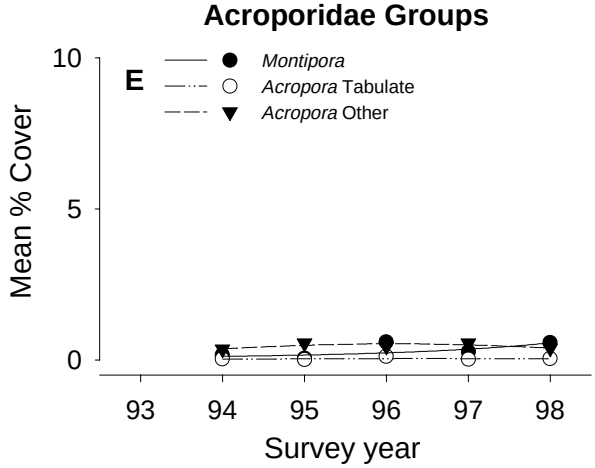
Border Island (No. 20-067) is an inner shelf fringing reef, that surrounds a high ,timbered, continental Island. It has an area 1.3 sq.km. Last surveyed February 1998

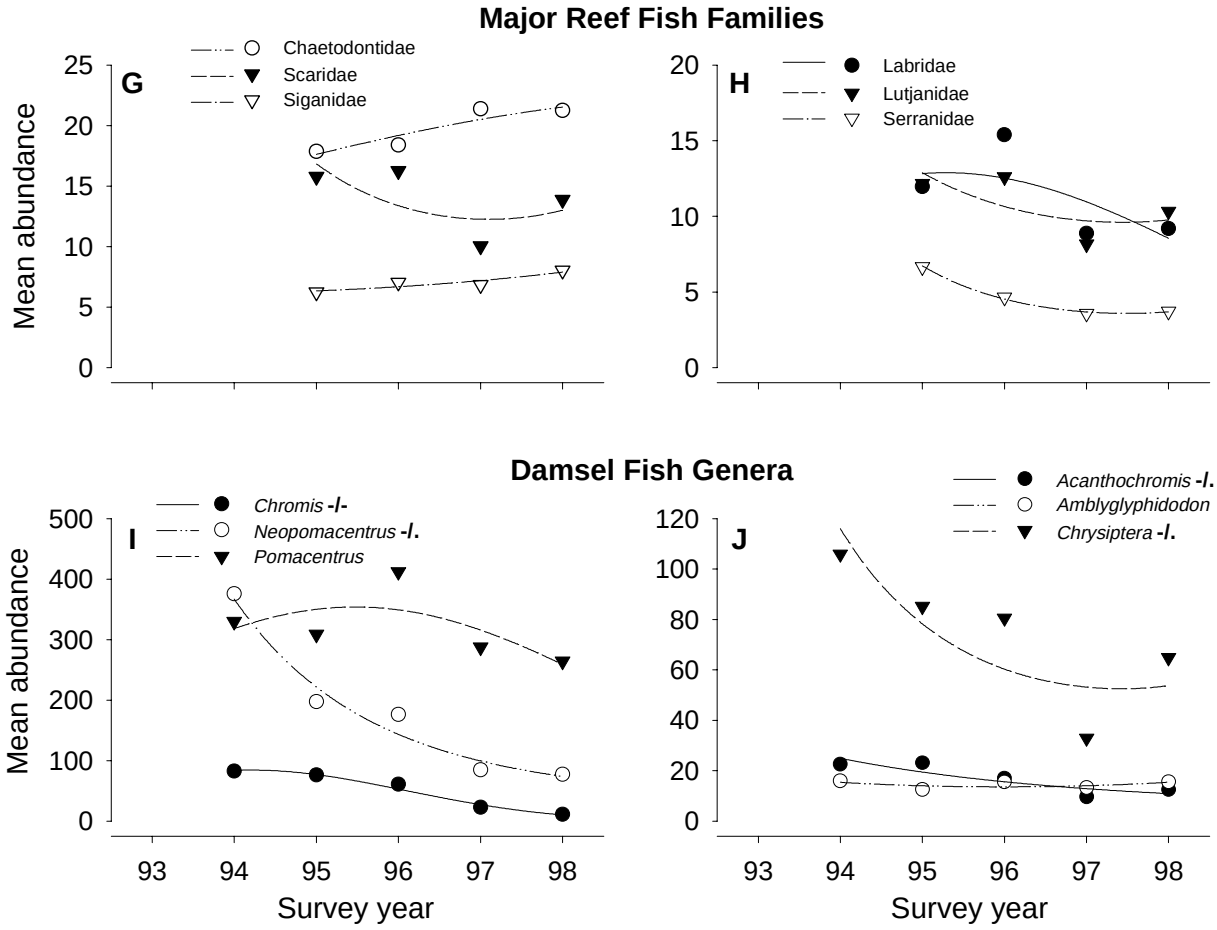












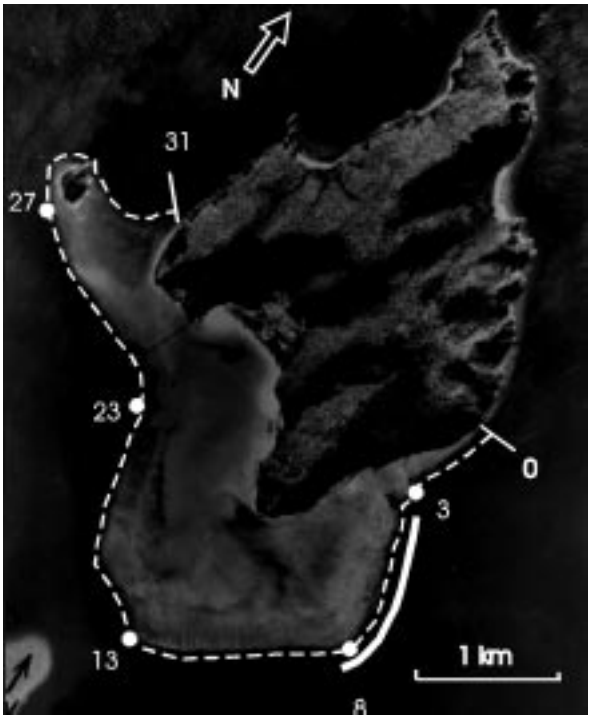
Border Island

This reef has been surveyed annually since 1995. Manta Tow data show that hard coral cover has remained stable at a moderate level. Detailed benthic surveys show that the sites are dominated by *Gonipora* spp. which has been stable over the survey period (28.8%). The cover of soft corals has decreased with a corresponding increase in algal cover. Of the area monitored 16% is sand or silt. No COTS have been observed on this reef which is currently classified as Non-Oubreaking. Low levels of coral bleaching were recorded in 1998.

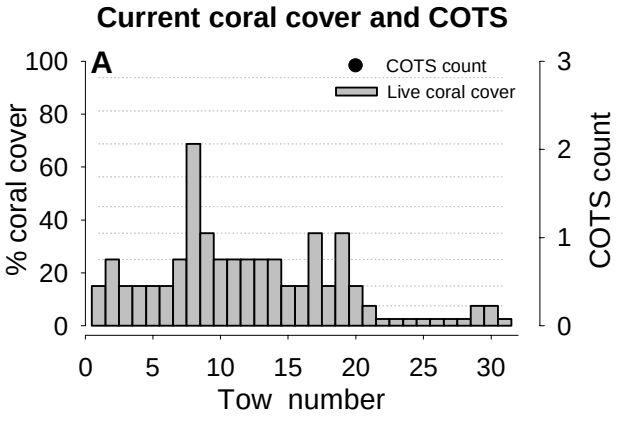
Larger reef fish numbers have been very stable with no groups showing statistically significant trends. Conversely the Pomacentrid community is in decline. *Acanthochromis polyacanthus, Chromis nitida, Chrysiptera rollandi*, *Neopomacentrus bankieri* and *N. azysron* have all declined strongly and represent the resultant trends in their genera.

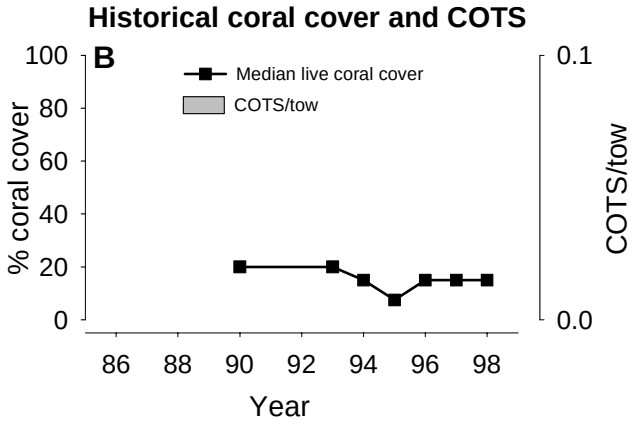
Figure 5.87

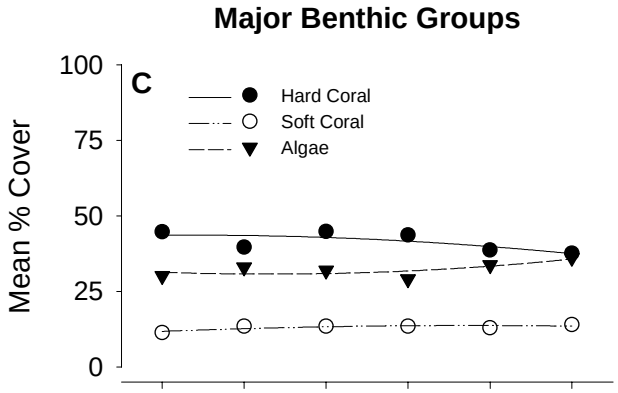
Hayman Island

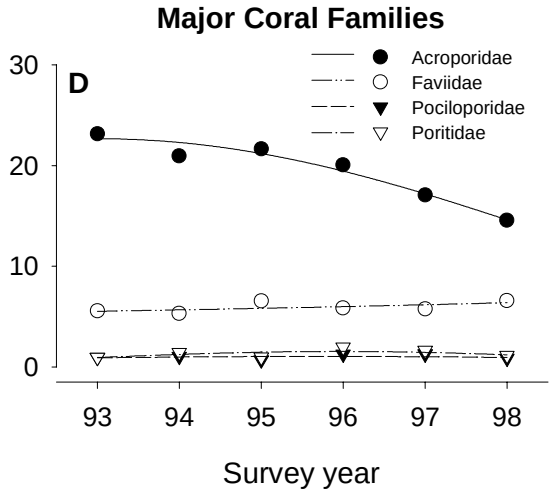


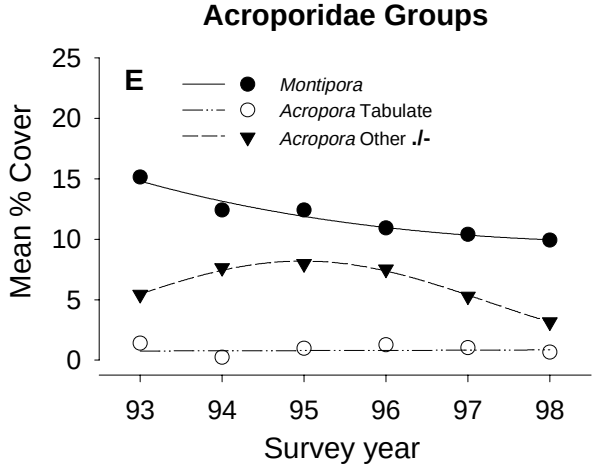
Hayman Island (No. 20-014) is an inner shelf fringing reef which surrounds two high continental islands. The reef has an area of 3.8 sq.km. Last surveyed April 1998.

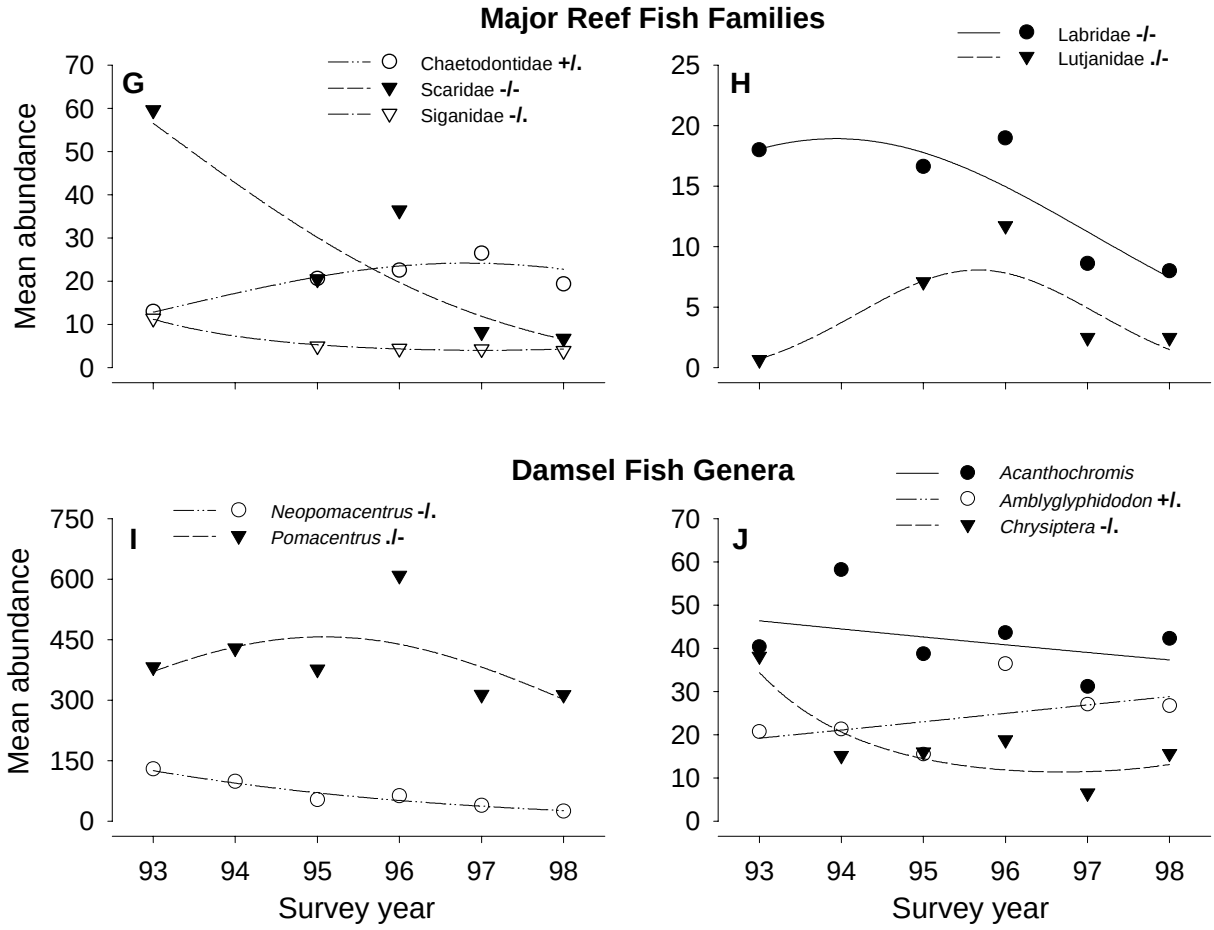












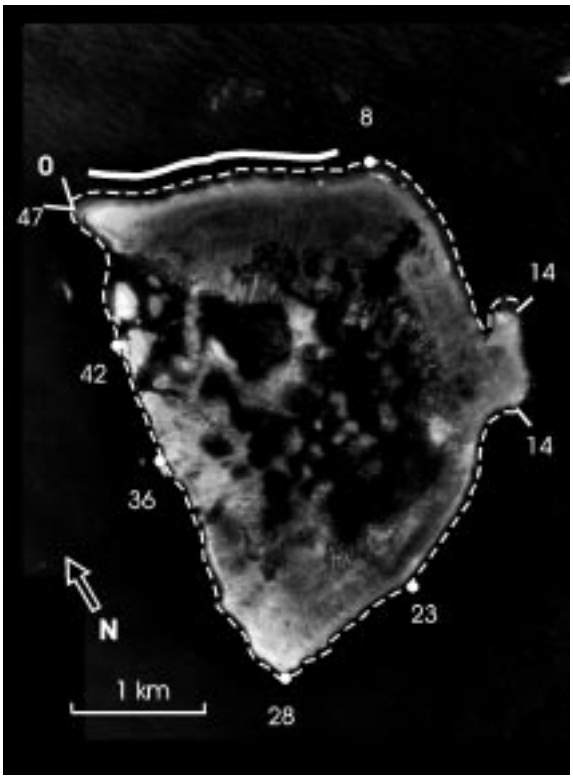
Hayman Island

This reef has been surveyed regularly since 1990. Coral cover has remained stable at a moderate level. Detailed benthic surveys on the southeastern flank show that hard coral cover has decreased slightly over the last two surveys to 37.6% in 1998, with a corresponding increase in algal cover. The decreases are due to a decline in the percentage cover of branching *Acropora* spp. and *Montipora* spp. This decline is largely on one site. Favid corals have continued to increase over the survey period and the cover of *Montipora* spp. is relatively high at 10.2%. No COTS have been observed on this reef which is currently classified as Non-Oubreaking. Low levels of coral bleaching were recorded in 1998.

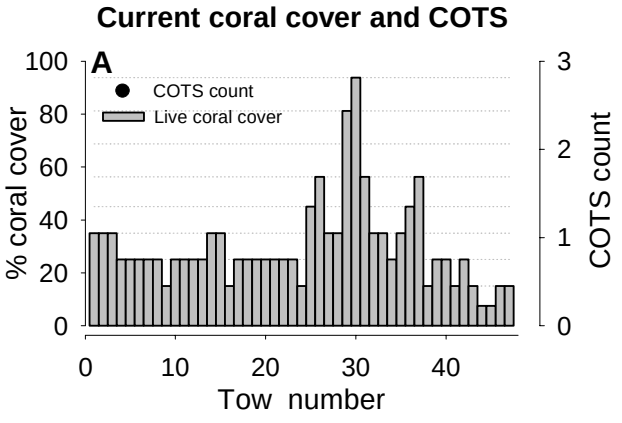
The fish community is in general decline with only the Chaetodontidae (due to *Chaetodon aureofasciatus, C. rainfordi* and *Chelmon rostratus*) and *Amblyglyphidodon curacao* increasing over the six years. *Chysiptera rollandi* and *Neopomacentrus azysron* showed major declines in the first, and first three, years respectively and they have since remained stable. Labridae (*Choerodon fasciatus, Hemigymnus fasciatus and H. melapterus*), Scaridae (*S. flavipectoralis, S. ghobban*, and *S. sordidus*) and Siganidae (*S. doliatus*) all declined steadily over the surveys.

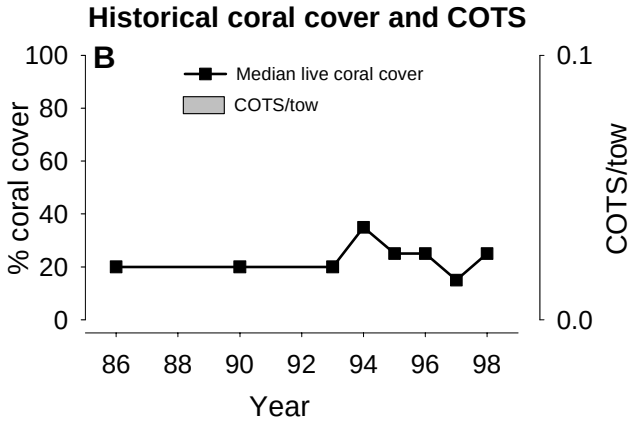
Figure 5.88

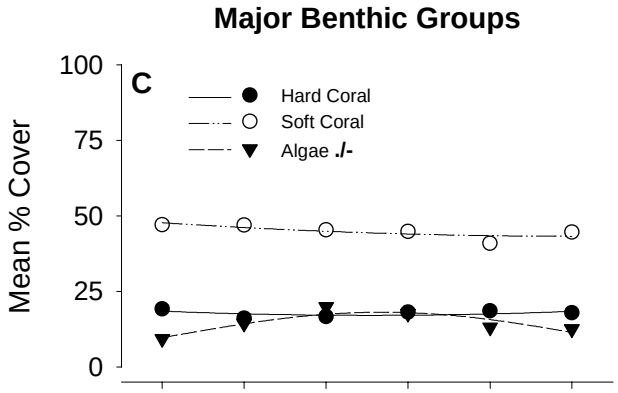
Hyde

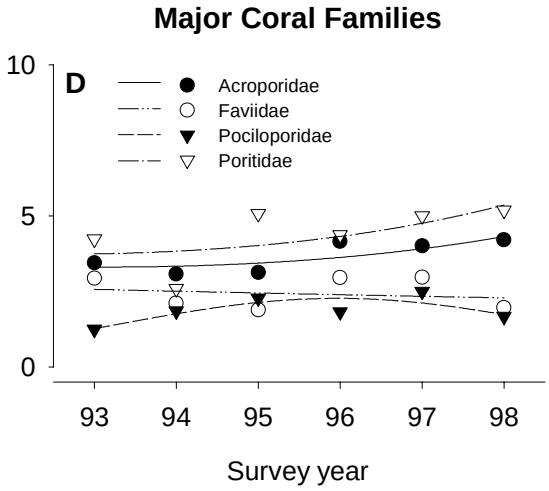


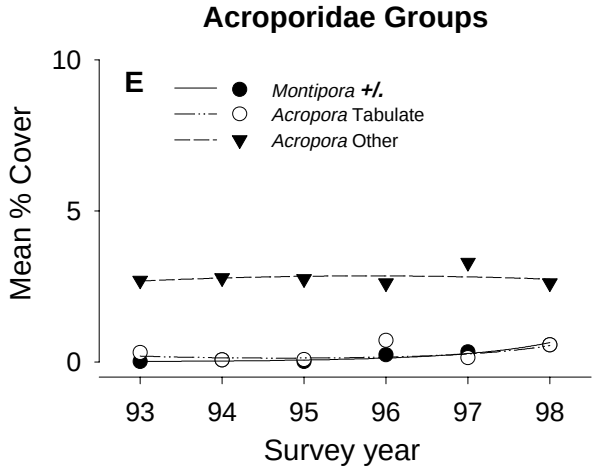
Hyde (No. 19-207) is an outer shelf lagoonal reef with an area of 12.5 sq.km. Last surveyed February 1998.

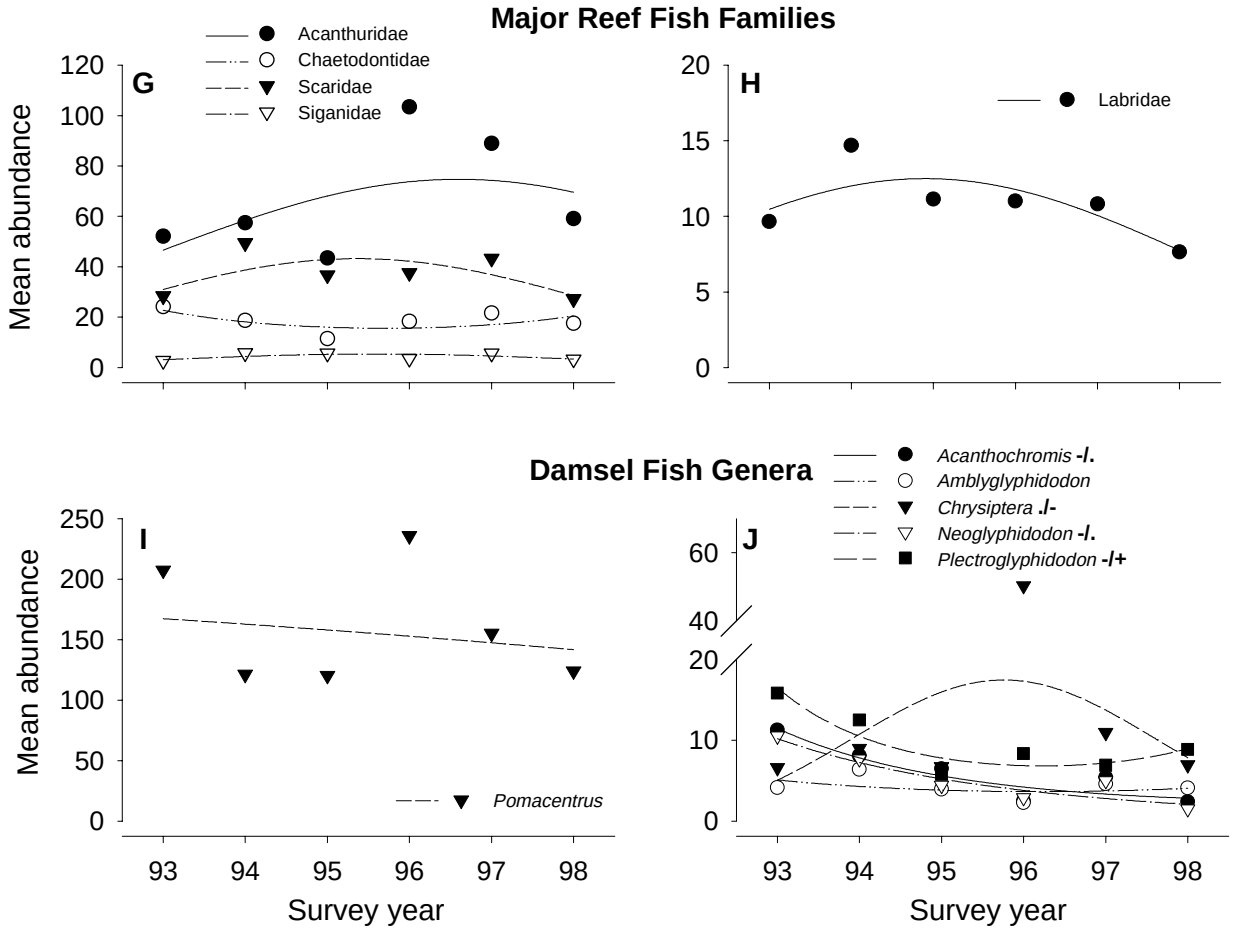










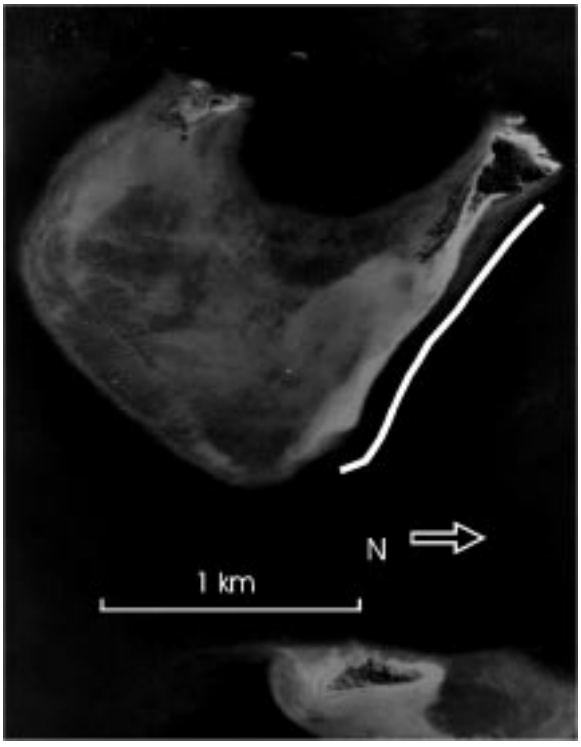


Hyde

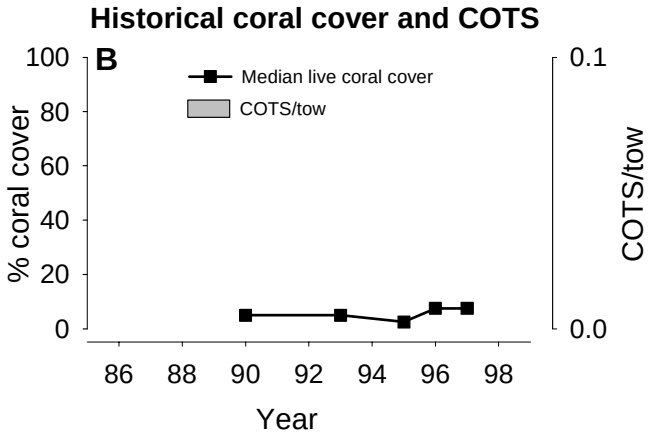
This reef has been surveyed eight times since 1986 using the manta tow technique. Over this time there has been little change in coral cover which has remained stable at a moderate level. This is supported by detailed coral surveys conducted since 1993 which show a stable coral cover of 18%. It is noteworthy that the cover of soft coral at this reef is the maximum recorded on our sites (44.6%). The cover of sponges is also relatively high (11.6%) with algal cover being correspondingly low (12.7%). No COTS have been observed and the reef is currently classified as Non-Oubreaking. Low levels of bleaching were recorded in 1998.

As with the mid shelf reefs of this sector, stable larger reef fish communities contrast with declines in the damsel fish community. *Acanthochromis polyacanthus* and *Neoglyphidodon melas* both decline over the period of survey. The current decline in *Chrysiptera rex* describes an influx in 1996 which did not reappear in the following survey. The trend in *Plectroglyphidodon* reflects a decline followed by a current increase in *P. lacrymatus*.

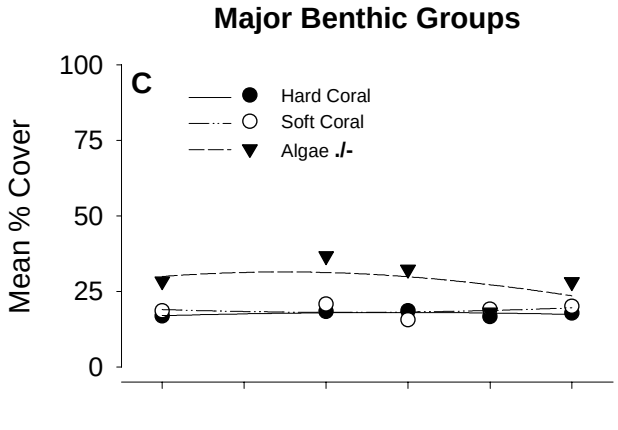
Figure 5.89 **Langford and Bird Islands**

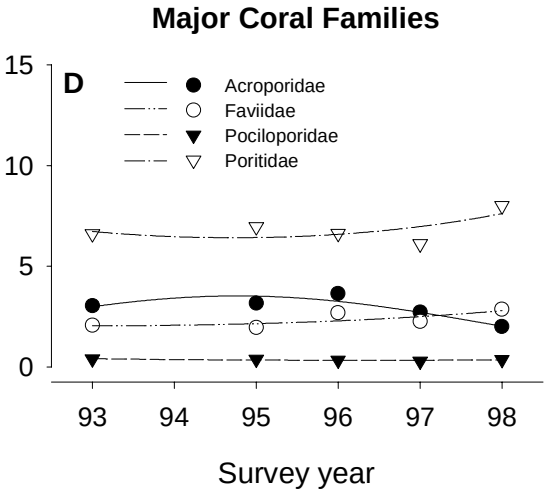


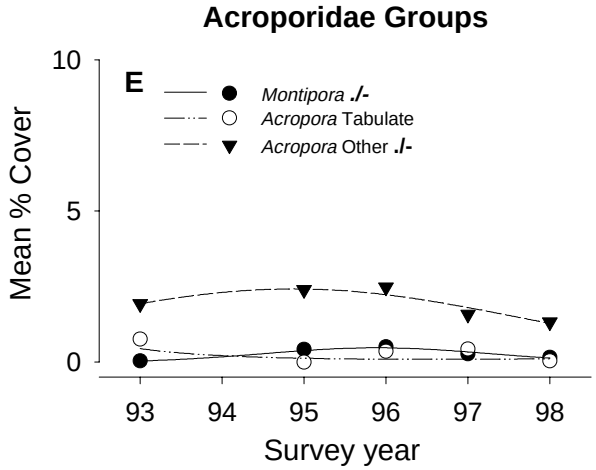
No manta tow surveys conducted on this reef in 1998 due to poor visibility.

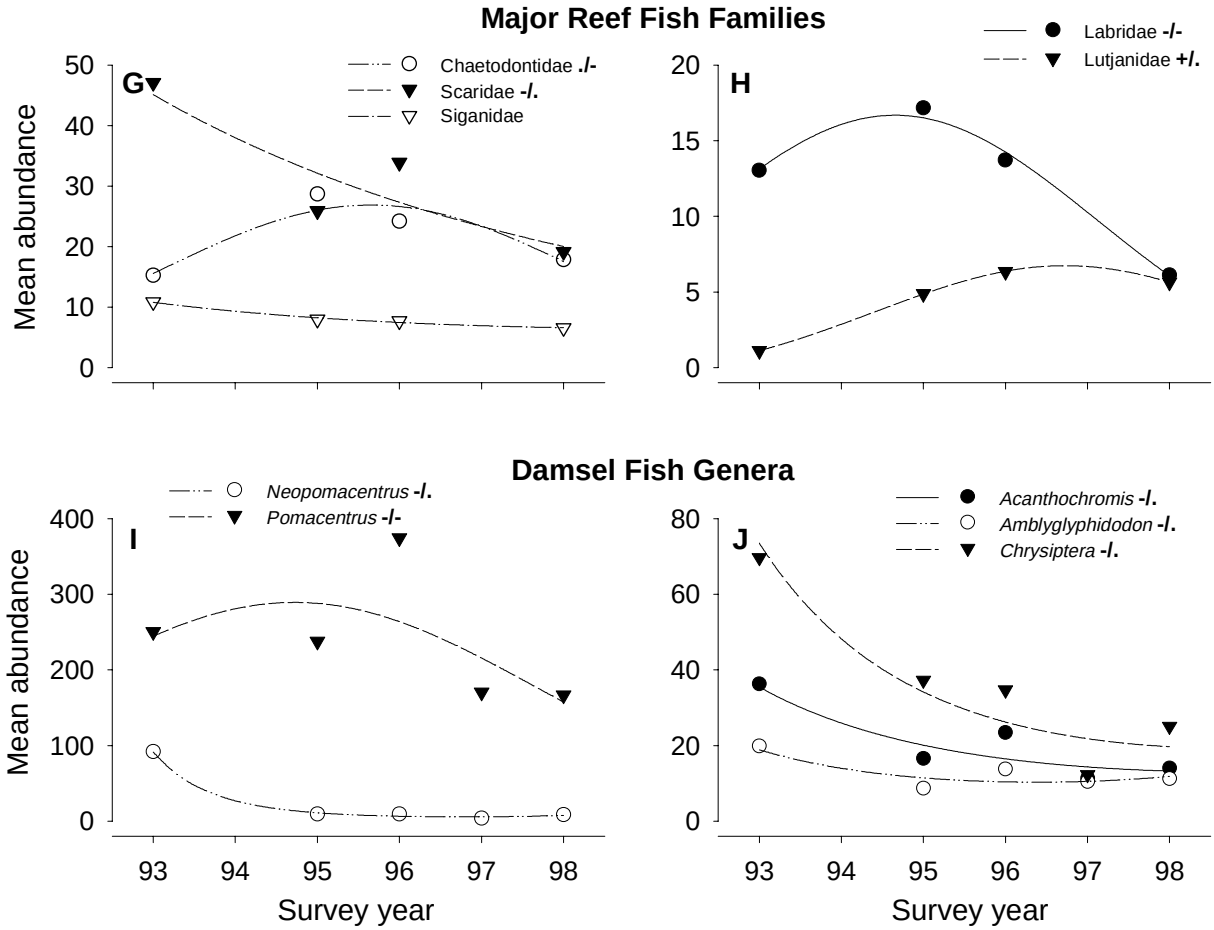


Langford and Bird Islands (No. 20-019) is an inner shelf fringing reef surrounding two high continental islands and a sand cay. The reef has an area of 2.5 sq.km. Last surveyed March 1998.









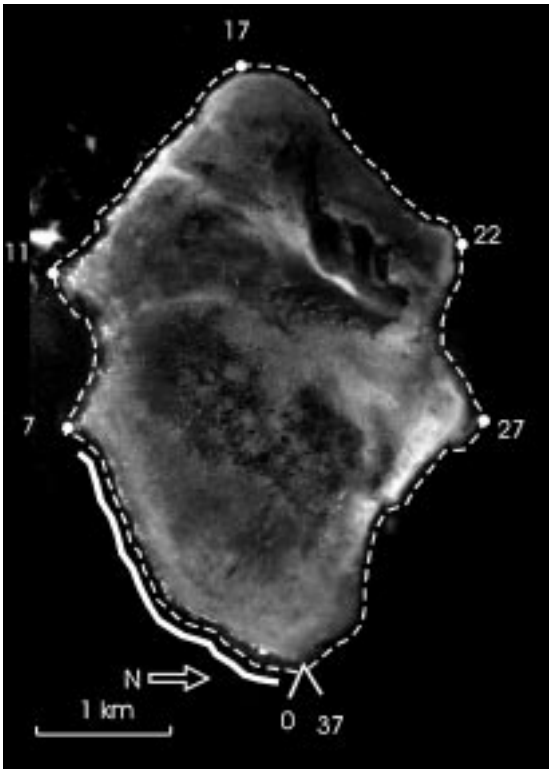
Langford and Bird Islands

This reef has been surveyed using manta tow five times since 1990. The coral cover has remained low. Manta tow surveys were not conducted on this reef in 1998 due to poor water visibility. Detailed benthic surveys reveal that this reef has a relatively high abundance of silt and sand on our sites (32% in 1998). The cover of hard coral cover is relatively low (17.9%) and has not changed over the survey period. *Goniopora* and *Porites* are the most abundant genera. Soft corals and algae are also stable. COTS have not been observed and the reef is currently classified as Non-Outbreaking. Moderate levels of bleaching were recorded (approx 20% of hard corals) in 1998.

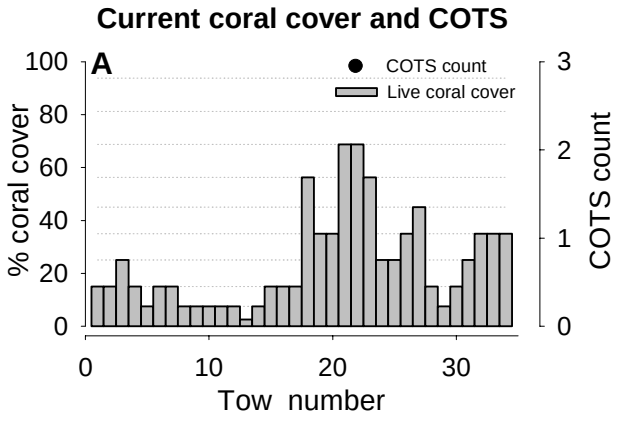
Eight fish groups show some trend in abundance with only one, Lutjanidae, showing an increase. *Acanthochromis polyacanthus*, *Amblyglyphidodon curacao*, *Chrysiptera rollandi*, and the Scarids *Scarus flavipectoralis, S. niger*, and *S. rivulatus* all show steady declines over the six years of surveys. Labrids have been declining since 1995 due predominantly to declines in *Cheilinus fasciatus* and *Choerodon fasciatus*. All three species of *Neopomacentrus, N. azysron, N. bankieri*, and *N. cyanomos* declined substantially after the first survey to very low abundances. Most species of *Pomacentrus* have declined over the period however some showed a brief increase in 1996 before again declining.

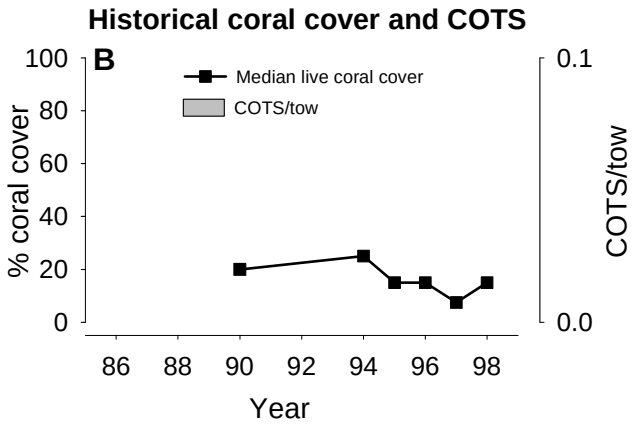
Figure 5.90

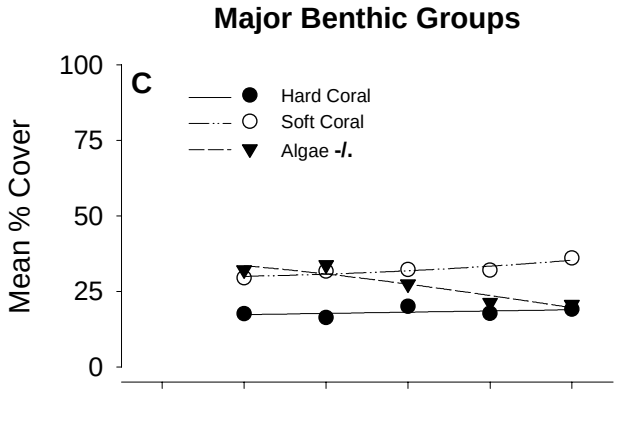
Rebe

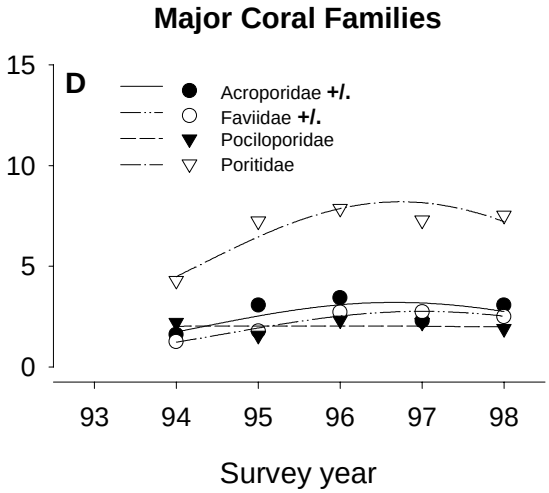


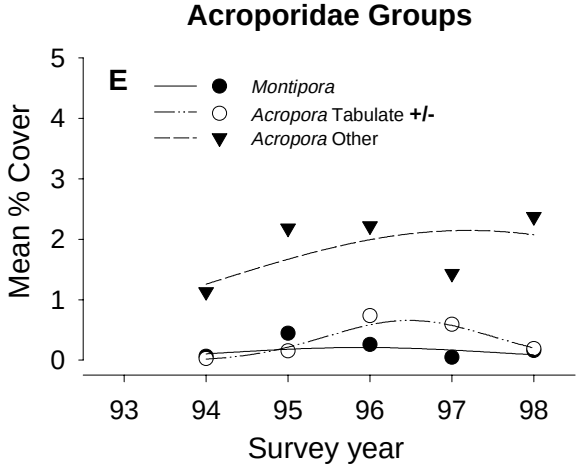
Rebe (No. 19-209) is an outer shelf planar reef with an area of 8.1 sq.km. Last surveyed February 1998

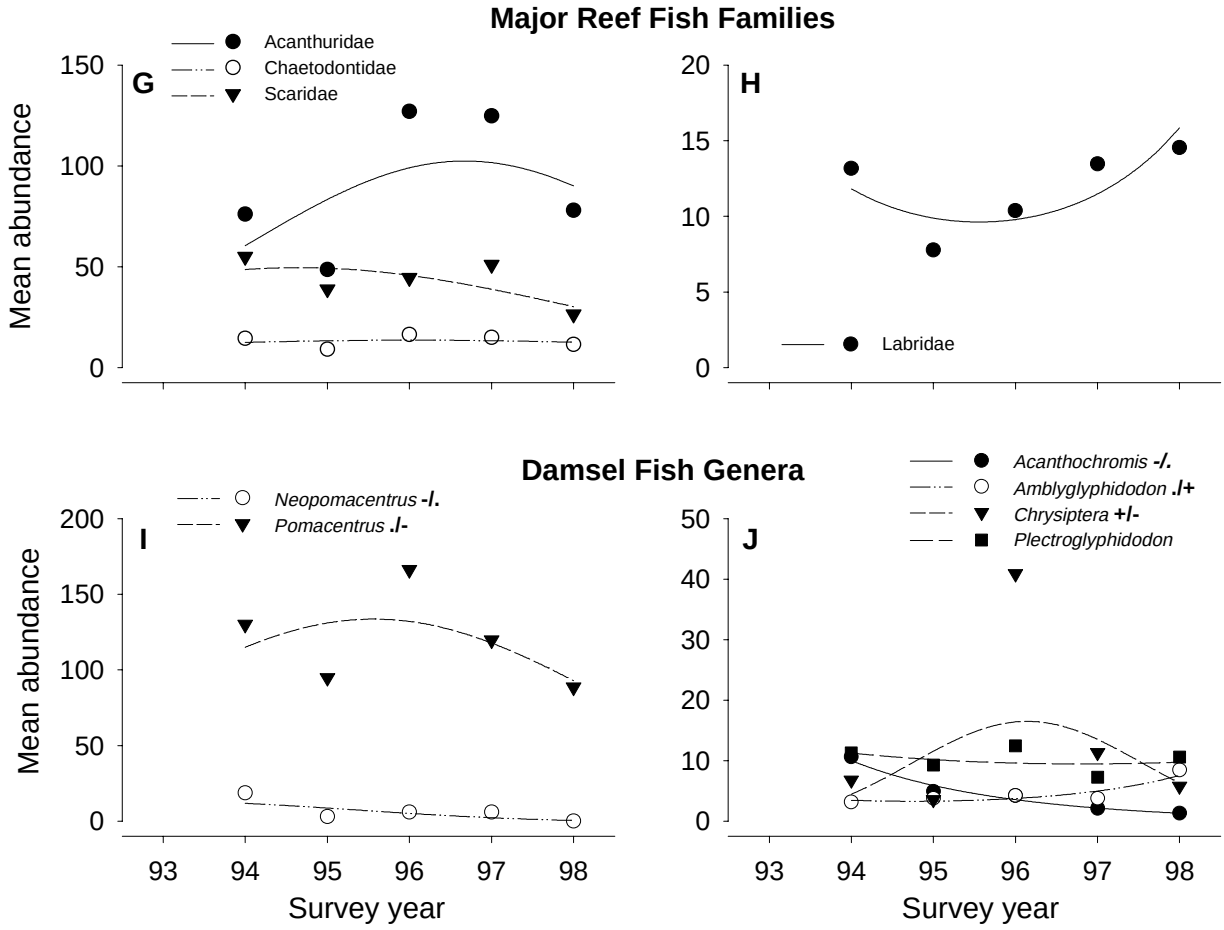












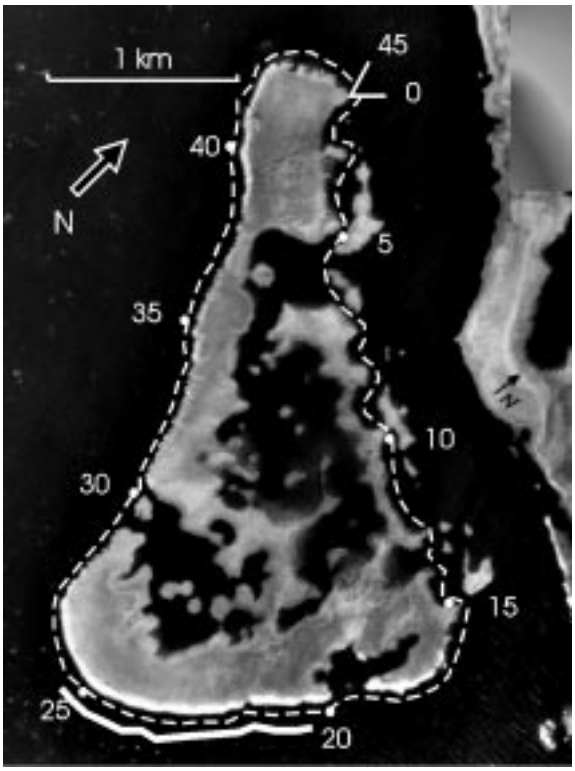
Rebe

This reef has been surveyed six times since 1990 using the manta tow technique. These surveys show that initially, coral cover remained stable at a moderate level before entering a period of decline from 1994. The reason for this decline in the absence of COTS is not clear however it is suggested that Cyclone Celeste (1996) and Cyclone Justin (1997) may have exacerbated the decline. Coral cover has currently returned to moderate levels. This trend is not supported by detailed coral surveys on the southeastern flank, which show that hard coral cover has remained relatively stable since 1994 and is currently at 19.1%. The cover of soft coral is relatively high (36.2%) and has been increasing over the survey period. The cover of sponges is also relatively high at 11.6%. The increase in soft corals has resulted in a corresponding decrease in the cover of algae. No COTS have been observed on this reef which is classified as Non-Oubreaking. Low levels of coral bleaching were recorded during 1998.

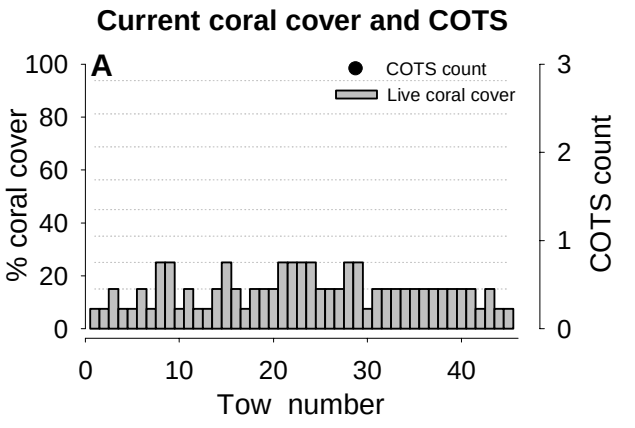
The trends in the fish community are very similar to those seen at Hyde. Again there is a general decline in *Acanthochromis polyacanthus* and a peak in abundance of *Chrysiptera rex* in 1996 which disappeared in the following survey. Declines in *Pomacentrus* include a steady decline in *P. banka*nensis and a current decline of *P. lepidogenys* from a high in 1996. *Amblyglyphidodon curacao* approximately doubled in the last survey. The trend in *Neopomacentrus* is derived from the alternate inclusion of small schools which is likely to be an effect of tidal state rather than real population fluctuations.

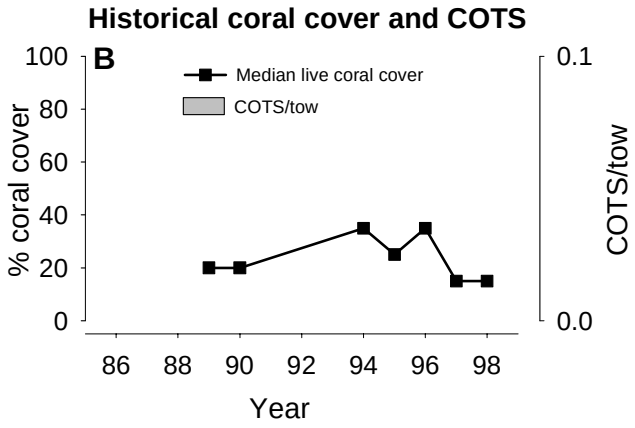
Figure 5.91

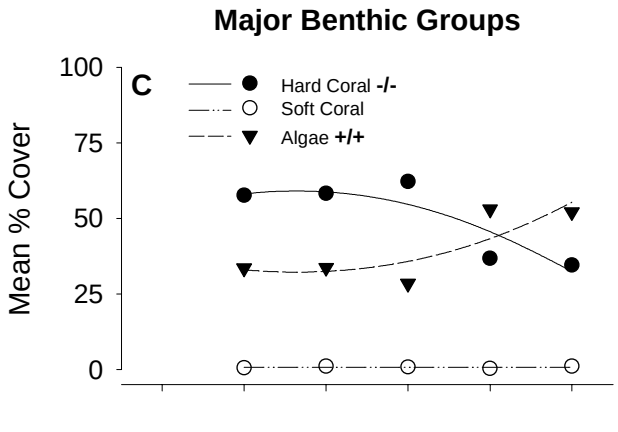
Reef No. 19-131

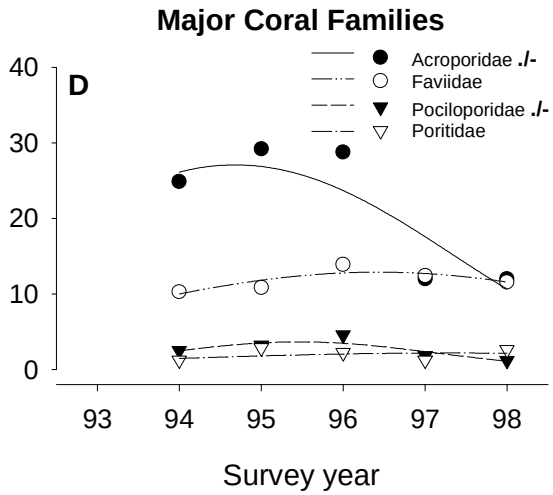


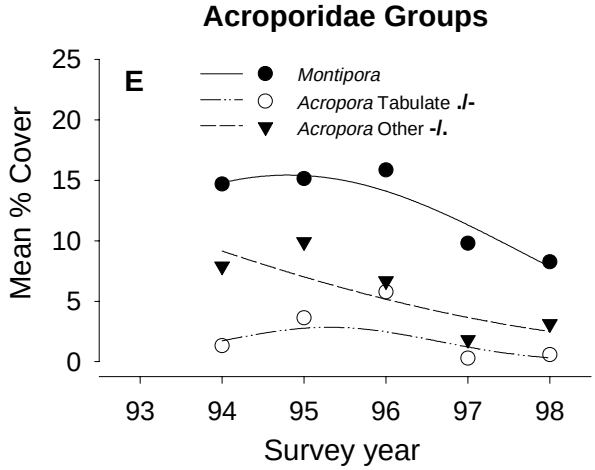
Reef No. 19-131 is a middle shelf lagoonal reef with an area of 5.6 sq.km. Last surveyed March 1998.

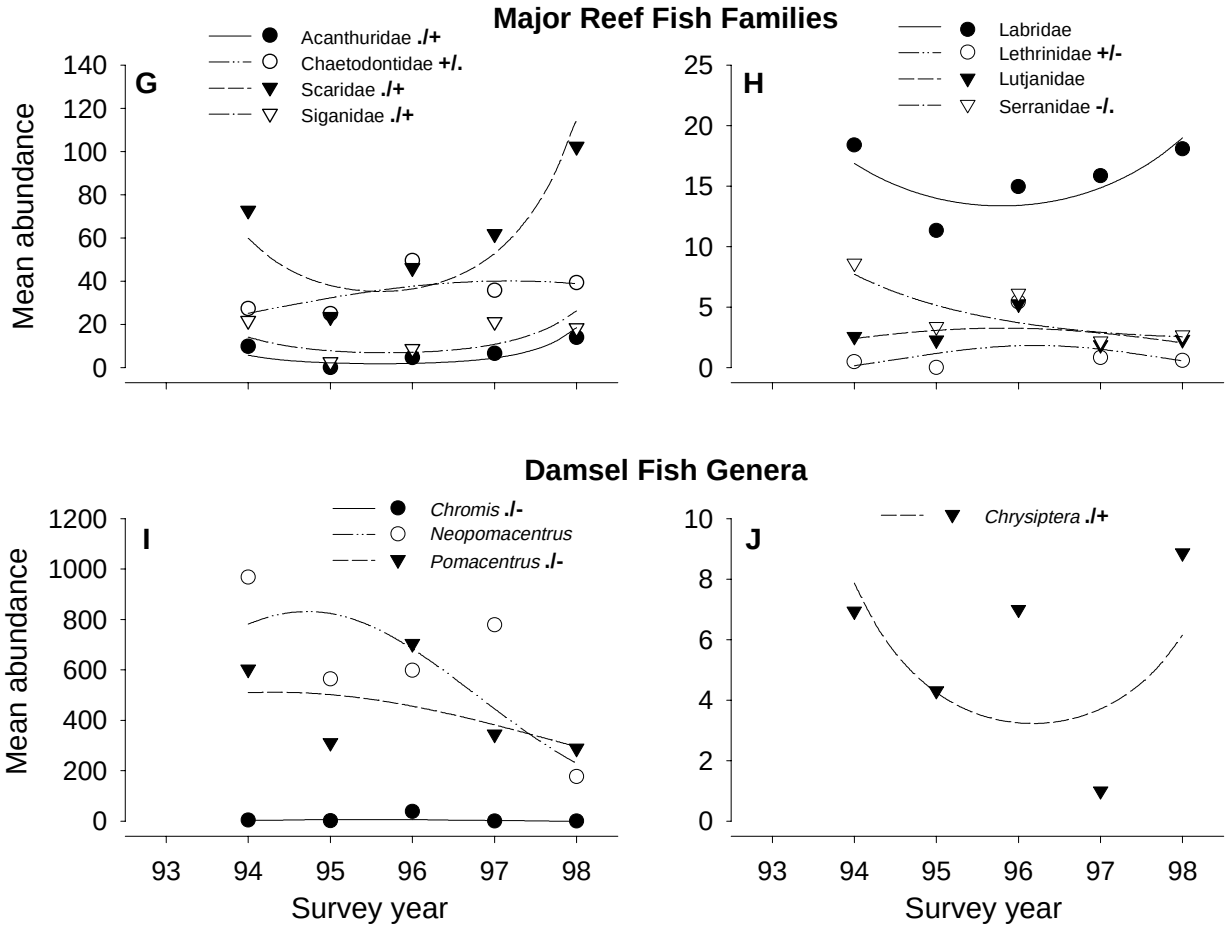










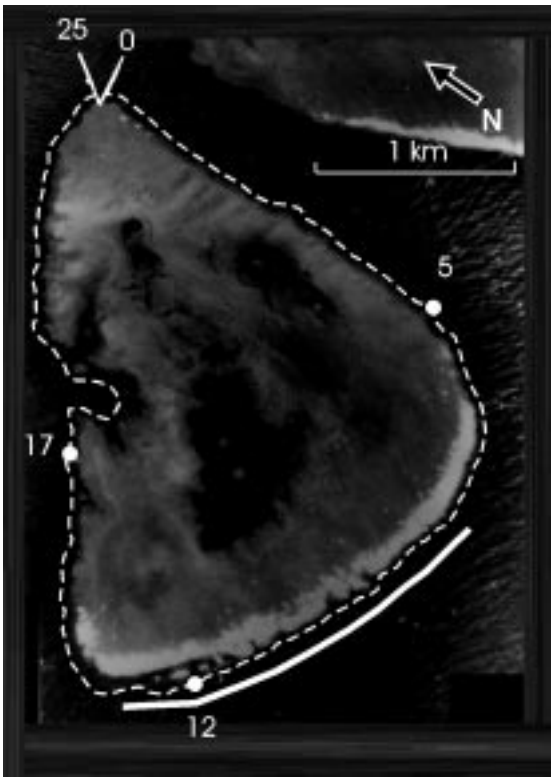


Reef No. 19-131

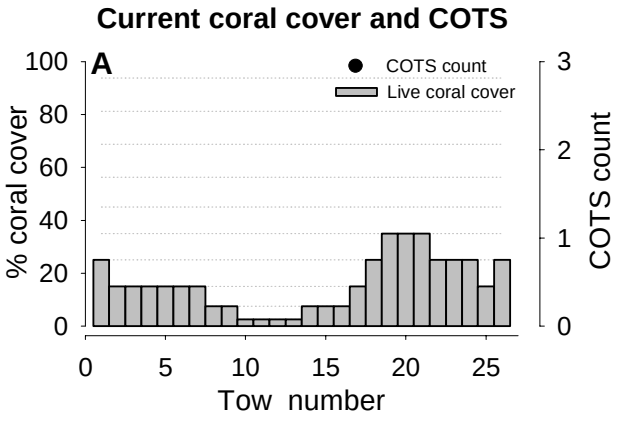
This reef has been surveyed regularly since 1989 using the manta tow technique. These surveys reveal a gradual trend of increasing coral cover until 1996 followed by a decline to current moderate levels. Detailed coral surveys, conducted since 1994 on the southeastern flank show that hard coral cover decreased from a maximum of 62% in 1996 to 35% in 1998. The drop in coral cover observed in both the detailed coral surveys and the manta tows, is attributed to the effects of cyclone Justin which remained off the Whitsunday coast for an extended period in March 1997 causing strong winds and high seas which impacted on the reefs in this area. Soft coral abundance has been consistently low (approximately 1%). No COTS have been observed on this reef and it is currently classified as Non-Oubreaking. Low level coral bleaching was recorded in 1998.

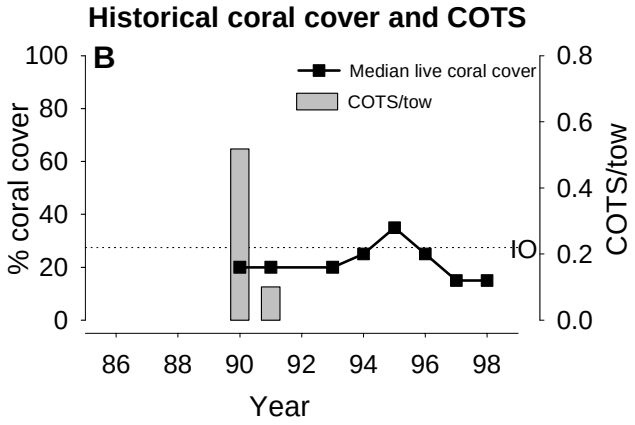
Trends in fish abundance have been very variable between groups with schooling species influencing several artificial trends. The trend in Lethrinidae is due to a school of *Lethrinus nebulosus* being included in 1996, whilst a school of *Naso tuberosus* in 1998 influences the observed trend in the Acanthuridae. Scarid abundance is highly variable at the species level however the majority of species do show higher counts in 1998 than in previous years. Chaetodontid abundance is relatively stable. *Chrysiptera rollandi* counts have been variable and therefore the current increase will need verification in future surveys. The decline in Serranidae is due to *Plectropomus leopardus.* The current decline in *Pomacentrus* is due to most species declining from 1996.

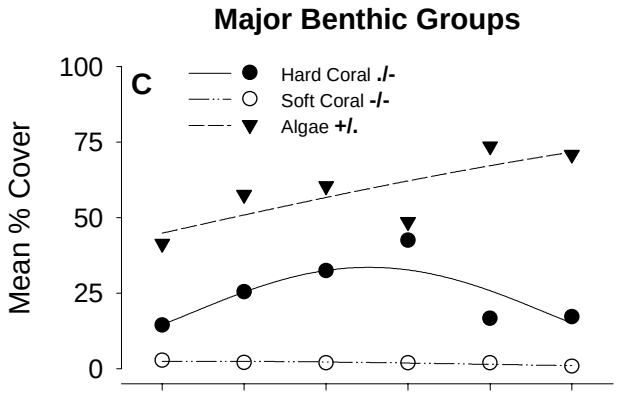
Figure 5.92 **Reef No. 19-138**

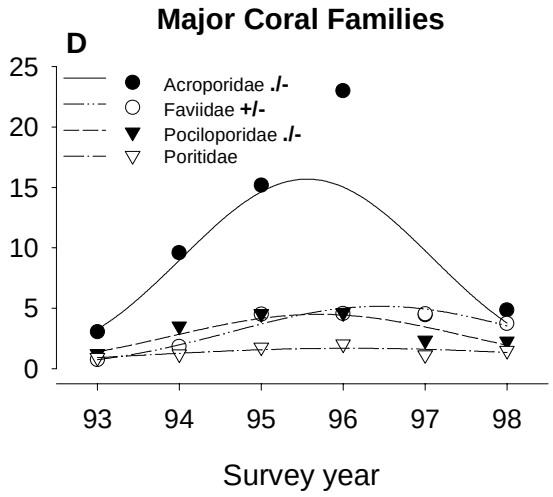


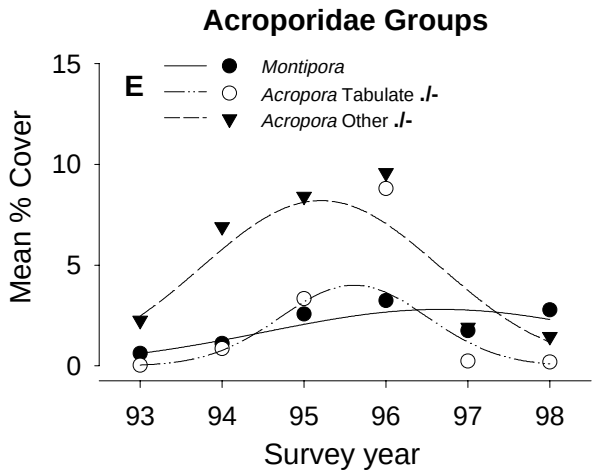
Reef No. 19-138 is a middle shelf lagoonal reef with an area of 2.5 sq. km. Last surveyed March 1998.

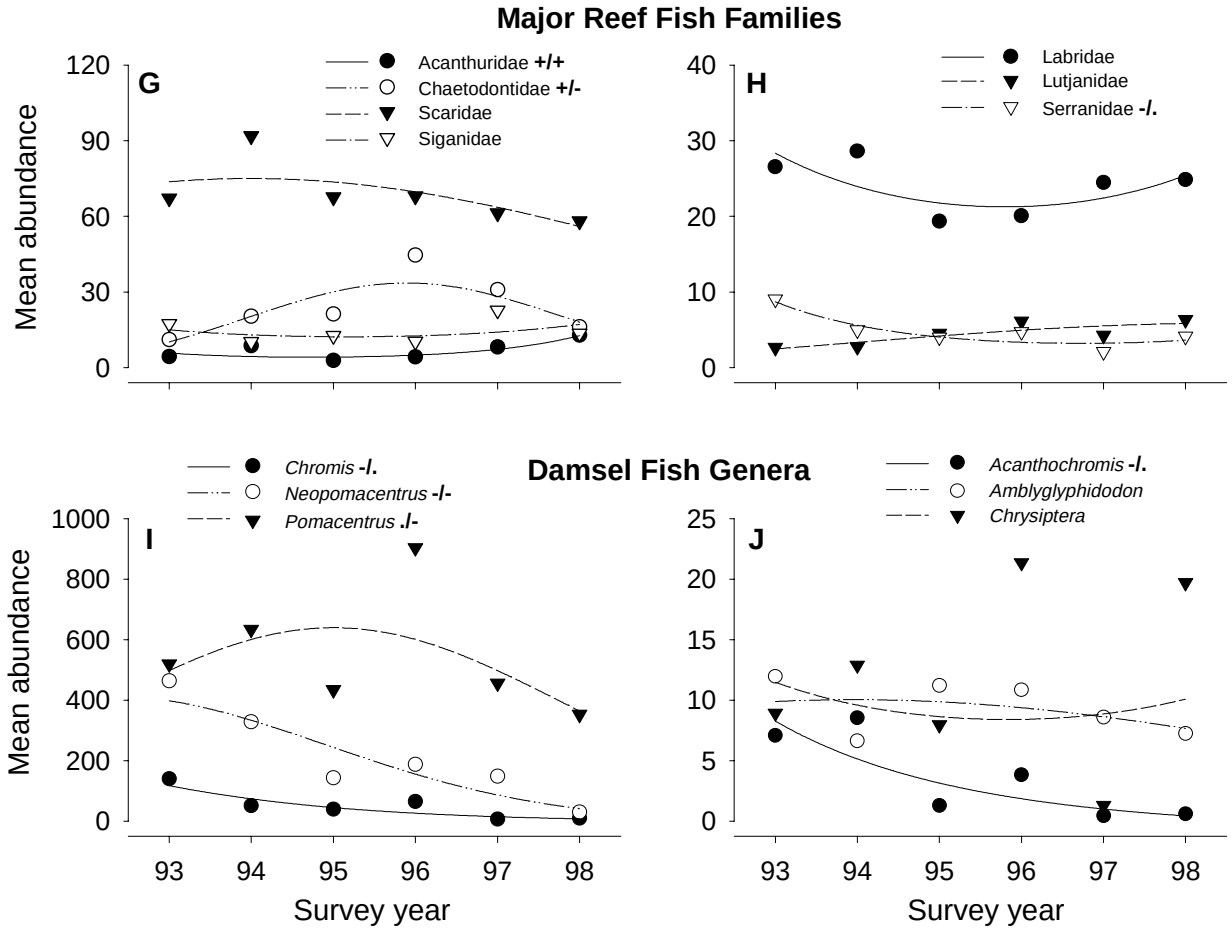












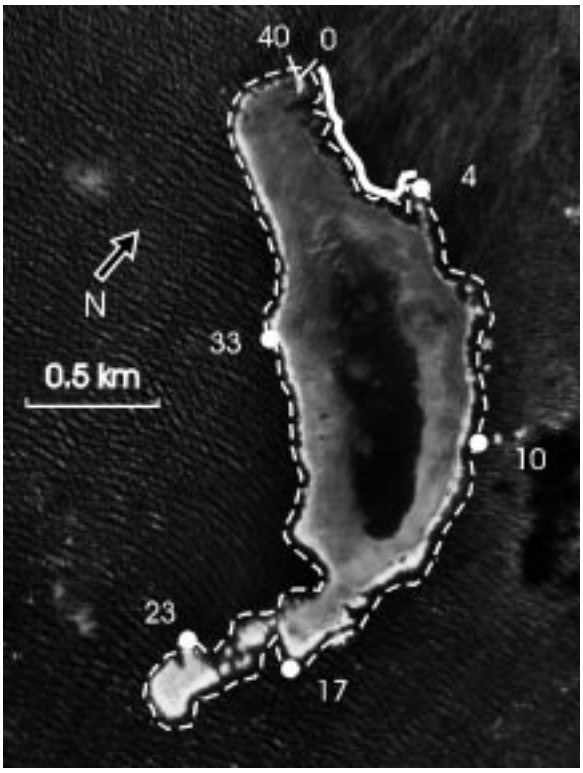
Reef No. 19-138

This reef has been surveyed regularly since 1990 using the manta tow technique. COTS were observed in relatively high numbers in the initial year of survey, then in low numbers the next year. Coral cover was low at this time suggesting that we may have observed the tail end of an outbreak cycle. Coral cover was slow to recover but increased from 1993-1995 before subsequently declining to a current moderate level. This trend is supported by detailed coral surveys on the southern flank conducted since 1993, which show hard coral cover increasing to a maximum of 43% in 1996 before a significant decline observed in 1997. The current level observed in 1998 was a moderately low 17%. We attribute the decline between 1996 and 1997 to the effects of Cyclone Justin (See description in Reef No. 19-131). The data show that the Acroporidae were the most affected family and in particular the tabulates. Soft coral abundance is low and decreasing. No COTS have been observed on this reef during recent surveys and it is currently classified as Non-Oubreaking. Low levels of coral bleaching were recorded in 1998.

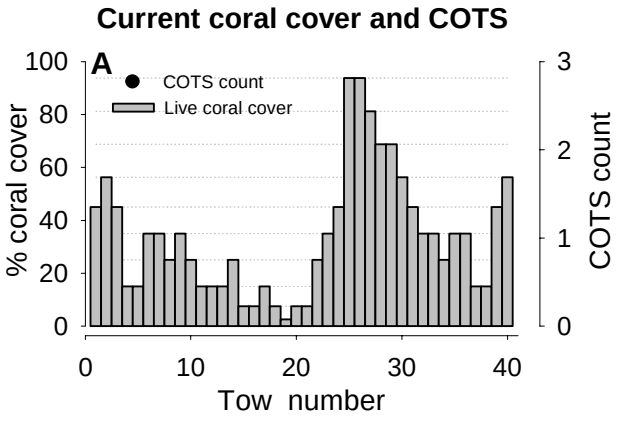
The declining damsel fish community contrasts with the larger reef fish, which have been predominantly stable. The only declines in the larger reef fish have been a slight drop in the Serranid, *Plectropomus leopardus,* and decreases in the two common Chaetodontids*, Chaetodon aureofasciatus* and *C. rainfordi*, from high abundances in 1996. The increase in Acanthuridae is due to an increase in *Naso unicornis* during the last survey. In contrast *Acanthochromis polyacanthus* and *Neopomacentrus azysron* both decreased over the surveys. The trend in *Chromis* is driven by a crash in *C. nitida* from 586 individuals in the first visit to just one in 1998. *Pomacentrus* numbers have been in general decline and it is only high abundances of *P. moluccensis* and *P. lepidogenys* in 1996 that restrict the trend to a current decline.

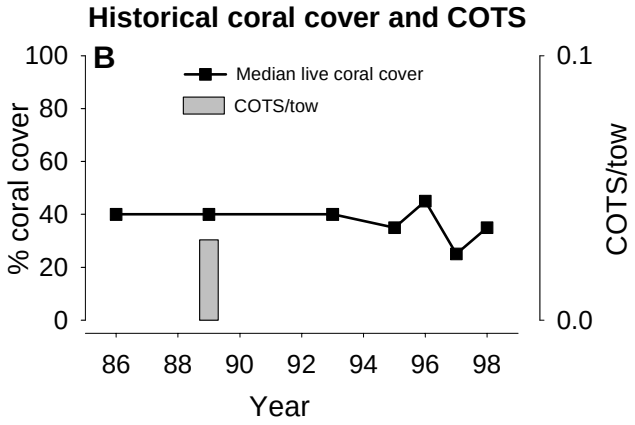
Figure 5.93

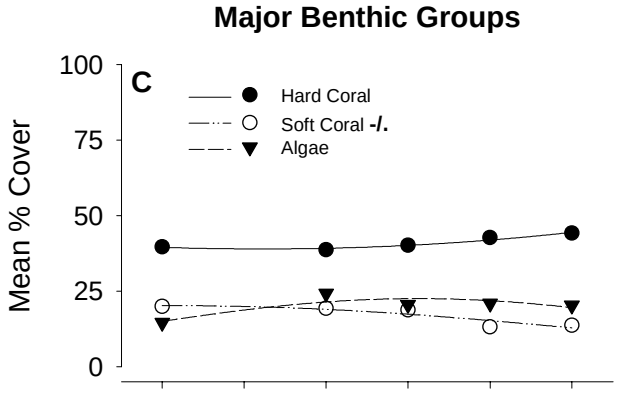
Reef No. 19-159

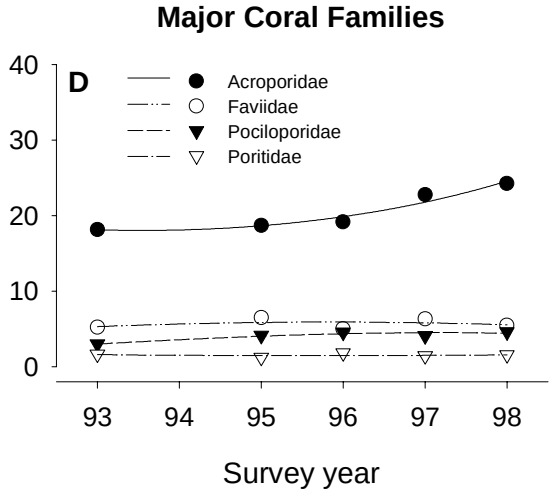


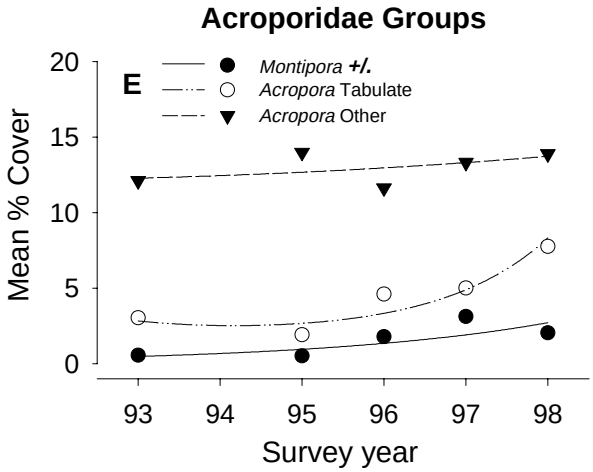
Reef No. 19-159 is an outer shelf lagoonal reef with an area of 3.8 sq.km. Last surveyed February 1998.

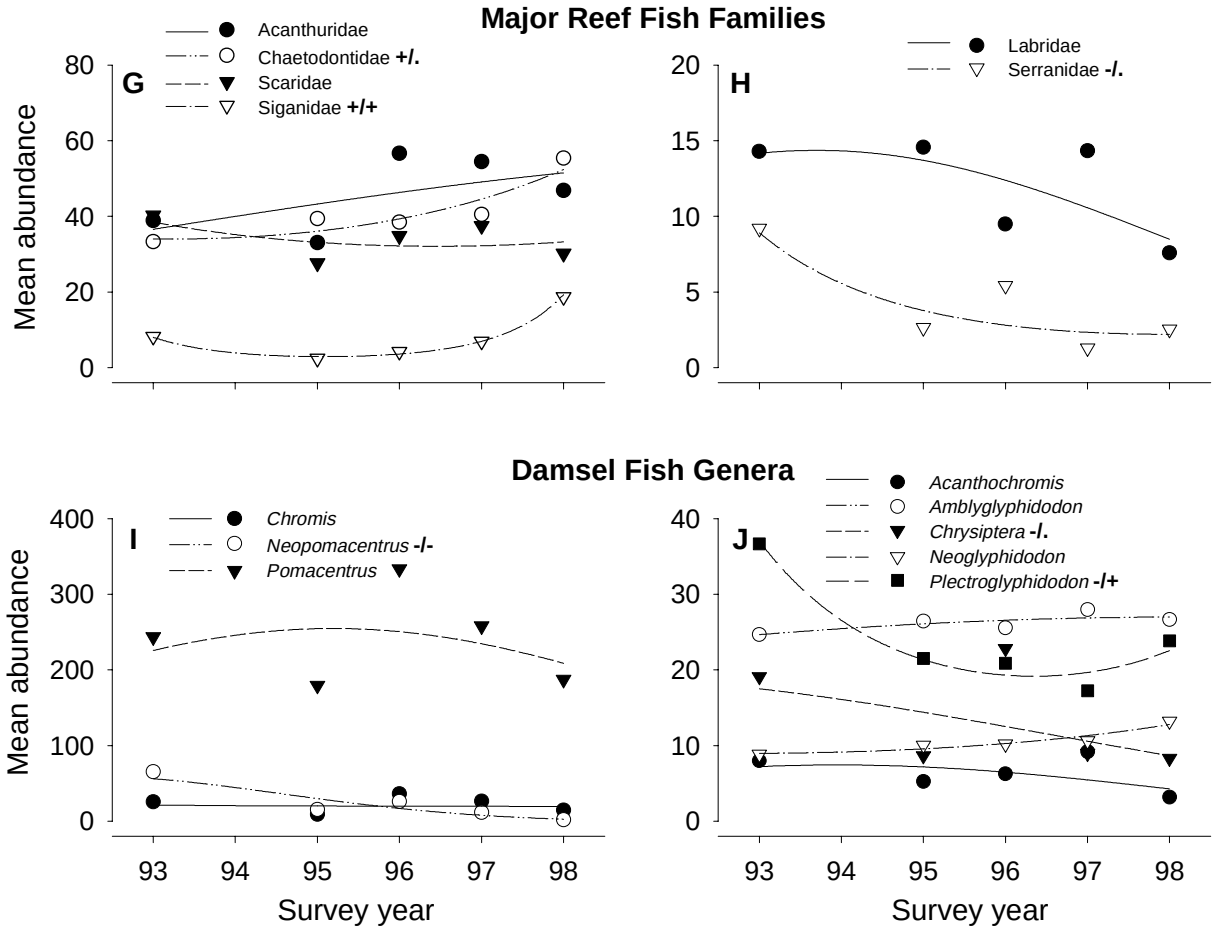












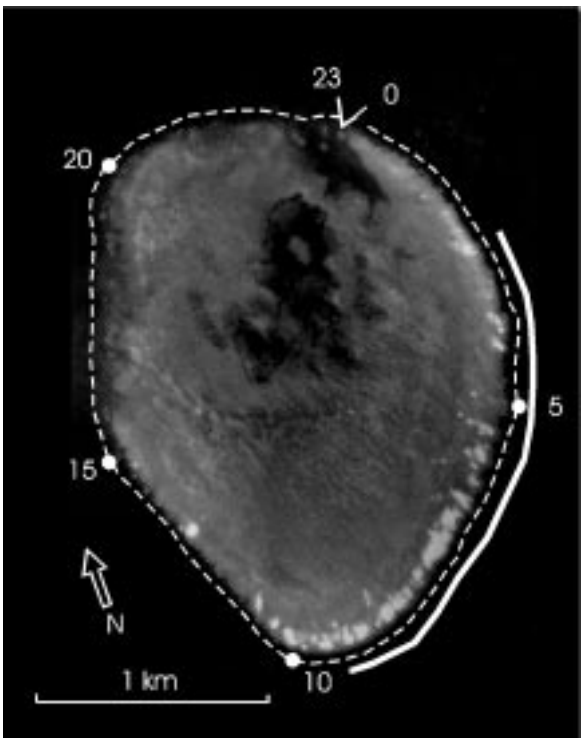
Reef No. 19-159

This reef has been surveyed regularly since 1986 using the manta tow technique. Coral cover has been stable at a high level over the period of survey. A decline in coral cover was observed between 1996 and 1997 and this is attributed to the effects of Cyclone Justin, which sat off the Queensland coast for an extended period in March 1997 resulting in large seas impacting on the reefs in the Whitsunday's. Detailed coral surveys have been conducted on this reef since 1993. The sites are less exposed and located on a steeper slope than Rebe and Hyde and declines in coral cover observed during manta tows were not observed in the area of the sites. Hard coral cover is moderately high (44%) and increased up to the last survey. Changes in coral cover during the survey period are due largely to changes in *Acropora* with tabulate, branching and Isoporid species all increasing. The cover of soft coral has decreased slightly while algae has remained relatively stable. Only one COTS has been observed on this reef during the seven surveys, the reef is currently classified as Non-Oubreaking. Low levels of bleaching were recorded in 1998.

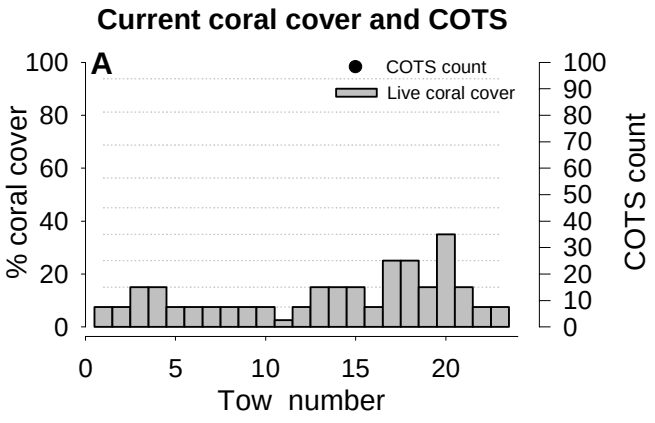
Reef fish communities have been stable over the last four years with the only declines occurring between the first and second survey. The species declining over this period, are the Serranid, *Plectropomus leopardus*, *Chrysiptera rex, Neopomacentrus azysron*, and *Plectroglyphidodon lacrymatus*. The increase in Chaetodontidae is due primarily to steady increases in *Chaetodon aureofasciatus* and *C. rainfordi*. The increase in Siganidae is due to a school of *Siganus punctatus* in 1998.

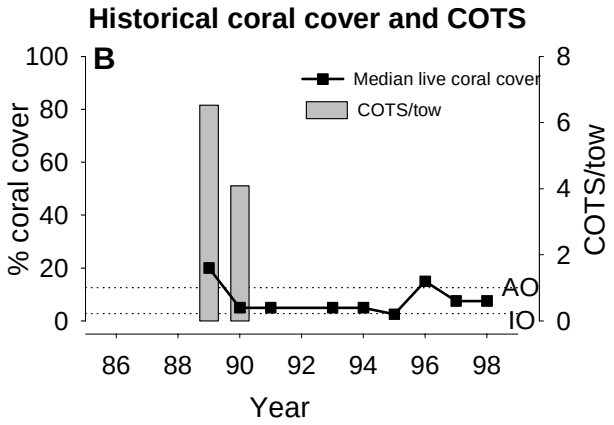
Figure 5.94

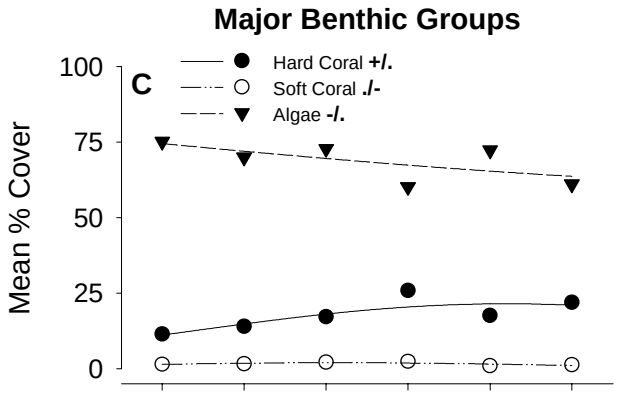
Reef No. 20-104

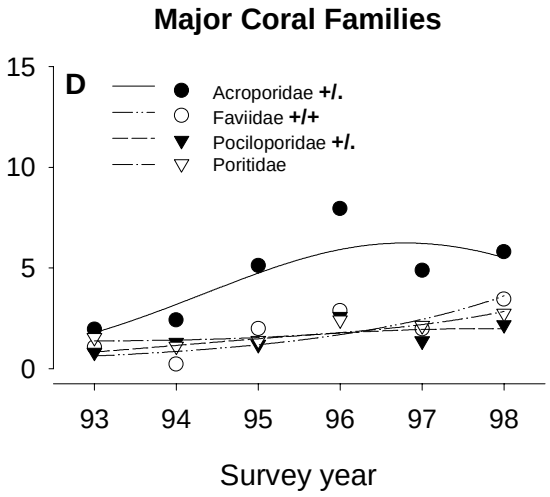


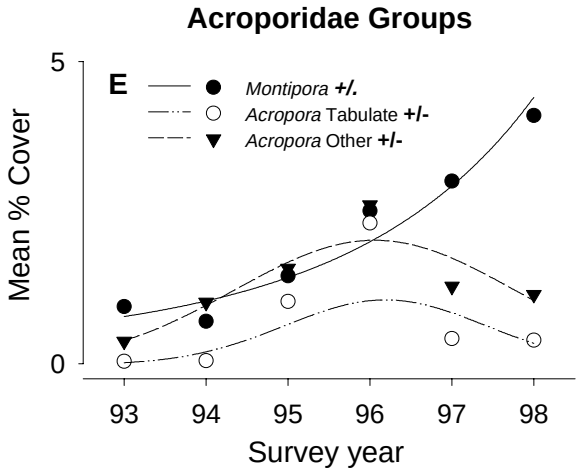
Reef No. 20-104 is a middle shelf lagoonal reef with an area of 1.9 sq.km. Last surveyed March 1998.

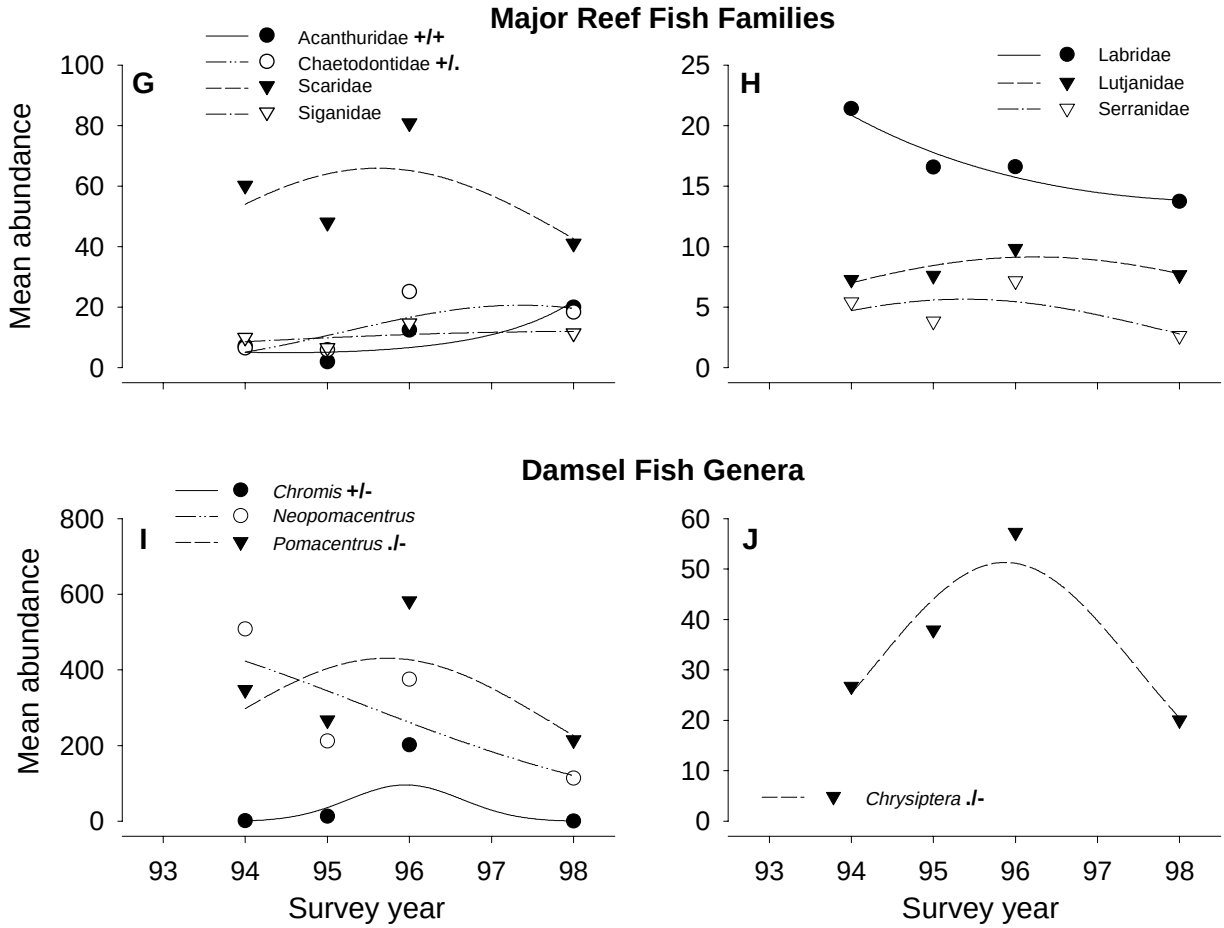












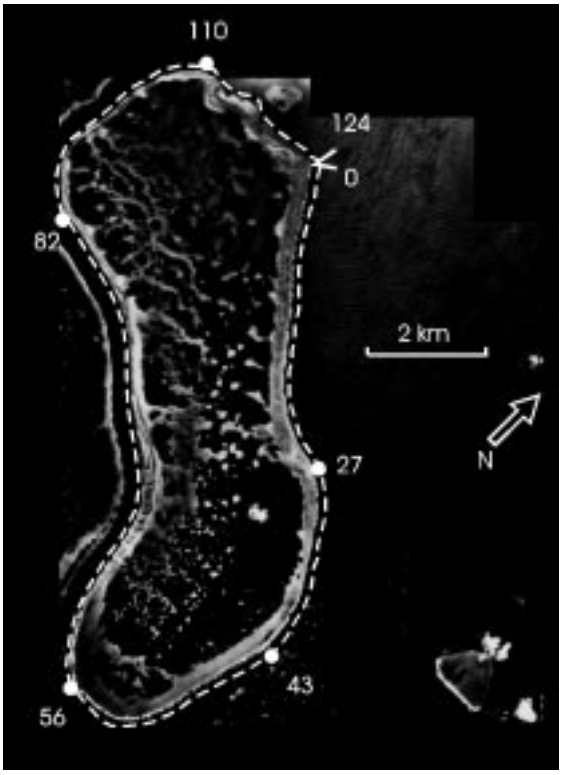
Reef No. 20-104

This reef has been surveyed regularly since 1989, using the manta tow technique. COTS were observed at outbreak levels during the first two years of surveys and coral cover declined to very low levels. Coral cover remained extremely low until 1996. Cyclone Justin caused strong winds and large seas during March 1997 and coral cover was observed to have declined in the next survey in 1997. Detailed coral surveys, conducted since 1993 on the southeastern flank show a slight increase in coral cover to 25.8% in 1996 then a decline, to 1997 followed by a slight recovery to a current cover of 22.4%. The decline in coral cover observed in 1997 was due mainly to a decline in *Acropora* spp. and in particular the tabulates. We attribute the decline to the effects of Cyclone Justin. It is worth noting that this reef has a relatively high cover of encrusting *Montipora* and these corals appeared unaffected by the cyclone. Low levels of coral bleaching were recorded during the most recent surveys.

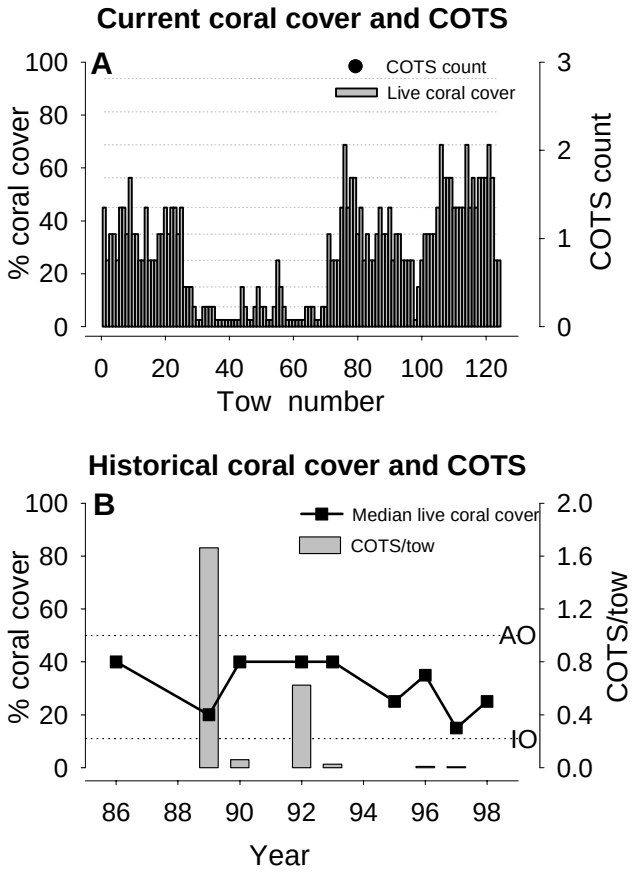
Whilst the larger fish community has remained relatively stable the already depauperate damsel fish community shows current decline. *Chromis nitida*, *Chrysiptera rex* and two *Pomacentrus* species, *P. lepidogenys* and *P. moluccensis* were all increasing up until 1996 after which time they decreased rapidly (C. nitida going from 777 in 1996 to zero in 1998). The increase in Chaetodontidae is predominantly reflecting increases in *Chaetodon aureofasciatus* and *C. rainfordi*. Higher counts of *Naso unicornis* and *N. tuberosus* in 1998 than other years, drives the observed increase in Acanthuridae.

Figure 5.95

Hardy



Hardy (No. 19-135) is a middle shelf crescentic reef with an area of 41.9 sq.km. Last surveyed April 1998



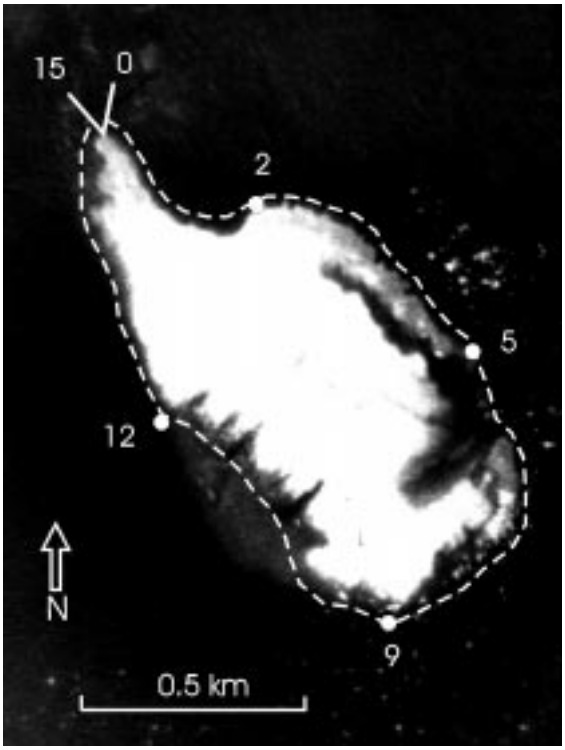
Hardy

This reef has an extensive history of broadscale surveys extending back to 1986. An Active Outbreak of COTS was first observed in 1989 and the reef has then continued to support smaller COTS populations which have been observed on most survey. There was an initial drop in coral cover between 1986 and 1989 corresponding to the elevated COTS populations but the reef soon recovered. Interestingly recent surveys indicate a trend of decreasing coral cover on this reef in the absence of large scale COTS activity. Several large cyclones have had an effect on the region in recent years. Cyclone Celeste (Category 3) passed to the north of Hardy in January 1996 and Cyclone Justin, remained off the Whitsunday coast in March 1997 for an extended period resulting in high winds and large seas in the area. Large scale physical damage has been observed at the southern end of the reef during recent manta tow surveys and it is suggested that both of these cyclones have impacted on the coral cover in recent times. Hardy reef is currently classified as Non-Oubreaking.

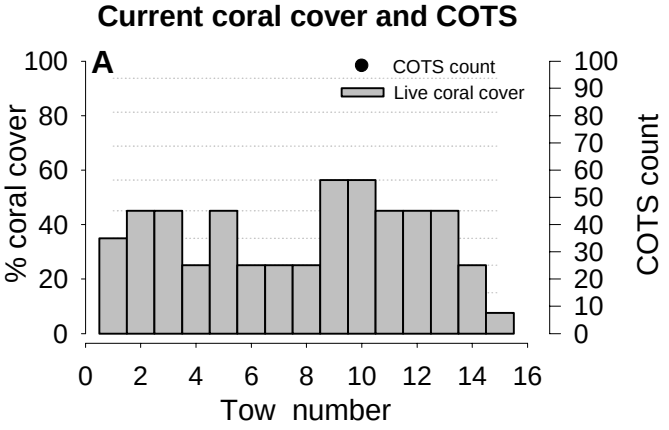
Pompeys reef pages

Figure 5.96

Ben



Ben (No. 20-113) is an outer shelf planar reef with an area of 1.2 sq.km. Last surveyed February 1998.



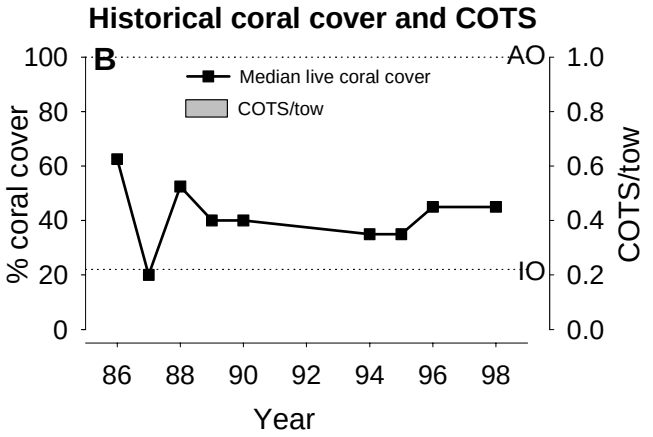
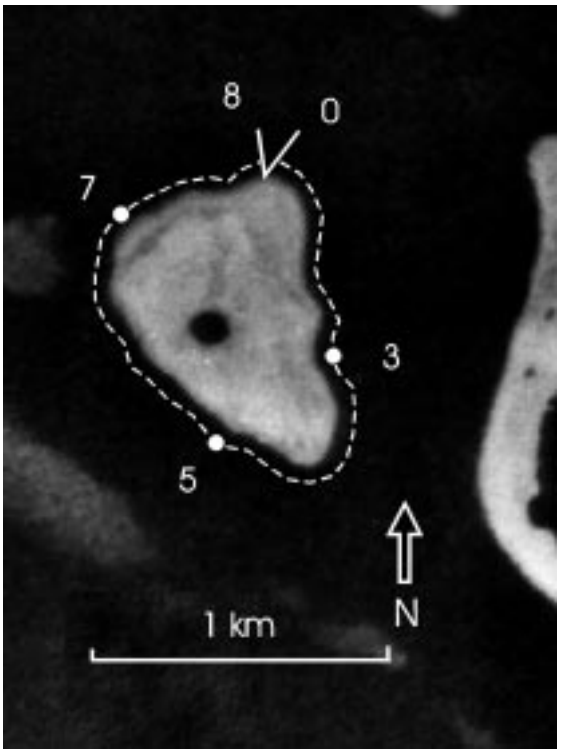
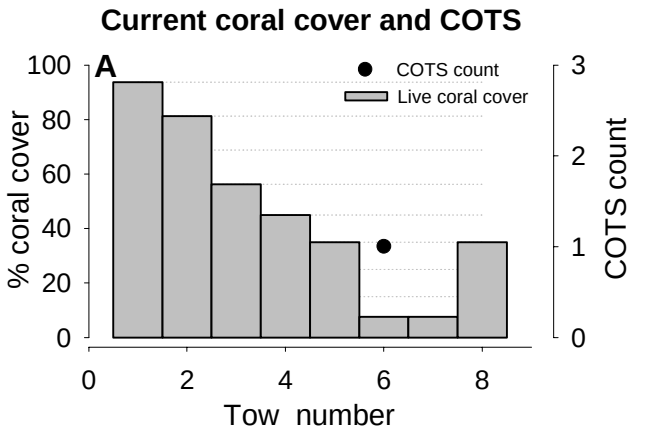


Figure 5.97

Briggs



Briggs (No. 20-299) is a middle shelf lagoonal reef with an area of 0.5 sq.km. Last surveyed March 1998.



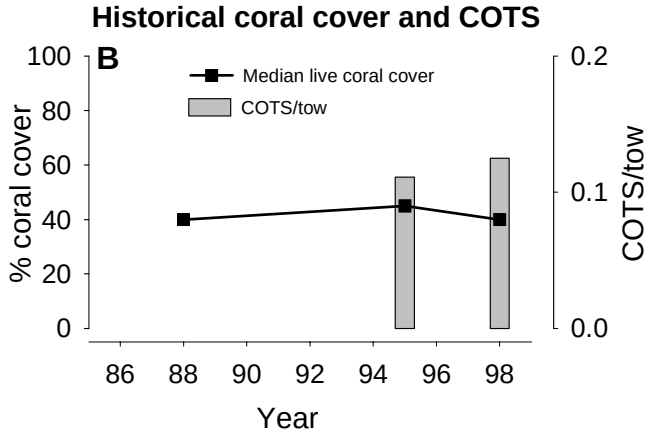
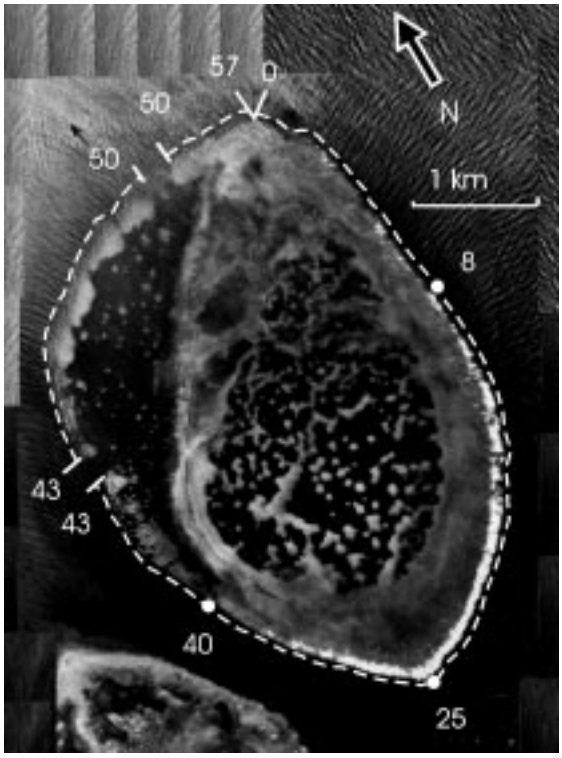
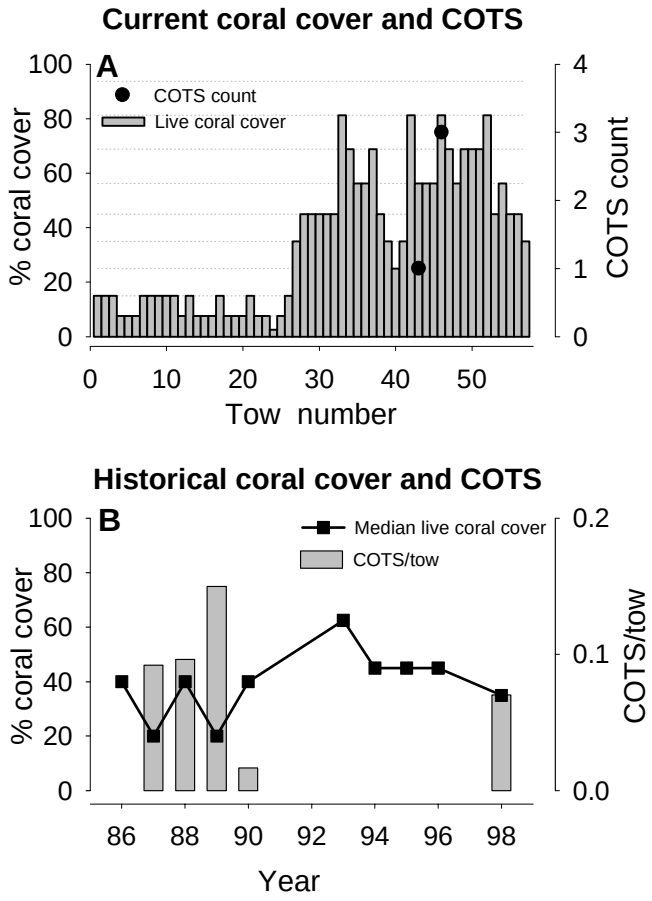


Figure 5.98

Credlin



Credlin (No. 20-287) is a middle shelf lagoonal reef with an area of 9.4 sq.km. Last surveyed March 1998.



Ben

This reef has been surveyed using manta tow since 1986. Coral cover has remained high with little change. No COTS have been recorded from this reef and it is currently classified as Non-Outbreaking.

Briggs

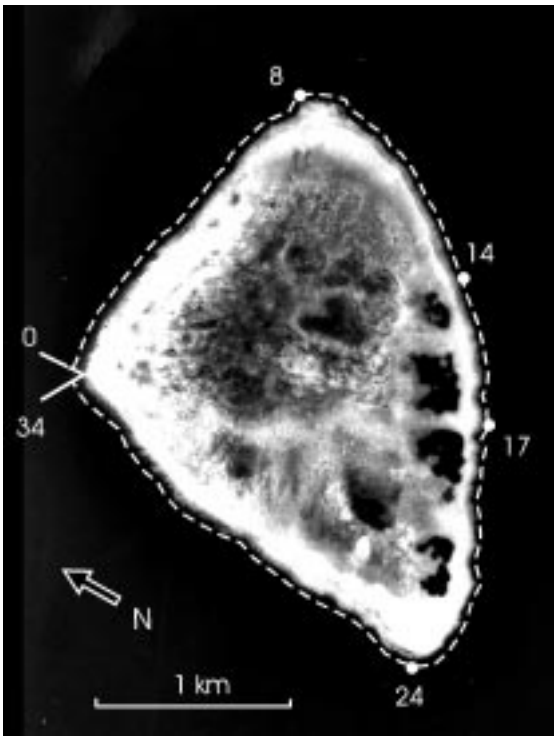
This reef has been surveyed three times using manta tow since 1988. There has been little change in coral cover which has remained stable at a high level. Surveys in 1995 and 1998 indicate the presence of COTS but in numbers too low to cause significant coral mortality. This reef is currently classified as Non-Outbreaking.

Credlin

This reef has been surveyed using manta tow since 1986. COTS were observed in low numbers up until 1990. Although there was some decrease in coral cover over this time it quickly recovered. Recent surveys indicate a trend of declining coral cover. This is probably a result of the effects of cyclone Justin in 1997. Recent surveys indicate the presence of COTS in numbers lower than those considered to cause significant coral mortality. This reef currently has high coral cover and is classified as Non-Oubreaking.

Figure 5.99

Reef No. 21-074



Reef No. 21-074 is a middle shelf lagoonal reef with an area of 4.4 sq.km. Last surveyed March 1998.

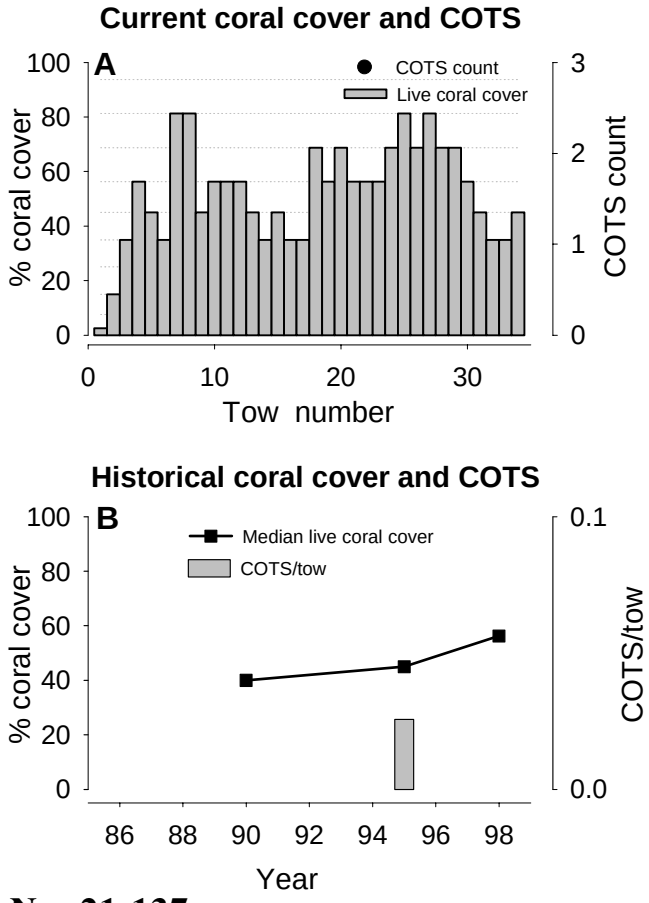
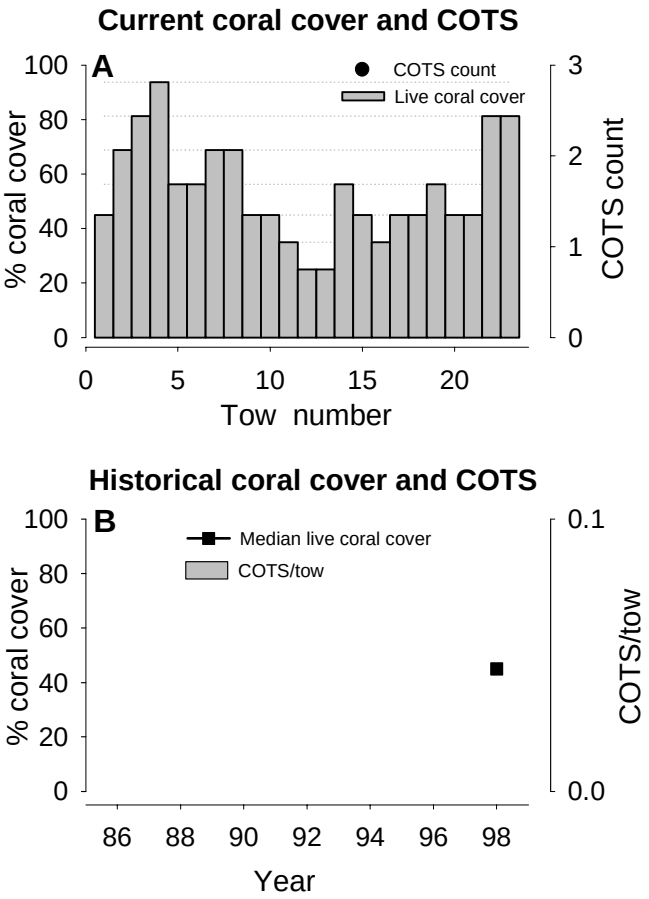


Figure 5.100

Reef No. 21-137

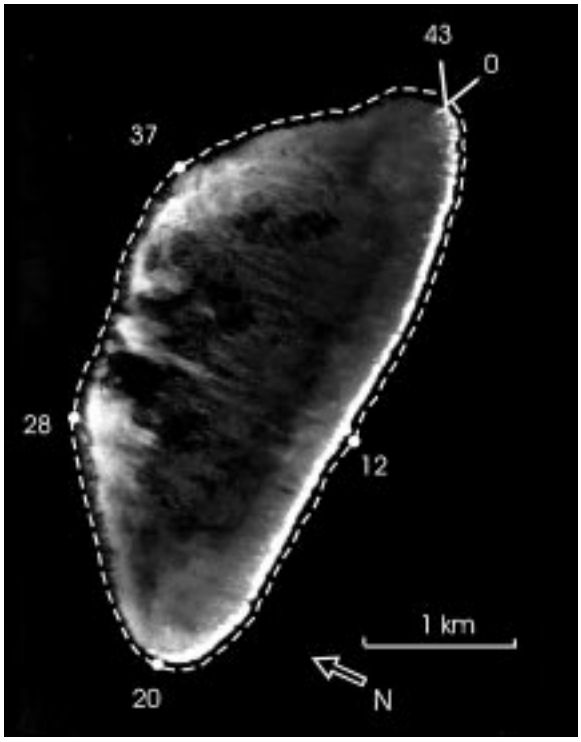
No aerial photograph currently available for this reef.



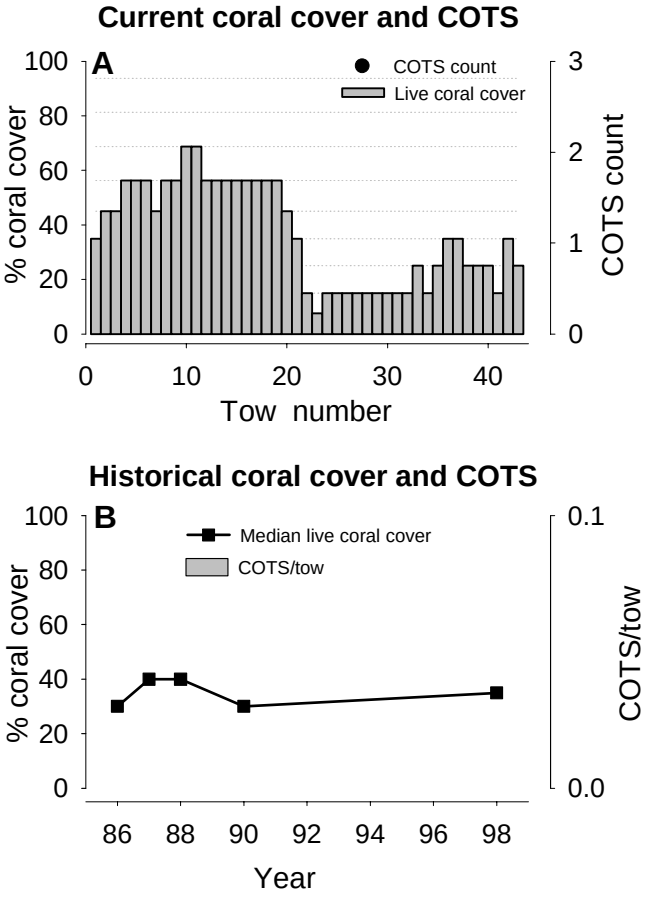
Reef No. 21-137 is a middle shelf planar reef with an area of 2.5 sq.km. Last surveyed March 1998.

Figure 5.101

Reef No. 21-140



Reef No. 21-140 is a middle shelf planar reef with an area of 5 sq.km. Last surveyed March 1998.



Reef No. 21-074

This reef has been surveyed using manta tow three times since 1990. There has been an increase in coral cover to the present very high level. Although COTS were observed on this reef in 1995 they were in numbers lower than those considered to cause significant coral mortality. This reef is currently classified as Non-Outbreaking.

Reef No. 21-137

This reef has only been surveyed in 1998. Coral cover is high and no COTS were observed. This reef is currently classified as Non-Outbreaking.

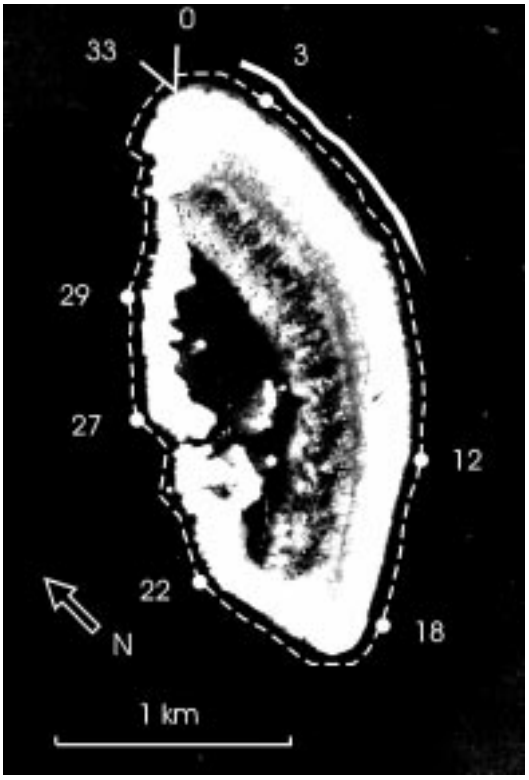
Reef No. 21-140

Although this reef has been surveyed five times since 1986 the current survey was the first since 1990. Results indicate that there has been little change in coral cover over this period, and cover remains high. No COTS have been observed on this reef and it is currently classified as Non-Outbreaking.

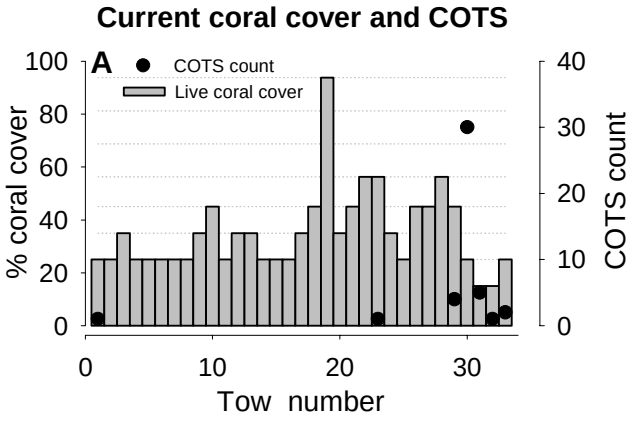
Swain
reef pages

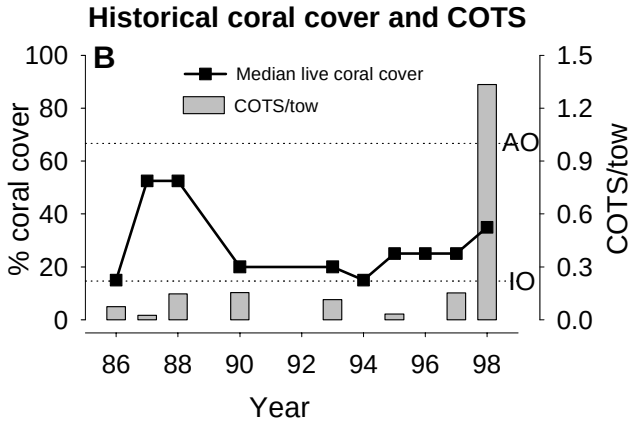
Figure 5.102

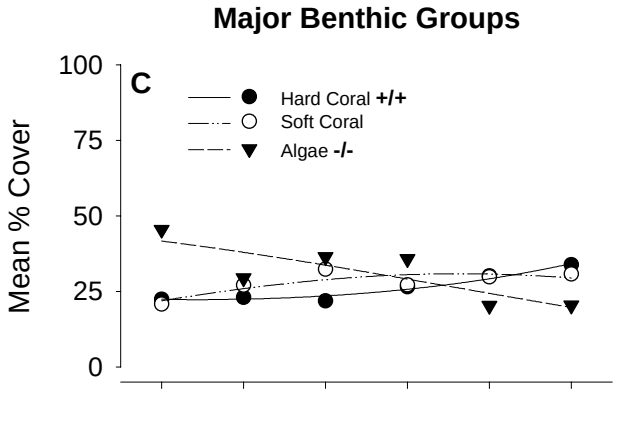
Chinaman

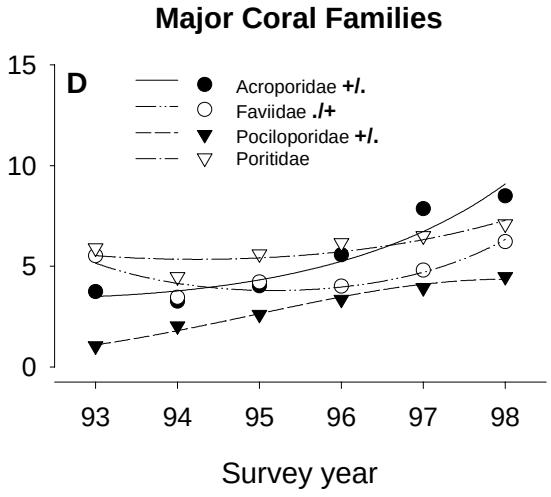


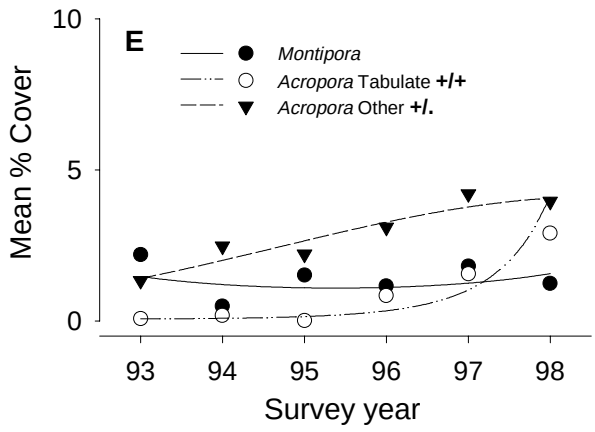
Chinaman (No. 22-102) is a middle shelf lagoonal reef with an area of 3.1 sq.km. Last surveyed December 1997.

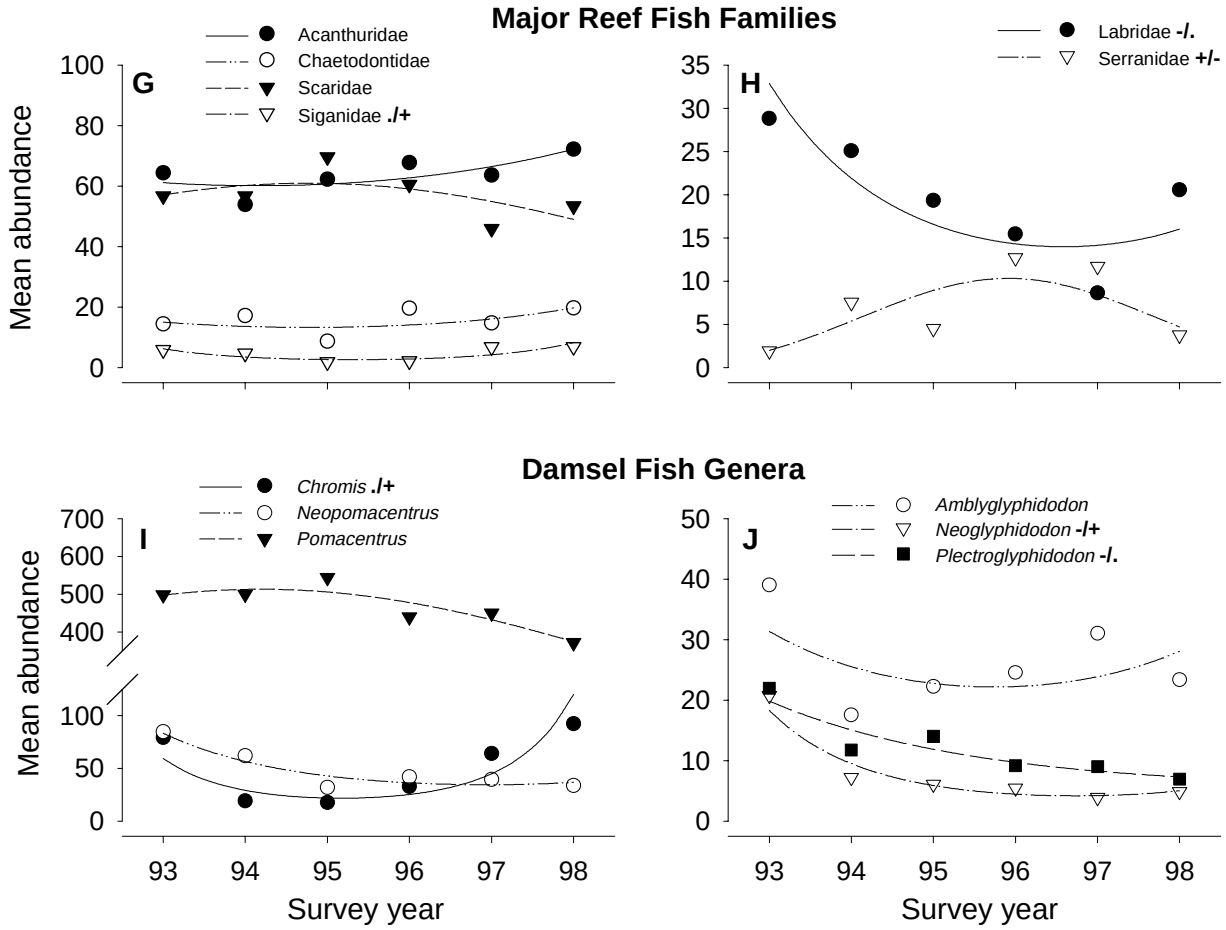












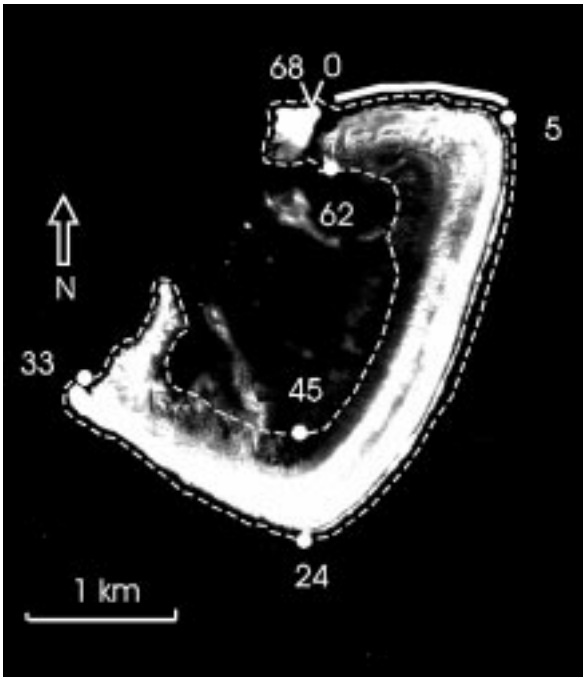
Chinaman

This reef has been surveyed extensively since 1986 using manta tow. Whilst COTS have been observed during most survey years it is only after our most recent surveys that the reef has been classified as an Active Outbreak. Over this time, coral cover has been variable. Of particular interest is the drop in coral cover between 1988 and 1990. The reasons for this remain unknown. It is unlikely that cyclones or COTS were responsible. No cyclones were reported within 200 km of Chinaman Reef between these years (Cyclone Harry passed within 593 km in 1988-89) and numbers of COTS were too low to cause significant coral damage. Since this time coral cover has recovered from moderate levels to the present moderately high level. This recovery is supported by detailed coral surveys since 1993 which show that hard coral cover has increased by 11.4% in the five years to 1998 and is currently moderately high at 33.4%. This is reflected in all the main hard coral families and there is a corresponding decrease in algal cover. Soft coral abundance is moderately high at 30.8% in 1998.

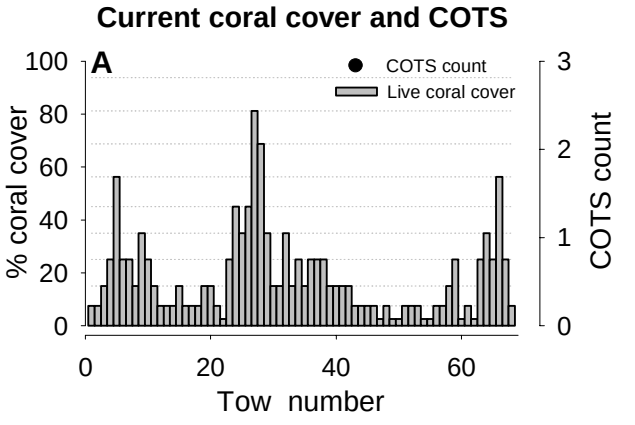
Only *Plectroglyphidodon* (*P. lacrymatus*) shows a linear change in abundance, declining over the survey period. Labridae (*Choerodon fasciatus*, *Gomphosus varius* and *Hemigymnus fasciatus*) and *Amblyglyphidodon curacao* both decline steadily until 1997 before a slight increase in 1998. The trend in Siganidae results from *S. corallinus*, which decreased until 1995 before increasing to 1997. Similarly *Chromis* (*C. nitida*) decreased initially before a steady increase. *Plectropomus leopardus* counts have been variable though tend to increase until 1997 before a slight decrease.

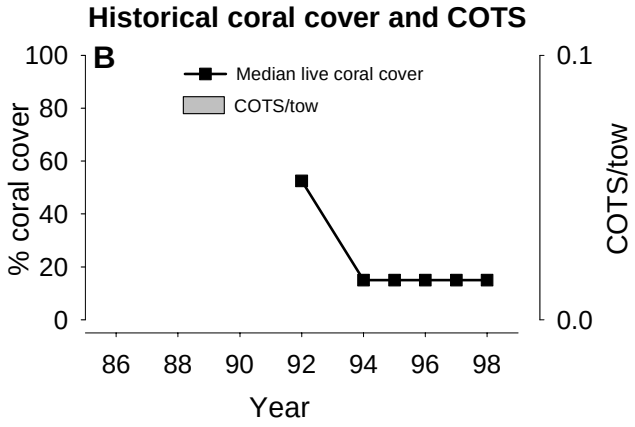
Figure 5.103

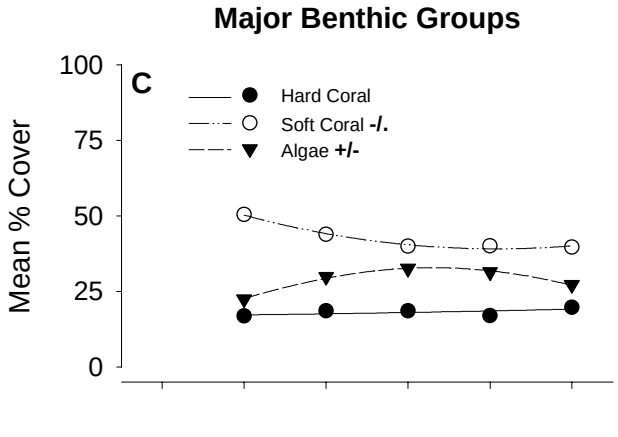
East Cay

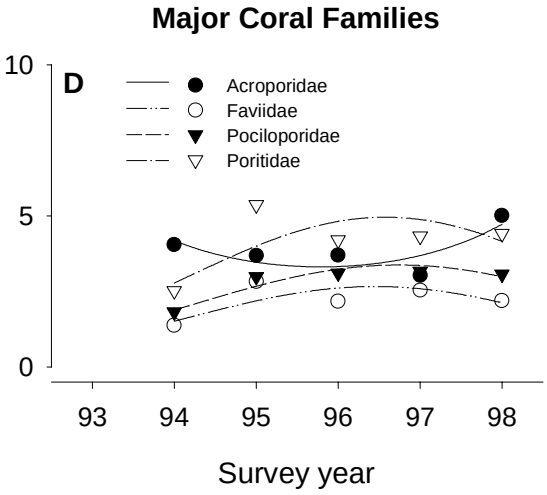


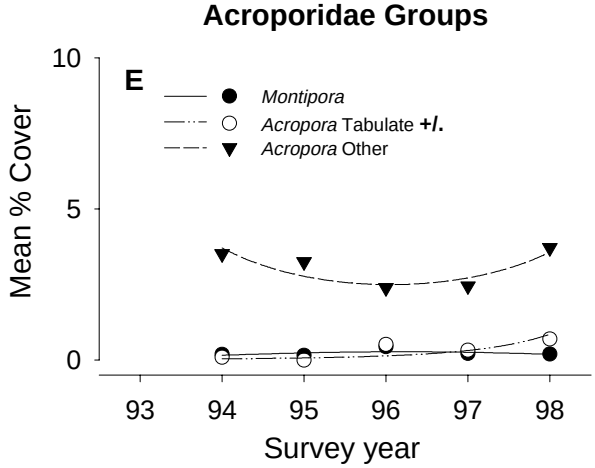
East Cay (No. 21-305) is an outer shelf crescentic reef with a sand cay on the north-western end. The reef has an area of 6.3 sq.km. Last surveyed November 1997.

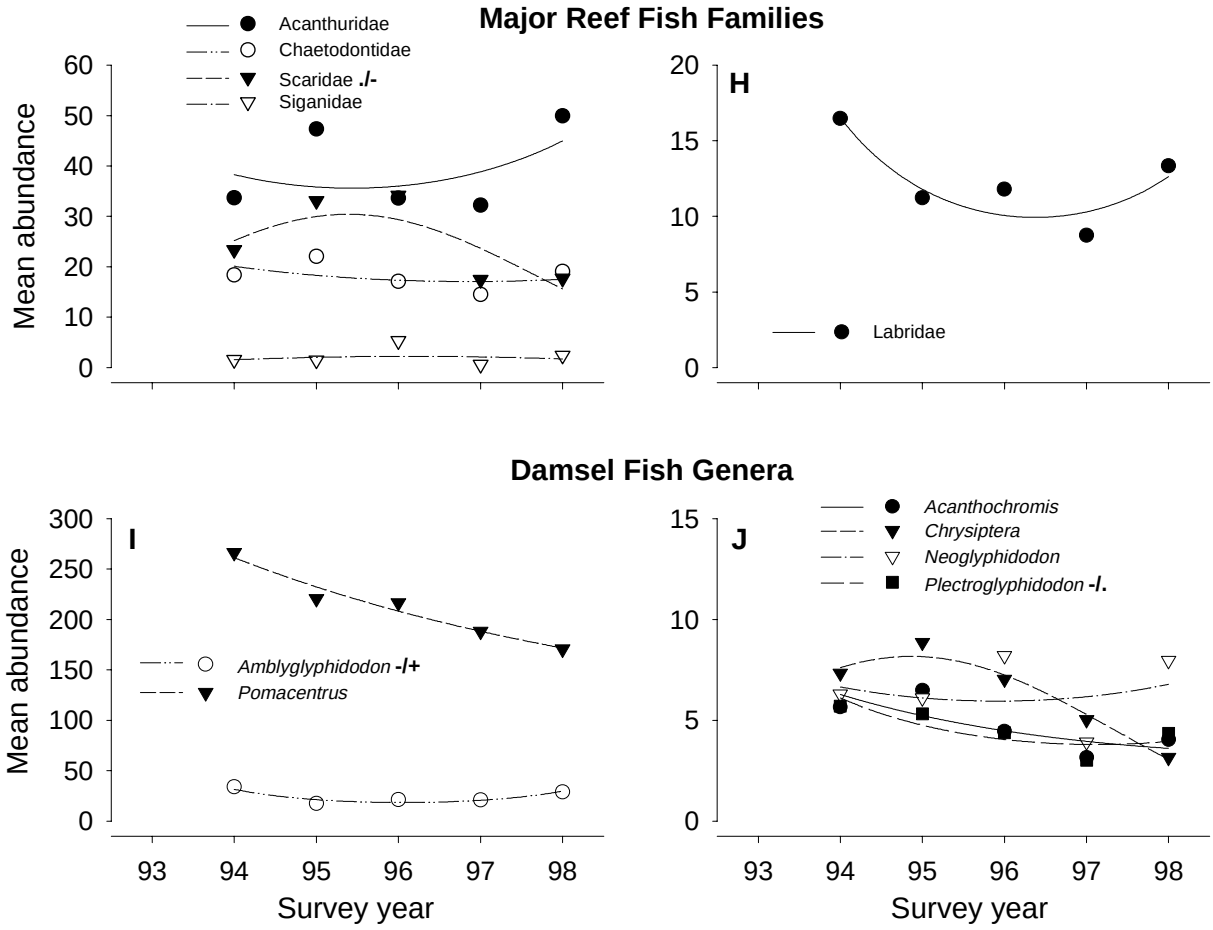












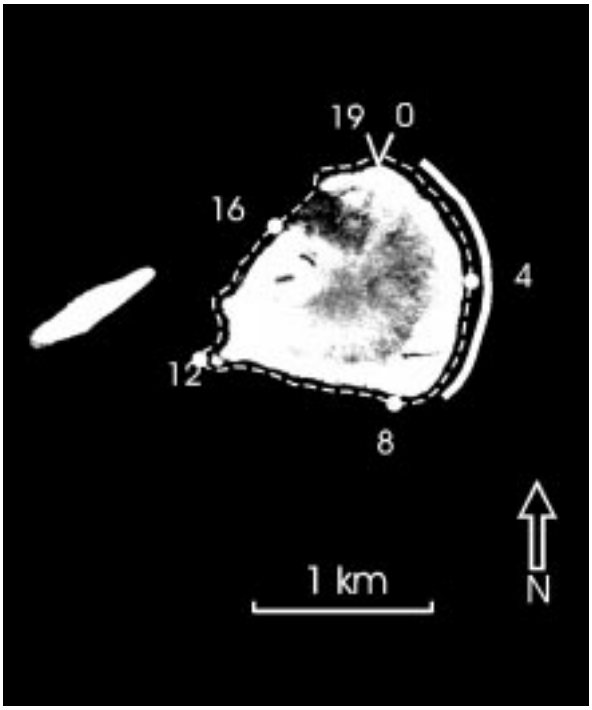
East Cay

This reef has been surveyed six times since 1992 using manta tow. The initial survey recorded high coral cover. Surveys in 1994 revealed that coral cover had declined to moderate levels There has been no change since. Detailed coral surveys on the northern flank also show little change in the benthic community over the survey period with hard coral cover currently moderate at 19.7%. The cover of soft coral has decreased but is still high at 39.7%. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

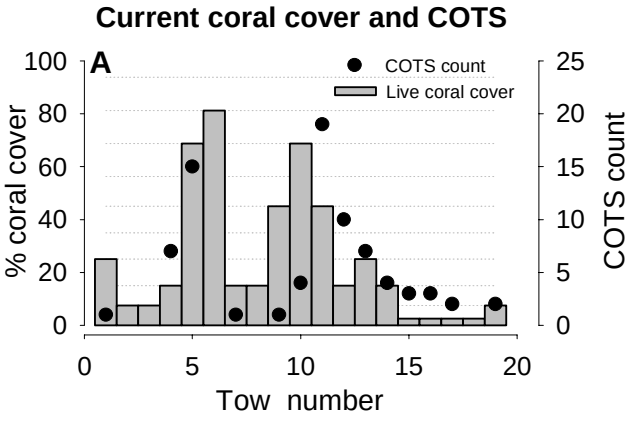
The stable benthic community is reflected in the fish community with few obvious trends. Whilst not statistically significant the steady decrease in *Pomacentrus* (*P. bankanensis, P. lepidogenys* and *P. moluccensis*) is the most obvious trend on the reef. *Plectroglyphidodon lacrymatus* also declined, though only to 1997 at which time counts increased slightly. The current downturn in Scaridae is representative of low counts in 1997 and 1998 for *Scarus chameleon*, *S. globiceps*, *S. psittacus*, and *S. sordidus. Amblyglyphidodon curacao* decreased between the first and second surveys and increased from that time on.

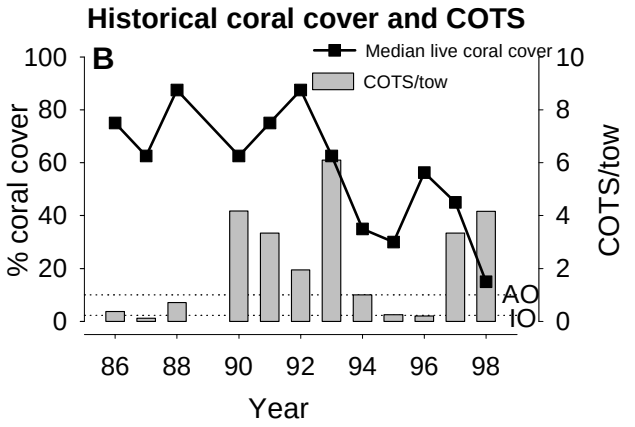
Figure 5.104

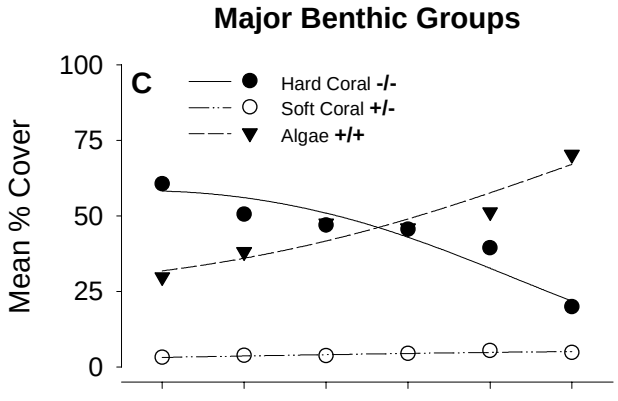
Gannet Cay

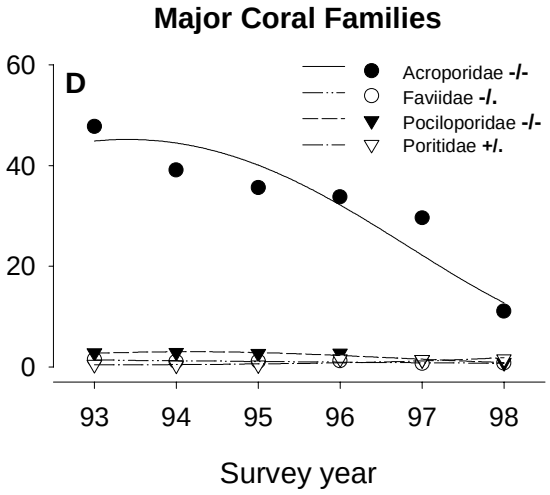


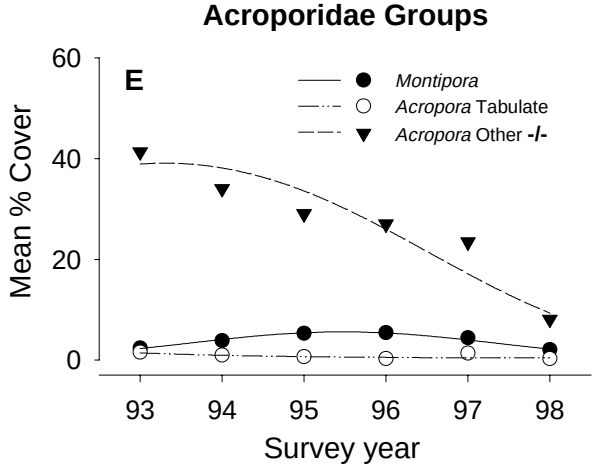
Gannet Cay (No. 21-556) is a middle shelf planar reef with a sand cay on the western side. The reef has an area of 1.2 sq.km. Last surveyed December 1997.

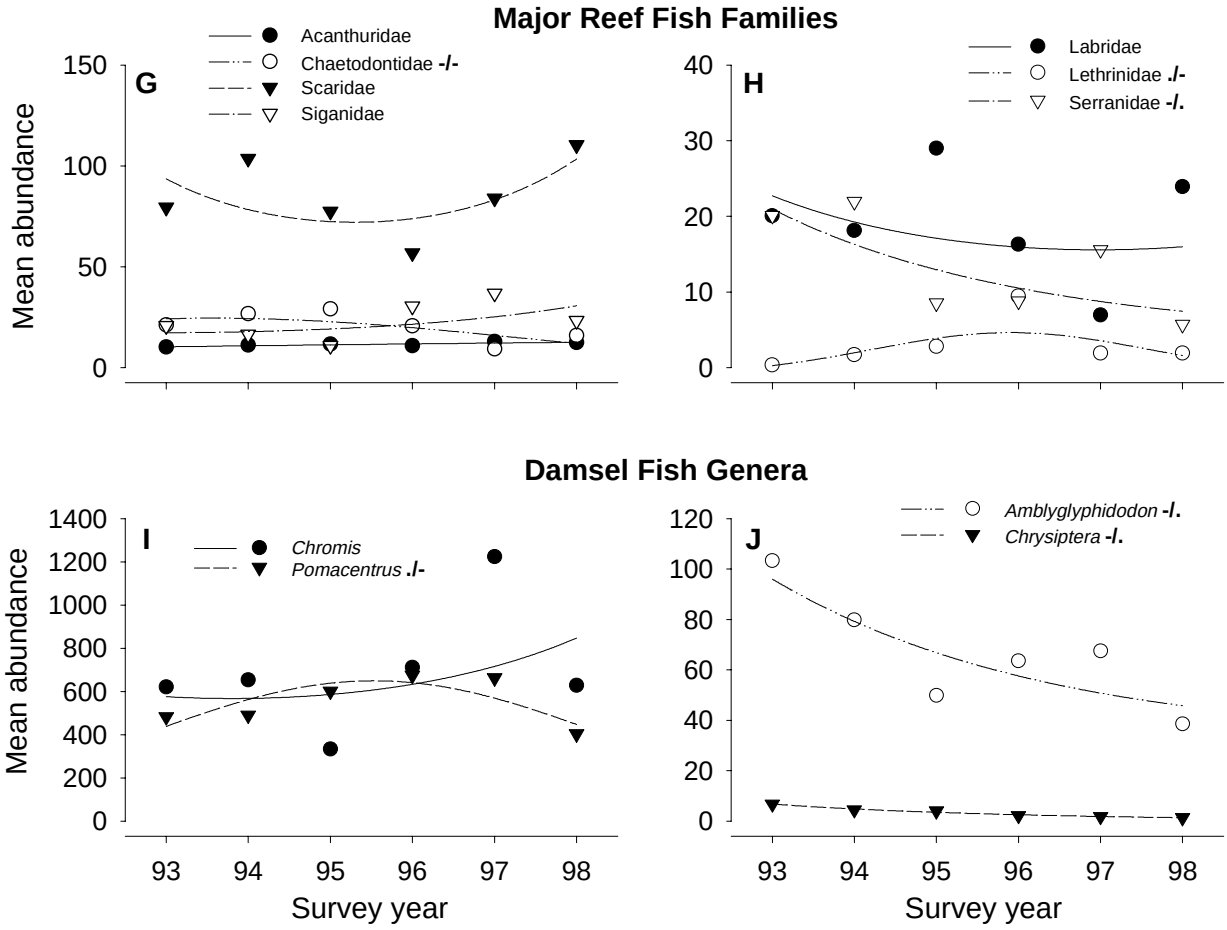












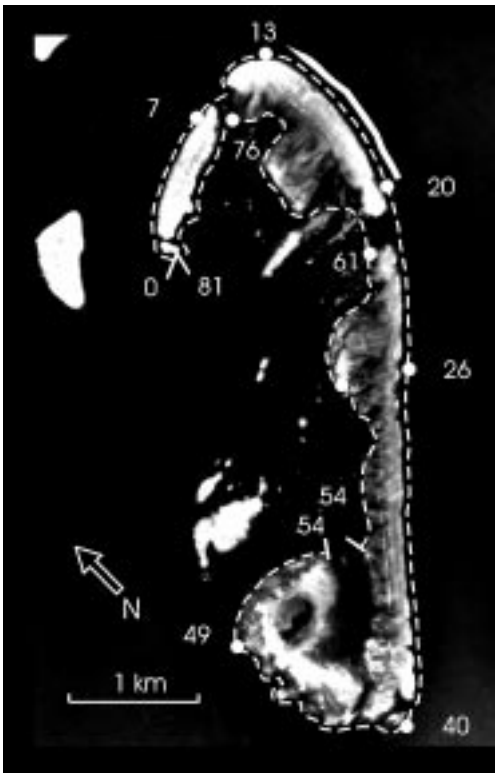
Gannet Cay

This reef has been surveyed extensively using manta tow since 1986. Over this time COTS have been present at Outbreak levels in seven of the twelve survey years. However, despite this high level of COTS activity it is only in the last year that coral cover has declined to moderate levels. Detailed coral surveys, conducted since 1993, also show a steady decline in hard coral cover with cover highest in the first year of survey at 60.4% and currently moderate at 21%. The decline is mostly due to loss of branching *Acropora* although Pocilloporidae and Faviidae have experienced small decreases. It is noteworthy that *Porites* (mostly *P.lichen*) has been stable or slightly increasing. This trend may be influenced by the selective avoidance of *Porites* by COTS. The decline in hard coral cover has seen a corresponding increase in algal cover while soft coral cover has remained low and stable. The reef is currently classified as an Active Outbreak.

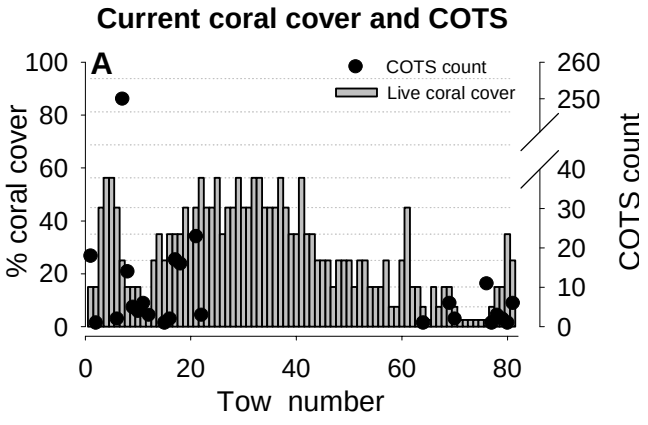
The decreasing coral cover is reflected in the fish community with a number of groups declining. *Amblyglyphidodon curacao*, Chaetodontidae (predominantly *Chaetodon aureofasciatus* and *C. rainfordi*), *Chrysiptera rollandi* and, although variable, *Plectropomus leopardus*, have all shown a steady decline. *Pomacentrus* species were generally stable (*P. lepidogenys, P. wardi*) or increasing (*P. moluccensis*) up until 1997 after which time there was a general decline. The observed trend in Lethrinidae is due to a school of *Lethrinus nebulosus* on one transect in 1996.

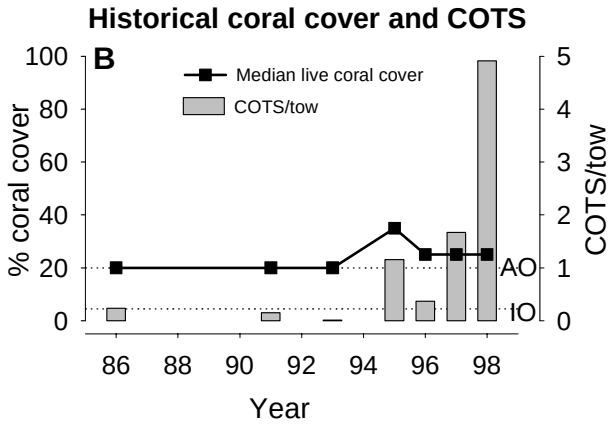
Figure 5.105

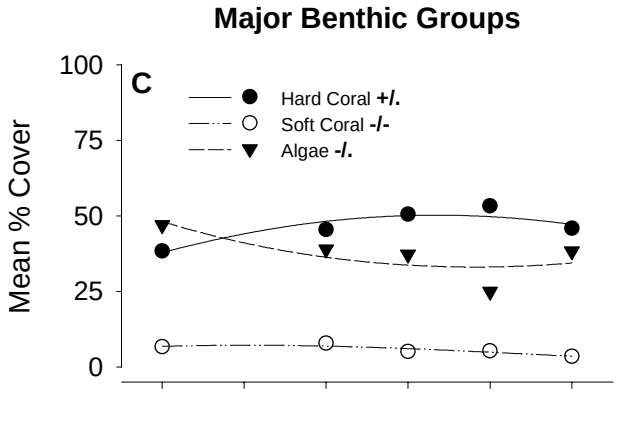
Horseshoe

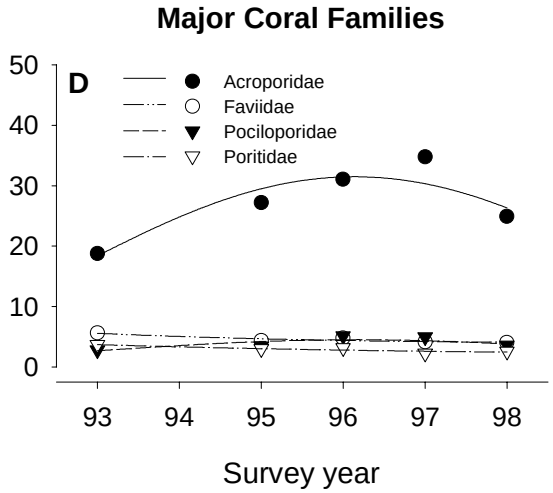


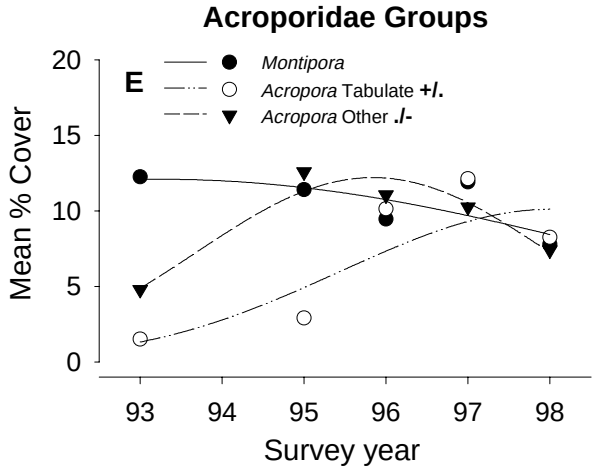
Horseshoe (No. 22-104) is a middle shelf crescentic reef with an area of 12.5 sq.km. Last surveyed December 1997.

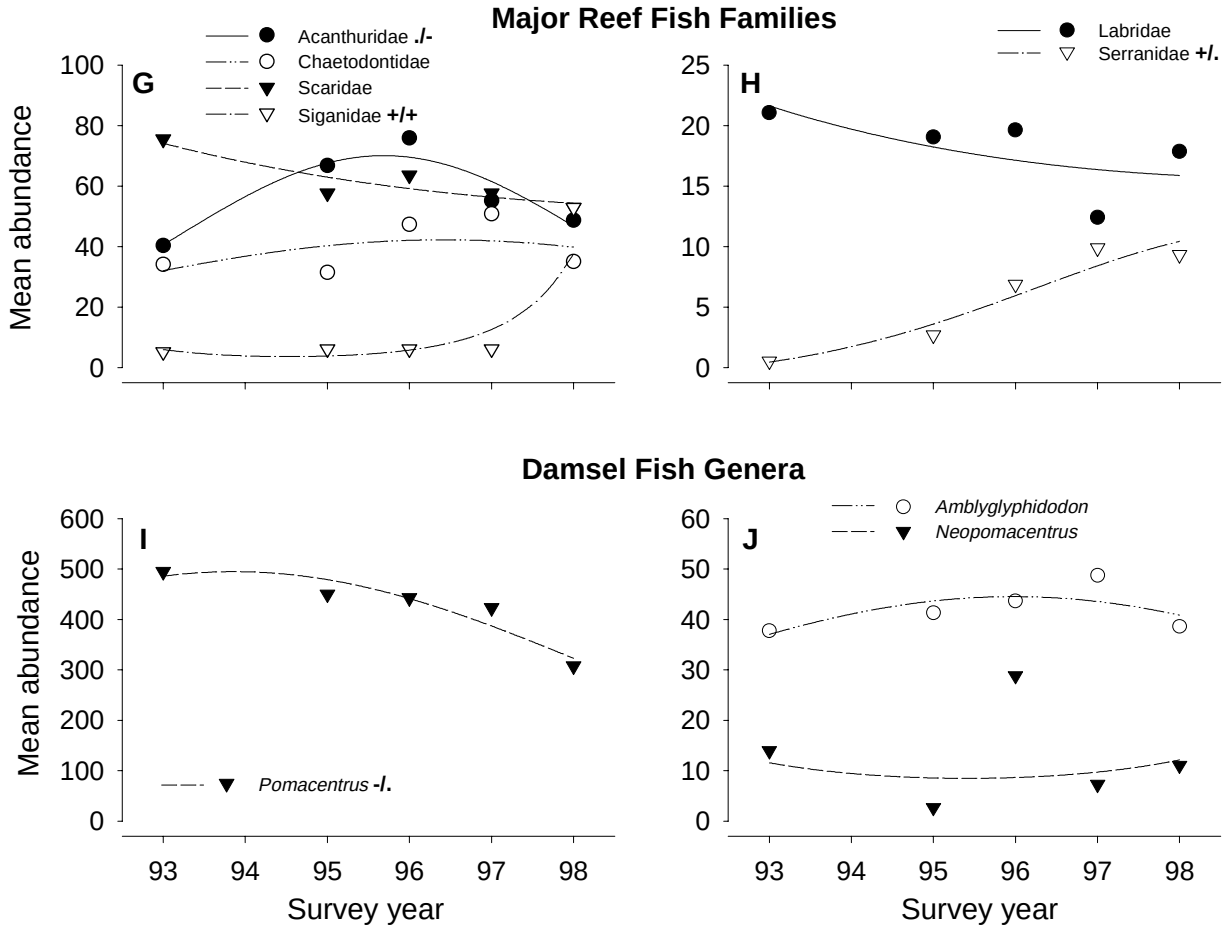












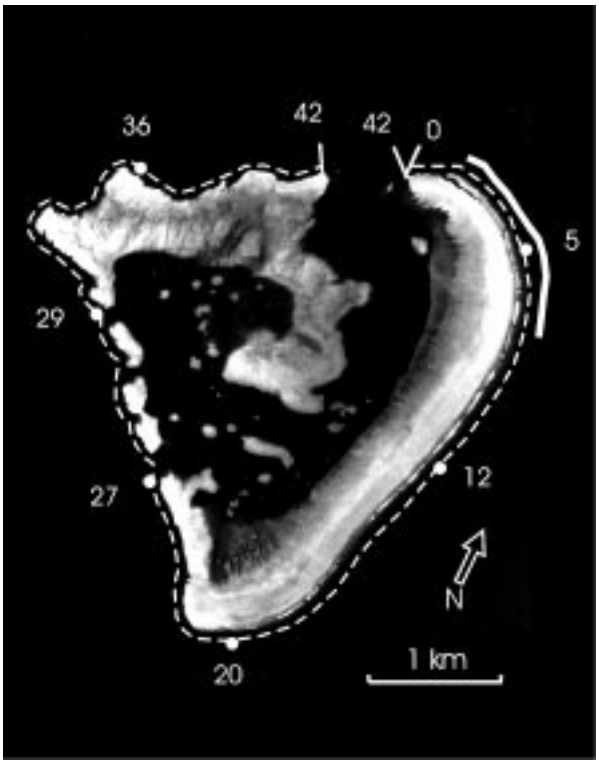
Horseshoe

This reef was originally surveyed by manta tow in 1986. The reef was initially classified as an Incipient Outbreak. Horseshoe Reef has been classified as an Active Outbreak since 1995 with extremely high numbers of COTS recorded during our most recent surveys. Manta tow surveys show that coral cover has generally remained at moderate levels over the period of survey. The detailed benthic surveys on the northeastern flank show that hard coral cover was increasing until 1997. Decreases in hard coral cover in 1998 coincide with the large increase of COTS. Figure 12.4A shows that the majority of COTS were concentrated in the vicinity of the survey sites. The decline in coral cover results mainly from decreases in the cover of *Acropora* spp. and *Montipora* spp. at one site. This is a typical pattern in COTS related mortality as they tend to aggregate and initially be selective in the coral species they feed on. At present hard coral cover is moderately high at 47.1% though this will almost certainly decline through to the next survey. The cover of soft corals has decreased from 7.1% to 3.4% over the survey period.

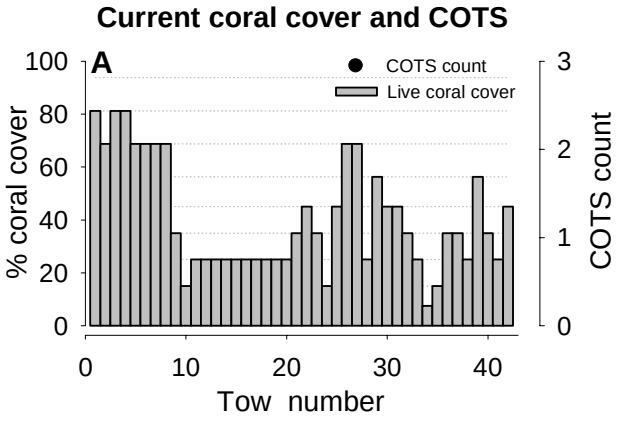
The damsel fish community shows low diversity at the genus level but relatively high numbers within three species of the genus *Pomacentrus* (*P. lepidogenys, P. moluccensis, P. wardi*) all of which are in decline. Of the larger fish, *Plectropomus leopardus* (Serranidae) has shown a steady increase, while the initial increase and current decline in Acanthuridae is driven by *Ctenochaetus spp*. and *Zebrasoma scopas*. The observed trend in Siganidae is due to the inclusion of a large school of *Siganus doliatus* in the last survey.

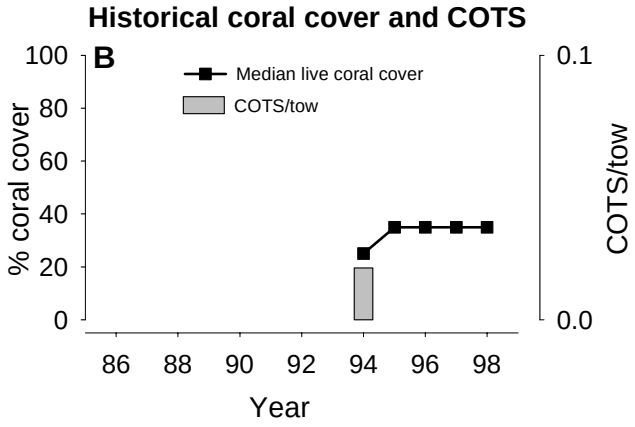
Figure 5.106

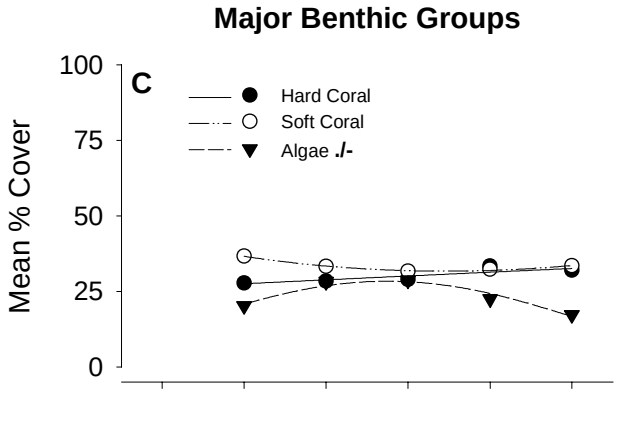
Turner Cay

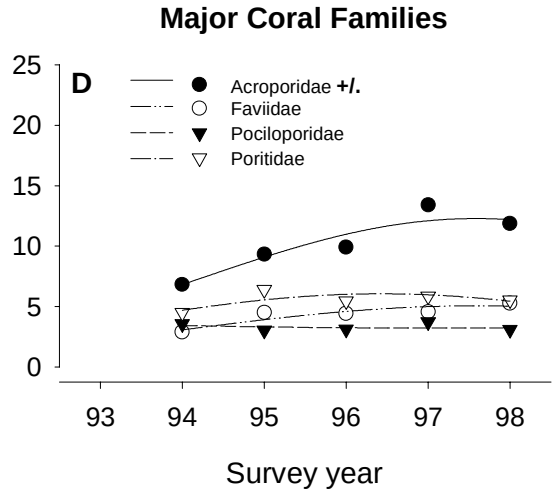


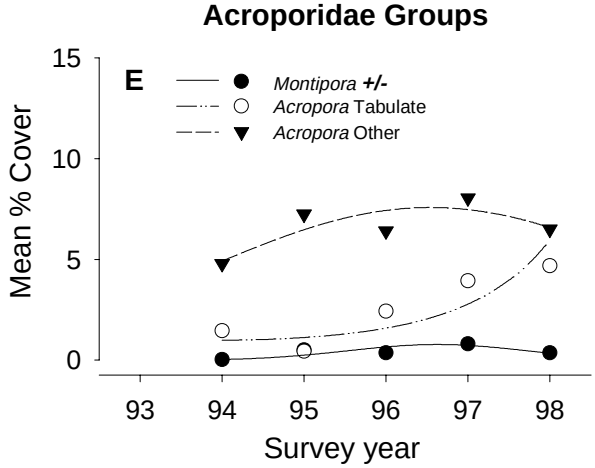
Turner Cay (No. 21-562) is an outer shelf lagoonal reef with an area of 5 sq.km. Last surveyed November 1997.

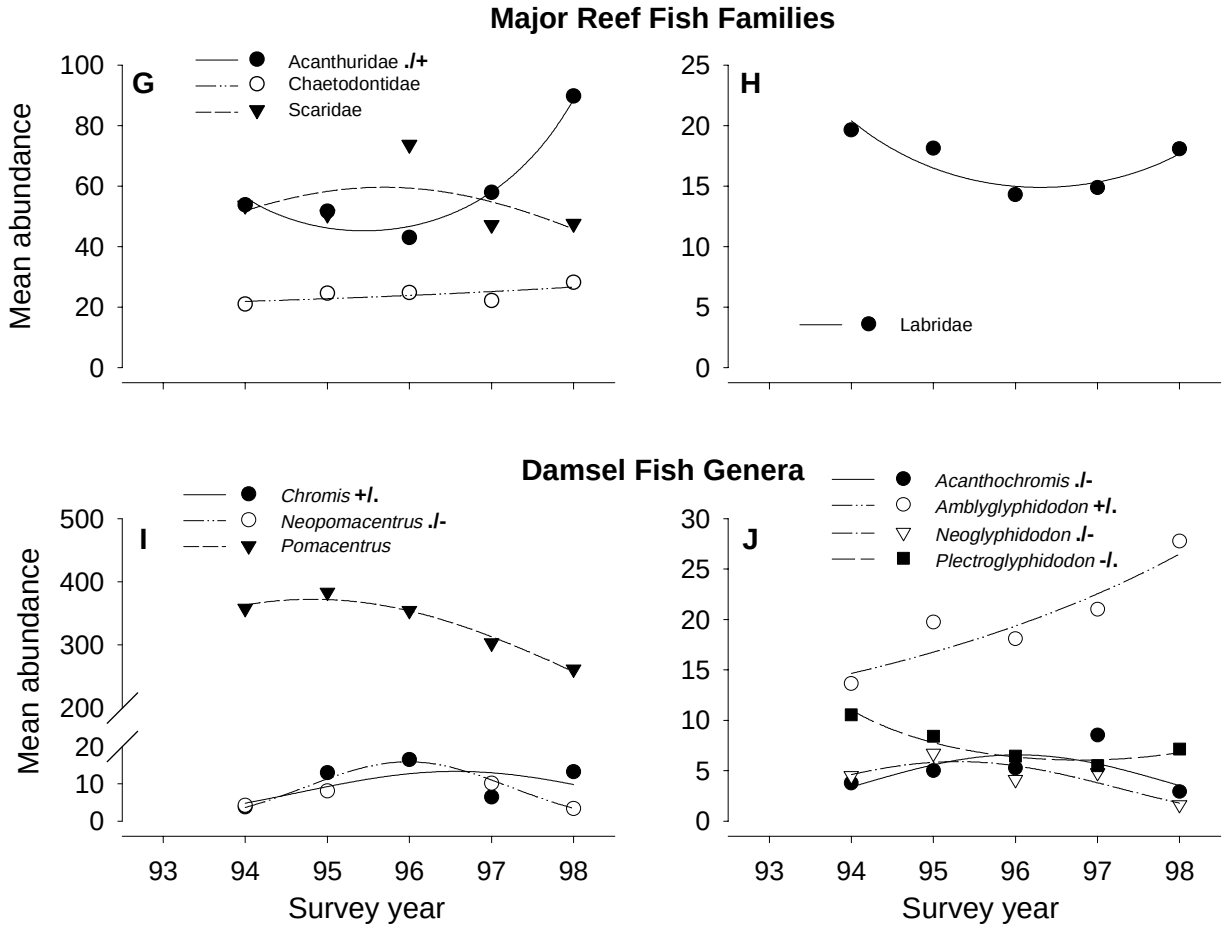












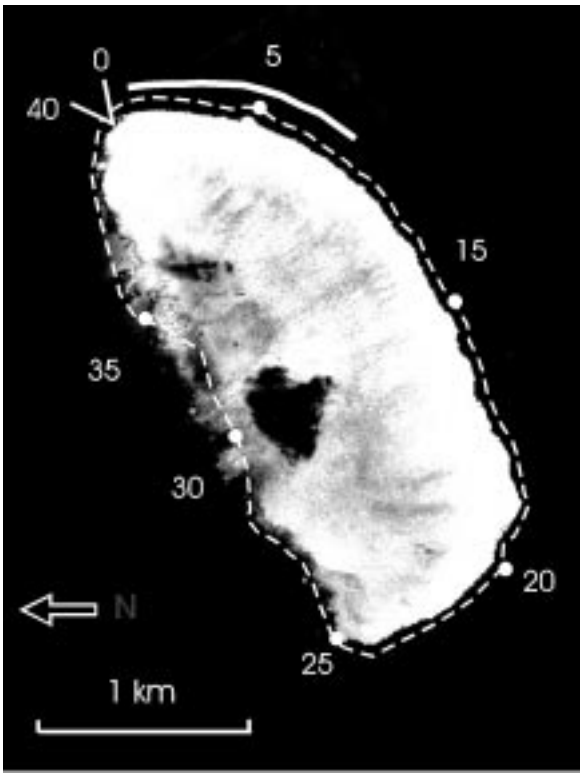
Turner Cay

This reef has been surveyed annually since 1994 using manta tow, benthic video transects and visual fish census. Over this time manta tow surveys show that coral cover has remained high. Detailed benthic surveys show that hard coral cover on the northeastern flank has increased by only 4.1% since 1994 and is currently moderately high at 32.1%. Acroporidae and Faviidae corals have both contributed to the small increase in cover. The abundance of soft corals is high at 36.6%. No COTS have been recorded in recent times on this reef and it is currently classified as Non-Outbreaking.

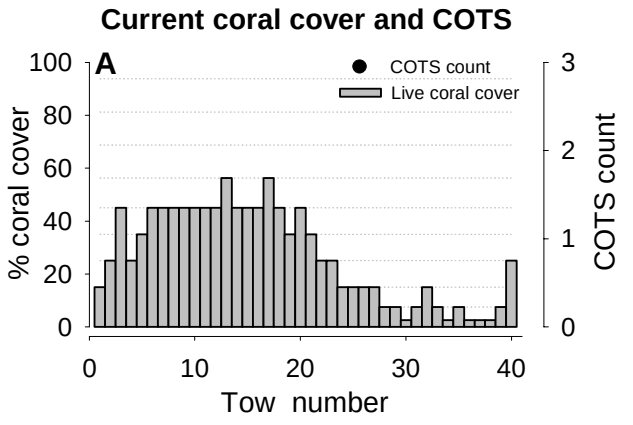
Many of the observed trends in the fish community are only slight due to the relatively low abundance of many of the groups. *Plectroglyphidodon lacrymatus* decreased steadily as did *Neoglyphidodon melas* from the second survey. *Amblyglyphidodon curacao* increased steadily as did *Acanthochromis polyacanthus* up until 1997. The general increase in *Chromis* is due to *C. nitida* while current increases in Acanthuridae involve *Acanthurus nigrofuscus, Ctenochaetus spp.* and *Zebrasoma scopas*.

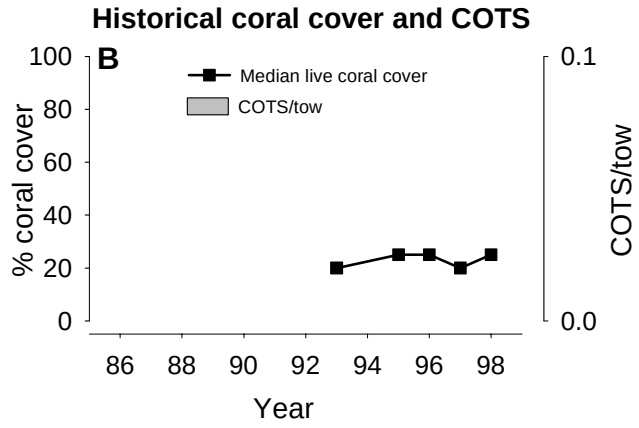
Figure 5.107

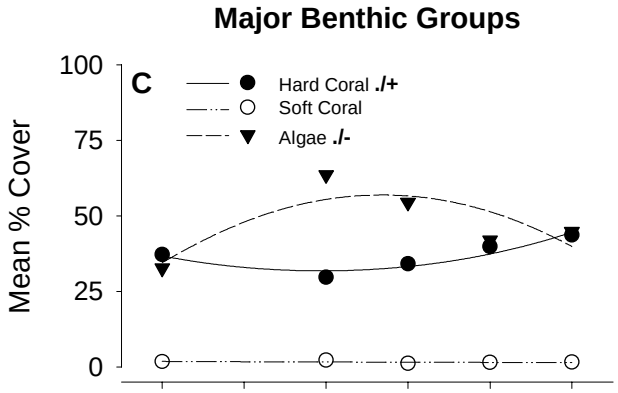
Reef No. 21-529

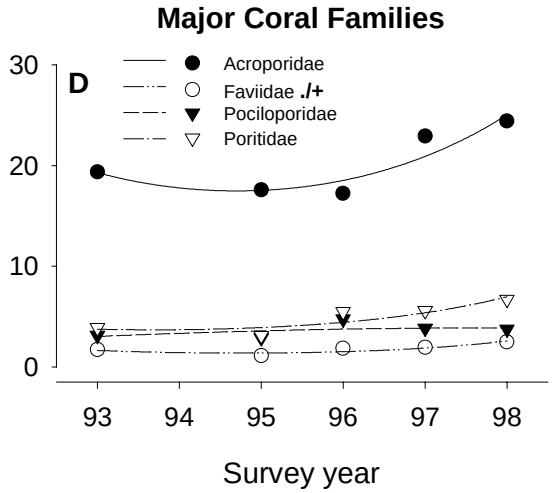


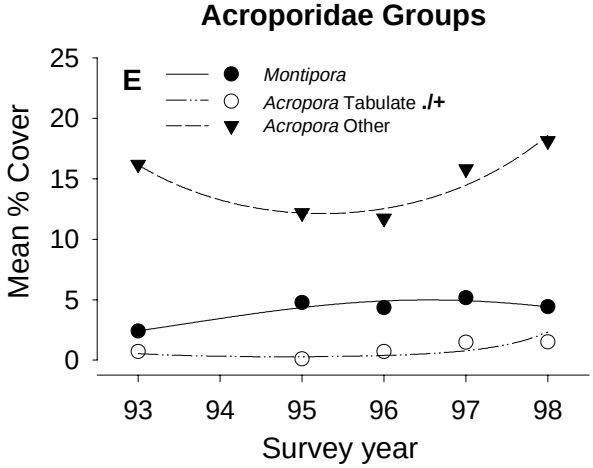
Reef No. 21-529 is a middle shelf crescentic reef with an area of 6.3 sq.km. Last surveyed November 1997.

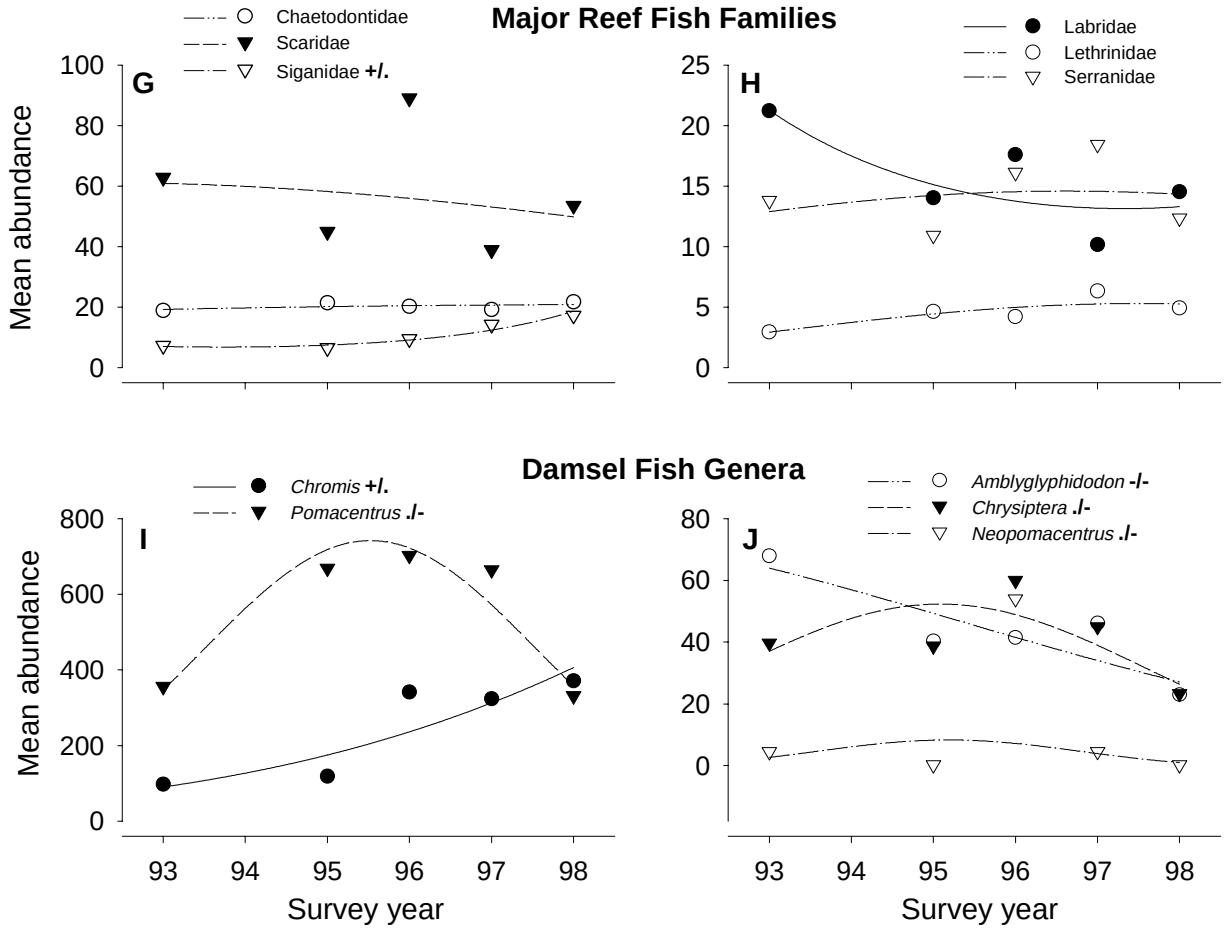










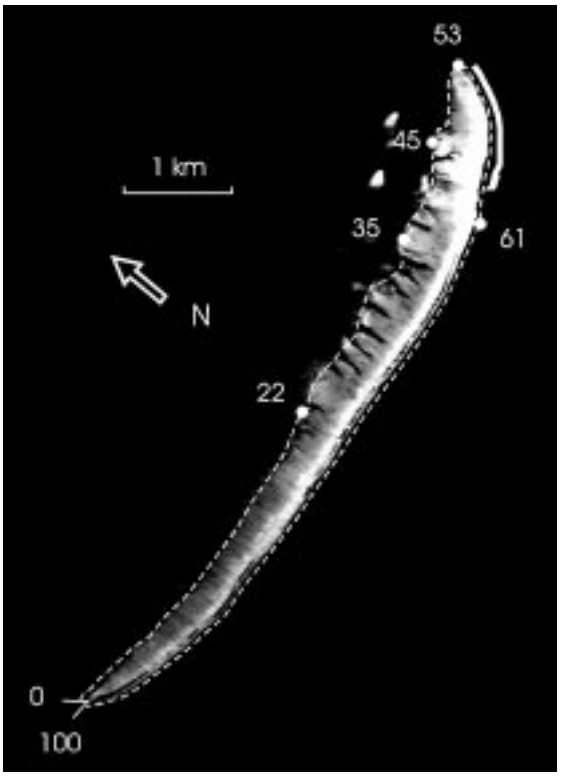


Reef No. 21-529

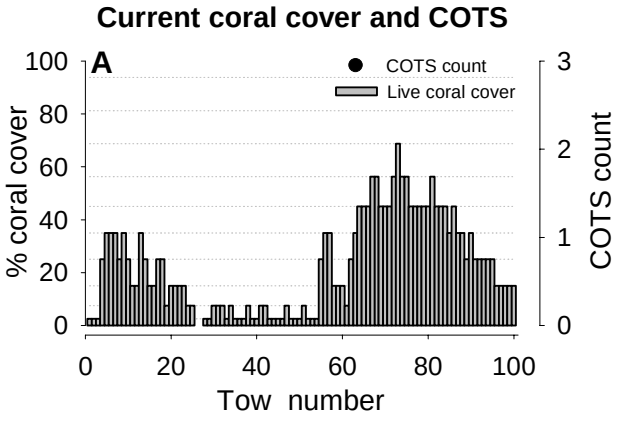
This reef has been surveyed five times since 1993 using manta tow, benthic video and visual fish census. Over this time manta tow surveys show that coral cover has remained at moderate levels. Detailed coral surveys on the northeastern flank show that hard coral cover has increased by 6% over the survey period and is currently moderately high at 43.6%. The increase is primarily due to an increase in *Acropora* spp. There is a relatively high percent cover of branching and bottlebrush *Acropora.* Faviid corals have also increased but are not abundant (2.5% cover). No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

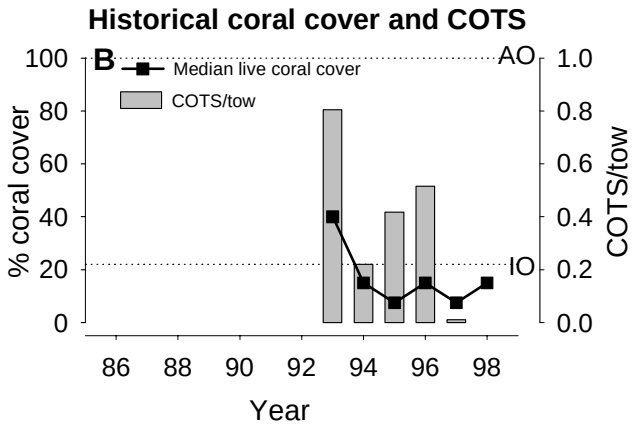
Two fish groups are increasing in abundance. The increase in *Chromis* is due solely to a steady increase in *C. nitida*, while the increase in Siganidae is due to steady increases in *Siganus argenteus*, *S. puellus* and *S. vulpinus*. Many of the *Pomacentrus* species were stable up until 1996 or 1997 then declined. The strong increase from 1993 to 1995 was due to increases in the common *P. moluccensis* and *P. lepidogenys* both of which remained stable before declining after 1997. *Chrysiptera rollandi* and *Neopomacentrus azysron* were similar in that they increased until 1996 then declined. In contrast *Amblyglyphidodon curacao* declined over the survey period.

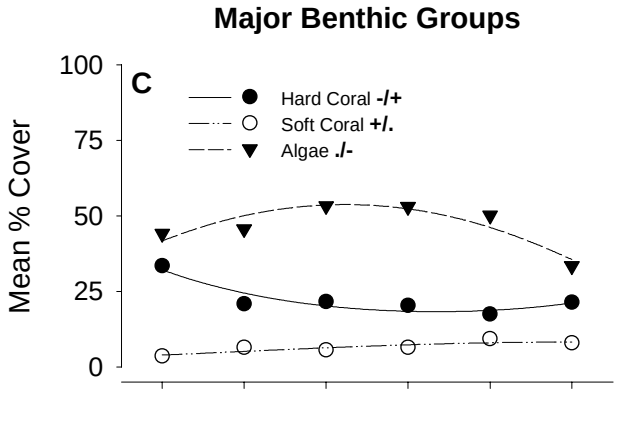
Figure 5.108 **Reef No. 22-088 (Snake)**

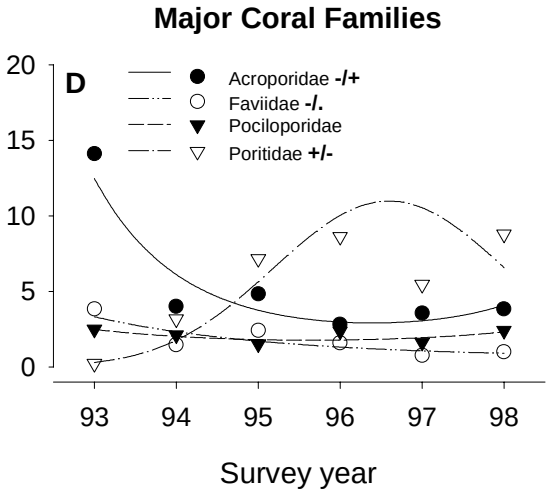


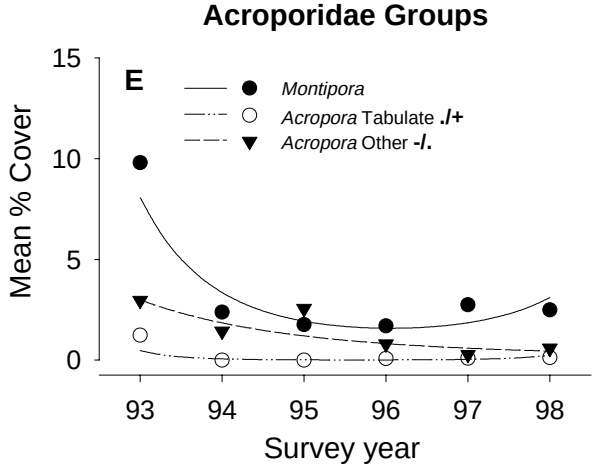
Reef No. 22-088 (Snake) is an inner shelf ribbon reef with an area of 14.4 sq.km. Last surveyed November 1997.

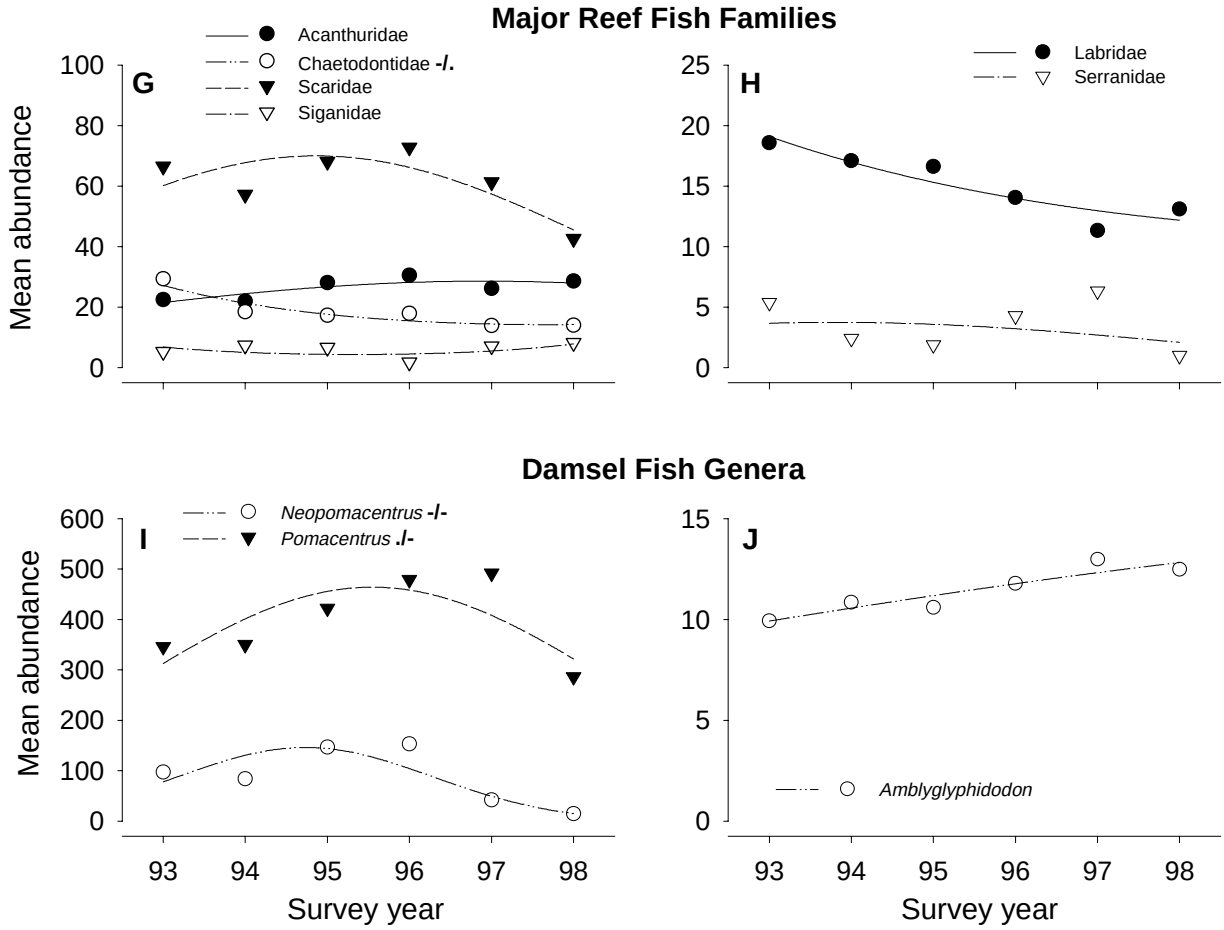












Reef No. 22-088 (Snake)

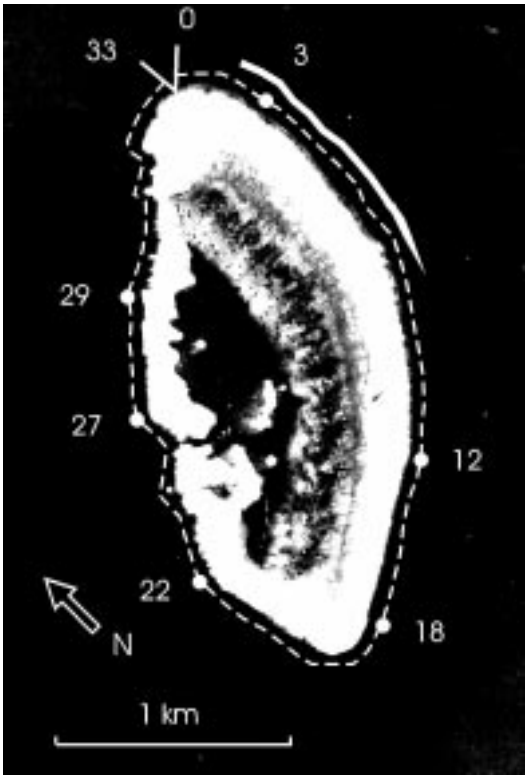
This reef has been surveyed six times since 1993 using manta tow, visual fish census and benthic video surveys. Initial surveys revealed relatively high COTS populations on this reef, and the reef was classified as having an Incipient Outbreak through to 1997. Manta tow surveys recorded a large drop in coral cover between 1993 and 1994, which is attributed to COTS activity. The detailed coral surveys on the northeastern flank also recorded an initial drop in coral cover: this was largely due to a decrease in the coverage of Acroporidae, in particular *Montipora* spp. Subsequent surveys have revealed little change with the exception of an increase in the abundance of *Porites* spp. which is currently the most abundant genus at 9% cover. Hard coral cover is currently moderate at 21.4%. The cover of algae decreased during the most recent survey interval. Our most recent broadscale surveys did not detect any COTS and coral cover showed signs of a recovery. The reef is currently classified as Recovering.

The relatively stable benthic community is reflected to some degree in the fish community with only Chaetodontidae showing changing abundance amongst the larger reef fish. This change reflects declines in the two abundant species *Chaetodon aureofasciatus* and *C. rainfordi*. Current declines in *Neopomacentrus* (*N. azysron*) and *Pomacentrus* (predominantly *P. lepidogenys*, *P. moluccensis* and *P. wardi*) occur after periods of increase with peaks in 1996 and 1997 respectively.

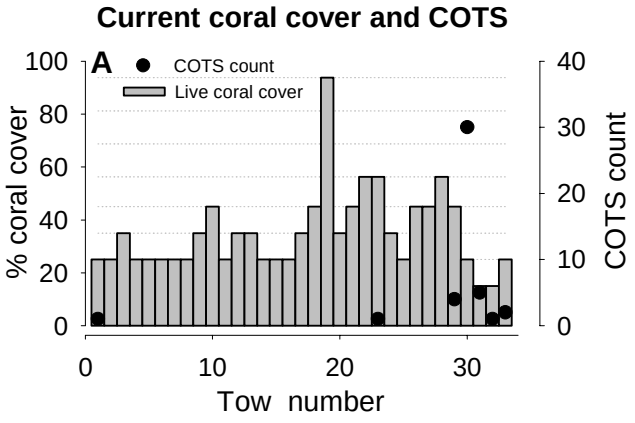
Swain
reef pages

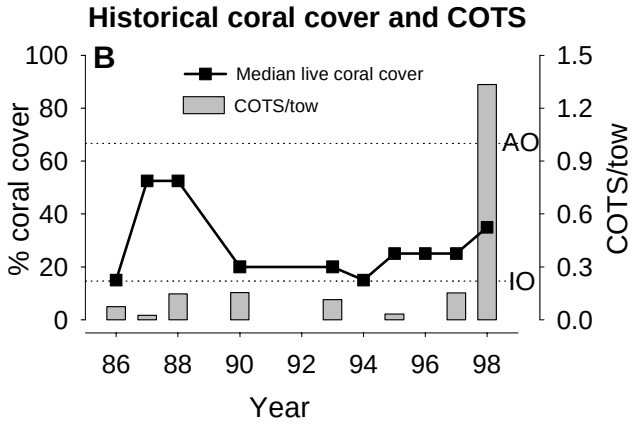
Figure 5.102

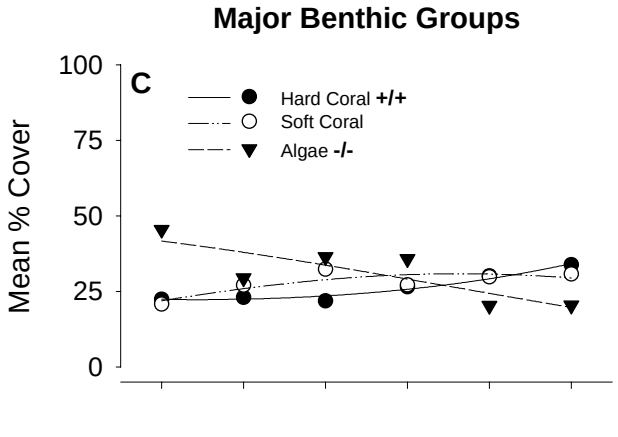
Chinaman

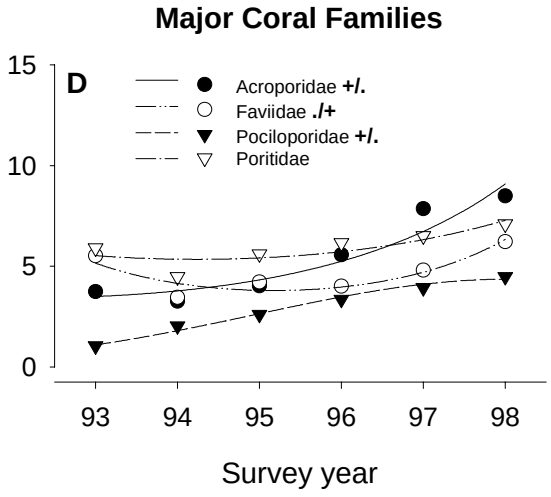


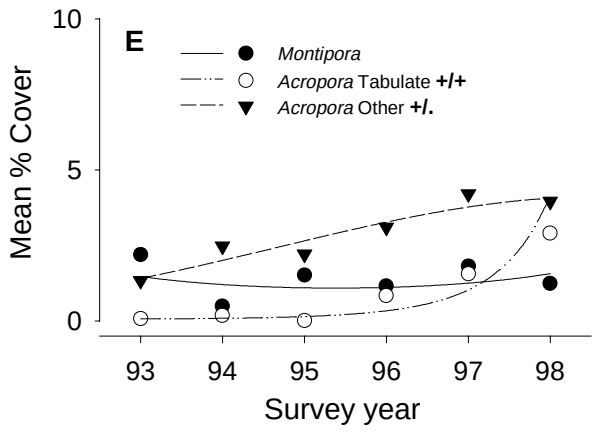
Chinaman (No. 22-102) is a middle shelf lagoonal reef with an area of 3.1 sq.km. Last surveyed December 1997.

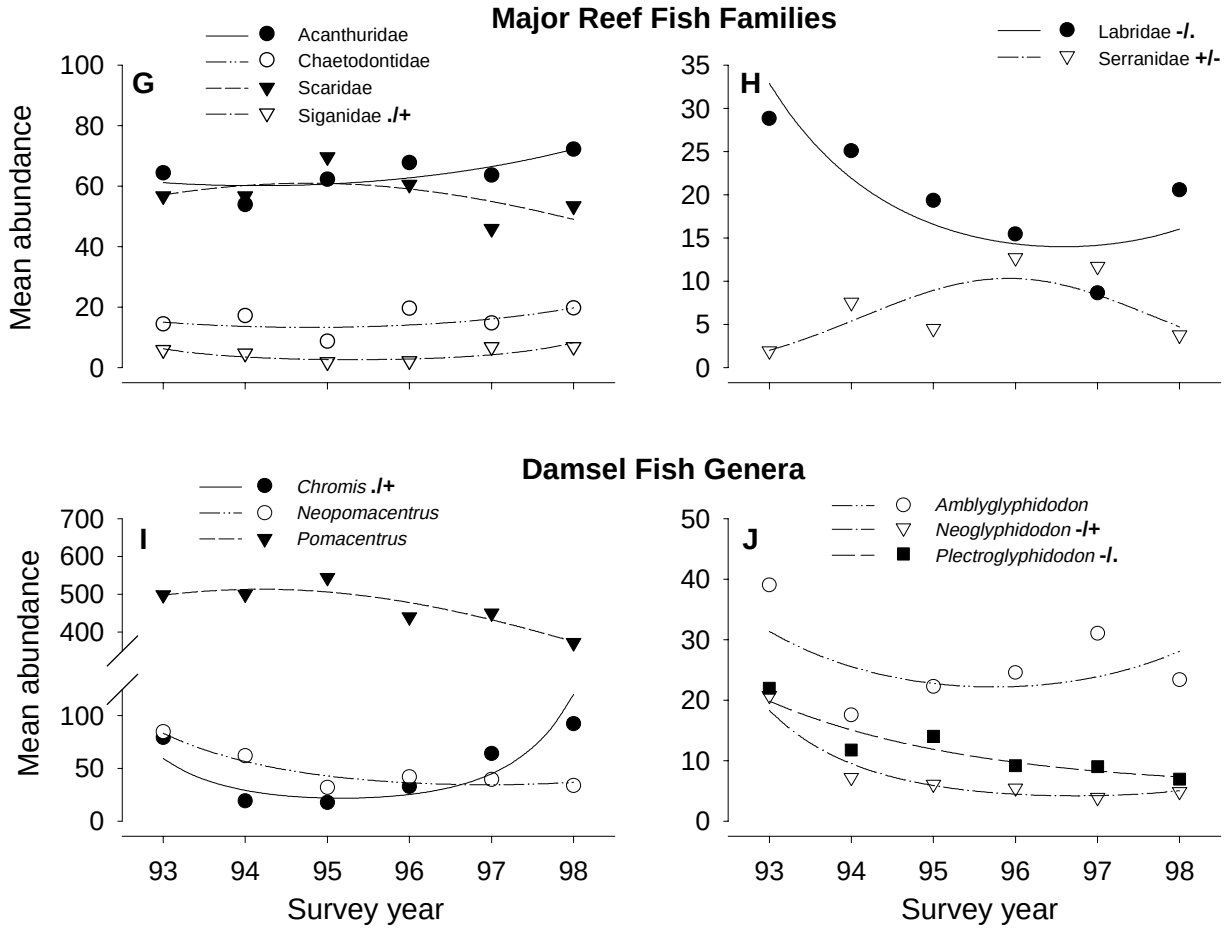












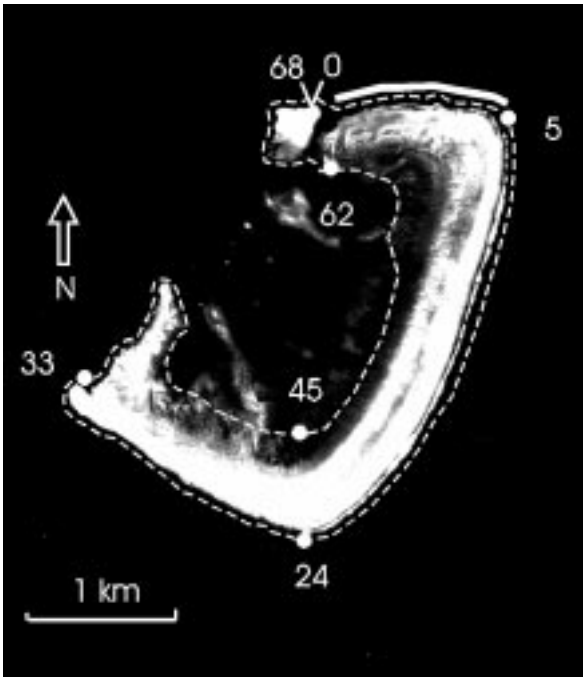
Chinaman

This reef has been surveyed extensively since 1986 using manta tow. Whilst COTS have been observed during most survey years it is only after our most recent surveys that the reef has been classified as an Active Outbreak. Over this time, coral cover has been variable. Of particular interest is the drop in coral cover between 1988 and 1990. The reasons for this remain unknown. It is unlikely that cyclones or COTS were responsible. No cyclones were reported within 200 km of Chinaman Reef between these years (Cyclone Harry passed within 593 km in 1988-89) and numbers of COTS were too low to cause significant coral damage. Since this time coral cover has recovered from moderate levels to the present moderately high level. This recovery is supported by detailed coral surveys since 1993 which show that hard coral cover has increased by 11.4% in the five years to 1998 and is currently moderately high at 33.4%. This is reflected in all the main hard coral families and there is a corresponding decrease in algal cover. Soft coral abundance is moderately high at 30.8% in 1998.

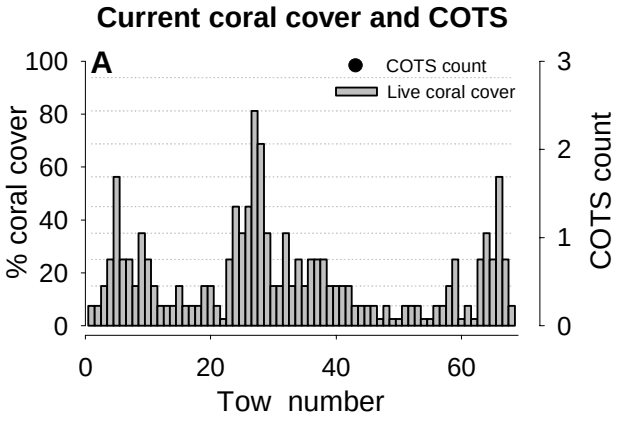
Only *Plectroglyphidodon* (*P. lacrymatus*) shows a linear change in abundance, declining over the survey period. Labridae (*Choerodon fasciatus*, *Gomphosus varius* and *Hemigymnus fasciatus*) and *Amblyglyphidodon curacao* both decline steadily until 1997 before a slight increase in 1998. The trend in Siganidae results from *S. corallinus*, which decreased until 1995 before increasing to 1997. Similarly *Chromis* (*C. nitida*) decreased initially before a steady increase. *Plectropomus leopardus* counts have been variable though tend to increase until 1997 before a slight decrease.

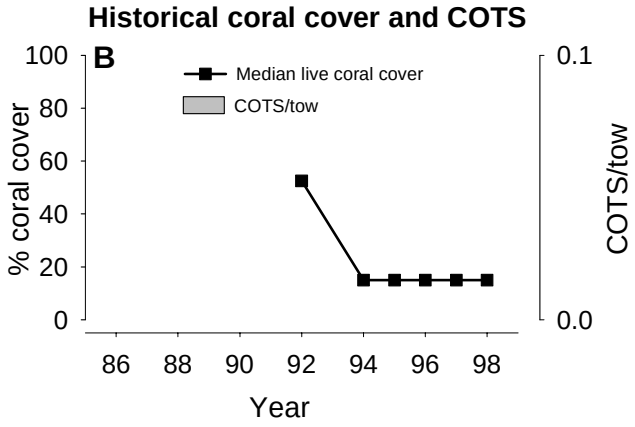
Figure 5.103

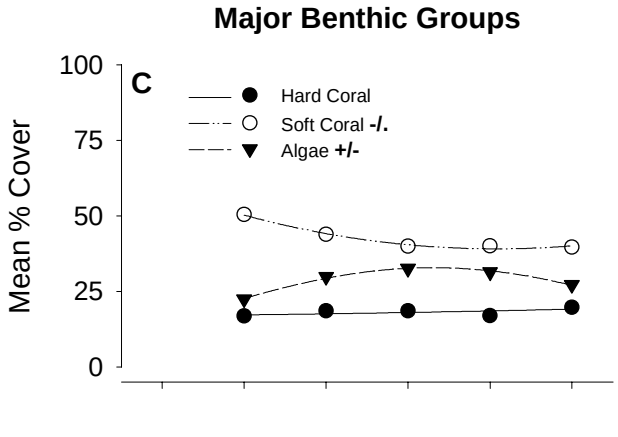
East Cay

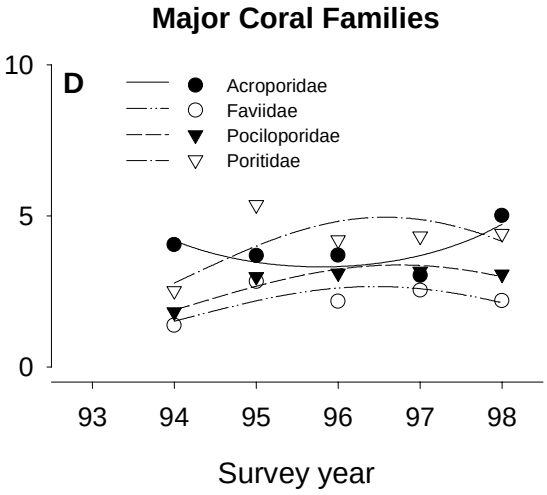


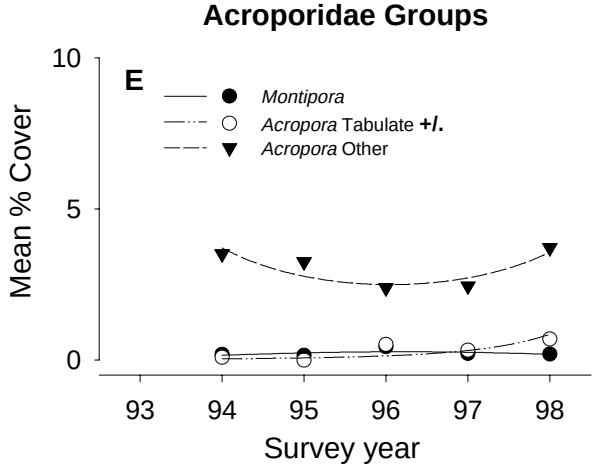
East Cay (No. 21-305) is an outer shelf crescentic reef with a sand cay on the north-western end. The reef has an area of 6.3 sq.km. Last surveyed November 1997.

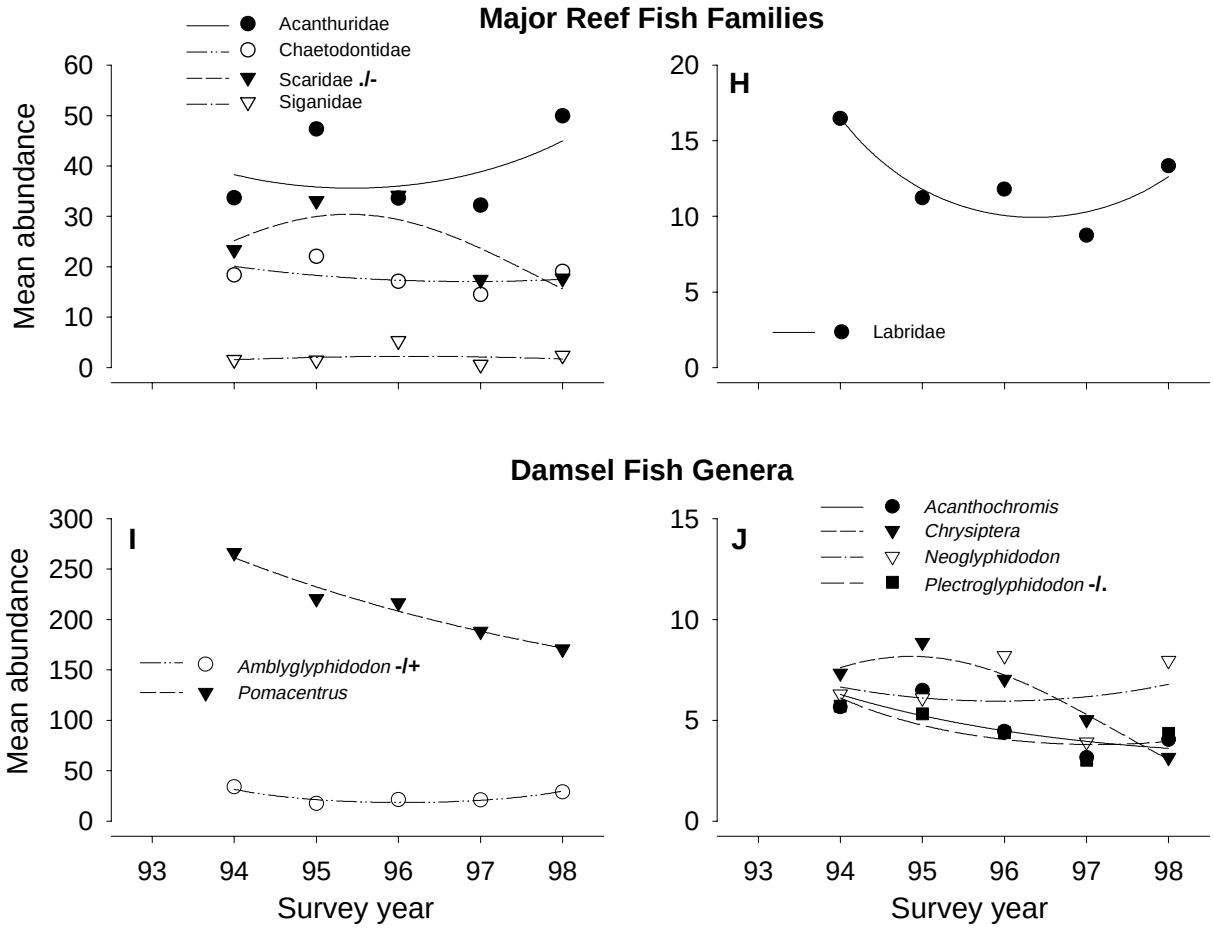












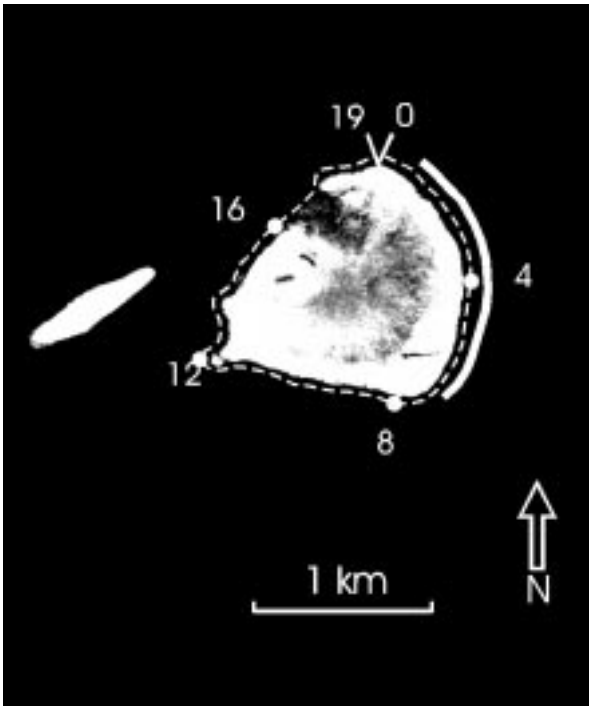
East Cay

This reef has been surveyed six times since 1992 using manta tow. The initial survey recorded high coral cover. Surveys in 1994 revealed that coral cover had declined to moderate levels There has been no change since. Detailed coral surveys on the northern flank also show little change in the benthic community over the survey period with hard coral cover currently moderate at 19.7%. The cover of soft coral has decreased but is still high at 39.7%. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

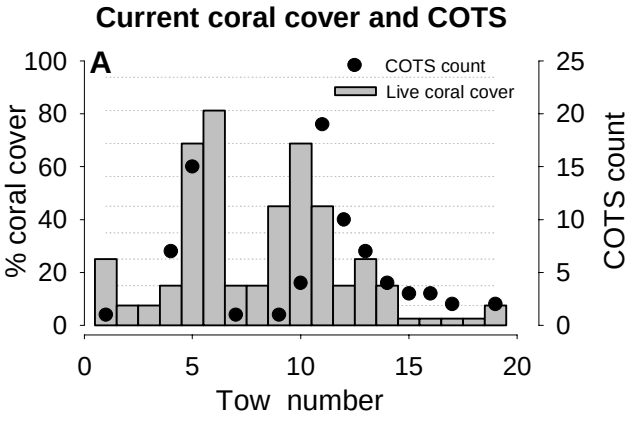
The stable benthic community is reflected in the fish community with few obvious trends. Whilst not statistically significant the steady decrease in *Pomacentrus* (*P. bankanensis, P. lepidogenys* and *P. moluccensis*) is the most obvious trend on the reef. *Plectroglyphidodon lacrymatus* also declined, though only to 1997 at which time counts increased slightly. The current downturn in Scaridae is representative of low counts in 1997 and 1998 for *Scarus chameleon*, *S. globiceps*, *S. psittacus*, and *S. sordidus. Amblyglyphidodon curacao* decreased between the first and second surveys and increased from that time on.

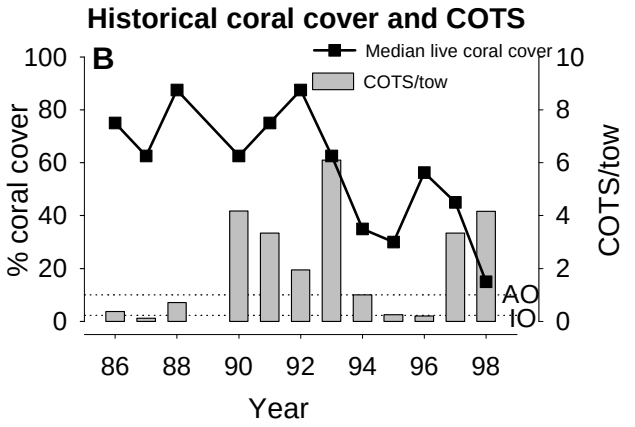
Figure 5.104

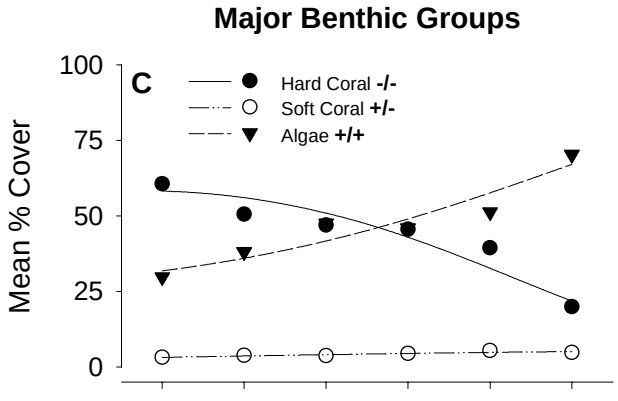
Gannet Cay

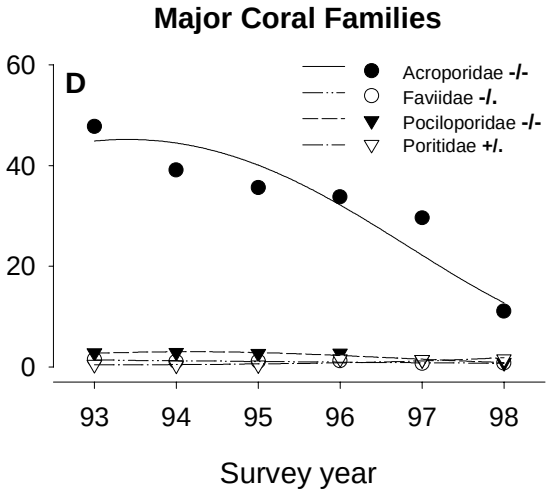


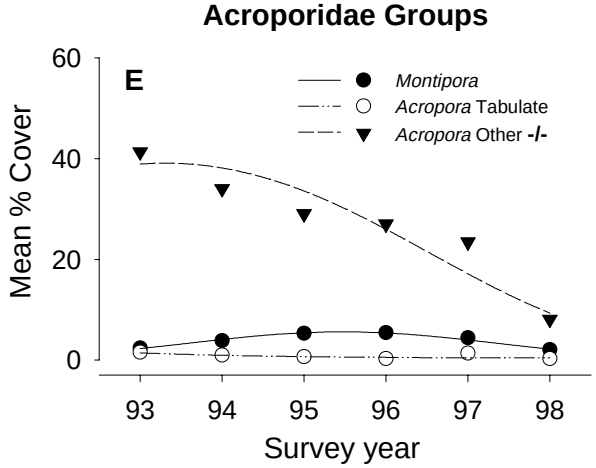
Gannet Cay (No. 21-556) is a middle shelf planar reef with a sand cay on the western side. The reef has an area of 1.2 sq.km. Last surveyed December 1997.

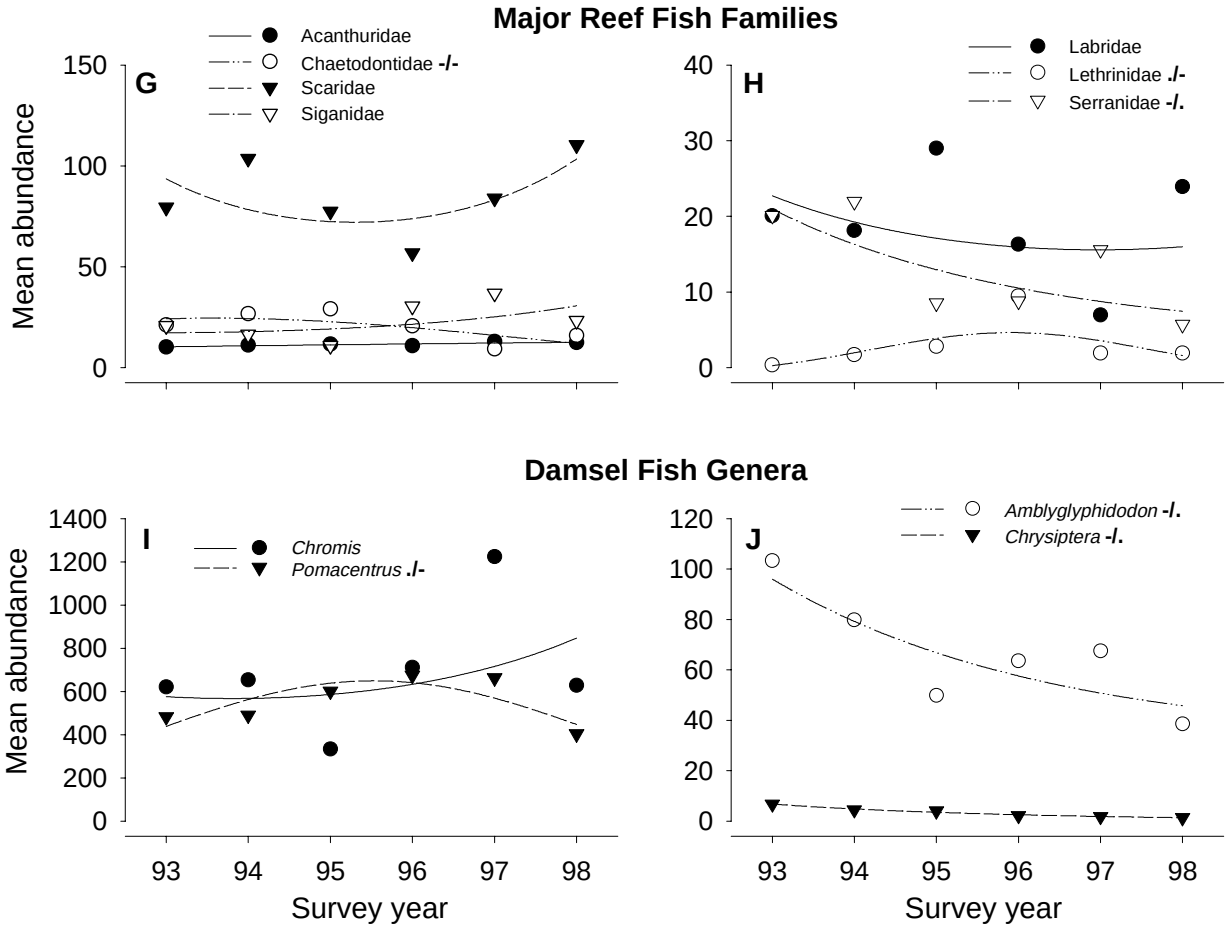












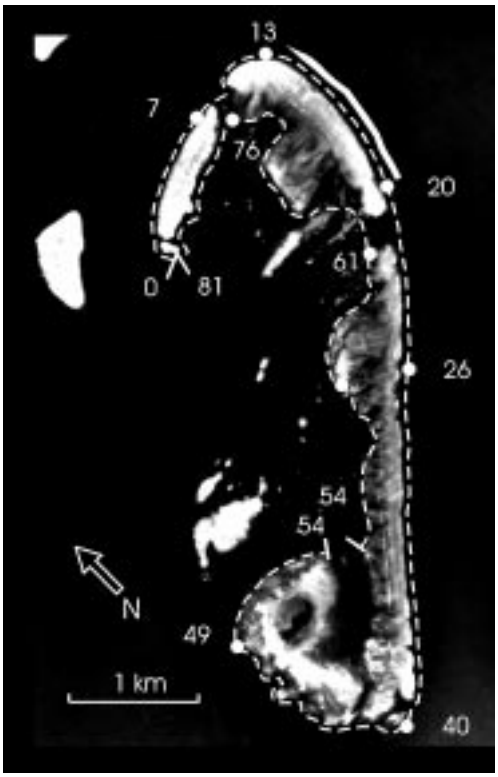
Gannet Cay

This reef has been surveyed extensively using manta tow since 1986. Over this time COTS have been present at Outbreak levels in seven of the twelve survey years. However, despite this high level of COTS activity it is only in the last year that coral cover has declined to moderate levels. Detailed coral surveys, conducted since 1993, also show a steady decline in hard coral cover with cover highest in the first year of survey at 60.4% and currently moderate at 21%. The decline is mostly due to loss of branching *Acropora* although Pocilloporidae and Faviidae have experienced small decreases. It is noteworthy that *Porites* (mostly *P.lichen*) has been stable or slightly increasing. This trend may be influenced by the selective avoidance of *Porites* by COTS. The decline in hard coral cover has seen a corresponding increase in algal cover while soft coral cover has remained low and stable. The reef is currently classified as an Active Outbreak.

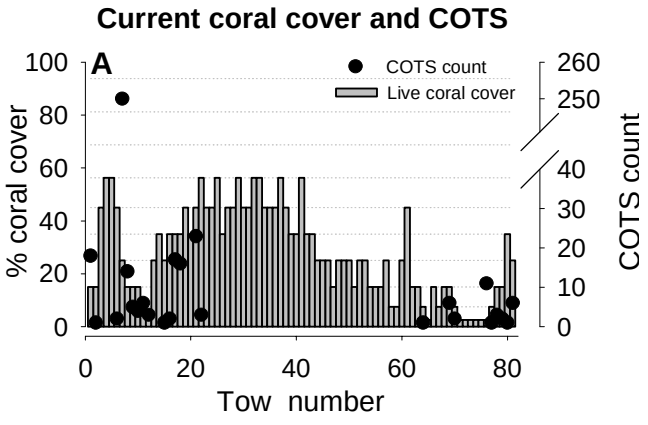
The decreasing coral cover is reflected in the fish community with a number of groups declining. *Amblyglyphidodon curacao*, Chaetodontidae (predominantly *Chaetodon aureofasciatus* and *C. rainfordi*), *Chrysiptera rollandi* and, although variable, *Plectropomus leopardus*, have all shown a steady decline. *Pomacentrus* species were generally stable (*P. lepidogenys, P. wardi*) or increasing (*P. moluccensis*) up until 1997 after which time there was a general decline. The observed trend in Lethrinidae is due to a school of *Lethrinus nebulosus* on one transect in 1996.

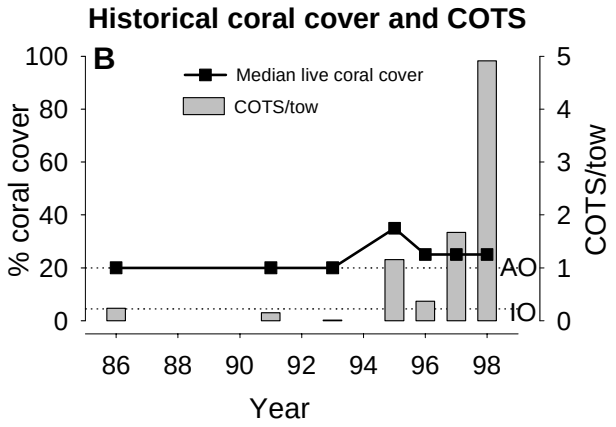
Figure 5.105

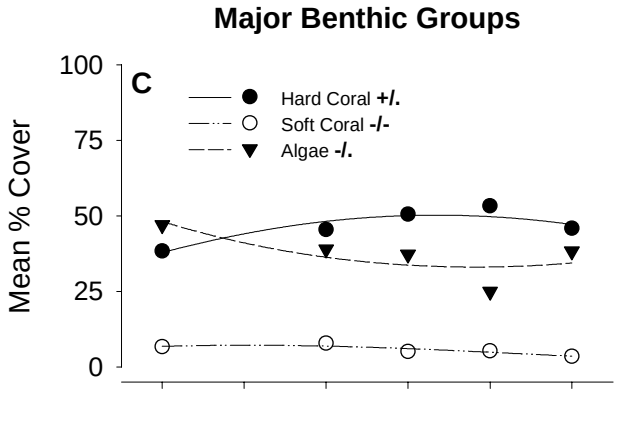
Horseshoe

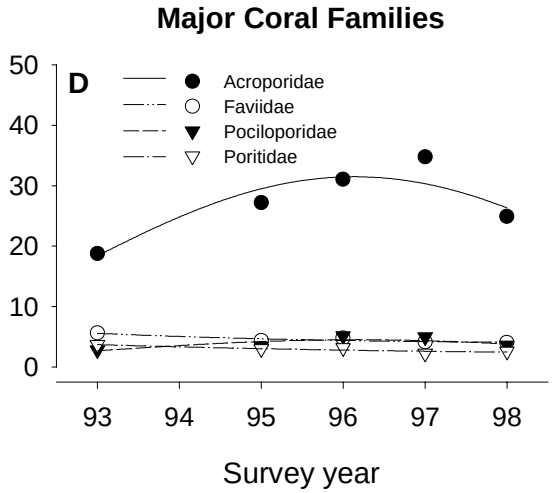


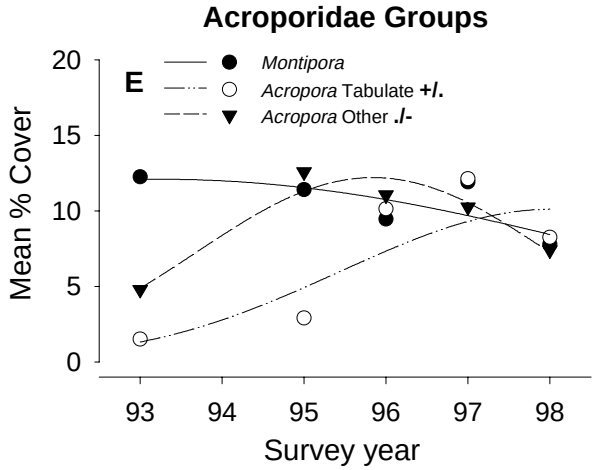
Horseshoe (No. 22-104) is a middle shelf crescentic reef with an area of 12.5 sq.km. Last surveyed December 1997.

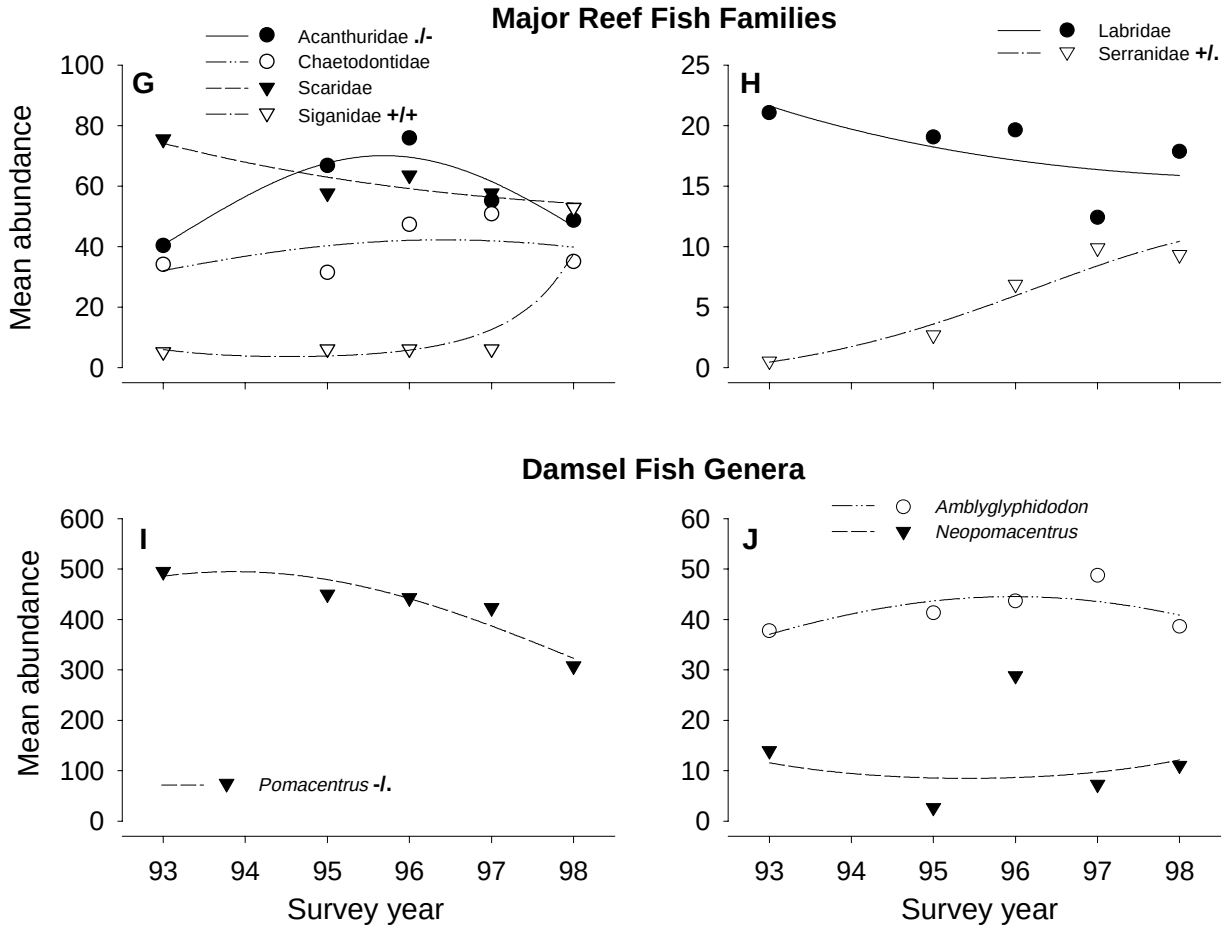












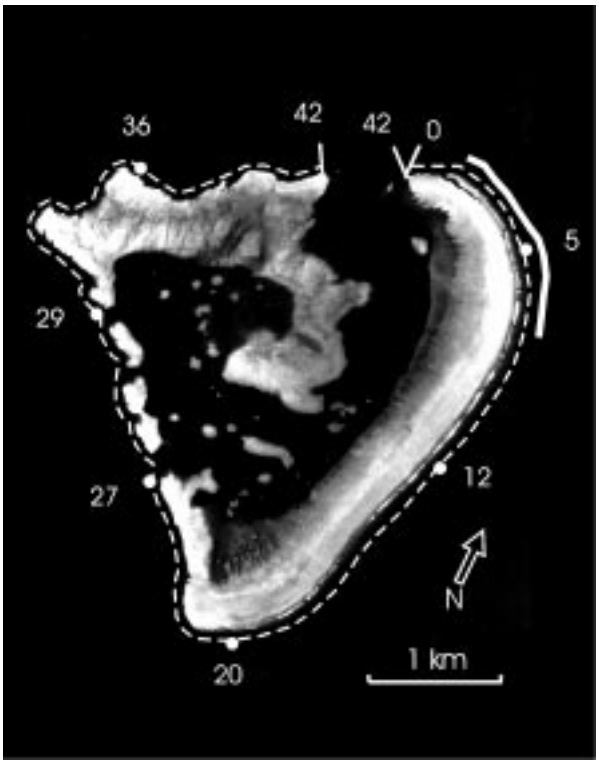
Horseshoe

This reef was originally surveyed by manta tow in 1986. The reef was initially classified as an Incipient Outbreak. Horseshoe Reef has been classified as an Active Outbreak since 1995 with extremely high numbers of COTS recorded during our most recent surveys. Manta tow surveys show that coral cover has generally remained at moderate levels over the period of survey. The detailed benthic surveys on the northeastern flank show that hard coral cover was increasing until 1997. Decreases in hard coral cover in 1998 coincide with the large increase of COTS. Figure 12.4A shows that the majority of COTS were concentrated in the vicinity of the survey sites. The decline in coral cover results mainly from decreases in the cover of *Acropora* spp. and *Montipora* spp. at one site. This is a typical pattern in COTS related mortality as they tend to aggregate and initially be selective in the coral species they feed on. At present hard coral cover is moderately high at 47.1% though this will almost certainly decline through to the next survey. The cover of soft corals has decreased from 7.1% to 3.4% over the survey period.

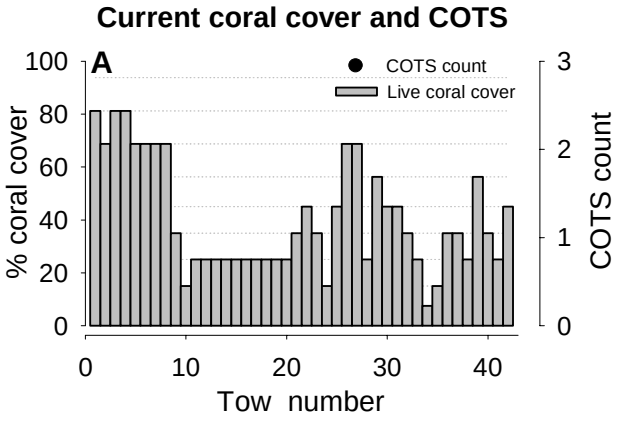
The damsel fish community shows low diversity at the genus level but relatively high numbers within three species of the genus *Pomacentrus* (*P. lepidogenys, P. moluccensis, P. wardi*) all of which are in decline. Of the larger fish, *Plectropomus leopardus* (Serranidae) has shown a steady increase, while the initial increase and current decline in Acanthuridae is driven by *Ctenochaetus spp*. and *Zebrasoma scopas*. The observed trend in Siganidae is due to the inclusion of a large school of *Siganus doliatus* in the last survey.

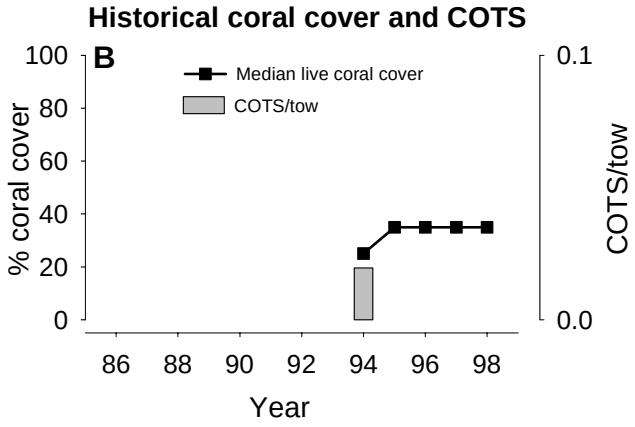
Figure 5.106

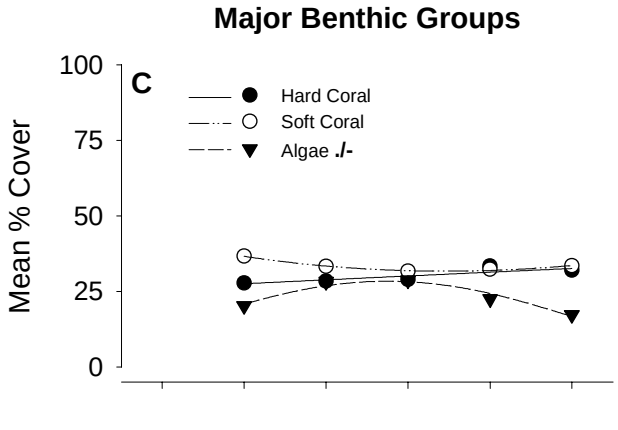
Turner Cay

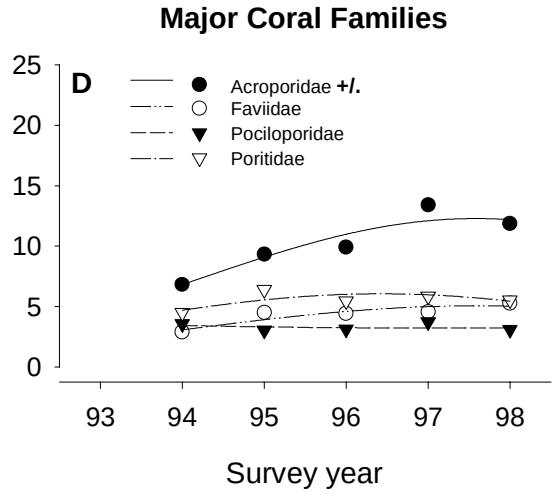


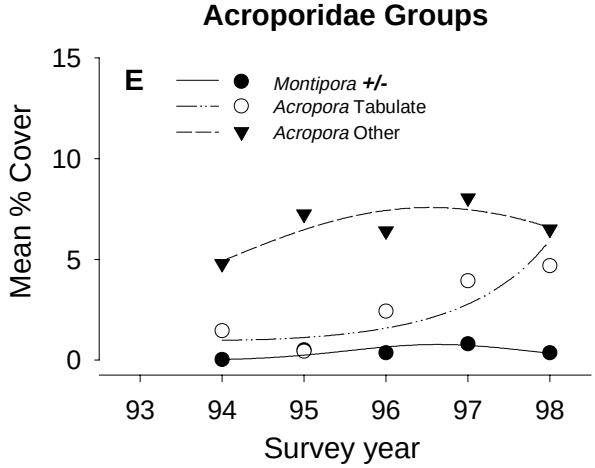
Turner Cay (No. 21-562) is an outer shelf lagoonal reef with an area of 5 sq.km. Last surveyed November 1997.

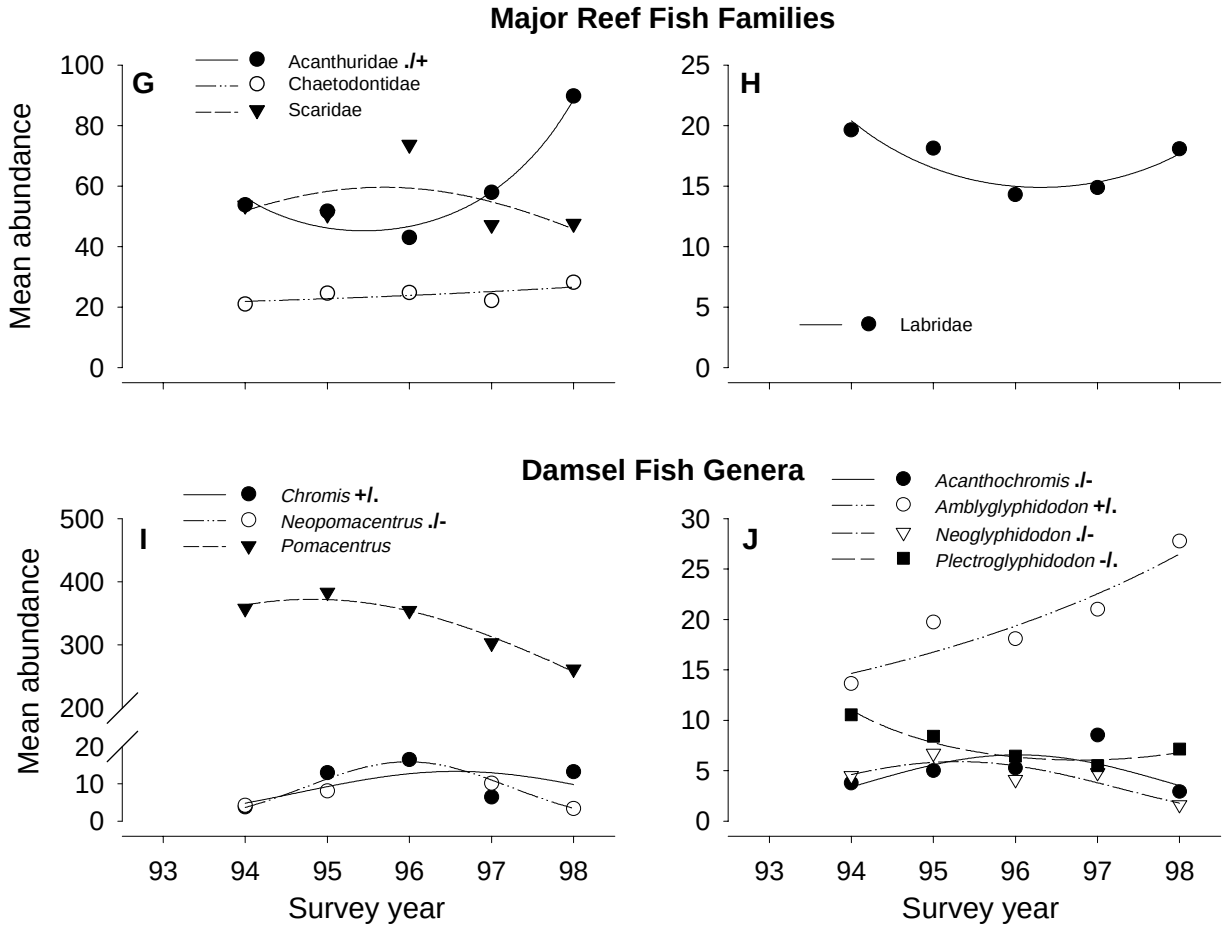












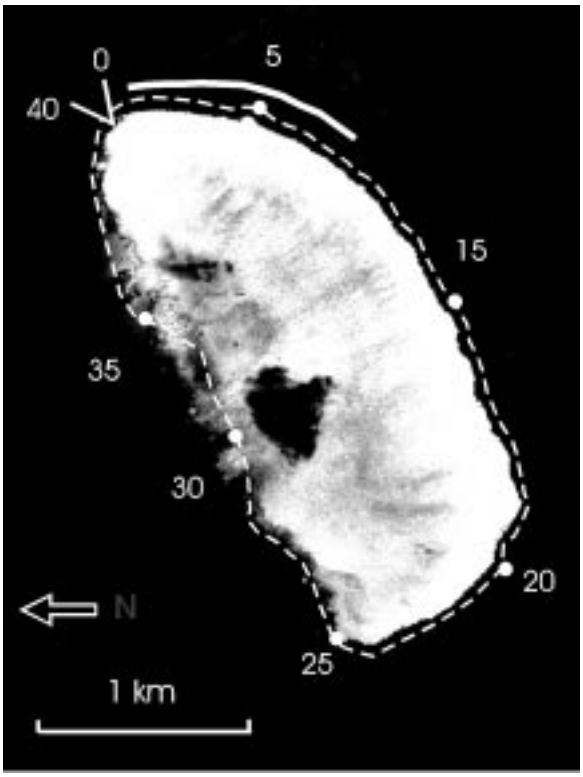
Turner Cay

This reef has been surveyed annually since 1994 using manta tow, benthic video transects and visual fish census. Over this time manta tow surveys show that coral cover has remained high. Detailed benthic surveys show that hard coral cover on the northeastern flank has increased by only 4.1% since 1994 and is currently moderately high at 32.1%. Acroporidae and Faviidae corals have both contributed to the small increase in cover. The abundance of soft corals is high at 36.6%. No COTS have been recorded in recent times on this reef and it is currently classified as Non-Outbreaking.

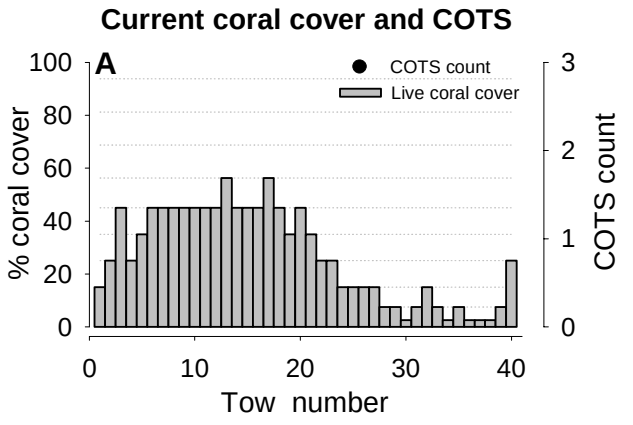
Many of the observed trends in the fish community are only slight due to the relatively low abundance of many of the groups. *Plectroglyphidodon lacrymatus* decreased steadily as did *Neoglyphidodon melas* from the second survey. *Amblyglyphidodon curacao* increased steadily as did *Acanthochromis polyacanthus* up until 1997. The general increase in *Chromis* is due to *C. nitida* while current increases in Acanthuridae involve *Acanthurus nigrofuscus, Ctenochaetus spp.* and *Zebrasoma scopas*.

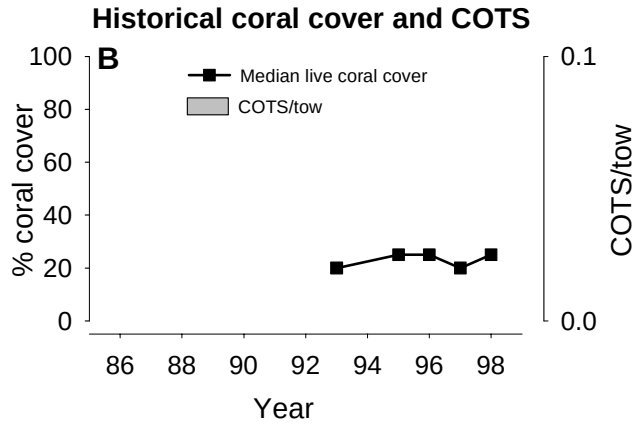
Figure 5.107

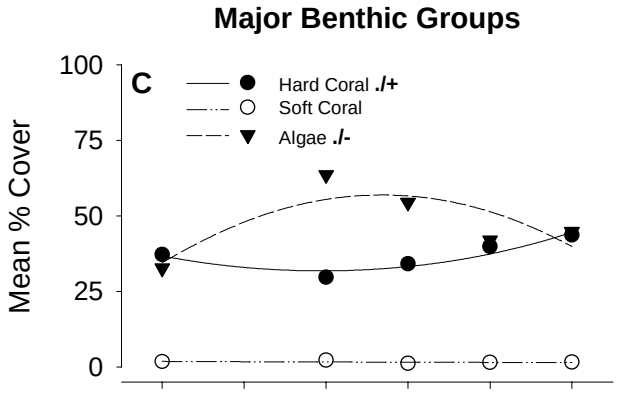
Reef No. 21-529

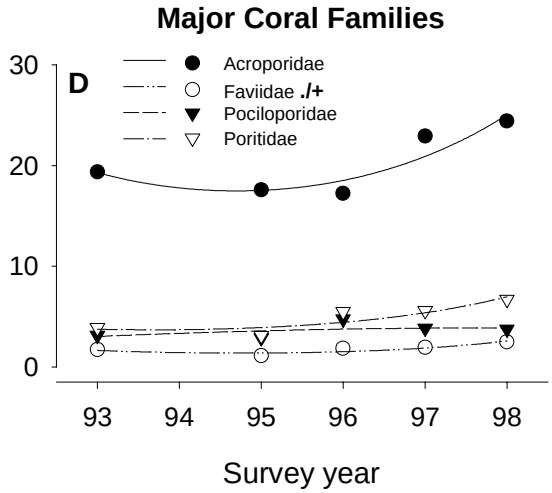


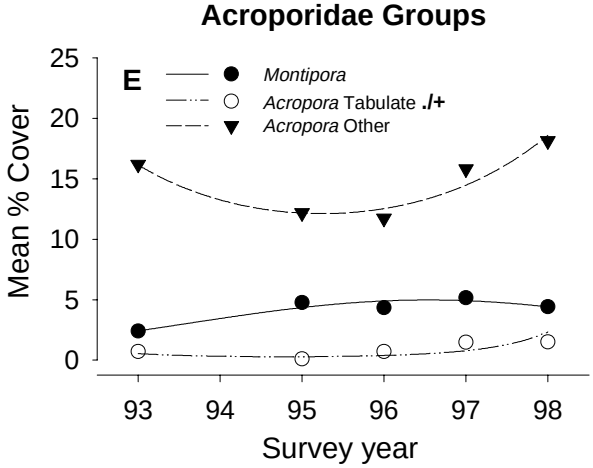
Reef No. 21-529 is a middle shelf crescentic reef with an area of 6.3 sq.km. Last surveyed November 1997.

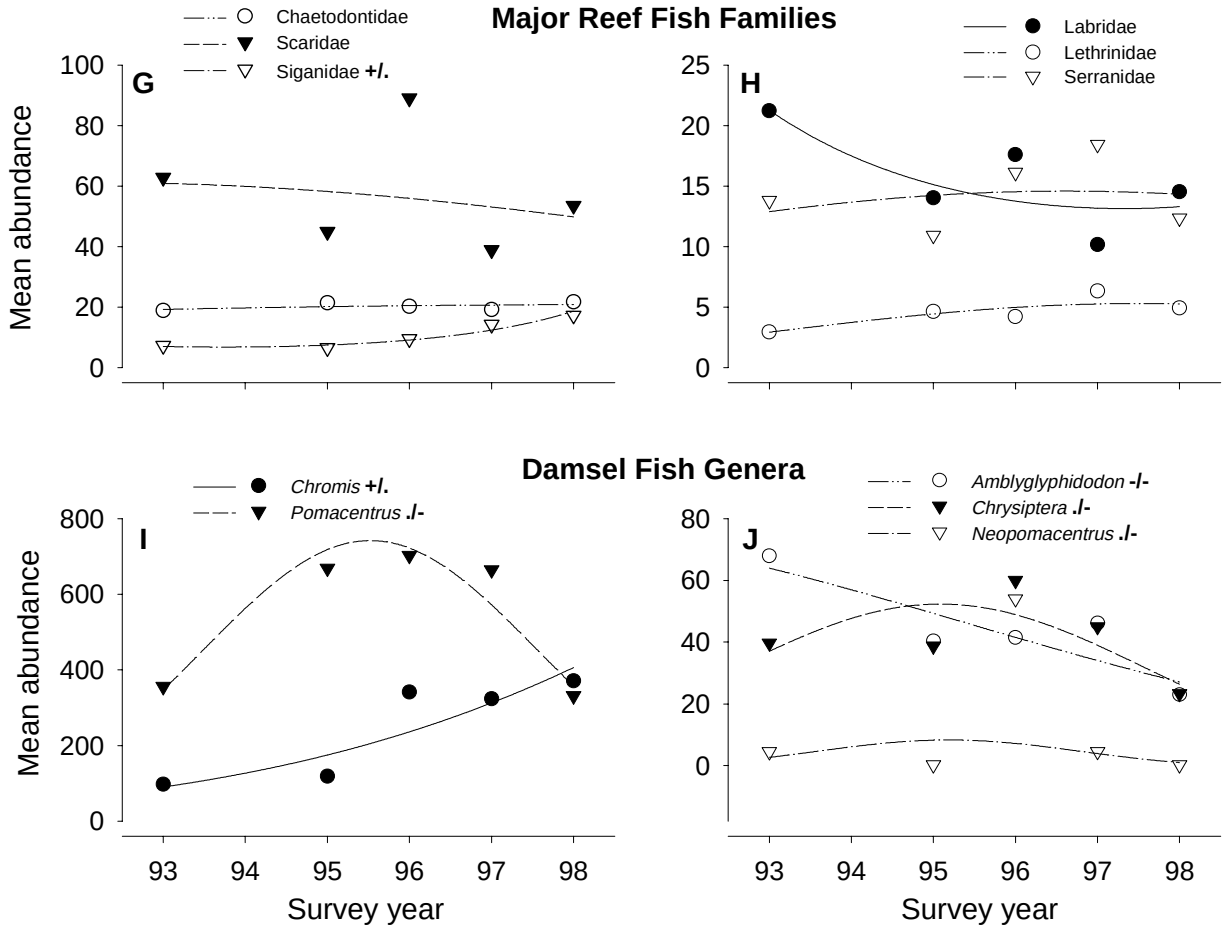










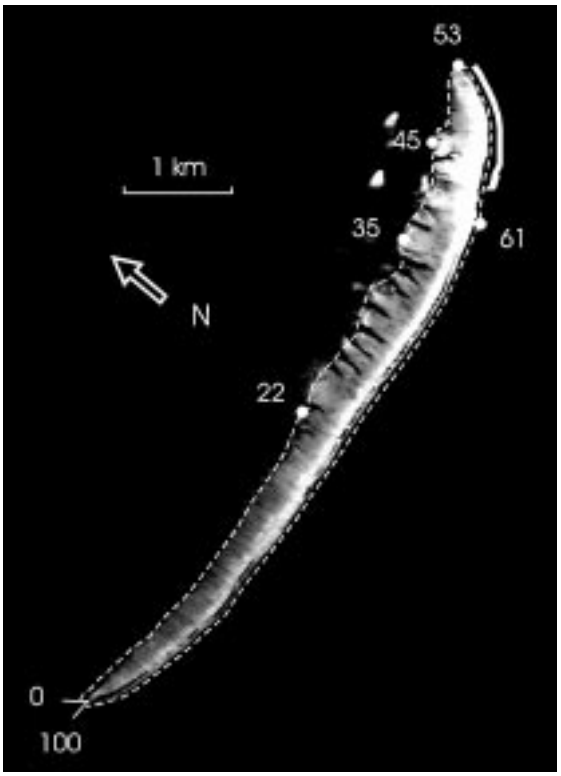


Reef No. 21-529

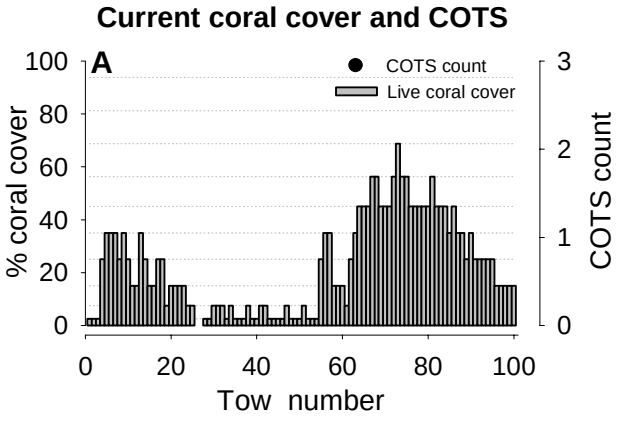
This reef has been surveyed five times since 1993 using manta tow, benthic video and visual fish census. Over this time manta tow surveys show that coral cover has remained at moderate levels. Detailed coral surveys on the northeastern flank show that hard coral cover has increased by 6% over the survey period and is currently moderately high at 43.6%. The increase is primarily due to an increase in *Acropora* spp. There is a relatively high percent cover of branching and bottlebrush *Acropora.* Faviid corals have also increased but are not abundant (2.5% cover). No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

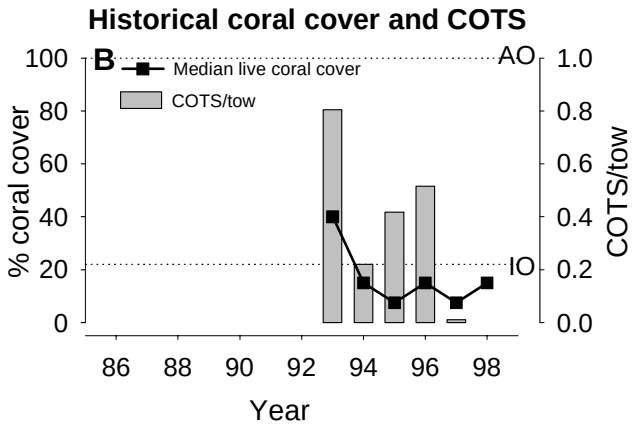
Two fish groups are increasing in abundance. The increase in *Chromis* is due solely to a steady increase in *C. nitida*, while the increase in Siganidae is due to steady increases in *Siganus argenteus*, *S. puellus* and *S. vulpinus*. Many of the *Pomacentrus* species were stable up until 1996 or 1997 then declined. The strong increase from 1993 to 1995 was due to increases in the common *P. moluccensis* and *P. lepidogenys* both of which remained stable before declining after 1997. *Chrysiptera rollandi* and *Neopomacentrus azysron* were similar in that they increased until 1996 then declined. In contrast *Amblyglyphidodon curacao* declined over the survey period.

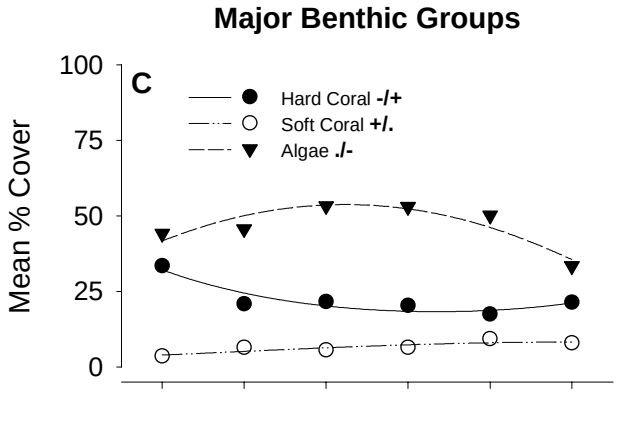
Figure 5.108 **Reef No. 22-088 (Snake)**

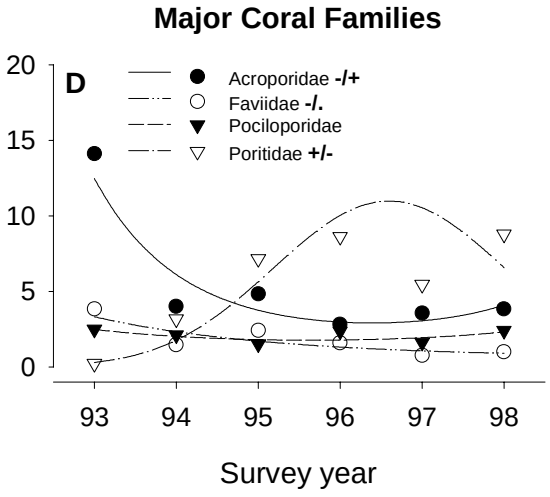


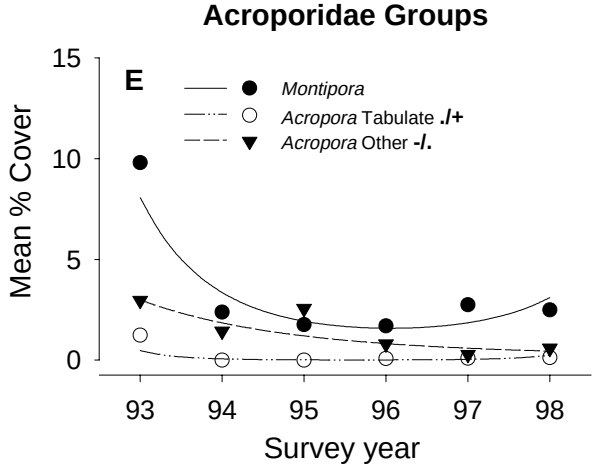
Reef No. 22-088 (Snake) is an inner shelf ribbon reef with an area of 14.4 sq.km. Last surveyed November 1997.

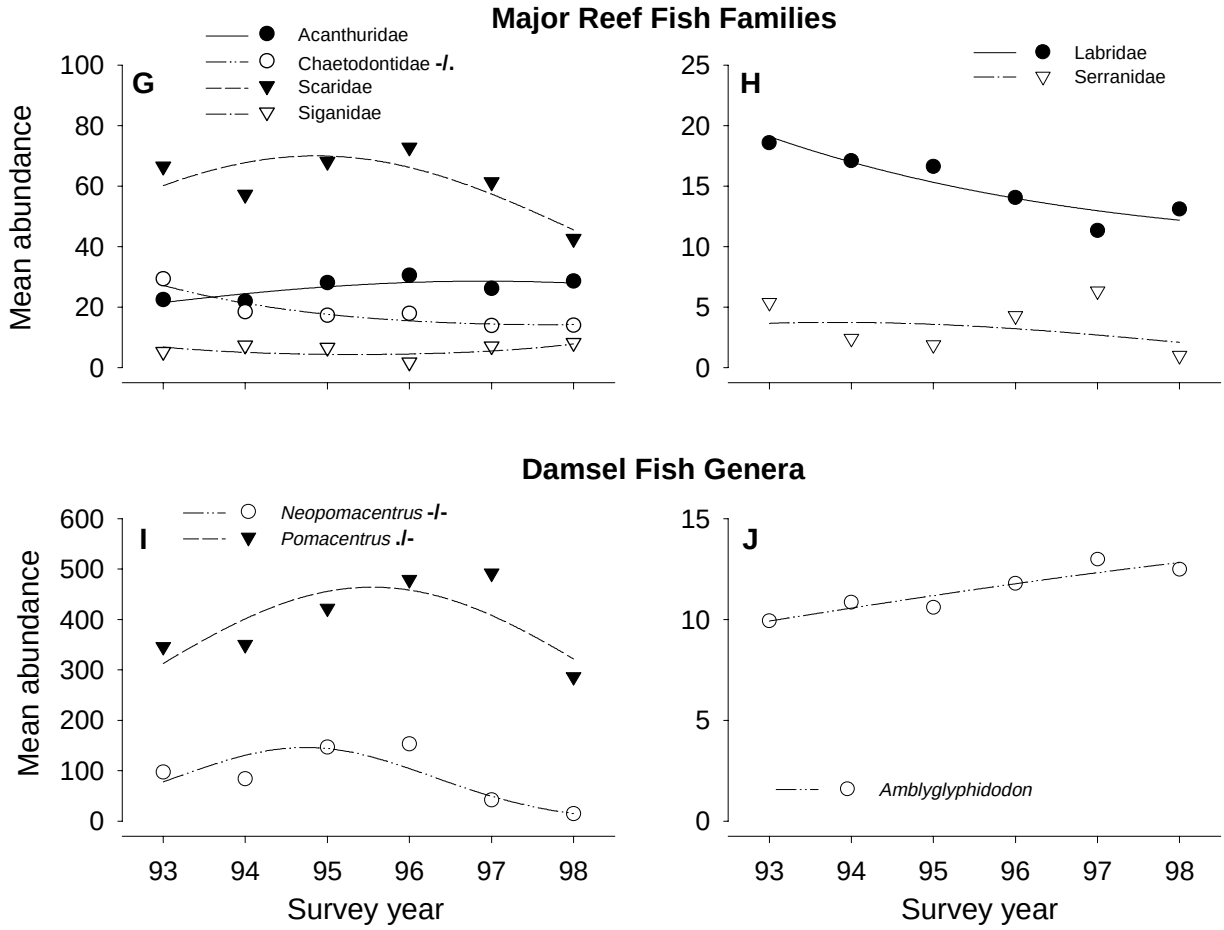












Reef No. 22-088 (Snake)

This reef has been surveyed six times since 1993 using manta tow, visual fish census and benthic video surveys. Initial surveys revealed relatively high COTS populations on this reef, and the reef was classified as having an Incipient Outbreak through to 1997. Manta tow surveys recorded a large drop in coral cover between 1993 and 1994, which is attributed to COTS activity. The detailed coral surveys on the northeastern flank also recorded an initial drop in coral cover: this was largely due to a decrease in the coverage of Acroporidae, in particular *Montipora* spp. Subsequent surveys have revealed little change with the exception of an increase in the abundance of *Porites* spp. which is currently the most abundant genus at 9% cover. Hard coral cover is currently moderate at 21.4%. The cover of algae decreased during the most recent survey interval. Our most recent broadscale surveys did not detect any COTS and coral cover showed signs of a recovery. The reef is currently classified as Recovering.

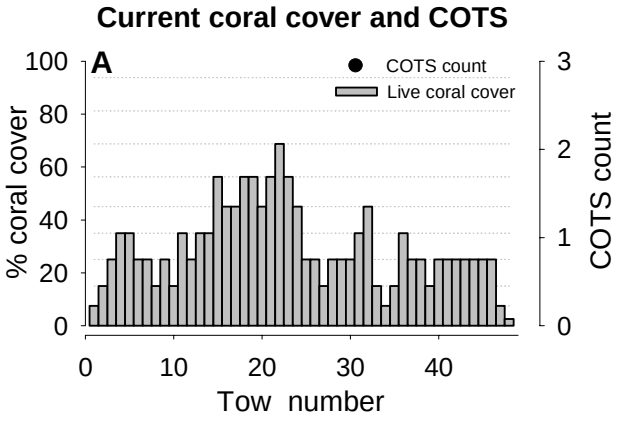
The relatively stable benthic community is reflected to some degree in the fish community with only Chaetodontidae showing changing abundance amongst the larger reef fish. This change reflects declines in the two abundant species *Chaetodon aureofasciatus* and *C. rainfordi*. Current declines in *Neopomacentrus* (*N. azysron*) and *Pomacentrus* (predominantly *P. lepidogenys*, *P. moluccensis* and *P. wardi*) occur after periods of increase with peaks in 1996 and 1997 respectively.

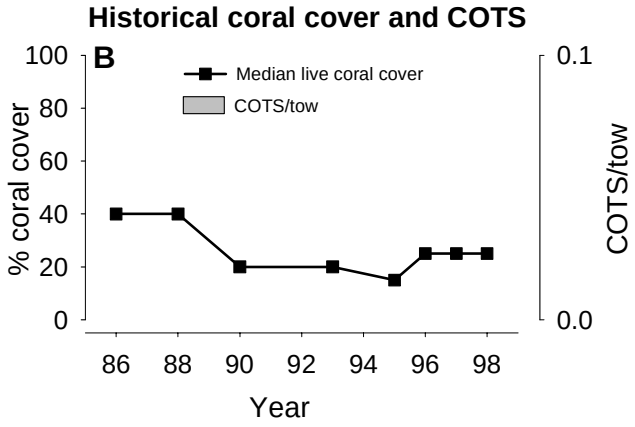
Capricorn-Bunkers
reef pages

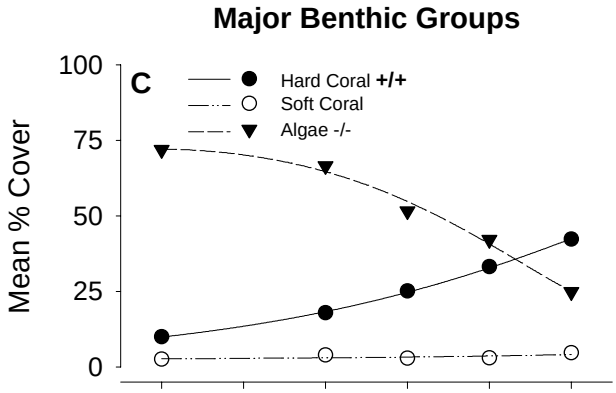
Figure 5.109

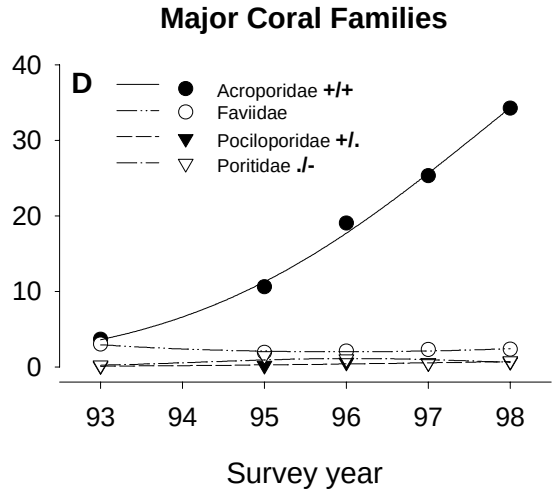
Broomfield

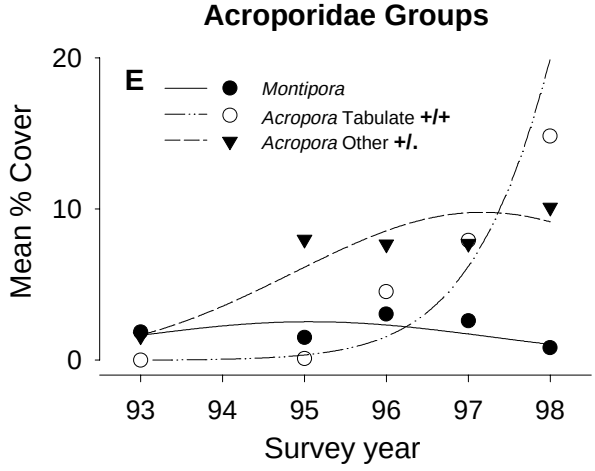
Broomfield (No. 23-048) is an outer shelf planar reef with an area of 21.3 sq.km. Last surveyed December 1997.

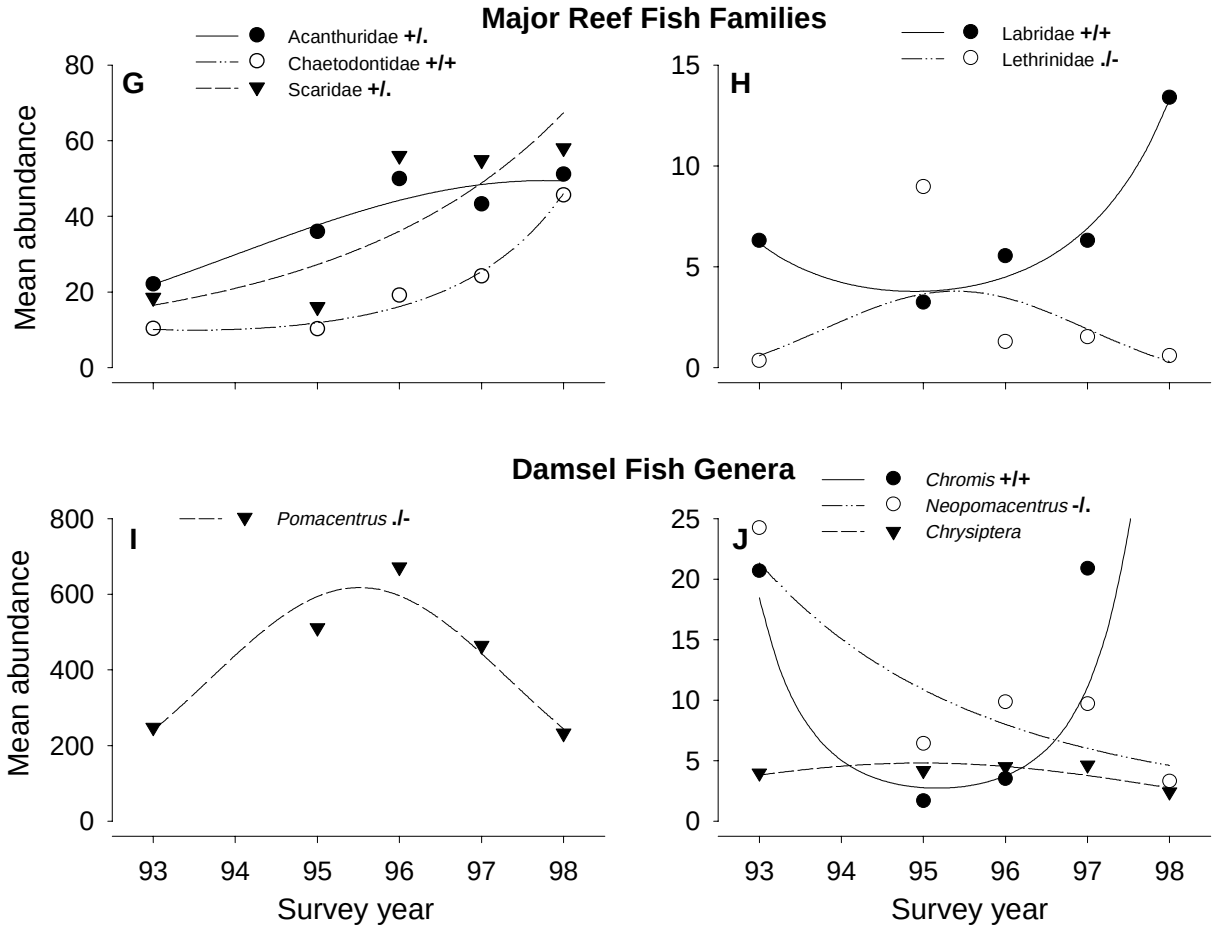












Broomfield

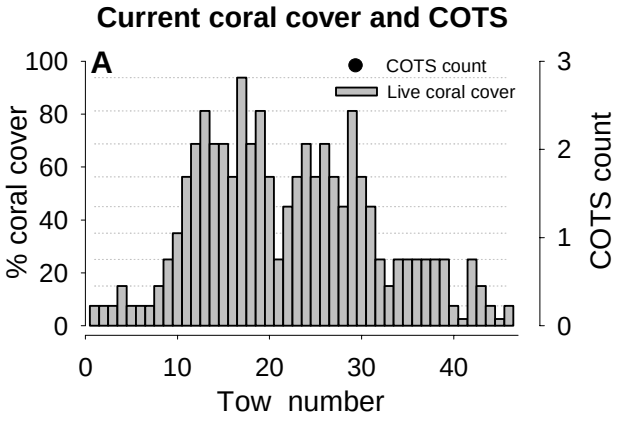
This reef has been surveyed since 1986 using manta tow. These surveys show that hard coral cover dropped dramatically from a high to moderate level between 1988 and 1990. Though the reason for this is unclear, evidence suggests corals were physically removed by strong wave action in the region. Since 1990 coral cover has been slowly increasing. Detailed surveys conducted since 1993 on the northeastern flank of the reef show a dramatic increase in hard coral cover from 10% in 1993 to 43% in 1998. Tabulate *Acropora* now occupy 24% of the substrate which contrasts dramatically with 0% in 1993, another 10% can be attributed to other *Acropora* lifeforms. Historical records indicate that dominance by tabulate *Acropora* is typical for reefs in this region. The cover of algae shows a decrease which corresponds to the increase in hard coral abundance. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

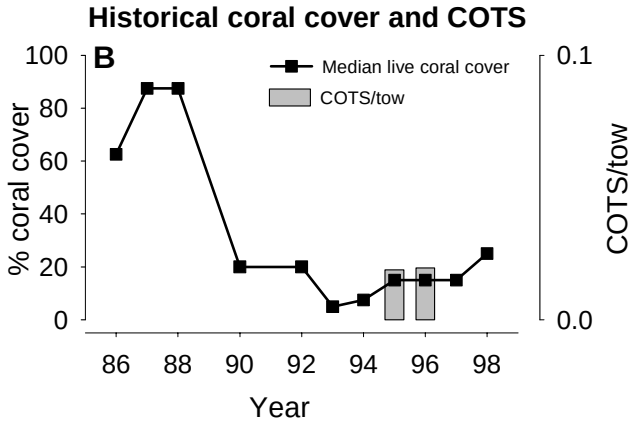
The recovery of the benthic community, and hence fish habitat, from severe disturbance is evident in the fish community with obvious increases in many groups. Acanthuridae (predominantly *Acanthurus nigrofuscus*, *Ctenocheatus* spp. *and Zebrasoma scopas*), Chaetodontidae (*Chaetodon citrinellus*, *C. kleinii*, *C. rainfordi*, and especially *C. trifascialis*), Labridae (*Gomphosus varius* and *Hemigymnus melapterus*), Scaridae (many species) and *Chromis nitida* have all increased greatly over the period of survey. The current negative trend in *Pomacentrus* reflects *P. coelestis* which recruited strongly in the first years post disturbance and is currently in decline. In addition, the decline in *Pomacentrus* reflects the decline of coral cover and habitat at site three which was not obliterated by the disturbance and acted as a refuge for *P. moluccensis*, *P. lepidogenys*, *P. wardi* and others. The increasing coral cover on sites one and two do not provide the habitat complexity that was afforded by site three. The decline in Lethrinidae is artificial reflecting the inclusion of a large school of *Lethrinus atkinsoni* in one survey.

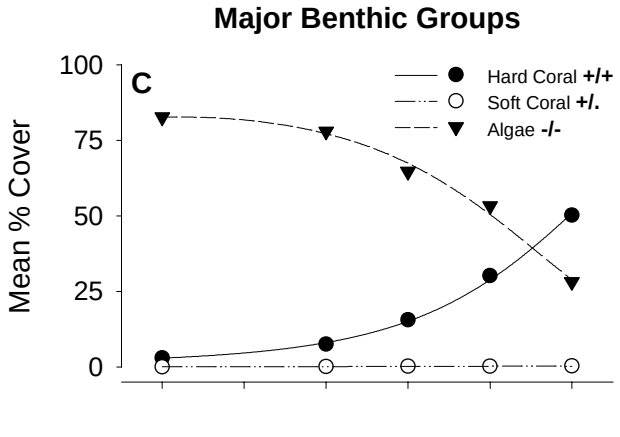
Figure 5.110

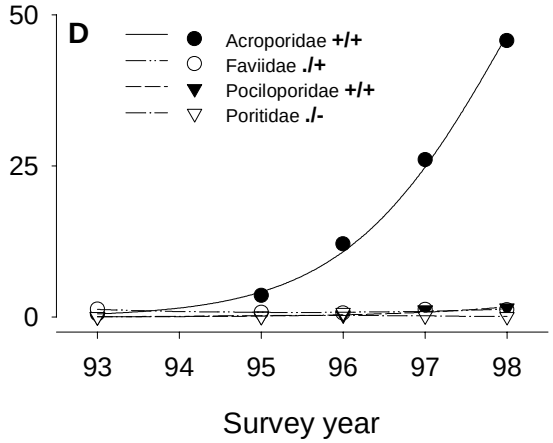
Lady Musgrave Island

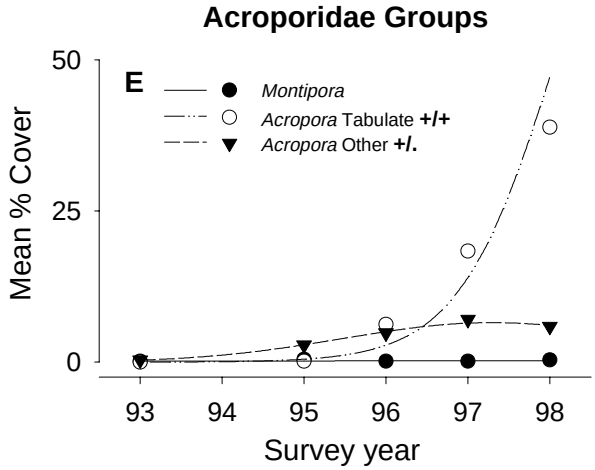
Lady Musgrave Island (No. 23-082) is an outer shelf lagoonal reef with a sand cay at the southwestern end. The reef has an area of 12.5 sq.km. Last surveyed December 1997.

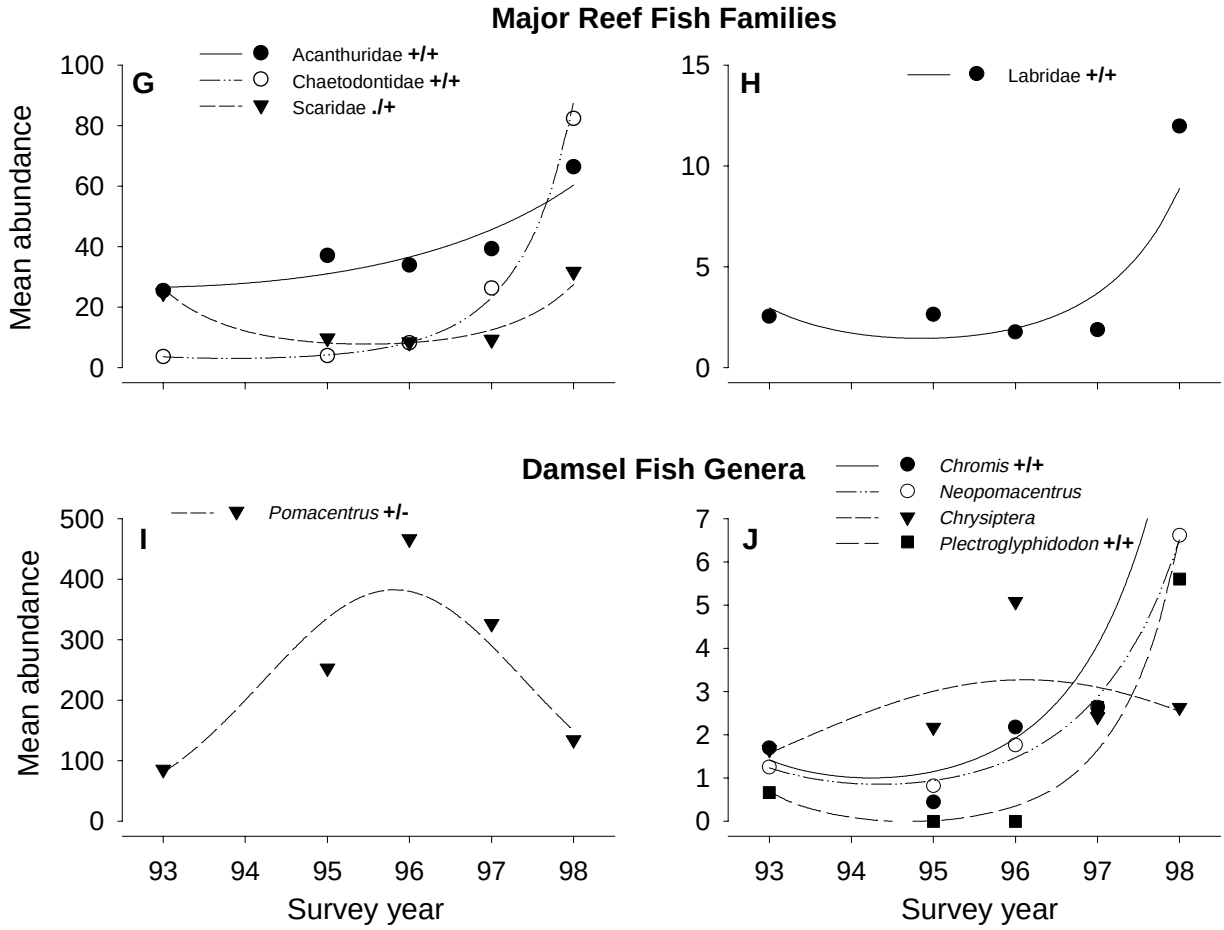












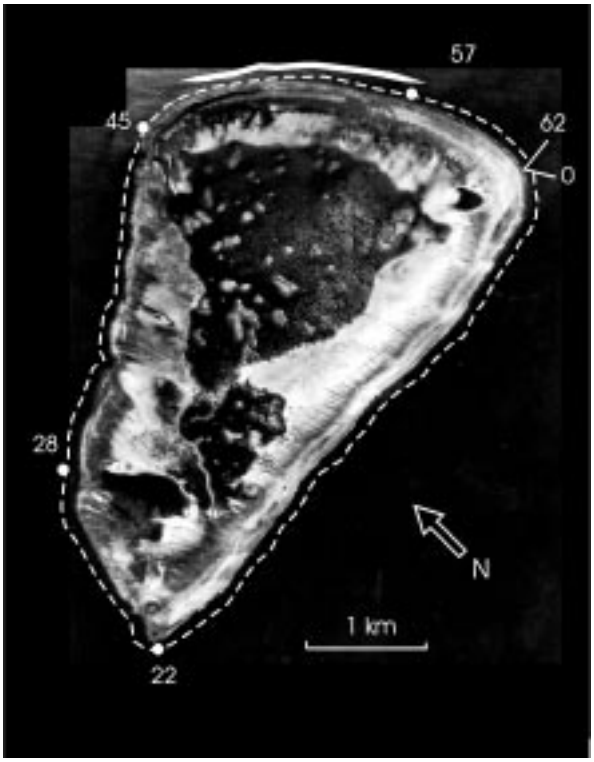
Lady Musgrave Island

This reef has been surveyed extensively using manta tow since 1986. These surveys show that coral cover on this reef dropped dramatically from an extremely high level to a moderate level between 1988 and 1990. Though the reason for this is unclear, evidence suggests corals were physically removed by strong wave action in the region. Coral cover on this reef continued to decline to low levels in 1993 before beginning to recover. Detailed benthic surveys conducted since 1993 on the northern flank of the reef show that hard coral cover has increased exponentially from less than 5% in 1993 to a current very high level of 50%. Cover of tabulate *Acropora* has increased dramatically from 0% in 1993 to a current level of 39.2%. Another 5% of cover can be attributed to other *Acropora* lifeforms. Historical records indicate that dominance by tabulate *Acropora* is typical for reefs in this region. Pocilloporidae corals have increased from less than 0.5% to 1.5%. Soft coral cover is low. The cover of algae shows a decrease which corresponds to the increase in hard coral cover. Although COTS have been observed on this reef on a number of occasions they have not been in sufficent numbers to be considered to affect coral cover. Overall coral cover on the reef is presently moderate and the reef is classified as Non-Outbreaking.

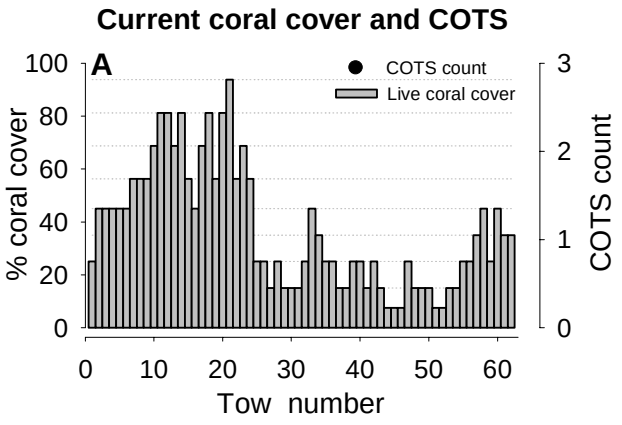
As with other reefs in the region the strong increase in abundance of most groups is associated with the recovery of the benthic community following catastrophic physical removal. The following groups and species have all increased over the period of survey, Acanthuridae (*Acanthurus nigrofuscus*), Chaetodontidae (*Chaetodon citrinellus*, *C. kleinii*, and *C. trifascialis*), *Chromis* (*C. margaritifer*, *C. vanderbilti*, *C. weberi*), Labridae (*Gomphosus varius*, and *Hemigymnus melapterus*), *Plectroglyphidodon* (*P. dickii* and *P. johnstonianus*). The current decline in *Pomacentrus* is due solely to *P. coelestis* which recruited to the disturbed area and is now in decline. *P. bankanensis* and *P. lepidogeny*s are currently increasing.

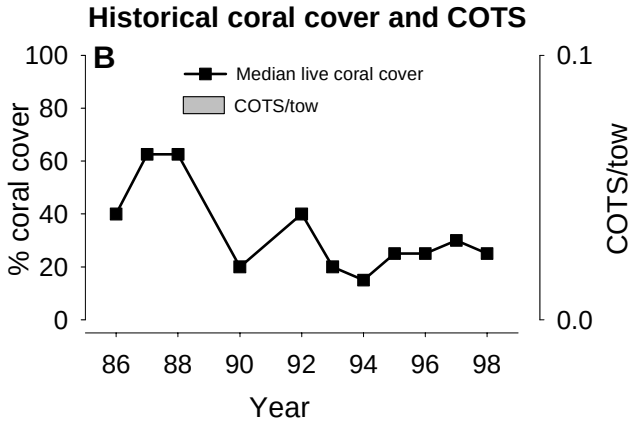
Figure 5.111

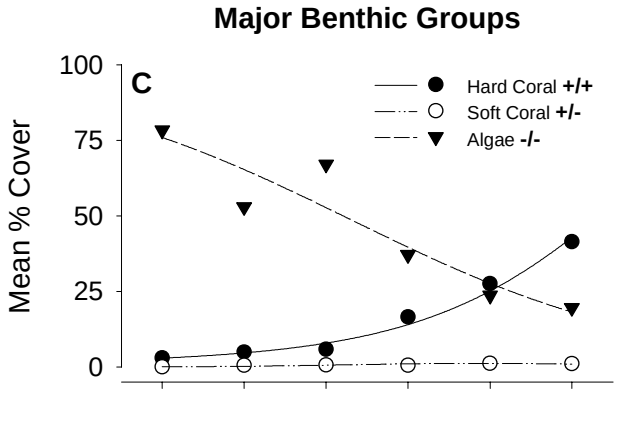
One Tree Island

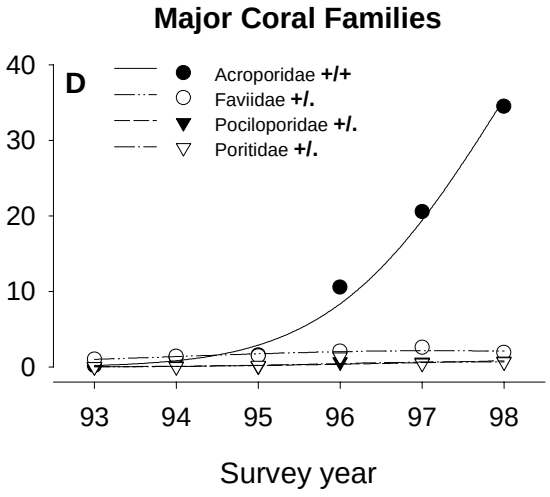


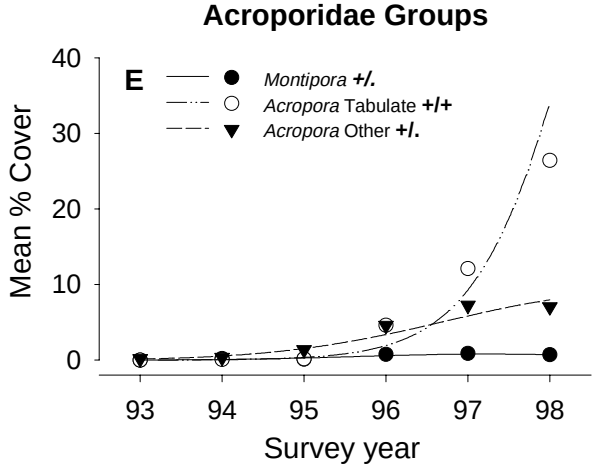
One Tree Island (No. 23-055) is an outer shelf lagoonal reef with a vegetated sand cay at the south-eastern end. The reef has an area of 18.09 sq.km. Last surveyed December 1997

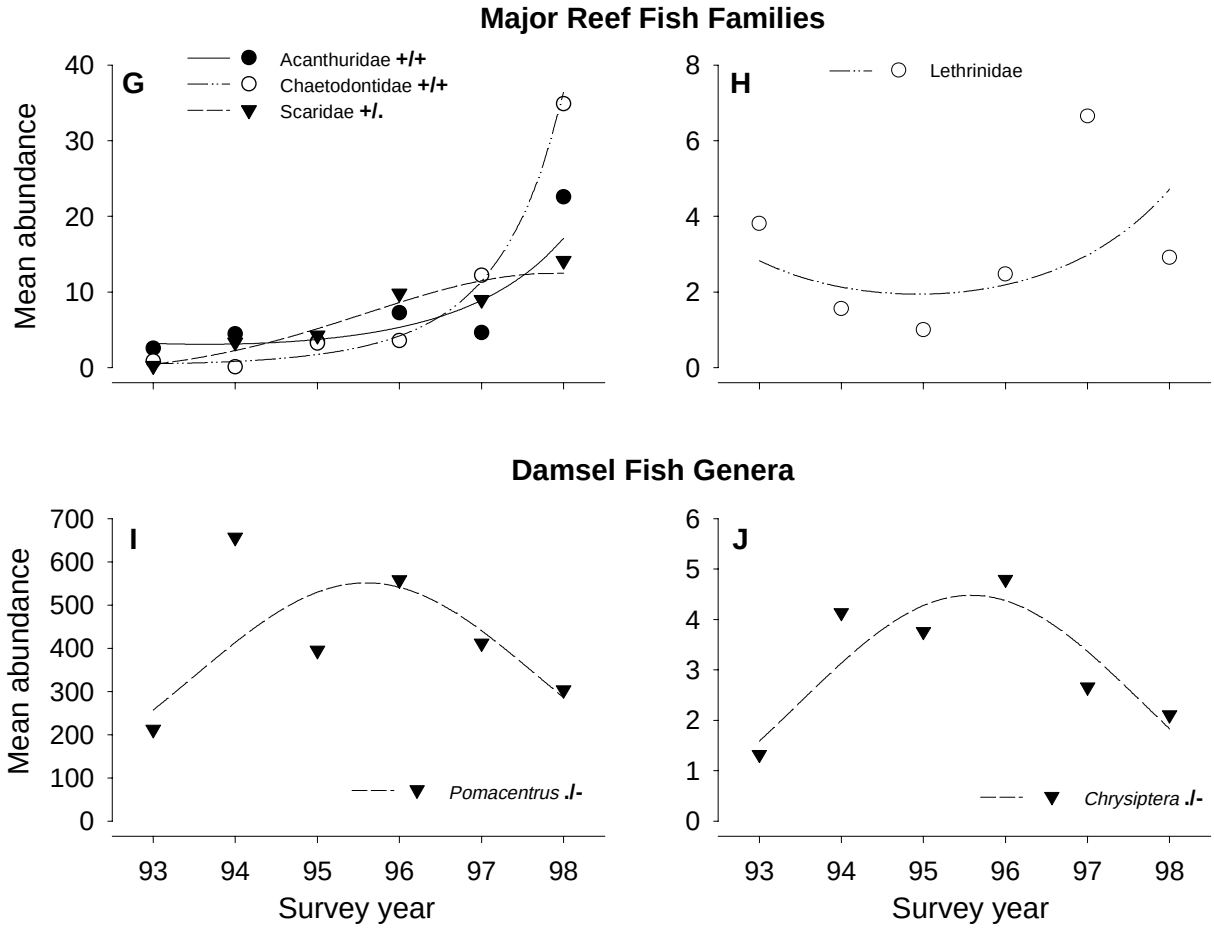












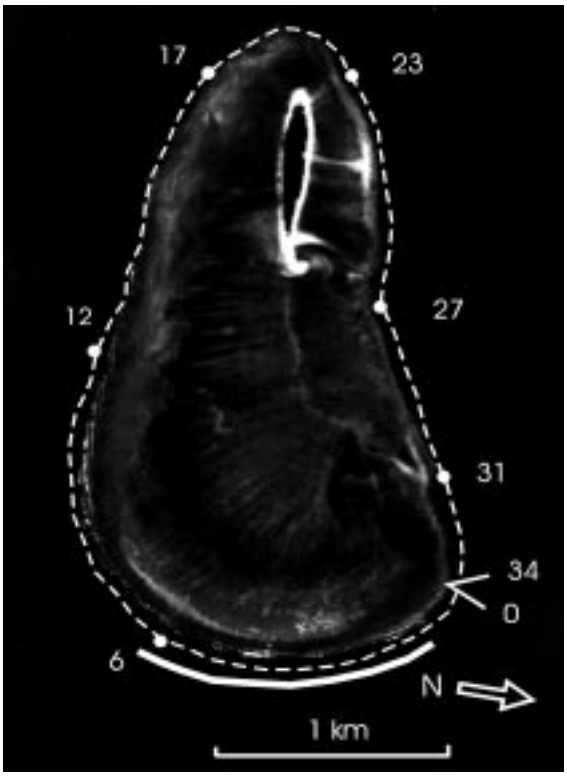
One Tree Island

This reef has been surveyed since 1986 using manta tow. These surveys show that coral cover dropped dramatically from a very high level to a moderate level between 1988 and 1990. Though the reason for this is unclear, evidence suggests corals were physically removed by strong wave action in the region. Manta tow surveys show that coral cover has been increasing since this time. Detailed benthic surveys conducted since 1993 on the northeastern flank show that coral cover has increased from less than 5% in 1993 to a current level of 42%. Tabulate *Acropora* make up 27% of the current cover, a dramatic increase from 0% in 1993. Another 7.3% of cover can be attributed to other *Acropora* lifeforms. Historical records indicate that dominance by tabulate *Acropora* is typical for reefs in this region. The cover of Favid corals currently 2.3% with other groups being 1% or less. The cover of algae has declined in line with the increase in hard coral cover. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

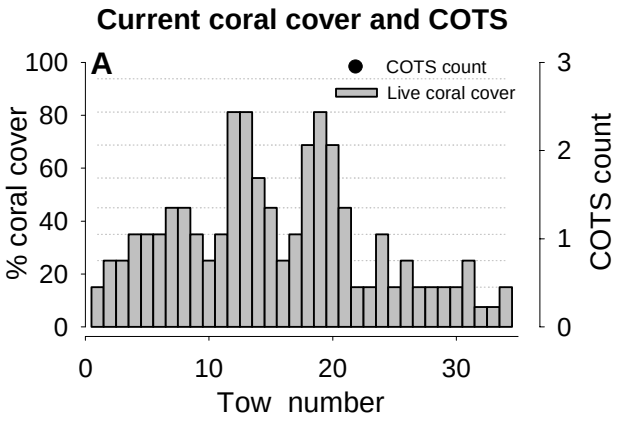
Of the reefs surveyed in this sector One Tree had the least habitat complexity following the large scale physical disturbance which is reflected in the still very depauperate fish community. Acanthuridae (predominantly *Acanthurus nigrofuscus*), Chaetodontidae (*C. citrinellus*, *C. flavirostris*, *C. kleinii*, *C. rainfordi* and *C. trifascialis*) and Scaridae (S. sordidus), all increased over the surveys. While *Pomacentrus coelestis* drives the rapid increase and current decline in *Pomacentrus*. The decrease in *Chrysiptera* is due to a combination of *C. flavippinnis,* which was present until 1995, and *C. rex* which is currently in decline.

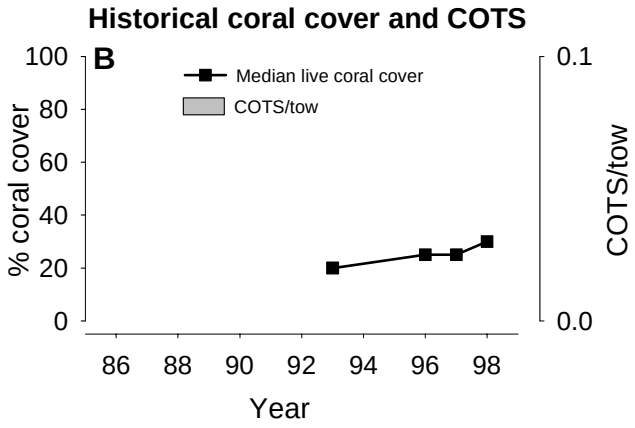
Figure 5.112

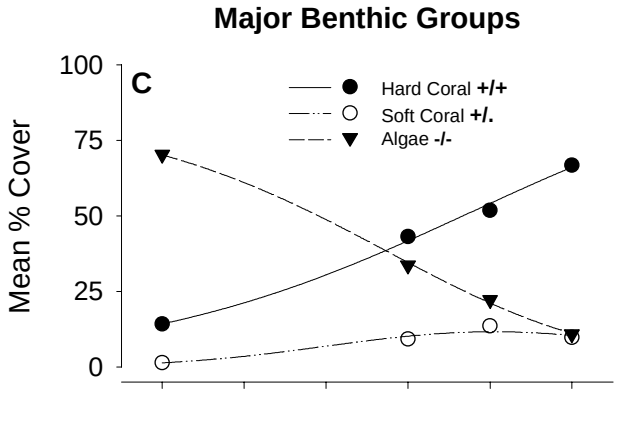
Wreck Island

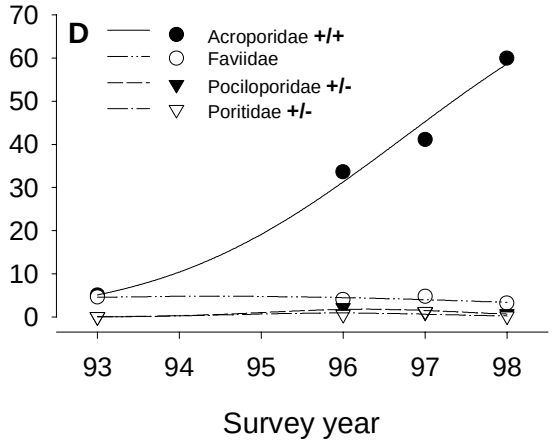


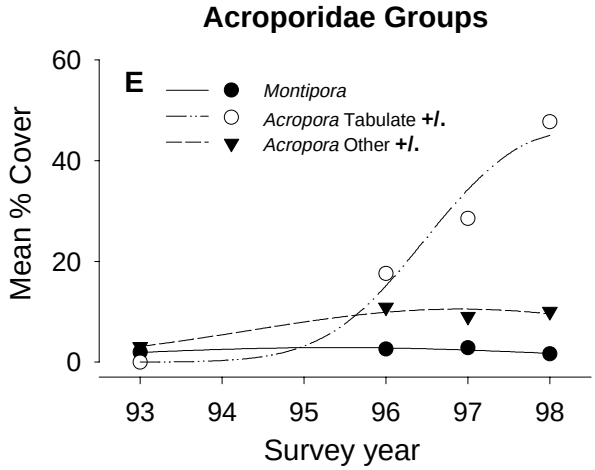
Wreck Island (No. 23-051) is an outer shelf planar reef with a vegetated sand cay on the western end. The reef has an area of 6.3 sq.km. Last surveyed December 1997

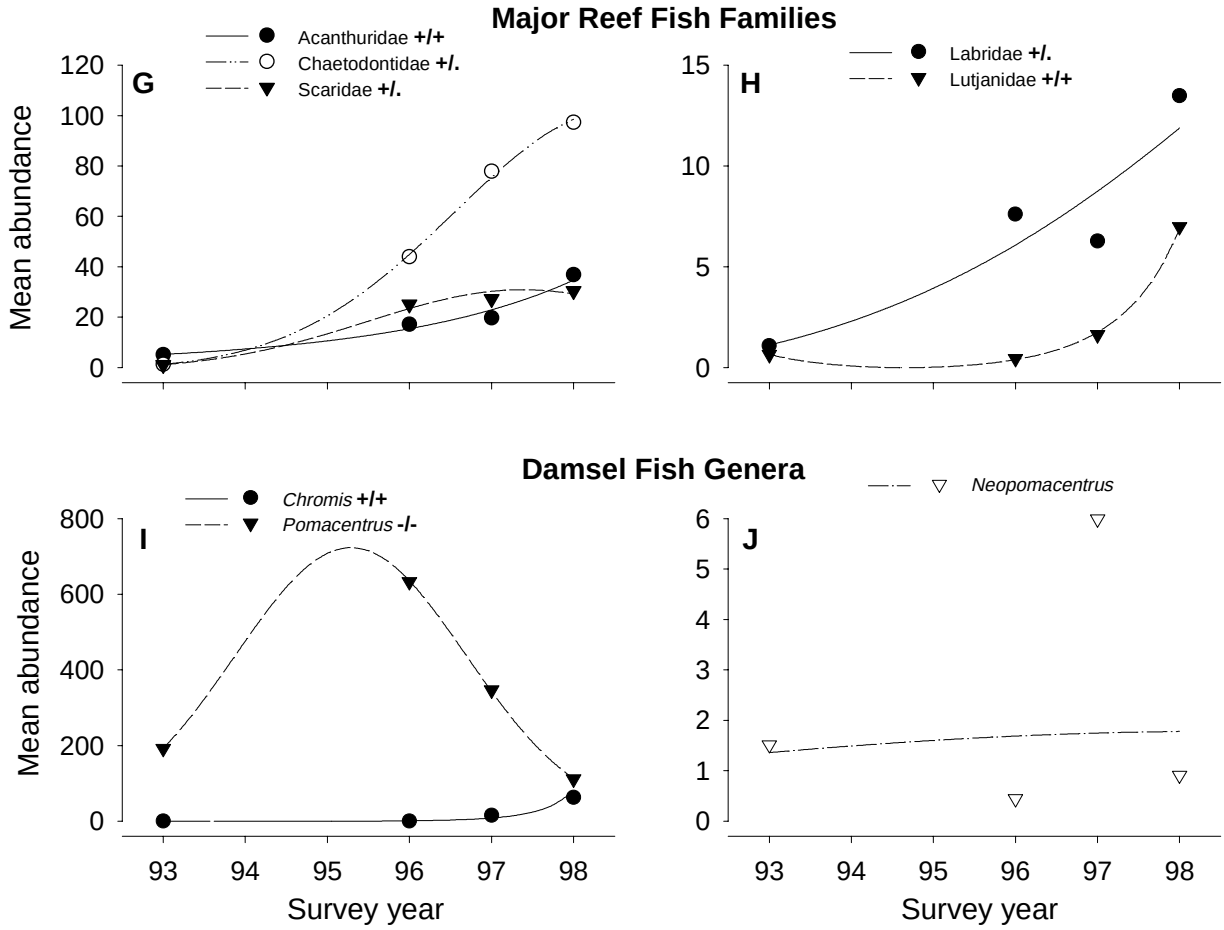












Wreck Island

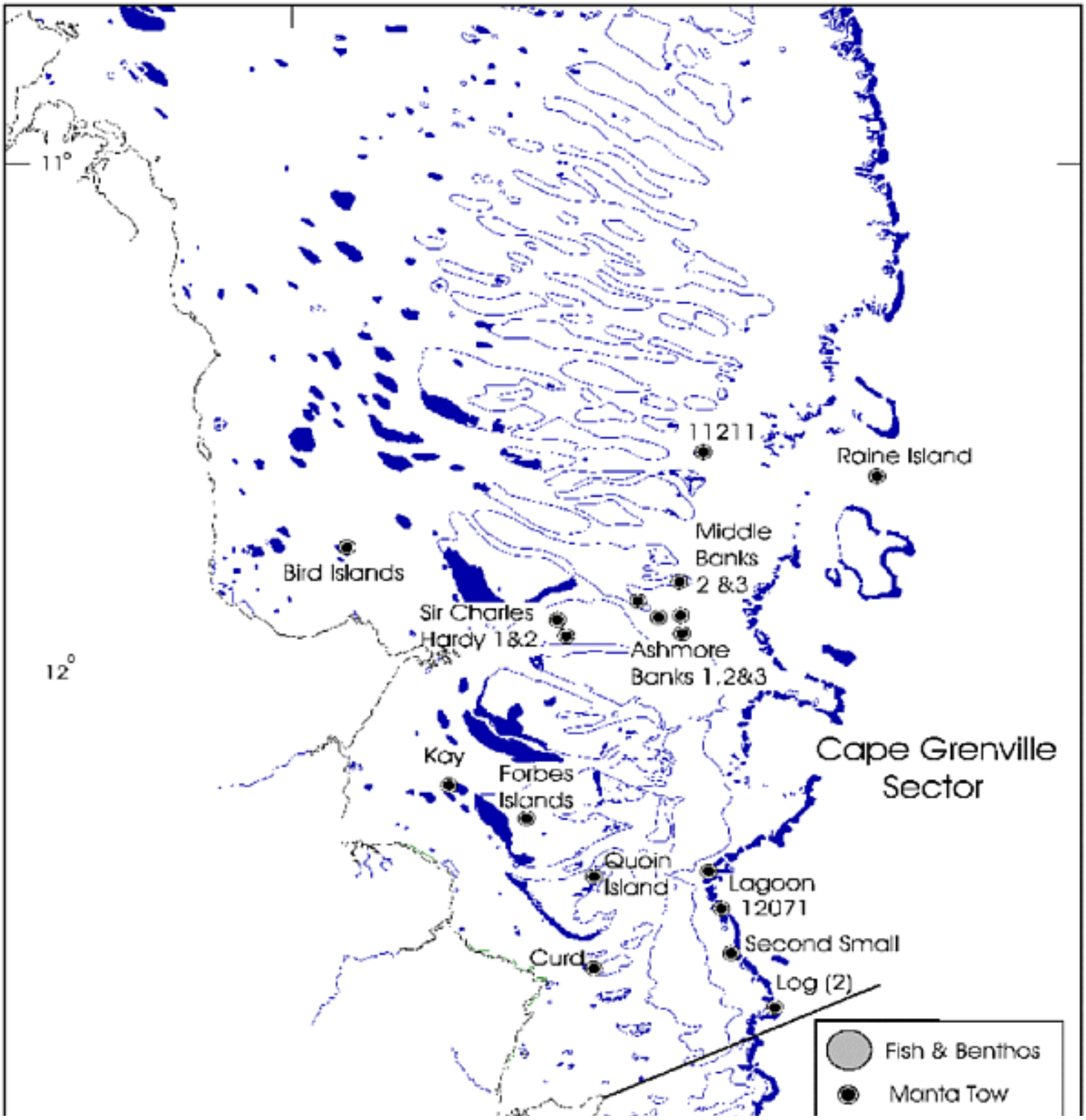
This reef has been surveyed four times since 1993 using manta tow, benthic video surveys, and visual fish surveys. Manta tow surveys show that at the reef level coral cover has remained at moderate levels over the period of survey with a trend of increasing coral cover. Detailed benthic surveys on the north-eastern flank show that hard coral cover has increased dramatically from around 15% in 1993 to 66.6% in 1998. Tabulate *Acropora* make up 47.8% of the total cover in 1998 from 0% cover in 1993. Another 10% cover can be attributed to other *Acropora* lifeforms. Historical records indicate that dominance by tabulate *Acropora* is typical for reefs in this region. Soft coral cover is relatively high compared with other reefs in this sector although, cover has declined from 14.8% to 10.7% in the most recent survey. The other hard coral families have also changed from an increasing to a decreasing trend in the most recent survey although numbers are very low. Further investigation is required to determine if overgrowth by tabulate *Acropora* causes mortality in other coral groups or whether the apparent decline is an "artifact" of the video technique favouring identification of the overgrowing tabulates. The cover of algae has declined as the cover of hard corals has increased. No COTS have been recorded on this reef and it is currently classified as Non-Outbreaking.

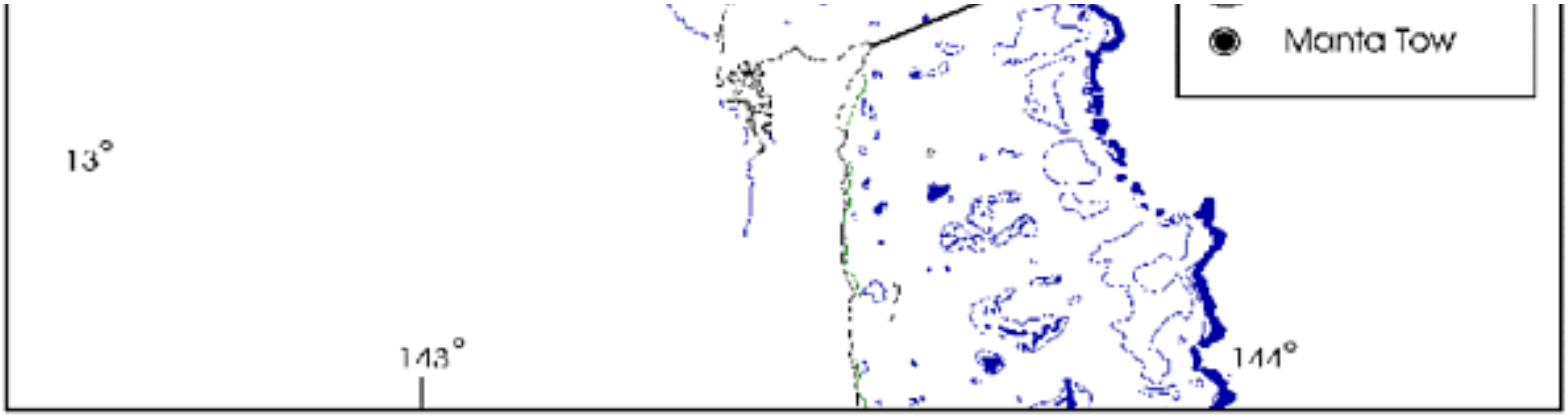
As with other reefs in this sector the increase in abundance of most fish groups is related to the recovery of habitat after severe physical disturbance. The following groups and species have all increased over the period of survey: Acanthuridae (*Acanthurus nigrofuscus* and *Ctenochaetus spp.*), Chaetodontidae (*Chaetodon citrinellus*, *C. kleinii*, *C. melannotus*, *C. plebeius*, *C. rainfordi* and *C. trifascialis*), *Chromis* (*C. nitida*), Labridae (*Gomphosus varius*, *Hemigymnus fasciatus* and *H. melapterus*) and Scaridae (*Scarus frenatus*, *S. globiceps*, *S. psittacus*, and *S. sordidus*). The current decline in *Pomacentrus* is due solely to *P. coelestis* which recruited to the disturbed area and is now in decline. *P. lepidogenys, P. moluccensis* and *P. wardi* are currently increasing.

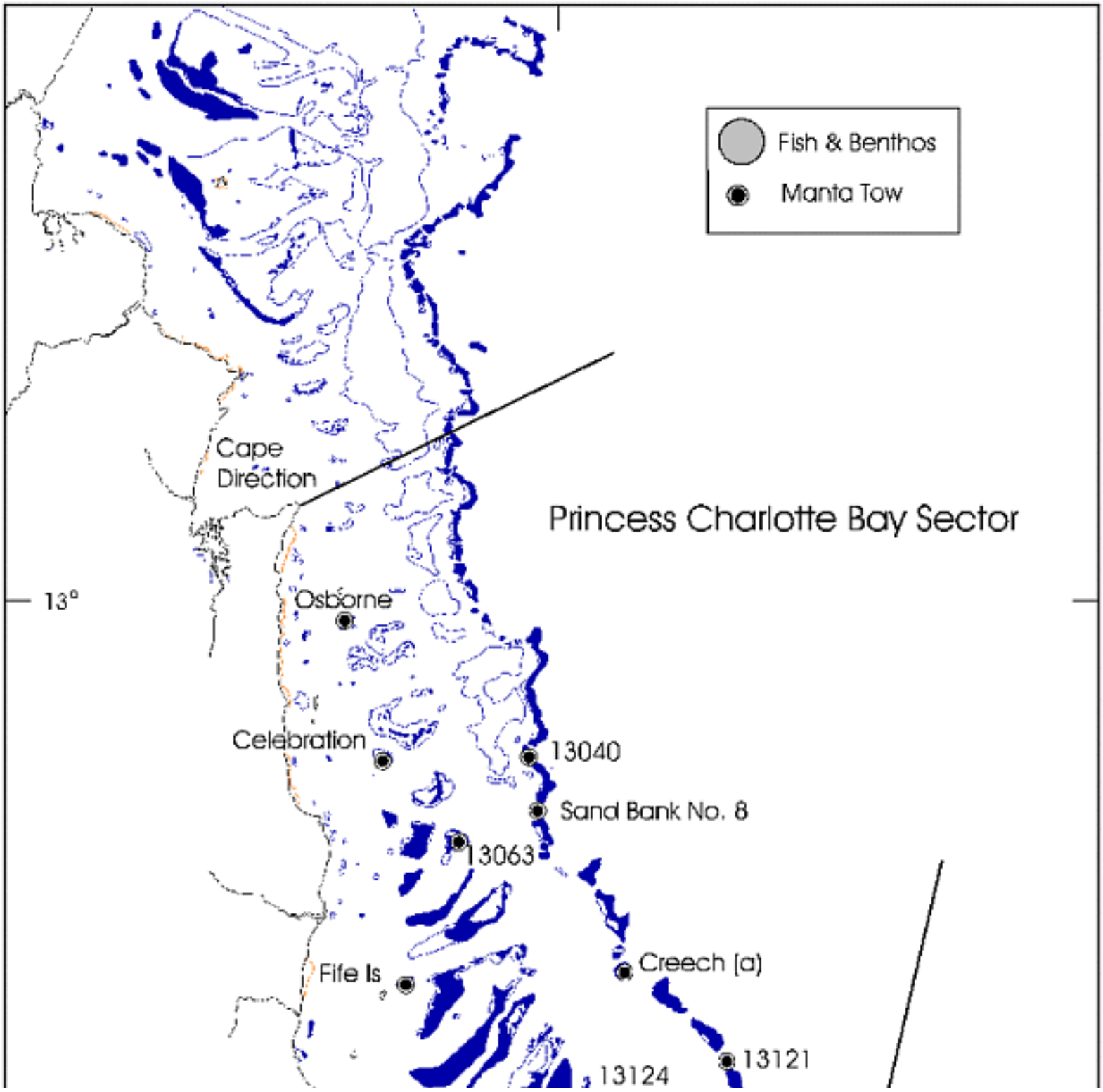
7. Appendices

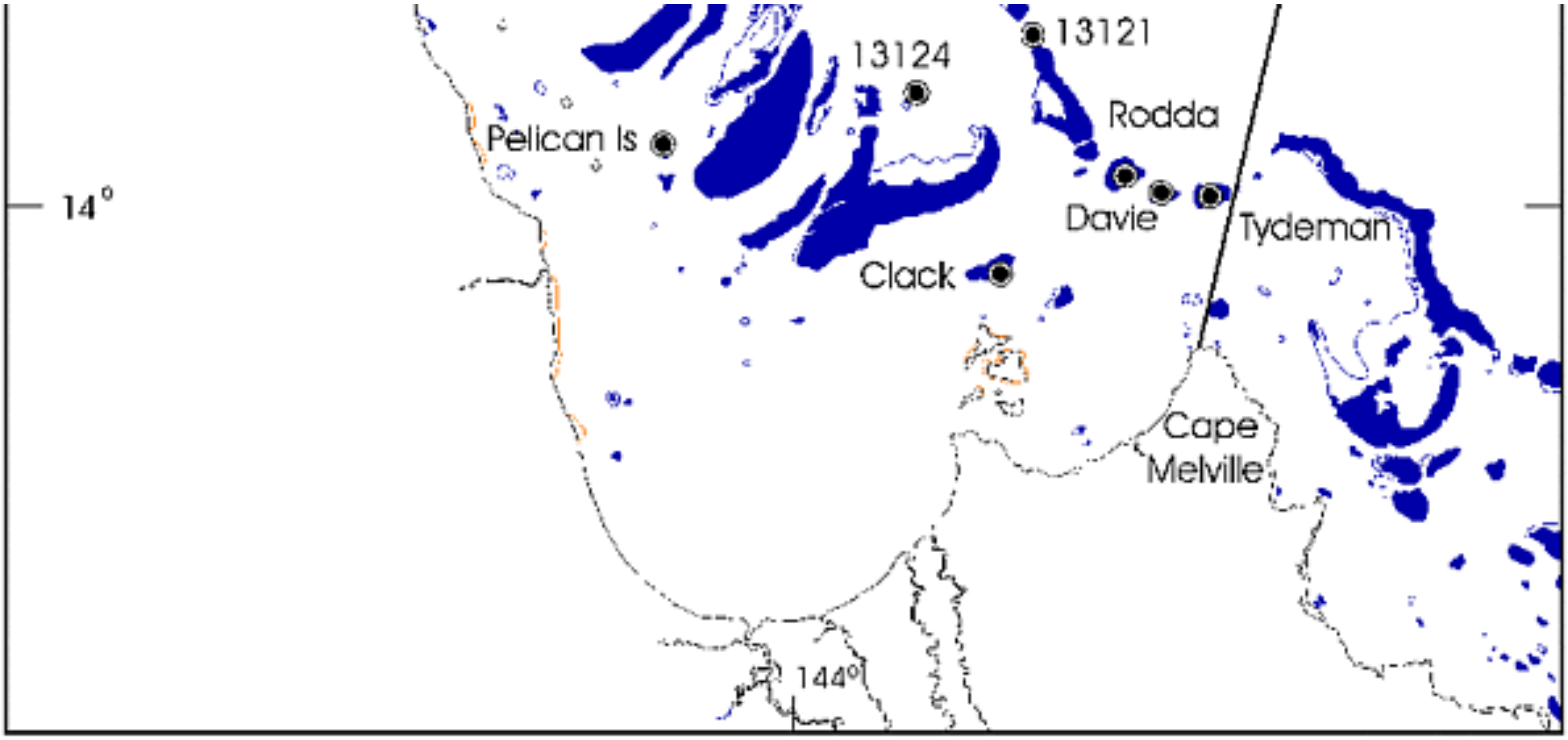
Appendix A

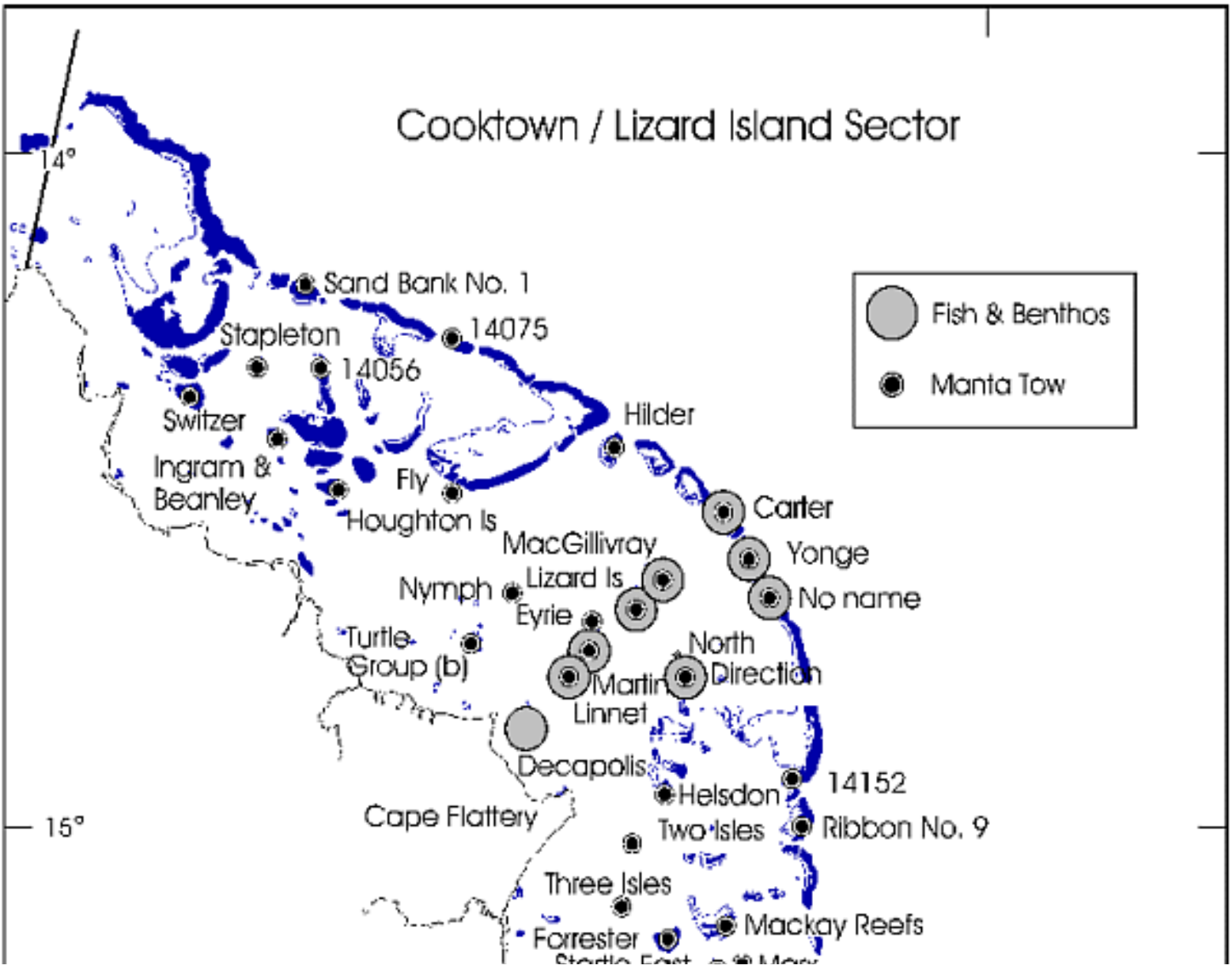
Locations of survey reefs and the types of samples taken.

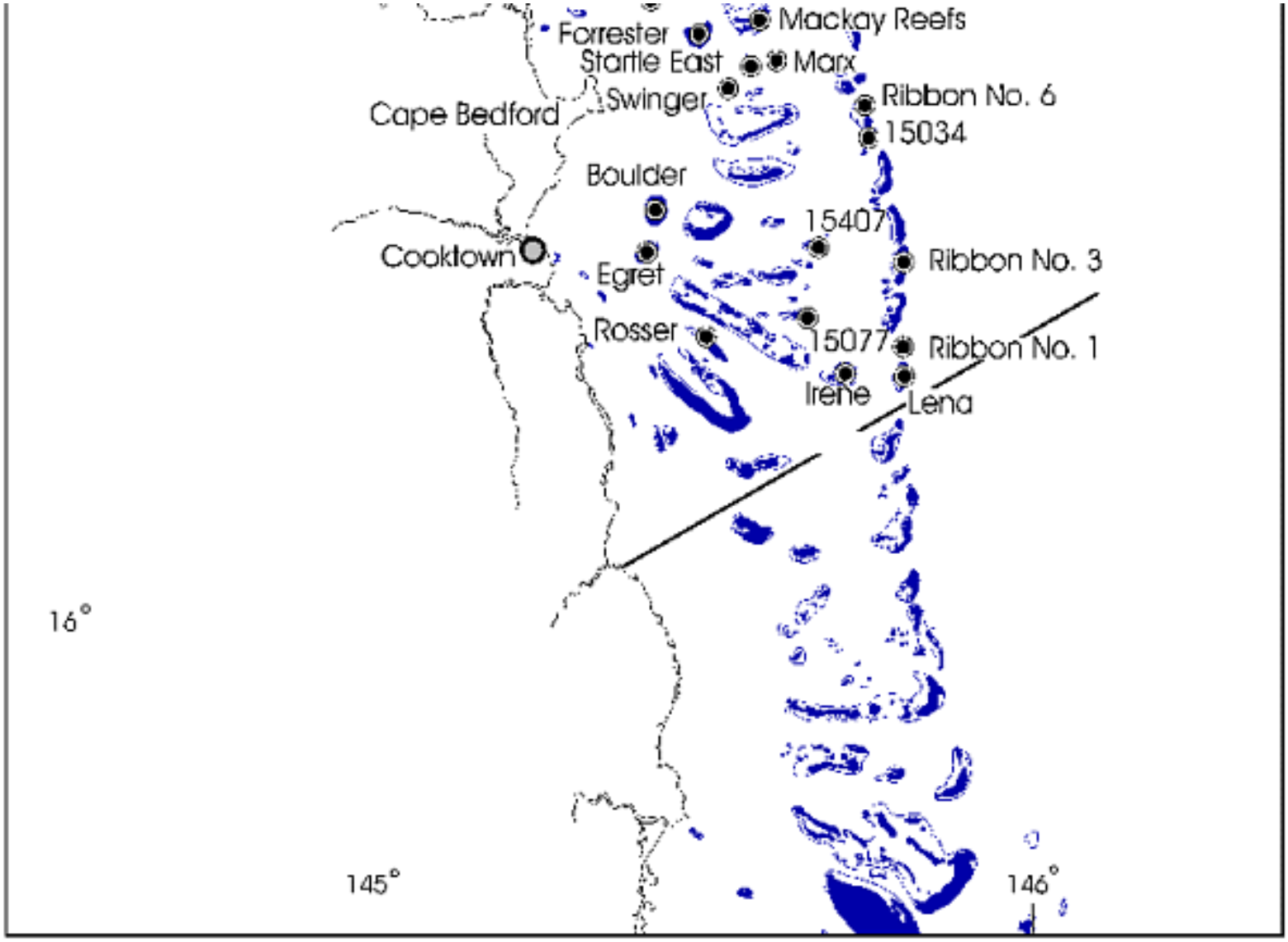


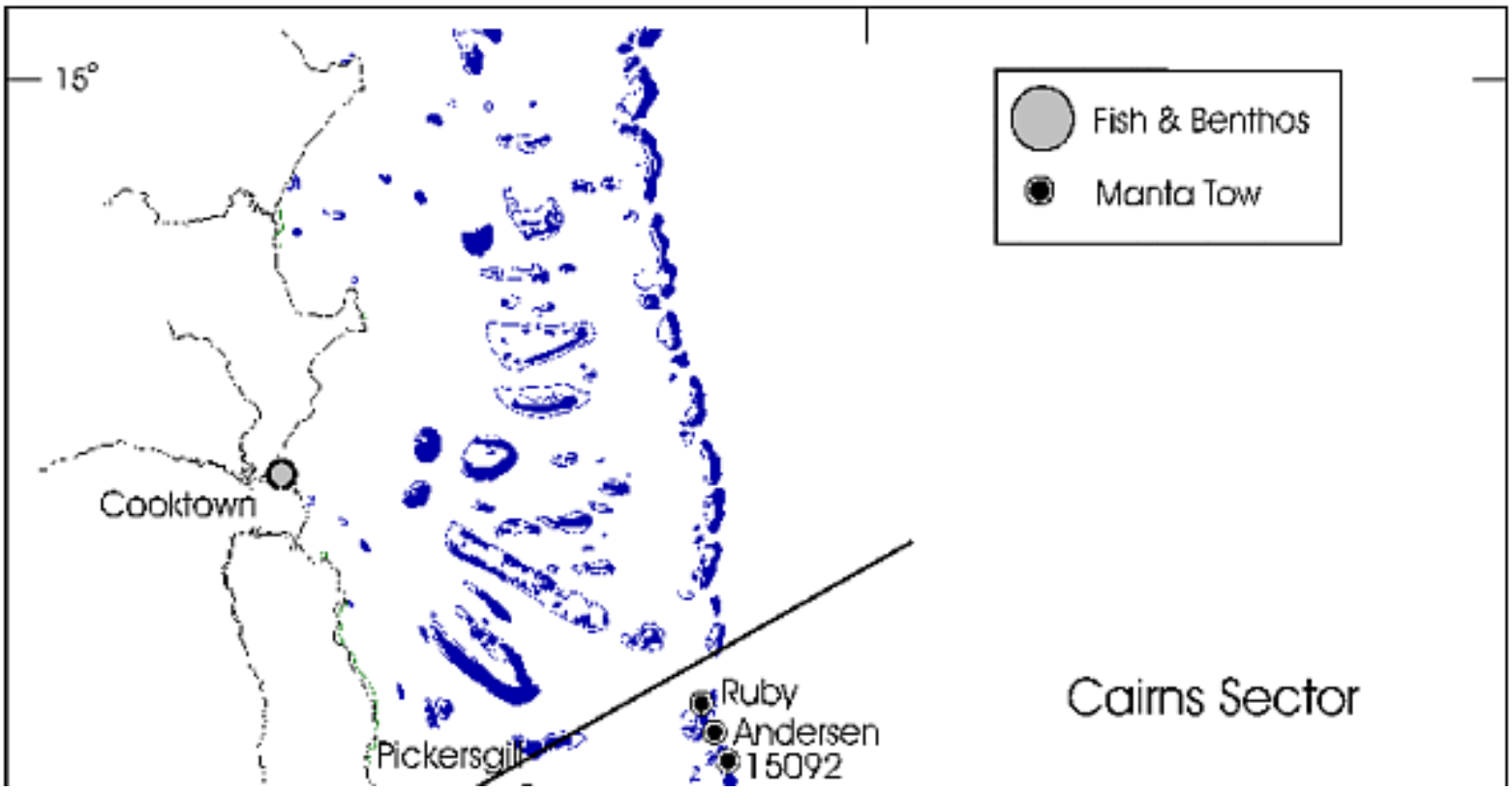

Manta Tow
13°
143°
144°

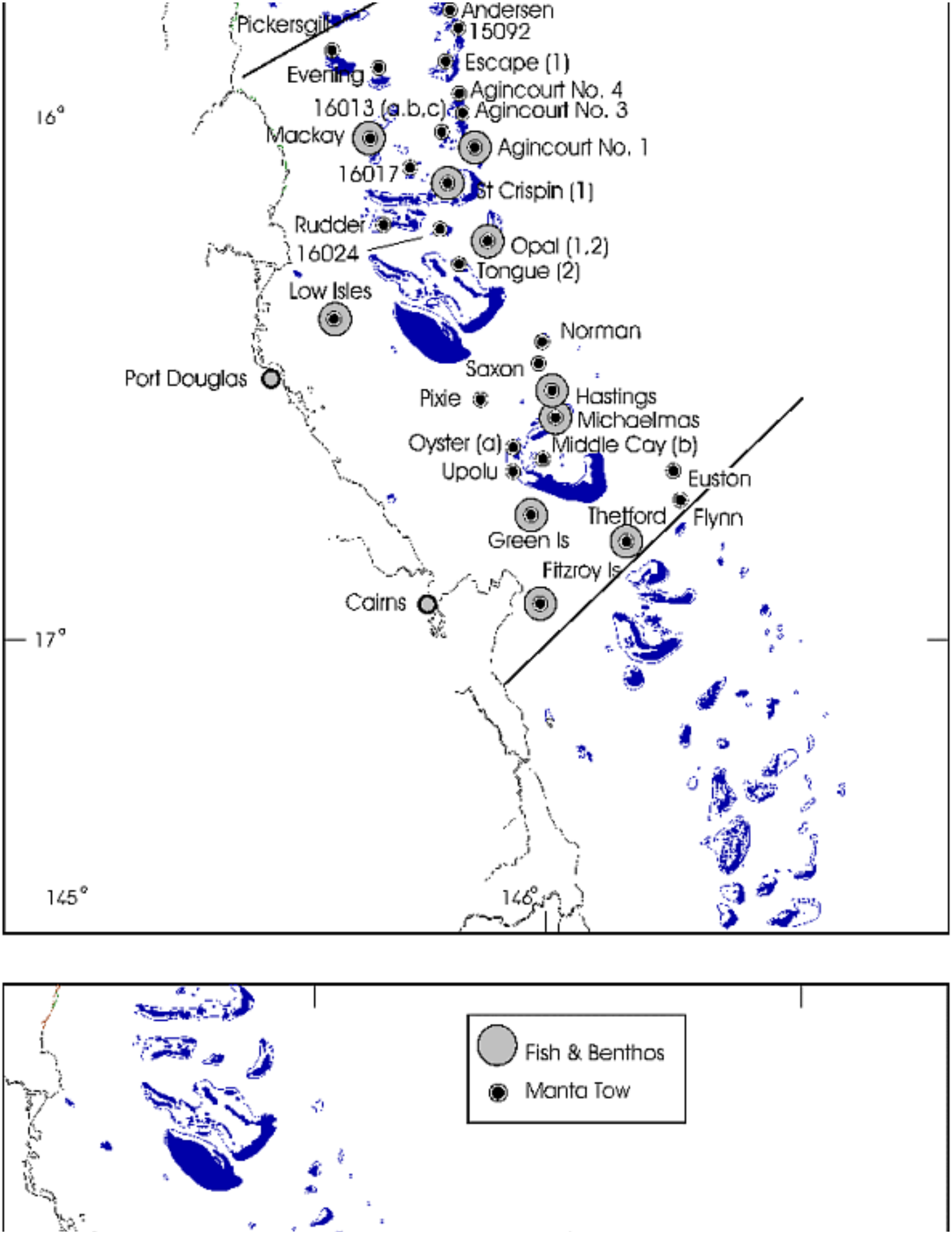

Fish & Benthos
Manta Tow
Cape
Direction
Princess Charlotte Bay Sector
13°
Osborne
Celebration
13040
Sand Bank No. 8
13063
Creech (a)
Fife Is
13121
13124

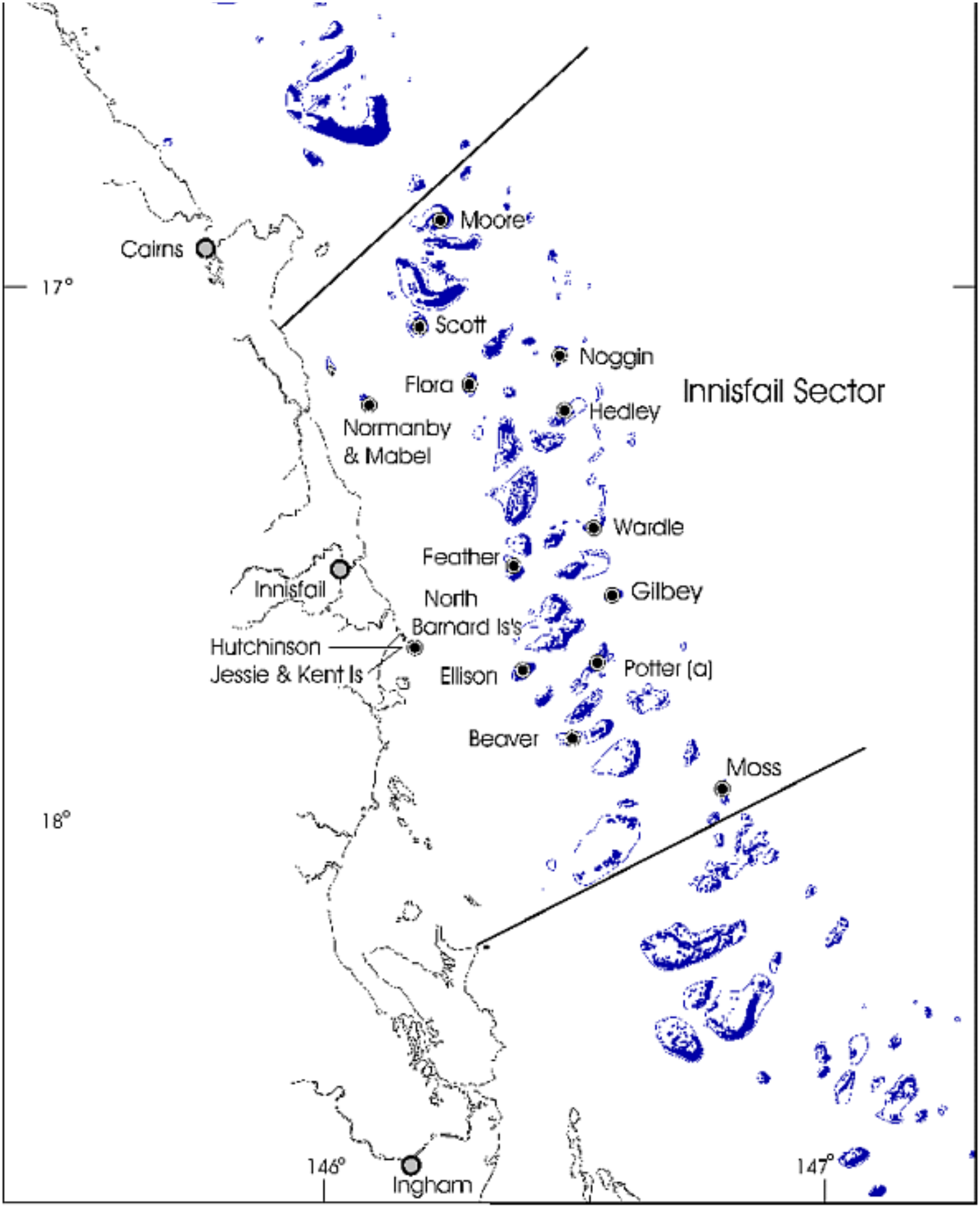

13121
13124
Rodda
Pelican Is
14°
Davie
Tydeman
Clack
Cape
Melville
144°

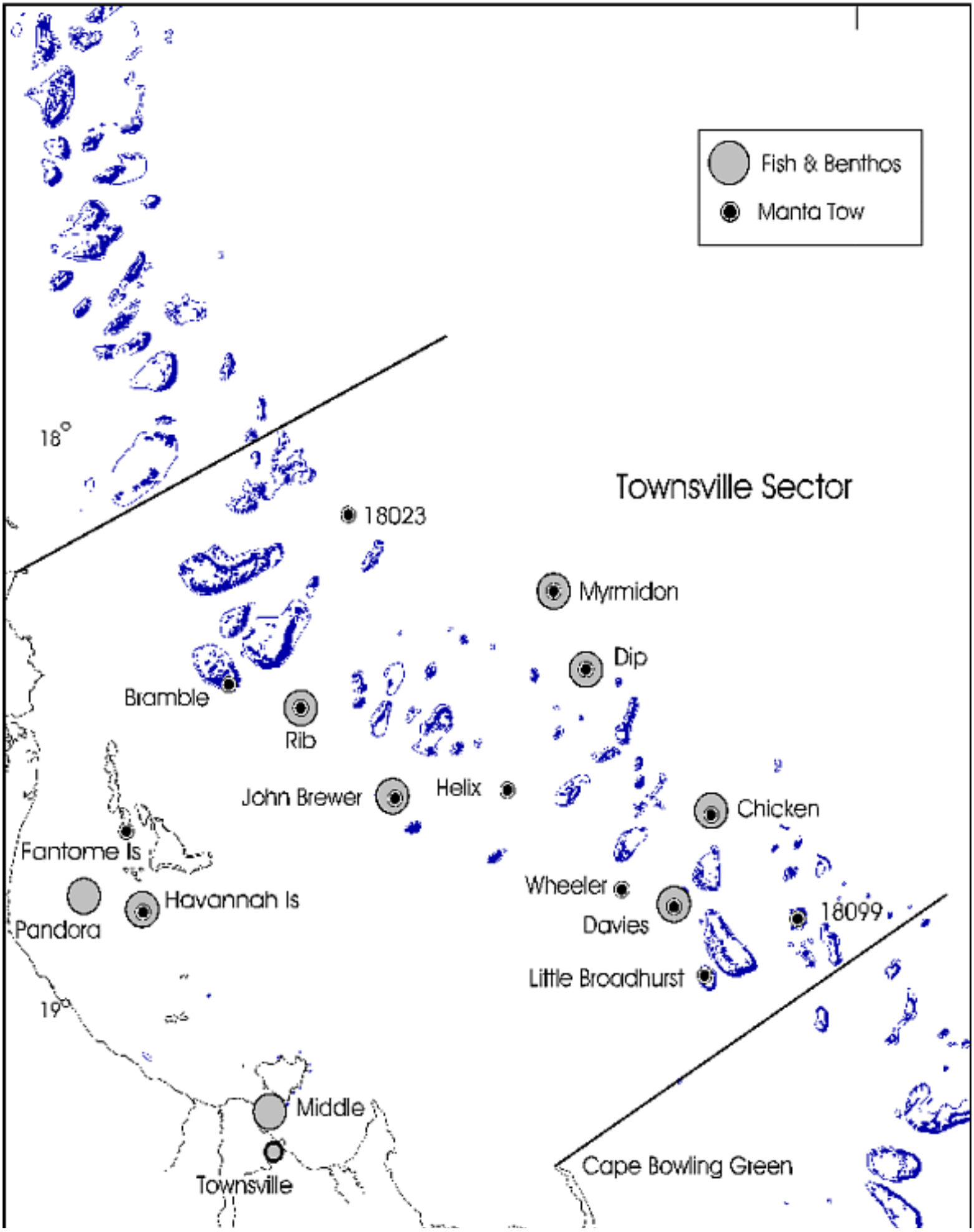

Cooktown / Lizard Island Sector
14°
Sand Bank No. 1
Stapleton
14075
14056
Switzer
Hilder
Ingram &
Beanley
Fly
Houghton Is
Carter
MacGillivray
Yonge
Lizard Is
Nymph
No name
Eyrie
Turtle
Group (b)
North
Direction
Martin
Linnet
Decapolis
14152
Helsdon
Cape Flattery
15°
Two Isles
Ribbon No. 9
Three Isles
Mackay Reefs
Forrester
Fish & Benthos
Manta Tow

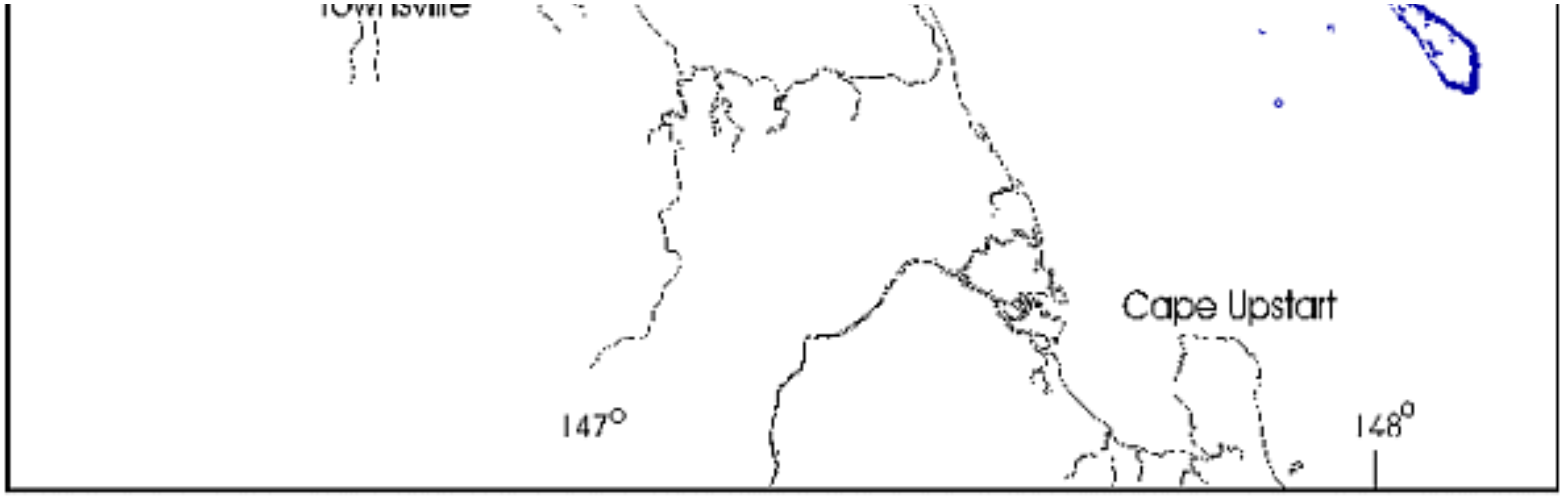

Forrester
Mackay Reefs
Startle East
Marx
Swinger
Ribbon No. 6
Cape Bedford
15034
Boulder
15407
Cooktown
Egret
Ribbon No. 3
Rosser
15077
Ribbon No. 1
Irene
Lena
16°
145°
146°

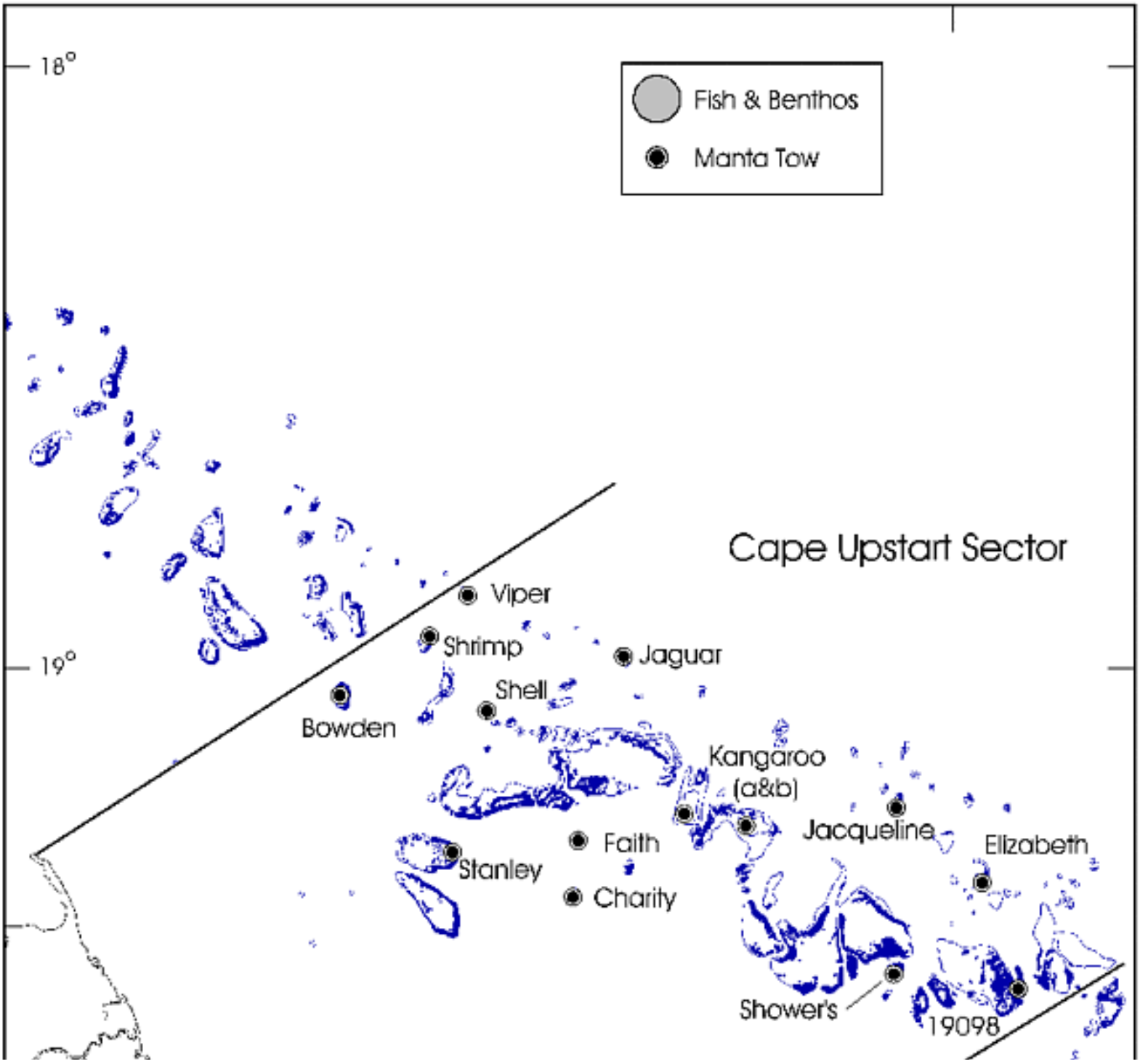

15°
Fish & Benthos
Manta Tow
Cooktown
Ruby
Andersen
15092
Pickersgill
Cairns Sector

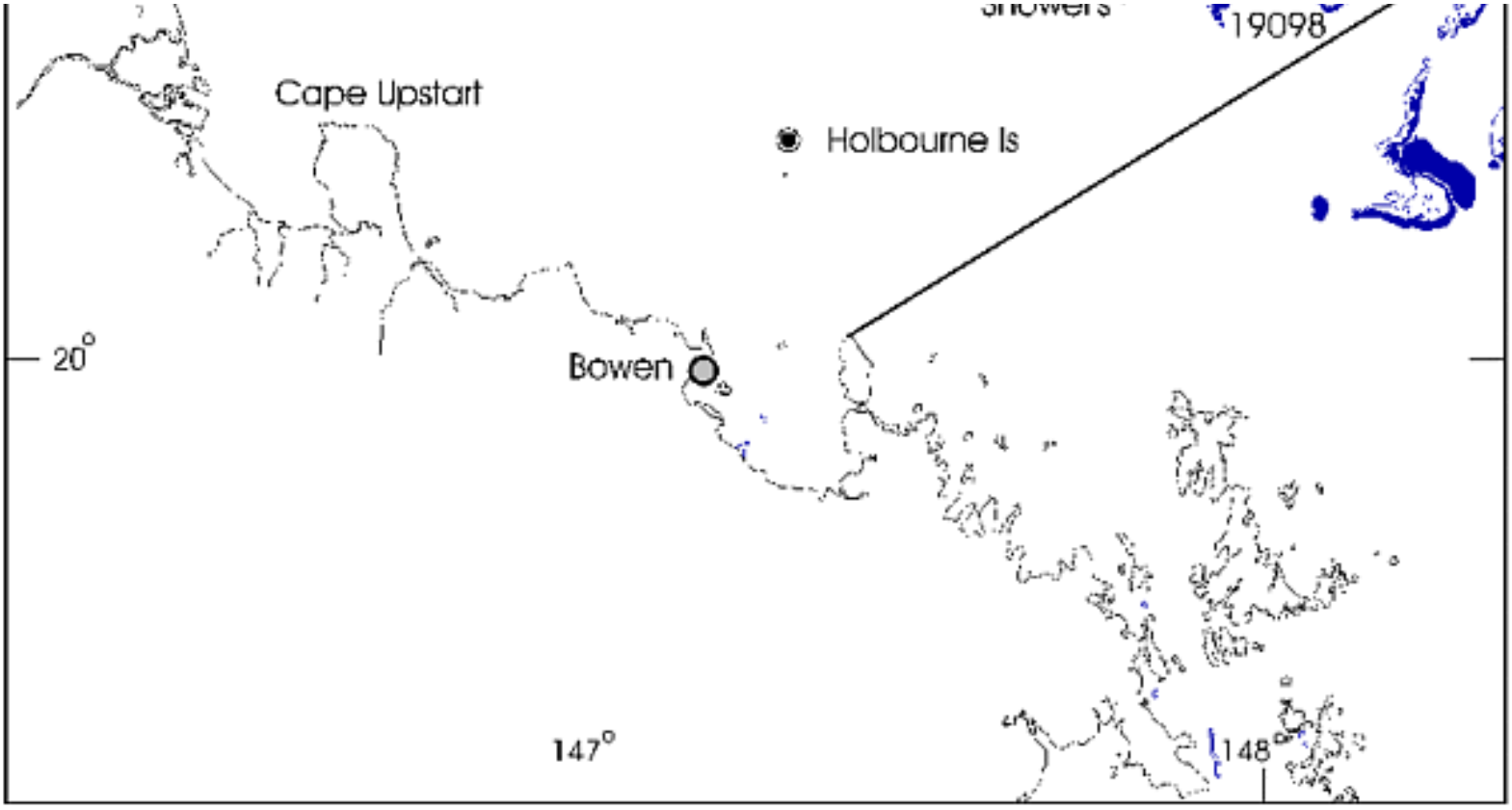

Pickersgill
Andersen
15092
Escape (1)
Evening
Agincourt No. 4
16013 (a,b,c)
Agincourt No. 3
16°
Mackay
Agincourt No. 1
16017
St Crispin (1)
Rudder
Opal (1,2)
16024
Tongue (2)
Low Isles
Norman
Saxon
Port Douglas
Pixie
Hastings
Michaelmas
Oyster (a)
Middle Cay (b)
Upolu
Euston
Thetford
Flynn
Green Is
Fitzroy Is
Cairns
17°
145°
146°
Fish & Benthos
Manta Tow

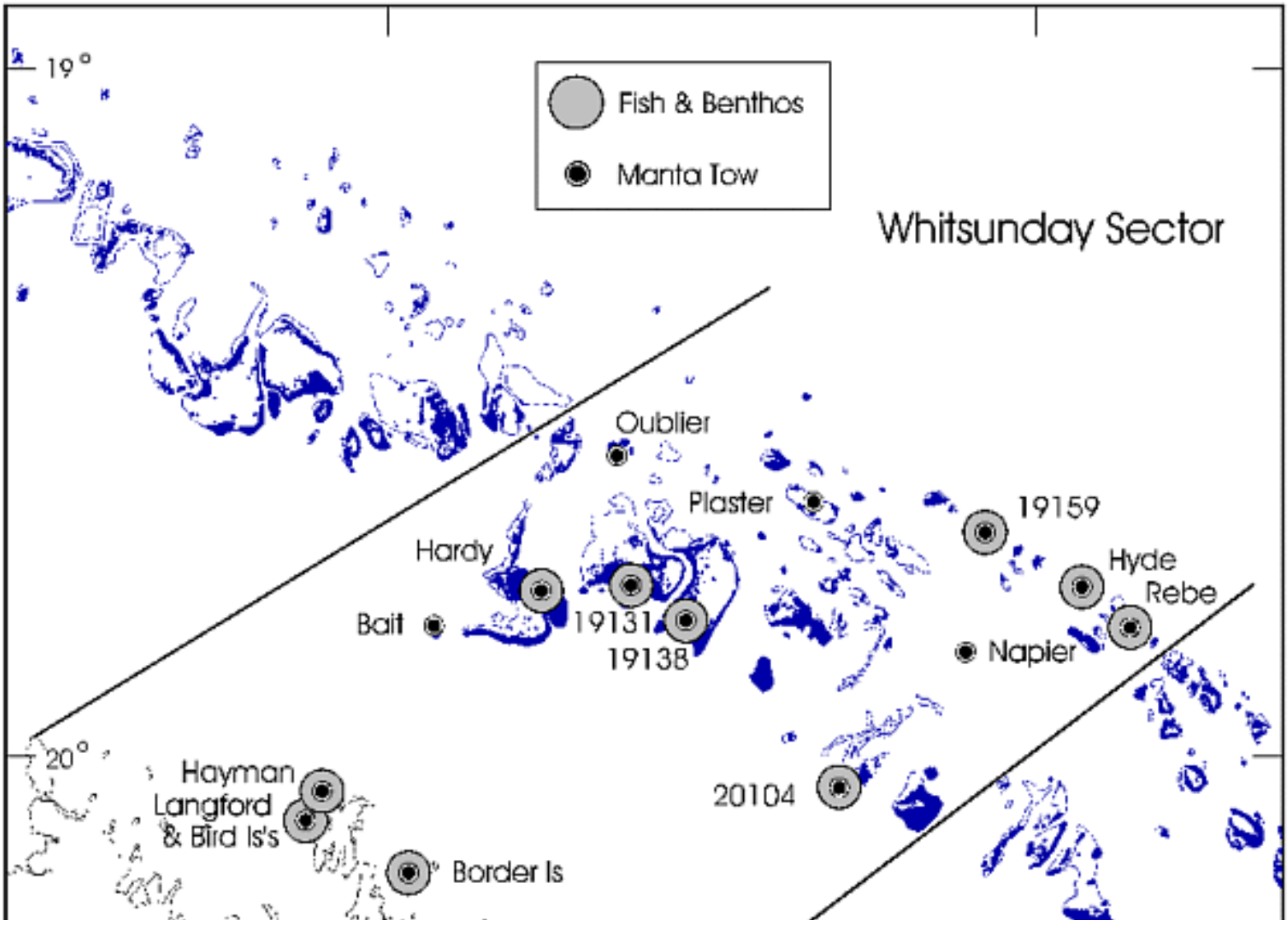

Cairns
17°
Moore
Scott
Noggin
Flora
Hedley
Innisfail Sector
Normanby
& Mabel
Wardle
Feather
Innisfail
North
Barnard Is's
Gilbey
Hutchinson
Jessie & Kent Is
Ellison
Potter (a)
Beaver
Moss
18°
146°
Ingham
147°

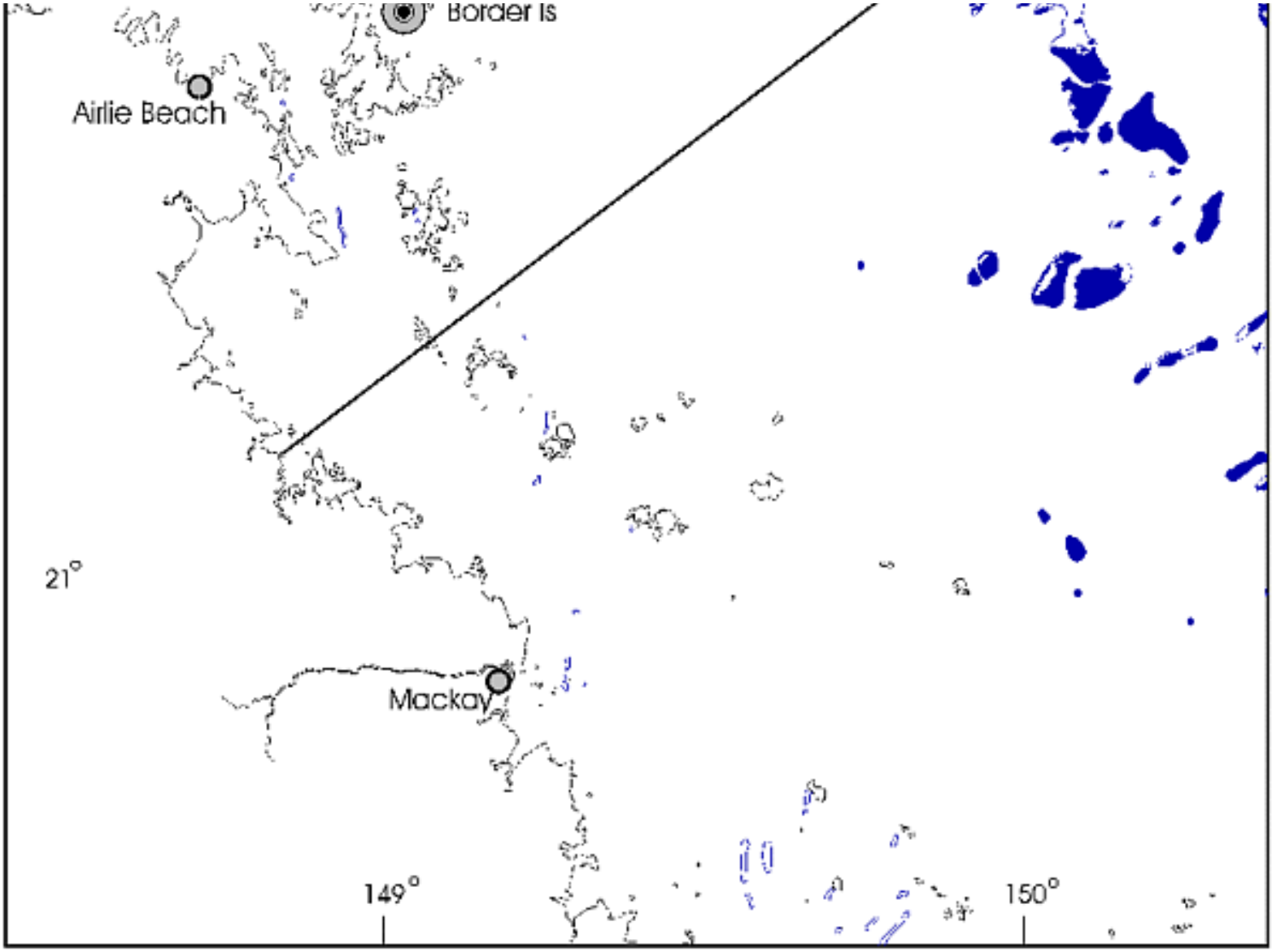

Fish & Benthos
Manta Tow
Townsville Sector
18°
18023
Myrmidon
Dip
Bramble
Rib
John Brewer
Helix
Chicken
Fantome Is
Wheeler
Havannah Is
Pandora
Davies
18099
Little Broadhurst
19°
Middle
Townsville
Cape Bowling Green

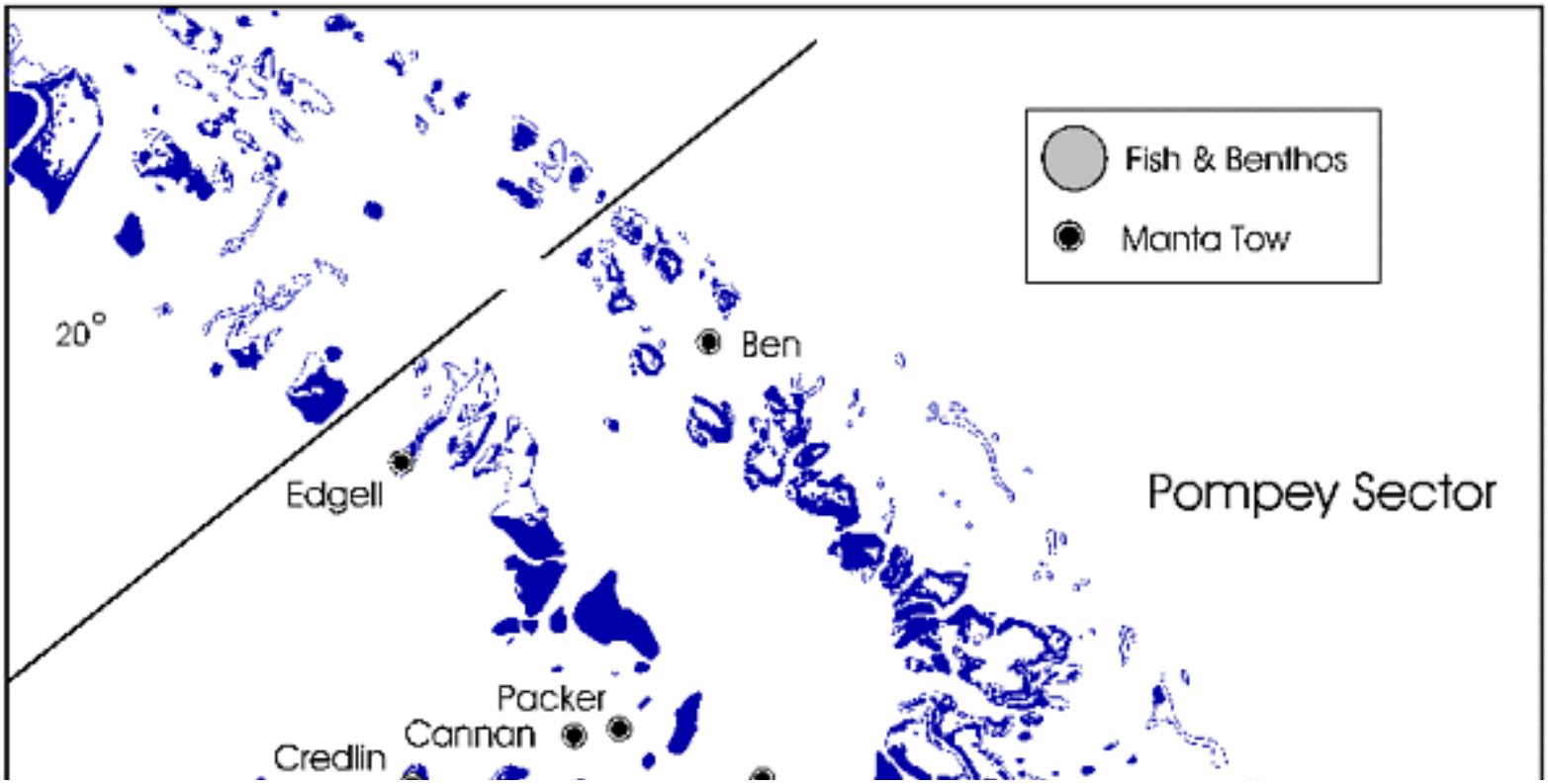

Townsville
Cape Upstart
147°
148°

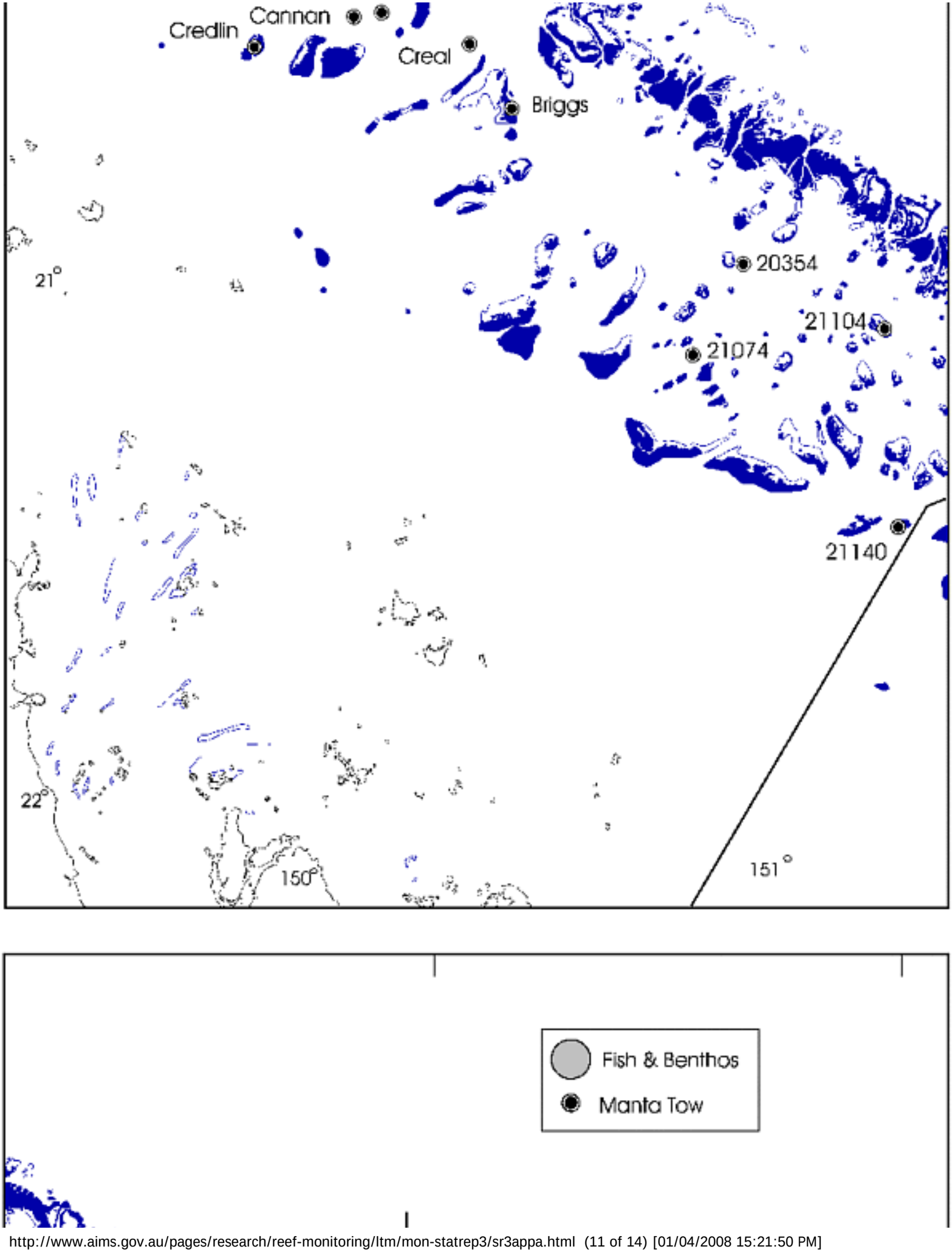

18°
19°
Fish & Benthos
Manta Tow
Cape Upstart Sector
Viper
Shrimp
Jaguar
Shell
Bowden
Kangaroo
(a&b)
Jacqueline
Elizabeth
Faith
Stanley
Charity
Shower's
19098

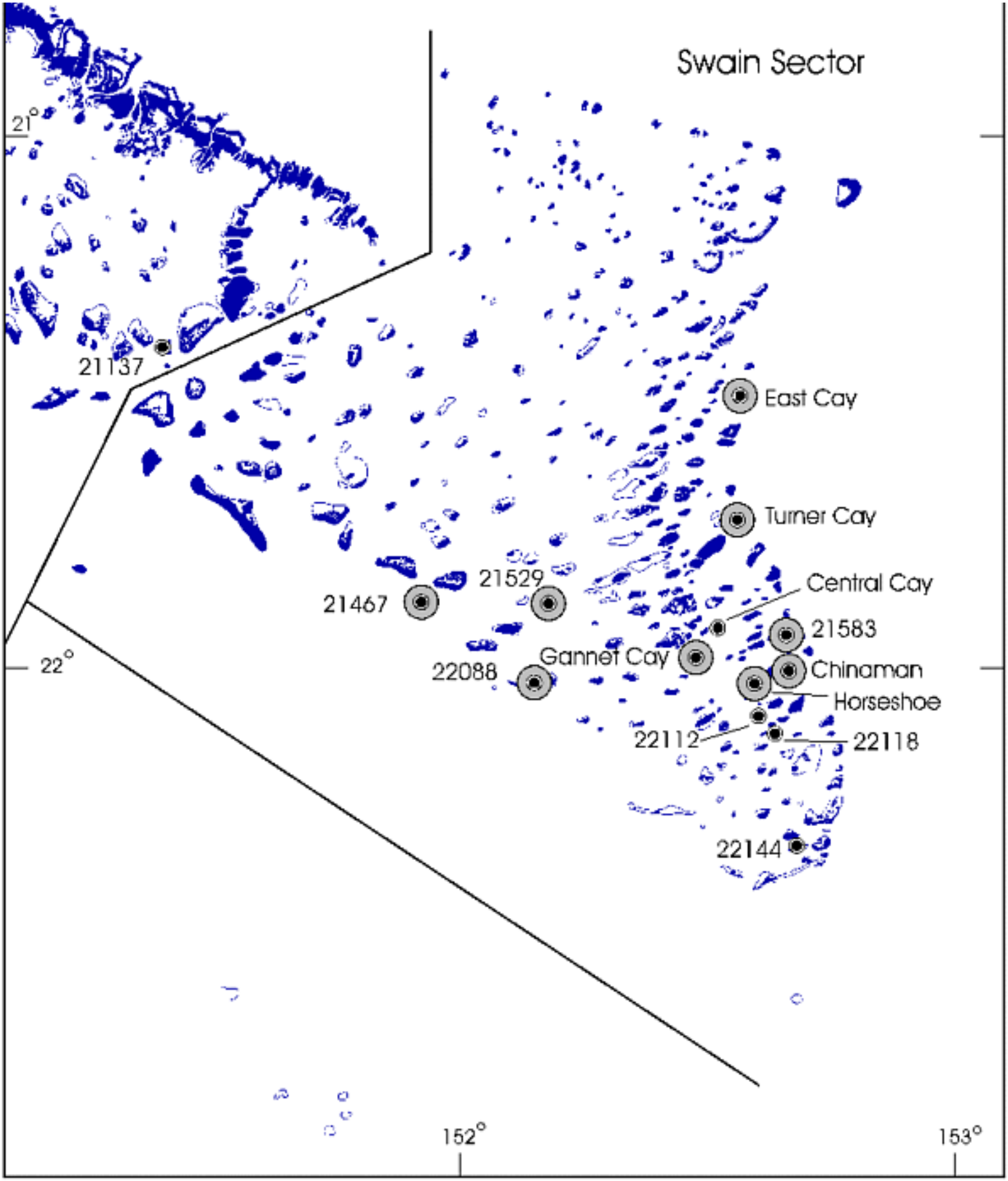

19098
Cape Upstart
Holbourne Is
20°
Bowen
147°
148°

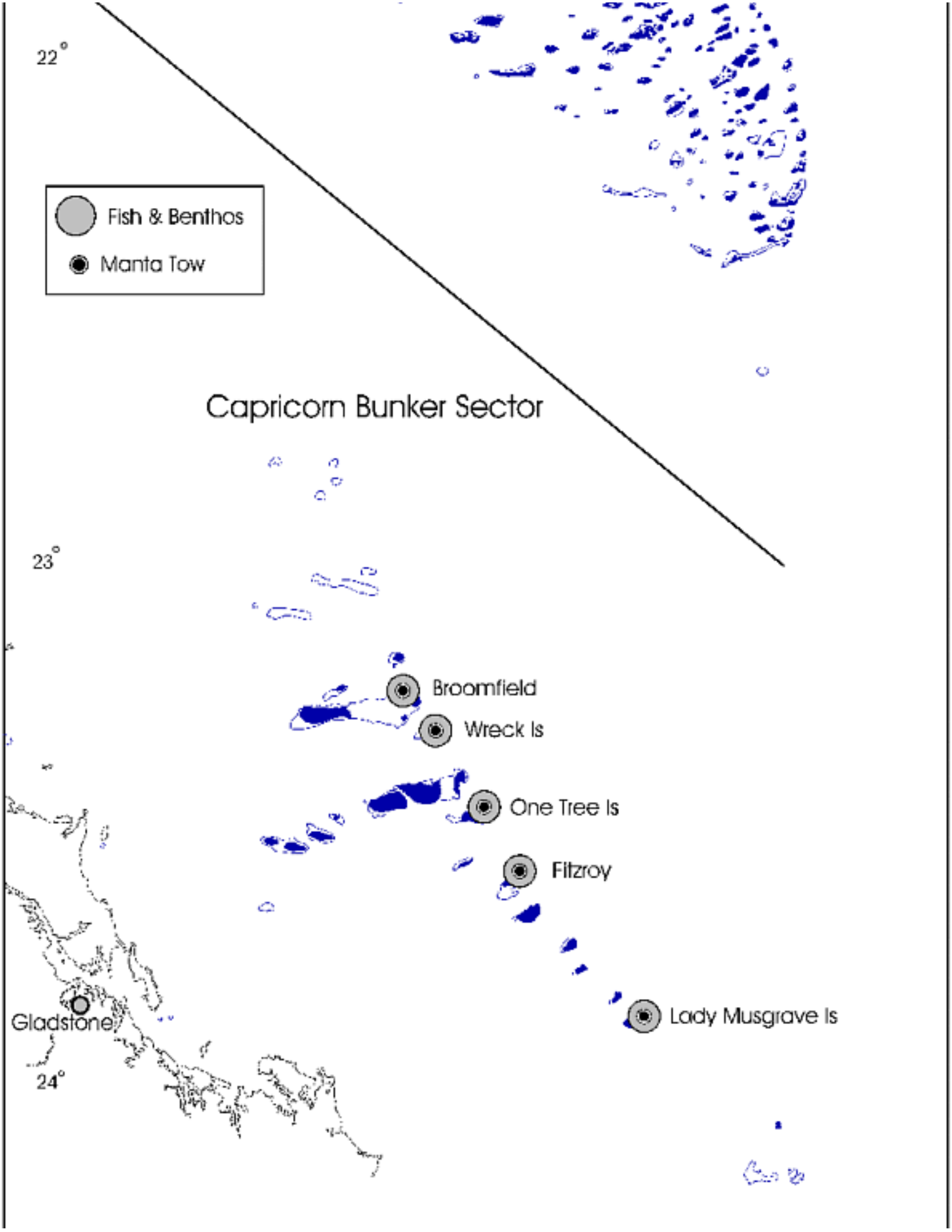

19°
Fish & Benthos
Manta Tow
Whitsunday Sector
Oublier
Plaster
19159
Hardy
Hyde
Rebe
Bait
19131
19138
Napier
20°
Hayman
Langford
& Bird Is's
20104
Border Is

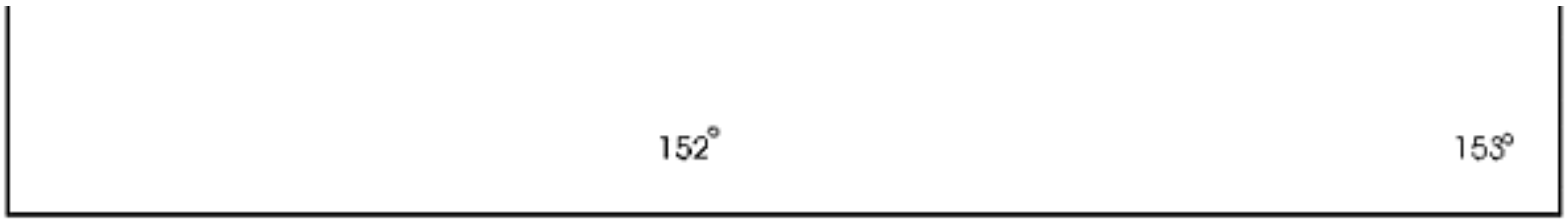

Border Is
Airlie Beach
21°
Mackay
149°
150°


Fish & Benthos
Manta Tow
20°
Ben
Edgell
Pompey Sector
Packer
Cannan
Credlin


Credlin
Cannan
Creal
Briggs
20354
21104
21074
21140
21°
22°
150°
151°
Fish & Benthos
Manta Tow


Swain Sector
21°
21137
East Cay
Turner Cay
21529
21467
Central Cay
21583
Gannet Cay
22088
Chinaman
Horseshoe
22112
22118
22144
22°
152°
153°


22°
Fish & Benthos
Manta Tow
Capricorn Bunker Sector
23°
Broomfield
Wreck Is
One Tree Is
Fitzroy
Lady Musgrave Is
Gladstone
24°


152°
153°

Appendix B

Summary of reefs surveyed in the last 3 years of the LTMP. Reef ID refers to the GBRMPA Gazetteer. Sampling codes: B = benthos, F = reef fishes, f = small fish species only, M = manta tow, W = water samples. Asterisks indicate reefs used to model trends in reef-wide coral cover and COTS.

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Cape Grenville	Inshore	11-167	*	BIRD IS.			M
		12-010	*	KAY	M		M
		12-102	*	CURD	M		
	Mid-Shelf	11-184	*	SIR CHARLES HARDY (1 & 2)	M		
		11-211		FORTY WINKS			M
		11-222		MIDDLE BANKS (2 & 3)			M
		11-237		ASHMORE BANKS (1, 2 & 3)			M
		12-016		FORBES IS.S			
		12-027	*	QUOIN IS.			M
	Outer-Shelf	11-243		RAINE IS.			M
		12-061	*	LAGOON	M		M
		12-071		12071S	M		
		12-098	*	SECOND SMALL			M
		12-107	*	LOG (2)			M
Princess Charlotte Bay	Inshore	13-006	*	OSBORNE	M		
		13-081		FIFE IS.			M
		13-107	*	PELICAN IS.			M
	Mid-Shelf	13-063		13063S	M		
		13-124		13124S	M		M
	Outer-Shelf	13-056		SAND BANK NO. 8	M		
		13-118		CREECH A			M
		13-127	*	RODDA	M		M
		13-130	*	DAVIE			M
		13-133	*	TYDEMAN	M		

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Cooktown/Lizard Island	Inshore	14-094		HOUGHTON IS.	M		
		14-120		TURTLE GROUP B	M		
		14-123		MARTIN (14123)	MBF	MBF	MBF
		14-126	*	LINNET	MBF	MBF	MBF
		14-131		DECAPOLIS	BF	BF	BF
		15-002	*	TWO ISLES	M		
		15-005	*	THREE ISLES		M	
		15-012	*	BOULDER	M	M	M
		15-013	*	EGRET	M		
	Mid-shelf	14-054		STAPLETON ISLET			M
		14-056		14056S	M		M
		14-061	*	SWITZER			M
		14-114	*	MACGILLIVRAY	MBF	MBF	MBF
		14-115		NYMPH IS.	M		
		14-116	*	LIZARD IS. LAGOON	MBF	MBF	MBF
		14-118		EYRIE			M
		14-135	*	HELSDON	M		
		14-143	*	NORTH DIRECTION IS.	MBF	MBF	MBF
		15-009	*	FORRESTER		M	
		15-024		MACKAYS			M
		15-027	*	MARX	M		
		15-028	*	STARTLE (EAST)			M
		15-030	*	SWINGER			M
		15-047	*	15047S	M		
		15-077		15077S			M
		15-081		ROSSER	M		
		15-084		IRENE		M	

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Cooktown/Lizard Island	Outer-Shelf	14-045		SAND BANK NO. 1	M		
		14-075		14075S			M
		14-137	*	CARTER	MBF	BF	MBF
		14-138		YONGE	MBF	MBF	MBF
		14-139	*	NO NAME	MBF	MBF	MBF
		14-154		RIBBON NO.9	M		
		15-034		15034S	M		
		15-050		RIBBON NO.3			M
		15-080	*	RIBBON NO.1			M
		15-085	*	LENA		M	
Cairns	Inshore	16-028	*	LOW ISLES	MBF	MBF	MBF
		16-049	*	GREEN IS.	MBF	MBF	MBF
		16-054	*	FITZROY IS.	MBF	BF	MBF
	Mid-Shelf	15-093	*	PICKERSGILL	M	M	M
		15-095	*	EVENING			M
		16-013		16013C			M
		16-013		16013A			M
		16-013		16013B			M
		16-015	*	MACKAY	MBF		MBF
		16-023		RUDDER	M		
		16-024		CHINAMAN		M	
		16-026		TONGUE (2)	M		
		16-032	*	SAXON	M		
		16-040	*	PIXIE	M		
		16-043		OYSTER	M		
		16-044		MIDDLE CAY B		M	
		16-046		UPOLU CAY			M
		16-057	*	HASTINGS	MBF	MBF	MBF
		16-060	*	MICHAELMAS	MBF	MBF	MBF
		16-068	*	THETFORD	MBF	MBF	MBF

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Cairns	Outer-Shelf	15-088	*	RUBY	M		
		15-090		ANDERSEN		M	
		15-092	*	15092S			M
		15-094	*	ESCAPE (1)		M	
		15-096	*	AGINCOURT NO.4	M		
		15-099	*	AGINCOURT NO.1	MBF	MBF	MBF
		15-099		AGINCOURTS NO.3		M	
		16-019	*	ST. CRISPIN	MBF	MBF	MBF
		16-025	*	OPAL (2)	MBF	MBF	MBF
		16-030	*	NORMAN			M
		16-063		EUSTON			M
		16-065	*	FLYNN			M
Innisfail	Inshore	17-012		NORMANBY IS. A	M		
		17-043		HUTCHISON IS			M
		17-043		JESSIE & KENT IS'S			M
	Mid-Shelf	16-071	*	MOORE		M	
		17-004	*	SCOTT			M
		17-010	*	FLORA	M		
		17-034	*	FEATHER	M	M	M
		17-044	*	ELLISON		M	
		17-051		BEAVER		M	
	Outer-Shelf	17-008	*	NOGGIN			M
		17-014		HEDLEY		M	
		17-032	*	WARDLE	M	M	M
		17-057		GILBEY	M		
		17-059	*	POTTER A			M
		17-068		MOSS	M		
Townsville	Inshore	18-051		PANDORA	BF	BF	BF
		18-053		FANTOME IS.	M	M	M
		18-065		HAVANNAH IS.	M	MBF	MBF
		19-011		MIDDLE	Bf	B	Bf

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Townsville	Mid-Shelf	18-029		BRAMBLE		M	
		18-032	*	RIB	MBF	MBF	MBF
		18-075	*	JOHN BREWER	MBF	MBF	MBF
		18-076	*	HELIX	M		
		18-095	*	WHEELER			M
		18-096	*	DAVIES	MBF	MBF	MBF
		18-099		18099S			M
		18-106	*	LITTLE BROADHURST	M		
	Outer-Shelf	18-023		18023S		M	
		18-034	*	MYRMIDON	MBF	MBF	MBF
		18-039	*	DIP	MBF	MBF	MBF
		18-086	*	CHICKEN	MBF	MBF	MBF
Cape Upstart	Inshore	19-103		HOLBOURNE IS.			M
	Mid-Shelf	18-118	*	SHRIMP		M	
		19-019	*	BOWDEN	M	M	M
		19-028	*	SHELL		M	
		19-044	*	FAITH	M	M	M
		19-045		STANLEY	M		
		19-047	*	CHARITY		M	
		19-063		KANGAROO (A & B)	M		
		19-076		SHOWERS		M	
		19-082	*	ELIZABETH			M
		19-098		19098S			M
	Outer-Shelf	18-112	*	VIPER	M		
		18-120	*	JAGUAR	M		
		19-061	*	JACQUELINE			M

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Whitsunday	Inshore	20-014		HAYMAN IS.	MBF	MBF	MBf
		20-019		LANGFORD AND BIRD IS.	MBF	MBf	BF
		20-067		BORDER IS. A	MBF	MBF	MBF
	Mid-Shelf	19-120	*	OUBLIER		M	
		19-131	*	19131S	MBF	MBF	MBF
		19-135	*	HARDY	MBF	MB	M
		19-137	*	BAIT	M		
		19-138		19138S	MBF	MBF	MBF
		19-147	*	PLASTER		M	
		19-195	*	NAPIER	M		
		20-104	*	20104S	MBF	MB	MBF
	Outer-Shelf	19-159	*	19159S	MBF	MBF	MBF
		19-207	*	HYDE	MBF	MBF	MBF
		19-209	*	REBE	MBF	MBF	MBF
Pompey	Mid-Shelf	20-145	*	PACKER		M	
		20-287	*	CREDLIN	M		M
		20-297	*	CREAL		M	
		20-299		SOUTHAMPTON (BRIGGS)			M
		20-354		20354S	M		
		21-074		21074S			M
		21-104		21104S	M		
		21-137		21137S			M
		21-140		21140S			M
	Outer-Shelf	20-113		BEN	M		M

Sector	Shelf position	Reef ID		Reef name	Year surveyed		
					96	97	98
Swain	Inshore	21-467		21467S	MBF		
		22-088		22088S	MBF	MBF	MBF
	Mid-Shelf	21-529		21529S	MBF	MBF	MBF
		21-556	*	GANNET CAY	MBF	MBF	MBF
		21-577		CENTRAL	M		
		22-102	*	CHINAMAN	MBF	MBF	MBF
		22-104	*	HORSESHOE	MBF	MBF	MBF
		22-112	*	22112S	M		
		22-118	*	22118S	M		
		22-144	*	22144S	M		
	Outer-Shelf	21-305		EAST CAY	MBF	MBF	MBF
		21-562		TURNER CAY	MBF	MBF	MBF
		21-583		21583S	MBF		
Capricorn/Bunker	Outer-Shelf	23-048	*	BROOMFIELD	MBF	MBF	MBF
		23-051		WRECK IS.	MBF	MBF	MBF
		23-055	*	ONE TREE IS.	MBF	MBF	MBF
		23-077	*	FITZROY	MBF	M	
		23-082	*	LADY MUSGRAVE IS.	MBF	MBF	MBF

Appendix C

C1. List of large, mobile fish species that would be counted on 5 m wide transects

Acanthuridae

Acanthurus albipectoralis
Acanthurus blochii
Acanthurus dussumieri
Acanthurus grammoptilus
Acanthurus lineatus
Acanthurus maculiceps
Acanthurus mata
Acanthurus nigricans
Acanthurus nigricauda
Acanthurus nigrofuscus
Acanthurus nigroris
Acanthurus olivaceus
Acanthurus pyropherus
Acanthurus spp.
Acanthurus triostegus
Acanthurus xanthopterus
Ctenochaetus (grouped)
Naso lituratus
Naso tuberosus
Naso unicornus
Paracanthurus hepatus
Zebrasoma scopas
Zebrasoma veliferum

Chaetodontidae

Chaetodon aureofasciatus
Chaetodon auriga
Chaetodon baronessa
Chaetodon bennetti
Chaetodon citrinellus
Chaetodon ephippium
Chaetodon flavirostris
Chaetodon kleinii
Chaetodon lineolatus
Chaetodon lunula
Chaetodon melannotus
Chaetodon meyerii
Chaetodon ocellicaudus
Chaetodon ornatissimus
Chaetodon pelewensis
Chaetodon plebeius
Chaetodon punctatofasciatus
Chaetodon rafflesi
Chaetodon rainfordi
Chaetodon reticulatus
Chaetodon speculum

Chaetodontidae (cont)

Chaetodon trifascialis
Chaetodon trifasciatus
Chaetodon ulietensis
Chaetodon unimaculatus
Chaetodon vagabundus
Chelmon rostratus
Forcipiger flavissimus
Forcipiger longirostrus
Hemitaurichthys polylepis

Labridae

Cheilinus fasciatus
Cheilinus undulatus
Choerodon fasciatus
Coris gaimardi
Epibulus insidiator
Gomphosus varius
Halichoeres hortulanus
Hemigymnus fasciatus
Hemigymnus melapterus

Lethrinidae

Lethrinus atkinsoni
Lethrinus harak
Lethrinus laticaudus
Lethrinus lentjan
Lethrinus miniatus
Lethrinus nebulosus
Lethrinus obsoletus
Lethrinus olivaceus
Lethrinus ornatus
Lethrinus xanthochilus
Monotaxis grandoculis

Lutjanidae

Lutjanus adetti
Lutjanus argentimaculatus
Lutjanus bohar
Lutjanus carponotatus
Lutjanus fulviflamma
Lutjanus fulvus
Lutjanus gibbus
Lutjanus kasmira
Lutjanus lutjanus
Lutjanus monostigma
Lutjanus quinquelineatus
Lutjanus russelli

Lutjanidae (cont)

Lutjanus vittus
Macolor (grouped)

Scaridae

Bolbometapon muricatum
Cetoscarus bicolor
Hipposcarus longiceps
Calotomus carolinus
Scarus altipinnis
Scarus bleekeri
Scarus chameleon
Scarus dimidiatus
Scarus flavipectoralis
Scarus forsteni
Scarus frenatus
Scarus ghobban
Scarus globiceps
Scarus microrhinos
Scarus niger
Scarus oviceps
Scarus psittacus
Scarus rivulatus
Scarus rubroviolaceus
Scarus schlegeli
Scarus sordidus
Scarus spinus
Scarus spp.

Serranidae

Plectropomus areolatus
Plectropomus laevis
Plectropomus leopardus
Plectropomus maculatus
Variola louti

Siganidae

Siganus argenteus
Siganus corallinus
Siganus doliatus
Siganus javus
Siganus lineatus
Siganus puellus
Siganus punctatissimus
Siganus punctatus
Siganus vulpinus

Zanclidae

Zanclus cornutus

C2 List of damselfish species that would be counted on 1 m wide transects

Acanthochromis polyacanthus
Amblyglyphidodon curacao
Amblyglyphidodon leucogaster
Amphiprion akindynos
Amphiprion chrysopterus
Amphiprion clarkii
Amphiprion melanopus
Amphiprion perideraion
Chromis acares
Chromis agilis
Chromis amboinensis
Chromis atripectoralis
Chromis atripes
Chromis chrysura
Chromis flavomaculata
Chromis iomelas
Chromis lepidolepis
Chromis margaritifer
Chromis nitida
Chromis retrofasciatus
Chromis ternatensis
Chromis vanderbilti
Chromis viridis
Chromis weberi
Chromis xanthura
Chrysiptera flavipinnis
Chrysiptera rex
Chrysiptera rollandi
Chrysiptera talboti
Dascyllus aruanus
Dascyllus reticulatus
Dascyllus trimaculatus
Dischistodus melanotus
Dischistodus perspicillatus
Dischistodus prosopotaenia
Dischistodus pseudochrysopoecilus
Hemiglyphidodon plagiometopon
Neoglyphidodon melas
Neoglyphidodon nigroris
Neoglyphidodon polyacanthus
Neopomacentrus azysron
Neopomacentrus bankieri
Neopomacentrus cyanomos
Plectroglyphidodon dickii
Plectroglyphidodon johnstonianus
Plectroglyphidodon lacrymatus
Pomacentrus amboinensis
Pomacentrus australis
Pomacentrus bankanensis
Pomacentrus brachialis
Pomacentrus chrysurus
Pomacentrus coelestis
Pomacentrus grammnorhyncus
Pomacentrus lepidogenys
Pomacentrus moluccensis
Pomacentrus nagasakiensis
Pomacentrus philippinus
Pomacentrus taeniometapon
Pomacentrus vaiuli
Pomacentrus wardi
Pomachromis richardsoni
Premnas biaculeatus
Stegastes apicalis
Stegastes fasciolatus
Stegastes nigricans

Appendix D

General status of crown-of-thorns starfish on the Great Barrier Reef, 1996-1998.

D1. Status of crown-of-thorns starfish (COTS) in each sector in 1996. AO = Active outbreak, IO = Incipient outbreak, RE = Recovering, NO = No outbreak.

Sector	No. of reefs	No. COTS/ tow	No. COTS	Number (%) of reefs with COTS		Median (range) coral cover		Mean coral cover ± SE	% AO or IO reefs	% RE reefs	% NO reefs
Cape Grenville	7	0.35	84	5	(71)	3+	(2- to 4-)	42.6±4.09	28.6	0.0	71.4
Princess Charlotte Bay	6	0.046	12	3	(50)	2+/3-	(2- to 3+)	27.7±3.78	0.0	33.3	66.7
Cooktown/Lizard Is	22	0.33	334	12	(55)	2+	(1+ to 3-)	24.6±1.55	31.8	22.7	45.5
Cairns	18	0.02	19	6	(33)	2-	(1- to 3-)	18.1±1.92	0.0	38.9	61.1
Innisfail	6	0.004	1	1	(17)	2+	(2- to 3-)	24.5±2.26	0.0	66.7	33.3
Townsville	10	0	0	0	(0)	2-/2+	(1+ to 3+)	24.4±3.36	0.0	60.0	40.0
Cape Upstart	7	0	0	0	(0)	2-	(1+ to 2+)	17.8±2.96	0.0	57.1	42.9
Whitsunday	12	0.004	2	2	(17)	2+	(1+ to 3+)	27.0±3.03	0.0	16.7	83.3
Pompey	4	0	0	0	(0)	3+	(2- to 3+)	39.7±6.19	0.0	0.0	100.0
Swains	13	0.17	87	5	(38)	2-/3-	(2- to 4+)	34.8±3.85	15.4	23.1	61.5
Capricorn Bunkers	5	0.01	3	2	(40)	2+	(2- to 2+)	26.8±2.51	0.0	0.0	100.0

D2. Status of crown-of-thorns starfish (COTS) in each sector in 1997. AO = Active outbreak, IO = Incipient outbreak, RE = Recovering, NO = No outbreak.

Sector	No. of reefs	No. COTS/ tow	No. COTS	Number (%) of reefs with COTS		Median (range) coral cover		Mean coral cover ± SE	% AO or IO reefs	% RE reefs	% NO reefs
Cooktown/Lizard Island	12	0.45	262	8	(67)	2-	(1+ to 3-)	22.7±2.16	41.7	25.0	33.3
Cairns	14	0.04	32	6	(43)	2-/2+	(1- to 3+)	22.1±2.25	7.1	35.7	57.1
Innisfail	6	0.05	16	2	(33)	2-/2+	(2- to 3-)	22.5±2.63	16.7	83.3	0.0
Townsville	10	0.01	6	3	(30)	2-	(1+ to 3+)	25.0±3.93	0.0	50.0	50.0
Cape Upstart	6	0.01	3	3	(50)	2-/2+	(1+ to 2+)	17.2±2.24	0.0	83.3	16.7
Whitsunday	12	0.002	1	1	(8.)	2-	(1+ to 2+)	18.9±1.86	0.0	16.7	83.3
Pompey	2	0	0	0	(0)	3-/3+	(3- to 3+)	46.2±6.86	0.0	0.0	100.0
Swains	7	0.54	201	4	(57)	2-	(1+ to 3+)	25.9±3.65	28.6	14.3	57.1
Capricorn Bunkers	5	0.01	4	1	(20)	2+	(2- to 3-)	31.4±1.11	0.0	0.0	100.0

D3. Status of crown-of-thorns starfish (COTS) in each sector in 1998. AO = Active outbreak, IO = Incipient outbreak, RE = Recovering, NO = No outbreak.

Sector	No. of reefs	No. COTS/ tow	No. COTS	Number (%) of reefs with COTS		Median (range) coral cover		Mean coral cover ± SE	% AO or IO reefs	% RE reefs	% NO reefs
Cape Grenville	13	0.003	1	1	(68)	3-/3+	(1+ to 4+)	39.7±4.27	0.0	7.7	92.3
Princess Charlotte Bay	6	0.02	5	1	(17)	2+	(2- to 3-)	28.4±3.84	0.0	16.7	83.3
Cooktown/Lizard Island	20	0.40	397	13	(65)	2-	(1- to 2+)	16.8±1.66	40.0	20.0	40.0
Cairns	20	0.08	66	10	(50)	2+	(1- to 3+)	22.0±2.11	15.0	25.0	60.0
Innisfail	7	0.24	81	5	(71)	2-	(1+ to 2+)	20.7±1.75	28.6	14.3	57.1
Townsville	10	0.01	6	2	(20)	2+	(2- to 3+)	27.4±3.15	0.0	60.0	40.0
Cape Upstart	6	0.01	3	2	(33)	2-	(1- to 2+)	19.5±3.29	0.0	33.3	66.7
Whitsunday	9	0	0	0	(0)	2-	(1+ to 3-)	21.2±2.6	0.0	22.2	77.8
Pompey	6	0.03	5	2	(33)	3-/3+	(3- to 4-)	43.2±3.51	0.0	0.0	100.0
Swains	7	1.36	521	3	(43)	2+	(2- to 3-)	28.0±2.88	42.9	14.3	42.9
Capricorn Bunkers	4	0	0	0	(0)	2+	(2- to /3-)	34.5±1.72	0.0	0.0	100.0

Appendix E

Percentage cover of selected groups of benthic organisms (see Table 2.4) recorded from regions in each survey year 1996-98.

E1. Mean percentage cover of benthic groups recorded in each region in the 1996 surveys CG = Cape Grenville, PC = Princess Charlotte Bay, CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsundays, SW = Swains, CB = Capricorn / Bunkers. I= Inshore, M = Mid-shelf, O = Outer shelf

Sector	Shelf	Algae	Hard Coral	Soft Coral	Acroporidae	Faviidae	Pocilloporidae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Montipora*
CG	I	73.8	11.6	1.3	3.0	1.3	1.3	0.5	0.2	1.4	1.2
CG	O	18.2	36.8	21.8	30.3	0.8	4.1	0.9	6.7	18.9	4.4
PC	M	44.3	13.1	18.3	3.7	0.6	1.4	7.1	0.2	3.0	0.4
PC	O	26.7	42.5	12.3	30.9	2.8	4.6	2.6	8.0	17.1	4.2
CL	I	47.1	28.0	4.8	8.4	3.6	4.4	3.4	1.6	3.9	1.9
CL	M	50.5	18.1	8.9	1.7	3.6	1.6	5.9	0.1	1.0	0.1
CL	O	25.3	34.5	5.7	19.6	1.5	7.8	0.8	5.3	13.1	0.9
CA	I	43.2	30.5	11.8	11.1	2.2	1.7	4.6	1.5	5.3	4.0
CA	M	44.2	25.4	14.0	10.0	4.0	4.3	1.6	2.7	5.9	1.0
CA	O	25.6	24.8	32.9	13.6	2.2	3.7	2.5	2.9	9.9	0.4
TO	M	35.1	46.8	5.1	30.4	3.3	5.1	2.0	19.5	9.7	0.7
TO	O	30.7	33.5	17.2	11.5	7.8	4.7	2.6	3.2	6.6	1.2
WH	I	29.4	29.8	19.3	8.6	3.7	0.7	7.3	0.6	3.5	4.0
WH	M	45.7	43.5	1.7	19.9	7.1	3.9	2.2	5.6	6.3	7.2
WH	O	21.8	26.1	31.9	8.9	3.6	2.9	4.7	2.0	5.5	0.8
SW	M	43.3	39.1	9.4	21.9	3.0	4.0	4.1	3.0	13.2	5.1
SW	O	30.6	23.7	35.8	6.8	3.3	3.1	4.8	1.5	4.4	0.4
CB	O	46.8	25.1	3.2	18.8	2.2	0.9	0.9	8.2	7.0	1.6

E2. Mean percentage cover of benthic groups recorded in each region in 1997 surveys. CG = Cape Grenville, PC = Princess Charlotte Bay, CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsundays, SW = Swains, CB = Capricorn / Bunkers. I= Inshore, M = Mid-shelf, O = Outer shelf

Sector	Shelf	Algae	Hard Coral	Soft Coral	Acroporidae	Faviidae	Pocilloporidae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Montipora*
CL	I	49.4	28.6	3.5	8.4	3.5	4.6	3.2	1.8	4.1	2.3
CL	M	58.1	14.1	8.1	0.6	3.1	0.8	5.8	0.0	0.4	0.0
CL	O	16.9	43.7	6.1	27.2	2.2	8.4	0.8	11.1	13.9	1.8
CA	I	45.2	26.0	10.6	9.5	1.6	1.4	3.5	1.1	4.4	3.6
CA	M	37.3	26.1	17.3	12.2	3.7	4.5	1.1	3.2	7.8	0.7
CA	O	21.0	24.1	34.0	12.4	1.6	4.1	2.1	2.4	9.5	0.3
TO	M	40.6	37.8	3.8	21.8	3.0	4.9	2.6	12.4	8.4	0.7
TO	O	34.0	31.1	15.7	10.5	6.5	4.3	3.2	2.5	5.8	1.5
WH	I	24.5	27.2	20.2	7.5	3.6	0.7	6.6	0.5	2.5	3.6
WH	M	66.3	23.7	1.1	7.1	6.3	1.9	1.5	0.3	1.7	4.8
WH	O	18.4	26.3	28.7	9.7	4.0	2.9	4.6	1.9	6.0	1.2
SW	M	34.6	40.7	10.5	23.8	2.9	3.5	3.9	4.1	13.4	5.8
SW	O	27.0	25.2	36.2	8.2	3.5	3.4	5.1	2.1	5.2	0.5
CB	O	35.3	35.7	4.5	28.2	2.7	0.8	0.6	16.7	7.7	1.6

E3. Mean percentage cover of benthic groups recorded in each region in 1998 surveys. CG = Cape Grenville, PC = Princess Charlotte Bay, CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsundays, SW = Swains, CB = Capricorn / Bunkers. I= Inshore, M = Mid-shelf, O = Outer shelf

Sector	Shelf	Algae	Hard Coral	Soft Coral	Acroporidae	Faviidae	Pocilloporidae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Montipora*
CL	I	49.2	29.7	3.4	8.7	3.7	4.7	3.4	2.0	3.8	2.5
CL	M	54.9	15.4	7.8	1.0	3.3	1.1	5.7	0.0	0.6	0.2
CL	O	10.3	52.4	6.5	35.3	1.4	9.8	0.7	19.5	13.9	1.2
CA	I	51.8	23.4	9.5	5.3	2.3	0.5	4.9	0.4	2.4	2.3
CA	M	38.8	27.8	14.3	11.2	3.9	4.0	1.9	4.2	5.7	0.9
CA	O	19.2	25.7	33.8	14.6	1.5	4.6	2.0	2.9	10.6	0.7
TO	M	46.1	37.0	2.4	22.1	3.6	3.6	2.5	11.1	9.4	1.4
TO	O	28.6	34.1	13.4	12.9	6.4	4.6	2.6	4.4	6.7	1.2
WH	I	31.3	27.9	19.2	6.0	4.1	0.5	7.4	0.2	1.6	3.5
WH	M	61.3	24.5	1.0	7.6	6.2	1.9	2.3	0.4	1.9	5.0
WH	O	17.8	27.1	31.4	10.5	3.3	2.7	4.8	2.8	6.3	0.9
SW	M	43.4	35.8	10.2	17.2	3.4	3.2	4.5	3.2	9.4	3.9
SW	O	22.2	25.8	36.6	8.4	3.7	3.1	5.0	2.7	5.1	0.3
CB	O	20.8	50.1	4.0	43.6	2.2	0.9	0.4	31.9	8.3	0.9

Appendix F

Summary counts of the different fish taxa recorded from each region 1996-98. Figures are regional means for the sums of individuals on 15 transects (3 sites) on each survey reef.

F1. Numbers of larger mobile fishes recorded in the regions in the 1996 survey

Sector	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	I	95	80	36	8	56	86	10	77	1
CL	M	120	120	51	23	43	93	15	36	1
CL	O	451	139	44	22	80	212	4	7	16
CA	I	58	71	54	2	109	110	4	37	0
CA	M	233	81	40	7	35	193	4	17	6
CA	O	376	114	30	14	20	210	2	10	6
TO	M	128	107	50	4	6	221	7	29	2
TO	O	337	66	34	6	15	166	8	11	4
WH	I	4	68	49	1	45	99	9	20	0
WH	M	25	123	55	11	25	208	19	36	0
WH	O	295	82	33	7	5	122	13	10	3
SW	M	122	82	54	14	9	213	39	53	4
SW	O	118	70	43	3	1	167	9	12	6
CB	O	98	63	17	8	1	93	5	0	1

F2. Number of larger mobile fishes recorded in the regions in the 1997 survey

Sector	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	I	74	88	43	17	49	66	8	129	0
CL	M	145	109	58	28	37	112	10	51	3
CL	O	382	163	44	19	76	175	1	3	17
CA	I	47	59	28	5	54	83	2	20	0
CA	M	236	61	26	3	9	223	4	9	4
CA	O	331	83	24	10	9	133	1	7	3
TO	M	117	121	45	13	6	191	9	51	1
TO	O	300	68	26	4	2	165	14	14	7
WH	I	3	74	28	0	19	42	12	18	0
WH	M	24	105	62	7	11	188	7	87	0
WH	O	277	83	43	7	11	161	4	15	5
SW	M	103	72	30	10	12	174	43	68	6
SW	O	141	58	36	4	3	99	10	8	10
CB	O	86	118	12	11	3	84	4	1	1

F3. Number of larger mobile fishes recorded in the regions in the 1998 survey

Sector	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	I	84	85	31	12	46	78	5	82	0
CL	M	110	67	45	29	26	117	8	42	1
CL	O	345	164	39	14	77	164	4	9	16
CA	I	65	80	39	2	109	132	6	55	0
CA	M	186	85	35	6	34	160	3	13	3
CA	O	241	83	37	12	22	180	0	8	2
TO	M	99	87	38	4	4	213	3	31	1
TO	O	334	69	21	3	2	152	10	11	5
WH	I	4	64	27	3	28	53	7	23	0
WH	M	56	76	61	9	20	212	11	44	1
WH	O	188	89	31	5	5	104	8	32	6
SW	M	104	71	59	7	10	215	25	87	6
SW	O	211	73	48	2	0	102	8	9	9
CB	O	140	217	33	6	16	107	8	2	4

F4. Numbers of damselfishes recorded in the regions in the 1996 surveys

Sector	Shelf	*Acantho-chromis*	*Amblygly phidodon*	*Amphip-rion*	*Chromis*	*Chrysip-tera*	*Dascyllus*	*Dischist-odus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Premnas*	*Stegastes*
CA	I	17	40	0	22	68	9	2	40	89	0	1	892	0	1
CA	M	18	36	3	48	28	8	7	15	220	0	70	698	0	17
CA	O	18	9	0	199	21	0	0	1	1	0	67	170	0	1
CB	O	2	0	0	7	16	0	0	0	13	0	1	1821	0	0
CL	I	81	49	1	32	62	2	0	11	482	0	1	1138	0	0
CL	M	55	73	1	63	177	31	6	12	214	0	24	938	1	0
CL	O	56	1	1	396	18	0	0	0	0	2	41	230	0	2
SW	M	5	134	4	874	52	0	0	6	158	0	10	1729	0	1
SW	O	18	66	5	45	16	0	1	21	61	0	23	903	0	9
TO	M	28	60	6	313	117	1	6	62	1136	0	19	1951	0	6
TO	O	26	3	2	168	35	8	1	0	598	2	125	659	0	35
WH	I	86	68	0	75	138	0	1	5	275	0	0	1410	0	0
WH	M	9	19	0	374	101	0	0	3	1356	0	0	2205	0	14
WH	O	14	34	3	66	121	2	0	24	70	0	50	772	0	2

F5. Numbers of damselfishes recorded in the regions in the 1997 surveys

Sector	Shelf	*Acantho-chromis*	*Amblygly phidodon*	*Amphip-rion*	*Chromis*	*Chrysip-tera*	*Dascyllus*	*Dischist-odus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Premnas*	*Stegastes*
CA	I	18	36	0	16	51	1	1	37	34	0	1	534	1	0
CA	M	13	4	1	95	11	7	0	2	213	0	108	621	0	14
CA	O	11	6	0	77	15	4	0	2	2	0	68	199	0	0
CB	O	2	0	1	59	12	0	0	0	33	1	5	1201	0	0
CL	I	60	69	0	17	42	4	1	15	404	0	0	1205	0	0
CL	M	56	82	3	82	148	23	8	10	66	0	20	777	1	0
CL	O	79	1	0	601	18	1	0	0	0	0	59	264	0	2
SW	M	8	152	3	1330	41	0	1	6	53	0	9	1672	0	2
SW	O	20	73	3	22	13	0	0	15	27	0	18	772	0	10
TO	M	37	78	5	344	93	1	6	68	284	0	19	1478	0	6
TO	O	26	1	4	252	27	12	0	0	267	0	140	554	0	30
WH	I	57	54	0	30	53	0	0	5	151	0	0	804	0	0
WH	M	2	20	0	10	4	0	0	1	1545	0	0	1202	0	11
WH	O	18	37	2	69	34	4	1	20	28	0	36	546	0	2

F6. Number of damselfishes recorded in the regions in the 1998 surveys

Sector	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphip-rion*	*Chromis*	*Chrysip-tera*	*Dascyllus*	*Dischist-odus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Premnas*	*Stegastes*
CA	I	19	44	0	13	109	0	2	43	97	0	2	594	1	1
CA	M	15	27	2	82	40	5	4	16	144	0	85	745	0	21
CA	O	24	10	1	129	27	5	0	3	9	0	73	295	0	0
CB	O	3	0	0	108	8	1	0	1	16	0	8	646	0	0
CL	I	71	83	0	120	30	5	1	13	418	0	0	1371	0	0
CL	M	59	78	1	118	133	22	5	8	136	0	21	805	1	0
CL	O	73	2	1	540	21	1	0	0	3	0	78	329	0	2
SW	M	7	96	5	1002	22	0	0	10	56	0	8	1088	0	3
SW	O	11	90	5	73	12	0	0	18	21	0	21	672	0	13
TO	M	43	74	7	197	65	2	4	65	353	0	26	1210	0	7
TO	O	22	2	3	311	22	6	0	0	178	0	133	413	0	23
WH	I	72	57	0	16	108	0	0	7	163	0	0	769	0	0
WH	M	5	12	1	25	59	0	0	1	442	0	0	872	0	12
WH	O	10	41	1	55	26	6	0	21	8	0	46	414	0	1

Appendix G

Percentage cover of benthic groups recorded on reefs in each survey year

G1. Percentage cover of benthic groups recorded on reefs in 1996 surveys. Mean values from all sites on each reef.

Sector	Reef	Reef ID	Shelf	Algae	Hard coral	Soft coral	Acro-poridae	Favii-dae	Pocillo-poridae	Pori-tidae	*Acropora* Tabulate	*Acropora* Other	*Monti-pora*
CG	Kay	12-010	I	73.8	11.6	1.8	8.0	1.8	1.8	0.5	0.2	1.4	1.2
CG	Lagoon	12-061	O	18.2	36.8	21.8	30.8	0.8	4.1	0.9	6.7	18.9	4.4
FC	131248	13-124	M	44.8	18.1	18.8	8.7	0.6	1.4	7.1	0.2	8.0	0.4
FC	Rodda	13-127	O	26.7	42.5	12.8	30.9	2.8	4.6	2.6	8.0	17.1	4.2
CL	Decapolis	14-131	I	57.9	17.9	1.8	7.8	0.9	0.9	1.8	0.9	1.8	8.8
CL	Linnet	14-126	I	45.9	42.5	5.4	11.6	8.4	6.8	5.6	2.6	6.8	1.9
CL	Martin	14-128	I	87.5	28.6	7.2	5.7	1.6	5.6	8.8	1.4	8.0	0.6
CL	Lizard Is	14-116	M	54.2	11.7	19.8	0.6	8.0	1.6	8.1	0.0	0.8	0.1
CL	Macgillivray	14-114	M	41.8	28.9	5.5	1.4	4.7	1.4	11.0	0.0	0.7	0.0
CL	N. Direction	14-148	M	55.9	18.7	2.0	8.0	8.1	1.7	8.6	0.2	2.0	0.2
CL	Carter	14-137	O	28.4	84.2	2.6	18.6	1.4	8.0	0.4	5.1	12.5	0.8
CL	No Name	14-139	O	20.1	41.5	12.0	24.8	1.5	8.7	1.2	8.5	14.8	1.0
CL	Yonge	14-138	O	82.2	27.9	2.6	16.0	1.7	6.6	0.6	2.2	12.5	1.0
CA	Fitzroy Is	16-054	I	80.6	87.0	20.4	18.8	2.0	8.9	5.6	1.8	6.7	5.2
CA	Green Is	16-049	I	68.1	14.8	8.6	8.2	1.7	0.0	2.0	1.5	5.4	0.7
CA	Low Isles	16-026	I	85.9	40.2	11.4	11.9	8.0	1.1	6.2	1.6	8.8	6.0
CA	Hastings	16-057	M	50.7	26.5	6.4	12.9	4.2	4.6	0.8	8.0	8.8	1.8
CA	Mackay	16-015	M	55.5	81.5	4.2	6.7	5.0	5.1	8.7	2.0	8.8	0.9
CA	Michaelmas	16-060	M	28.8	21.2	80.9	10.4	2.8	8.8	0.2	8.9	5.6	0.8
CA	Thetford	16-068	M	42.0	22.4	14.8	9.8	8.9	4.0	1.8	1.9	6.8	0.8
CA	Agincourt No.1	15-099	O	26.8	27.4	28.5	16.0	1.9	5.8	1.4	8.8	12.2	0.5
CA	Opal (2)	16-025	O	22.0	22.1	40.4	18.8	1.4	2.8	1.5	1.6	11.1	0.8
CA	St Crispin	16-019	O	28.7	25.0	84.7	11.0	8.4	8.1	4.5	8.8	6.5	0.4
TO	Middle	19-011	I	16.8	84.4	17.4	8.0	1.6	0.0	9.6	1.5	0.4	0.7
TO	Pandora	18-051	I	17.7	58.8	14.5	6.2	8.8	0.2	18.9	0.1	5.4	0.2
TO	Davies	18-096	M	42.1	40.9	8.7	10.4	7.8	7.5	5.8	4.0	5.6	0.7
TO	John Brewer	18-075	M	46.1	80.8	6.0	20.9	1.4	4.0	0.1	12.6	7.5	0.8
TO	Rib	18-082	M	17.2	68.6	5.6	59.8	1.8	8.9	0.8	42.1	16.1	1.2

G1 continued. Percentage cover of benthic groups recorded on reefs in 1996 surveys. Mean values from all sites on each reef.

Sector	Reef	Reef ID	Shelf	Algae	Hard coral	Soft coral	Acro-poridae	Faviidae	Pocillo-poridae	Poritidae	*Acropora* Tabulate	*Acropora* Other	*Montipora*
TO	Chicken	18-086	O	32.1	38.4	14.2	14.8	8.1	6.5	2.6	5.4	8.7	0.6
TO	Dip	18-089	O	35.7	27.4	11.7	12.8	3.8	3.9	1.5	2.1	8.4	1.0
TO	Myrmidon	18-084	O	24.4	34.6	25.6	7.0	11.6	3.7	3.8	2.0	2.6	1.8
WH	Border Is A	20-067	I	27.0	27.2	28.9	2.0	2.7	0.6	13.4	0.1	0.4	0.6
WH	Hayman Is	20-014	I	29.0	48.6	13.5	20.0	5.8	1.3	1.9	1.3	7.5	10.9
WH	Langford & Bird Is	20-019	I	32.2	18.5	15.5	3.6	2.7	0.3	6.6	0.3	2.5	0.5
WH	191318	19-131	M	28.4	62.1	0.8	28.8	13.9	4.6	2.2	5.8	6.7	15.8
WH	191388	19-138	M	48.6	42.5	1.9	23.0	4.6	4.6	2.0	8.8	9.6	3.2
WH	201048	20-104	M	60.2	25.8	2.4	7.9	2.9	2.6	2.4	2.3	2.6	2.5
WH	191598	19-159	O	20.5	40.2	18.7	19.2	5.0	4.6	1.6	4.6	11.6	1.8
WH	Hyde	19-207	O	17.7	18.0	44.8	4.2	3.0	1.8	4.4	0.7	2.6	0.2
WH	Rebe	19-209	O	27.4	20.0	32.2	3.4	2.7	2.3	7.9	0.7	2.2	0.3
SW	220888	22-088	I	53.0	20.4	6.4	2.8	1.6	2.3	8.6	0.1	0.8	1.7
SW	215298	21-529	M	54.5	34.1	1.2	17.2	1.9	4.7	5.5	0.7	11.7	4.3
SW	Chinaman	22-102	M	35.7	26.5	27.1	5.6	4.0	3.3	6.2	0.8	3.1	1.2
SW	Gannet Cay	21-556	M	45.9	45.5	4.5	33.7	1.2	2.7	1.6	0.3	27.0	5.4
SW	Horseshoe	22-104	M	37.2	50.5	5.0	31.0	4.8	5.1	3.1	10.1	11.1	9.5
SW	East Cay	21-805	O	32.6	18.6	39.9	3.7	2.2	3.1	4.2	0.5	2.4	0.4
SW	Turner Cay	21-562	O	28.7	28.9	31.7	9.9	4.4	3.1	5.5	2.4	6.4	0.4
CE	Broomfield	23-048	O	51.6	25.1	2.9	19.0	2.1	0.6	1.0	4.5	7.7	3.0
CE	Lady Musgrave Is	23-082	O	64.7	15.6	0.2	12.1	0.7	0.3	0.7	6.2	4.8	0.1
CE	One Tree Is	23-055	O	37.1	16.5	0.5	10.6	2.1	0.6	1.3	4.6	4.6	0.8
CE	Wreck Is	23-051	O	33.6	43.2	9.2	33.6	4.0	2.1	0.6	17.6	10.9	2.5

G2. Percentage cover of benthic groups recorded on reefs in 1997 survey. Mean values from all sites on each reef.

Sector	Reef	Reef ID	Shelf	Algae	Hard coral	Soft coral	Acro-poridae	Faviidae	Pocillo-poridae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Montipora*
CL	Deeagolis	14-131	I	59.3	21.5	1.4	8.7	0.6	1.2	1.8	2.2	2.4	3.8
CL	Linnet	14-126	I	48.4	39.5	4.6	9.6	7.9	6.6	5.6	1.5	5.7	2.3
CL	Martin	14-123	I	40.5	24.8	4.3	6.8	2.1	6.1	2.4	1.5	4.2	0.9
CL	Lizard Is	14-116	M	58.7	11.3	17.6	0.2	3.7	1.4	2.9	0.0	0.1	0.1
CL	Macgillivray	14-114	M	51.8	17.4	4.7	0.7	3.5	0.1	10.2	0.0	0.4	0.0
CL	N. Direction Is	14-148	M	68.7	13.8	1.9	1.0	2.0	0.8	4.3	0.0	0.8	0.0
CL	Carter	14-137	O	15.9	50.5	2.6	33.9	1.7	8.1	0.1	14.5	15.9	2.7
CL	No Name	14-139	O	12.7	46.0	10.8	30.0	1.7	8.2	1.5	13.5	14.3	1.7
CL	Yonge	14-138	O	22.2	34.5	4.8	17.9	3.2	8.9	0.7	5.4	11.5	0.8
CA	Fitzroy Is	16-054	I	25.7	37.0	19.5	13.7	2.0	2.6	4.6	0.6	6.6	4.3
CA	Green Is	16-049	I	71.8	5.8	2.0	2.3	0.7	0.0	1.6	0.4	1.7	0.1
CA	Low Isles	16-028	I	38.1	35.1	10.2	12.4	2.2	1.4	4.3	2.1	2.9	6.5
CA	Hastings	16-057	M	45.1	27.7	8.0	12.5	4.0	5.5	1.3	2.9	6.5	0.7
CA	Michaelmas	16-060	M	27.0	24.2	28.9	12.3	3.5	3.4	0.3	4.1	7.1	0.8
CA	Thetford	16-068	M	39.7	26.4	15.1	11.9	3.7	4.4	1.8	2.6	7.7	0.5
CA	Agincourt No.1	15-099	O	18.4	27.3	25.7	14.4	1.4	7.3	1.0	2.5	11.6	0.1
CA	Opal (2)	16-025	O	19.7	21.5	36.2	13.6	0.8	2.2	1.1	1.9	10.7	0.5
CA	St Crispin	16-019	O	24.8	23.5	40.0	9.2	2.6	2.7	4.3	2.6	6.1	0.4
TO	Havannah Is	18-065	I	34.8	43.6	18.2	36.2	1.2	0.8	1.4	0.2	24.3	10.9
TO	Middle	19-011	I	18.3	36.1	13.6	5.7	1.4	0.3	12.3	1.7	2.1	1.3
TO	Pandora	18-051	I	15.0	60.4	16.5	5.7	2.9	0.2	17.3	0.1	4.6	0.8
TO	Davies	18-096	M	41.0	38.8	2.9	9.2	7.0	7.5	6.9	2.2	5.3	1.1
TO	John Brewer	18-075	M	47.5	27.0	5.9	17.8	0.7	4.6	0.3	9.6	7.8	0.1
TO	Rib	18-082	M	33.4	47.5	2.5	38.3	1.2	2.6	0.7	25.2	11.9	0.8
TO	Chicken	18-086	O	34.7	36.0	12.9	14.4	6.5	6.8	2.8	4.9	8.2	1.1
TO	Dip	18-089	O	40.4	24.6	10.0	9.0	3.1	3.2	2.7	0.7	5.3	1.4
TO	Myrmidon	18-084	O	26.8	32.6	24.1	8.0	10.0	2.9	4.1	1.9	4.0	1.9
WH	Border Is A	20-067	I	21.8	26.3	28.5	2.8	2.7	0.5	12.2	0.0	0.6	0.3
WH	Hayman Is	20-014	I	33.8	38.7	12.9	17.1	5.8	1.3	1.6	1.0	5.3	10.4
WH	Langford & Bird Is	20-019	I	18.1	16.6	19.1	2.7	2.3	0.3	6.1	0.4	1.6	0.3
WH	19131S	19-131	M	53.0	36.8	0.5	12.0	12.4	1.8	1.2	0.3	1.8	9.8
WH	19138S	19-138	M	73.6	16.6	1.9	4.4	4.5	2.3	1.1	0.2	1.9	1.7

G2 continued. Percentage cover of benthic groups recorded on reefs in 1997 survey. Mean values from all sites on each reef.

Sector	Reef	Reef ID	Shelf	Algae	Hard coral	Soft coral	Acro-poridae	Faviidae	Pocillo-poridae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Monti-pora*
WH	201046	20-104	M	72.3	17.6	1.0	4.9	2.0	1.4	2.1	0.4	1.3	3.0
WH	191596	19-159	O	20.9	42.6	13.2	22.8	6.3	4.1	1.4	5.0	13.3	3.1
WH	Hyde	19-207	O	13.1	18.6	40.8	4.0	3.0	2.5	5.0	0.1	3.3	0.3
WH	Rebe	19-209	O	21.2	17.7	32.0	2.3	2.7	2.2	7.3	0.6	1.4	0.0
SW	220688	22-088	I	50.1	17.5	9.3	3.6	0.8	1.6	5.5	0.1	0.3	2.7
SW	215296	21-529	M	41.9	39.9	1.5	22.9	1.9	3.8	5.6	1.5	15.8	5.1
SW	Chinaman	22-102	M	20.3	30.1	29.8	7.8	4.8	3.9	6.5	1.6	4.2	1.8
SW	Gannet Cay	21-556	M	51.3	39.4	5.3	29.6	0.7	1.4	1.4	1.3	23.4	4.4
SW	Horseshoe	22-104	M	25.0	53.3	5.3	34.7	4.2	4.9	2.2	12.1	10.3	11.9
SW	East Cay	21-605	O	31.4	17.0	40.1	3.0	2.5	3.2	4.3	0.3	2.4	0.2
SW	Turner Cay	21-562	O	22.5	33.4	32.3	13.4	4.6	3.7	3.8	3.9	8.0	0.8
CB	Broomfield	23-048	O	42.1	33.1	3.0	25.3	2.3	0.5	0.5	7.9	7.7	2.6
CB	Lady Musgrave Is	23-082	O	53.2	30.2	0.1	26.0	1.2	1.2	0.2	18.3	7.0	0.1
CB	One Tree Is	23-055	O	23.6	27.5	1.2	20.6	2.6	0.6	0.5	12.1	7.2	0.9
CB	Wreck Is	23-051	O	22.2	51.8	13.6	41.1	4.7	1.1	1.3	28.5	9.0	2.8

G3. Percentage cover of benthic groups recorded on reefs in 1998 survey. Mean values from all sites on each reef.

Sector	Reef	Reef ID	Shelf	Algae	Hard coral	Soft coral	Acro-poridae	Faviidae	Pocillo-poridae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Montipora*
CL	Decapolis	14-131	I	60.7	21.1	2.0	10.4	0.5	1.1	0.9	2.8	2.7	4.5
CL	Linnet	14-126	I	44.6	44.5	4.1	11.8	8.6	7.0	6.4	1.5	7.0	2.7
CL	Martin	14-123	I	42.3	28.4	4.5	8.9	1.9	6.0	3.0	1.8	1.6	0.2
CL	Lizard Is	14-116	M	54.1	12.8	17.3	0.8	3.5	2.0	3.2	0.0	0.0	0.1
CL	Macgillivray	14-114	M	50.9	17.4	4.8	0.8	3.2	0.6	9.8	0.0	0.1	0.8
CL	N. Direction Is	14-148	M	59.7	16.5	1.8	2.0	3.1	0.7	4.5	0.1	1.6	0.1
CL	Carter	14-137	O	9.5	59.2	2.9	42.3	1.5	9.5	0.4	21.7	17.6	1.8
CL	No Name	14-139	O	8.2	58.1	11.8	35.7	1.1	9.5	1.4	24.4	10.6	0.5
CL	Yonge	14-138	O	18.3	44.8	4.8	27.8	1.6	10.3	0.4	12.6	13.5	1.2
CA	Fitzroy Is	16-054	I	41.1	34.7	13.2	11.0	3.8	1.1	5.5	0.5	5.5	4.6
CA	Green Is	16-049	I	71.0	4.9	2.5	0.4	0.6	0.0	1.4	0.1	0.8	0.0
CA	Low Isles	16-028	I	48.8	30.4	12.7	4.7	2.5	0.4	7.7	0.6	1.5	2.2
CA	Hastings	16-057	M	48.3	27.7	5.8	15.1	2.7	4.4	1.8	4.8	8.9	1.2
CA	Mackay	16-015	M	54.0	28.9	3.8	8.5	5.8	8.2	4.0	1.8	1.5	0.6
CA	Michaelmas	16-060	M	24.8	28.6	30.6	11.9	3.1	3.8	0.4	4.7	5.9	0.9
CA	Thetford	16-068	M	28.0	30.8	17.1	14.1	4.1	5.1	2.0	6.0	6.5	0.7
CA	Agincourt No.1	15-099	O	13.9	32.4	28.8	18.7	1.8	8.1	0.9	4.4	13.0	1.0
CA	Opal (2)	16-025	O	20.6	20.7	37.5	14.2	0.5	2.7	1.1	1.1	12.6	0.4
CA	St Crispin	16-019	O	23.0	24.0	40.1	10.8	2.2	3.1	4.0	3.3	6.8	0.8
TO	Havannah Is	18-065	I	50.5	28.3	17.6	21.9	1.4	0.2	0.7	0.1	13.8	7.8
TO	Middle	19-011	I	20.6	34.2	9.8	5.4	1.3	0.5	11.0	2.0	1.3	0.7
TO	Pandora	18-051	I	27.3	54.3	9.8	5.5	4.0	0.4	19.4	0.1	4.6	0.3
TO	Davies	18-096	M	35.3	41.9	2.4	12.3	8.0	6.4	6.5	4.8	6.3	1.1
TO	John Brewer	18-075	M	55.4	25.5	2.2	18.1	1.3	3.0	0.3	9.1	7.9	1.0
TO	Rib	18-082	M	47.5	48.7	2.7	36.0	1.6	1.5	0.7	19.5	14.1	2.1
TO	Chicken	18-086	O	26.6	42.7	10.2	18.0	6.3	7.0	3.0	7.3	9.9	0.6
TO	Dip	18-089	O	34.0	24.1	9.8	10.9	3.1	3.0	2.4	2.7	5.8	0.8
TO	Myrmidon	18-084	O	25.2	35.4	20.2	9.8	9.8	4.0	2.4	3.1	4.4	2.2
WH	Border Is A	20-067	I	29.6	28.2	28.8	1.6	2.8	0.3	18.1	0.0	0.4	0.6
WH	Hayman Is	20-014	I	36.2	37.6	14.0	14.6	6.6	0.8	1.1	0.6	3.2	9.9
WH	Langford & Bird Is	20-019	I	28.1	17.8	19.9	2.0	2.8	0.4	8.0	0.0	1.3	0.1
WH	191318	19-131	M	52.1	34.6	1.0	12.0	11.6	1.2	2.6	0.6	5.1	8.2

G3 continued. Percentage cover of benthic groups recorded on reefs in 1998 survey. Mean values from all sites on each reef.

Sector	Reef	Reef ID	Shelf	Algae	Hard coral	Soft coral	Acro-poridae	Faviidae	Pocillo-poridae	Poritidae	*Acropora* Tabulate	*Acropora* 'Other'	*Montipora*
WH	19138S	19-138	M	70.8	17.1	0.8	4.8	3.7	2.3	1.5	0.2	1.5	2.8
WH	20104S	20-104	M	61.1	21.9	1.2	5.8	3.5	2.2	2.7	0.4	1.1	4.1
WH	19159S	19-159	O	20.3	44.2	13.6	24.2	5.5	4.6	1.6	7.8	13.9	2.0
WH	Hyde	19-207	O	12.5	17.9	44.5	4.2	2.0	1.7	5.2	0.6	2.6	0.6
WH	Rebe	19-209	O	20.6	19.1	36.0	3.1	2.5	1.9	7.5	0.2	2.4	0.2
SW	22088S	22-088	I	33.4	21.4	7.9	3.8	1.0	2.4	3.8	0.1	0.6	2.5
SW	21529S	21-529	M	44.7	43.6	1.6	24.4	2.5	3.8	6.7	1.5	18.1	4.4
SW	Chinaman	22-102	M	20.3	33.8	30.8	8.5	6.2	4.5	7.1	2.9	4.0	1.2
SW	Gannet Cay	21-556	M	70.2	19.9	4.8	11.1	0.7	0.9	1.6	0.3	3.1	2.1
SW	Horseshoe	22-104	M	38.3	45.9	3.5	24.9	4.1	3.6	2.6	8.2	7.4	7.8
SW	East Cay	21-605	O	27.2	19.6	39.7	5.0	2.2	3.1	4.4	0.7	3.7	0.2
SW	Turner Cay	21-562	O	17.3	32.0	33.5	11.9	5.3	3.1	5.5	4.7	6.5	0.4
CB	Broomfield	23-048	O	24.8	42.2	4.7	34.2	2.3	0.7	0.8	14.8	10.1	0.8
CB	Lady Musgrave Is	23-082	O	28.1	50.2	0.3	45.7	1.2	1.5	0.1	38.8	5.9	0.3
CB	One Tree Is	23-055	O	19.6	41.4	1.1	34.5	1.9	0.7	0.6	26.4	7.1	0.7
CB	Wreck Is	23-051	O	10.8	66.7	9.8	59.9	3.2	0.7	0.2	47.7	10.0	1.6

Appendix H

Summary counts of the different fish taxa recorded on reefs in each survey year. Sector codes: CG = Cape Grenville, PC = Princess Charlotte Bay, CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsundays, SW = Swains, CB = Capricorn / Bunkers

H1. Numbers of larger, mobile fishes recorded on reefs in 1996. Sum from all transects on each reef.

Sector	Reef	Reef ID ID	Shelf	Acanth-uridae	Chaeto-dontidae	Labr-idae	Lethrin-idae	Lutjan-idae	Scar-idae	Serran-idae	Sigani-idae	Zan-clidae
CL	Decapolis	14-131	I	8	11	4	0	18	5	11	56	0
CL	Linnet	14-126	I	128	128	67	4	87	119	8	130	2
CL	Martin	14-128	I	155	106	86	19	68	134	12	45	2
CL	Lizard Is	14-116	M	176	126	51	14	62	108	27	89	1
CL	Macgillivray	14-114	M	112	127	52	29	50	71	17	18	2
CL	N. Direction	14-148	M	72	106	51	25	17	105	2	52	0
CL	Carter	14-137	O	481	149	86	17	134	196	1	6	24
CL	No Name	14-139	O	366	156	48	29	84	196	7	18	18
CL	Yonge	14-138	O	505	112	52	20	21	248	4	2	12
CA	Fitzroy Is	16-054	I	22	61	72	0	168	59	5	81	0
CA	Green Is	16-049	I	142	88	55	6	79	221	8	67	0
CA	Low Isles	16-028	I	11	68	84	0	86	50	8	18	0
CA	Hastings	16-057	M	521	86	40	17	42	171	1	18	18
CA	Mackay	16-015	M	48	100	50	7	86	108	4	21	4
CA	Michaelmas	16-060	M	251	64	84	1	46	181	4	17	1
CA	Thetford	16-068	M	815	72	85	2	14	817	8	10	4
CA	Agincourt No.1	15-099	O	445	128	84	17	18	202	1	6	6
CA	Opal (2)	16-025	O	884	90	21	6	9	151	1	16	8
CA	St Crispin	16-019	O	298	124	86	20	89	277	4	9	8
TO	Pandora	18-051	I	0	98	22	1	48	10	2	5	0
TO	Davies	18-096	M	81	62	49	8	4	248	5	28	2
TO	John Brewer	18-075	M	162	97	58	1	9	251	10	88	1
TO	Rib	18-082	M	142	162	48	8	5	169	6	25	2
TO	Chicken	18-086	O	255	71	40	14	89	206	14	20	2
TO	Dip	18-089	O	488	86	87	4	4	168	6	9	2
TO	Myrmidon	18-084	O	269	92	24	1	2	129	8	4	7
WH	Border Is A	20-067	I	8	56	47	2	40	50	17	28	0

H1 continued. Numbers of larger, mobile fishes recorded on reefs in 1996. Sum from all transects on each reef.

Sector	Reef	Reef ID ID	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
WH	Hayman Is	20-014	I	4	73	57	0	59	140	4	14	0
WH	Langford & Bird Is	20-019	I	4	74	42	1	37	106	6	24	0
WH	19131S	19-131	M	14	153	45	19	18	169	19	27	0
WH	19138S	19-138	M	20	140	69	4	20	204	16	31	0
WH	20104S	20-104	M	41	77	51	9	37	250	22	49	0
WH	19159S	19-159	O	173	126	30	10	10	106	18	13	6
WH	Hyde	19-207	O	323	62	35	2	1	120	11	11	1
WH	Rebe	19-209	O	390	59	35	8	4	140	11	5	3
SW	22088S	22-088	I	93	60	44	0	7	248	14	7	6
SW	21529S	21-529	M	11	61	58	13	14	272	61	31	0
SW	Chinaman	22-102	M	209	61	47	2	5	188	43	12	1
SW	Gannet Cay	21-556	M	39	62	51	33	6	197	30	144	3
SW	Horseshoe	22-104	M	229	144	60	9	9	193	23	26	11
SW	East Cay	21-605	O	103	63	40	5	1	103	15	17	6
SW	Turner Cay	21-562	O	133	76	46	1	1	231	2	6	5
CB	Broomfield	23-048	O	179	66	26	5	1	184	7	0	0
CB	Lady Musgrave Is	23-082	O	136	29	8	4	0	54	2	0	2
CB	One Tree Is	23-055	O	22	12	8	21	0	56	4	0	0
CB	Wreck Is	23-051	O	54	143	24	0	2	76	7	0	0

H2. Numbers of larger, mobile fishes recorded on reefs in 1997. Sum from all transects on each reef.

Sector	Reef	Reef ID	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	Decapolis	14-131	I	8	20	18	11	19	5	11	157	0
CL	Linnet	14-128	I	105	128	71	1	66	95	5	158	0
CL	Martin	14-123	I	113	115	46	38	61	99	8	112	1
CL	Lizard Is	14-116	M	173	120	48	20	60	148	15	57	7
CL	Macgillivray	14-114	M	156	108	71	27	38	104	7	37	1
CL	N. Direction	14-148	M	105	98	55	37	18	88	8	59	0
CL	Carter	14-137	O	372	206	30	8	101	136	1	4	12
CL	No name	14-139	O	387	160	50	27	94	215	2	8	24
CL	Yonge	14-138	O	487	124	52	21	82	174	1	2	14
CA	Fitzroy Is	16-054	I	13	64	25	0	74	13	1	12	0
CA	Green Is	16-049	I	120	58	25	5	51	202	1	35	1
CA	Low Isles	16-028	I	9	54	38	9	38	84	4	14	0
CA	Hastings	16-057	M	298	70	38	5	15	162	2	4	5
CA	Michaelmas	16-060	M	173	68	22	2	7	141	7	13	4
CA	Thetford	16-068	M	242	44	24	8	5	367	8	11	2
CA	Agincourt No.1	15-099	O	372	108	38	15	14	147	1	5	6
CA	Opal (2)	16-025	O	315	56	6	7	7	79	0	12	0
CA	St Crispin	16-019	O	305	91	34	9	7	172	1	5	2
TO	Havannah Is	18-065	I	0	62	56	0	25	104	5	9	0
TO	Pandora	18-051	I	1	88	28	0	47	32	11	37	0
TO	Davies	18-096	M	127	126	57	16	8	229	12	30	1
TO	John Brewer	18-075	M	128	101	58	18	4	199	12	74	0
TO	Rib	18-082	M	101	137	26	5	6	144	8	50	1
TO	Chicken	18-086	O	186	68	35	4	1	159	8	34	1
TO	Dip	18-089	O	408	47	28	7	5	202	28	6	8
TO	Myrmidon	18-084	O	307	88	15	2	1	135	6	2	12
WH	Border Is A	20-067	I	8	65	28	0	27	57	13	21	0
WH	Hayman Is	20-014	I	8	82	27	0	11	26	10	14	0
WH	191318	19-131	M	21	117	49	8	8	190	7	64	0
WH	191388	19-138	M	27	98	75	10	13	185	7	109	0
WH	191598	19-159	O	177	131	44	9	20	114	5	21	12

H2 continued. Numbers of larger, mobile fishes recorded on reefs in 1997. Sum from all transects on each reef.

Sector	Reef	Reef ID	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
WH	Hyde	19-207	O	270	70	42	5	6	216	4	18	1
WH	Rebe	19-209	O	383	49	43	6	6	153	2	7	3
SW	220888	22-088	I	82	44	35	0	6	193	19	30	6
SW	215298	21-529	M	5	60	31	19	12	126	56	45	0
SW	Chinaman	22-102	M	196	46	26	6	9	158	57	25	2
SW	Gannet Cay	21-556	M	40	29	21	8	14	255	47	179	7
SW	Horseshoe	22-104	M	174	154	40	7	13	175	30	22	13
SW	East Cay	21-605	O	99	48	27	6	3	53	8	2	16
SW	Turner Cay	21-562	O	182	66	45	1	3	144	11	14	4
CB	Broomfield	23-048	O	130	96	21	5	0	167	6	2	2
CB	Lady Musgrave Is	23-082	O	158	85	6	6	1	60	4	2	1
CB	One Tree Is	23-055	O	16	49	1	20	2	27	0	0	0
CB	Wreck Is	23-051	O	60	248	20	12	7	82	6	0	0

H3. Numbers of larger, mobile fishes recorded on reefs in 1998. Sum from all transects on each reef.

Sector	Reef	Reef ID	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	Decapolis	14-131	I	7	27	11	13	29	10	8	127	0
CL	Linnet	14-126	I	92	106	37	2	47	79	4	95	0
CL	Martin	14-128	I	154	122	46	21	62	144	4	23	0
CL	Lizard Is	14-116	M	159	90	48	27	7	129	10	38	0
CL	Macgillivray	14-114	M	127	49	38	20	46	102	2	29	0
CL	N Direction Is	14-148	M	45	68	48	40	24	121	12	58	2
CL	Carter	14-137	O	412	218	42	18	100	146	8	4	26
CL	No Name	14-139	O	245	156	32	15	115	157	5	14	11
CL	Yonge	14-138	O	879	122	48	10	16	188	4	9	10
CA	Fitzroy Is	16-054	I	16	100	37	4	137	54	2	31	0
CA	Green Is	16-049	I	168	45	36	8	99	245	10	44	1
CA	Low Isles	16-028	I	15	95	45	0	90	97	6	91	0
CA	Hastings	16-057	M	266	94	32	9	19	80	2	10	4
CA	Mackay	16-015	M	48	81	38	8	35	102	1	23	0
CA	Michaelmas	16-060	M	175	106	35	8	66	97	5	11	5
CA	Thetford	16-068	M	256	59	36	4	16	359	2	9	2
CA	Agincourt No.1	15-099	O	290	89	39	14	17	242	0	6	8
CA	Opal (2)	16-025	O	251	62	19	5	44	104	1	10	2
CA	St Crispin	16-019	O	182	98	52	16	4	194	0	8	2
TO	Havannah Is	18-065	I	2	54	42	0	60	111	8	6	0
TO	Pandora	18-051	I	0	107	20	2	91	19	9	17	0
TO	Davies	18-096	M	89	84	43	6	11	206	2	21	2
TO	John Brewer	18-075	M	116	62	43	8	2	208	5	32	2
TO	Rib	18-082	M	91	114	29	4	0	225	8	40	0
TO	Chicken	18-086	O	887	56	27	4	8	147	12	17	4
TO	Dip	18-089	O	405	50	20	8	8	161	8	12	4
TO	Myrmidon	18-084	O	209	101	16	2	0	147	10	8	7
WH	Border Is A	20-067	I	6	64	28	8	88	48	12	26	0
WH	Langford & Bird Is	20-019	I	2	68	26	2	17	68	1	20	0
WH	19131S	19-131	M	49	118	61	2	11	828	9	55	0

H3 continued. Numbers of larger, mobile fishes recorded on reefs in 1998. Sum from all transects on each reef.

Sector	Reef	Reef ID	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
WH	19138S	19-138	M	43	60	91	11	24	192	14	44	0
WH	20104S	20-104	M	78	59	45	14	27	128	9	86	3
WH	19159S	19-159	O	152	171	23	7	6	97	13	78	10
WH	Hyde	19-207	O	179	56	23	5	8	134	8	12	5
WH	Rebe	19-209	O	254	89	46	4	2	82	2	5	4
SW	22068S	22-068	I	86	48	41	1	5	157	4	25	5
SW	21529S	21-529	M	8	66	45	18	8	164	38	55	2
SW	Chinaman	22-102	M	218	61	65	3	6	185	14	21	5
SW	Gannet Cay	21-556	M	39	49	72	7	10	333	20	83	9
SW	Horseshoe	22-104	M	149	106	54	0	15	176	28	190	7
SW	East Cay	21-605	O	150	59	40	2	0	60	4	8	14
SW	Turner Cay	21-562	O	272	86	55	2	0	144	11	10	3
CB	Broomfield	23-048	O	162	182	43	3	2	175	12	1	6
CB	Lady Musgrave Is	23-082	O	219	253	36	2	0	98	2	0	3
CB	One Tree Is	23-055	O	69	136	9	10	8	56	6	0	4
CB	Wreck Is	23-051	O	111	295	43	10	55	99	13	7	1

H4. Numbers of damselfishes recorded on reefs in 1996 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-nas*	*Stega-astes*
CL	Decapolis	14-131	I	6	0	0	0	0	0	0	3	345	0	0	339	0	0
CL	Linnet	14-126	I	200	113	2	59	85	0	0	23	429	0	2	1710	0	1
CL	Martin	14-123	I	37	33	0	36	102	6	1	8	673	0	0	1365	0	0
CL	Lizard Is	14-116	M	68	78	2	55	193	59	1	17	570	0	31	1564	0	0
CL	Macgillivray	14-114	M	60	66	0	108	162	26	2	9	60	0	28	741	2	0
CL	N Direction	14-143	M	36	74	1	27	177	8	15	9	13	0	12	508	0	0
CL	Carter	14-137	O	47	2	3	297	16	0	0	0	0	3	23	180	0	3
CL	No name	14-139	O	79	1	0	369	10	0	0	0	0	2	52	342	0	2
CL	Yonge	14-138	O	41	1	0	523	28	1	0	0	0	1	49	169	0	2
CA	Pelzer Is	16-054	I	4	39	0	0	26	0	0	74	78	0	0	764	0	3
CA	Green Is	16-049	I	14	67	0	66	152	25	4	10	41	0	3	947	1	0
CA	Low Isles	16-028	I	32	15	0	0	26	2	3	37	147	0	0	966	0	0
CA	Hastings	16-057	M	8	6	2	40	7	15	0	0	83	0	81	419	0	47
CA	Mackay	16-015	M	36	129	0	10	62	8	26	56	17	0	2	1100	0	0
CA	Michaelmas	16-060	M	4	4	5	80	11	0	0	2	722	0	89	562	0	10
CA	Thetford	16-068	M	23	4	4	60	31	7	0	2	59	0	105	710	0	10
CA	Agincourt No.1	15-099	O	17	0	0	99	34	0	0	1	0	0	71	139	0	2
CA	Opal (2)	16-025	O	14	3	1	192	24	0	0	1	4	0	70	78	0	0
CA	St. Crispin	16-019	O	24	24	0	305	5	1	0	2	0	0	61	292	0	0
TO	Middle	19-011	I	12	0	0	0	0	0	0	4	698	0	0	56	0	0

H4 continued. Numbers of damselfishes recorded on reefs in 1996 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-nas*	*Stega-astes*
TO	Pandora	18-051	I	29	10	0	0	0	0	0	41	3044	0	0	407	0	0
TO	Davies	18-096	M	33	86	14	73	126	2	0	98	587	0	21	2476	0	1
TO	John Brewer	18-075	M	26	45	3	60	141	2	14	46	686	0	11	1654	0	15
TO	Rib	18-002	M	24	50	2	802	85	0	3	41	2135	0	24	1723	0	1
TO	Chicken	18-086	O	28	1	6	20	67	0	0	0	1323	0	123	1176	0	58
TO	Dip	18-009	O	19	1	1	161	32	2	2	1	393	0	112	345	0	42
TO	Myrmidon	18-004	O	31	7	0	322	7	21	0	0	78	5	140	255	0	6
WH	Border Is A	20-067	I	52	49	0	223	250	0	0	2	540	0	0	1249	0	0
WH	Hayman Is	20-014	I	131	110	0	2	60	0	0	9	206	0	0	1838	0	1
WH	Langford & Bird Is	20-019	I	74	44	0	1	105	1	2	5	78	0	0	1143	0	0
WH	19131S	19-131	M	4	7	0	122	25	0	0	0	1940	0	0	2118	0	16
WH	19138S	19-138	M	14	34	1	222	66	1	0	1	869	0	0	2730	0	17
WH	20104S	20-104	M	10	17	0	777	213	0	0	7	1259	0	0	1768	0	8
WH	19159S	19-159	O	19	77	6	162	70	1	0	44	100	0	74	1055	0	6
WH	Hyde	19-207	O	9	10	1	7	167	3	0	15	0	0	26	736	0	0
WH	Rebe	19-209	O	13	14	2	28	127	2	0	12	109	0	51	525	0	0
SW	22088S	22-088	I	1	37	2	1	11	0	0	1	502	0	1	1460	0	12
SW	21529S	21-529	M	2	126	2	1119	187	1	0	1	207	0	3	2130	0	2
SW	Chinaman	22-102	M	11	77	5	200	2	0	0	19	327	0	29	1300	0	0
SW	Cannet Cay	21-556	M	5	200	5	2149	10	0	0	3	1	0	2	2062	0	1
SW	Horseshoe	22-104	M	2	133	5	23	9	0	0	1	95	0	4	1395	0	2

H4 continued. Numbers of damselfishes recorded on reefs in 1996 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	***Poma-chromis***	***Plectrogly-phidodon***	***Poma-centrus***	***Prem-nas***	***Stega-astes***
SW	21583S	21-583	O	21	66	11	97	10	3	0	3	358	0	30	1499	0	0
SW	East Cay	21-005	O	17	65	3	5	24	0	1	27	46	0	17	709	0	3
SW	Turner Cay	21-561	O	18	67	6	84	7	0	0	14	75	0	28	1097	0	15
CB	Broomfield	22-048	O	8	0	0	18	14	0	0	0	31	0	1	2078	0	0
CB	Lady Musgrave Is	22-082	O	0	0	0	7	16	0	0	0	20	0	0	1416	0	0
CB	One Tree Is	22-055	O	0	0	0	0	26	0	0	0	0	0	0	1794	0	0
CB	Wreck Is	22-051	O	0	0	0	2	7	0	0	0	2	0	2	1995	0	0

H5. Numbers of damselfishes recorded on reefs in 1997 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromus*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-snas*	*Stega-ates*
CL	Decapolis	14-131	I	5	2	0	0	1	0	0	4	254	0	0	250	0	0
CL	Linnet	14-126	I	132	156	0	32	55	2	0	26	464	0	0	1740	0	1
CL	Martin	14-123	I	44	49	0	19	70	9	3	15	493	0	0	1626	0	0
CL	Lizard Is	14-116	M	81	87	5	74	136	41	0	12	176	0	22	1278	0	0
CL	MacgillivrayI	14-114	M	60	65	0	156	132	19	2	7	7	0	21	528	2	0
CL	N. Direction Is	14-140	M	23	95	3	16	177	8	21	11	15	0	18	526	0	0
CL	Carter	14-137	O	47	1	0	486	20	0	0	0	0	0	64	204	0	4
CL	No Name	14-139	O	128	1	0	593	12	1	0	0	0	0	63	366	0	0
CL	Yonge	14-138	O	61	0	0	725	23	1	0	0	0	0	49	221	0	1
CA	Pelzoy Is	16-054	I	17	35	0	2	13	0	0	50	31	0	0	379	0	0
CA	Green Is	16-049	I	18	48	0	45	115	4	0	13	19	0	2	538	2	0
CA	Low Isles	16-028	I	19	26	0	0	25	0	3	49	53	0	0	684	0	1
CA	Hastings	16-057	M	13	2	3	89	4	18	1	0	104	0	120	659	0	23
CA	Michaelmas	16-060	M	10	6	1	130	13	0	0	3	525	0	90	650	0	9
CA	Thetford	16-068	M	17	5	0	66	17	4	0	3	11	0	115	555	0	11
CA	Agincourt No.1	15-099	O	3	0	0	133	27	1	0	0	1	0	93	211	0	0
CA	Opal (2)	16-025	O	15	0	0	70	16	0	0	1	6	0	71	102	0	0
CA	St. Crispin	16-019	O	15	19	0	27	3	11	0	4	0	0	39	285	0	0
TO	Havannah Is	18-065	I	75	25	0	0	0	0	0	38	407	0	0	509	0	3

H5 continued. Numbers of damselfishes recorded on reefs in 1997 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromus*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-snas*	*Stega-ates*
TO	Pandora	18-051	I	31	7	0	0	0	0	0	33	1819	0	0	324	0	0
TO	Davies	18-096	M	41	88	10	111	131	1	1	108	315	0	18	1832	0	0
TO	John Brewer	18-075	M	47	75	3	133	100	1	16	65	473	0	18	1664	0	16
TO	Rib	18-032	M	24	72	1	789	44	0	2	32	64	0	20	937	0	1
TO	Chicken	18-086	O	27	0	4	149	46	0	0	0	648	0	128	1025	0	47
TO	Dip	18-039	O	17	0	6	275	29	8	1	0	153	0	142	453	0	38
TO	Myrmidon	18-094	O	33	2	1	201	6	29	0	0	0	0	150	185	0	4
WH	Border Is A	20-067	I	29	40	0	89	102	0	0	5	264	0	0	864	0	0
WH	Hayman Is	20-014	I	96	86	0	2	20	0	0	5	126	0	0	1011	0	0
WH	Langford & Bird Is	20-019	I	45	37	0	0	37	0	0	4	60	0	0	536	0	0
WH	19131S	19-131	M	2	7	0	0	4	0	0	0	2350	0	0	1006	0	10
WH	19138S	19-138	M	2	33	0	20	4	0	0	1	740	0	0	1368	0	11
WH	19159S	19-159	O	28	85	4	158	27	4	2	38	66	0	55	780	0	5
WH	Hyde	19-207	O	18	14	3	26	40	4	0	16	0	0	22	480	0	0
WH	Rebe	19-209	O	7	12	0	23	36	5	0	6	19	0	30	377	0	1
SW	22088S	22-088	I	4	41	5	0	5	0	0	3	127	0	1	1512	0	6
SW	21529S	21-529	M	11	140	2	1318	141	0	0	2	31	0	1	2026	0	2
SW	Chinaman	22-102	M	8	102	7	258	0	0	0	14	136	0	29	1360	0	3
SW	Cannet Cay	21-556	M	9	219	2	3738	12	0	3	5	0	0	2	2008	0	0
SW	Horseshoe	22-104	M	2	148	1	6	12	0	0	1	46	0	2	1290	0	1
SW	East Cay	21-305	O	14	71	4	2	18	0	0	14	15	0	16	600	0	3

H5 continued. Numbers of damselfishes recorded on reefs in 1997 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-nas*	*Stega-astes*
SW	Turner Cay	21-362	O	26	75	2	41	7	0	0	15	39	0	20	943	0	16
CB	Broomfield	23-048	O	6	0	0	66	14	0	0	0	70	0	6	1413	0	0
CB	Lady Musgrave Is	23-082	O	0	0	0	33	12	1	0	0	17	1	8	1009	0	0
CB	One Tree Is	23-055	O	0	0	0	1	12	0	0	0	0	0	1	1333	0	0
CB	Wreck Is	23-051	O	0	0	5	134	9	0	0	1	45	0	4	1048	0	0

H6 Numbers of damselfishes recorded on reefs in 1998 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-nas*	*Stega-astes*
CL	Decapolis	14-131	I	17	2	0	1	2	0	0	1	173	0	0	440	0	0
CL	Linnet	14-126	I	160	171	0	147	43	2	0	25	461	0	1	1996	0	0
CL	Martin	14-123	I	32	75	0	213	46	14	3	12	620	0	0	1678	1	0
CL	Lizard Is	14-116	M	66	86	2	228	108	35	1	12	344	0	26	1212	0	0
CL	MacgillivrayI	14-114	M	69	59	0	100	100	21	1	5	14	0	18	524	3	0
CL	N. Direction	14-140	M	43	88	1	26	189	10	12	8	50	0	18	680	1	0
CL	Carter	14-137	O	75	2	2	587	16	1	0	0	4	1	75	314	0	4
CL	No Name	14-139	O	105	4	0	561	9	1	0	0	4	0	79	421	0	1
CL	Yonge	14-138	O	42	0	0	472	39	1	0	0	0	0	81	252	0	2
CA	Pikeroy Is	16-054	I	26	51	0	1	35	0	1	69	12	0	0	489	0	2
CA	Green Is	16-049	I	6	58	0	39	201	0	4	9	23	0	6	374	3	0
CA	Low Isles	16-028	I	26	22	0	0	92	0	1	50	237	0	0	918	0	0
CA	Hastings	16-057	M	13	6	6	125	10	7	0	2	141	0	122	643	0	68
CA	Mackay	16-015	M	26	89	0	6	127	6	14	60	5	0	1	955	0	0
CA	Michaelmas	16-060	M	4	8	0	128	8	0	0	1	422	0	114	723	0	6
CA	Thetford	16-068	M	13	6	1	67	13	3	0	2	8	0	104	660	0	8
CA	Agincourt No.1	15-099	O	23	0	0	188	38	1	0	1	0	0	98	301	0	0
CA	Opal (2)	16-025	O	26	2	0	105	38	1	0	4	26	0	54	138	0	0
CA	St. Crispin	16-019	O	24	28	2	94	5	12	0	4	0	0	66	447	0	0

H6 continued. Numbers of damselfishes recorded on reefs in 1998 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-nas*	*Stega-astes*
TO	Havannah Is	18-065	I	102	25	0	0	1	0	0	41	460	0	1	774	0	6
TO	Middle	19-011	I	43	0	0	0	0	0	0	2	453	0	1	51	0	0
TO	Pandora	18-051	I	25	6	0	0	0	0	0	36	1226	0	0	404	0	0
TO	Davies	18-096	M	32	78	18	110	86	1	1	102	273	0	20	1648	0	1
TO	John Brewer	18-075	M	39	55	3	141	72	5	6	53	364	0	17	1054	0	15
TO	Rib	18-032	M	57	88	1	340	38	0	4	40	421	0	40	919	0	4
TO	Chicken	18-086	O	16	0	3	57	37	0	0	0	265	0	130	609	0	49
TO	Dip	18-039	O	21	1	4	257	23	1	0	0	264	0	117	375	0	17
TO	Myrmidon	18-034	O	30	6	3	619	5	18	0	0	5	1	153	226	0	4
WH	Border Is A	20-067	I	38	47	0	47	198	0	0	3	242	0	0	794	0	0
WH	Hayman Is	20-014	I	135	86	0	2	50	0	0	9	151	0	0	982	0	0
WH	Langford & Bird Is	20-019	I	43	38	1	0	77	0	0	8	97	0	0	531	0	0
WH	19131S	19-131	M	3	7	0	3	33	0	0	0	570	0	0	872	0	9
WH	19138S	19-138	M	3	25	2	73	78	0	0	0	379	0	0	1084	0	13
WH	20104S	20-104	M	10	5	0	0	67	0	0	3	378	0	0	661	0	15
WH	19159S	19-159	O	10	80	2	147	29	7	0	43	22	0	74	577	0	4
WH	Hyde	19-207	O	14	15	0	8	31	6	0	6	1	0	27	379	0	0
WH	Rebe	19-209	O	5	27	1	9	18	4	0	13	0	0	38	285	0	0
SW	22088S	22-088	I	2	40	6	1	9	0	0	6	70	0	0	877	0	13
SW	21529S	21-529	M	5	70	1	1312	74	0	0	4	1	0	0	1026	0	2

H6 continued. Numbers of damselfishes recorded on reefs in 1998 surveys. Sum from all transects at all sites on each reef.

Sector	Reef	Reef ID	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphi-prion*	*Chro-mis*	*Chrys-iptera*	*Dasc-yllus*	*Dischis-todus*	*Neogly-phidodon*	*Neopoma-centrus*	*Poma-chromis*	*Plectrogly-phidodon*	*Poma-centrus*	*Prem-nas*	*Stega-astes*
SW	Chinaman	22-102	M	14	75	7	481	0	0	0	31	131	0	22	1151	0	3
SW	Cannet Cay	21-556	M	8	126	7	2208	7	0	1	3	0	0	3	1219	0	3
SW	Horseshoe	22-104	M	1	116	6	7	6	0	0	1	90	0	8	955	0	3
SW	East Cay	21-305	O	13	91	2	1	16	0	0	26	19	0	17	542	0	7
SW	Turner Cay	21-562	O	9	89	8	144	8	0	0	10	25	0	25	801	0	18
CB	Broomfield	23-048	O	7	1	0	136	8	0	0	0	16	0	5	728	0	0
CB	Lady Musgrave Is	23-082	O	1	0	1	39	10	0	0	0	40	0	17	407	0	0
CB	One Tree Is	23-055	O	0	0	0	22	7	0	0	0	0	0	0	950	0	0
CB	Wreck Is	23-051	O	3	0	0	235	8	2	0	3	6	0	8	520	0	0

Appendix I

Temporal trends in the major groups of benthic organisms on core survey reefs in each sector over six years.

For interpretation: The tables contain symbols which are in two parts. The line to the left of the vertical tick refers to the general trend over the six years of surveys. The line to the right of the vertical tick refers to the trend at the most recent survey (1998). The slope of the line indicates the strength of the trend: a horizontal line indicates no trend, a dashed sloping line indicates marginal evidence for a trend (probability that the true slope is zero lies between 0.1 and 0.01) and a solid (and steeper) sloping line indicates that the probability that the true slope is zero is less than 0.01. The direction of the slope of the line from left to right indicates whether the trend is positive or negative (a downward directed slope indicates a decrease, and an upward directed slope indicates an increase). Where neither the general nor the current trends were significant, the cell was left blank.

I1. Cooktown / Lizard Is sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	MARTIN			
	LINNET			
	DECAPOLIS			
Mid	MACGILLIVRAY			
	LIZARD IS			
	NORTH DIRECTION IS			
Outer	CARTER			
	YONGE			
	NO NAME			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Poritidae
Inner	MARTIN				
	LINNET				
	DECAPOLIS				
Mid	MACGILLIVRAY				
	LIZARD IS				
	NORTH DIRECTION IS				
Outer	CARTER				
	YONGE				
	NO NAME				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	MARTIN			
	LINNET			
	DECAPOLIS			
Mid	MACGILLIVRAY			
	LIZARD IS			
	NORTH DIRECTION IS			
Outer	CARTER			
	YONGE			
	NO NAME			

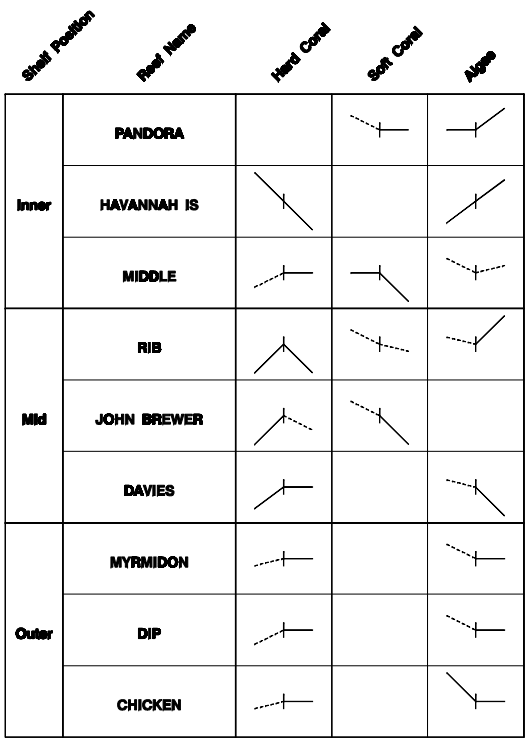
I2. Cairns sector

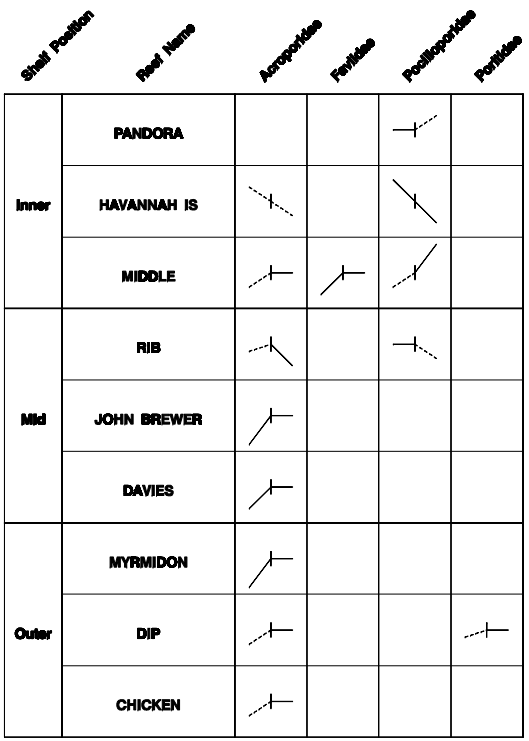
Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	LOW ISLETS			
	GREEN IS			
	FITZROY IS			
Mid	MACKAY			
	HASTINGS			
	MICHAELMAS			
	THETFORD			
Outer	AGINCOURT NO.1			
	ST. CRISPIN			
	OPAL (2)			

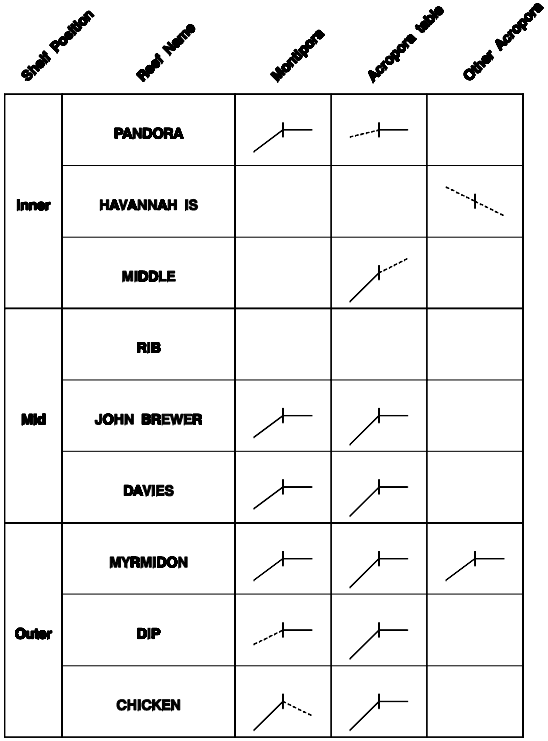
Shelf Position	Reef Name	Acroporidae	Faviidae	Pociloporidae	Portidae
Inner	LOW ISLETS				
	GREEN IS				
	FITZROY IS				
Mid	MACKAY				
	HASTINGS				
	MICHAELMAS				
	THETFORD				
Outer	AGINCOURT NO.1				
	ST. CRISPIN				
	OPAL (2)				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	LOW ISLETS			
	GREEN IS			
	FITZROY IS			
Mid	MACKAY			
	HASTINGS			
	MICHAELMAS			
	THETFORD			
Outer	AGINCOURT NO.1			
	ST. CRISPIN			
	OPAL (2)			

I3. Townsville sector







I4. Whitsunday sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	HAYMAN IS			
	LANGFORD & BIRD IS'S			
	BORDER IS (A)			
Mid	19131			
	19138			
	20104			
Outer	19159			
	HYDE			
	REBE			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Poritidae
Inner	HAYMAN IS				
	LANGFORD & BIRD IS'S				
	BORDER IS (A)				
Mid	19131				
	19138				
	20104				
Outer	19159				
	HYDE				
	REBE				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	HAYMAN IS			
	LANGFORD & BIRD IS'S			
	BORDER IS (A)			
Mid	19131			
	19138			
	20104			
Outer	19159			
	HYDE			
	REBE			

I5. Swain sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	22088			
Mid	21529			
	GANNET CAY			
	CHINAMAN			
	HORSESHOE			
Outer	EAST CAY			
	TURNER CAY			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Poritidae
Inner	22088				
Mid	21529				
	GANNET CAY				
	CHINAMAN				
	HORSESHOE				
Outer	EAST CAY				
	TURNER CAY				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	22088			
Mid	21529			
	GANNET CAY			
	CHINAMAN			
	HORSESHOE			
Outer	EAST CAY			
	TURNER CAY			

I6. Capricorn / Bunker sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner				
Mid				
Outer	BROOMFIELD			
	WRECK IS			
	ONE TREE IS			
	LADY MUSGRAVE IS			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Portitidae
Inner					
Mid					
Outer	BROOMFIELD				
	WRECK IS				
	ONE TREE IS				
	LADY MUSGRAVE IS				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner				
Mid				
Outer	BROOMFIELD			
	WRECK IS			
	ONE TREE IS			
	LADY MUSGRAVE IS			

Appendix I

Temporal trends in the major groups of benthic organisms on core survey reefs in each sector over six years.

For interpretation: The tables contain symbols which are in two parts. The line to the left of the vertical tick refers to the general trend over the six years of surveys. The line to the right of the vertical tick refers to the trend at the most recent survey (1998). The slope of the line indicates the strength of the trend: a horizontal line indicates no trend, a dashed sloping line indicates marginal evidence for a trend (probability that the true slope is zero lies between 0.1 and 0.01) and a solid (and steeper) sloping line indicates that the probability that the true slope is zero is less than 0.01. The direction of the slope of the line from left to right indicates whether the trend is positive or negative (a downward directed slope indicates a decrease, and an upward directed slope indicates an increase). Where neither the general nor the current trends were significant, the cell was left blank.

I1. Cooktown / Lizard Is sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	MARTIN			
	LINNET			
	DECAPOLIS			
Mid	MACGILLIVRAY			
	LIZARD IS			
	NORTH DIRECTION IS			
Outer	CARTER			
	YONGE			
	NO NAME			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Poritidae
Inner	MARTIN				
	LINNET				
	DECAPOLIS				
Mid	MACGILLIVRAY				
	LIZARD IS				
	NORTH DIRECTION IS				
Outer	CARTER				
	YONGE				
	NO NAME				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	MARTIN			
	LINNET			
	DECAPOLIS			
Mid	MACGILLIVRAY			
	LIZARD IS			
	NORTH DIRECTION IS			
Outer	CARTER			
	YONGE			
	NO NAME			

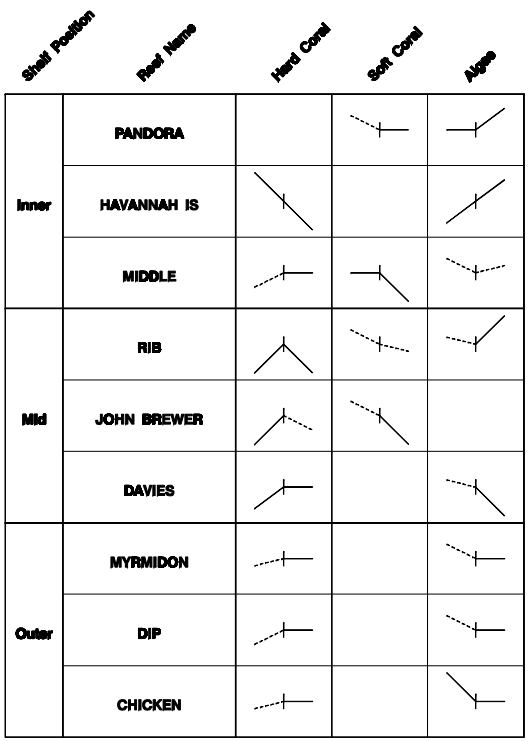
I2. Cairns sector

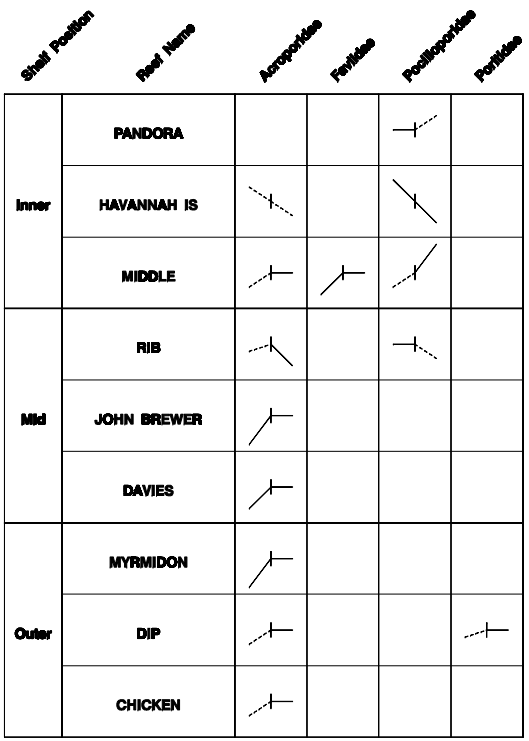
Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	LOW ISLETS			
	GREEN IS			
	FITZROY IS			
Mid	MACKAY			
	HASTINGS			
	MICHAELMAS			
	THETFORD			
Outer	AGINCOURT NO.1			
	ST. CRISPIN			
	OPAL (2)			

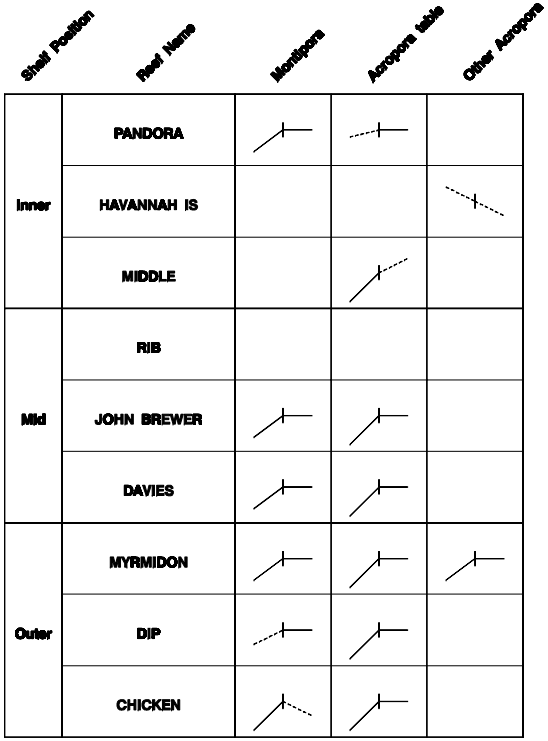
Shelf Position	Reef Name	Acroporidae	Faviidae	Pociloporidae	Portidae
Inner	LOW ISLETS				
	GREEN IS				
	FITZROY IS				
Mid	MACKAY				
	HASTINGS				
	MICHAELMAS				
	THETFORD				
Outer	AGINCOURT NO.1				
	ST. CRISPIN				
	OPAL (2)				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	LOW ISLETS			
	GREEN IS			
	FITZROY IS			
Mid	MACKAY			
	HASTINGS			
	MICHAELMAS			
	THETFORD			
Outer	AGINCOURT NO.1			
	ST. CRISPIN			
	OPAL (2)			

I3. Townsville sector







I4. Whitsunday sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	HAYMAN IS			
	LANGFORD & BIRD IS'S			
	BORDER IS (A)			
Mid	19131			
	19138			
	20104			
Outer	19159			
	HYDE			
	REBE			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Poritidae
Inner	HAYMAN IS				
	LANGFORD & BIRD IS'S				
	BORDER IS (A)				
Mid	19131				
	19138				
	20104				
Outer	19159				
	HYDE				
	REBE				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	HAYMAN IS			
	LANGFORD & BIRD IS'S			
	BORDER IS (A)			
Mid	19131			
	19138			
	20104			
Outer	19159			
	HYDE			
	REBE			

I5. Swain sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner	22088			
Mid	21529			
	GANNET CAY			
	CHINAMAN			
	HORSESHOE			
Outer	EAST CAY			
	TURNER CAY			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Poritidae
Inner	22088				
Mid	21529				
	GANNET CAY				
	CHINAMAN				
	HORSESHOE				
Outer	EAST CAY				
	TURNER CAY				

Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner	22088			
Mid	21529			
	GANNET CAY			
	CHINAMAN			
	HORSESHOE			
Outer	EAST CAY			
	TURNER CAY			

I6. Capricorn / Bunker sector

Shelf Position	Reef Name	Hard Coral	Soft Coral	Algae
Inner				
Mid				
Outer	BROOMFIELD			
	WRECK IS			
	ONE TREE IS			
	LADY MUSGRAVE IS			

Shelf Position	Reef Name	Acroporidae	Faviidae	Pocilloporidae	Portitidae
Inner					
Mid					
Outer	BROOMFIELD				
	WRECK IS				
	ONE TREE IS				
	LADY MUSGRAVE IS				

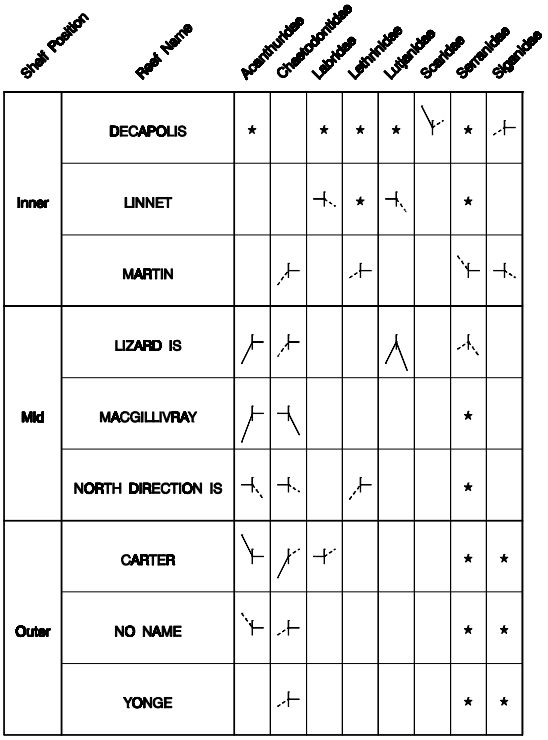
Shelf Position	Reef Name	Montipora	Acropora table	Other Acropora
Inner				
Mid				
Outer	BROOMFIELD			
	WRECK IS			
	ONE TREE IS			
	LADY MUSGRAVE IS			

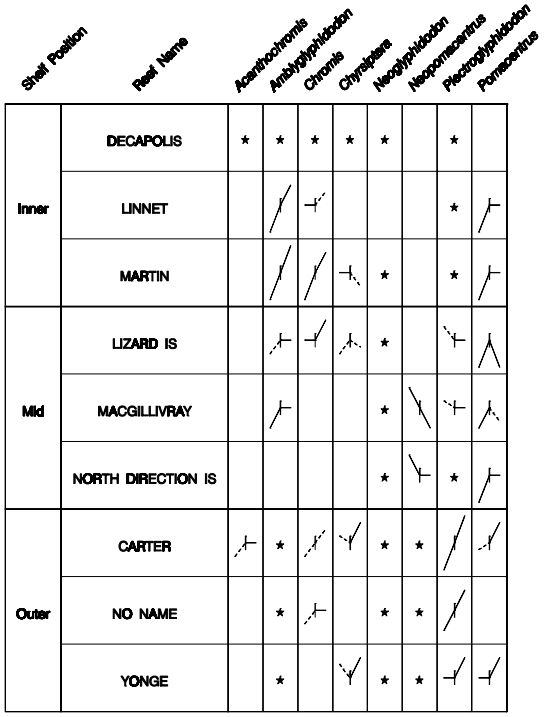
Appendix J

Temporal trends in the major groups of reef fishes on core survey reefs in each sector over six years.

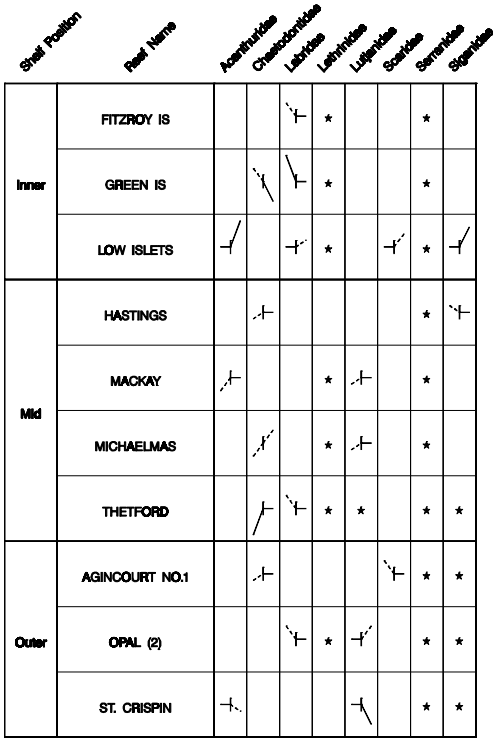
J1 Summary of temporal trends in (A) the larger reef fishes and (B) damselfishes on core survey reefs in the Cooktown / Lizard Is. sector.

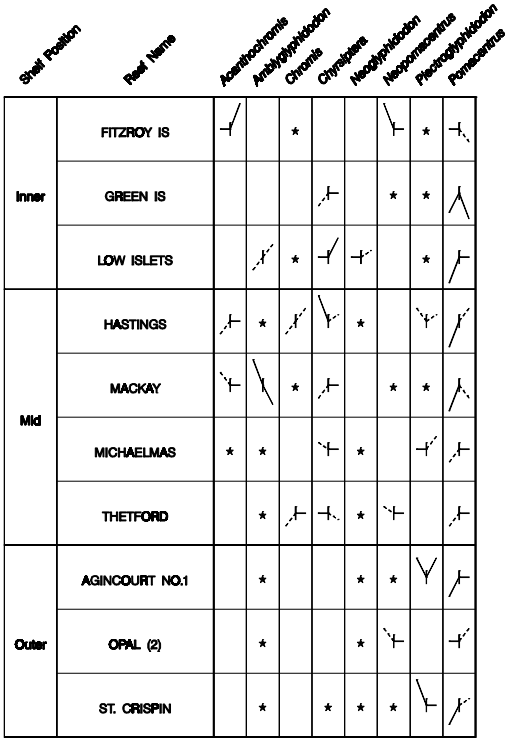
For interpretation: the steepness and direction of slope of the line to the left of the vertical tick mark indicate the strength and direction of the average trend on reefs in a region over six years. The line to the right of the vertical tick mark represents the same information for trends at the last survey in 1998. Marginally significant trends (0.1 > p >0.01) are indicated by broken lines. Where neither the general nor the current trends were significant, the cell was left blank. A star (★) indicates that the data were insufficient to detect a trend with any certainty.



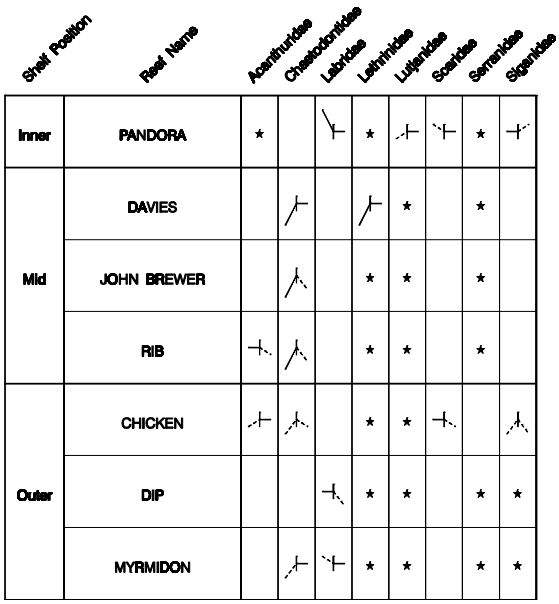


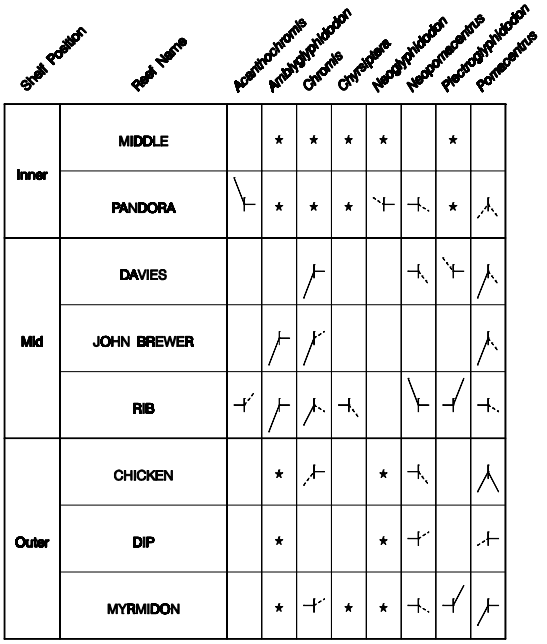
J2 Summary of temporal trends in (C) the larger reef fishes and (D) damselfishes on core survey reefs in the Cairns sector. *For interpretation see Cooktown / Lizard Is. sector above*



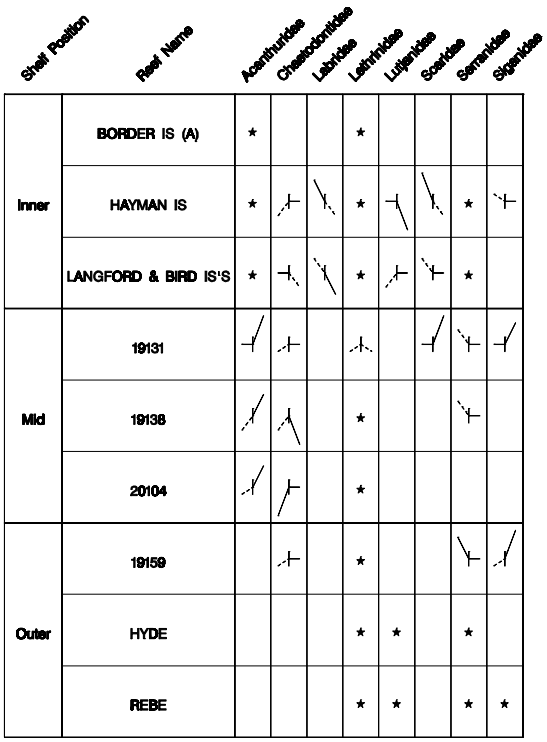


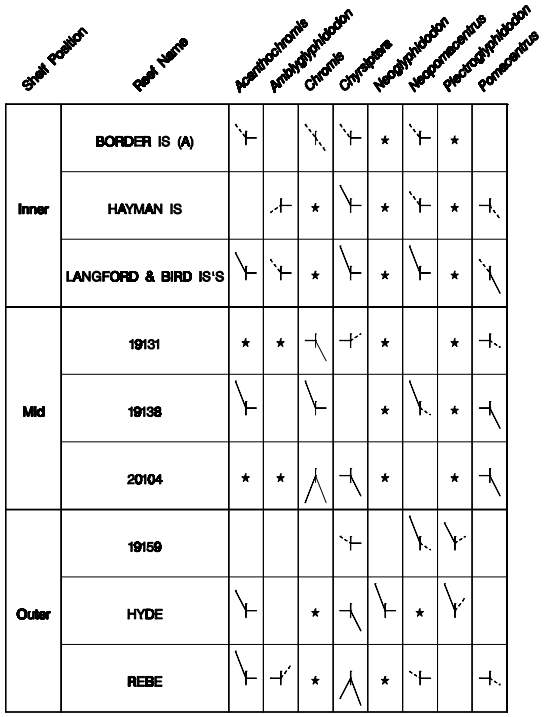
J3 Summary of temporal trends in (E) the larger reef fishes and (F) damselfishes on core survey reefs in the Townsville sector. *For interpretation see Cooktown / Lizard Is. sector above*



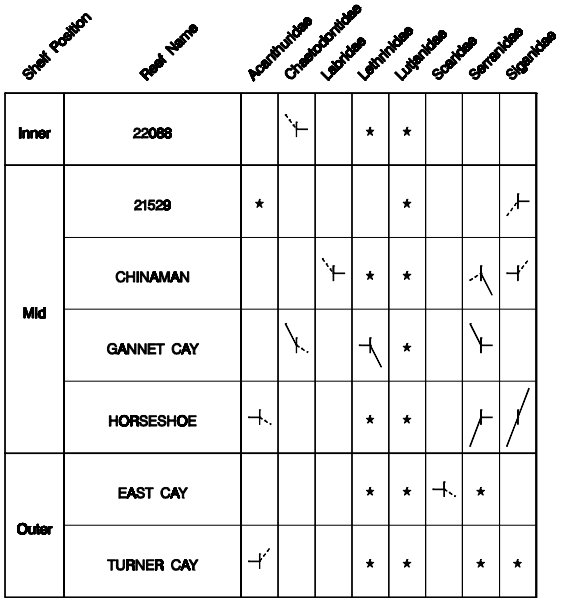


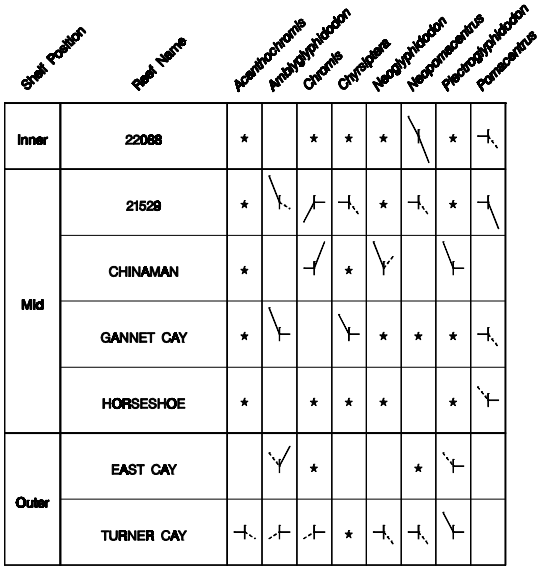
J4 Summary of temporal trends in (G) the larger reef fishes and (H) damselfishes on core survey reefs in the Whitsunday sector. *For interpretation see Cooktown / Lizard Is. sector above*



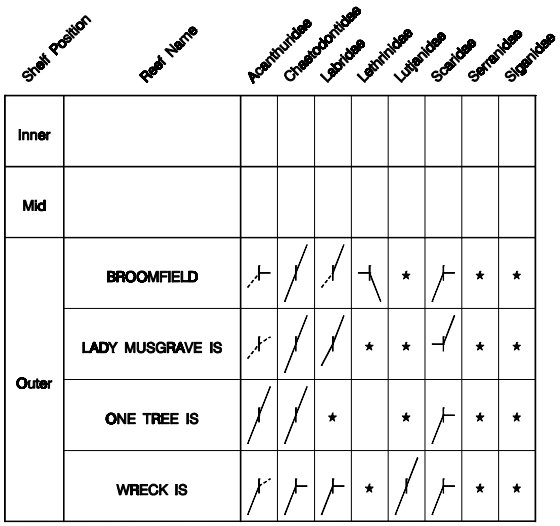


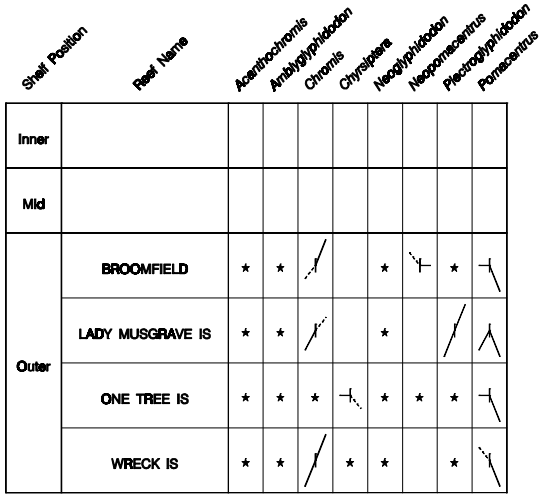
J5 Summary of temporal trends in (I) the larger reef fishes and (J) damselfishes on core survey reefs in the Swain sector. *For interpretation see Cooktown / Lizard Is. sector above*





J6 Summary of temporal trends in (K) the larger reef fishes and (L) damselfishes on core survey reefs in the Capricorn / Bunker sector. *For interpretation see Cooktown / Lizard Is. sector above*





Appendix K

Statistical Analysis of the LTMP Survey Data

Analysis of Individual Reef Trends

Fish

Fish abundance data were collected using under water visual surveys. Initially, these surveys used transects that were 2 m wide for small site attached fish, and 10 m wide for larger mobile fish. These transects were found to be too wide and widths were decreased from 2 m to 1 m and 10 m to 5 m, prior to the third year of the survey.

The model chosen to describe fish counts (y_{ijklm} represents the natural logarithm of the number of fish-plus-one of a particular taxon counted on site *l* for the k^{th} reef in the ij^{th} region at time *m*) was:

$$y_{ijklm} = \beta_{oijk} + \delta x_{\delta} + \beta_{1ijk} x_{ijklm} + \beta_{2ijk} x^2_{ijklm} + \varepsilon_{ijklm}$$

where

β_{oijk} represents the response at $x_{ijklm} = 0$ for the k^{th} reef in the ij^{th} region,

δ represents the change in $\ell n(count + 1)$ between transects of different width,

x_{δ} is a dummy variable which takes on the value 1 for transects surveyed in the first two years of the study and 0 for the remaining transects,

β_{1ijk} represents the instantaneous rate of change of the response at $x_{ijklm} = 0$ for the k^{th} reef in the ij^{th} region,

β_{2ijk} represents the curvature of the response for the k^{th} reef in the ij^{th} region,

x_{ijklm} is the coded survey number for the l^{th} site, k^{th} reef in the ij^{th} region at time *m*,

and ε_{ijklm} is the error term

Coding of survey number

The data were analysed twice using the survey number coded as:

$$x_{ijklm} = (survey\ number - 3.5)$$

and

$$x_{ijklm} = (survey\ number - 6.0)$$

to allow direct estimation of β_{oijk} and β_{1ijk} at two different times during the survey period. When the survey number is centered around 3.5, the parameters β_{oijk} and β_{1ijk} represent the average value of the response over the period of the survey for reef *ijk* and the linear change in the response over the period of the survey for reef *ijk*, respectively. When the survey number is centered around 6, the parameters β_{oijk} and β_{1ijk} represent the estimated average value of the response for reef *ijk* in the last survey year and the instantaneous linear change in the response for reef *ijk* in the last survey year, respectively.

Correction factor for the change in transect width

The term δ represents the change in $\ell n(count + 1)$ due to the change in transect width. This change was assumed to be the same for all reefs at all sites for an individual taxon. This implies that the only difference between fish counts on transects of different widths was due to sampling error, and that there were no consistent regional differences.

Choosing a covariance structure

It was assumed that the errors were distributed as a multivariate normal with mean 0 and covariance structure Σ. The form of Σ was chosen as follows:

(1) the value of the likelihood was obtained for the model above assuming each of the following covariance structures:

(a) independence

(b) compound symmetry

(c) first order autoregressive

(d) autoregressive moving average (ARMA(1,1))

(e) Toeplitz

In each case the structure was assumed to be homogeneous for all reefs.

(2) the likelihood ratio test was then used to compare nested models and to choose the simplest nested covariance structure which described the model adequately.

Power

The measure of power that was used for this analysis was the minimal detectable rate of change. This estimates the smallest rate of change significantly different from zero $(\Delta\beta_{1ij})$ that could be detected reliably (90% of the time at the 5% level of significance). This measure was calculated for each taxon at each reef using the following formula:

$$\Delta\beta_{1ijk} = se_{\beta_{1ijk}}(\phi(0.975)+\phi(0.90))$$

where

$se_{\beta_{1ijk}}$ is the standard error of the rate of change for reef *ijk*

$\phi(0.975)$ is the 97.5 percentile of the standard normal distribution which corresponds to a two sided test for and $\alpha = 0.05$

$\phi(0.90)$ is the 90th percentile of the standard normal distribution corresponding to a power of 90% (Zar 1984).

The average minimum detectable rate of change was tabulated on the logarithmic scale and can be converted to a rate of change on the count scale using Figure K1. To do this:

(1) estimate the mean abundance of fish per site for the reef of interest or the abundance of fish for the reef of interest in the last survey year (see appropriate reef page or Appendix H)

(2) find this value on the horizontal axis of Figure K1.

(3) draw a vertical line through this point until it intersects the two isopleths (or the margins of the figure) which bracket the minimal detectable rate of change of the taxa of interest (from Table K1)

(4) draw a horizontal line through each of these points until they intersect the left hand vertical axis

(5) the points of intersection on the vertical axis bracket the minimal detectable rate of change in abundance for the reef for interest.

Table K1: Average minimum detectable rate of change for abundances of different reef fish taxa based on means for sites on reefs. MDD over 6 years is the minimum detectable rate of change for the average trend, MDD (current) refers to minimum detectable rate of change at the most recent survey. Note that these values are absolute; they apply to both positive and negative rates of change. These values are used in conjunction with Figure K1.

Larger fishes	**MDD over 6 years**	**MDD (current)**
Acanthuridae	0.30	0.79
Chaetodontidae	0.24	0.63
Labridae	0.27	0.73
Lethrinidae	0.44	1.16
Lutjanidae	0.40	1.05
Scaridae	0.33	0.88
Serranidae	0.39	1.03
Siganidae	0.42	1.12

Damselfishes	**MDD over 6 years**	**MDD (current)**
Acanthochromis	0.38	1.04
Amblyglyphidodon	0.23	0.65
Chromis	0.55	1.53
Chrysiptera	0.38	1.05
Neoglyphidodon	0.30	0.84
Neopomacentrus	0.69	1.90
Plectroglyphidodon	0.20	0.56
Pomacentrus	0.20	0.56

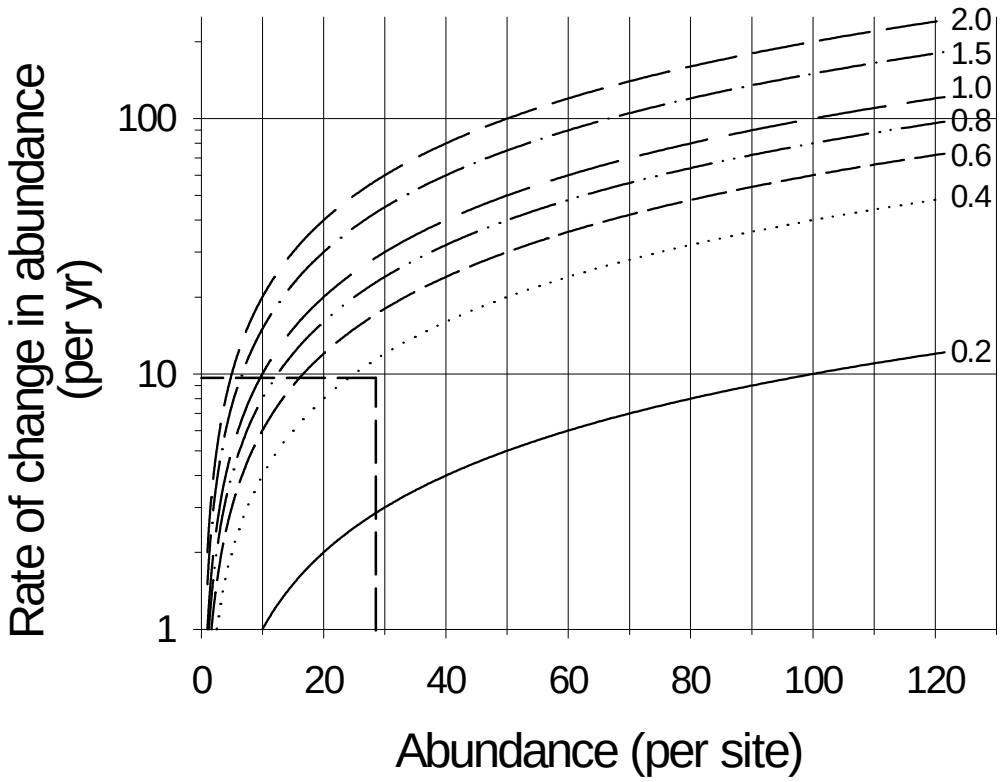


Figure K1: Relationship between mean abundance of fish per site and detectable rate of change in abundance for different values of minimum rate of change (MDD). Note detectable rate of change is given on a log scale. ***Interpretation:*** Drop-line gives an estimate of minimum detectable rate of change for overall trends in abundance of *Acanthochromis* on inshore reefs in the Whitsunday sector. From Appendix 5, mean abundance in 1996 was 86 fish per reef, thus the abundance per site was 86/3 = 28.6 (X axis). From Table K1, average minimum detectable rate of change over six years was 0.38. Using an interpolated MDD curve below that for MDD = 0.4, the estimated minimum detectable rate of change would be a gain or loss of about 10 fish annually.

transect recorded on videotape. Statistical analysis of these estimates differed from the analysis described for the fish taxa in the following ways:

(1) the response (average percent cover of 5 transects) is transformed using the empirical logit:

$$log\left(\frac{p+cf}{100-p+cf}\right)$$

where p was the average percentage cover for a given benthic group and cf represented the correction factor for zero $\left(cf = \frac{1}{2} * \frac{1}{200} * \frac{1}{15} * 100\right)$ where $\frac{1}{2}$ is the correction factor suggested by McCullagh and Nelder (1989), $\frac{1}{200}$ averages this single point over the number of points sampled for a video transect (200), $\frac{1}{15}$ average this number over the 15 transects and 100 puts this on a percentage scale).

(2) the statistical model is the same as the model used for the fish taxa analysis, but with the term representing the change in transect width (δ) removed.

(3) for the calculation of power: estimates of the level of cover are obtained from the appropriate reef page or Appendix G; Figure K2 is used in conjunction with Table K2.

Table K2: Average minimum detectable rate of change for percent cover of different taxa of benthic organisms based on means for sites on reefs. MDD over 6 years is the minimum detectable rate of change for the average trend, MDD (current) refers to the minimum detectable rate of change at the most recent survey. Note that these values are absolute: they apply to both positive and negative rates of change. These values are used in conjunction with Figure K2.

Taxon	MDD over 6 years	MDD (current)
Hard Corals	0.20	0.50
Acroporidae	0.38	0.96
Tabulate *Acropora* spp.	0.95	2.76
Other *Acropora* spp.	0.42	1.06
Montipora spp.	0.84	2.35
Faviidae	0.38	1.03
Pocilloporidae	0.48	1.26
Poritidae	0.60	1.57
Soft Corals	0.29	0.84
Algae	0.22	0.61

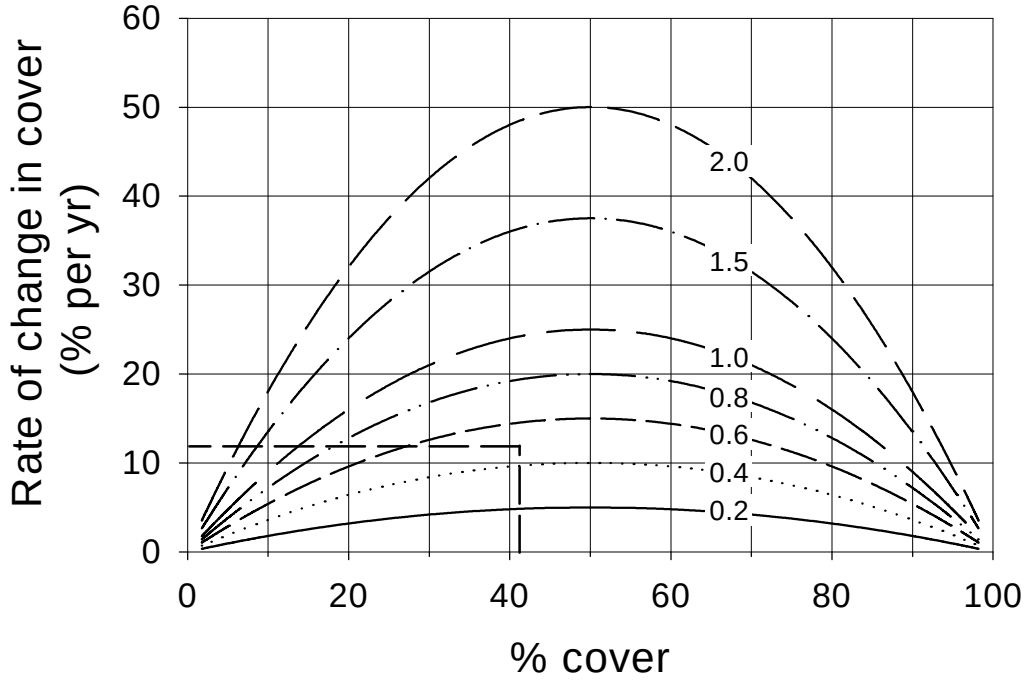


Figure K2: Relationship between cover of benthic taxa per site and detectable rate of change in percent cover for different values of minimum detectable difference (MDD) in rate of change. ***Interpretation:*** Drop-line gives an estimate of minimum detectable rate of change for the current trend in hard corals on Davies Reef (Townsville sector). From Appendix 4, mean percent cover in 1998 was 41.9 (X axis). From Table K2, the average minimum detectable rate of change is 0.50. Using an interpolated MDD curve between those for MDD = 0.4 and MDD = 0.6, the estimated minimum detectable rate of change would be a gain or loss of about 12% cover annually.

Analysis of regional trends

Fish abundance and benthic cover data

The regional analysis for both groups was carried out using the same models from the corresponding reef trend analysis, with the following changes:

(1) reef means were used instead of site means for the benthic cover analysis

(2) reef means of $\ell n(count+1)$ were used instead of $\ell n(count+1)$ for the fish count data

(3) covariance structures which were heterogeneous across shelf position were considered.

(4) for the calculation of power: estimates of the benthic cover or fish abundance are obtained from Appendices E or F; Tables K3 and K4 are used instead of Tables K1 and K2.

Table K3: Average minimum detectable rate of change for abundances of different reef fish taxa based on **regional** means for sites on reefs. MDD over 6 years is the minimum detectable rate of change for the average trend, MDD (current) refers to the minimum detectable rate of change at the most recent survey. Note that these values are absolute; they apply to both positive and negative rates of change. These values are used in conjunction with Figure K1.

Larger fishes	**MDD over 6 years**	**MDD (current)**
Acanthuridae	0.27	0.53
Chaetodontidae	0.21	0.46
Labridae	0.18	0.38
Lethrinidae	0.36	0.85
Lutjanidae	0.32	0.99
Scaridae	0.23	0.54
Serranidae	0.29	0.73
Siganidae	0.32	0.92

Damselfishes	**MDD over 6 years**	**MDD (current)**
Acanthochromis	0.36	0.66
Amblyglyphidodon	0.26	0.50
Chromis	0.70	1.46
Chrysiptera	0.37	0.86
Neoglyphidodon	0.28	0.57
Neopomacentrus	0.66	1.53
Plectroglyphidodon	0.23	0.48
Pomacentrus	0.20	0.40

Table K4: Average minimum detectable rate of change for percent cover of different taxa of benthic organisms based on **regional** means for sites on reefs. MDD over 6 years is the minimum detectable rate of change for the average trend, MDD (current) refers to the minimum detectable rate of change at the most recent survey. Note that these values are absolute: they apply to both positive and negative rates of change. These values are used in conjunction with Figure K1.

Taxon	MDD over 6 years	MDD (current)
Hard Corals	0.26	0.61
Acroporidae	0.41	1.02
Tabulate *Acropora* spp.	1.28	3.88
Other *Acropora* spp.	0.45	1.09
Montipora spp.	0.83	2.42
Faviidae	0.32	0.95
Pocilloporidae	0.55	1.45
Poritidae	0.54	1.61
Soft Corals	0.36	0.91
Algae	0.36	1.01

Broad scale survey data

The broad scale data are visual estimates of the average number of COTS per tow and the average hard coral cover per tow. The analysis of these data was based upon the use of summary statistics to obtain the best estimates of the sector trend. The sector trends were obtained in the following fashion:

(1) for each reef the following quadratic model was fit:

$$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \varepsilon_i$$

where y_i represents the average coral cover or the $\ell n(average\,COTS\,count + 1)$ on a given reef for year *i*, β_o represents the average response at year Z, β_1 represents the rate of change at year Z, β_2 represents the curvature of the trend, x_i = *survey number* - Z, and ε_i represents the error.

(2) for each reef the response for each year (including the years where observations are missing) was estimated using the model presented in (1).

(3) for each region, the estimate of the average response was obtained by averaging the predicted response for each reef for each year.

(4) finally, the average response was back transformed to the original scale where required.

Statistical computing

The SAS system software (SAS Institute Inc., Cary, NC, USA) was used for all analyses. The MIXED procedure was used to fit the statistical models described for the fish abundance and benthic cover data. The REG procedure was used to obtain the estimates described for the broad scale survey data.