LONG-TERM MONITORING

OF THE

GREAT BARRIER REEF

Status Report

Number 7, 2005

by

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Executive summary

The Great Barrier Reef (GBR) has great economic importance as well as immense aesthetic value, contributing an estimated $5.8 billion to the Australian economy, principally through tourism and other recreational activities as well as fisheries in the Great Barrier Reef catchment area. Inscription on the World Heritage List recognises the area's global significance and entails regular reporting on its status. Information about natural variability of populations is essential for informed management. The AIMS Long-term Monitoring Program is designed to provide information on population trends in 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 World Heritage Area (GBRWHA). The results contained within this report are intended to be a primary source of strategic information for the Great Barrier Reef Marine Park Authority (GBRMPA), the Commonwealth Government lead agency for matters concerning the care and development of the GBRWHA.

This report presents a synthesis of monitoring data collected up to the 2005 field season. Data from 2004 and 2005 have not been reported previously.

Broadscale manta tow surveys have been carried out in 11 latitudinal sectors spanning the length of the GBR for a period of 19 years (1986-2005) and have significantly increased our understanding of the crown-of-thorns-starfish (COTS) phenomenon. The perimeters of 89 reefs were surveyed using manta tow in 2004; the figure for 2005 was 99 reefs.

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 survey reef. Sites on 47 reefs were surveyed in 2004 and on 46 reefs in 2005.

Major results were:

Crown-of-thorns starfish

The percentage of reefs on the GBR with outbreaks of COTS has fluctuated: there were Active or Incipient Outbreaks on 16% of the 89 reefs surveyed in 2004 and on 11% of 99 reefs surveyed in 2005. The highest percentage of reefs with Active Outbreaks recorded in the 19 years of surveys was 17%, recorded in 1987, 1999 and 2000.

A similar pattern is seen in the overall density of COTS on the GBR. The overall mean number of COTS per tow was 0.24 in 2004 and 0.14 in 2005. This was less than in 2003 when the overall mean was 1.21 COTS per tow. For comparison, the highest overall mean number of COTS per tow on the GBR during the last major wave of COTS outbreaks was 1.17 in 1988.

Details of the current distribution of COTS are as follows:

- The densities of COTS in the Townsville and Swain sectors decreased between 2003 and 2005, though significant numbers of starfish remained in the Townsville sector.
- Average COTS density on reefs in the Pompey sector increased since 2003 with two reefs having incipient outbreaks and one reef having an active outbreak. Average densities of COTS increased slightly on reefs in the Cape Grenville sector (two reefs with incipient outbreaks) and the Whitsunday sector (one reef with an incipient outbreak)

- There were no significant changes in COTS densities within the other six GBR sectors.

Coral Cover

The salient changes on the Great Barrier Reef over the thirteen years to 2005 reflect the impact of COTS and cyclones, and to a lesser extent bleaching and disease, on reef communities and their subsequent recovery from such disturbances. Key results were:

- The highest mean value for cover of living coral on the perimeter of reefs (henceforth: reef-wide live coral cover) in 2004 and 2005 (43% and 48% respectively) occurred on mid-shelf reefs in the far northern Cape Grenville sector. The recorded values for reef-wide live cover were higher (59% and 61% respectively) in the outer-shelf region in the Pompey sector, but only one reef (Ben Reef) was surveyed.
- Lowest values for reef-wide live coral cover (10% and 7%) in 2004 and 2005 were found on mid-shelf reefs in the Innisfail sector. Reefs in the Innisfail sector had large COTS populations in the recent past as well as mass bleaching in 1998. Cover on inshore reefs in the Cairns sector was similarly low (11% and 9% respectively).
- Surveys of permanent survey sites on northeast faces of 48 reefs in 2005 found that cover of hard coral was highest in the Capricorn Bunker sector (55%), followed by reefs in the mid shelf region of the Whitsunday sector (42%). These regions have been recovering from storm damage over the 13 years of intensive surveys.
- Hard coral cover on permanent survey sites was lowest on the midshelf reefs of the Townsville sector (13%) in 2005. Many of these reefs have been affected by COTS outbreaks in recent years.
- Hard coral cover increased on the permanent survey sites in the outer shelf region of the Cooktown - Lizard Is. sector and the Capricorn Bunker sector over the 13 years of surveys, though the rate of increase has slowed since 1999. Reefs in these regions were damaged by storms in the late 1980s but had high coral cover in 2005.
- Hard coral cover on the permanent survey sites in the inner regions of the Cairns and Townsville sectors declined in the late 1990s due to coral bleaching and COTS. There is evidence of a slow recovery.
- The occurrence of coral diseases declined in all regions from the high levels recorded in 2003. Occurrence of white syndrome is lower but still common on outer shelf reefs in the Cooktown - Lizard Is sector

Reef fishes

While abundance of 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 in a region showed a consistent trend:

- The majority of larger, more mobile fish families, and damselfish genera, increased in abundance over the 13 years of surveys in the Capricorn Bunker sector. Several groups, such as surgeonfishes, butterflyfishes, parrotfishes, wrasses and coral associated damselfishes, continued to increase over the last two years. Coral cover increased greatly in this region from very low levels recorded in 1989; the changes in fish assemblages reflect this.

- The numbers of surgeonfishes and parrotfishes has increased on the majority of reefs in the Townsville sector in recent years.
- In other sectors, most families of larger mobile fishes showed little net change in abundance over the 13 years of surveys. Most families also did not change in abundance over the last two surveys, though slightly more increased than decreased.
- Abundances of two genera of coral associated damselfish increased over the 13 years of survey at all reefs in the Cooktown - Lizard Is. sector; this again reflects large increases in coral cover in this region.
- In other sectors, changes in abundance of most damselfish genera were not consistent within regions over the 13 years of surveys.
- Abundances in the majority of damselfish genera increased over the last two surveys in the Cooktown - Lizard Is., Cairns, Townsville and Whitsunday sectors.
- Abundance of a sizeable minority of damselfish genera declined on reefs in the Swain sector over the last two surveys, particularly *Pomacentrus* spp.

1. Introduction

Background

The Australian Institute of Marine Science set up a long-term monitoring program for the Great Barrier Reef (GBR) in 1992. The program is based on some previous 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 and subsequently the Cooperative Research Centre for the GBR World Heritage Area.

Scope and limitations of the program

The objective of coral reef monitoring is to track 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 changes in reef communities on the GBR. The GBR World Heritage Area (GBRWHA) includes the GBR Marine Park, administered by the Commonwealth of Australia, and a small area owned by the State of Queensland. About 2% of the GBRWHA is not declared as Marine Park. The Great Barrier Reef Marine Park Authority (GBRMPA) is the lead agency for GBRWHA issues and principal adviser to the Commonwealth Government on care and development of the GBR Marine Park. Information from the AIMS LTMP contributes significantly to the GBRMPA's reporting on the status of the GBRWHA as required by the World Heritage Commission of UNESCO. It also allows park managers to place small scale, site-specific changes in the context of changes that are observed over much larger scales. This provides some perspective on the importance and significance of site-specific status and change.

The specific 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 GBR 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 northeast face of each survey reef, but the perimeter of each reef is also surveyed by manta tow to give a reef-wide estimate of hard coral cover.

Structure of this report

This report describes changes on a large scale that includes most of the GBR (Section 3) and at individual reef scale organised by latitude (sector) and cross-shelf position (Section 4). Data from broadscale manta tow surveys are presented from 1986 to 2005. Data from intensive sampling of reef fish and benthic communities and are presented from 1993 to 2005. Data from 2004 and 2005 have not been reported previously. Because of the biological

imperative to look at periods longer than one year and the increasing complexity of statistical functions required to model variation over long periods, a number of unique statistical analysis have been developed for this report (Appendix I). This is in contrast to previous reports (Sweatman et al. 1998, 2000) where linear models have been used to interpret data from the most recent six surveys rather than the entire data set.

This and previous reports are now available on the Institute's web site along with up to date results of recent surveys:

http://www.aims.gov.au/reef-monitoring

2. Methods

Program design

The AIMS Long-term Monitoring Program is designed to track changes in reef communities over time at a regional scale. In this context, reefs in a "region" are those that lie in one of three positions across the shelf (inshore, middle shelf, outer shelf) within one band of latitude (a sector). Surveys by the Long-term Monitoring Program involve three "tasks": manta tow surveys for crown-of-thorns starfish (COTS) and reef-wide coral cover (broadscale surveys), surveys of sessile benthic organisms using video and visual counts of reef fishes. Broadscale surveys cover reefs in 11 sectors. Reefs are only surveyed intensively in six of the sectors. The data that are collected by each task are listed in Table 2.1.

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 (reefs in 11 sectors)	Crown-of-thorns starfish counts; estimates of cover of live hard and soft coral, dead coral, other incidental observations (e.g. coral bleaching, giant clams, reef aesthetics)
SCUBA search	Visual search along fixed transects at selected sites in one reef habitat (reefs in 6 sectors)	Search for agents of coral mortality: adult and juvenile COTS, *Drupella,* coral diseases
Benthic Organisms	Video records along fixed transects at selected sites in one reef habitat (reefs in 6 sectors)	Percent cover of all identifiable sessile benthic organisms
Fishes	Visual surveys on fixed transect at selected sites in one reef habitat (reefs in 6 sectors)	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 the variation in composition of coral and fish communities (Done 1982, Williams 1982), which are known to be greater across the GBR from the coast to the Coral Sea, than they are along its length.

The core reefs were selected within six of the 11 cross-shelf sectors (Fig. 2.1) that had been identified for broadscale, manta-tow surveys for COTS (Bainbridge et al. 1994). Where

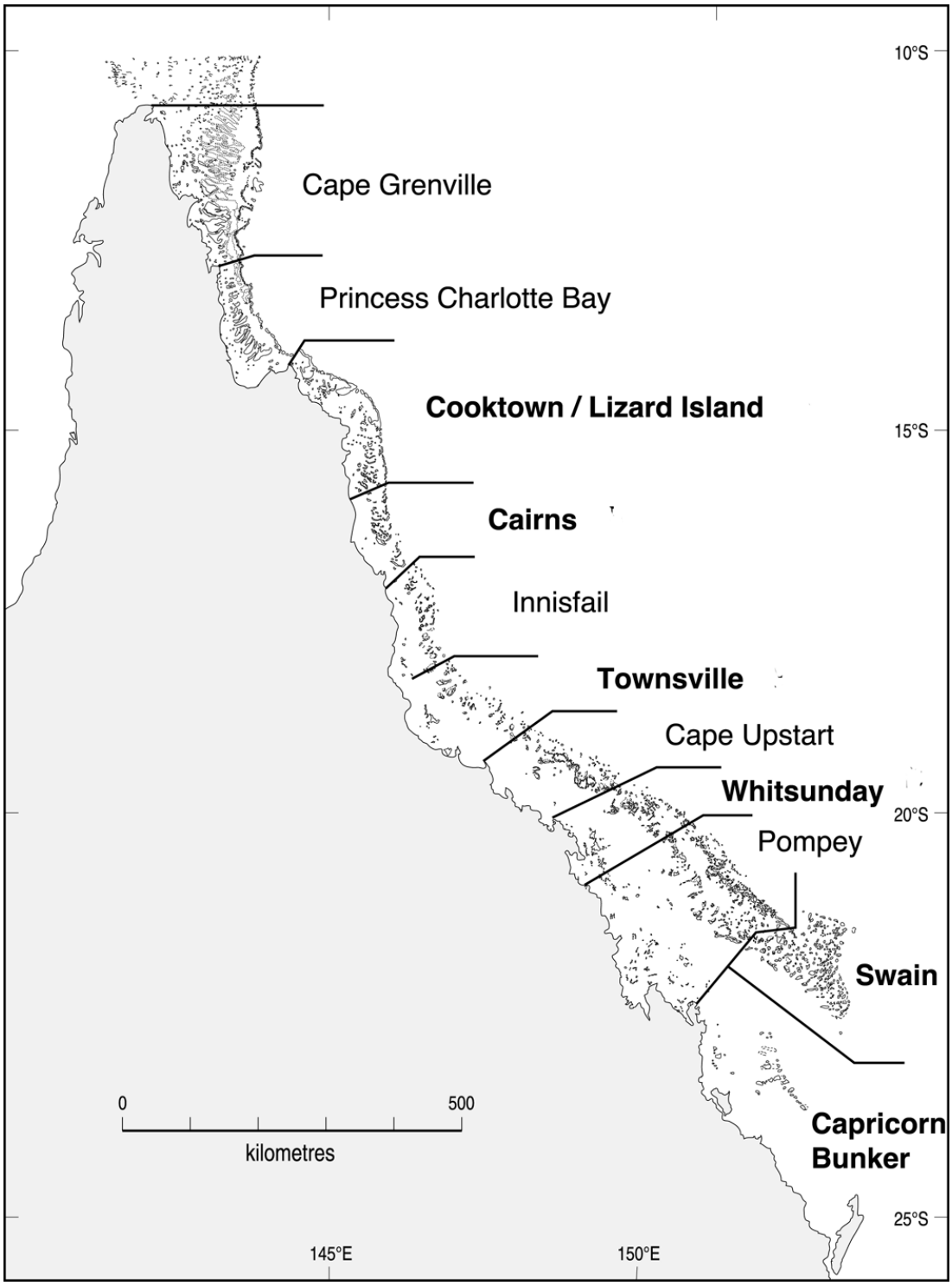


Figure 2.1 Map of the GBR showing the locations of latitudinal sectors. The six sectors where LTMP core survey reefs are located are shown in bold face type.

possible, in each sector, three or more reefs were selected in each of three positions across the continental shelf: inshore, middle shelf and outer shelf.

There are no inshore or middle shelf reefs in the Capricorn Bunker sector. Also, the innermost reefs in the Swains sector are more than 100 km from the mainland and so are not subject to coastal influences. These innermost Swain reefs are therefore grouped with middle shelf reefs in this report.

The core survey reefs were chosen from the reefs within each region (sector by shelf position combination) 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 since been reduced to 47 because some reefs could not be sampled reliably on a regular basis.

Each year an additional 55 reefs from the 11 sectors are scheduled to be surveyed using manta tow only. Some of these reefs are surveyed every year (key reefs); others are surveyed every third year (cycle reefs). These manta tow reefs take second priority to core survey reefs and the full set of surveys is rarely completed because of bad weather and limited ship time. Maps and a listing of reefs surveyed in 2005 are given in Appendices A and B.

Sampling methods

The core survey reefs are sampled in two stages (Fig. 2.2). Fishes and benthic organisms are surveyed intensively along transects at three sites in a habitat that is standardised across the survey 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 towards the front reef in a clockwise direction. The sites are usually situated on the northeast flank of the reef. Sites are separated by at least 250 m where possible. The entire perimeter of each reef is surveyed using manta tows, providing a reef-wide context for the intensive surveys.

There are five 50 m transects within each site. These transects were initially laid haphazardly, roughly following depth contours with 10 - 40 m between them. Transects are permanently marked with a star picket at each end and with lengths of reinforcing rod at

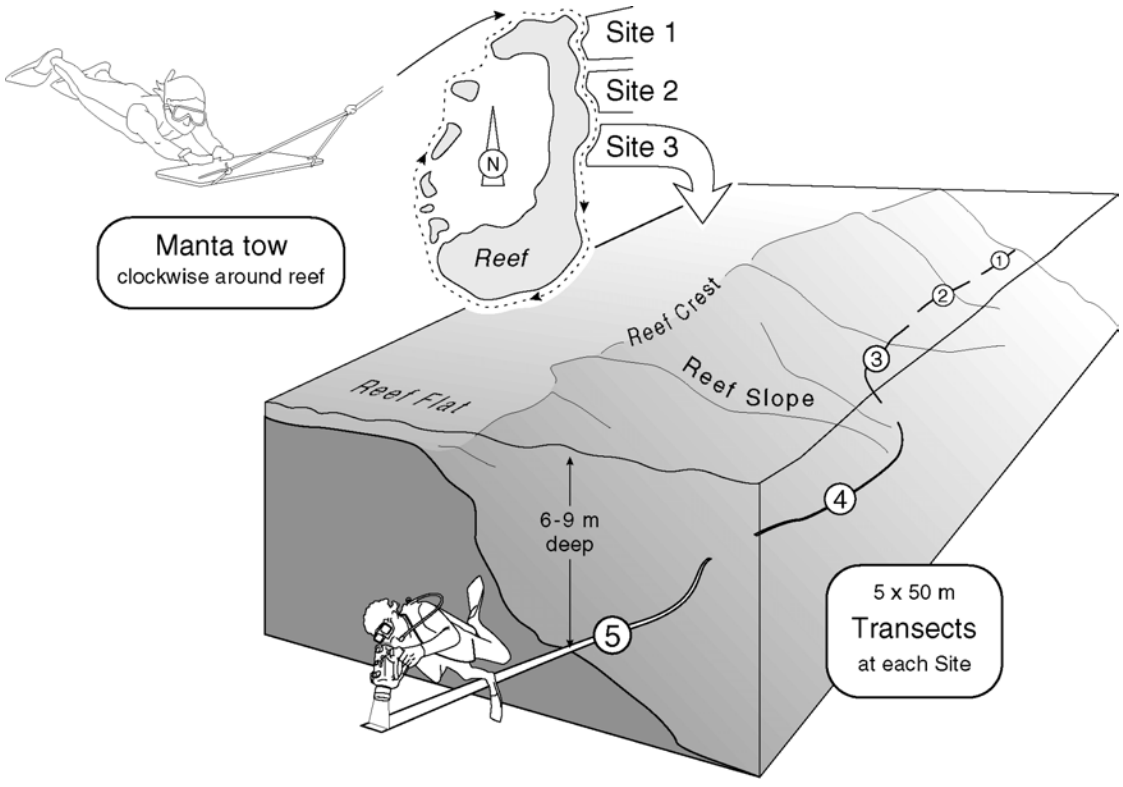


Figure 2.2: Schematic arrangement of sampling effort on a core survey reef.

10 m intervals. Transects run parallel to the reef crest at about 6-9 m depth (Fig. 2.2).

Surveys are made between July of one year and June of the next year. The reefs in each sector are surveyed at about the same time each year in a series of five or six cruises that alternate to the north and the south of Townsville.

In this report, annual surveys are referred to by the year in which the field season ended: thus surveys made between July 2004 and June 2005 are referred to as 2005 surveys.

47 core reefs were sampled for fish and/or benthos in 2004. In 2005, 46 core reefs were sampled (Appendix B). Perimeters of 89 reefs were surveyed by manta tow in 2004 (Appendix B). Perimeters of 99 reefs were surveyed by manta tow in 2005.

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 Operational Procedures (SOPs, Table 2.2). These document 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/reef-monitoring).

Table 2.2: Titles of standard operational procedures. These are available in electronic form at www.aims.gov.au/reef-monitoring

Broadscale surveys	Miller IR, Coleman G and Abdo D (2004) Crown-of-thorns starfish and coral surveys using the manta tow and SCUBA search techniques. Standard Operational Procedure No. 8, AIMS, Townsville. 38 pp.
Fishes	Halford AR and Thompson AA (1996) Visual census surveys of reef fish. Standard Operational Procedure No. 3, AIMS, Townsville. 24 pp.
Benthos	Abdo D, Burgess S, Coleman G, and Osborne K (2003) Surveys of benthic reef communities using underwater video. Standard Operational Procedure No. 9, AIMS, Townsville. 48 pp.
Data handling	Baker VJ and Coleman GJ (2000) A guide to the Reef Monitoring database. Standard Operational Procedure No. 5, AIMS, Townsville. 72 pp.

Data storage and access

Data are entered using a number of purpose-designed data entry and checking programs. All data are stored in an Oracle™ database at AIMS. The structure of the database is described in Baker and Coleman (2000).

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 COTS on the Great Barrier Reef. Manta tow surveys also include estimates of percent cover of living hard corals, living soft coral and recently dead hard coral, allowing assessment of the impact of COTS outbreaks and other large-scale disturbances. This report presents coral cover and COTS data from 18 years of broadscale surveys on the GBR.

Sampling techniques

Broadscale surveys use the manta tow technique as described by Miller et al. (2004) 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).

Quality control

Quality control occurs in two stages. First, all observers are trained before participating in the broadscale surveys (see Miller et al. 2004). Second, where time permits, on each sampling trip, a sub-sample of reefs is surveyed by two observers following the same towpath. This gives a measure of the variability between observers, which 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 hard and soft coral and dead hard 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). 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 perimeter and >30% of hard coral was dead. An 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 corresponds to 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" level.

Table 2.3: Primary variables recorded every 2 minutes during a manta tow survey. See Miller et al. (2004) 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 (11 categories)	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

Reef level trends in broadscale data on median live hard coral cover and average COTS density from manta tow surveys were calculated from the visual estimates of the number of COTS per tow and the live hard coral cover per tow. For each reef these data are provided on a per tow basis for the current survey year, to represent variability within a reef, and as reef averages in each survey year, to represent patterns over time. The reef-averaged data

are then averaged over all reefs in each sector to provide descriptive summaries for comparison among all sectors of the GBR.

Surveys of sessile benthos

Sampling techniques

Benthic organisms were surveyed on the five marked transects within each site on the core reefs. A 30 cm wide swathe was recorded along each 50 m transect using a digital video camera held 25-30 cm above the substrate. Percent cover of corals and other benthic categories (Table 2.4) 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 (Abdo et al. 2003).

Table 2.4**:** Explanation of benthic categories.

Major Benthic Group	
Hard Corals	Order Scleractinia
Soft Corals	Subclass Alcyonaria
Algae	Macro-algae, turf and coralline algae
Group Other	Other biota
Major Benthic Families	
Acroporidae	Family Acroporidae
Faviidae	Family Faviidae
Pocilloporidae	Family Pocilloporidae
Poritidae	Family Poritidae
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 in identifying organisms in the recordings and an on-going program monitoring agreement between all observers. A second on-going program checks field identifications against identifications in the recordings. The precision of estimates of cover for benthic organisms grouped to different levels of taxonomy has been estimated by Ninio et al. (2003).

Data handling and analysis

For each category of benthic organisms, the mean values (based on the five marked transects) for percent cover at each site in each survey 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 before analysis. Linear mixed-effects models were then used to estimate the temporal trend in the transformed annual estimates of abundance. The form of the temporal trend (i.e. no trend, linear, quadratic or smooth (nonlinear) trend) was determined by model selection (see Appendix I for a technical explanation).

The selected model was then used to estimate the overall trend (over all 13 annual surveys) and current trend for each core survey reef for each benthic category. Substantial increasing or decreasing trends in hard coral cover were defined as absolute annual changes of greater than 3% cover. Smaller changes (i.e. <3%) indicated no substantial trend. The number of reefs exhibiting increasing, decreasing or no trend in hard coral cover were then summed within each sector. The proportions of reefs exhibiting each type of trend were then represented in arrow plots to facilitate GBR-wide comparisons.

Surveys of reef fishes

Sampling technique

Fishes of 191 species (Appendix C) were counted on the same five 50 m transects at three sites on each reef where the benthic organisms were surveyed. Because the surveys span the annual recruitment season, 0+ individuals were excluded from counts. Full details of the sampling method are given in the SOP (Halford and Thompson 1996).

Quality control

All observers cross-calibrate their counts during each field season. Estimating the cut off point for 0+ individuals and rules for exclusion or inclusion of individuals crossing transect boundaries are 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 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 analysis

Counts were summed over the five transects, giving estimates of abundance at each of the three sites in the one area of each reef. As in previous Status Reports (Oliver et al. 1995, Sweatman 1997, Sweatman et al. 1998, Sweatman et al. 2000, Sweatman et al. 2001, Sweatman et al. 2004), larger species have been grouped into families and damselfishes (Family Pomacentridae) have been grouped into genera. This increases the power of the analyses, but complicates interpretation. Individual taxa were considered too rare to test if their average density was less than one per transect in any year.

To look at trends in abundance of fishes on individual reefs, the abundances for each site were log transformed [ln(y + 1)] to reduce the influence of abundant taxa and to stabilise

variances for analyses. Linear mixed-effects models were then used to estimate the temporal trend in the transformed annual estimates of abundance. The form of the temporal trend (i.e. no trend, linear, quadratic or smooth (nonlinear) trend) was determined by model selection (see Appendix I for a technical explanation). The selected model was then used to estimate the overall trend (over all 11 annual surveys) and current trend for each core survey reef. Substantial increasing or decreasing trends were defined as proportional annual changes of greater than 10%. Smaller proportional changes (i.e. <10%) were considered to indicate no substantial trend. The number of families of larger species, or the number of genera of smaller damselfishes on each reef that showed increasing, decreasing or no trend were then summed and those numbers were summed over all reefs within each sector. The resulting proportions of each group of fishes showing each type of trend were then represented in arrow plots to facilitate GBR-wide comparisons.

Surveys of agents of coral mortality (Scuba search)

Sampling technique

A diver swims with the intensive survey team and records COTS, classified as juvenile and small or large adult starfish, COTS feeding scars, *Drupella* spp., *Drupella* feeding scars, unknown scars, percentage of corals that are bleached and the numbers of colonies with five categories of coral disease that occur in a 2 m wide belt that is centred on the survey tapes. Full details of the sampling method are given in the SOP (Miller et al. 2004).

Quality control

All observers cross-calibrate their counts and categories of coral disease at the start of each field season.

Data handling and analysis

Summary data are given on the reef pages.

3. Reefs of the Great Barrier Reef: general trends

The aim of this section is to summarise the broad pattern of changes throughout the GBR. Trends in populations of organisms in regions of the GBR depend on the history of large-scale disturbances and the time that has been available for recovery. The principal disturbances in recent years have been due to crown-of-thorns starfish activity as the third recorded wave of outbreaks has continued to progress southward.

The analyses (Methods, Appendix I) of percent cover of benthic organisms and abundances of fishes on individual reefs identified two types of trends: average trends over the thirteen annual surveys, and current trends: those evident over the two years prior to the 2005 survey. Trends for the GBR are summarised here by considering the proportions of core survey reefs in each sector that show increasing, decreasing, or no substantial trends in cover of hard coral and abundance of reef fishes (see explanatory box below).

The crown-of-thorns starfish (COTS), *Acanthaster planci*, is an important cause of coral mortality when populations build up to outbreak levels. AIMS staff have been monitoring COTS populations since 1986. The results of these surveys are summarised in Fig. 3.1. Populations of the starfish have decreased to very low levels in the Innisfail sector. Starfish numbers decreased in the Townsville sector, though a new incipient outbreak was recorded at Helix Reef in 2005 and the number of reefs with outbreaks increased in the Cape Upstart sector. This is consistent with observations of previous waves of outbreaks, where the incidence of reefs with new active outbreaks moved south over time. The mechanism is assumed to be southward transport of larvae by the East Australian Current. Outbreaks in the Swains appear to occur independently of the main southward moving wave of COTS infestations. Only one reef in the Swains sector (Horseshoe Reef) had outbreak densities of COTS in 2005, compared with three reefs in 2004 and four reefs in 2003. The number of COTS recorded at Horseshoe Reef was also much lower than in 2004.

There has been a general increase in hard coral cover in the Capricorn Bunker sector over the 13 surveys (Fig. 3.2). Storms removed much of the coral from these reefs in 1988 (Fig. 3.1), but by 2003 the intensive survey sites in the Capricorn Bunker sector had the highest coral cover values in any region. The rate of increase in coral cover has slowed since 1999. Outer shelf reefs in the Cooktown / Lizard Is. sector showed a similar pattern over the survey period, though the sector-wide cover values were moderated by the limited recovery on middle shelf reefs in the sector after COTS outbreaks. The general situation in the Swain sector was that coral cover had increased, on average, on reefs without COTS, though in coral cover on the Swain reefs with high COTS numbers declined. Coral cover was declining on the majority of reefs in the Townsville sector in 2005, due to the feeding activity of COTS. Coral cover on reefs in the Cairns and Whitsunday sectors has changed little over the 13 years of surveys.

The general increasing trend in abundance of larger, more mobile reef fishes in the Capricorn Bunker sector over the past 13 years (Fig. 3.3) was associated with the increase in coral cover and habitat complexity. Most reefs in most sectors showed no net trends in abundances of larger reef fishes over 13 years, but a sizable minority of families showed current increasing trends in the Cooktown / Lizard Is., Cairns and Townsville sectors.

Several genera of damselfishes increased in abundance over the 13 survey years in the Capricorn Bunker sector in the south and the Cairns and Cooktown / Lizard Is. sectors in the north (Fig. 3.4). The increases in the Capricorn Bunker sector were associated with the increase in coral cover. Abundances of several damselfish genera increased on both inshore and outer-shelf reefs in the Cooktown / Lizard Is. sector. Coral cover increased on outer-shelf reefs, but there was no simple explanation for increases on inshore reefs. Abundances of the majority of damselfish genera increased over the last two surveys in all sectors except the Whitsunday and Swain sectors.

Explanation of summary plots

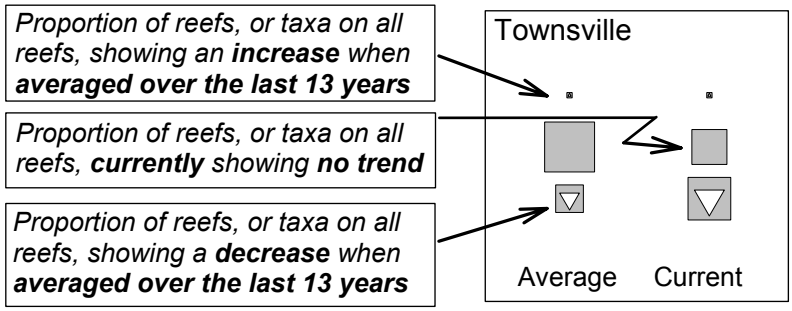
Trends in reef-wide cover of hard coral and in COTS estimated from broadscale surveys are represented by conventional line and bar graphs (Fig. 3.1).

The trends in hard coral cover and in fishes from intensive survey sites on reefs in each sector are represented by two sets of plots. The left hand set of squares represents the average "forced" linear trends over the past thirteen years while the right hand set represents current trends based on average change in the smoothed fitted curve over the last two years. Dimensions of the three filled squares reflect the proportion of taxa on survey reefs in each sector showing substantial (arbitrarily set at >3% change in hard coral cover and >10% proportional change in fish abundance) increasing trends, decreasing trends or no significant trend. Arrowheads within the squares indicate direction of trend.

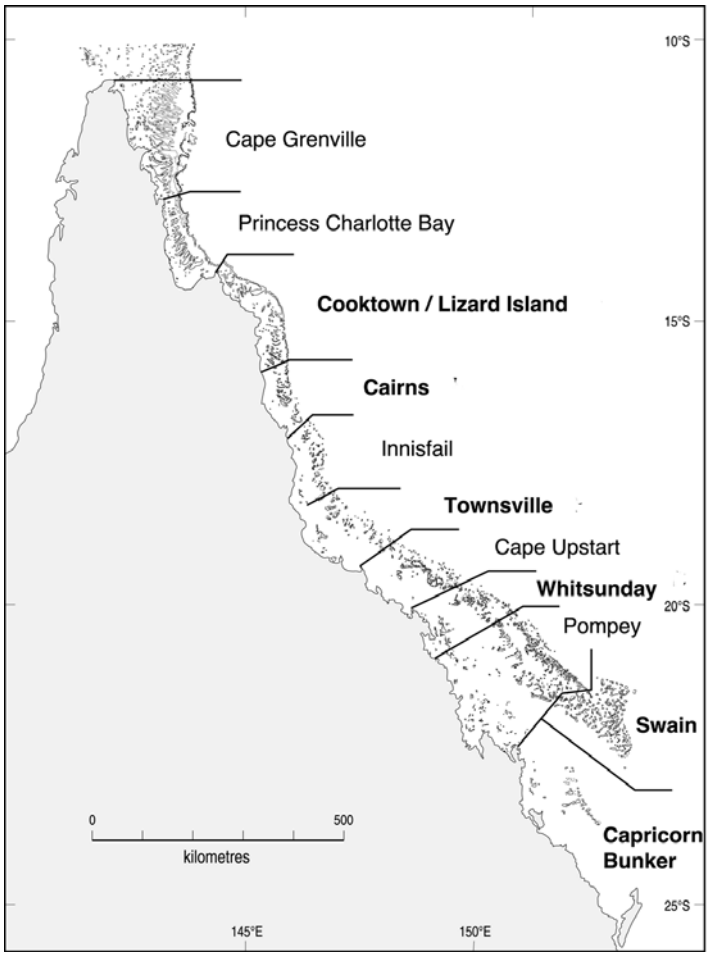
For hard coral cover (Fig. 3.2), the dimensions of the squares represent the proportion of reefs in each sector showing each trend (total = No. of reefs). For fishes (Figs. 3.3, 3.4), the dimensions of the squares represent the proportion of all taxa on all reefs in the sector that showed each trend (total = No. of fish taxa x No. of reefs).

Taxa that were too rare to allow a trend to be estimated were omitted.

An annotated example:



Summary of crown-of-thorns starfish activity on the Great Barrier Reef 1986-2005



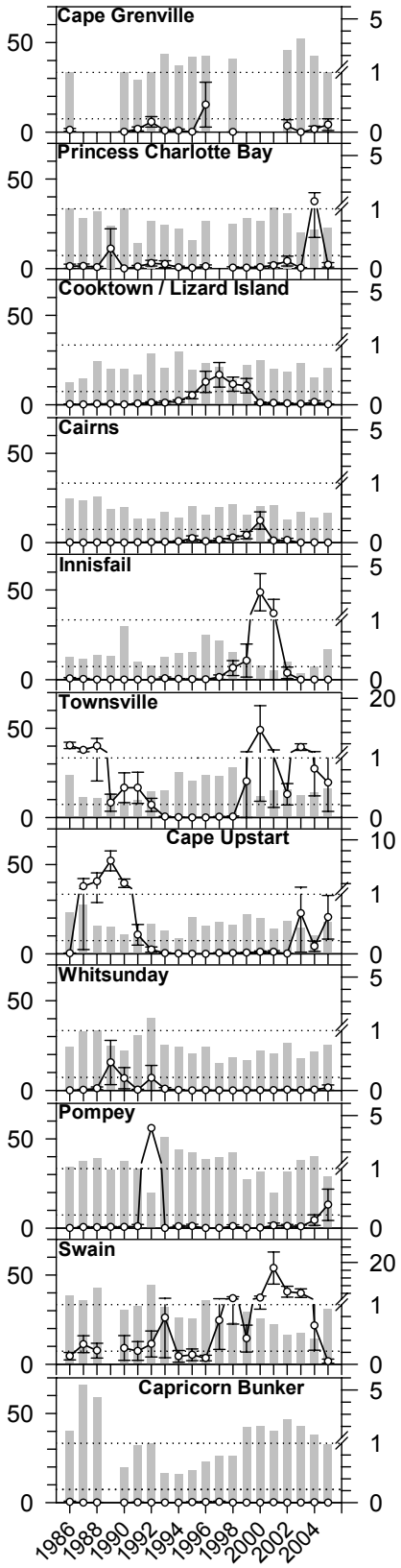


Figure 3.1 Summary of COTS populations and live coral cover for each survey sector on the GBR since 1986. Bar charts show mean live coral cover in each year (left hand axis); line plots show COTS abundances (COTS/tow ±SE) in each year (right hand axis). Lower dotted line = Incipient outbreak level (0.22 COTS/tow), upper dotted line = Active outbreak level (1.0 COTS/tow).

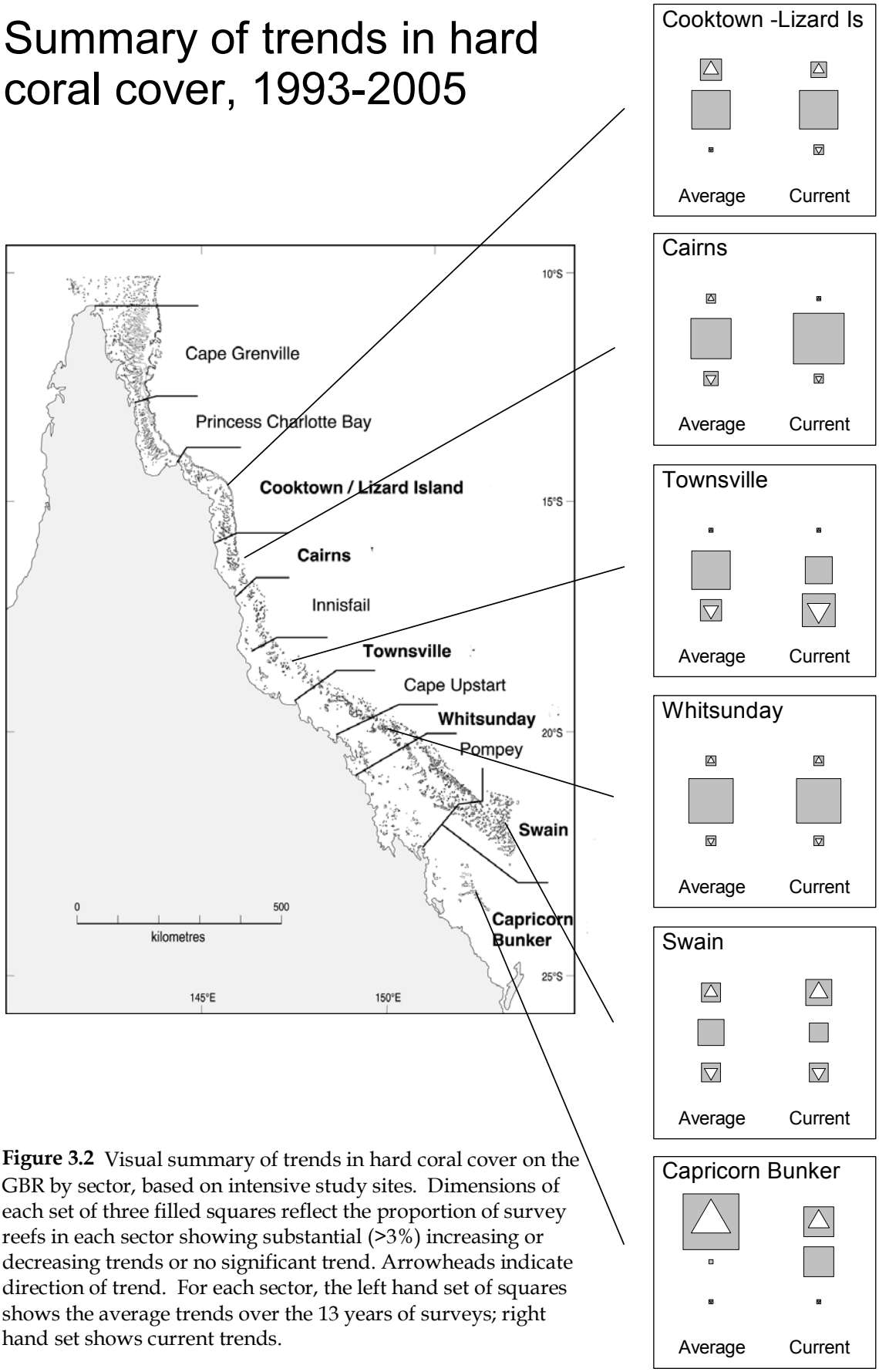


Figure 3.2 Visual summary of trends in hard coral cover on the GBR by sector, based on intensive study sites. Dimensions of each set of three filled squares reflect the proportion of survey reefs in each sector showing substantial (>3%) increasing or decreasing trends or no significant trend. Arrowheads indicate direction of trend. For each sector, the left hand set of squares shows the average trends over the 13 years of surveys; right hand set shows current trends.

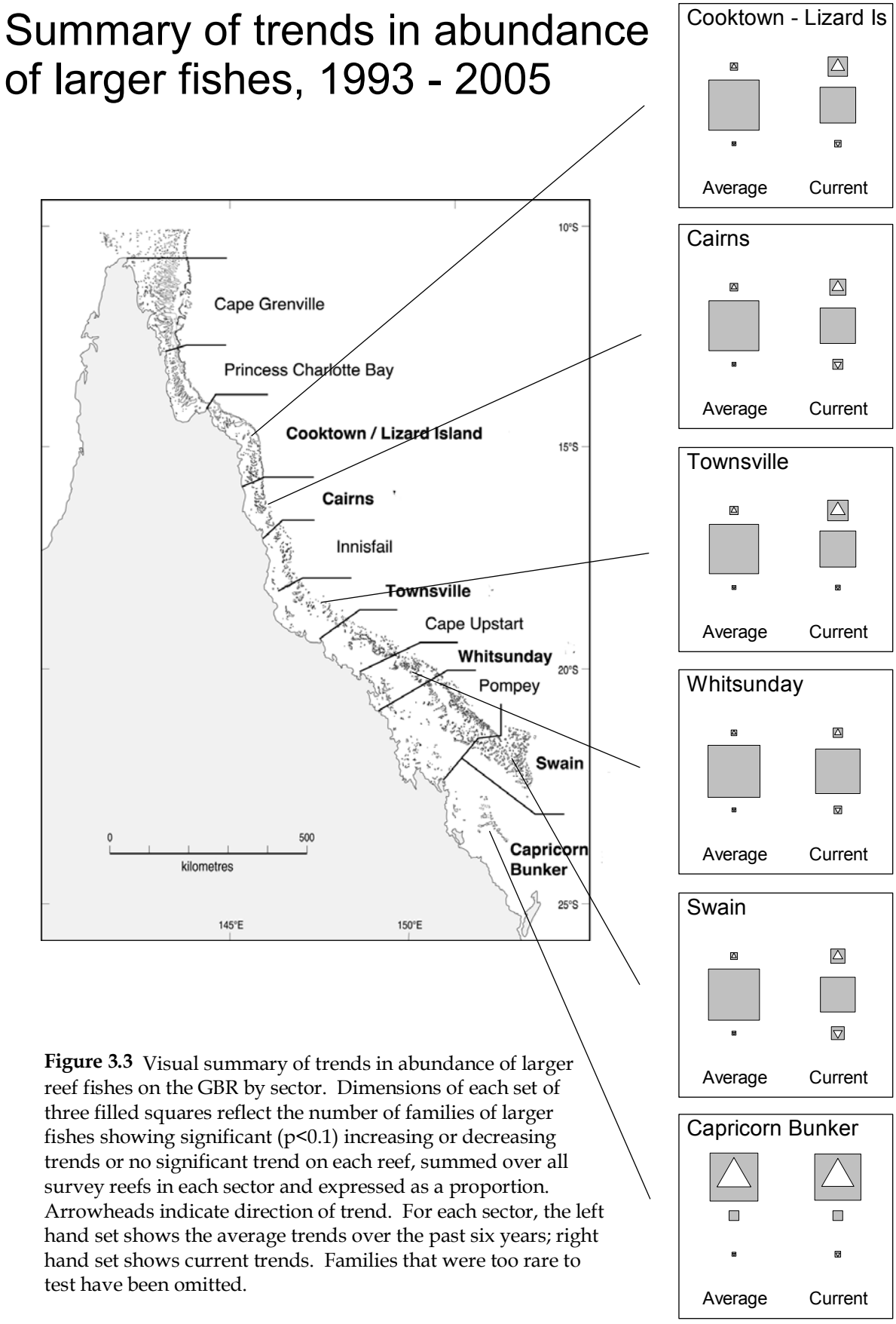


Figure 3.3 Visual summary of trends in abundance of larger reef fishes on the GBR by sector. Dimensions of each set of three filled squares reflect the number of families of larger fishes showing significant ($p<0.1$) increasing or decreasing trends or no significant trend on each reef, summed over all survey reefs in each sector and expressed as a proportion. Arrowheads indicate direction of trend. For each sector, the left hand set shows the average trends over the past six years; right hand set shows current trends. Families that were too rare to test have been omitted.

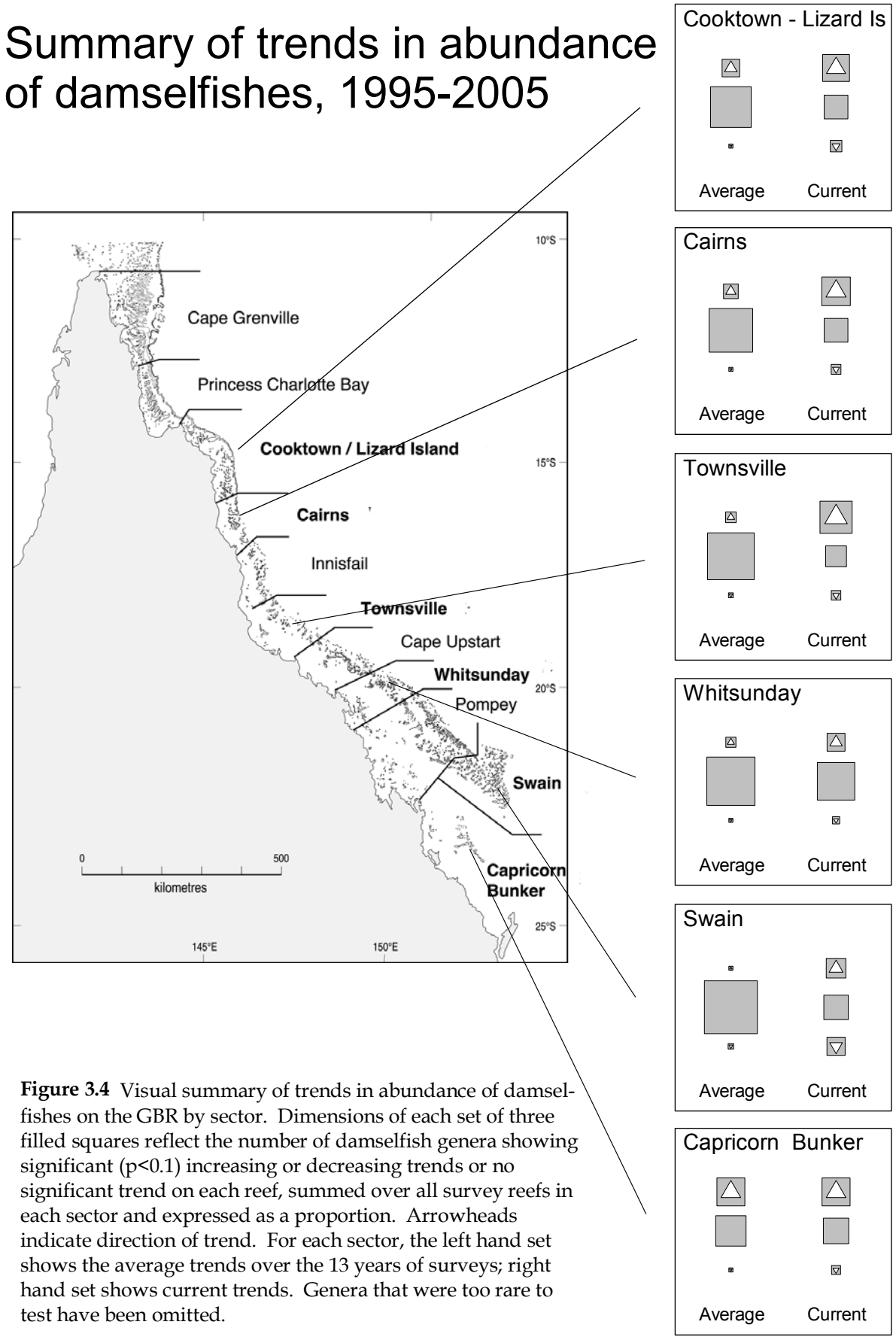


Figure 3.4 Visual summary of trends in abundance of damselfishes on the GBR by sector. Dimensions of each set of three filled squares reflect the number of damselfish genera showing significant ($p<0.1$) increasing or decreasing trends or no significant trend on each reef, summed over all survey reefs in each sector and expressed as a proportion. Arrowheads indicate direction of trend. For each sector, the left hand set shows the average trends over the 13 years of surveys; right hand set shows current trends. Genera that were too rare to test have been omitted.

Cape Grenville

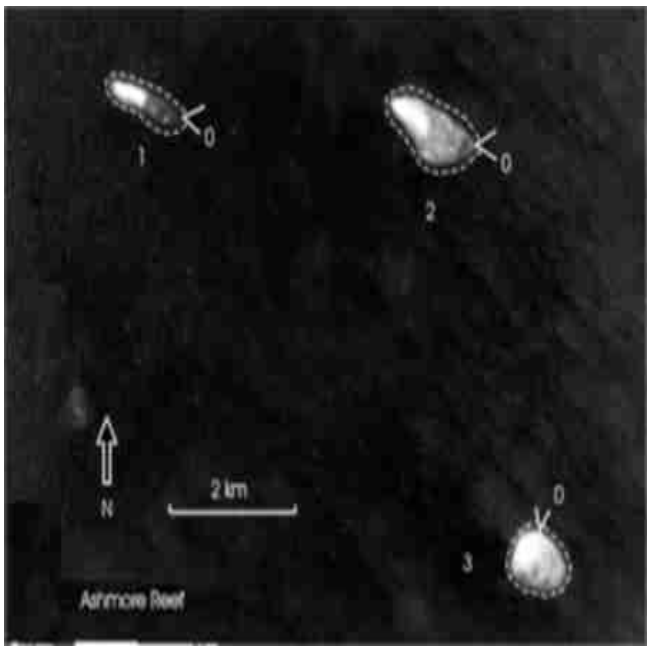
Reef Pages

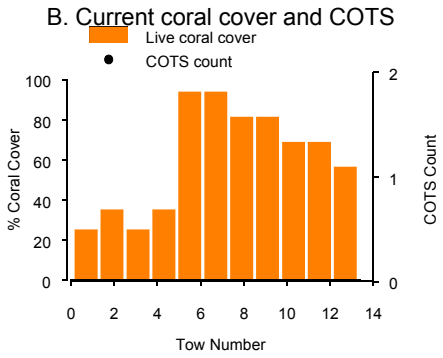
ASHMORE BANKS (1)

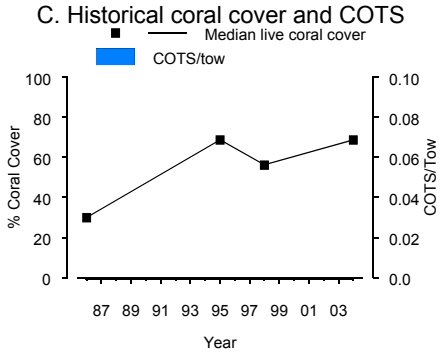
Surveyed September 2003.

Ashmore Banks (1) reef has been surveyed four times since 1986. There was an initial increase in reef-wide live coral cover between the first two surveys in 1986 and 1995 from a high (20-30%) to a very high (50-75%) level. Since 1995 coral cover has remained very high on this reef. No COTS have ever been observed and the reef was classified as No Outbreak in 2004.

Figure 4.1 A







Ashmore Banks (1) (No. 11-237) is a middle shelf patch reef with an area of 1 sq.km.

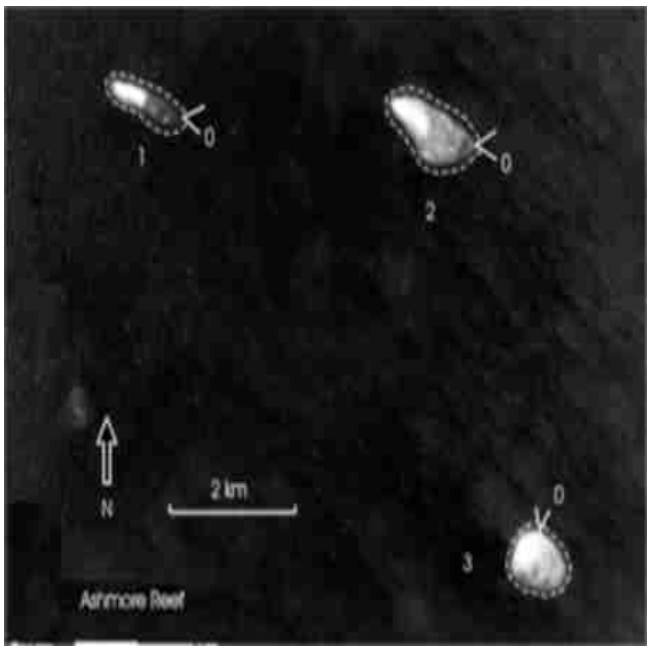
ASHMORE BANKS (2)

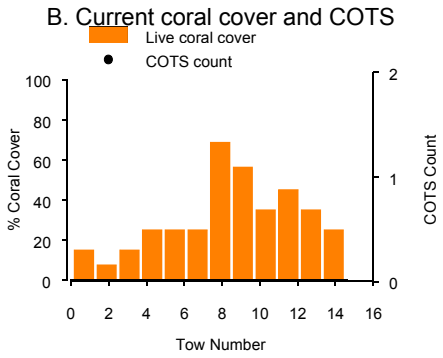
Surveyed September 2003.

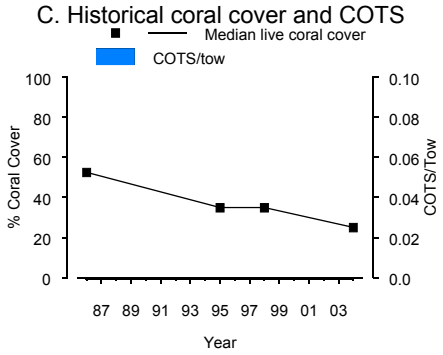
Ashmore Banks (2) reef has been surveyed four times since 1986. Unlike Ashmore Banks (1) there has been an apparent decline in reef-wide live coral cover on this reef over the period of survey from a high (40-50%) level to a current moderate level (20-30%). The reason for this apparent decline is not known. No COTS have ever been observed and the reef was classified as No Outbreak in 2004.

Figure 4.2

A







Ashmore Banks (2) (No. 11-237) is a middle shelf patch reef with an area of 1 sq.km.

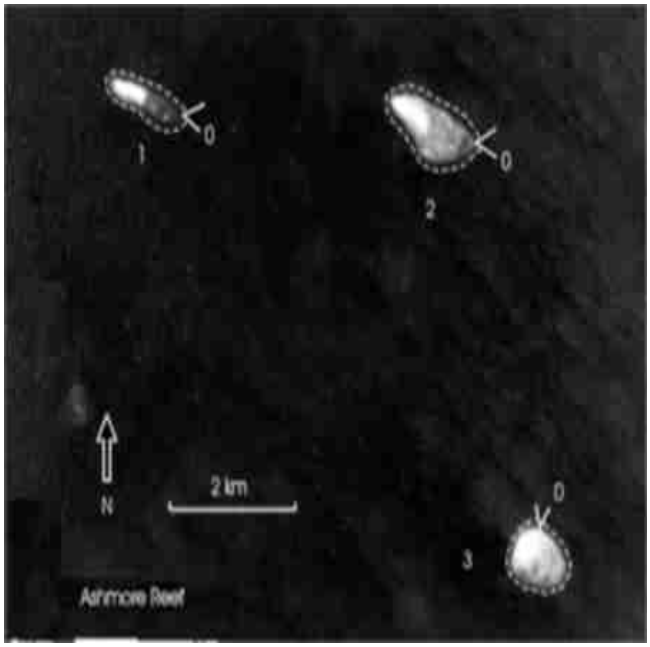
ASHMORE BANKS (3)

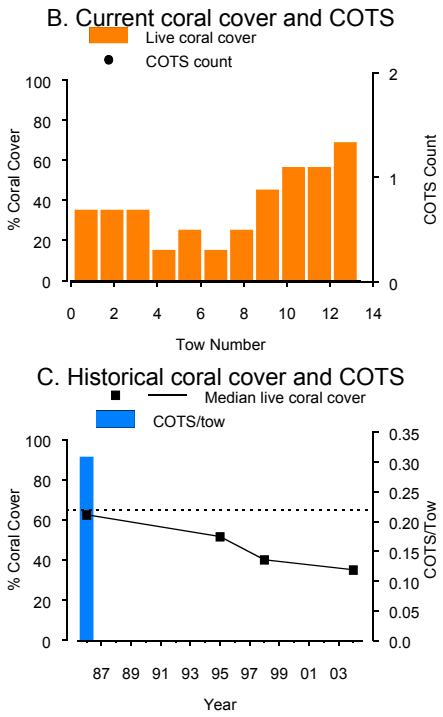
Surveyed September 2003.

Ashmore Banks (3) reef has been surveyed four times since 1986. Similar to Ashmore Bank (2) there has been an apparent decline in reef-wide live coral cover on this reef over the period of survey from a very high (50-60%) level to a current moderate level (20-30%). The initial decline may have been due to COTS which were observed at Incipient Outbreak levels in the first year of survey (1986). In the absence of COTS in later survey years the reason for the continued decline is not known. No COTS were observed during surveys in 2004 and the reef was classified as No Outbreak.

Figure 4.3

A





Ashmore Banks (3) (No. 11-237) is a middle shelf patch reef with an area of 1 sq.km.

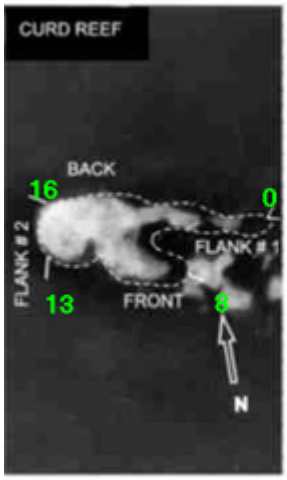
CURD

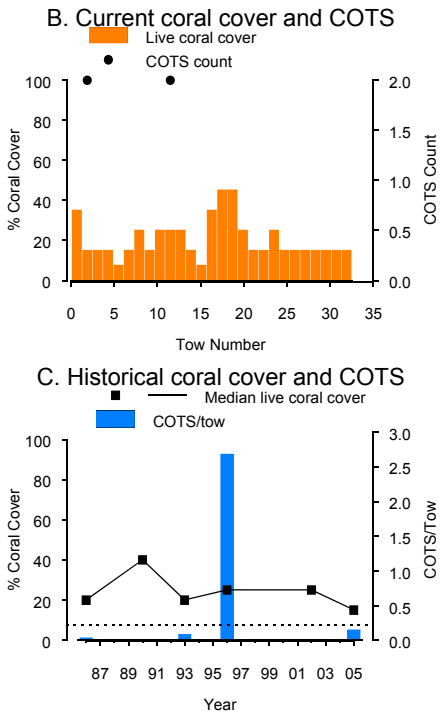
Surveyed September 2004.

Curd Reef has been surveyed six times since 1986. In 1996 an Active Outbreak of COTS was recorded on this reef. Reef-wide live coral cover on Curd Reef has remained relatively stable at a moderate to high (20-40%) level since 1986. While surveys in 2002 found no COTS and Curd Reef was classified as Recovering. Surveys in 2005 revealed small numbers of COTS though these were below outbreak levels. Curd Reef was classified as Recovering. No bleaching or coral disease was recorded on this reef in manta tow surveys in 2005.

Figure 4.4

A





Curd (No. 12-102) is an inner shelf patch reef with an area of 21.9 sq.km.

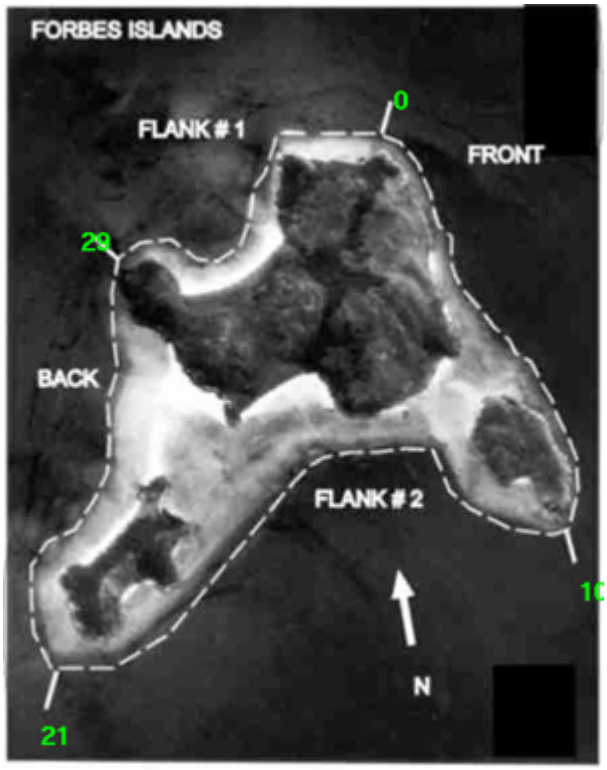
FORBES IS'S

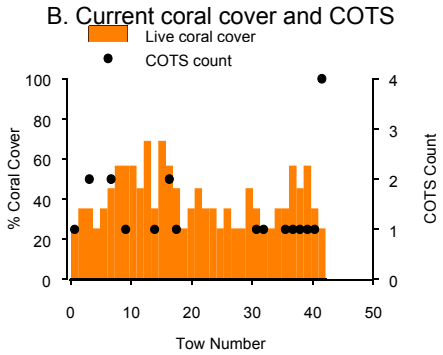
Surveyed September 2004.

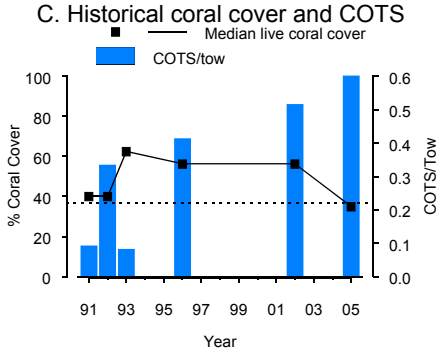
Forbes Islands Reef has been surveyed six times since 1991. Incipient Outbreak levels of COTS were recorded from this reef in 1992, 1996, 2002 and during the most recent surveys in 2005. Despite outbreak levels of COTS, an appreciable decline in reef wide live coral cover was only evident in the most recent surveys. Until recently coral cover has been high enough to sustain this level of COTS activity with reef-wide live coral cover remaining at a very high (50-75%) level between 1991 and 2002. Forbes Islands Reef was classified as Incipient Outbreak in 2005. No bleaching or coral disease was recorded during manta tow surveys.

Figure 4.5

A







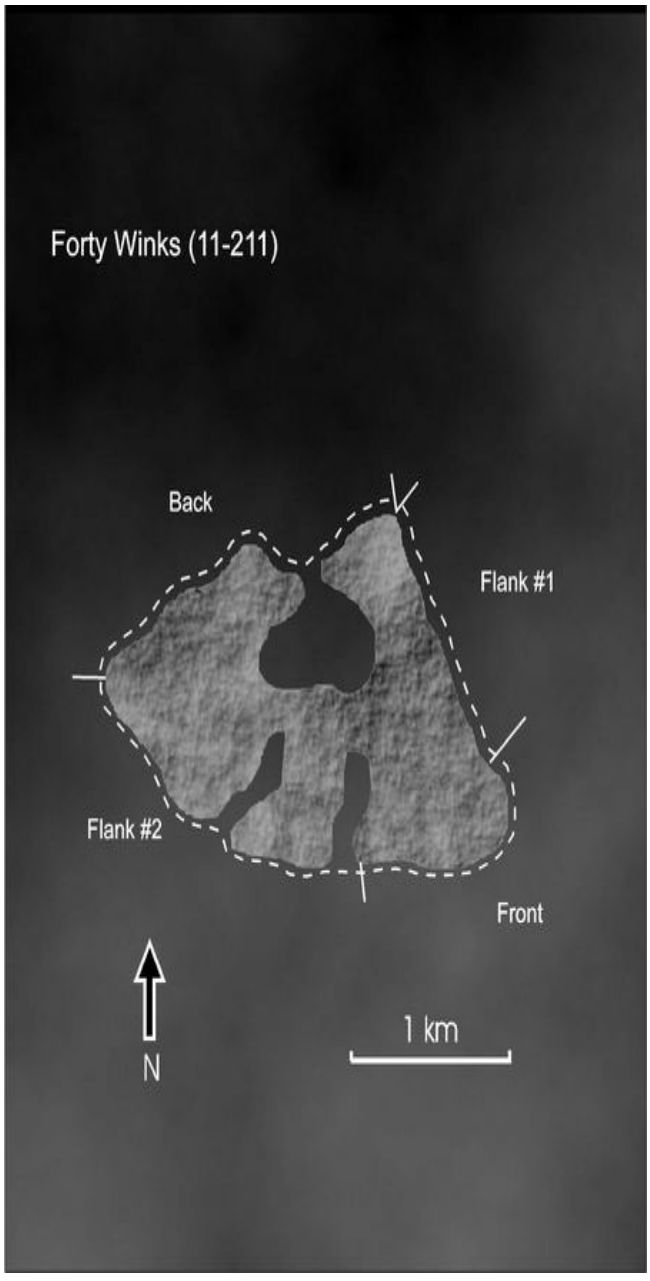
Forbes Is's (No. 12-016) is a middle shelf fringing reef with an area of 1.2 sq.km.

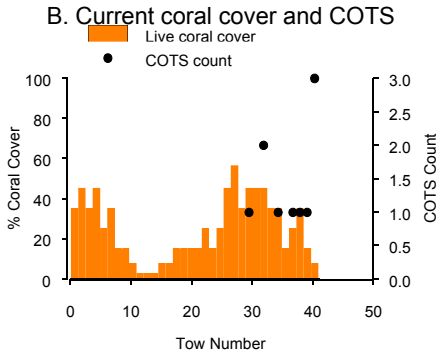
FORTY WINKS

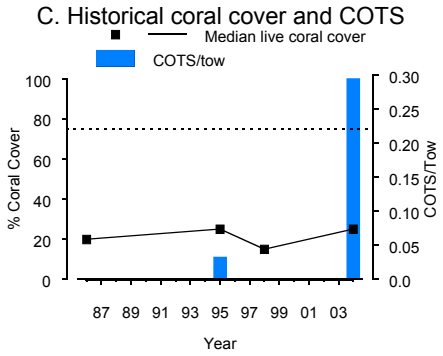
Surveyed September 2003.

Forty Winks reef has been surveyed four times since 1986. During this time reef-wide live coral cover has remained stable at a moderate level (20-30%). Small numbers of COTS have been seen on this reef in previous years but substantial numbers of COTS were recorded in 2004. Forty Winks Reef was classified as an Incipient Outbreak in 2004. No coral bleaching and only low levels of white syndrome disease (restricted to small numbers of scattered coral colonies) were observed during manta tow surveys in 2004.

Figure 4.6 A







11211 (No. 11-211) is a middle shelf lagoonal reef with an area of 3.1 sq.km.

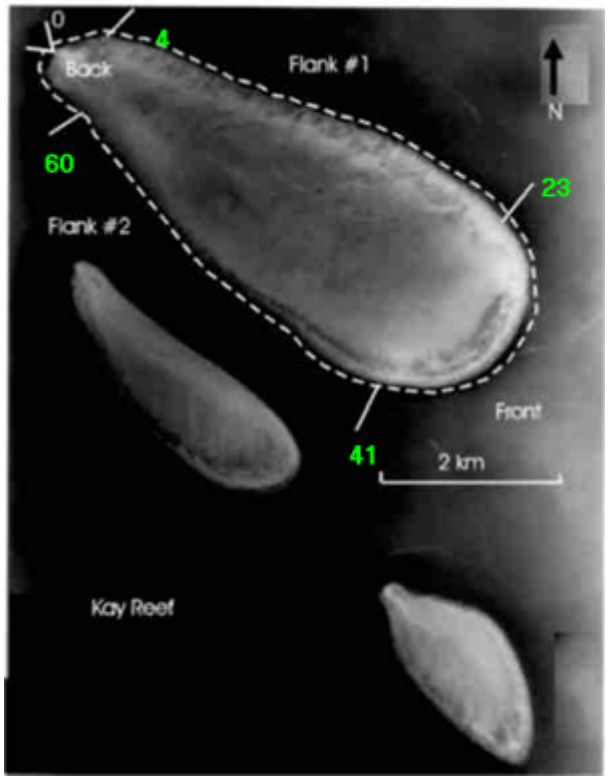
KAY

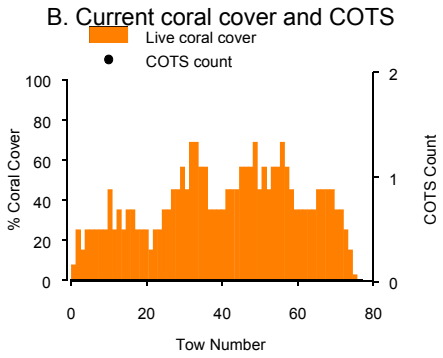
Surveyed September 2004.

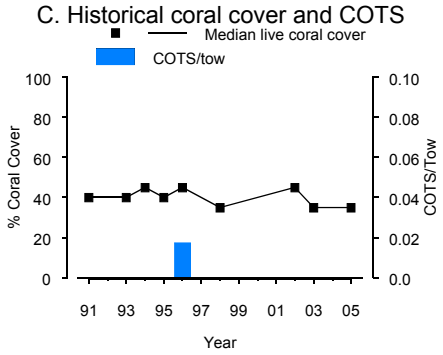
Kay reef has been surveyed nine times using manta tow since 1991. Reef-wide live coral cover has been relatively stable at a high level (30-50%) through to 2005. Whilst small numbers of COTS were recorded in 1996, they were below levels that would be expected to reduce reef-wide live coral cover. Kay reef was classified as No Outbreak in 2005. No bleaching or coral disease was recorded in 2005.

Figure 4.7

A







Kay (No. 12-010) is an inner shelf planar reef with an area of 7.5 sq.km.

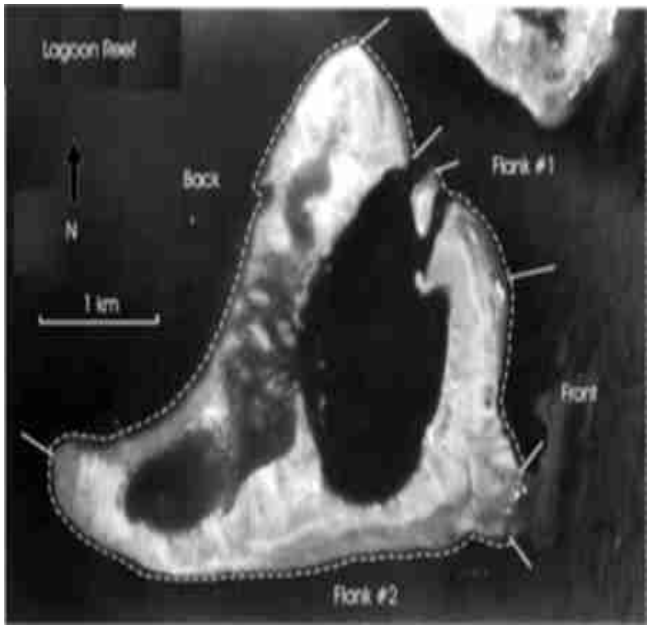
LAGOON

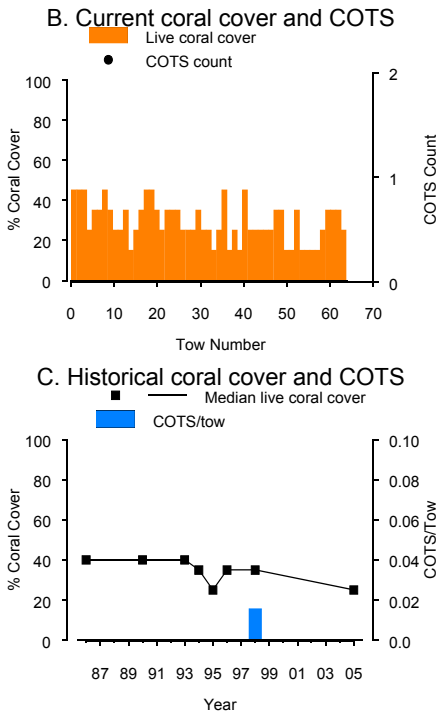
Surveyed September 2004.

Lagoon Reef has been surveyed eight times using manta tow by AIMS since 1986. Reef-wide live coral cover has remained high in the majority of surveys. Small numbers of COTS were observed on Lagoon Reef during surveys in 1998 but these were below outbreak levels. Surveys in 2003 recorded a small decrease in reef-wide live coral cover to a moderate level which persisted in 2005. The long period between consecutive surveys has made it difficult to pinpoint the factors responsible for the decline. White syndrome was common on the back of Lagoon Reef in 2005. No bleaching was observed in manta tow surveys.

Figure 4.8

A





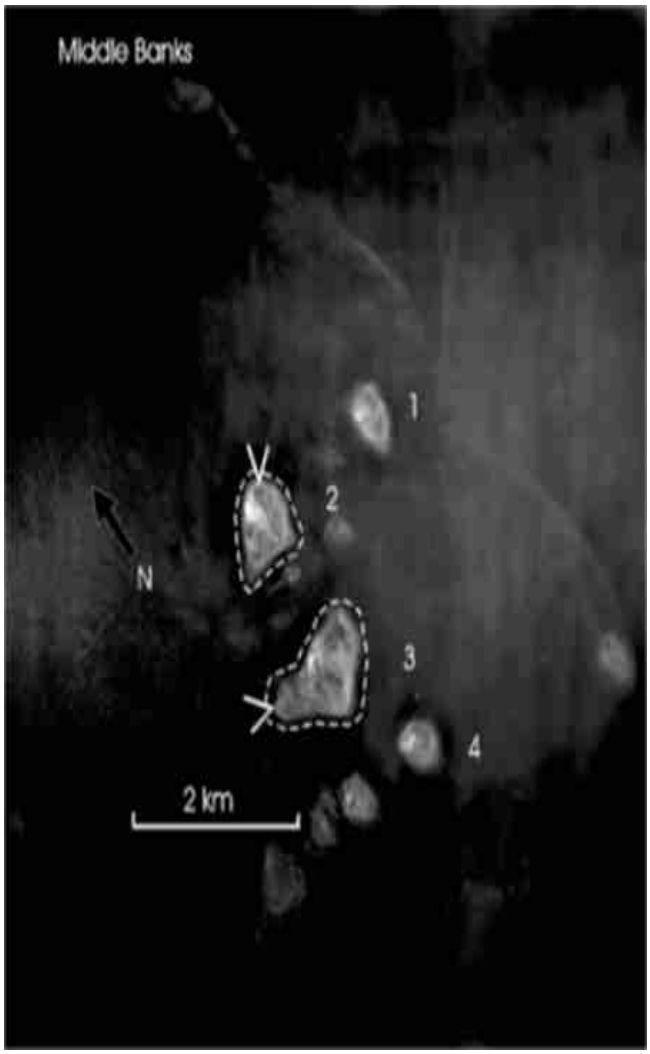
Lagoon (No. 12-061) is an outer shelf lagoonal reef with an area of 7.2 sq.km.

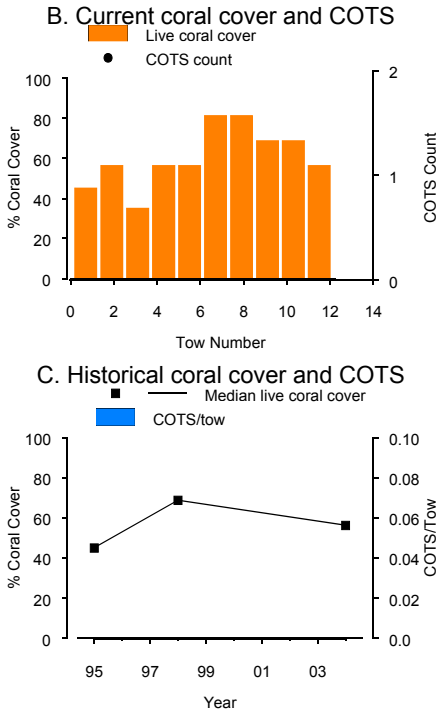
MIDDLE BANKS (2)

Surveyed September 2003.

This reef has been surveyed three times since 1995. reef-wide live coral cover increased between the first two surveys from high (40-50%) to a very high (50-75%) levels. Cover remained very high in 2004. No COTS have been recorded during surveys and the reef was classified as No Outbreak in 2004.

Figure 4.9 A





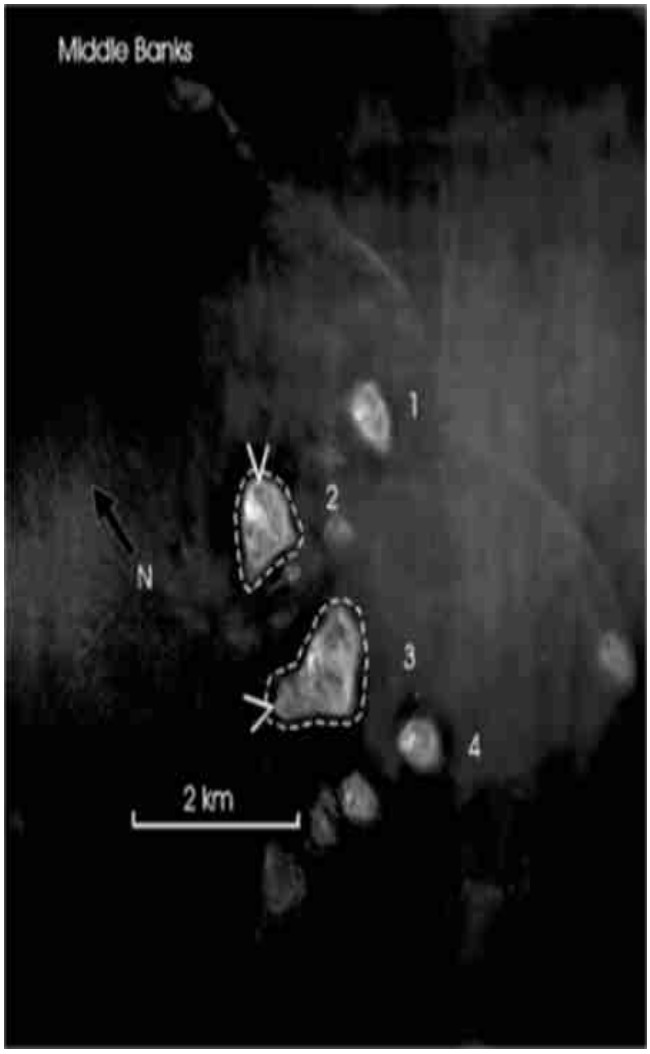
Middle Banks (2) (No. 11-222) is a middle shelf submerged/patches reef with an area of sq.km.

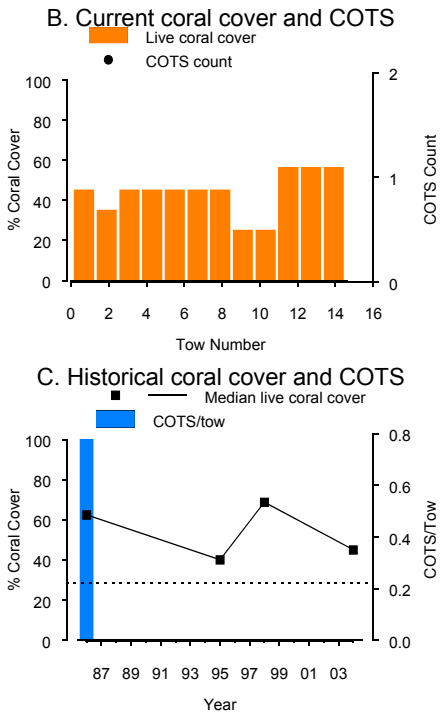
MIDDLE BANKS (3)

Surveyed September 2003.

This reef has been surveyed four times since 1986. Initial surveys showed reef-wide live coral cover to be very high (50-75%) and Incipient Outbreak levels of COTS. A subsequent survey showed a decease in coral cover to a high level (40-50%). While the period between surveys makes it difficult to prescribe reasons for this decline it is possible that high COTS in the past numbers may have contributed. Recent surveys show that coral cover has increased and was back to a very high level in 2004. No COTS were seen in 2004 and the reef was classified as No outbreak.

Figure 4.10 A





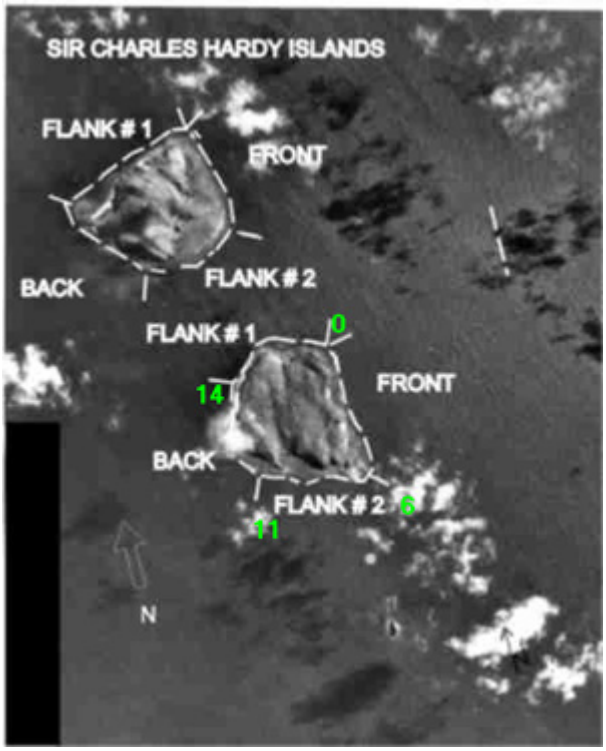
Middle Banks (3) (No. 11-222) is a middle shelf submerged/patches reef with an area of sq.km.

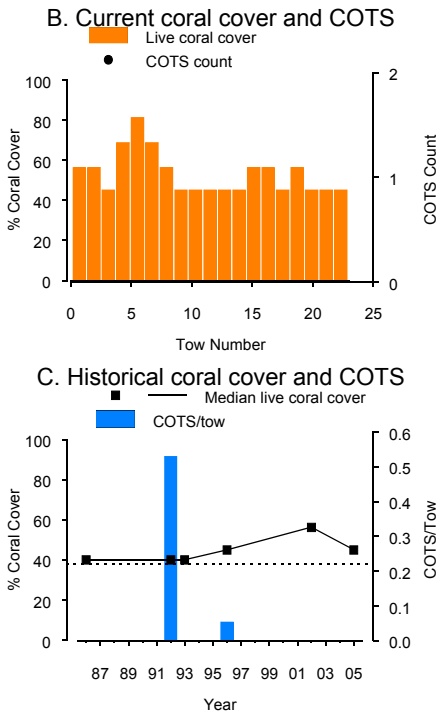
SIR CHARLES HARDY (1)

Surveyed September 2004.

Sir Charles Hardy Islands (1) Reef has been surveyed six times since 1986. COTS were recorded at Incipient Outbreak levels in 1992, but have been absent in the majority of survey years. Reef-wide live coral cover increased from high (30-50%) in 1986 to be very high (50-75%) in 2002 and remained high (40-50%) in 2005. No COTS have ever been observed in 2005 and Sir Charles Hardy Islands (1) Reef was classified as No Outbreak. No coral bleaching and only low levels of white syndrome disease (restricted to small numbers of scattered coral colonies) were observed during manta tow surveys in 2005.

Figure 4.11 A





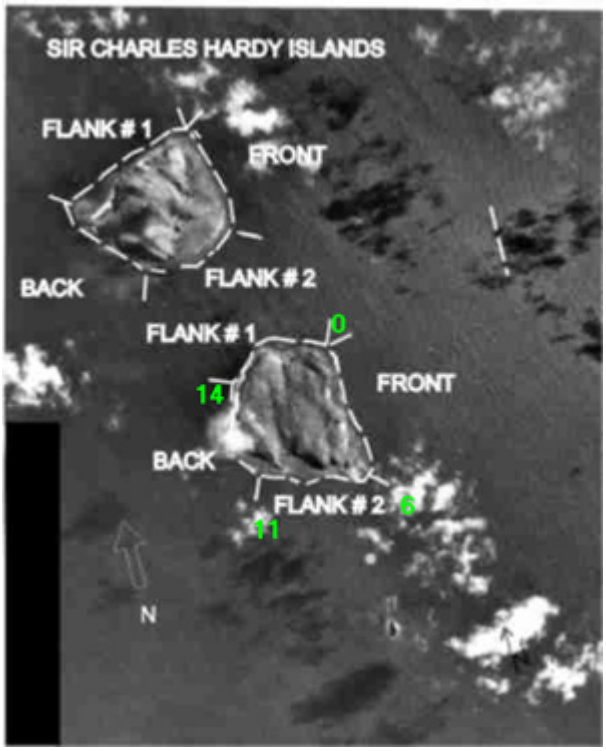
Sir Charles Hardy (1) (No. 11-184) is a middle shelf fringing reef with an area of 3 sq.km.

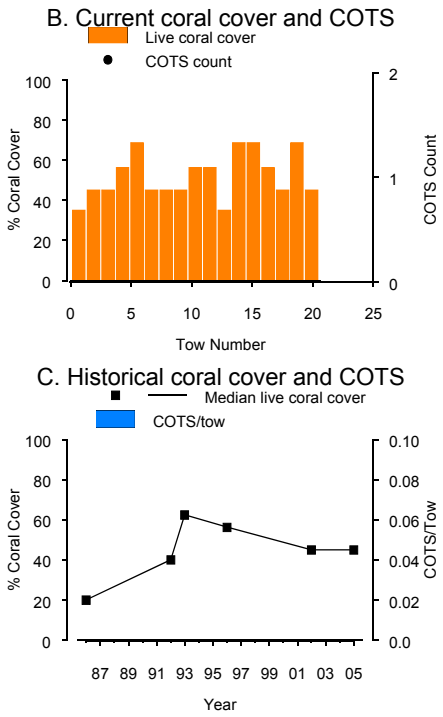
SIR CHARLES HARDY (2)

Surveyed September 2004.

Sir Charles Hardy Islands (2) Reef has been surveyed six times since 1986. Although small numbers of COTS were recorded in 1996 they have generally been absent during surveys and Sir Charles Hardy Islands (2) Reef was classified as No Outbreak in 2005. Reef-wide coral cover increased from a moderate (10-30%) level in 1986 to a very high level (50-75%) in 1993. Surveys in 2005 recorded high reef-wide live coral cover (30-50%). No bleaching or coral disease was recorded from Sir Charles Hardy Islands (2) Reef in 2005.

Figure 4.12 A





Sir Charles Hardy (2) (No. 11-184) is a middle shelf fringing reef with an area of 3 sq.km.

Princess Charlotte Bay

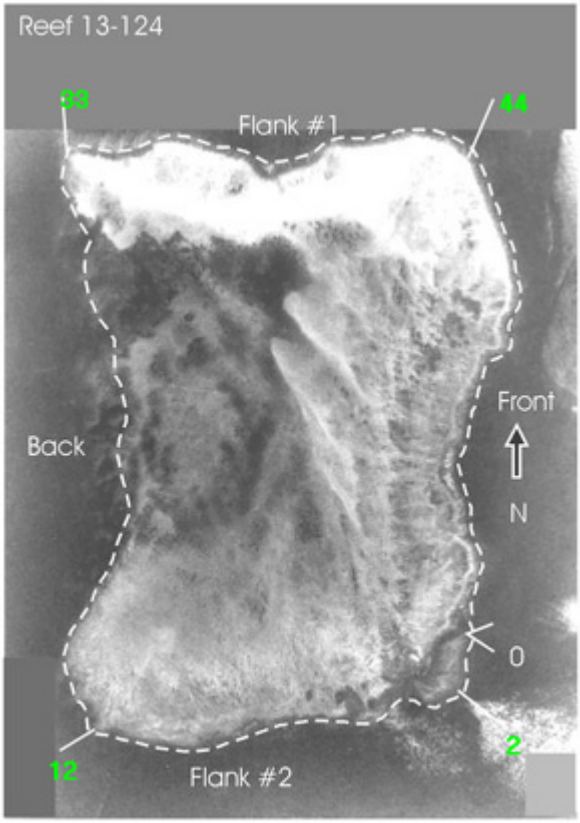
Reef Pages

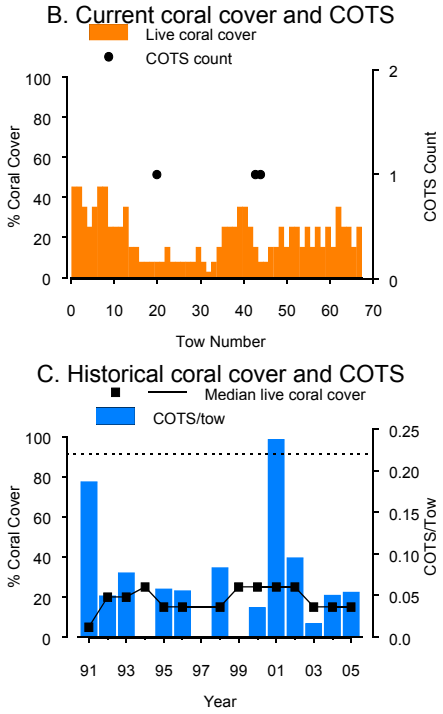
13-124

Surveyed September 2004.

Reef 13-124 has been surveyed 14 times by manta tow since 1991. Reef-wide coral cover has remained at moderate levels of 10-30%. COTS have been consistently recorded on Reef 13-124, though in most years densities have been too low to reduce reef-wide live coral cover. Only small numbers of COTS were observed in 2005 and reef-wide live coral cover was slightly down compared to prior surveys. Cover remained moderate at 10-30% and Reef 13-124 was classified as No Outbreak. No bleaching or coral disease was recorded during manta tow surveys in 2005.

Figure 4.13 A





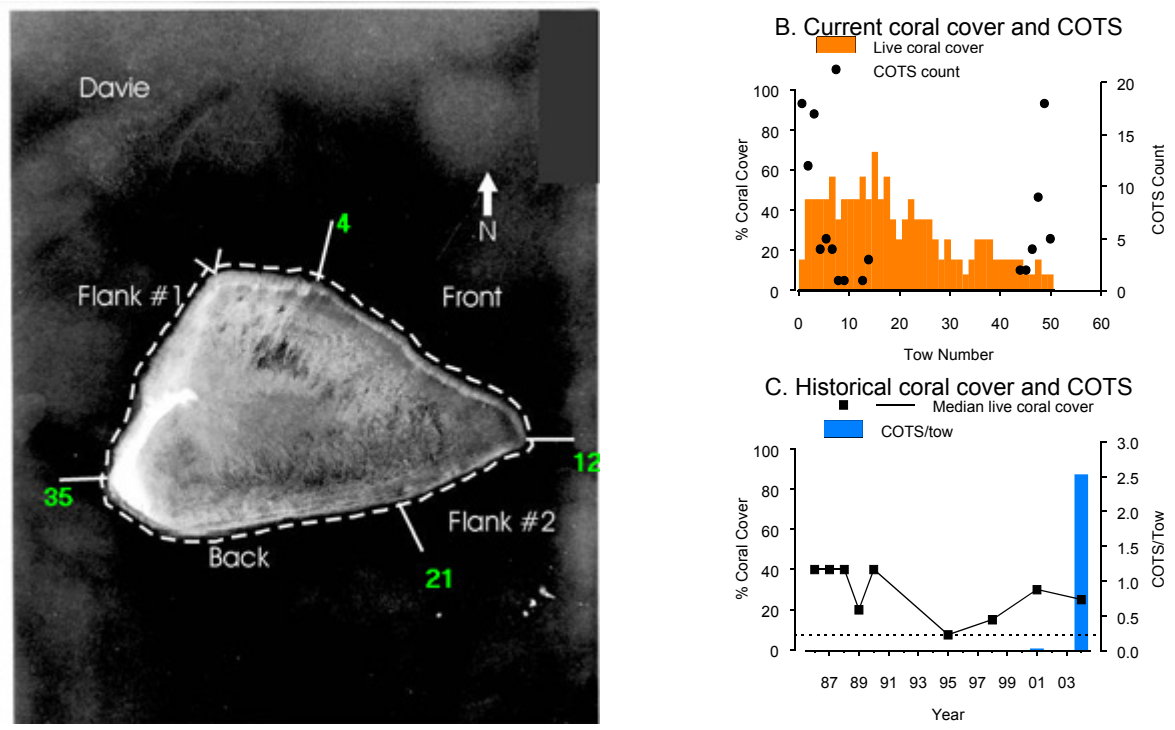
13124 (No. 13-124) is a middle shelf crescentic reef with an area of 11.3 sq.km.

DAVIE

Surveyed September 2003.

Davie reef has been surveyed 9 times since 1986. Reef-wide live coral cover remained high (40-50%) up until 1990. By 1995 coral cover had decreased. Reef-wide live coral cover continued to increase up to 2001 then levelled out at a moderate level (20-30%). While it is difficult to ascribe reasons for the drop in coral cover, Cyclone Ivor did pass close in March 1991. Large numbers of COTS were observed in 2004 and the reef was classified as an Active Outbreak. Coral cover is likely to decline in coming years. No bleaching and only low levels of black band disease and white syndrome disease (affecting a few scattered coral colonies) were recorded in 2004.

Figure 4.14



Davie (No. 13-130) is an outer shelf planar reef with an area of 5.6 sq.km.

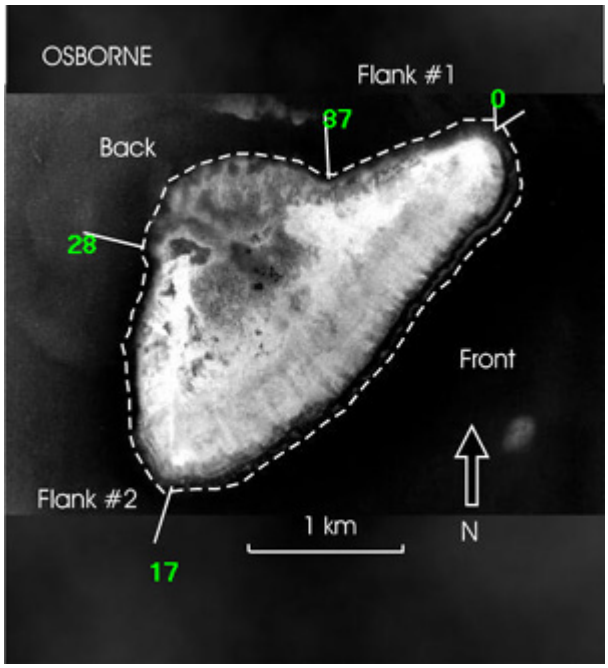
OSBORNE

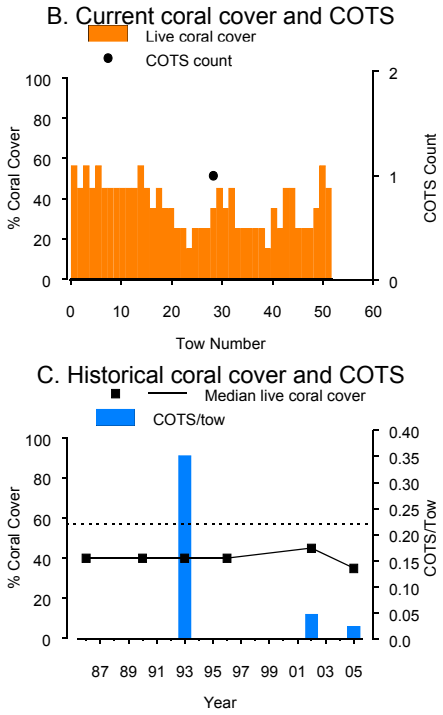
Surveyed September 2004.

Osborne Reef has been surveyed six times since 1986. Over this time, reef-wide live coral cover has remained relatively stable at a high level (30-50%). Incipient Outbreak levels of COTS were recorded in 1993 but they had little affect on reef-wide live coral cover. Low numbers of COTS were recorded during surveys in 2002 and 2005 but well below the densities that would cause significant coral mortality. Osborne Reef was classified as No Outbreak in 2005. No bleaching or coral disease was recorded from this reef.

Figure 4.15

A





Osborne (No. 13-006) is an inner shelf planar reef with an area of 5 sq.km.

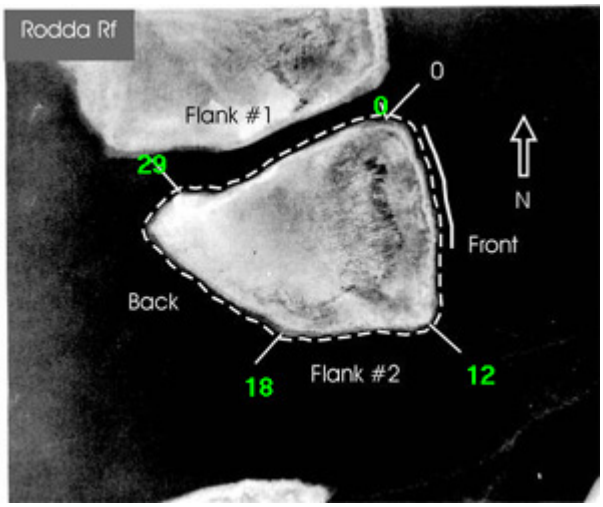
RODDA

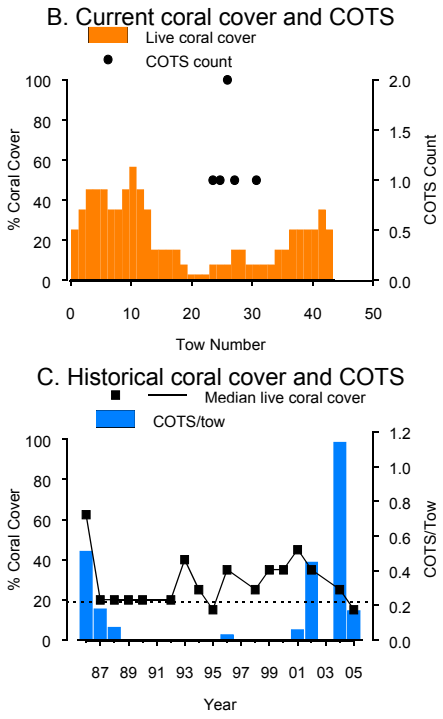
Surveyed September 2004.

Rodda Reef has been surveyed by manta tow 17 times since 1986. Data suggests a rapid decline in reef-wide live coral cover from a very high level (50-75%) in 1986 to a moderate level (10-30%) in 1987, probably due to an outbreak of COTS recorded in 1986. Reef-wide live coral cover remained at a moderate (10-30%) level until 1995 then began to increase. Manta tow surveys in 2002 recorded increased COTS numbers and Rodda Reef was classified as an Incipient Outbreak. COTS numbers continued to increase and the reef was re-classified as an Active Outbreak in 2004. Surveys in 2005 indicated COTS numbers have declined and Rodda Reef was classed as Recovering. COTS activity has been responsible for a dramatic decline in reef wide live coral cover from a high (40-50%) level in 2001 to moderate levels (10-20%) in 2005. No bleaching was observed during manta tow surveys in 2005 and white syndrome disease was restricted to a few scattered colonies.

Figure 4.16

A





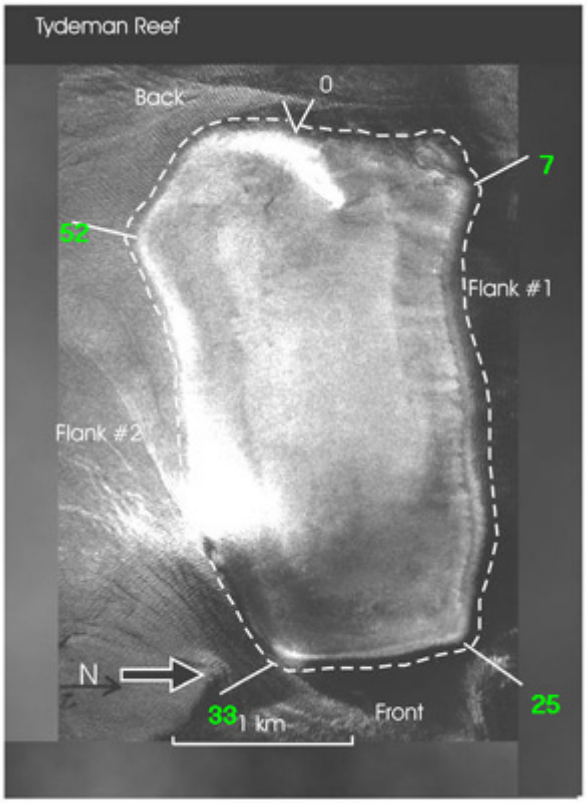
Rodda (No. 13-127) is an outer shelf planar reef with an area of 4.39 sq.km.

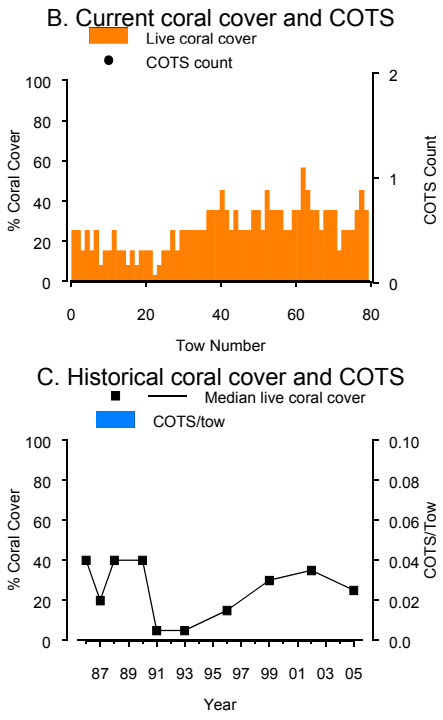
TYDEMAN

Surveyed September 2004.

Tydeman Reef has been surveyed 10 times since 1986 using manta tow. No COTS have been recorded over this time. While initially high, reef-wide live coral cover declined dramatically to a low level (0-10%) between 1990 and 1991. This was likely due to Cyclone Ivor, which passed close by in March 1990. Reef-wide live coral cover then increased to a high level (30-50%) in 2002. Surveys in 2005 recorded a decline in coral cover to a moderate level (20-30%). The reason for this decline is not known, though Cyclone Fritz (Category One) passed within a few kilometres in February 2004. Tydeman Reef was classified as No Outbreak. No bleaching was observed during manta tow surveys in 2005 and white syndrome disease was restricted to a few scattered colonies.

Figure 4.17 A





Tydeman (No. 13-133) is an outer shelf planar reef with an area of 10 sq.km.

Cooktown / Lizard Island

Reef Pages

CARTER

Surveyed September 2004.

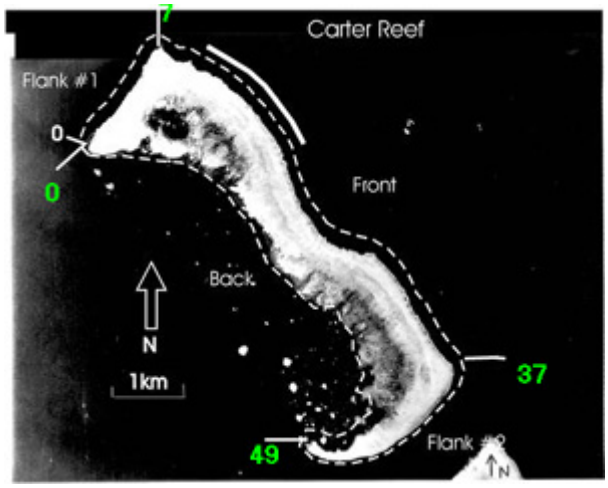
Carter Reef is a Preservation Reef within the GBRMP and so has the highest protection status. Carter Reef has a history of manta tow surveys dating back to 1986. Reef-wide live coral cover remained stable from 1986 to 1990 before dropping appreciably in 1991. Although there were COTS on the reef at this time they were well below the level that results in significant reef-wide coral mortality. The decline in coral cover was almost certainly a result of Cyclone Ivor which affected the region in March 1990. Massive damage to the windward margin of the reef was observed during the 1991 surveys. Coral cover subsequently recovered on the front reef reaching a high level (30-40%) in 2003. Reef-wide live coral cover declined to a moderate (10-20%) level in 2004 where it remained in 2005. The reason for this decline was not clear, though disease may have been a factor. Very low cover on the back reef reduced the reef-wide average. Carter Reef was classified as No Outbreak in 2005. No bleaching was recorded during manta tow surveys in 2005. Black band disease and white syndrome disease (WSD) were restricted to scattered colonies in most parts of the reef perimeter except for the first flank front reef where live coral cover was the highest. WSD was common on the front and first flank, affecting 10 or more hard coral colonies per two-minute tow.

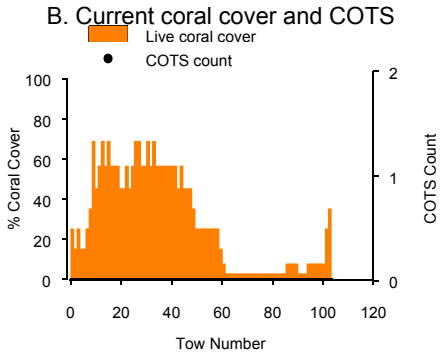
On the intensive survey sites coral cover increased rapidly from 13% in 1992 to 67% in 1999. This represents excellent recovery from Cyclone Ivor, which impacted the region in 1990. After 1999, coral cover gradually decreased until 2005 where it dropped to an average of 39% cover. Tabulate *Acropora* spp. which dominated the benthic community between 1997 and 2004 decreased in 2005 to an average cover of 16%. The corallivorous snail, *Drupella* spp. was observed at a density of 213/ha during 2005 SCUBA searches. The number of colonies with disease (especially white syndromes) has remained high since 2002.

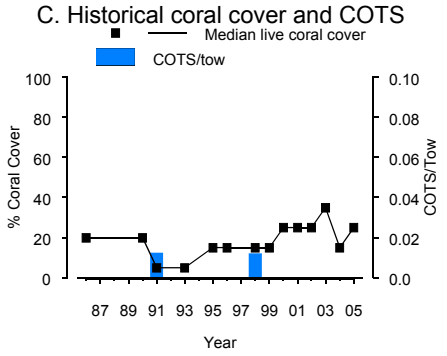
Changes in the fish community over the survey period appeared to be strongly correlated with changes in coral cover. As coral cover has increased, abundances of some herbivorous species have decreased and abundances of certain species that rely on coral for food or shelter have increased. The surgeonfishes, *Acanthurus nigrofuscus* and *Ctenochaetus* spp., were notable examples of grazing and detritus feeding species respectively, that declined in abundance. However, other grazing species remained stable and two species, *Scarus niger* and *Chlorurus sordidus*, increased in abundance. Several coral-dependent taxa, such as *Chaetodon trifascialis*, *Plectroglyphidodon dickii* and certain *Chromis* spp., showed marked increases in abundance with increasing coral cover through to 2005.

Figure 4.18

A

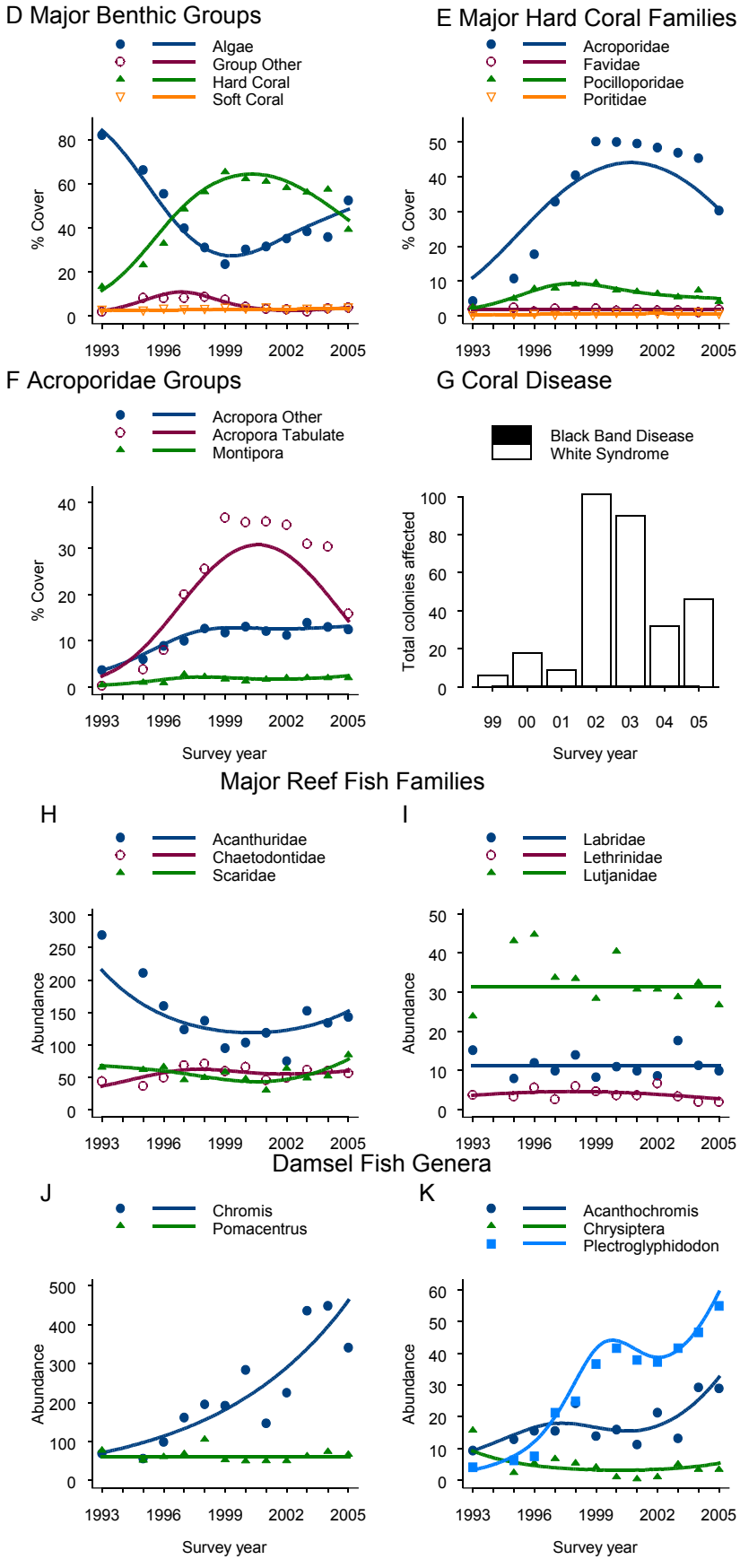






Carter (No. 14-137) is an outer shelf ribbon reef with an area of 13.7 sq.km.

Figure 4.18 (Cont).



LINNET

Surveyed August 2004.

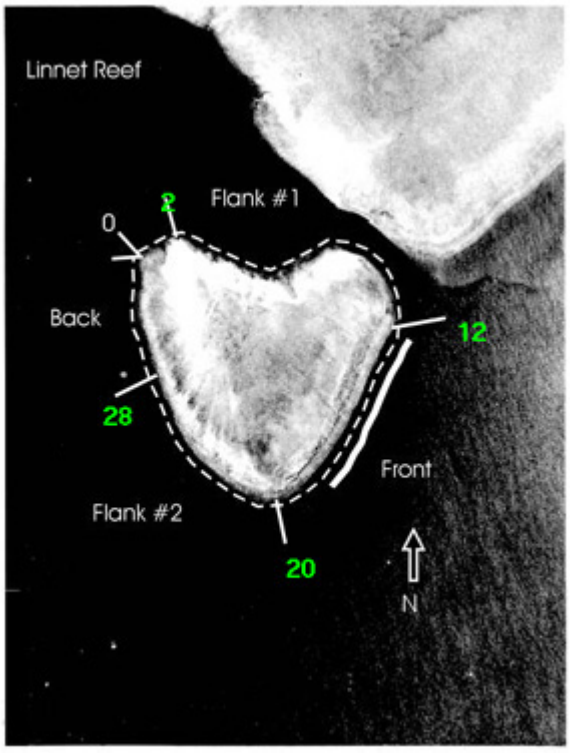
Linnet Reef has been surveyed 18 times using manta tow since 1986. COTS have been recorded from this reef on numerous occasions since 1995. Linnet Reef had an Incipient Outbreak in 1996 and COTS numbers remained at this level until 2000 when the reef was reclassified as No Outbreak. Reef-wide live coral cover declined between 1999 and 2000, presumably as a result of COTS feeding activity, but then stabilised. Low numbers of COTS were observed in 2003 and 2004. Reef-wide live coral cover has been moderate (10-30%) in recent years. No COTS were observed in 2005 and Linnet Reef was classified as No Outbreak. No bleaching was recorded and black band disease and white syndrome disease were restricted to a few scattered coral colonies.

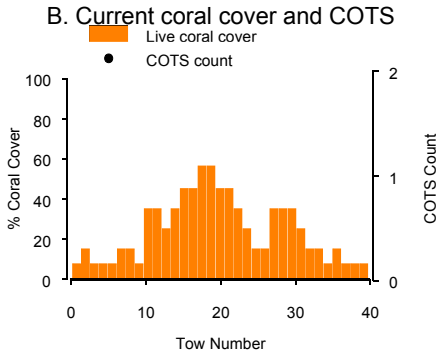
Coral cover in the intensive study sites has increased over the survey period and was 49% in 2005. Cover of algae showed a corresponding decline to 42% in 2005. The increase in cover of hard corals is largely due to increases within the family Acroporidae, particularly branching and bottlebrush growth forms. The slight increase in the percent cover of the family Faviidae was mostly due to increases in the cover of foliose *Echinopora* spp. *Drupella* spp. were observed at a density of 140/ha during SCUBA search surveys in 2005. A sharp increase in coral diseases was recorded in 2003, but this dropped back to low levels in 2004.

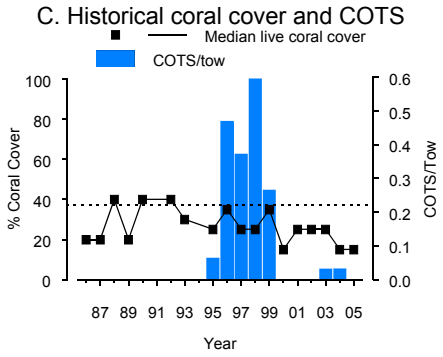
The majority of large, mobile reef fish species displayed no consistent trends in abundance over the 13 years of survey. Most chaetodontid species remained stable in abundance in 2005. Numbers of family Acanthuridae had tended to decline to 2004, but in 2005 numbers had increased to a 5 year high. Species from family Lutjanidae showed a marked increase in abundance from the previous year's surveys, and this was driven by large increases in three species, *Lutjanus vitta*, *L. carponotatus* and *L. lutjanus*. While a few damselfish species increased in abundance, many species (particularly the numerically dominant *Pomacentrus moluccensis*) had reached a plateau prior to 2004 and have since declined. Numbers of *Acanthochromis polyacanthus* had increased in abundance in 2005 after having steadily declined since 1999.

Figure 4.19

A

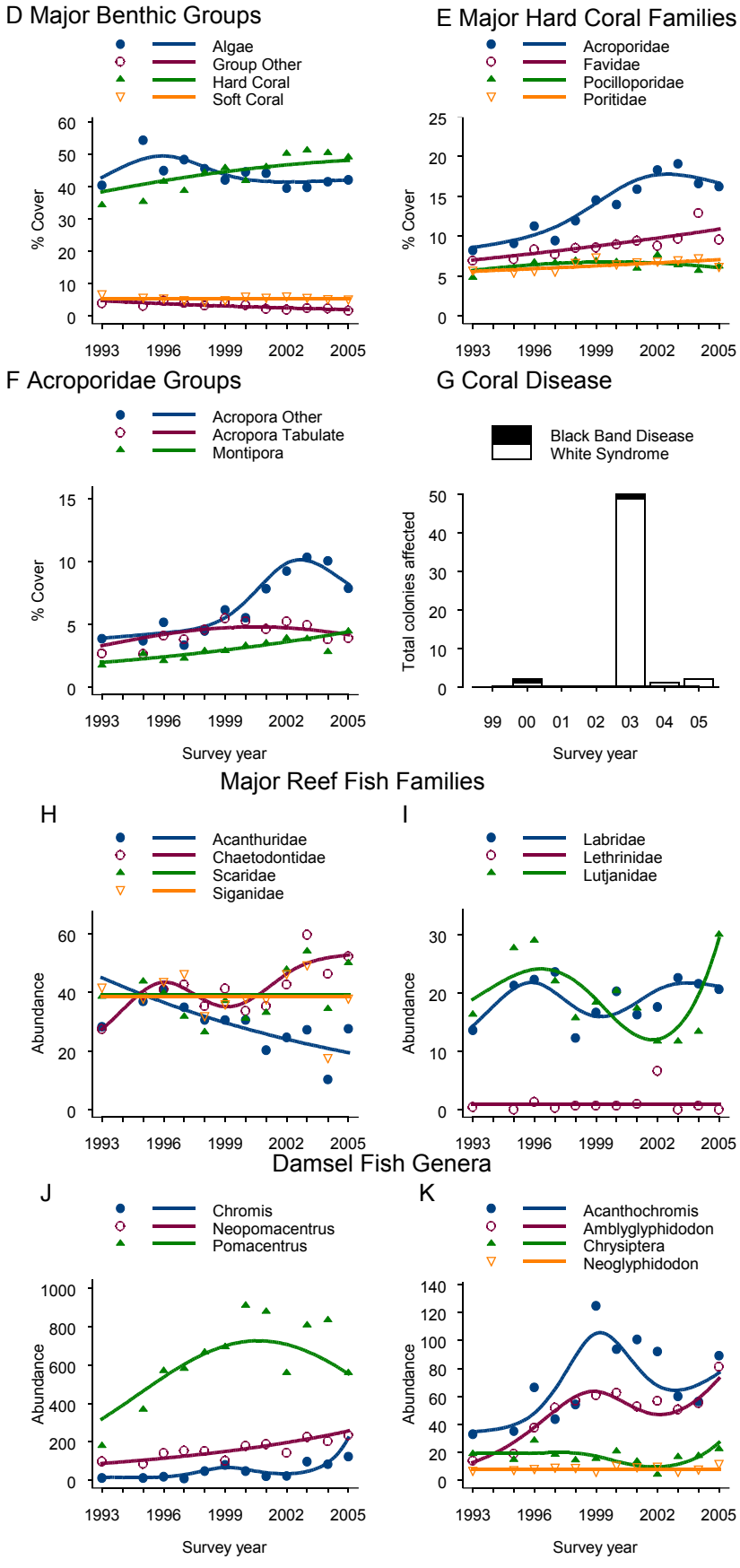






Linnet (No. 14-126) is an inner shelf planar reef with an area of 3.5 sq.km.

Figure 4.19 (Cont).



LIZARD IS

Surveyed August 2004.

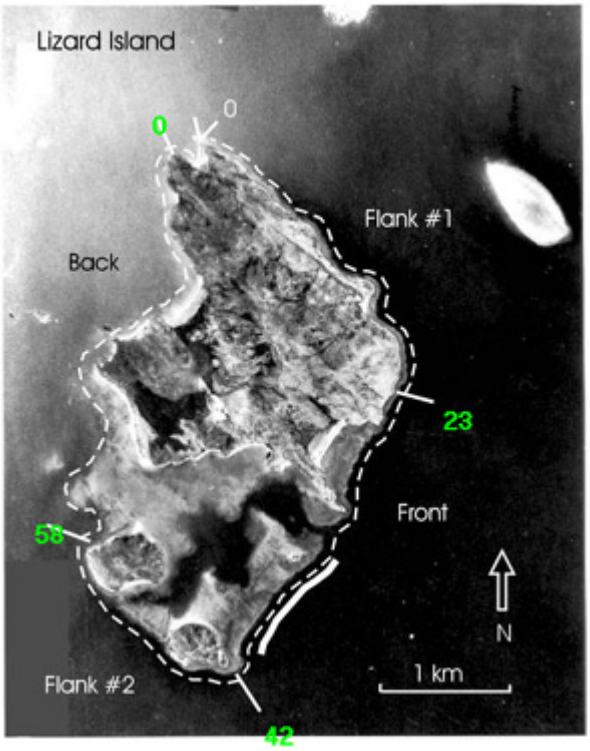
Lizard Island Reef has been surveyed 18 times using manta tow since 1986 when it was considered to be Recovering from previous COTS activity. From 1996 until 1999 the reef was classified as Active Outbreak. Since 1998 reef-wide live coral has remained low (1-10%) on Lizard Island Reef which has been classified as Recovering since 1999 even though small numbers of COTS have persisted. Surveys in 2005 indicate signs of recovery with median reef-wide live coral cover at moderate levels (10-20%) compared with the low level (5-10%) recorded in 2004. No bleaching was recorded, while black band disease and white syndrome disease were restricted to a few scattered coral colonies.

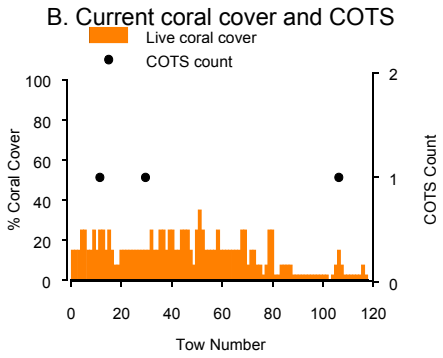
Cover of hard coral on the intensive study sites has remained at low to moderate levels (<20%) since 1994. In 2005, the cover of hard coral averaged 17%. Algae was the dominant benthic group and in 2005 averaged 56%. Hard and soft corals were equally represented in the coral community in low abundance. The increasing trend in *Porites* and faviids may be the result of avoidance of these corals by COTS. There has been a very low incidence of coral disease recorded on SCUBA search in the past 6 years since 1999. Two COTS were observed during the 2005 SCUBA searches. No *Drupella* spp. were observed for the first time since surveys began.

The majority of large mobile fish species displayed no consistent trends. There was high variability in the abundance of most scarid species, although numbers of a few species had increased since 2004. Numbers of the two most abundant acanthurid species, *Ctenochaetus* spp. and *Acanthurus nigrofuscus* declined after 2002, however, 2005 surveys indicated a small increase in abundance. Numbers of the commercially important coral trout species, *Plectropomus leopardus*, steadily increased after 2002 and were at a survey maximum in 2005. Among damselfishes there were few consistent trends, although numbers of *Pomacentrus moluccensis* and *P. brachialis* increased in 2005 after declining, following a peak in 2003. *Chrysiptera talboti* and *C. flavipinnis* remained stable in 2005 after numbers had increased in 2003 following four to five years of decline. *Acanthochromis polyacanthus* continued to recover in 2005 after numbers had declined from a peak in 1999. From 2002 to 2005 numbers of *Neopomacentrus azysron* increased from a survey minimum to a survey maximum.

Figure 4.20

A





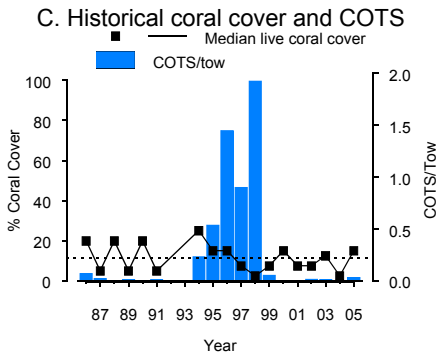
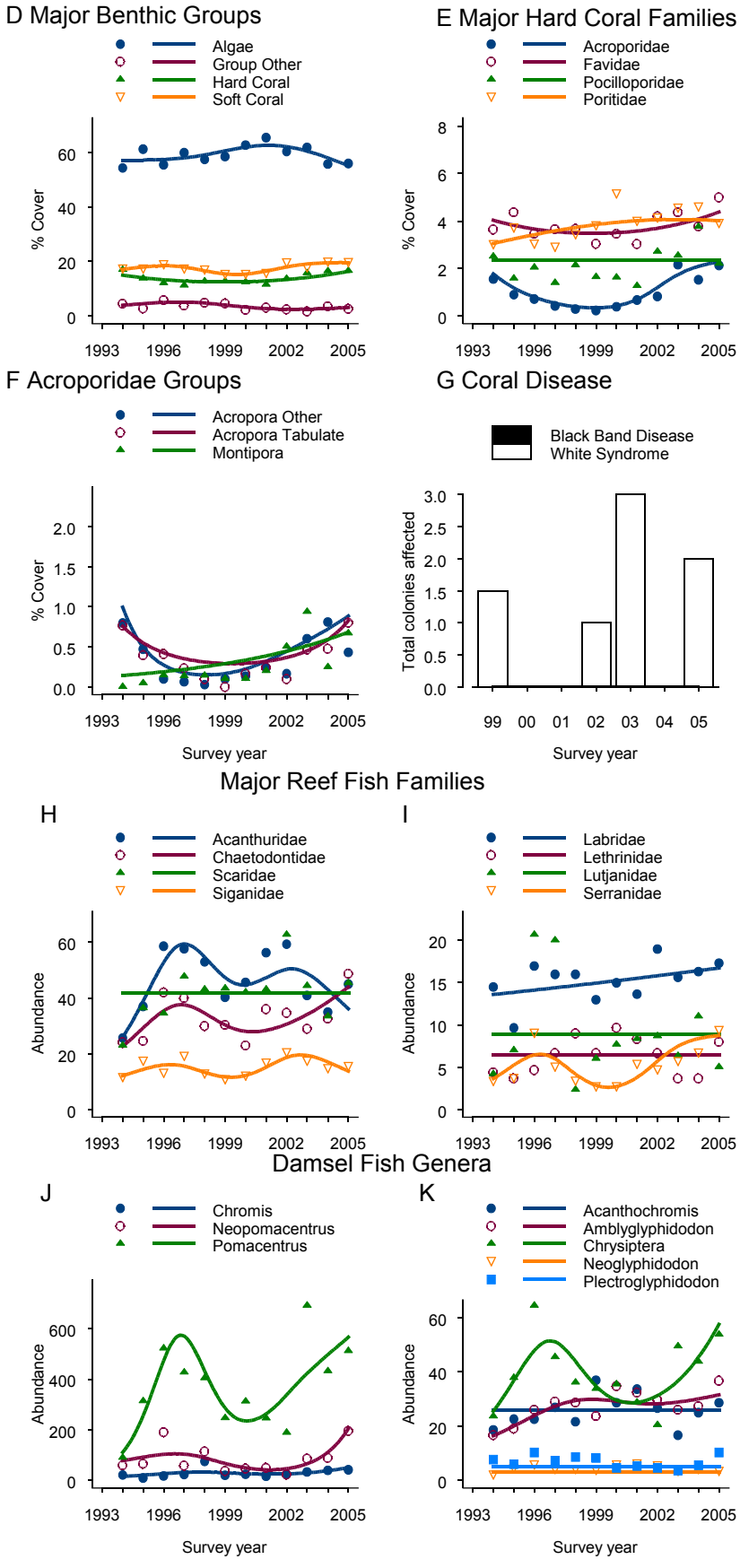


Figure 4.20 (Cont).



MACGILLIVRAY

Surveyed August 2004.

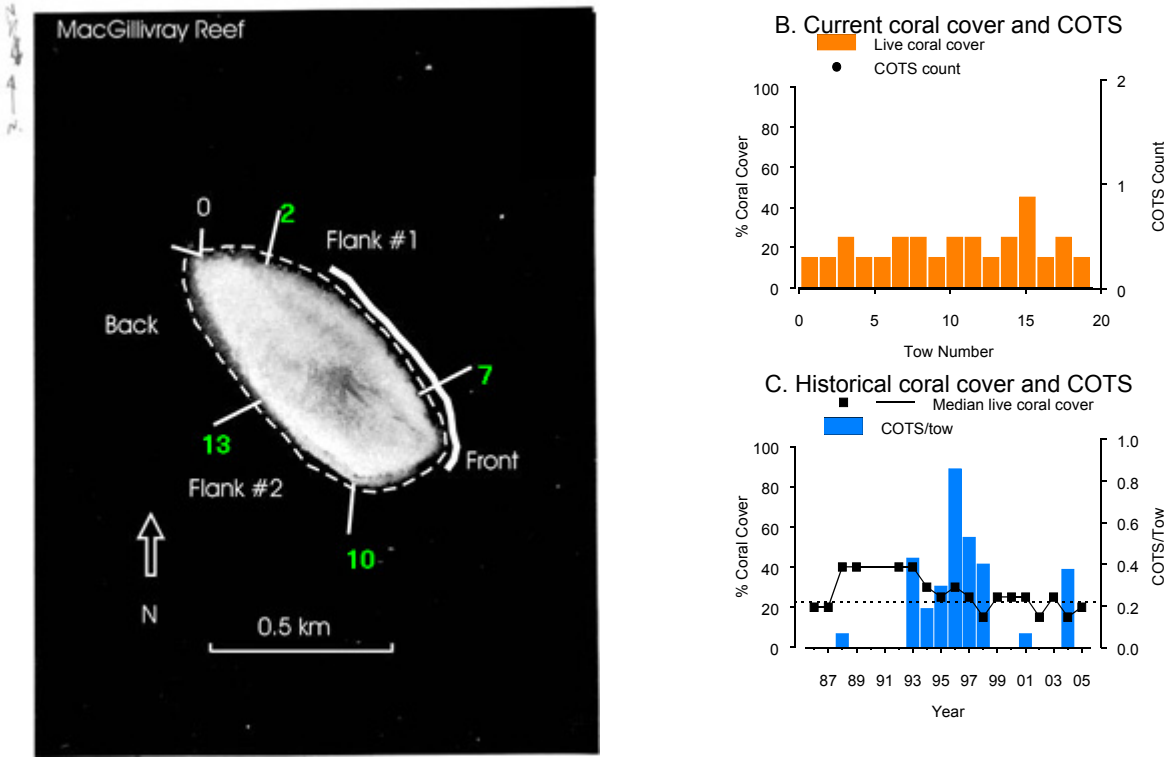
Macgillivray Reef has been surveyed 18 times using manta tow since 1986 when it was classified as Recovering from a previous COTS outbreak. Reef-wide live coral cover remained high until 1994. In 1993 elevated COTS populations were recorded and Macgillivray Reef was re-classified as Incipient Outbreak. COTS remained at or around Incipient Outbreak levels until 1998. There was a gradual decline in reef-wide live coral cover to moderate (10-30%) levels by 1998. Since then, coral cover has remained moderate (10-30%). By 2004 COTS numbers had once again risen to outbreak levels reducing coral cover. Surveys in 2005 did not record any COTS on Macgillivray Reef which was classified as Recovering. Reef wide live coral cover was moderate (20-30%). No bleaching was recorded during manta tow surveys in 2005. White syndrome disease (WSD) was restricted to scattered colonies in most parts of the reef perimeter except for the front and second flank. WSD was common on the front, where live coral was most abundant, affecting 10 or more hard coral colonies per two-minute tow.

At the intensive survey sites on Mcgillivray Reef cover of hard coral was moderate, averaging 21% in 2005. The coral community has been dominated by massive *Porites* since surveys began in 1993. Several coral families exhibited a slow increasing trend following a decline associated with COTS activity in the mid-90's. However, the percent cover of *Porites* has changed relatively little over the 11 years prior to 2005 and this reflects the avoidance of this genus by COTS. Cover of soft coral and algae has remained stable, and in 2005 averaged 6% and 51% respectively. It is also worth noting that the percent cover of sand at the fixed transects at Macgillivray Reef is relatively high (~20%) compared to other survey reefs. In 2005, very low numbers of colonies with coral diseases were recorded during SCUBA searches. *Drupella* spp. were recorded at a density of 193/ha., an increase from previous years.

Species of large, mobile fish families were either stable or increasing in abundance. Numbers of family Scaridae continued to increase at a slow rate in 2005. One species from the family Acanthuridae, *Acanthurus blochii* increased in 2005 whilst all other species showed a slight decrease in abundance. Families Chaetodontidae and Labridae both remained relatively stable in numbers. Within the damselfish community all species of *Pomacentrus* continued to decline after 2003, although the overall trend has been one of curvilinear increase since 1999. In 2005 numbers of other damselfish taxa remained relatively stable or had shown small declines, most notably *Acanthochromis polyacanthus* and the genus *Amblyglyphidodon* .

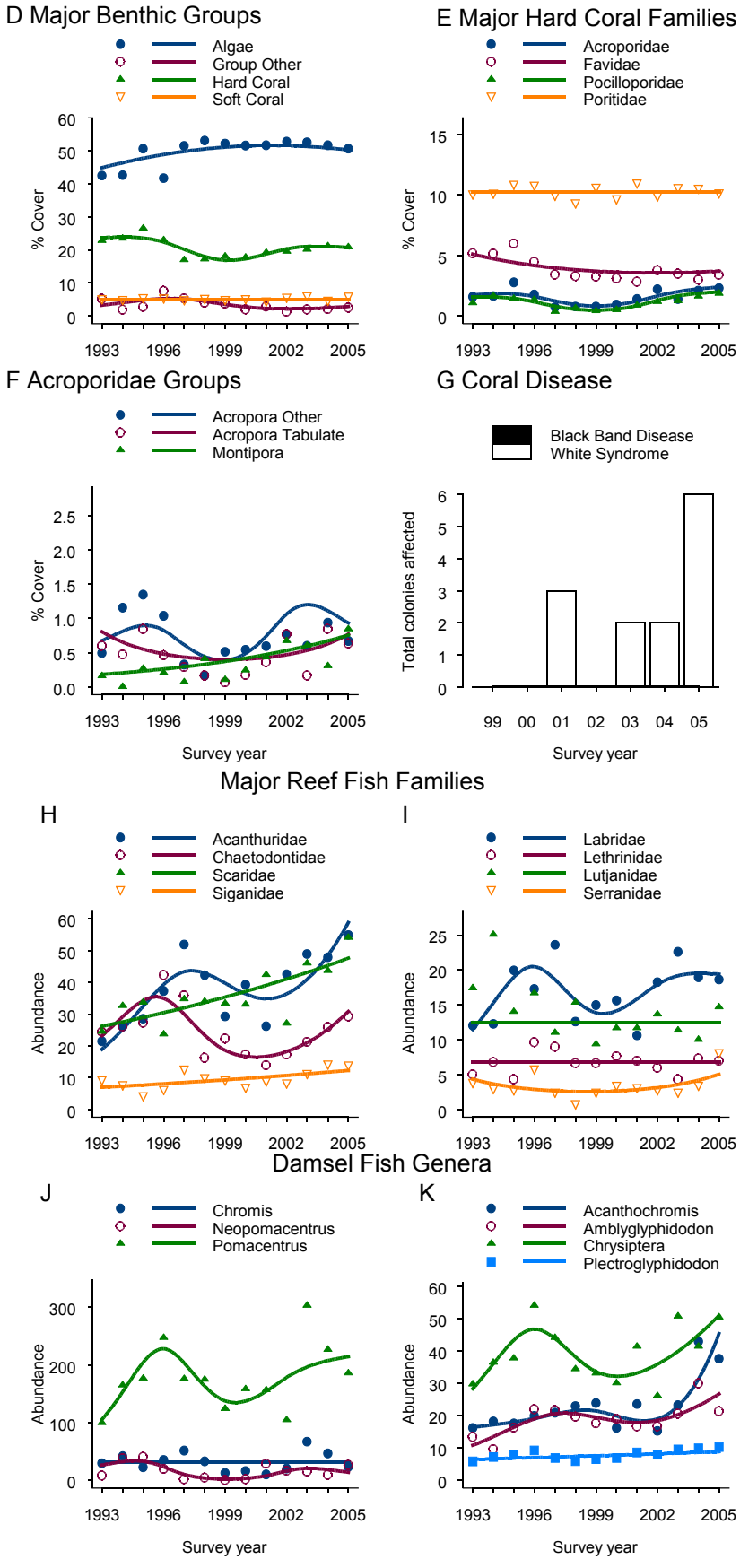
Figure 4.21

A



Macgillivray (No. 14-114) is a middle shelf planar reef with an area of .5 sq.km.

Figure 4.21 (Cont).



MARTIN

Surveyed August 2004.

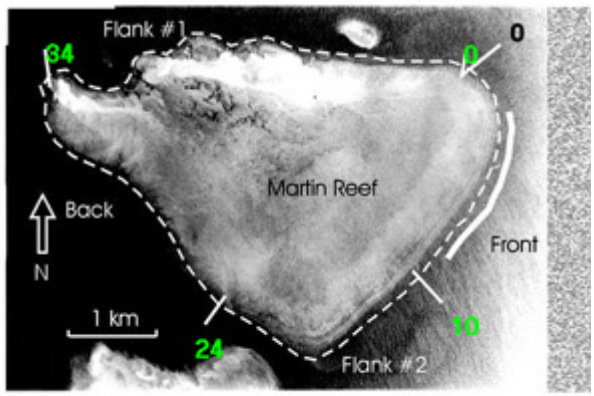
Martin Reef has been surveyed 14 times using manta tows since 1990. Reef-wide live coral cover has not changed significantly and was moderate (10-30%) in 2005. COTS populations were at incipient outbreak levels in 1998 and 1999, but no COTS have been seen in recent years. Martin Reef was classified as No Outbreak in 2005. Manta tow surveys in 2005 recorded no bleaching and only a few scattered colonies showing white syndrome and black band disease.

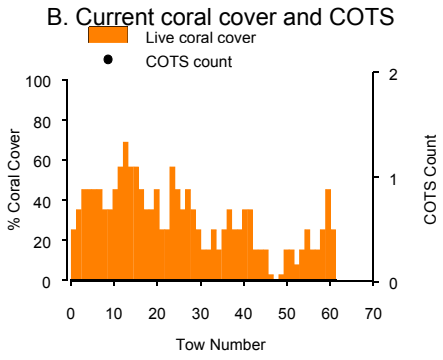
Hard coral cover on the intensive survey sites rose slightly to 28% in 2005. Cover of soft coral remained stable at 4%. The increase in cover of algae (45%) after 1998 was due to colonisation of sand and rubble. The decline in the family Pocilloporidae was probably due to bleaching mortality. Incidence of coral diseases was low in 2005 and the density of *Drupella* spp. was recorded at 47/ha.

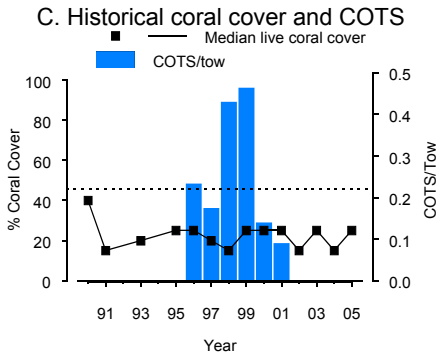
Numbers of large, mobile fish species showed no consistent trends, or tended to increase over the survey period. Numbers of the families Scaridae, Chaetodontidae, Lutjanidae and Labridae all fluctuated around an increasing trend over the 13 years of survey. Two species of the family Lutjanidae, *Lutjanus carponotatus* and *L. fulviflamma* had increased in abundance since 2003 and numbers in 2005 were the highest since surveys began. Abundances of a number of common species from the family Acanthuridae had decreased to a 12-year low in 2004, however several species had increased in abundance in the surveys of 2005, most notably *Acanthurus blochii*. Trends in the damselfish community were largely driven by changes in a few abundant species. Numbers of *Pomacentrus moluccensis* declined after 2000 and have driven the observed trends in the genus *Pomacentrus*. Numbers of *Amblyglyphidodon curacao* had been declining up to 2004 but increased markedly in 2005.

Figure 4.22

A

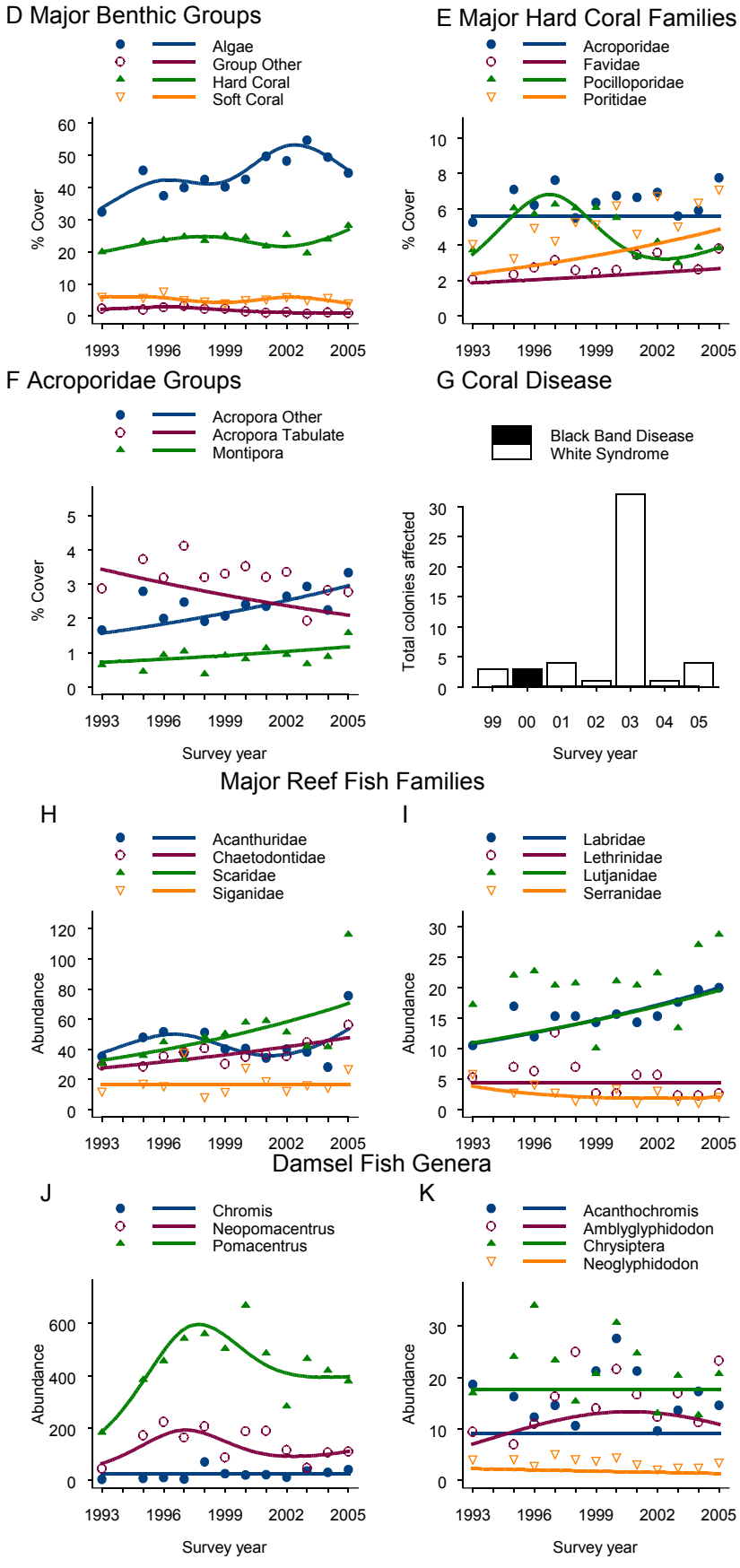






Martin (No. 14-123) is an inner shelf planar reef with an area of 10.1 sq.km.

Figure 4.22 (Cont).



NO NAME

Surveyed August 2004.

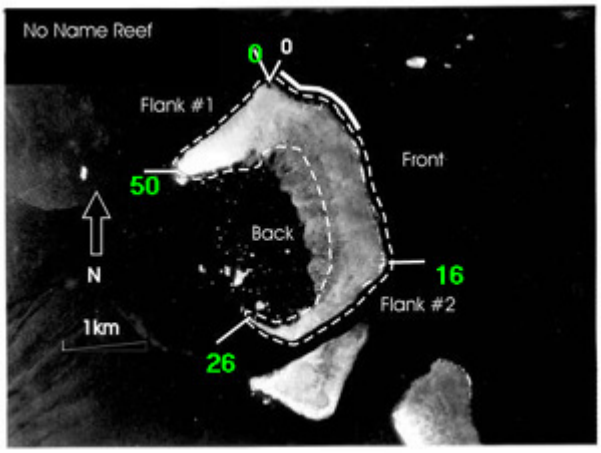
No Name Reef has been surveyed 17 times using manta tow since 1986. No Name Reef was originally classified as Recovering from a COTS outbreak prior to the beginning of surveys which probably caused the low initial coral cover. Cyclone Ivor also passed by this region in 1990 and caused significant physical damage. No COTS have been recorded since in manta tow surveys and reef-wide coral cover increased to the high cover (30-50%) seen in 2005. No Name Reef was reclassified as No Outbreak in 2001. No bleaching was recorded in 2005 but white syndrome disease (WSD) was common on most of the reef perimeter (affecting more than ten individuals coral colonies per two minute manta tow). Black band disease was also common on the back reef area.

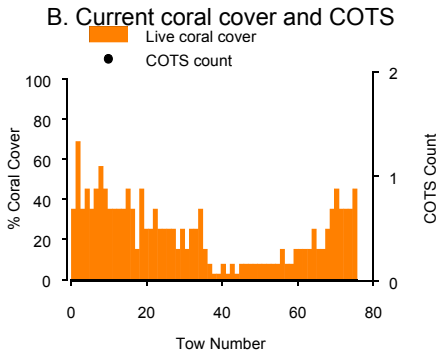
Cover of hard coral on the intensive survey sites increased from 21% in 1994 to a peak of 59% in 1999. This was primarily due to increases in the cover of fast growing tabulate *Acropora* corals from approximately 5% in 1994 to 30% in 1999. Total hard coral cover was 38% in 2005. SCUBA search counts recorded a dramatic increase in coral colonies with white syndrome disease in 2002 and it is likely that disease led to the observed decline in coral cover. Incidence of coral disease has fallen since. *Drupella* spp. were recorded at a density of 240/ha. Cover of algae rose to 52% in 2005, while soft coral has decreased steadily since 1994 reaching a low of 4% in 2005.

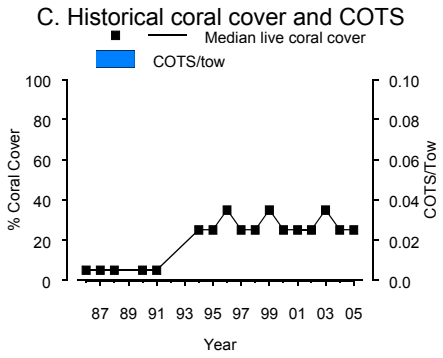
Numbers of the majority of large fish species had stabilised by 2005. Members of the family Acanthuridae had initially decreased in abundance as coral cover increased, but since 1997, as coral cover began to plateau, most species from this family have shown little change in abundance. Families Chaetodontidae, Scaridae and Siganidae all showed little change in abundance from 2004 to 2005. Trends in the family Lutjanidae are driven mainly by the numerically abundant *Lutjanus gibbus*, which decreased in abundance in 2005. In the damselfish community, increases in *Chromis*, were largely defined by numerically dominant species such as *C. ternatensis*. Other damselfish genera have shown a general increase in numbers since 2002, however in 2005, many of these species actually declined in numbers without affecting the long- term patterns (e.g. *Plectroglyphidodon*).

Figure 4.23

A

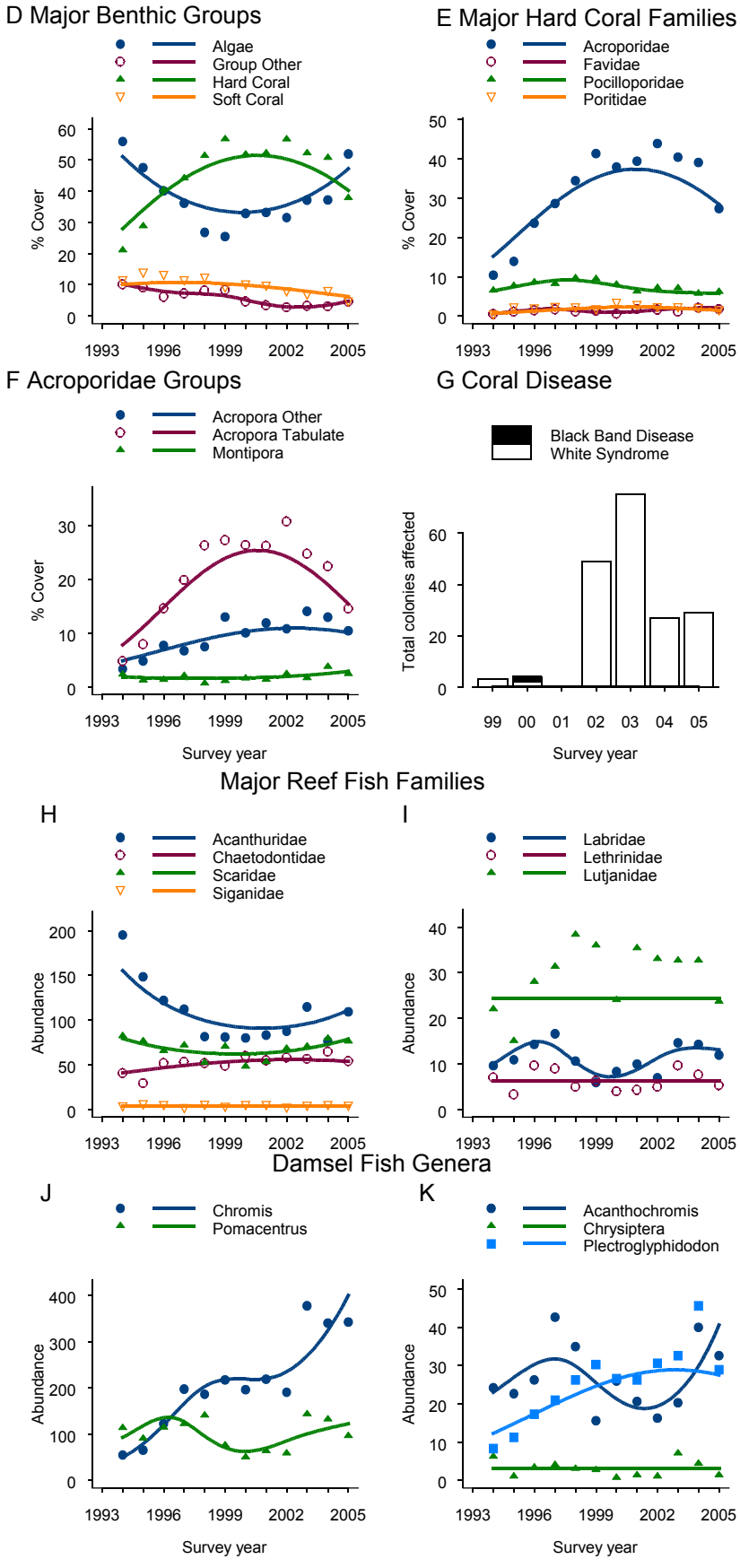






No Name (No. 14-139) is an outer shelf ribbon reef with an area of 7 sq.km.

Figure 4.23 (Cont).



NORTH DIRECTION IS

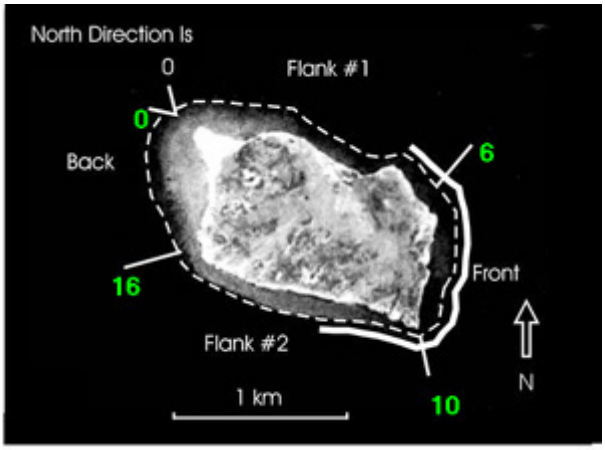
Surveyed August 2004.

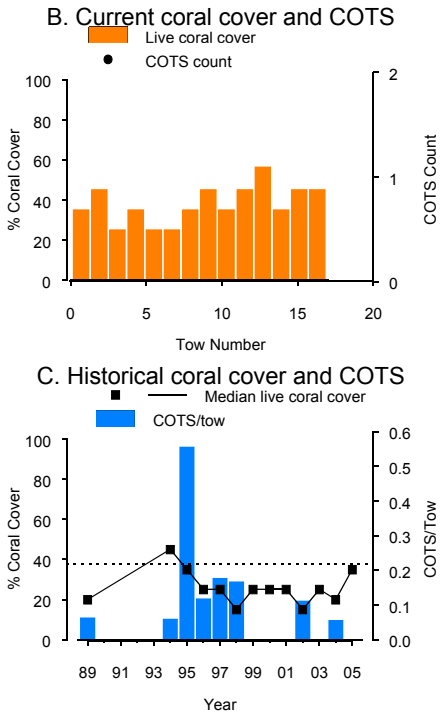
North Direction Island Reef was initially surveyed using manta tow in 1989 and has been surveyed annually since 1994. Reef-wide live coral cover increased between 1989 and 1994 before declining through to 1998. COTS activity is the most likely cause of the decline with North Direction Island Reef classified as Incipient Outbreak from 1995 to 1996. Small numbers of COTS have been observed in recent years but no COTS were observed during surveys in 2005. Reef-wide live coral cover increased and was high (30-40%) in 2005. No coral bleaching was recorded and white syndrome was restricted to a few scattered coral colonies. North Direction Island Reef was classified as Recovering in 2005.

Hard coral cover on the intensive survey sites was 25% in 2005, similar to the previous value. Soft coral cover remained low averaging 2%, while cover of algae was stable at about 60%. The coral community was not dominated by any one family with cover of all four major families increasing. A low number of diseased coral colonies were recorded in SCUBA searches in 2005, however both white syndrome and skeletal eroding band were present. A high concentration of *Drupella* spp. have been recorded since 1998, in 2005 the density reached 1080/ha.

All families of large, mobile reef fishes increased in abundance in 2005, with the exception of the family Serranidae, which decreased slightly. Most species from family Acanthuridae, Scaridae and Labridae increased in abundance in 2005, however, the general increase in family Chaetodontidae is attributable to a single, numerically dominant species, *Chaetodon trifasciatus*. The damselfish community remained, on the whole, relatively stable. Few genera showed any significant changes in numbers, although one species, *Chromis ternatensis*, had increased significantly in 2005.

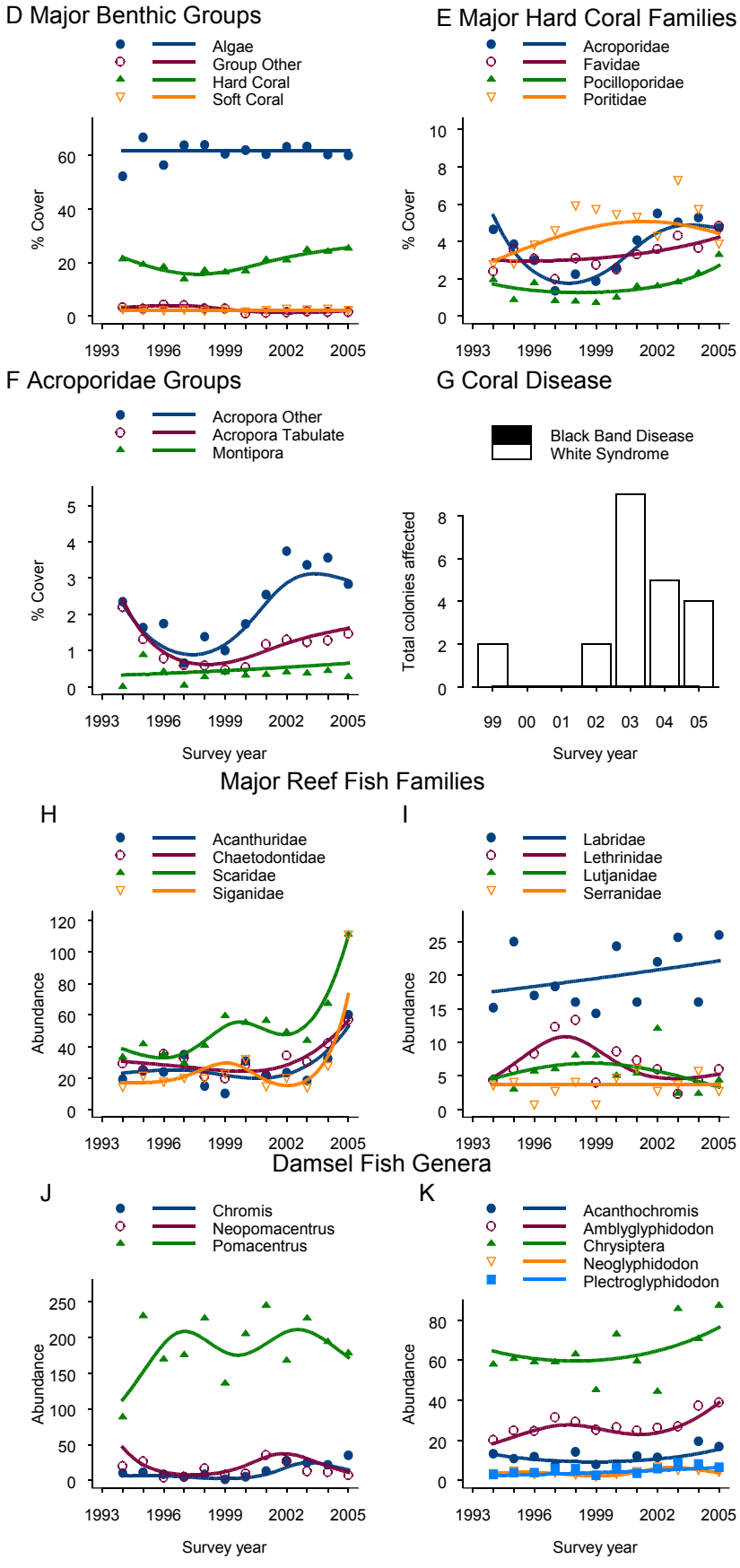
Figure 4.24 A





North Direction Is (No. 14-143) is a middle shelf fringing reef with an area of .9 sq.km.

Figure 4.24 (Cont).



YONGE

Surveyed August 2004.

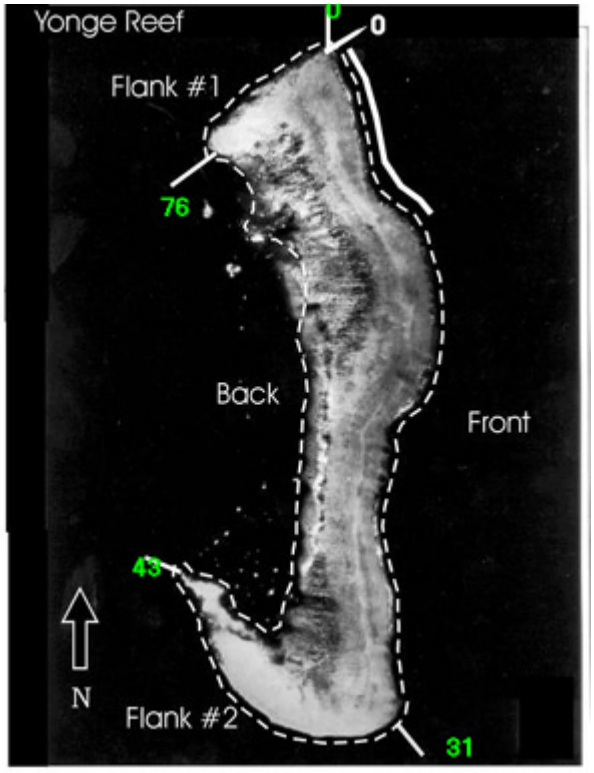
Yonge Reef has been surveyed annually using manta tow since 1992. COTS have only been observed on one occasion (1994) at extremely low density. However Yonge Reef was considered to be recovering from COTS activity before surveys began. Yonge Reef was first classified as No Outbreak in 2001. Reef-wide live coral cover increased to moderate levels (10-30%) by 2000. There was a slight decline in 2002 and 2003 before bouncing back to moderate levels in 2004 and 2005. Yonge Reef has been recovering from the effects of Cyclone Ivor (which passed through the area in 1990). No coral bleaching was recorded during manta tow surveys in 2005. While white syndrome disease affected relatively few colonies around much of the reef perimeter, it was common on the first flank and front reef where coral cover was highest, affecting 10 or more coral colonies per two-minute tow. Yonge Reef was classified as No Outbreak in 2005.

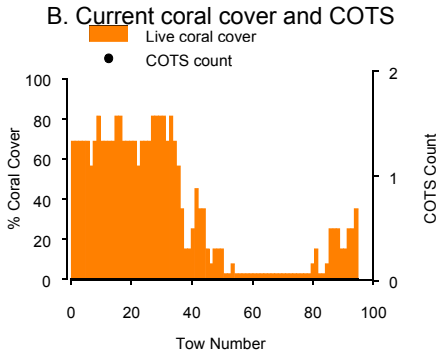
The cover of hard coral at Yonge Reef has increased from 10% in 1993 to 61% in 2002. Hard coral cover changed little in subsequent years only slightly declining to 48% by 2005. This decline may be attributed to a low level incidence of coral disease (mostly White Syndrome) between 2002 and 2005. The benthic community is dominated by tabulate *Acropora*, which reached a maximum cover of 34% in 2002 and averaged 26% in 2005. *Drupella* spp. were recorded at a density of 73/ha. in 2005.

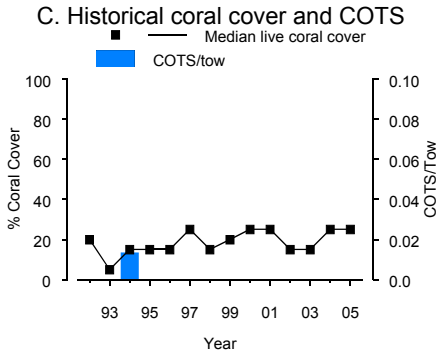
Species of herbivorous fishes had previously declined in numbers up to 2000 as hard coral cover increased. Since this time, species from family Acanthuridae have stabilised (as had coral cover), with some species increasing in abundance in 2005 (e.g.. *Ctenochaetus* group, *Acanthurus nigrofuscus* and *A. nigrofuscus*). Similarly, most species from family Scaridae increased in abundance after a long period of decline up to 2004. Numbers Chaetodontidae continued to increase in 2005. All other families of large, mobile fishes showed no consistent trend in abundance. In 2005, there were decreases in the abundance of the damselfish genus, *Chromis*, due to several species. However, this had little effect on the overall increasing trend over the 13 years of surveys. A similar pattern was evident for *Acanthochromis polyacanthus*.

Figure 4.25

A

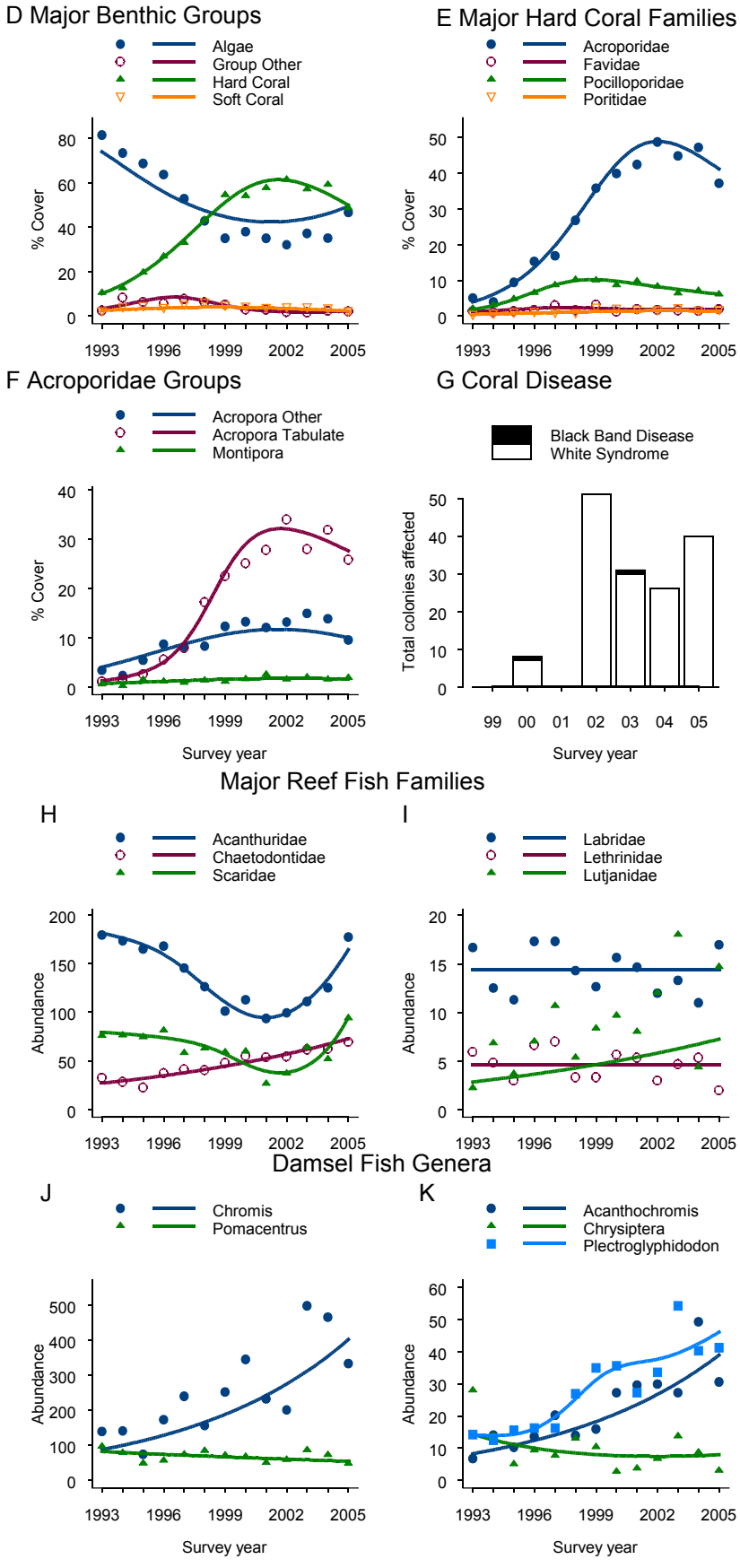






Yonge (No. 14-138) is an outer shelf ribbon reef with an area of 11.1 sq.km.

Figure 4.25 (Cont).

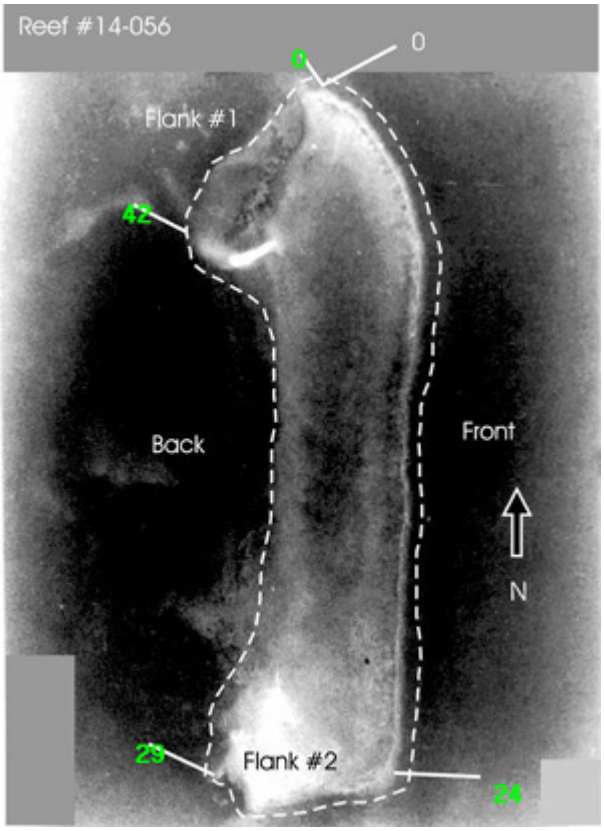


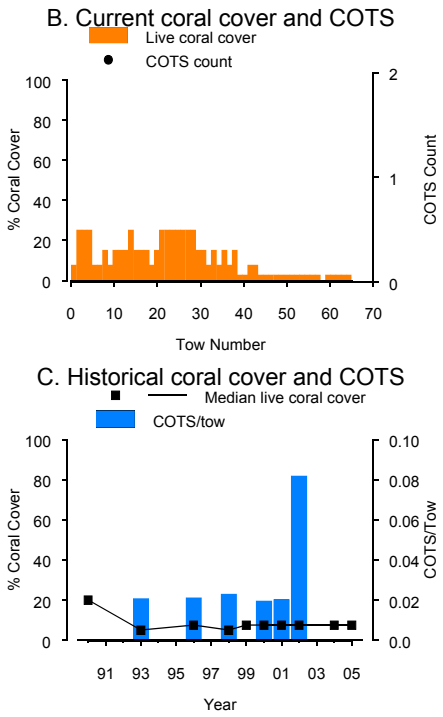
14-056

Surveyed September 2004.

Reef 14-056 has been surveyed 10 times since 1990. Initially reef-wide live coral cover was moderate (10-30%) before declining in the early nineties to the current low (1-10%) level where it has stabilised. COTS have been observed in most survey years though generally in numbers too low to cause significant reef-wide live coral mortality. Manta tow surveys in 2005 found that reef-wide live coral cover remained low (1-10%). Reef 14-056 was classified as No Outbreak. No bleaching was recorded. White syndrome disease was present in 2005 but was restricted to a few scattered coral colonies.

Figure 4.26 A





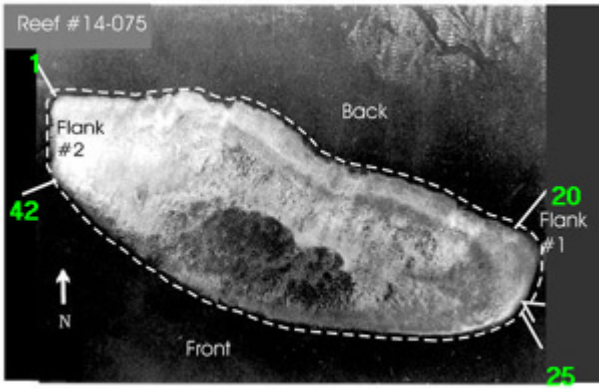
14056 (No. 14-056) is a middle shelf crescentic reef with an area of 7.8 sq.km.

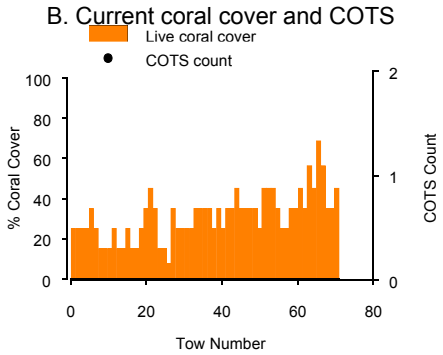
14-075

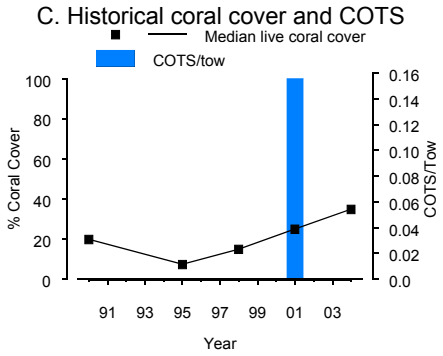
Surveyed September 2003.

Reef 14-075 has been surveyed five times since 1990. Reef-wide live coral cover declined between 1990 and 1995 before recovering. Coral cover has been increasing and was at a high level (30-40%) in 2004. The small number of COTS recorded in 2001 appears to have had little impact on reef-wide live coral cover. No COTS were recorded in 2004 and the reef was classified as No Outbreak. There were no signs of coral bleaching and white syndrome was present but restricted to a few scattered coral colonies.

Figure 4.27 A







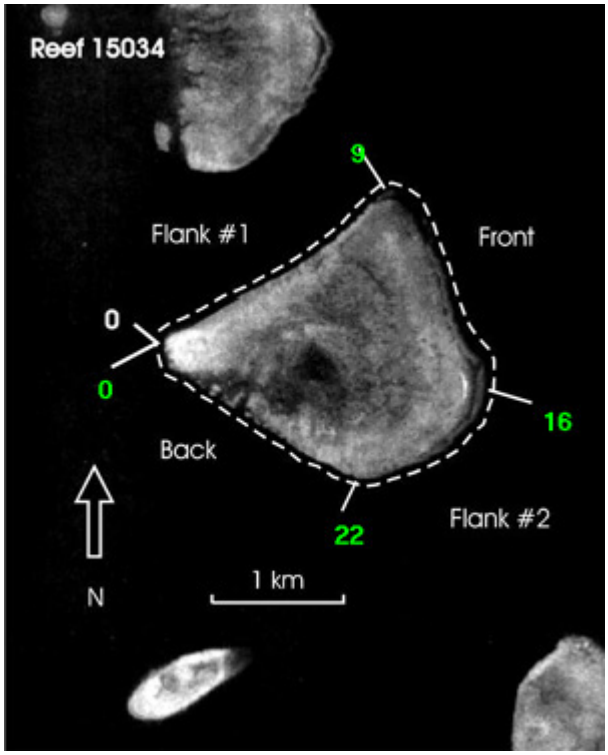
14075 (No. 14-075) is an outer shelf ribbon reef with an area of 8 sq.km.

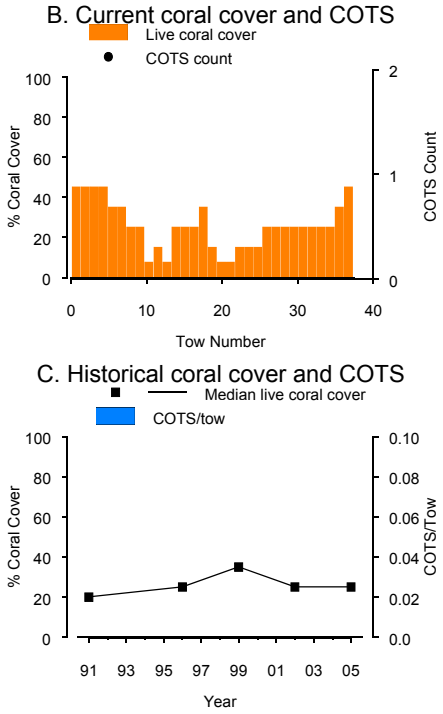
15-034

Surveyed August 2004.

Reef 15-034 has been surveyed five times since 1991 when it was initially classified as No Outbreak. Reef-wide live coral cover increased from moderate (10-30%) to high (30-50%) up until 1999. Surveys in 2002 showed a small decline in coral cover to moderate (10-30%) levels where it remains in 2005. No COTS have been recorded in any survey and Reef 15-034 was classified as No Outbreak in 2005. No bleaching and only low levels of white syndrome disease (restricted to small numbers of individual coral colonies) were recorded during manta tow surveys in 2005.

Figure 4.28 A





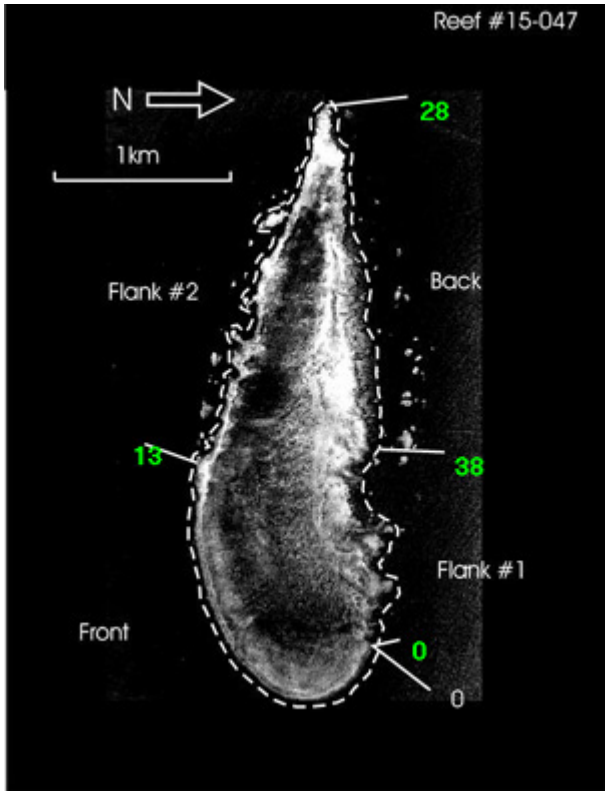
15034 (No. 15-034) is an outer shelf ribbon reef with an area of 2.9 sq.km.

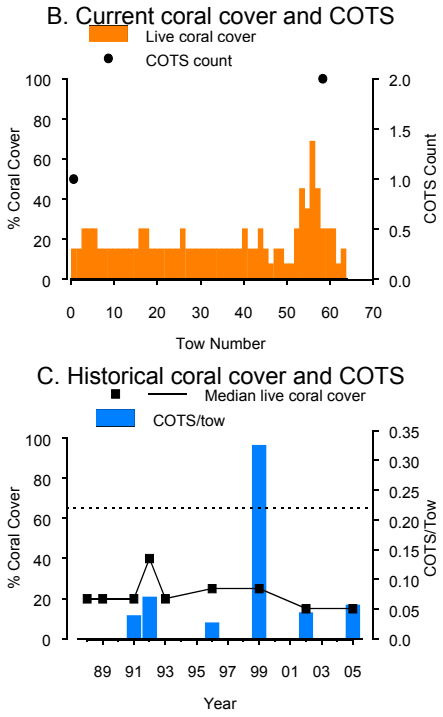
15-047

Surveyed August 2004.

Reef 15-047 has been surveyed nine times using manta tow since 1988 when reef-wide live coral cover was moderate (10-30%). In subsequent years low numbers of COTS were recorded in 5 of 6 surveys and had reached Incipient Outbreak levels by 1999. While subsequent surveys have shown that COTS have remained active, their numbers have declined to below outbreak level. The small decline in reef-wide live coral cover that occurred between between 1999 and 2002 was most likely due to COTS feeding activity. Reef 15-047 was classified as No Outbreak in 2005. No bleaching was observed and white syndrome disease was restricted to a small number of scattered coral colonies during manta tow surveys in 2005.

Figure 4.29 A





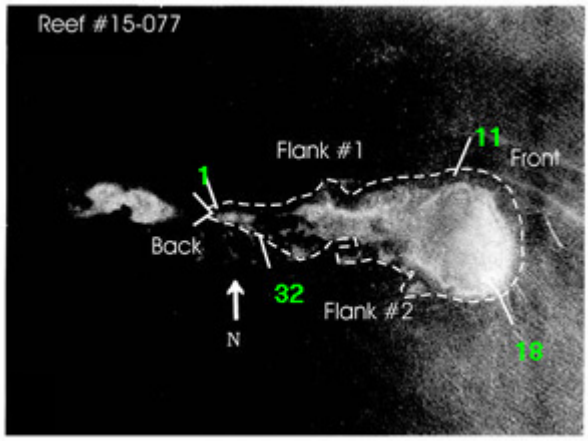
15047 (No. 15-047) is a middle shelf crescentic reef with an area of 4.89 sq.km.

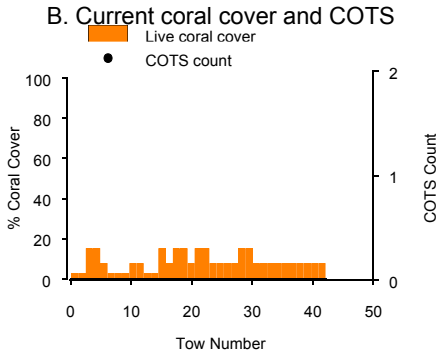
15-077

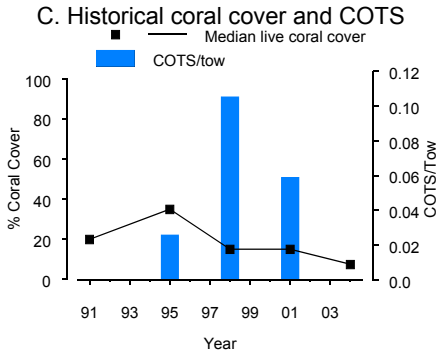
Surveyed August 2003.

Reef 15077 has been surveyed five times since 1991. Reef-wide live coral cover peaked during surveys in 1995 before declining in later surveys. Although the decline coincided with increased COTS activity, COTS numbers have been too low to impact significantly on reef-wide live coral cover. No COTS were observed during surveys in 2004 and the reef was classified as No Outbreak. No bleaching was recorded. White syndrome disease was present in 2004 but was restricted to a few scattered coral colonies.

Figure 4.30 A







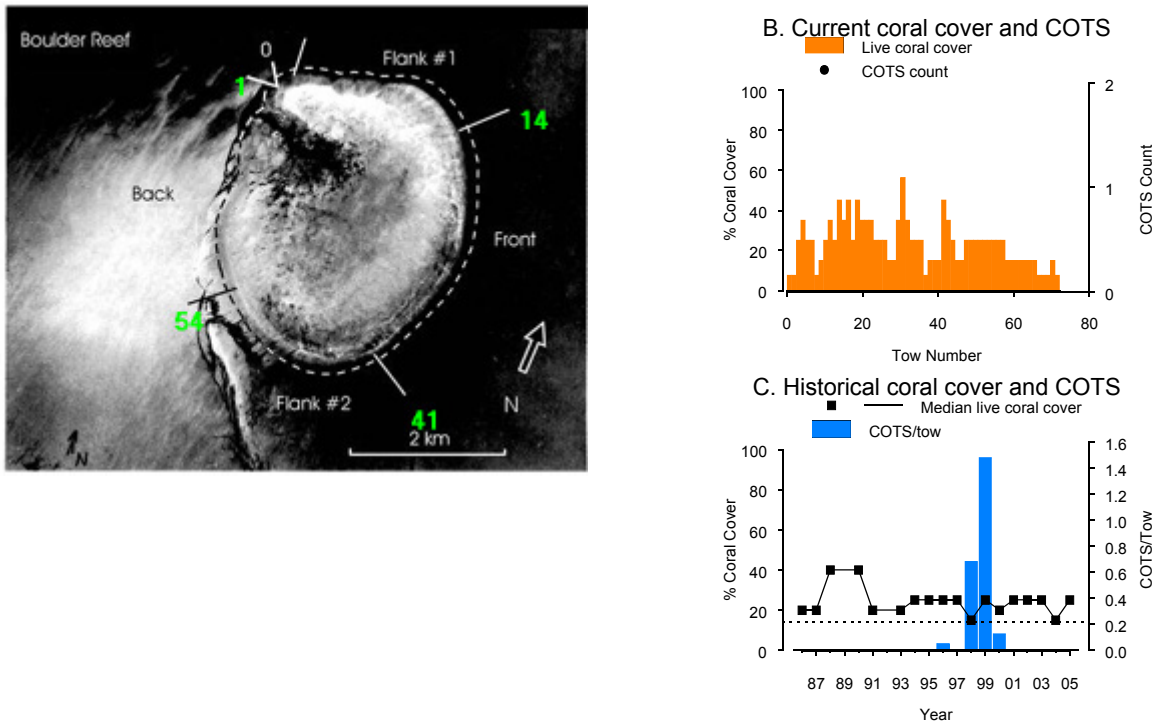
15077 (No. 15-077) is a middle shelf planar reef with an area of 6 sq.km.

BOULDER

Surveyed September 2004.

Boulder Reef has been surveyed 18 times using manta tow since 1986. Early surveys found that reef-wide live coral cover increased, peaking around 1990, followed by a decline and then remained stable at moderate levels (10-30%) through to 2003. COTS were first recorded in 1996 and reached Incipient Outbreak levels in 1998. Surveys in 1999 revealed further increases in COTS and Boulder Reef was reclassified as an Active Outbreak. However, elevated COTS numbers were relatively short lived and no COTS have been observed Boulder Reef since 2001. Live coral cover was only slightly affected during the outbreak and the reason for the decline in COTS numbers is uncertain. Boulder Reef was classified as No Outbreak in 2002 and remained so in 2005. Coral cover was moderate (10-30%). Manta tow surveys in 2005 recorded no bleaching and only a few scattered colonies showing white syndrome disease.

Figure 4.31 A



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

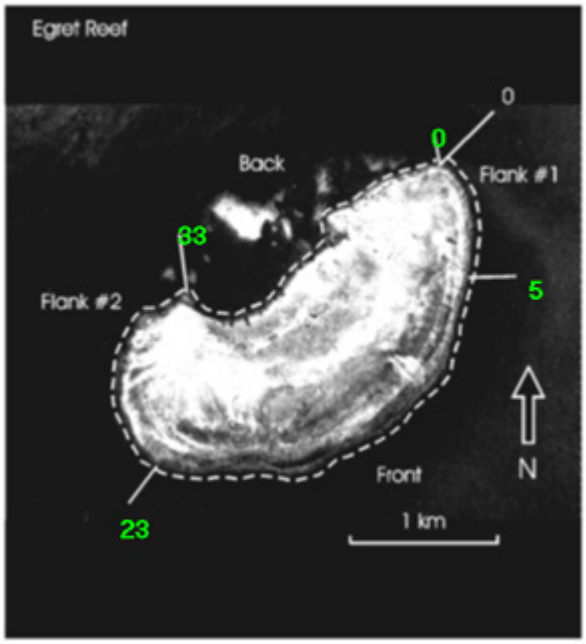
EGRET

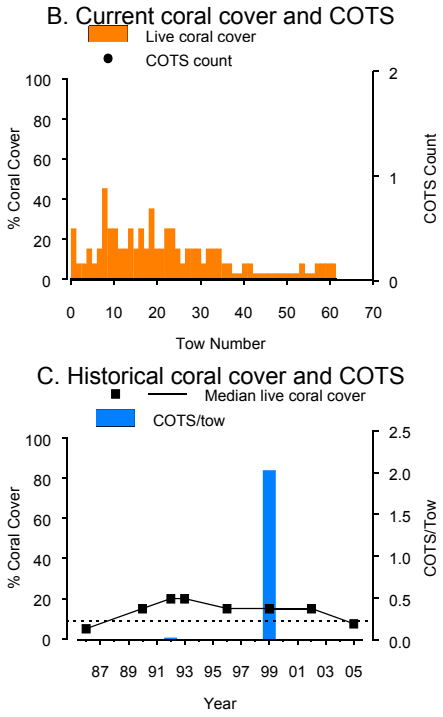
Surveyed August 2004.

Egret Reef has been surveyed eight times since 1986. Reef-wide live coral cover initially increased and then remained stable at moderate levels (10-30%) through to the survey in 2002. COTS were first recorded on this reef in 1992 and had reached Active Outbreak levels by 1999. No COTS have been observed since 2001 and Egret Reef was classified as Recovering in 2005. In 2005, median reef-wide live coral cover had declined to a low level (5-10%). In the absence of COTS the reason(s) for this decline is unknown. Low levels of bleaching and only a few scattered colonies with white syndrome disease were observed during manta tow surveys in 2005.

Figure 4.32

A





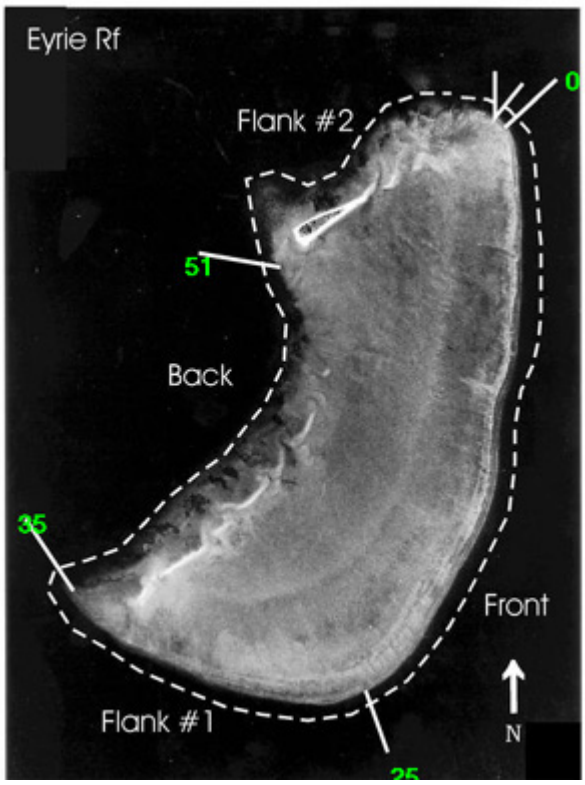
Egret (No. 15-013) is an inner shelf crescentic reef with an area of 9.7 sq.km.

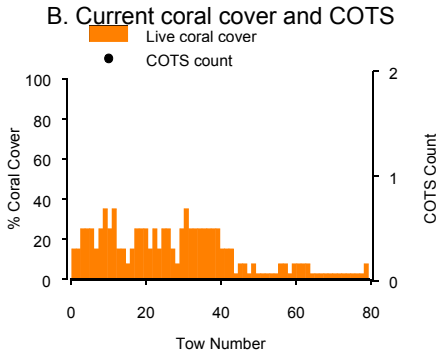
EYRIE

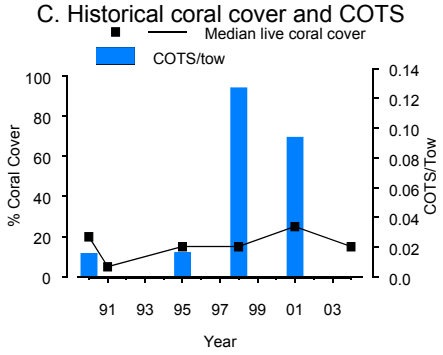
Surveyed August 2003.

Eyrie reef has been surveyed six times since 1990. Small numbers of COTS have been observed on this reef during most surveys. The initial decline in reef-wide live coral cover (1990-1991) is unexplained. Although COTS were recorded at the time, they were in numbers normally considered too low to affect reef-wide live coral cover. Coral cover gradually increased until 2001 when it was moderate (10-30%). Small numbers of COTS have been recorded during most survey years though below outbreak levels. No COTS were observed during surveys in 2004 and coral cover was moderate. The reef was classified as No Outbreak in 2004. No bleaching or disease was recorded during manta tow surveys.

Figure 4.33 A







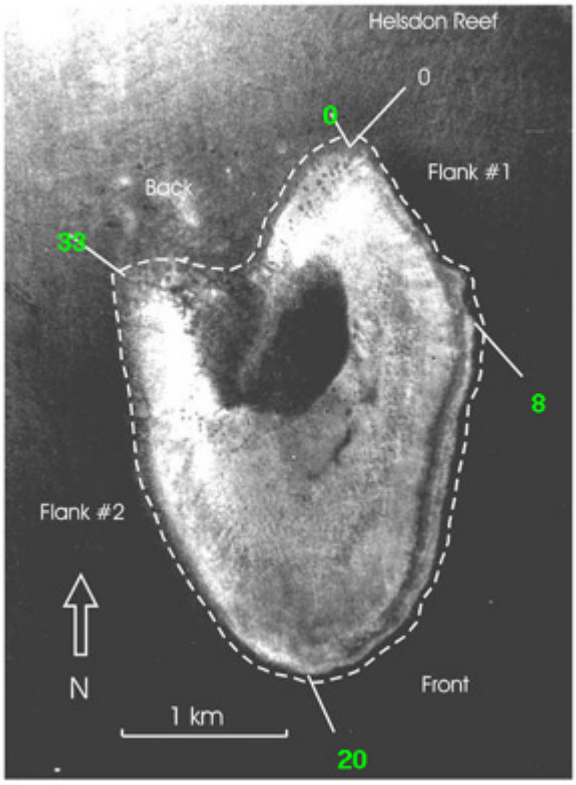
Eyrie (No. 14-118) is a middle shelf planar reef with an area of 12 sq.km.

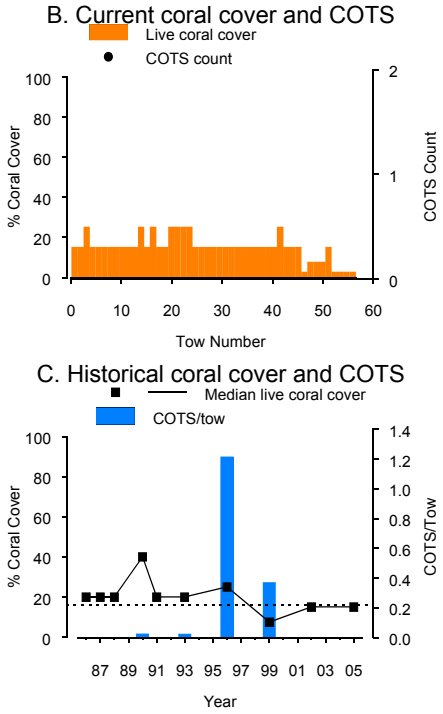
HELSDON

Surveyed August 2004.

Helsdon Reef has been surveyed 10 times since 1986. The reef was initially classified as Recovering and had moderate (10-30%) reef-wide live coral cover. COTS numbers reached Active Outbreak levels in 1996 and 1999 and coral cover decreased to low levels (1-10%), probably due to COTS feeding. In 2005 no COTS were seen and reef-wide live coral cover was moderate at 10-30%. Helsdon Reef is was classified as Recovering in 2005. No bleaching and only low levels of white syndrome disease (restricted to small numbers of scattered coral colonies) were recorded in 2005.

Figure 4.34 A





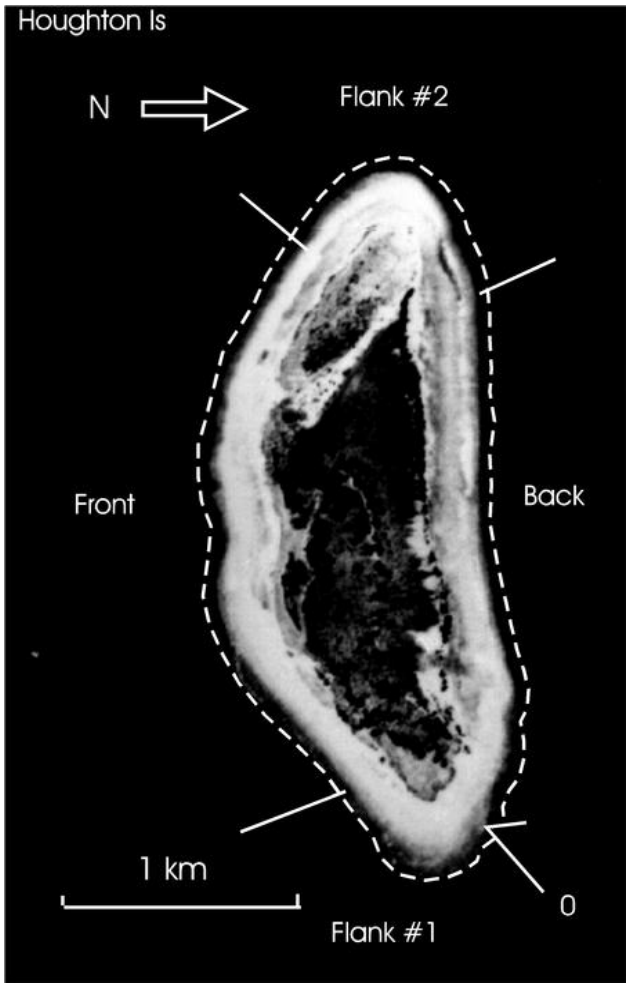
Helsdon (No. 14-135) is a middle shelf Crescentic reef with an areaod 1.06 sq.km.

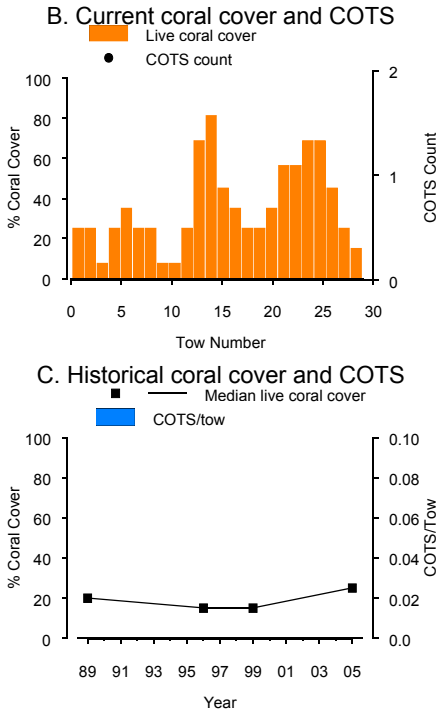
HOUGHTON IS

Surveyed August 2004.

Houghton Island Reef has been surveyed four times since 1989. Over this time median reef wide live coral cover has remained stable at a moderate (10-30%) level. No COTS have been observed and Houghton Island Reef was classified as No Outbreak in 2005. No bleaching or coral disease was recorded in 2005.

Figure 4.35 A





Houghton Is (No. 14-094) is an inner shelf planar reef with an area of 1.6 sq.km.

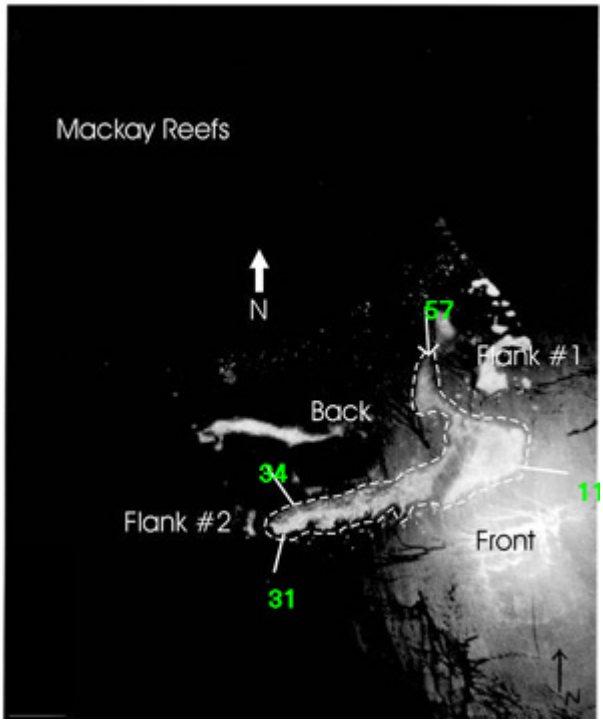
MACKAY REEFS

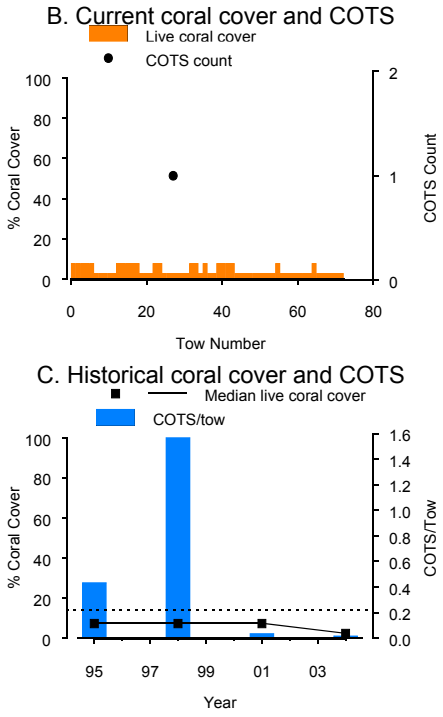
Surveyed September 2003.

The Mackay Reefs have been surveyed four times since 1995. COTS were recorded in all surveys and the reef was declared an Active Outbreak in 1998. A single COTS was seen in 2004. Reef-wide live coral cover was very low (1-5%) , the lowest for the entire period of survey. The low value for coral cover was almost certainly due to COTS feeding. There was no coral bleaching in 2004 and white syndrome disease was present but restricted to a few scattered coral colonies. The reef was classifed as recovering.

Figure 4.36

A





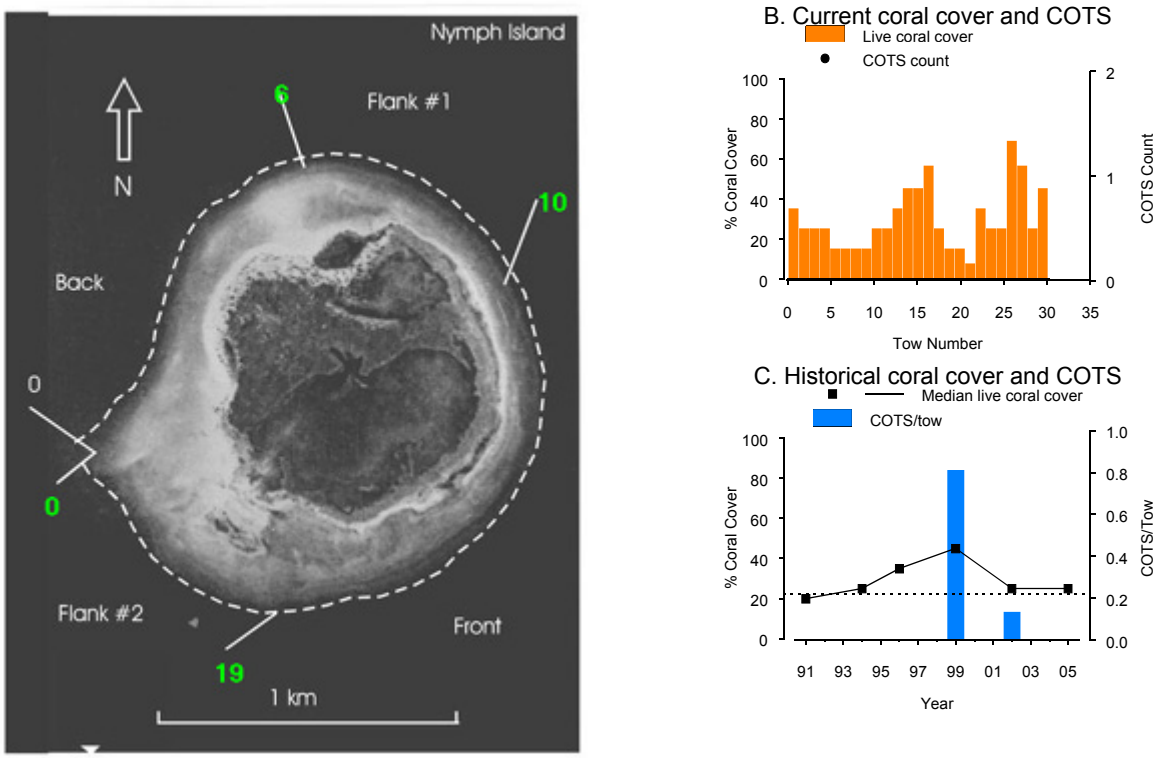
Mackay Reefs (No. 15-024) is a middle shelf patch reef with an area of 25.9 sq.km.

NYMPH IS

Surveyed August 2004.

Nymph Island Reef has been surveyed six times since 1991 when it was classified as No Outbreak. During the initial years of surveys reef-wide live coral cover increased from moderate (10-30%) to high coral cover (30-50%) by 1999 when an Incipient Outbreak of COTS was recorded. Surveys in 2002 showed that COTS densities had declined below outbreak levels. There had been a decline in reef-wide live coral cover to a moderate level of 10-30% which persisted in 2005. This decline is most likely due to COTS feeding activity. In 2005 Nymph Island Reef was classified as No Outbreak. No coral bleaching or white syndrome disease was observed. Black band disease was restricted to a few individual coral colonies on the first flank.

Figure 4.37 A



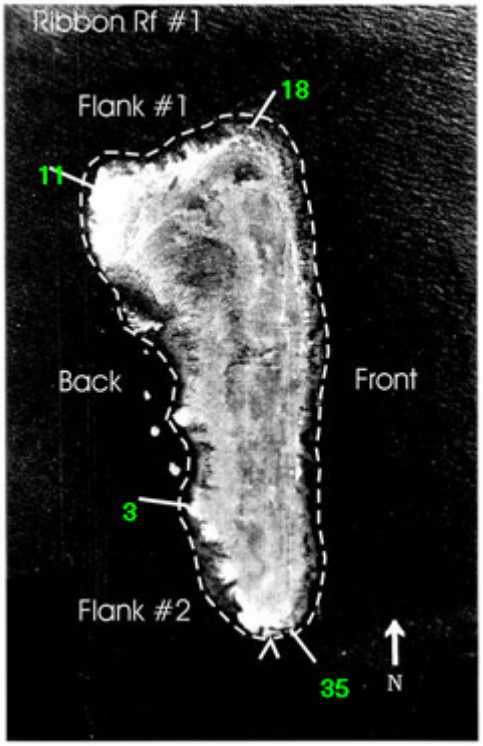
Nymph Is (No. 14-115) is a middle shelf planar reef with an area of 1.6 sq.km.

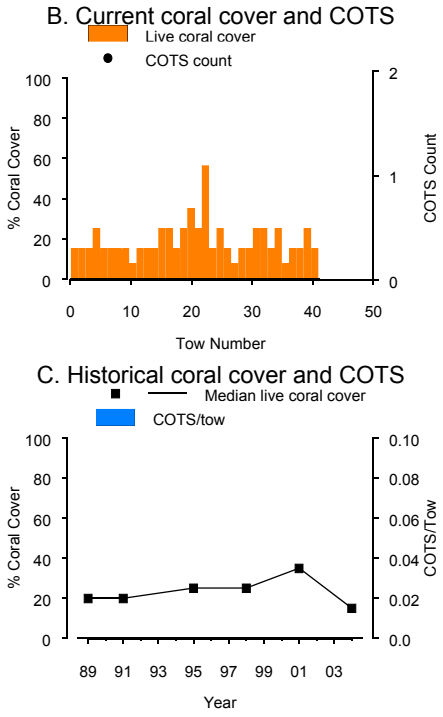
RIBBON NO.1

Surveyed August 2003.

Ribbon reef No. 1 has been surveyed 6 times since 1989. Coral cover increased between 1989 and 2001 but then fell from a high level (30-40%) in 2001 to a moderate (10-20%) level in 2004. The reason for this decline remains enigmatic. No COTS have been recorded from this reef and it was classified as No Outbreak in 2004. Surveys in 2004 found no coral bleaching and white syndrome was present but restricted to a few scattered coral colonies.

Figure 4.38 A





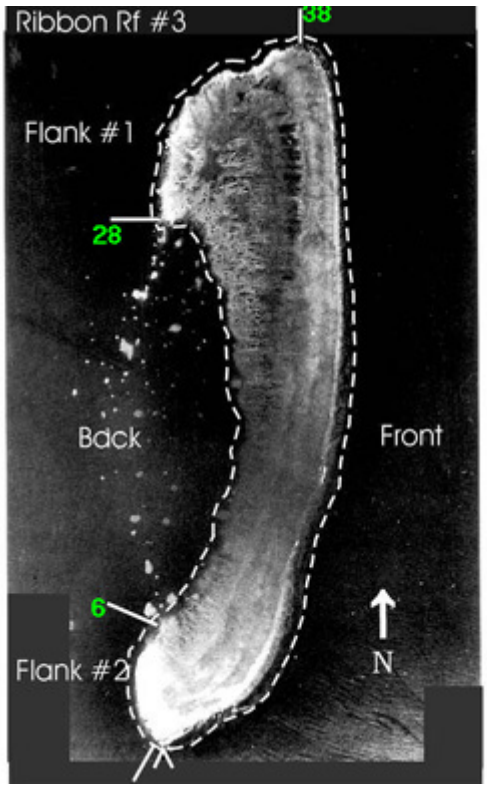
Ribbon No.1 (No. 15-080) is an outer shelf ribbon reef with an area of 3.3 sq.km.

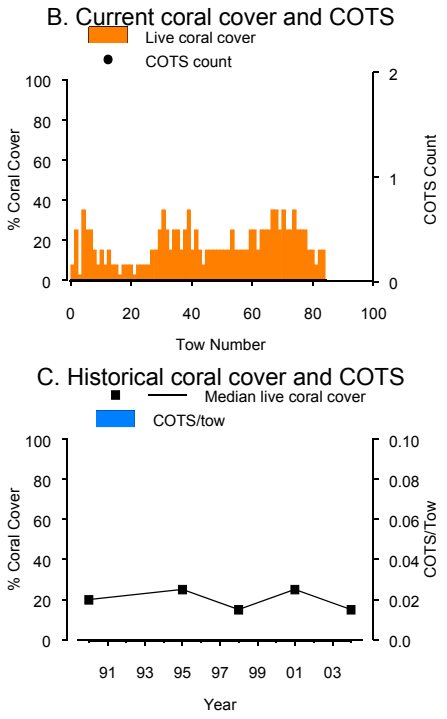
RIBBON NO.3

Surveyed August 2003.

Ribbon reef No. 3 has been surveyed five times since 1990. Reef-wide coral cover has remained moderate (20-30%). No COTS have been recorded from this reef and it was classified as No Outbreak in 2004. Surveys in 2004 found no coral bleaching and white syndrome and black band disease were present but restricted to a few scattered coral colonies.

Figure 4.39 A





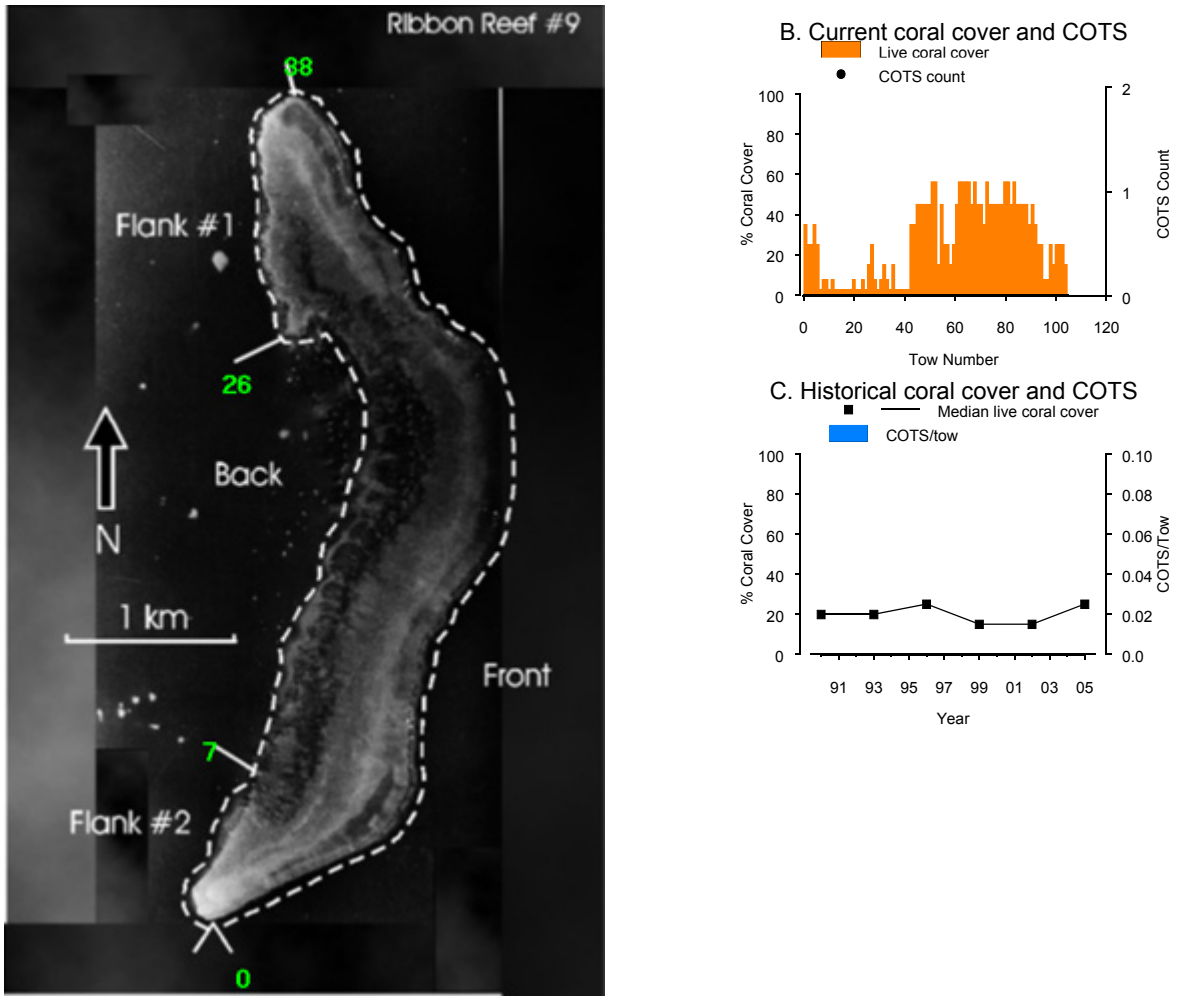
Ribbon No.3 (No. 15-050) is an outer shelf ribbon reef with an area of 11 sq.km.

RIBBON NO.9

Surveyed August 2004.

Ribbon Reef No. 9 has been surveyed six times since 1990 when it was classified as Recovering from COTS activity prior to the commencement of surveys. Since then reef-wide live coral cover has remained moderate (10-30%). No COTS have been recorded from Ribbon Reef No. 9 in any survey and it was classified as No Outbreak in 2005. No bleaching was observed and white syndrome disease was restricted to a small number of scattered coral colonies in 2005.

Figure 4.40 A



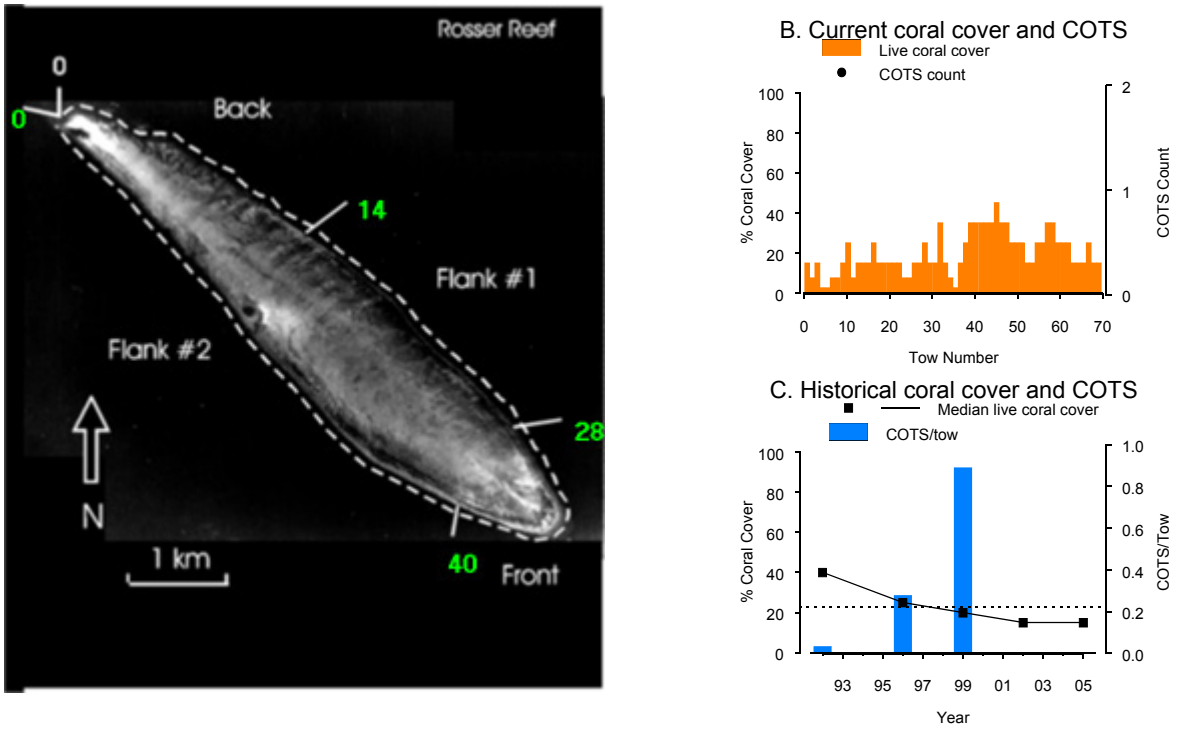
Ribbon No.9 (No. 14-154) is an outer shelf ribbon reef with an area of 18.8 sq.km.

ROSSER

Surveyed August 2004.

Rosser Reef has been surveyed five times since 1992 when it was classified as No Outbreak. Initial surveys showed reef-wide live coral cover to be high (30-50%) but surveys in 1996 and 1999 recorded Incipient Outbreak densities of COTS. Increased COTS activity was matched by a corresponding decline in reef-wide live coral cover to moderate levels (10-30%). COTS were no longer present in 2002 and Rosser Reef was reclassified as Recovering. In 2005, median reef-wide live coral cover was moderate. Rosser Reef was classified as Recovering. No bleaching was observed and low levels (restricted to a few scattered coral colonies) of white syndrome disease were recorded in 2005.

Figure 4.41 A



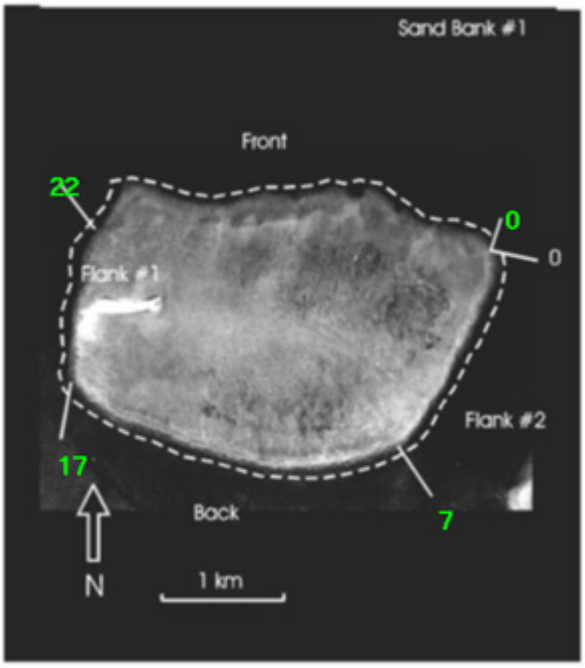
Rosser (No. 15-081) is a middle shelf planar reef with an area of 7.2 sq.km.

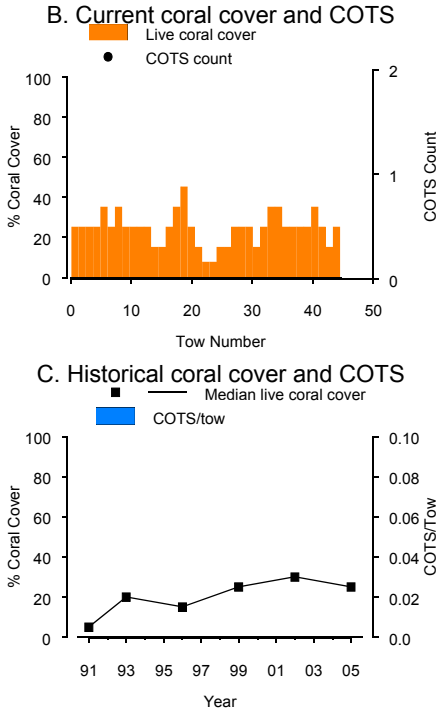
SANDBANK NO.1

Surveyed September 2004.

Sandbank Reef No. 1 has been surveyed six times since 1991 when it was classified as No Outbreak. Since then reef-wide live coral cover has increased steadily from the initial low cover (1-10%) to a moderate level (20-30%) in 2005. No COTS have been recorded at any survey and Sandbank Reef No. 1 was classified as No Outbreak in 2005. White syndrome disease was generally rare, being restricted to a few scattered colonies. However, white syndrome disease was common in the back reef area, infecting 10 or more coral colonies per two-minute tow. No bleaching was observed during surveys in 2005.

Figure 4.42 A





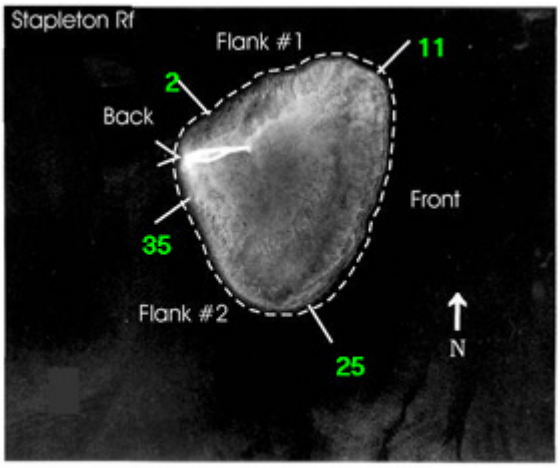
Sandbank No.1 (No. 14-045) is an outer shelf planar reef with an area of 5.3 sq.km.

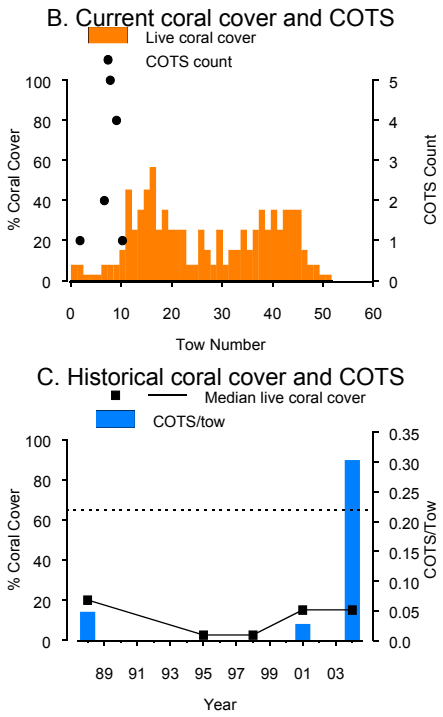
STAPLETON IT

Surveyed September 2003.

Stapleton Islet reef has been surveyed five times since 1988. After an initial decline between 1988 and 1995, reef-wide coral cover remained low (5-10%). COTS were present in early surveys and are probably responsible for the decline in coral cover. Reef-wide live coral cover was beginning to recover by 2001 and was a moderate (20-30%) in 2004. However COTS have reached outbreak densities in recent surveys so coral cover may decline in future. The reef was classified as Incipient Outbreak in 2004. There was no coral bleaching in 2004. White syndrome was present but restricted to a few scattered coral colonies.

Figure 4.43 A





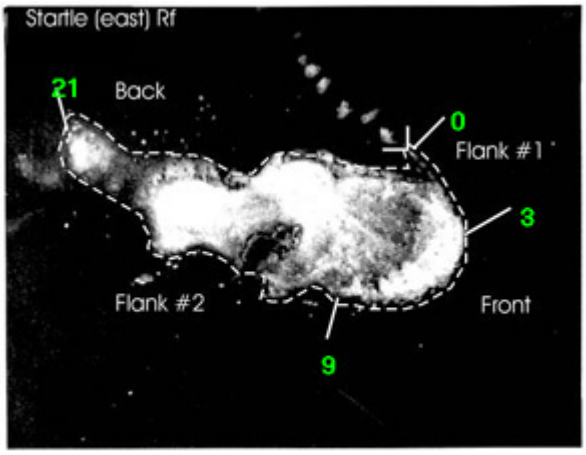
Stapleton It (No. 14-054) is a middle shelf planar reef with an area of 4.8 sq.km.

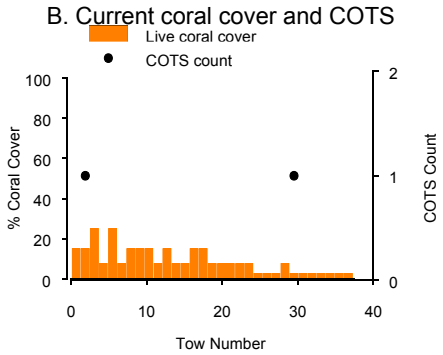
STARTLE (EAST)

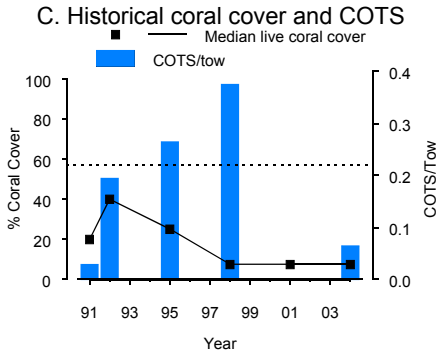
Surveyed September 2003.

Startle (East) reef has been surveyed six times since 1991. Reef-wide live coral cover declined from a high level (30-40%) in 1992 to a low level (5-10%) in 1998 which persisted until 2004. Outbreaks of COTS were recorded in 1995 and 1998 and these are the most likely cause of the decline in coral cover. The reef was classified as Recovering in 2004. Small numbers of COTS were recorded and these may hamper recovery. No bleaching or disease was recorded in 2004.

Figure 4.44 A







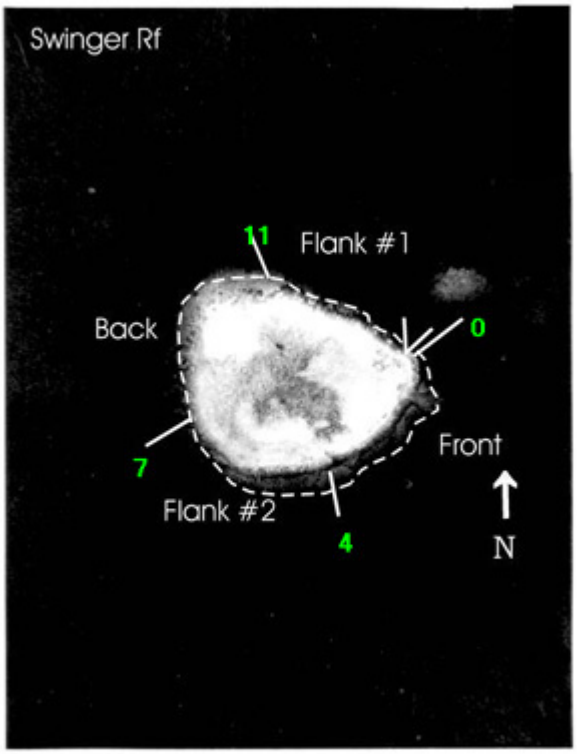
Startle (East)

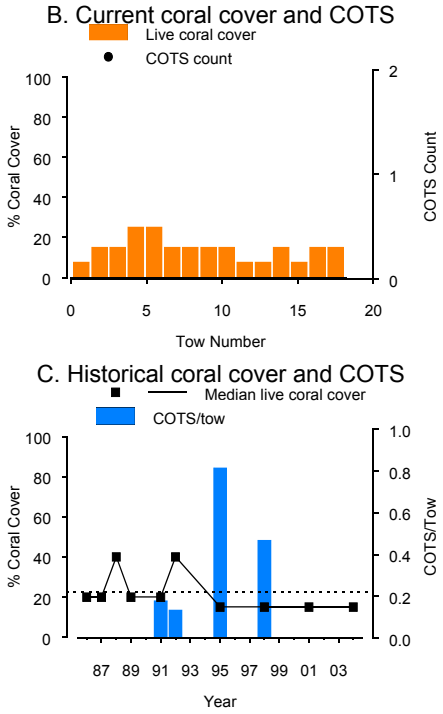
SWINGER

Surveyed September 2003.

This reef has been surveyed 10 times since 1986. Reef-wide live coral cover was high (20-40%) until 1992 but declined to moderate levels (10-20%) in 1995 where it has remained. This is a reflection of COTS activity. Starfish were present in 1991 and their numbers increased up until 1995. Outbreak levels of COTS were present between 1995 and 1998. No COTS were seen in 2004 and the reef was reclassified as Recovering. No bleaching was recorded in 2004 and white syndrome was present but restricted to a few scattered coral colonies.

Figure 4.45 A





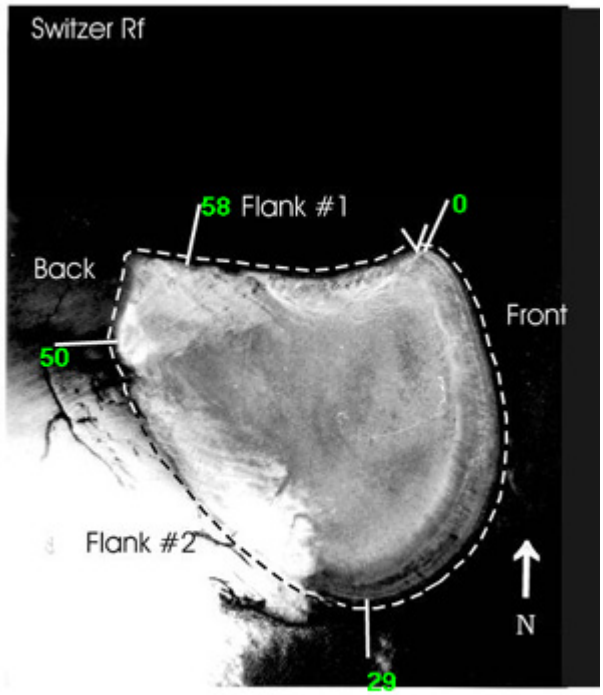
Swinger (No. 15-030) is a middle shelf planar reef with an area of 2.5 sq.km.

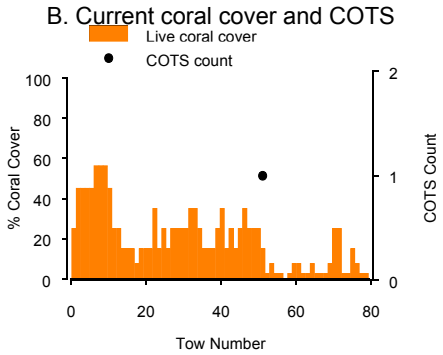
SWITZER

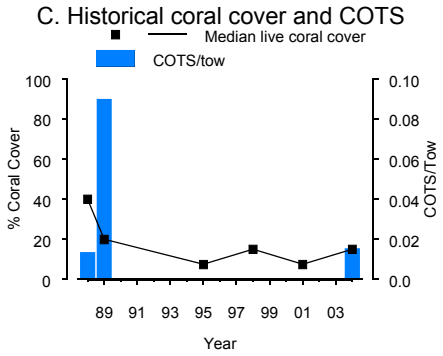
Surveyed September 2003.

This reef has been surveyed six times since 1988. Reef-wide live coral cover decreased from a high level (30-40%) to a low (5-10%) level in 1995. While COTS were recorded on this reef between 1988 and 1989 there were too few to affect reef-wide live coral cover. Small numbers of COTS were seen in 2004 and the coral cover was moderate (10-20%). Switzer Reef was classified as No Outbreak in 2004. No bleaching was recorded and white syndrome was present but restricted to a few scattered coral colonies.

Figure 4.46 A







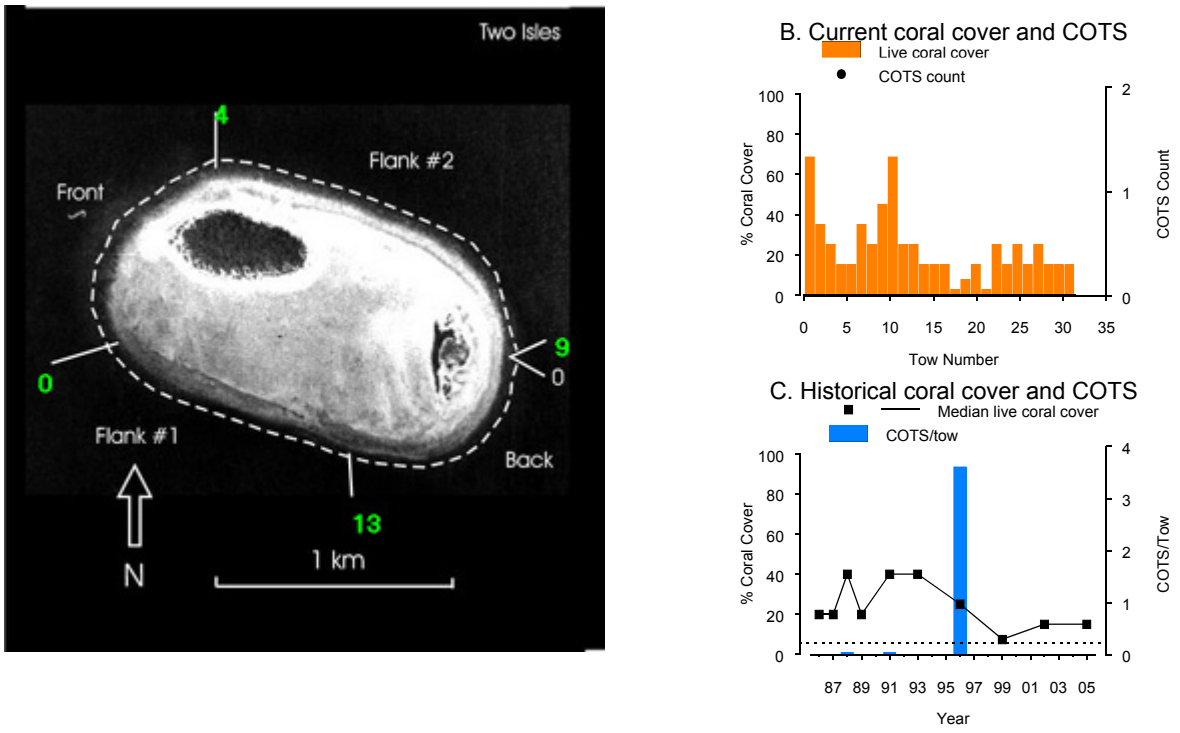
Switzer (No. 14-061) is a middle shelf planar reef with an area of 14.3 sq.km.

TWO ISLES

Surveyed August 2004.

Two Isles Reef has been surveyed 10 times since 1986. Reef-wide live coral cover was initially moderate (10-30%), peaking around 1993 and then decreasing to a low level (0-10%) following an Active Outbreak of COTS in 1996. No COTS have been observed since 1999 and Two Isles Reef was classified as Recovering in 2005. Reef-wide live coral cover was moderate (10-30%) in 2005. No bleaching was recorded during manta tow surveys in 2005 and white syndrome disease was restricted to a few scattered coral colonies.

Figure 4.47 A



Two Isles (No. 15-002) is an inner shelf planar reef with an area of 1.8 sq.km.

Cairns

Reef Pages

AGINCOURT NO.1

Surveyed January 2005.

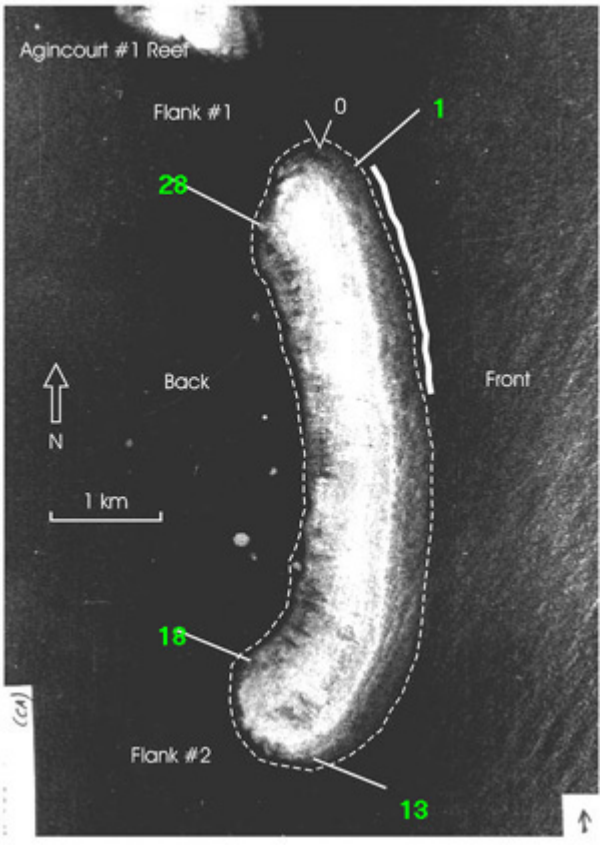
Agincourt Reef No.1 was first surveyed using manta tows in 1989, and has been surveyed annually since 1994. Reef-wide live coral cover increased to a high level (30-50%) in 2000, then decreased to a moderate level (10-30%) in 2003. No COTS have been recorded in any survey year and the cause of decline is uncertain. Coral cover had once again reached high levels (30-50%) in 2005 and Agincourt Reef No.1 remains classified as no outbreak. No bleaching was observed in 2005. White syndrome disease was common on the front of the reef but affected only a few dispersed coral colonies elsewhere.

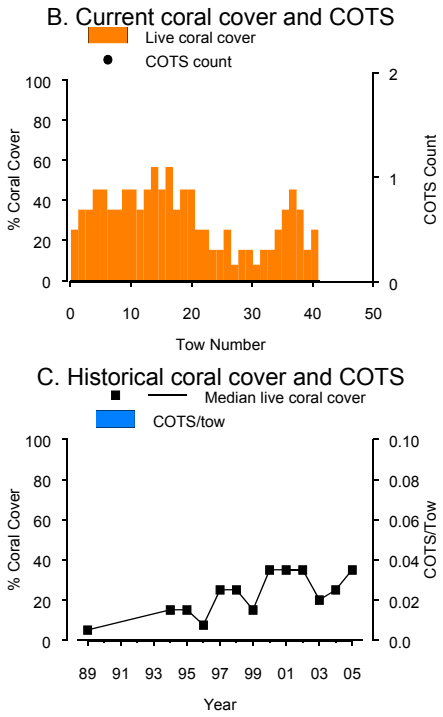
An increase in hard coral cover over 10 years of surveys peaked at 39% in 2002. This was largely due to the increases in tabulate and branching *Acropora* spp. In 2005, percent cover of *Acropora* was 23%. Pocilloporidae, Faviidae, and Poritidae spp. remained fairly steady since 1994. Agincourt No 1. sites have the highest abundance of *Pocillopora* spp (5% percent cover) on the GBR survey reefs. Soft coral abundance has been declining since 2002, but is still moderate at 17%. The density of corallivorous snails *Drupella* spp. has remained low throughout the surveys with densities of 93/ha in 2005. White syndrome disease has been present at low levels since 2001.

Numbers of fishes from family Acanthuridae had declined to 2003, after which numbers increased, particularly in the numerically dominant species such as *Ctenochaetus* group and *Acanthurus nigrofuscus*, which tend to drive the patterns for the family as a whole. All species from family Chaetodontidae increased in numbers in 2005, continuing the general upward trend since surveys began. Family Scaridae increased in numbers since 2003, and this trend continued in 2005. Other large, mobile reef fish species remained stable in 2005, with the exception of family Labridae, which continued the increase that began in 2002. Damselfish genera were on the whole, relatively stable, with the exception of *Plectroglyphidodon* which had continued to increase in 2005.

Figure 4.48

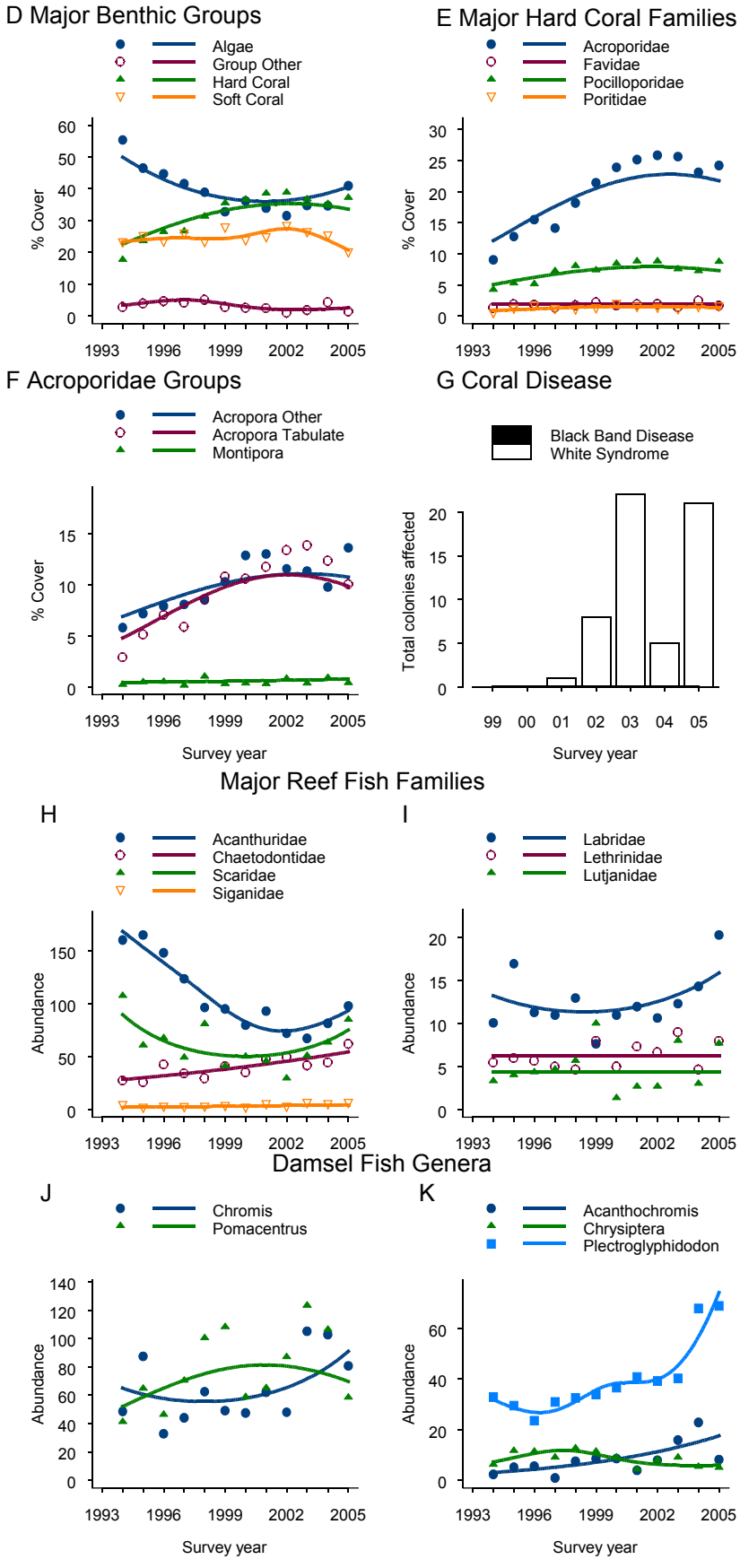
A





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

Figure 4.48 (Cont).



FITZROY IS

Surveyed February 2005.

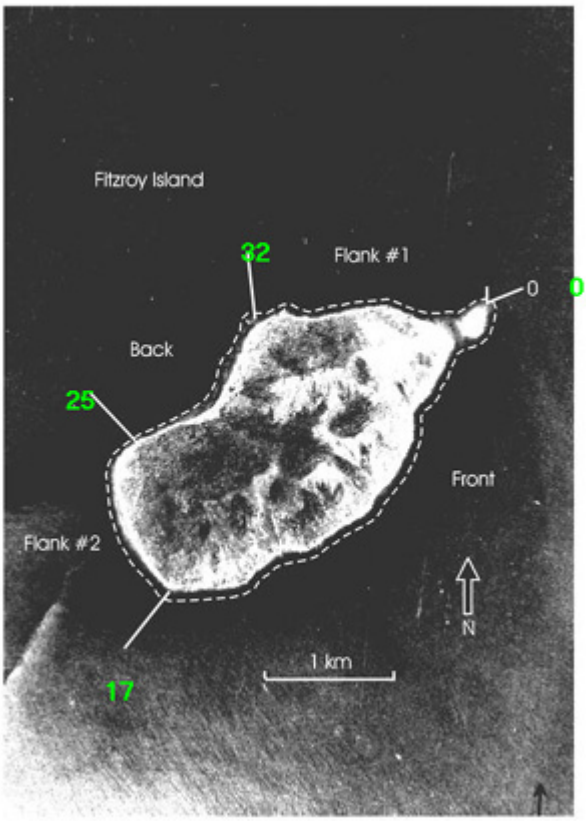
Fitzroy Island Reef has been surveyed 14 times since 1986. Reef-wide live coral cover was initially moderate (10-30%) before falling to a low level (1-10%) between 1989 and 1990, probably as a result of the 1989 flood on the northern GBR (surveys in 1989 were conducted at a time when Fitzroy Island Reef was bathed in flood waters). Coral cover increased between 1995 and 1998 and then declined in 1999. A large proportion of corals were bleached at the time of survey in 1998. Small numbers of COTS were also observed during manta tows at this time. Surveys in 1999 recorded many dead standing coral colonies, particularly tabulate *Acropora* spp. that died approximately twelve months previously based on the minimal erosion observed. This time frame for mortality coincides with the 1998 bleaching event. Reef-wide live coral cover remained very low (<5%) in 2002. No manta tow surveys were conducted in 2003 or 2004 due to poor visibility. Surveys in 2005 indicate reef-wide live coral cover is beginning to recover and it is now at a moderate (10-20%) level. No COTS have been recorded in recent surveys and Fitzroy Island Reef is classified as No Outbreak. No bleaching or coral disease was recorded during manta tow surveys in 2005.

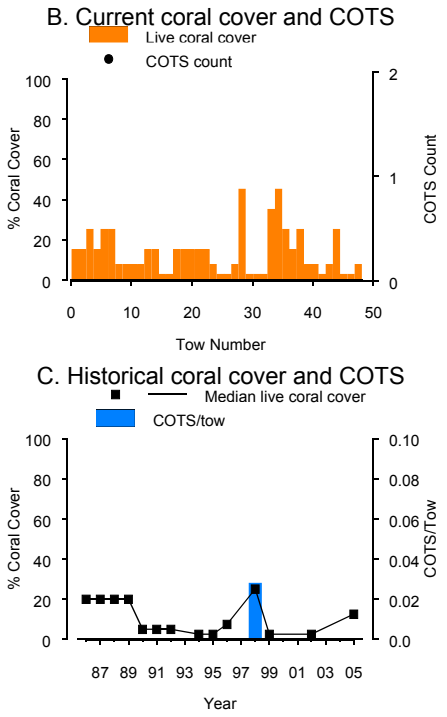
Detailed surveys of fixed sites show that hard coral cover declined following the summer of 1999. Hard coral decreased to less than 10% in 1999 and has slowly increased to 15% by 2005. A similar pattern of decline was observed in all four main hard coral families except Poritidae. The most likely causes for low levels of mortality on the sites would include predation by Crown-of-thorns and bleaching. The cover of soft corals increased slightly to 25% in 2005. Disease was not observed to affect any coral colonies in 2005 and no *Drupella* spp. were recorded.

The abundances of many fish taxa have been variable with only a few consistent trends evident as a result of the 1999 disturbance that dramatically reduced hard coral cover. Those species that have declined (many chaetodontid species and *Pomacentrus moluccensis*) tend to have strong associations with hard coral as food and/or habitat. Numbers from family Chaetodontidae and *P. moluccensis* had begun to recover in 2005; most species had increased in abundance since 2004, coincident with hard coral cover increases. Since 2003 there has been an increase in abundance of most species from the family Lutjanidae and some damselfish species that defend algal farms (e.g. *Pomacentrus wardi*), usually on dead coral. The majority of the damselfish community remained stable in 2005, except *Neopomacentrus azysron* and *N. bankieri*, which both increased in numbers in 2004 and 2005.

Figure 4.49

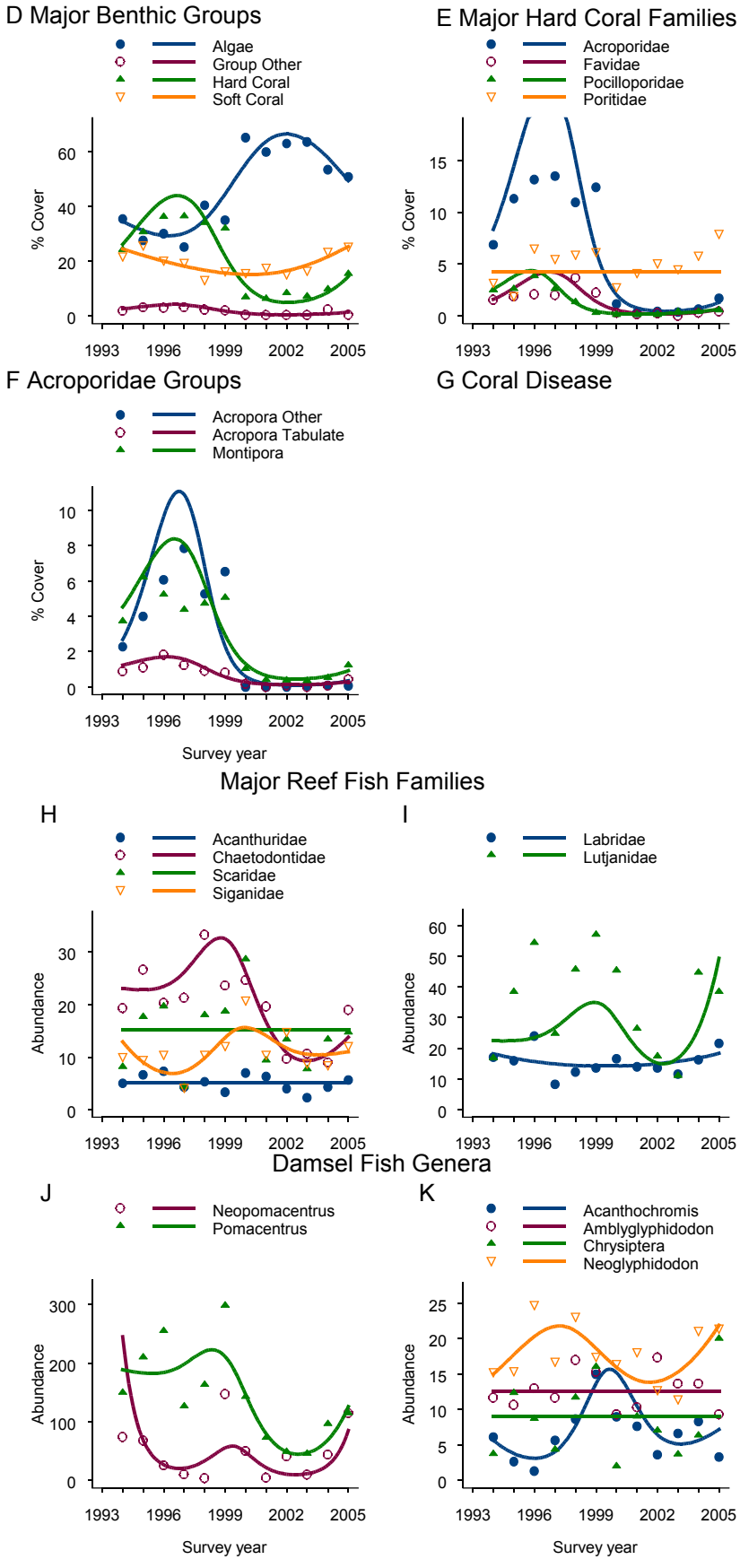
A





Fitzroy Is (No. 16-054) is an inner shelf fringing reef with an area of .2 sq.km.

Figure 4.49 (Cont).



GREEN IS

Surveyed February 2005.

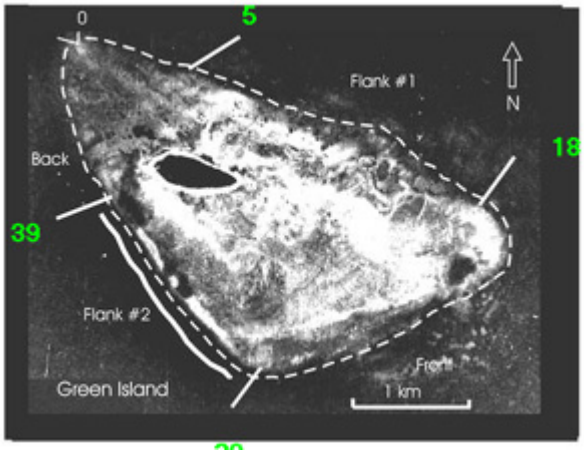
Green Island Reef has been surveyed 18 times since 1986, when it was classified as Recovering from a previous COTS outbreak. Since then, reef-wide live coral cover has shown little change. An apparent small recovery in reef-wide live coral cover in 1995 and 1996 subsequently stalled as COTS numbers on this reef rose again. COTS have not been observed in manta tows since 1999. Surveys in 2005 indicate reef-wide coral cover remains very low (<5%). Green Island Reef was classified as Recovering in 2005, there had been little evidence of recovery over the past 6 years. No bleaching was observed and white syndrome disease was restricted to a few scattered coral colonies on the reef flank in 2005.

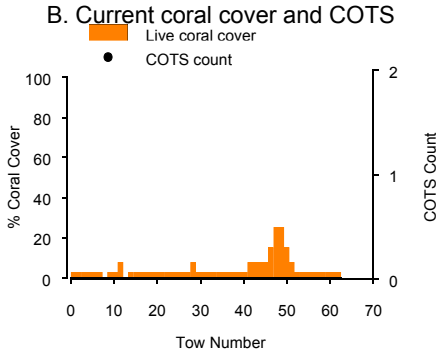
Detailed surveys of intensive survey sites show that hard coral cover on Green Island Reef has been consistenly low since surveys began in 1993. Hard coral cover remains low, surveyed at 9% in 2005. Cover of all coral groups has remained below 5%. Soft coral was also stable at 5%. Algae cover has varied inversely to hard coral and was 69% in 2005. 2005 surveys recorded a low prevalence of disease and no *Drupella* spp. were observed.

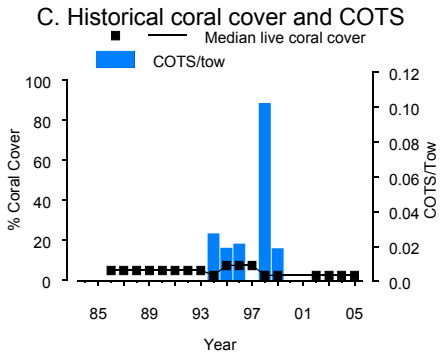
The abundances of many fish taxa have been variable with no consistent trends. Those species that have declined in abundance (a number of species from the family Chaetodontidae and *Pomacentrus moluccensis*), tend to have strong associations with hard coral as food and/or habitat. However, since 2002 numbers of *P. moluccensis* and *Chaetodon vagabundus* have shown a consistent increase as hard coral cover has slowly begun to rise.

Figure 4.50

A

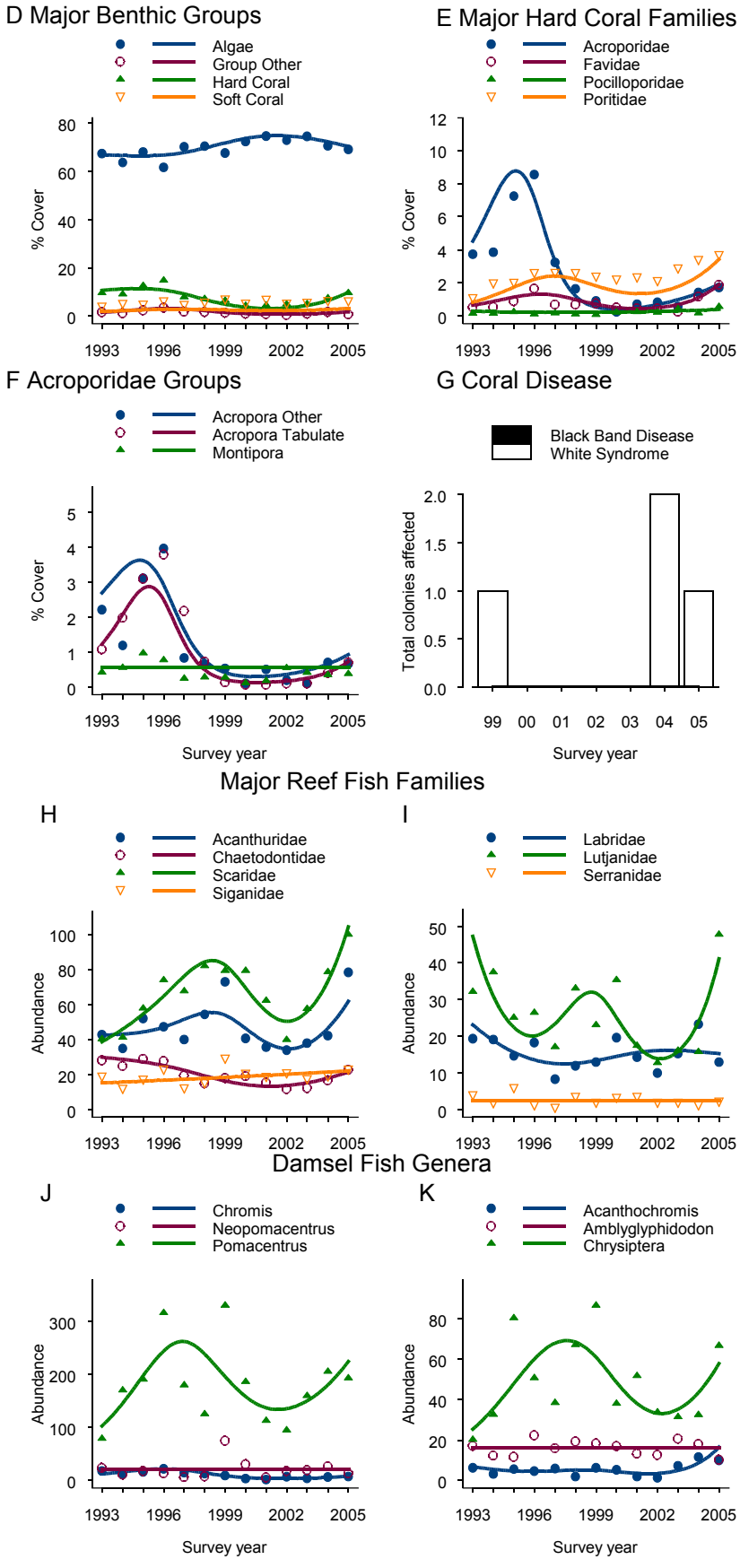






Green Is (No. 16-049) is an inner shelf planar reef with an area of 7.1 sq.km.

Figure 4.50 (Cont).



HASTINGS

Surveyed January 2005.

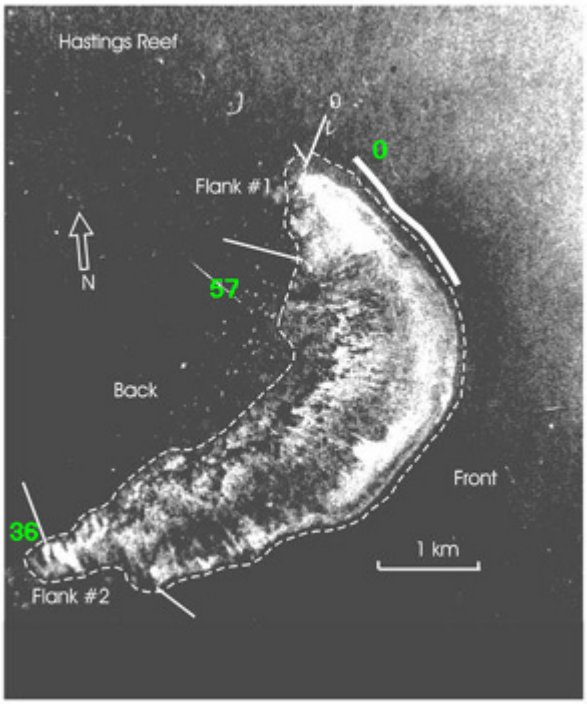
Hastings Reef has been surveyed 17 times since 1986. Over the period of survey reef-wide live coral cover has generally remained at moderate levels (10-30%). COTS numbers increased in 2000 and Hastings Reef was then reclassified as Incipient Outbreak. COTS numbers peaked in 2002 with a corresponding decline in coral cover. Surveys in 2003 and 2004 failed to detect any COTS and Hastings Reef was re-classified as Recovering. Surveys in 2005 indicate little appreciable change in reef-wide live coral cover which is low (1-10%) and Hastings Reef remains classified as Recovering. No bleaching was observed and black band disease and white syndrome disease was restricted to a few scattered coral colonies on the back and reef flank respectively in 2005.

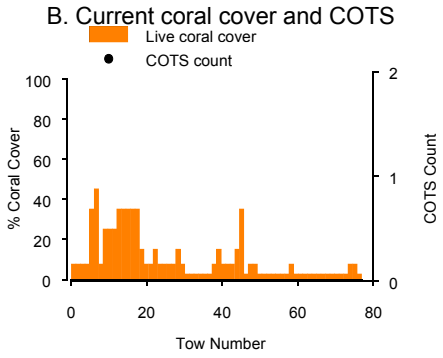
Hard coral cover on the intensive survey sites has shown little change since 1994 when the permanent sites were established. Hard coral cover fluctuations have ranged between 20% and 31%. Hard coral cover reached its highest level (31%) in 1999 and was 24% in 2005. Acroporidae are the dominant coral group, however Faviidae and Pocilloporidae are also relatively abundant in the benthic community. High levels of white syndrome were observed in 2003. However by 2005 the prevalence of disease decreased substantially. *Drupella* spp. were observed during 2005 SCUBA searches at a density of 100/ha.

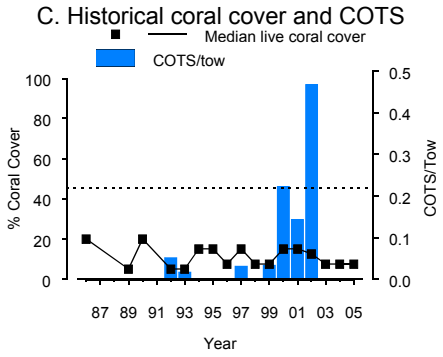
The relatively stable coral community was reflected in the fish community, which showed few strong trends. Numbers of family Chaetodontidae continued to increase in 2005. Damselfish genera were also relatively stable over time, with the exception of *Acanthochromis polyacanthus*, which had increased in abundance since 2001.

Figure 4.51

A

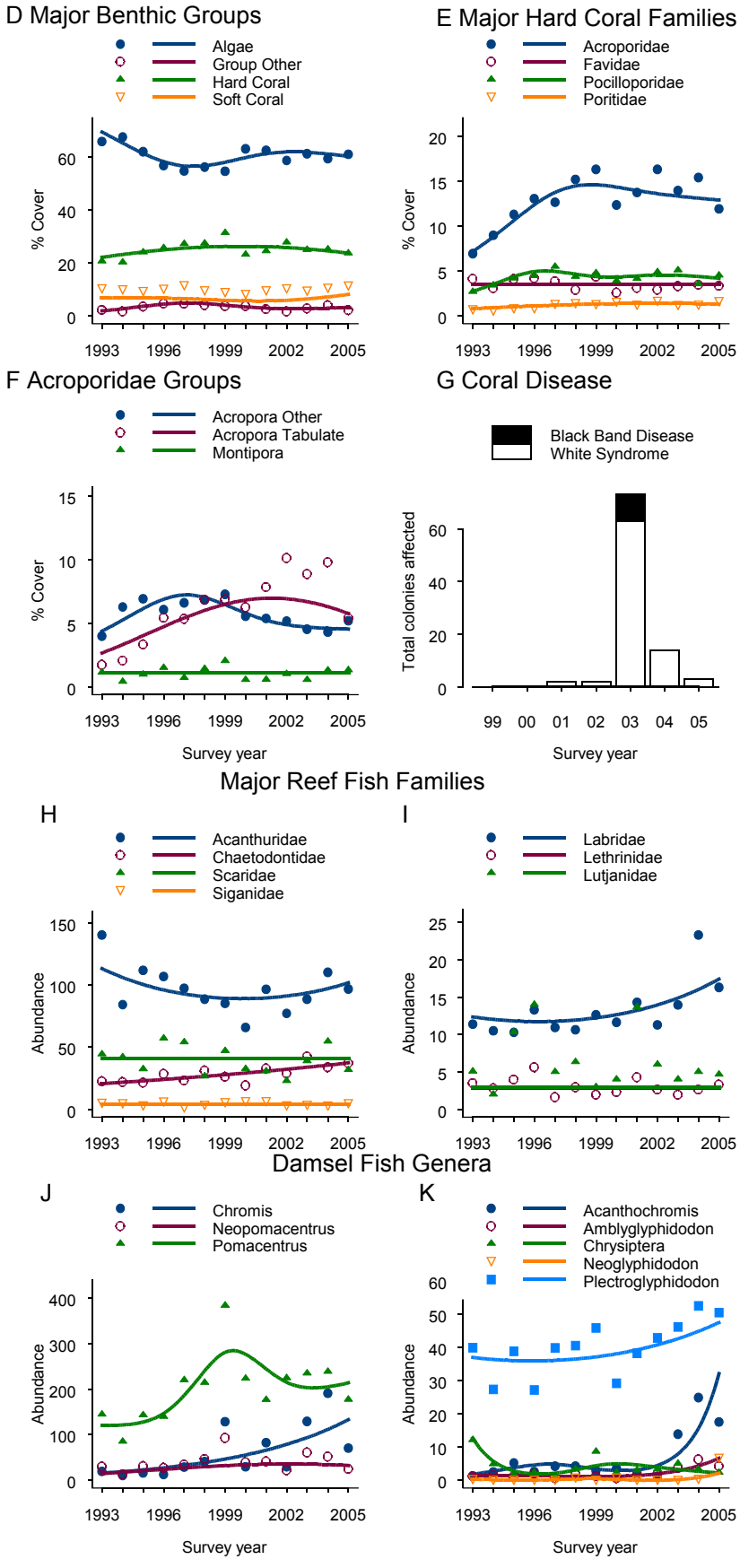






Hastings (No. 16-057) is a middle shelf crescentic reef with an area of 10.2 sq.km.

Figure 4.51 (Cont).



LOW ISLETS

Surveyed January 2005.

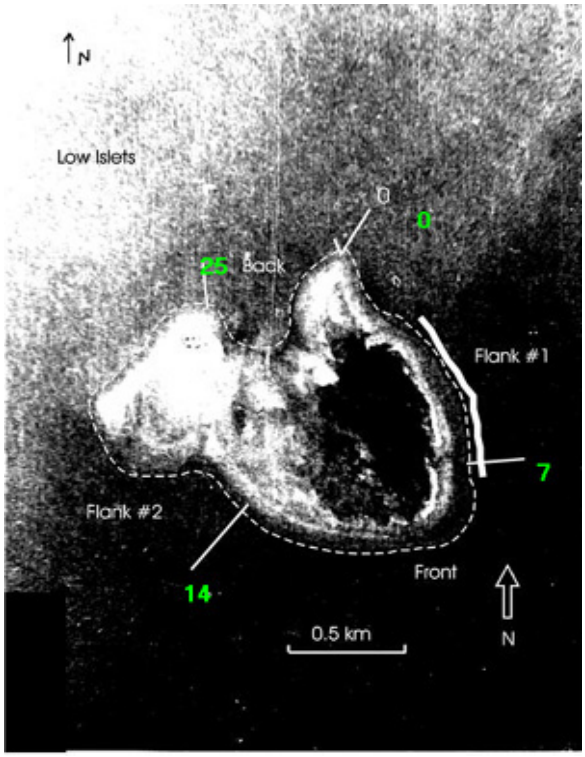
Low Islets Reef has been surveyed 13 times since 1986. No broadscale surveys were conducted in 2005 due to poor visibility. COTS were recorded in 1998 for the first time since surveys started. In 1999 there was a marked decline in reef-wide live coral cover from a high (30-40%) level in 1998 to a low level of 5-10%. This decline was due to the combined effects of increasing COTS activity, coral bleaching and cyclone Rona. In the most recent survey in 2004, reef-wide coral cover has begun to show signs of recovery and is currently moderate (10-20%). Low levels of coral bleaching (restricted to a few scattered coral colonies) and no disease was recorded from this reef in 2004. Low Islets Reef remains classified as No Outbreak.

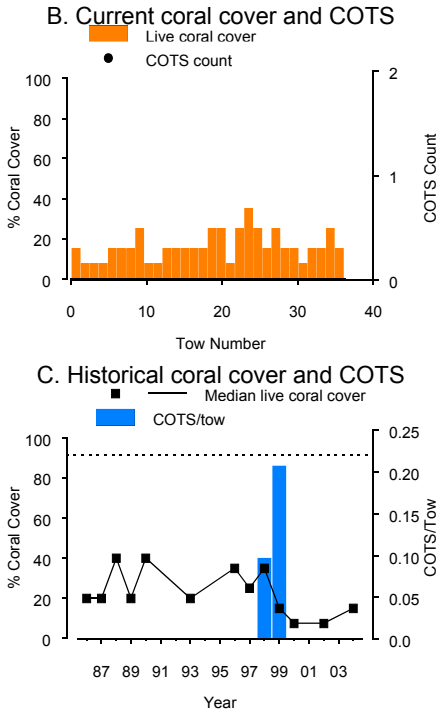
The coral community on the intensive survey sites have been affected by multiple impacts. In 1996 hard coral reached a maximum of 40% cover. Following Cyclone Rona in 1999 coral cover decreased and by 2000 had become stable at around 10% , with all families declining over that period. In 2005 a small increase in coral cover to 16% was recorded. This increase was due to increased cover of *Porites* spp. with other coral families remaining at a low level. Soft coral also decreased from a maximum of 17% in 1995 to 7% in 2003 and in 2005 was 9%. Low Isles Reef experienced high water temperatures in the summer of 2002 which may have inhibited recovery. *Drupella* were recorded at a density of 73/ha in 2005, while no coral diseases were recorded.

Many of the observed changes in the fish community may be related to the effects of cyclone Rona though these fall into two distinct categories, those species or groups showing a decline following the cyclone and those showing an increase. Declines were observed in several species of butterflyfishes (Chaetodontidae), and damselfishes of the genus *Pomacentrus*, directly after the cyclone. By 2005 there were signs of recovery with increased abundance. Species that showed this response included *Chaetodon aureofasciatus*, *C. rainfordi*, *C. vagabundus*, *Pomacentrus moluccensis* and *P. adelus*. Some species of rabbitfish (Siganidae), surgeonfish (Acanthuridae) and wrasse (Labridae) showed the opposite trend with abundance increasing after the cyclone. Species that showed this response included, *Siganus doliatus*, *Cheilinus fasciatus*, *Naso unicornis* and though variable, *Acanthurus blochii* and *Ctenochaetus* spp.. Seemingly unrelated to the cyclone is the steady increase in abundance of snappers (Lutjanidae) with increases in the abundance of *Lutjanus vitta* contributing most to this trend though record highs of *L.* fulviflamma and *L. carponotatus* in 2004-5 also contributed.

Figure 4.52

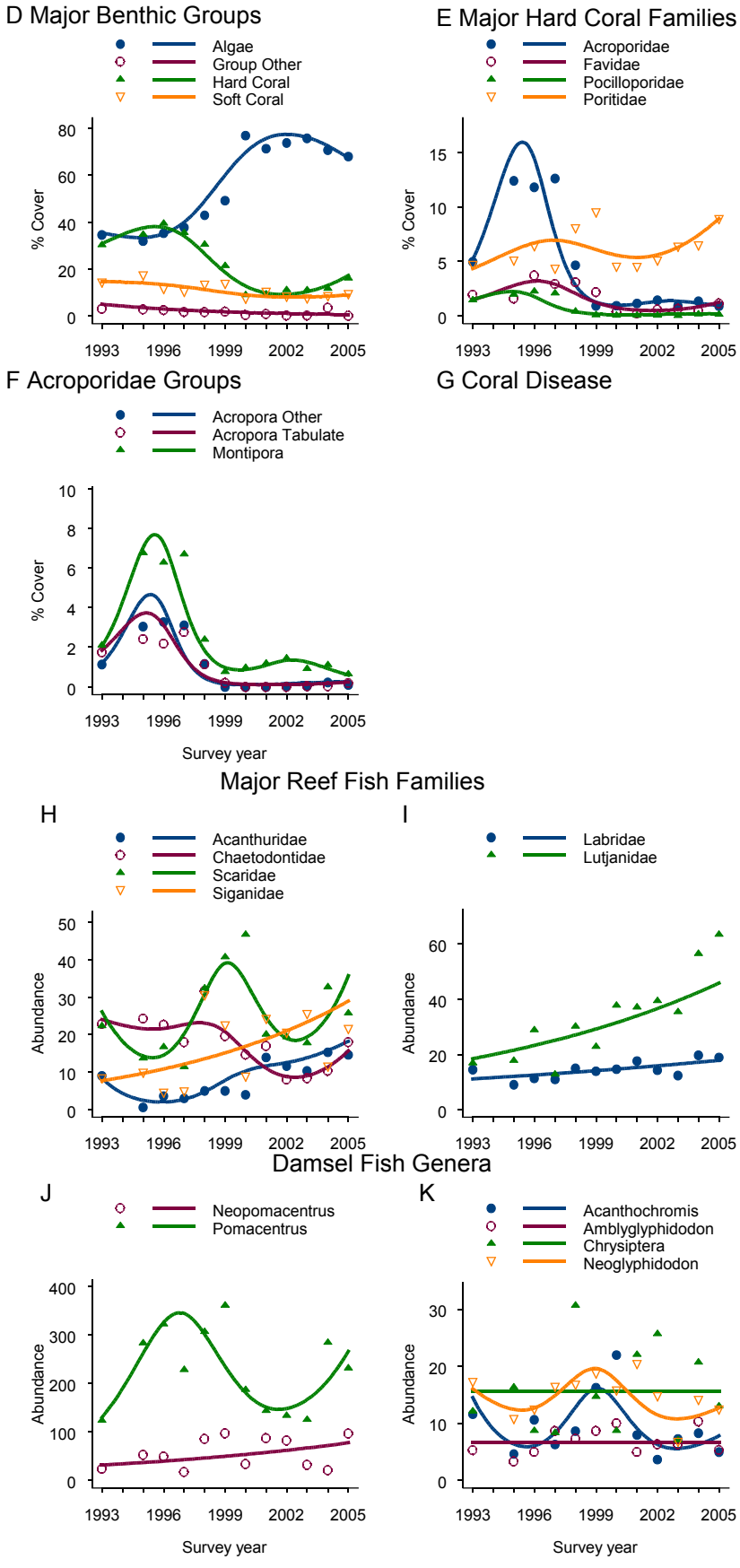
A





Low Islets (No. 16-028) is an inner shelf planar reef with an area of 2.3 sq.km.

Figure 4.52 (Cont).



MACKAY

Surveyed January 2005.

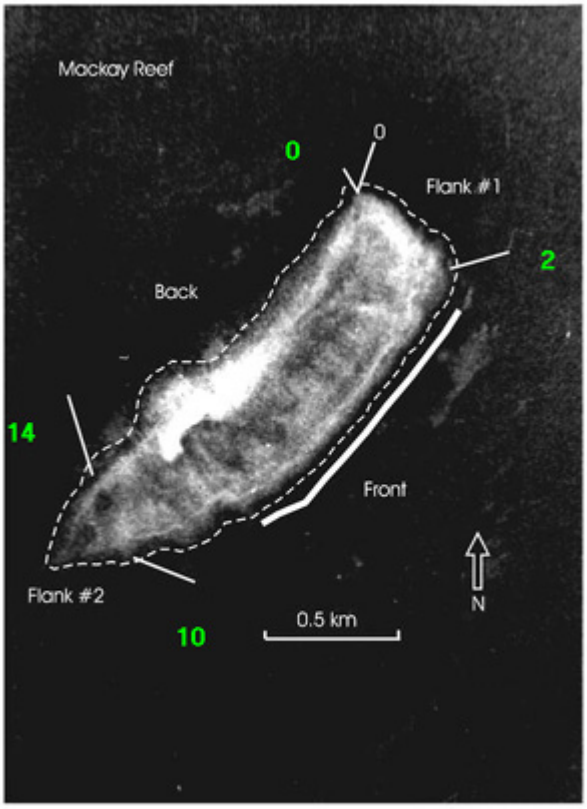
Mackay Reef has been surveyed 14 times since 1986 when it was classified as Recovering from prior COTS activity. Reef-wide live coral cover rose to a high level (30-50%) in 1993, when COTS were recorded in low numbers. COTS numbers built up and peaked in 1998 when Mackay Reef was classified as an Incipient Outbreak. Increased COTS activity coincided with a gradual decline in reef-wide live coral cover to moderate levels (10-30%). Mackay Reef was also affected by Tropical Cyclone Rona which crossed the area in 1999. In 2005 reef wide coral cover was moderate (20-30%). No coral bleaching was recorded and white syndrome disease was restricted to a few individual colonies. The reef remains classified as Recovering.

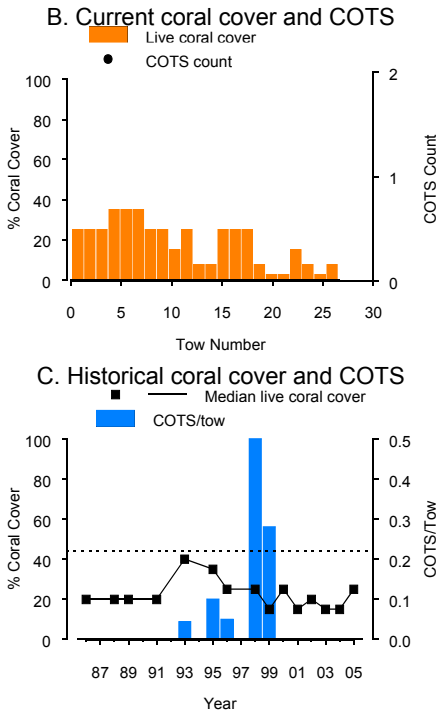
Hard coral cover on the intensive survey sites has been fairly stable over the survey period and in 2005 was 27%. Algae has exhibited an inverse relationship to hard coral reaching a maximum cover of 65% in 2004. Faviidae was the dominant family in the community increasing to 7% in 2005 due to increased abundance of *Echinopora* spp. Black band and White Syndrome disease have been recorded in scuba search, however both were rare in 2005. *Drupella* spp. were observed at a moderate density of 247/ha.

The relatively stable coral community on this reef is reflected in the largely stable fish community especially among the large, mobile reef fish families. Within the damselfishes, the pattern observed for the genus *Pomacentrus* largely reflects the numerically dominant species, *P. moluccensis*, that increased in abundance rapidly from the lowest recorded level in 1993 at the same time as *Acropora* cover increased. *P. moluccensis* tends to preferentially inhabit *Acropora* corals. Subsequent declines in abundance and then stable levels through to 2005 may also reflect the decline of *Acropora* cover between 1996 and 1998. The reason for record low abundances of *Acanthochromis polyacanthus* and *Amblyglyphidodon curacao* in 2005 are unknown.

Figure 4.53

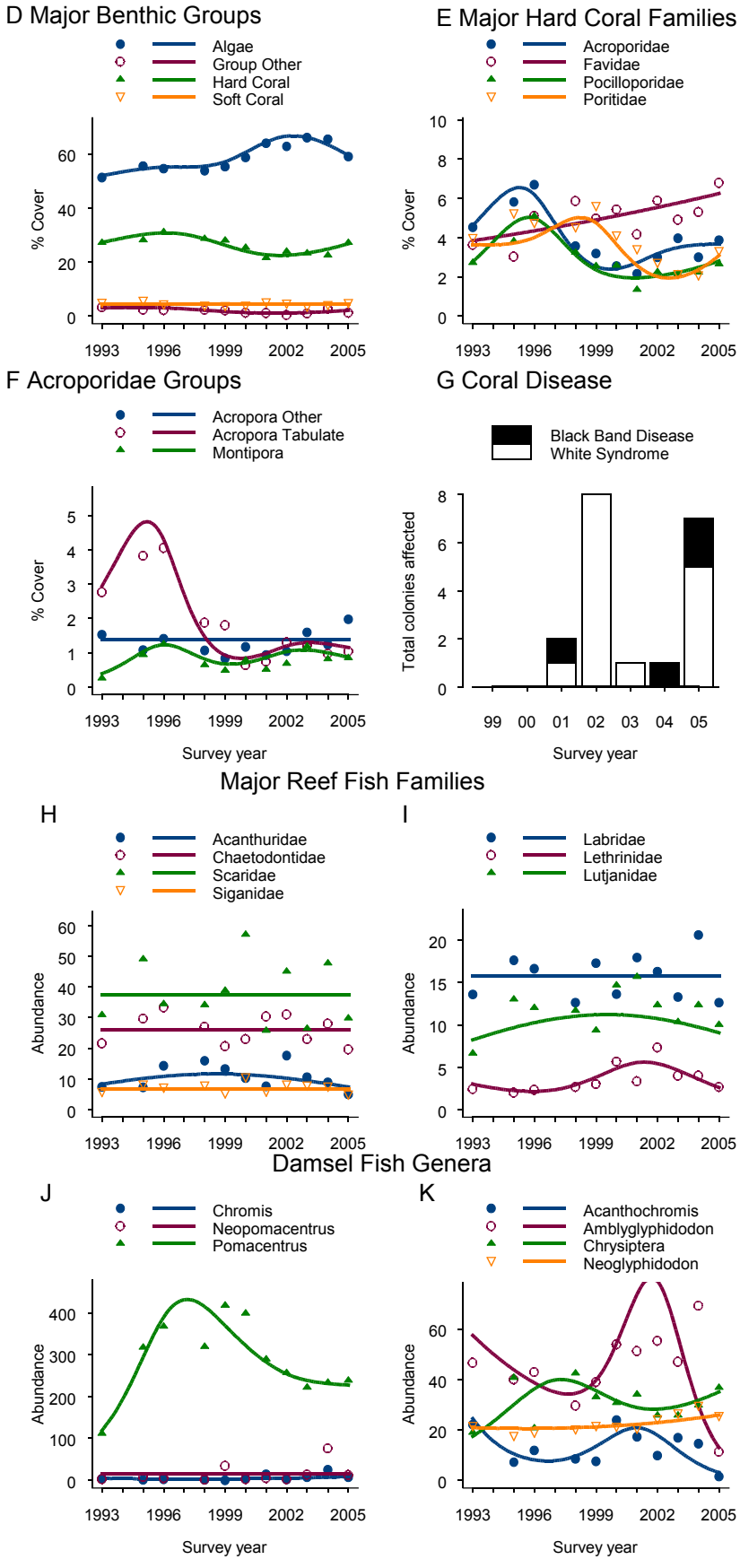
A





Mackay (No. 16-015) is a middle shelf planar reef with an area of 4.2 sq.km.

Figure 4.53 (Cont).



MICHAELMAS

Surveyed January 2005.

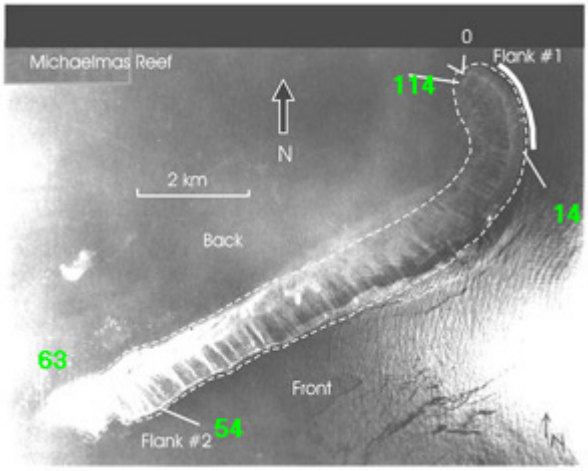
Michaelmas Reef has been surveyed 18 tiems since 1986. Reef-wide live coral cover dropped from moderate to low levels in the initial years of survey and remained generally low (1-10%) through to 2004. COTS populations have been a common feature since 1993. 2003 was the first year since 1991 that COTS had not been recorded. Overall COTS numbers have been below outbreaking levels, However, they have had localised impacts on coral communities in small sections of this very large reef. Michaelmas Reef remains classified as No Outbreak. No bleaching was observed during surveys in 2005. Black band disease and white syndrome were restricted to small numbers of individual colonies on the front and back of the reef.

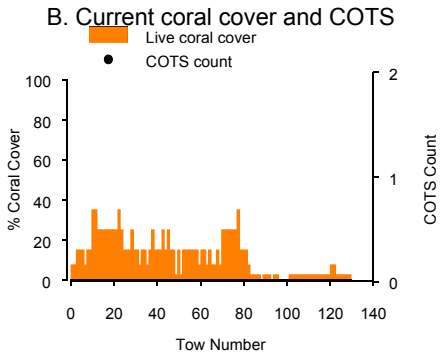
The cover of hard coral on the intensive survey sites has reached a plateau. Cover increased from <15% in 1993 to a maximum of 26% in 1999 and by 2005 had changed little at 23%. Tabulate *Acropora* had an increasing trend over the survey period until 2002 where it reached a maximum of 10%. Soft coral cover has been moderately high and stable since 1994 with surveys in 2005 recording cover at 28%. 2005 SCUBA searches found *Drupella* spp. present at a density of 147/ha.

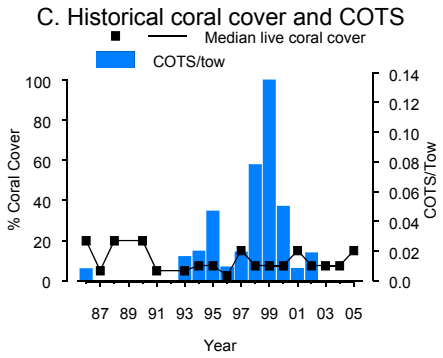
Large mobile fish species showed few consistent trends. Numbers of family Acanthuridae have shown a slight decrease after small increases from 2000 until 2002. The abundance of family Chaetodontidae, after having increased slightly since the beginning of sampling, had reached a plateau by 2000. This trend mirrors that of hard coral cover. Large increases in the abundance of some damselfish genera prior to 2004 are largely the result of increases in one species per genus, for example; *Chromis atripectoralis*, *Pomacentrus lepidogenys* and *Plectroglyphidodon lacrymatus*. Three of the five damselfish genera showed a slight decrease in abundance in 2005. Numbers of *Plectroglyphidodon* continued to increase.

Figure 4.54

A

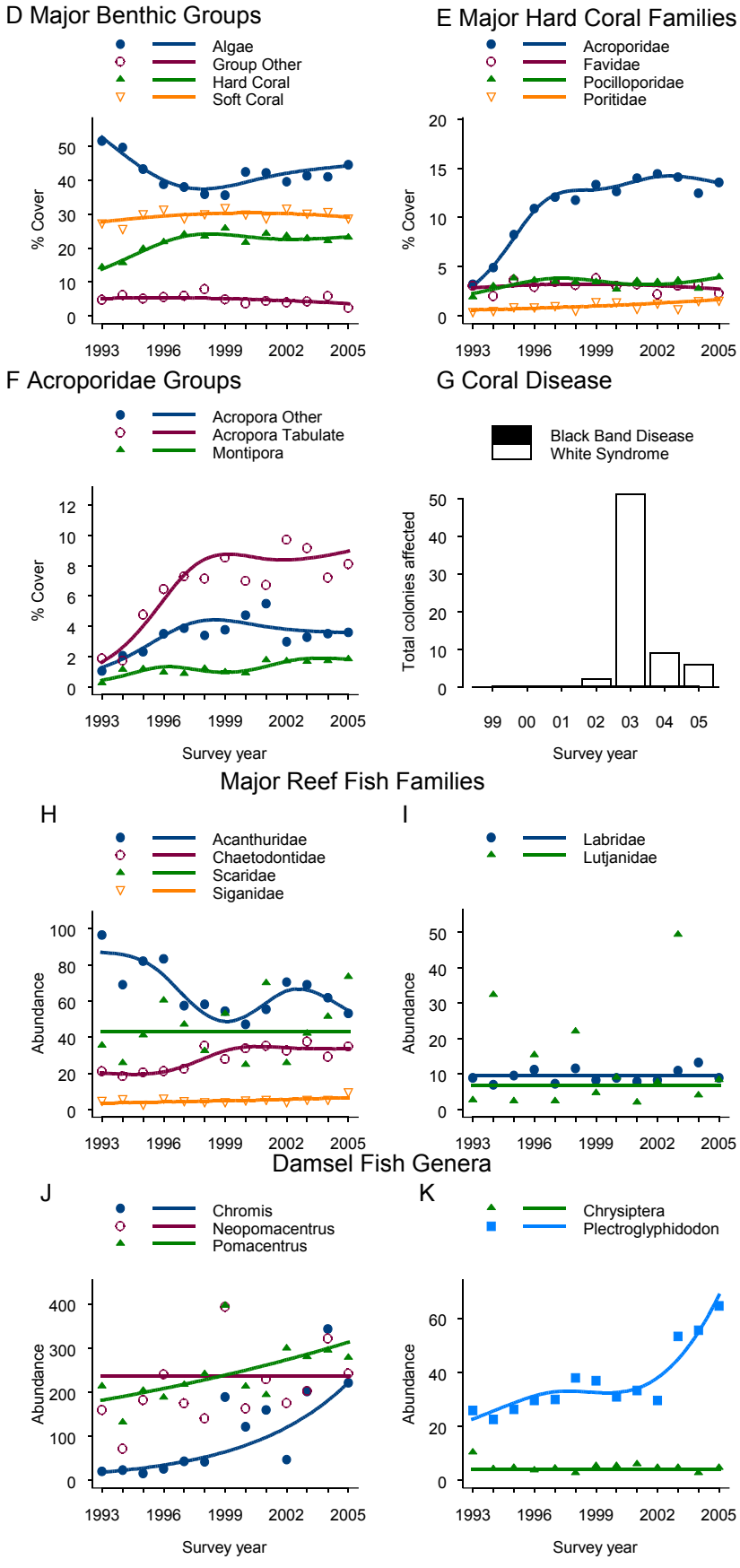






Michaelmas (No. 16-060) is a middle shelf crescentic reef with an area of 30 sq.km.

Figure 4.54 (Cont).



OPAL (2)

Surveyed January 2005.

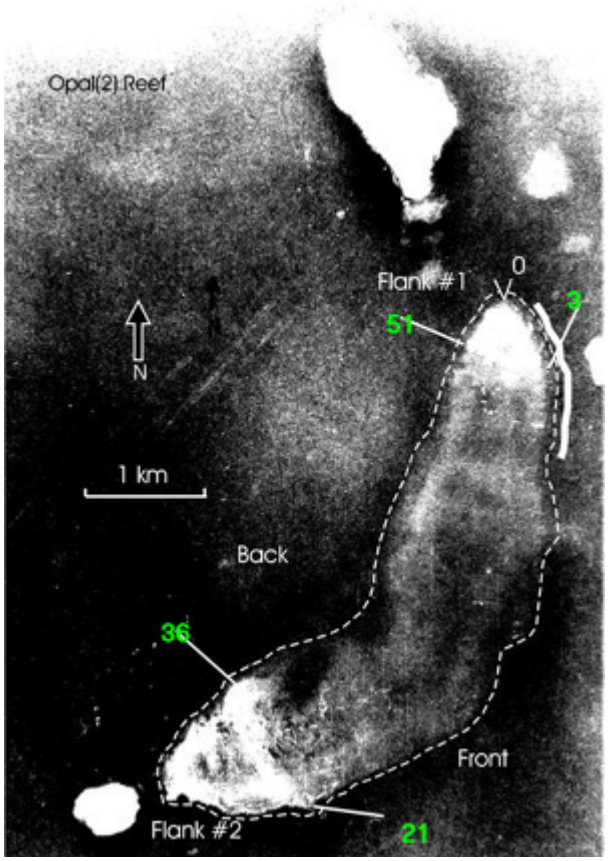
Opal (2) Reef has been surveyed 14 times since 1986. Until 1999 reef-wide live coral cover remained at moderate levels (10-30%). There were high COTS densities (2 COTS per tow) in 2000 and Opal (2) Reef was classified as Active Outbreak. COTS numbers declined rapidly and in the following year had dropped below outbreak levels and Opal (2) Reef was re-classified as Recovering. Residual COTS populations persisted up until 2002. As a result of the COTS feeding, reef-wide live coral cover declined to a low level (1-10%) by 2003. No COTS were observed during surveys in 2005 and coral cover remains low. No bleaching was recorded and white syndrome was restricted to a few scattered coral colonies in 2005.

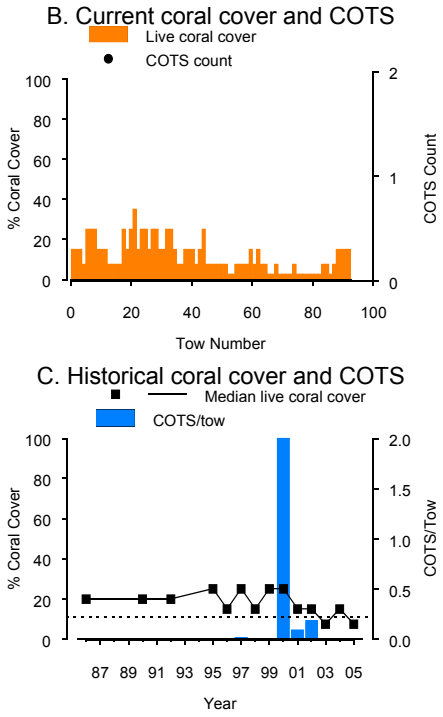
Hard coral cover has declined slightly on the intensive survey sites and was moderate at 21% in 2005. Algal cover primarily composed of filamentous and coralline algae has fluctuated inversely with the abundance of soft coral. Soft coral cover was moderately high (33%) during the 2005 survey, having reached a maximum of 39% in 1996. *Drupella* spp. were observed during SCUBA searches at a density of 13/ha in 2005 in addition to a small number of coral colonies affected by white syndrome disease.

Numbers of fish within most taxa were relatively stable or had increased over the study period, although temporal variability was often high. The negative trend in numbers of acanthurids to 2004, influenced strongly by *Acanthurus nigrofuscus*, was halted in 2005 by an increase in numbers of *A. nigrofuscus*. Numbers of Scaridae were at a survey high in 2005. Numbers of many damselfish species had declined in 2004 but most increased again in 2005. This resulted in overall increases in abundance of most genera over the study period, in each case due largely to one or two numerically dominant species.

Figure 4.55

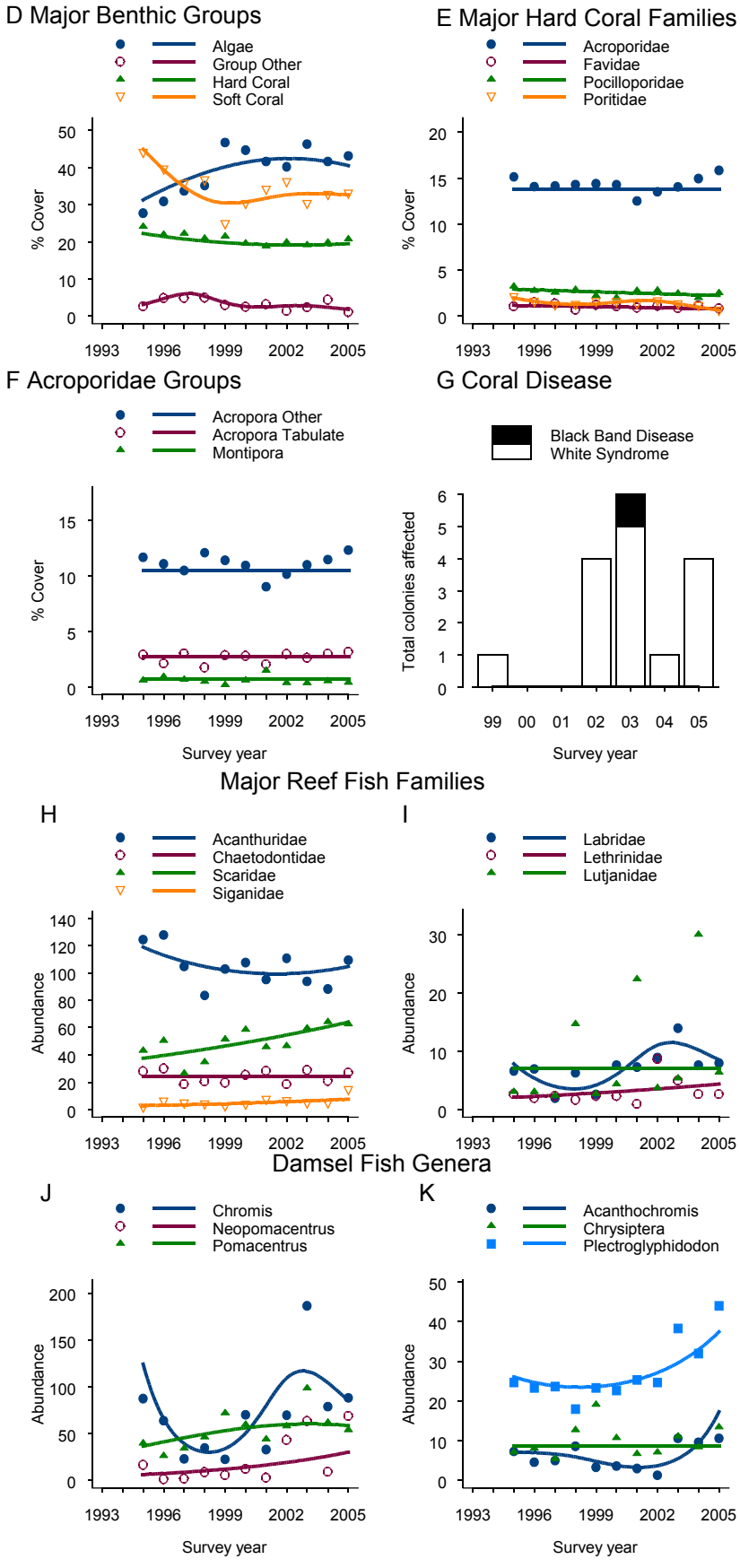
A





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

Figure 4.55 (Cont).



ST. CRISPIN

Surveyed January 2005.

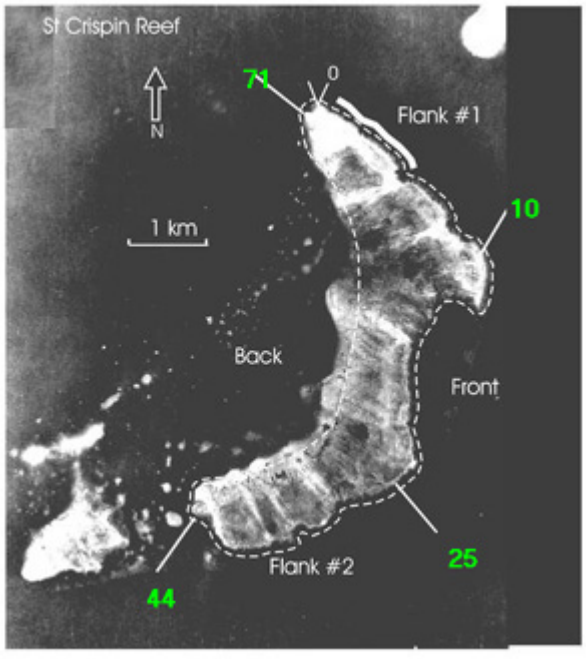
St Crispin Reef has been surveyed 15 times since 1986. Over this time reef-wide live coral cover remained at moderate levels (10-30%) before increasing slightly in 2000 and 2001. Low numbers of COTS were present in 1993. Numbers of COTS just below Incipient Outbreak levels were recorded in 2000 and may have initially been responsible for the small decline in reef-wide live coral cover in subsequent surveys. What factors were responsible for the continued decline exhibited up to 2004 are unknown. Reef-wide live coral cover was moderate (10-20%) in 2005 and St Crispin Reef was classified as No Outbreak. No bleaching was recorded and low levels of white syndrome disease were observed on a few scattered coral colonies in 2005.

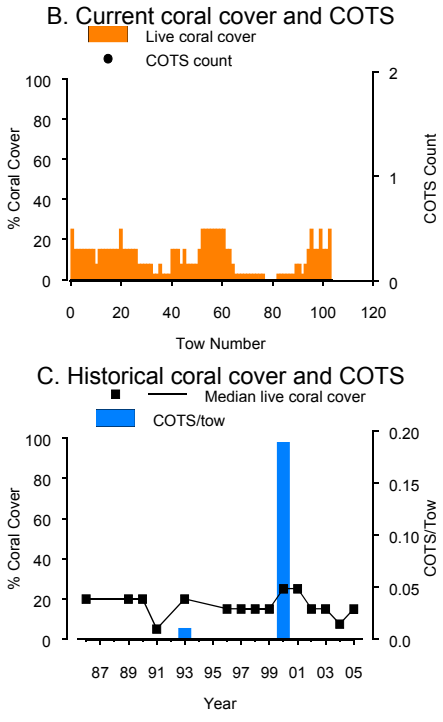
Hard coral cover has steadily increased since 1999 and in 2005 was 27%, the highest level since surveys began in 1993. Much of this increase is due to increases in cover of branching and tabulate *Acropora* spp. Whereas algal levels generally vary in response to hard coral growth and disturbance at St. Crispin the percent cover of algae fluctuates inversely with the cover of soft coral. Soft coral cover has varied between 33-42% during the survey period and in 2005 was 38%. The density of corallivorous snails *Drupella* spp. was 73/ha in 2005. White syndrome disease has been observed consistently in scuba search counts but was rare in 2005.

The abundance of the majority of large, mobile reef fish species was variable with few consistent trends since surveys began in 1993. The butterflyfishes (Chaetodontidae) differ in that numbers had steadily increased in abundance over the period of survey. This trend was common to a number of *Chaetodon* species. Of the damselfish community, several genera increased in abundance over the study period. For *Plectroglyphidodon* this increase was due to a doubling in the abundance of *P. lacrymatus* since 2001. The density of *P. lacrymatus* in 2005 was the highest recorded from this reef. The increasing trend for *Acanthochromis polyacanthus* was driven by consistent increases in abundance between 2000 and 2004, though in 2005 abundance had decreased. In 2005 the genus *Chromis* had higher abundance than in any other survey, with several species including *C. ternatensis*, *C. margaritifer* and *C. weberi* all showing record abundances. This trend may be linked to increases in cover of branching and tabulate *Acropora*, in and under which these *Chromis* species often shelter.

Figure 4.56

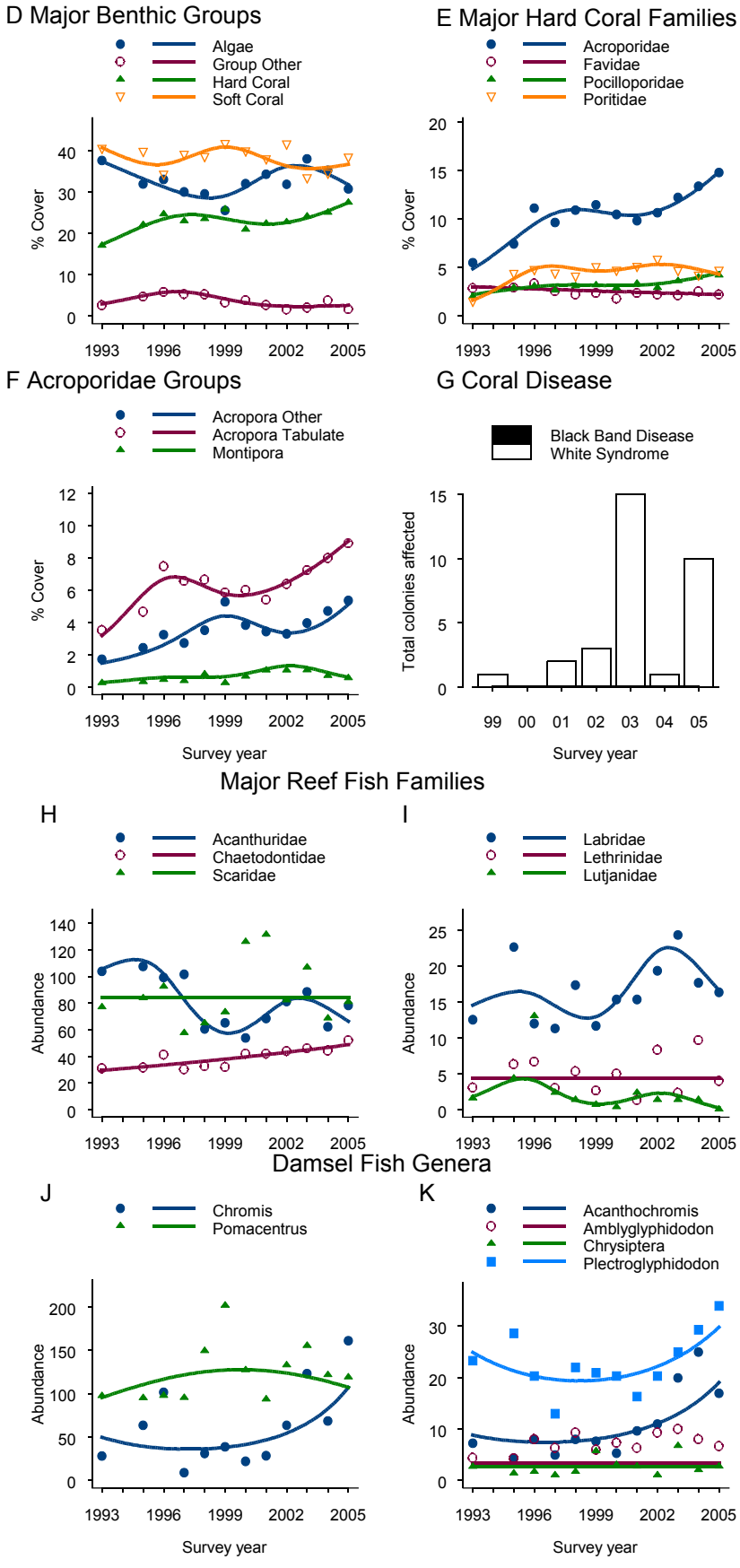
A





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

Figure 4.56 (Cont).



THETFORD

Surveyed February 2005.

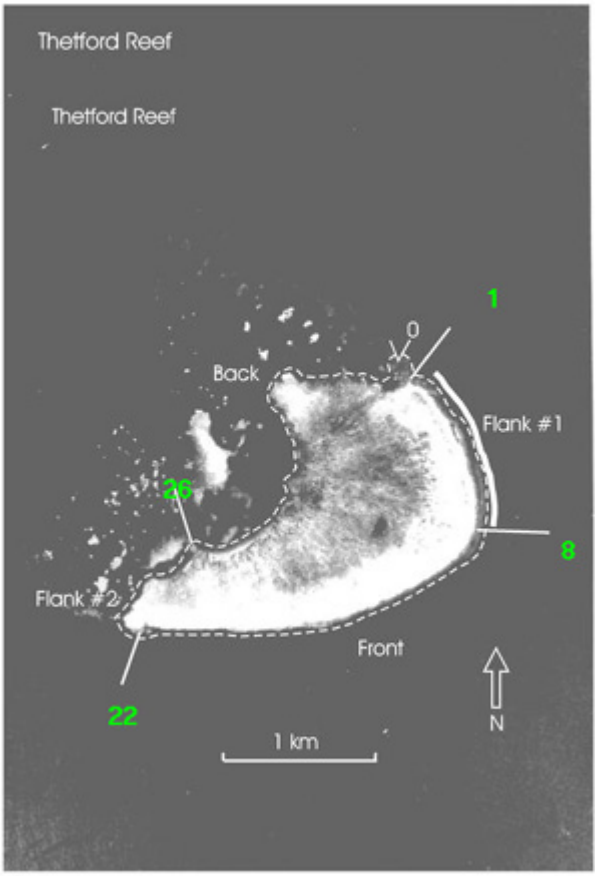
Thetford Reef has been surveyed 15 times since 1986. Reef-wide live coral cover showed a declining trend till 1994. There was then a gradual increase to a moderate level (10-30%) by 1999. Surveys in 2000 indicated COTS numbers had increased and the reef was classified as Incipient Outbreak. Since then reef-wide live coral cover has declined to a low level (1-10%), most likely as a result of COTS feeding activity. No COTS were seen in 2005 and Thetford Reef is currently classified as Recovering. Median reef-wide live coral cover remains low. No bleaching was observed and white syndrome disease was restricted to a few scattered coral colonies in 2005.

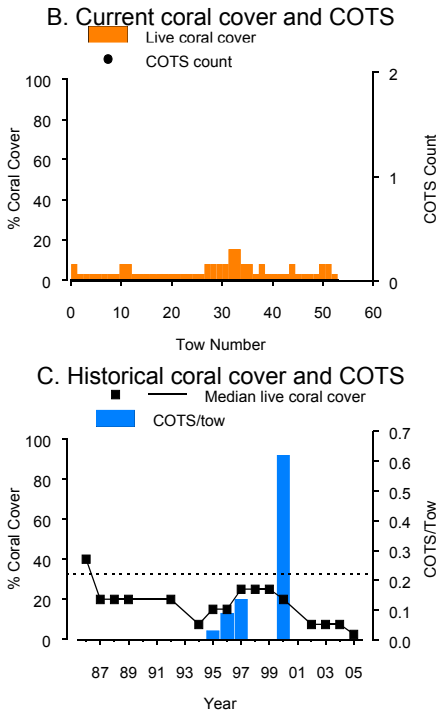
On the intensive survey sites hard coral cover increased between 1994 and 2000 when it reached it highest cover of 36%. Reductions in coral cover since 2000 are probably attributed to crown-of-thorns feeding. Hard coral cover in 2005 was very low (8%). The largest taxa decline was in *Acropora* spp. although Faviidae and Pocilloporidae also showed declining trends. Soft coral cover has been stable over the survey period and in 2005 was 14%. *Drupella* spp. were observed during SCUBA searches at a density of 20/ha, and a couple of colonies were recorded with white syndrome disease.

No clear long-term trends in the fish populations were evident on this reef. A number of *Lutjanus* species had relatively low abundance in 2004, but numbers had increased in 2005. Some coral dependent species showed increasing trends, correlating with coral growth until 1999, after which they declined. This included several species of butterflyfishes (Chaetodontidae) and some damselfish in the genus *Chromis*. Trends in the genus *Pomacentrus* were driven largely by the numerically dominant *P. lepidogenys*. This species dramatically increased in abundance in 1999 then subsequently declined in numbers. One species of damselfish, *Plectroglyphidodon lacrymatus*, had increased in abundance since 2002.

Figure 4.57

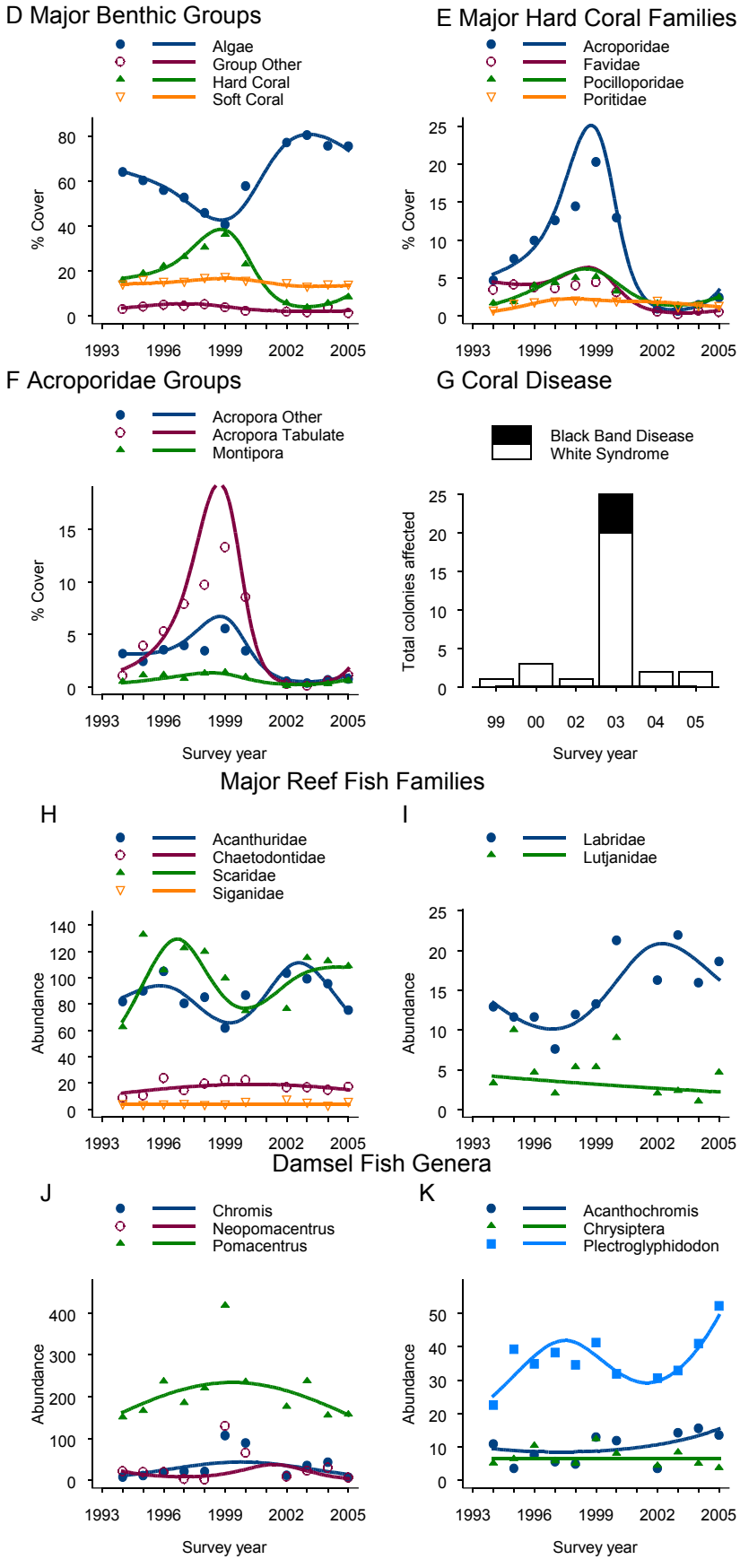
A





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

Figure 4.57 (Cont).



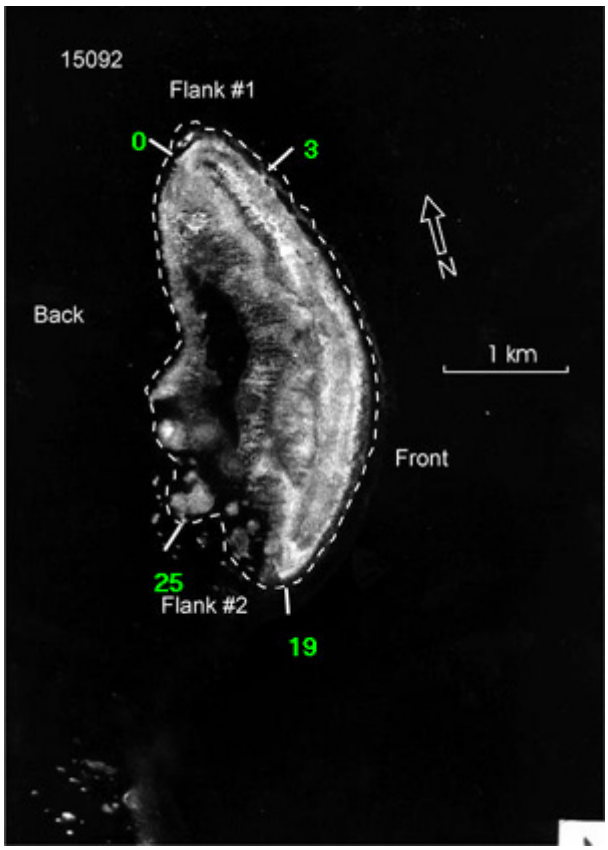
15-092

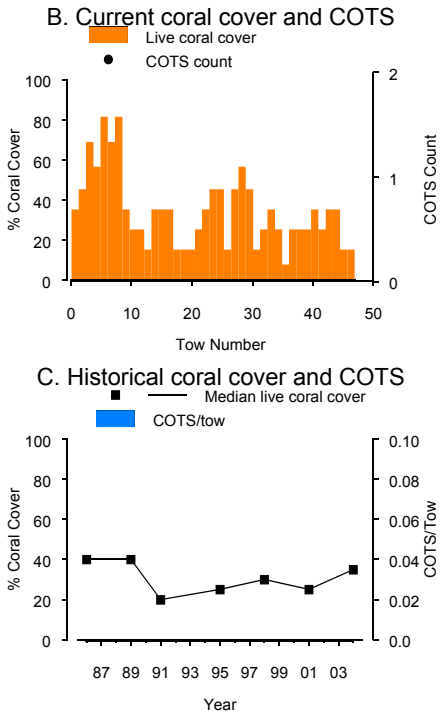
Surveyed January 2004.

Reef 15092 has been surveyed seven times since 1986. Reef-wide live coral cover has generally been at moderate to high levels (20-40%) with a slight trend of increasing coral cover since 1991. No COTS have been observed on this reef and it was classified as No Outbreak in 2004. No bleaching was observed in 2004 and white syndrome disease was restricted to a few scattered coral colonies.

Figure 4.58

A





(No. 15-092) is an outer shelf ribbon reef with an area of 4.2 sq.km.

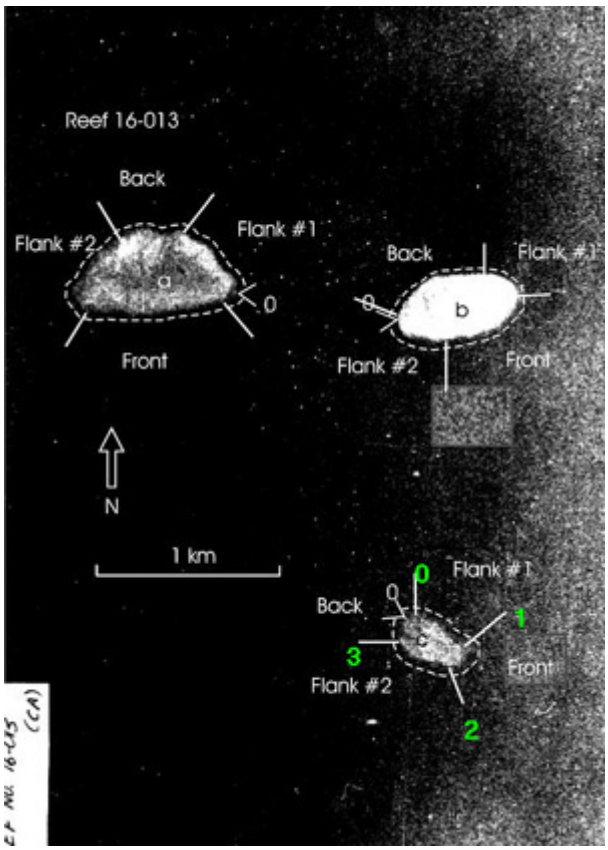
16-013 (A)

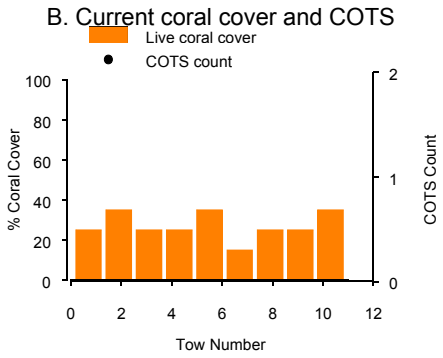
Surveyed January 2004.

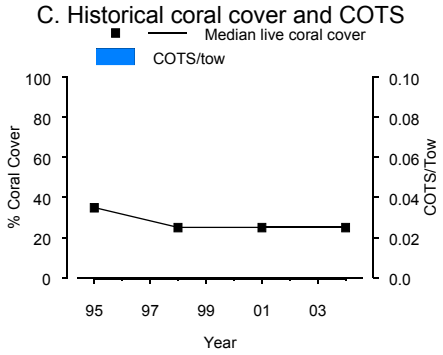
Reef 16013 has been surveyed four times since 1995. Over this time there has been little appreciable change in reef-wide live coral cover, which has remained at moderate levels (20-30%). No COTS have been observed on this reef during surveys. No bleaching was recorded in 2004 and white syndrome was restricted to a few scattered coral colonies.

Figure 4.59

A







16013 (A) (No. 16-013) is a middle shelf patch reef with an area of .4 sq.km.

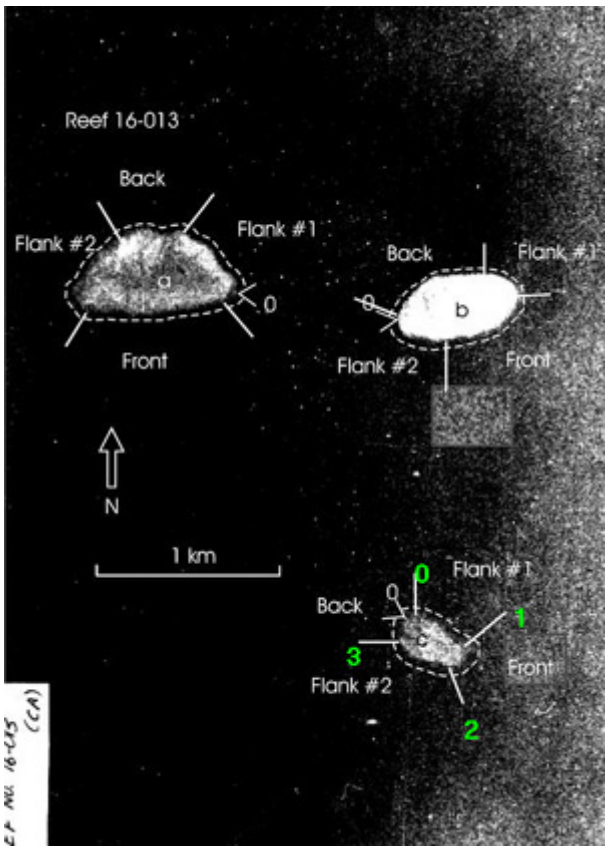
16-013 (B)

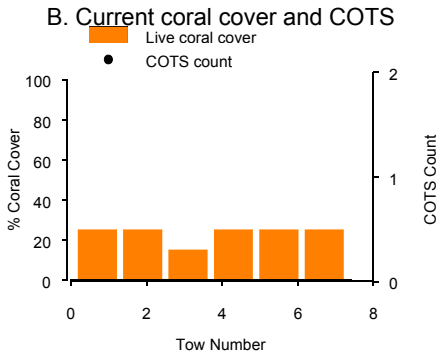
Surveyed January 2004.

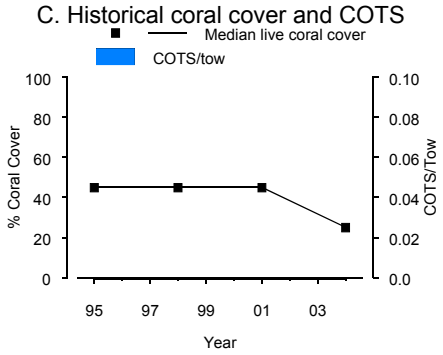
Reef 16013 (B) has been surveyed four times since 1995. Reef-wide live coral cover was high (40-50%) in the first three surveys. In 2004 coral cover declined to a moderate level (20-30%). No COTS have been observed on this reef and the reason for the decline remains enigmatic. No bleaching or disease was recorded in 2004 and the reef was classified as No Outbreak.

Figure 4.60

A







16013 (B) (No. 16-013) is a middle shelf patch reef with an area of .2 sq.km.

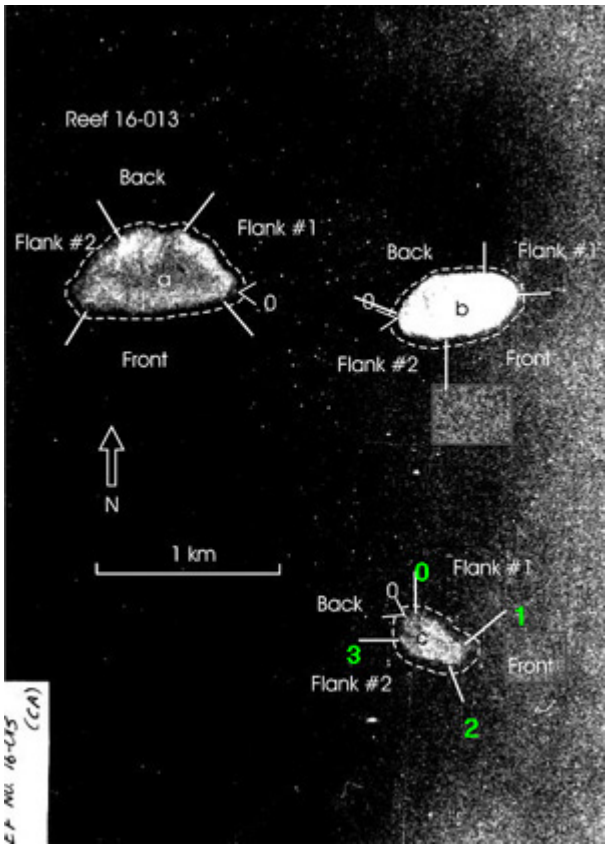
16-013 (C)

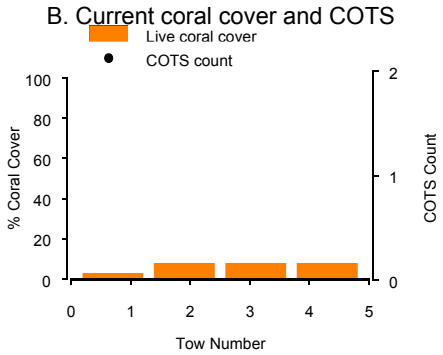
Surveyed January 2004.

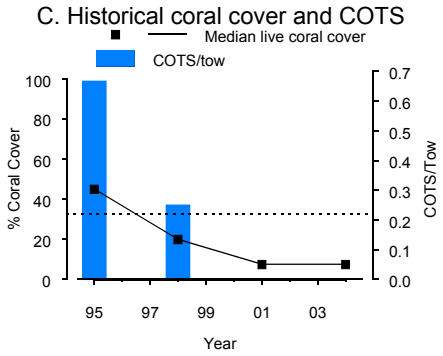
Reef 16013 (C) has been surveyed four times since 1995. Initial surveys revealed a high COTS population on this reef and it was classified as Incipient Outbreak. COTS remained active up until surveys in 2001 when no COTS were sighted. COTS feeding activity has resulted in a decline in reef-wide live coral cover to a current low level of 5-10%. The reef has been reclassified as Recovering. No bleaching or disease was recorded in 2004.

Figure 4.61

A







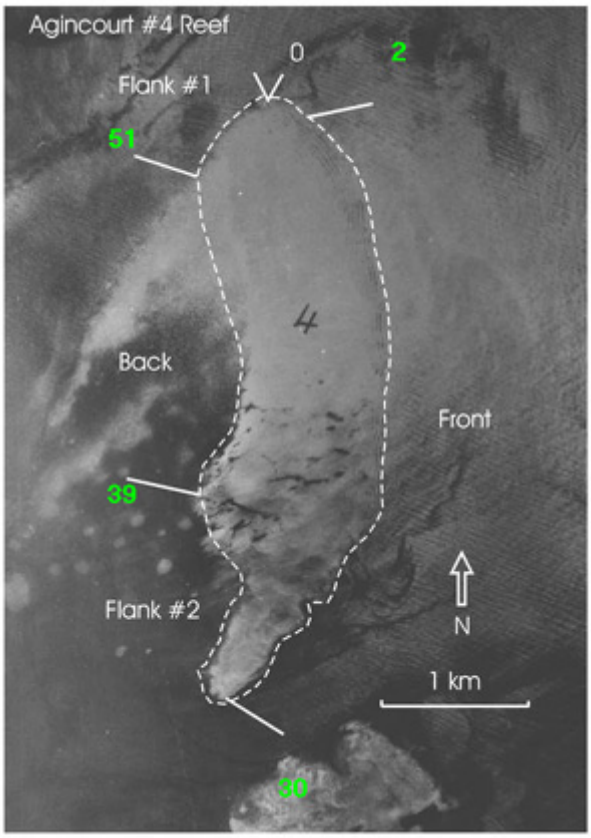
16013 (C) (No. 16-013) is a middle shelf patch reef with an area of .2 sq.km.

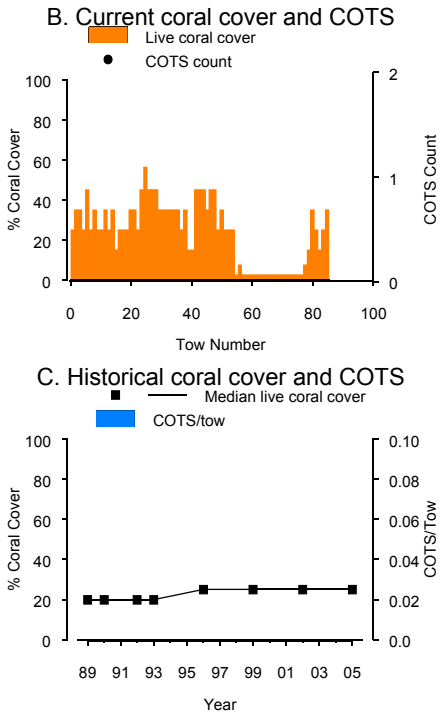
AGINCOURT NO.4

Surveyed January 2005.

Agincourt Reef No.4 has been surveyed eight times since 1989. Reef-wide live coral cover has been moderate (10-30%) over this time. No COTS have been recorded from Agincourt Reef No.4 in any survey. No bleaching was observed during manta tow surveys in 2005. White syndrome disease was common on the back and front of the reef but affected only a few dispersed coral colonies elsewhere.

Figure 4.62 A





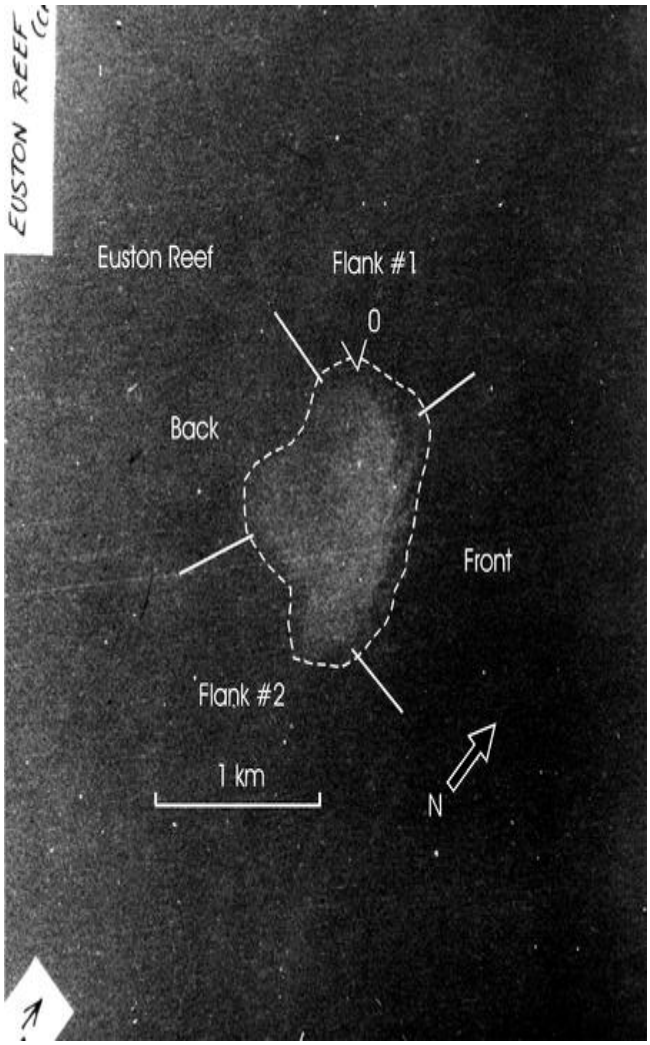
Agincourt No.4 (No. 15-096) is an outer shelf ribbon reef with an area of 12.6 sq.km.

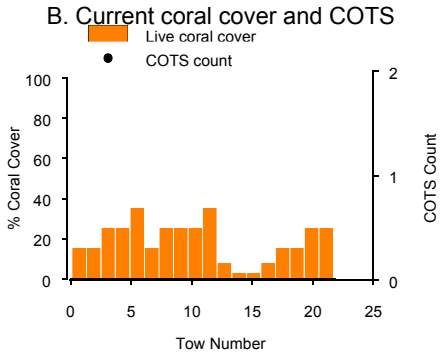
EUSTON

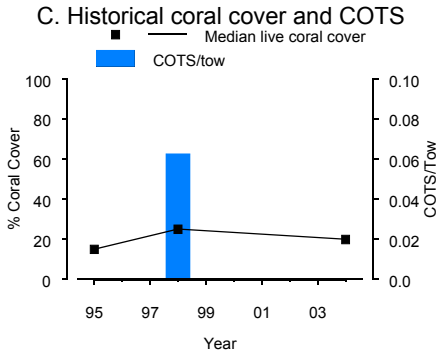
Surveyed January 2004.

Euston Reef has been surveyed three times since 1995. Over this time there has been little change in reef-wide live coral cover which has remained at moderate (10-30%) levels. Small numbers of COTS, below outbreak levels, were observed in 1998 but appear to have had little impact on coral cover. Euston Reef was classified as No Outbreak in 2004. No bleaching was observed and white syndrome affected only a few scattered colonies.

Figure 4.63 A







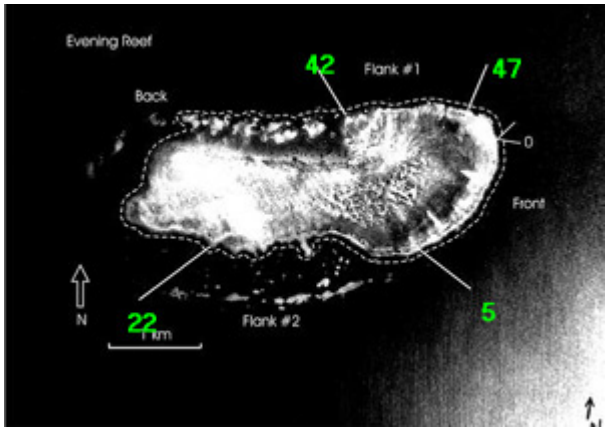
Euston (No. 16-063) is an outer shelf patch reef with an area of .7 sq.km.

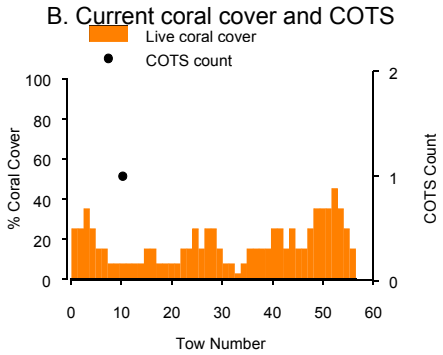
EVENING

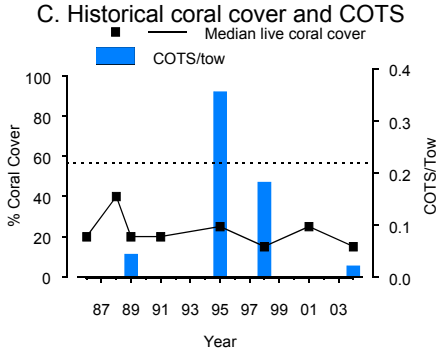
Surveyed January 2004.

Evening reef has been surveyed 8 times since 1986. Over this time reef-wide live coral cover has remained at moderate (20-30%) levels. Initially the reef was classified as recovering from COTS activity prior to the commencement of surveys in 1986. Large numbers of COTS were observed in 1995 when it was reclassified as an Incipient Outbreak. A decline in COTS in 1998 saw the reef reclassified as Recovering. Small numbers of COTS below outbreak densities were observed in 2004. Reef wide live coral cover remains moderate. No disease was observed in 2004 but bleaching was prevalent on the second flank affecting between 5-10% of all hard coral colonies.

Figure 4.64 A







Evening (No. 15-095) is a middle shelf planar reef with an area of 8.79 sq.km.

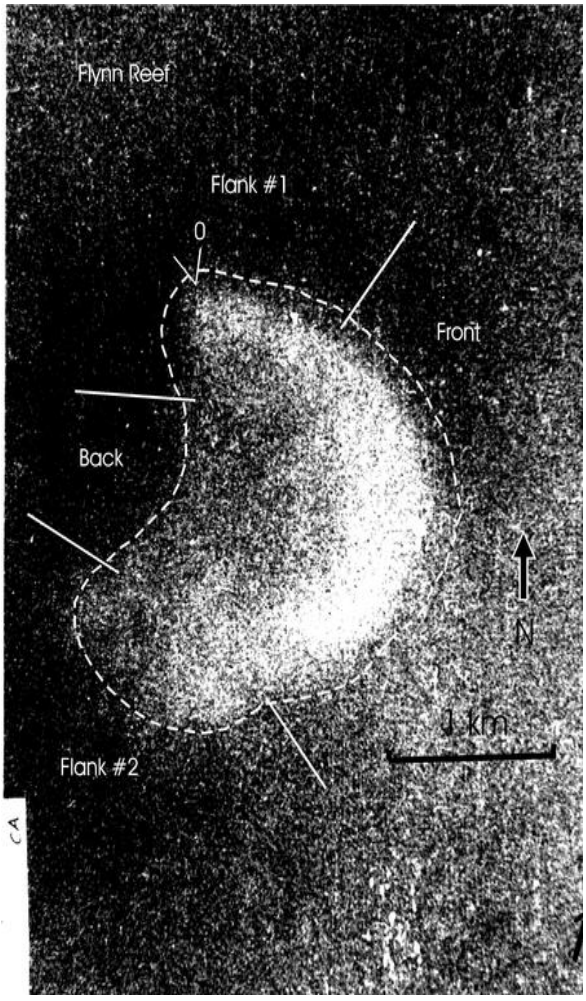
FLYNN

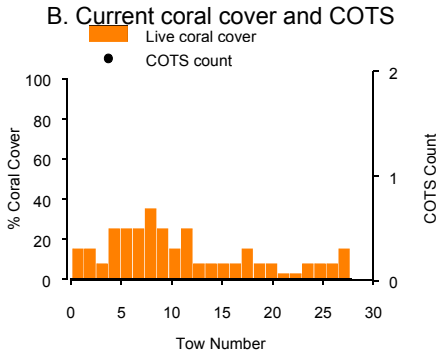
Surveyed January 2004.

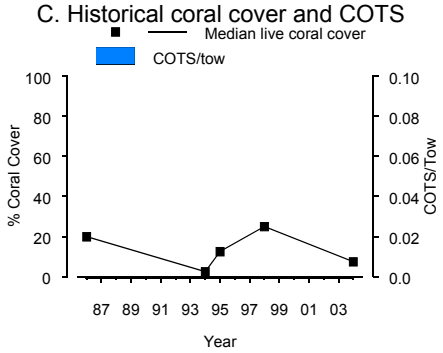
Flynn reef has been surveyed five times since 1986. Over the period of survey reef-wide coral cover has varied, decreasing from a moderate (10-30%) level in 1986 to a low (1-10%) level in 1994. It subsequently recovered to a moderate level in 1998 before declining again to the low level recorded in 2004. No COTS were seen and the reasons for this pattern are not known. Flynn Reef was classified as No Outbreak in 2004. Coral bleaching was restricted to a few scattered individual colonies. This was also true for white syndrome, except for the first flank where white syndrome was common in 2004, affecting more than ten colonies per two minute manta tow.

Figure 4.65

A







Flynn (No. 16-065) is an outer shelf planar reef with an area of 2.19 sq.km.

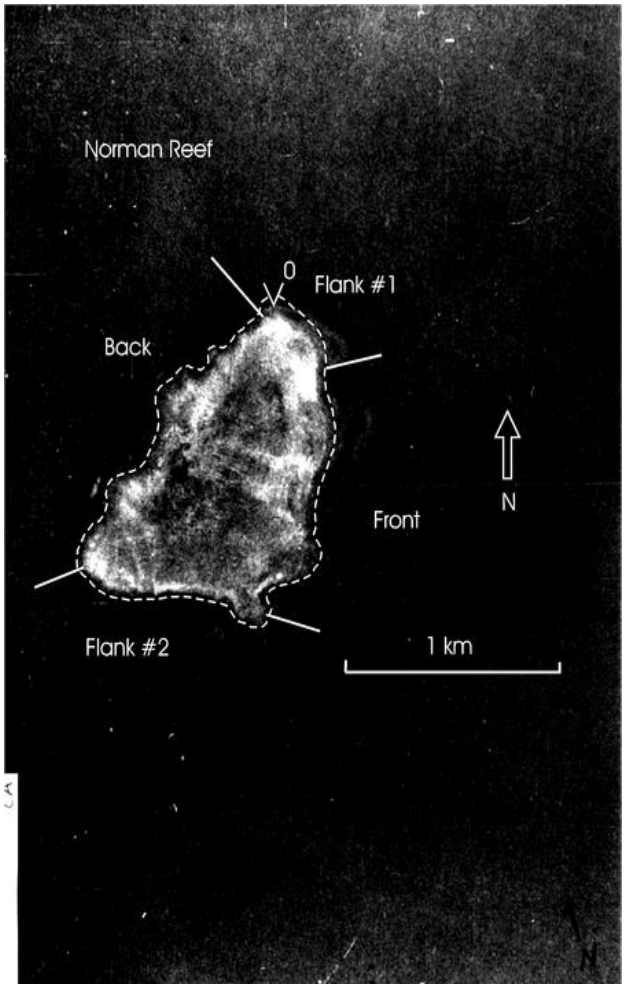
NORMAN

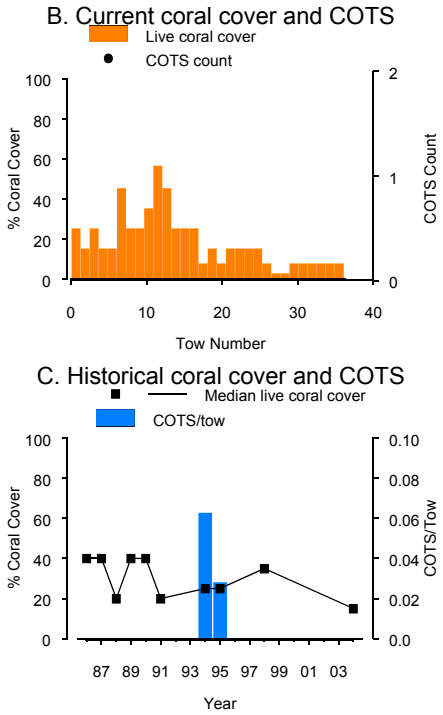
Surveyed January 2004.

Norman reef has been surveyed 10 times using manta tow since 1986. Reef-wide coral cover was generally high (30-40%) in the initial years of survey, then it dropped to moderate levels (10-30%) in 1991. No COTS had been recorded and the reason for this decline is unknown, though cyclone Joy did impact reefs in the area just prior to the 1991 survey. From 1991 to 1998 coral cover recovered to a high level despite the presence of small numbers of COTS on the reef. Surveys in 2004 show that coral cover has again declined on this reef. The long period between surveys makes it difficult to ascribe reasons for this decline. Norman reef was classified as No Outbreak in 2004. No bleaching or disease was recorded.

Figure 4.66

A





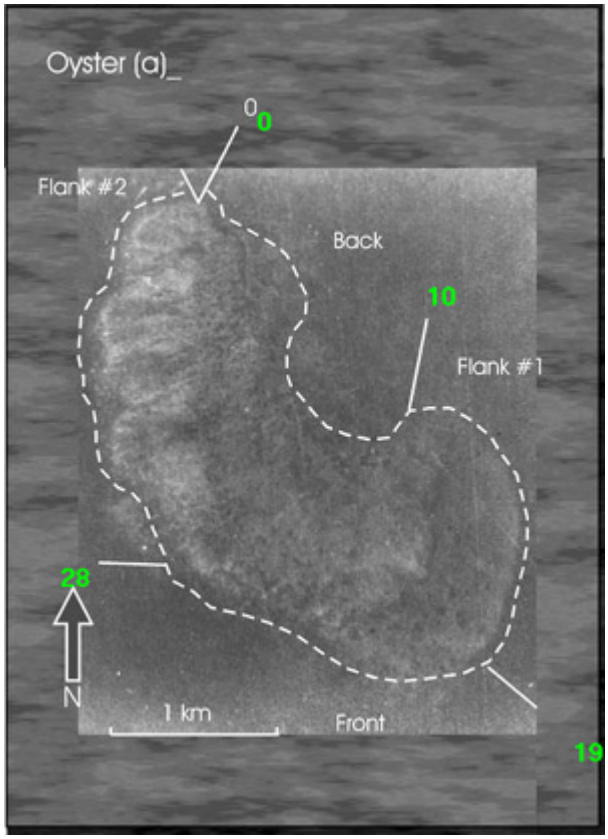
Norman (No. 16-030) is an outer shelf planar reef with an area of 4.3 sq.km.

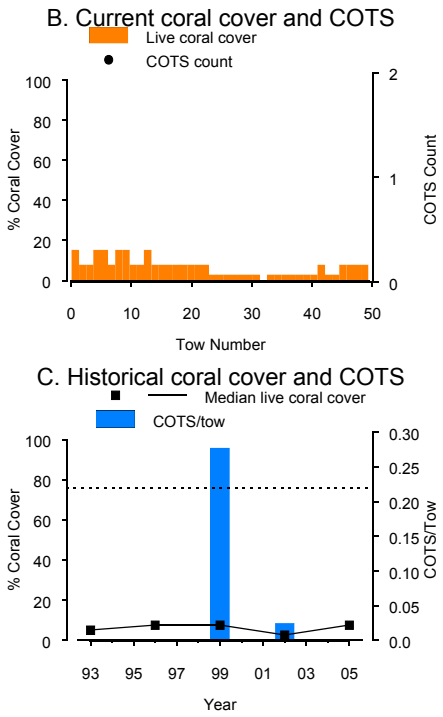
OYSTER (A)

Surveyed January 2005.

Oyster (A) Reef has only been surveyed five times since 1993. There has been little change in reef-wide live coral cover which remained low (1-10%) in 2002. Surveys in 1999 found COTS at Incipient Outbreak levels. Manta tow surveys in 2002 found that COTS populations had declined and reef-wide live coral cover was low. Oyster (A) Reef was reclassified as No Outbreak. No COTS were observed during surveys in 2005 and coral cover remained low. No bleaching was observed and white syndrome disease was restricted to small numbers of scattered colonies in 2005.

Figure 4.67 A





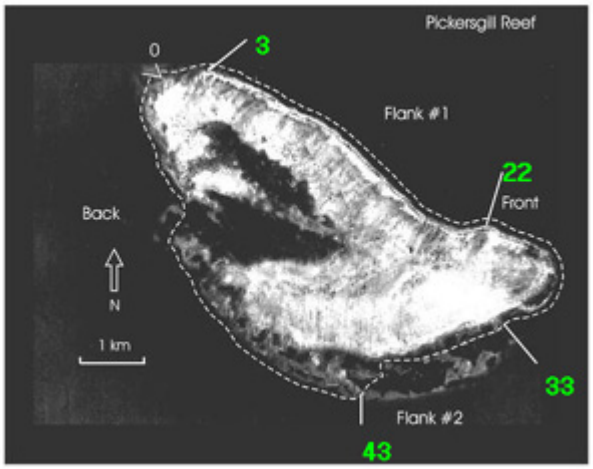
Oyster (A) (No. 16-043) is a middle shelf planar reef with an area of 14.5 sq.km.

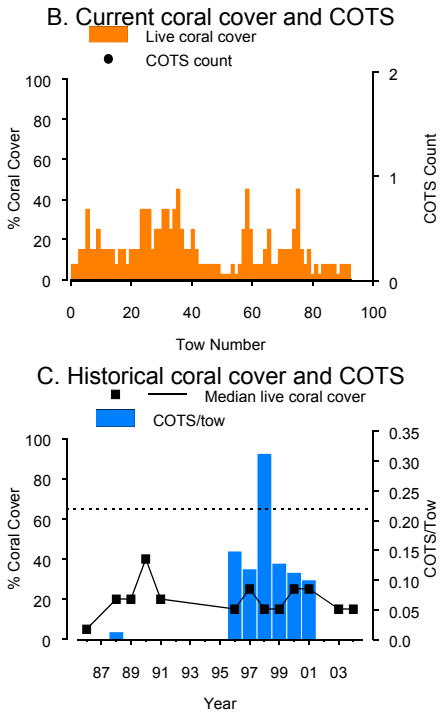
PICKERSGILL

Surveyed January 2004.

Pickersgill Reef has been surveyed 13 times by manta tow since 1986. Originally classified as Recovering from COTS activity prior to the first surveys, reef-wide live coral cover increased until 1990. Coral cover dropped appreciably in 1991. The reasons for this are uncertain; there were no large COTS populations but Cyclone Joy passed near the area in December 1990. After 1991 there was little change in coral cover although COTS numbers continued to grow up until 1998, when the reef was classified as an Incipient Outbreak. Persistent COTS populations at or below outbreak levels have hampered recovery on this reef and reef-wide live coral cover was moderate (10-30%) in 2004. No COTS were observed and the reef remains classified as Recovering. No bleaching was recorded and white syndrome disease was restricted to small numbers of individual coral colonies.

Figure 4.68 A





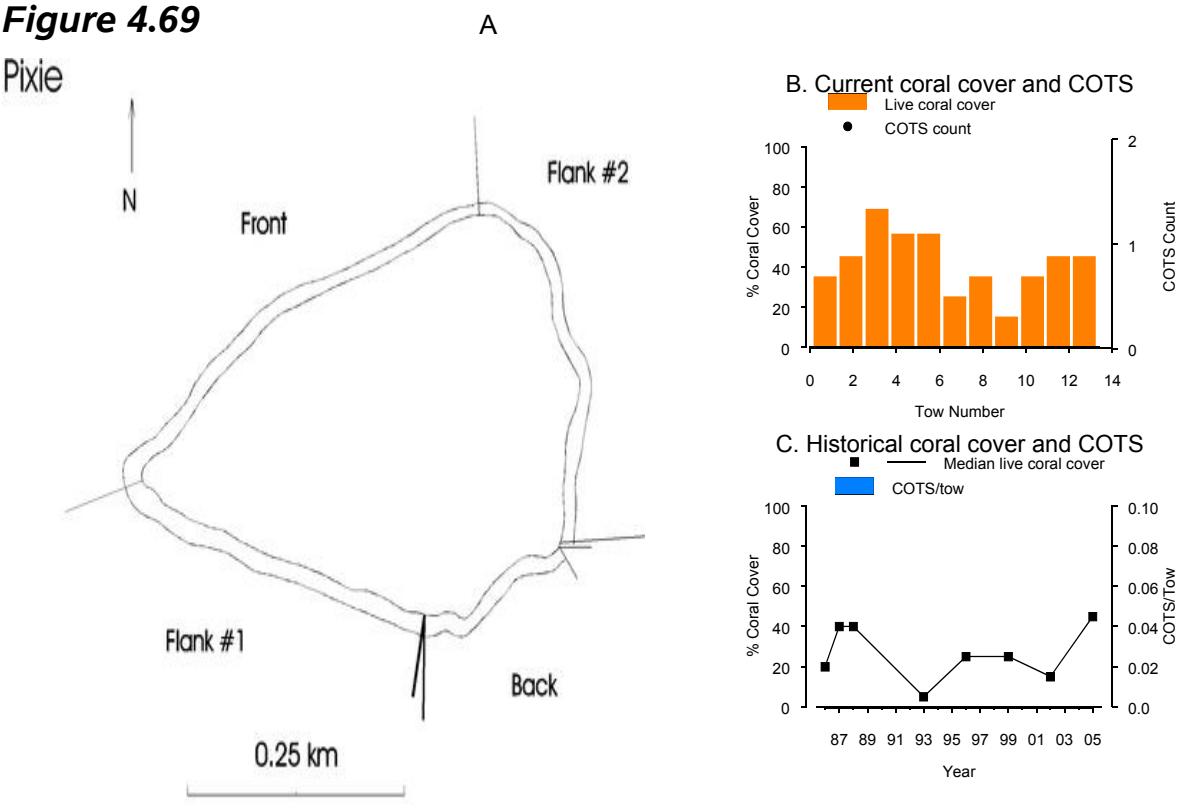
Pickersgill (No. 15-093) is a middle shelf lagoonal reef with an area of 17 sq.km.

PIXIE

Surveyed January 2005.

Pixie Reef has been surveyed eight times since 1986. Reef-wide live coral cover was high (30-50%) during the late eighties before a significant drop in 1993. Given the interval between surveys and that no COTS had been seen, the cause of the drop in coral cover remains unknown. From 1993 reef-wide live coral cover recovered to some extent and was moderate (10-30%) in 2002. In 2005 Pixie Reef was classified as No Outbreak with reef wide coral cover returning to high levels (30-50%). No COTS or coral bleaching was recorded from this reef in 2005, however white syndrome disease was common on both the back and southern flank of the reef.

Figure 4.69



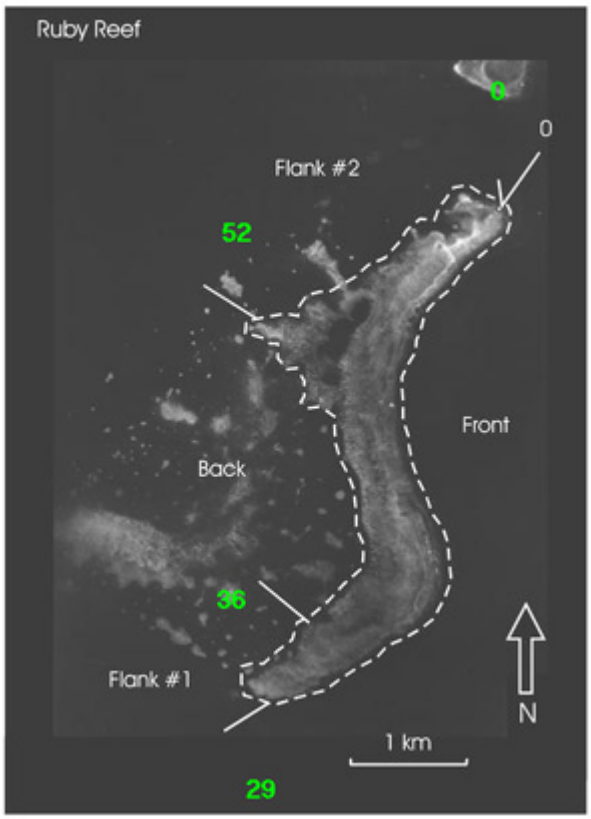
Pixie (No. 16-040) is a middle shelf planar reef with an area of .7 sq.km.

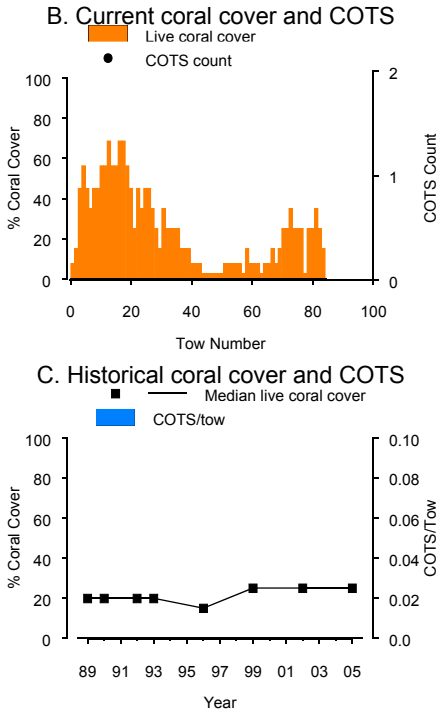
RUBY

Surveyed January 2005.

Ruby Reef has been surveyed eight times since 1989. Over this time there has been little change in median reef-wide live coral cover which remained at moderate levels (10-30%). No COTS have been observed during any surveys and Ruby Reef remains classified as No Outbreak. No bleaching was recorded and white syndrome disease was observed on a few coral colonies around the reef perimeter during manta tow surveys in 2005.

Figure 4.70 A





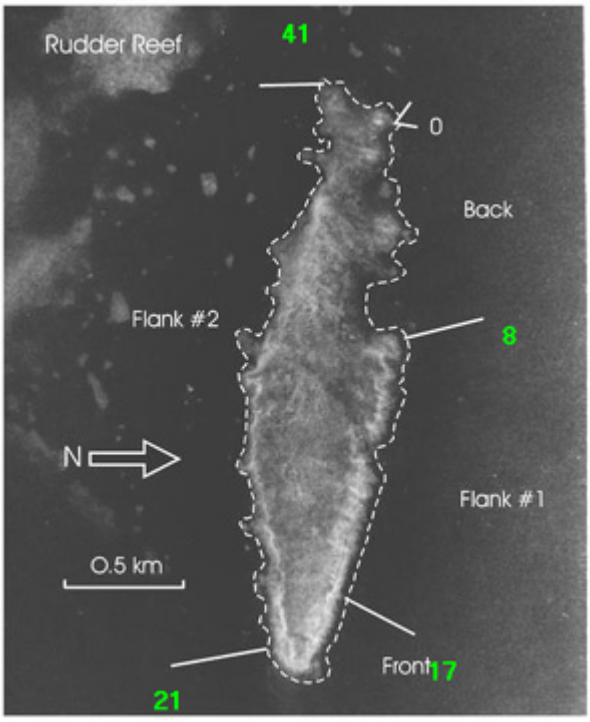
Ruby (No. 15-088) is an outer shelf ribbon reef with an area of 12 sq.km.

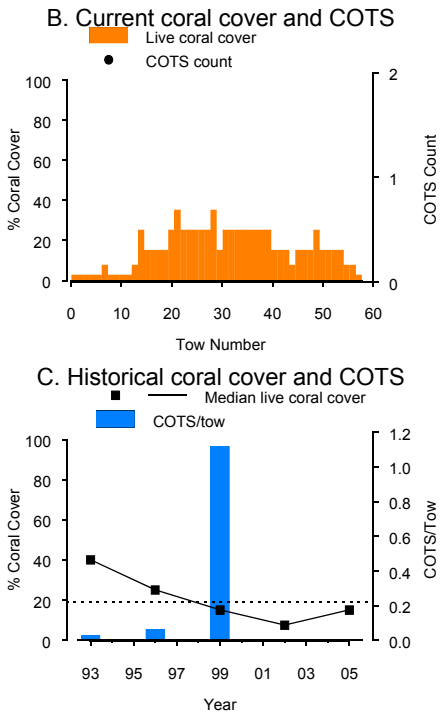
RUDDER

Surveyed January 2005.

Rudder Reef has been surveyed five times since 1993. Reef-wide live coral cover was initially high (30-50%), but COTS were recorded at each visit between 1993 and 1999 reaching Active Outbreak levels by 1999. Increased COTS activity saw a subsequent decline in Reef-wide live coral cover to a low level (1-10%) in 2002 when Rudder Reef was classified as Recovering. In 2005 reef-wide coral cover had increased to moderate levels (10-20%). No evidence of COTS or bleaching was seen and white syndrome disease only affected a few scattered coral colonies.

Figure 4.71 A





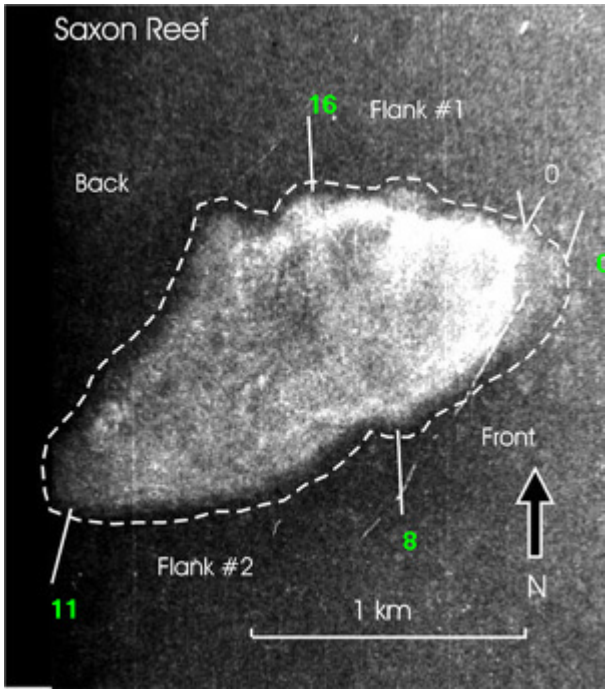
Rudder (No. 16-023) is a middle shelf patch reef with an area of 0 sq.km.

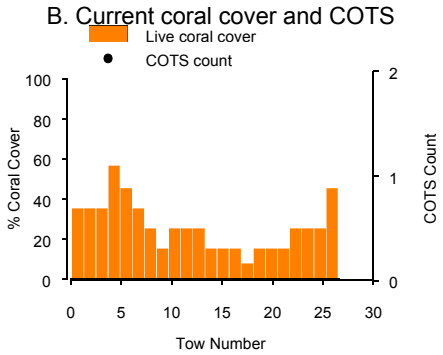
SAXON

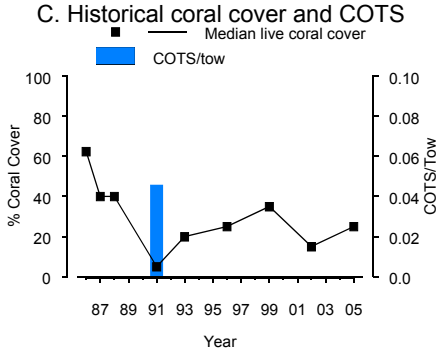
Surveyed January 2005.

Saxon Reef has been surveyed nine times since 1986. Reef-wide live coral cover was initially very high (50-75%) through the late 1980s, but declined in the early 1990s for unknown reasons, but possibly due to the persistent low numbers of COTS. From 1991 to 1999 reef-wide live coral cover recovered to a high level (30-50%) before declining to a moderate level (10-30%) in 2002. The reason for this decline is also unknown. No COTS were recorded from Saxon Reef during recent surveys and it was classified as No Outbreak in 2005. Coral cover appears to have improved but still remains moderate. No bleaching was observed and white syndrome disease only affected a few scattered coral colonies in 2005.

Figure 4.72 A







Saxon (No. 16-032) is a middle shelf planar reef with an area of 1.9 sq.km.

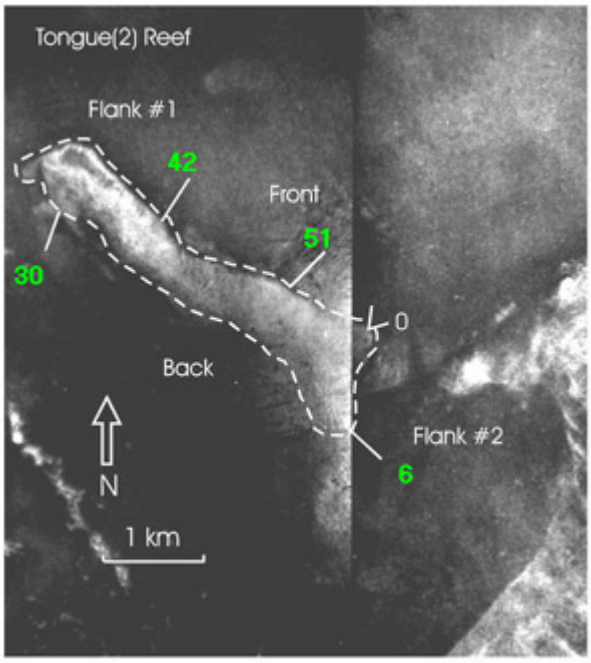
TONGUE (2)

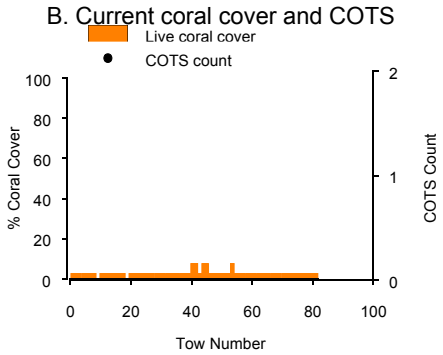
Surveyed January 2005.

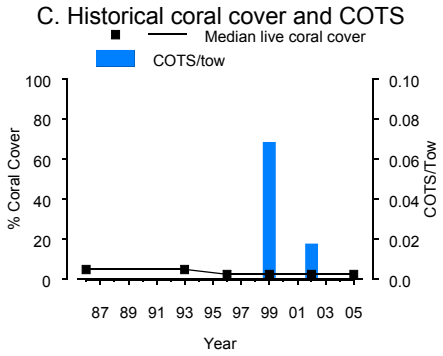
This reef has been surveyed six times since 1986. There has been little change in reef-wide live coral cover which remained low (1-10%) in 2005. Although COTS were recorded from this reef in 1999, their numbers were too low to cause much reduction in live coral cover. The reef was classified as No Outbreak in 2002. No bleaching was observed and white syndrome disease and black band disease were observed on a few scattered coral colonies during surveys in 2005.

Figure 4.73

A







Tongue (2) (No. 16-026) is a middle shelf crescentic reef with an area of 213.3 sq.km.

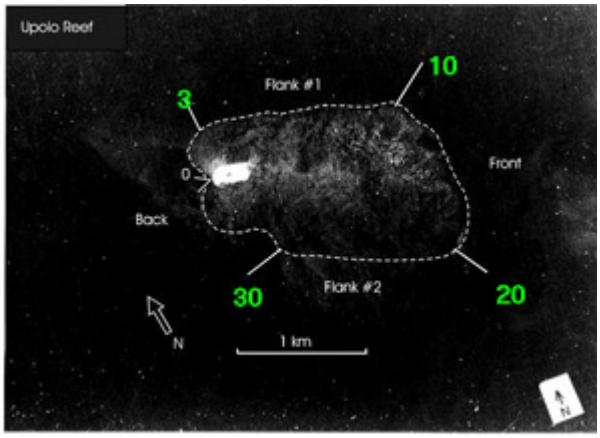
UPOLU CAY

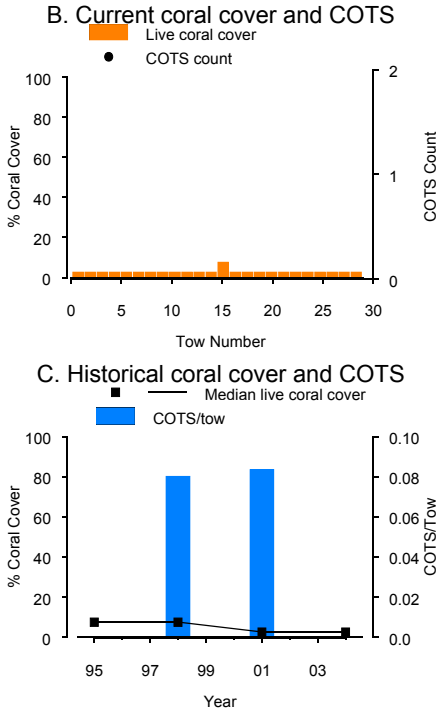
Surveyed January 2004.

This reef has been surveyed four times since 1995. Over this time there appears to have been a reduction in reef-wide live coral cover from low (5-10%) to very low (<5%) levels. Small numbers of COTS have been observed on this reef in the previous two surveys. Although below what is considered to be outbreak levels, given the low coral cover on this reef, they may well have been responsible for the observed decline. Upolu Cay is currently classified as No Outbreak. No bleaching was observed and white syndrome disease was restricted to small numbers of individual coral colonies during surveys in 2004.

Figure 4.74

A





Upolu Cay (No. 16-046) is a middle shelf planar reef with an area of 12.1 sq.km.

Innisfail

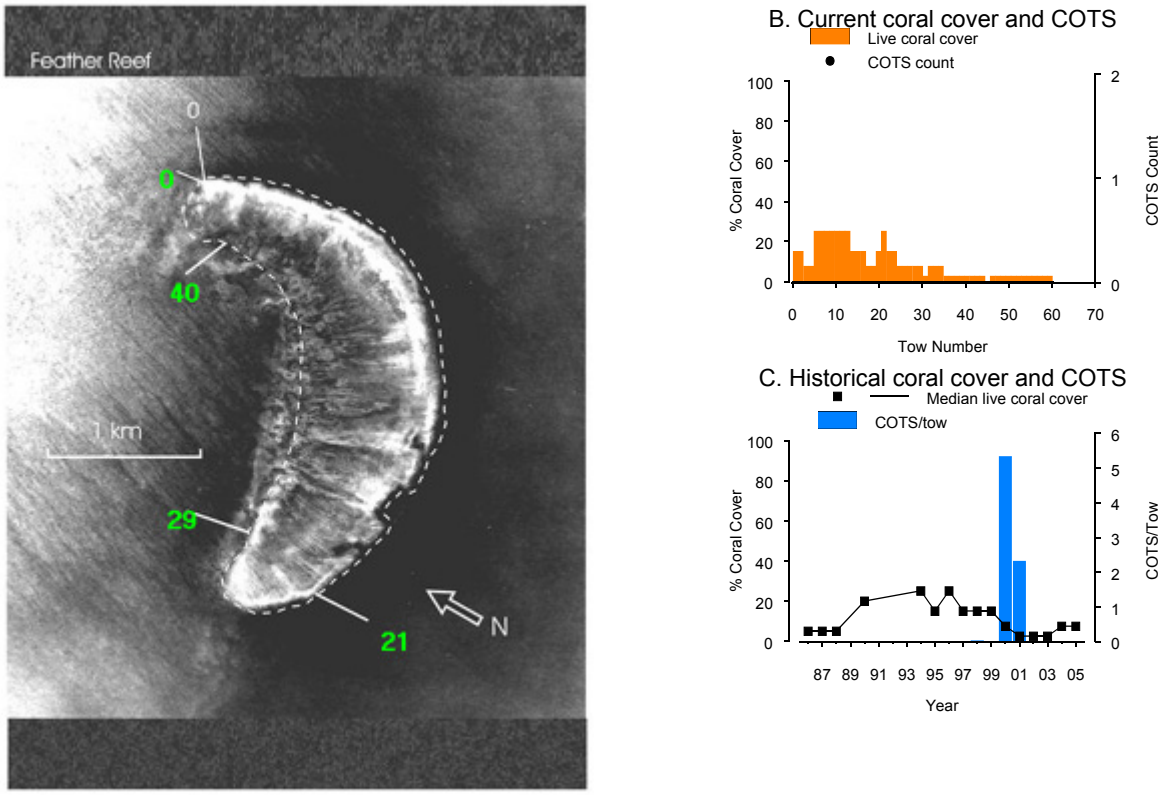
Reef Pages

FEATHER

Surveyed February 2005.

Feather reef has been surveyed 16 times since 1986. It was initially classified as Recovering from previous COTS activity. There was a gradual increase in reef-wide live coral cover to a moderate level (10-30%) during the late 1980s and early 1990*s.* The recovery of coral cover stalled in the mid 1990s, possibly due to the effects of cyclones (Cyclones Gillian, Ita and Justin were active in the area) and remained at moderate levels through the late 1990*s.* In 2000 Feather Reef experienced a COTS outbreak and there was a corresponding decline in reef-wide live coral cover to a low level (1-10%) by 2001. By 2002 COTS numbers had declined and the reef was reclassified as Recovering. Reef-wide live coral cover remains low in 2005 and the reef is classified as Recovering. No bleaching was observed and white syndrome coral disease was restricted to a few scattered coral colonies on the reef's southern flank in 2005..

Figure 4.75



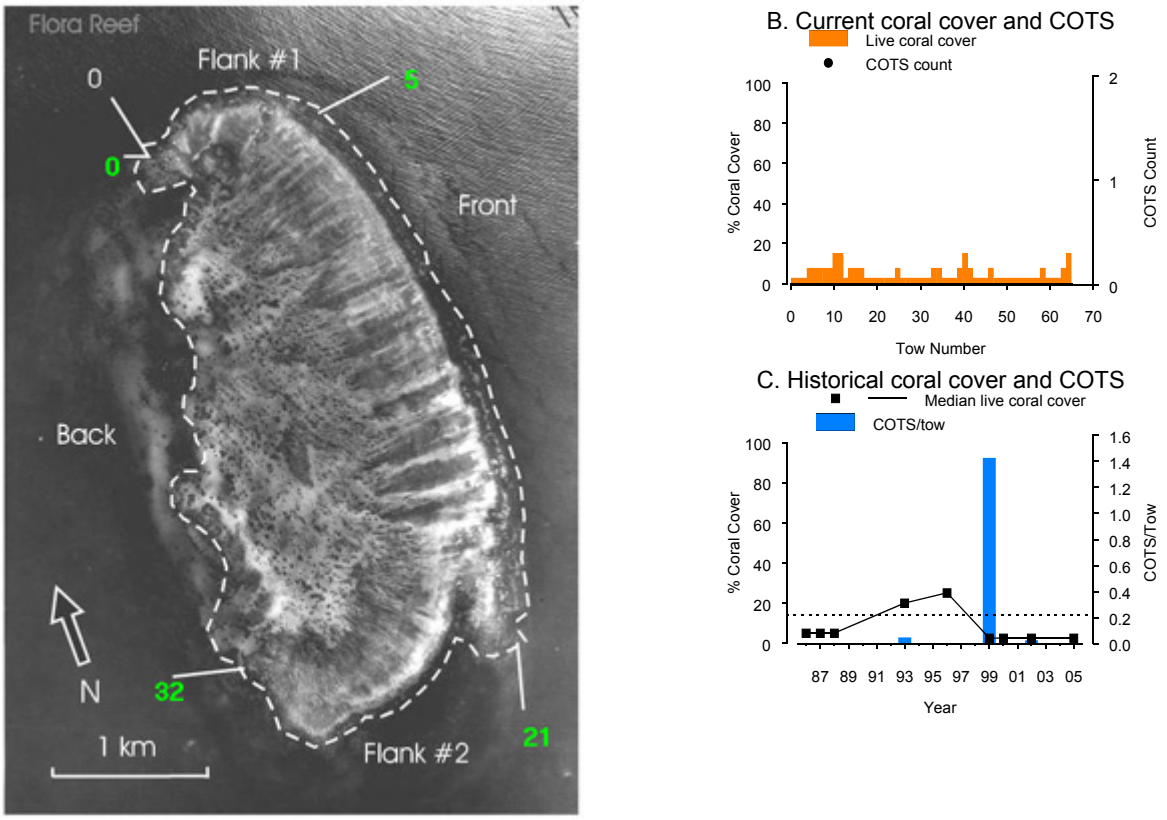
Feather (No. 17-034) is a middle shelf crescentic reef with an area of 14.1 sq.km.

FLORA

Surveyed February 2005.

Flora Reef has been surveyed nine times since 1986 when it was classified as Recovering from prior COTS activity. Reef-wide live coral cover was initially low (1-10%) and increased gradually to a moderate level (10-30%) by 1996. Surveys in 1999 found a decline in reef-wide live coral cover to a low level (1-10%). Large numbers of COTS were present and Flora Reef was re-classified as an Active Outbreak. Although COTS certainly played an important role in the decline of live coral cover, bleaching, which was extensive on the GBR in 1998, may have also contributed. COTS in small numbers were last observed in 2002 when reef-wide live coral cover was low and Flora Reef was classified as Recovering. No COTS were observed during surveys in 2005 and reef-wide live coral cover remains low. No bleaching was observed and white syndrome disease was restricted to small numbers of scattered coral colonies on the back reef in 2005.

Figure 4.76 A



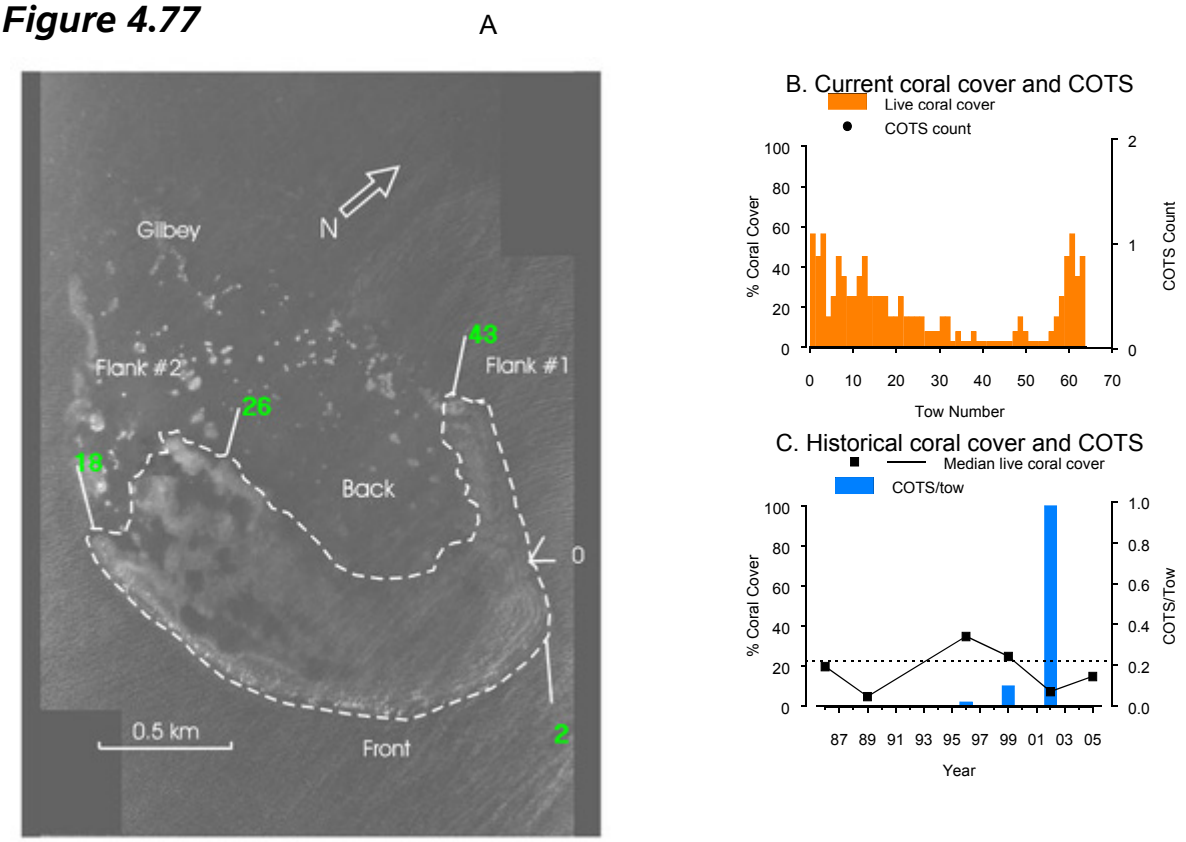
Flora (No. 17-010) is a middle shelf crescentic reef with an area of 8.79 sq.km.

GILBEY

Surveyed February 2005.

Gilbey Reef has been surveyed six times since 1986 when it was classified as Recovering from COTS activity. Reef-wide live coral cover declined and then recovered to a moderate level (10-30%) in 1996. Small numbers of COTS were recorded during surveys in 1996 and 1999. In 2002 there were large numbers of COTS recorded and Gilbey Reef was re-classified as an Incipient Outbreak. As a result of COTS activity, reef-wide live coral cover declined to low levels (1-10%) by 2002. Surveys in 2005 failed to observe any COTS and indicate reef-wide live coral cover is beginning to recover and is now at a moderate (10-20%) level. No bleaching was observed in 2005 and white syndrome disease was restricted to a small number of scattered coral colonies on the reef front.

Figure 4.77



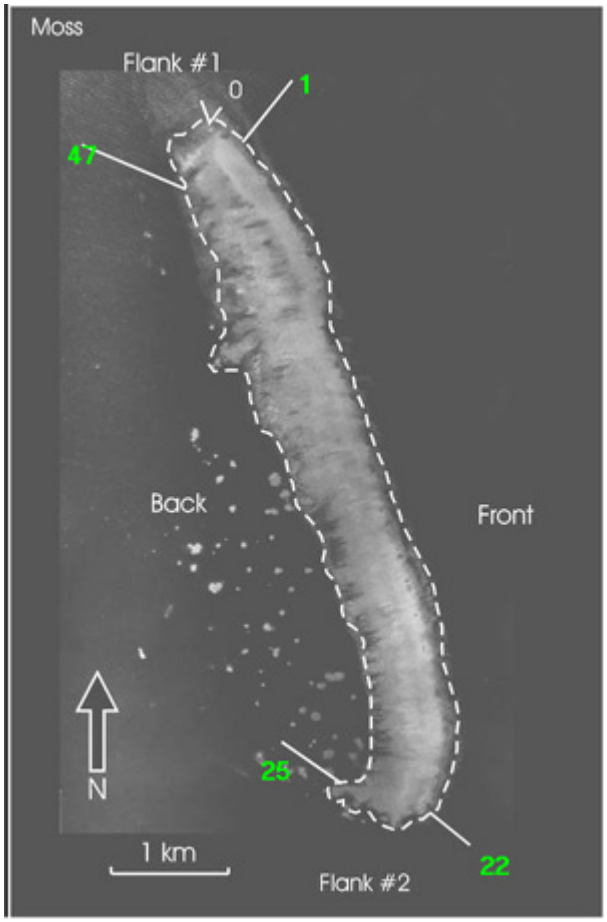
Gilbey (No. 17-057) is an outer shelf crescentic reef with an area of 6.6 sq.km.

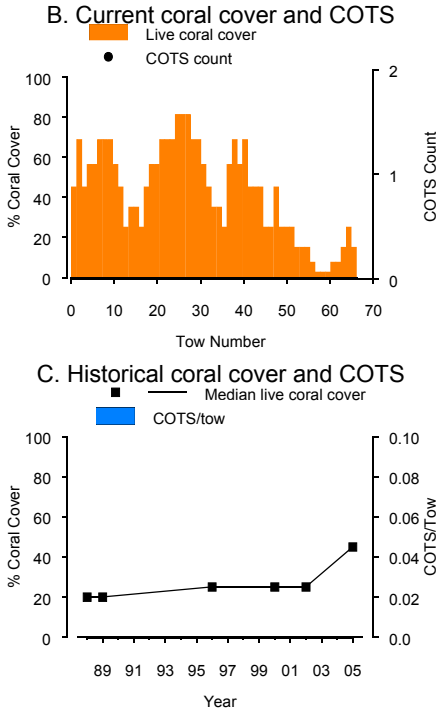
MOSS

Surveyed February 2005.

Moss Reef has been surveyed six times since 1988 when it was classified as No Outbreak. Reef-wide live coral cover showed little change remaining at moderate levels (10-30%) up until 2002. Surveys in 2005 indicate that coral cover has increased in recent years to a current high level (40-50%). No COTS have been observed during any survey and Moss Reef remained classified as No Outbreak in 2005. No bleaching was observed, and white syndrome disease was restricted to a small number of scattered coral colonies on the front and back of the reef.

Figure 4.78 A





Moss (No. 17-068) is an outer shelf ribbon reef with an area of 6.2 sq.km.

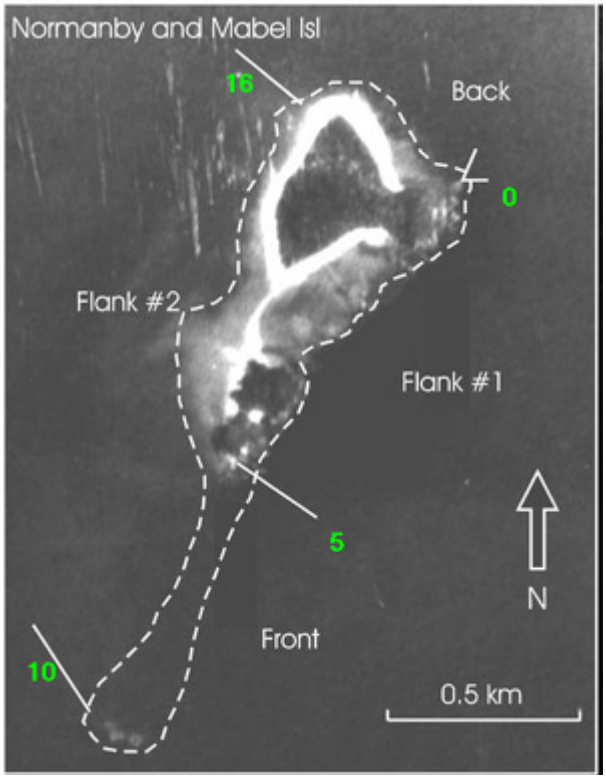
NORMANBY AND MABEL IS'S

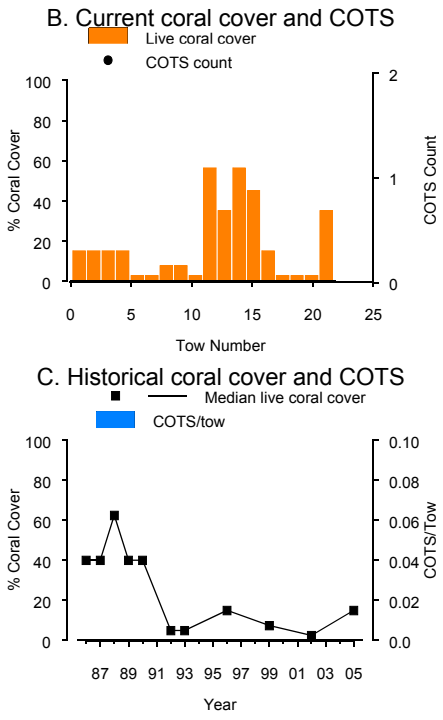
Surveyed February 2005.

Normanby and Mabel Islands A. Reef has been sampled 11 times since 1986. No COTS have been recorded in any surveys. Reef-wide live coral cover was initially high (30-50%) before a major decline between 1990 and 1992. The reasons for this drop in coral cover were uncertain but flooding from Cyclone Ivor (March 1990) may have been a factor. There was some recovery of reef-wide live coral cover up to 1996 before another period of decline most likely driven by the 1998 coral bleaching event. Reef-wide live coral cover was low (1-10%) by 2002. Surveys in 2005 indicate reef-wide live coral cover is beginning to recover and is now at a moderate (10-20%) level. Normanby and Mabel Islands A. Reef remains classified as No Outbreak. No bleaching or disease was observed during surveys in 2005.

Figure 4.79

A





Normanby And Mabel Is's (No. 17-012) is an inner shelf submerged reef with an area of .4 sq.km.

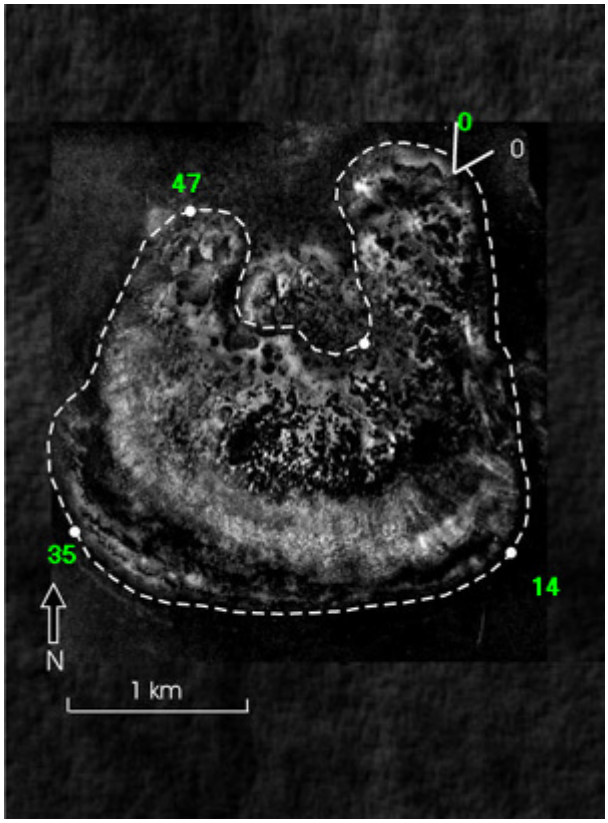
SCOTT

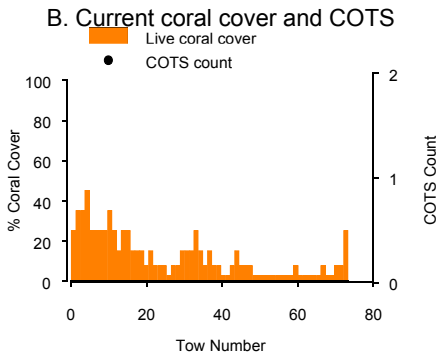
Surveyed January 2003.

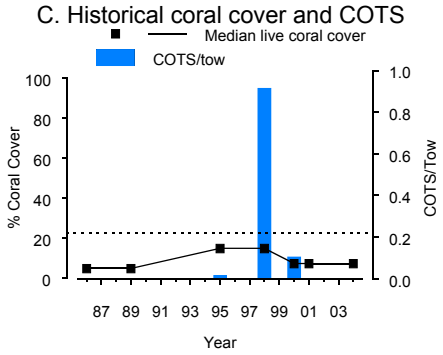
Scott reef has been surveyed seven times since 1986. The reef was initially classified as Recovering from COTS activity prior to surveys beginning in 1986 . From 1986 to 1997 reef-wide live coral cover exhibited a modest recovery from a low level (1-10%) in 1986 to moderate levels (10-20%) by 1995. In 1998 elevated COTS populations were recorded and it was reclassified as an Incipient Outbreak. Surveys in 2000 indicated a decline in reef wide coral cover to a low level (5-10%), probably as a result of continued COTS feeding activity. No COTS have been observed since this time, coral cover remains low and the reef remains classified as Recovering. Low levels of coral bleaching , white syndrome and black band disease restricted to small numbers of individual colonies were recorded from this reef during surveys in 2004.

Figure 4.80

A







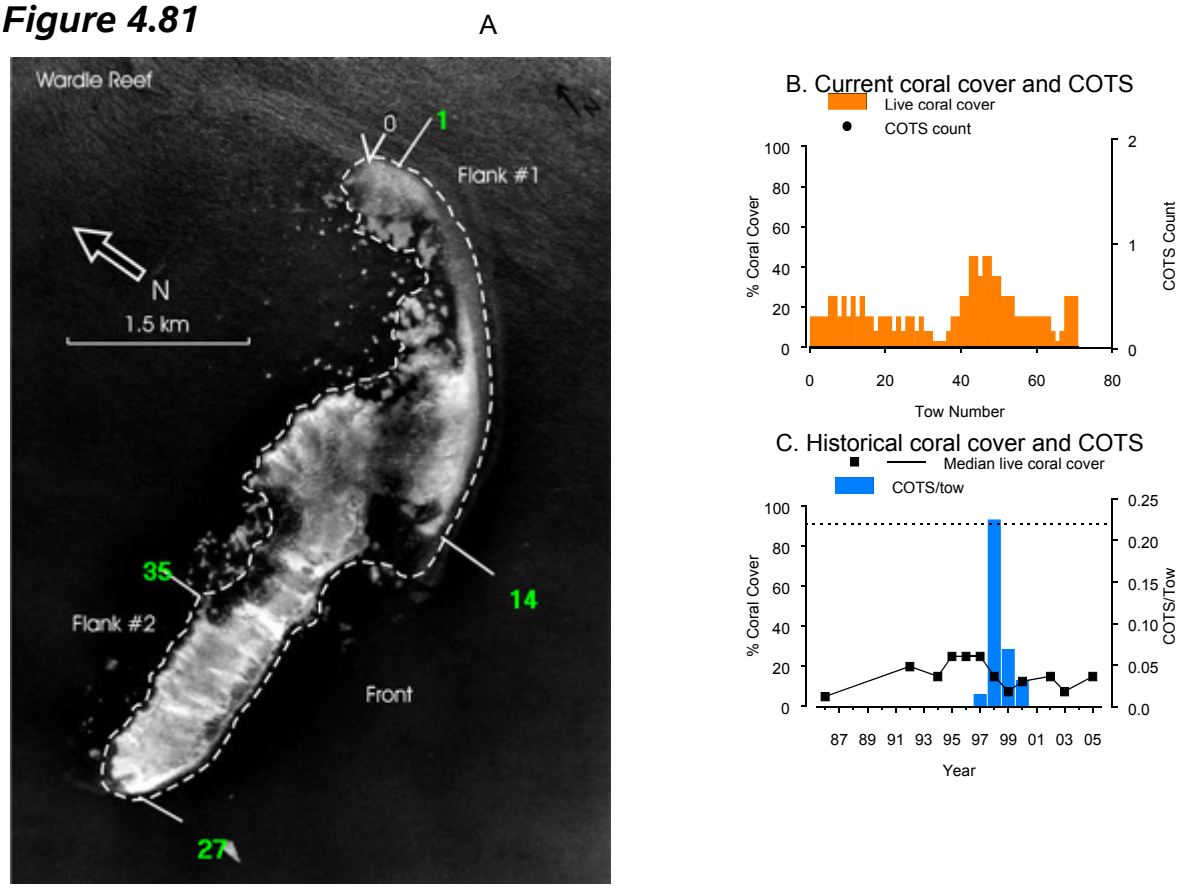
Scott (No. 17-004) is a middle shelf crescentic reef with an area of 16.7 sq.km.

WARDLE

Surveyed February 2005.

Wardel Reef has been surveyed 12 times since 1986, when it was classified as Recovering from COTS activity. There was a gradual recovery of reef-wide live coral cover to a moderate level (10-30%) by 1997. Incipient Outbreak levels of COTS were then recorded in 1998, and by 1999 coral cover had declined to a low level (1-10%). COTS numbers had also declined and Wardel Reef was re-classified as Recovering. Reef-wide live coral cover has shown signs of recovery in recent years and was moderate in 2005. No COTS were recorded in 2005 and Wardel Reef remains classified as Recovering. No bleaching was seen and white syndrome disease was restricted to a small number of scattered coral colonies on the front and southern flank of the reef.

Figure 4.81



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

Townsville

Reef Pages

CHICKEN

Surveyed May 2005.

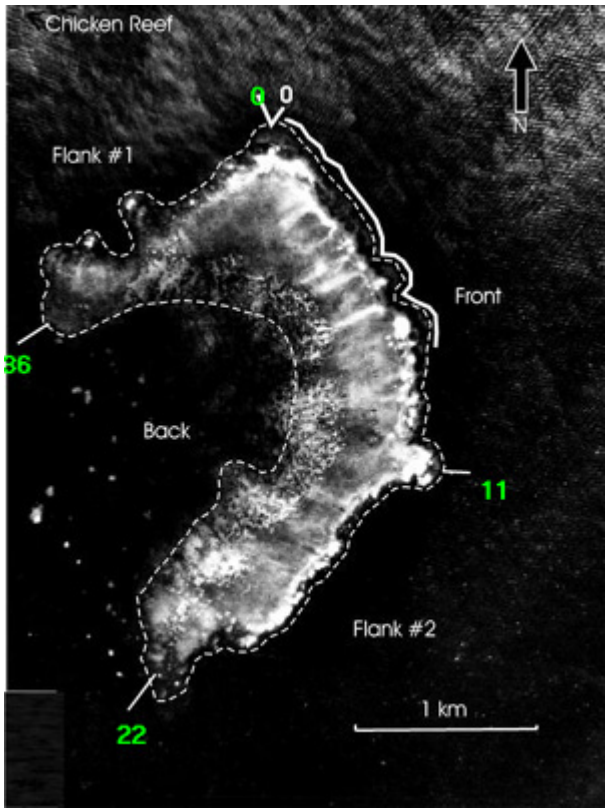
Chicken Reef has been surveyed 15 times since 1986. Reef-wide live coral cover was initially high (30-50%) but dropped to a moderate level in 1989, possibly due to COTS. Reef-wide live coral cover remained stable at moderate levels (10-30%) between 1989 and 2003. COTS numbers increased sharply in 2003 and the reef was reclassified from No Outbreak to Active Outbreak. COTS numbers remained above outbreak levels in 2004 and there was a corresponding decline in reef-wide live coral cover. Surveys in 2005 show COTS numbers to remain high and Chicken Reef remains classified as an Active Outbreak. No coral bleaching was observed and white syndrome disease affected a few scattered coral colonies on the back reef during surveys in 2005.

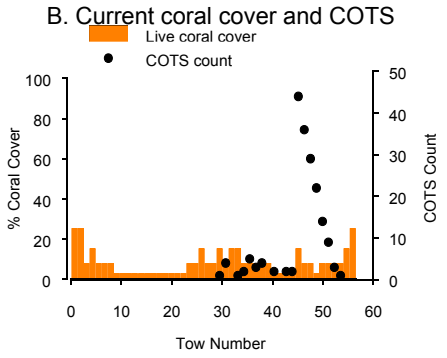
On the intensive survey sites coral cover increased from 30%, when surveys began in 1993, to 42% in 1999. Coral cover was reduced to 37% in 2000 (possibly due to Cyclone Tessi) and decreased further to 13% in 2005 as a result of crown-of-thorns feeding activity. The observed changes in hard coral cover are mostly due to losses of *Acropora* spp. but are also evident in Faviidae and Pocilliporidae. The soft coral community has been stable over the survey period. SCUBA searches in 2003 recorded adolescent COTS at a density of 220/ha. and adult COTS at 387/ha. In 2005, no COTS were seen on SCUBA search, However, large numbers of COTS were counted around the reef perimeter. *Drupella* spp. were recorded at 40/ha. in 2005. No colonies with white syndrome disease were recorded in 2005.

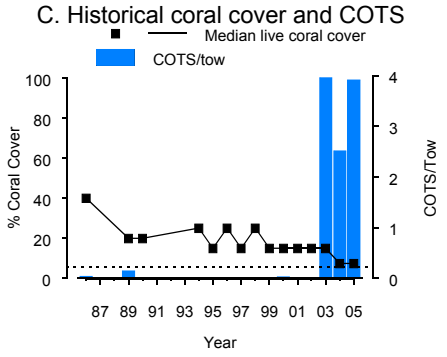
There have been few consistent trends in abundance of most reef fish taxa and interannual variability was often high. The 2004 survey saw the end of a decline in the abundance of two species of Acanthuridae, *Acanthurus nigrofuscus* and *Ctenochaetus* spp. Between 2004 and 2005, both species increased in abundance. Abundance of Labridae has been increasing since 2003, driven largely by two species, *Halichoeres hortulanus* and *Hemigymnus fasciatus*. All labrids declined in abundance in 2005. Numbers of Scaridae consistently increased from 1999 to a survey maximum in 2005. Numbers of the damselfish *Chrysiptera rex* decreased over the survey period.

Figure 4.82

A

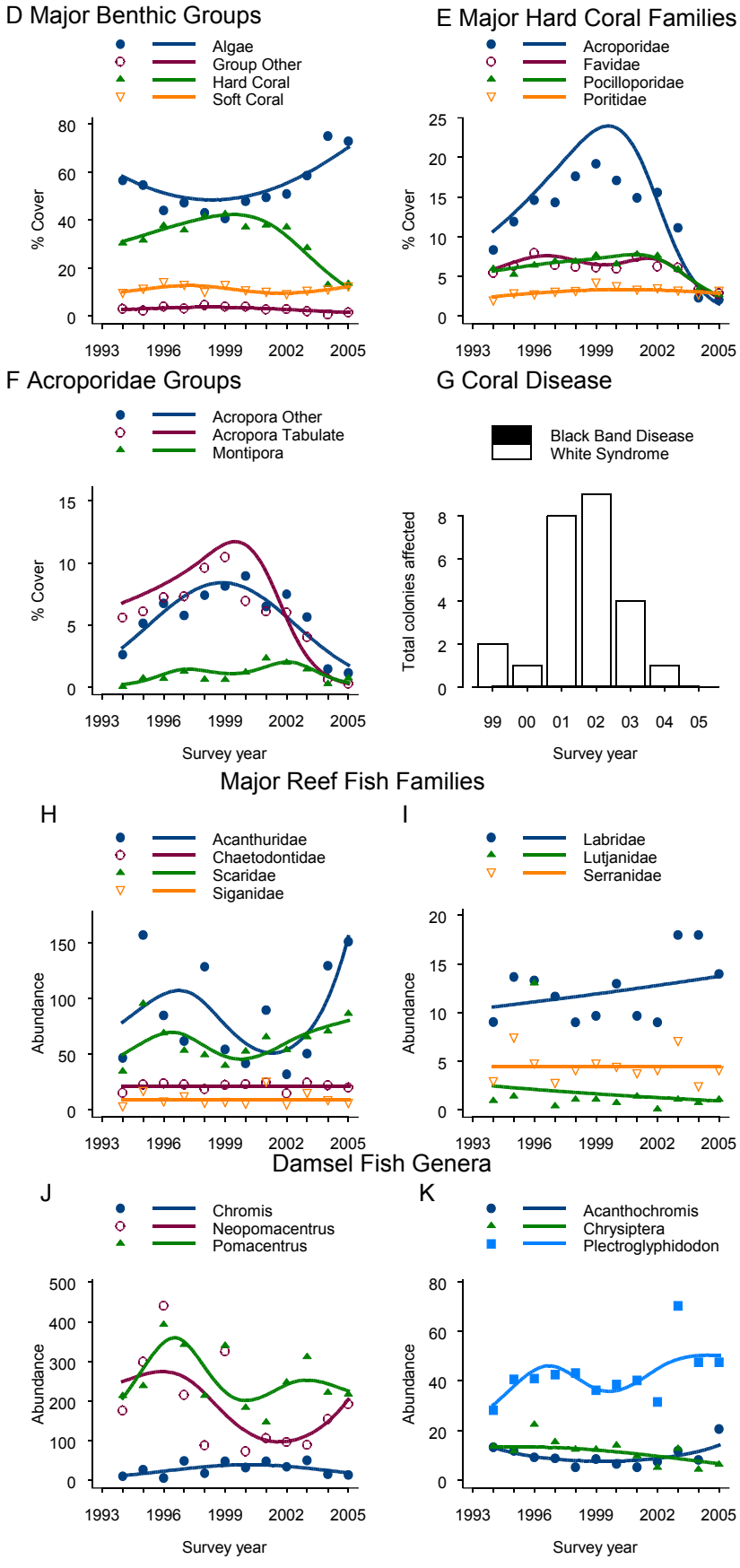






Chicken (No. 18-086) is an outer shelf crescentic reef with an area of 3.8 sq.km.

Figure 4.82 (Cont).



DAVIES

Surveyed April 2005.

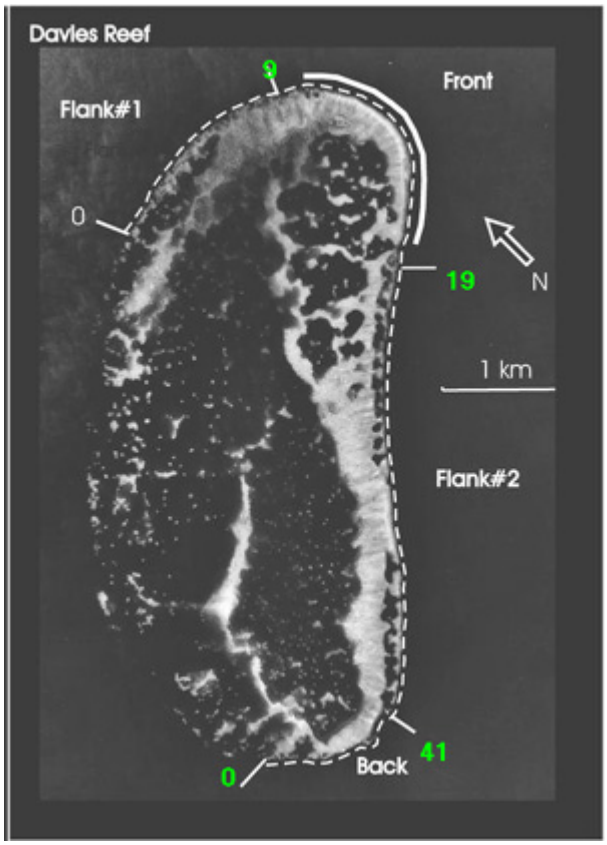
Davies Reef has been surveyed 20 times since 1986, when it was originally classified as No Outbreak. In 1988, COTS numbers increased and Davies Reef was classified as an Active Outbreak. COTS numbers subsequently peaked in 1990 and had declined by 1993 when Davies Reef was reclassified as Recovering. Despite decreased numbers of COTS, median reef-wide live coral cover remained moderate and it was not until 1998 that there was a noticeable increase to a high level (30-50%). Small numbers of COTS were observed in 1997 and 1998 but well below levels that should affect reef-wide live coral cover. Coral cover declined between 1999 and 2001 to moderate levels (10-30%) where it has remained until 2005. There has been an increase in COTS activity in recent years reaching Incipient Outbreak levels in 2003. Numbers have not subsequently increased and the reef in 2005 was classified as Recovering. No bleaching was observed and white syndrome disease was restricted to a few scattered colonies on the back reef during manta tow surveys in 2005.

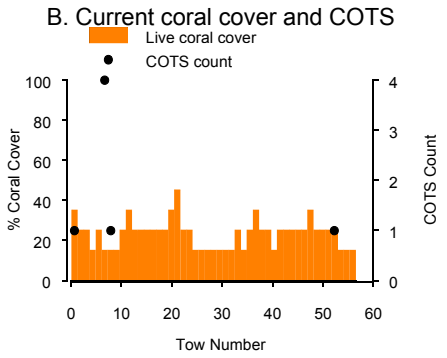
Coral cover on the intensice survey sites initially increased to 41% in 1999 and decreased until 2004 to 27%. In 2005 hard coral cover had begun to recover increasing to 31%. The decline in hard coral is likely to be a result of multiple low level disturbances associated with COTS, bleaching and cyclones. Soft coral cover has not changed over the survey period and was below 3% in 2005. Since 1999 white syndrome disease has been observed at very low levels. *Drupella* spp. were recorded during SCUBA searches in 2005 at a density of 133/ha.

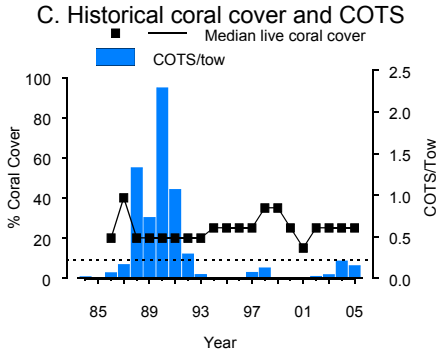
There were few consistent trends in reef fish abundance over the survey period. However, a large number of taxa tended to increase in abundance from around 2000. All species from family Scaridae, except *Scarus globiceps*, increased in abundance in 2005, driving the increasing trend for that family. All damselfish continued their upward trend in 2005, although these trends are mainly driven by one or two dominant species. Patterns in the genus *Pomacentrus* are driven by the abundant *P. lepidogenys* that recruited in high numbers in 1996. Changes in abundance of the genus *Chrysiptera* resulted from similar recruitment pulses for *C. rollandi* and *C. talboti*.

Figure 4.83

A

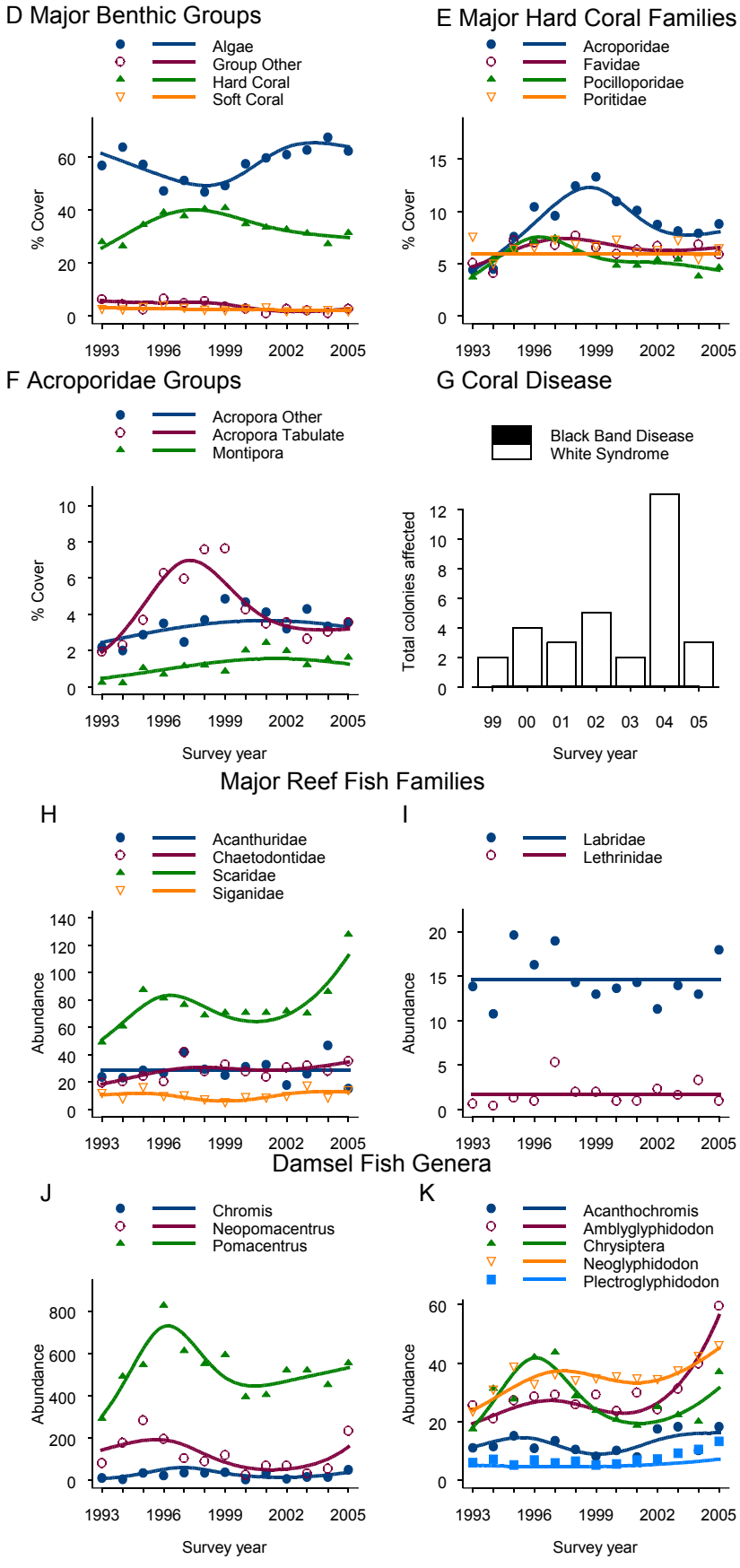






Davies (No. 18-096) is a middle shelf lagoonal reef with an area of 13.8 sq.km.

Figure 4.83 (Cont).



DIP

Surveyed May 2005.

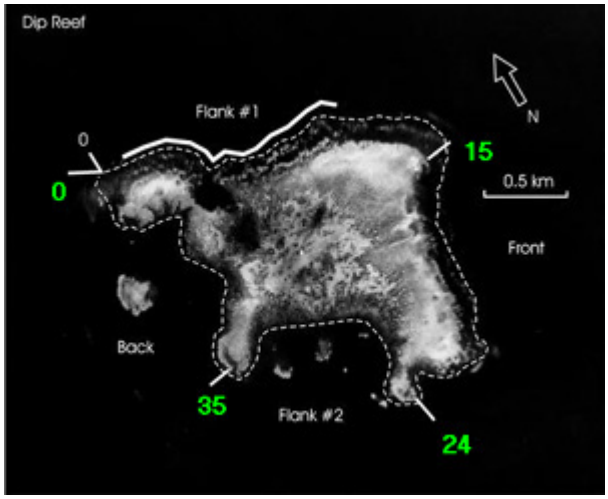
Dip Reef has been surveyed 15 times since 1984, when it was classified as No Outbreak. High COTS densities were seen in 1986 and the reef was classified as Active Outbreak. Dip Reef was reclassified as Recovering in 1988. Reef-wide live coral cover declined dramatically to a low (1-10%) level as a result of COTS activity between 1986 and 1988. From 1988 median reef-wide live coral cover recovered to moderate (10-30%) levels in 1993 that has persisted through to 2005. No COTS have been observed from 1986 to 2005 where Dip Reef was classified as Recovering. No bleaching was observed and white syndrome disease was restricted to a few scattered colonies on the northern flank during manta tow surveys in 2005.

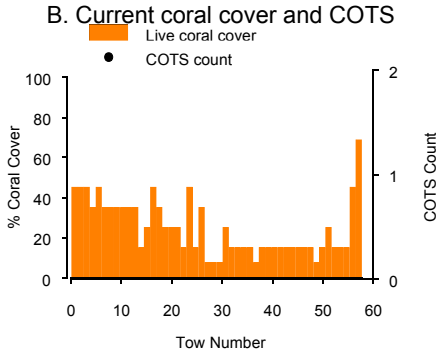
On the intensive survey sites the hard coral community has been relatively stable varying between 25% and 29% cover. The family Acroporidae included a relatively high cover of *Isopora* spp. The decrease in tabulate *Acropora* in 1997 and 2000 is likely to be due to Cyclones Justin and Tessi respectively. The soft coral and algal communities have also been stable over the survey period. Very low levels of white syndrome have been recorded since 1999. *Drupella* spp. were observed during SCUBA searches in 2005 at a density of 147/ha.

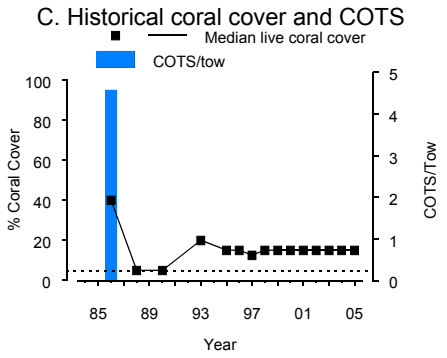
Most Acanthuridae continued the trend of 2004 by increasing in abundance in 2005. Abundance of Scaridae and Labridae has been variable in past surveys and this pattern was the case again in 2005. The abundance of both families has generally increased since 1998. Among damselfishes, most *Chromis* species deceased in abundance in 2005. Other genera maintained a generally stable trajectory in 2005.

Figure 4.84

A

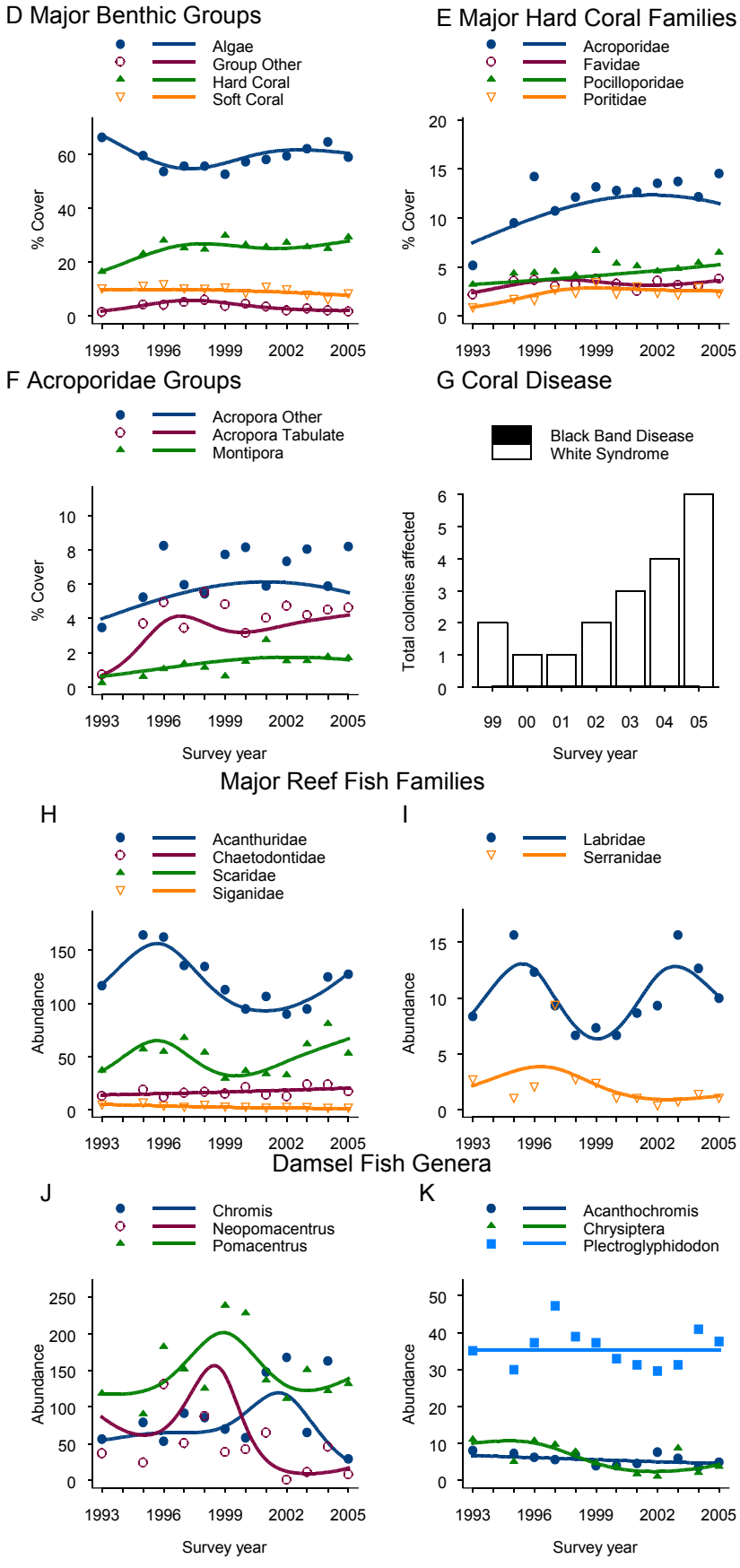






Dip (No. 18-039) is an outer shelf crescentic reef with an area of 5.6 sq.km.

Figure 4.84 (Cont).



HAVANNAH IS

Surveyed May 2005.

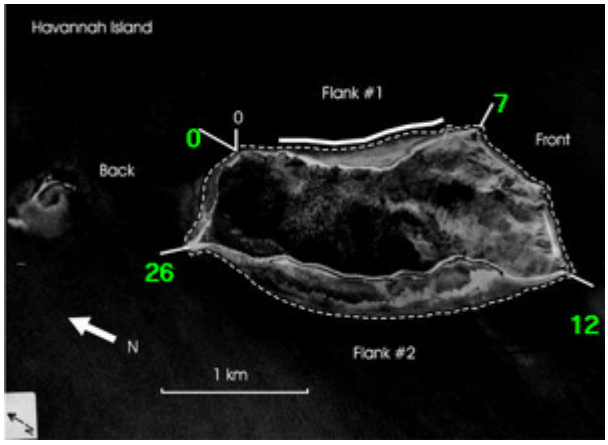
Havannah Island reef has been surveyed 11 times since 1987 with annual surveys since 1996. No surveys were conducted in 2004 due to poor visibility. Reef-wide live coral cover initially increased from moderate levels in 1987 to high levels by 1997. There was a sharp decrease in median reef-wide live coral cover due to extensive bleaching which was observed during the surveys in 1998. Reef-wide live coral cover continued to decline through to 1999. Surveys in 2003 indicated median reef-wide live coral cover remained very low (1-5%). Surveys in 2005 indicate the beginnings of a recovery in coral cover though it is still low (5-10%). No COTS have been recorded during any manta tow surveys and on Havannah Island reef is classified as No Outbreak. No bleaching or coral disease was observed during manta tow surveys in 2005.

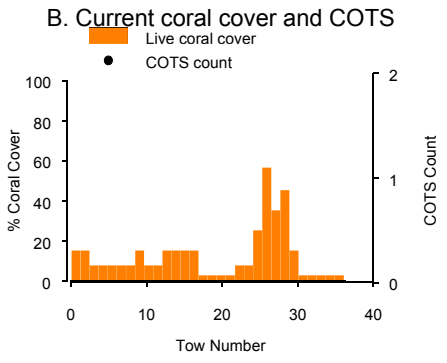
The intensive survey sites at Havannah Island Reef were established in 1997. Trends on the sites are similar to the those from reef-wide manta tow surveys. The cover of hard corals in 1997 was dominated by branching and bottlebrush corals of the genus *Acropora* (36% cover). By 1999, cover of *Acropora* spp. had declined to 16% as a result of bleaching mortality. Since 1999 other disturbances have contributed to the further decline in hard coral. In 2000 Cyclone Tessi passed close to the reef and in 2001 small COTS were found during SCUBA searches, though not in manta tows. Macro algae have increased in percent cover and was the dominant life form in 2005 at 49% cover. It is possible that the observed decline in soft corals since 1999 (mostly Briareum sp.) could be an artifact of the algal canopy reducing sampling efficiency from video tapes but bleaching mortality is also a likely explanation. No *Drupella* spp. were recorded in 2005 SCUBA search surveys. No white syndrome disease was observed in 2005.

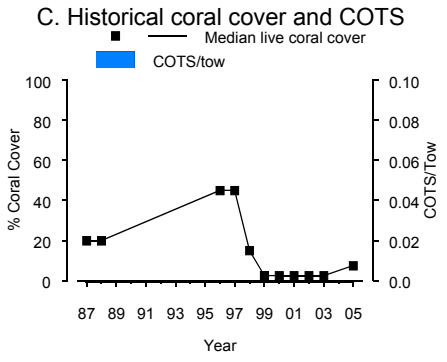
In 2005 the majority of large mobile fish species were stable or still declining following massive decreases in live coral cover. This was true of family Scaridae, in which the numerically dominant *Scarus rivulatus* showed little change from 2004 surveys. The Chaetodontidae continued their decline in abundance, although this trend is driven largely by a single species, *Chaetodon aureofasciatus*. The remaining large fish families showed little change in 2005. Damselfish genera increased in abundance in 2005, although again this was largely driven by a single numerically dominant species in each genus. Increases in number of *Neopomacentrus bankieri* were particularly dramatic, with numbers of this small planktivorous species reaching a survey maximum in 2005.

Figure 4.85

A

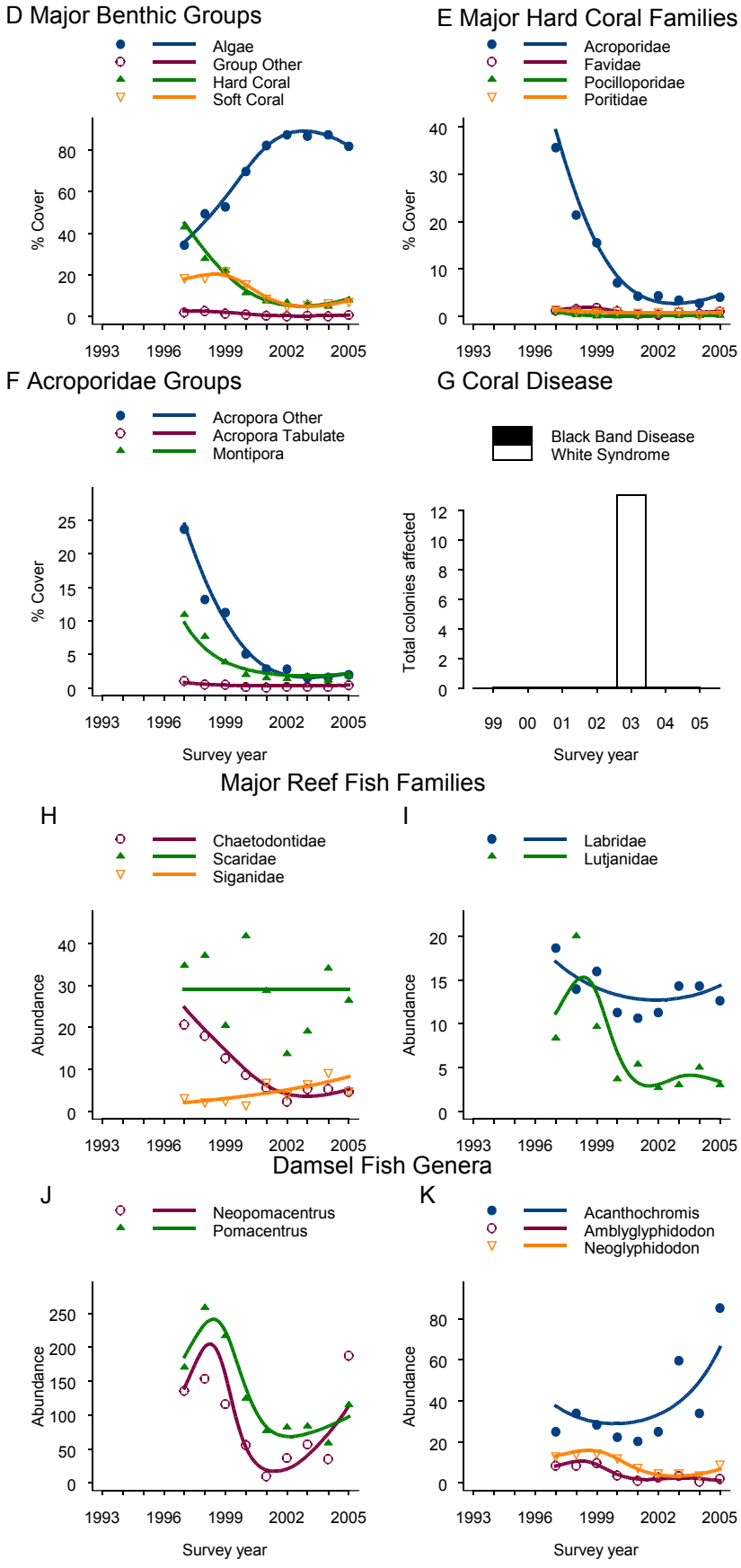






Havannah Is (No. 18-065) is an inner shelf fringing reef with an area of .3 sq.km.

Figure 4.85 (Cont).



JOHN BREWER

Surveyed April 2005.

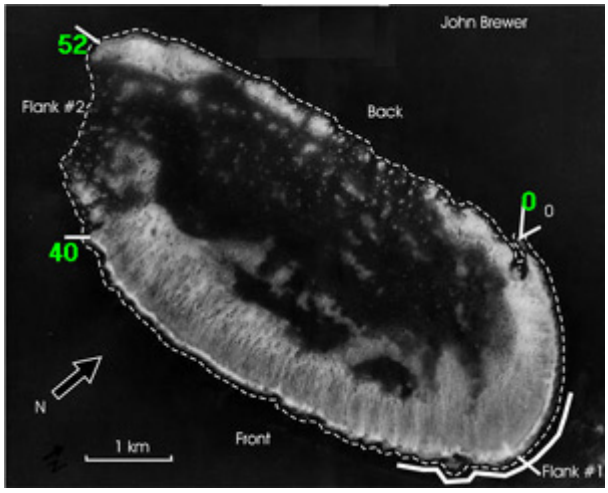
John Brewer Reef has been surveyed 17 times since 1984, when John Brewer Reef had extremely high COTS populations and the reef was classified as an Active Outbreak. COTS populations subsequently declined and in 1986 the reef was reclassified as Recovering. Median reef-wide live coral cover remained low (1-10%) through to 1990 before beginning to increase. Surveys in 1993 showed reef-wide live coral cover had increased to moderate (10-30%) levels and by 1998 reef-wide live coral cover was at high levels (30-50%). Surveys in 2001 recorded high COTS numbers and the reef was reclassified as Active Outbreak. COTS remained at outbreak levels through to 2003 and there was a corresponding drop in coral cover to a very low (1-5%) level where it has remained up until present. No COTS were observed during surveys in 2004 and the reef was reclassified as Recovering. John Brewer Reef remains classified as recovering in 2005. No coral bleaching or disease was recorded during surveys in 2005.

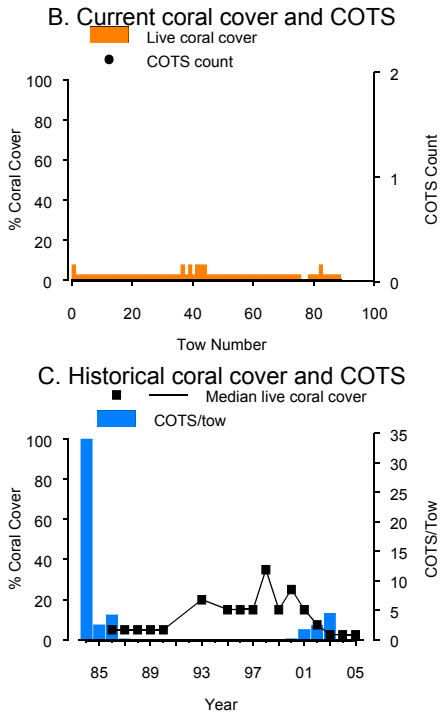
The benthic community at the intensive survey sites has experienced multiple disturbances over the survey period. In 1996 hard coral cover reached a maximum of 31%. Hard coral cover declined slightly in 1997 and this was attributed to the impact of Cyclone Justin on tabulate *Acropora* spp. A low level of coral bleaching was recorded in 1998 and 1999 on the transects but cover of hard corals did not decrease significantly over these years. By 2004 hard coral cover had declined dramatically to 0.6% as a result of crown-of-thorns feeding activity and in 2005 was 1.3%. The cover of soft corals has been gradually declining since 1998 and in 2005 was 2%. The algal community was dominated by turf algae (88%). In 2003, 153 adult COTS were observed during SCUBA searches, giving an estmated density of 1020/ha. This is the highest density of COTS ever recorded during routine SCUBA searches on any of the AIMS survey reefs. No COTS were observed in 2004 or 2005, in SCUBA searches or manta tow surveys. No *Drupella* spp. or white syndrome disease were observed in 2005.

The decline in coral cover since 1999 has not been reflected in the general fish community and although inter-annual variation in abundance was often high, numbers of many taxa have remained relatively stable over the survey period. In 2005 a number of coral-associated butterfly fish (Chaetodontidae) had recovered slightly after decreasing in abundance since 1999. While the abundance of families Acanthuridae, Labridae and several damselfish genera declined through to 2001, these taxa and the Scaridae then generally increased in abundance in 2005. The species that increased in abundance are not strongly associated with living coral. Numbers of the coral-dependent *Pomacentrus moluccensis* recovered slightly in 2005 from an 11 year low in 2004. Numbers of coral-living *Chromis* species declined with coral cover and were very low in 2005.

Figure 4.86

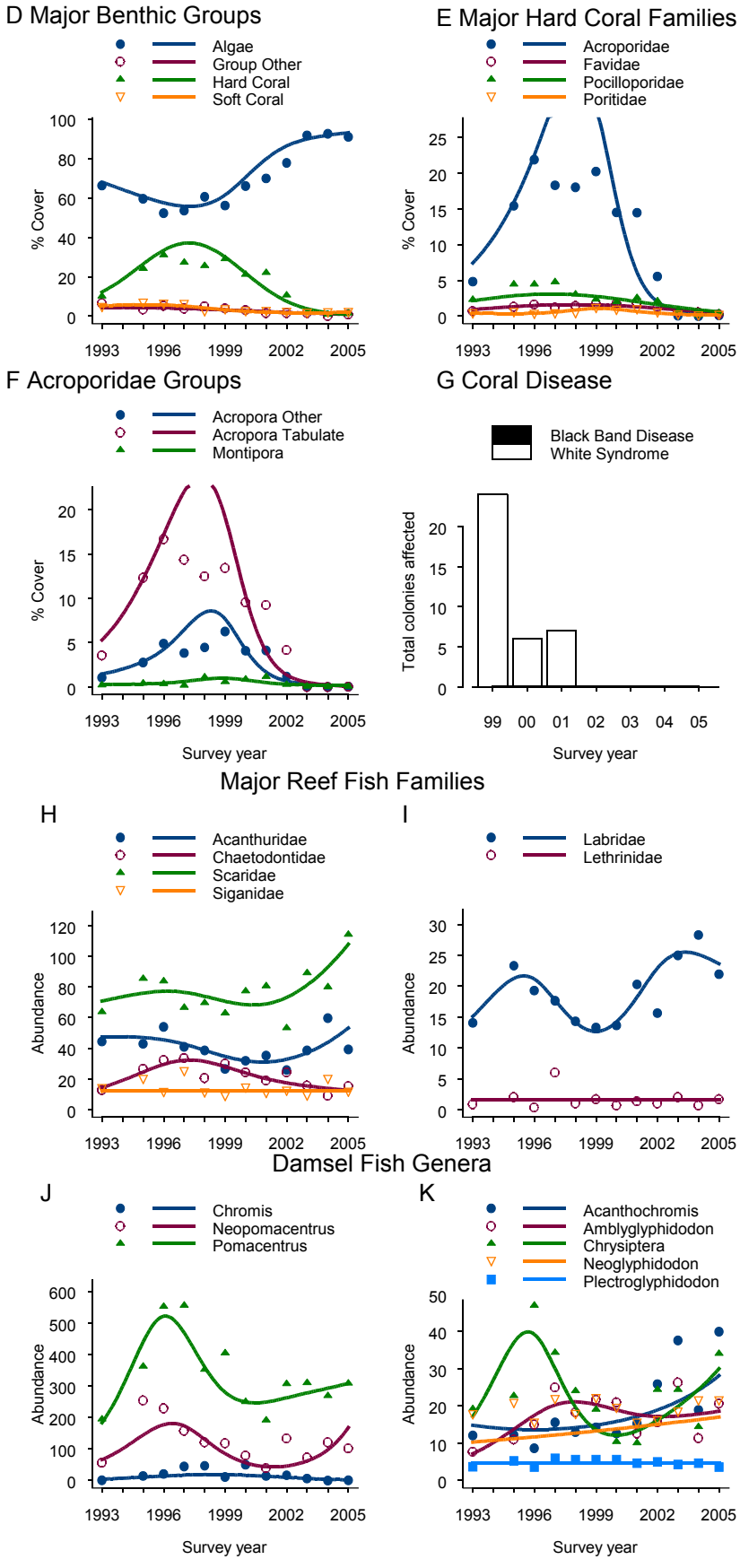
A





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

Figure 4.86 (Cont).



MIDDLE

Surveyed September 2005.

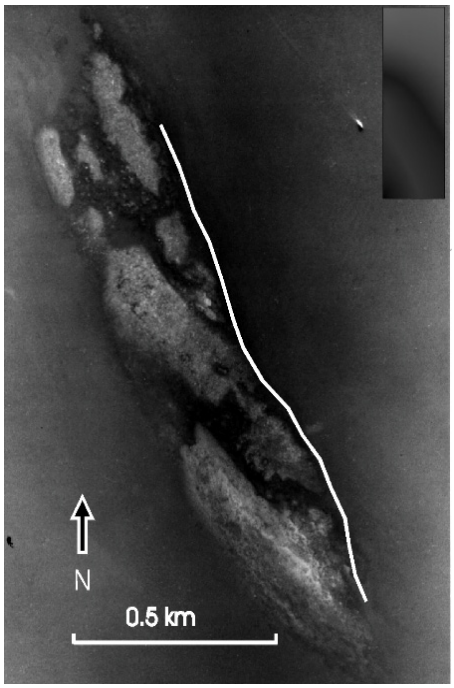
Manta tow surveys are not conducted on this reef due to poor underwater visibility.

Estimates of hard coral cover from the intensive survey sites at Middle Reef in 2005 reveal that cover was 40%, an increase of 10% since 2004. Widespread bleaching of hard and soft corals was observed in 1998 and 2002. This was associated with a decline in soft coral cover (from a maximum of 21% to 4% in 2005) with there being little evidence of recovery up to 2005. Bleaching affected cover of most hard coral families but to a lesser extent than that seen in soft corals. The cover of hard corals appeared to have recovered from both bleaching events. Hard corals were dominated by *Goniopora* spp. and *Montipora* spp. In 2005, divers noted several small *Turbinaria* spp. juveniles. There were no corallivorous snails *Drupella* spp, or incidents of coral disease recoded in the 2005 scuba search surveys.

Surveys of large, mobile reef fish species are not conducted on this reef as visibility is typically too low. The damselfish fauna is dominated by just three species, *Pomacentrus wardi*, *Neopomacentrus bankieri* and *Acanthochromis polyacanthus*. Populations of these fishes have been variable over the period of survey and suggest recruitment to this reef is sporadic.

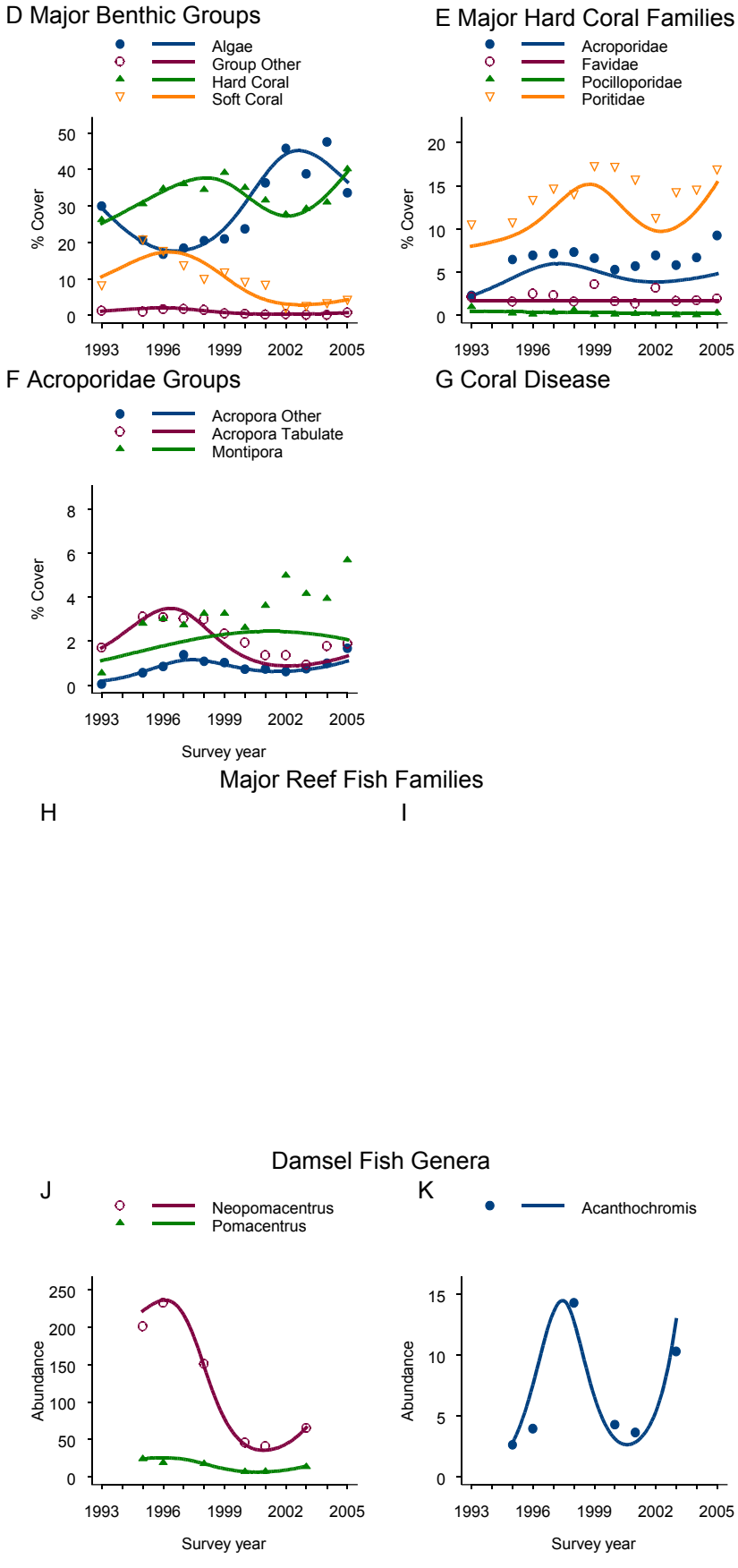
A

Figure 4.87



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

Figure 4.87 (Cont).



MYRMIDON

Surveyed May 2005.

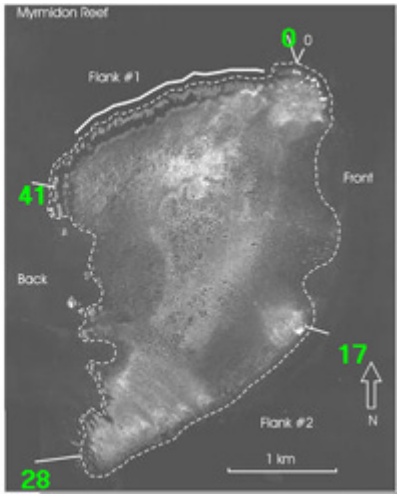
Myrmidon Reef has been surveyed 17 times since 1988. Median reef-wide live coral cover has remained at moderate levels (10-30%) during the survey period. COTS have only been observed once and in numbers too low to cause significant coral mortality. Surveys in 2005 indicate reef-wide live coral cover remains moderate though does show the sign of some increase compared to previous years. Myrmidon Reef remains classified as No Outbreak in 2005. No coral bleaching was observed. White syndrome and black band disease were restricted to a few scattered coral colonies on the back and north flank of Myrmidon Reef in 2005.

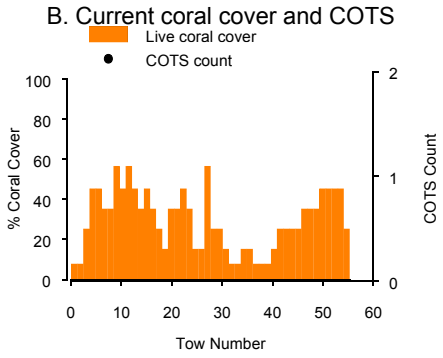
Hard coral cover in the intensive survey sites increased up until 1999, reaching a maximum of 39%. It then decreased, probably because of Cyclone Tessi in April 2000 and bleaching in 2002. In 2005 hard coral cover was 29% and increasing. It is clear that the most recent declines in the Acroporidae and Faviidae were due to bleaching. The recent declines in soft coral abundance are probably also the result of bleaching. *Drupella* spp. were observed at 480/ha in SCUBA searches in 2005. No white syndrome disease was observed in 2005.

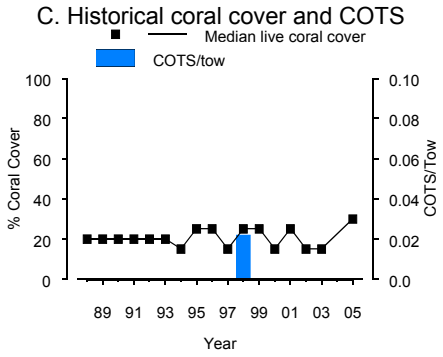
Abundances of most taxa of large reef fishes have varied but have generally increased over the period of survey. Numbers of Scaridae and Acanthuridae continued to increase in 2005, although the increase in Acanthuridae was largely due to a single species, *Acanthurus nigrofuscus*. Other large fish families showed little change from 2004 to 2005. The damselfishes have also generally increased over the survey period. Numbers have been stable since 2003.

Figure 4.88

A

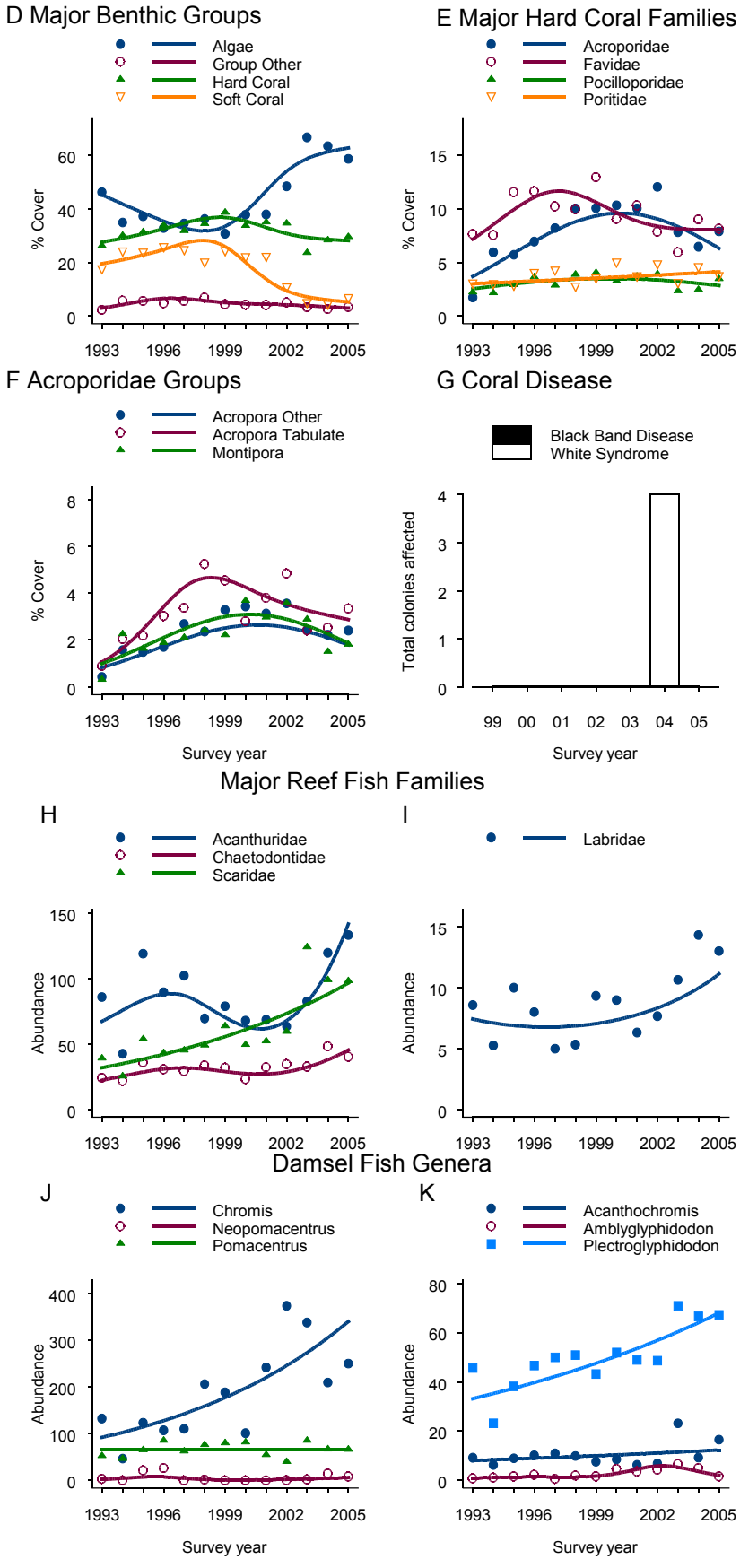






Myrmidon (No. 18-034) is an outer shelf planar reef with an area of 6.2 sq.km.

Figure 4.88 (Cont).



PANDORA

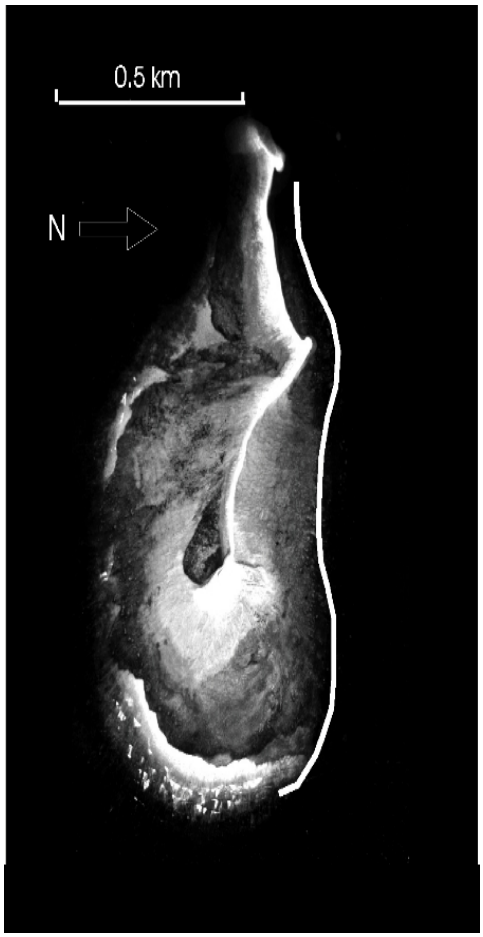
Surveyed May 2005.

Manta tow surveys are no longer conducted on Pandora Reef due to persistent low visibility.

Between 1993 and 1997 cover of hard coral increased on the intensive survey sites by approximately 11% to a maximum cover of 58% in 1997. Moderate bleaching had affected all abundant hard and soft coral families during the surveys in January 1998. Following these surveys the Townsville region experienced a major flood event and approximately four weeks after these floods, around 80% of the corals on Pandora Reef were bleached to a depth of around 10 metres (Devantier, Fabricius unpublished). Bleaching mortality reduced coral cover to 46% in 1999 with Acroporidae being most affected. There have been further small declines in hard coral since, possibly due to the impact of Cyclone Tessi in 2000, with foliose corals *Echinopora* spp. and *Turbinaria* spp. being the most affected. Porites spp increased, reaching 7% in 2005. Soft coral was also affected by bleaching in 1998 and was 13% in 2005, The dominant algal lifeform is turf algae with macroalgae averaging around 10% since 2003. No *Drupella* spp. were recorded in 2005 SCUBA search surveys. No white syndrome disease was observed in 2005.

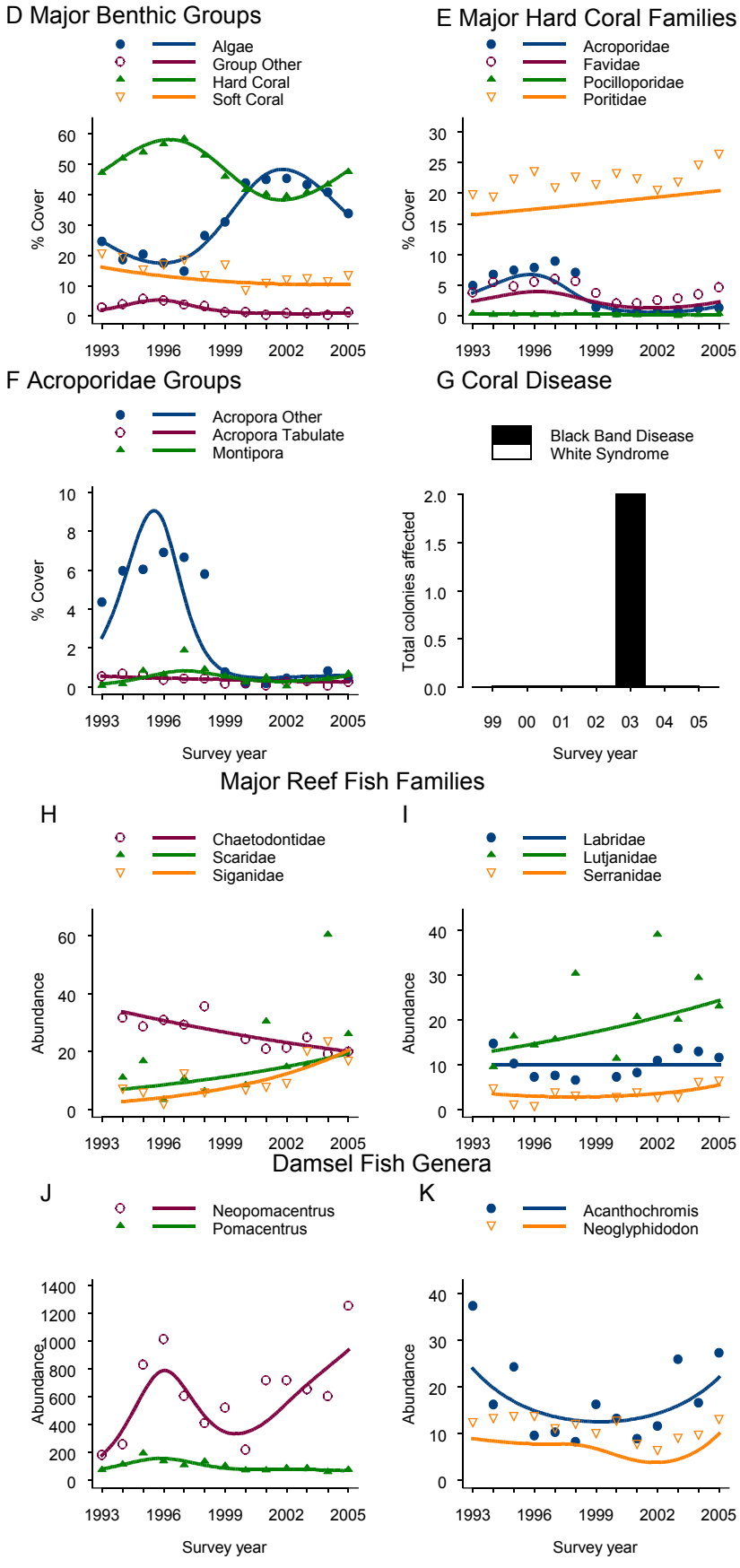
Most large fish families showed little change in abundance in 2005, although one parrotfish species, *Scarus rivulatus*, declined by about half. Siganidae have generally incraesed over the past seven years. 2005 saw a dramatic increase in abundance of a planktivorous damselfish, *Neopomacentrus bankieri*. Other damselfish genera displayed more modest increases in abundance between 2004 and 2005.

Figure 4.89 A



Pandora (No. 18-051) is an inner shelf planar reef with an area of .6 sq.km.

Figure 4.89 (Cont).



RIB

Surveyed May 2005.

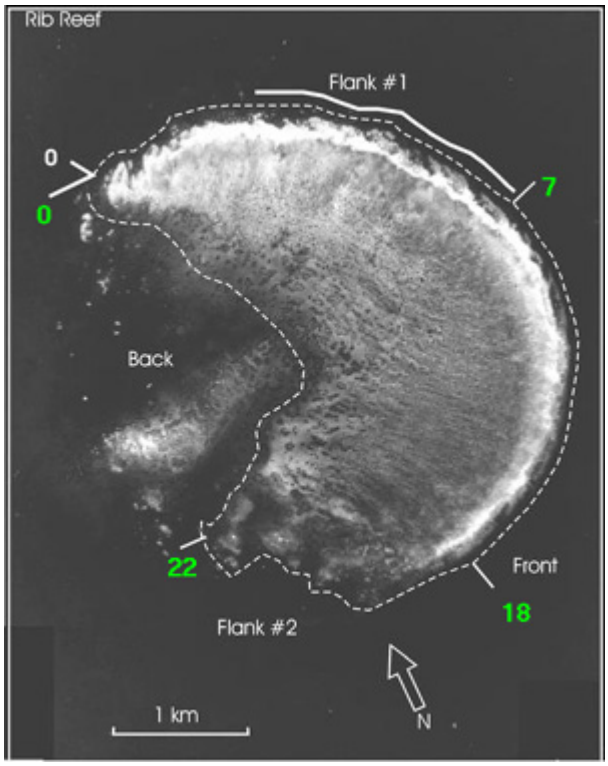
Rib Reef has been surveyed 16 times since 1987. A residual COTS population and large areas of old dead coral indicated that Rib Reef had previously been subject to high COTS populations. No COTS were observed in 1988 and the reef was classified as Recovering. Between 1990 and 1994, in the absence of COTS activity, median reef-wide live coral cover increased markedly from low to high levels (40-50%). Cover remained high through to 1998. In 1999 large numbers of COTS were observed and the reef was reclassified as Active Outbreak. Annual surveys through to 2003 showed that COTS numbers remained at Active Outbreak levels with a corresponding drop in reef-wide live coral cover to a very low (1-5%) level. Surveys in 2004 indicate COTS were no longer at outbreak levels and the reef was reclassified as Recovering. For the first time since 1999, surveys in 2005 recorded no COTS. They showed reef-wide live coral cover remains low (5-10%) which remains classified as Recovering. No bleaching or disease was recorded during manta tow surveys in 2005.

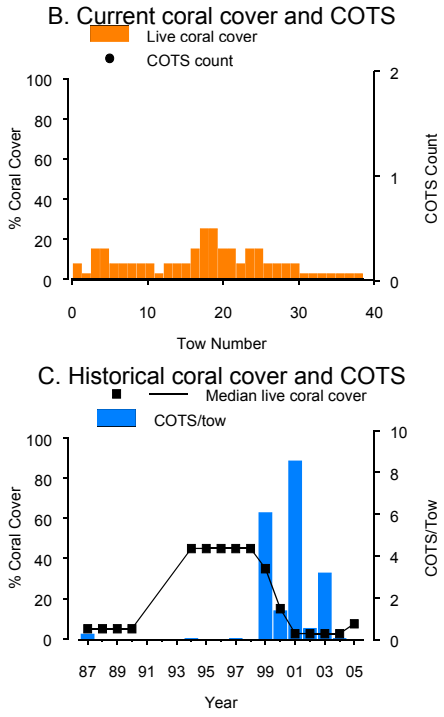
The intensive survey sites were established in 1994 and show that coral cover reached a maximum of 66% in 1996. A decrease in cover of hard coral in 1997 was attributed to the impact of Cyclone Justin on tabulate *Acropora* spp. Declines since 1999 can be attributed to crown-of-thorns feeding activity. Rib Reef has had a history of COTS (especially between 1999 and 2003), but no COTS were observed during the SCUBA search surveys in 2004 or 2005. Hard coral cover in 2005 was 5.1%, a small increase from the previous year. Following Cyclone Justin, cover of soft corals declined to approximately half their original levels. In 2005 soft coral was 8%, the highest level recorded to date. 95% of the algal community in 2004 was turf algae. *Drupella* spp. have been recorded at densities of up to 1127/ha. on Rib Reef (in 1999) but in 2005 SCUBA surveys found a density of only 127/ha. As *Drupella* spp. are corallivores it is not surprising that the very low coral cover observed in 2004 did not support a large population. No white syndrome disease was recorded in 2005.

Most large fish families showed little change in abundance in 2005. Numbers of family Chaetodontidae were at a survey minimum and Scaridae abundance remained around a survey maximum, possibly reflecting differing reactions to large coral cover declines during the survey period. Of the damselfishes, *Neoglyphidodon nigroris* continued to increase in abundance in 2005, a trend that began in 2000. Other damselfish genera also tended to increase in abundance between 2004 and 2005. However, *Chromis* numbers were still very low in 2005, reflecting the lack of recovery of their preferred coral habitat.

Figure 4.90

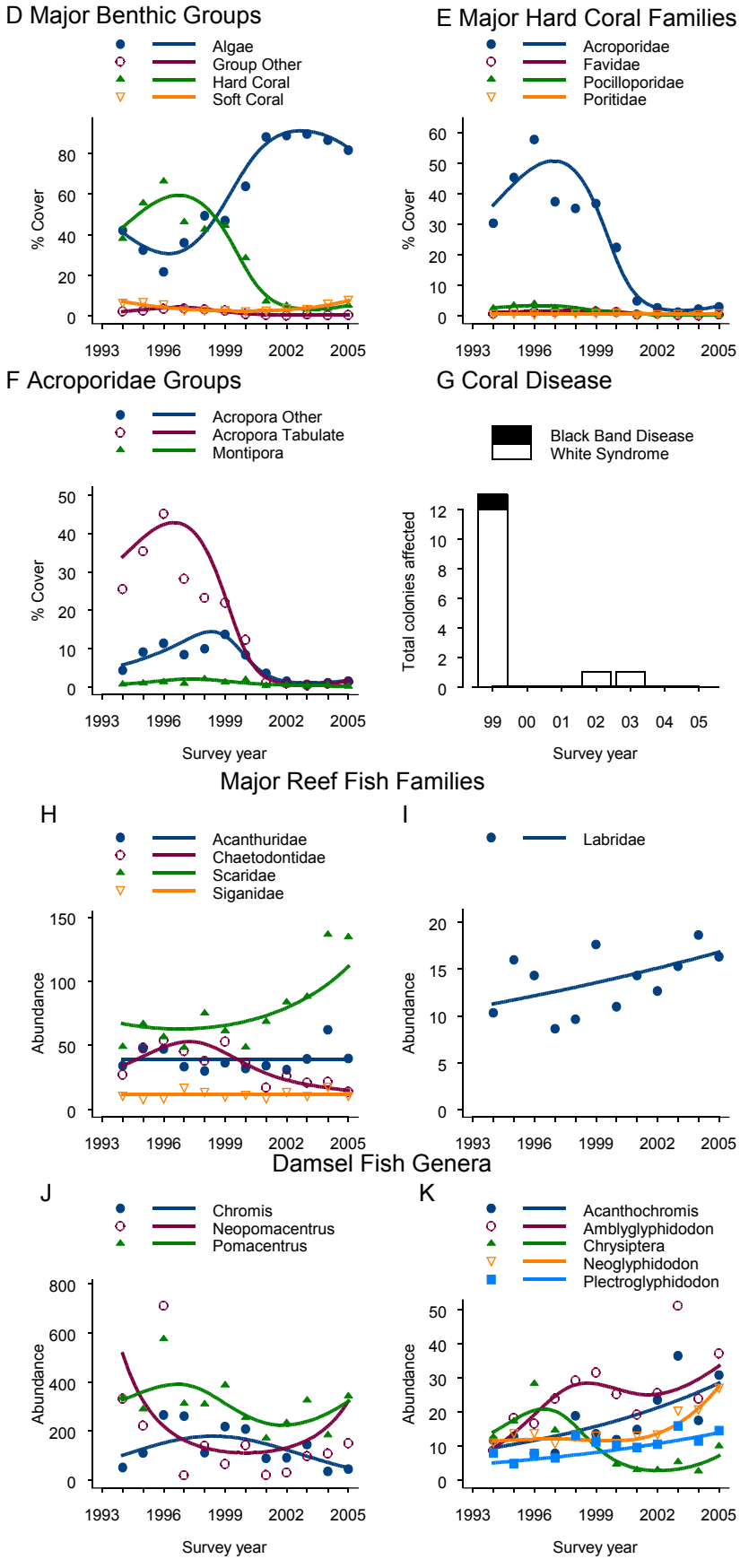
A





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

Figure 4.90 (Cont).



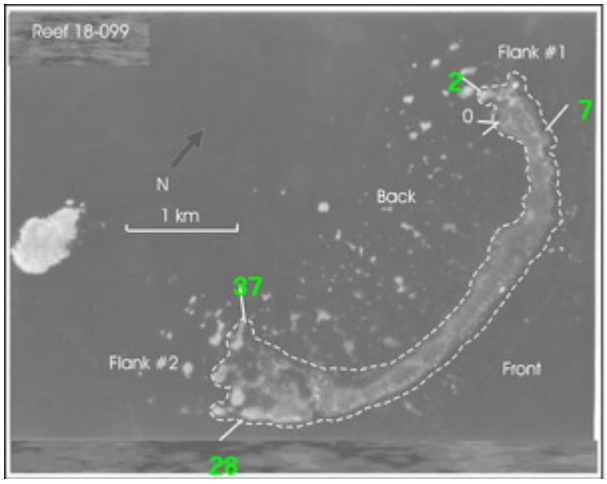
18-099

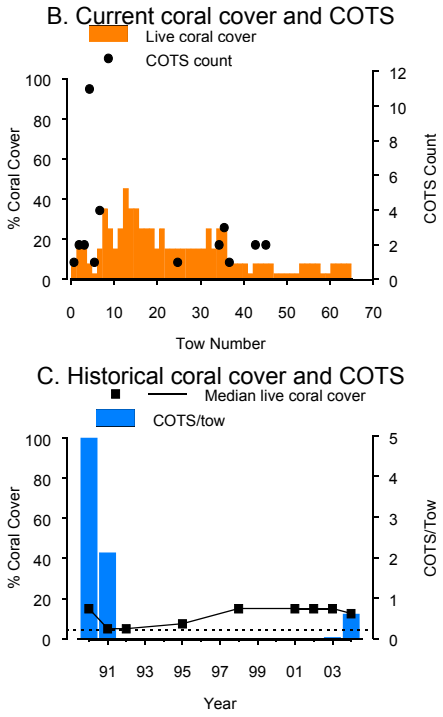
Surveyed May 2004.

Reef 18099 has been surveyed nine times since 1990. COTS numbers were high and reef-wide live coral cover was low in 1990 and the reef was classified as an Active Outbreak. No COTS were seen in 1992 and it was reclassified as Recovering. There was then a slow but steady increase in reef-wide live coral cover to a moderate (10-20%) level by 1998. Small numbers of COTS were recorded in 2003 and COTS activity increased in 2004. The reef was reclassified as Incipient Outbreak in 2004. Coral cover remained moderate (10-20%) . Surveys in 2004 found a high level of bleaching (30-50% of all hard corals) on the second flank. White syndrome was restricted to a few scattered colonies.

Figure 4.91

A





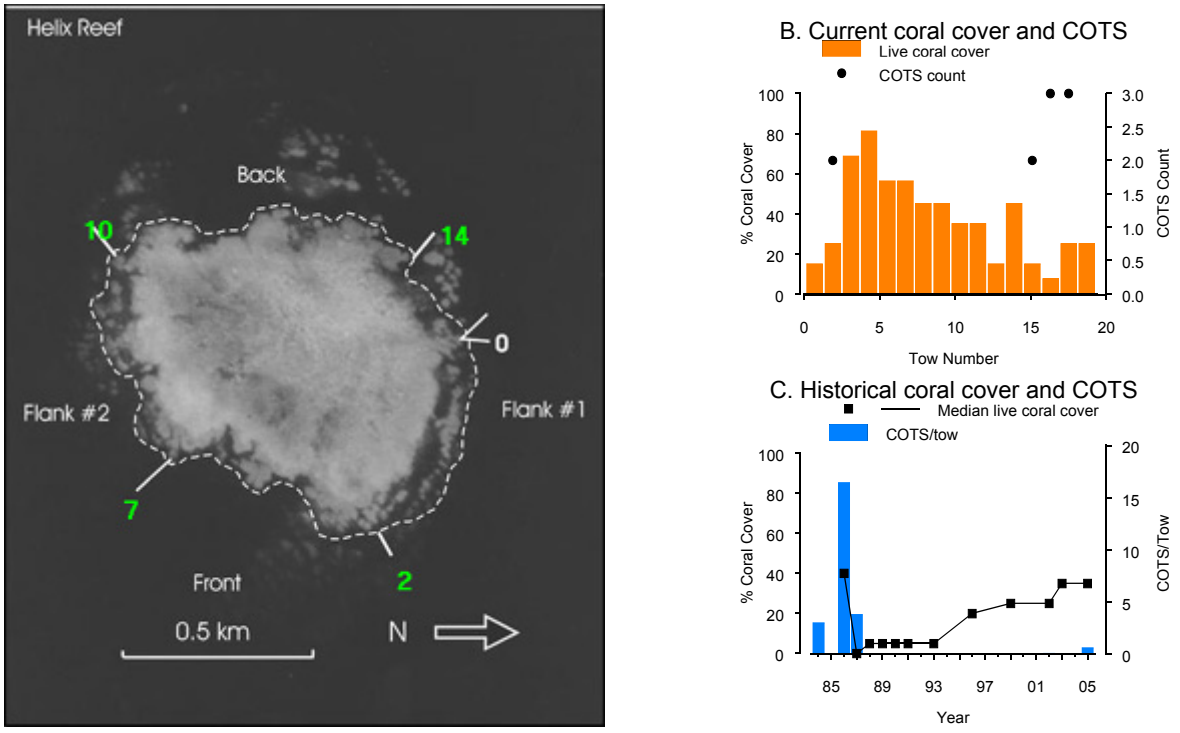
18099 (No. 18-099) is a middle shelf crescentic reef with an area of 12.5 sq.km.

HELIX

Surveyed May 2005.

Helix Reef has been surveyed 13 times since 1984, when it was classified as an Active Outbreak. Reef-wide live coral cover was initially high (30-50%) before rapidly declining to an extremely low level (0%) by 1997 due to intense COTS activity. Helix reef was reclassified as Recovering in 1998 and median reef-wide live coral increased (particularly in recent years) to a high level (30-50%) by 2003. Surveys in 2005 show that COTS activity has increased and it has been reclassified as Incipient Outbreak. Recent increases in coral cover have now come to a halt and cover may decline in future. No bleaching was observed and white syndrome disease and black band disease were observed on a few scattered coral colonies around most of the reef perimeter during surveys in 2005. White syndrome was common on the southern flank.

Figure 4.92



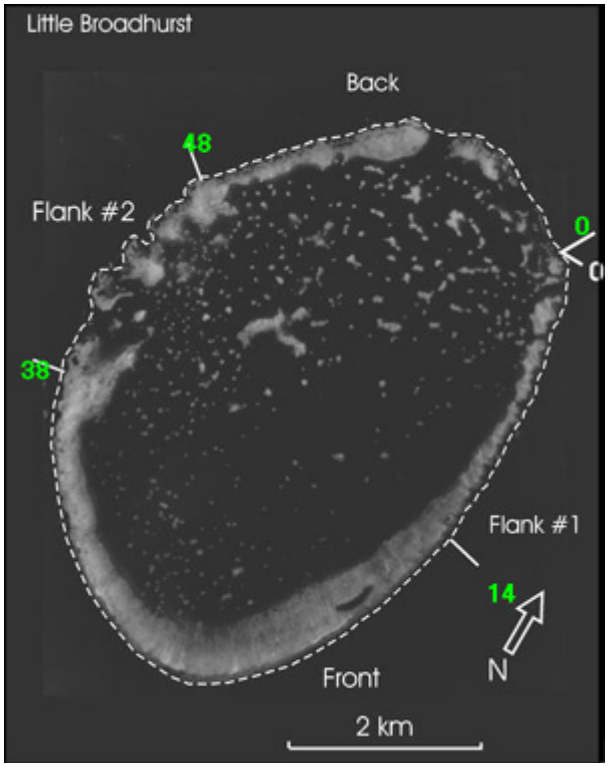
Helix (No. 18-076) is a middle shelf patch reef with an area of .6 sq.km.

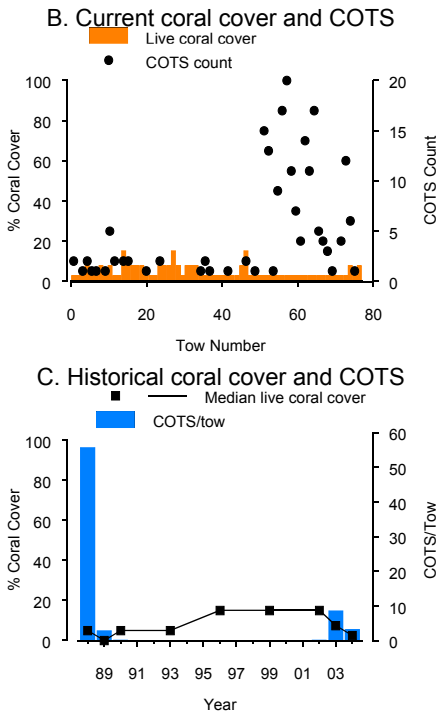
LITTLE BROADHURST

Surveyed May 2004.

Little Broadhurst reef has been surveyed 9 times since 1988. Reef-wide live coral cover was low (1-10%) in early surveys, COTS were extremely abundant and the reef was classified as Active Outbreak. By 1990 COTS densities had dropped dramatically and Little Broadhurst was considered to be Recovering. Reef-wide live coral cover increased and was at moderate (10-30%) levels from 1996 to 2002. COTS numbers increased in 2003 and the reef was reclassified to Active Outbreak. Surveys in 2004 show COTS remain at outbreak levels on this reef. With the increase in COTS activity there was a decline in reef-wide live coral cover to the current low levels (1-5%). White syndrome disease and coral bleaching affected a few scattered coral colonies during surveys in 2004.

Figure 4.93 A





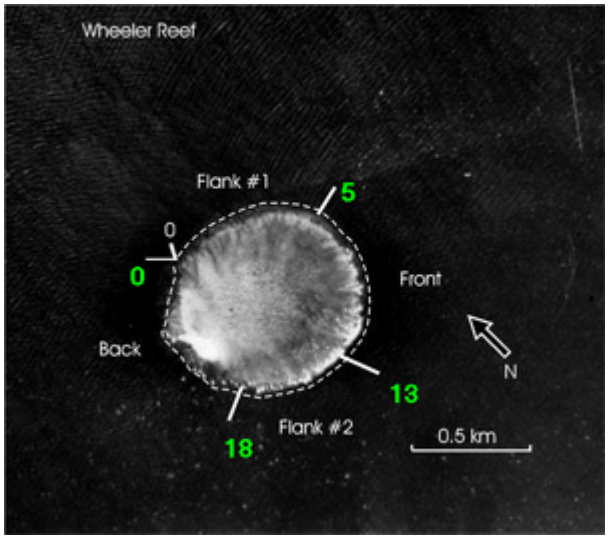
Little Broadhurst (No. 18-106) is a middle shelf lagoonal reef with an area of 12.5 sq.km.

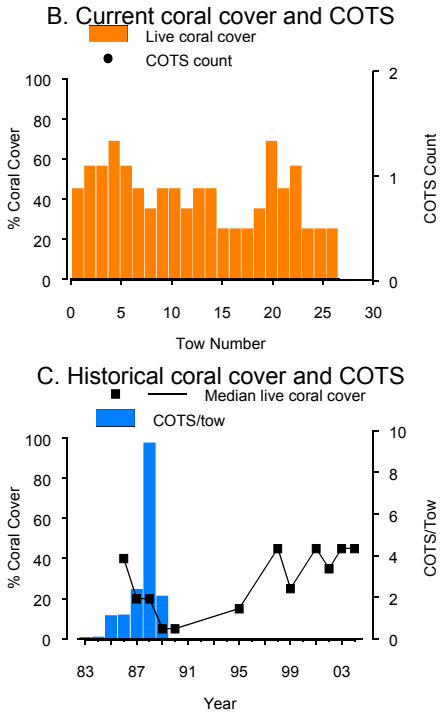
WHEELER

Surveyed May 2004.

Wheeler reef has been surveyed 12 times since 1983, when it was classified as No Outbreak. Active Outbreak levels of COTS were first observed in 1985 and remained through to 1989, with a peak in 1988. No COTS have been observed from 1990 to 2004 and the reef was reclassified as Recovering in 1991. Reef-wide live coral cover dropped from a high level (30-50%) in 1986 to a low level (1-10%) in 1988. In 2004, it had recovered to the high levels (30-50%) that were recorded before outbreaks in the early 1980's. Coral bleaching, white syndrome and black band disease affected a few scattered coral colonies during surveys in 2004.

Figure 4.94 A





Wheeler (No. 18-095) is a middle shelf planar reef with an area of 1.9 sq.km.

Cape Upstart

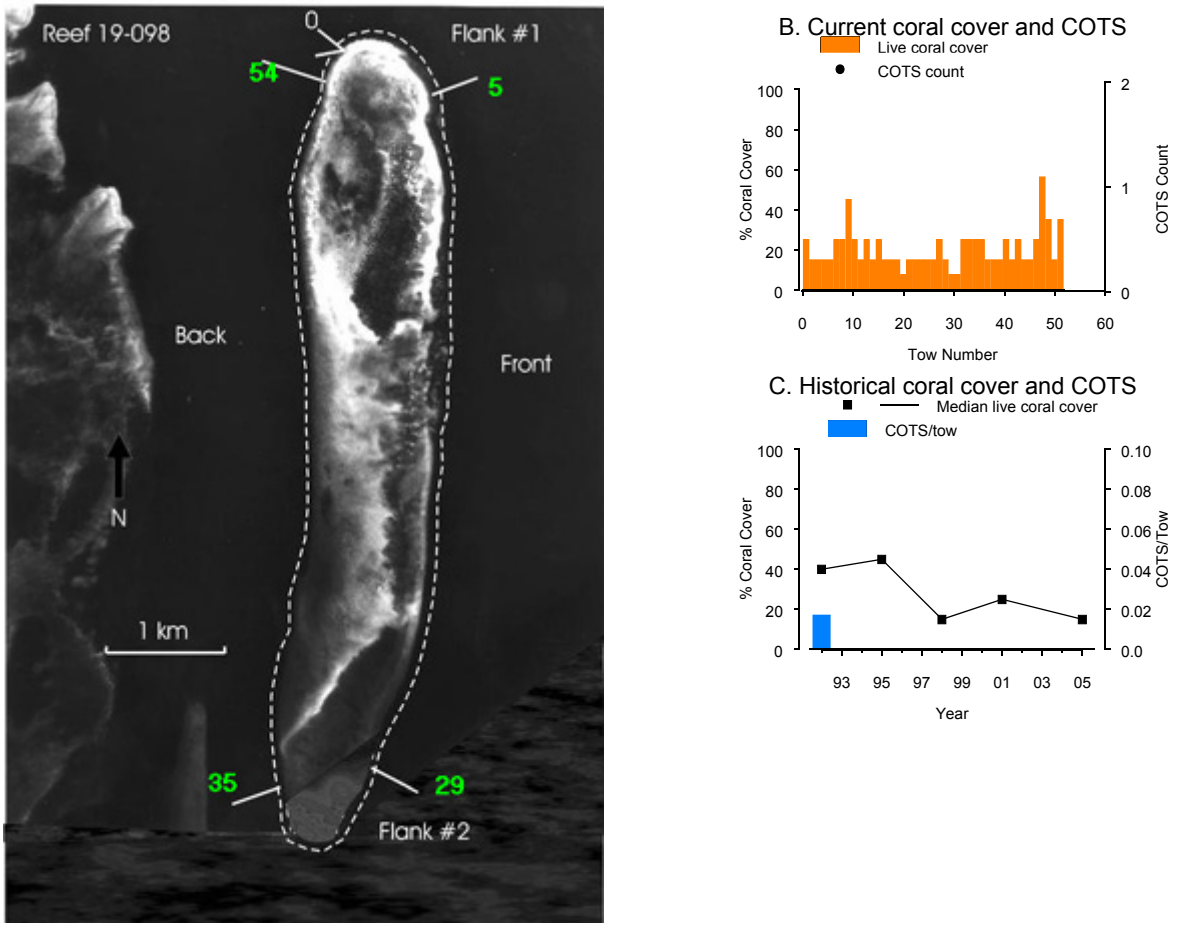
Reef Pages

19-098

Surveyed March 2005.

Reef 19-098 has been surveyed five times since 1992. Although COTS were observed in the initial year of survey, the numbers were too low to cause a significant reduction in reef-wide live coral cover. Coral cover remained high (30-50%) on this reef from 1992 through to 1995 then dropped to a moderate level (20-30%) in 1998. This was probably due to the effects of Cyclone Justin which influenced reefs in this area in March 1997. A small increase in reef wide coral cover in 2001 did not continue into the 2005 survey and reef-wide live coral cover remains moderate. The reef is classified as No Outbreak. No bleaching was observed during surveys in 2005 and black band disease and white syndrome disease was restricted to small numbers of scattered coral colonies on the back and front reef.

Figure 4.95



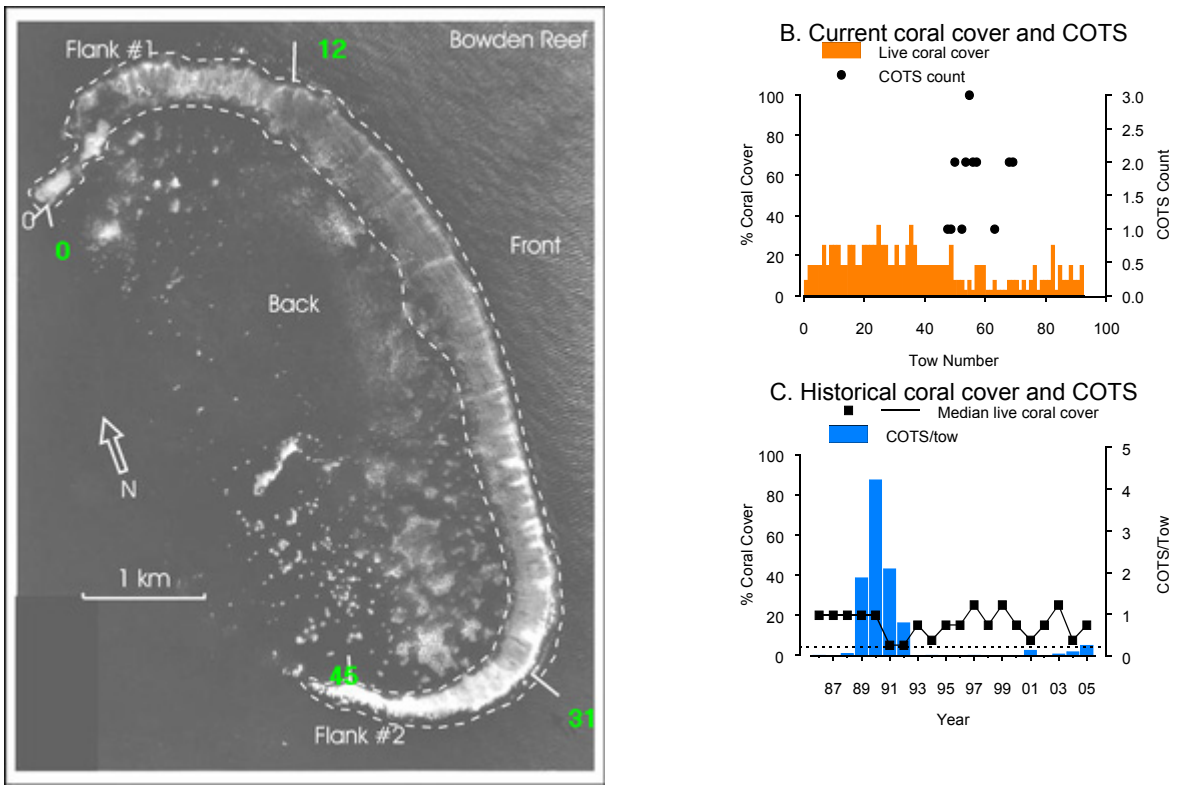
19098 (No. 19-098) is a middle shelf lagoonal reef with an area of 5 sq.km.

BOWDEN

Surveyed March 2005.

Bowden Reef has been surveyed 20 times since 1986. A major outbreak of COTS between 1989 and 1992 resulted in a sharp decline in reef-wide live coral cover from a moderate (10-30%) to a low level (1-10%). From 1993, COTS numbers were very low and reef-wide live coral cover slowly increased. COTS were present in 2001, 2003 and 2004 but at densities below outbreak levels. Manta tow surveys in 2005 recorded moderate reef-wide live coral cover (10-20%) and the highest level of COTS since the end of the previous outbreak in 1992. COTS were in numbers that may be expected to cause some loss in coral cover. Bowden Reef has been reclassified as an Incipient Outbreak. No coral bleaching was recorded and white syndrome disease and black band disease were observed on a few scattered coral colonies on the back reef/north flank and southern flank respectively.

Figure 4.96 A



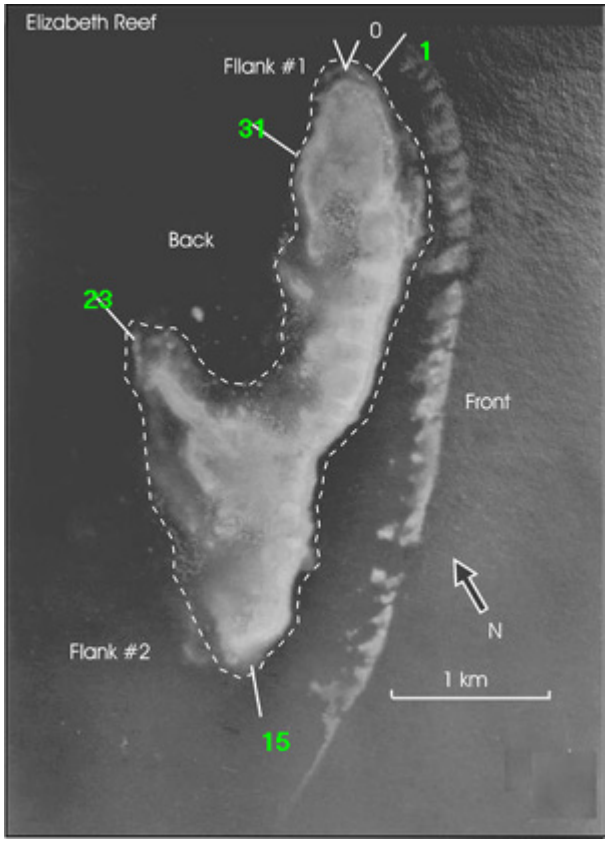
Bowden (No. 19-019) is a middle shelf crescentic reef with an area of 9.4 sq.km.

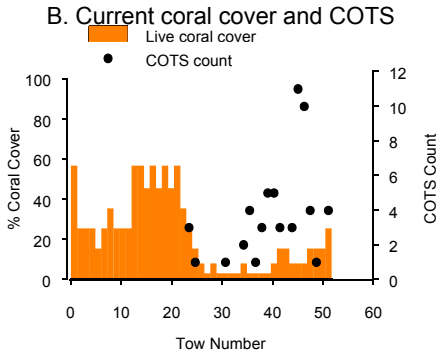
ELIZABETH

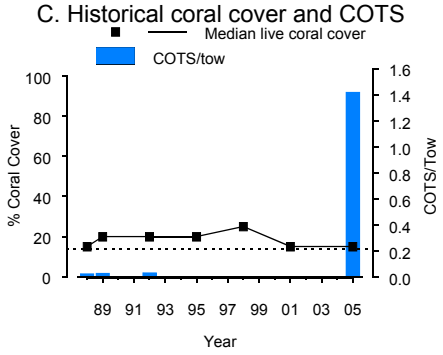
Surveyed March 2005.

Elizabeth Reef has been surveyed seven times since 1988. Although COTS were observed in the initial years of survey they were in numbers not considered large enough to impact on reef-wide live coral cover. Coral cover has generally remained at a moderate level (20-30%) on this reef over the period of survey. Surveys in 2005 show a dramatic increase in COTS activity on this reef which has been reclassified as an Active Outbreak. Reef-wide live coral cover remains moderate (20-30%) but given the level of COTS activity will almost certainly decline in coming years. No bleaching was observed and white syndrome disease was restricted to a small number of scattered coral colonies on the front reef during surveys in 2005.

Figure 4.97 A







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

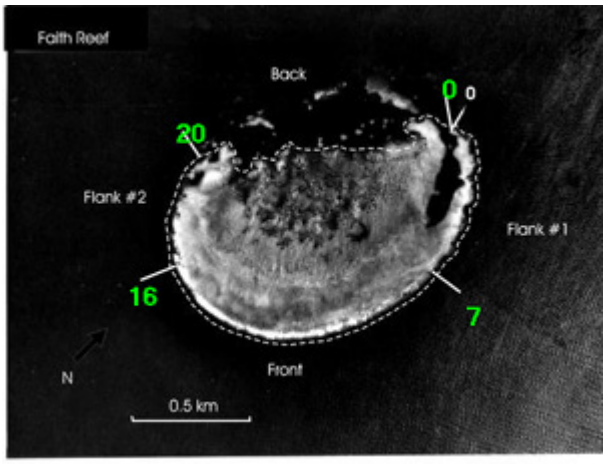
FAITH

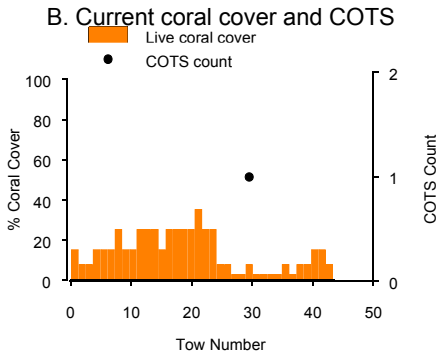
Surveyed May 2005.

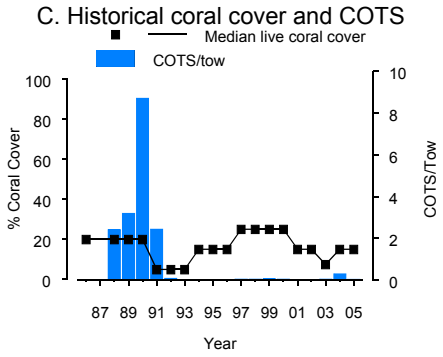
Faith Reef has been surveyed 19 times since 1986. Reef-wide live coral cover was moderate (10-30%) until 1990 when an outbreaking population of COTS reduced coral cover to below 10%. Reef-wide live coral cover had recovered to former levels by 1997 and the reef was reclassified as No Outbreak. Reef-wide live coral cover then declined to a low level (1-10%) in 2003 for unknown reasons. COTS have been observed in 6 of the past 8 survey years though numbers were too low to affect reef-wide live coral cover until recently. Low levels of COTS activity and bleaching events in 1998 and 2002 may have contributed to the observed decline in reef-wide live coral cover. Surveys in 2004 found that COTS numbers had increased and Faith Reef was reclassified as an Incipient Outbreak. Only small numbers of COTS were observed during surveys in 2005 and the reef has been reclassified as No Outbreak. Reef-wide live coral cover remains moderate (10-20%). No bleaching and low levels of white syndrome disease restricted to small numbers of individual coral colonies around the reef perimeter were observed during surveys in 2005.

Figure 4.98

A







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

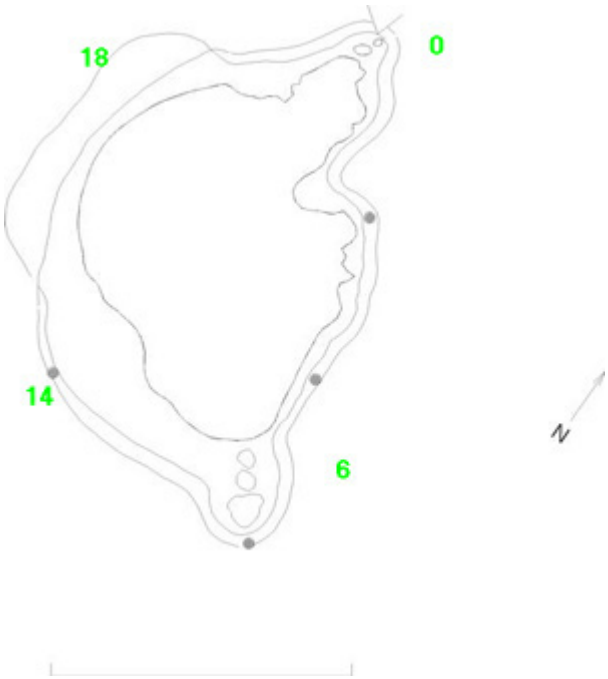
HOLBOURNE IS

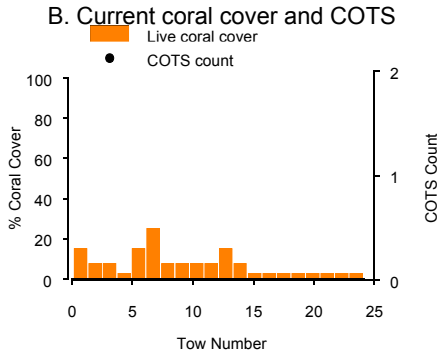
Surveyed November 2003.

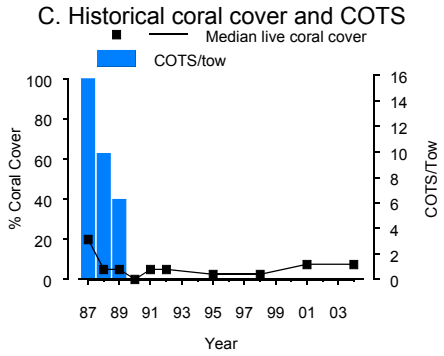
Holbourne Island reef has been surveyed 10 times since 1987. Reef-wide live coral cover was moderate (20-30%) in initial surveys but outbreak densities of COTS were present. COTS populations and coral cover subsequently declined. Coral cover has remained low (1-10%) and has shown little sign of recovery since. The reef was classified as Recovering in 2004. No bleaching was observed and white syndrome was restricted to a few individual coral colonies.

Figure 4.99

A







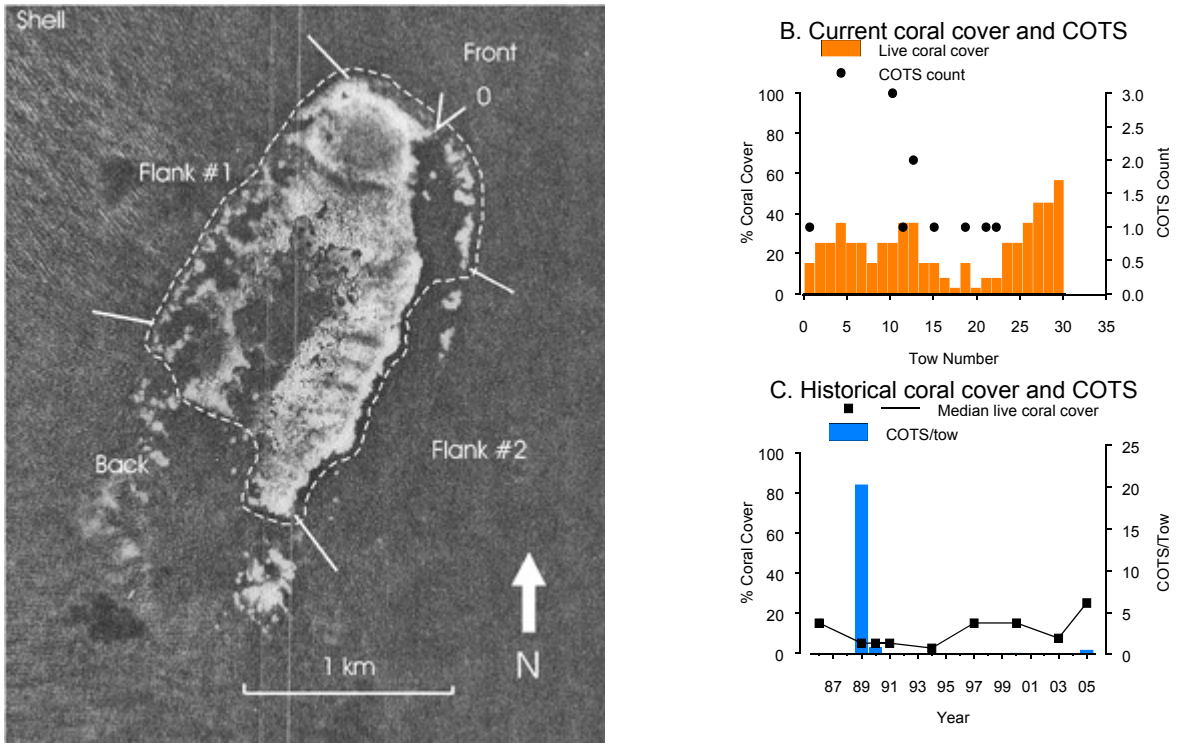
Holbourne Is (No. 19-103) is an inner shelf fringing reef with an area of 1.2 sq.km.

SHELL

Surveyed May 2005.

Shell Reef has been surveyed nine times by manta tow since 1986. Initially reef-wide live coral cover was moderate (10-30%) but dropped to a low level (0-10%) in 1990 following a COTS outbreak in 1989 and 1990. Shell Reef was classified as Recovering in 1991. From 1994, reef-wide live coral cover slowly increased to a moderate level in 1997 but had decreased in 2000 and 2003. COTS had been seen in the last two surveys but in numbers too few to affect reef-wide live coral cover. The reason for the decrease in reef-wide live coral cover is unknown. Surveys in 2005 indicate an increase in COTS activity and Shell Reef has been reclassified as Incipient Outbreak. Despite increased COTS activity, reef-wide coral cover is higher than hat seen in previous years and is currently moderate (20-30%). No bleaching was observed in 2005 and white syndrome disease affected only a few scattered colonies on the front and back of the reef.

Figure 4.100



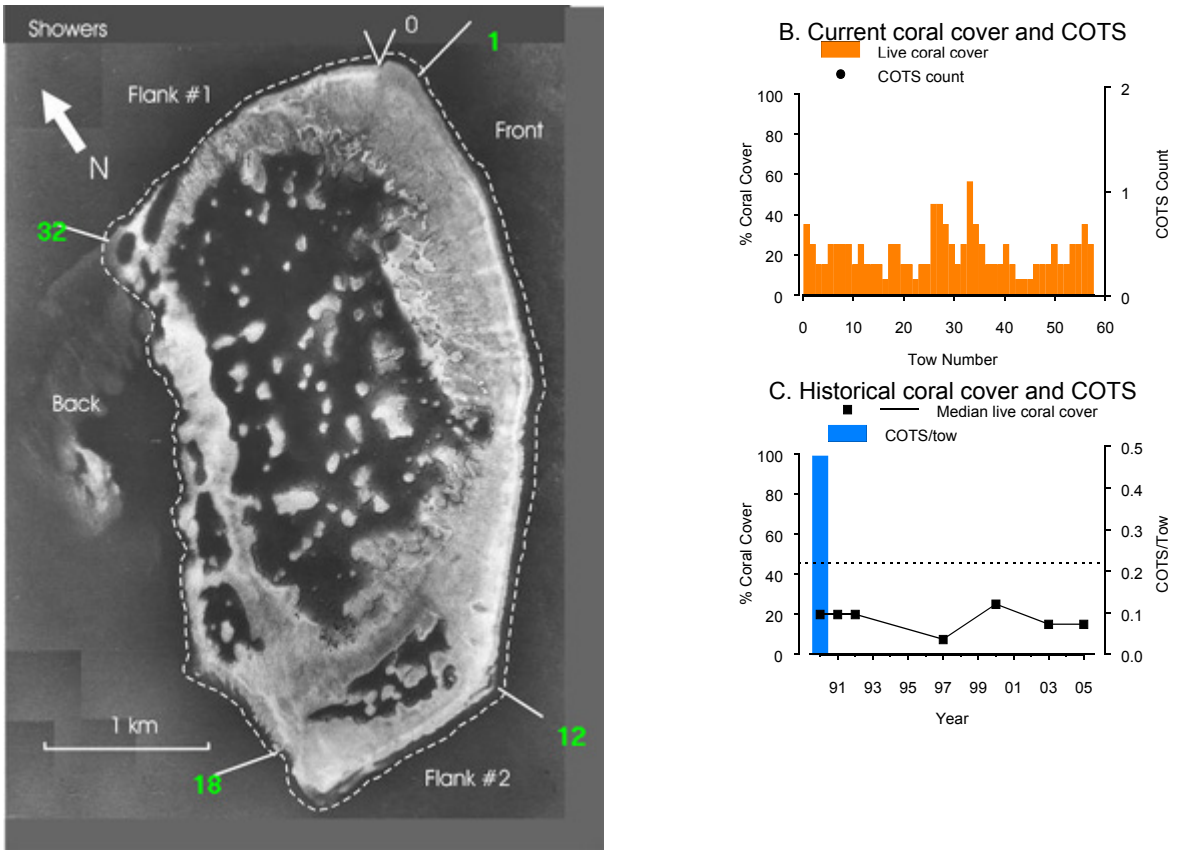
Shell (No. 19-028) is a middle shelf crescentic reef with an area of 2.5 sq.km.

SHOWERS

Surveyed March 2005.

Showers Reef has been surveyed seven times since 1990, when there was an Incipient Outbreak of COTS and reef-wide live coral cover was moderate (10-30%). Reef-wide live coral cover has remained moderate since this time. No COTS were observed during surveys in 2005, coral cover was moderate and the reef is still classified as Recovering. No bleaching was recorded and white syndrome disease affected a few scattered coral colonies around the reef perimeter during surveys in 2005.

Figure 4.101 A



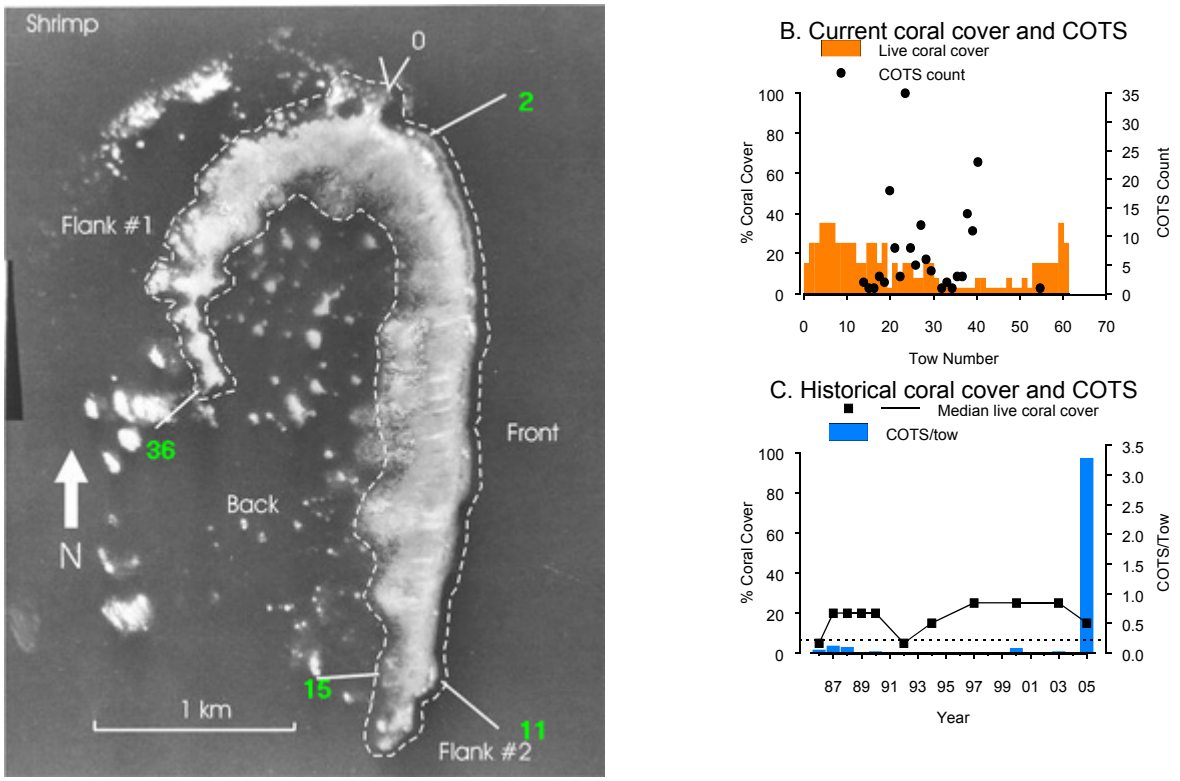
Showers (No. 19-076) is a middle shelf lagoonal reef with an area of 8.79 sq.km.

SHRIMP

Surveyed May 2005.

Shrimp Reef has been surveyed 11 times since 1986. Reef-wide live coral cover was low initially (1-10%) but reached moderate levels (10-30%) in 1990 then declined to a low level by 1992. Low COTS numbers were recorded during this period and the cause of this decline is unknown. Between 1992 and 2000, reef-wide live coral cover gradually increased, returning to moderate levels (10-30%). COTS were seen in 2000 and 2003, but in numbers too low to affect reef-wide live coral cover. Reef wide live coral cover was still moderate in 2005 although large numbers of COTS were present in 2005 and there has been a corresponding decline in reef-wide live coral cover. Shrimp Reef has been reclassified as Active Outbreak. No bleaching was recorded and white syndrome disease affected a few scattered coral colonies around the reef perimeter during surveys in 2005.

Figure 4.102 A



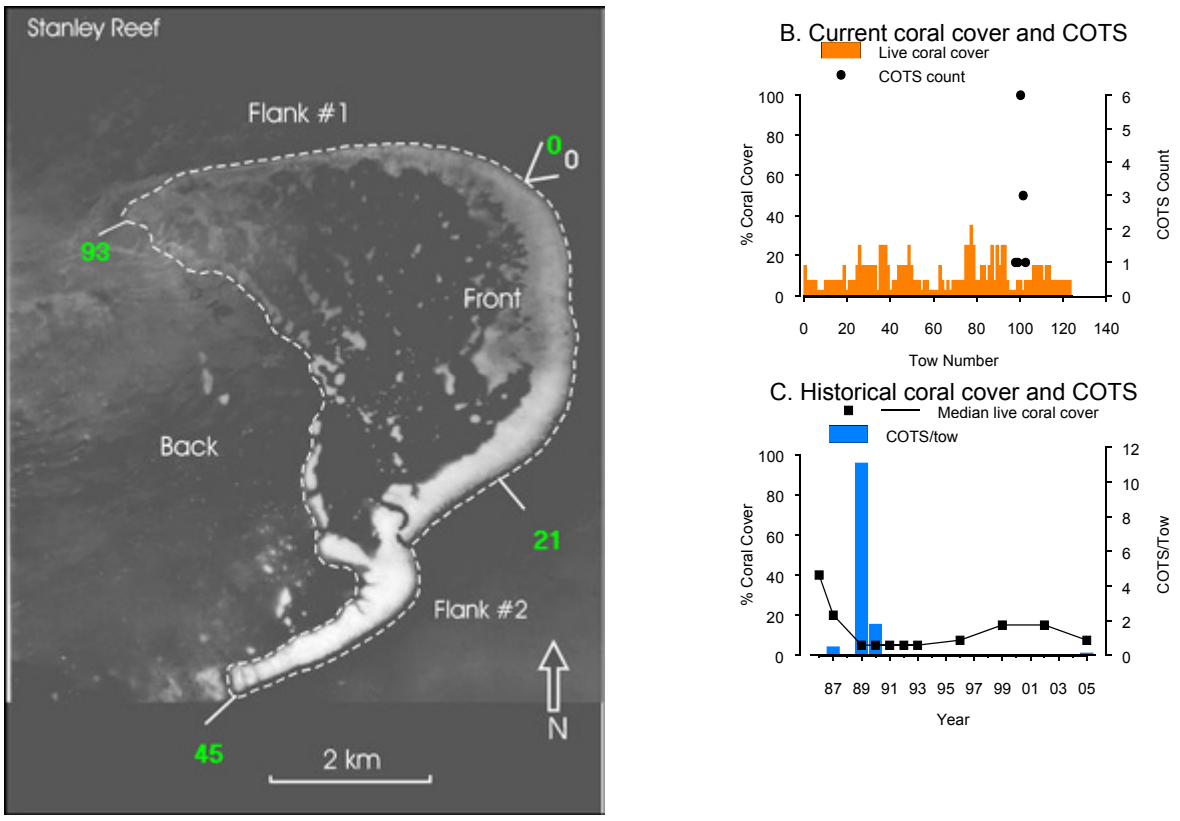
Shrimp (No. 18-118) is a middle shelf crescentic reef with an area of 7.5 sq.km.

STANLEY

Surveyed May 2005.

Stanley Reef has been surveyed 11 times since 1986 when reef-wide live coral cover was high (30-50%). Coral cover declined to a low level (1-10%) in 1989 due to a COTS outbreak which persisted until 1991. Reef-wide live coral cover increased gradually through the 1990s to a moderate level. COTS were recorded in 2002, but in numbers too few to affect reef-wide live coral cover which remained moderate (10-30%). Stanley Reef was still classified as Recovering. Surveys in 2005 indicate a decline in reef-wide coral cover to a low level (1-10%). While COTS were observed on the reef they were below outbreak levels, but local populations were large enough to cause significant coral mortality on the parts of the reef affected. Stanley Reef remains classified as Recovering. No bleaching was recorded and white syndrome disease affected a few scattered coral colonies around the reef perimeter during surveys in 2005.

Figure 4.103 A



Stanley (No. 19-045) is a middle shelf crescentic reef with an area of 58.1 sq.km.

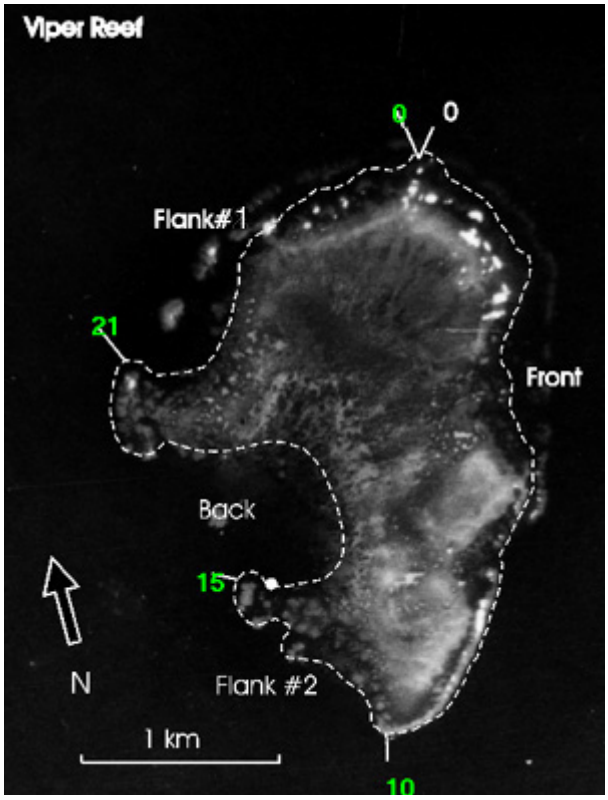
VIPER

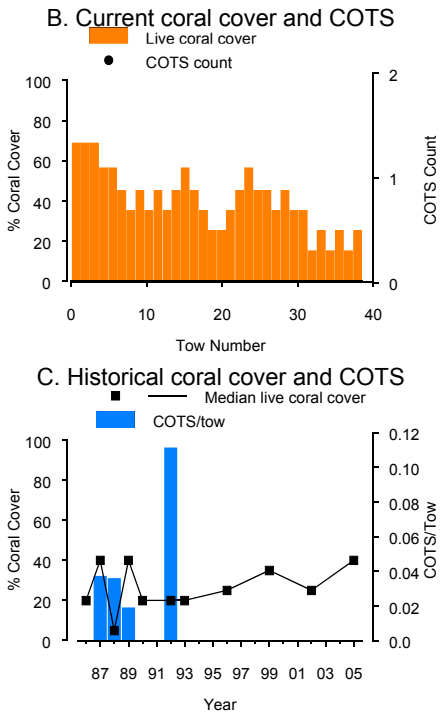
Surveyed May 2005.

Viper Reef has been surveyed 11 tiems since 1986. COTS have been recorded on a number of occasions, particularly during the early years of survey, but always in numbers considered too low to affect reef-wide live coral cover. Reef-wide live coral cover did decline in the late eighties for no clear reason. Cover increased to a moderate level (10-30%) in 2002. No COTS were observed and Viper Reef was classified as No Outbreak. Surveys in 2005 observed no COTS and indicate reef-wide live coral cover continues to rise and is currently high (40-50%). Viper Reef remains classified as No Outbreak. No coral bleaching was recorded and white syndrome disease and black band disease were observed on a few scattered coral colonies on the back north/south flanks and back reef respectively in 2005.

Figure 4.104

A





Viper (No. 18-112) is an outer shelf crescentic reef with an area of 1.9 sq.km.

Whitsunday

Reef Pages

19-131

Surveyed March 2005.

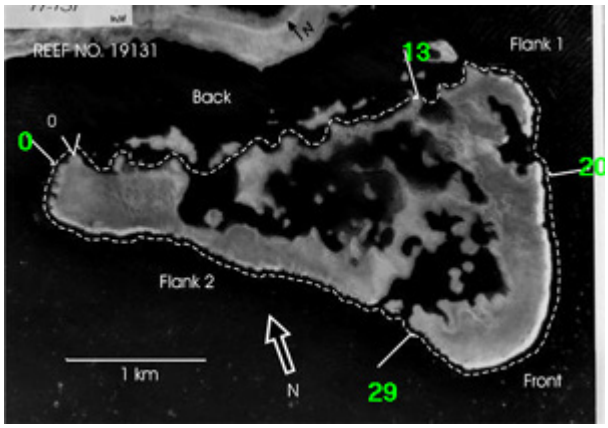
Reef 19-131 has been surveyed by manta tow 14 times since 1989. Reef-wide live coral cover increased between 1989 and 1994 and was moderate (10-30%) until 1996. There was then a decline to a low level (1-10%) in 1999, probably due to Cyclone Justin, which remained off the Whitsunday coast for an extended period in March 1997. Reef-wide live coral cover then increased to a moderate level in 2002. Surveys in 2003 recorded a decline to low cover (1-10%), most likely a result of coral bleaching in 2002. No COTS have been recorded at Reef 19-131 and it was classified as No Outbreak in 2005 when reef-wide live coral cover remained moderate (10-20%). No bleaching was observed and white syndrome disease was restricted to a few scattered colonies on the southern flank and front reef.

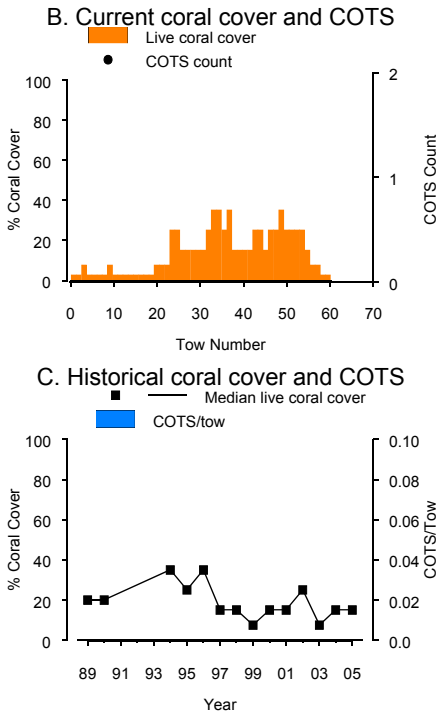
On the intensive survey sites there was a gradual increase in hard coral cover until 1996 followed by a marked decline to 35% cover (approximately 25% of the previous levels) in 1997. This decline occurred following Cyclone Justin in 1997. Hard corals in the family Acroporidae were most susceptible to this disturbance with large declines recorded in the genus *Montipora* and in tabulate *Acropora* spp. Hard coral cover remained stable until 2001, then increased to 41% in 2002. The 2003 survey recorded another decrease in hard coral cover, which may be attributed to the bleaching event in 2002. In 2005 hard coral cover had increased again to 40%. Soft coral cover has been consistently low (approximately 1%). Algal cover has generally increased since 1989, complementing the changes in hard coral cover. The occurrence of white syndrome disease was low in 2005 and the density of corallivorous snails (*Drupella* spp.) was 33.3/ha.

Numbers of many fish taxa fluctuated greatly between years from 1994 to 2005 but there have been no prolonged increases or decreases. Abundance values for all families and genera in 2005 were within the previously recorded range. In this sense, most fish taxa have remained relatively stable over the 13 year survey period.

Figure 4.105

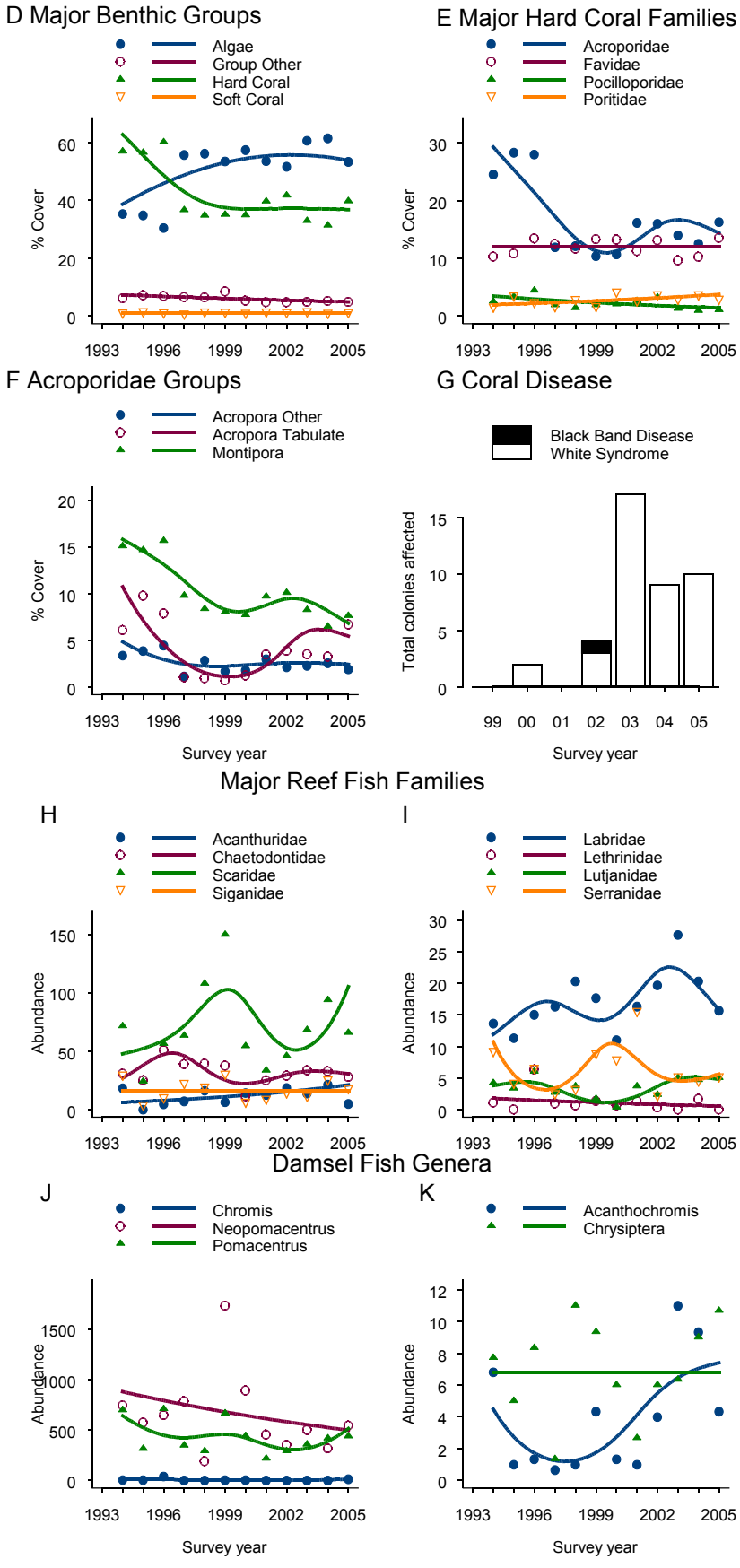
A





19131 (No. 19-131) is a middle shelf lagoonal reef with an area of 5.6 sq.km.

Figure 4.105 (Cont).



19-138

Surveyed March 2005.

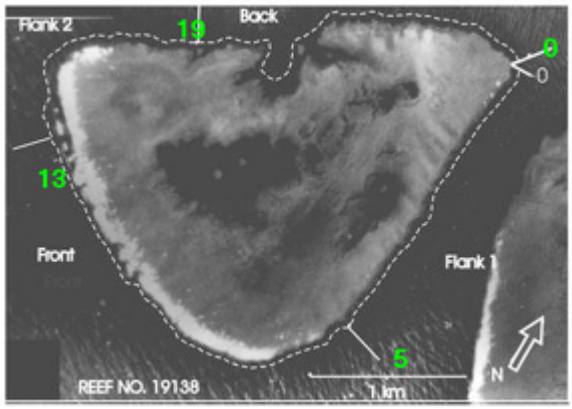
Reef 19-138 has been surveyed by manta tow 15 times since 1990, when there were relatively high numbers of COTS and Reef 19-138 was classified as an Incipient Outbreak. COTS numbers declined without a large affect on reef-wide live coral cover. Coral cover increased until 1995 before declining to a moderate level (10-30%). The decline was probably due to Cyclone Justin, which remained off the Whitsunday coast for an extended period in March 1997. Reef-wide live coral cover remained moderate before declining once more in 2003. No COTS were recorded, so the most likely cause of decline is the coral bleaching event in 2002. Subsequent surveys indicate reef-wide live coral cover has continued to increase since this time. Reef-wide live coral cover was moderate (20-30%) and Reef 19-138 was classified as Recovering in 2005. No bleaching was recorded and white syndrome disease was restricted to a few scattered colonies around the reef perimeter.

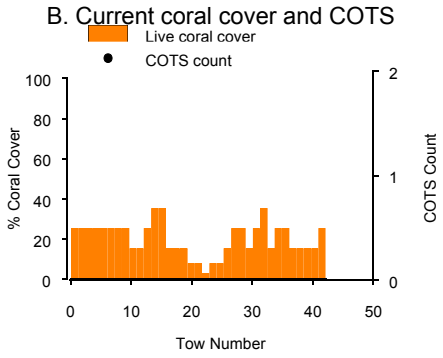
The intensive survey sites were established in 1993. Hard coral cover increased to a maximum of 42% in 1996 before dropping sharply to 17% in 1997. We attribute the decline in hard coral cover between 1996 and 1997 to the effects of Cyclone Justin. Hard coral cover increased by 2005 to 39%, mainly due to increases in branching and tabulate *Acropora* spp. No corallivorous snails *Drupella* spp. were observed in 2005. The incidence of white syndrome disease has gradually increased since 2002 but is still low.

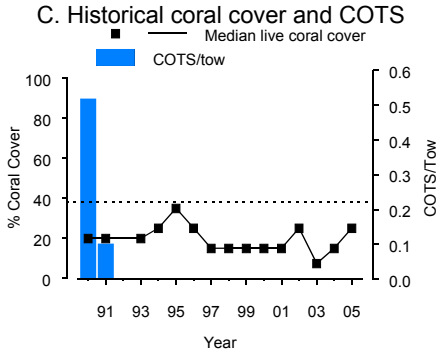
Numbers of many fish taxa have fluctuated greatly over the study period, but there have been few prolonged increases or decreases. Abundance of Labridae has fluctuated since the start of surveys and declined significantly in 2005. This was due to a large decrease in numbers of the numerically dominant species *Epibulus insidiator*. In 2005, numbers of *Lutjanus carponotatus* had declined significantly after having increased since 2001. Abundance of Chaetodontidae closely tracked changes in hard coral cover. Numbers of the damselfish species *Pomacentrus moluccensis* and *Chromis nitida* decreased dramatically after about 50% of hard coral was lost due to Cyclone Justin in March 1997. In 2005, numbers of *C. nitida* remained low, while numbers of *P. moluccensis* had recovered to pre-cyclone levels as had the hard coral cover.

Figure 4.106

A

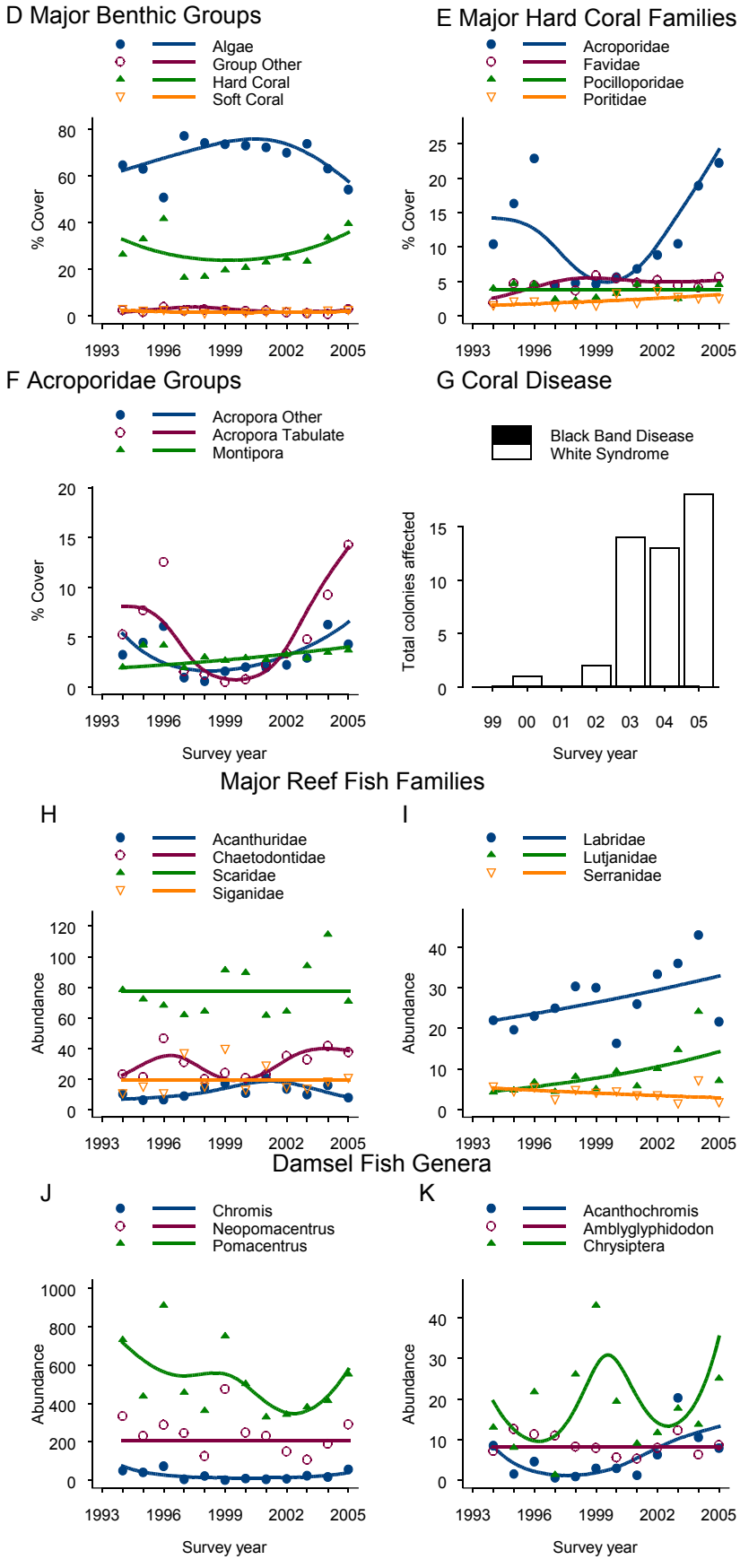






19138 (No. 19-138) is a middle shelf lagoonal reef with an area of 2.5 sq.km.

Figure 4.106 (Cont).



19-159

Surveyed March 2005.

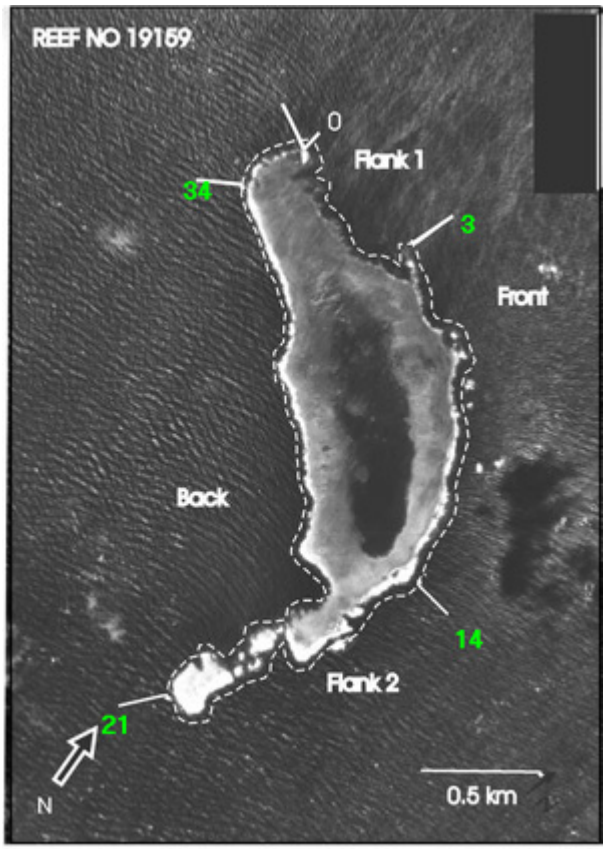
Reef 19-159 has been surveyed 14 times by manta tow since 1986 when it was classified as No Outbreak with a high reef-wide live coral cover (30-50%). Coral cover remained relatively stable until 1997 when there was a sharp decline to a moderate level (10-30%), most likely due to Cyclone Justin. Coral cover recovered and remained steady at a high level (30-50%) until 2004. Small numbers of COTS, below outbreak densities, were recorded in 1999, 2000 and 2004. Surveys in 2005 indicate that reef-wide coral cover has increased to a current high level (40-50%). No COTS were recorded and Reef 19-159 remained classified as No Outbreak. No bleaching was recorded and white syndrome disease was restricted to a few scattered colonies around the reef perimeter.

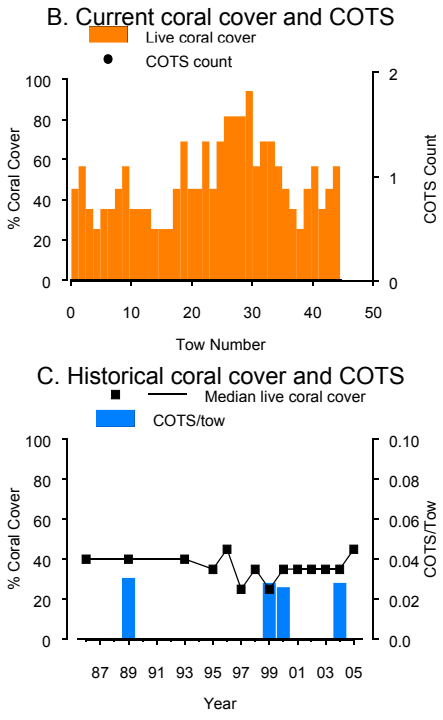
Surveys at the permanently established sites show that hard coral cover has been high throughout the survey period. Cover reached 44% in 2003 and has remained this high to the 2005 survey. The dominant coral lifeform is bottlebrush and branching *Acropora*. The decrease in hard coral cover in 2000 may have been caused by non-outbreaking COTS populations in those years. Incidence of white syndrome disease was very low. No corallivorous snails *Drupella* spp. were observed.

Numbers of large mobile fish species have often fluctuated from year to year but there have been no obvious long-term trends over the study period with the possible exception of an increase in numbers of scarids. Numbers of the commercially important coral trout (*Plectropomus leopardus*) increased greatly in 2004 and reached a survey maximum in 2005. Lutjanidae abundance also increased after 2002. Numbers of most damselfish species have been relatively stable. However, *Pomacentrus* numbers declined to a survey minimum in 2005. This trend was driven by a number of species. Numbers of *Acanthochromis polyacanthus* increased up to 2003 but decreased dramatically in 2004 and 2005.

Figure 4.107

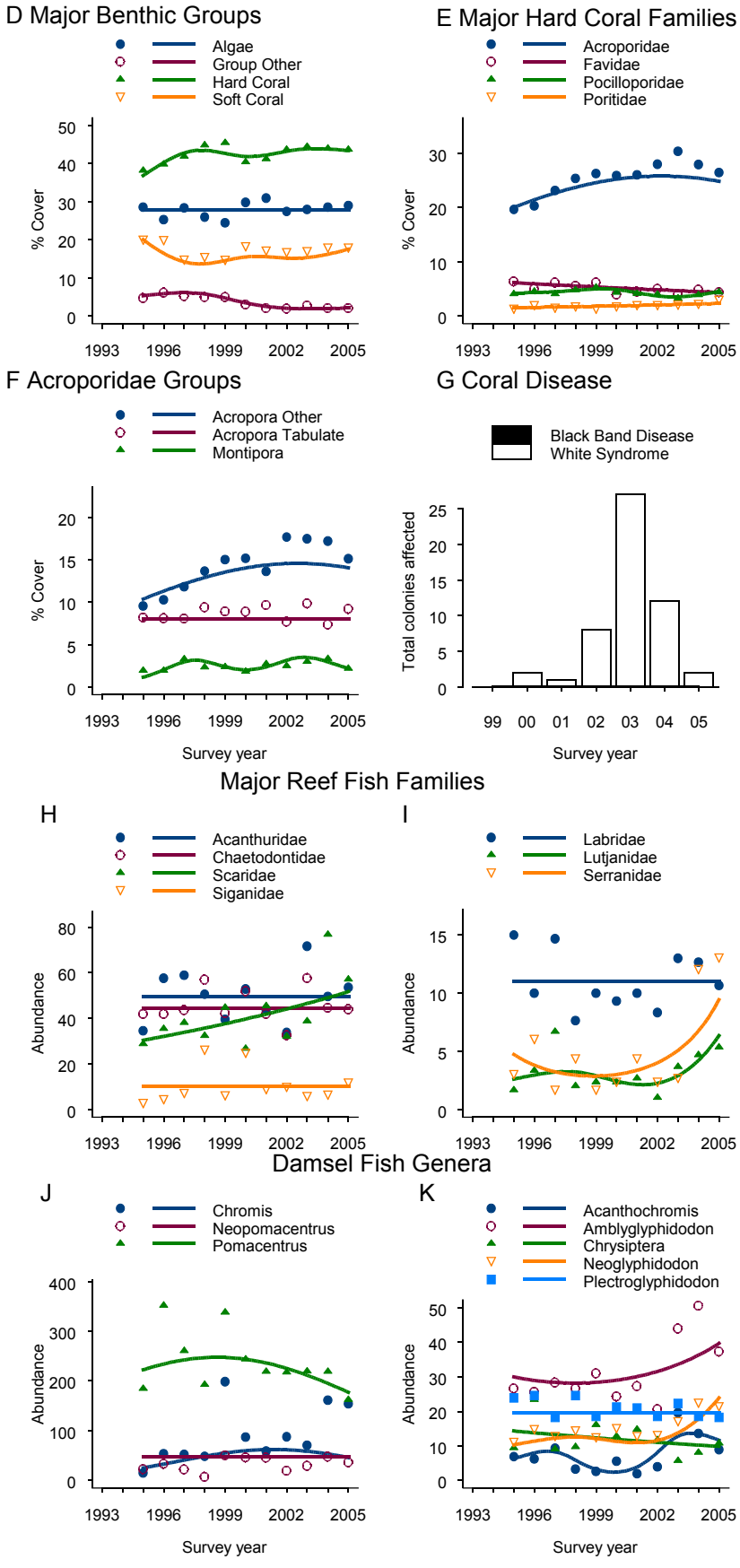
A





19159 (No. 19-159) is an outer shelf lagoonal reef with an area of 3.8 sq.km.

Figure 4.107 (Cont).



20-104

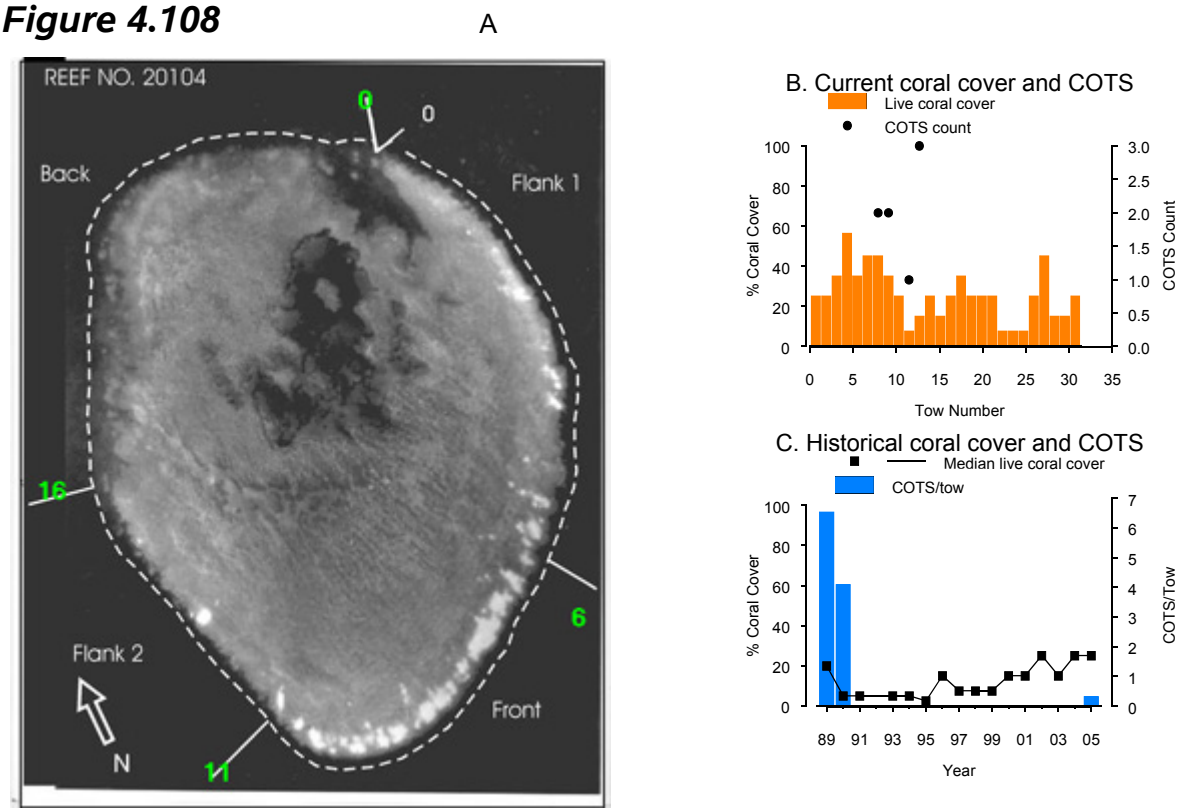
Surveyed March 2005.

Reef 20-104 has been surveyed 16 times since 1989 when it was initially declared an Active Outbreak due to the presence of a large number of COTS. Reef-wide live coral cover declined to low levels (1-10%) in the early 1990s. Reef 20-104 was reclassified as Recovering from COTS in 1991. Reef-wide live coral cover then gradually increased to a moderate level (10-30%) in 2002. There was a setback in 1997, most likely as a result of the passage of Cyclone Justin just before the 1997 surveys. Reef-wide live coral cover declined once more in 2003. No COTS were recorded, so the most likely cause of the decline was the 2002 bleaching event. Surveys in 2004 found that coral cover had returned to moderate levels (20-30%). Coral cover remained moderate in 2005 and COTS numbers had increased and may cause some reef-wide coral mortality. Consequently Reef 20-104 has been reclassified as an Incipient Outbreak. No bleaching was recorded and white syndrome disease was generally restricted to a few scattered colonies around the reef perimeter, except for the front reef where it was common (more than ten affected colonies per two minute manta tow).

Hard coral cover on the intensive survey sites increased consistently from 11.2% in the initial survey to 48% in 2005. This increase was mainly driven by the Acroporidae which have increased from 2% in 1993 to 30% in 2005. Soft coral cover remained relatively stable at a low level (1-2%) over the survey period. Algal cover decreased steadily from 73.8% in 1993 to 45% in 2005, with *Halimeda* spp. showing the largest decline from 37% in the initial survey in1993, to <1% in 2005. Incidence of white syndrome disease was very low in 2005, and the density of corallivorous snails, *Drupella* spp., was 73/ha.

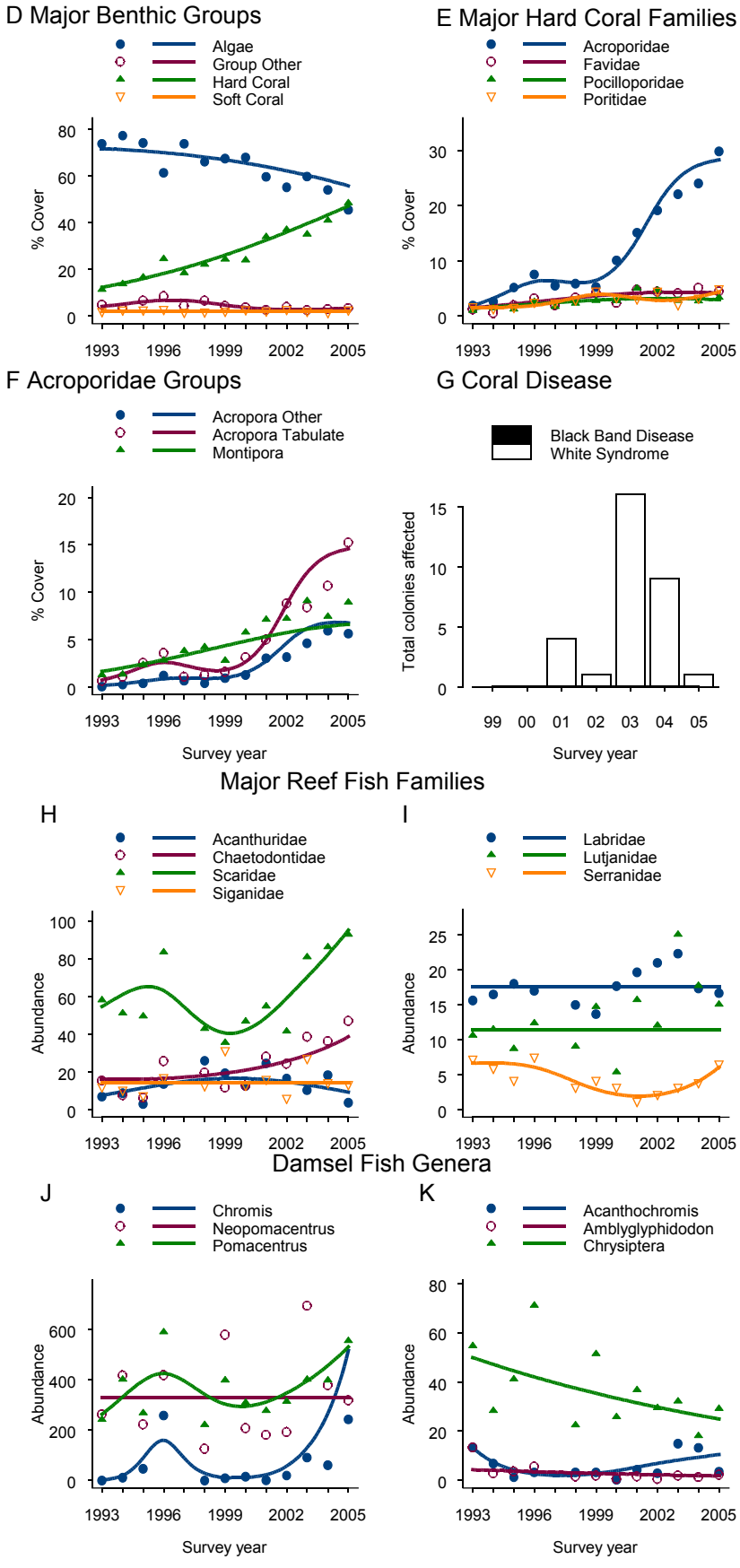
Although many fish species have fluctuated in abundance over the study period, few have shown consistent long-term trends. Two closely related butterflyfish species (*Chaetodon aureofasciatus* and *C. rainfordi*) increased in abundance as hard coral cover increased, and this trend continued in 2005. There was a slight increase in the abundance of Scaridae in 2005 to a survey maximum while acanthurid numbers had decreased to a 10 year low. Numbers of the commercially important coral trout (*Plectropomus leopardus*) continued to increase in 2005. 2005 also saw a large increase in abundance of two damselfish species, *Chromis atripectoralis* and *C. nitida*. Similarly, *Pomacentrus moluccensis* doubled in abundance in 2005, driving the increasing trend in that genera. All other damselfish genera remained relatively stable.

Figure 4.108



20104 (No. 20-104) is a middle shelf lagoonal reef with an area of 1.9 sq.km.

Figure 4.108 (Cont).



BORDER IS (A)

Surveyed March 2005.

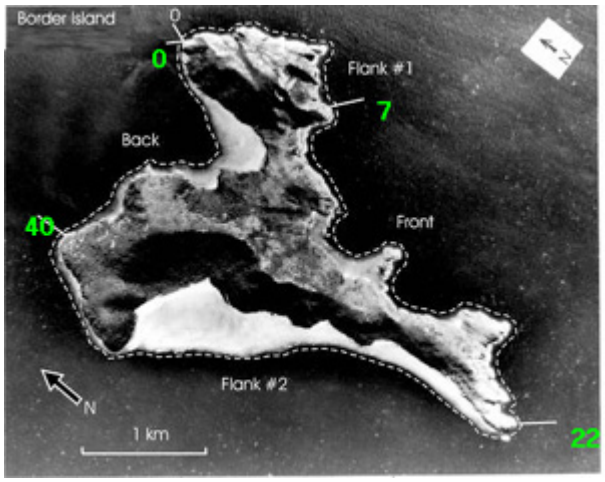
Border Island A Reef has been surveyed eight times by manta tow since 1995. No manta tow surveys surveys were conducted in 2005 due to poor weather and visibility. Reef-wide live coral cover in 2004 remained moderate (10-30%). No COTS were observed in 2004 and Border Island A Reef remains classified as No Outbreak. White syndrome disease was present but only affected a few scattered coral colonies. Elevated levels of coral bleaching were observed particularly on the back reef and on the second flank where up to 10% of the total hard coral cover was affected.

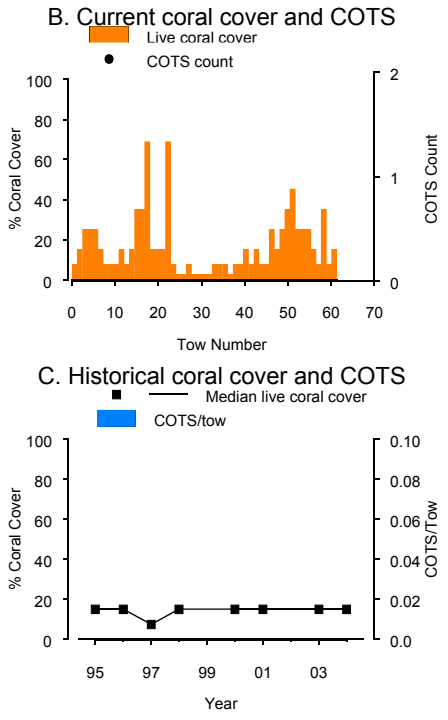
Cover of hard coral at the intensive survey sites has shown a slight increasing trend and in 2005 was moderate at 27%. Hard coral cover was dominated by the Poritidae, particularly *Goniopora* spp. Soft coral cover varied considerably between survey years with 2 main declines noted in 1998 and 2002. Both were associated with high water temperature induced bleaching. By 2005 soft coral cover was equal to pre-bleaching levels (36%). The algal community was dominated by turfs. Algal cover has fluctuated in recent years reaching a maximum of 39% in 2003. Cover of algae was 27% in 2005. The density of corallivorous snails *Drupella* spp. increased from 2004 to 13/ha. There was no recorded incidence of white syndrome disease.

Although numbers of most fish taxa have fluctuated over the study period there has been little tendency for prolonged increases or decreases. One exception may be the commercially important coral trout (*Plectropomus leopardus*). Coral trout numbers at Border Island have declined since 1994 and are currently stable but low. Numbers of Lutjanidae decreased to a survey minimum in 2001. Since this time their numbers have remained low but stable. Numbers of the small planktivorous damselfish, *Neopomacentrus bankieri*, increased dramatically in 2005 to a survey maximum.

Figure 4.109

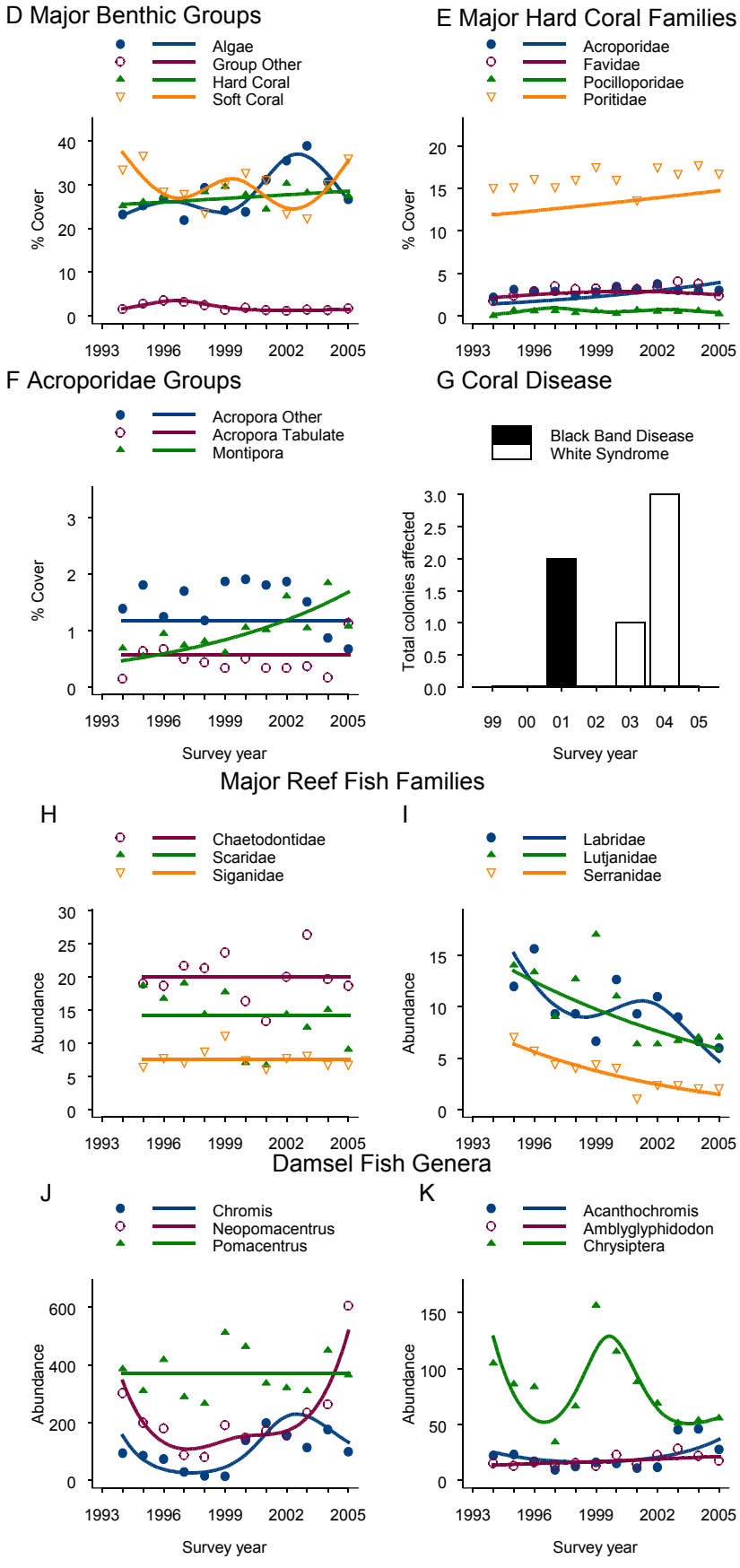
A





Border Is (A) (No. 20-067) is an inner shelf fringing reef with an area of 1.3 sq.km.

Figure 4.109 (Cont).



HAYMAN IS

Surveyed March 2005.

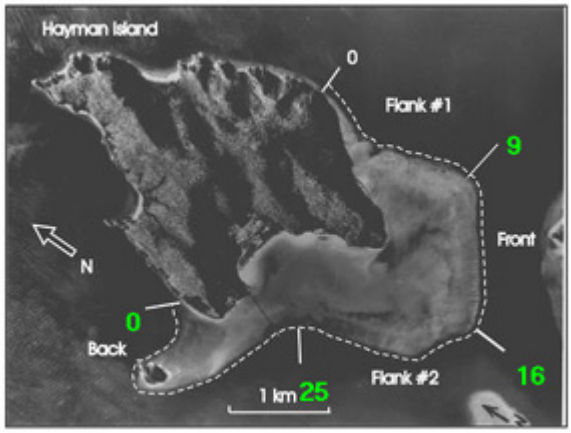
Hayman Island Reef has been surveyed by manta tow 12 times since 1990. Hayman Island fringing reef was not surveyed by manta tow in 2005 due to poor weather conditions and low visibility. Between 1990 and 1994 reef-wide live coral cover remained at moderate levels (10-30%) but declined in 1995. Coral cover has then increased gradually up to the present surveys. No COTS were found on reefs around Hayman Island in 2004 and it continues to be classified as No Outbreak. Coral bleaching and white syndrome disease was observed on a few scattered colonies in 2004.

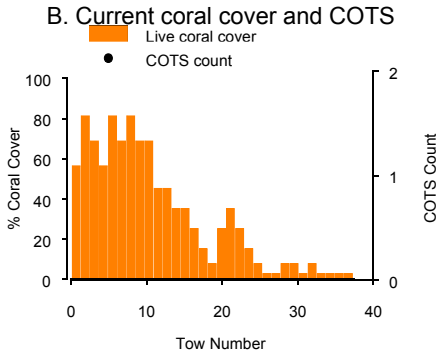
Intensive surveys record fluctuations in mean hard coral cover around 42%. Slight declines were observed in 1994, 1997, and 2003 which may be attributed to Cyclone Beni, Cyclone Justin, and high water temperature bleaching respectively. By 2005 cover had reached 45%. *Montipora* was the most abundant hard coral genus which, along with branching *Acropora* spp., shaped trends in hard coral cover. In 2005 the cover of algae dipped down to 30%. White syndrome disease were noted at moderate levels in 2003, but incidence decreased dramatically by 2005. No corallivorous snails *Drupella* spp. were observed in 2005.

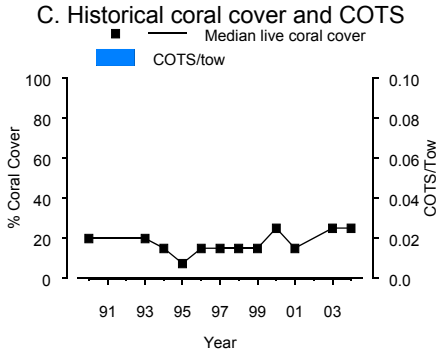
Numbers of most fish taxa have fluctuated over the period of surveys and there have been few consistent long term trends. 2004 saw a jump in the abundance of Lutjanidae, although this is largely due to the presence of a large school of *Lutjanus vitta*. In 2005, numbers of this species returned to previous levels. Numbers of a few *Pomacentrus* species have declined over the study period. Abundance of *P. moluccensis* in particular, declined dramatically after 1999 to a 12-year low in 2004. Numbers were still very low in 2005. Numbers of *P. lepidogenys* and *P. brachialis* also declined over the study period to survey minimums in 2005. A similar trend was recorded for *Pomacentrus* species at the nearby Langford and Bird Islands. Numbers of *Chrysiptera* and *Neopomacentrus* species have displayed a similar declining trend. These trends are unlikely to be habitat related as the cover of most benthic variables has changed little over the study period. *Chromis atripectoralis* decreased in abundance to a level similar to pre-2003. This is largely due to a recruitment pulse in 2002 and the subsequent assimilation into the adult population.

Figure 4.110

A

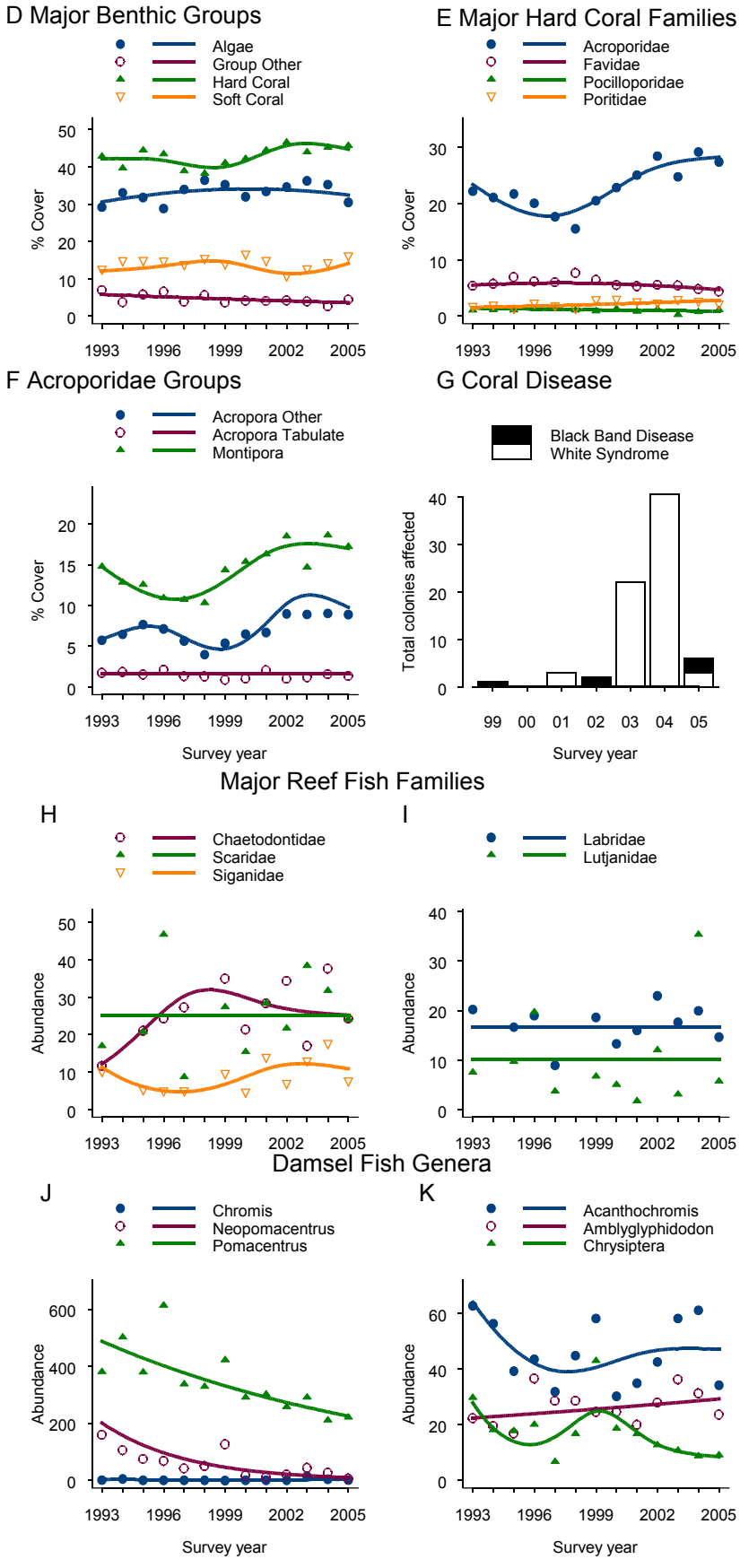






Hayman Is (No. 20-014) is an inner shelf fringing reef with an area of 3.8 sq.km.

Figure 4.110 (Cont).



HYDE

Surveyed March 2005.

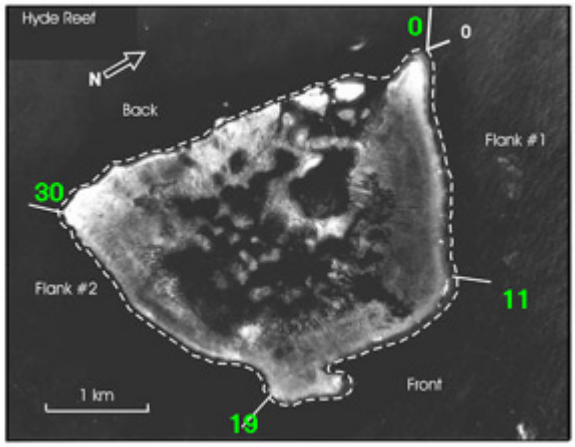
Hyde Reef has been surveyed 15 times since 1986. Reef-wide live coral cover was moderate (10-30%) in 1986 and has changed little since. No COTS have been observed and Hyde Reef remains classified as No Outbreak. Surveys in 2005 show reef-wide live coral cover remains moderate (20-30%). No bleaching was recorded and white syndrome disease only affected a few scattered coral colonies on the back reef during surveys in 2005.

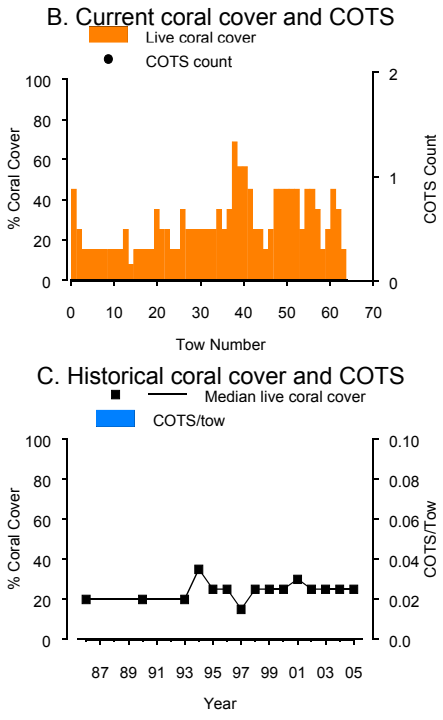
Surveys of the intensive study sites since 1993 show a stable benthic community. Hard coral cover in 2005 was moderate (15%). Cover of soft corals has varied around approximately 45% and algal cover has fluctuated around 21%. Soft corals on Hyde are dominated by the family Xeniidae. In 2005 Hyde had the highest cover of soft coral of all reefs surveyed.The cover of sponges was also relatively high (about 10%). White syndrome disease occurred at very low levels in 2005. No corallivorous snails, *Drupella* spp. were observed.

Although numbers of most fish taxa have varied from year to year there has been little tendency for prolonged increases or decreases over the 12-year study period. This may reflect the relative stability of the benthos over the same period. Numbers of Scaridae had increased markedly in 2004, but this was due to localised aggregations of spawning species, particularly *Scarus rivulatus*, *S. globiceps* and *S. psittacus*. Scarid numbers had returned to pre-2004 levels in 2005. Numbers of *Chrysiptera* spp. declined to very low levels in 2004 but had recovered slightly in 2005. Three of four *Chrysiptera* species were usually present up to 2000, but only *C. rex* was recorded after 2000. 2005 saw the return of *C. rollandi* and *C. talboti*. As habitat and general fish assemblage structure appear to have remained relatively stable, it is possible that the supply of larval *Chrysiptera* has been minimal for some time.

Figure 4.111

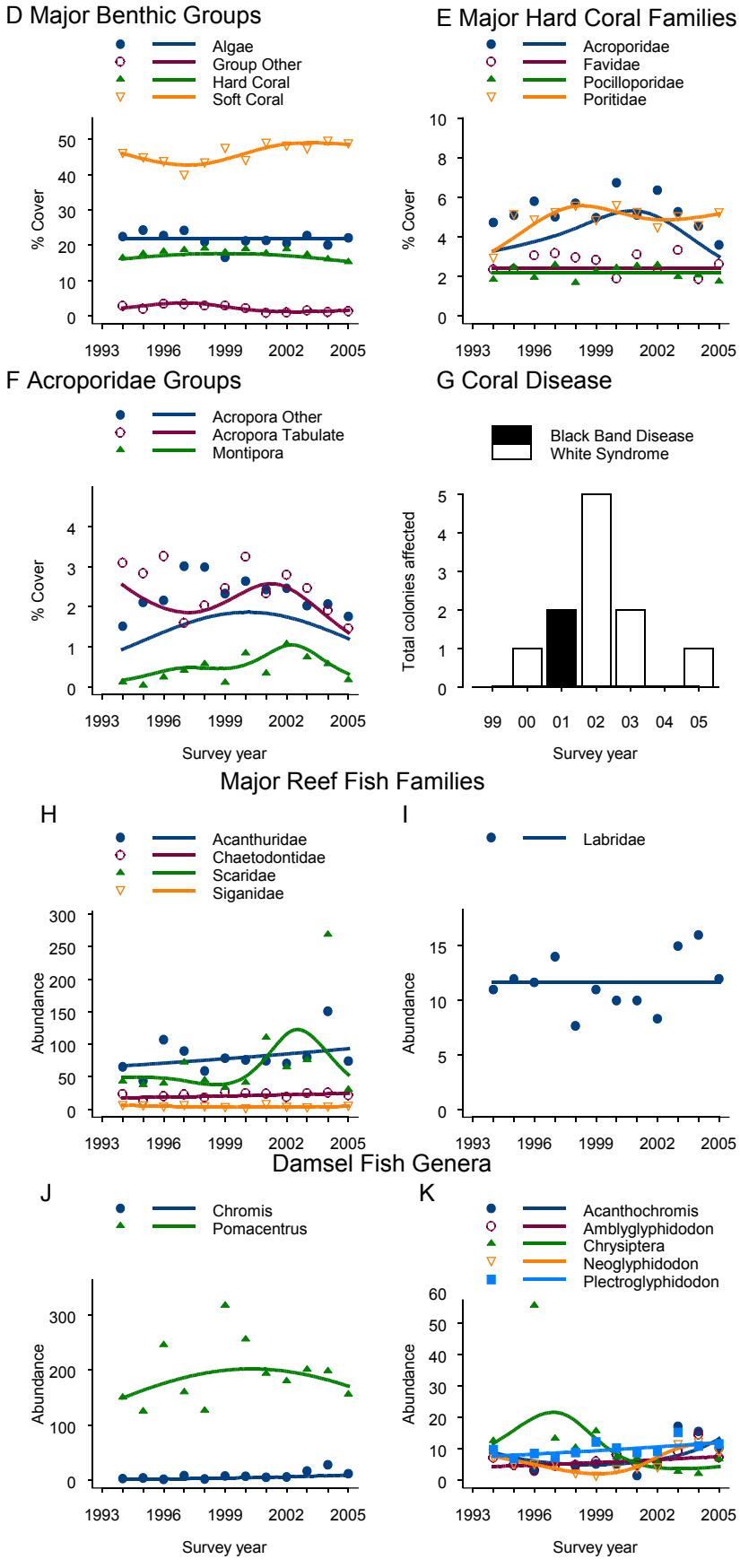
A





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

Figure 4.111 (Cont).



LANGFORD AND BIRD IS'S

Surveyed March 2005.

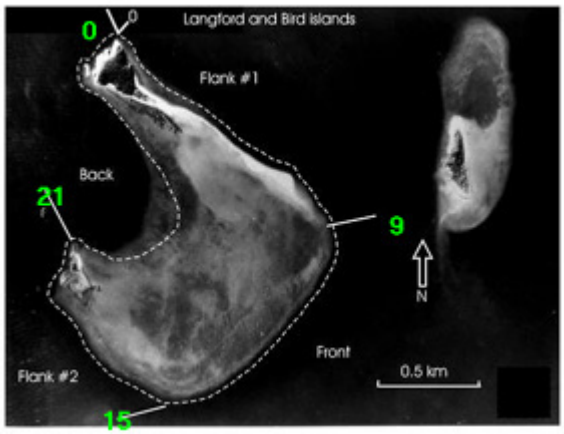
Langford and Bird Islands have been surveyed 10 times by manta tow since 1990. Langford and Bird Islands fringing reef was not surveyed by manta tow in 2005 due to poor weather conditions and low visibility. Reef-wide live coral cover has increased from low levels (1-10%) in 1990 to moderate levels (10-30%) by 1999 where it has remained. Small numbers of COTS, below outbreak levels, recorded in 2003 appear to have had little impact on coral cover. Surveys in 2004 failed to detect COTS and Langford and Bird Islands Reef remained classified as No Outbreak. Coral bleaching and white syndrome disease was observed on a few scattered colonies in 2004.

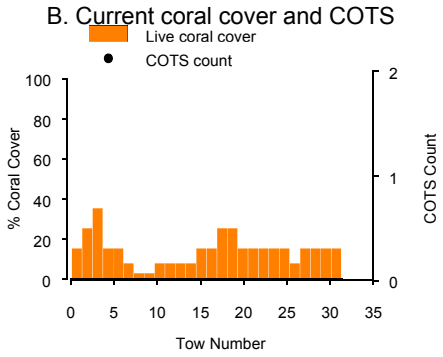
The intensive survey sites include a lot of sandy substrate. Hard coral cover was initially low (16.5% in 1993) and has increased gradually over the survey period to 22% in 2005. *Goniopora* and *Porites* were the most abundant genera. The cover of soft corals was fairly stable (19.5% on average) until a decrease in 2002, falling to 10.5% in 2003. This decline was associated with the 2002 bleaching event. Soft coral recovered to 23% by 2005, this rapid recovery resulted in soft coral cover higher than previous levels surveys. The cover of algae increased from 30% in 1999, reaching 46% in 2003. By 2005 algal cover dropped back down to 28%. Prevalence of white syndrome disease was low, and no corallivorous snails *Drupella* spp. were observed in 2005.

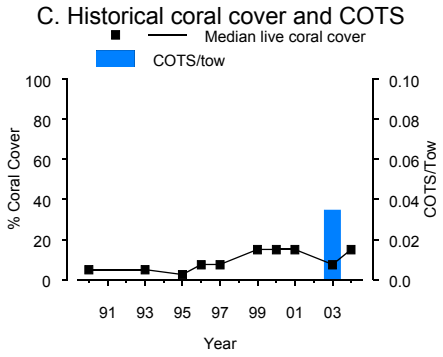
No long term trends are apparent in any of the large, mobile fish species, although numbers have fluctuated from year to year. Damselfish of the genus *Pomacentrus* have shown a long term decline driven by a number of species and this trend continued in 2005. A similar trend was recorded for *Pomacentrus* at the nearby Hayman Island. Numbers of *Acanthochromis polyacanthus* increased dramatically after 2002, however 2005 saw a decrease in their abundance Numbers of *Chrysiptera rollandi* have been steadily decreasing since 1999, however 2005 saw the first increase in their numbers since 1998. Numbers of other genera of Pomacentridae have remained variable but relatively stable over the longer term.

Figure 4.112

A

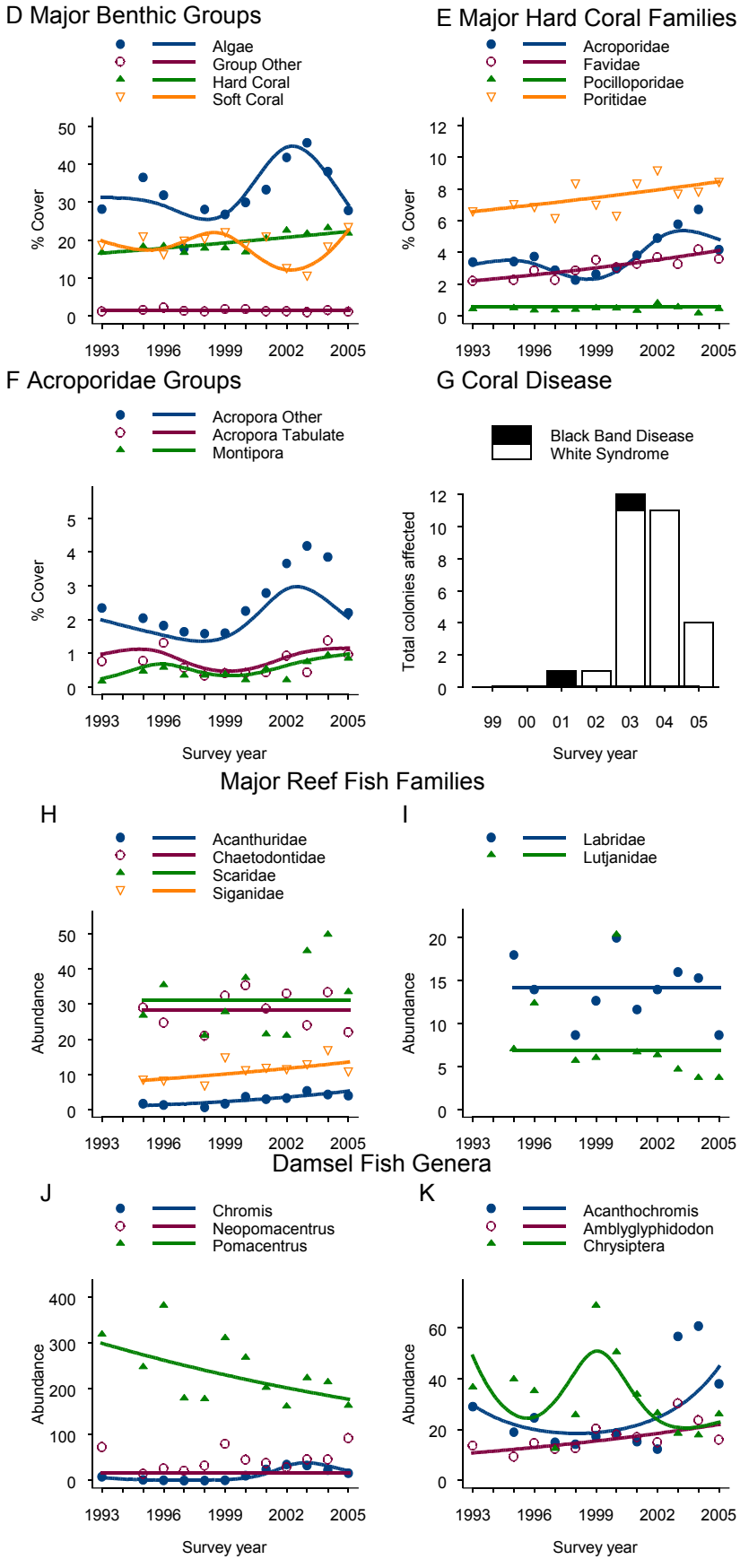






Langford And Bird Is's (No. 20-019) is an inner shelf fringing reef with an area of 2.5 sq.km.

Figure 4.112 (Cont).



REBE

Surveyed March 2005.

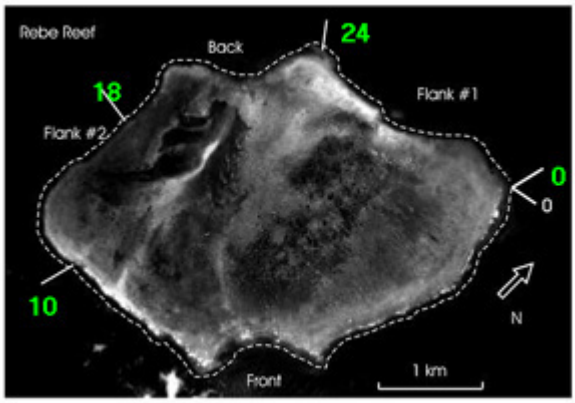
Rebe Reef has been surveyed 13 times since 1990 when it had a moderate reef-wide live coral cover (10-30%) and was classified as No Outbreak. Coral cover remained stable at a moderate level before entering a period of decline to a low level (1-10%) from 1994. No COTS were recorded, so the reason for this decline is unknown. Cyclone Celeste (1996) and Cyclone Justin (1997) may have played a part. Since 1997, reef-wide live coral cover has recovered to moderate levels (10-30%). There was a slight decline in reef-wide live coral cover in 2003 possibly as a result of the 2002 bleaching event. Surveys in 2005 show a slight recovery in reef-wide live coral cover which is moderate (20-30%). Rebe Reef remains classified as No Outbreak. No bleaching was recorded and white syndrome disease only affected a few scattered coral colonies on the front and southern flank during surveys in 2005.

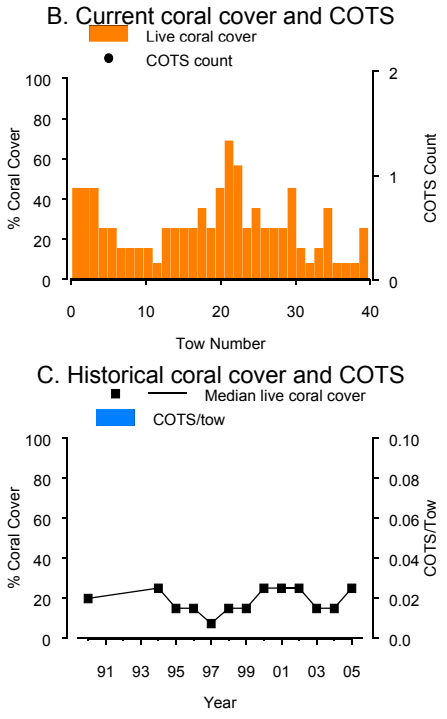
Intensive surveys show that hard coral cover remained relatively stable between 1994 and 2005 at about 20% . The cover of soft coral is relatively high and has been increasing over the survey period from 29.3% in 1994 to 47% in 2005. There has been a corresponding decrease in the cover of algae from 39.4% to 19%. Rebe Reef has the greatest cover of sponges (14%) of any of our core survey reefs. White syndrome disease was not found on this reef in 2005, and has previously only been observed in low numbers. No corallivorous snails, *Drupella* spp., were observed.

Although numbers of most fish taxa have varied from year to year there have been few prolonged increases or decreases over the 13-year study period. This may reflect the relative stability of the benthos over the same period. Only one taxon, *Chrysiptera*, has shown a clear decline in numbers and richness. Three species were regularly recorded until 1999, after which only *C. rex* was observed. In 2004, *C. rollandi* had returned in very low numbers but was not observed again in 2005. Numbers of *C. rex* increased slightly in 2005 after falling to the lowest level recorded at this reef in 2004. As habitat and general fish assemblage structure appear to have remained relatively stable, it is possible that the supply of larval *Chrysiptera* has been minimal for some time.

Figure 4.113

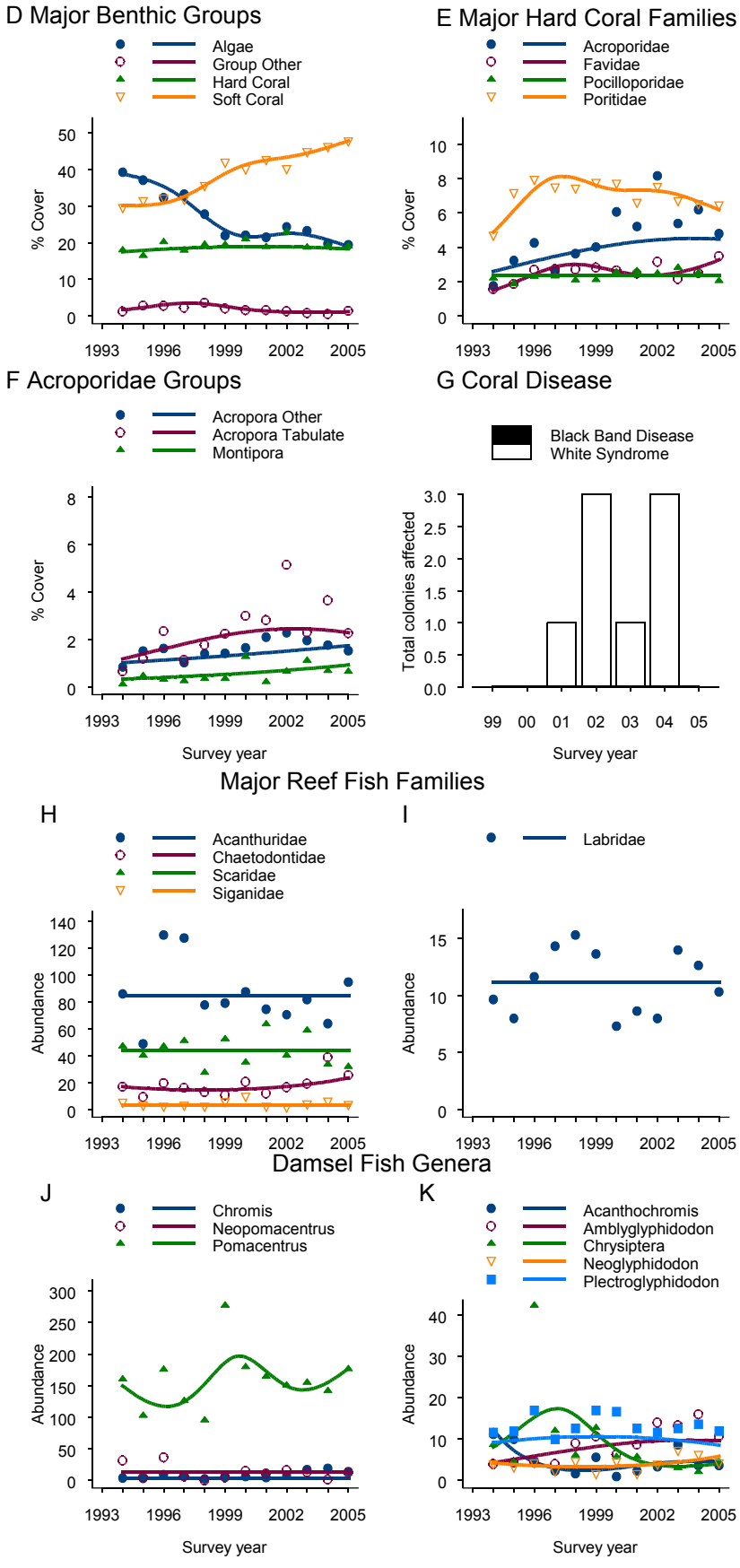
A





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

Figure 4.113 (Cont).

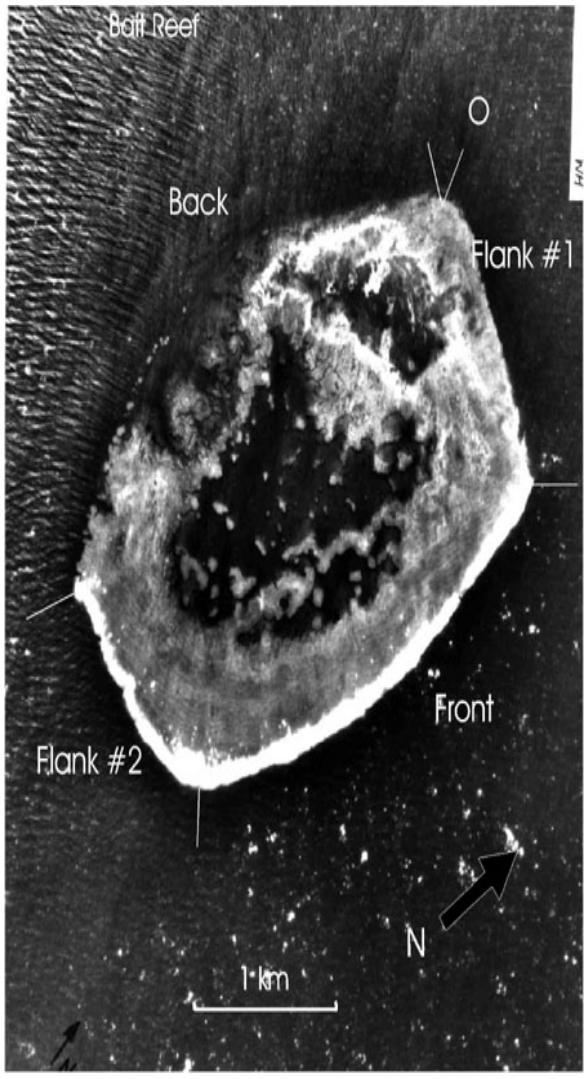


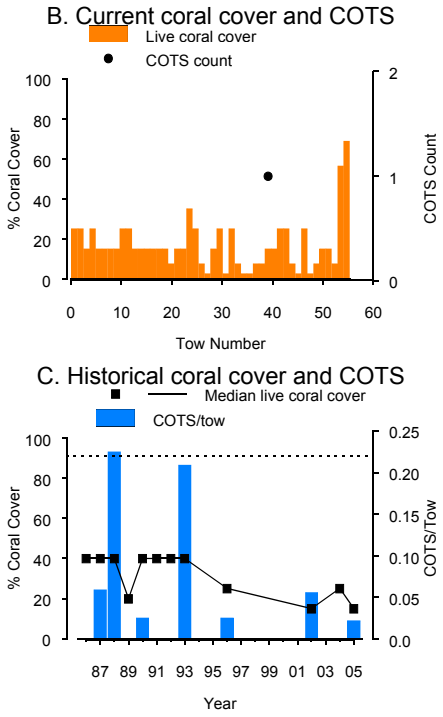
BAIT

Surveyed March 2005.

Bait Reef has been surveyed 12 times since 1986 when it had a high reef-wide live coral cover (30-50%) and was classified as No Outbreak. Coral cover remained stable at a high level before declining in 1989 following an incipient COTS outbreak in 1988. Outbreak levels of COTS were short lived and coral cover bounced back to a high level in 1990 where it remained until 1993 when increased numbers of COTS were recorded. A break in surveys ensued with only two surveys up until 2002. These surveys recorded low COTS numbers and a decline in coral cover to a moderate level presumably due to COTS activity. This time also corresponded with Cyclone Justin (1997) which strongly influenced other reefs in the region, as well as the 2002 bleaching event. In recent years coral cover has remained moderate and small numbers of COTS were recorded during surveys in 2005. Bait Reef remains classified as No Outbreak. No bleaching was recorded and white syndrome disease affected only a few scattered coral colonies on the back reef and northern flank during surveys in 2005.

Figure 4.114 A





Bait (No. 19-137) is a middle shelf lagoonal reef with an area of 5.6 sq.km.

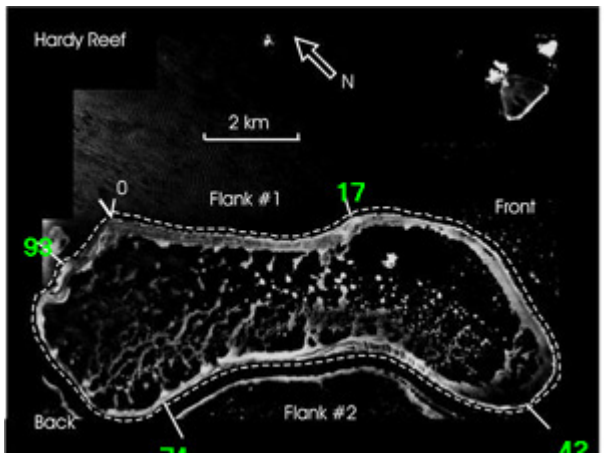
HARDY

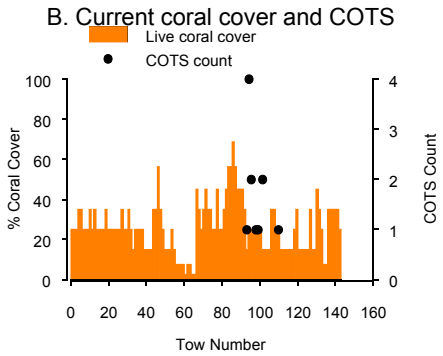
Surveyed March 2004.

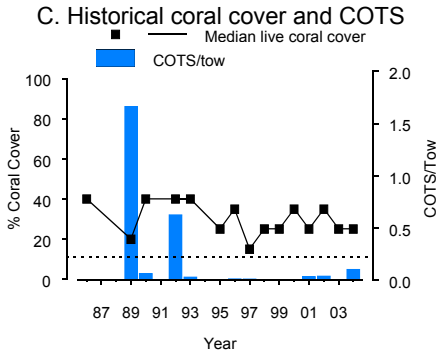
Hardy Reef has been surveyed 15 timees since 1986 when it had high reef-wide live coral cover (30-50%) and was classified as No Outbreak. An outbreaking population of COTS developed between 1986 and 1989, resulting in a sharp decline in coral cover. The coral then recovered and reef-wide live coral cover remained high in subsequent years despite an Incipient Outbreak in 1992. Between 1993 and 1997 coral cover once again declined with a sharp drop recorded in 1997, most likely due to Cyclone Justin. Reef-wide live coral cover has increased gradually since 1997 and remains moderate (10-30%) in 2004. COTS were observed during surveys in 2004 but in numbers well below those expected to cause significant coral damage. Bleaching and white syndrome disease was restricted to a few scattered colonies during surveys in 2004 withthe exception of the second flank where coral bleaching affected up to 5% of total hard coral cover.

Figure 4.115

A







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

Pompey

Reef Pages

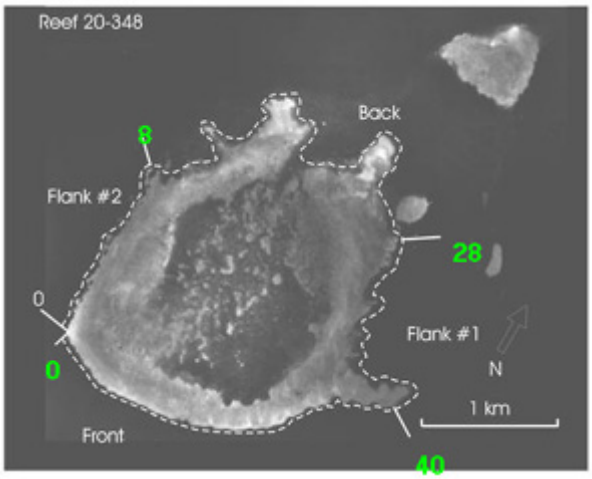
20-348

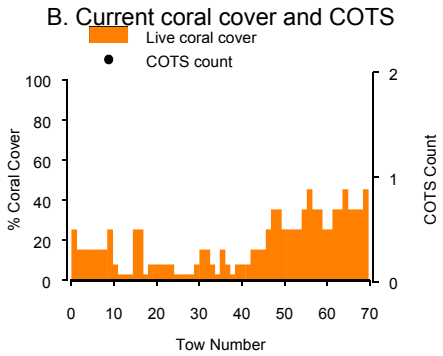
Surveyed December 2004.

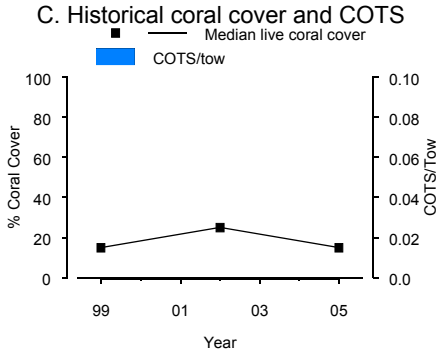
Reef 20-348 has been surveyed three times since 1999. No COTS have been observed during any survey. In 2005, reef-wide live coral cover was moderate (10-20%) and at a level similar to that seen in previous years. Reef 20-348 remains classified as No Outbreak. No bleaching was recorded and white syndrome disease affected only a few scattered coral colonies around the reef perimeter.

Figure 4.116

A







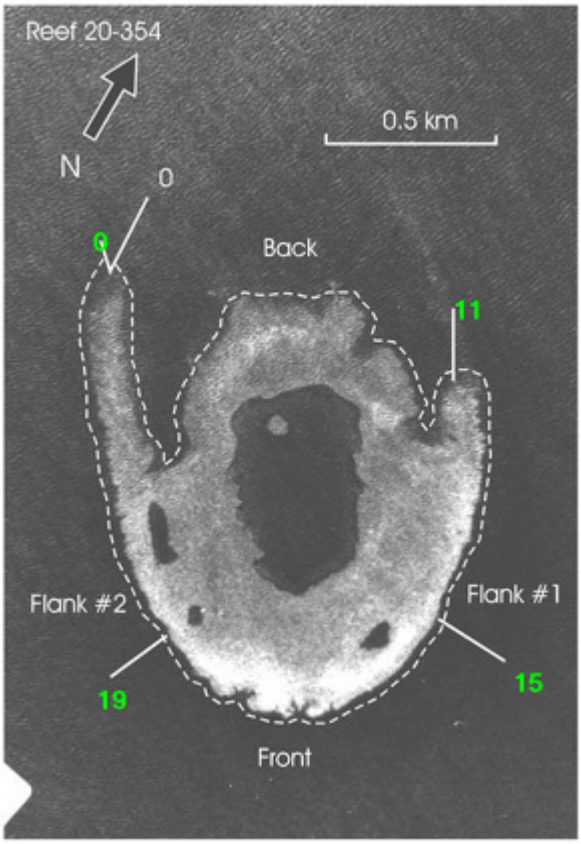
20348 (No. 20-348) is a middle shelf lagoonal reef with an area of 12.5 sq.km.

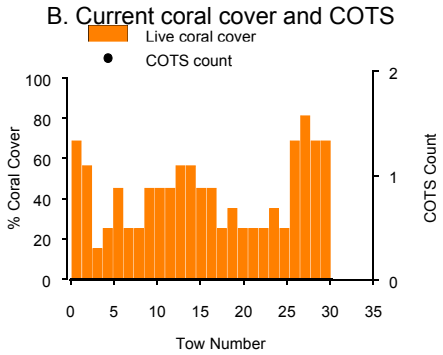
20-354

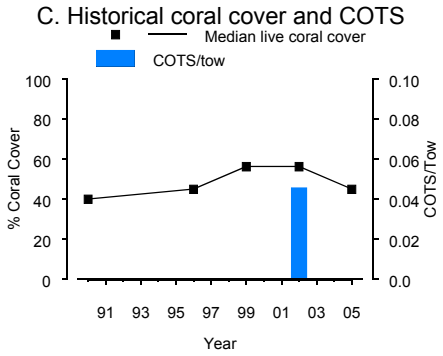
Surveyed December 2004.

Reef 20-354 has been surveyed five times since 1990. Reef-wide live coral cover was initially high (30-50%) and increased to very high (50-75%) in 2002. A single COTS was recorded from Reef 20-354, and it was classified as No Outbreak. Surveys in 2005 indicate reef-wide live coral cover remains high (40-50%). No bleaching was observed and the incidence of white syndrome disease was low, affecting only a few scattered colonies. Interestingly, black-band disease was common around most of the reef perimeter in 2005.

Figure 4.117 A







20354 (No. 20-354) is a middle shelf crescentic reef with an area of 2.5 sq.km.

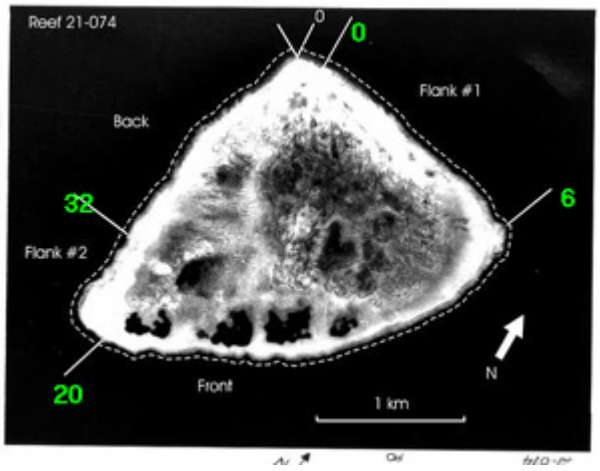
21-074

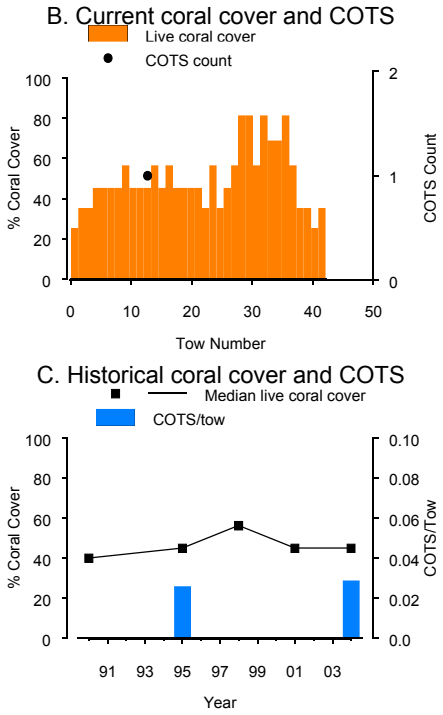
Surveyed October 2003.

Reef 21074 has been surveyed five times since 1990 using manta tow. Reef-wide live coral cover has been generally high over the period of survey (40-50%) and remained so in 2004. COTS were recorded in 1995 and in 2004, but in numbers too low to cause significant reef-wide coral mortality. This reef is currently classified as No Outbreak. No bleaching was observed in 2004 and white syndrome disease was restricted to a few scattered coral colonies.

Figure 4.118

A





21074 (No. 21-074) is a middle shelf lagoonal reef with an area of 4.39 sq.km.

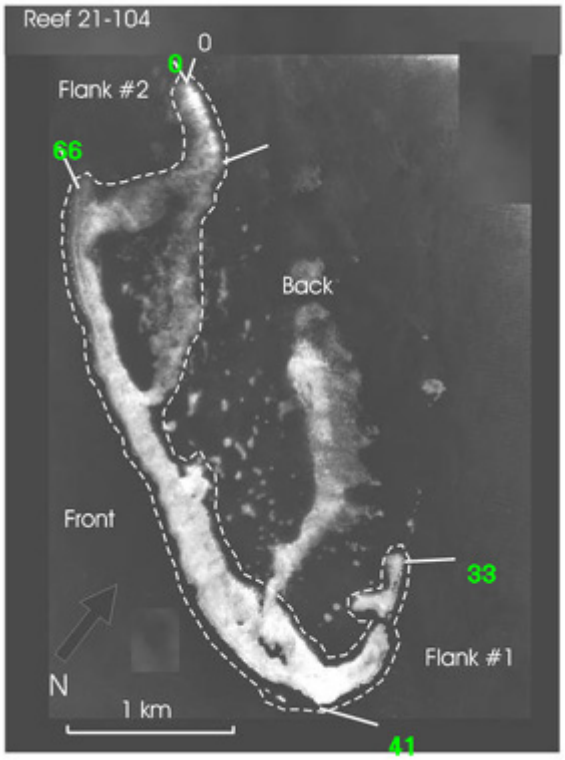
21-104

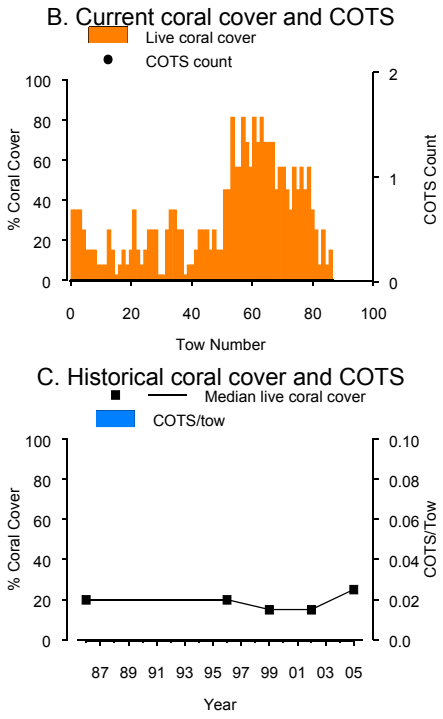
Surveyed December 2004.

Reef 21-104 was surveyed five times since 1986. There has been little change in reef-wide live coral cover, which remained at a moderate level (10-30%). No COTS have been recorded on any surveys and Reef 21-104 was classified as No Outbreak in 2005. No bleaching and low levels of white syndrome disease and black band disease were recorded, affecting only a few scattered coral colonies.

Figure 4.119

A





21104 (No. 21-104) is a middle shelf lagoonal reef with an area of 15.6 sq.km.

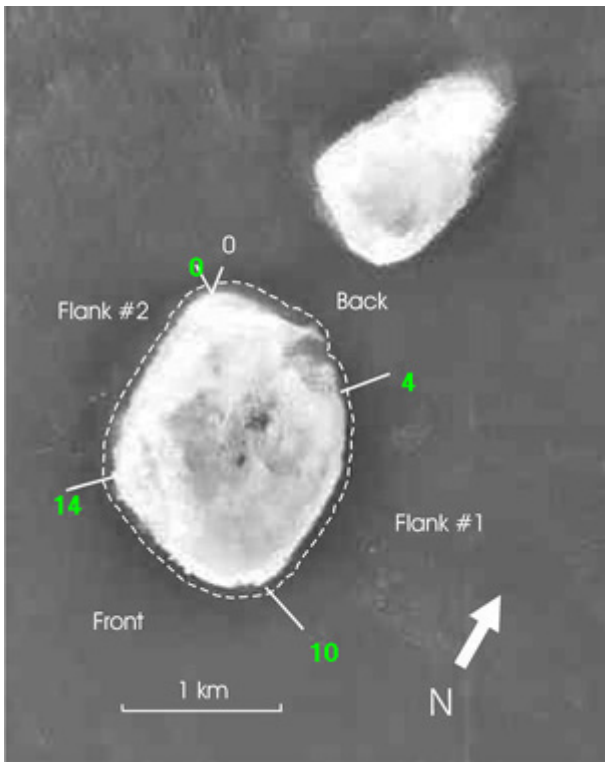
21-137

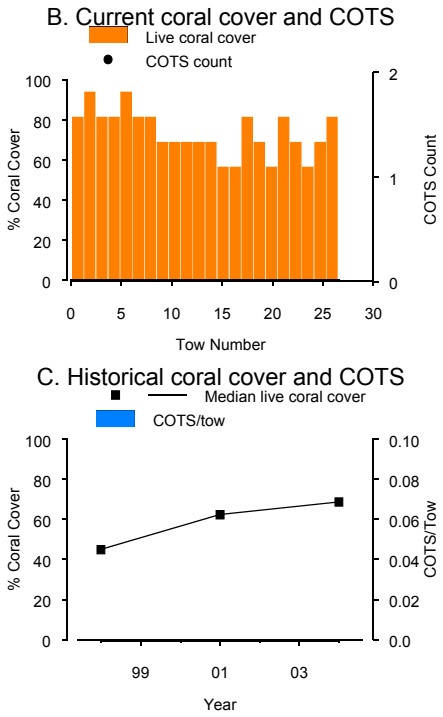
Surveyed October 2003.

Reef 21137 has been surveyed three times since 1998. In the absence of COTS and other forms of disturbance reef-wide live coral cover has continued to increase and was very high (62-75%) in 2004. The reef was classified as No Outbreak. No bleaching was observed in 2004 and white syndrome disease was restricted to a few scattered coral colonies.

Figure 4.120

A





21137 (No. 21-137) is a middle shelf planar reef with an area of 2.5 sq.km.

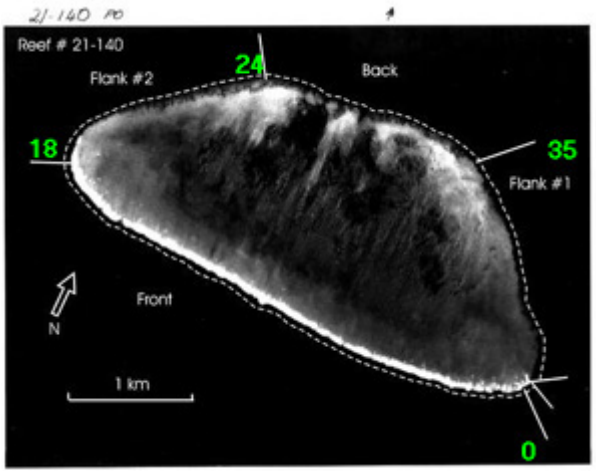
21-140

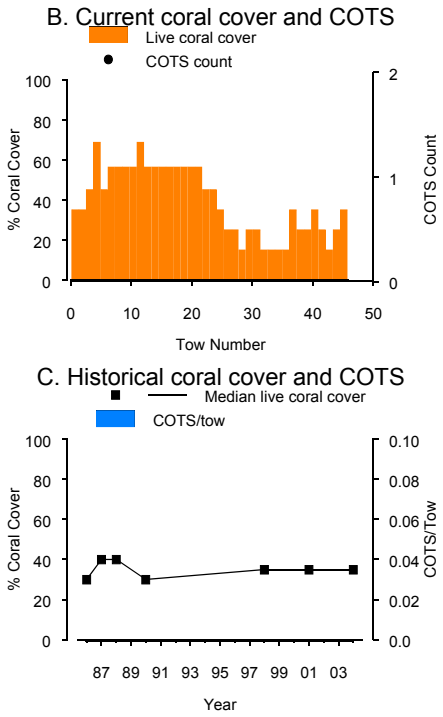
Surveyed October 2003.

Reef 21-140 has been surveyed seven times since 1986. There has been little change in reef-wide live coral cover over this time. Cover was high (30-40%) in 2004. No COTS or bleaching were observed in 2004 and white syndrome disease was restricted to a few scattered colonies. The reef continued to be classified as No Outbreak.

Figure 4.121

A





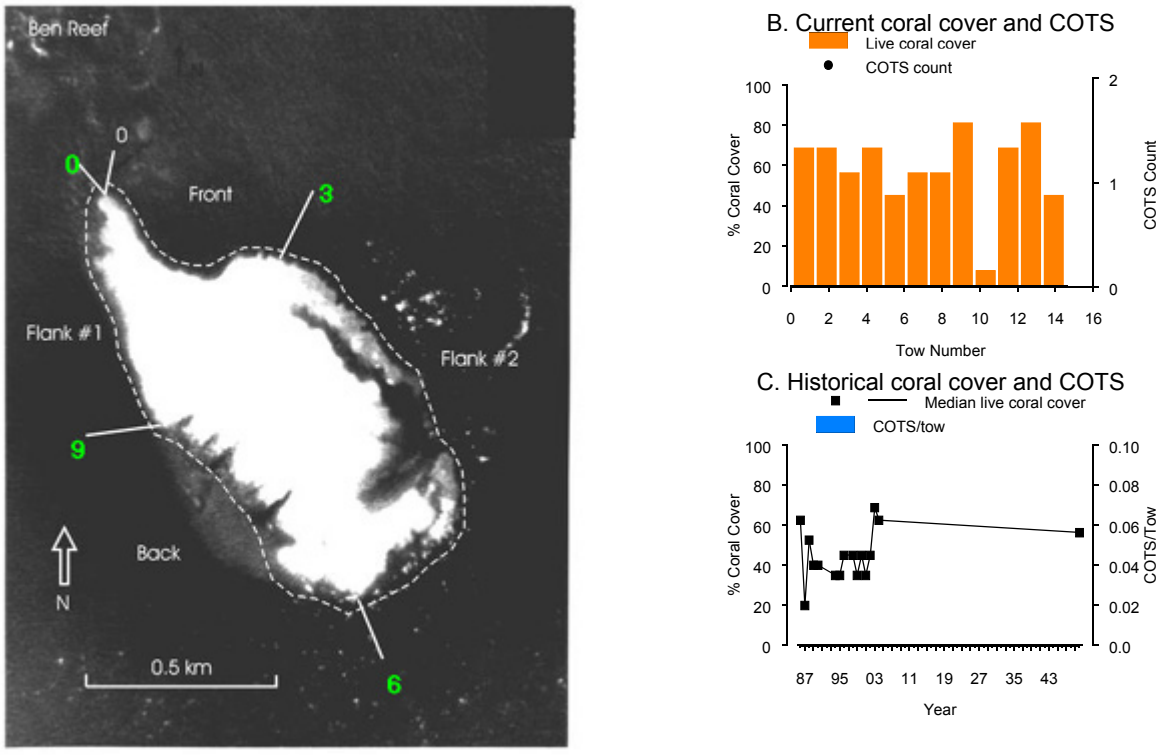
21140 (No. 21-140) is a middle shelf planar reef with an area of 5 sq.km.

BEN

Surveyed December 2004.

Ben Reef has been surveyed regularly since 1986. Reef-wide live coral cover was initially very high (50-75%) but declined to high levels (30-50%) during the 1990s then recovered to very high levels again in 2003. Coral cover remained very high in 2005. Ben Reef remained classified as No Outbreak in 2005. No bleaching was observed and the incidence of white syndrome disease was low, affecting only a few scattered coral colonies around the reef perimeter.

Figure 4.122 A



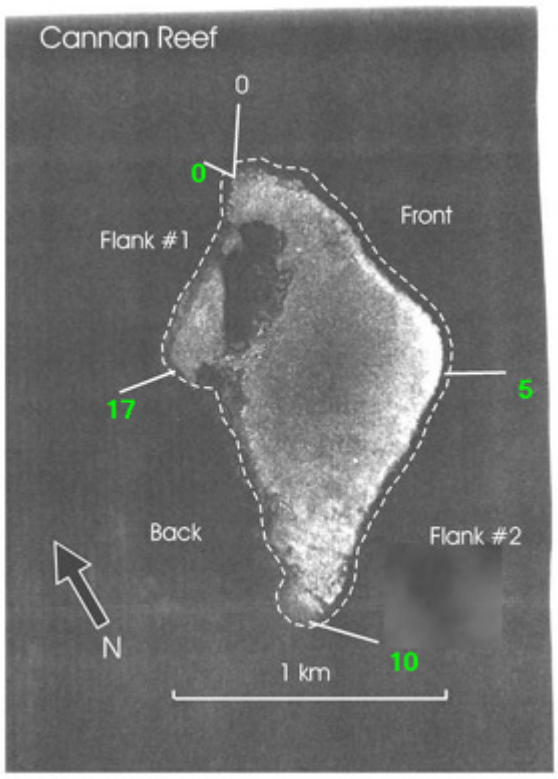
Ben (No. 20-113) is an outer shelf planar reef with an area of 1.2 sq.km.

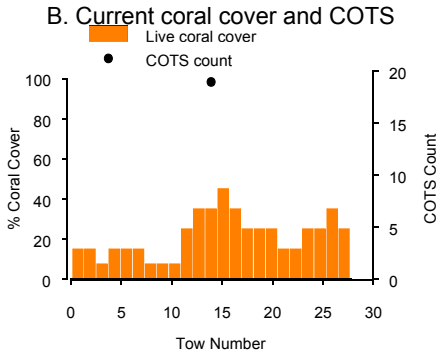
CANNAN

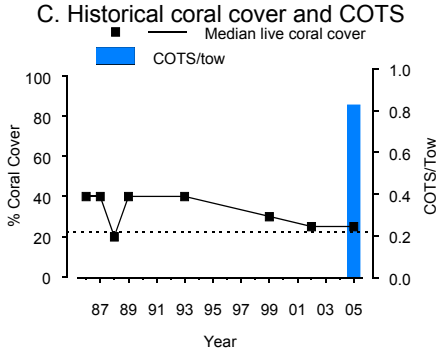
Surveyed December 2004.

Cannan Reef has been surveyed eight times since 1986. Reef-wide live coral cover was high (30-50%) initially but it decreased to be moderate (10-30%) in 2002. No COTS had been recorded, so the cause of the decline is unknown. Surveys in 2005 indicate reef-wide live coral cover remains moderate despite the presence of relatively large numbers of COTS (just below Active Outbreak levels) on Cannan Reef and it has been re-classified as Incipient Outbreak. No bleaching was recorded and the incidence of white syndrome disease was low, affecting only a few scattered coral colonies around the reef perimeter during surveys in 2005.

Figure 4.123 A







Cannan (No. 20-144) is a middle shelf crescentic reef.

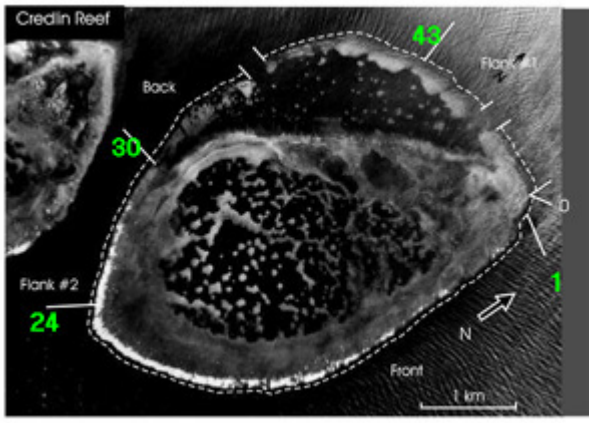
CREDLIN

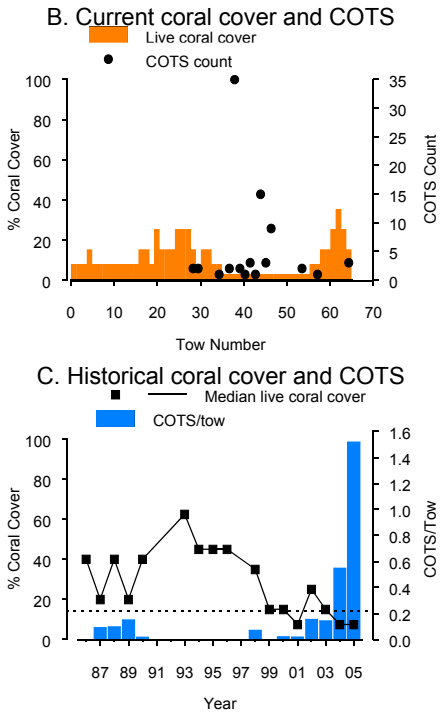
Surveyed December 2004.

Credlin Reef has been surveyed 17 since 1986 when it had high reef-wide live coral cover (30-50%) and no COTS. COTS were observed between 1987 and 1990, though in numbers usually considered too low to have an effect on overall coral cover. Reef-wide live coral cover peaked in 1993 at very high levels (50-75%), then declined to be low (1-10%) in 2001. The reasons for this decline were unclear, but cyclone Justin in 1997 may have contributed. COTS almost certainly have contributed with populations observed in 1998 and 2000 to 2003 but below outbreak densities. There was a further decrease in 2003 which was almost certainly due to bleaching in 2002. In 2005 COTS activity has continued increase on Credlin Reef and it was re-classified from an Incipient Outbreak in 2004 to Active Outbreak in 2005. Elevated COTS activity have contributed to a further decline in coral cover on this reef which is now at a low level (1-10%). No bleaching was recorded and the incidence of white syndrome disease was low, affecting only a few scattered coral colonies on the front and southern flank of the reef during surveys in 2005.

Figure 4.124

A





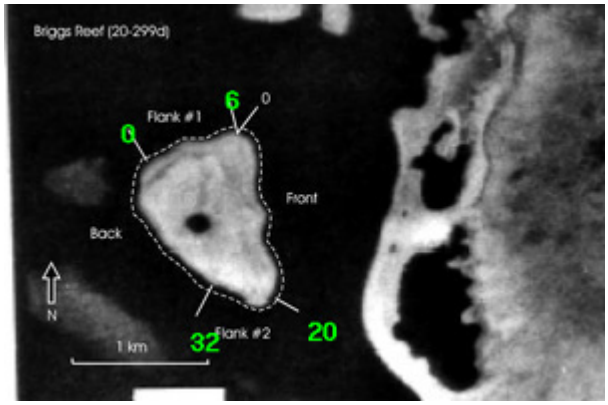
Credlin (No. 20-287) is a middle shelf lagoonal reef with an area of 9.4 sq.km.

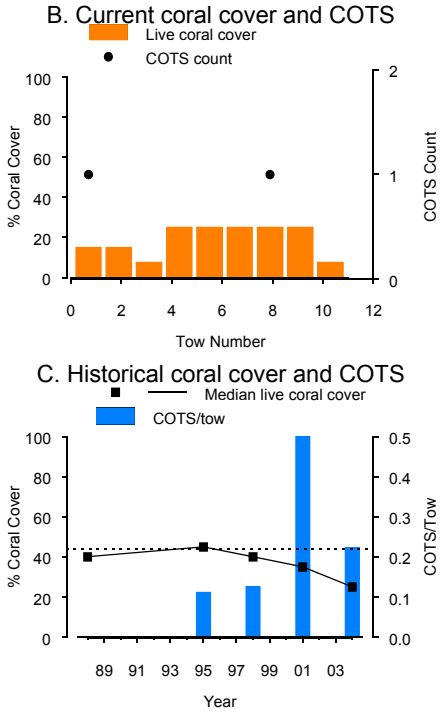
SOUTHAMPTON (BRIGGS)

Surveyed October 2003.

Southampton (Briggs) Reef has been surveyed five times since 1986 using manta tow. During much this time there was little change in reef-wide live coral cover which remained high (40-50%) until 2001. Surveys in 2001 revealed COTS in numbers high enough to cause significant coral mortality and the reef has been reclassified from No Outbreak to Incipient Outbreak. Surveys in 2004 show COTS remain active on this reef and there has been a corresponding decline in coral cover to a current moderate (20-30%) level. The reef remains classified as Incipient Outbreak. No bleaching or disease was observed during surveys in 2004.

Figure 4.125 A





Southampton (Briggs) (No. 20-299) is a middle shelf lagoonal reef with an area of sq.km.

Swain

Reef Pages

21-529

Surveyed November 2004.

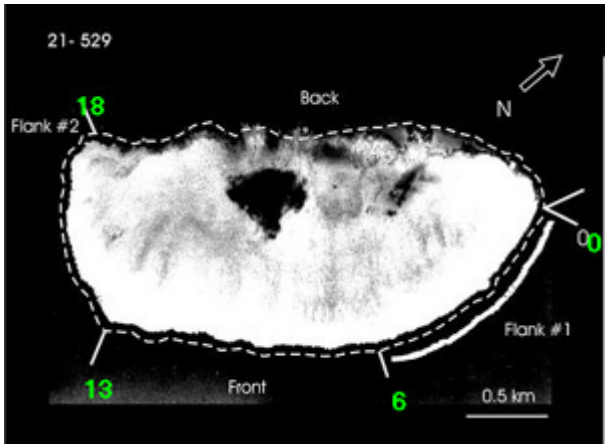
Reef 21-529 has been surveyed 12 times since 1993. Broadscale surveys show that reef-wide live coral cover remained at moderate levels (10-30%) until 1997. From 1998 up until 2004 reef-wide live coral increased steadily to very high values (50-75%). Surveys in 2005 indicate reef-wide live coral cover continues to increase. No COTS have been observed in any survey and Reef 21-529 was classified as No Outbreak in 2005. No bleaching was observed, however, low levels of white syndrome disease and black band disease were recorded. Disease affected only a few scattered coral colonies around the reef perimeter.

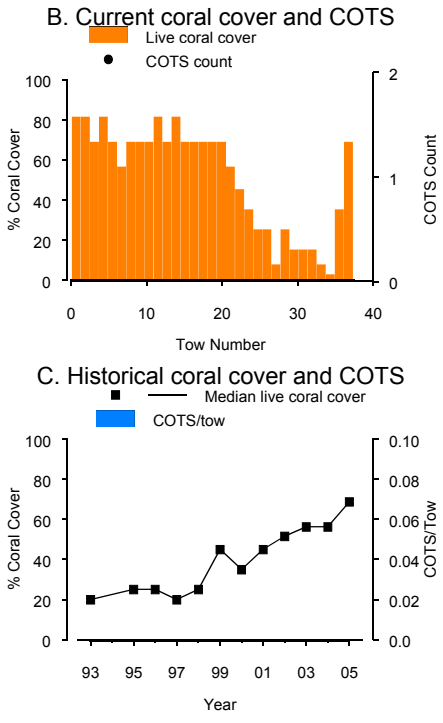
Detailed coral surveys showed that cover of hard coral has risen steadily over the period of surveys. Hard coral cover increased from an average of 29% in 1995 to reach a maximum of 64% in 2002. In 2005 hard coral cover was 51%. Algal cover declined correspondingly, from 64% in 1995 to 43% in 2005. Soft coral cover remained very low (< 2%) since the first survey. Changes in hard coral cover have largely been due to changes in cover of bottlebrush and branching *Acropora* spp., these taxa have remained dominant throughout this study. The prevalence of disease was high on this reef in 2003 but dropped to a moderately low level by 2005. The density of corallivorous snails *Drupella* spp. was 160/ha in 2005.

Although abundances of fishes have varied from year to year there has been little tendency for prolonged increases or decreases in most taxa over the 13-year study period. Numbers of the common coral trout (*Plectropomus leopardus*) were at 13 year high in 2005, although numbers had varied considerably from year to year. One genus (*Pomacentrus*), tended to decline in abundance. In 2003, numbers of three *Pomacentrus* species, *P. wardi*, *P. brachialis* and *P. lepidogenys*, were the lowest since surveys began and for the first time *P. coelestis* was not recorded in surveys. Numbers were still low in 2005.

Figure 4.126

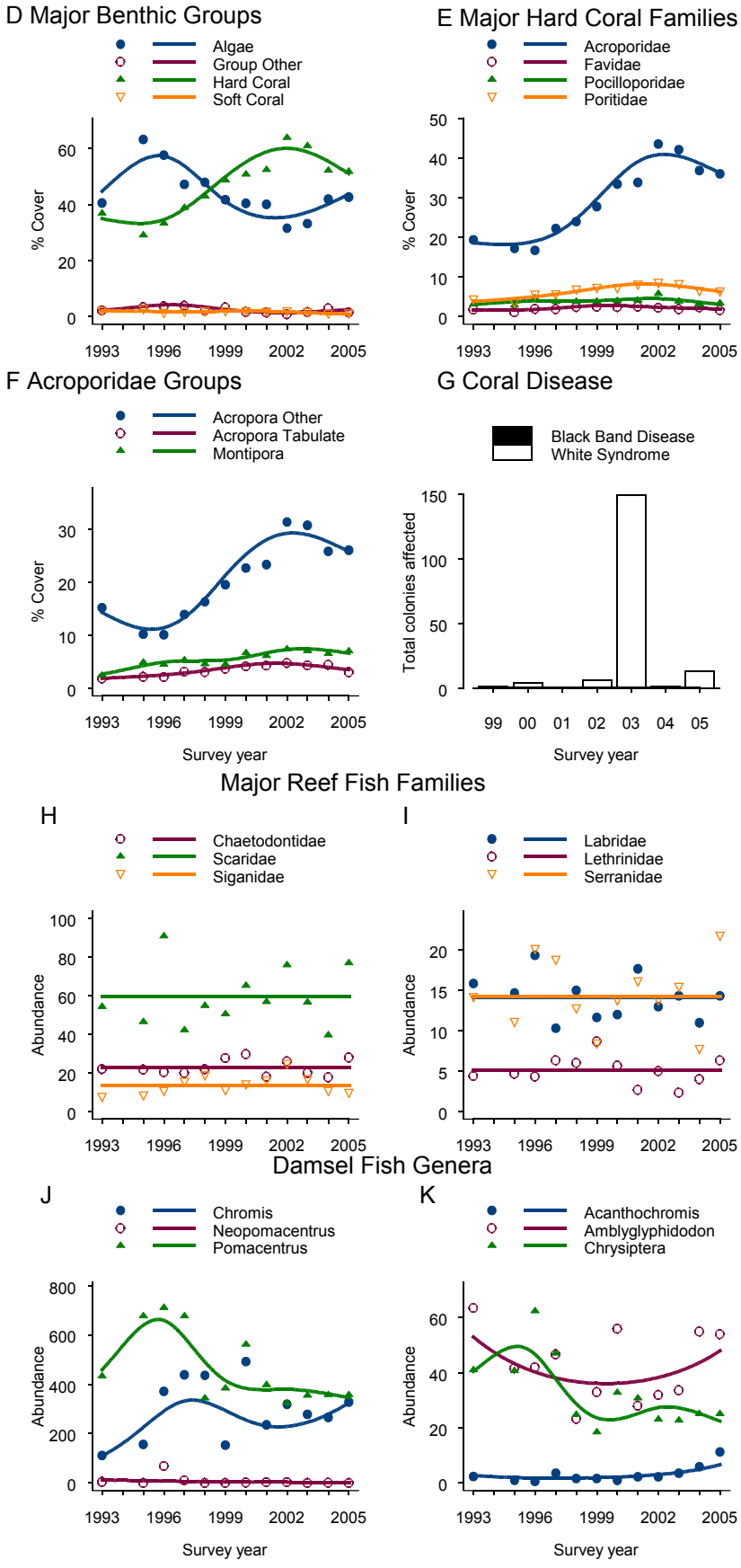
A





21529 (No. 21-529) is a middle shelf crescentic reef with an area of 6.3 sq.km.

Figure 4.126 (Cont).



CHINAMAN

Surveyed November 2004.

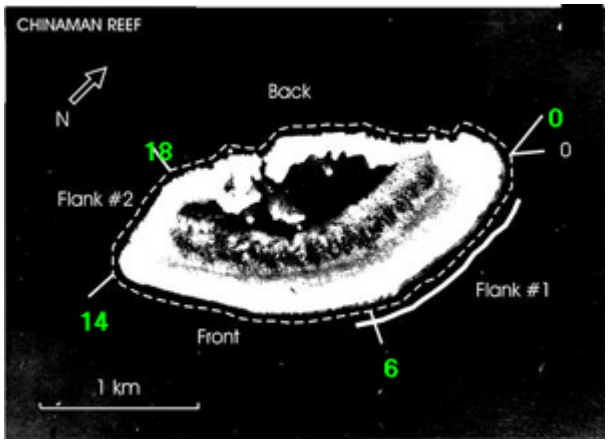
Chinaman Reef has been surveyed 17 times since 1986. Although COTS have been recorded regularly during manta tow surveys, Chinaman Reef was only classified as an Active Outbreak in 1998. Reef-wide live coral cover has fluctuated over the period of survey. There was a notable drop in coral cover between 1988 and 1990, coinciding with similar declines on reefs in the Capricorn Bunker sector. Storm damage is considered the most likely cause. From 1990 reef-wide live coral cover increased reaching high levels (30-50%) in 1999. Since then there has been an Active Outbreak of COTS that caused a decline in reef-wide live coral cover to low levels (1-10%). Surveys in 2004 showed COTS were still active on Chinaman Reef and it remained classified as Active Outbreak. Even though small numbers of COTS (1) were observed in 2005 Chinaman Reef has been reclassified as Recovering. Reef-wide live coral cover was moderate (10-20%) in 2005. No bleaching was recorded in 2005 and white syndrome disease was restricted to a few scattered coral colonies on the northern flank.

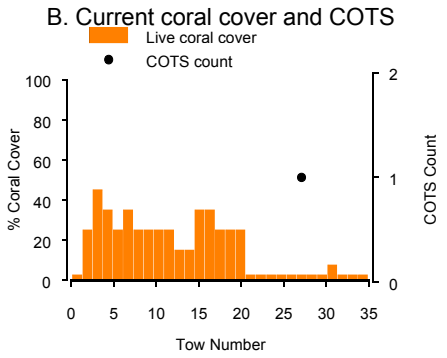
Hard coral cover increased from approximately 22% initially to 44% in 2003, and was 40% in 2005. The increase was mainly driven by Acroporidae, particularly tabulate *Acropora* spp, however the second most abundant family, the Poritidae, show the same increasing trend. Algal cover decreased correspondingly since 1993. Declines in soft coral occurred following the summers of 1998 and 2002 , probably due to bleaching mortality. The soft coral community was dominated by Xeniidae and cover in 2005 was moderately high at 27%. The density of corallivorous snails *Drupella* spp. was 140/ha in 2005 and there were a small number of colonies recorded with white syndrome disease.

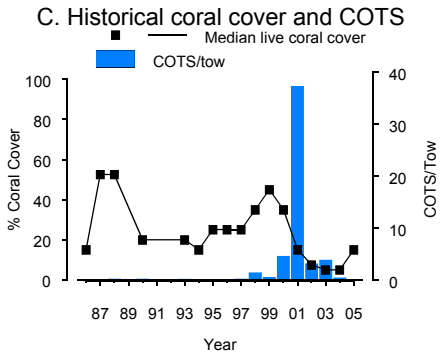
Although year-to-year variation in abundance was common there was little tendency for prolonged increases or decreases in most taxa. The decline in numbers of family Acanthuridae since 1999 was arrested in 2005, largely due to increases in abundance of *Ctenochaetus* species and *Zebrasoma scopas*. The increase in numbers of family Chaetodontidae over the 13 years of surveys was driven by the coral-associated species, *Chaetodon rainfordi*, *C. trifascialis* and *C. trifasciatus*. Numbers of three larger bodied damselfish species, *Plectroglyphidodon lacrymatus*, *Acanthochromis polyacanthus* and *Amblyglyphidodon curacao*, were at a 13 year high in 2005. A decrease in numbers of the genus *Pomacentrus* in 2005 was largely due to the numerically dominant *P. lepidogenys*. Conversely, numbers of *P. wardi*, a species whose numbers had declined over the study period, had increased dramatically in 2005. Numbers of *Neopomacentrus azysron* remained very low in 2005.

Figure 4.127

A

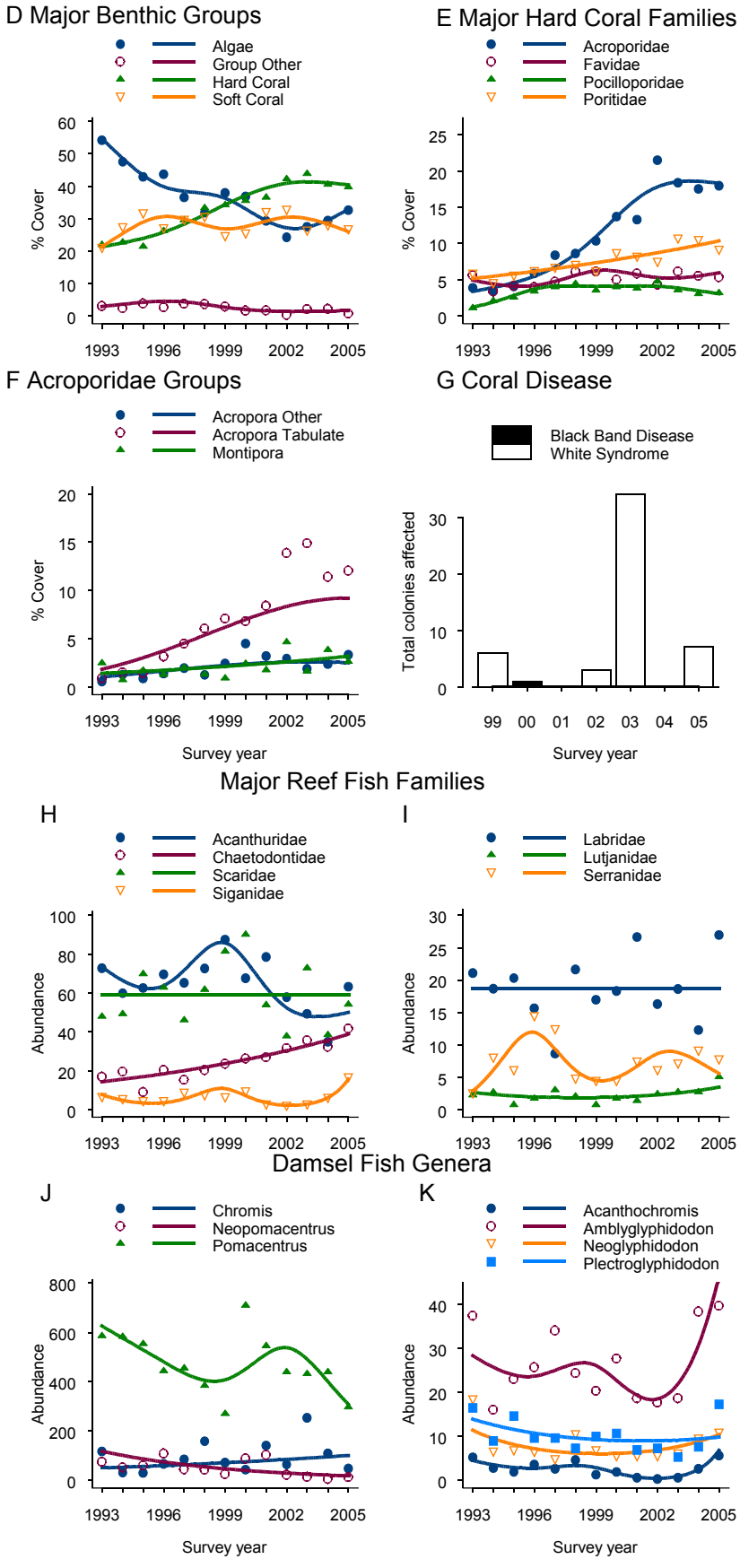






Chinaman (No. 22-102) is a middle shelf lagoonal reef with an area of 3.1 sq.km.

Figure 4.127 (Cont).



EAST CAY

Surveyed November 2004.

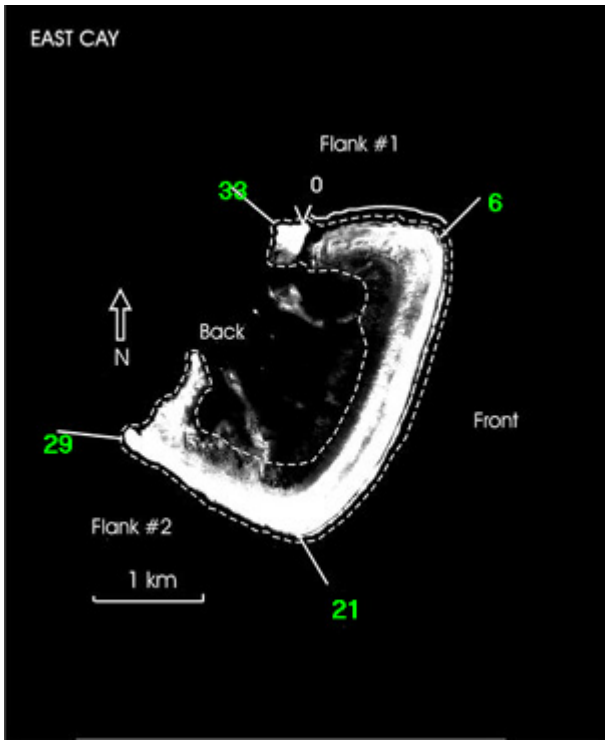
East Cay Reef has been surveyed 13 times since 1992 when reef-wide live coral cover was high (30-50%). Coral cover dropped to moderate levels (10-30%) in 1994 for unknown reasons and cover remained moderate in 2005. COTS have been recorded sporadically but below outbreak densities. Low numbers of COTS were observed in 2002, 2003 and 2004 and East Cay Reef was classified as No Outbreak. No COTS were observed in 2005. No bleaching was recorded in 2005 and white syndrome disease was restricted to a few scattered coral colonies on the back and southern flank of the reef.

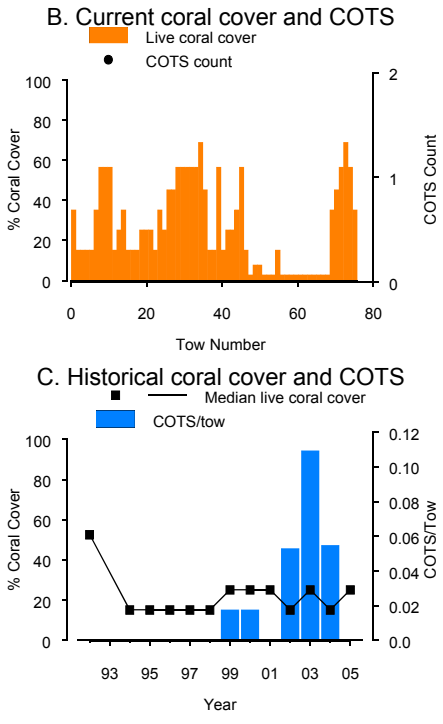
Hard coral cover at the intensive survey sites increased gradually after 1994 and average 19% in 2005. Turfing algae and soft corals were the dominant benthic groups, averaging 30% and 22% respectively. There were small declines in cover of several hard coral families and a large decline in cover of Xeniidae soft corals. High sea surface temperatures were recorded in the summer of 2002 and bleaching mortality was the likely cause. The cover of sponges was the highest in the Swain sector at 3% in 2005. No COTS were recorded during SCUBA search surveys in 2005 however *Drupella* were recorded at a density of 47/ha, and 1 coral colony was recorded with white syndrome.

Numbers of the family Acanthuridae peaked in 2002 then declined to previous levels. This trend was driven largely by the genus *Ctenochaetus* and may reflect a local aggregation of this genus during 2002 surveys. Numbers of scarids were also high in 2003, but had fallen considerably by 2005. The large rise in family Labridae numbers in 2005 was driven largely by high counts of *Hemigymnus fasciatus* and *Gomphosus varius* on some transects. Numbers of a larger damselfish species, *Amblyglyphidodon curacao* declined steadily from 1998 to a low in 2003. The reasons for these declines are unknown but successful recruitment events may be sporadic in this region. Numbers had recovered to the levels present at the start of the surveys in 2004 before falling again in 2005.

Figure 4.128

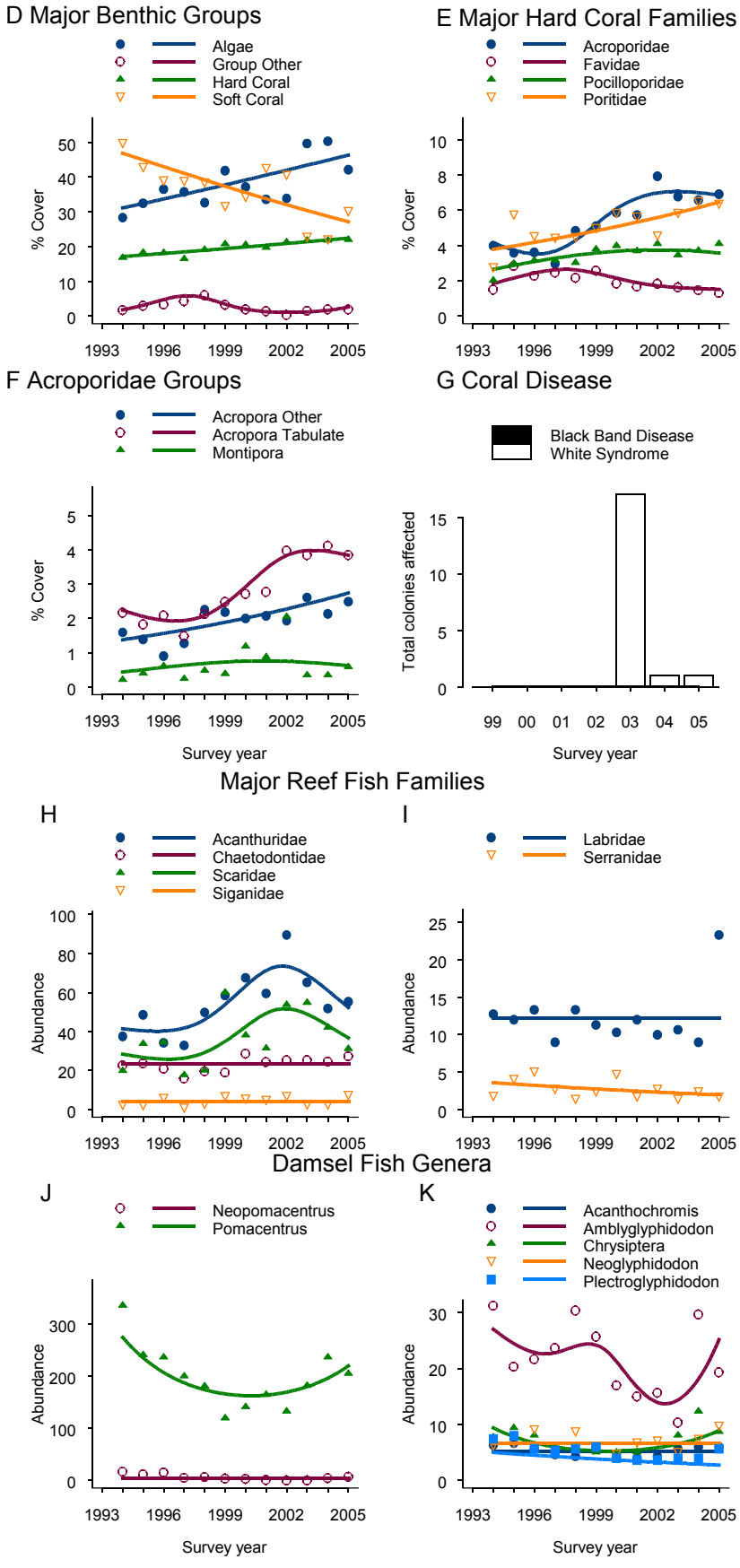
A





East Cay (No. 21-305) is an outer shelf crescentic reef with an area of 6.3 sq.km.

Figure 4.128 (Cont).



GANNET CAY

Surveyed November 2004.

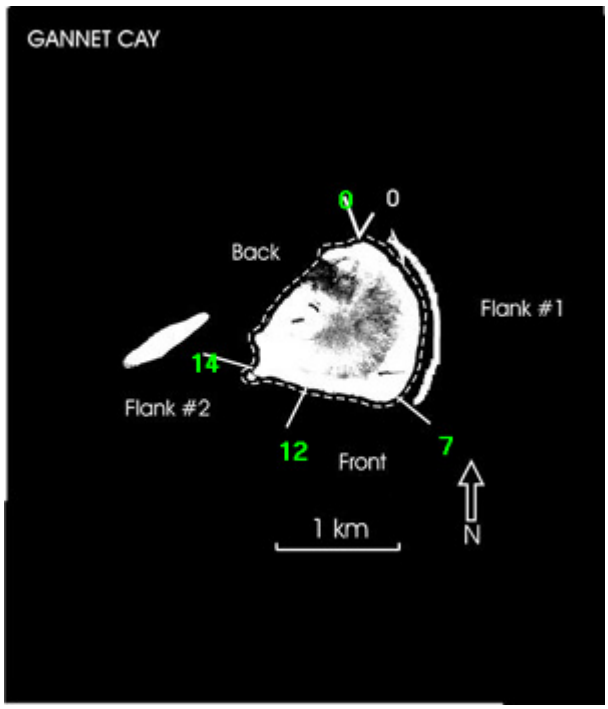
Gannet Cay Reef has been surveyed 19 times using manta tow since 1986. COTS have been present at Outbreak levels at fifteen of the nineteen surveys. As a result, reef-wide live coral cover has declined dramatically from the extremely high levels (75-100%) in the 1980s to a very low level (1-5%) by 2002. While there was some recovery between 1995 and 1997 when COTS were below outbreak levels, increases in COTS numbers, particularly in 2001, have seen a general downward trend in coral cover since the early 1990's. Surveys in 2004 showed COTS numbers had declined on Gannet Cay Reef (most likely due to lack of coral cover) and it has been reclassified as Recovering. Reef-wide coral cover remained very low on this reef in 2005 and no COTS were observed. Gannet Cay Reef remains classified as Recovering. No bleaching or coral disease was recorded in 2005.

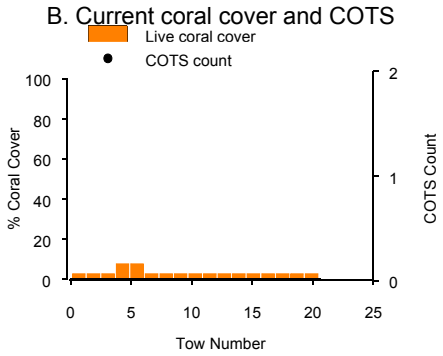
Surveys of the intensive study sites since 1993 show a steady decline in hard coral cover due to COTS predation. Cover of hard corals was 60% in the first year of survey but has declined consistently to a low of approximately 9% cover in 2005. This decline is mostly due to the loss of branching *Acropora* colonies. Cover of Pocilloporidae also decreased slightly. In 2005, Poritidae was the most abundant family at 2% cover. Algal cover has shown a corresponding increase in cover (32% in 1993 to 80% in 2005), due largely to an increase in turf algae. Soft coral cover has increased overall from 3% to 8% in 2005. The density of corallivorous snails *Drupella* spp. was 53/ha in 2005 and 1 COTS was observed during scuba search surveys. No instances of coral disease were recorded.

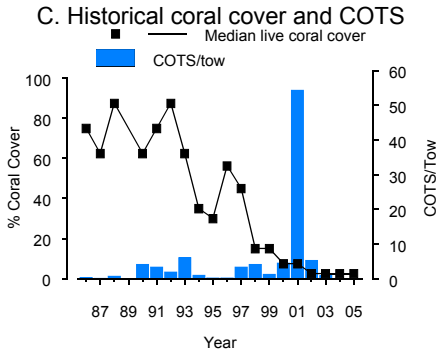
The decline in hard coral cover from over 60% to under 10% over the study period has almost certainly influenced some fish taxa, yet numbers of most taxa appear to be varying independently of the massive coral declines. One exception is the coral dwelling damselfish, *Pomacentrus moluccensis*. This species was initially abundant but numbers have slowly declined to a 13-year low in 2005. Two coral-associated butterflyfish, *Chaetodon rainfordi* and *C. aureofasciatus*, had decreased in abundance, yet both increased in abundance in 2005 to 6 and 4 year highs respectively, even though coral cover was still very low. Numbers of the snapper *Lutjanus carponotatus* and the commercially important coral trout, *Plectropomus leopardus* reached a 12-year low in 2003 but numbers of both species had increased by 2005. Large increases in *Chromis* abundance in 2005 was due to *C. nitida*, a plankton feeding damselfish which often swarms in very large numbers.

Figure 4.129

A

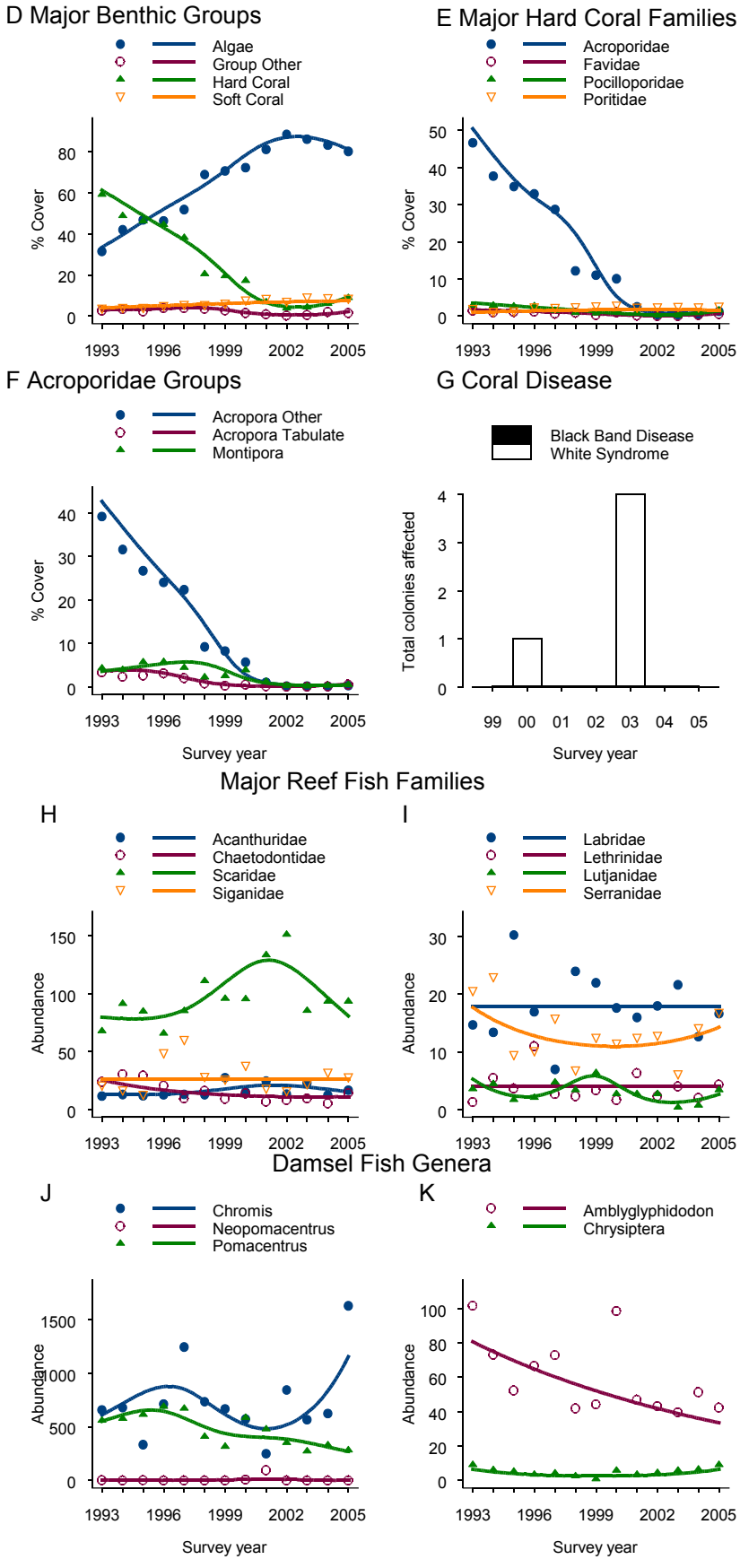






Gannet Cay (No. 21-556) is a middle shelf planar reef with an area of 1.2 sq.km.

Figure 4.129 (Cont).



HORSESHOE

Surveyed November 2004.

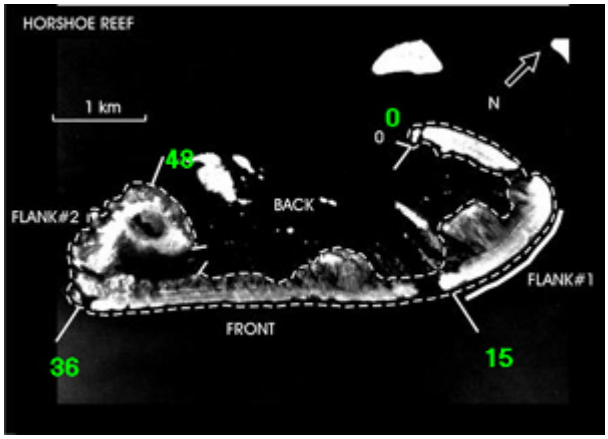
Horseshoe Reef has been surveyed 14 times since 1986. There was an Incipient Outbreak of COTS in 1986 then COTS numbers dropped below outbreak levels until 1995. There was a small increase in reef-wide live coral cover up until 1995. COTS activity then increased, peaking in 1998 and again in 2003, with a corresponding decline in reef-wide live coral cover. In 2004 reef-wide coral cover was the lowest yet recorded (1-5%). Surveys in 2005 indicate COTS remain active on Horseshoe Reef and it stays classified as an Active Outbreak. Reef-wide live coral cover remains very low. No bleaching or disease was recorded during surveys in 2005.

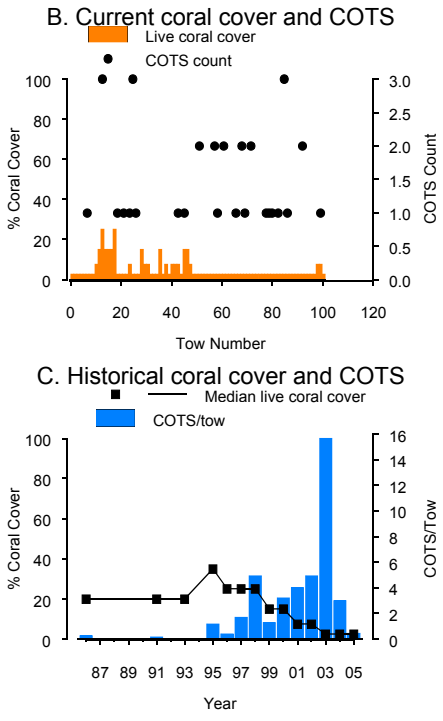
The detailed benthic surveys on Horseshoe Reef show that hard coral cover increased until 1997. Coinciding with an active outbreak of COTS in 1998, coral cover then declined to 11% in 2003. In 2005 coral cover was 15%. In 2005 Poritidae was the most abundant coral family at 4.7%. The cover of soft corals remained reasonably stable, fluctuating around a mean of 5%. The cover of algae increased after 1997 and was 78% in 2005, which was comprised of 10% Coralline algae, 67% turf algae and 1% other algae groups. There were no corallivorous snails *Drupella* spp, or incidents of coral disease recoded in the 2005 scuba search surveys.

The decline in coral cover since 1997 has almost certainly affected some fish taxa, yet numbers of many taxa appear to be varying independently of the major coral declines. Two coral-associated species from family Chaetodontidae, *Chaetodon rainfordi* and *C. plebeius*, have decreased in abundance, however *Chaetodon* numbers had increased in 2005 even though coral cover was still low. Numbers of Labridae have increased over the 12 years of surveys. Numbers of *Lutjanus carponotatus* and the commercially important common coral trout, *Plectropomus leopardus* increased from the13 year lows in 2003. The damselfish, *Pomacentrus moluccensis* was initially abundant but had declined to very low numbers in 2005; this species lives among the small branching corals that were most affected during the crown-of-thorns starfish outbreak. Numbers of another previously abundant *Pomacentrus* species, *P. lepidogenys* were also at a 13 year low in 2005. In stark contrast, *P. wardi* numbers had increased to a 13 year high in 2005. A number of *Chromis* species, previously present in low numbers have not been recorded since 2003.

Figure 4.130

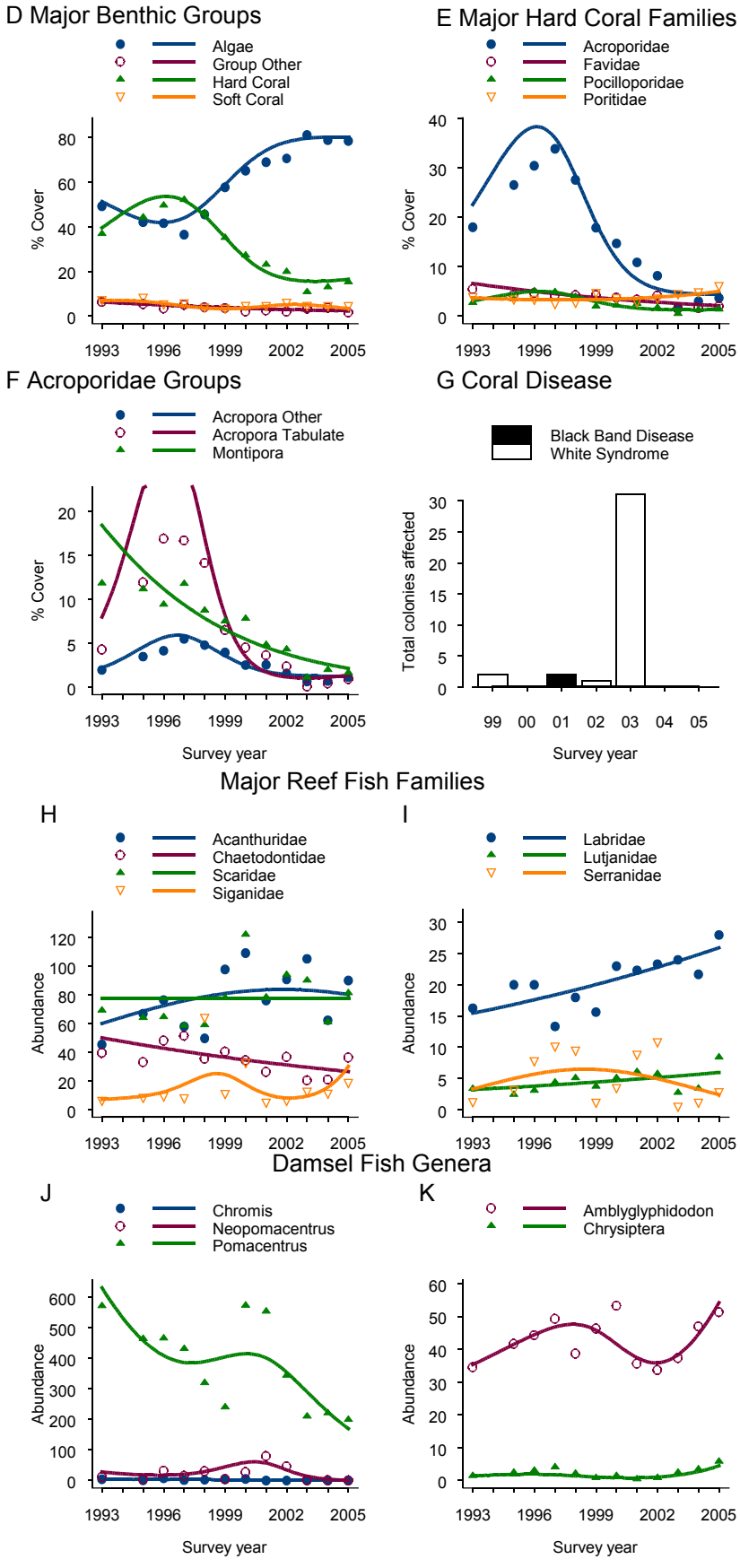
A





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

Figure 4.130 (Cont).



SNAKE

Surveyed November 2004.

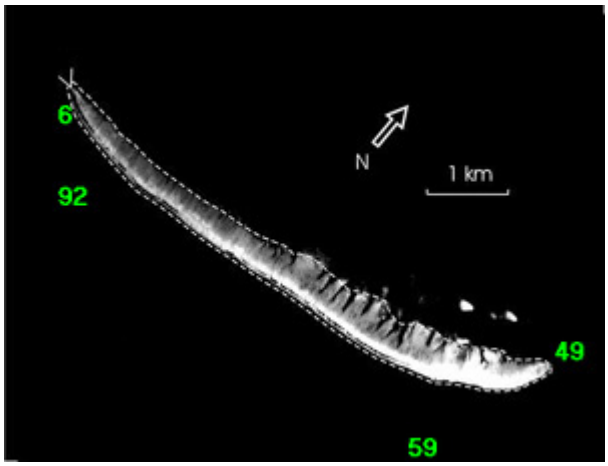
Snake Reef has been surveyed 13 times since 1993 when COTS numbers were high. Snake Reef was classified as having an Incipient Outbreak until 1997 and reef-wide live coral cover dropped from a high level (30-50%) in 1993 to a low level (1-10%) by 1997. Snake Reef was reclassified as Recovering from then on. No COTS were observed after 1997 and there has been a steady recovery in reef-wide live coral cover to moderate (10-30%) levels. Surveys in 2005 show reef-wide live coral cover is moderate on Snake Reef and it remains classified as Recovering. Low levels of bleaching, black band disease and white syndrome disease, restricted to a few scattered coral colonies around the reef perimeter, were observed during surveys in 2005.

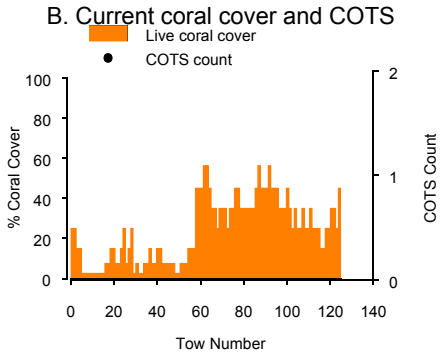
Cover of hard corals in the intensive survey sites decreased to a low of 17.4% in 1997, coinciding with an incipient outbreak of COTS. After 1998 hard coral cover increased to 54% in 2005. There has been a steady increase in the abundance of the families Acroporidae which is currently the most abundant family of hard corals on this reef with an average cover of 22%. The cover of algae decreased correspondingly, averaging 34% in 2005. While soft coral abundance was low, there had been a gradual increase in cover, and in 2005, soft corals averaged 9%. The density of corallivorous snails *Drupella* spp. was 120/ha in 2005. Coral diseases have been observed on this reef in moderate numbers since 2002 and in 2005 there were was a moderate to high record of sightings.

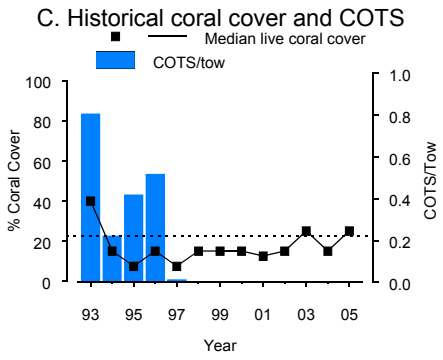
Although year-to-year variation in abundance has been common there has been little tendency for prolonged increases or decreases in most taxa. The increase in numbers of Chaetodontidae reflected an influx of coral-associated species such as *Chaetodon rainfordi* and *C. aureofasciatus*. Numbers of the genus *Pomacentrus*, have shown no long-term trends. However, numbers of the numerically dominant species *P. lepidogenys* increased dramatically from 1999 to 2000, most probably due to a particularly good recruitment season. Numbers of *P. wardi* declined consistently from 1996 to 2003, but reached a seven year high in 2005.

Figure 4.131

A

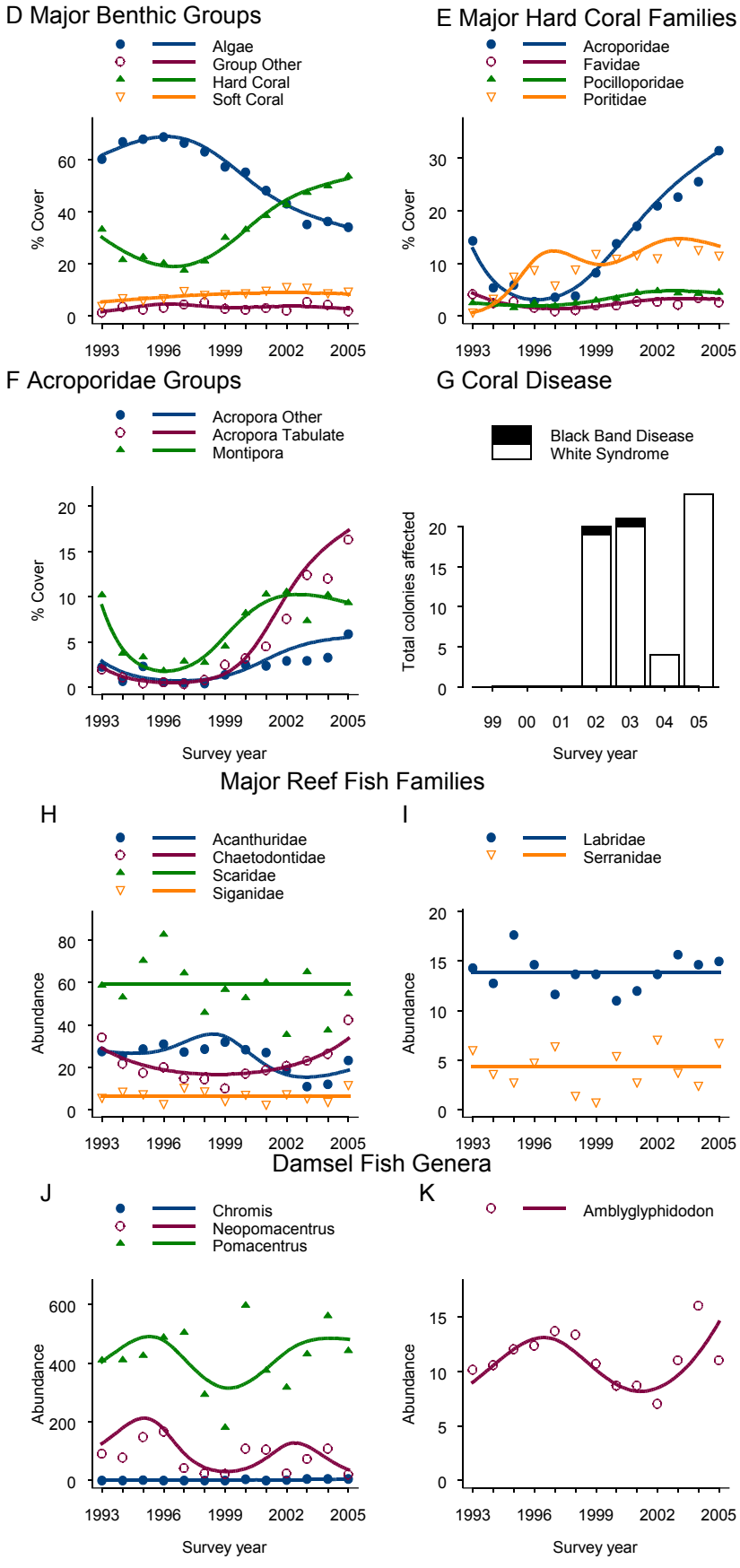






22088 (No. 22-088) is an middle shelf ribbon reef with an area of 14.4 sq.km.

Figure 4.131 (Cont).



TURNER CAY

Surveyed November 2004.

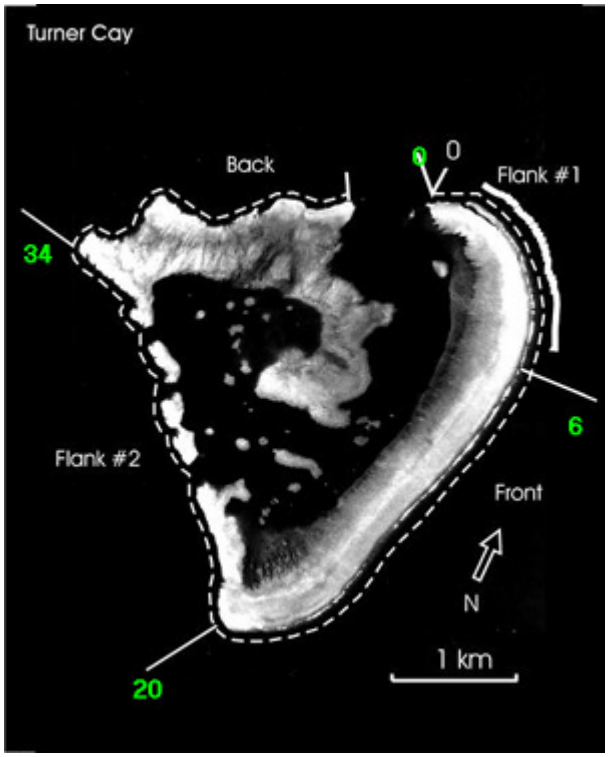
Turner Cay Reef has been surveyed 12 times since 1994. Over this time, reef-wide live coral cover gradually increased to high levels (30-50%), peaking in 1999. Reef-wide live coral cover remained at this level until 2001, when COTS numbers increased dramatically to very high levels and Turner Cay Reef was reclassified as an Active Outbreak. The Active Outbreak persisted until 2004 and reef-wide live coral cover declined to a low level (1-10%). Surveys in 2005 indicate a large reduction in COTS numbers on Turner Cay Reef and it has been reclassified as Recovering. No bleaching was recorded in 2005 and the incidence of white syndrome disease was low, affecting a few scattered coral colonies on the back and southern flank of the reef.

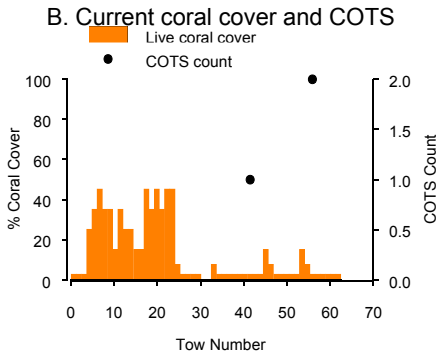
Cover of hard corals on the intensive survey sites exhibited an increasing trend from 1994, when surveys began, to 1999 where the cover was 33%. By 2004, hard coral cover decreased to 13%. This decline coincided with an outbreak of COTS which lasted from 2001 to 2004. By 2005, no COTS were observed during scuba searches and coral cover increased slightly to 15%. The cover of soft corals in 2005 was 24% which was slightly lower than previous surveys, while algal cover (mostly turf and coralline) remained at 57% from 2003-2005. *Drupella* were not observed during 2005 SCUBA search surveys, nor were any coral diseases.

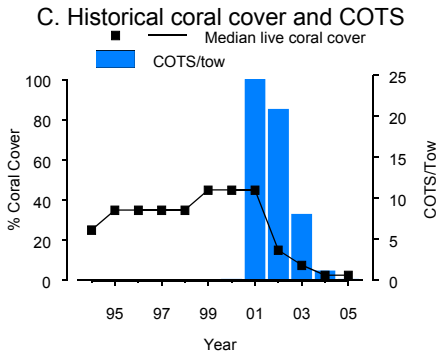
Large mobile fish species numbers were either fairly stable or tended to increase in abundance between 1993 and 2005, even though hard coral cover had considerably declined since 2001. In 2005, numbers of the families Acanthuridae, Labridae and the commercially important coral trout, *Plectropomus leopardus*, were the highest yet recorded. Numbers of three coral-associated butterflyfishes, *Chaetodon rainfordi*, *C. melannotus* and *C. trifascialis*, decreased substantially after 2002 when the large outbreak of crown-of-thorns starfish reduced live coral cover. By 2005, numbers of *C. rainfordi*, and *C. melannotus* had recovered to previous levels. Numbers of damselfish taxa tended to be stable or had declined during the study period. Abundance patterns for *Pomacentrus* spp. followed the abundant *P. lepidogenys*. Numbers of *P. wardi* and *P. coelestis* were also relatively low in 2005 after significant declines. In 2005, abundances of a number of other taxa, including the genus *Chromis*, *Neopomacentrus azysron*, *Neoglyphidodon melas* and *Chrysiptera rex*, were around the lowest yet recorded. We suspect that successful recruitment events for small, site-attached damselfishes may occur sporadically in this region.

Figure 4.132

A

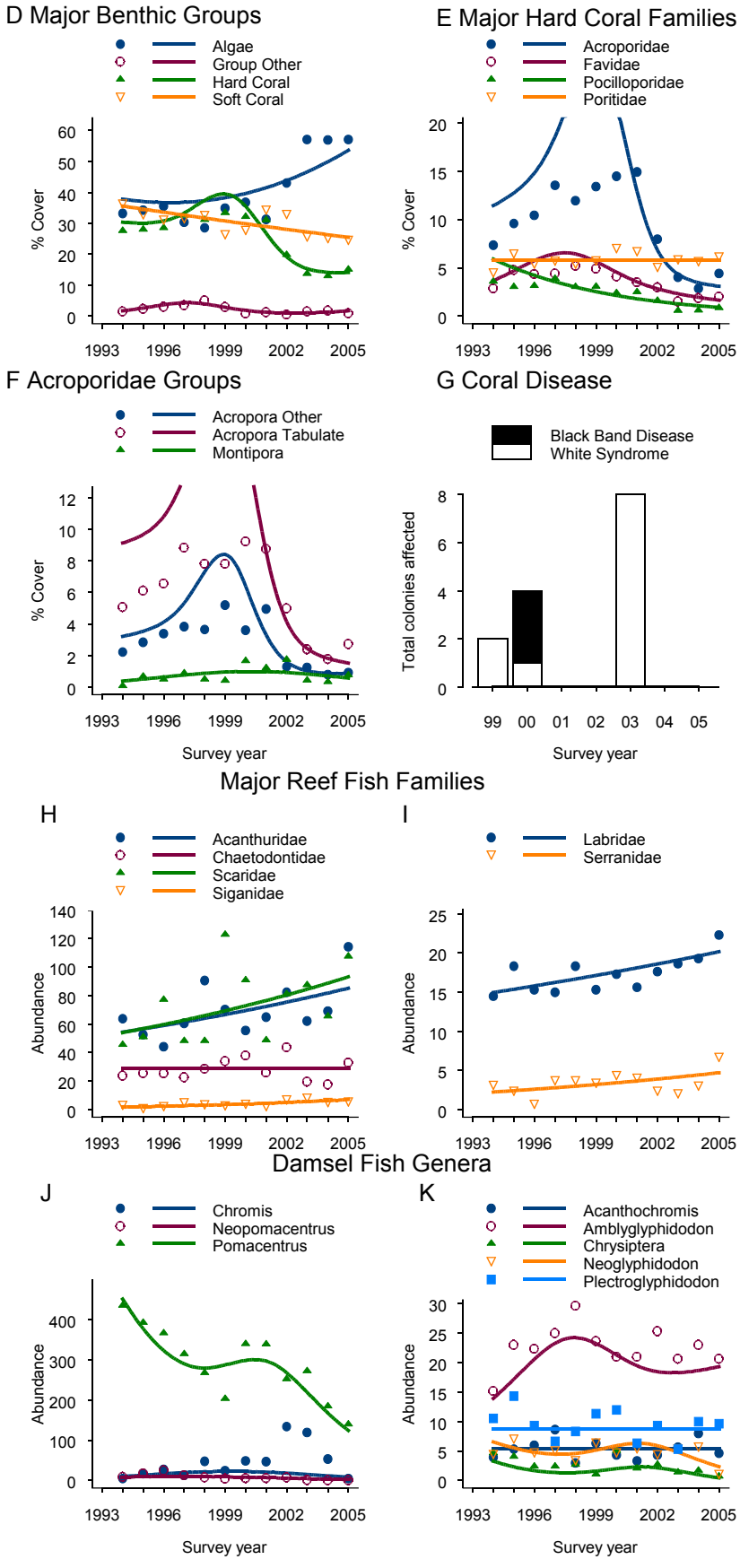






Turner Cay (No. 21-562) is an outer shelf lagoonal reef with an area of 5 sq.km.

Figure 4.132 (Cont).



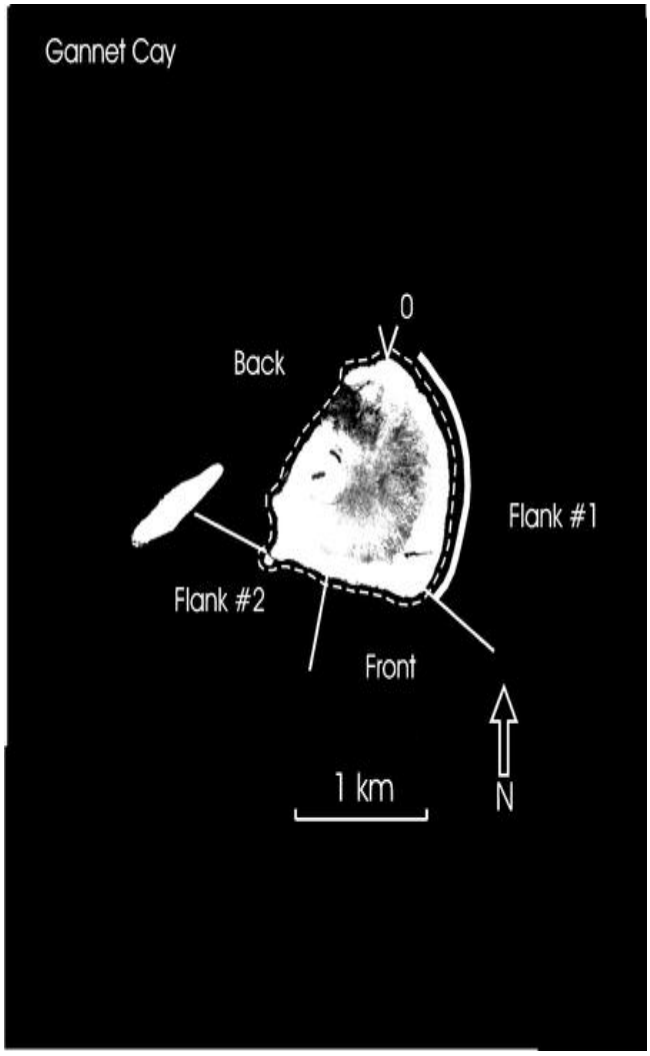
21-557

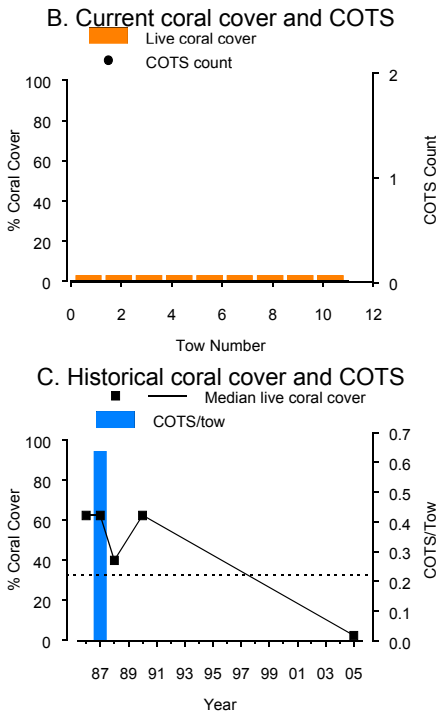
Surveyed November 2004.

Reef 21-557 has been surveyed four times between 1986 and 1990. During this time reef-wide live coral cover decreased from very high values (50-75%) to moderate levels (30-50%). COTS were also observed in low numbers at the same time and may be associated with the drop in coral cover. Cover declined to an all time low during the recent survey in 2005 (0-5%). Reef 21-557 lies in close proximity to Gannet Cay where an extensive COTS outbreak decimated coral cover over the corresponding time period (1990-2005). It is highly likely that COTS were responsible for the observed current low level of coral cover on Reef 21-557. No COTS were observed in 2005 and Reef 21-557 was classified as No Outbreak. No bleaching or coral diseases were observed.

Figure 4.133

A





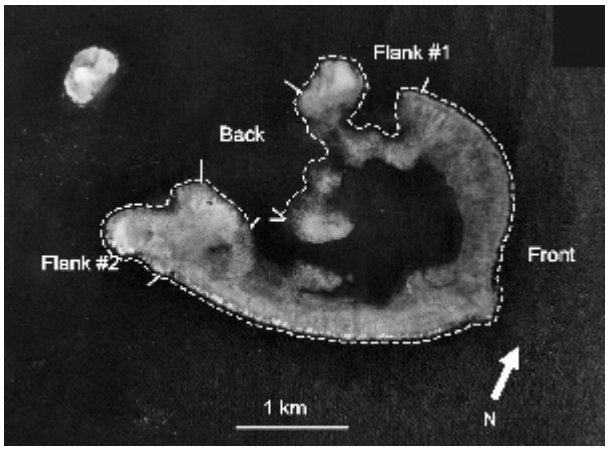
21557 (No. 21-557) is a middle shelf patch reef with an area of .1 sq.km.

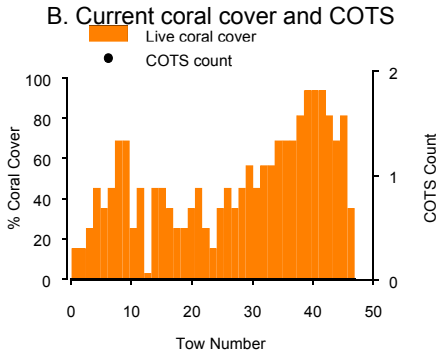
CENTENERY CAY

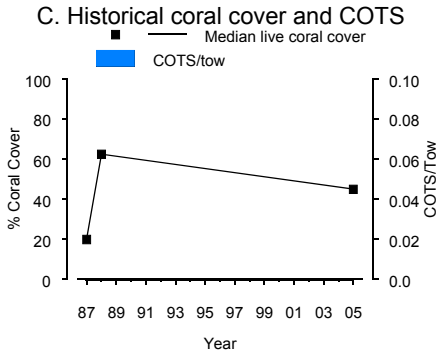
Surveyed November 2004.

Centenery Cay Reef was previously surveyed in 1987 and 1988 when reef-wide live coral cover increased from moderate levels (10-30%) to very high values (50-75%). Cover in 2005 was also very high (50-75%). No COTS have been observed in any survey and Centenery Cay Reef was classified as No Outbreak in 2005. No bleaching was observed however low levels of white syndrome disease and black band disease were recorded.

Figure 4.134 A







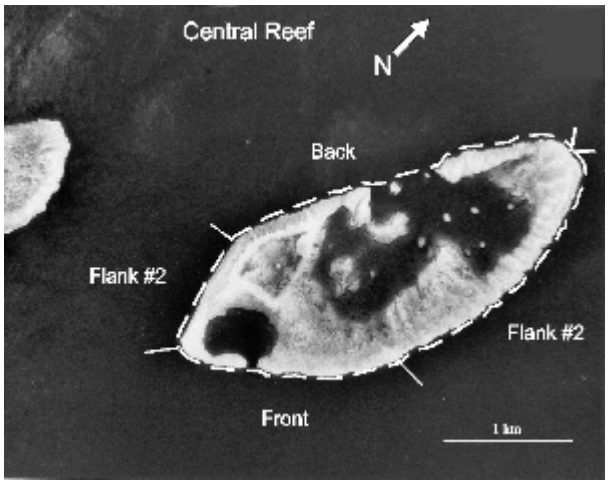
Centenery Cay (No. 21-241) is a middle shelf crescentic reef with an area of 4.39 sq.km.

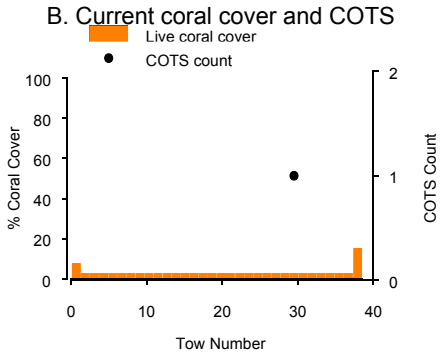
CENTRAL

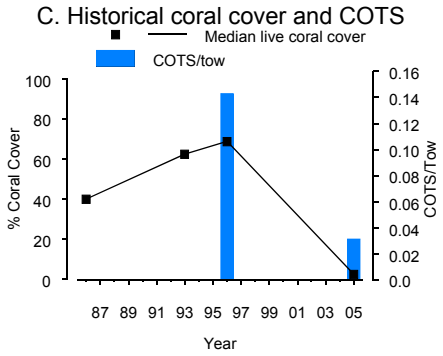
Surveyed November 2004.

Central Reef has been surveyed four times since 1986 where reef-wide live coral cover increased from moderate levels (30-50%) in the initial survey to very high levels (50-75%) in 1996. The 2005 survey recorded a dramatic decline in coral cover to less than 5%. The cause of this decline is unknown. COTS were also observed in low numbers in 1996, and an individual COTS was observed in 2005. No bleaching or coral diseases were observed and in 2005 Central Reef was classified as No Outbreak.

Figure 4.135 A







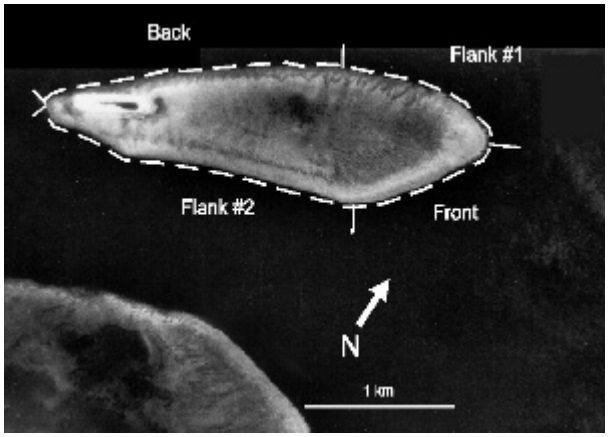
Central (No. 21-577) is a middle shelf lagoonal reef with an area of 3.8 sq.km.

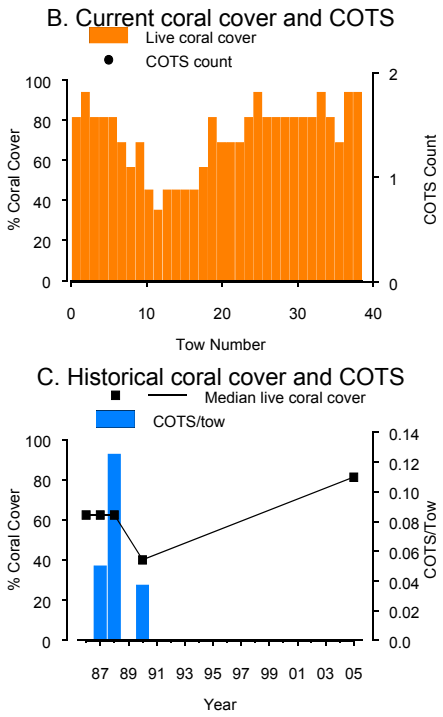
FRIGATE CAY

Surveyed November 2004.

Frigate Cay Reef was previously surveyed four times between 1986 and 1990 where reef-wide live coral cover decreased from very high values (50-75%) to moderate levels (10-30%). COTS were also observed in low numbers at the same time and may be associated with the drop in coral cover. In the recent 2005 survey, cover was recorded at extremely high levels (75-100%). No COTS were observed in 2005 and Frigate Cay Reef was classified as No Outbreak. No bleaching was observed, however, white syndrome was common on the reef front and low levels were recorded on the flanks of the reef.

Figure 4.136 A





Frigate Cay (No. 21-511) is a middle shelf planar reef with an area of 1.2 sq.km.

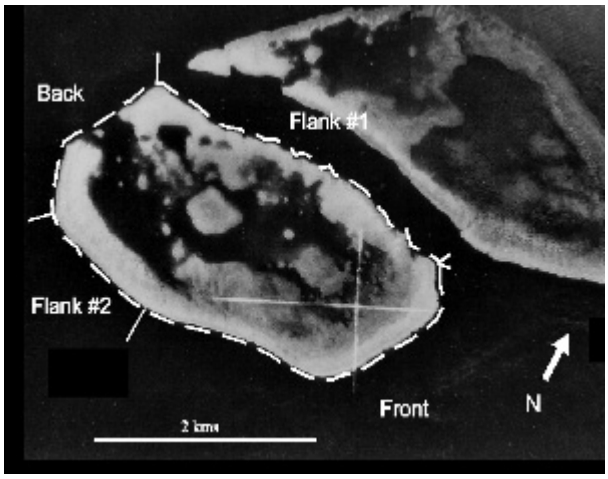
RECREATION CAY

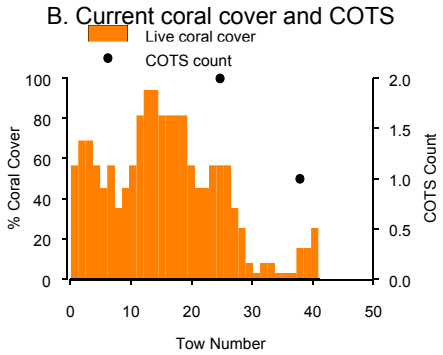
Surveyed November 2004.

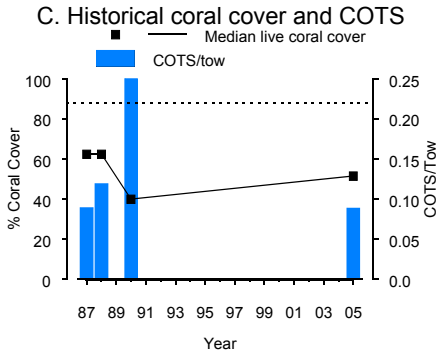
Recreation Cay Reef was previously surveyed three times between 1987 and 1990 where reefwide coral cover decreased from very high values (50-75%) to moderate levels (10-30%). COTS were also observed in low numbers at the same time and may be associated with the drop in coral cover. In the recent 2005 survey, cover was recorded at very high levels 50-75%, and several individual COTS were observed. No bleaching was observed, however low levels of white syndrome disease were recorded.

Figure 4.137

A







Recreation Cay (No. 21-501) is a middle shelf lagoonal reef with an area of 3.1 sq.km.

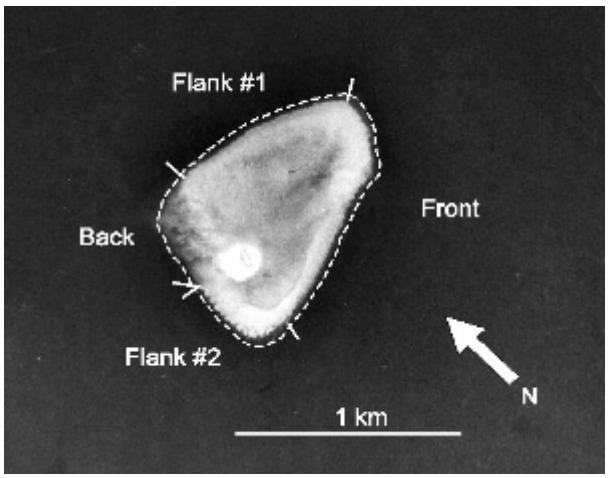
THOMAS CAY

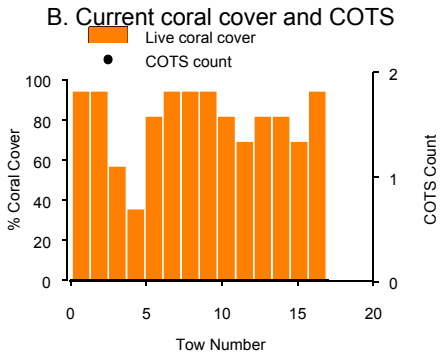
Surveyed November 2004.

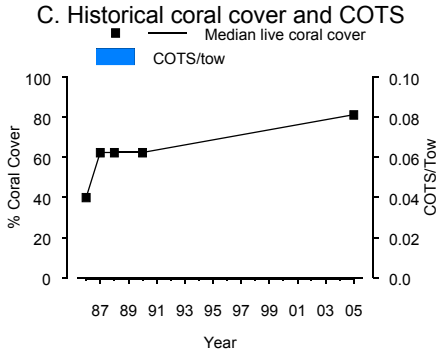
Thomas Cay Reef was previously surveyed four times between 1986 and 1990 where reef-wide live coral cover increased from moderate levels (10-30%) to very high values (50-75%). Cover peaked in the recent 2005 survey at 75-100%. No COTS have been observed in any survey and Thomas Cay Reef was classified as No Outbreak in 2005. No bleaching or coral diseases were observed.

Figure 4.138

A







Thomas Cay (No. 21-497) is a middle shelf patch reef with an area of 12.5 sq.km.

Capricorn Bunker

Reef Pages

BROOMFIELD

Surveyed December 2004.

Broomfield Reef has been surveyed 15 times using manta tow since 1986. Reef-wide live coral cover dropped dramatically between 1988 and 1990. Strong weather in the region during this time may have partly influenced this decline. Since 1993 reef-wide coral cover has slowly increased to a high level (30-50%). No COTS have been recorded on Broomfield Reef and it remains classified as No Outbreak. Surveys in 2004 and 2005 recorded a small drop in coral cover from the levels seen between 1999 and 2003. No bleaching was observed and white syndrome type disease was restricted to a few scattered coral colonies around the reef perimeter in 2005.

Intensive surveys on Broomfield Reef show a dramatic increase in hard coral cover from 10% in 1993 to 56% in 2002. Hard coral cover was 48% in 2005. *Acropora* spp. occupied 35% of the substrate in 2004, in stark contrast to 0% in 1993. This rise in abundance of tabulate *Acropora*, along with an increase in other *Acropora* lifeforms is responsible for the speedy recovery of hard coral on this reef. The decline of Tabulate *Acropora* spp. since 2002 accounts for the decline in coral observed with other coral groups being stable or increasing. High levels of white syndrome disease were recorded in 2003 with 315 colonies affected. Only 11 diseased colonies were recorded in 2005. Partial mortality of Tabulate *Acropora* was common however. Tabulate *Acropora* typically dominate reefs in this region, while soft corals usually remain low in cover (<1%). The cover of algae has shown an inverse trend to hard coral, decreasing with the corresponding increase in hard coral. Cover of algae in 2005 was a moderate 42%. The density of corallivorous snails *Drupella* spp. was 7/ha.

Hard coral cover provides most of the topographic complexity on the gently sloping reefs characteristic of the exposed Capricorn Bunker sector. The removal of most hard coral during the late 1980s created a relatively featureless environment and fish abundance was low in early surveys. However abundance of many species of large mobile fish from the families Acanthuridae, Scaridae, Chaetodontidae and Labridae, increased dramatically after 1994 as hard coral cover also began to increase. Damselfishes have shown less dramatic changes with the exception of *Pomacentrus coelestis* and *Plectroglyphidodon* species. *P. coelestis*, a species that preferentially recruits to bare or rubble substrate, flourished during the time of low coral cover and dominated the damselfish community, with peak numbers recorded in 1996. Numbers subsequently declined and had stabilized by 1998. Most other damselfish species have displayed slow or minimal changes, due possibly to the slower recovery of fine scale habitat (small branching corals, crevices etc) necessary to sustain high numbers and diversity of these relatively site-attached species.

Figure 4.139

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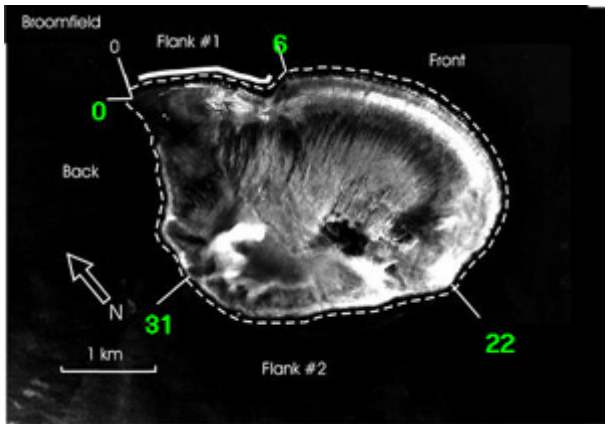
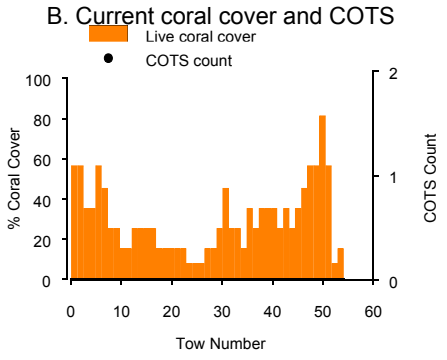
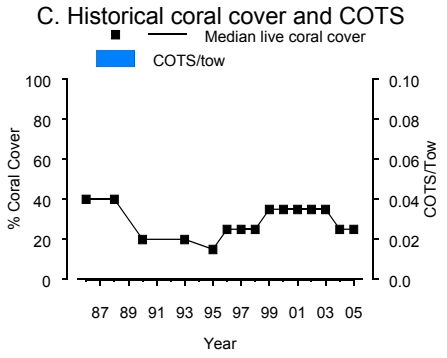
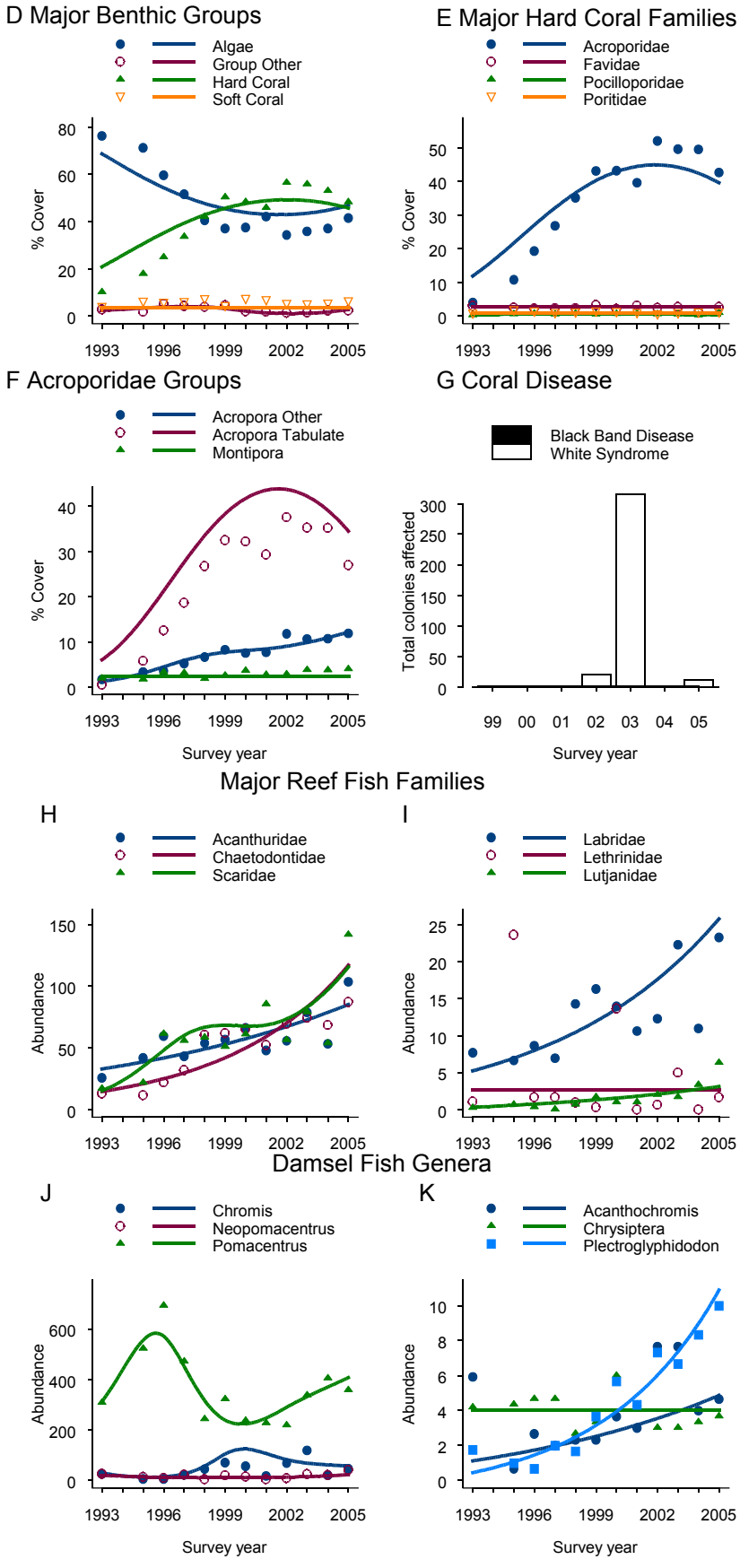






Broomfield (No. 23-048) is an outer shelf planar reef with an area of 21.3 sq.km.

Figure 4.139 (Cont).



LADY MUSGRAVE IS

Surveyed November 2004.

Lady Musgrave Island Reef has been surveyed 18 times since 1986. Reef-wide live coral cover fell dramatically between 1988 and 1990, apparently due to strong weather. Coral cover continued to decline until 1993 before recovering. COTS have been recorded on several occasions, but too few to affect reef-wide live coral cover. Reef-wide live coral cover reached a very high (50-75%) level in 2002, before showing signs of decline once more. Reef-wide live coral cover was high (40-50%) in 2005 and Lady Musgrave Island Reef remains classified as No Outbreak. No bleaching was recorded in 2005 and white syndrome disease generally affected only a few scattered colonies around the reef perimeter, except for the southern flank where it was common.

Intensive surveys on Lady Musgrave Island Reef show that hard coral cover increased dramatically from less than 5% in 1993 to a very high level of 75% in 2004. The increase in coral cover was due almost entirely to tabulate *Acropora* spp. which increased dramatically from 0% in 1993 to a maximum of 72% in 2004. In 2005, hard coral cover dropped to 68% due to a decline in Tabulate *Acropora*. Branching *Acropora* has continued to increase and in 2005 was 8%. Pocilloporidae, Faviidae, and Poritidae have remained steady over the survey period. Historical records indicate tabulate *Acropora* spp. typically dominate reefs in this region, while cover of soft corals is low (<1%). The cover of algae decreased from 94% in 1993 to 23% in 2004. This decline in algal cover corresponds to the increasing hard coral cover. In 2005, algal cover was 32%. White syndrome disease was recorded at low levels for 3 years before a dramatic increase in 2003, when SCUBA searches recorded 343 colonies affected by white syndrome. This is the highest incidence of white syndrome ever recorded in our surveys. In contrast, only 35 affected colonies were recorded in 2005. The density of corallivorous snails (*Drupella* spp.) was 287/ha.

Hard coral cover provides most of the topographic complexity on the gently sloping reefs characteristic of the exposed Capricorn Bunker sector. The removal of most hard coral during the late 1980s created a relatively featureless environment and fish abundance was low in early surveys. Abundance of many species of large mobile fish from the families, Acanthuridae, Scaridae, Chaetodontidae, Labridae and Lutjanidae increased after 1994 as hard coral cover also increased. Damselfishes have shown more variable changes. *Pomacentrus coelestis*, a species that preferentially recruits to bare or rubble substrate, flourished during the time of low coral cover and dominated the damselfish community, with maximum numbers recorded in 1996. Numbers subsequently declined and in 2005 *P. coelestis* was only present in very low numbers. Numbers of some damselfishes (*Pomacentrus lepidogenys*, *P. bankanensis* and two *Plectroglyphidodon* species) increased consistently over the study period, while a number of *Chromis* species and *P. moluccensis* only began to recover in 2003. Numbers of *C. atripectoralis* had increased considerably in 2005. The later recovery of these coral associated species may reflect the slower recovery of fine scale habitat (small branching corals, crevices etc) necessary to sustain high numbers and diversity of site-attached species.

Figure 4.140

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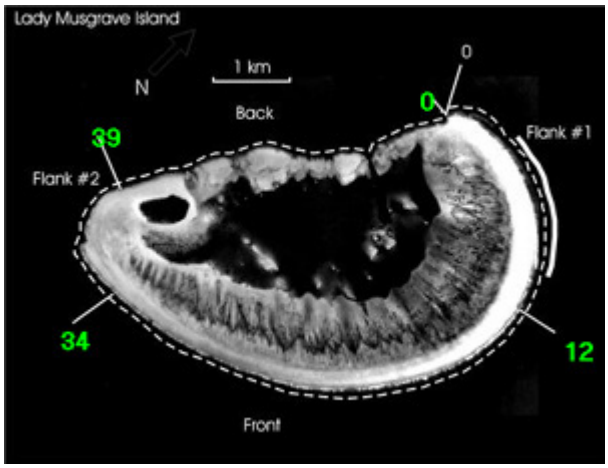
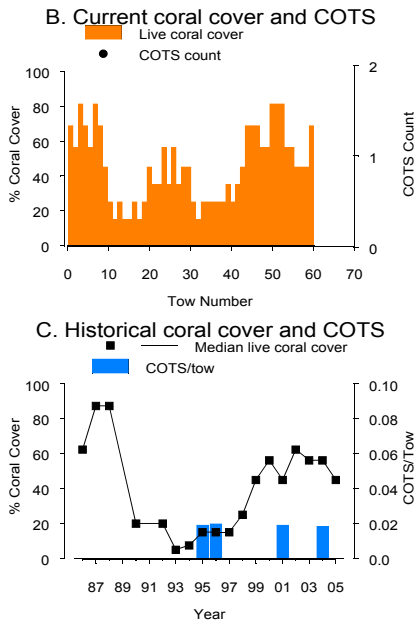
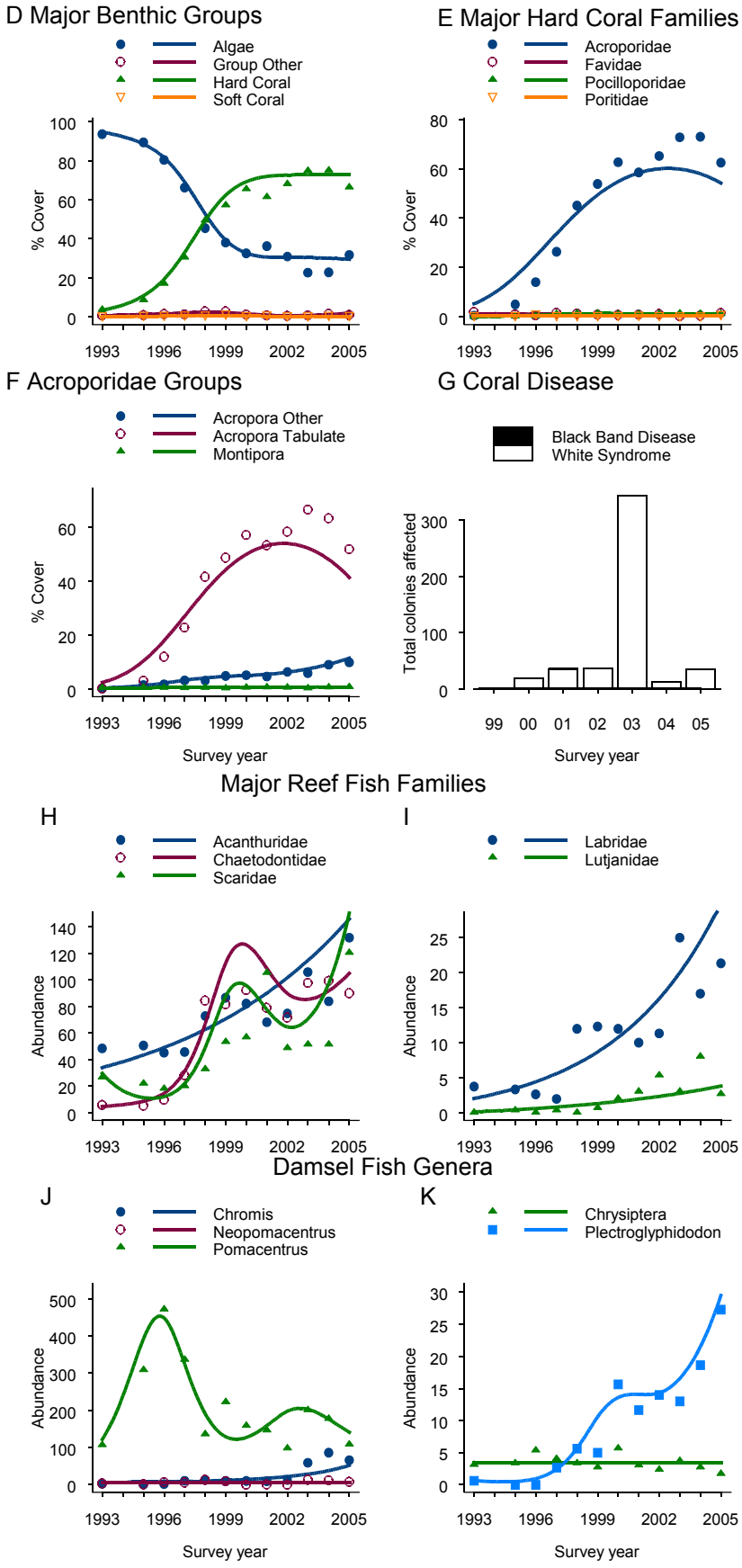




Lady Musgrave Is (No. 23-082) is an outer shelf lagoonal reef with an area of 12.5 sq.km.

Figure 4.140 (Cont).



ONE TREE IS

Surveyed December 2004.

One tree Reef has been surveyed 18 times since 1986. Reef-wide live coral cover dropped dramatically between 1988 and 1990, apparently caused by strong weather. Reef-wide live coral cover increased slowly after 1990 to reach high levels (30-50%) by 1999 where it has generally remained. Surveys in 2005 indicate reef-wide live coral cover remains high. No COTS have been recorded on One tree Reef and it remains classified as No Outbreak. No bleaching was recorded and white syndrome disease and black band disease were generally restricted to a few individual colonies around the reef perimeter in 2005, the exception being the southern reef flank where white syndrome was common.

Intensive surveys on One Tree Island Reef show that coral cover has increased from less than 5% in 1993 to a maximum 72% in 2004. Tabulate *Acropora* spp. make up 66% of that cover, a dramatic increase from 0% in 1993. In 2005 coral cover was 65%. Tabulate *Acropora* was declining in 2005 while the cover of Branching has slowly increased to 7%. The cover of algae reached a maximum 77% in 1993, and in 2005 was 33%. Cover of soft coral has remained low (1-2%) since surveys began. White syndrome disease increased dramatically from 17 affected colonies in 2002 to 336 affected colonies in 2003. In 2005 only 34 colonies were recorded as affected by disease. No corallivorous snails, *Drupella* spp., were observed in 2005.

Hard coral cover provides most of the topographic complexity on the gently sloping reefs characteristic of the exposed Capricorn Bunker sector. The removal of most hard coral during the late 1980's created a relatively featureless environment and fish abundance was low in early surveys. Numbers of most large mobile fish taxa increased after 1994 and often tracked increases in hard coral cover. Numbers of family Lethrinidae were low in 2005. Similarly low numbers had been recorded in 1995. *Pomacentrus coelestis*, a damselfish species that preferentially recruits to bare or rubble substrate, flourished during the time of low coral cover and dominated the damselfish community, peaking in 1994. Numbers have subsequently declined, while most other *Pomacentrus* species have increased in abundance. While numbers of most damselfishes have increased, some increased steadily while others (e.g. *Plectroglyphidodon* spp., *Pomacentrus moluccensis* and *Chromis* spp.) only reappeared in numbers later in the survey period. Such differences in recovery rate are likely linked to the slower recovery of fine scale habitat (small branching corals, crevices etc) necessary to sustain high numbers and diversity of relatively site attached damselfish species.

Figure 4.141

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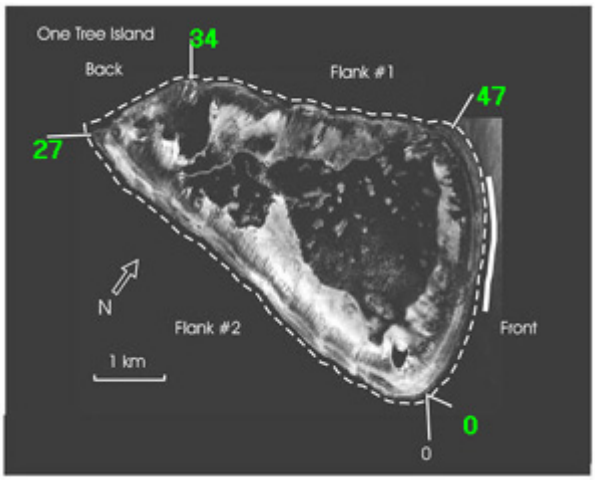
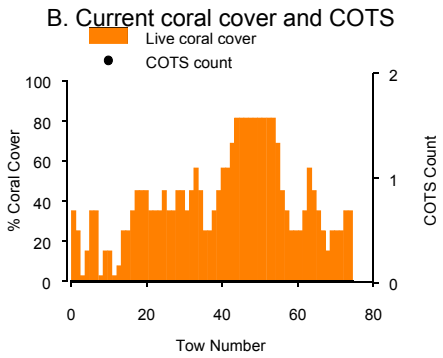
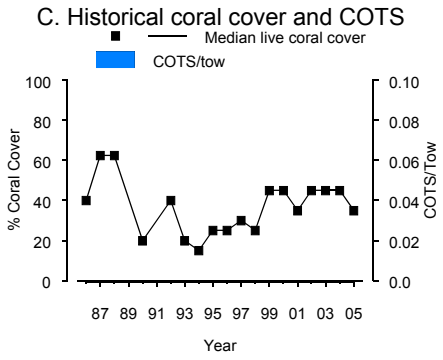
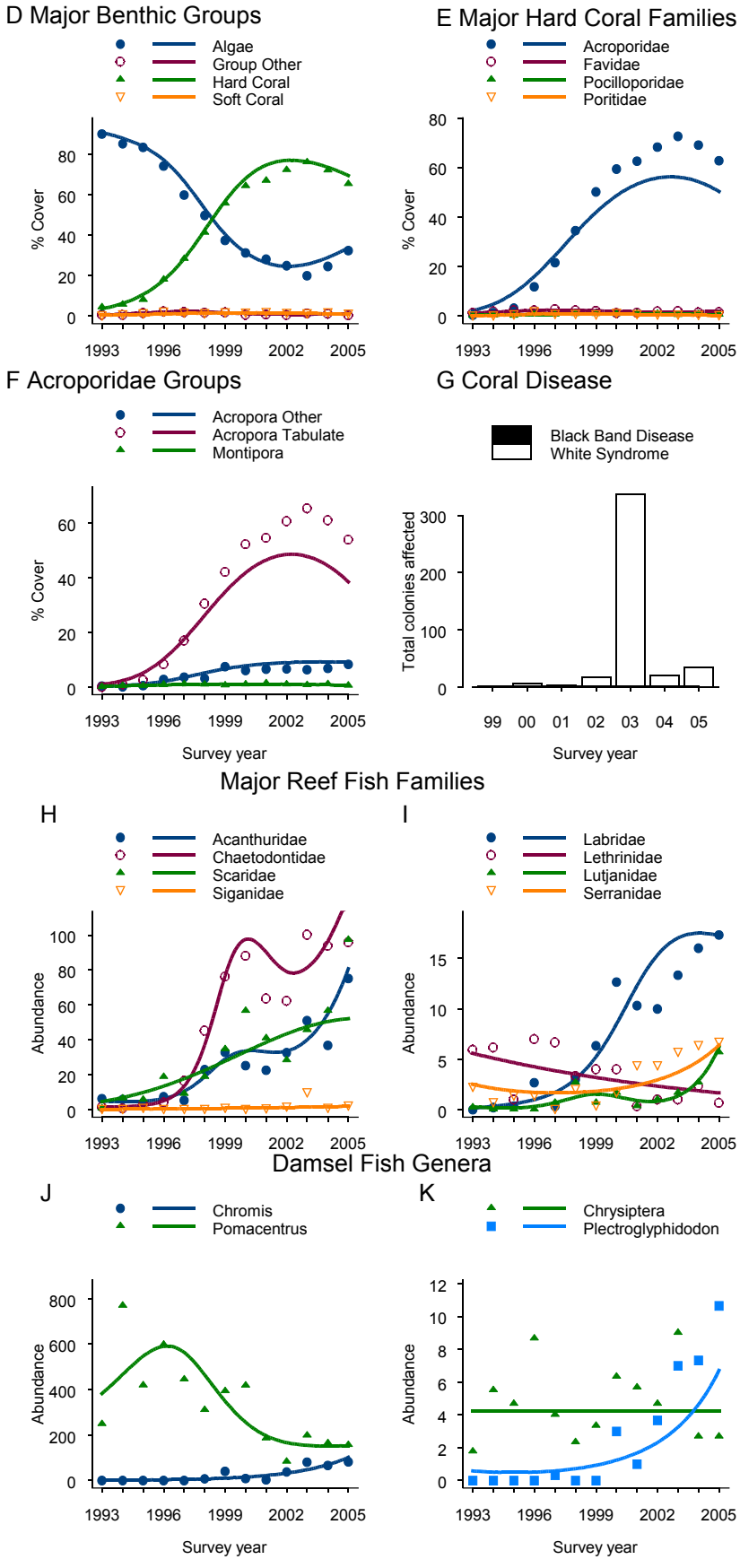






One Tree Is (No. 23-055) is an outer shelf lagoonal reef with an area of 18.09 sq.km.

Figure 4.141 (Cont).



WRECK IS

Surveyed December 2004.

Wreck Island Reef has been surveyed 11 times since 1993. During the initial period of survey median reef-wide live coral cover was generally moderate before increasing to a high level (30-50%) which was maintained between 1999 and 2002. Surveys over the last few years show that there has been a decline in coral cover to a current moderate level of 20-30%. The reason for this decline is unclear but increased levels of white syndrome recorded in 2003 may have played some role. No COTS have been observed on Wreck Island Reef during surveys and it remains classified as No Outbreak. No bleaching was recorded and white syndrome disease was restricted to a few individual colonies around the reef perimeter in 2005.

Intensive surveys sites of Wreck Reef show a dramatic increase in hard coral cover from 10% in 1993 to a maximum of 71% in 1999. Hard coral cover has been declining since then and was 56% in 2005. Both the increase and subsequent decline were due to change in the dominant coral lifeform, Tabulate *Acropora* spp. Another 10% of the substrate is occupied by other *Acropora* lifeforms. Historical records indicate that dominance by tabulate *Acropora* spp. is typical for reefs in this region, as is very low cover of soft corals (<1%). The cover of algae has decreased with a corresponding increase in hard coral. In 2005 the cover of algae was 52%. The decrease in hard coral cover between 2002 and 2004 is possibly due to increasing levels of white syndrome disease recorded. A total of 315 colonies were recorded as affected by white syndrome in 2003, by 2005 this number dropped to 31 affected colonies. However there were many colonies with old scars resulting from partial mortality. The density of corallivorous snails *Drupella* spp. was 80/ha in 2005.

Hard coral cover provides most of the topographic complexity on the flat gently sloping reef bases characteristic of the exposed Capricorn Bunker reefs. Judging by the low numbers of fish present when surveys began in 1993, we presume that the removal of much hard coral during the late 1980s created a relatively featureless environment unsuitable for sustaining large fish populations. However, numbers of most large mobile fish taxa increased after 1994 and often tracked increases in hard coral cover. *Pomacentrus coelestis*, a damselfish species that preferentially recruits to bare or rubble substrate, flourished during the time of low coral cover and dominated the damselfish community, peaking in 1996. Numbers then declined steadily to a 13 year low in 2005. Most other *Pomacentrus* species increased in abundance over the same period. The genera *Neopomacentrus* and *Chrysiptera* were stable over the study period, while *Chromis* spp. and *Plectroglyphidodon* spp. increased in abundance. Recovery rates in the damselfishes varied considerably. This pattern is likely linked to the slow recovery of fine scale habitat (small branching corals, crevices etc) necessary to sustain high numbers and diversity of relatively site attached damselfish species..

Figure 4.142

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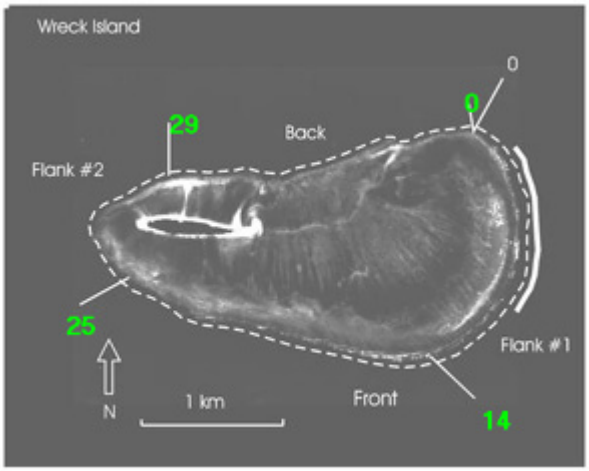
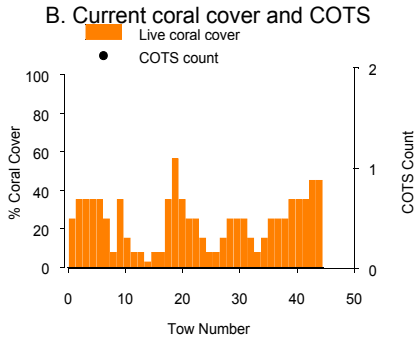
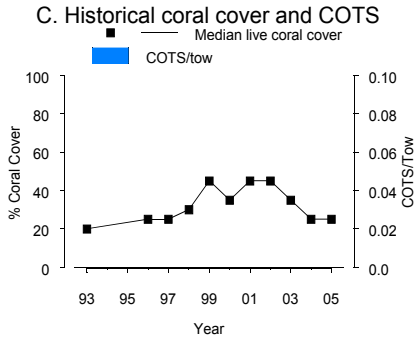
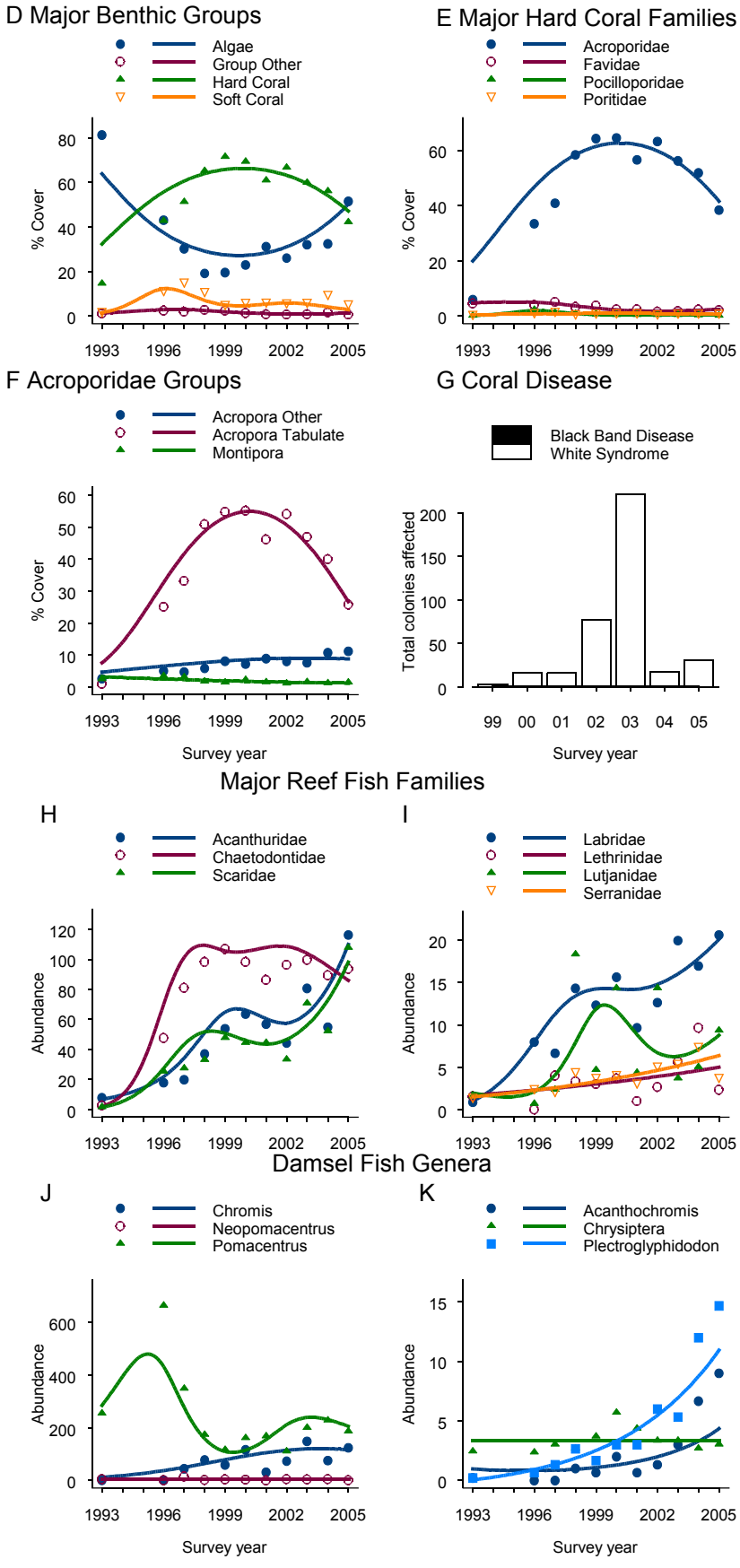






Wreck Is (No. 23-051) is an outer shelf planar reef with an area of 6.3 sq.km.

Figure 4.142 (Cont).



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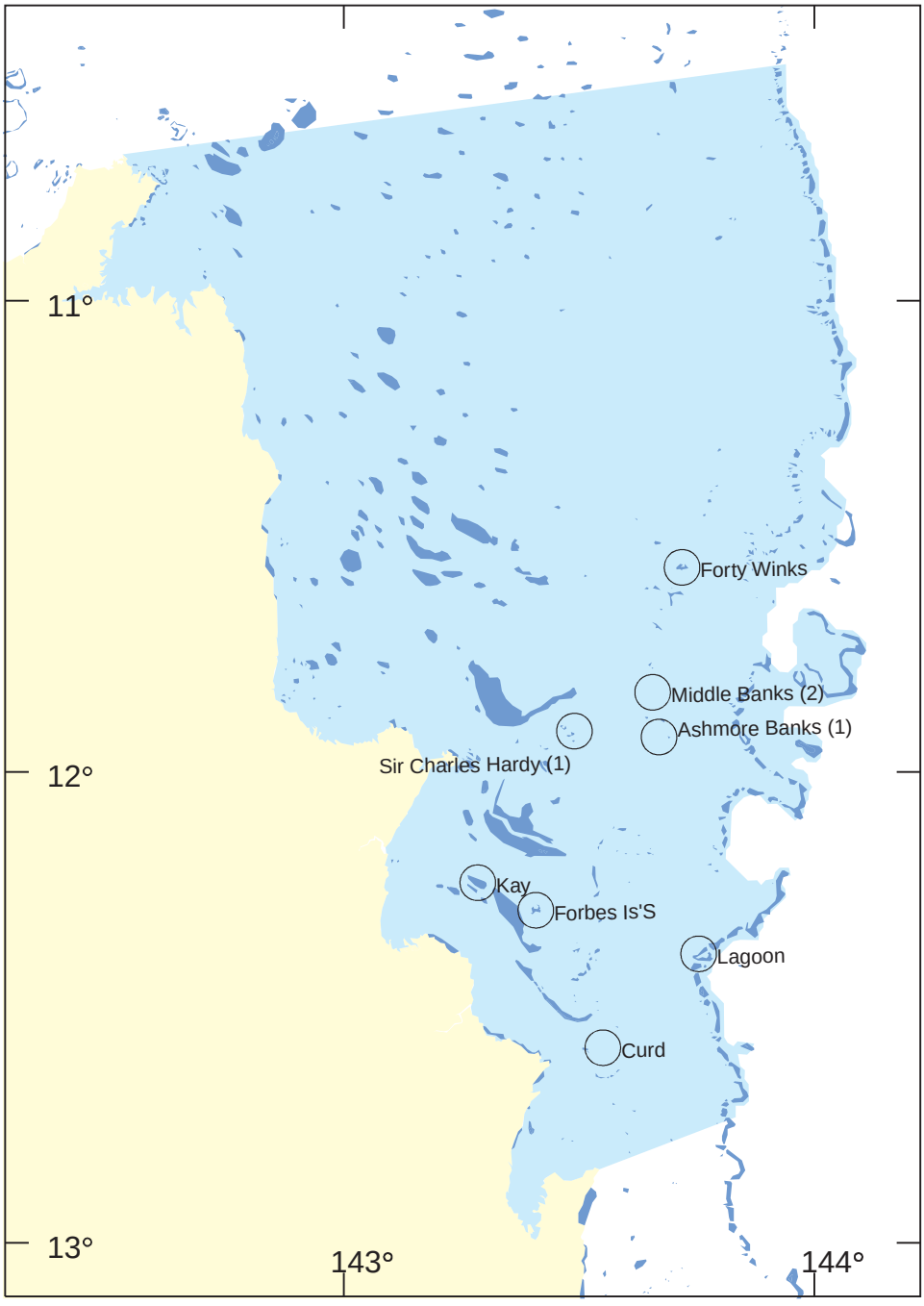
6. Appendices

Appendix A

Location of reefs surveyed in 2005 and the types of surveys taken.

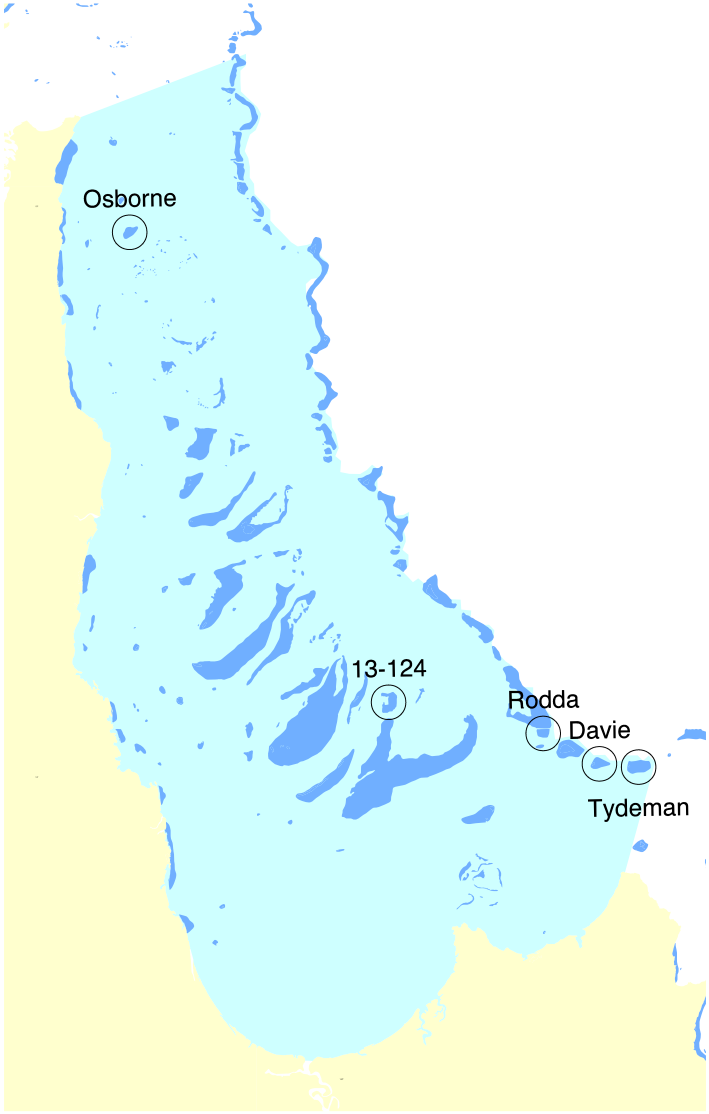
Cape Grenville Sector



- Fish and Benthos

○ Manta Tow

Princess Charlotte Bay Sector



- Fish and Benthos

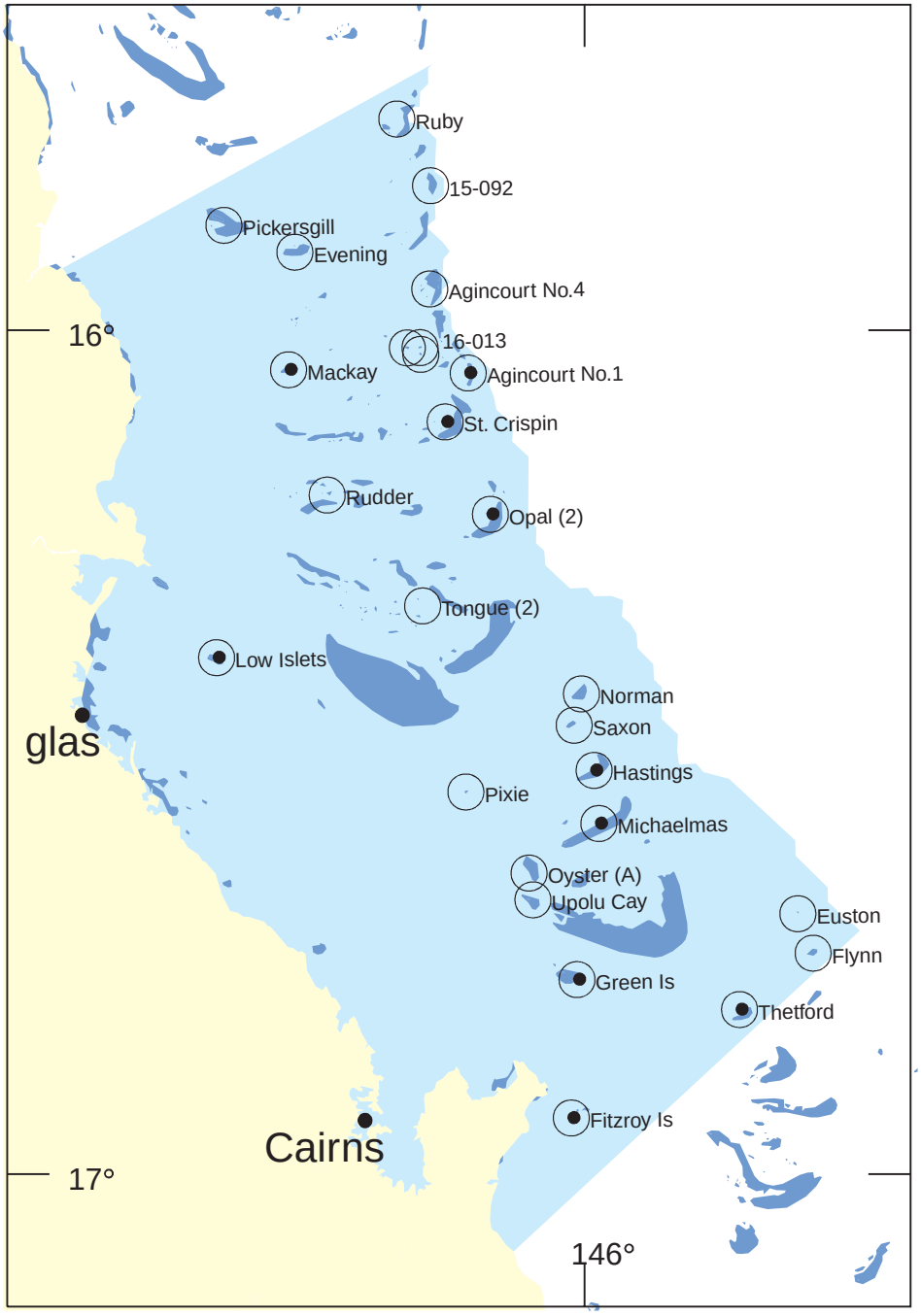
○ Manta Tow

Cooktown / Lizard Island Sector

- Fish and Benthos

○ Manta Tow

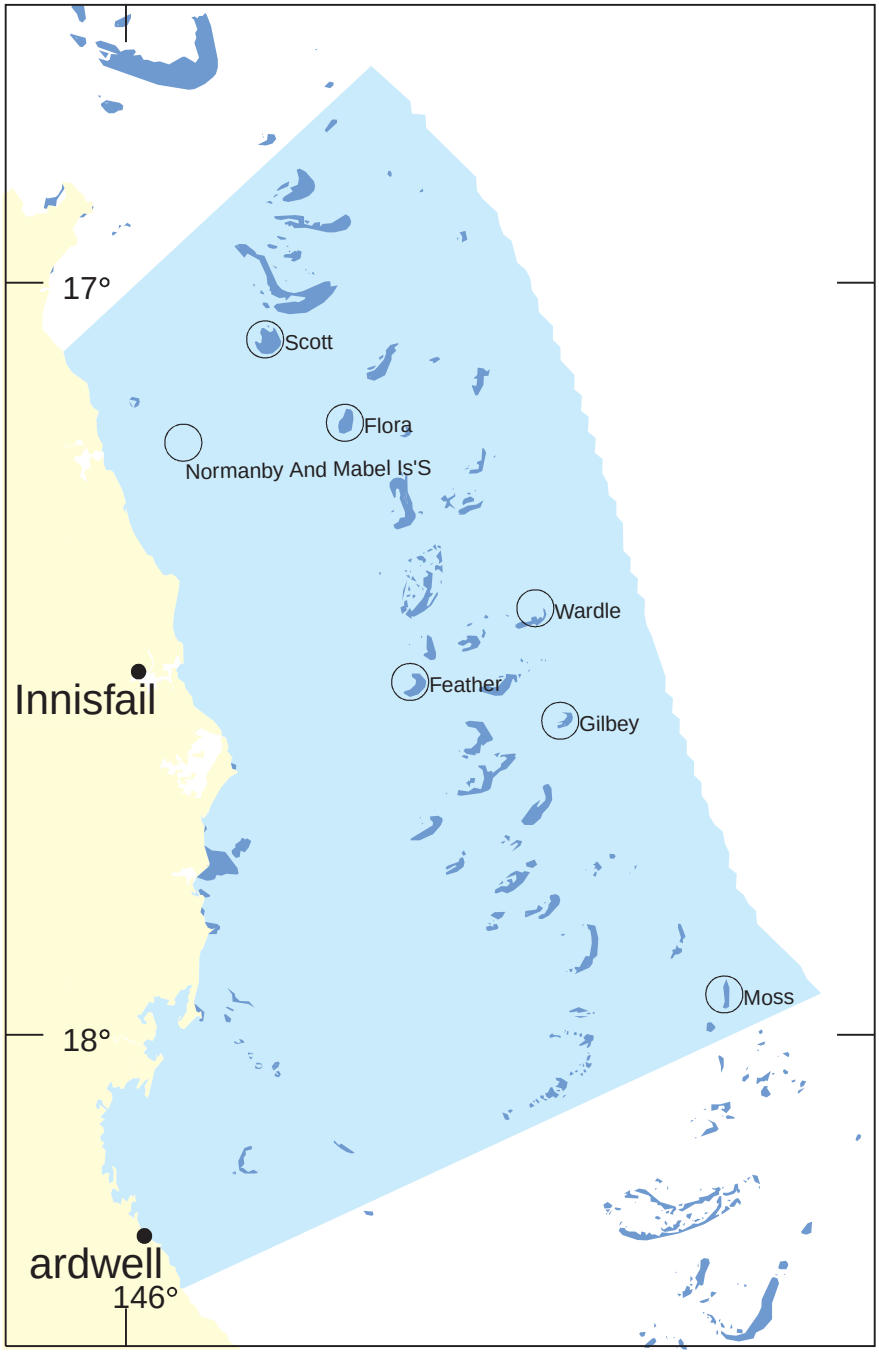
Cairns Sector



- Fish and Benthos

○ Manta Tow

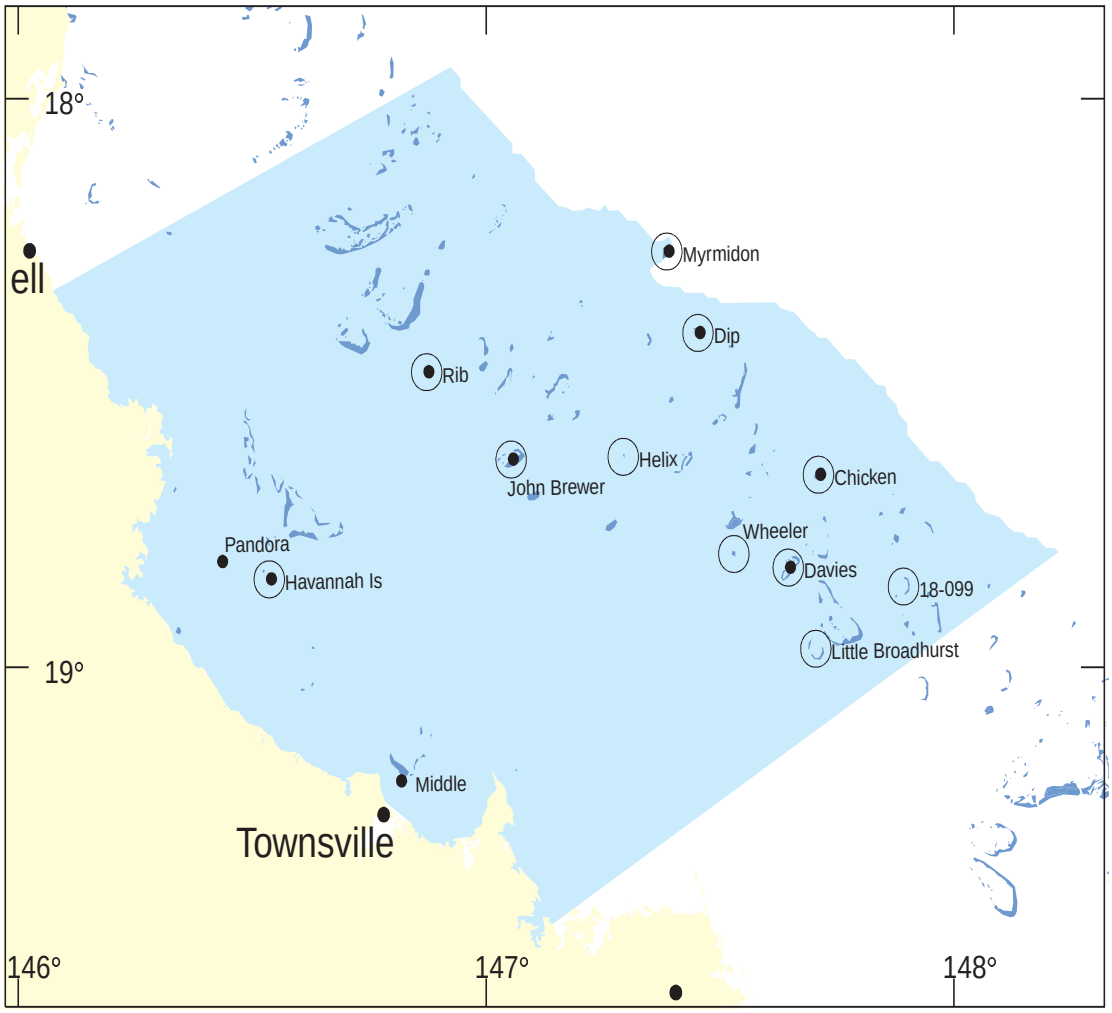
Innisfail Sector



- Fish and Benthos

○ Manta Tow

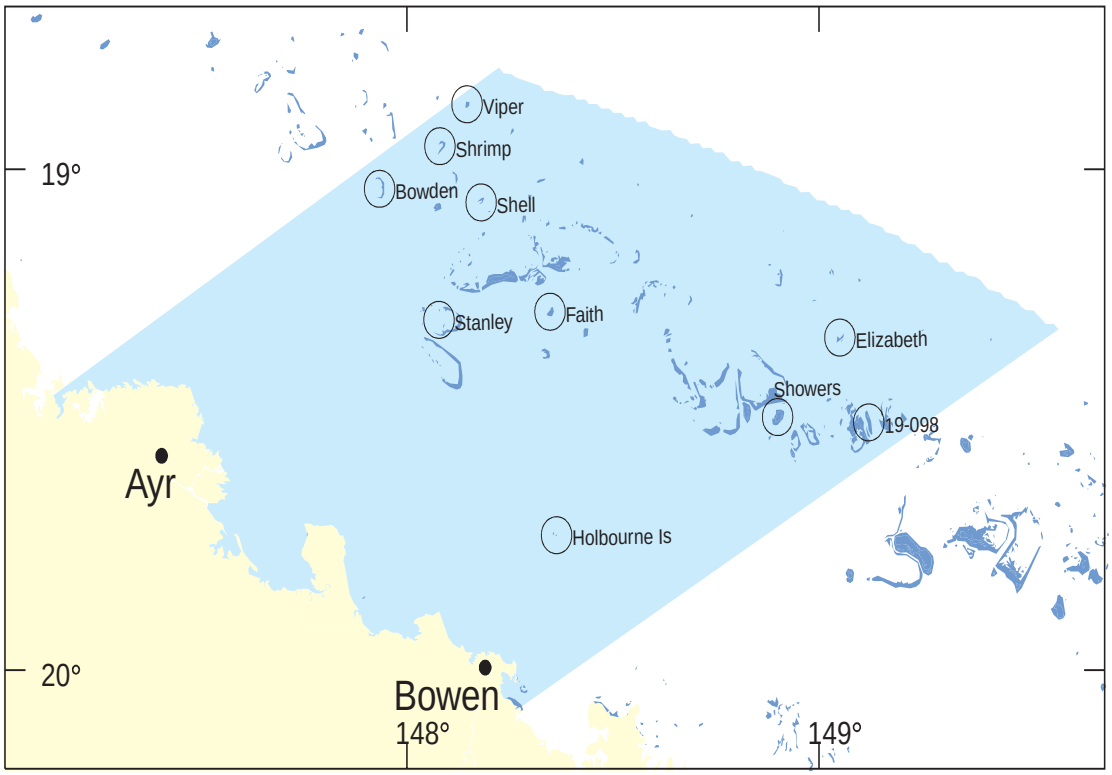
Townsville Sector



- Fish and Benthos

○ Manta Tow

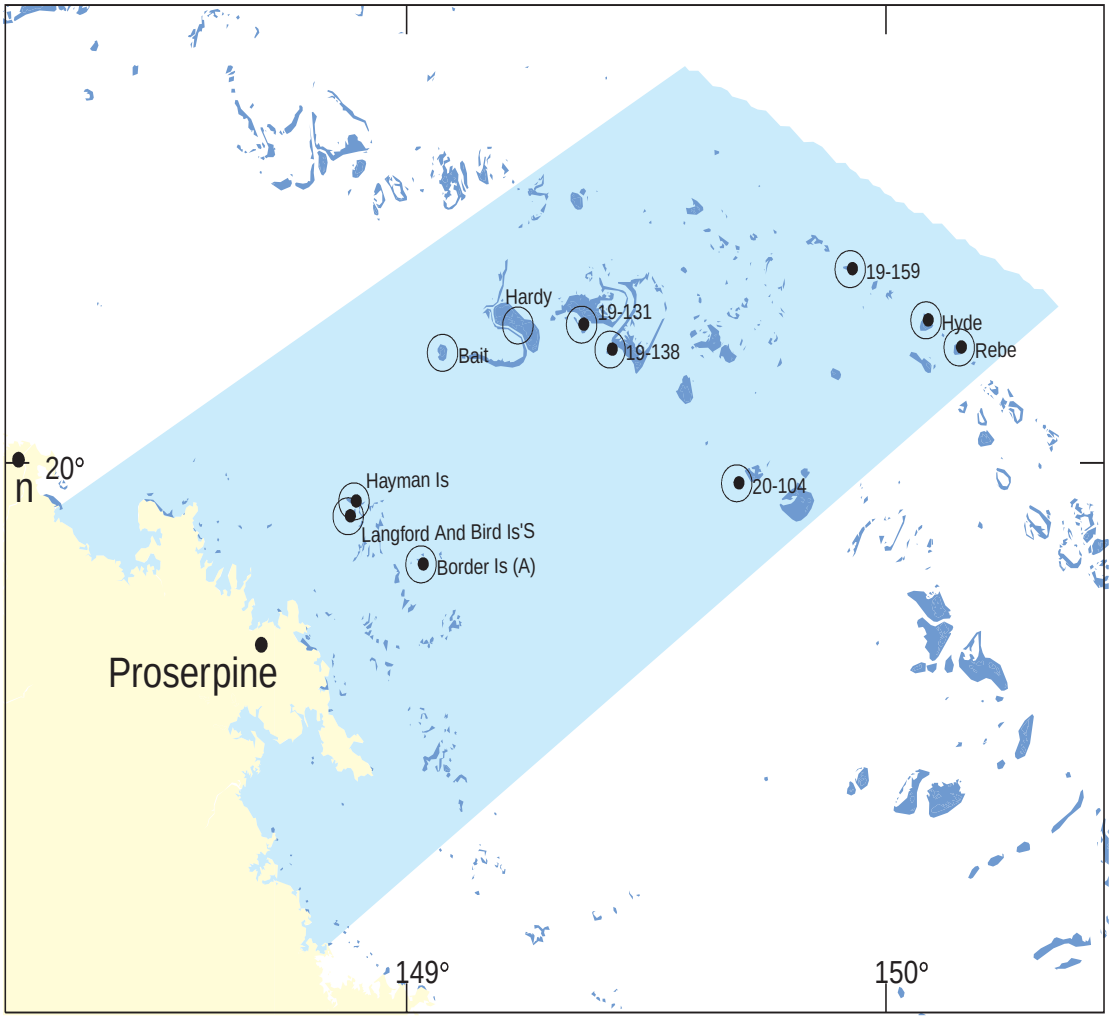
Cape Upstart Sector



- Fish and Benthos

◯ Manta Tow

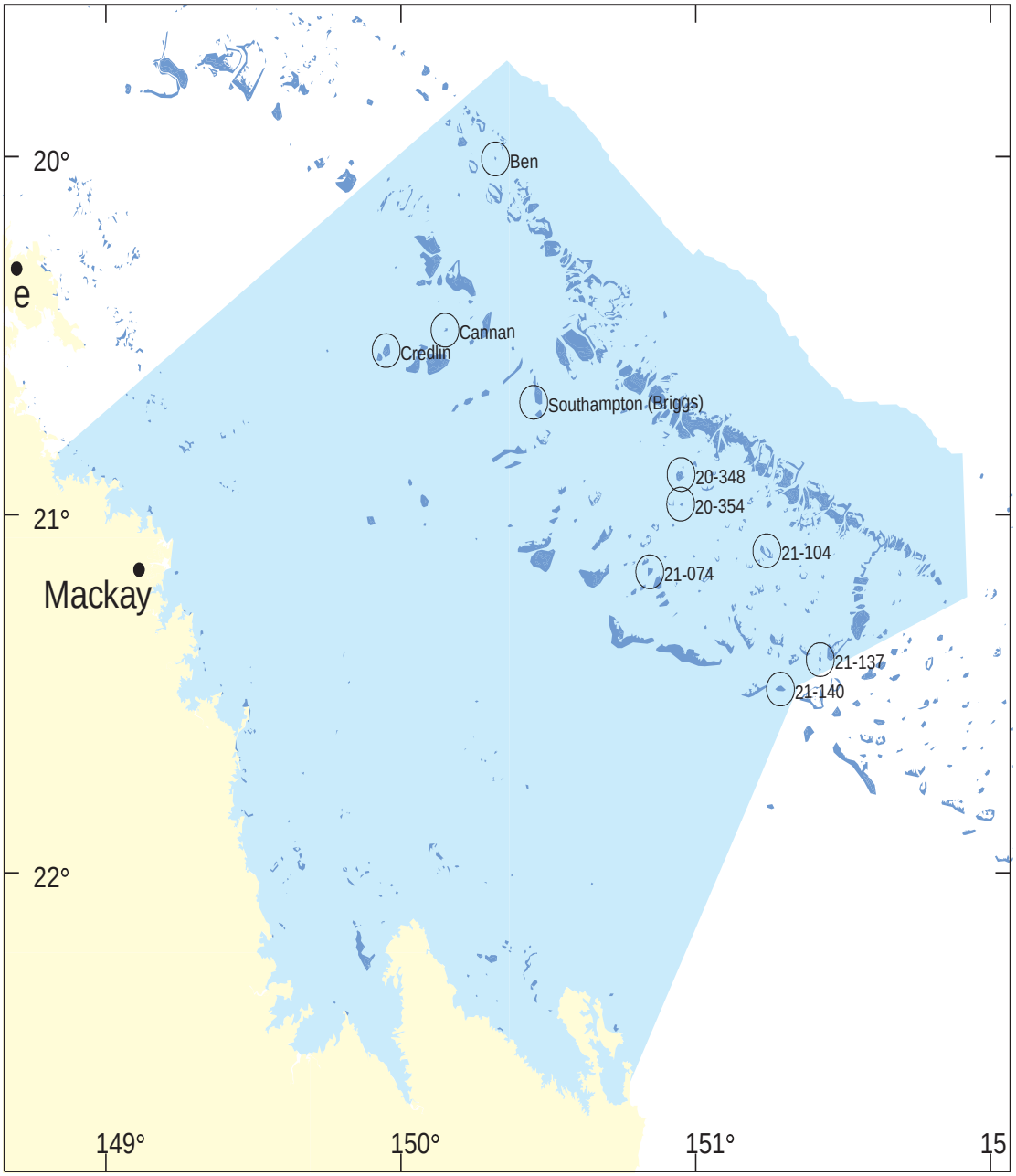
Whitsunday Sector



- Fish and Benthos

○ Manta Tow

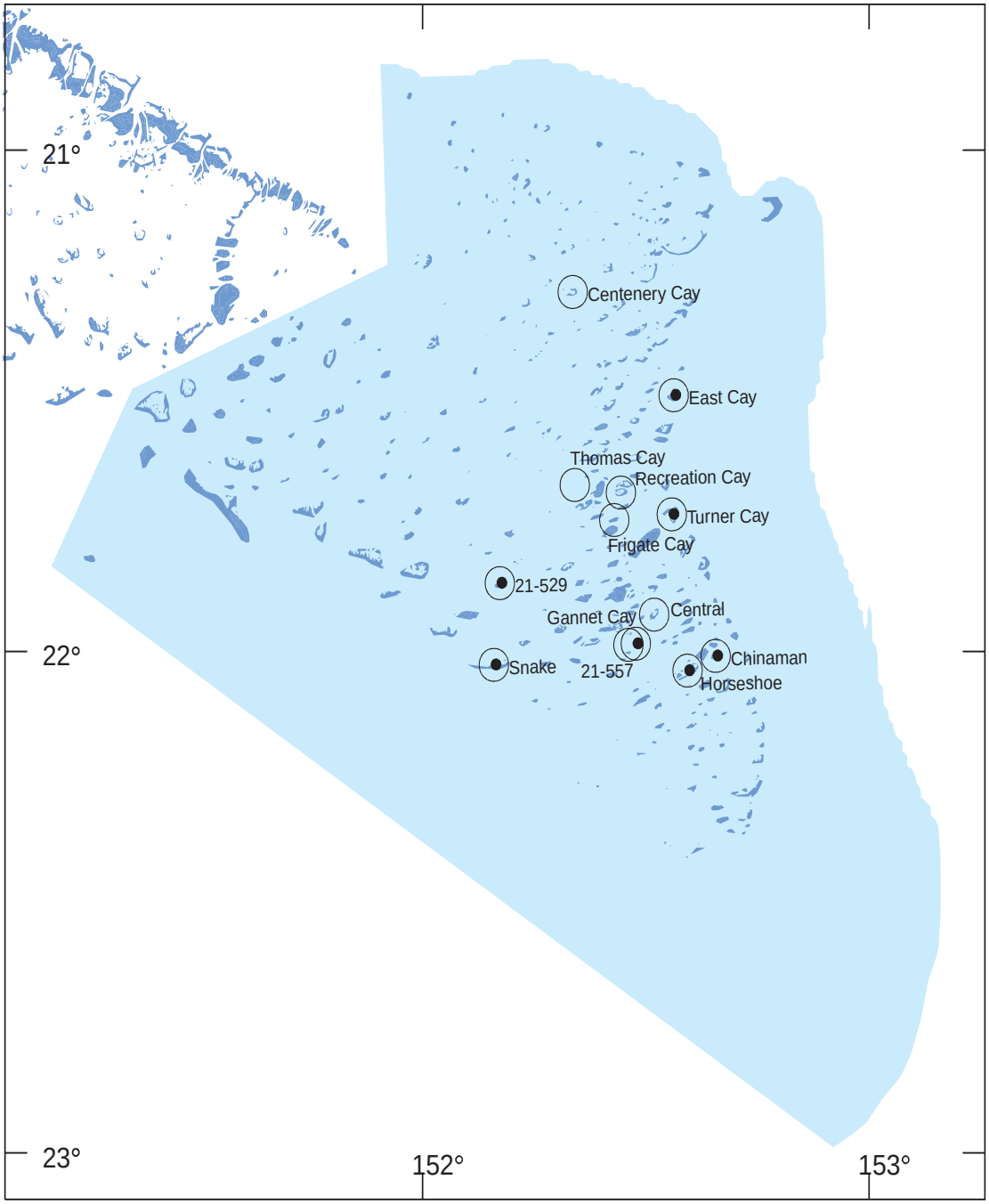
Pompey Sector



- Fish and Benthos

○ Manta Tow

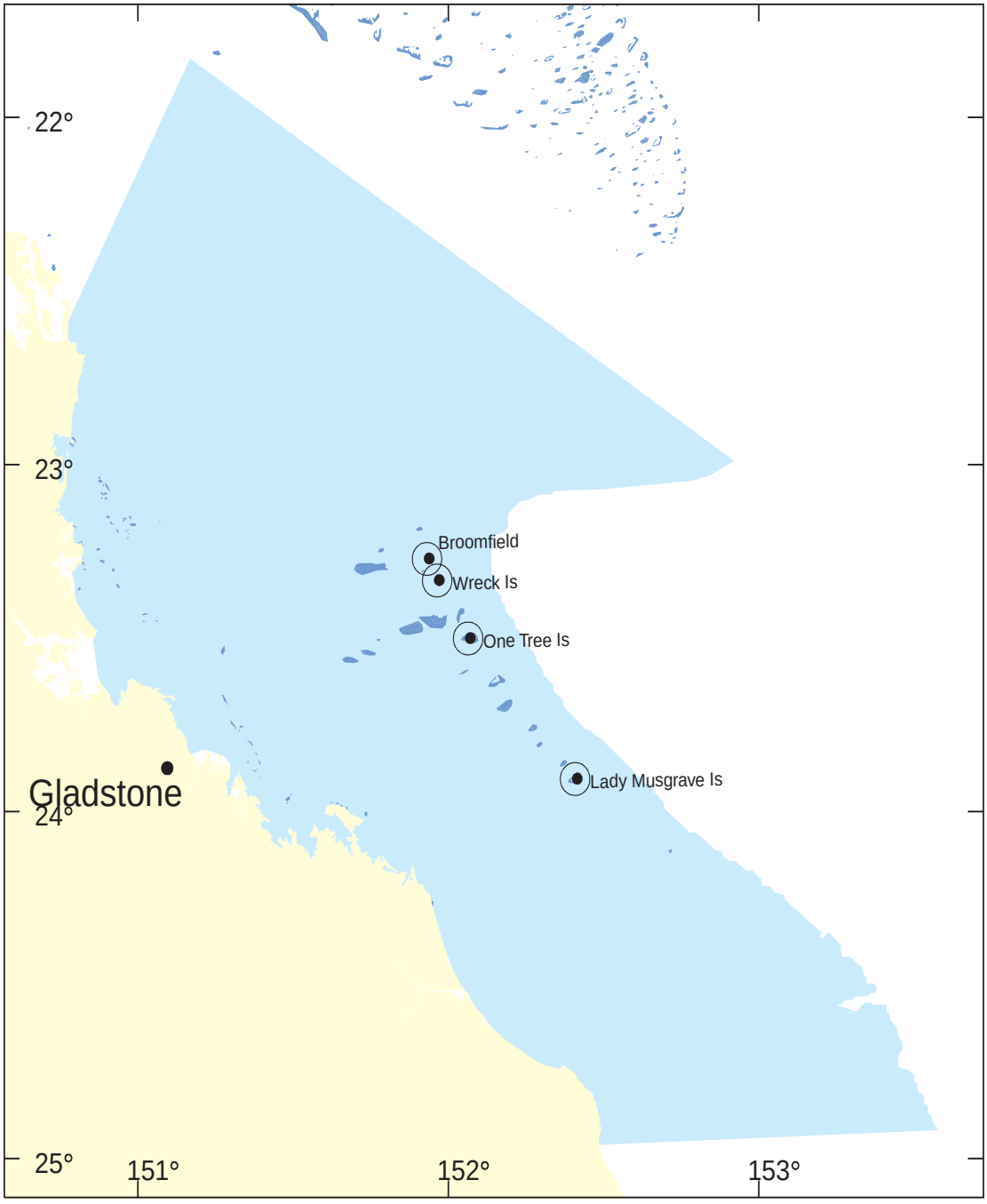
Swain Sector



- Fish and Benthos

○ Manta Tow

Capricorn Bunker Sector



- Fish and Benthos

○ Manta Tow

Appendix B

Summary of reefs surveyed in 2004 or 2005. Reef ID refers to the GBRMPA Gazetteer. Sampling codes:
B = benthos, F = reef fishes, f = small fish species only, M = manta tow.

Sector	Shelf Position	Reef ID	Reef Name	Sampling Methods
Cape Grenville	Inshore	12010	Kay	M
		12102	Curd	M
Cape Grenville	Middle Shelf	11184	Sir Charles Hardy (1)	M
		11184	Sir Charles Hardy (2)	M
		11211	Forty Winks	M
		11222	Middle Banks (3)	M
		11222	Middle Banks (2)	M
		11237	Ashmore Banks (3)	M
		11237	Ashmore Banks (1)	M
		11237	Ashmore Banks (2)	M
		12016	Forbes Is'S	M
Cape Grenville	Outer-Shelf	12061	Lagoon	M
Princess Charlotte Bay	Inshore	13006	Osborne	M
Princess Charlotte Bay	Middle Shelf	13124	13-124	M
Princess Charlotte Bay	Outer-Shelf	13127	Rodda	M
		13130	Davie	M
		13133	Tydeman	M

Sector	Shelf Position	Reef ID	Reef Name	Sampling Methods
Cooktown / Lizard Is	Inshore	14094	Houghton Is	M
		14123	Martin	MBF
		14126	Linnet	MBF
		15002	Two Isles	M
		15012	Boulder	M
		15013	Egret	M
Cooktown / Lizard Is	Middle Shelf	14054	Stapleton It	M
		14056	14-056	M
		14061	Switzer	M
		14114	Macgillivray	MBF
		14115	Nymph Is	M
		14116	Lizard Is	MBF
		14118	Eyrie	M
		14135	Helsdon	M
		14143	North Direction Is	MBF
		15024	Mackay Reefs	M
		15028	Startle (East)	M
		15030	Swinger	M
		15047	15-047	M
		15077	15-077	M
		15081	Rosser	M
Cooktown / Lizard Is	Outer-Shelf	14045	Sandbank No.1	M
		14075	14-075	M
		14137	Carter	MBF
		14138	Yonge	MBF
		14139	No Name	MBF
		14154	Ribbon No.9	M
		15034	15-034	M
		15050	Ribbon No.3	M
		15080	Ribbon No.1	M

Sector	Shelf Position	Reef ID	Reef Name	Sampling Methods
Cairns	Inshore	16028	Low Islets	MBF
		16049	Green Is	MBF
		16054	Fitzroy Is	MBF
Cairns	Middle Shelf	15093	Pickersgill	M
		15095	Evening	M
		16013	16-013 (A)	M
		16013	16-013 (B)	M
		16013	16-013 (C)	M
		16015	Mackay	MBF
		16023	Rudder	M
		16026	Tongue (2)	M
		16032	Saxon	M
		16040	Pixie	M
		16043	Oyster (A)	M
		16046	Upolu Cay	M
		16057	Hastings	MBF
		16060	Michaelmas	MBF
		16068	Thetford	MBF
Cairns	Outer-Shelf	15088	Ruby	M
		15092	15-092	M
		15096	Agincourt No.4	M
		15099	Agincourt No.1	MBF
		16019	St. Crispin	MBF
		16025	Opal (2)	MBF
		16030	Norman	M
		16063	Euston	M
		16065	Flynn	M
Innisfail	Inshore	17012	Normanby And Mabel I	M
Innisfail	Middle Shelf	17004	Scott	M
		17010	Flora	M
		17034	Feather	M
Innisfail	Outer-Shelf	17032	Wardle	M
		17057	Gilbey	M
		17068	Moss	M

Sector	Shelf Position	Reef ID	Reef Name	Sampling Methods
Townsville	Inshore	18051	Pandora	BF
		18065	Havannah Is	MBF
		19011	Middle	B
Townsville	Middle Shelf	18032	Rib	MBF
		18075	John Brewer	MBF
		18076	Helix	M
		18095	Wheeler	M
		18096	Davies	MBF
		18099	18-099	M
		18106	Little Broadhurst	M
Townsville	Outer-Shelf	18034	Myrmidon	MBF
		18039	Dip	MBF
		18086	Chicken	MBF
Cape Upstart	Inshore	19103	Holbourne Is	M
Cape Upstart	Middle Shelf	18118	Shrimp	M
		19019	Bowden	M
		19028	Shell	M
		19044	Faith	M
		19045	Stanley	M
		19076	Showers	M
		19082	Elizabeth	M
		19098	19-098	M
Cape Upstart	Outer-Shelf	18112	Viper	M
Whitsunday	Inshore	20014	Hayman Is	MBF
		20019	Langford And Bird Is'S	MBF
		20067	Border Is (A)	MBF
Whitsunday	Middle Shelf	19131	19-131	MBF
		19135	Hardy	M
		19137	Bait	M
		19138	19-138	MBF
		20104	20-104	MBF
Whitsunday	Outer-Shelf	19159	19-159	MBF
		19207	Hyde	MBF
		19209	Rebe	MBF
Pompey	Middle Shelf	20144	Cannan	M
		20287	Credlin	M
		20299	Southampton (Briggs)	M
		20348	20-348	M
		20354	20-354	M
		21074	21-074	M
		21104	21-104	M
		21137	21-137	M
		21140	21-140	M
Pompey	Outer-Shelf	20113	Ben	M

Sector	Shelf Position	Reef ID	Reef Name	Sampling Methods
Swain	Middle Shelf	21241	Centenery Cay	M
		21497	Thomas Cay	M
		21501	Recreation Cay	M
		21511	Frigate Cay	M
		21529	21-529	MBF
		21556	Gannet Cay	MBF
		21557	21-557	M
		21577	Central	M
		22088	Snake	MBF
		22102	Chinaman	MBF
		22104	Horseshoe	MBF
Swain	Outer-Shelf	21305	East Cay	MBF
		21562	Turner Cay	MBF
Capricorn Bunker	Outer-Shelf	23048	Broomfield	MBF
		23051	Wreck Is	MBF
		23055	One Tree Is	MBF
		23082	Lady Musgrave Is	MBF

Appendix C

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

Acanthuridae

Acanthurus albipectoralis
Acanthurus auranticavus
Acanthurus Bariene
Acanthurus blochii
Acanthurus dussumieri
Acanthurus grammoptilus
Acanthurus lineatus
Acanthurus maculiceps
Acanthurus mata
Acanthurus nigricans
Acanthurus nigricauda
Acanthurus nigrofuscus
Acanthurus nigroris
Acanthurus olivaceus
Acanthurus pyroferus
Acanthurus spp.
Acanthurus thompsoni
Acanthurus triostegus
Acanthurus xanthopterus
Ctenochaetus (grouped)
Naso lituratus
Naso tuberosus
Naso unicornis
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 mertensii
Chaetodon meyeri
Chaetodon ornatissimus
Chaetodon pelewensis
Chaetodon plebeius
Chaetodon punctatofasciatus
Chaetodon rafflesii
Chaetodon rainfordi
Chaetodon reticulatus
Chaetodon speculum
Chaetodon trifascialis
Chaetodon trifasciatus
Chaetodon ulietensis
Chaetodon unimaculatus
Chaetodon vagabundus
Chelmon rostratus
Forcipiger flavissimus
Forcipiger longirostris
Hemitaurichthys polylepis

Labridae

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

Lethrinidae

Lethrinus atkinsoni
Lethrinus erythracanthus
Lethrinus harak
Lethrinus laticaudis
Lethrinus lentjan
Lethrinus miniatus
Lethrinus nebulosus
Lethrinus obsoletus
Lethrinus olivaceus
Lethrinus ornatus
Lethrinus rubrioperculatus
Lethrinus semicinctus
Lethrinus xanthochilus
Monotaxis grandoculis

Lutjanidae

Lutjanus adetii
Lutjanus argentimaculatus
Lutjanus biguttatus
Lutjanus bohar
Lutjanus boutton
Lutjanus carponotatus
Lutjanus fulviflammus
Lutjanus fulvus
Lutjanus gibbus
Lutjanus kasmira
Lutjanus lemniscatus
Lutjanus lutjanus
Lutjanus monostigma
Lutjanus quinquelineatus
Lutjanus rivulatus
Lutjanus russellii
Lutjanus sebae
Lutjanus semicinctus
Lutjanus vitta
Macolor (grouped)

Scaridae

Bolbometopon muricatum
Calotomus carolinus
Cetoscarus bicolor
Chlorurus bleekeri
Chlorurus gibbus
Chlorurus japanensis
Chlorurus sordidus
Hipposcarus longiceps
Scarus altipinnis
Scarus chameleon
Scarus dimidiatus
Scarus flavipectoralis
Scarus forsteni
Scarus frenatus
Scarus ghobban
Scarus globiceps
Scarus longipinnis
Scarus niger
Scarus oviceps
Scarus psittacus
Scarus rivulatus
Scarus rubroviolaceus
Scarus schlegeli
Scarus spinus
Scarus spp.

Serranidae

Plectropomus areolatus
Plectropomus laevis
Plectropomus leopardus
Plectropomus maculatus
Variola louti

Siganidae

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

Zanclidae

Zanclus cornutus

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

Acanthochromis polyacanthus
Amblyglyphidodon aureus
Amblyglyphidodon curacao
Amblyglyphidodon leucogaster
Amphiprion akindynos
Amphiprion chrysopterus
Amphiprion clarkii
Amphiprion melanopus
Amphiprion percula
Amphiprion perideraion
Cheiloprion labiatus
Chromis acares
Chromis agilis
Chromis amboinensis
Chromis atripectoralis
Chromis atripes
Chromis chrysura
Chromis flavomaculata
Chromis iomelas
Chromis lepidolepis
Chromis lineata
Chromis margaritifer
Chromis nitida
Chromis retrofasciata
Chromis ternatensis
Chromis vanderbilti
Chromis viridis
Chromis weberi
Chromis xanthochira
Chromis xanthura
Chrysiptera flavipinnis
Chrysiptera rex
Chrysiptera rollandi
Chrysiptera talboti
Dascyllus aruanus
Dascyllus reticulatus
Dascyllus trimaculatus
Dischistodus melanotus
Dischistodus perspicillatus
Dischistodus prosopotaenia
Dischistodus pseudochrysopoecil
Hemiglyphidodon plagiometopon
Neoglyphidodon melas
Neoglyphidodon nigroris
Neoglyphidodon polyacanthus
Neopomacentrus azysron
Neopomacentrus bankieri
Neopomacentrus cyanomos
Plectroglyphidodon dickii
Plectroglyphidodon johnstonianu
Plectroglyphidodon lacrymatus
Pomacentrus adelus
Pomacentrus amboinensis
Pomacentrus australis
Pomacentrus bankanensis
Pomacentrus brachialis
Pomacentrus chrysurus
Pomacentrus coelestis
Pomacentrus grammorhynchus
Pomacentrus imitator
Pomacentrus lepidogenys
Pomacentrus moluccensis
Pomacentrus nagasakiensis
Pomacentrus philippinus
Pomacentrus tripunctatus
Pomacentrus vaiuli
Pomacentrus wardi
Pomachromis richardsoni
Premnas biaculeatus
Stegastes apicalis
Stegastes fasciolatus
Stegastes gascoynei
Stegastes nigricans

Appendix D

General status of crown-of-thorns starfish in each sector on the Great Barrier Reef for survey year 2005.

D1. Status of crown-of-thorns starfish (COTS) in each sector in 2005. 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 category (range) coral cover		Mean % Coral Cover ± SE	% AO or IO reefs	% RE reefs	% NO reefs
Cape Grenville	6	0.12	25	2 (33)	3-	(2- to 3+)	38.71 ± 5.20	16.67	16.67	66.7
Princess Charlotte Bay	4	0.05	10	3 (75)	2-/2+	(2- to 3-)	26.27 ± 3.71	0	50	50
Cooktown / Lizard Island	20	0.006	6	2 (10)	2+	(1+ to 3-)	23.96 ± 1.70	0	30	70
Cairns	16	0	0	0 (0)	2-	(1- to 3+)	16.20 ± 2.72	0	31.25	68.8
Innisfail	6	0	0	0 (0)	2-	(1- to 3+)	18.62 ± 5.28	0	66.67	33.3
Townsville	8	0.59	201	3 (38)	1+/2-	(1- to 3-)	18.3 ± 4.25	25	50	25
Cape Upstart	9	0.59	271	6 (67)	2-	(1+ to 3-/3+)	20.03 ± 2.93	44.44	22.22	33.3
Whitsunday	7	0.03	9	2 (29)	2+	(2- to 3+)	25.86 ± 4.42	14.29	14.29	71.4
Pompey	6	0.41	101	2 (33)	2+	(1+ to 4-)	31.04 ± 7.67	33.33	0	66.7
Swain	13	0.08	45	5 (38)	2+	(1- to 5-)	30.07 ± 7.45	7.692	30.77	61.5
Capricorn Bunker	4	0	0	0 (0)	2+/3-	(2+ to 3+)	34.82 ± 4.91	0	0	100

Appendix E

Percentage cover of selected groups of benthic organisms recorded from each region in 2005 Survey.

Figures are regional means.

CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsunday, SW = Swain, CB = Capricorn Bunker. I= Inshore, M = Middle shelf, O = Outer shelf

Sector	Shelf	Hard Coral	Soft Coral	Algae	Acroporidae	Faviidae	Pocilloporidae	Poritidae	Acropora	Acropora Other	Montipora
									Acropora Tabulate	Acropora Other	
CL	I	38.5	4.3	43.3	12.0	6.7	5.0	6.6	3.3	5.6	3.0
CL	M	20.8	9.1	55.5	3.1	4.4	2.4	5.9	1.0	1.3	0.6
CL	O	41.8	3.3	50.4	31.7	1.9	5.4	1.1	18.8	10.8	2.0
CA	I	13.6	13.4	62.7	1.5	1.2	0.4	6.8	0.4	0.3	0.7
CA	M	20.5	14.5	60.1	8.0	3.3	3.4	1.9	3.9	2.9	1.1
CA	O	28.4	30.3	38.4	18.3	1.6	5.1	2.2	7.4	10.5	0.4
TO	I	27.7	10.0	57.9	2.8	2.9	0.3	13.7	0.3	1.2	1.2
TO	M	12.6	3.7	78.4	4.0	2.2	1.8	2.4	1.7	1.7	0.6
TO	O	24.0	8.9	63.6	8.2	4.9	4.2	3.0	2.7	3.9	1.4
WH	I	31.6	25.0	28.4	11.6	3.5	0.6	9.0	1.1	3.9	6.4
WH	M	42.4	1.8	51.0	22.8	7.9	2.9	3.3	12.1	4.0	6.7
WH	O	26.0	38.0	23.6	11.6	3.5	2.7	4.8	4.3	6.1	1.0
SW	M	33.7	9.8	53.7	18.1	2.4	2.7	7.0	6.6	7.4	4.2
SW	O	18.5	27.3	49.7	5.7	1.7	2.5	6.2	3.3	1.7	0.7
CB	O	55.4	3.1	39.5	51.5	1.9	0.9	0.5	39.5	10.4	1.6

Appendix F

Summary counts of the different fish taxa recorded from each region in 2005 Survey.
Figures are regional means for the sums of individuals on 15 transects (3 sites) on each survey reef.

F1. Number of larger more mobile fishes recorded in the regions in the 2003 survey.

CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsunday, SW = Swain, CB = Capricorn Bunker. I= Inshore, M = Middle shelf, O = Outer shelf

Sector	Shelf	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	I	155	163	61	4	88	249	5	96	1
CL	M	160	135	62	21	24	210	20	140	3
CL	O	430	180	39	9	65	254	2	8	20
CA	I	99	60	54	1	149	140	5	56	0
CA	M	173	82	43	6	21	183	3	18	3
CA	O	286	141	45	15	14	228	2	21	7
TO	I	3	37	37	2	39	79	13	32	0
TO	M	95	65	56	4	3	376	9	35	2
TO	O	413	78	37	6	6	237	5	8	9
WH	I	6	65	29	0	16	66	4	25	0
WH	M	17	113	54	1	27	229	13	50	0
WH	O	223	92	33	4	8	119	20	20	7
SW	M	119	98	61	8	14	216	33	49	5
SW	O	255	91	69	2	8	208	13	19	7
CB	O	321	275	62	4	18	350	12	4	7

F2. Number of damselfishes recorded in the regions in the 2005 survey.

CL = Cooktown / Lizard Is, CA = Cairns, TO = Townsville, WH = Whitsunday, SW = Swain, CB = Capricorn Bunker. I= Inshore, M = Midle shelf, O = Outer shelf

Sector	Shelf	*Acantho-chromis*	*Amblygly-phidodon*	*Amphip-rion*	*Chromis*	*Chrysip-tera*	*Dascyllus*	*Dischist-odus*	*Neogly-phidodon*	*Neopoma-centrus*	*Plectrogly-phidodon*	*Poma-centrus*	*Poma-chromis*	*Premnas*	*Stegastes*
CL	I	156	157	0	252	65	7	2	22	521	3	1407	0	0	1
CL	M	83	97	2	102	191	52	9	11	230	27	875	0	0	0
CL	O	92	5	0	1019	8	11	0	0	0	125	209	0	0	1
CA	I	18	25	0	8	100	7	2	36	225	0	538	0	1	0
CA	M	27	17	2	232	36	18	10	24	215	126	638	0	0	31
CA	O	36	7	1	330	21	17	0	4	69	147	231	0	0	0
TO	I	169	5	0	0	1	0	0	33	2162	0	285	0	0	2
TO	M	89	118	9	99	81	2	9	94	487	32	1202	0	0	8
TO	O	42	3	4	294	11	18	1	0	209	153	413	0	0	31
WH	I	100	57	0	118	90	1	1	4	703	0	745	0	0	0
WH	M	16	14	0	315	65	0	0	1	1156	0	1543	0	0	20
WH	O	23	55	3	181	22	6	2	34	49	42	494	0	0	7
SW	M	14	119	5	1209	27	1	1	12	20	11	943	0	0	8
SW	O	16	60	2	8	14	0	0	16	11	23	516	0	0	21
CB	O	11	4	2	240	8	16	0	2	38	47	605	0	0	5

Appendix G

Mean Percentage cover of selected groups of benthic organisms recorded from each reef in 2005 Survey.

Sector	Reef	Reef ID	Shelf	Algae	Hard Coral	Soft Coral	Acro-poridae	Favii-dae	Pocillo-poridae	Pori-tidae	*Acropora* Tabulate	*Acropora* Other	*Monti-pora*
CL	Martin	14123	I	44.5	28.1	3.8	7.8	3.8	3.8	7.1	2.8	3.3	1.6
CL	Linnet	14126	I	42.1	48.9	4.9	16.3	9.6	6.2	6.1	3.9	7.9	4.4
CL	Macgillivray	14114	M	50.6	20.8	5.7	2.3	3.4	1.8	10.1	0.6	0.7	0.8
CL	Lizard Is	14116	M	56.0	16.6	19.5	2.1	5.0	2.2	3.9	0.8	0.4	0.7
CL	North Direction I	14143	M	60.0	25.1	2.1	4.7	4.8	3.3	3.8	1.5	2.8	0.3
CL	Carter	14137	O	52.5	39.0	3.6	30.3	1.9	4.1	0.4	15.9	12.5	1.9
CL	Yonge	14138	O	46.8	48.5	1.9	37.3	1.9	6.0	1.5	25.9	9.6	1.8
CL	No Name	14139	O	52.0	37.8	4.4	27.4	1.8	6.1	1.3	14.6	10.4	2.4
CA	Low Islets	16028	I	68.0	16.0	9.1	0.9	1.2	0.1	8.8	0.2	0.1	0.6
CA	Green Is	16049	I	69.3	9.5	5.9	1.7	1.9	0.5	3.6	0.7	0.7	0.4
CA	Fitzroy Is	16054	I	51.0	15.3	25.1	1.7	0.4	0.5	7.9	0.4	0.1	1.2
CA	Mackay	16015	M	59.1	27.0	4.6	3.9	6.8	2.6	3.3	1.0	2.0	0.8
CA	Hastings	16057	M	61.2	23.6	11.3	12.0	3.4	4.5	1.6	5.4	5.2	1.3
CA	Michaelmas	16060	M	44.5	23.0	28.4	13.6	2.3	3.9	1.5	8.1	3.6	1.8
CA	Thetford	16068	M	75.5	8.4	13.7	2.5	0.5	2.4	1.2	1.1	0.8	0.6
CA	Agincourt No.1	15099	O	41.0	37.1	19.8	24.2	1.7	8.7	1.5	10.1	13.7	0.4
CA	St. Crispin	16019	O	30.9	27.4	38.3	14.8	2.2	4.2	4.6	8.9	5.4	0.5
CA	Opal (2)	16025	O	43.2	20.7	32.8	15.9	0.9	2.5	0.5	3.2	12.3	0.4
TO	Pandora	18051	I	33.9	47.5	13.3	1.4	4.7	0.4	26.3	0.3	0.5	0.7
TO	Havannah Is	18065	I	82.0	7.9	6.7	4.1	1.0	0.2	1.0	0.4	2.0	1.7
TO	Rib	18032	M	81.8	5.1	7.8	3.0	0.6	0.4	0.7	1.4	1.5	0.1
TO	John Brewer	18075	M	91.1	1.3	1.7	0.1	0.3	0.4	0.1	0.0	0.1	0.0
TO	Davies	18096	M	62.3	31.3	1.7	8.8	5.9	4.6	6.4	3.6	3.6	1.6
TO	Myrmidon	18034	O	58.7	29.5	6.4	7.9	8.1	3.4	3.7	3.3	2.4	1.8
TO	Dip	18039	O	59.1	29.2	8.2	14.6	3.8	6.4	2.3	4.6	8.2	1.7
TO	Chicken	18086	O	72.9	13.4	12.1	2.1	2.9	2.7	3.1	0.3	1.1	0.7
WH	Hayman Is	20014	I	30.5	45.6	15.8	27.5	4.4	1.1	1.9	1.3	8.9	17.2
WH	Langford And Bir	20019	I	27.9	21.8	23.3	4.2	3.6	0.4	8.4	1.0	2.2	0.8
WH	Border Is (A)	20067	I	26.7	27.4	35.8	3.0	2.4	0.2	16.7	1.1	0.7	1.1
WH	19-131	19131	M	53.3	39.7	0.8	16.3	13.5	1.0	2.7	6.7	1.9	7.6
WH	19-138	19138	M	54.1	39.3	2.3	22.2	5.6	4.5	2.5	14.3	4.3	3.6
WH	20-104	20104	M	45.6	48.3	2.1	29.8	4.5	3.3	4.7	15.3	5.7	8.9
WH	19-159	19159	O	29.0	43.6	17.8	26.5	4.4	4.4	2.9	9.2	15.1	2.1
WH	Hyde	19207	O	22.2	15.2	48.7	3.6	2.6	1.7	5.2	1.5	1.8	0.2
WH	Rebe	19209	O	19.4	19.1	47.5	4.8	3.5	2.0	6.4	2.3	1.5	0.6
SW	21-529	21529	M	42.7	51.5	1.0	36.0	1.6	3.3	6.2	3.0	26.1	6.9
SW	Gannet Cay	21556	M	80.4	8.8	8.2	1.3	0.5	1.5	2.3	0.5	0.3	0.4
SW	Snake	22088	M	34.2	53.6	9.2	31.5	2.6	4.5	11.3	16.3	5.9	9.3
SW	Chinaman	22102	M	32.7	39.6	26.5	18.0	5.4	3.1	9.1	12.0	3.3	2.6
SW	Horseshoe	22104	M	78.5	15.1	4.2	3.7	2.0	1.3	6.0	0.9	1.1	1.6
SW	East Cay	21305	O	42.2	21.9	30.1	6.9	1.3	4.1	6.3	3.8	2.5	0.6
SW	Turner Cay	21562	O	57.2	15.1	24.5	4.4	2.0	0.8	6.1	2.7	0.9	0.7
CB	Broomfield	23048	O	41.6	48.2	6.0	42.8	2.7	1.0	0.8	27.0	11.9	3.9
CB	Wreck Is	23051	O	51.5	42.2	5.0	38.4	2.2	0.2	0.7	25.8	11.2	1.4
CB	One Tree Is	23055	O	32.5	65.4	0.9	62.8	1.6	0.6	0.1	54.0	8.4	0.5
CB	Lady Musgrave Is	23082	O	31.8	66.8	0.2	62.6	1.2	2.0	0.5	51.8	10.3	0.5

Appendix H

Summary counts of the different fish taxa recorded from each reef in 2005 Survey.
Figures are the sums of individuals on 15 transects (3 sites) on each survey reef.

H1. Number of larger more mobile fishes recorded in the reefs in the 2003 survey.

Sector	Reef	Reef Shelf ID	Acanthuridae	Chaetodontidae	Labridae	Lethrinidae	Lutjanidae	Scaridae	Serranidae	Siganidae	Zanclidae
CL	Martin	14123 I	227	169	60	8	86	348	6	79	1
CL	Linnet	14126 I	83	157	62	0	90	150	4	113	1
CL	Macgillivray	14114 M	165	88	56	21	44	162	24	41	1
CL	Lizard Is	14116 M	135	146	52	24	15	136	28	46	3
CL	North Direction I	14143 M	181	171	78	18	13	333	8	332	6
CL	Carter	14137 O	430	169	30	6	80	252	1	2	23
CL	Yonge	14138 O	532	209	51	6	44	281	0	12	27
CL	No Name	14139 O	328	163	36	16	71	228	4	11	9
CA	Low Islets	16028 I	44	54	57	0	190	77	2	64	0
CA	Green Is	16049 I	235	68	39	1	143	299	6	67	0
CA	Fitzroy Is	16054 I	17	57	65	2	115	44	7	36	1
CA	Mackay	16015 M	15	59	38	8	30	89	7	14	1
CA	Hastings	16057 M	291	112	49	10	14	95	1	14	5
CA	Michaelmas	16060 M	160	105	27	4	25	220	2	28	4
CA	Thetford	16068 M	227	52	56	3	14	326	0	16	2
CA	Agincourt No.1	15099 O	295	186	61	24	23	255	0	17	6
CA	St. Crispin	16019 O	235	156	49	12	0	242	5	4	3
CA	Opal (2)	16025 O	329	81	24	8	19	187	2	41	12
TO	Pandora	18051 I	4	60	35	3	69	78	19	50	0
TO	Havannah Is	18065 I	1	14	38	0	9	79	6	14	0
TO	Rib	18032 M	120	42	49	4	3	403	4	31	0
TO	John Brewer	18075 M	118	46	66	5	1	342	10	34	0
TO	Davies	18096 M	46	106	54	3	5	383	13	41	5
TO	Myrmidon	18034 O	400	121	39	4	11	294	0	5	19
TO	Dip	18039 O	383	52	30	7	5	158	3	4	3
TO	Chicken	18086 O	455	60	42	6	3	259	12	16	5
WH	Hayman Is	20014 I	5	73	44	0	17	72	1	22	0
WH	Langford And Bir	20019 I	12	66	26	0	11	100	5	32	0
WH	Border Is (A)	20067 I	2	56	18	0	21	27	6	20	0
WH	19-131	19131 M	15	84	47	0	15	197	15	51	0
WH	19-138	19138 M	24	113	65	1	21	212	5	61	0
WH	20-104	20104 M	11	141	50	2	45	278	19	38	1
WH	19-159	19159 O	161	132	32	6	16	171	39	35	9
WH	Hyde	19207 O	224	66	36	3	1	91	12	15	7
WH	Rebe	19209 O	285	77	31	4	6	95	9	9	6
SW	21-529	21529 M	13	84	43	19	13	230	65	28	0
SW	Gannet Cay	21556 M	51	43	50	13	10	280	50	82	4
SW	Snake	22088 M	70	127	45	1	9	164	20	34	6
SW	Chinaman	22102 M	190	125	81	5	15	162	23	49	3
SW	Horseshoe	22104 M	270	109	84	0	25	243	8	54	10
SW	East Cay	21305 O	166	82	70	1	2	93	5	22	8
SW	Turner Cay	21562 O	343	99	67	3	13	322	20	16	5
CB	Broomfield	23048 O	311	262	70	5	19	425	11	5	2
CB	Wreck Is	23051 O	349	281	62	7	28	323	11	5	7
CB	One Tree Is	23055 O	226	288	52	2	17	292	20	6	7
CB	Lady Musgrave Is	23082 O	396	270	64	3	8	361	7	1	12

H2. Number of damselfishes recorded in the reefs in the 2005 survey.

Sector	Reef	Reef ID	Shelf	*Acanthochromis*	*Amblyglyphidodon*	*Chromis*	*Chrysiptera*	*Neoglyphidodon*	*Neopomacentrus*	*Plectroglyphidodon*	*Pomacentrus*
CL	Martin	14123	I	44	70	127	62	10	332	0	1135
CL	Linnet	14126	I	268	244	377	67	34	709	6	1678
CL	Macgillivray	14114	M	113	64	72	151	11	81	31	557
CL	Lizard Is	14116	M	86	110	127	161	10	585	31	1533
CL	North Direction I	14143	M	51	117	106	262	12	23	20	534
CL	Carter	14137	O	87	6	1024	10	0	0	165	198
CL	Yonge	14138	O	92	0	1003	9	1	0	124	143
CL	No Name	14139	O	98	10	1029	4	0	0	87	287
CA	Low Islets	16028	I	15	16	0	39	37	290	0	693
CA	Green Is	16049	I	30	31	23	200	7	41	1	577
CA	Fitzroy Is	16054	I	10	28	0	60	64	345	0	344
CA	Mackay	16015	M	5	34	24	110	76	38	2	714
CA	Hastings	16057	M	53	13	214	7	20	76	152	532
CA	Michaelmas	16060	M	10	14	666	14	0	727	194	834
CA	Thetford	16068	M	41	6	24	11	1	20	157	473
CA	Agincourt No.1	15099	O	25	0	243	15	2	0	207	175
CA	St. Crispin	16019	O	51	20	483	8	7	0	102	356
CA	Opal (2)	16025	O	32	0	265	40	4	207	132	161
TO	Pandora	18051	I	82	3	0	1	39	3761	0	226
TO	Havannah Is	18065	I	256	6	0	0	26	563	0	344
TO	Rib	18032	M	93	112	140	30	81	453	44	1025
TO	John Brewer	18075	M	120	62	2	102	64	304	11	922
TO	Davies	18096	M	55	179	154	111	138	704	40	1659
TO	Myrmidon	18034	O	50	5	750	2	0	25	202	197
TO	Dip	18039	O	15	3	89	11	0	25	113	393
TO	Chicken	18086	O	62	0	43	19	1	577	143	649
WH	Hayman Is	20014	I	103	71	5	27	3	19	0	659
WH	Langford And Bir	20019	I	114	48	48	78	5	277	0	487
WH	Border Is (A)	20067	I	84	53	301	166	4	1814	0	1090
WH	19-131	19131	M	13	8	40	32	1	1633	0	1311
WH	19-138	19138	M	24	26	174	75	0	876	0	1651
WH	20-104	20104	M	11	7	730	87	1	959	0	1666
WH	19-159	19159	O	27	112	464	32	64	110	55	486
WH	Hyde	19207	O	31	22	37	20	27	1	35	467
WH	Rebe	19209	O	11	32	43	13	12	37	36	528
SW	21-529	21529	M	34	162	985	75	2	0	1	1066
SW	Gannet Cay	21556	M	11	127	4900	27	11	0	2	838
SW	Snake	22088	M	3	33	16	13	10	60	0	1326
SW	Chinaman	22102	M	17	119	145	1	32	39	52	890
SW	Horseshoe	22104	M	4	154	0	17	7	0	0	594
SW	East Cay	21305	O	18	58	0	26	29	20	17	615
SW	Turner Cay	21562	O	14	62	15	2	3	1	29	416
CB	Broomfield	23048	O	14	3	141	11	2	125	30	1071
CB	Wreck Is	23051	O	27	6	374	9	3	3	44	559
CB	One Tree Is	23055	O	3	0	247	8	1	0	32	466
CB	Lady Musgrave Is	23082	O	0	8	199	5	0	22	82	324

Appendix I

Statistical Analysis of the Survey Data

Analysis of reef trends [Section 4]

Temporal trends in percent cover of benthic groups and families and abundance of fish families were examined at each reef within each Sector/Shelf region using linear mixed-effects models. Estimated trends and observed means for each measure were plotted against survey year to provide a visual presentation of temporal patterns.

Benthic cover analyses

Estimates of percent cover for the benthic groups are obtained by point sampling a 50 m transect recorded on videotape. The response at each site (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).

Fish abundance analyses

Counts of fish abundance are obtained from 50 m transects adjacent to the benthic video surveys. The response at each site (summed counts over 5 transects) is transformed to the natural logarithm of the observed count ($log(y + 1)$).

Mixed-effects models

Linear mixed-effects models (Laird and Ware 1982, Pinheiro and Bates 2000), which extend the linear model to include random effects to account for correlation among observations on the same sampling unit, were used to examine the relationship between the response and time (i.e. survey year). The response, y_i, for the i^{th} sampling unit is expressed as:

$$y_i = X_i\beta + Z_i b_i + \varepsilon_i, \quad i = 1,...,M,$$
$$b_i \sim N(0,\Sigma), \quad \varepsilon_i \sim N(0,\sigma^2 I)$$

where X_i and Z_i are known fixed-effect and random-effect regressor matrices, β are the fixed-effects, b_i are the random-effects, and ε_i is the within-sampling-unit error with a spherical Gaussian distribution, $N(0,\sigma^2 I)$. The random-effects and within-sampling-unit errors are assumed independent between sampling units and within sampling units. The distribution of the random-effects is characterised by the variance-covariance matrix, Σ.

The model chosen to describe the response (y_{ijklm}) represents the empirical logit of percent cover of a particular benthic group, or the log of abundance of a particular fish family, recorded on site *l* for the k^{th} reef in the ij^{th} region at time (*m*) as:

$$y_{ijklm} = f(x_{ijklm}) + b_{ijkl} + \varepsilon_{ijklm}$$

where $f(x_{ijklm})$ represents the fixed-effects as some function of the response for the l^{th} site at the k^{th} reef in the ij^{th} region at survey time *m*, b_{ijkl} represents the random-effects (i.e. random intercepts) for individual reefs and ε_{ijklm} is the within-sampling unit error. The random intercepts form for the random-effects in the model results in a scalar variance estimate for between sampling unit variation. The assumption that the variance of the ε_i is equal to $\sigma^2 I$ can be relaxed to allow within-sampling unit correlation structures. The errors were assumed to conform to a multivariate normal distribution with mean = 0 and covariance structure = Σ. To account for temporal correlation within sampling units, models were fitted with and without a continuous autoregressive covariance structure (Pinheiro and Bates 2000). The structure was assumed to be homogeneous for all reefs.

Form of the fixed-effects component

The following forms for the fixed-effects relationship between the response and survey year were examined:

Constant - $y_{ijklm} = \beta_{0ijk} + \varepsilon_{ijklm}$,

Linear - $y_{ijklm} = \beta_{0ijk} + \beta_{1ijk} x_{ijklm} + \varepsilon_{ijklm}$,

Quadratic - $y_{ijklm} = \beta_{0ijk} + \beta_{1ijk} x_{ijklm} + \beta_{2ijk} x^2_{ijklm} + \varepsilon_{ijklm}$,

Natural spline - $y_{ijklm} = s_{ijk}(x_{ijklm}) + \varepsilon_{ijklm}$,

where

β_{0ijk} represents the response at $x_{ijklm} = 0$ for the k^{th} reef in the ij^{th} region,
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,
s_{ijk} represents a natural spline, with specified degrees of freedom, in the response for the k^{th} reef in the ij^{th} region,
x_{ijklm} is the 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.

Natural splines are flexible, smooth and nonlinear functions of the explanatory variables which represent the relationship with the response. Natural splines 'smooth' the relationship by dividing the data along the *x*-axis into regions separated at user-defined breakpoints and fitting polynomial regressions to each group constrained to be continuous (i.e. 'smooth') at the breakpoints. The degree of flexibility (i.e. the smoothness) is determined by the number of breakpoints as defined by the degrees of freedom of the spline.

Models containing each of the fixed effects structures described were defined *a priori* as candidate models. This candidate set included models with natural splines with either three or four degrees of freedom. The set of models accounted for temporal correlation within sampling units by fitting models for each fixed effects structure both with and without a continuous autoregressive correlation structure.

Model selection

The 'best' approximating model among the set of candidate models outlined above was determined using Akaike's Information Criteria (AIC) (Akaike 1973, Burnham and Anderson 1998). The criterion is defined as:

$$AIC = -2\log(L(\hat{\theta} \mid y)) + 2K$$

where $L(\hat{\theta} \mid y)$ represents the likelihood of the model parameters, $\hat{\theta}$, given the data, y, and *K* represents the number of parameters in the model. The AIC value is then a measure of the goodness-of-fit of the model to the data, penalised by the number of parameters in the model. This is equivalent to the trade-off between bias and variance that is implicit in the principle of parsimony: selecting a model with the smallest number of parameters which adequately represents the data.

From the set of candidate models, the model that minimised AIC was subsequently used for inference.

Coding of the survey year

To estimate average and current trends in the response the data were analysed using the survey year coded both as:

$$x_{ijklm} = \left(survey\ year - 1998.5\right)$$

and

$$x_{ijklm} = (survey\ \ year - 2005)$$

to allow direct estimation of β_{0ijk} and β_{1ijk} at two different times during the survey period. When the survey year is centred around 1998.5, the parameters β_{0ijk} and β_{1ijk} represent the average value of the response over the last 13 years for reef *ijk* and the linear change in the response over the period of the surveys for reef *ijk*, respectively. When the survey year is centred around 2005, the parameters β_{0ijk} 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. These estimates were then used to summarise the average and current changes in the response at the Sector level for GBR-wide summaries.

Statistical computing

The S-Plus (2000) statistical software (Insightful Corp., Seattle, WA) was used for all analyses. The **`lme`** function was used to fit the linear mixed-effects models described for the benthic cover and fish abundance analyses.