Australian Government
Great Barrier Reef
Marine Park Authority

GREAT BARRIER REEF
WATER QUALITY PROTECTION PLAN (REEF PLAN)

Annual Marine Monitoring Report

Reporting on data available from December 2004 to April 2006

Joelle Prange, David Haynes,
Britta Schaffelke and Jane Waterhouse

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Preface

This report provides a synthesis of data obtained from monitoring activities undertaken between December 2004 and June 2005 as part of the Reef Water Quality Protection Plan. The information contained in this report has been extracted primarily from the November 2006 Final Report 'Water Quality and Ecosystem Monitoring Program Reef Water Quality Protection Plan, provided by the monitoring contractors.

The Great Barrier Reef Marine Park Authority would like to acknowledge the input from the authors of this report.

River sediment and nutrient loads - Miles Furnas (AIMS), Britta Schaffelke (AIMS), Michele Skuza (AIMS), John Carleton (AIMS), Glen De'ath (AIMS), Gavin Feather (AIMS), Peter Gilbey (NRW), Geoff Pocock (NRW), Vince Manley (NRM);

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Mud crab bioaccumulation monitoring - Andrew Negri (AIMS), Munro Mortimer (EPA), Jochen Mueller (Entox).

Acronyms

AIMS	Australian Institute of Marine Science
COTS	Crown-of-thorns starfish
CRC Reef	CRC Reef Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DON	Dissolved Organic Nitrogen
DOP	Dissolved Organic Phosphorus
DPI&F	Queensland Department of Primary Industries and Fisheries
ED	Empore Disk (passive sampler)
EnTox	National Research Centre for Environmental Toxicology at UQ
EPA	Queensland Environmental Protection Agency
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
LOD	Limit of detection
MODIS	Moderate resolution Imaging Spectrometer
NH4	Ammonia
NO2	Nitrite
NO3	Nitrate
NRM	Natural Resource Management
NRW	Queensland Department of Natural Resources and Water
PAH	Polyaromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PN	Particulate Nitrogen
PO4	Phosphate
PP	Particulate Phosphorus
QHSS	Queensland Health Scientific Services
QPWS	Queensland Parks and Wildlife Services
MMP	(Reef Water Quality Protection Plan) Marine Monitoring Programme
Reef Plan	Reef Water Quality Protection Plan
SPMD	Semipermeable Membrane Device (passive sampler)
SS	Suspended Solids
TDN	Total Dissolved Nitrogen
TDP	Total Dissolved Phosphorus
TSS	Total Suspended Solids
UQ	University of Queensland

Contents

Tables

Figures

Executive Summary

The Reef Water Quality Protection Plan (Reef Plan) was released by the Australian and Queensland Governments in October 2003. The Reef Plan focuses on identifying and implementing solutions to improve water through sustainable natural resource management, with the ultimate goal to "*halt and reverse the decline in water quality entering the Reef within 10 years*". As part of the Reef Plan, the Reef Water Quality Protection Plan Marine Monitoring Programme, was established in 2005 to help assess the long-term status and health of Great Barrier Reef ecosystems. The Marine Monitoring Programme is a critical component of the assessment of any long-term improvement in regional water quality that will occur as best land management practices are widely adopted across Great Barrier Reef catchments. Data collected over the first eighteen months of the monitoring programme have improved our understanding of Great Barrier Reef rivers, inshore lagoon waters, inshore reef and seagrass ecosystems. Innovative monitoring techniques have provided critical information that will be used as a baseline by which to judge future improvements in Great Barrier Reef water quality and ecosystem health.

Five elements of the Marine Monitoring Programme have been successfully implemented over the last 18 months (late 2004 to April 2006) to derive this information. These include:

- Water quality monitoring in ten river mouths of priority Great Barrier Reef catchment rivers to determine current status of concentrations and loads of the major land sourced pollutants (sediments, nutrients and pesticides) that can potentially harm Great Barrier Reef ecosystems. In the long term, this data will also help illustrate the effectiveness of ongoing activities undertaken by communities and governments in the Great Barrier Reef Catchment to reduce the transfer of pollutants to the Great Barrier Reef.

- Monitoring of marine water quality to determine current status of water turbidity, chlorophyll, suspended sediment, nutrient and pesticide concentrations at key inshore Great Barrier Reef lagoon and open water sites. This data will provide baselines for the assessment of future improvements in the waters of the Great Barrier Reef resulting from any reductions in pollutants from the river mouths. Sampling combines traditional water sampling techniques, remote sensing and state-of-the-art sensors with long-term data logging capacity.

- Monitoring of intertidal seagrass beds and inshore coral reefs at risk from land-based pollutants to ensure that any change in their status is identified.

- Monitoring mud crabs for the presence of toxicants. This measurement provides a sensitive, early warning of the presence of pollutants before conventional monitoring techniques may detect them.

- Information on reef-based industries and activities such as tourism and commercial fishing that contribute about $5.8 billion annually to Australia's economy. Socio-economic monitoring assesses the contribution a healthy Great Barrier Reef ecosystem makes to the welfare of Queensland's regional communities and to Australia in general.

The key findings of the Marine Monitoring Programme to date include:

- Eight of the ten major Great Barrier Reef rivers monitored in the programme were found to exceed Queensland Water Quality Guideline values for most nutrients and suspended sediment concentrations. The exceptions were the Pioneer and Burnett Rivers which had very low wet season flows (due to low rainfall) and as a consequence, lower pollutant discharges over the monitoring period.

- Elevated levels of nutrient and suspended sediment in the inshore Great Barrier Reef lagoon were detected locally, following flooding rains and land runoff and periods of inshore wave action caused by storm events.

- The Marine Monitoring Programme confirmed pesticides to be an ubiquitous contaminant in the inshore areas of the Great Barrier Reef. The herbicides, atrazine and diuron were present at low concentrations at river mouths, inshore reefs and intertidal seagrass monitoring locations. Concentrations of the herbicides were detected at higher concentrations during the wet season.

- There were also different pesticides detected in the vicinity of different land use activities. For example, tebuthiuron was typically found in cattle grazing areas, whereas diuron was more likely to be present adjacent to intensive agriculture. The ecological consequences of chronic low level exposure to these types of pollutants are yet to be fully understood, although laboratory experiments have demonstrated their acute toxicity to seagrass and corals.

- Banned organochlorine pesticides were commonly found in mud crabs collected along the Great Barrier Reef coast from 7 of the 11 major rivers sampled. Pollutants detected included PCBs, dieldrin and the breakdown products of DDT. Mud crabs collected from rivers with urban inputs such as the Burnett, Pioneer, Fitzroy and Barron Rivers contained the highest frequency and concentrations of organochlorine compounds. The level of pollutants found in the mudcrabs are well below the Australian Food Saftey Standards and furthermore the tissue material sampled (the hepatopancreas) is not usually eaten.

- Monitoring of inshore reef communities indicated that reefs situated closer to river mouths often had higher quantities of macroalgae and lower densities and biodiversity of small corals, although coral settlement did not typically show a clear relationship with distance from river mouths. Previous research has shown that sedimentation and light reduction (e.g. due to high turbidity) can decrease coral recruitment and the survival of small corals. Future monitoring will be important to determine how recruitment rates vary year to year and whether the coral juveniles survive to form adult colonies in the future.

- Seagrass monitoring has shown that there is distinct local variability in seagrass populations. Significant declines in seagrass cover and distribution were detected at sites affected by Tropical Cyclone Larry (Lugger Bay) and there were significant declines in intertidal *Zostera* meadows in Gladstone and other southern/central Queensland locations. These declines may be related to variations in rainfall, wind and water temperature. Importantly, assessment of seagrass reproductive health indicated that all seagrass meadows except those at Lugger Bay had the capacity to recover from short-term disturbance via seed banks.

- The monitoring programme confirmed a general southward gradient in mean chlorophyll *a* concentration, especially in the coastal zone. There was no significant cross-shelf gradient in chlorophyll concentrations in the Cape York region, while all other monitored areas further south have significantly higher chlorophyll values inshore than offshore. Chlorophyll is widely used as a proxy for nutrient availability, suggesting that there are more nutrients available in the inshore coastal zone, particularly in the southern regions.

- The Marine Monitoring Programme was successful in providing significant advances in satellite-based spatial and temporal information about near-surface concentrations of chlorophyll and suspended solids in lagoonal and coastal waters of the Great Barrier Reef. This technique is likely to replace conventional water sampling for chlorophyll monitoring in the future, and will provide greater spatial and temporal understanding on the concentrations of chlorophyll (and thus nutrients) in the

Great Barrier Reef.

- The Marine Monitoring Programme was also successful in the testing and validation of autonomous data logging instruments to measure marine water concentrations of chlorophyll and turbidity. While remote sensing will allow the monitoring of large-scale patterns, autonomous instruments are expected to be increasingly used in the future as they have the benefit of obtaining high frequency data series at locations of particular interest, e.g. a reef or seagrass bed where long-term monitoring of biological status is undertaken.

The success of many of the components of the Marine Monitoring Programme is reliant on the continuing support of the community, industry and government. Volunteer samplers carry out much of the fieldwork for river monitoring, marine pesticide sampling, chlorophyll *a* monitoring and intertidal seagrass monitoring. The Great Barrier Reef Marine Park Authority would like to thank these people and organisations for their valuable contribution. A review of the existing programme will be carried out in 2007 to ensure that monitoring continues to be appropriately co-ordinated across the Great Barrier Reef catchments and inshore and offshore marine environments. The review will also help to ensure that future marine monitoring can be aligned with monitoring activities carried out as part of local catchment management strategies. If this can be achieved, it will be possible to document the anticipated improvement in catchment and marine water quality and to provide support for current and future catchment based activities under the Reef Water Quality Protection Plan.

Part 1

About the Marine Monitoring Programme

Introduction

The Reef Water Quality Protection Plan (Reef Plan) was released by the Australian and Queensland Governments in October 2003 with the goal to "*halt and reverse the decline in water quality entering the Reef within 10 years*". The Reef Plan focuses on identifying and implementing solutions to improve water quality through sustainable natural resource management (NRM). It is being implemented through partnerships between Regional NRM bodies, industry sectors and the general community and will help to ensure the long-term sustainability of the Great Barrier Reef, its catchments and the industries and communities it supports.

The Reef Plan Marine Monitoring Programme

A key component of the Reef Plan is the implementation of long-term water quality, ecosystem and socio-economic monitoring programmes in the Great Barrier Reef lagoon. This is the specific responsibility of the Great Barrier Reef Marine Park Authority (GBRMPA) and will help to *assess the long-term effectiveness of the Reef Plan in reversing the decline in Great Barrier Reef water quality.* Management of the monitoring programme is carried out by the GBRMPA, in a partnership with seven monitoring providers with a long-term track record of monitoring and research in the Great Barrier Reef Marine Park. The consortium (co-ordinated by the CRC Reef Research Centre) includes:

- The Australian Institute of Marine Science (AIMS);
- The University of Queensland- National Research Centre for Environmental Toxicology (ENTOX);
- The Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- The Queensland Department of Primary Industry and Fisheries (DPI&F);
- The Queensland Department of Natural Resources and Water (NRW);
- The Queensland Environmental Protection Agency (EPA); and
- Sea Research

The Marine Monitoring Programme has four sub-programmes: River mouth water quality monitoring, inshore marine water quality monitoring, marine biological monitoring, and socio-economic monitoring.

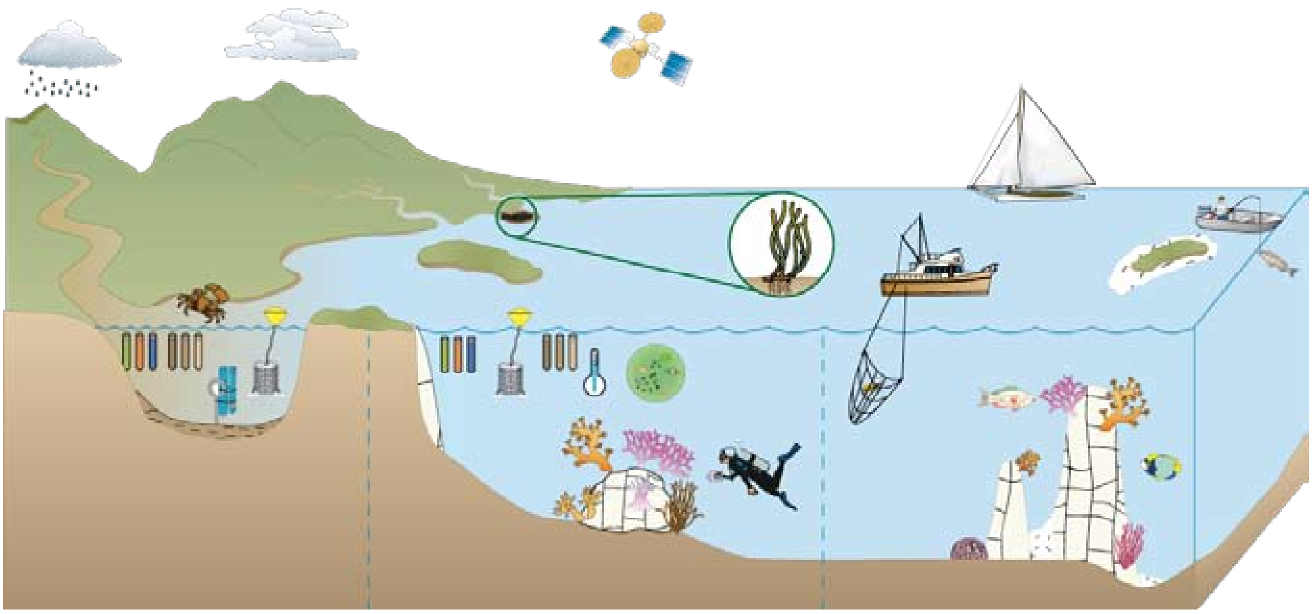
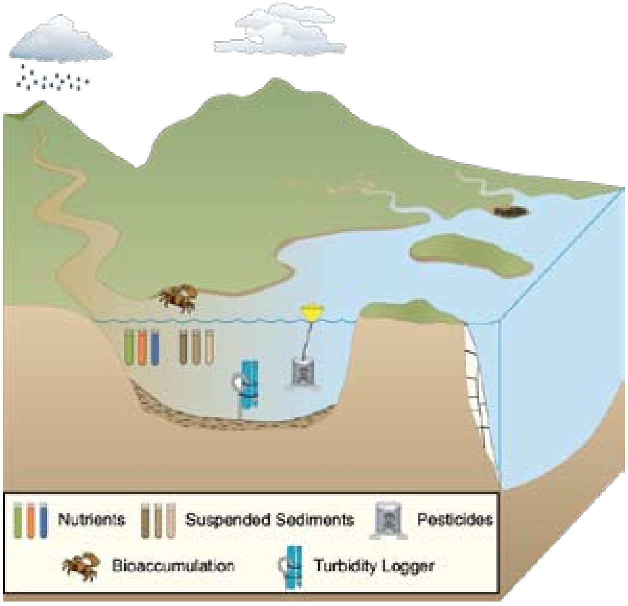


Figure 1 Pictorial representation of the components monitored as part of the Marine Monitoring Programme



River mouth water quality monitoring

Water quality monitoring at river mouths assesses change over time in concentrations and loads of land-sourced pollutants that can potentially harm Great Barrier Reef ecosystems. This data can be used to determine change in the discharge of pollutants from the catchment and can help illustrate the effectiveness of activities undertaken by communities and governments in the Great Barrier Reef Catchment to reduce the transfer of pollutants to the Reef.

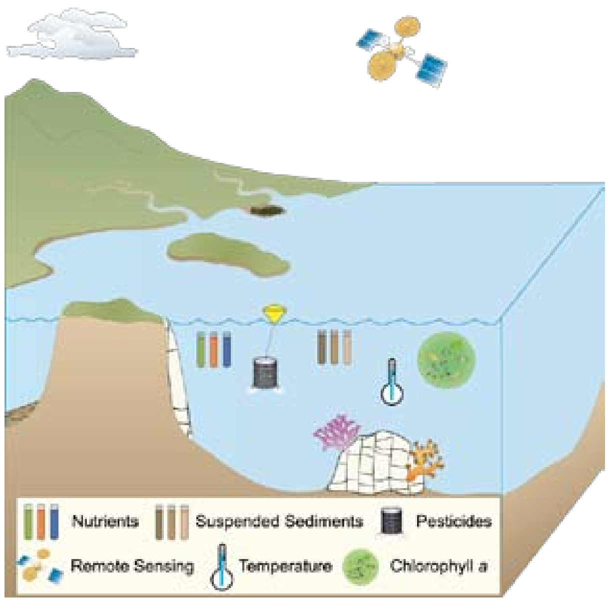
Water quality monitoring is undertaken at ten river mouth locations. These ten rivers are considered high priority because of their size/flow and potential impacts to the Great Barrier Reef.

Monitoring at these river mouths includes:

- The concentration of water column nutrients and suspended sediments, particularly during flood events, when the majority of pollutants are transported to the Reef;
- The measurement of pesticides in the water column using contiuously deployed passive samplers that provide estimates of time averaged concentrations;
- Deployment of automated turbidity loggers at the river mouth sites to determine the loads of sediment that are exported to the reef; and
- The analysis of mud crab tissue for pesticides and other pollutants that may accumulate in the body of these animals.

Inshore marine water quality monitoring

Marine water quality monitoring is carried out in the inshore waters of the Great Barrier Reef (within twenty kilometres of the coast) to assess change over time in concentrations of key water quality indicators. Monitoring of marine water quality is required to establish the extent of improvements in lagoon water resulting from any reductions in pollutants discharged from Great Barrier Reef catchments. Monitoring is conducted at a number of coastal and inshore sites, particularly where marine biological monitoring is also being undertaken to allow comparison of these data sets. Community monitoring partnerships are an important aspect of this programme.



Monitoring at inshore sites includes:

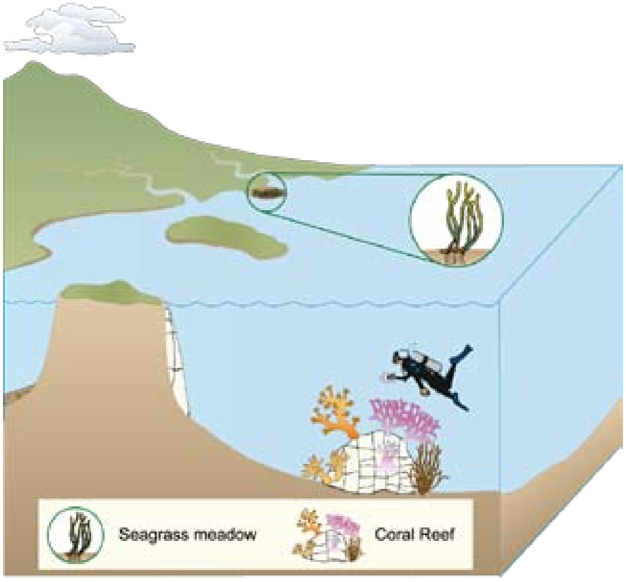
- The concentration of water column nutrients and suspended sediments around inshore reefs during the wet and dry seasons. There is also a component investigating the usefulness of automated long-term water quality loggers;
- The concentration of pesticides in the water column is monitored with the assistance of tourism operators, at >10 inshore reef and island sites;
- The concentration of chlorophyll *a* in th water column at more than 50 sites from Cape York to the

Burnett Mary regions. This task is assisted by community groups and tourism operators;

- Seawater temperatures monitoring, using long-term data loggers at 28 sites; and
- The development of remote sensing techniques to determine spatial and temporal variation in surface concentrations of suspended sediments and chlorophyll *a.*

Marine biological monitoring

Land-based water quality pollutants can have negative impacts on the marine ecosystems that make up the Great Barrier Reef Marine Park. Monitoring of the major marine ecosystem types recognised as being most at risk from land-based pollutants (coral reefs and seagrass meadows) is carried out to ensure that any change in their status is identified.

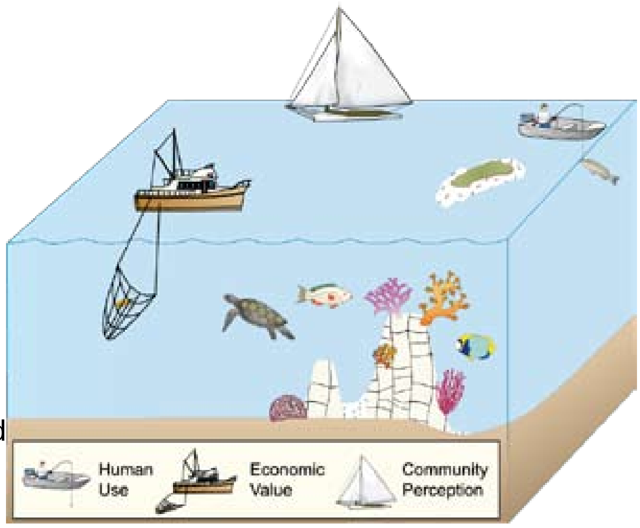


The status of inshore coral reefs is determined by monitoring benthic cover (algae, hard and soft corals), taxonomic composition and coral demographics (the size classes of corals). Coral settlement rates are also measured at reefs in two regions.

Intertidal seagrass meadows are monitored for percent cover, species composition, reproductive health and seagrass tissue nutrient status. This task is assisted by the community-based Seagrass-Watch programme (www.seagrasswatch.org).

Social and economic monitoring

The flow-on effect of the tourism industries which rely on the continued health of the Reef system for long-term economic sustainability, underpins a significant and growing proportion of Queensland's regional economy. Declining water quality directly threatens sustainability of the Great Barrier Reef's natural capital and therefore the ongoing prosperity of the industries and the communities that rely upon them.



The social and economic components of the Marine Monitoring Programme report on:

- Market values of Great Barrier Reef industries and their inputs to regional economies;
- Patterns of human use of the Great Barrier Reef, particularly non-commercial recreational activities, tourism and commercial fishing; and
- Community and visitor perceptions of, and satisfaction with, Great Barrier Reef health.

Community Involvement

Monitoring partnerships with the community are an essential component of the Marine Monitoring Programme.

Community groups are assisting in four major areas of the monitoring programme by helping with:

- The collection of water quality samples and deployment of mudloggers at river sites;
- The deployment and collection of passive samplers at river and inshore reef locations;
- The collection of chlorophyll samples (at coastal and inshore sites); and
- The assessment of seagrass health in intertidal meadows.

The GBRMPA would like to acknowledge and thank the efforts of the following organisations and individuals who were/are involved in sample collection for the Marine Monitoring Programme.

Cape York: Cook Shire Council; Undersea Explorer; Commercial mudcrab fishers; Seagrass-Watch volunteers; Queensland Parks and Wildlife Service.

Wet Tropics: FNQ NRM Community Waterway Monitoring Programme; BRICMA; Treeforce; Herbert Catchment Group; Undersea Explorer; Quick Cat Scuba Adventures; Quicksilver Connections; Frankland Island Cruise and Dive; Raging Thunder, Fitzroy Island Resort; Voyages Dunk Island; Low Isles Caretaker; Bedarra Resort; Cardwell State School; Commercial mudcrab fishers; Seagrass-Watch volunteers; Queensland Parks and Wildlife Service.

Burdekin: Sunferries; Orpheus Island Resort; Alan Mitchell (Magnetic Island volunteer); Commercial mudcrab fishers; Seagrass-Watch volunteers; Australian Centre for Tropical and Freshwater Research.

Mackay Whitsunday: Whitsunday Catchment Landcare; Mackay Whitsunday NRM Group; Mackay Whitsunday Healthy Waterways; Pioneer Catchment Group; Long Island Dive and Snorkel; Fantasea; Daydream Island Resort; Hamilton Island Resort; Commercial mudcrab fishers; Seagrass-Watch volunteers; Queensland Parks and Wildlife Service.

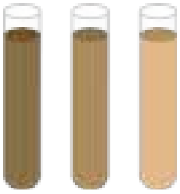
Fitzroy: North Keppel Island Education Centre; Fitzroy River Water; CapReef; Freedom Fast Cats; Tannum Boyne Coastcare group; Commercial mudcrab fishers; Seagrass-Watch volunteers; Queensland Parks and Wildlife Service.

Burnett Mary: Bundaberg City Council; Woongarra Marine Park Monitoring and Education Project; Queensland Sea Scallops Ltd; Commercial mudcrab fishers; Seagrass-Watch volunteers.

Water quality monitoring indicators

The Marine Monitoring Programme assesses the health of the Marine Park by measuring key water quality, ecosystem and socio-economic indicators.

The quality of water entering the Great Barrier Reef lagoon has declined since European settlement and is impacting on the condition of Great Barrier Reef ecosystems. Human activity in Great Barrier Reef catchments, particularly land clearing for agricultural and urban development, is the primary cause of altered water quality and has resulted in the increased loads of pollutants to the Reef. The three major classes of water quality pollutants of concern are sediments, nutrients and pesticides. These pollutants can have negative effects on the different ecosystems that make up the Great Barrier Reef Marine Park, such as mangroves, seagrass and corals.



Suspended sediment

Land clearing has increased soil erosion and sediment loss to local waterways. Small sediment particles (suspended sediments) stay in suspension for extended periods in the water column and are often transported out into the marine environment.

Excess quantities of suspended sediment can result in environmental damage by reducing light penetration through the water column, smothering of benthic organisms like corals and seagrass, irritation of fish gills and can transport nutrients and pesticides to the Reef.

The Marine Monitoring Programme tracks long-term change in sediment concentrations in inshore and reef waters. Suspended sediments are measured at 10 river mouth sites and 29 marine sites. Remote sensing techniques are also being developed to determine spatial and temporal change in surface concentrations of suspended sediments throughout the Great Barrier Reef lagoon.

Turbidity loggers

Water turbidity is the result of suspended sediment and is the relative measure of the clarity of water: the greater the turbidity, the murkier the water.

Automated river turbidity loggers (AIMS Mudloggers) have been deployed near the mouths of 10 priority rivers. These loggers provide frequent (every 30 minutes) measurements of turbidity and water depth at the deployment sites. Data from the loggers are combined with the annual river freshwater flow data to calculate the amount of suspended sediment flowing from the 10 priority rivers into the Great Barrier Reef lagoon. Marine turbidity loggers are being trialled for long-term application.

Nutrients

Phosphorus and nitrogen are nutrients that occur naturally in river and seawater and are essential elements for plant and animal health. However, excessive nutrients can cause a shift in natural processes within the marine environment. Nutrients may be dissolved in the water (dissolved nutrients) or may be attached to sediment and other particles (particulate nutrients). Elevated concentrations of nutrients entering the marine environment are caused by increased soil runoff, and loss of fertilisers during high rainfall events.

The Great Barrier Reef environment is characterised by high sunlight and warm water temperatures, which is generally beneficial to aquatic plant growth. When there are excessive concentrations of nutrients, phytoplankton and algae can grow rapidly and impact the marine environment.

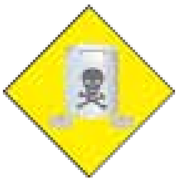
Nitrogen

Particulate forms of nitrogen,(*particulate nitrogen or PN*) consist of organic material, such as plankton or detritus. or nitrogen in or bound to mineral particles and suspended sediment. Dissolved nitrogen may be inorganic, (*dissolved inorganic nitrogen or DIN*), which includes nitrate (NO_3^-), nitrite (NO_2^-) and ammonium (NH_4^+) or organic, (*dissolved organic nitrogen or DON*, which includes amino acids, proteins and urea). Dissolved inorganic nitrogen is generally of most interest, as it is most available for marine plants to take up.

Phosphorus

Particulate forms of phosphorus, (*particulate phosphorus or PP)*, consist of organic material or phosphorus in or bound to mineral particles and suspended sediment. Dissolved phosphorus may be inorganic, (*dissolved inorganic phosphorus or DIP)* such as orthophosphates ($H_2PO_4^-$, HPO_4^{2-}, PO_4^{3-}) or organic phosphorus-containing compounds, (*dissolved organic phosphorus or DOP)*. Dissolved inorganic phosphorus is generally of most interest as it is the most available for marine plants.

The Marine Monitoring Programme is measuring nutrients at 10 river mouth sites and 29 marine sites.



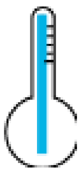
Pesticides

Pesticides are chemical contaminants from agricultural, industrial and urban sources. They are generally divided into three categories; herbicides (used to control weeds), insecticides (used to control pest insects) and fungicides (used to control fungi that cause plant disease).

The use of pesticides in the Great Barrier Reef catchments has increased, particularly in agricultural and urban areas. There has also been a shift from the use of chemicals such as DDT, dieldrin and heptachlor (restricted, and then banned for use between 1973 and 1994), to the use of modern triazine, organophosphate and urea-based pesticides. Both historically used and current agricultural pesticides are widely distributed in Queensland catchment soils, irrigation drains, river sediments and in the nearshore marine environment adjacent to human activity.

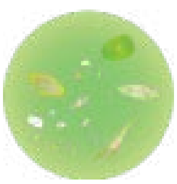
Pesticides used on the land can enter waterways and harm some organisms as they are transported through the environment and may end up in marine waters. Some pesticides persist in the environment and may progressively accumulate in sediments or in biological tissues to concentrations that are much higher than water column concentrations.

The Marine Monitoring Programme is measuring pesticides at river mouth sites and marine sites using passive samplers.



Seawater temperature

Water temperature can influence the survival of organisms in the marine environment. Coral are particularly vulnerable to increased seawater temperature as they survive within a relatively narrow temperature range. If these temperatures are exceeded by a few degrees, for a certain period of time, coral bleaching and coral death can occur. Measuring seawater temperature provides a means to determine the extent to which reef disturbances might be associated with coral bleaching or bleaching risk. Temperature loggers have been deployed at 26 marine sites. The loggers instantaneously measure seawater temperature every 30 minutes and the collected data are downloaded every 6 to 12 months. This information provides a means to determine the extent to which observed coastal reef disturbances might be associated with coral bleaching or bleaching risk.



Chlorophyll *a*

Chlorophyll *a* is a green pigment found in plants. It absorbs sunlight and converts it to sugar during photosynthesis. Chlorophyll *a* concentrations are an indicator of phytoplankton abundance and biomass in the water column.

In tropical waters, phytoplankton rapidly grows in response to nutrients entering the marine environment. Elevated concentrations of phytoplankton (and hence chlorophyll *a*) can thus reflect the availability of nutrients in the water column. In the Great Barrier Reef, phytoplankton populations have turnover times (the rate at which phytoplankton can be regenerated) of 24 hours, so chlorophyll-based estimates of phytoplankton provide an integrative measure of nutrient availability and the quantity of nutrients actively cycling in reef waters.

The Marine Monitoring Programme is measuring chlorophyll *a* at inshore coastal and marine sites. Tourism operators and community groups are undertaking the majority of the sampling. Remote sensing techniques are also being developed to look at spatial and temporal changes in chlorophyll across the entire Great Barrier Reef.

Coral monitoring

Inshore coral reef communities are at risk from impacts caused by cyclonic winds, bleaching, outbreaks of crown-of-thorns starfish as well as being exposed to sediments, nutrients and pesticides from land runoff. Under the Marine Monitoring Programme, the status of inshore reefs are being assessed to document long-term changes in reef communities. Annual underwater photographic surveys are undertaken along transects established at 35 inshore reef sites. These surveys are an effective way of monitoring benthic cover and reef community demographics. In two regions (Wet Tropics and Mackay Whitsunday), coral settlement rates are also measured after the annual coral spawning (using settlement plates, see Figure 2). Adult corals can tolerate poorer levels of water quality than new coral recruits, thus one of the ways in which water quality is likely to impact reef communities is through an effect on coral reproduction and recruitment.

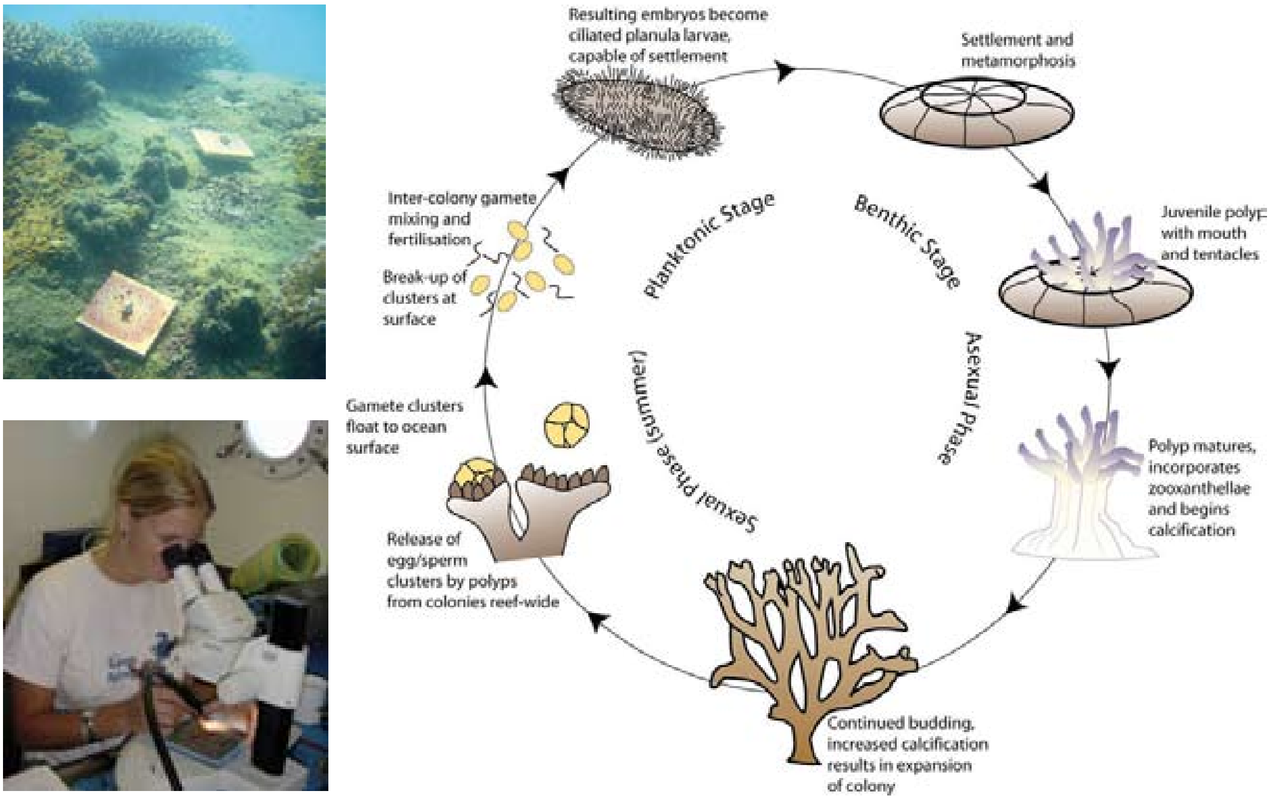
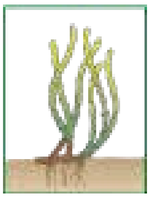


Figure 2. Coral life cycle, settlement plate deployed on a reef and microscopic analysis of coral settlement plates (L. Smith, AIMS)



Seagrass monitoring

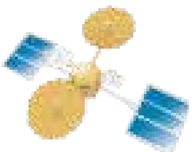
Seagrasses are marine plants that can grow in intertidal, subtidal and reef habitats in estuarine and coastal environments. One of the most common causes of seagrass loss is the reduction of light available for photosynthesis. This reduction in light may be due to excessive growth of algae, either in the water column (phytoplankton) or on the seagrass itself (epiphytes), caused by high concentrations of nutrients, and high levels of suspended sediments (or turbidity). In the Great Barrier Reef there are nearly 6,000 km^2 of seagrasses in shallow water close to the coast, in locations that can potentially be influenced by adjacent land use practices.

The Marine Monitoring Programme uses the Seagrass-Watch programme as a cornerstone for this component of the monitoring programme. Seagrass-Watch groups are monitoring seagrass cover and species composition, seagrass reproductive health (through seed bank monitoring). Seagrass surveys are undertaken at the end of winter in October and following the wet season in April. Additional information is also collected on sediment pesticide and absorbed nutrient concentrations within seagrass meadows and seagrass tissue nutrients.

Bioaccumulation monitoring

Organisms exposed to pollutants often develop subtle cellular differences and may accumulate certain water quality pollutants. Measurements of these cellular changes and assessment of body burdens of pollutants in key indicator organisms can provide a sensitive, early warning of the presence of pollutants. Crustaceans, crabs in particular, are widely recognised as useful species for biomonitoring.

The mud crab *Scylla serrata* is common in estuaries along the entire Queensland coast. As part of the Marine Monitoring Programme, commercial fishermen have been collecting mud crabs from 11 coastal locations adjacent to high priority rivers. The hepatopancreas tissue (a digestive organ) is separated from the crab carcass and analysed for pesticides that accumulate in these tissues.



Remote sensing

Remote sensing techniques are being trialled and developed for future application to determine spatial and temporal information on near-surface concentrations of suspended solids, temperature and chlorophyll *a* in the Great Barrier Reef.

This is achieved by acquiring MODIS satellite imagery data from NASA, which is processed and validated using the directly measured chlorophyll *a* and suspended sediment data and automated instrument data.

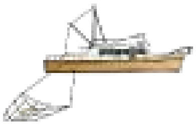
Human use

Reporting Great Barrier Reef patterns of use by recreational visitors will indicate the spatial extent of reef use. The monitoring programme annually reports the spatial extent, intensity and type of activity of tourism and other recreational activities in the Marine Park.

This programme reports on:

- The spatial extent and intensity of use of the Great Barrier Reef Marine Park by visitors using marine tourism operators;
- The range of activities undertaken by recreational users of the Great Barrier Reef Marine Park from Queensland coastal communities;
- The frequency of recreational visitation into the Marine Park and the proportion of the Queensland Great Barrier Reef coastal population that undertakes recreational activities in the Marine Park;

- The spatial extent of recreational use in the Great Barrier Reef Marine Park with reference to locations visited and point of entry into the Marine Park; and
- The number of registered recreational visitors.



Economic value

Recent economic valuation studies reporting the market use values (Access Economics 2005) provided a baseline upon which to monitor the market values of the industries that will benefit from improved water quality in the Great Barrier Reef.

The social and economic monitoring programme reports on:

- The trends in gross financial values of the direct uses of the Great Barrier Reef Marine Park in the context of Queensland regional and state economies;
- The inputs from marine based tourism and commercial fishing activities to regional, state and national economies in terms of employment and other economic and social indicators;
- The social and economic profile of Great Barrier Reef regional communities and presenting, where available, historical time series data showing trends in key social and economic indicators; and
- Estimates of the gross financial value to regional economies that can be attributed to the recreational use of the Great Barrier Reef Marine Park.

Community perceptions

Great Barrier Reef community perceptions of, and satisfaction with, the Great Barrier Reef are measured through extensive telephone surveys.

Pesticides - What they are ?

POLAR PESTICIDES

Polar pesticides are those that are relatively water soluble. Under the marine monitoring programme, Empore Disk (EDs) passive samplers are used to measure these chemicals. Polar pesticides detected in this programme include:

Diuron: Diuron is used to control weeds by inhibiting photosynthesis, this means that plants cannot convert sunlight energy to grow. Most of the registered uses are in agriculture (sugarcane, cotton and some horticultural crops such as pineapples and bananas) to control a variety of weeds. Diuron is also used as a component of antiifouling paints to protect boats from marine algae growth.

Simazine: Simazine is a herbicide used to control broad-leaved weeds and annual grasses (by inhibiting photosynthesis).

Atrazine: Atrazine is one of the most widely used herbicides in Australian agriculture where it has been registered for use since the late 1970s for the control of annual grasses and broadleaf weeds (by inhibiting photosynthesis). Atrazine is most widely used in the sugarcane industry.

Hexazinone: Hexazinone is a herbicide used against many weeds as well as some woody plants. Its registered use is mostly on non-crop areas, but it is also used selectively for the control of weeds amongst sugarcane, pineapples, and lucerne. Hexazinone works by inhibiting photosynthesis in the target plants.

Ametryn: Ametryn, is a herbicide which inhibits photosynthesis and other enzymatic processes. It is used to control broadleaf weeds and annual grasses in pineapple, sugarcane and bananas.

Tebuthiuron: Tebuthiuron is a broad-spectrum herbicide used to control weeds in non-cropland areas, grazing lands and industrial sites. It is effective on woody and herbaceous plants in grasslands and sugarcane. Tebuthiuron is sprayed or spread dry on the soil surface, as granules or pellets.

NON - POLAR PESTICIDES

Non-polar pesticides are those that are less soluble in water. Semi-permeable membrane device (SPMDs) passive samplers are used to measure these compounds. In total, 50 pesticides are looked for in these samplers, those that have been detected in this study include:

Chlorpyrifos: Chlorpyrifos is a broad-spectrum organophosphate insecticide (control insects). In agricultural applications, chlorpyrifos is registered to control a broad range of insect pests across many crops. In domestic and commercial settings it is registered for the control of pests such as termites, fleas and cockroaches.

Endosulfan: Endosulfan is a broad-spectrum organochlorine insecticide and acaricide (control mites) which is registered in Australia for the control of a large variety of insects and mites in crops. It is a common pesticide in the cotton industry.

DDE: is a breakdown product of DDT, an insecticide that was widely used towards the end and after the Second World War to kill disease carriers, such as mosquitoes that carried malaria, and as an agricultural spray to kill pests. It has been banned for use in Australia due to concerns about its tendency to bioconcentrate in organisms.

Passive Samplers - What they are ?

As part of the Marine Monitoring Programme, passive samplers are used to monitor organic pollutants in water. Passive samplers enable continuous cost-effective sampling where samplers can be deployed for periods ranging from days up to months. Following the collection from the field the samplers are analysed and the amount of a given chemical detected is used to estimate an average concentration in the water at the site where the sampler was deployed.

Besides the advantage of being able to cost effectively undertake continuous monitoring of pesticides, very low concentrations of bioavailable pesticides can be measured, which is expected to provide important information on sources and long-term changes in the use and management of pesticides on the land.

Two types of passive samplers are used: Semipermeable Membrane Devices (SPMDs) and Empore Disk ® Samplers (EDs).

The SPMD sampler is suitable for passive monitoring of nonpolar (less water soluble) organic pollutants such as organochlorine pesticides (dieldrin, DDT) and polyaromatic hydrocarbons (PAHs) (eg. petrol, diesel) that are found in water. These samplers are deployed in stainless steel devices that protect the membranes and limit water flow (see pictures below).

The ED sampler is suitable for monitoring more polar organic compounds (more water soluble) such as herbicides. The disks are deployed in a custom made white teflon device for protection and to control uptake of compounds and bio-fouling (see pictures below).

SPMD attached to an opened sampling cage

Empore Disk deployment device. Left - sealed with the transportation cap. Right - ready for deployment.

SPMD and EDs being placed in the water at a sampling site.

Passive samplers are left in the water at the monitoring site for days (river flood sampling), one month (dry season sampling) or two months (during the wet season). During this time the samplers accumulate pollutants from the water. The concentration of pollutants in the samplers are converted to a water concentration using sampling rates determined by laboratory studies. The concentration is therefore an estimated or average concentration over the time that the sampler has been in the water.

2006

Part 2

Great Barrier Reef

Monitoring Summary

The Great Barrier Reef and the Reef Catchment

The Great Barrier Reef is the largest coral reef system on earth and is home to many thousands of species of plants and animals. The Great Barrier Reef World Heritage Area (GBRWHA) stretches for 2000 km along the coast of Queensland and covers 348,000 km^2 (an area larger than that of the United Kingdom, Holland and Switzerland combined).

The Great Barrier Reef provides a range of vital ecosystem services and functions to Australian communities at a regional, state and national level. The Great Barrier Reef Marine Park is managed as a multi-use marine park, with reef-based industries and activities contributing an estimated $5.2 billion per year (gross value of product). This economic worth relies on the environmental value of its aquatic ecosystems. In 2005, more than 1.9 million people visited the Great Barrier Reef with commercial operators, and a further estimated 4.5 million for private recreational visits (Access Economics, 2006). The total (direct plus indirect) economic contribution of tourism, commercial fishing, and cultural and recreational activity of the Great Barrier Reef Catchment area in 2004-05 was:

- For value-added product, over $3.5 billion per year;
- For gross product, (which adds net indirect taxes less subsidies to value-added) over $4.1 billion per year; and
- For employment (full time equivalent basis), about 51 000 persons.

Tourism dominates these contributions, (approximately 86% of value added and gross product and 85% of employment). The flow-on effect of these industries underpins a significant and growing proportion of Queensland's regional economy. Declining water quality in the Great Barrier Reef lagoon directly threatens maintenance of the Great Barrier Reef's natural capital and therefore the ongoing prosperity of the industries and the communities that rely upon them.

Water quality in the Great Barrier Reef is principally affected by land-based activities in its adjacent catchments, including vegetation modification, grazing, agriculture, urban development, industrial development and aquaculture. Nutrients, sediments and pesticides are the pollutants of most concern for the health of the Great Barrier Reef.

The lands adjacent to the Great Barrier Reef (the Reef Catchment) is comprised of 26 river catchments within six Natural Resource Management (NRM) regions (Cape York, Wet Tropics, Burdekin Dry Tropics, Mackay Whitsunday, Fitzroy Basin and Burnett Mary). The Reef Plan and other Regional planning activities focus on identifying and implementing solutions to improve water quality through sustainable natural resource management and improvements in land management practices. It is being implemented through partnerships between Regional NRM Bodies, industry sectors and the general community and will help to ensure the long-term sustainability of the Great Barrier Reef and its catchments and the industries and communities it supports.

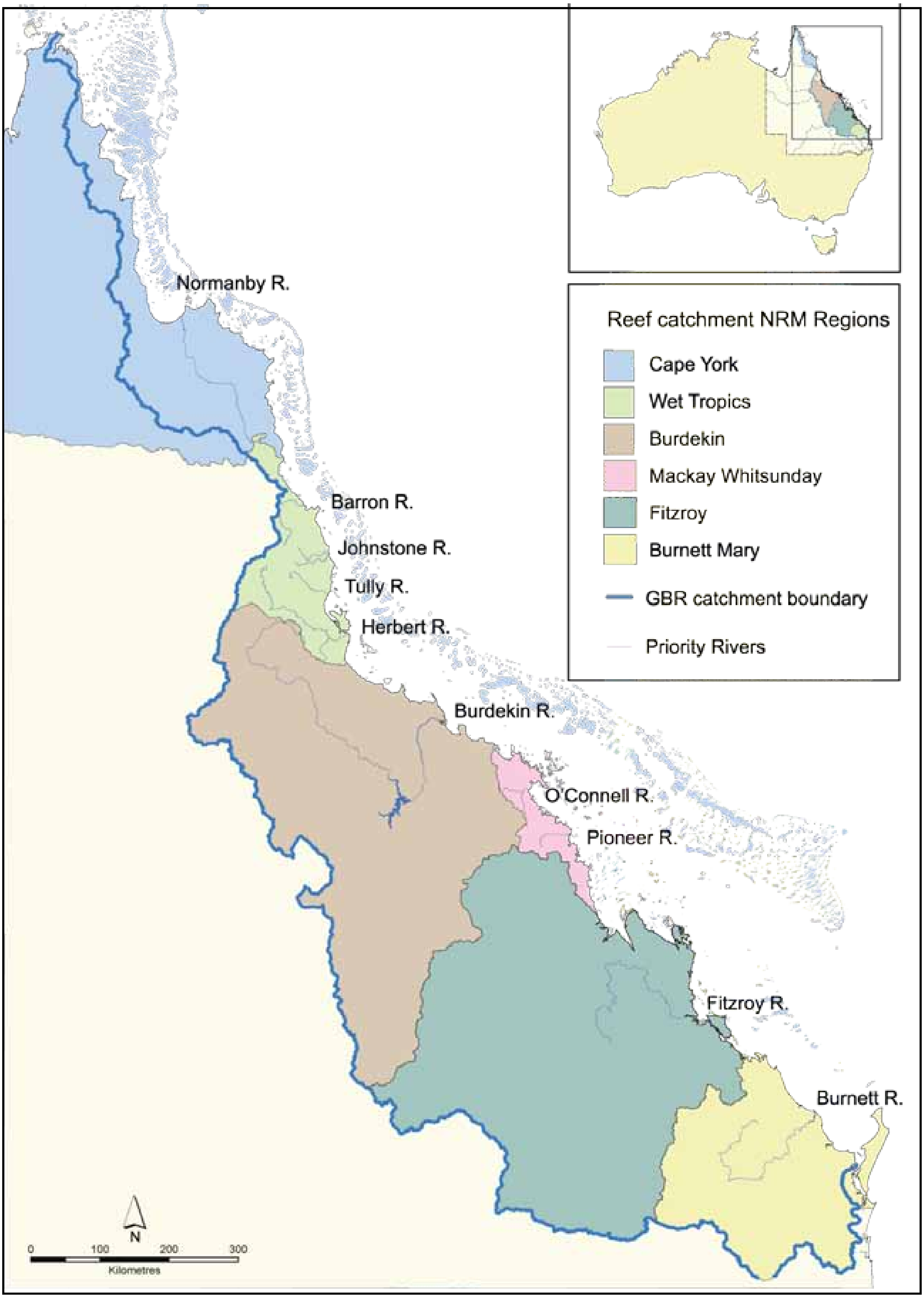
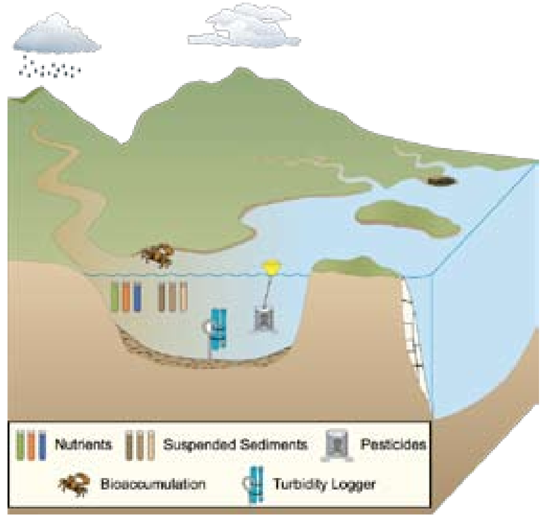


Figure 3 Map of the Great Barrier Reef showing the ten priority rivers and the six NRM regions within the Reef Catchment

Great Barrier Reef monitoring outcomes

River mouth water quality monitoring

Water quality monitoring for suspended sediments and nutrients at river mouth sites was carried out in the ten priority rivers that drain into the Reef lagoon. These ten rivers are the Normanby, Barron, Johnstone, Tully, Herbert, Burdekin, O'Connell, Pioneer, Fitzroy and Burnett Rivers. Monitoring was carried out over the 2004/05 and 2005/06 wet and dry seasons, with a focus towards sampling during flood events. Due to the transient nature of freshwater flows, rivers were sampled at various times, with only limited sampling in some rivers.



Freshwater flows

The 2004/05 and 2005/06 wet seasons were characterised by freshwater discharges considerably below the long-term averages for most rivers, despite the occurrence of category 5 Tropical Cyclone Larry (TC Larry) in 2006, which only increased rainfall and river discharge locally (Figure 4). Very low discharges were recorded from central and southern Great Barrier Reef catchments (Burdekin, Pioneer, Fitzroy and Burnett Rivers) due to the ongoing drought.

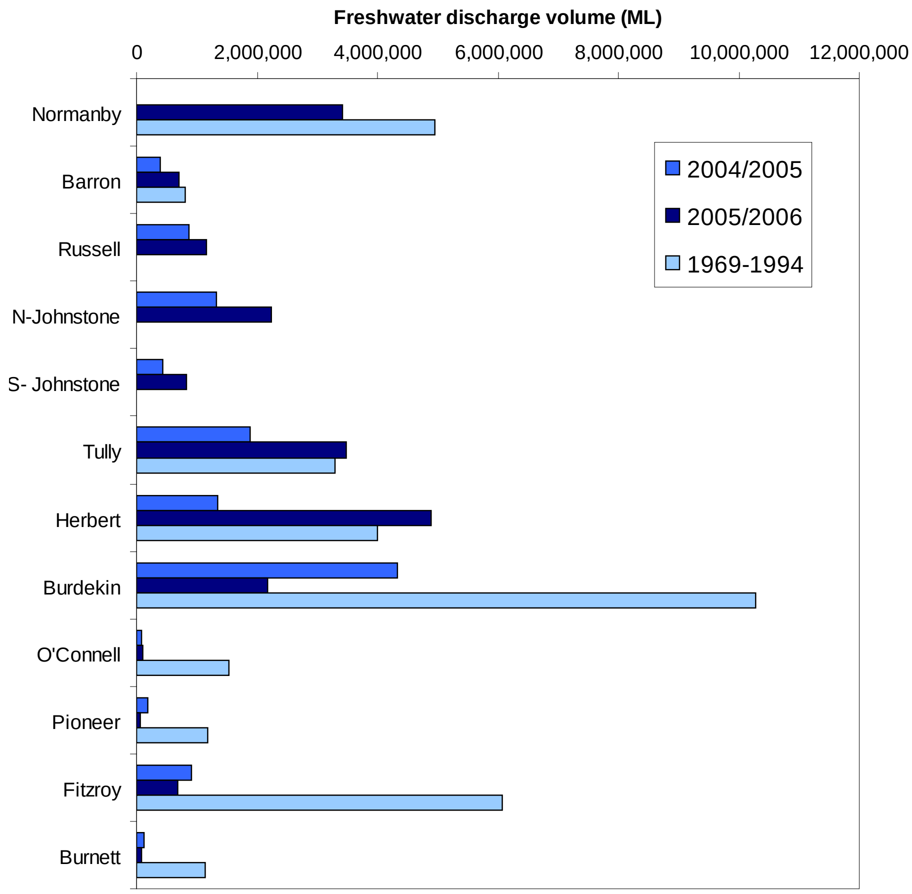


Figure 4 Freshwater discharge volumes (ML) for the 2004/05, 2005/06 wet seasons and for comparison, the long-term (1969 – 1994) average.

River mouth suspended sediments and nutrients

Suspended sediment and their associated nutrients exported by rivers to the Reef are generally proportional to the quantity of freshwater discharge.

Concentrations in rivers draining the southern catchments were generally higher than the concentrations of the Wet Tropics and Cape York rivers. However, all rivers exceeded the Queensland Water Quality Guideline values for most nutrients and suspended sediment concentrations, except for the Pioneer and Burnett Rivers where the wet season flows were significantly lower than long-term averages.

There are very few values measured for the dry season. In general the Dry Tropics rivers had higher concentrations of nutrients than Wet Tropics rivers. DIN was highest in the O'Connell and Burdekin Rivers, DON in the O'Connell and Fitzroy, PN and SS in the Burdekin and Fitzroy. Phosphate was highest in the Fitzroy and O'Connell, DOP in the Fitzroy and Pioneer, and PP in the Burdekin and Herbert Rivers.

Wet-season ranges of suspended sediment concentrations were consistently higher than ranges observed in dry season samples, reflecting the generally higher levels of rainfall, catchment erosion and sediment transport in the wet season (Figure 5). Wet season sediment concentration ranges often overlapped the narrow dry season range as a number of low-flow samplings were carried out during the nominal wet season period, either before floods occurred, or during the period between flood events. Suspended sediment concentrations in the Burdekin and Fitzroy Rivers were higher than those of the smaller rivers of the Wet Tropics and central Great Barrier Reef, in part due to the perennially higher turbidity levels in these rivers from very small clay particles.

Suspended sediment and nutrient loads

Land derived inputs to the Great Barrier Reef lagoon within the last two years were 20 to 50 per cent below the long-term average due to low rainfall and freshwater runoff over the last year. The Burdekin River had the highest suspended sediment exports in 2005-06; on a discharge-weighted basis the Fitzroy had the highest sediment load, followed by the Burdekin River (Figure 6). Nitrogen and phosphorus exports were highest in the Tully and Herbert Rivers, respectively. However, the discharge-weighted loads were highest in the O'Connell River, which was the river with the lowest discharge volume in this year (Figure 7).

Total load and discharge weighted load

The amount (or load) of suspended sediments/nutrients that ultimately end up in the Great Barrier Reef lagoon, is a function of the quantities of these pollutants that are moved off the land by runoff, the amount deposited within waterways during transport, and the amount of rainfall over a given period of time.

In this report we represent loads as both a total export and discharge-weighted load.

Total export = the total amount of pollutant that exits a river mouth at a particular site over a given time (i.e. concentration measured in water X amount of water discharged, over months/days)

Discharge weighted load = the amount of pollutant that exits a river mouth per megalitre of water over a given time

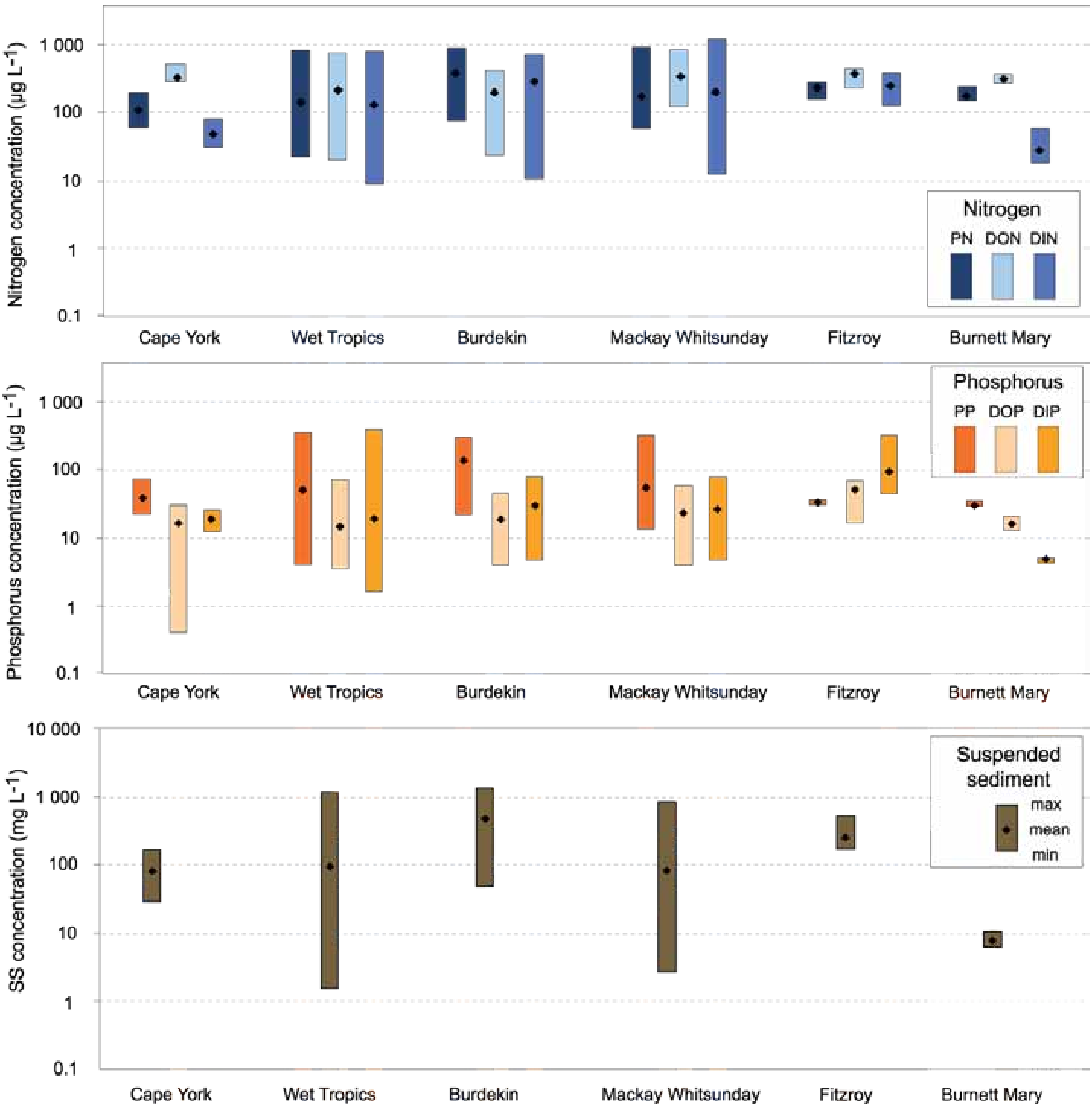


Figure 5 Regional minimum, maximum and mean nitrogen (PN - particulate nitrogen; DON - dissolved organic nitrogen; DIN - dissolved inorganic nitrogen), phosphorus (PP - particulate phosphorus; DOP - dissolved organic phosphorus; DIP - dissolved inorganic phosphorus) and suspended sediment concentrations in rivers during the 2005/06 wet season

(Cape York - Normanby River; Wet Tropics - Barron, Johnstone, Tully and Herbert Rivers; Burdekin - Burdekin River; Mackay Whitsunday - Pioneer and O'Connell Rivers; Fitzroy - Fitzroy River; Burnett Mary - Burnett River)

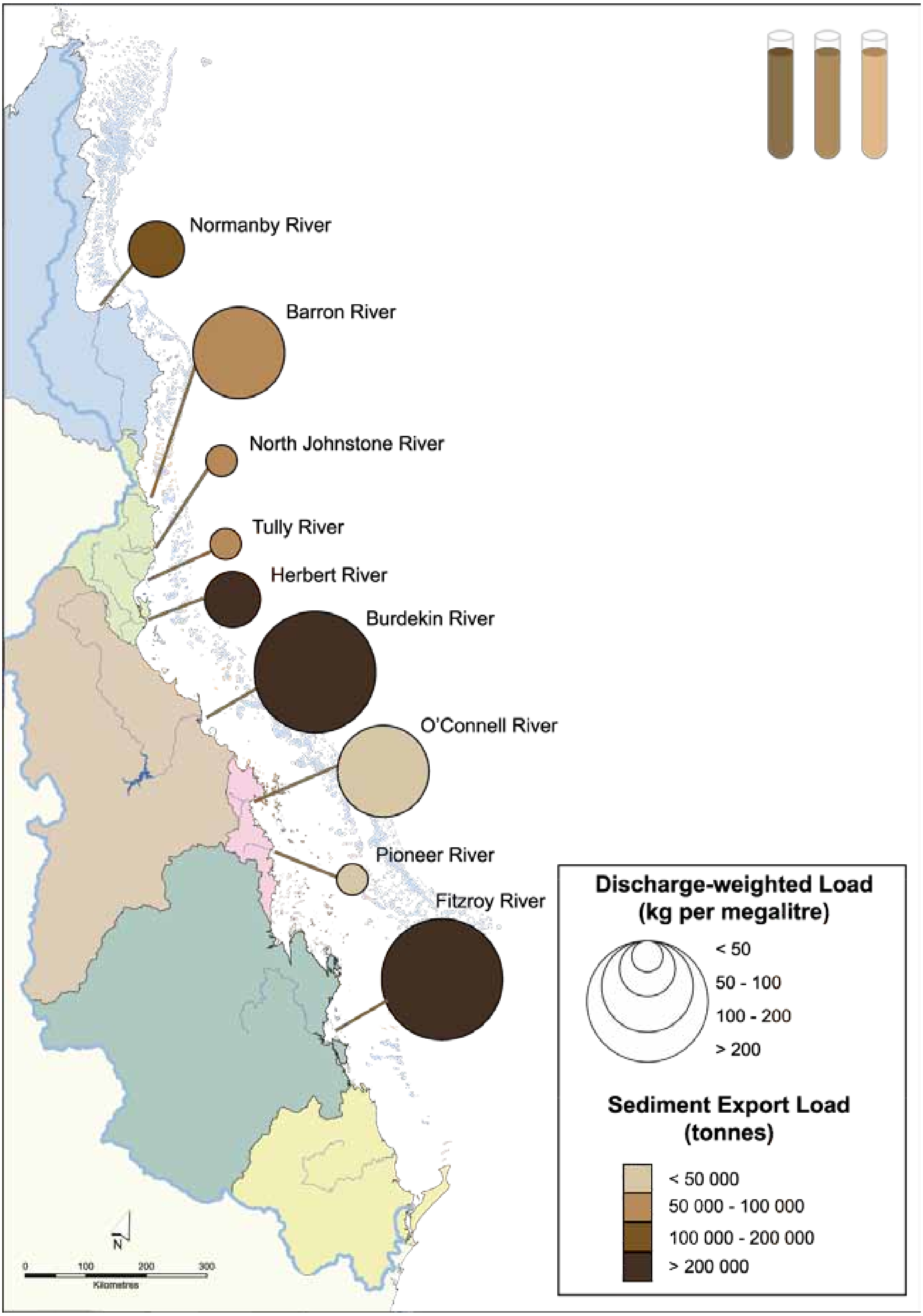


Figure 6 River mouth suspended sediment loads for the 2005/06 wet season calculated from mudlogger data (discharge weighted and total tonnes)

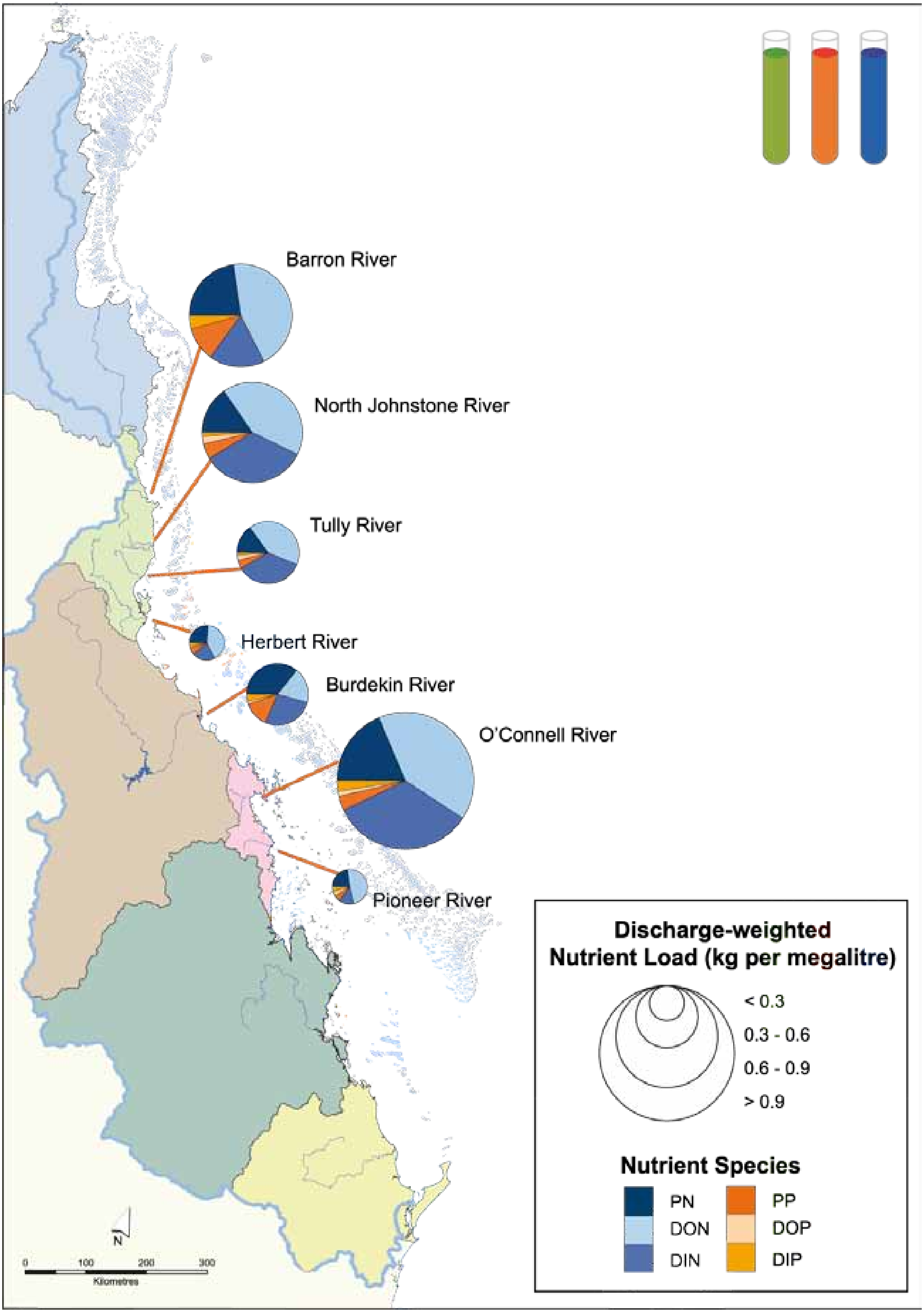


Figure 7 River mouth nutrient loads calculated from samples collected during the 2005 dry and 2005/06 wet seasons

River mouth pesticide monitoring

Passive samplers were used for the evaluation of organic pollutants at a number of Great Barrier Reef river mouth sites and a range of organic pesticides were detected (Figure 8). Polar samplers were analysed for a suite of 10 herbicides including diuron, simazine, atrazine, hexazinone, ametryn and tebuthiuron. Non-polar samplers were analysed for more than 50 pesticides including chlorpyrifos, endosulfan, DDT and degradation products. Pesticide monitoring demonstrated that the use of passive sampling techniques provides highly reproducible results and allows assessment of seasonal variability as well as variability between sampling sites. The passive sampling data were consistent with a limited number of grab water samples collected in the rivers. However, the passive sampling techniques allowed a broader range of chemicals to be quantified, while the grab water sampling data showed substantial variability.

Diuron was found at all river mouth sites for each season and was also the compound found at highest concentrations. In addition to diuron, other herbicides such as simazine, atrazine, hexazinone, ametryn and tebuthiuron were detected at various sites at different times. Diuron and atrazine are the most heavily applied pesticides in agricultural practices in the Reef catchment, thus it is not surprising that these are the most commonly detected pesticides in rivers. Predicted concentrations of diuron, atrazine and hexazinone were greater in the wet season than the dry season, due to higher rainfall and resultant runoff. The southern NRM regions had a greater variety of pesticides detected compared to the rivers in the Wet Tropics NRM region, which possibly reflects the greater diversity of pesticides applied in these regions. Diuron made up the greatest proportion of the pesticides found at sites in the Wet Tropics, whereas atrazine made up a greater proportion of the total pesticides detected in the southern NRM regions. The O'Connell and Pioneer Rivers from the Mackay Whitsunday region had the highest concentrations of pesticides detected.

Concentrations of most herbicides were consistently higher in rivers during the wet season. There were a greater variety of pesticides detected at Wet Tropics river mouth sites; however the total pesticide concentration was higher in rivers of the Mackay Whitsunday region.

Mud crab bioaccumulation monitoring

Mud crab biomonitoring proved complementary to passive sampler monitoring of the same rivers (Figure 9). Mud crabs from 7 of the 11 rivers sampled (33% of all mud crabs sampled during the monitoring period) contained persistent organochlorine contaminants such as PCBs, dieldrin and the breakdown products of DDT. The concentrations of pollutants found in the mudcrabs are well below the Australian Food Saftey Standards and furthermore the tissue material sampled (the hepatopancreas) is generally not eaten. Pesticides such as chlorpyrifos and diuron were not detected in individual crabs, probably due to their comparatively short half-lives in the environment and higher polarity, which means they would be absorbed and accumulated less readily, as well as metabolised and excreted more rapidly than DDTs and dieldrin. Rivers with urban inputs such as the Burnett, Pioneer, Fitzroy and Barron contained the highest diversity and concentrations of organochlorine compounds.

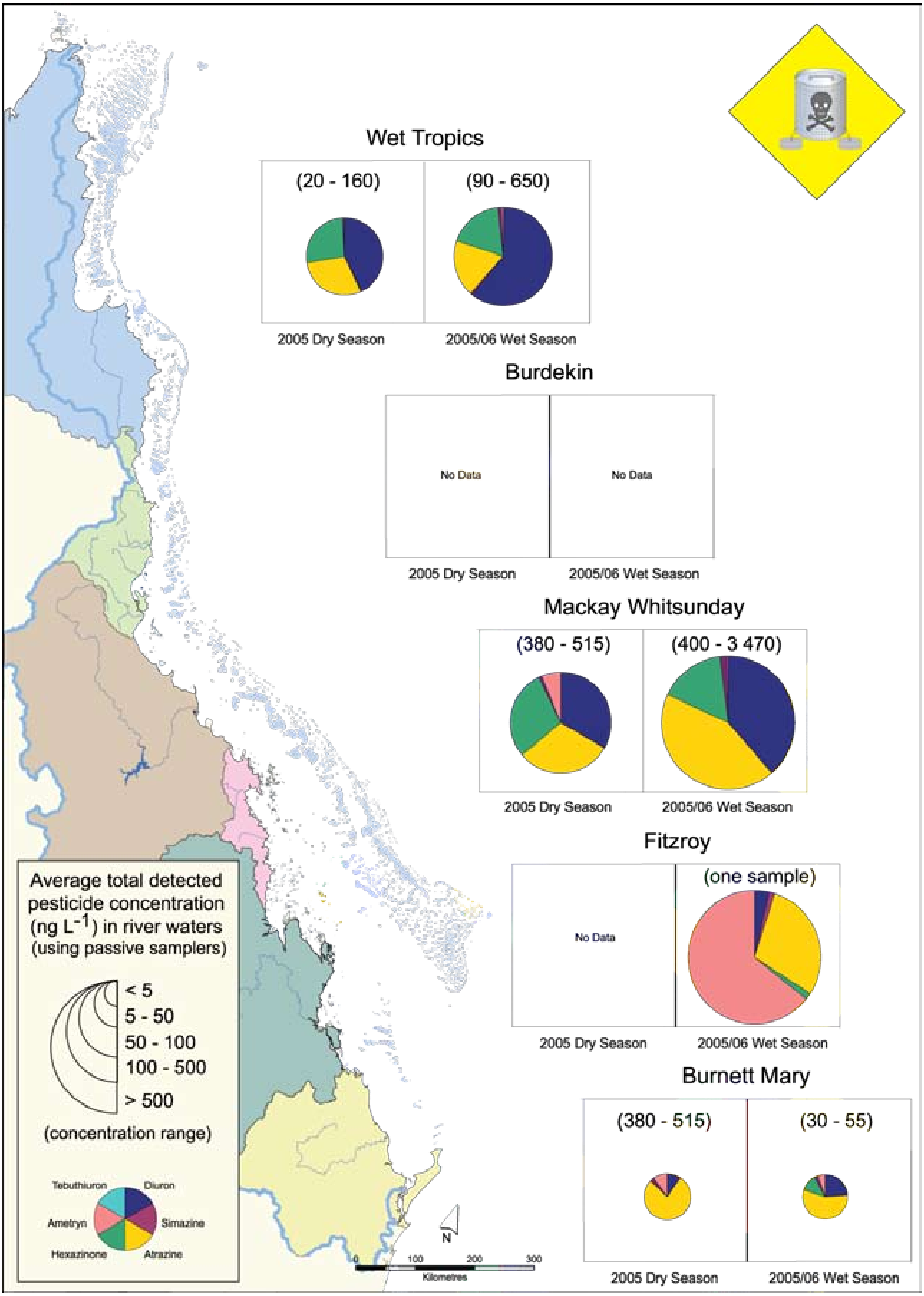


Figure 8 Regional minimum, maximum and average pesticides concentrations (and compound distribution) of total detected pesticides in river mouth waters (predicted using passive samplers)

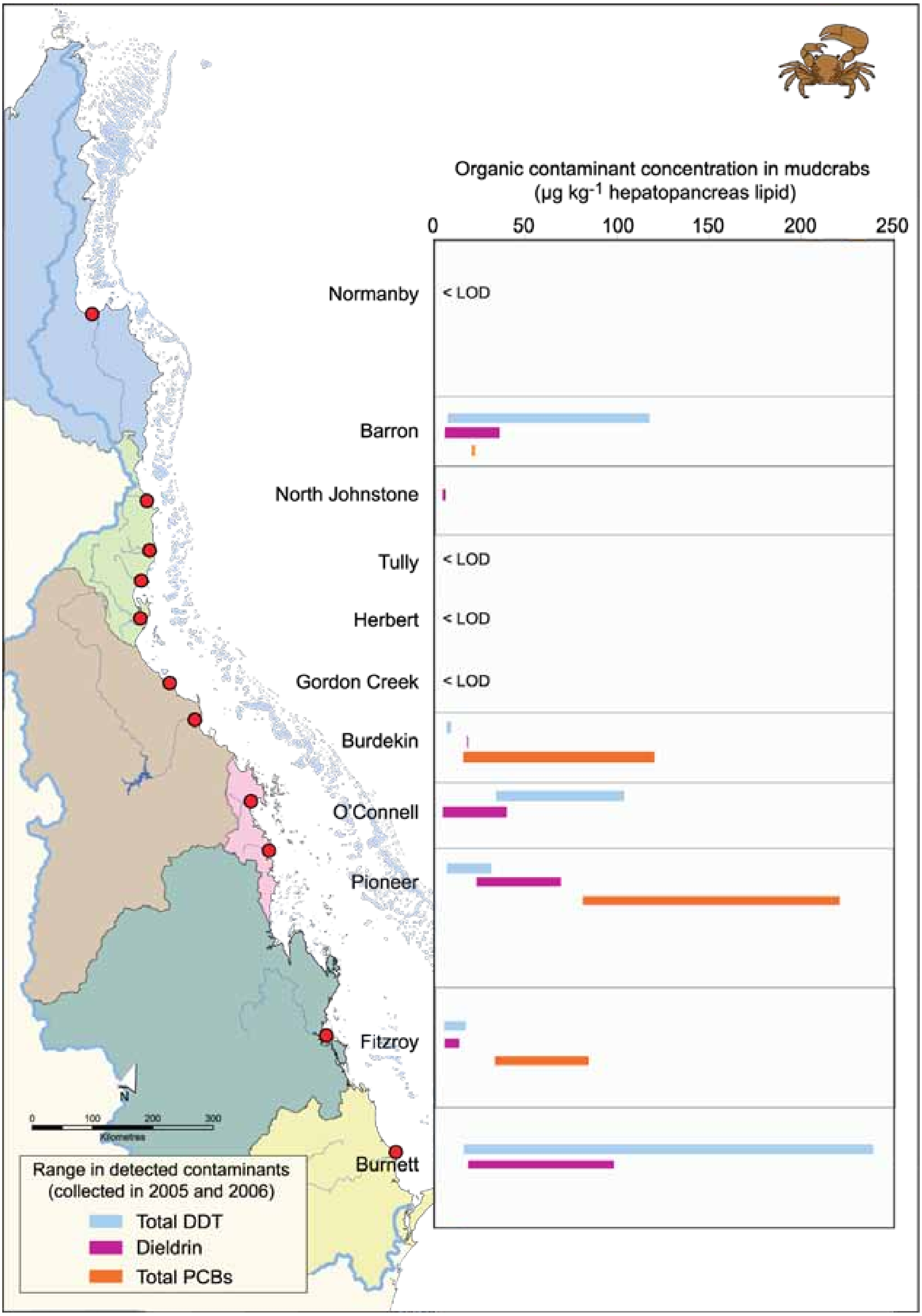
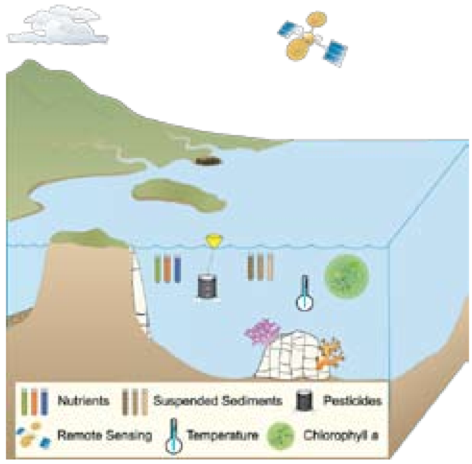


Figure 9 Range in the concentration of total detected contaminants (DDT, dieldrin and PCBs) in mud crabs collected from river mouths (< LOD = less than limit of detection)

Inshore marine water quality monitoring

The inshore marine water quality monitoring involves five major components;

- suspended sediment and nutrients;
- chlorophyll a;
- remote sensing and data loggers;
- temperature; and
- pesticides monitoring.



Inshore nutrient and suspended sediments

In the Reef lagoon, dry season median water column concentrations of bio-available inorganic nitrogen were generally very low, while the wet season values were elevated, mainly due to high ammonium concentrations (Figure 10). Dissolved organic nitrogen and particulate nitrogen were also higher during the wet season, indicating re-suspension and higher plankton biomass. During the 2005-06 dry season, elevated levels of phosphate and dissolved organic phosphorus were measured while particulate phosphorus did not vary from the wet season concentrations. It is likely that re-suspension of marine sediments led to these higher values, which were also reflected in the higher and more variable values of suspended sediment concentrations in the wet season.

There are very few datasets available for comparisons of the nutrient concentrations measured in the inshore lagoon. However, the data from the current monitoring period were generally within previously reported ranges. The longest and most detailed time series of water quality data for the Great Barrier Reef was collected by AIMS in coastal waters between Cape Tribulation and Cairns (Cape Grafton) from 1989 to the present. Sampling these stations was continued under the Marine Monitoring Programme. Over time, increases in total dissolved phosphorus and suspended sediments have been identified, while particulate phosphorus decreased and particulate nitrogen and total dissolved nitrogen show non-linear fluctuations.

Chlorophyll *a*

Surface chlorophyll concentrations in Great Barrier Reef waters have been measured since 1992 as part of a long-term monitoring programme (Brodie et al., in press). The Marine Monitoring Programme continued a large number of these stations and added 11 new locations in the coastal zone.

General patterns that have been previously detected in the long-term chlorophyll dataset were confirmed. There is a general southward increase in mean chlorophyll a concentration, especially in the coastal zone (Figure 11). There is no significant cross-shelf gradient in chlorophyll concentrations in the Cape York region, while further south significantly higher chlorophyll values are found inshore, compared to offshore. The data to date show some long-term fluctuations in mean chlorophyll concentrations, but these are not consistent between regions and generally have no clear upward or downward trend. Chlorophyll is widely used as a proxy for nutrient availability, the data collected to date suggests that there are more nutrients available in the inshore coastal zone, particularly in the southern regions.

Remote sensing and data loggers

The testing and development of remote sensing techniques to determine surface concentrations of chlorophyll and suspended solids in lagoonal and coastal waters of the Great Barrier Reef is promising. A regional remote sensing water quality algorithm was developed and a viable remote sensing water quality product is now available. The general spatial patterns of chlorophyll concentrations

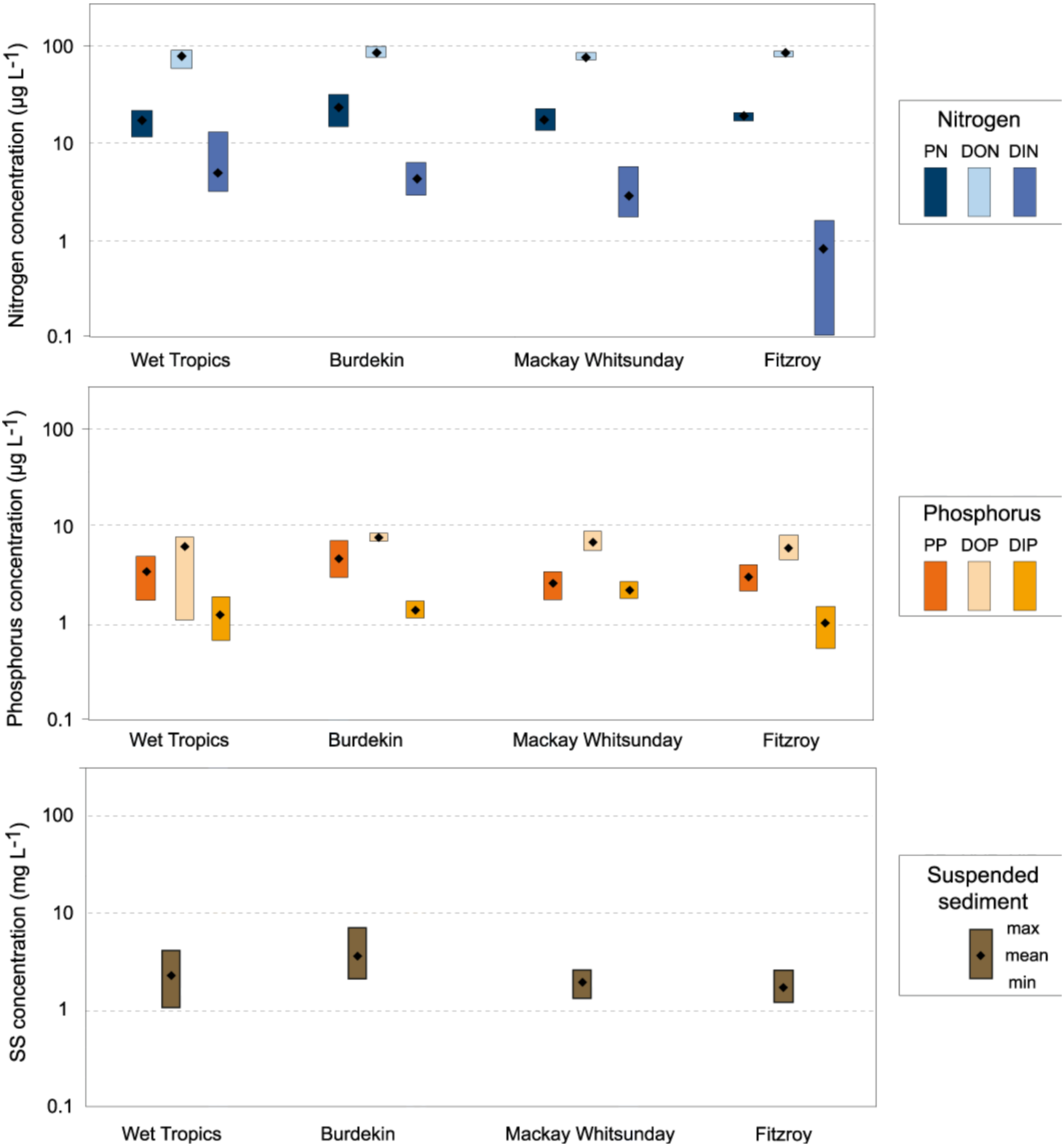


Figure 10 Regional minimum, maximum and mean nitrogen, phosphorus and suspended sediment concentrations at inshore reef locations during the 2005/06 wet season

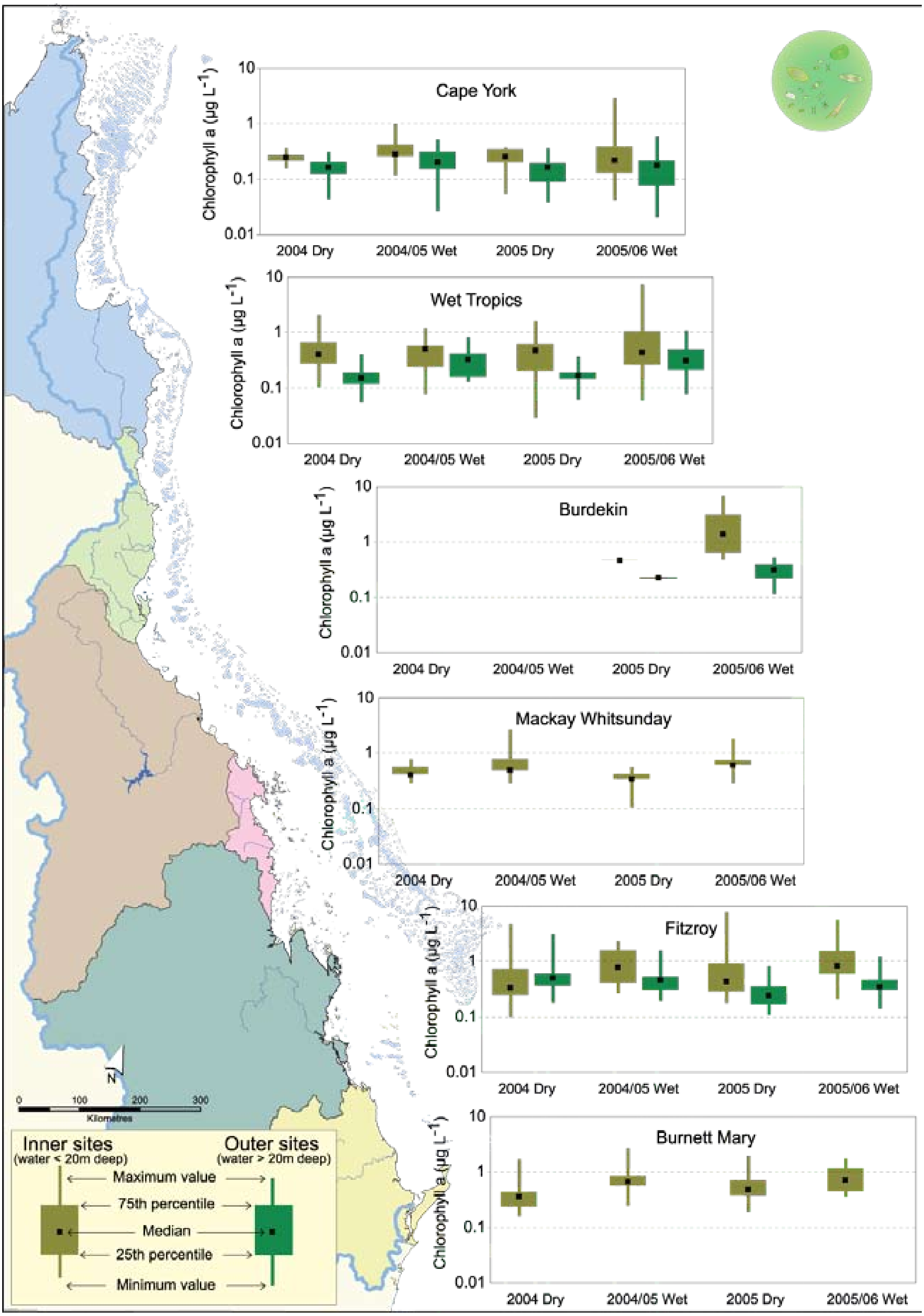


Figure 11 Minimum, maximum and median chlorophyll a concentrations at inner and outer sites in each of the NRM regions from the 2004/05 dry season and 2005/06 wet seasons

support the results from the long-term chlorophyll monitoring programme. However, the level of detail from remote sensing is significantly higher than from traditional grab sampling and likely to be more cost-effective in the long term. This technique is likely to replace the grab sample monitoring for chlorophyll in the future, after some further validation and development.

Autonomous data logging instruments were used as a third way to measure chlorophyll and turbidity under the Reef Plan Marine Monitoring Programme. Test deployments indicated the suitability of these loggers to deliver useful time series data. While remote sensing will allow the monitoring of large-scale patterns, autonomous instruments will have the benefit of obtaining high frequency data series at locations of particular interest, e.g. a reef or seagrass bed where long-term monitoring of biological status is undertaken.

Inshore reef pesticide monitoring

Pesticide passive sampling results are available for eight inshore reef locations. Samplers were analysed for a suite of 10 herbicides including two degradation products as well as for more than 50 pesticides including some of their degradation products.

Organic pollutants were detectable at relatively low concentrations at all inshore reef sites (Figure 12). The key compounds detected at these sites were herbicides. In particular diuron, was found at all sites except Normanby Island (however the number of successful deployments at this site were limited). Simazine, atrazine and hexazinone were the other pesticides that were detected routinely at inshore reef sites. There was a consistent trend toward higher concentration of herbicides in the wet season at inshore reef sites, due to higher rainfall and associated runoff from the land. This is further highlighted by the fact that at a range of inshore reef sites, atrazine, hexazinone and diazinon were only detectable during the wet season sampling period (Low Isles, Fitzroy Island and Magnetic Island). In contrast, simazine was only detected in the dry season (at Fitzroy Island and Normanby Island). Concentrations of most herbicides were consistently lower at inshore reef sites than those measured at river sites. At inshore reef sites, the total detected pesticide concentrations were higher in the Wet Tropics region in comparison to inshore sites further south.

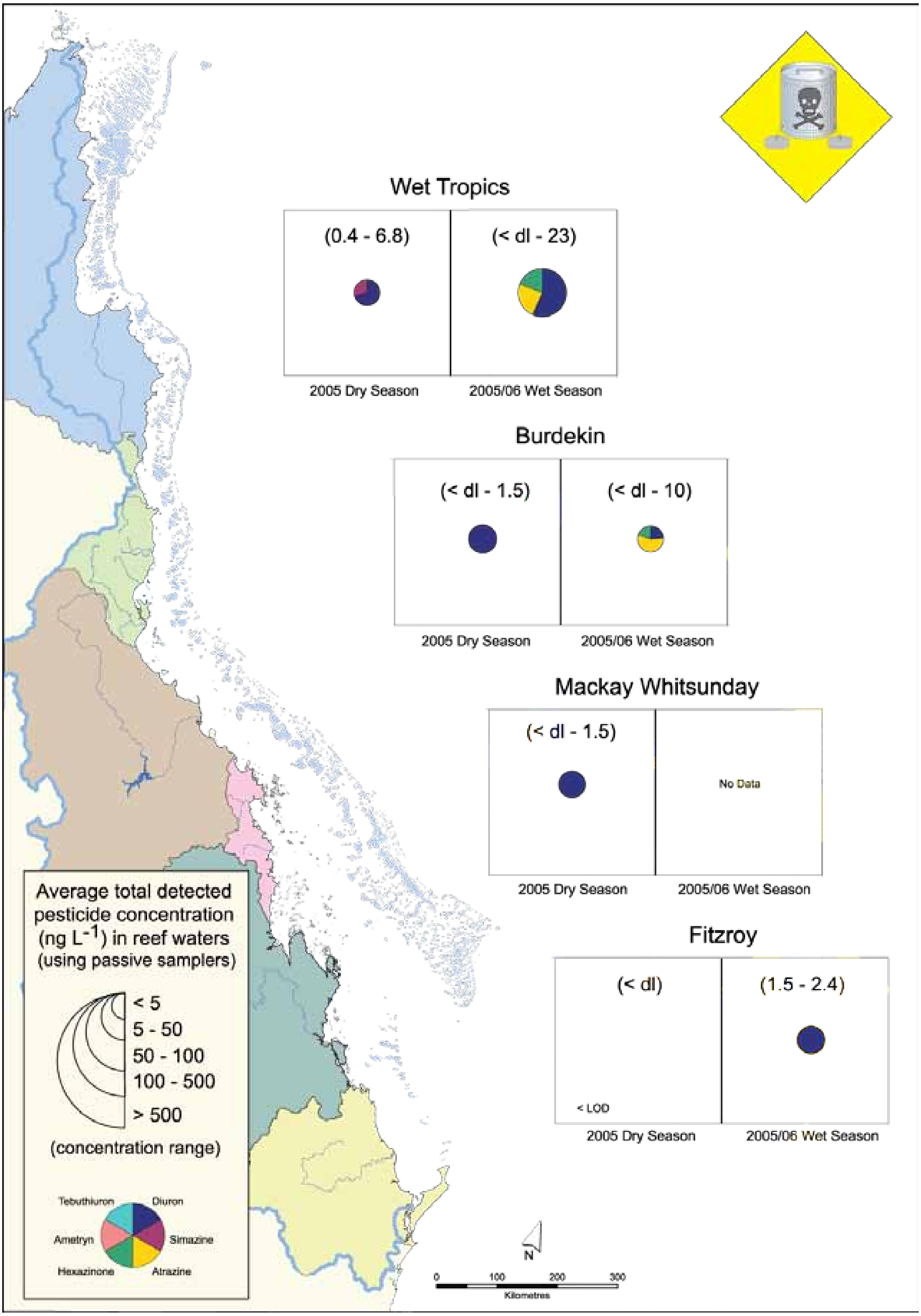
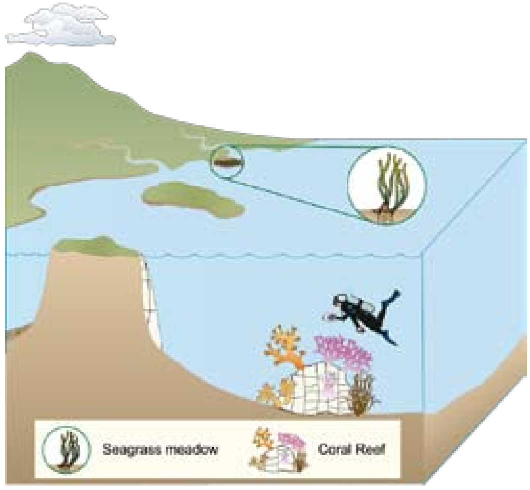


Figure 12 Regional minimum, maximum and average pesticides concentrations (and compound distribution) of total detected pesticides at inshore reef sites

Marine biological monitoring

Coral monitoring



Biological monitoring of inshore reefs is intended to document population trends in the benthic reef communities and represent a baseline for assessing future changes. These changes may be due to acute disturbances such as cyclonic winds, bleaching and crown-of-thorns starfish, as well as those related to runoff (e.g. floods), which disrupt processes of recovery such as recruitment and growth.

The coral communities on inshore reefs of the Great Barrier Reef varied greatly in all the characteristics that were measured. Many nearshore reefs supported substantial numbers of adult corals of many genera and considerable numbers of juveniles. Exceptions to this were reefs in the Burdekin region, which had low coral cover and low numbers of recruits. The surveys gave an optimistic view of the status of the majority of nearshore reefs in most regions. Reefs in the Burdekin region are the greatest cause for concern, having both relatively low coral cover and relatively low densities of recruit-sized colonies. These reefs need to be observed over the longer term to see if these trends are consistent.

Hard coral, soft coral and macroalgae

Total coral cover, which is the simplest and most commonly-used indicator of reef status, varied from very high to very low on the inshore reefs surveyed. The regional median hard coral cover was substantially higher in the Fitzroy and Mackay Whitsunday regions than the Wet Tropics and Burdekin regions (Fig. 13). Hard coral cover varied with depth but generally cover was higher at 5 m than at 2 m. This relationship was consistent among NRM regions, though it did vary among reefs within regions.

Hard coral diversity, as measured by number of genera (richness), was highest on reefs of the Mackay Whitsunday region and low on the reefs of the Fitzroy region, which had high coral cover but heavy dominance of a few *Acropora* (Staghorn coral) species (Fig. 14). Richness showed no consistent pattern with distance from river mouths. More genera were recorded at 5 m than at 2 m in all NRM regions with the exception of the Fitzroy region where the richness was similarly low at both 2 m and 5 m.

There was substantial variation in the cover of soft corals among reefs within the different NRM regions and there was no consistent relationships with distance from rivers. Soft coral cover was higher on reefs in the Mackay Whitsunday and Wet Tropics than at all other NRM regions. The cover of soft corals showed no consistent variation with depth though did vary between depths at individual reefs.

Macroalgal cover varied substantially among reefs within NRM regions and tended to be higher on reefs that were nearer to river mouths or very close to the coast. Over all, macroalgal cover was higher at 2 m depth than at 5 m, although the magnitude of this difference varied among regions, higher cover was observed in the Wet Tropics and Burdekin regions.

Hard coral recruits

The density and diversity (number of genera) of recruits were higher in the Wet Tropics and Mackay Whitsunday region than in the other NRM regions (Figs. 13 and 14). Inshore reefs in the Wet Tropics have relatively low coral cover, most probably due to mortality from bleaching in 1998, but the numbers and diversity of recruit-sized colonies suggests that recovery is proceeding. Comparing mean densities of recruit-sized colonies among reefs within regions found no strong relationship between recruit density and proximity to river. However, the lowest density of recruit-sized colonies at a number of sites were all on reefs that were close to river mouths.

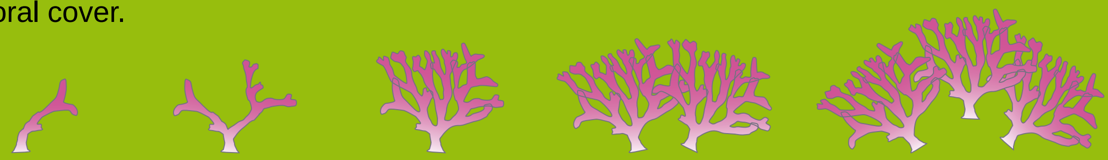
Understanding coral reef data

Graphic illustrations of data have been used throughout this document to present data collected in the Marine Monitoring Programme.

The coral reef monitoring data display the cover (or density) of coral reef benthic organisms that are collected as part of the surveys.

Hard coral cover | Soft coral cover | Macroalgae cover | Density of hard coral recruits (< 10 cm) | Density of soft coral recruits (< 10 cm)

The cover (or density) of benthic communities are displayed from low to very high. The example below is for hard coral cover.



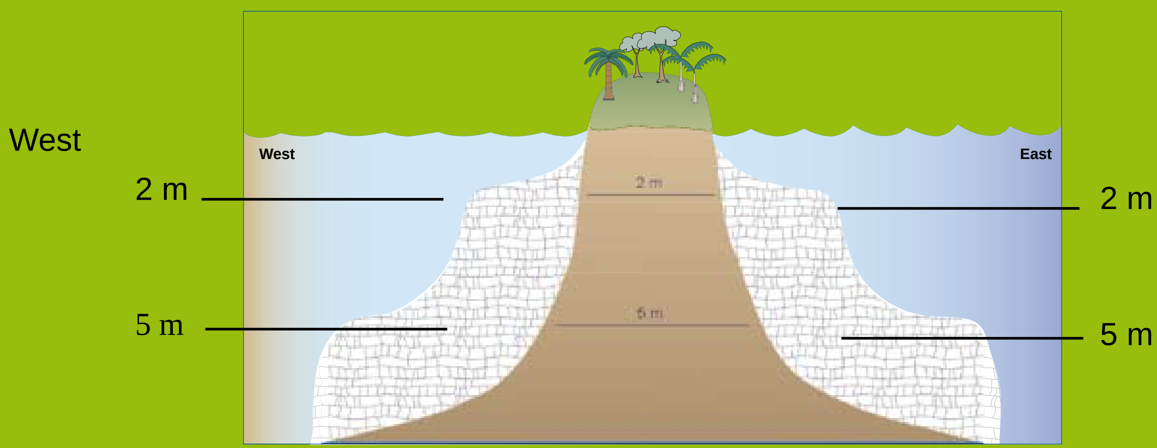
Very Low | Low | Medium | High | Very High

Different benthic communities were classified (from very low to very high) according to the range in the data from the 2005 survey year. Percentiles (which indicate the percentage of data below or above a certain figure) were used to calculate the classifications.

Per cent cover and density values used for the classification of benthic communities

	Very low	Low	Medium	High	Very high
Hard coral cover (%)	< 10	10 - 20	20 - 30	30 - 40	> 40
Soft coral cover (%)	< 1	1 - 5	5 - 10	10 - 15	> 15
Macroalgae (%)	< 1	1 - 5	5 - 10	10 - 15	> 15
Hard coral recruits (# recruits per m2)	< 5	5 - 10	10 - 15	15 - 20	> 20
Soft coral recruits (# recruits per m2)	< 1	1 - 2	2 - 5	5 - 10	> 10

At each site, reefs are surveyed both 2 m and 5 m. In some cases (i.e. Wet Tropics) surveys are also conducted on the eastern and western (or northern and southern) side of islands.



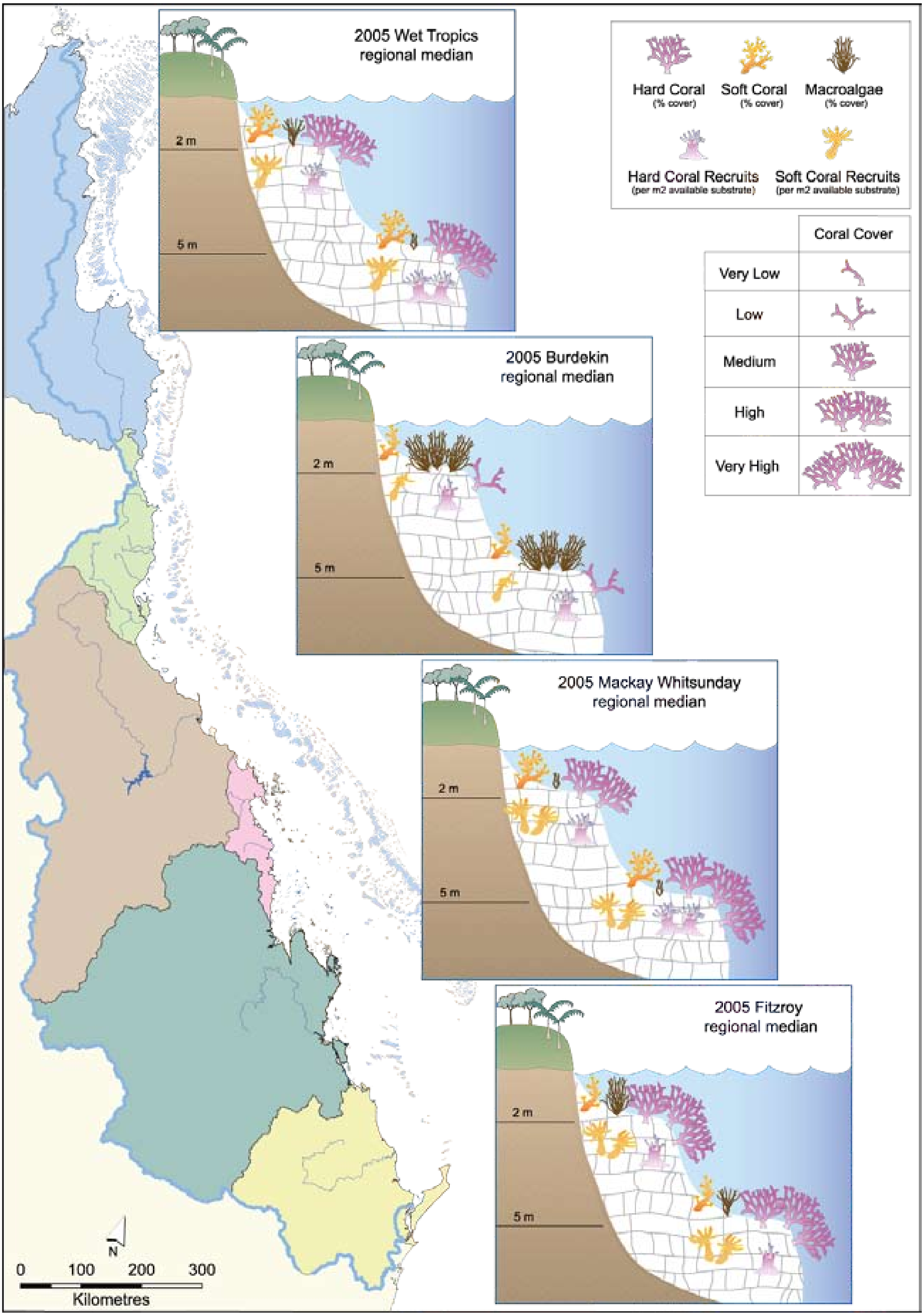


Figure 13 Regional median benthic cover for hard coral, soft coral and macroalgal (per cent cover) and density of hard and soft coral recruits at reefs surveyed at 2 m and 5 m

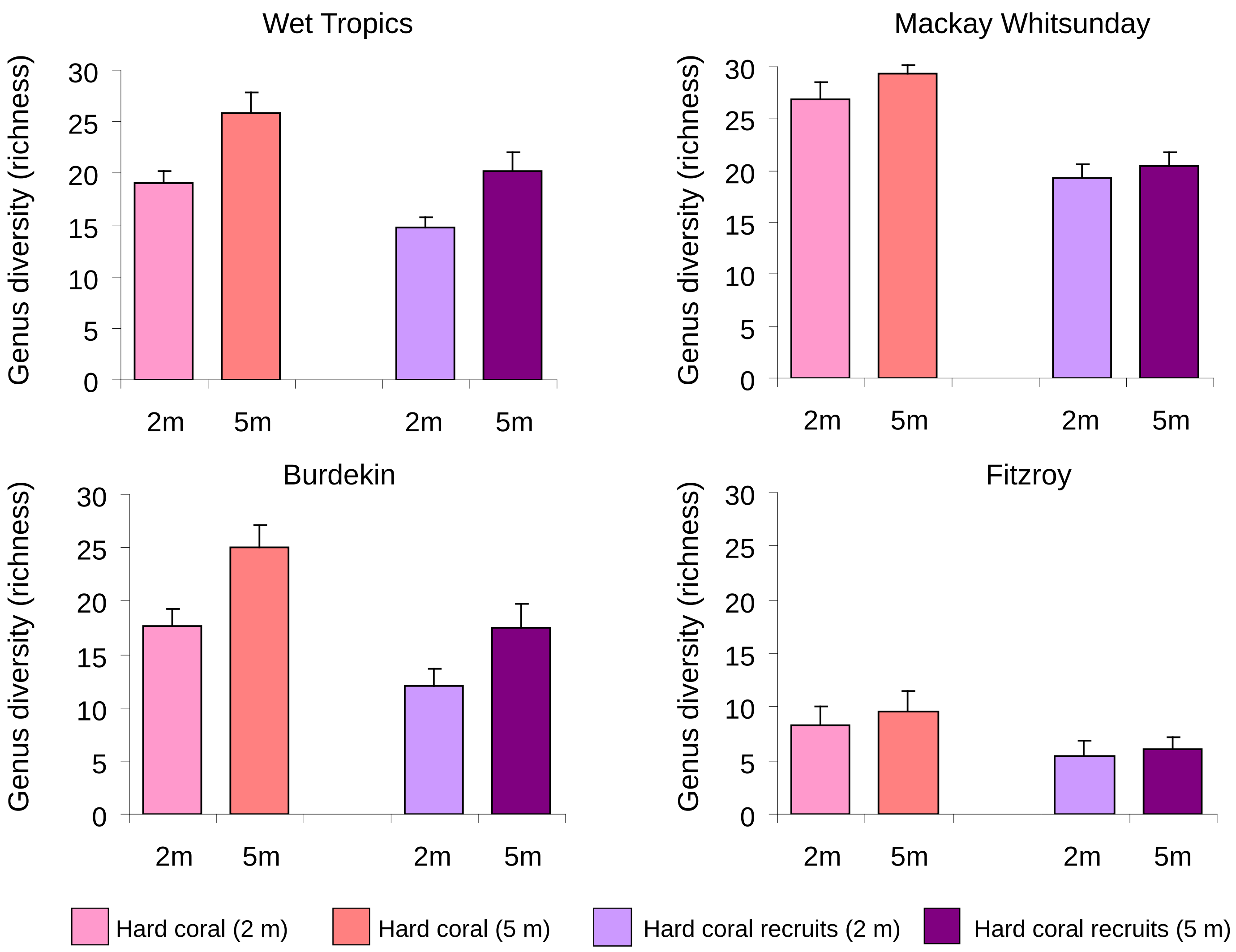
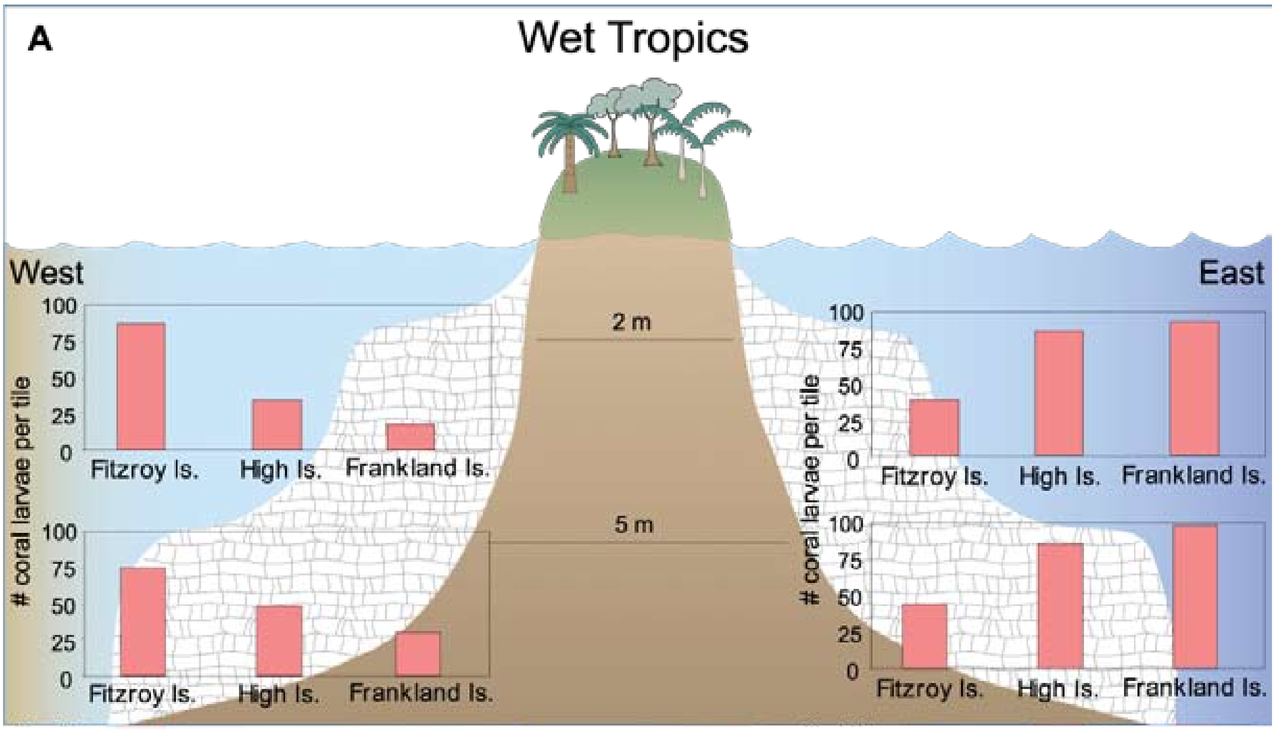


Figure 14 Regional average genus diversity (richness) of adult hard coral and hard coral recruits at 2 m and 5 m

Coral larvae settlement

Settlement of coral larvae was estimated in two regions (Wet Tropics and Mackay Whitsunday) using terracotta tiles as settlement plates. Settlement rates in 2005 were high (> 4 times) in comparison to those measured in previous studies. The average number of coral recruits settling onto tiles was overall higher at reefs in the Wet Tropics than in the Mackay Whitsunday region (Fig. 15). In both regions settlement was slightly higher at 5m than at 2m. Coral settlement did not show clear relationships with distance from rivers. With such high levels of recruitment in 2005 it will be interesting to see how many baby corals grow into small-sized colonies in the future to see if the coral popoulations are increasing. It will also be interesting to see if the 2006 recruitment is as high as 2005, or whether this was an unusual event.



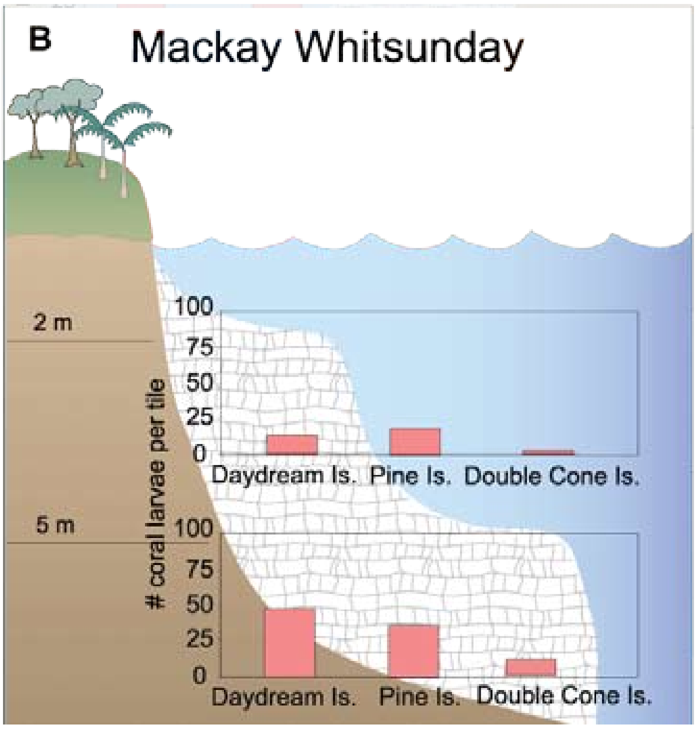


Figure 15 Coral larvae recruitment to tiles at west and east, 2 m and 5 m sites in the Wet Tropics (A) and 2 m and 5 m sites in the Mackay Whitsunday (B) regions

Seagrass monitoring

Seasonal fluctuations in seagrass cover were observed at a majority of the monitoring sites between October 2005 and April 2006. Intertidal seagrass monitoring has indicated that despite some temporary losses, intertidal seagrass in Queensland remain in relatively good condition. There are some exceptions along the southern locations, including Great Sandy Strait, Hervey Bay, Gladstone, and some sites in the Mackay Whitsunday region. Severe declines in intertidal *Zostera* meadows in Gladstone and other southern/central Queensland locations may be related to atypical climate variables such as rainfall, wind and water temperature occurring in the region between October 2005 and April 2006. Significant declines in seagrass cover and distribution were detected at the Lugger Bay site (close to Mission Beach), believed to be caused by Tropical Cyclone Larry.

The dominant species of seagrass recorded at Marine Monitoring Programme sites were *Halophila ovalis, Halodule uninervis* and *Zostera capricorni*. *Halophila ovalis* occurred at all monitoring locations, *Halodule uninervis* was found at nine of the eleven monitoring locations, and *Zostera capricorni* was present at five locations (Table 1).

All meadows, with the exception of Lugger Bay, showed a capacity to recover from short-term disturbance via seed banks and thus represent healthy seagrass meadows. No strong correlation was found with sediment nutrient concentration and seagrass flowering, however, higher tissue nitrogen concentrations were positively correlated with reproductive effort in *Halophila ovalis* suggesting that nutrient limitation may inhibit flowering capacity.

Sediment nutrients were found in concentrations similar to those previously recorded. The relationships between tissue nutrients with sediment nutrients, sediment type and the delivery of these nutrients remain unclear for Great Barrier Reef seagrasses and require further study.

Low, but detectable concentrations of diuron in seagrass meadow sediments were recorded in both years. These concentrations were well below previously recorded concentrations. Longer term and potentially more frequent sampling of herbicide concentrations would be necessary to resolve spatial and temporal variability.

Table 1 Presence (■) of *Halophila ovalis*, *Halodule uninervis* and *Zostera capricorni* in monitoring locations

GBR region	NRM region	Catchment	Seagrass monitoring location	Site name	*H. ovalis*	*H. uninervis*	*Z. caprcorni*
Far Northern	Cape York	Endeavour	Cooktown	Archer Point	■	■	
Northern	Wet Tropics	Daintree	*NA*				
		Russell / Mulgrave Johnstone	Green Island	Green Island	■	■	
			Cairns	Yule Point	■	■	
		Tully	Mission Beach	Lugger Bay	■*	■	
Central	Burdekin	Herbert	*NA*				
		Burdekin	Magnetic island	Picnic & Cockle Bays	■	■	■+
			Townsville	Shelley Beach Bushland Beach	■	■	
	Mackay Whitsunday	Proserpine	Whitsundays	Pioneer Bay	■	■	■
		Pioneer	Mackay	Sarina Inlet	■		■
Southern	Fitzroy	Fitzroy	Shoalwater Bay	Ross Creek Wheelans Hut	■*	■*	■
	Burnett Mary	Burnett	Gladstone	Gladstone Hbr	■	■*	■
		Mary	Hervey Bay	Urangan	■*		■

* indicates presence adjacent, but not within, 50 m x 50 m site. + only found at Picnic Bay

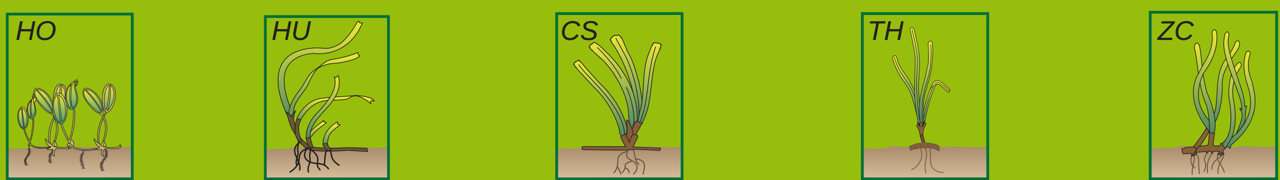
Understanding seagrass data

Graphic illustrations of data have been used throughout this document to present data collected in the Marine Monitoring Programme. The seagrass monitoring data display the above ground per cent cover of seagrass present during the surveys. At each location two sites within the seagrass meadow are monitored. Results from each of these sites is provided.

For the purpose of this report, one coloured seagrass leaf represents 10 % cover for eaxample:

10 % seagrass cover   50 % seagrass cover   100 % seagrass cover

The species of seagrass present at a particular monitoring site are represented as follows.



Halophila ovalis   *Halodule uninervis*   *Cymodocea serrulata*   *Thalassia hemprichii*   *Zostera capricorni*

2006

Part 3

Cape York

Regional Monitoring Summary

Cape York region

The Cape York Peninsula catchment region covers an area of 137 000 square kilometres and supports a population of 18 000 people living in the three largest towns of Thursday Island, Weipa and Cooktown. The majority of the land is relatively undeveloped, although mining is the dominant industry accounting for over half of the region's gross productivity. Cattle grazing is carried out over half of the region's land area. The region has significant cultural value to both Indigenous and Non-Indigenous communities. Key natural resource management issues for the region include:

- Inappropriate fire regimes
- Degradation in northern tropical savanna by cattle grazing
- Invasive pests
- Infrastructure development which pose potential threats to the natural heritage values of the region.

Cape York Peninsula can be described as one of Australia's remaining wilderness areas, and as a consequence, is an area of exceptional conservation value. Its natural environments are extremely diverse with dusty, desert landscapes, rainforests, rugged mountains and swampy marshlands. The eastern side of Cape York is fringed by the waters of the Great Barrier Reef Marine Park. The Normanby River is one of the priority rivers monitored as part of the Marine Monitoring Programme and is characterised by high intermittent flows, particularly during the wet season.

Table 2 Cape York Marine Monitoring Programme sites and indicators measured

	Nutrients	Suspended Sediments	Pesticides	Turbidity Logger	Temp	Crab Bioaccum.	Chl *a*	Coral Reef	Seagrass
Wallace Islet					M				
Mantis Reef							M		
Dolphin Pass							M		
Log Reef							M		
Lockhart River							M		
Night Island					M		M		
Normanby River	R	R		R		R			
Rodda Reef							M		
Cape Melville							M		
Osprey Reef							M		
Codhole							M		
Strickland							M		
Harrier Reef							M		
Bedford							M		
Cooktown							M		
Archer Point									B

R - River mouth water quality monitoring; **M** - Inshore marine water quality monitoring; **B** - Marine biological monitoring monitoring

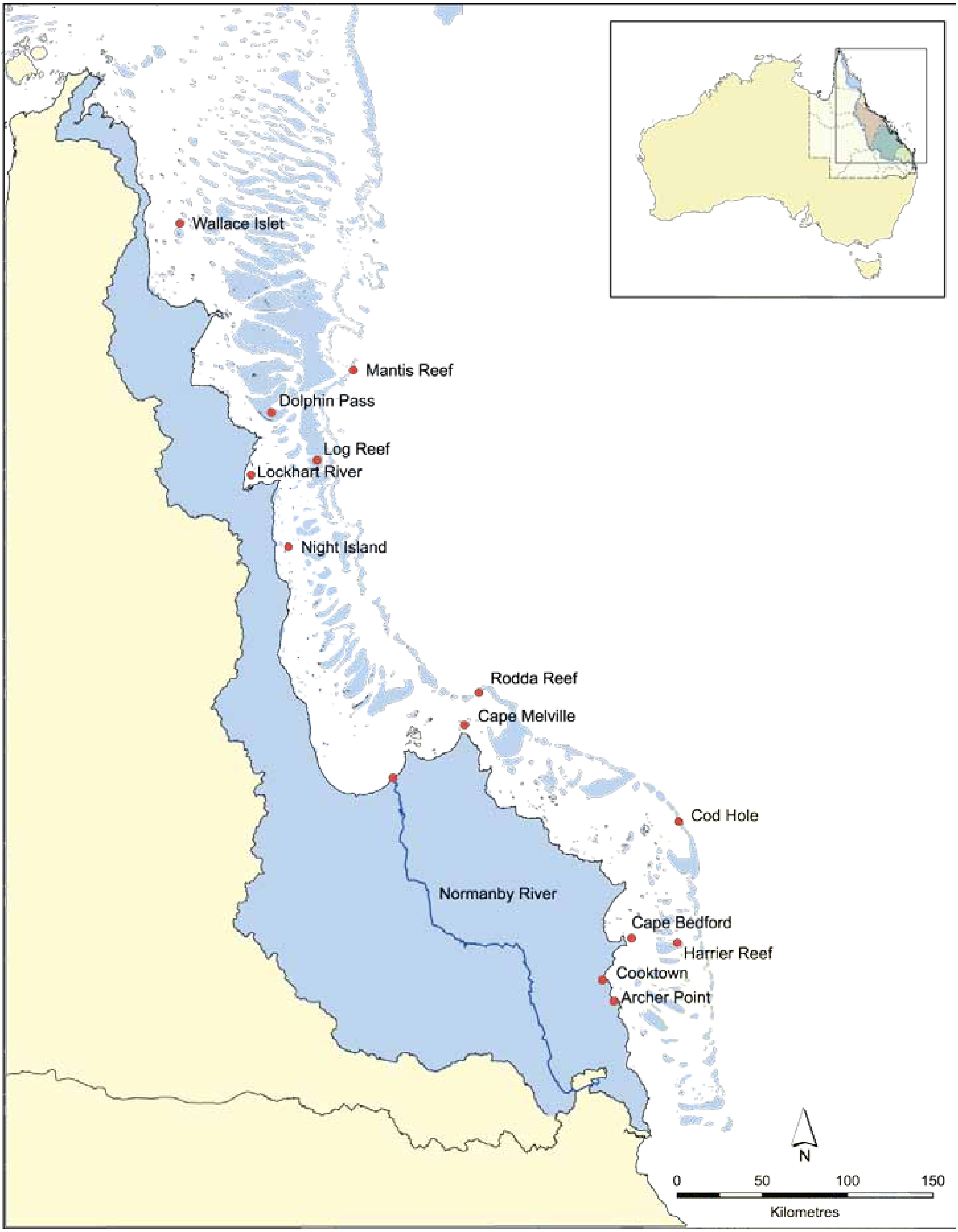
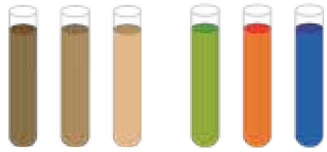


Figure 16 Map of the Cape York Reef catchment region and monitoring sites

Cape York water quality monitoring

The Cape York region, in comparison to other regions in the Reef's Catchment is relatively pristine and unimpacted by development and agricultural expansion. Due to the environmental characteristics and difficulty accessing the site, sampling under the Marine Monitoring Programme in the 2005 dry and 2005/06 wet season was limited. River water quality was monitored in the Normanby River during one major event, chlorophyll *a* monitoring is a more long-term and extensive programme and an additional seagrass monitoring sites was established at Archer Point.

Suspended sediment and nutrient monitoring



The gauging station at Kalpowar was established by the Department of Natural Resources and Water (NRW) personnel in December 2005. Sampling in the Normanby River was limited to one significant flood event (17 samples) in mid-March 2006, collected by NRW hydrographic staff (Fig. 17).

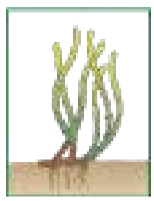
Suspended sediment concentrations exhibited a well defined peak during the event, with the highest concentrations on the leading edge of the hydrograph. Concentrations of both PN and PP varied directly with river flow and suspended sediment concentrations. DIN and DIP concentrations were low and fairly constant throughout the event, regardless of flow. DON and DOP concentrations were higher and more variable than inorganic N and P during the flood.

Chlorophyll *a* monitoring

Chlorophyll *a* monitoring in the Cape York regions is undertaken by Cooktown Shire Council and Undersea Explorer, with Undersea Explorer undertaking long-term monitoring in the region since 1997. Chlorophyll *a* concentrations are low throughout the region, with the majority of samples being less than Queensland Guideline Values for coastal waters (Fig. 18). There is no significant cross-shelf gradient or seasonal differences in chlorophyll concentrations in the Cape York region although higher chlorophyll values were recorded at coastal sites.

Cape York biological monitoring

Seagrass monitoring



The two Cooktown sites (AP1 and AP2) are located on a fringing reef platform in a protected section of Archer Point, fringed by mangroves, approximately 15 km south of Cooktown (Fig. 19). The sites were dominated by *Halodule uninervis* and *Halophila ovalis* and seagrass cover varied between 20 per cent in winter and 35 per cent in spring. Monitoring was established at one site in late 2003, an additional site was established in May 2005. Species composition remained relatively stable over the past 12 months. Seagrass cover over the past 12-24 months appeared to follow a seasonal trend with higher abundance in late spring/early summer.

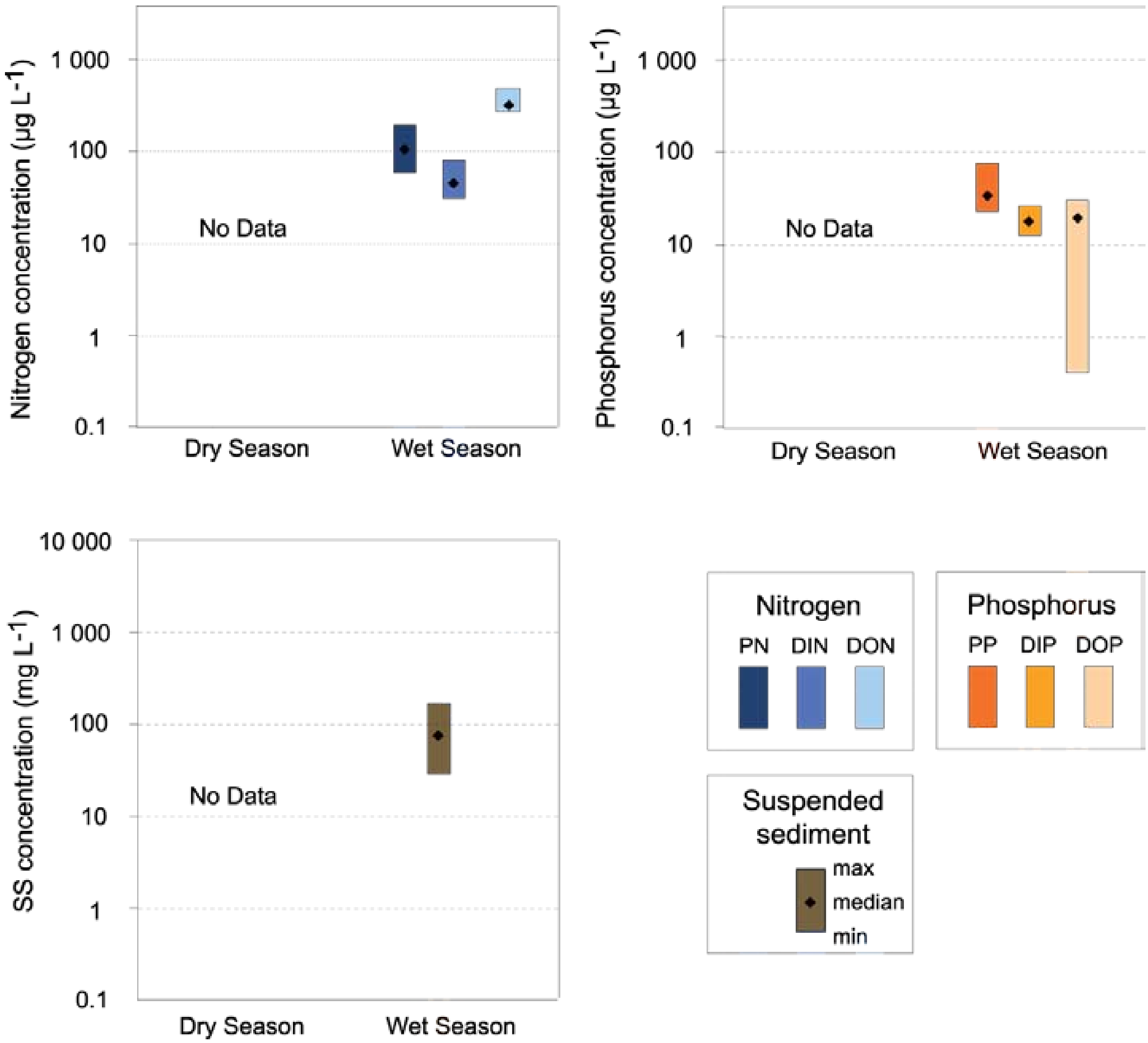


Figure 17 Summary of nitrogen, phosphorus and suspended sediment concentrations in the Normanby River during the 2005/06 wet seasons

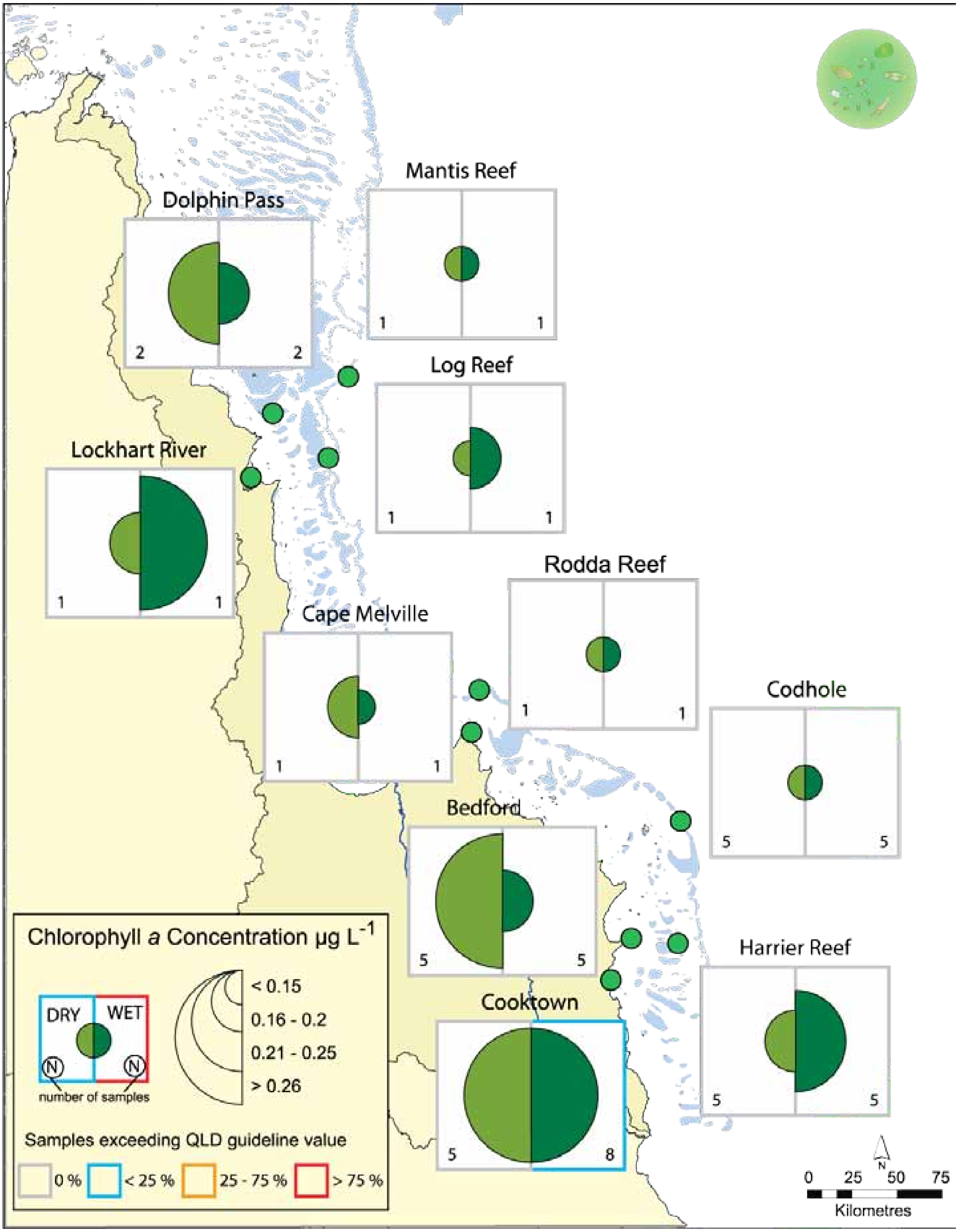


Figure 18 Chlorophyll *a* concentrations at sites in the Cape York region

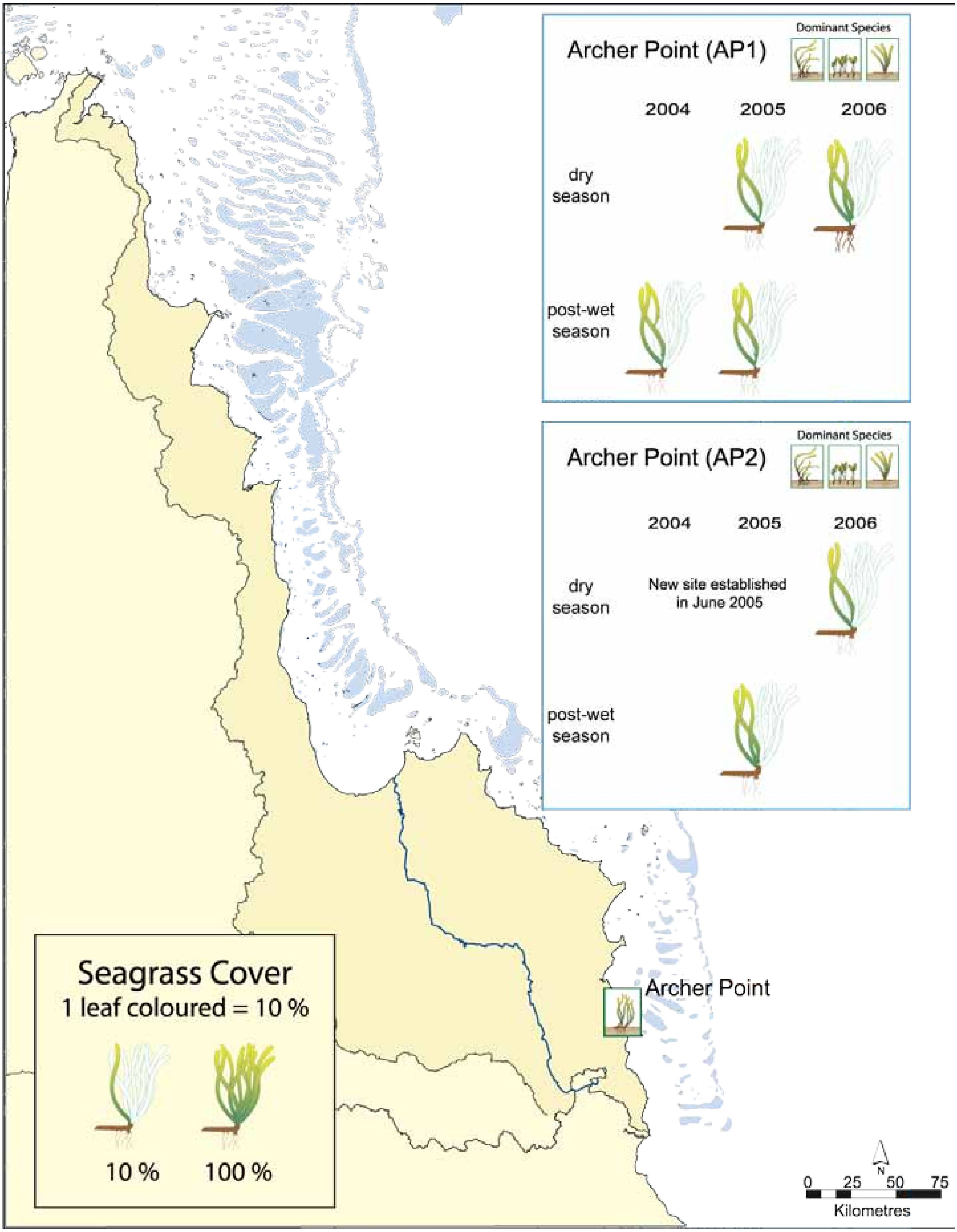


Figure 19 Seagrass cover at Archer Point in the Cape York region

Cape York regional synopsis

The key findings of the Marine Monitoring Programme include:

- A new gauging station was set up on the Normanby River in late 2005. This station will provide accurate long- term flow records in the river into the future.
- Queensland Water Quality Guideline values for all nutrient concentrations (except ammonia) were exceeded in samples collected in the 2005/06 wet season from the Normanby River.
- Marine water chlorophyll *a* concentrations were similar in inshore and offshore areas in the Cape York region. (Chlorophyll *a* is a measure of nutrient availability in the water column).
- Mud crabs collected from the Normanby River contained traces of the pesticide chlordane.
- Seagrass cover remained relatively stable over the last 12 months at Cape York monitoring sites and seagrass cover followed a seasonal trend with higher seagrass abundances in early summer months. The meadows have the capacity to recover from disturbance via seed banks.
- There are no inshore reef communities monitored in the Cape York region.

Part 4

Wet Tropics

Regional Monitoring Summary

Wet Tropics NRM Region

The Wet Tropics catchment region covers 22 000 km^2 and supports a population of 200 000 people, with 90 per cent residing in the Cairns area. The main vegetation type is wet tropical rainforest, although there are significant areas of other vegetation including sclerophyll forests and open woodlands. The major land uses in the region include cane and banana farming, dairy, beef, cropping and tropical horticulture. The natural values and assets of the land are of cultural and spiritual significance for the 23 Aboriginal Traditional Owner groups living in this region. The region holds most of the Wet Tropics World Heritage Area. The catchments that make up the Wet Tropics region are the Daintree/Mossman, Barron, Russell/Mulgrave, Johnstone, Tully, Murray and Herbert. The Wet Tropics region is a unique area of Australia, and as its name suggests, has one of the highest annual rainfall in the country. This rain falls mostly in the wet season, creating distinctive wet and dry seasons. Four of the ten high priority GBR rivers are presently monitored in the Wet Tropics region; the Barron, Johnstone, Tully and Herbert Rivers. Key natural resource management issues for the region include:

- Vegetation loss, particularly in the coastal lowlands.
- Loss and decline of native species and biodiversity;
- Riparian and in-stream degradation from clearing, flooding and sedimentation and natural erosion processes;
- Terrestrial animal and plant pest species; and
- Declining water quality due to sedimentation and other forms of pollution.

The waters adjacent to the Wet Tropics region include some of the most important habitats in the Great Barrier Reef, particularly for tourism.

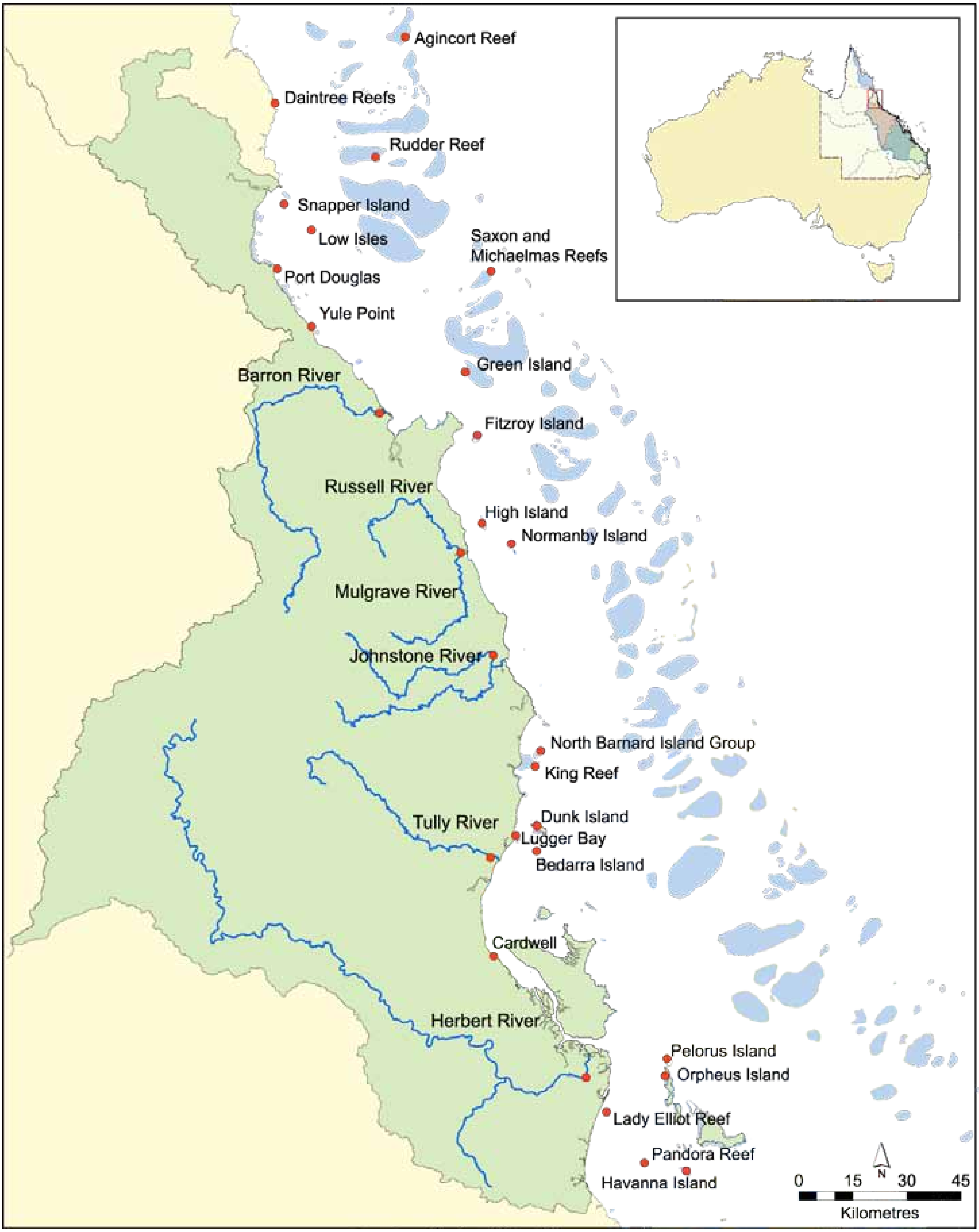


Figure 20 Map of the Wet Tropics NRM region and monitoring sites

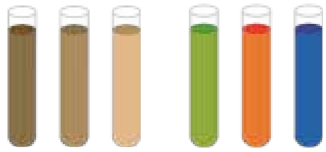
Table 3 Wet Tropics Marine Monitoring Programme sites and indicators measured

	Nutrients	Suspended Sediments	Pesticides	Turbidity Logger	Temp	Crab Bioaccum.	Chl a	Coral Reef	Seagrass
Agincourt Reef							M		
Daintree Reefs	M	M					M	B	
Rudder Reef							M		
Coconut Bch Reef					M				
Snapper Is	M	M					M	B	
Low Isles			M		M		M		
Port Douglas							M		
Barron River	R	R	R	R		R	M		
Yule Point									B
Ellie Point							M		
Saxon Reef							M		
Nicholas Reef							M		
Michaelmas Cay							M		
Green Island					M		M		B
Fitzroy Island			M		M		M	B	
High Island	M	M	M		M		M	B	
Mulgrave River			R						
Russell River			R	R					
Normanby Island	M	M	M		M		M	B	
Black Rock Reef							M		
N Johnstone River	R	R	R	R		R			
North Barnard Is	M	M			M		M	B	
King Reef	M	M			M			B	
Lugger Bay									B
Dunk Island	M	M					M	B	
Bedarra Island			M						
Tully River	R	R		R		R			
Cardwell							M		
Herbert River	R	R	R	R		R			
Pelorus Island*								B	
Orpheus Island*	M	M	M				M	B	
Lady Elliot Reef*	M	M					M	B	
Pandora Reef*	M	M					M	B	
Havannah Is.*	M	M					M	B	

R - River mouth water quality programme; M - Inshore marine water quality programme; B - Marine biological monitoring

* Monitoring locations influenced by both Wet Tropics and Burdekin rivers (reported under both regions)

Wet Tropics water quality



Suspended sediment and nutrient monitoring

Four rivers in the Wet Tropics region were monitored during 2005/06 (Barron, North Johnstone, Tully and Herbert Rivers). Water samples from these rivers were collected primarily during flood events by FNQ NRM Ltd staff and NRW staff. Inshore marine water quality was monitored at eight sites in the Wet Tropics region, during two AIMS cruises (the dry and wet seasons). Water quality data has been summarised for sites within each of the three major Wet Tropics river catchments (Barron, Johnstone and Tully/Herbert).

Barron River Catchment

Intensive sampling was carried out during four flow events in the Barron River (21 samples in total), including the flood associated with Tropical Cyclone Larry and later in mid-April. Only one sampling event was conducted during the dry season, but a number of samples were collected under low-flow conditions during the summer.

Suspended sediment concentrations exhibited sharp peaks during the two monitored flood events, with a peak concentration of 1.2 g L^{-1} (Fig. 21). High dissolved inorganic phosphorus concentrations were recorded on two occasions (associated with floods). Apart from these two samples, measured concentrations of both inorganic nitrogen and phosphorus were low and relatively stable. Dissolved organic nitrogen comprised nearly half of the estimated nitrogen exported from the Barron River over 2005/06. Particulate phosphorus was the primary form of phosphorus exported by the Barron.

Two inshore marine sites (Daintree Reefs and Snapper Island) were considered to be influenced by the Barron (and Daintree) Rivers. Based on the limited sampling available, the concentrations of suspended sediments and nutrients were generally low at these sites. Dissolved inorganic nitrogen (mostly nitrate) was particularly high at Snapper Island during the dry season. Dissolved organic and particulate nitrogen and phosphorus were higher during the summer sampling, indicating re-suspension and higher plankton biomass. The average concentration of nutrients in marine waters were highest in the Barron Catchment, compared to the other three Wet Tropics catchments.

North Johnstone River Catchment

Thirty (30) sampling events were carried out in the North Johnstone River during 2005/06 by FNQ NRM Ltd and NRW personnel. Two of these sampling events were conducted during the nominal "dry" season.

Suspended sediment concentrations varied considerably, with peak concentrations occurring during both large and small flood events (Fig. 22). The maximum SS concentrations (ca. 250 mg L^{-1}) was considerably lower than that recorded in the nearby Barron River. Both DIP and DIN were low and fairly stable over the course of the year. Prior to and during the early part of the wet season, DON comprised a significant proportion of the total N in the North Johnstone River. The DON concentration declined steadily over the course of the wet season. Both PN and PP exhibited peak concentrations during flood events.

Three inshore reef sites are considered to be influenced by the Johnstone River (Frankland Islands, High Island and Fitzroy Island). The concentration of suspended sediments and nutrients were generally low at these sites and primarily comprised of organic species.

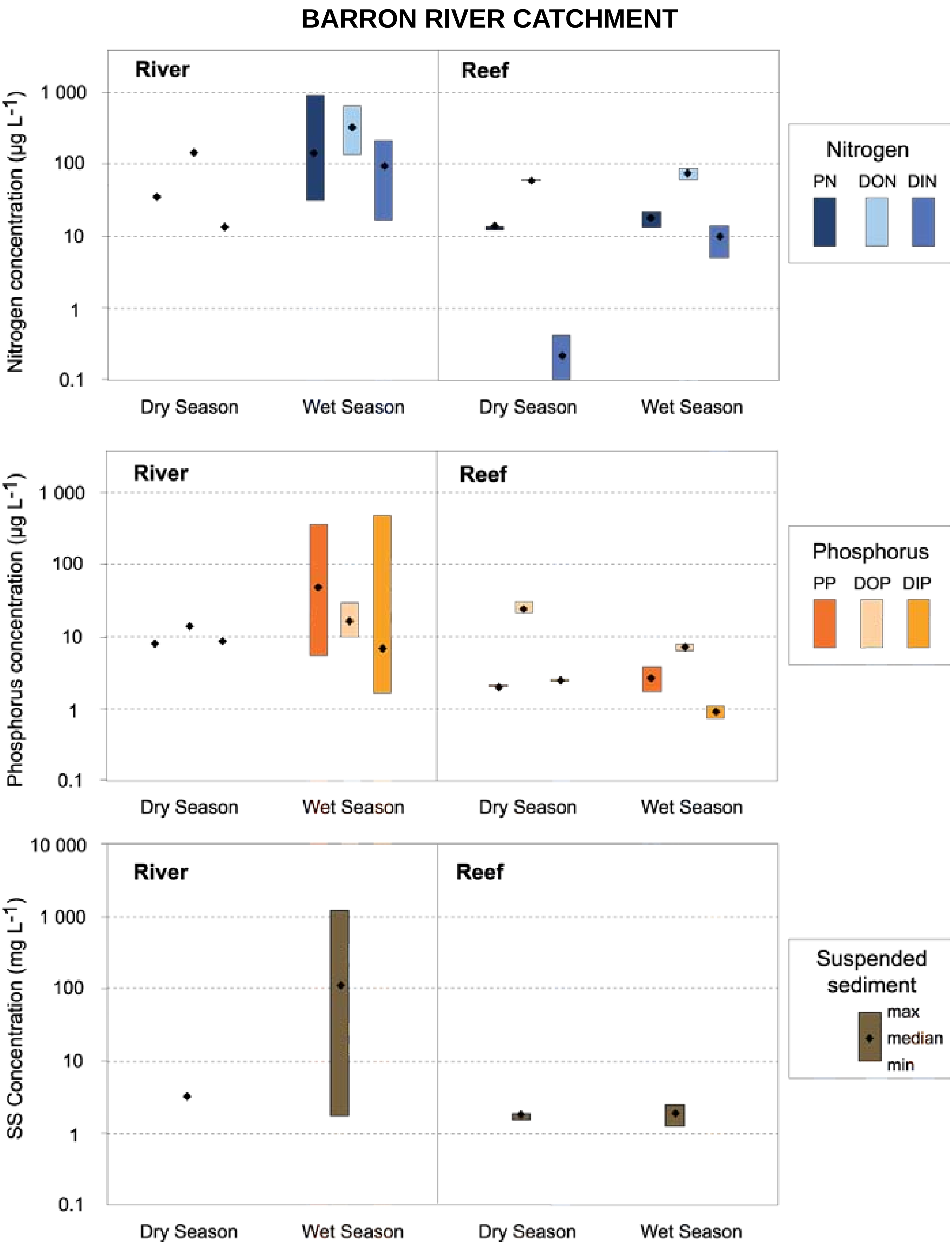


Figure 21 Nitrogen, phosphorus and suspended sediment concentrations in the Barron River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

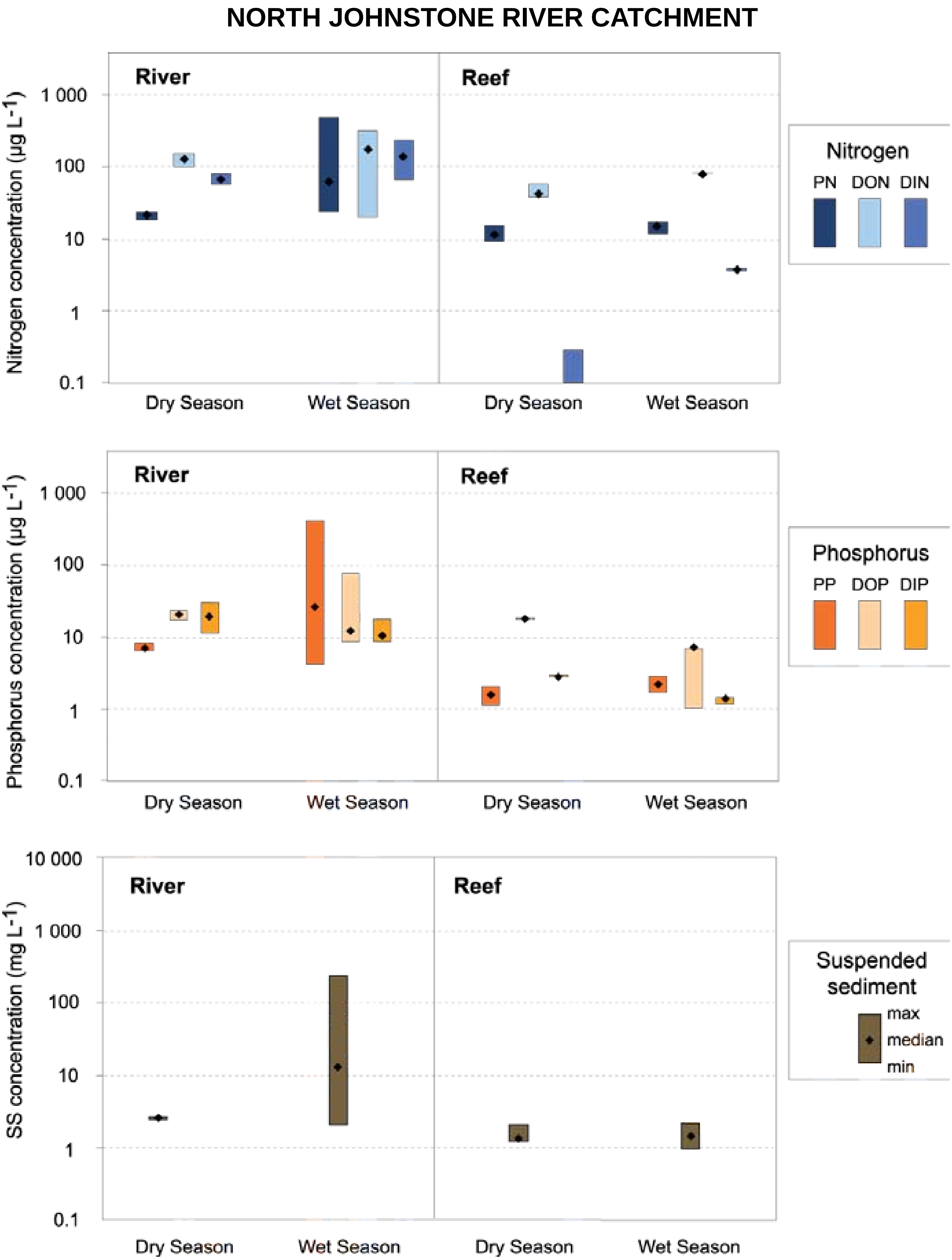


Figure 22 Nitrogen, phosphorus and suspended sediment concentrations in the North Johnstone River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

Tully River Catchment

Twenty one sample events were carried out in the Tully River over the 2005/06 year by FNQ NRM Ltd and NRW personnel. Two sampling events were undertaken in each of these rivers during the nominal “dry” season.

Small, but significant increases in base-flow nitrate, phosphate and particulate nitrogen have been observed in the lower Tully River over a 10 year period (1990-2000) following an intensification of agricultural land-use in the catchment, indicating greater losses from land sources (Furnas 2005; De’ath 2005).

Suspended sediment concentrations were generally low in the Tully (< 100 mg L^{-1}). The Tully River had a short-lived peak in DIN and DON during a small flow event at the end of January, thereafter both DIN and DON concentrations were low and fairly constant over the wet season (Fig. 23). After a small peak in late-January, PN concentrations were low throughout the summer. As in other rivers, PP concentrations peaked during flood events.

Three inshore marine monitoring sites are considered to be potentially influenced by the Tully River (Dunk Island, King Reef and North Barnard Group). Similarly to other sites in the Wet Tropics region, the concentrations of suspended sediments and nutrients in inshore marine waters were low and dominated by DON and DOP.

Herbert River Catchment

Twenty three sample events were carried out in the Herbert River over the 2005/06 year by community volunteers and NRW personnel. Two sample events were undertaken in each of these rivers during the nominal “dry” season.

Suspended sediment concentrations were generally low in the Herbert River (< 25 mg L^{-1}). Apart from two samples collected at the end of April and early May, DIN concentrations were low and relatively constant throughout the summer period (Fig. 24). A very large fraction of the total N transported in the Herbert River was in the form of DON. Despite large variations in discharge, DON concentrations remained fairly constant through the wet season. PN concentrations peaked during the two significant flow events sampled. With the exception of one sample during the March post-Larry flood, concentrations of DIP and DOP were low and relatively constant over the wet season.

The Herbert River may influence inshore monitoring locations in the Wet Tropics and Burdekin regions, and thus have been reported under both regional reports. Four inshore marine monitoring sites are considered to be potentially influenced by the Herbert (and Burdekin) Rivers these include: Orpheus Island, Lady Elliot Reef, Pandora Reef and Havannah Island. The concentrations of suspended sediments and nutrients in inshore marine waters at these locations were low and dominated by DON and DOP.

TULLY RIVER CATCHMENT

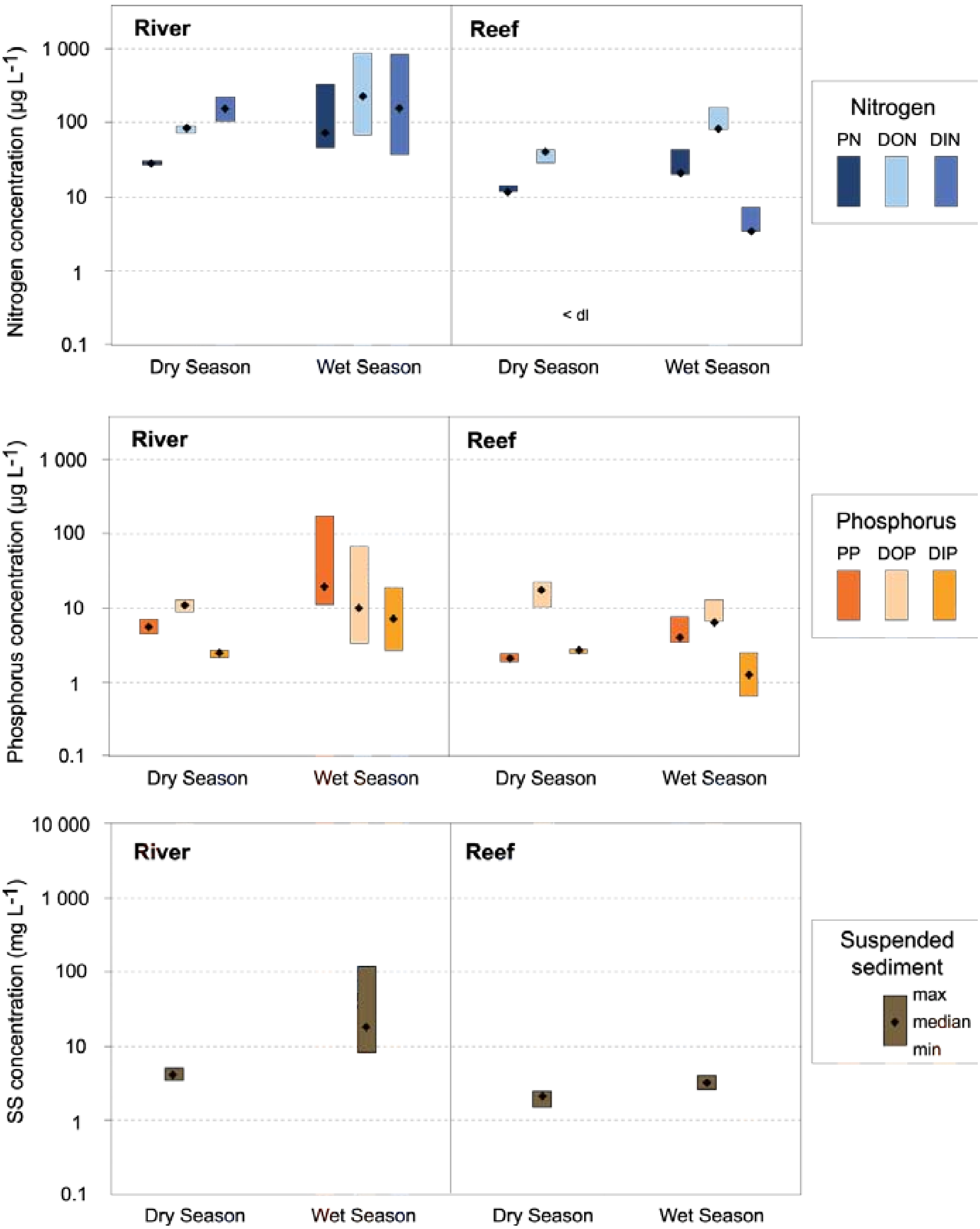


Figure 23 Nitrogen, phosphorus and suspended sediment concentrations in the Tully River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

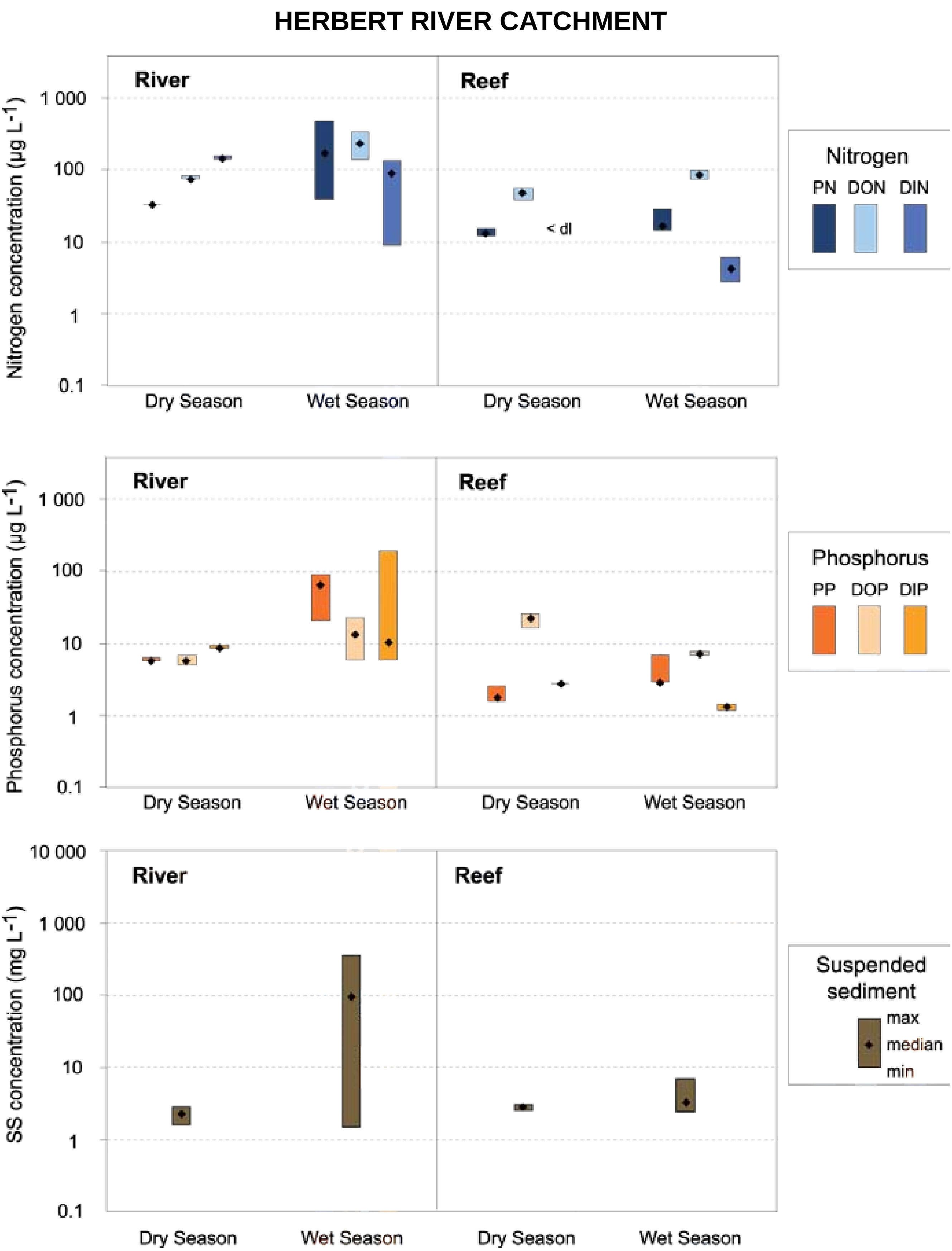


Figure 24 Nitrogen, phosphorus and suspended sediment concentrations in the Herbert River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

Chlorophyll *a* monitoring

Chlorophyll *a* monitoring in the Wet Tropics region in the 2005 dry and 2005/06 wet season was undertaken by Undersea Explorer, Queensland Parks and Wildlife Servvice, Raging Thunder, Fitzroy Island, Quick Cat Scuba Adventures and Cardwell State School. Unfortunately due to Tropical Cyclone Larry, samples from Clump Point, Dunk Island, Beaver Cay and Bedarra Island were lost due to the loss of power supply to freezers. The data from the majority of sites in the Wet Tropics showed similar patterns to the long-term chlorophyll *a* monitoring programme, with elevated concentrations of chlorophyll *a* at inshore sites compared with sites further offshore (Fig. 25). Higher chlorophyll *a* concentrations were also observed in the wet season compared with the dry season, due to increased nutrient supply from the rivers during flood events. Chlorophyll *a* concentrations are generally low throughout the region, although some sites, particularly those closest to the coast, are above Queensland Guideline Values for coastal waters.

Pesticide monitoring

River pesticide monitoring was undertaken, using passive samplers, at five river mouth and five inshore reef locations in the Wet Tropics region in the 2005 dry and 2005/06 wet seasons (Fig. 26). Although there were only limited numbers of samples collected, the data provides a baseline for future comparisons.

River pesticides

Monitoring occurred in the Barron, Russell-Mulgrave and Herbert Rivers. The average concentration of pesticides in river mouth waters in the Wet Tropics region was highest in the Russell/Mulgrave rivers. Results from the Russell and Mulgrave Rivers followed a similar seasonal and compound profile. In both rivers diuron, hexazinone and atrazine were the key compounds detectable. Figure 26 presents average pesticide concentration of these two rivers combined. Concentrations were consistently lower in the Mulgrave River compared to the Russell River, except there was an increase of hexazinone towards the wet season in the Mulgrave River. In contrast, the concentration of total pesticides was lower in the Barron and North Johnstone Rivers (only measured in the wet season). The Barron River had a lower contribution of diuron, although concentrations of simazine were higher. Tebuthiuron was elevated in one sample in the North Johnstone River during the wet season.

Inshore reef pesticides

Five inshore reef sites (Low Isles, Fitzroy, Normanby, Bedarra and Orpheus Islands) were monitored for pesticide concentrations. Sampling across the wet/dry seasons was achieved only at Low Isles, Fitzroy and Orpheus Islands. Low Isles was the only site to show a higher concentration of diuron during the wet season period. Atrazine and hexazinone were detected at Low Isles and Fitzroy Island during the wet season sampling.

The total concentration of pesticides detected at Normanby, Bedarra and Orpheus Islands were low (< 6 ng L^{-1}). The overall concentrations at Orpheus Island were consistently below the Limit of Detection (LOD) for all analysed organic pollutants, except for diuron which was detectable at very low concentrations in both the dry and wet seasons.

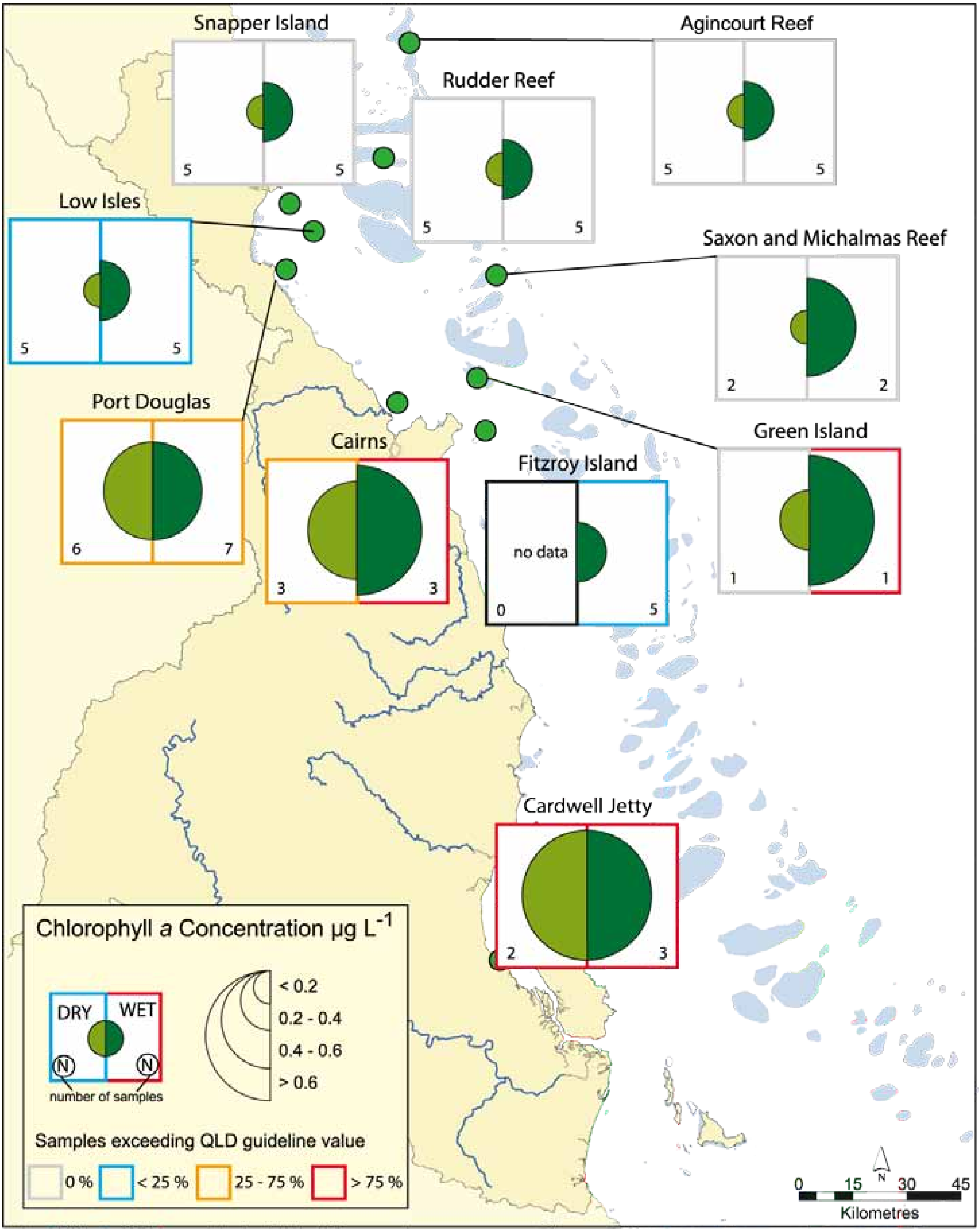


Figure 25 Chlorophyll *a* concentrations at sites in the Wet Tropics region

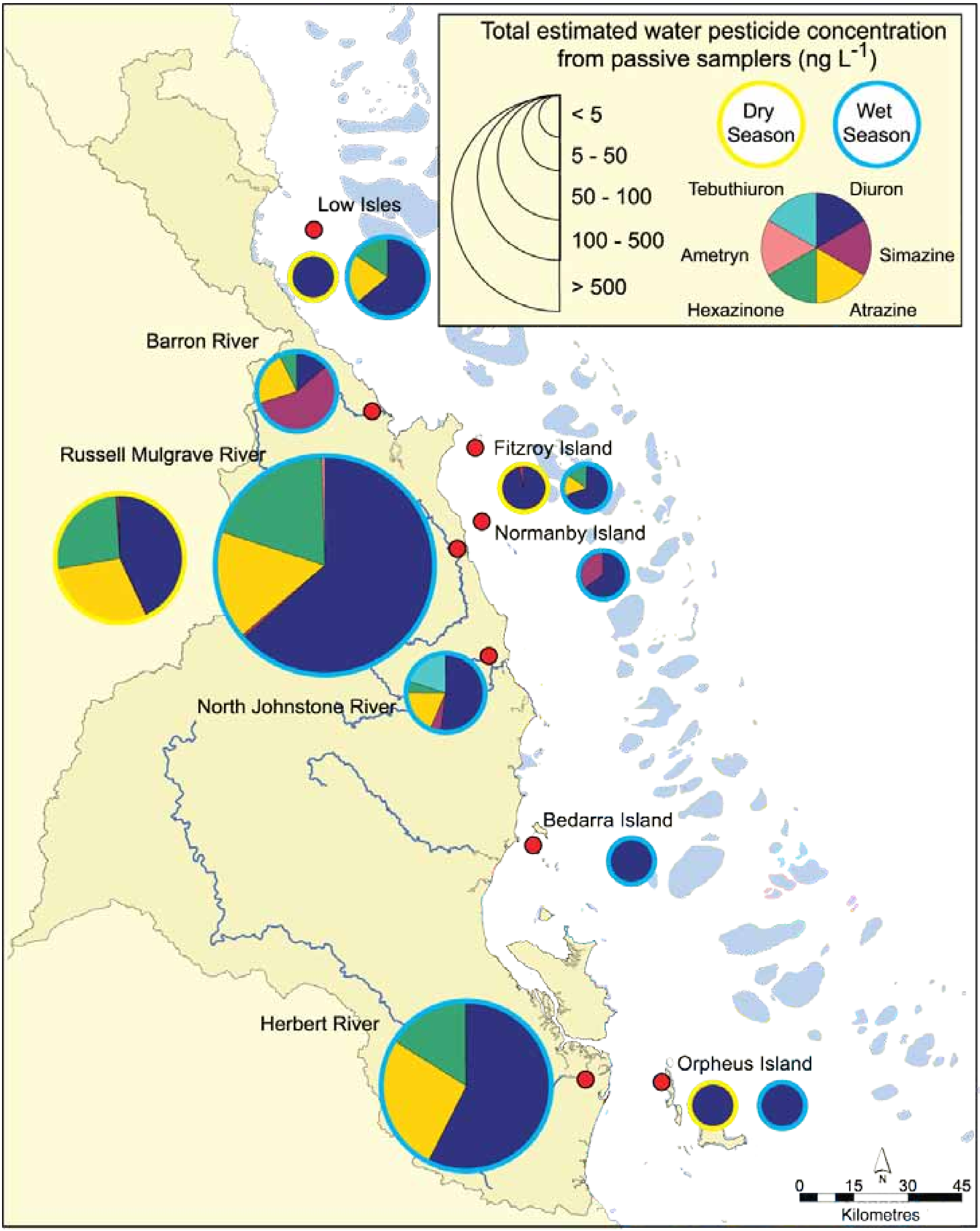


Figure 26 Pesticide concentrations in river and inshore marine waters at sites in the Wet Tropics region collected during the 2005 dry season and 2005/06 wet season

Wet Tropics marine biological monitoring

Coral monitoring

Inshore reef condition reporting for the Wet Tropics NRM region has been divided into three sub-regions due to the number and spread of sites in this region. These sub-regions are based on the gradient of possible exposure from the River catchments of the Barron-Daintree Rivers; the Johnstone/Russell-Mulgrave Rivers; and the Herbert/Tully Rivers.

Barron and Daintree Sub-Region

Five reefs were monitored to represent a gradient of possible exposure to river-borne contaminants, from the mouths of the Daintree and Barron Rivers (Southern Snapper Island - North Snapper Island - Daintree Reef South - Daintree Reef Central - Daintree Reef North).

Long-term monitoring of the reefs in this region shows the frequent and localised nature of disturbances. These disturbances include flooding of the Daintree River (impacting Snapper Island sites), bleaching events and crown-of-thorns starfish infestations at Daintree Reef South.

The cover of hard coral at 2 m depth is significantly lower at Snapper Island South and Daintree Reef South and than at other reefs (Fig. 27). Low hard coral cover at Snapper Island south is most likely the result of mortality associated with freshwater inundation during the 1996, 1997 and 2004 floods. The soft coral community was also impacted by these events. The direct impact of these floods was restricted to the upper 2-3 m of the reef, with the deeper communities being largely unaffected. Low coral cover at Daintree South was the result of a localised crown-of-thorns outbreak. Following the outbreak, high macroalgae cover has been observed and may be influencing the observed low density of recruit-sized colonies (of both hard and soft corals). The density of soft and hard coral recruits were low at Daintree South and both Snapper Island sites and, as such, may be limiting the rate of coral community recovery.

Historical and current observations indicate that Daintree Central and Daintree North reefs are relatively stable and unlikely to change dramatically in the short term.

Johnstone and Russell - Mulgrave sub-region

The influence of the Johnstone and Russell-Mulgrave Rivers extends in a northerly direction as plumes and sediments are generally transported by prevailing south-east winds. Infrequent major floods of the Burdekin River can also extend to this region (as happened in 1994). The closest reefs to the rivers are High Island West – High Island East – Frankland Group West – Frankland Group East – Fitzroy Island West – Fitzroy Island East.

Three major disturbances have recently affected survey reefs in this region (coral bleaching in 1998 and in 2002, and crown-of-thorn starfish (COTS) outbreaks in 1999-2000). Freshwater plumes associated with major flooding have been recorded at most reefs in 1994, 1995, 1996, 1997 and 1999, though there were no marked impacts on coral cover directly attributable to these events at the depth of monitoring sites.

The reefs on the western side of both High Island and the Frankland Group were different, having lower densities of recruit-sized colonies, richness of genera represented by recruit-sized colonies and richness over all (Fig. 27). These western reefs are most likely to be exposed to river runoff and this may be reflected in the generally lower richness and density of recruits.

The hard coral community on High Island West and Frankland Group West (both at 2 m and 5 m) slope are dominated by massive *Porites spp*, whereas Faviidae, Acroporidae and Poritidae dominate the hard coral recruits at these sites. In contrast, the coral settlement tiles indicated higher numbers of Acroporidae settled after the 2005 spawning, suggesting that Porites are more resilient to the environmental conditions at this location. It will be interesting to see if this supply of coral larvae from different coral taxa at these western, river exposed sites, translates into the development of a more diverse community or if disturbance and competition for space continue to limit the community diversity.

In contrast, the Frankland Group East and High Island East reefs have relatively high hard coral cover, especially at 2 m where there was a high component of the fast growing *Acropora* genus. This, combined with the observed higher density of recruit-sized colonies (which included a diverse range of families) indicates continued recruitment and recovery at these sites.

The west and eastern sites at Fitzroy Island have been subjected to a series of disturbances in the past decade (bleaching, floods and COTS outbreaks). Benthic communities at Fitzroy Island West are dominated by soft coral, with low hard coral cover, while the communities on the eastern side had low to moderate soft and hard coral cover. The high abundance and diversity of recruit-sized colonies, coupled with the increasing cover of Acroporidae corals, indicates these reefs are in a state of recovery. The availability of larvae as indicated by the extent of settlement to tiles should further sustain this process.

Herbert and Tully sub-region

Four reefs were selected to represent a gradient of likely exposure to river borne contaminants, assumed to be largely a function of their distance from the mouths of the Herbert, Murray, Hull and Tully Rivers (i.e. Dunk Island South – Dunk Island North - King Reef – North Barnard Group).

Flood plume observations indicate that all reefs were subject to flood events on three or more occasions between 1991 and 2001. The impacts on the benthic communities are unknown as there is no long-term coral monitoring data available. Recent modelling work indicates hard coral communities in this sub-region are likely to have been impacted by coral bleaching in 1998 and 2002.

In 2005, the communities at both 2 m and 5 m at King Reef had significantly lower estimates of hard coral cover, lower density of recruit-sized colonies and significantly higher cover of macroalgae than reefs at either Dunk Island North or the North Barnard Group (Fig. 27). The richness of genera represented by recruit-sized colonies was also low at King Reef. The cover of hard coral at 2 m and density of recruit-sized colonies at 5 m was also lower at Dunk Island South than at either Dunk Island North or the North Barnard Group while the cover of macroalgae was higher. The reef at Dunk Island South is closest to the rivers that might affect these reefs. While King Reef is further from the main rivers than the sites at Dunk Island North, it may be affected by local creeks.

The impact of Tropical Cyclone Larry (March 2006) on these coral communities varied dramatically (See text box on page 65). Hard and soft coral cover was significantly reduced at both the North Barnard Group and Dunk Island North, as were the density of recruit-sized colonies.

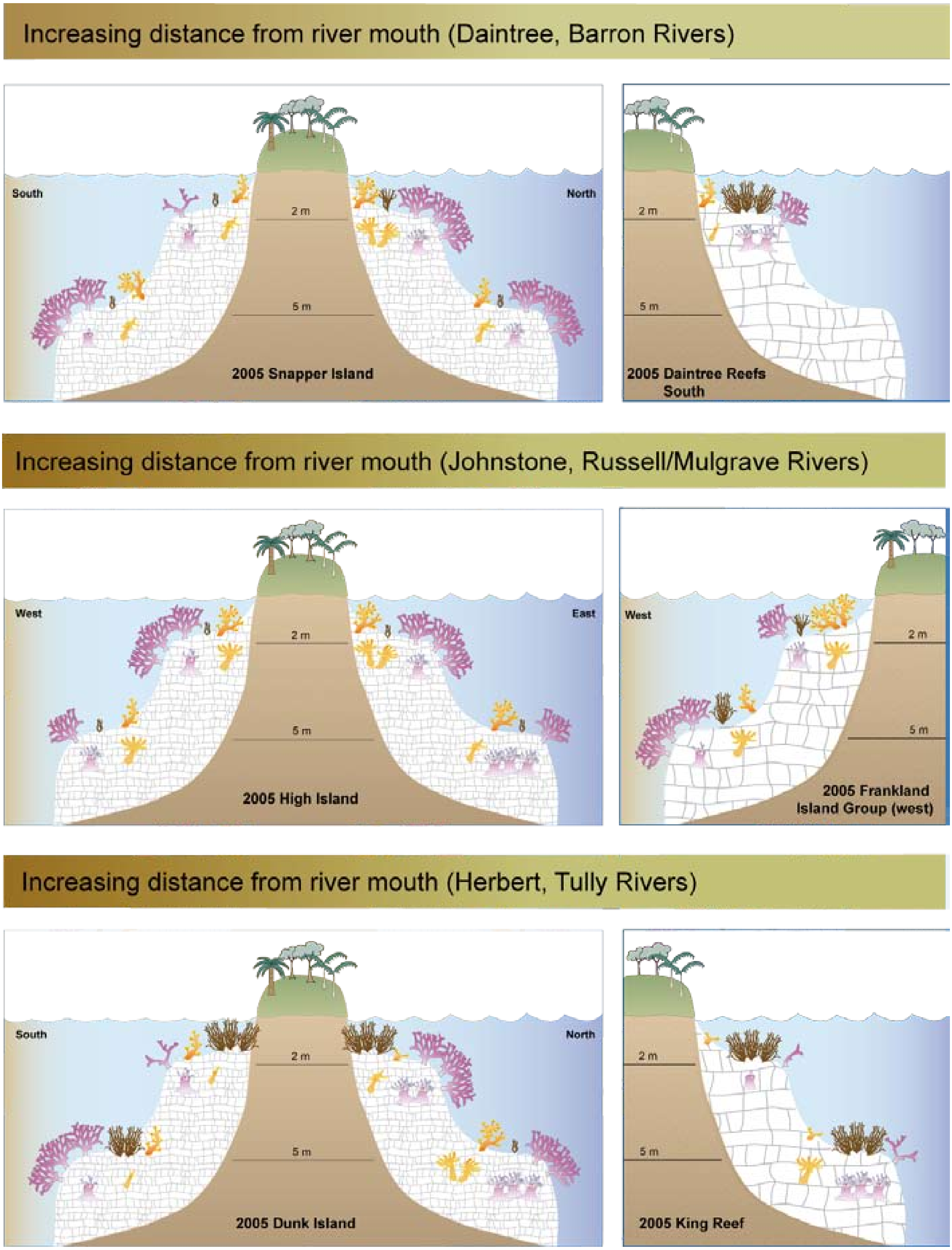
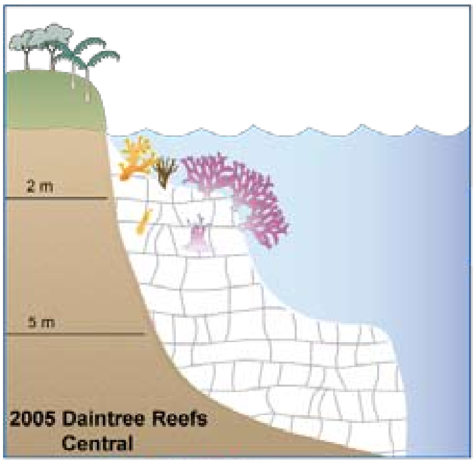
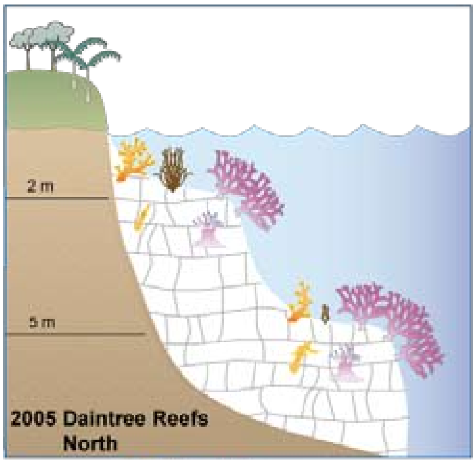
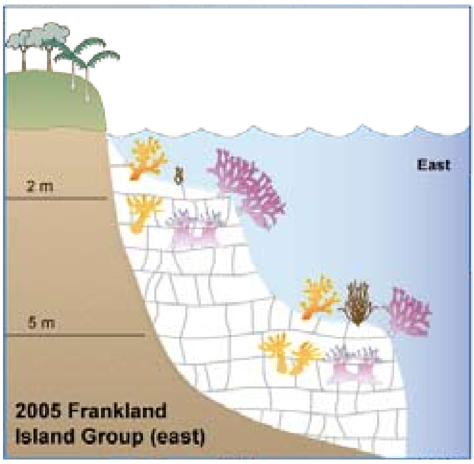
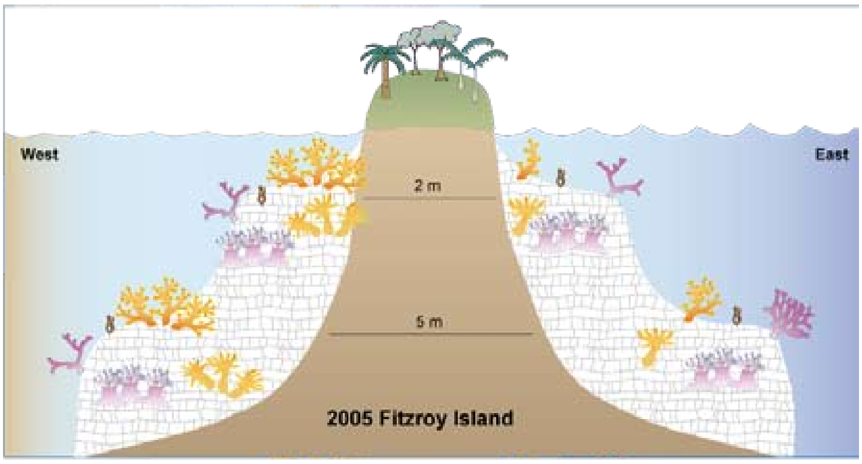


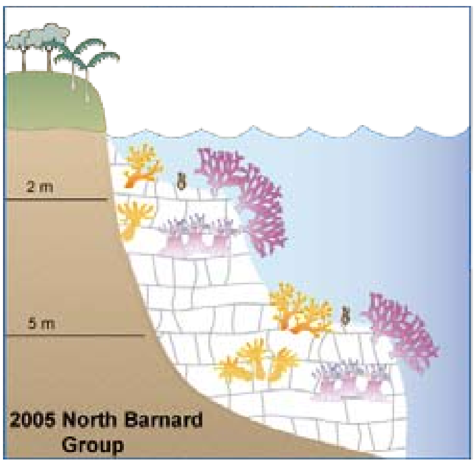
Figure 27 Benthic cover (percent hard coral, soft coral and macroalgae and density of hard and soft coral

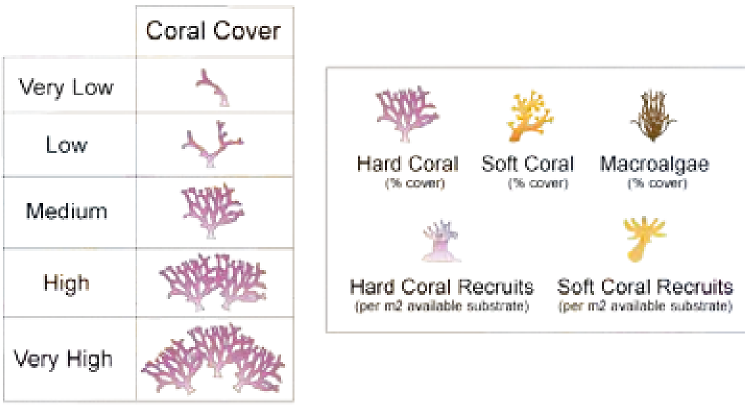












recruits) at inshore reef sites in the Wet Tropics region

Coral larvae settlement

There are two previous coral settlement studies in the Wet Tropics region comparable with the data collected in 2005. The average number of recruits per tile observed in 2005 exceeded the levels recorded in any previous study. There was substantial variability in recruitment in previous years but at Wet Tropics reefs there was an approximate 6-fold difference between the highest level of recruitment recorded previously and observations in 2005. The western expiosed reefs of the Frankland Group and High Island has the lowest recruitment of the reefs in the Wet Tropics.

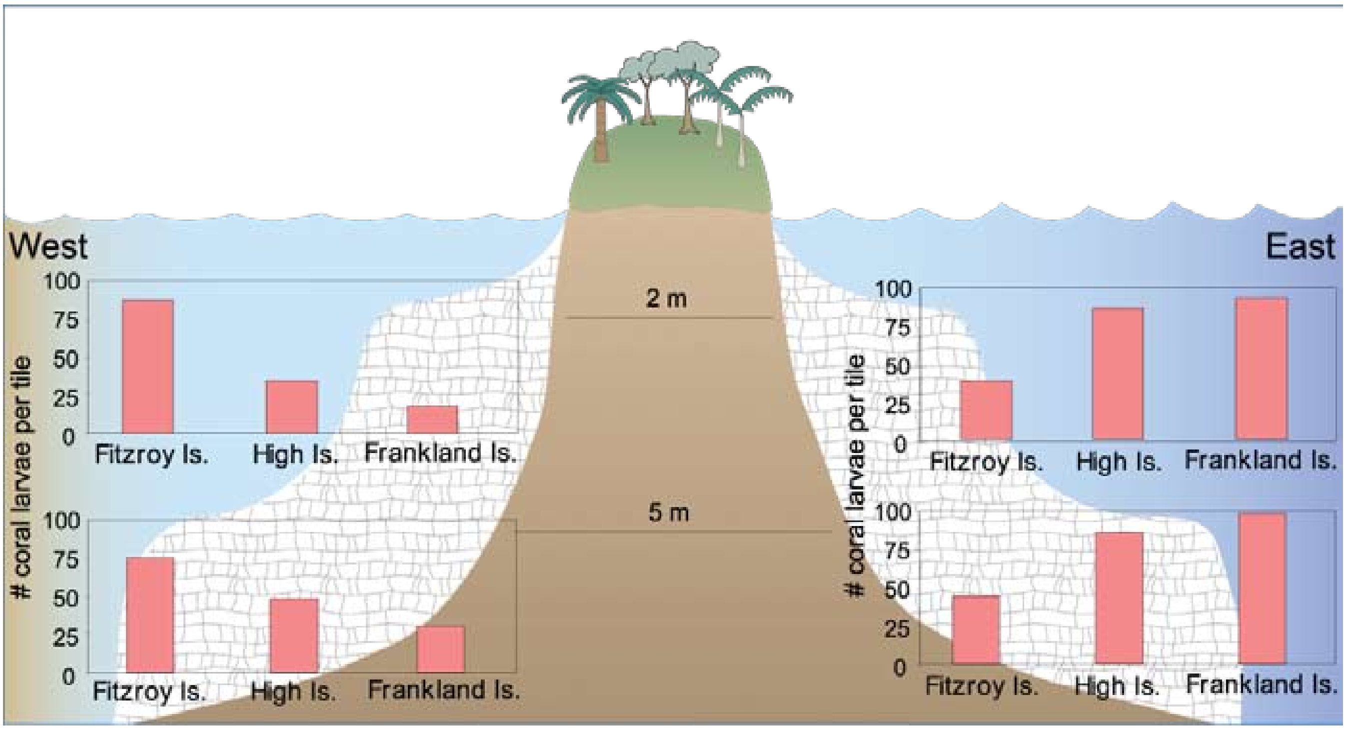
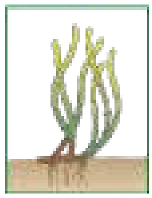


Figure 28 Coral larvae recruitment to tiles at west and east, 2 m and 5 m sites in the Wet Tropics region.



Seagrass monitoring

The coastal sites selected for seagrass monitoring in the Wet Tropics region were at Yule Point, Green Island and Lugger Bay, Mission Beach. The Yule Point sites (monitored since 2000) were representative of inshore seagrass communities in the region, and dominated by *Halodule uninervis* and *Halophila ovalis*. Seagrass cover over the past 12-24 months followed a seasonal trend with higher abundance in summer. Finer sediments (e.g. fine sand) increased over 2004, but there were no detected changes in the taxonomic composition of the monitored seagrass meadows. Overall, the sites appear to differ little from 1967 when den Hartog (1970) described the species present and the sediment condition at this site. Green Island sites are on a reef-platform on a sand cay, approximately 27 km north-east of Cairns. One site was established in late 2003 and an additional site was established in April 2005. The sites are located south-west of the cay and are dominated by *Cymodocea rotundata* and *Thallasia hemprichii* with some *H. uninervis* and *H. ovalis*. The sites appeared to follow a seasonal pattern in abundance, with high cover in the summer and low cover in winter, and no significant changes in species composition were observed since regular monitoring started (Fig. 29).

The Mission Beach sites are located in Lugger Bay. This meadow is only exposed at very low tides (<0.4 m) and is composed of *H. uninervis*. The monitoring site was established in May 2005. Seagrass cover was generally low (< 10%), which is similar to observations in the early 1990s at this location. Between 2005 and 2006, seagrasses significantly declined in cover and distribution at Mission Beach. This appears to be a consequence of severe Tropical Cyclone Larry, which crossed the coast 50 km north of Mission Beach on 20 March 2006. Although Tropical Cyclone Larry crossed the coast during a neap tide, there was a significant storm surge and waves that caused the sea level to exceed highest astronomical tide levels. Immediately following the cyclone in late April, the abundance and distribution of the Mission Beach seagrass meadow was significantly lower than the same time in 2005. In July 2006, the meadow showed little sign of recovery and abundances were lower than in April. The sites however occur on a naturally dynamic intertidal sand bank, which is often exposed to regular periods of disturbance from wave action and consequent sediment movement. It is unknown how long the meadow will take to recover, as there is no seed bank (no seeds have ever been found on the sites) and recovery will be limited to vegetative reproduction of seagrass fragments from other areas.

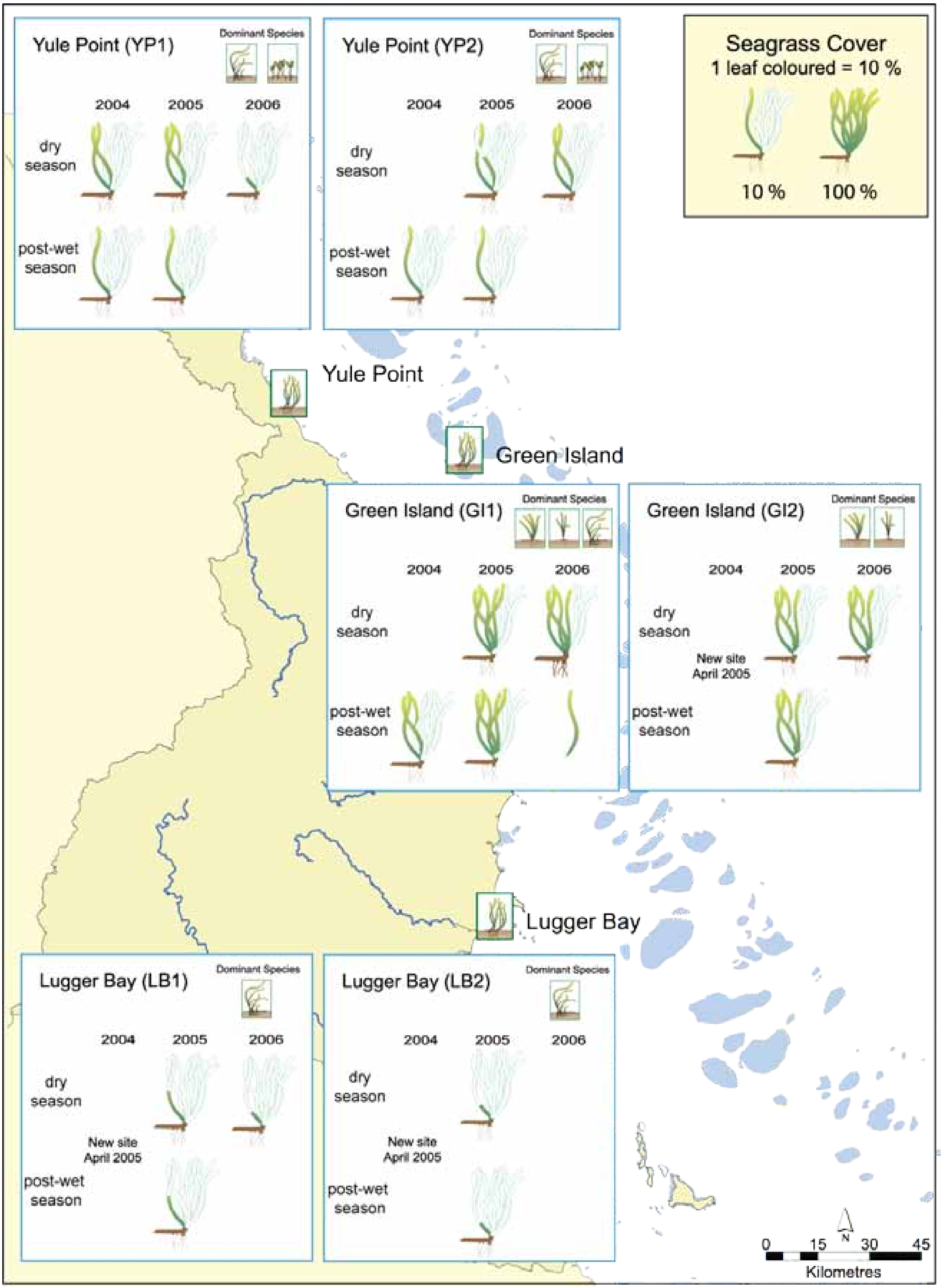
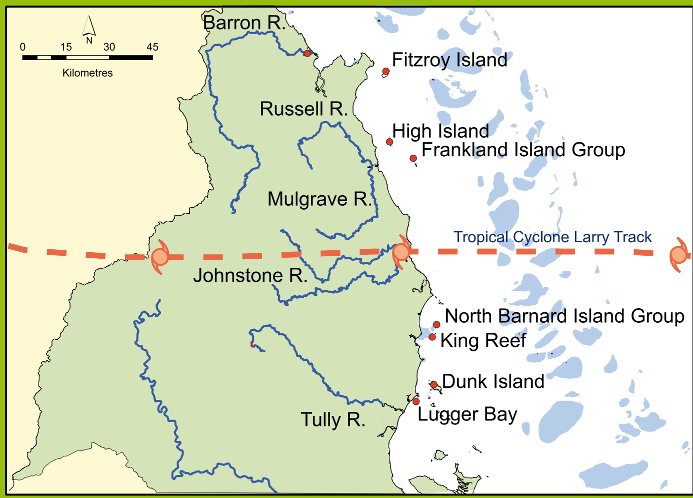


Figure 29 Seagrass cover at Yule Point, Green Island and Lugger Bay in the Wet Tropics region.

Impacts from Tropical Cyclone Larry



Tropical Cyclone Larry (a Category 5 cyclone) crossed the Queensland coastline near Innisfail on 20th March 2006. The cyclone was the largest in the North Queensland region in the last 50 years. Freshwater flows associated with the cyclone were among the highest for the 2005/06 wet season in the region, particularly in the North Johnstone, Tully and Herbert rivers. However, the cyclone was relatively fast moving and was not a particularly 'wet' cyclone.

Localised impacts in the marine environment were observed after the cyclone. Significant declines in seagrass cover and distribution were observed at the Lugger Bay site at Mission Beach (Figure 29). It is unknown how long it may take for the seagrass at this site to recover as there is no seed bank at this site, thus recovery will be by vegetative reproduction or fragment colonisation.

Coral reef communities are periodically affected by major disturbances such as cyclones as the intense winds generated can create massive waves that break upon coral reefs. These waves, and the debris carried by them, can completely destroy all the standing corals and break up the physical structure that forms the reef platform.

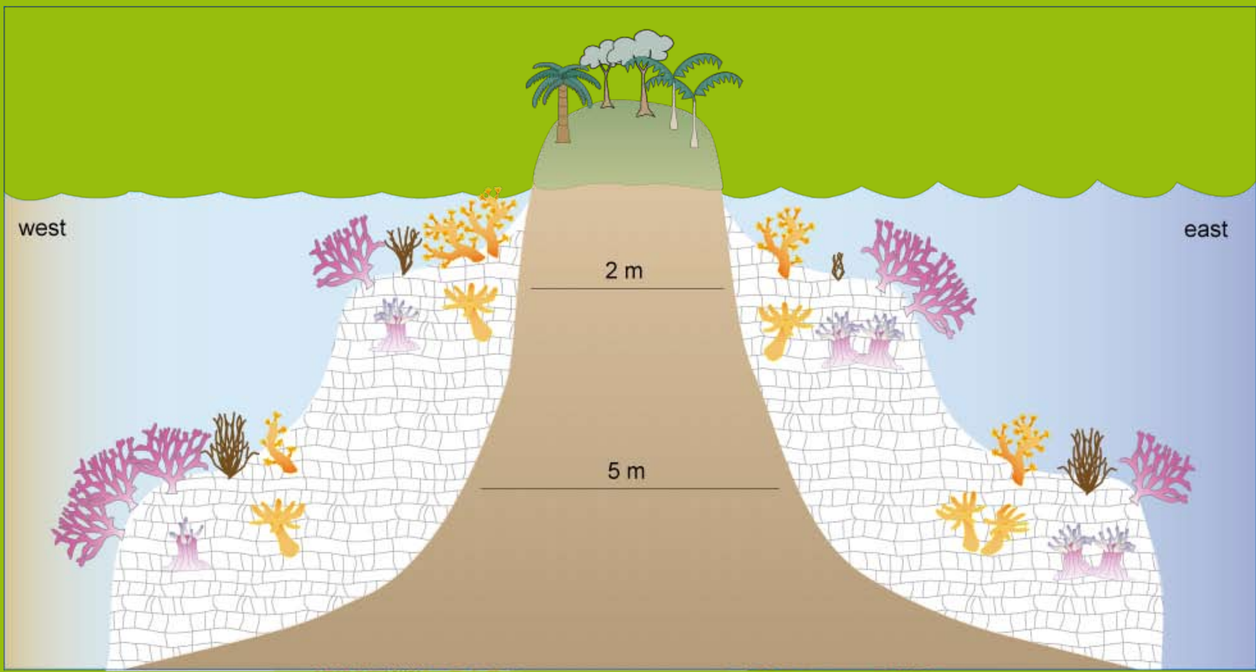
At the inshore coral reef locations monitored as part of the Marine Monitoring programme, the extent of impact of Cyclone Larry was varied (as is typical for most cyclones). The greatest impacts were observed at Frankland Island East, Dunk Island North, North Barnard Group and King Reef survey locations. At these locations there was a decrease in hard coral, soft coral and macroalgae cover. On the other hand there was little damage at Fitzroy Island (East and West), Dunk Island South, High Island (East and West) and Frankland Island Group West. The sites surveyed in the study generally show that the locations closest to the track of the cyclone were most impacted, as were sites on the eastern exposed areas. An example of the impacts of Cyclone Larry on inshore reefs is shown overleaf.

In the absence of further disturbances or impacts, coral reefs usually recover from cyclones in subsequent years. The rate of recovery however, is thought to depend on a number of factors including:

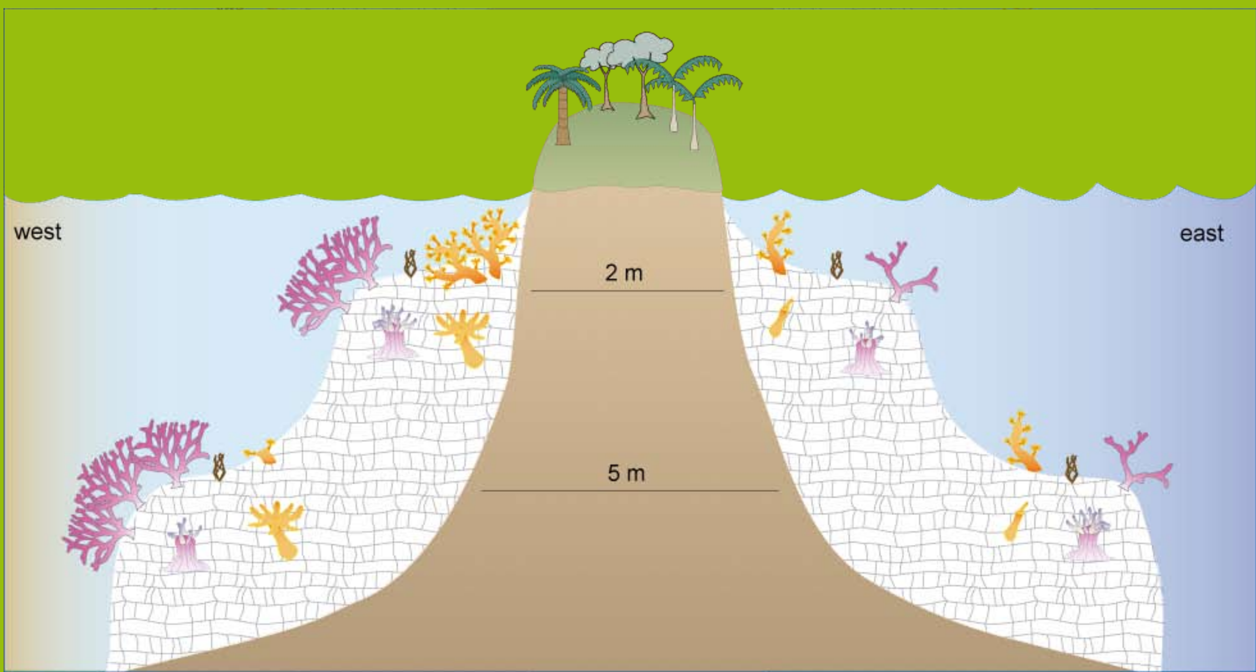
- the amount of damage caused
- the amount and type of coral remaining (fast growing species hasten recovery)
- additional factors such as subsequent storms, coral bleaching, crown-of-thorns starfish outbreaks
- the surrounding water quality condition, and
- the variety of topography whereby refuge from cyclone damage is offered by overhangs, ridges and outcrops, thus enabling the surviving corals to quickly re-establish the coral community

It will be important to monitor the recovery of the reefs impacted by Cyclone Larry to further understand the impacts of water quality on inshore reef communties after such disturbances.

Impacts from Tropical Cyclone Larry



Coral reef benthic communities at Frankland Island Group prior to Tropical Cyclone Larry (2005)



Coral reef benthic communities at Frankland Island Group after Tropical Cyclone Larry (2006)

Wet Tropics regional synopsis

The key findings of the Marine Monitoring Programme include:

- There were an estimated 145,000 tonnes of sediment exported from the Barron River, 58,310 tonnes of sediment from the North Johnstone, 71,640 tonnes of sediment from the Tully River and 180,100 tonnes of sediment from the Herbert River in 2005/06. Queensland Water Quality Guideline values for all nutrient concentrations (except DON) were exceeded in samples collected in the 2004/05 wet season from the Barron, North Johnstone and South Johnstone Rivers. Water Quality Guideline values for all nutrient concentrations (except ammonia) were exceeded in samples collected in the 2005/06 wet season from the Barron, North Johnstone, Tully and Herbert Rivers.

- Pesticides were a ubiquitous contaminant of rivers of the Wet Tropics region. Pesticides detected included diuron, atrazine, simazine, hexazinone, ametryn, chlorpyrifos and tebuthiuron.

- Mud crabs collected from the Wet Tropics region contained traces of the pesticides DDT, dieldrin, chlordane and heptachlor.

- Pesticides were a ubiquitous contaminant of inshore areas in the Wet Tropics. Pesticides detected included diuron, atrazine, simazine and hexazinone.

- The median concentration of total phosphorus in marine waters exceeded Queensland water quality guidelines. Marine water chlorophyll *a* concentrations were higher in inshore waters than offshore areas in the Wet Tropics region (chlorophyll *a* is a measure of nutrient availability in the water column).

- The data collected for inshore reef locations in the Wet Tropics region provides an important baseline assessment. The results from the surveys show that inshore reef communities in the Wet Tropics are extremely variable. In general, the inshore reefs closest to rivers, on western sides and at the shallower depths, showed higher macroalgae cover, lower small-sized hard corals and/or lower hard coral diversity. Coral recruitment studies in the Wet Tropics region indicate that in 2005 the number of coral recruits that settled onto tiles exceeded numbers recorded in any previous studies It will be important to continue monitoring at these sites to understand future trends.

- Seagrass cover remained relatively stable over the last 12 months at the Yule Point and Green Island monitoring sites. Seagrass cover followed a seasonal trend with higher seagrass abundances in early summer months. The Mission Beach sampling site had significantly lower seagrass abundance and cover following Cyclone Larry. The monitoring shows that there are no seagrass seeds present at the Mission Beach location, suggesting that recovery from the cyclone may be slow.

2006

Part 5

Burdekin

Regional Monitoring Summary

Burdekin NRM region

The Burdekin region covers 140 678 km^2 and is located on Queensland's northern coast. The main vegetation types in the region are eucalypt dominated savannah woodlands and grasslands. The main population centre is Townsville, which has a population of approximately 160 000 residents. Tourism, sugarcane farming, horticultural cropping and beef cattle grazing are the major industries in the region. The Burdekin region encompasses the Burdekin and Belyando-Suttor Catchments, with the Burdekin River being the dominant river that flows into the waters of the Great Barrier Reef Marine Park, and potentially influences Magnetic Island and the Palm Island Group. Key natural resource management issues for the region include:

- Woodlands clearing;
- Coastal urban and industry development
- Invasion of weeds; and
- Declining water quality due to nutrients and sediment runoff.

Sites monitored as part of the Marine Monitoring Programme are outlined in table 4.

Table 4 Burdekin region Marine Monitoring Programme sites and indicators measured

	Nutrients	Suspended Sediments	Pesticides	Turbidity Logger	Temp	Crab Bioaccum.	Chl *a*	Coral Reef	Seagrass
Pelorus Island*								B	
Orpheus Island*	M	M	M				M	B	
Lady Elliot Reef*	M	M					M	B	
Pandora Reef*	M	M					M	B	
Havannah Island*	M	M					M	B	
Magnetic Island	M	M	M		M		M	B	B
Middle Reef					M			B	
Shelley & Bushland Beach									B
Townsville Channel							M		
John Brewer Reef							M		
Burdekin River	R	R	R	R		R			

R - River mouth water quality monitoring; M - Inshore marine water quality monitoring; B - Marine biological monitoring

* Monitoring locations influenced by both Wet Tropics and Burdekin rivers (reported under both regions)

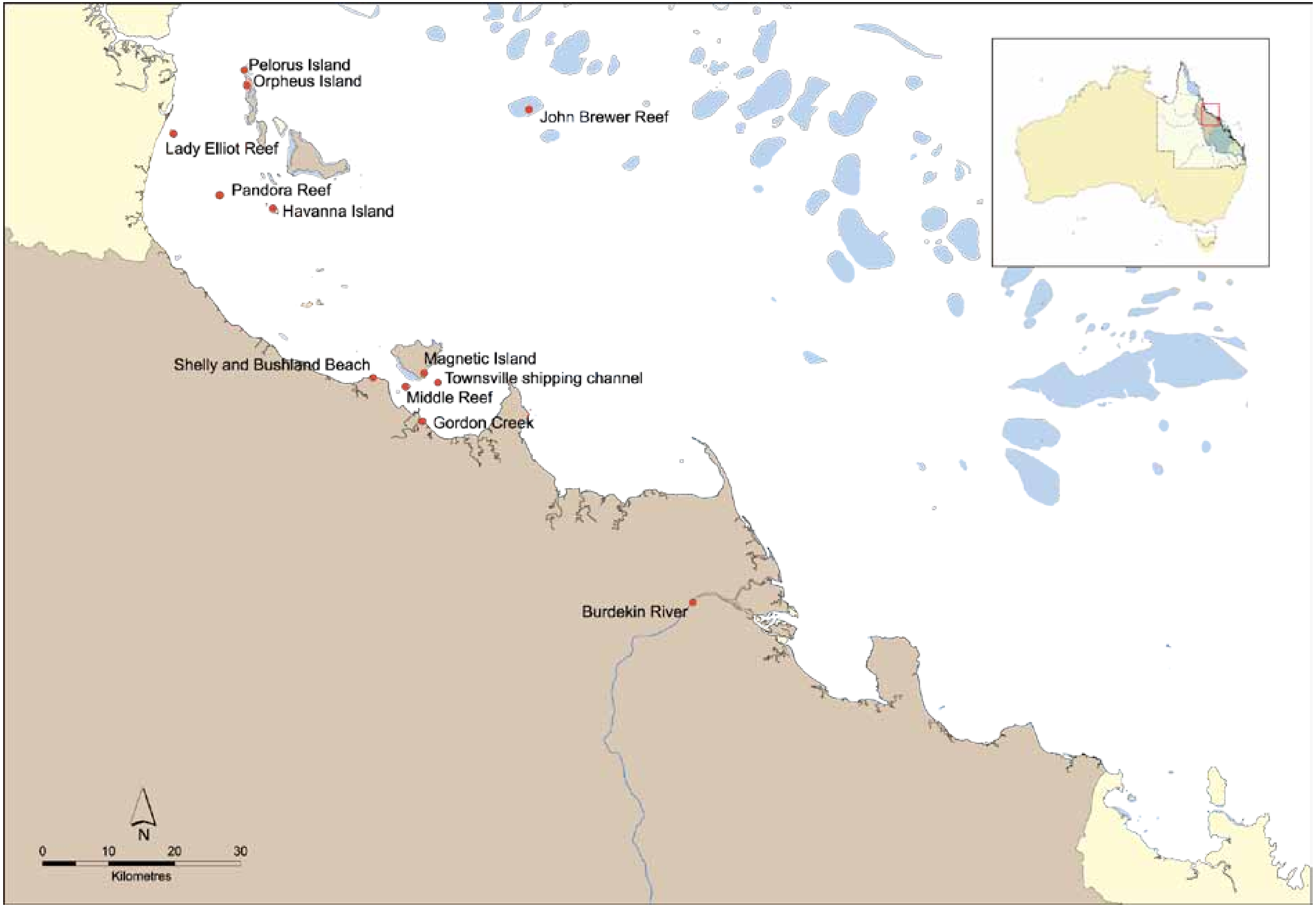
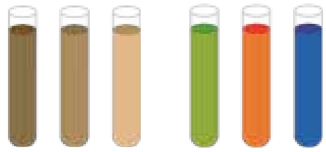


Figure 30 Map of the coastal area of the Burdekin NRM region, adjacent reefs and sampling sites.

Burdekin water quality monitoring

Suspended sediment and nutrient monitoring



Burdekin River Catchment

Twenty eight water samples were collected from the lower Burdekin River over the course of the 2005/06 wet season. No dry season samples were collected due to the lack of flow.

Suspended sediment concentrations peaked during two summer flow events, with maximum concentrations slightly exceeding 1 g L^{-1} (Fig. 31). Particulate nitrogen (PN) and phosphorus (PP) concentrations peaked in parallel with the suspended sediment load. DIN and DON concentrations were low during low-flow periods between the flood events, rising to ca. 250 µg N L^{-1} during the flood events, with a small number of higher concentrations. With a few exceptions, DIP and DOP were relatively low through the summer with slight elevations (to ca. 50 µg P L^{-1}) during the flood events.

Inshore marine water quality was monitored at two sites influenced by the Burdekin River (Middle Reef and Geoffrey Bay, Magnetic Island), during two AIMS cruises (the dry and wet seasons).

Herbert River Catchment

Twenty three sample events were carried out in the Herbert River over the 2005/06 year by community volunteers and NRW personnel. Two sample events were undertaken in each of these rivers during the nominal “dry” season.

Suspended sediment concentrations were generally low in the Herbert River (< 25 mg L-1). Apart from two samples collected at the end of April and early May, DIN concentrations were low and relatively constant throughout the summer period (Fig. 32). A very large fraction of the total N transported in the Herbert River was in the form of DON. Despite large variations in discharge, DON concentrations remained fairly constant through the wet season. PN concentrations peaked during the two significant flow events sampled. With the exception of one sample during the March post-Tropical Cyclone Larry flood, concentrations of DIP and DOP were low and relatively constant over the wet season.

The Herbert River may influence inshore monitoring locations in the Wet Tropics and Burdekin regions, and thus have been reported under both regional reports. Four inshore marine monitoring sites are considered to be potentially influenced by the Herbert (and Burdekin) Rivers, these include: Orpheus Island, Lady Elliot Reef, Pandora Reef and Havannah Island. The concentrations of suspended sediments and nutrients in inshore marine waters at these locations were low and dominated by DON and DOP.

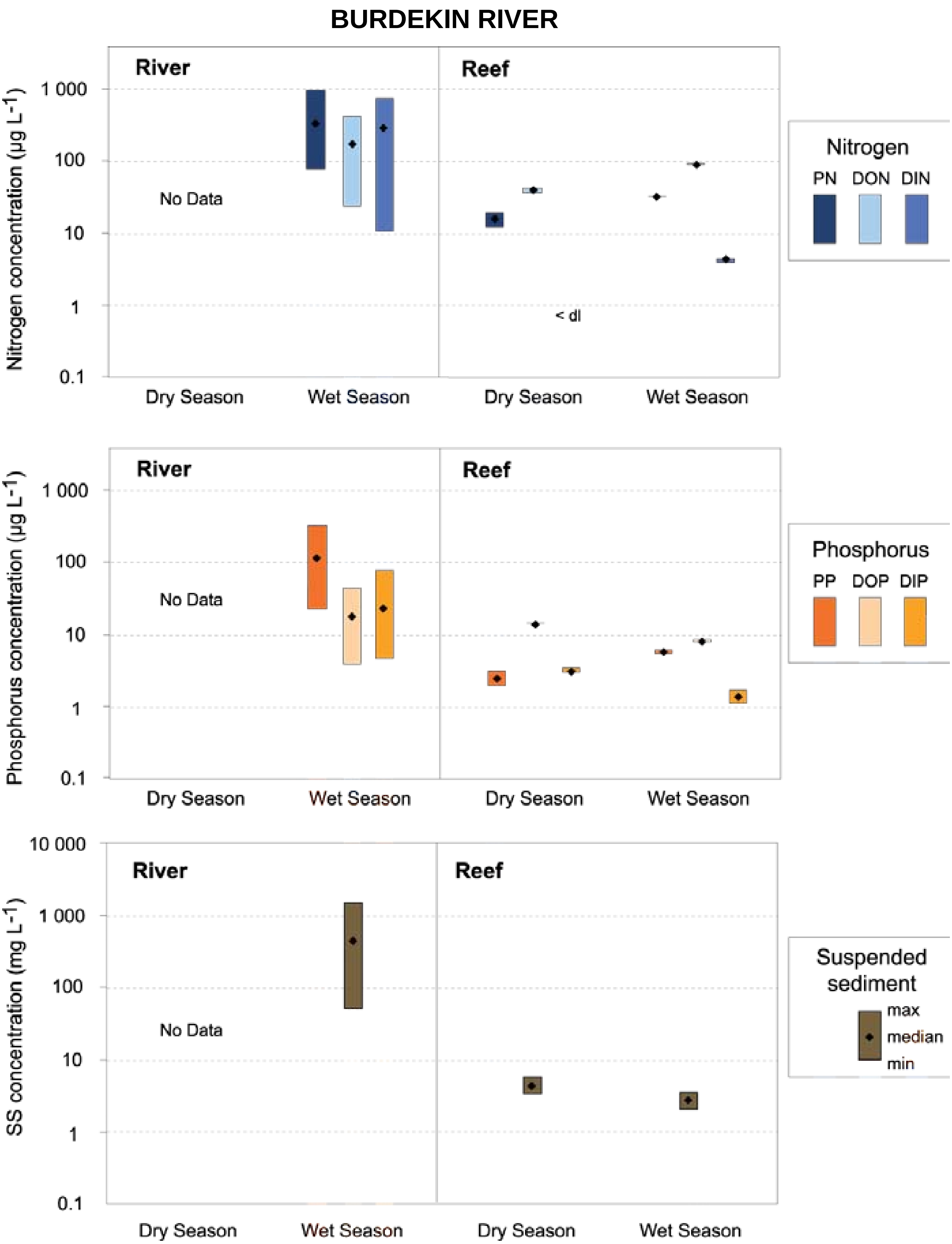


Figure 31 Nitrogen, phosphorus and suspended sediment concentrations in the Burdekin River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

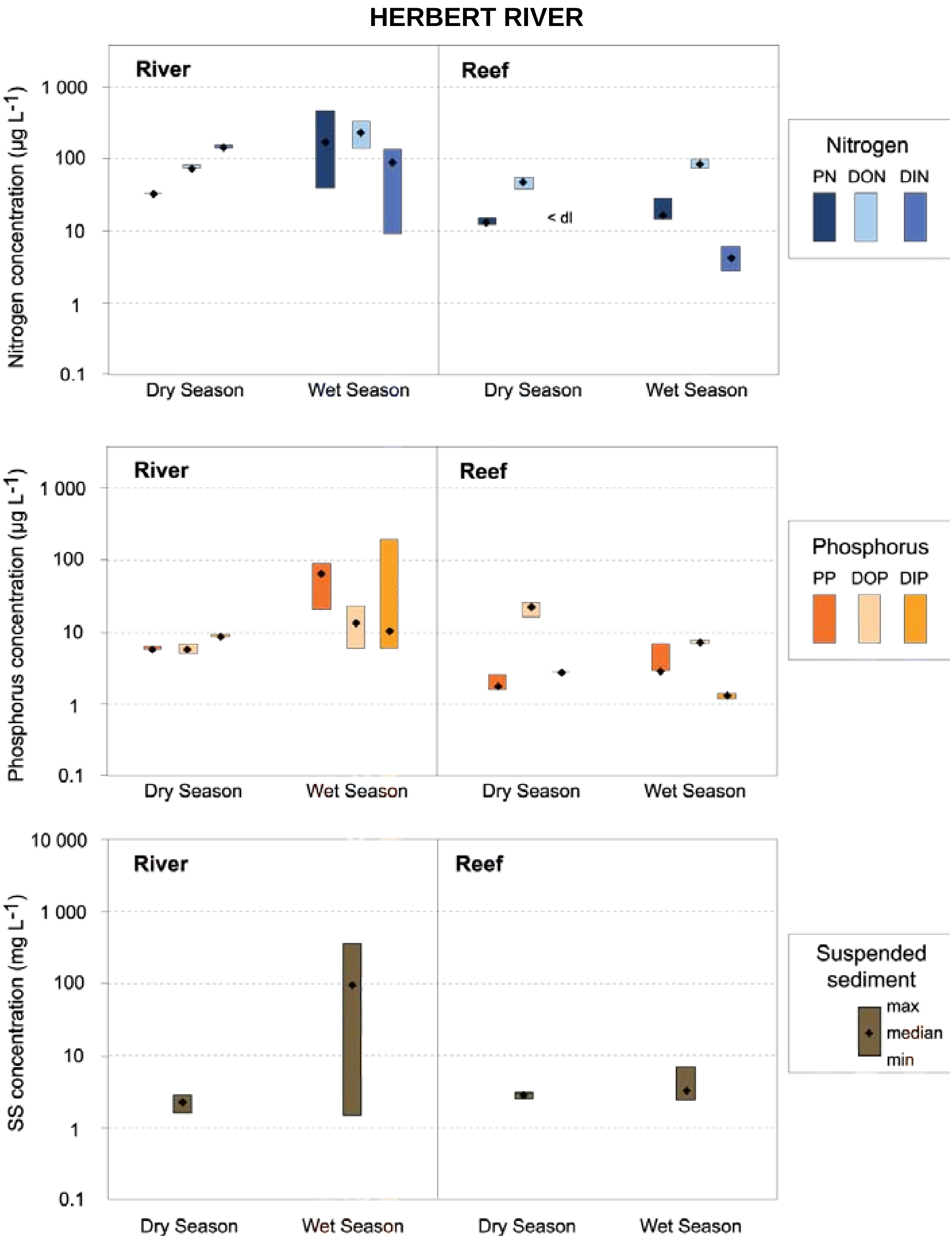


Figure 32 Nitrogen, phosphorus and suspended sediment concentrations in the Herbert River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

Chlorophyll *a* monitoring

Chlorophyll *a* monitoring in the Burdekin region in the 2005 dry and 2005/06 wet season was undertaken at three locations by one community volunteer and Sunferries. Although limited data is available, the data showed similar patterns to the long-term chlorophyll *a* monitoring programme, with elevated concentration of chlorophyll *a* at inshore sites compared with sites further offshore (Fig. 33). Higher chlorophyll *a* concentrations were also observed in the wet season compared with the dry season, resulting from the increased nutrient supply from the rivers during flood events. Chlorophyll *a* concentrations during the wet season, at sites closest to the coast, were influenced by flood waters.

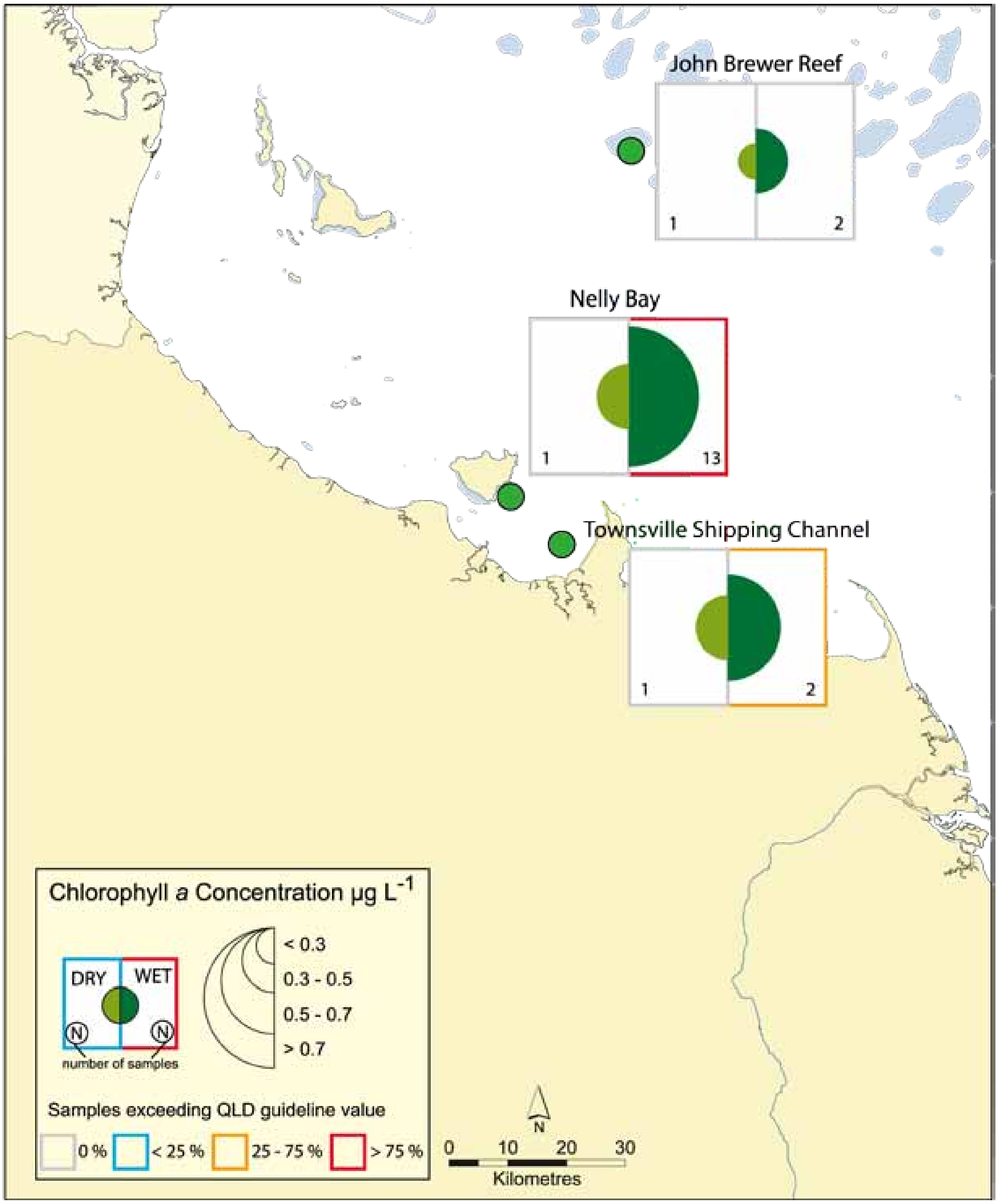


Figure 33 Chlorophyll *a* concentrations at sites in the Burdekin region

Pesticide monitoring

River mouth monitoring data for pesticides is not available for the Burdekin River due to lack of freshwater flows.

However, limited pesticides monitoring is available from two inshore marine locations in the Burdekin region (Orpheus Island and Magnetic Island), for both the dry and wet seasons (Fig. 34). The highest diuron concentration at Magnetic Island was observed in the only successful deployment undertaken in the wet season (3.2 ng/L in December 2005). Additionally, atrazine and diazinon were detected in this sample. The overall concentrations at Orpheus Island were consistently below the limit of detection for all the organic pollutants considered except for diuron which was detectable at very low concentrations in both the dry and wet seasons.

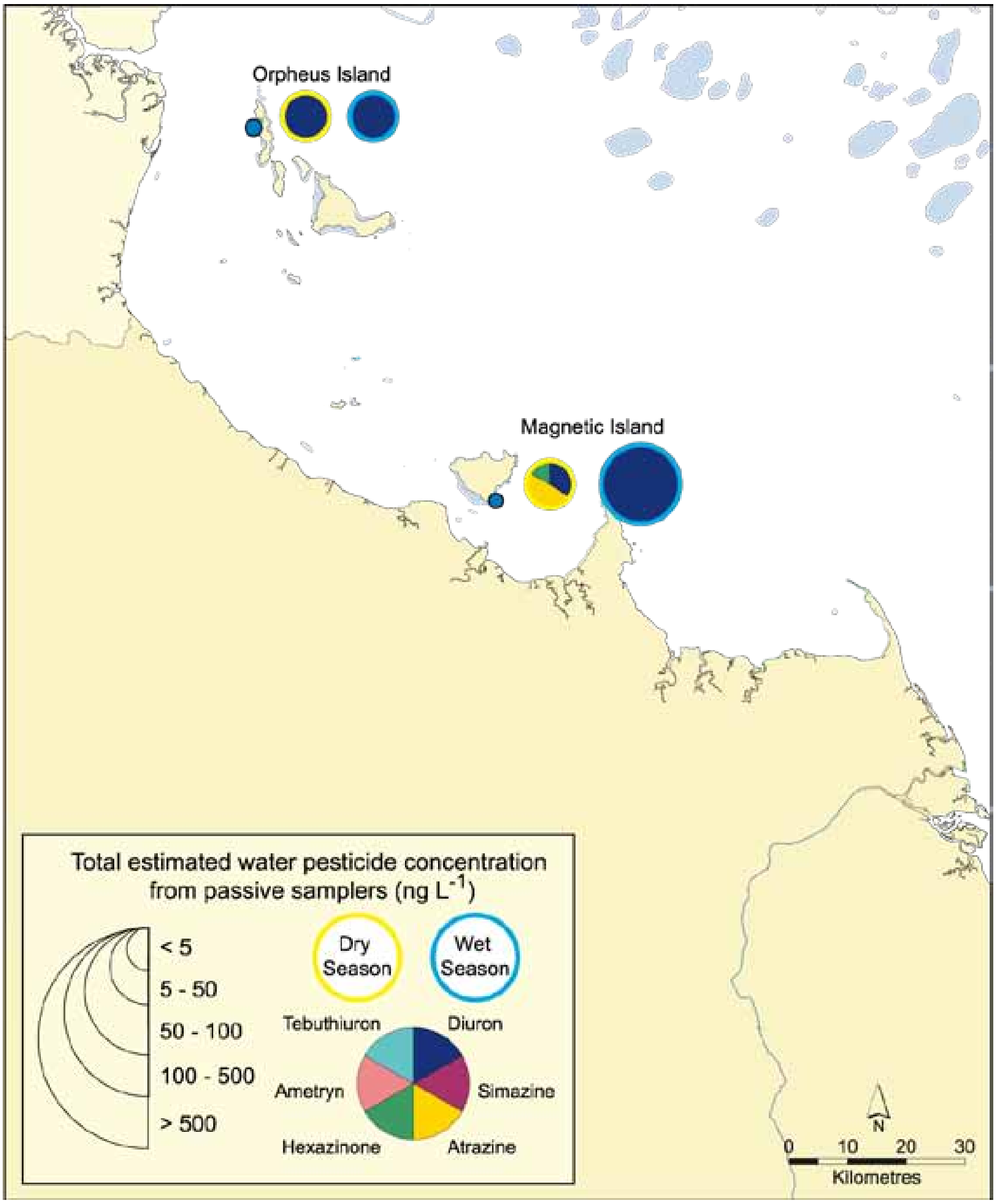


Figure 34 Pesticide concentrations in inshore marine waters at sites in the Burdekin region collected during the 2005 dry season and 2005/06 wet season

Coral monitoring

The influence of the Burdekin River extends in the north to Orpheus and Pelorus Islands (and even further during major floods). The closest reefs to the Burdekin River mouth chosen for this study are Middle Reef, adjacent to Townsville and Geoffrey Bay on Magnetic Island. Five reefs to the north of these locations were chosen to reflect a decreasing influence of the Burdekin River (but are likely to also be influenced by smaller coastal rivers). Lady Elliot Reef is situated the closest to the coast. Pandora Reef, Havannah Island, the western reefs of Orpheus/Pelorus Island and finally the eastern side of Orpheus Island complete the gradient of decreasing exposure to runoff (Fig. 35).

Previous monitoring of the reefs in this region reveals that the area has been subject to intense and frequent disturbances. The 2002 bleaching, cyclonic disturbances in 1990, 1996 and 2000, crown-of-thorns outbreaks and flood events have variously impacted these reefs. The largest disturbance was coral bleaching in 1998, which affected all coral communities on the target reefs in this region. Given the frequency and severity of disturbances to reefs in this region over the preceding decade it is not surprising hard coral cover was lower on average than in the other regions.

The cover of hard coral at Middle Reef was the highest for the region and was dominated by the families Poritidae and Agariciidae. The presence of very large colonies of *Pachyseris spp.* and *Goniopora spp.* indicates the resilience of these colonies to major disturbances such as bleaching and cyclones. The density of recruit-sized colonies was well above average, with the families Dendrophylliidae, Faviidae and Acroporidae all well represented. The large numbers of recruits from these families suggests their presence may rapidly increase within a community now dominated by large colonies of other taxa.

The benthic communities at Geoffrey Bay had a high cover of macroalgae and relatively low cover of hard corals. The community appears to be recovering from previous disturbances with high numbers of Acroporidae recruits. At 5 m, the hard coral community was more diverse with a number of families represented, although the families Acroporidae, Faviidae and Poritidae still represented the majority of coral cover. The high cover of macroalgae at these sites may play a part in limiting recovery, through shading and the competition for space.

Lady Elliot Reef is situated only 2 km offshore from Taylors Beach and is close to the mouth of Cattle Creek. Bleaching in 1998 and 2002 is highly likely to have affected this community as have flood events during the last decade. It is likely that these disturbances have influenced the benthic community especially on the shallow slope where macroalgae cover was high compared to the cover of hard and soft corals. In contrast, at 5 m the cover of macroalgae was very low, hard coral cover high and no soft corals were recorded. The coral community appears to be healthy and diverse with good recruitment levels. The presence of high numbers of small colonies from the fast growing Acroporidae family and few larger colonies at 2 m suggests this community is recovering from past disturbances.

The northern side of Pandora Reef and Havannah Island have been well studied in the past. Previous monitoring indicates that prior to bleaching and flood events in the late 1990s/early 2000s, hard coral cover was high at both of these sites. In 2005, the southern Pandora Reef and northern Havannah Island reefs were dominated by macroalgae, with low soft and hard coral cover. The density of recruit-sized colonies was well below average at both sites and depths. The potential for recovery of these reefs appears to be compromised by the low recruitment densities, low cover of hard coral and high levels of macroalgae.

The benthic community at both 2 m and 5 m at Pelorus/Orpheus Island West and Orpheus Island East have a high cover of soft coral, low cover of hard coral and no or very little macroalgae. The densities of recruit-sized hard coral colonies were low at 2 m at both sites, with higher recruits at the 5 m depths. The reef communities appear to be recovering from the devastating disturbances experienced in the last decade. However, with low recruitment, low cover of adult colonies and the presence of large colonies of soft corals

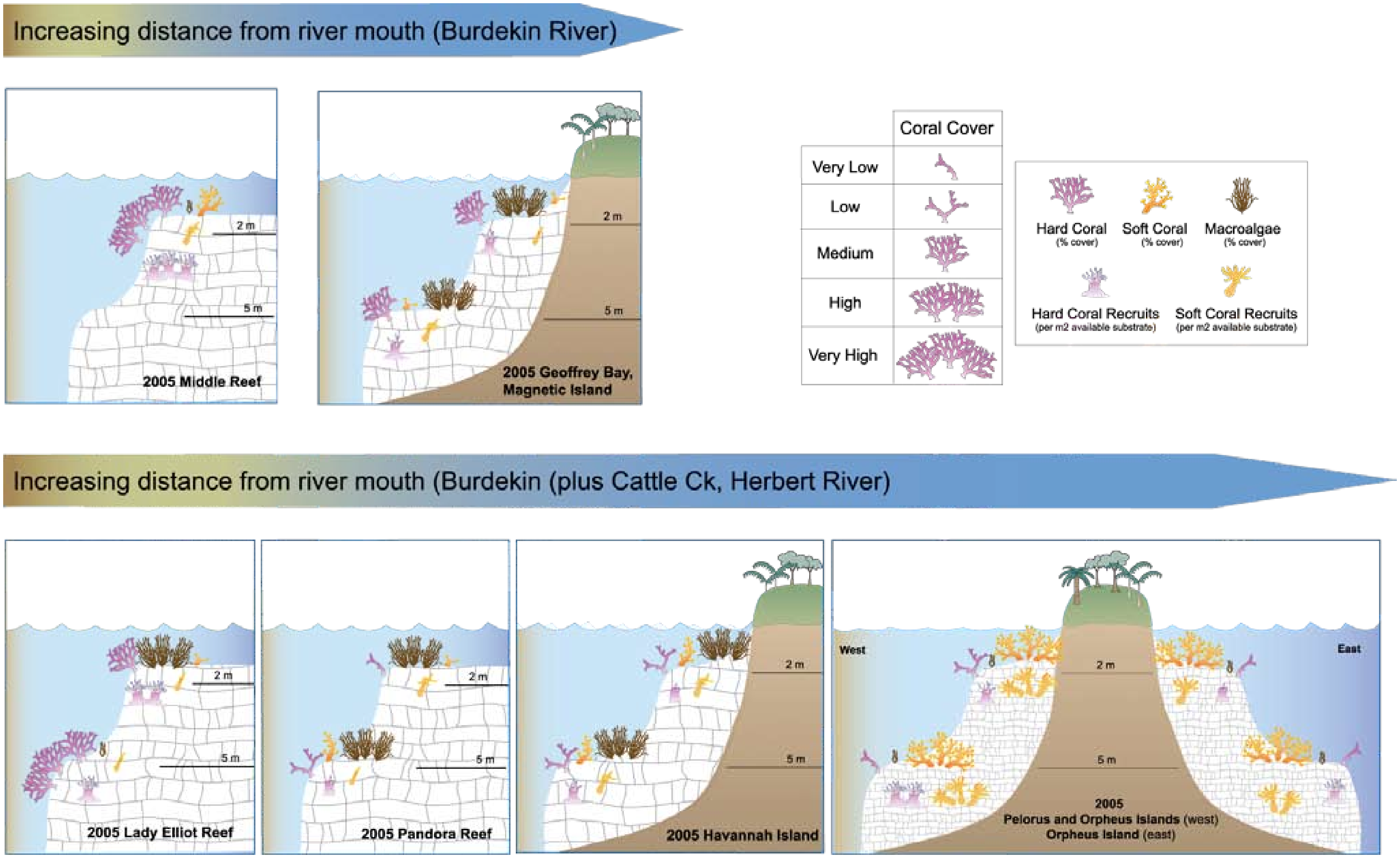
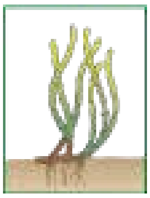


Figure 35 Benthic cover (per cent hard coral, soft coral and macroalgae and density of hard and soft coral recruits) at inshore reef sites in the Burdekin region

Seagrass monitoring



The sites selected for monitoring in Townsville were located on the southern shores of Halifax Bay. The most northern site is at Bushland Beach, while the southern site is located at Shelley Beach (Cape Pallarenda). Both sites were dominated by *Halodule uninervis* with varying amounts of *Halophila ovalis* (Fig. 36). Seagrass cover has increased at Bushland Beach over the past 12-24 months, although cover at Shelley Beach remained relatively similar to past years. There were no detected changes in species composition and both sites showed a seasonal pattern in seagrass cover (high in summer and low in winter). Two new sites were established on Magnetic Island. The site at Picnic Bay (MI1) was dominated by *Halodule uninervis* with *Halophila ovalis*. The Cockle Bay site was dominated by *Halophila ovalis* with *Cymodocea serrulata/ Thalassia hemprichii/ Halodule uninervis*. A very small patch of *Zostera capricorni* recruited to the Picnic Bay site in the past 6-12 months. Both sites are located on fringing reef flats. At this early stage, it is difficult to describe a seasonal pattern in seagrass cover with sufficient certainty. Diuron was detected in low concentrations in sediments collected at Magnetic Island.

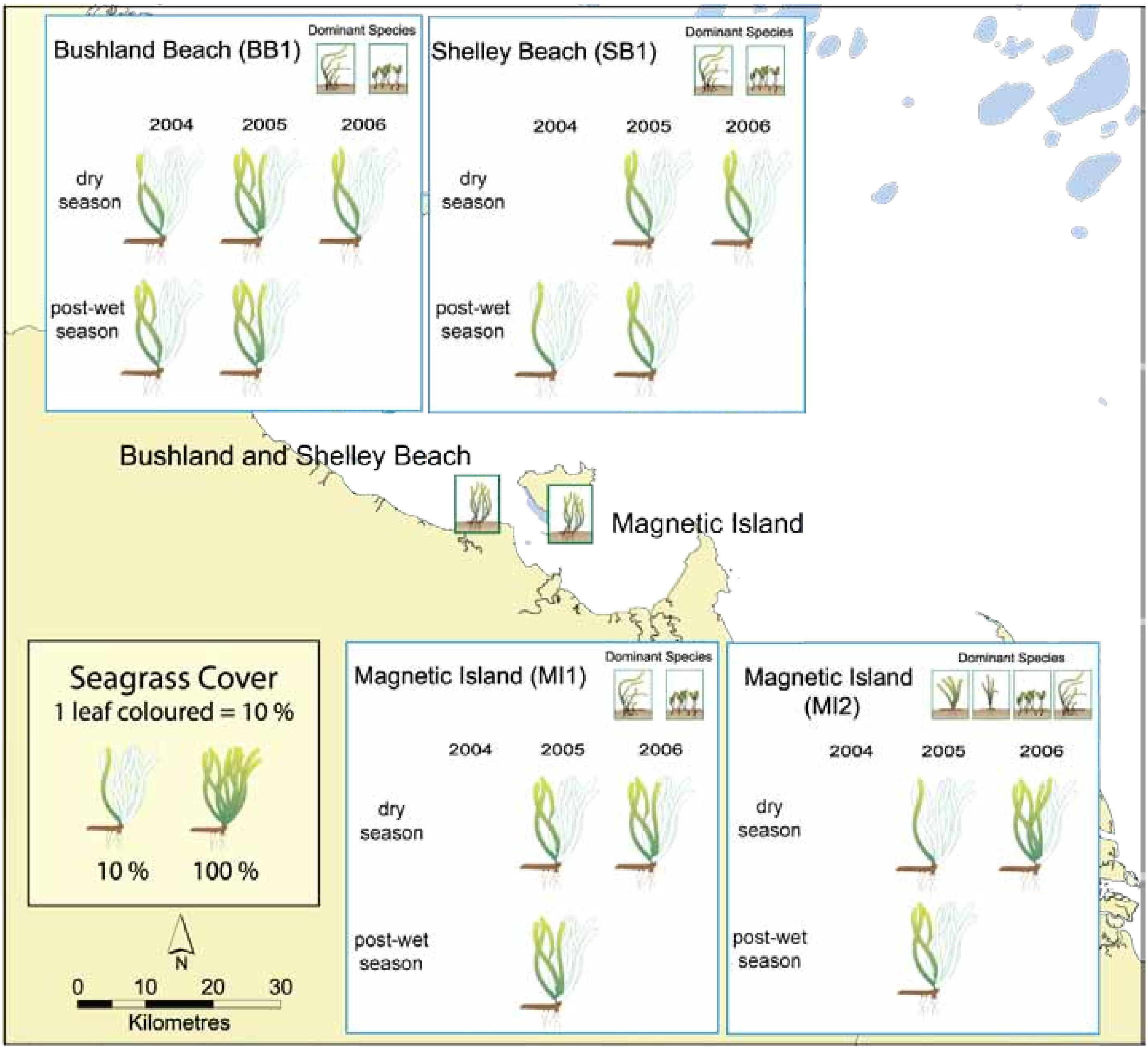


Figure 36 Seagrass cover at Bushland Beach, Shelley Beach and Magnetic Island in the Burdekin region

Burdekin regional synopsis

The key findings of the Marine Monitoring Programme include:

- There were an estimated 437,300 tonnes of sediment exported from the Burdekin River in 2005/06. Queensland Water Quality Guideline values for all nutrient concentrations (except DON) were exceeded in samples collected in the 2004/05 wet season from the Burdekin River. Water Quality Guideline values for all nutrient concentrations were exceeded in samples collected in the 2005/06 wet season from the Burdekin River.

- Pesticides were detected in inshore areas in the Burdekin region. Pesticides detected included diuron and hexazinone.

- Mud crabs collected from the Burdekin region contained traces of the pesticides DDT, dieldrin and heptachlor.

- Median nearshore Burdekin regional seawater total phosphorus values exceeded Queensland water quality guidelines. Marine water chlorophyll *a* concentrations were higher in inshore waters than offshore areas in the Burdekin Region. Chlorophyll *a* is a measure of nutrient availability in the water column.

- There is a wealth of historical data available for many of the inshore reef sites studied in the Burdekin region. Many of the reefs in this region, particularly those closest to river mouths and that have been subjected to more frequent and severe disturbances (e.g. floods, COTS outbreaks, cyclones), show low hard coral cover and high macroalgae cover. Low densities of small-sized hard corals at a number of sites in the region question the ability of these reef communities to recover.

- Seagrass cover remained relatively stable over the last 12 months at the Halifax Bay monitoring sites and seagrass cover followed a seasonal trend with higher seagrass abundances in early summer months. The meadows had a capacity to recover from disturbance via seed banks.

2006

Part 6

Mackay Whitsunday

Regional Monitoring Summary

Mackay Whitsunday NRM Region

The Mackay Whitsunday region is located in a narrow coastal strip along the central Queensland coast. The region covers an area of 9000 km^2 and has a population of 113 000 people, centred around Mackay, Sarina and Proserpine. Mackay City is the major city in the region and provides extensive infrastructure to support industries such as sugar, coal, engineering and support services for retail, beef, grain and tourism. The catchment region includes the three major catchment areas of Proserpine, Pioneer and O'Connell. These waterways discharge directly into the Great Barrier Reef lagoon and Coral Sea and are two of the priority rivers monitored as part of the Marine Monitoring Programme. Sites monitored as part of the programme are outlined in table 5. The key priorities of the region include:

- Coordination of natural resource policy, planning and management;
- Water and waterway management;
- Coastal and marine management;
- Vegetation management and biodiversity conservation; and
- Pollution control and waste management.

Table 5 Mackay Whitsunday Marine Monitoring Programme sites and indicators measured

	Nutrients	Suspended Sediments	Pesticides	Turbidity Logger	Temp	Crab Bioaccum.	Chl *a*	Coral Reef	Seagrass
Double Cone Is	M	M			M		M	B	
Hayman Island					M				
Hook Island	M	M					M	B	
Daydream Is	M	M			M		M	B	
Whitsunday Is	M	M					M		
Cid Island							M		
Shute & Tancred Is	M	M					M	B	
Henning Island							M		
Long Island			M						
Dent Island	M	M			M		M	B	
Pine Island	M	M			M		M	B	
Seaforth Island	M	M			M		M	B	
Pioneer Bay							M		B
Shute Harbour							M		
O'Connell River	R	R	R	R		R			
Pioneer River	R	R	R	R		R			
Mackay Marina							M		
Sarina Inlet									B

R - River mouth water quality monitoring; **M** - Inshore marine water quality monitoring; **B** - Marine biological monitoring

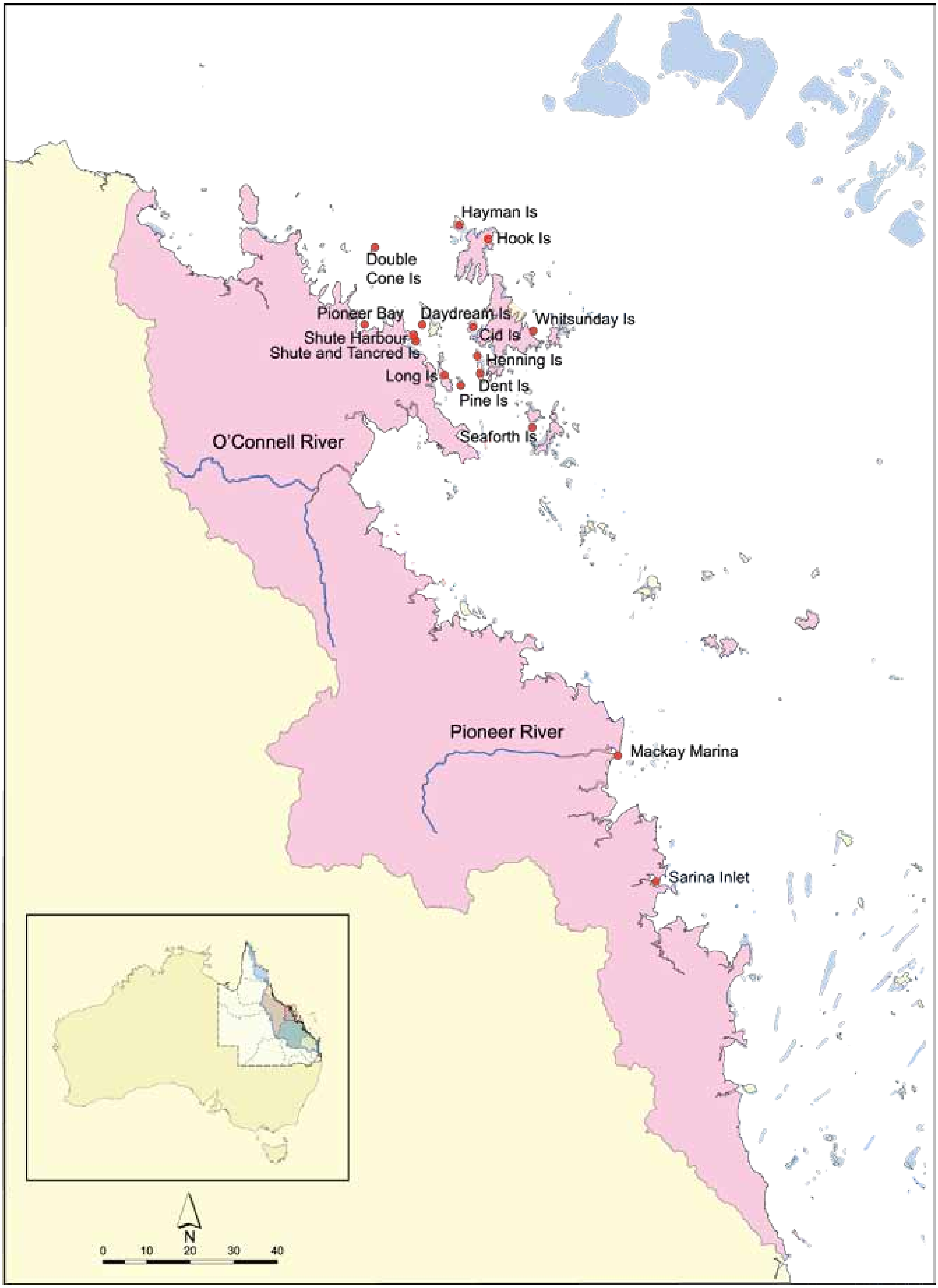
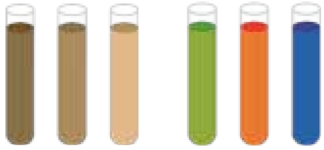


Figure 37 Map of the Mackay Whitsunday NRM region, adjacent reef and monitoring locations

Mackay Whitsunday water quality

Suspended sediment and nutrient monitoring



Two rivers in the Mackay Whitsunday region were monitored during 2005/06 (O'Connell and Pioneer Rivers). Water samples from these rivers were collected primarily during flood events by community groups and NRW staff. Inshore marine water quality was monitored at seven sites in the region, during two AIMS cruises (during both the dry and wet seasons).

O'Connell and Pioneer River Catchments

The O'Connell catchment is a small coastal river catchment. Twelve water samples were taken over the course of 2005/06. One sampling event was undertaken prior to the wet season. During much of the year, there was little flow in the O'Connell River.

The highest suspended sediment concentration (800 mg L^{-1}) was recorded during the first small flow event in early January. The peak sediment load during the larger late-January event was approximately half that value (400 mg L^{-1}). The highest concentrations of DIN (1,200 µg N L^{-1}) and DIP (77 µg P L^{-1}) were also recorded during the small first flush event. DON was a significant contributor (45%) to total N loads in the O'Connell River over the wet season. In contrast, DOP concentrations were relatively low during both high and low-flow conditions. Particulate N concentrations were low compared to DON through much of the wet season. PP concentrations, however, increased sharply during both early wet season flood events, regardless of magnitude.

The Pioneer River was characterised by very low flow over the 2005/06 wet season, with a maximum daily discharge of 1 600 ML. Five water samples were collected from a site in the pool above the Dumbleton Weir near Mackay. Because of the low flow, little new sediment and nutrient material was washed into the river. The observed concentrations of nutrients and their lack of variation likely reflect the dominance of biological uptake, storage and recycling processes in the weir pool rather than catchment processes as a determinant of nutrient concentrations in this year.

Seven inshore marine monitoring sites (Double Cone, Hook, Daydream, Shute and Tancred, Dent, Pine and Seaforth Islands) are considered to be influenced by the O'Connell and Pioneer Rivers. The average concentration of nutrients in the Mackay Whitsunday region was relatively low and dominated by DON and DOP. During the wet season, both nitrogen and phosphorus were among the highest recorded for all regions, even though the two main region rivers had extremely low flow and nutrient/sediment loads.

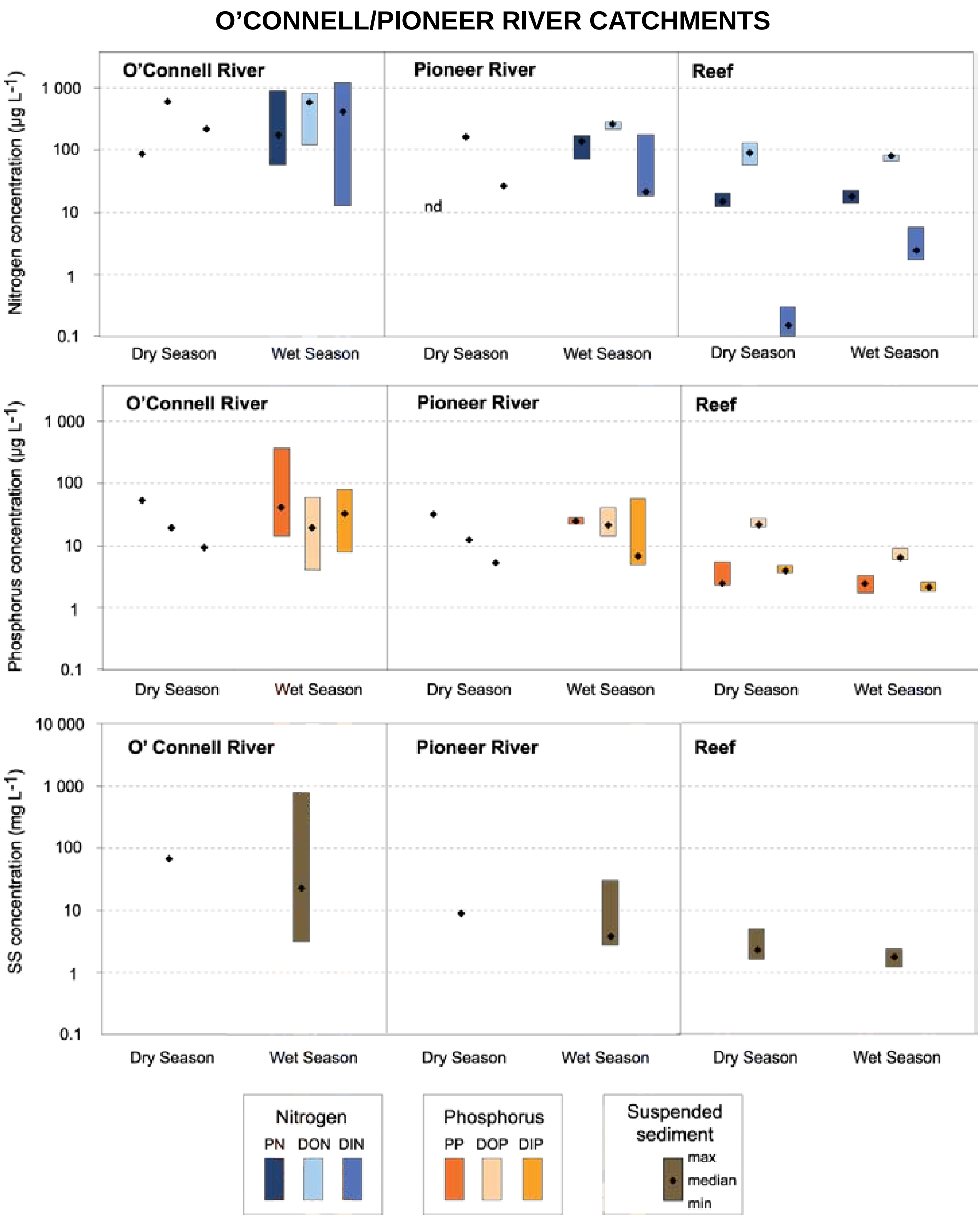
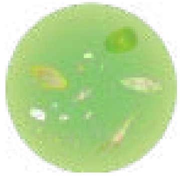


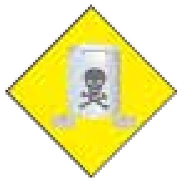
Figure 38 Nitrogen, phosphorus and suspended sediment concentrations in the O'Connell and Pioneer River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

Chlorophyll *a* monitoring



Chlorophyll *a* monitoring in the Mackay Whitsunday region in the 2005 dry and 2005/06 wet season was undertaken by Queensland Parks and Wildlife Service, Whitsunday Catchment Landcare and the Department of Natural Resources and Water. The data from the majority of sites in the Mackay Whitsunday region showed similar patterns to the long-term chlorophyll *a* monitoring programme, with elevated concentration of chlorophyll *a* at inshore sites compared with sites further offshore. Higher concentrations were also observed in the wet season compared with the dry season, with the increased nutrient supply from the rivers during summer flows and higher temperature that increases productivity. In general, chlorophyll *a* concentrations are low throughout the region.

Pesticide monitoring



In the Mackay Whitsunday region, sampling commenced in October 2005. Thus, one dry season deployment occurred (in both the Pioneer and O'Connell Rivers). In both rivers, atrazine and diuron were the dominant compounds in both their occurrence and predicted concentrations, followed by hexazinone. In contrast to other herbicides, tebuthiuron concentrations declined throughout the wet season (samples were available from the Pioneer River).

Only one inshore marine site (Long Island) was monitored in the Mackay Whitsunday region, with limited samples collected over the dry season, when low concentrations of diuron were detected.

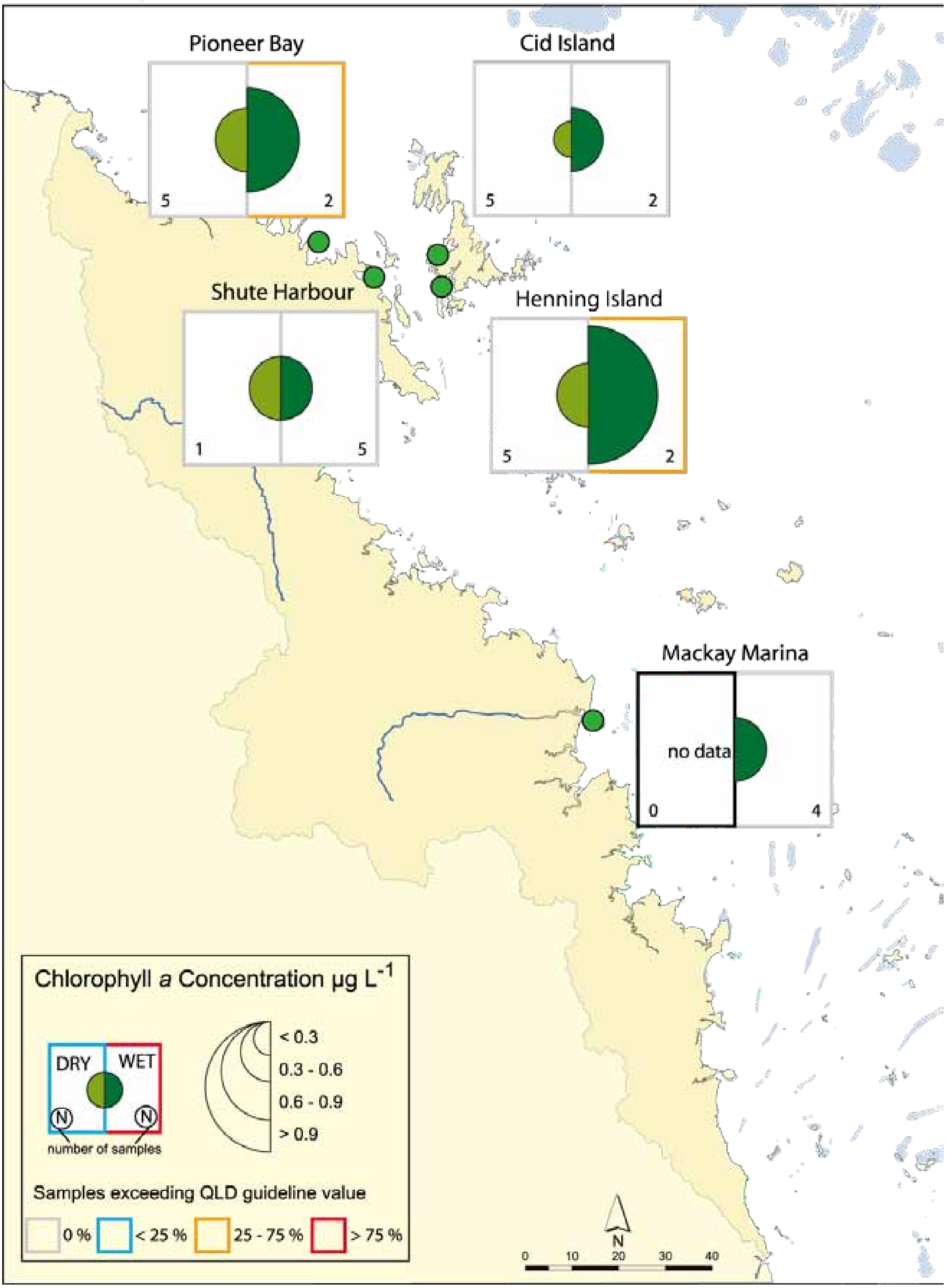


Figure 39 Chlorophyll *a* concentrations at sites in the Mackay Whitsunday region

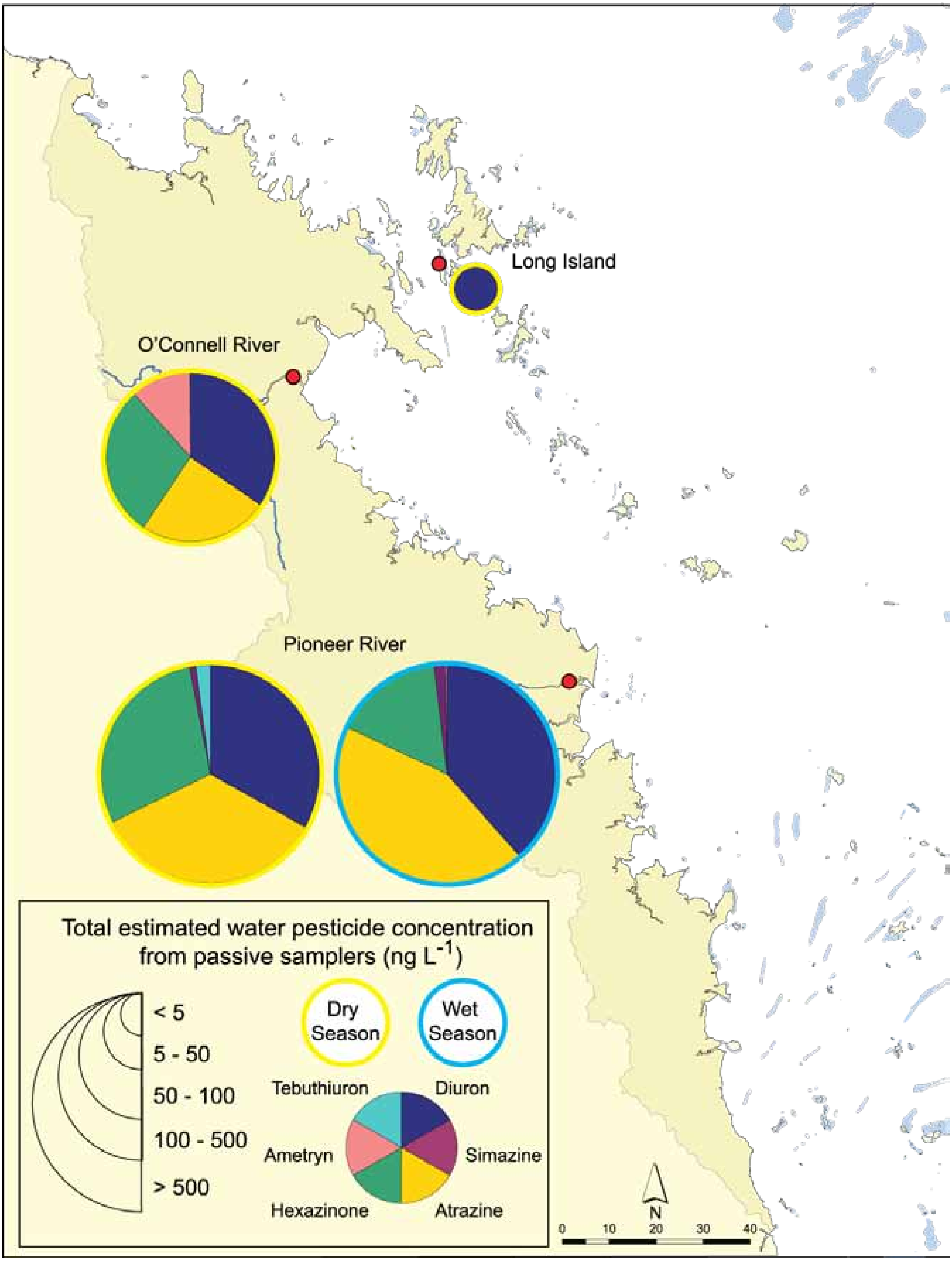


Figure 40 Pesticide concentrations in river and inshore marine waters at sites in the Mackay Whitsunday region collected during the 2005 dry season and 2005/06 wet season

Mackay Whitsunday biological monitoring

Coral monitoring

The influence of the Proserpine, O'Connell and Pioneer Rivers is most likely to extend in a northerly direction as plumes and sediments are transported by a northerly near-shore drift. It is worth noting that during the 1997 flooding of the Burdekin River the prevailing northerly winds forced the flood plume to extend to the south influencing the reef communities in the northern Whitsunday region. The reefs studied in this region are considered as two gradients of influence based on their distance from the shore. The 'inshore' gradient consists of four fringing reefs all located within 10 km distance from the shoreline spread along a northerly direction of decreasing river influence (Pine Island – Shute and Tancred Island – Daydream Island – Double Cone Island). The 'off shore' gradient consists of three reefs located more than 10 km from shore (Seaforth Island – Dent Island – Hook Island).

The largest recent disturbances include coral bleaching events in 1998 and 2002, and are likely to have affected all reefs in this region. In 1997 flood plumes from the Burdekin River extended to the 'inshore' gradient reefs.

The cover of macroalgae was significantly higher at Seaforth Island and Pine Island than on the other reefs in this region; these reefs are the closest to the rivers potentially influencing reefs in this region.

In 2005 the benthic communities at the 2 m depth at Pine Island had a high cover of macroalgae and hard coral and low cover of soft coral. At 5 m there was higher hard and soft coral cover and low macroalgae cover. Acroporidae and Poritidae dominated the density of hard coral recruits at both depths, although densities were higher at the deeper site. The recruitment of corals to settlement tiles at Pine Island was the highest for the reefs examined in this region.

The benthic communities at Shute and Tancred Islands were similar at both depths, with above average cover of soft coral, medium hard coral cover and almost no macroalgae. The hard coral communities had a high proportion of the family Acroporidae. The high cover of *Acropora* spp indicates a lack of recent disturbances at this site. The high diversity and high recruitment density indicate the potential for future increases in coral cover and richness at this location, limited on the shallow slope somewhat by the prolific soft coral community.

The site at Daydream Island is a healthy coral community, characterised by high coral cover, low macroalgae, high density and diversity of recruit-sized colonies and high recruitment to settlement tiles. The hard coral communities at both depths were dominated by Acroporidae (mostly large stands of branching *Acropora spp.*), which indicates a lack of recent disturbances.

The reef communities at both depths at the Double Cone Island site had high to very high hard coral cover and average soft coral cover. The two depths however contain very different coral communities with the deep slope dominated by large fields of *Goniopora spp.* and the shallow slope dominated by *Acropora* and *Montipora spp*. The aggressive nature of the sub-massive *Goniopora spp.* may maintain this community separation by actively killing or suppressing the growth of other nearby corals. The presence of a high cover of *Acropora* and *Montipora spp.* on the shallow slope indicate a lack of recent disturbances. The low recruitment densities and recruit numbers may limit the increase in the coral cover and richness at 2 m.

The surveys of Seaforth Island are the first known assessments of the reefs at this location. Similarly to the Pine Island site, there was high macroalgae cover and moderate to low hard and soft coral cover. The hard coral community at both depths was dominated by Poritidae (mostly branching *Porites spp.*). The density of hard coral recruits was average; with the majority of recruits being Faviidae, Poritidae, Mussidae and Acroporidae.

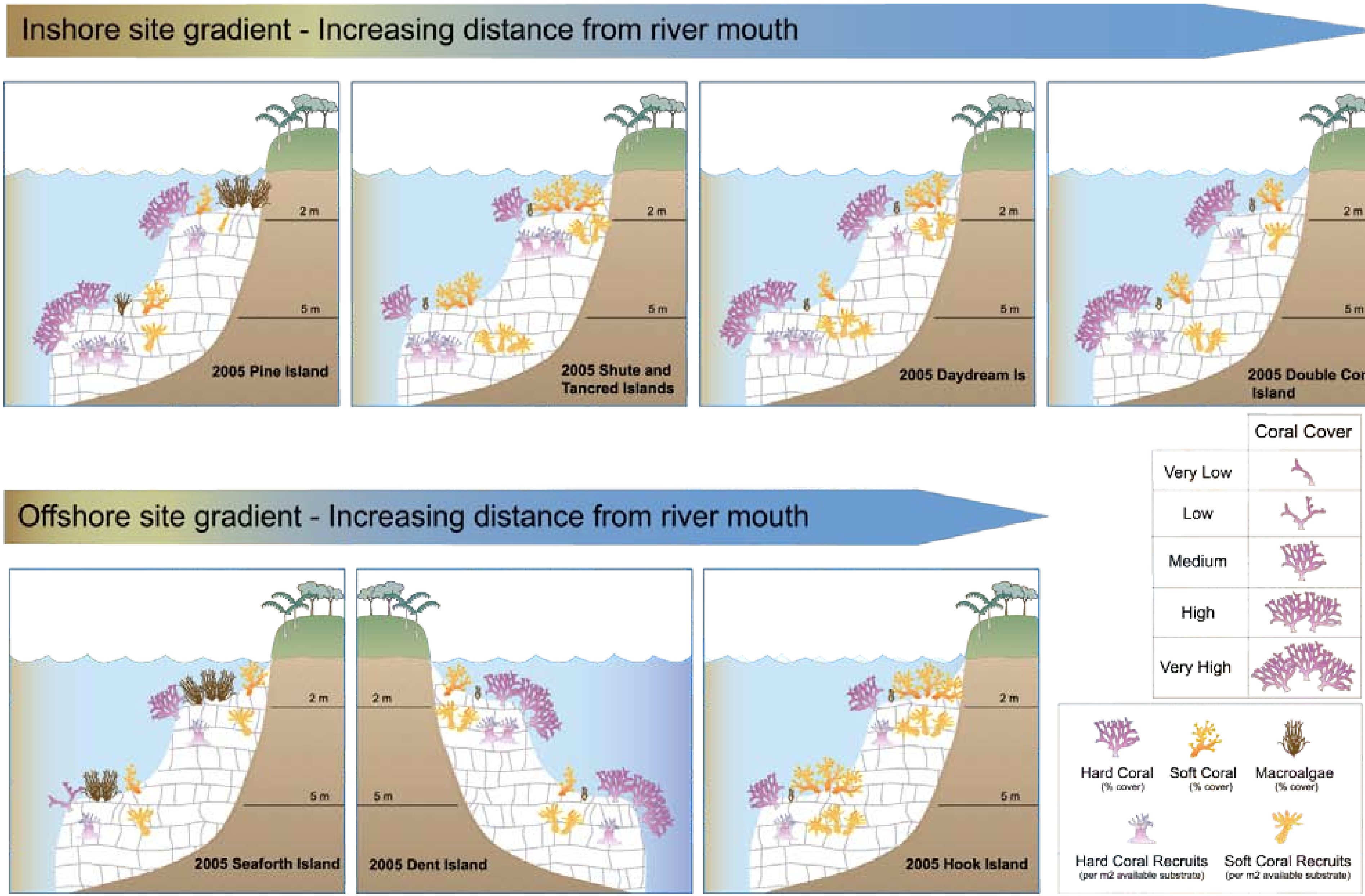


Figure 41 Benthic cover (per cent hard coral, soft coral and macroalgae and density of hard and soft coral recruits) at inshore reef sites in the Mackay Whitsunday region

The coral community at both depths at Dent Island are characterised by very high hard coral with very little macroalgae and low to moderate soft coral cover. The hard corals at both depths are dominated by Acroporidae (mostly branching *Acropora spp.*) and Poritidae. The high cover of Acroporidae and *Acropora spp.* recruits indicates the continued increase in dominance of this family given no disturbances in the near future.

The benthic communities at Hook Island, were similar at the 2 m and 5 m depths with a very high cover of soft coral, average hard coral cover and very little macroalgae. The hard coral community was dominated by massive and branching *Porites spp.* and Acroporidae (mostly branching *Acropora spp.*) (at 2 m) and Poritidae (mostly massive and branching *Porites spp.*, Faviidae and Acroporidae (at 5 m)).

Coral larvae settlement

Recruitment in 2005 in the Mackay Whitsunday region was 10 times that recorded in 1993, though spatial patterns were consistent in that the numbers of recruits per tile were lower at Double Cone Island than at Pine Island in both years. There was no clear increase in recruitment with distance from the major rivers influencing the Whitsunday transect.

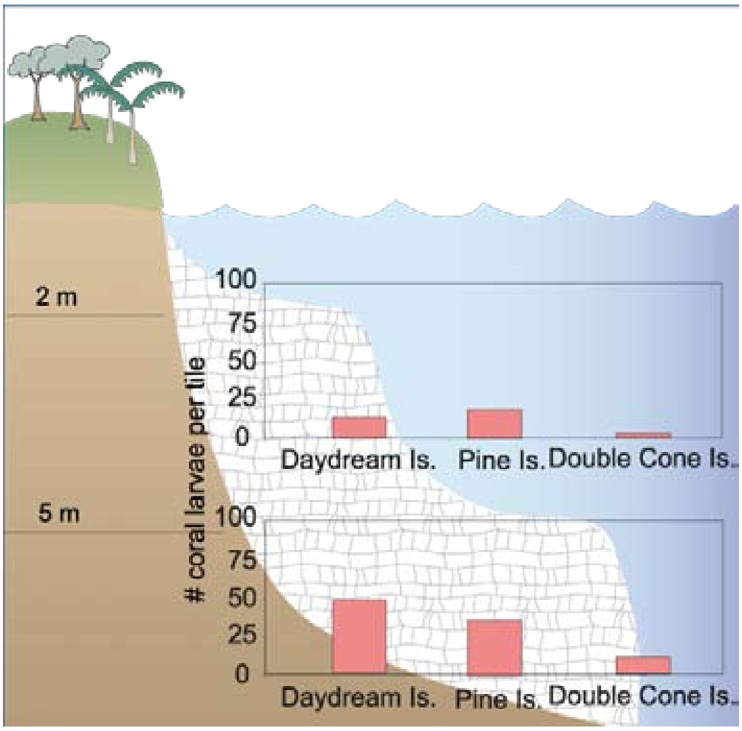
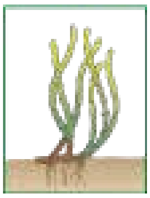


Figure 42 Coral larvae recruitment to tiles at 2 m and 5 m sites at Mackay Whitsunday reefs

Seagrass monitoring



Monitoring sites are located on intertidal sand/mud flats adjacent to Cannonvale in southern Pioneer Bay. The meadows cover approximately 60 ha and were dominated by *Halodule uninervis* and *Halophila ovalis* mixed with low amounts of *Zostera capricorn*i. Species composition remained stable over the monitoring period and indicated natural seasonal patterns. New sites were established at Sarina Inlet south of Mackay in 2005 as no easily accessible and significantly sized intertidal seagrass meadows were located closer to the mouth of the Pioneer River. The sites were located on an intertidal mud/sand bank of the inlet. The meadow was dominated by *Zostera capricorni* with some *Halophila ovalis*. Seagrass cover in April 2006 was significantly lower than that recorded in September/October 2005, but was similar to cover recorded in April 2005. As the dataset for this location is limited to 12 months, it is not yet possible to determine if this is a natural/seasonal fluctuation in seagrass abundance. Diuron was detected in sediments collected at Pioneer Bay and Sarina Inlet.

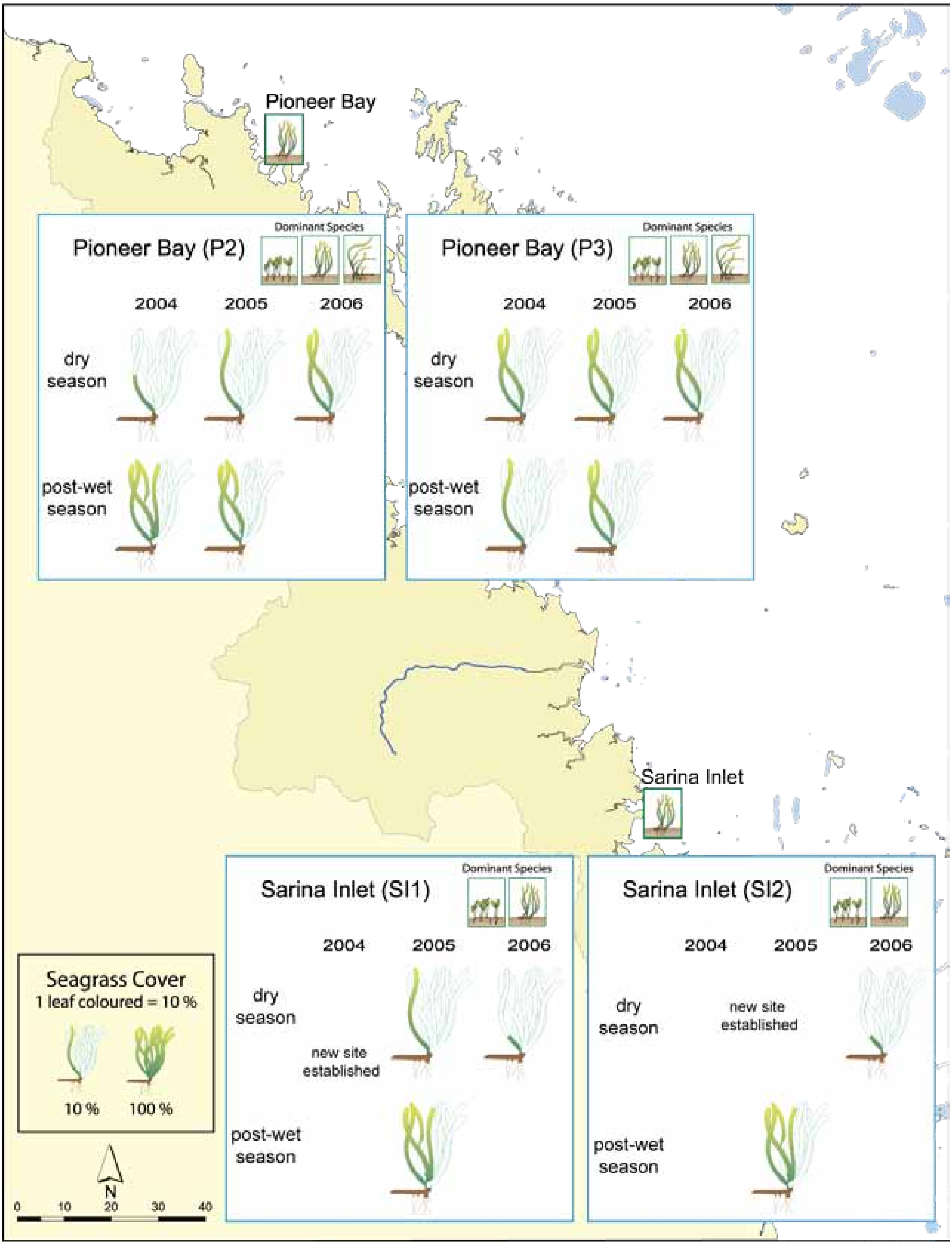


Figure 43 Seagrass cover at Pioneer Bay and Sarina Inlet in the Wet Tropics region

Mackay Whitsunday regional synopsis

The key findings of the Marine Monitoring Programme include:

- There were an estimated 21 660 tonnes of sediment exported from the O'Connell River and 327 tonnes of sediment from the Pioneer River in 2005/06. Queensland Water Quality Guideline values for phosphorus concentrations were exceeded in samples collected in the 2005/06 wet season from the Pioneer River. In contrast, Water Quality Guideline values for all nutrient concentrations were exceeded in samples collected in the 2005/06 wet season from the O'Connell River.

- Pesticides were detected in the O'Connell and Pioneer Rivers. Pesticides detected included diuron, atrazine, simazine, hexazinone, ametryn and tebuthiuron.

- Mud crabs collected from the Mackay Whitsunday region contained traces of the pesticides DDT and dieldrin.

- Pesticides were detected in inshore areas in the Mackay Whitsunday region. Pesticides detected included diuron, atrazine and hexazinone.

- Median nearshore Mackay Whitsunday regional seawater total phosphorus values exceeded Queensland Water Quality Guidelines.

- Inshore reef communities studied in the Mackay Whitsunday region show marked differences in hard and soft coral cover, density of small-sized corals and richness. In general the cover of macroalgae was higher at sites closest to the river mouths, although there was no clear association with other community parameters studied. Coral recruitment studies in the region indicate that in 2005 the number of coral spawn that settled to tiles exceeded levels recorded in any previous study. It will be important in future monitoring to see whether these corals will form into adult colonies in the future.

- Seagrass cover remained relatively stable over the last 12 months at the Pioneer Bay monitoring sites and seagrass cover followed a seasonal trend with higher seagrass abundances in early summer months. There were significant decreases in seagrass cover at the Sarina monitoring site, but the decreased levels were similar to those recorded in 2005. This meadow has the capacity to recover from disturbance via it's seed banks.

2006

Part 7

Fitzroy

Regional Monitoring Summary

Fitzroy NRM region

The Fitzroy region covers an area of nearly 300,000 km^2, constituting 10 per cent of Queensland, and supports a population of nearly 200,000 people. The region varies from rugged ranges and alluvial plains in the north to a to hilly landscape with extensive lowlands, plains and low ridge plateau in the south. It experiences a semi-arid to tropical climate with dry winters. The dominant regional vegetation consists of eucalypt woodlands with forests of Brigalow, Blackwood and Gidgee. The region is one of the richest areas in the state in terms of land, mineral and water resources, and supports grazing, irrigated and dryland agriculture, mining, forestry and tourism land uses. The Fitzroy Basin is the largest river system running into the Great Barrier Reef lagoon. The key priorities of the region include:

- Water management and planning;
- Land protection from clearing; and
- Vegetation management and planning.

Table 6 Fitzroy Marine Monitoring Programme sites and indicators measured

	Nutrients	Suspended Sediments	Pesticides	Turbidity Logger	Temp	Crab Bioaccum.	Chl a	Coral Reef	Seagrass
Shoalwater Bay									B
Middle Island	M	M					M	B	
Barren Island	M	M			M		M	B	
Humpy Island	M	M					M	B	
Halfway Island					M			B	
North Keppel Is	M	M	M				M	B	
Peak Island	M	M			M		M	B	
Pelican Island	M	M			M		M	B	
Rosslyn Bay							M		
Northwest Is							M		
Heron Island							M		
Outer Rock							M		
Wreck Point							M		
Fitzroy River	R	R	R	R		R	M		
Gladstone Harb**									B
Oyster Rocks**							M		
The Lillies**							M		
Boyne River**							M		
Wild Cattle Ck**							M		
Colosseum Inlet**							M		
Seal Rocks**							M		

R - River mouth water quality monitoring; **M** - Inshore marine water quality monitoring; **B** - Marine biological monitoring

** Monitoring locations influenced by both Fitzroy and Burnett Mary rivers (reported under both regions)

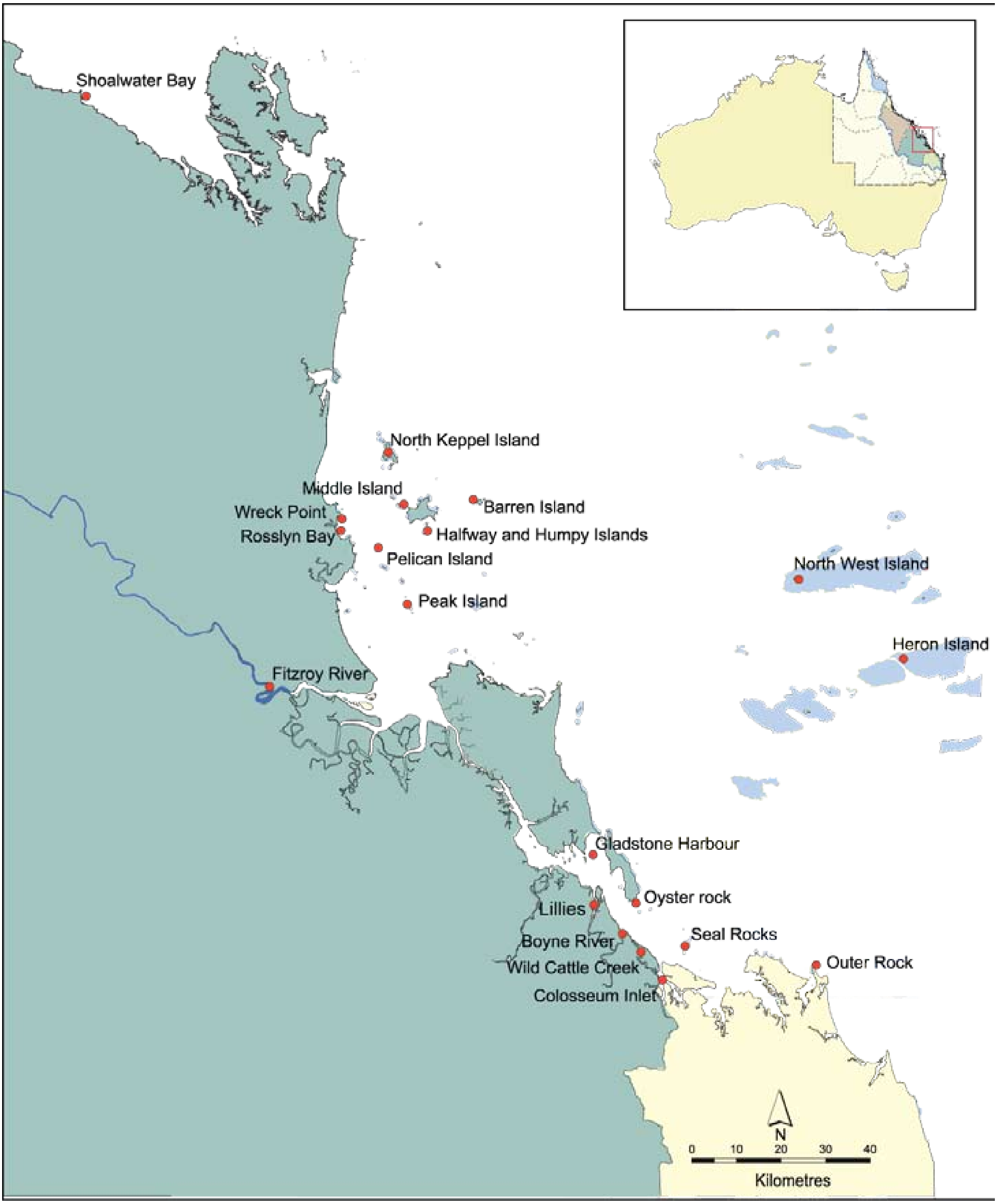
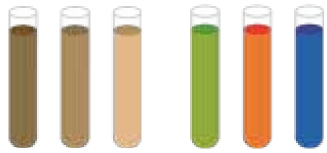


Figure 44 Map of the coastal area of the Fitzroy NRM region, adjacent reef and monitoring sites

Fitzroy water quality monitoring

Suspended sediment and nutrient monitoring

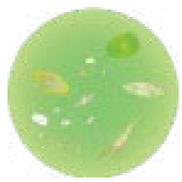


Four small and one moderate-sized flow events occurred in the Fitzroy River over the course of the 2005/06 wet season. Overall, only four samples were collected from the Fitzroy River (at the Water treatment plant, Rockhampton). None of the samples were collected during any of the peak periods of flow.

Suspended sediment concentrations were fairly low in three of the four samples collected, with the highest concentration found in the sample taken during the falling stage of the hydrograph during a mid-April 2006 flood event. Concentrations of the major forms of nitrogen differed little between samples. Most of the N was in dissolved form (DIN and DON). Elevated concentrations of all forms of P were recorded during the small mid-March flow event.

Six inshore marine monitoring sites are considered to be influenced by the Fitzroy River (Peak Island, Pelican Island, Barren Island, North Keppel Island, Middle Island, and Humpy and Halfway Islands). The concentrations of suspended sediments and nutrients at these locations were low, in particular DIN (which was primarily ammonium) and DIP.

Chlorophyll *a* monitoring



Chlorophyll *a* monitoring in the Fitzroy region in the 2005 dry and 2005/06 wet season was undertaken by Queensland Parks and Wildlife Service, CapReef and the Tannum Boyne Coastcare Group. The long-term chlorophyll *a* monitoring programme indicates that in the Keppels to Capricorn Bunkers region, chlorophyll *a* increased ~3.5 fold from 2001 to 2006. The data from the majority of sites in the Fitzroy showed similar patterns to the long-term chlorophyll *a* monitoring data, with elevated concentration of chlorophyll *a* at inshore sites compared with sites further offshore. Higher concentrations were also observed in the wet season compared with the dry season, with the increased nutrient supply from the rivers during summer flood events and elevated temperatures. Sites along the Tannum Boyne coast indicated similar or higher chlorophyll *a* values in the dry season and this may be attributable to the resuspension of sediments (and associated nutrients) and large tidal flows. Chlorophyll *a* concentrations are generally low throughout the region, although some sites, particularly during the wet season, are above Queensland Guideline Values for coastal waters.

Pesticide monitoring

There was limited pesticide monitoring in the Fitzroy region, with only one sample collected in the Fitzroy River during the wet season. In contrast to the other regions, the Fitzroy River sample contained lower concentrations of diuron and elevated concentrations of tebuthiuron. At the inshore reef locations, all pesticides were below the limit of detection during the dry season and low concentrations of diuron were detected in the wet season.

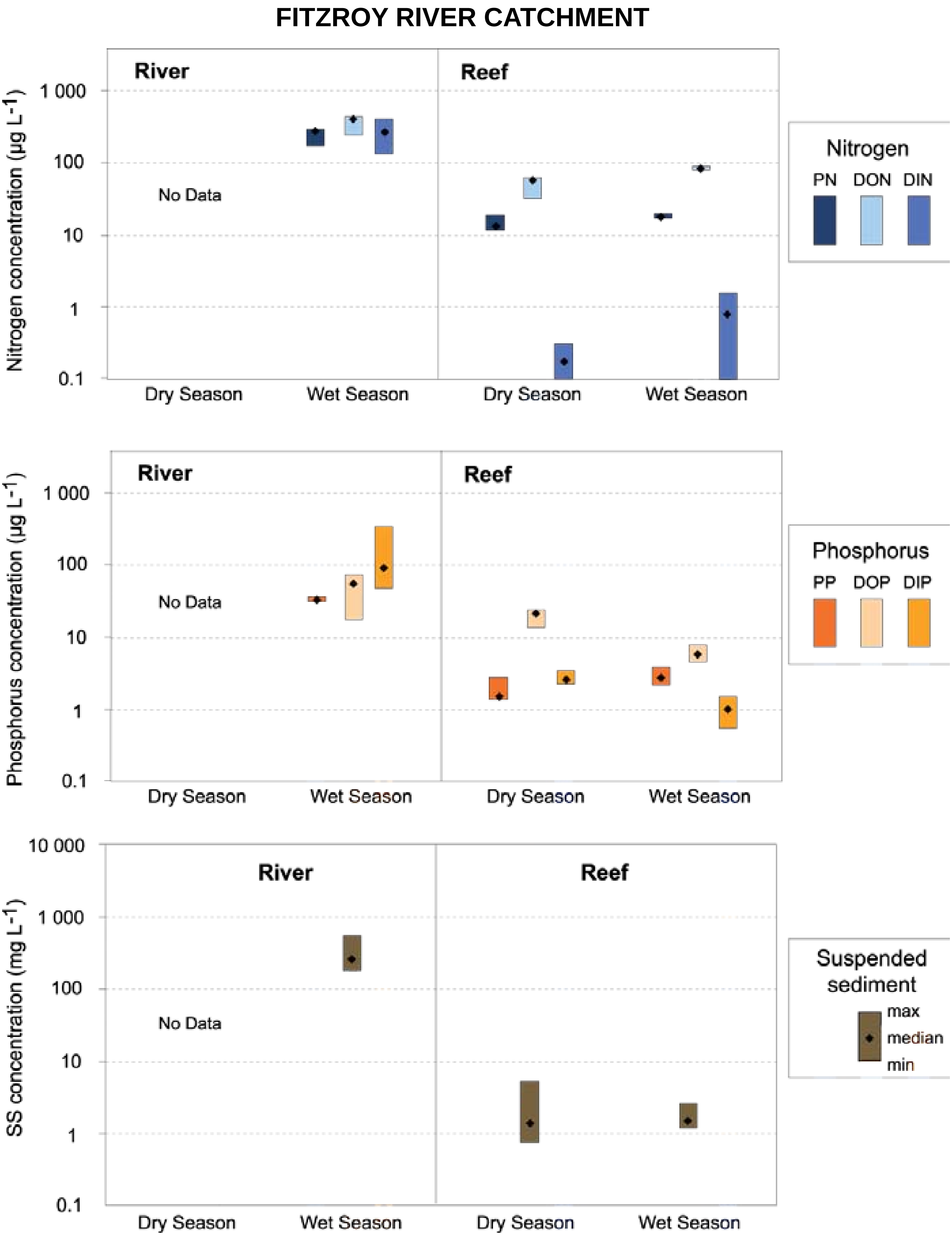


Figure 45 Nitrogen, phosphorus and suspended sediment concentrations in the Fitzroy River and associated inshore marine sited measured during the 2005 dry and 2005/06 wet seasons

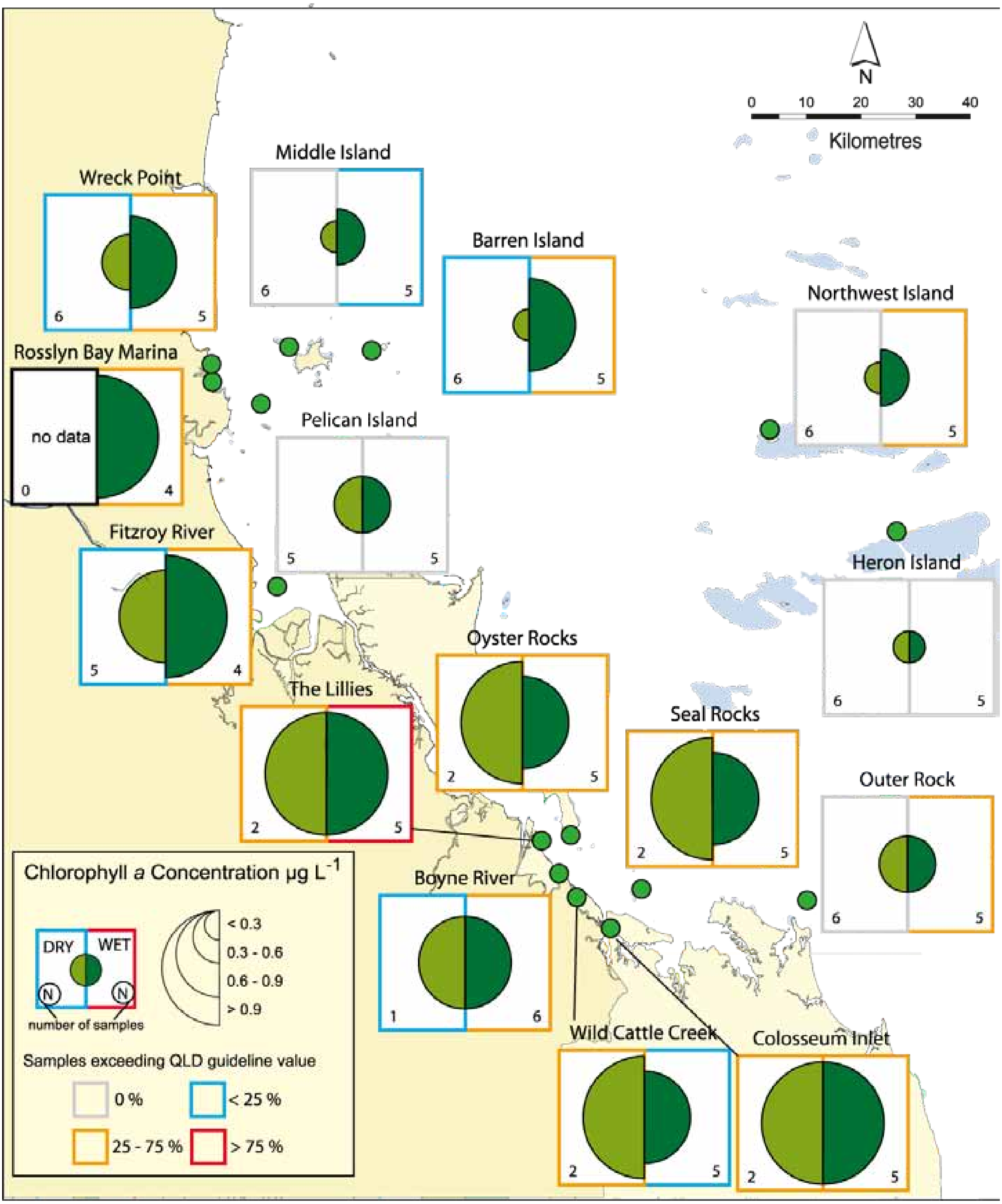


Figure 46 Chlorophyll *a* concentrations at sites in the Fitzroy region

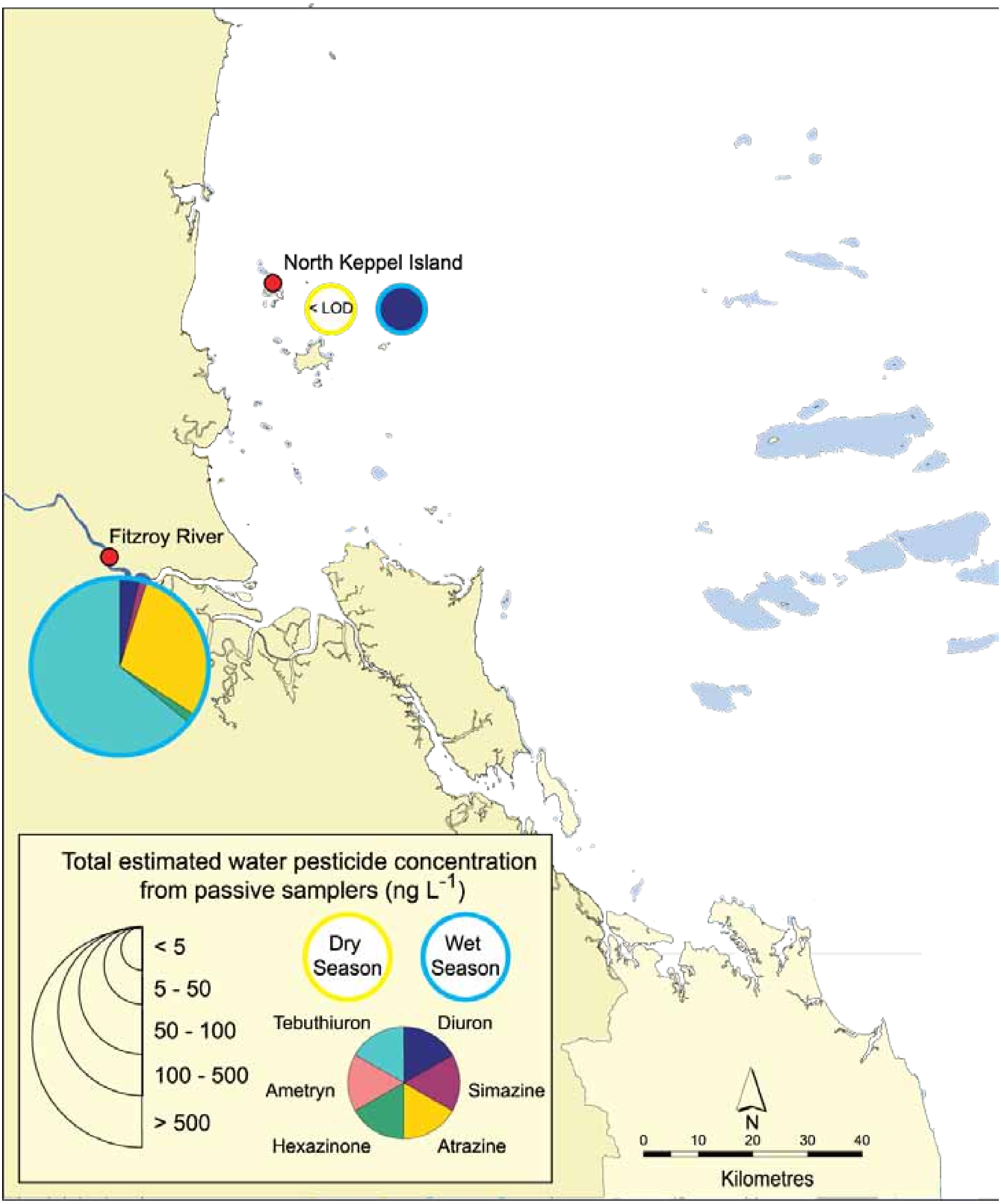


Figure 47 Pesticide concentrations in river and inshore marine waters at sites in the Fitzroy region collected during the 2005 dry season and 2005/06 wet season

Fitzroy marine biological monitoring

Coral monitoring

Six reefs at different distances from the mouth of the Fitzroy River were selected to represent a gradient of likely exposure to river borne contaminants (i.e. Peak Island – Pelican Island – Humpy and Halfway Islands – Middle Island – North Keppel Island – Barren Island).

Major disturbance events in this region include the 1991 Fitzroy River flood, and coral bleaching in 1998, 2002 and 2006. No crown-of-thorns starfish have been observed on these reefs.

There is a clear distinction in the benthic communities between those closest to the Fitzroy River (Peak Island and Pelican Island) and those further offshore. Peak Island and Pelican Island reefs have significantly lower cover of hard corals, higher cover of macroalgae and low densities of hard coral recruits. The community composition of both hard corals and hard coral recruits at the 2 m depths at both of these sites consisted mostly of the families Faviidae and Acroporidae. The coral community at the Peak Island 5 m site was unusually dominated by Siderastreidae (and Faviidae), while Pelican Island was dominated by Faviidae and Merulinidae. Proximity to the Fitzroy River mouth, below average coral cover and lack of a substantial carbonate reef base all suggest that these coral communities are likely to be transient in the longer term.

The benthic communities at Humpy and Halfway Islands, Middle Island and North Keppel Island are characterised by a low cover of soft coral and very high cover of hard coral. Acroporidae dominate the hard coral communities on both the shallow and deeper slopes at all of these sites. The density of recruit-sized colonies was low at all sites and depths, except for the deeper site at Humpy and Halfway Islands. These reef communities may be particularly susceptible to disturbances which result in large scale mortality amongst the adult population. Recovery from such events would likely be very slow given the low numbers of recruits.

There were no data on benthic reef communities at Barren Island prior to this survey. In 2005, the community at 2 m had above-average cover of both soft coral (16%) and hard coral (48%) and no macroalgae. Similarly to the other outer sites in the region, the hard coral community was dominated by Acroporidae at both the 2 m and 5 m depths. The density of recruit-sized colonies was very low at 2 m with only a few recruits from the families Acroporidae, Faviidae and Pocilloporidae observed. However, at 5 m, the density of recruits was extremely high. This is believed to be an effect of the very high adult coral cover that limited the available substrate for recruitment and causes higher recruitment in the limited available space.

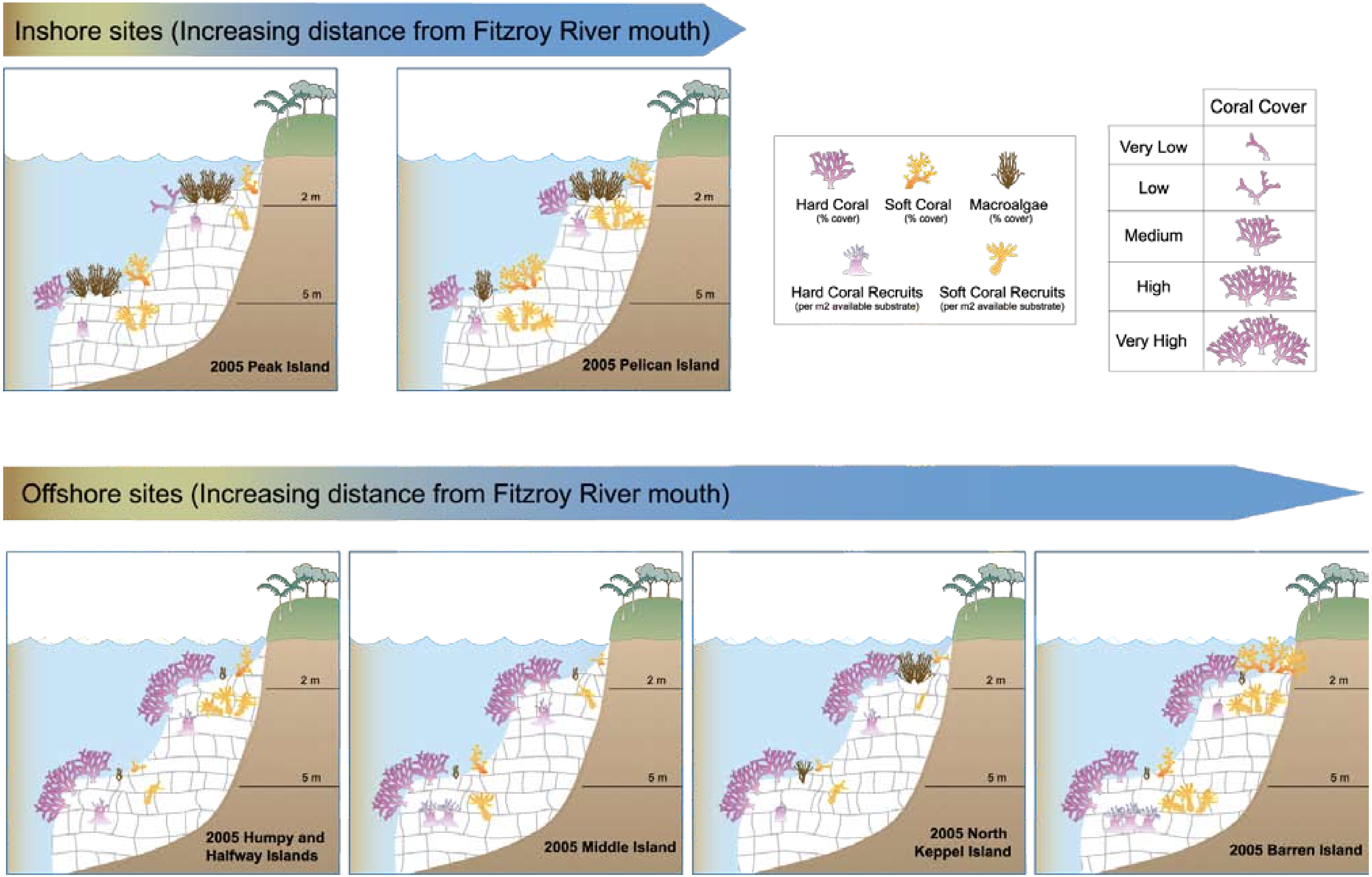
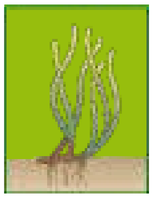


Figure 48 Benthic cover (percent hard coral, soft coral and macroalgae and density of hard and soft coral recruits) at inshore reef sites in the Fitzroy region

Seagrass monitoring



Existing Seagrass-Watch sites were selected for monitoring in Shoalwater Bay as no easily accessible and significantly sized seagrass meadows were located nearer to the mouth of the Fitzroy River. The Ross Creek (RC1) and Wheelan's Hut (WH1) sites were north of Sabina Point on the north western shores of Shoalwater Bay. Average seagrass cover ranged from ~15 to 45 per cent. Species compositions at each site appear fairly similar between years with *Zostera capricorni* dominating, with no apparent seasonal patterns.

The seagrass monitoring site in Gladstone Harbour may be influenced by river inputs from both the Fitzroy and Burnett Mary regions, thus results for this site are reported under both regions. Gladstone Harbour sites are located on a large *Zostera capricorni* dominated meadow on the extensive intertidal Pelican Banks south of Curtis Island. This meadow is also part of the annual Port of Gladstone Environmental Monitoring Programme. A recent (February 2006) reconnaissance survey indicated that seagrass cover has decreased throughout the entire region. This was confirmed in April 2006 when the monitoring sites GH1 and GH2 were examined. The declines were most likely attributable to natural seasonal variation, coupled with a combination of other climatic factors such as rainfall, wind and water temperature occurring in the region between October 2005 and April 2006, rather than the impacts of the oil spill from the bulk carrier "Global Peace" on 24 January 2006. Declines occurred in meadows outside of the oil spill area, including the meadow on Pelican Banks, within which the Seagrass-Watch monitoring sites are located. The Pelican Banks meadow decreased by 79% in biomass and 19% in area, since October 2005. Due to a paucity of long term monitoring data for this meadow there is no knowledge of the range of natural changes one could expect.

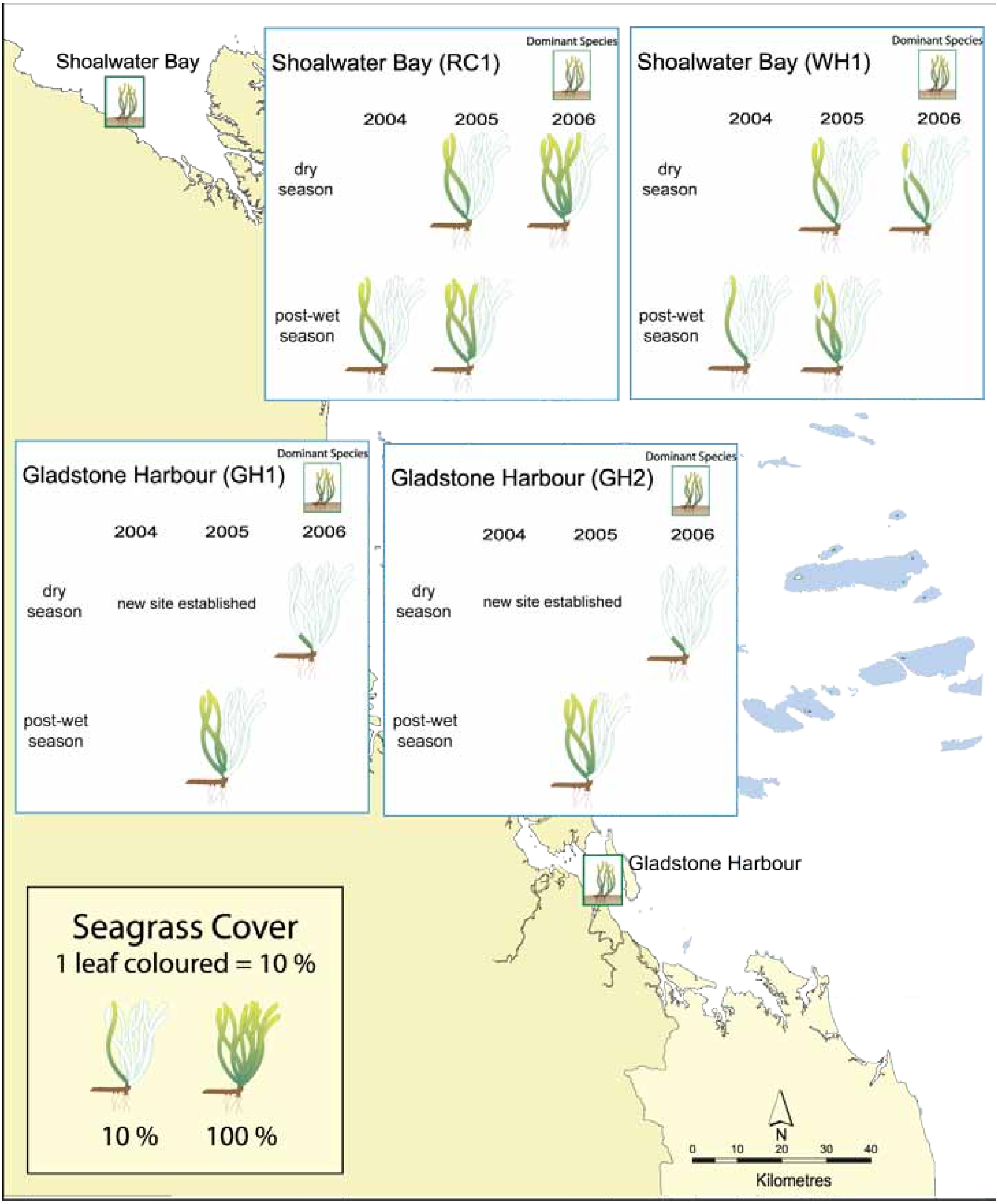


Figure 49 Seagrass cover at Shoalwater Bay and Gladstone Harbour sites in the Fitzroy region

Fitzroy regional synopsis

The key findings of the Marine Monitoring Programme include:

- Queensland Water Quality Guideline values for all nutrient concentrations (except DON) were exceeded in samples collected in the 2004/2005 and 2005/06 wet seasons from the Fitzroy River.
- Pesticides were detected in the Fitzroy River. Pesticides detected included diuron, atrazine, simazine, hexazinone and tebuthiuron.
- Mud crabs collected from the Fitzroy region contained traces of the pesticides chlorpyrifos, DDT and dieldrin.
- The herbicide diuron was detected in inshore areas in the Fitzroy region.
- Median nearshore Fitzroy regional seawater total phosphorus values exceeded Queensland Water Quality Guidelines. Marine water chlorophyll *a* concentrations were higher in inshore waters than offshore areas in the Fitzroy region. Chlorophyll *a* is a measure of nutrient availability in the water column.
- The data collected for inshore reef locations in the Fitzroy region provides an important baseline assessment, as three of the six chosen sites have no previous monitoring. There is a clear distinction in the reef communities between the sites closest to the Fitzroy River and those further offshore. Sites in close proximity to the river have significantly lower cover of hard corals, markedly higher cover of macroalgae. Overall genus level richness of adult and recruit-sized corals is significantly lower than other regions.
- Seagrass cover was variable over the four years of monitoring at the Shoalwater Bay monitoring sites although species composition has remained relatively constant over the monitoring period. The meadows have a capacity to recover from disturbance as there is a seed bank present.

2006

Part 8

Burnett Mary

Regional Monitoring Summary

Burnett Mary NRM region

The Burnett-Mary region covers an area of 88 000 km^2 and supports a population of over 257 000 people, largely in the main centres of Bundaberg, Maryborough, Gympie and Kingaroy. The region is comprised of a number of catchments including the Burnett River, Baffle Creek, Kolan, Burnett, Burrum and Mary Rivers. The two largest catchments are the Burnett River and the Mary River, which discharge into Hervey Bay. The Burnett River flows into the southern end of the Great Barrier Reef Marine Park. It supports a large grazing, sugarcane and grain crops industries such as sorghum and wheat and to a lesser extent industries such as dairy, vine and tree crop and citrus. The key priorities of the region include:

- Terrestrial weeds and pests;
- Water quality and impacts on the Great Barrier Reef World Heritage Area;
- Water quantity and supply;
- Dryland salinity;
- Population pressure and coastal development; and
- Natural and cultural heritage.

Under the Marine Monitoring Programme, monitoring is undertaken primarily in the Burnett River region although there are some sites in the north of the region that may be influenced by catchments in both the Fitzroy and Burnett Mary region, and are thus reported under both NRM regions (Table 7).

Table 7 Burnett Mary Marine Monitoring Programme sites and indicators measured

	Nutrients	Suspended Sediments	Pesticides	Turbidity Logger	Temp	Crab Bioaccum.	Chl a	Coral Reef	Seagrass
Gladstone Harb**									B
Oyster Rocks**							M		
The Lillies**							M		
Boyne River**							M		
Wild Cattle Ck**							M		
Colosseum Inlet**							M		
Seal Rocks**							M		
Burnett River	R	R	R	R		R	M		
Double Rocks							M		
Barolin Rocks							M		
Hoffman's Rocks							M		
Burkitts Reef							M		
Hervey Bay							M		
Urangan & Booral									B

R - River mouth water quality monitoring; **M** - Inshore marine water quality monitoring; **B** - Marine biological monitoring

* Monitoring locations influenced by both Fitzroy and Burnett Mary rivers (reported under both regions)

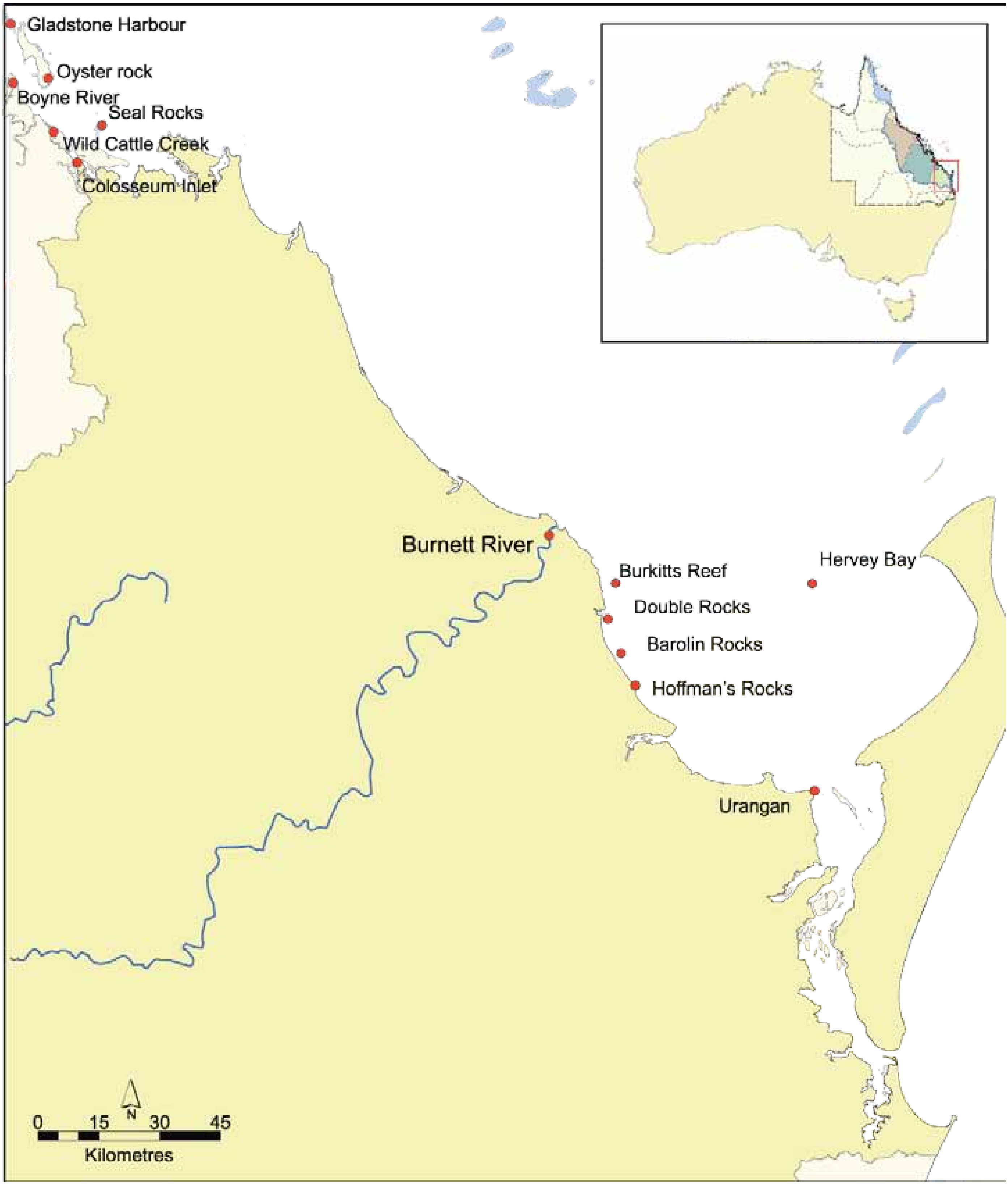
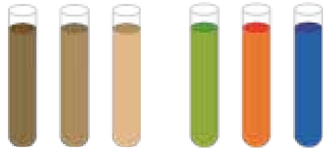


Figure 50 Map of the coastal region of the Burnett Mary NRM region and adjacent reef

Burnett Mary water quality monitoring

Suspended sediment and nutrient monitoring



There was very little discharge from the Burnett River over the course of 2005/06 (approximately 6 per cent of the long-term average flow). Six water samples were collected from the Bundaberg weir pool in Burnett River over the 2005/06 wet season, including periods of relatively higher and lower flows.

Because of the low flow conditions in the river, suspended sediment concentrations were low (< 10 mg L^{-1}) and constant through the 'wet' season. Very little temporal variation was observed in either dissolved or particulate nutrient species. Concentrations of both DIN and DIP were very low, reflecting the importance of biological uptake by aquatic plants in the river and denitrification in river sediments. Despite the low flow of the river, most of the phosphorus was present in particulate form, high particulate nitrogen and organic nitrogen were observed.

There are no inshore marine water quality monitoring locations in the Burnett Mary region.

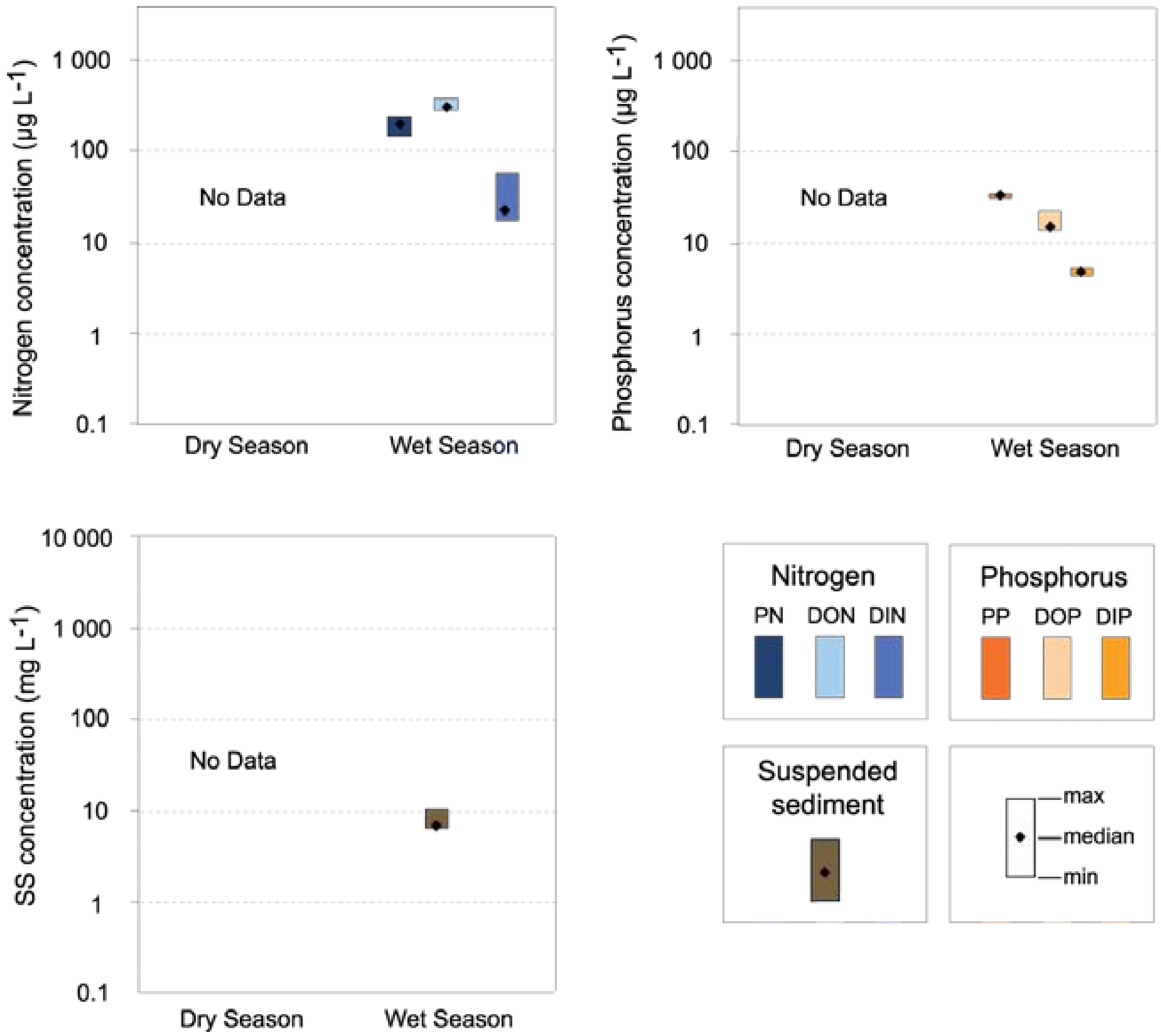


Figure 51 Nitrogen, phosphorus and suspended sediment concentrations in the Burnett River measured during the 2005/06 wet seasons

Chlorophyll *a* monitoring

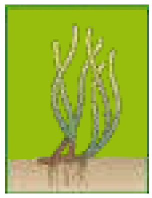
Chlorophyll *a* monitoring in the Burnett Mary region in the 2005 dry and 2005/06 wet season was undertaken by Woongarra Marine Park Monitoring and Education Project, Tannum Boyne Coastcare (see also Fitzroy region), and Queensland Sea Scallop Ltd. There are no offshore sites in the Burnett Mary region. In contrast to the other regions, chlorophyll *a* values are generally similar during the dry and wet seasons. The median concentrations of chlorophyll *a* were generally above Queensland Guideline Values for coastal waters at more than half of the sites in the region.

Pesticide monitoring

In the Burnett River, diuron levels were much higher in December to March (11-12 ng/L) compared with October and November (2.2-4.4 ng/L). Atrazine and ametryn concentrations were also higher in the wet season deployments. Simazine was detected in the wet season but was not detectable in the dry season.

Burnett Mary marine biological monitoring

Seagrass monitoring



The seagrass monitoring site in Gladstone Harbour may be influenced by rivers from both the Fitzroy and Burnett Mary regions, thus results for this site are reported under both regions. Gladstone Harbour sites are located on a large *Zostera capricorni* dominated meadow on the extensive intertidal Pelican Banks south of Curtis Island. This meadow is also part of the annual Port of Gladstone Environmental Monitoring Programme. A recent (February 2006) reconnaissance survey indicated that seagrass cover has decreased throughout the region. This was confirmed in April 2006 when the monitoring sites GH1 and GH2 were examined. The declines were most likely attributable to natural seasonal variation, coupled with a combination of other climatic factors such as rainfall, wind and water temperature occurring in the region between October 2005 and April 2006, rather than the impacts of the oil spill from the bulk carrier “Global Peace” on 24 January 2006. Declines occurred in meadows outside of the oil spill area, including the meadow on Pelican Banks, within which the Seagrass-Watch monitoring sites are located. The Pelican Banks meadow decreased by 79% in biomass and 19% in area, since October 2005. There is not a reliable long term understanding of the natural background range of changes likely to be expected in Gladstone and a longer data set is needed for interpretation. Hervey Bay sites were located adjacent to the Urangan marina and close to the Mary River mouth. The sites were dominated by *Zostera capricorni* with minor components of *Halophila ovalis* and some *Halodule uninervis*. Following a major flood in August 1999, seagrass was absent (0% cover) until May 2000. In July 2000 seedlings of *Zostera capricorni* appeared. Since then cover has increased significantly. A decline was recorded in early 2004, however cover increased in late 2004. A similar decline occurred in April 2006, and may be part of a seasonal pattern developing at the location. Diuron was detected in sediments collected at Gladstone and Hervey Bay. The meadow also recorded the highest absorbed ammoniumin the sediment for any of the catchments.

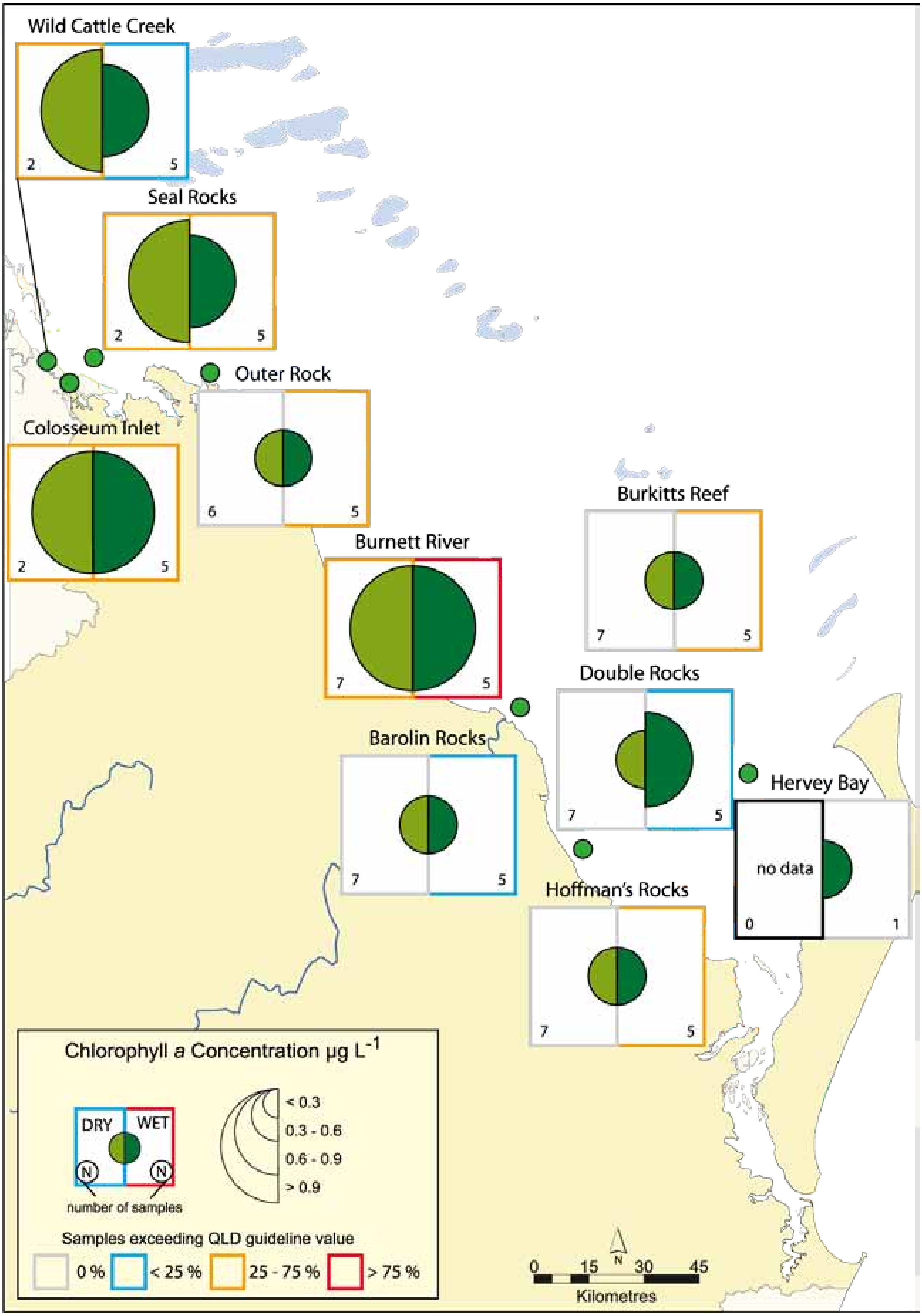


Figure 52 Chlorophyll a concentrations at sites in the Burnett Mary region

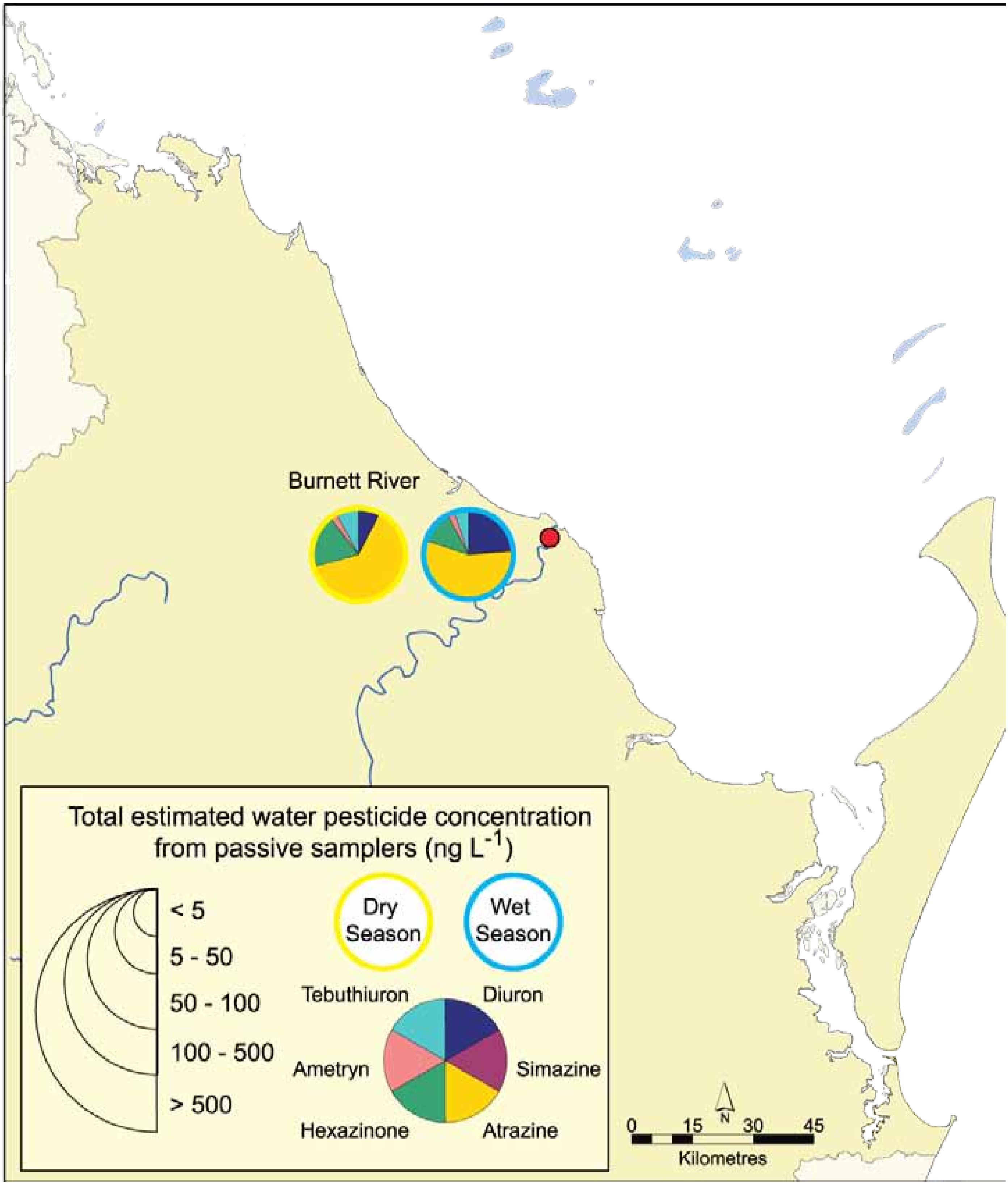


Figure 53 Pesticide concentrations in the Burnett River waters collected during the 2005 dry season and 2005/06 wet season

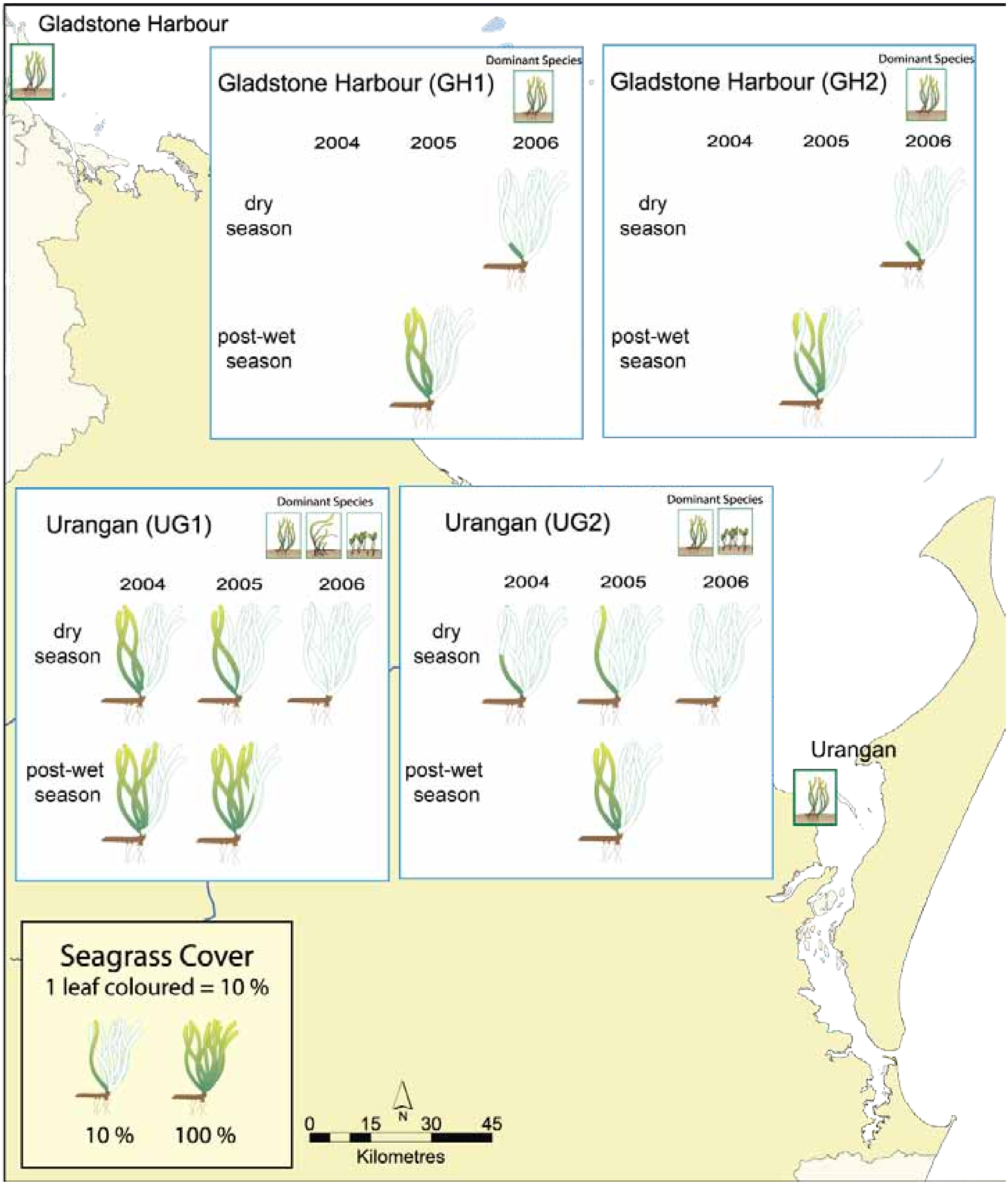


Figure 54 Seagrass cover at Gladstone Harbour and Urangan sites in the Burnett Mary region

Burnett Mary regional synopsis

The key findings of the Marine Monitoring Programme include:

- Queensland Water Quality Guideline Values for all nutrient concentrations (except NOX and Total N) were exceeded in samples collected in the 2005/06 wet season from the Burnett River.

- Pesticides were detected in the Burnett River. Pesticides detected included diuron, atrazine, simazine, ametryn, hexazinone and tebuthiuron.

- Mud crabs collected from the Burnett Mary region contained traces of the pesticides DDT and dieldrin.

- There are no inshore reef communities monitored in the Burnett Mary region.

- There were significant decreases in seagrass cover at the Gladstone Harbour and Hervey Bay monitoring sites. These declines may be a consequence of atypical climate conditions in the area. The meadows had a capacity to recover from disturbance via seed banks.