



Australian Government

Great Barrier Reef  
Marine Park Authority

# Science Strategy and Information Needs

2014 - 2019

SUPERSEDED





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# Executive summary

Management informed by the best available knowledge is fundamental to ensuring a healthy Great Barrier Reef for future generations.

The Great Barrier Reef Marine Park Authority (the agency) seeks to base its management on a comprehensive and up-to-date understanding of the Great Barrier Reef — its values and processes and the pressures affecting it.

The *Science Strategy and Information Needs 2014–2019* sets out the future scientific information needs of the agency. It aims to ensure that science activities are relevant, targeted to address critical management issues and their outcomes are easily accessible.

The strategy is based on the outcomes of the [Great Barrier Reef Outlook Report 2014](#) and the recently completed [Great Barrier Reef Region Strategic Assessment](#), plus the critical thinking applied in developing the synthesis documents that informed those reports.

Timed around the five-yearly cycle of the Outlook Reports, development of a science strategy is an opportunity for the agency to review and prioritise science information needs in conjunction with its partners. This strategy has a five-year life and replaces a previous version developed following release of the first Outlook Report in 2009.

The strategy is designed for use by the agency and its partners, particularly the scientific community (based in research institutions, universities and government agencies), research funding providers, and providers of monitoring and other relevant information such as Reef-based industries, Traditional Owners and members of the community.

Knowledge, integration and innovation is one of the foundational areas of the agency's 25-year management program. This strategy identifies priority information needs, grouped under four thematic areas:

- A. Drivers and pressures
- B. Key values
- C. Thresholds and desired condition
- D. Management responses

A series of key research questions for each theme is articulated in the strategy and more detailed research questions, which may be updated through the life of the strategy, are provided on a web-based register of detailed knowledge needs.

## GLOSSARY OF KEY TERMS

**Adaptation:** an adjustment that moderates harm or exploits beneficial opportunities in natural or human systems in response to actual or expected climatic changes or their effects. A ‘biological adaptation’ is a phenotypic variant that results in highest fitness among a specific set of variants in a given environment; it occurs when the more vulnerable members of a population are eliminated by an environmental stress, leaving the more tolerant organisms to reproduce and recruit to available habitat

**Adaptive capacity:** the potential for an organism, species, ecosystem or social group (including industry sector) to adapt to change (including changes in variability and extremes) so as to maximise fitness; moderate potential damages; or take advantage of opportunities, such as increased space availability

**Best available science:** all relevant scientific information, generated by various sources and approaches, contributing to the evidence base for management

**Biocultural diversity:** includes the biological, cultural, and linguistic dimensions of diversity, which are interrelated (and possibly coevolved) within a complex socio-ecological adaptive system

**Community benefits:** the social, cultural and economic benefits (i.e. ecosystem services) derived from the environment

**Cumulative effects:** the net change to the environment resulting from the effects of one or more pressures, and the interactions between those pressures, added to other past, present, and reasonably foreseeable future pressures

**Driver:** an overarching cause of change in the environment

**Effect:** a positive or negative change to the environment

**Environment:** ecosystems and their constituent parts, including people and communities; natural and physical resources; the qualities and characteristics of locations, places and areas heritage values of places; and the social, economic and cultural aspects of the above

**Exposure:** the nature and degree to which an organism, species or ecosystem or social group (including industry sector) is exposed to significant pressure(s) and activities

**Heritage value:** a place’s natural and cultural environment having aesthetic, historic, scientific or social significance, or other significance, for present and future generations of Australians

**Influencing factor:** human activities that directly or indirectly cause one or more pressures on the environment

**Net environmental benefit:** having an overall positive effect on the environment

**Outcome:** an end result that is being aimed for

**Precautionary principle:** the principle that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible damage

**Pressure:** a mechanism that causes a change in the condition of the environment

**Region values:** the ecological, heritage, social and economic values of the Great Barrier Reef Region

**Resilience:** the capacity of an organism, species, ecosystem or social group to resist and recover from disturbances while still retaining the same function, structure, integrity and feedbacks. Resilience (activity and adaptive capacity) describes the likely response of an organism, species or ecosystem to exposure to a disturbance. The concept is dynamic and is closely related to vulnerability

**Sensitivity:** the degree to which an organism, species, ecosystem or social group (including industry sector) is affected, either adversely or beneficially, by pressures and activities

**Standard:** a specified desired state and/or set of conditions that is adhered to or maintained

**Target:** the management intent for a matter relevant to the condition of the environment. It can relate to an issue, habitat, species, activity or any other matter

**Threat:** see ‘Pressure’

**Threshold:** comprises three aspects: degradation threshold — the point beyond which the average condition of an ecosystem begins to degrade; ecosystem state and process threshold — a set of conditions that determine whether the ecosystem will exhibit natural recovery or shift towards a different and less desirable condition; physiological threshold — a set of conditions where the environment becomes so hostile that fundamental physiological functions are grossly impaired

**Value:** those aspects of an environment that make it of significance

**Vulnerability:** the degree to which an organism, species, ecosystem or social group (including industry sector) is susceptible to, or unable to cope with, adverse effects. Vulnerability is a function of the character, magnitude, and rate to which a system or species is exposed, its sensitivity, and its adaptive capacity



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# 1. Context

## 1.1. The Great Barrier Reef and its management

The Great Barrier Reef is the world's largest coral reef ecosystem, comprising a maze of reefs and islands, thousands of species and a diversity of habitats, from mangroves and seagrasses to coral reefs and open water.

It is a place of great significance to its Traditional Owners who have a unique and continuing connection with the area. It is also critical to the cultural, economic and social wellbeing of the more than one million people living in its catchment, and is valued by the national and international community.

The Reef's importance is recognised through its listing as a world heritage area and its protection as a marine park.

The [Great Barrier Reef Marine Park Act 1975](#) and its supporting regulations are the principal legislation for protection and management of the Great Barrier Reef. The main object of the Act is to provide for the long-term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region. It establishes the Great Barrier Reef Marine Park Authority — an Australian Government statutory agency — and governs its operations.

The agency manages the Great Barrier Reef Marine Park in accordance with the Act. This Commonwealth marine protected area is complemented by the Queensland Great Barrier Reef Coast Marine Park in adjacent Queensland waters. The Australian and Queensland governments work in partnership to protect and manage the Great Barrier Reef.

The agency also works in strong partnership with a range of other organisations and individuals who directly participate in protecting and managing the Reef. Examples include: Traditional Owners, local governments, natural resource management bodies, research institutions, industries, community groups and schools.

## 1.2. Current state of the Great Barrier Reef

The [Great Barrier Reef Outlook Report 2014](#) concludes that the northern third of the Great Barrier Reef has good water quality and its ecosystem is in good condition. In contrast, key habitats, species and ecosystem processes in central and southern areas, especially inshore, have continued to deteriorate from the cumulative effects of many pressures. Traditional Owners maintain their connections to the Region, however, related cultural and heritage values have deteriorated. Some of the Region's historic heritage values are well recognised and managed, while many others are poorly recorded and their condition is not well understood.

The report shows that, while the Great Barrier Reef continues to provide strong economic and social benefits, changes to the condition of its ecosystem and heritage values have implications for the benefits provided to the community.

Climate change, poor water quality from land-based run-off, impacts from coastal development and some impacts of fishing were identified as the major pressures on the future health and resilience of the Great Barrier Reef. Pressures assessed as being of highest risk included sea temperature increase, ocean acidification, sea level rise, altered weather patterns, sediments and nutrients in land-based run-off, outbreaks of crown-of-thorns starfish, illegal fishing and poaching, incidental catch of species of conservation concern and modifying coastal habitats.

In response to the findings of the Outlook Report and the recently completed Great Barrier Reef Region Strategic Assessment, the agency adopted a 25-year management program for the Reef – The [Great Barrier Reef Region Strategic Assessment Program Report](#).



### 1.3. The contribution of science to management

A comprehensive and up-to-date understanding of the Great Barrier Reef, its values, the processes that support it and the pressures that are affecting it is fundamental to protecting and restoring the Great Barrier Reef and making informed decisions on avoiding, mitigating and offsetting the pressures affecting it.

Knowledge, integration and innovation is one of the three foundational areas of the agency's 25-year management program. The future role of science in Reef management is built on the work of the past four decades, over which time the agency's management arrangements have consistently been underpinned by the best available science. Examples include: zoning plans, plans of management, permit assessments and specific policies, and other information. Improved knowledge and understanding has also directly contributed to key synthesis documents about the Reef and its catchment which have in turn informed higher level policy development, program planning and reporting.

### 1.4. Sources of scientific information

The agency receives scientific information about the Reef and its management from a range of sources including:

- Research institutions and government agencies — research, monitoring and modelling is carried out by scientists and technicians that are highly trained in relevant fields. Results are generally made available to the agency through published peer reviewed journal articles, reports, meetings, conferences and symposia.
- Reef-based industries — monitoring is conducted by individuals and companies within sectors such as tourism and commercial fishing. The level of technical expertise and training is variable. Gathering the information may be a voluntary contribution to management or may be undertaken to meet a permit condition or a compulsory reporting obligation.
- Members of the community — typically a voluntary contribution, and generally associated with recognised 'citizen science' monitoring programs that provide training and oversight.
- Traditional Owners — research and monitoring undertaken through Traditional Use of Marine Resources Agreements and other natural resource management initiatives. Some programs are partnerships with research institutions or government agencies.

The agency engages with research providers and major research programs through a number of long-standing formal relationships, including participation in relevant boards and committees, and formal membership in research teams, as well as through on-to-one communication between individual staff members and the scientific community.



## 2. About the strategy

### 2.1. Purpose

The purpose of the strategy is to guide the provision of scientific information relevant to protection and management of the Great Barrier Reef. It is designed to raise the awareness and profile of the scientific information needs of the agency, especially within research organisations and funding bodies.

The strategy supports the agency's vision:

**A healthy Great Barrier Reef for future generations**

and its four goals:

- protecting and restoring the ecosystem health and biodiversity
- safeguarding the Reef's heritage values
- ensuring use is ecologically sustainable and benefits current and future generations
- reducing cumulative impacts and building resilience.

### 2.2. Objectives

The objectives of the strategy are:

- to foster the generation of scientific information that informs management and improves outcomes for the values of the Great Barrier Reef
- to underpin an open dialogue between the agency and research institutes, reef based industries and the broader community about priority knowledge gaps; feasible research, modelling and monitoring options; and the application of scientific information
- to develop and maintain an open dialogue with Traditional Owners about research relevant to their sea country.

### 2.3. Scope and timeframe

The strategy sets out the priority scientific information needs of the agency in relation to its protection and management of the Great Barrier Reef Region.

All the aspects of the Region's environment are considered, comprising:

- biodiversity and ecosystem health
- heritage values
- community (social, economic and cultural) benefits derived from the environment.

Timed around the cycle of Outlook Reports for the Great Barrier Reef, the strategy applies to the period from 2014 to 2019. It is intended that the strategy will be reviewed every five years to reflect the changing state of the Great Barrier Reef and the issues it is facing. It may be amended in response to emerging issues or new information. Changes in research priorities will be reflected in amendments to a web-based register of detailed research questions available at [www.gbrmpa.gov.au](http://www.gbrmpa.gov.au).





## 2.4. Development process

Development of the strategy was principally informed by the [Great Barrier Reef Region Strategic Assessment Report](#) and the [Great Barrier Reef Outlook Report 2014](#).

The strategic assessment and its resulting 25-year management program set out how scientific knowledge will be applied to protection and management of the Great Barrier Reef.

The outcomes of the [Great Barrier Reef Outlook Report 2014](#) informed analysis of key priority areas. The relevant assessments are summarised in Appendix A, comprising:

- current condition and trends of the Region's values
- current effects and trends of pressures on those values
- state of knowledge (level of confidence) for each assessment — a guide to where information gaps may be limiting management's ability to act.

Appendix B is a summary of the assessment of the likely future risks to the Reef as presented in the Outlook Report.

Finer scale analysis and synthesis documents were also considered. These include:

- [Biodiversity Conservation Strategy 2013](#) and associated vulnerability assessments for high risk species and habitats
- [Informing the Outlook for Great Barrier Reef Coastal Ecosystems](#)
- [Coastal Ecosystem Assessment Framework and basin assessments](#)
- [Great Barrier Reef Climate Change Adaptation Strategy and Action Plan, 2012-2017](#)
- [Ecological risk assessment of the East Coast Otter Trawl Fishery in the Great Barrier Reef Marine Park: technical report](#)
- [Recreation Management Strategy](#)
- [Reef Plan Scientific Consensus Statement, 2013](#)
- [Reef Water Quality Protection Plan – Research Development and Innovation Strategy 2013–2018](#)
- [Resilience-based framework for environmental decision making in the Great Barrier Reef World Heritage Area](#)
- [Integrated Monitoring Framework](#).

In each of the above documents, the identification of knowledge gaps and recommendations for future research, monitoring and modelling were based on comprehensive risk-based approaches and included external expert opinion and stakeholder consultation.

Advice from key research institutions as well as Australian and Queensland government partners was taken into account in developing this strategy.

## 2.5. Framework and terminology

This strategy is based on the driver, pressure, state, impact and response (**DPSIR**) framework (Figure 1), which has been widely adapted and applied in managing and reporting on the state of the environment, including by the [European Environment Agency](#), [United States Environmental Protection Agency](#) and the [Australian Government](#). This framework is constructed on a set of cause-and-effect relationships where drivers and influencing factors cause pressures that affect the state (or condition) of both the ecological and human systems that make up the environment. The condition of those ecological and human systems has an impact on the benefits derived by the community. Management responses are adapted to reflect changes in all components of the system.

All aspects of the environment in the Great Barrier Reef Region, including ecological, heritage, social and economic values are collectively referred to as the 'Region's values'.

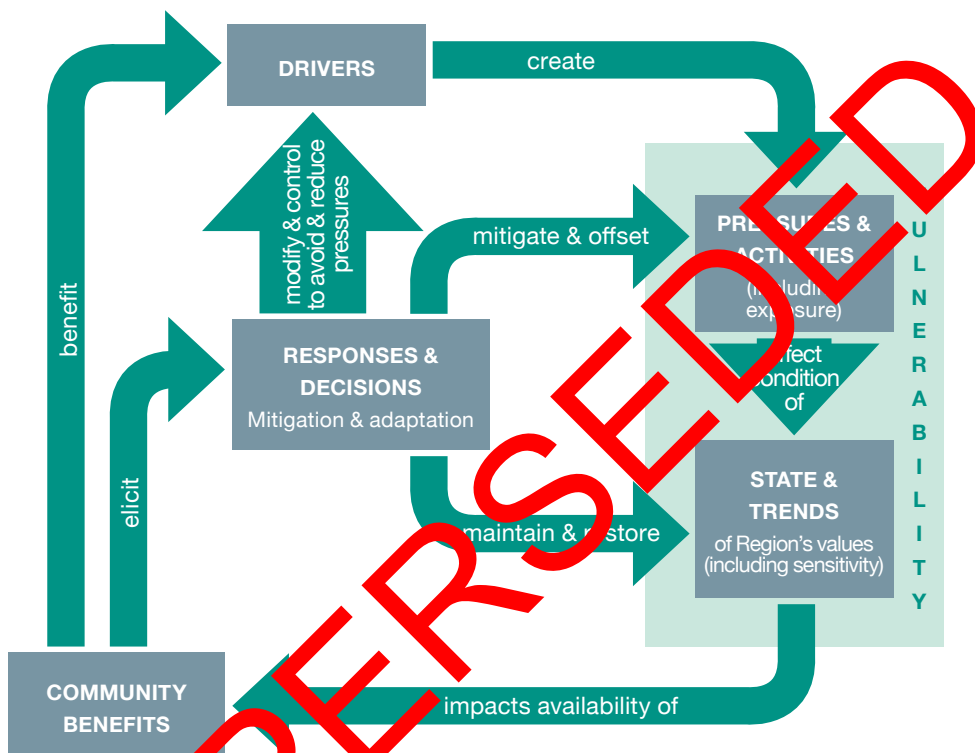


Figure 1. How research, modelling and monitoring inform adaptive management, based on a Driver, Pressure, State, Impact, and Response framework. To adaptively manage the complex system, each of the components of the driver, pressure, state, impact, response framework, and their cause and effect links, need to be understood through monitoring, research and modelling. Results are reviewed against management objectives, outcomes and targets and decision alternatives selected, based on a management strategy. Responses include modifying and/or controlling drivers to avoid and reduce pressures, mitigate and offset pressures and activities, and maintaining or restoring the state of the Region's values.



# 3. Scientific approaches to inform adaptive management

To adaptively manage a system as complex as the Great Barrier Reef, each component of the DPSIR framework (Figure 1) and their cause-and-effect links needs to be understood through the three major scientific approaches — monitoring, targeted research and modelling. Combinations of all three approaches will be required to address the science information needs articulated in this strategy. Results are reviewed against management objectives, outcomes and targets, with the results used to adapt management responses. Their outcomes will ultimately improve future management responses to avoid, mitigate or offset pressures, deliver net environmental benefit and promote appreciation of the Region's values.

## 3.1. Monitoring, including community knowledge

Monitoring is required to track each component of the DPSIR framework over time. It provides information on the condition of the Region's values and factors influencing those values. It also plays a fundamental role in evaluating management effectiveness and assessing future risks. It is critical to informing the development, refinement and application of models that help managers better understand trends and patterns occurring in the Region.

Monitoring data are used to meet statutory reporting requirements such as the agency's five-yearly Outlook Report and its annual report, as well as other reporting obligations including communicating the outcomes of actions under the [Reef Water Quality Protection Plan 2013](#).

One of the key new initiatives outlined in the agency's 25-year management program is an integrated Reef-wide monitoring and reporting program to support adaptive management (see Section 5.3).

## 3.2. Targeted research

Targeted research improves understanding of cause-and-effect relationships in the ecological and human systems; improves interpretation of monitoring information; contributes to the refinement of models; identifies ecosystem thresholds and pressures, including a better understanding of cumulative effects; contributes to identifying indicators, and informs the selection of management responses.

The agency engages with, undertakes, commissions, influences or is a partner in a wide range of targeted research relating to the Region. It will continue to rely on such research to enhance understanding of the Reef and to inform and improve management measures.

## 3.3. Modelling

Modelling is required to better understand the complex, variable and interconnected systems that make up the Great Barrier Reef. It allows assumptions to be made about the condition of values and the extent of pressures at larger scales than would be possible from research or monitoring data alone. It can also be used to test management measures and predict their effectiveness at achieving desired outcomes and targets.

The agency recognises the need to build staff capacity in modelling and its application to management. The agency will strengthen collaboration with partner organisations with modelling expertise, including the Australian Institute of Marine Science, CSIRO and Australian Research Council Centre of Excellence for Integrated Coral Reef Studies.

# 4. Science needs, 2014 to 2019

## 4.1. Focus

The agency has adopted a set of outcomes and targets to provide a clear line of sight between statutory objectives and management actions. Outcomes apply to the full suite of the Region's values and will guide the agency's planning and decision-making. Targets have been nominated for a set of key values, processes and pressures (listed in Appendix C) and are designed to ensure actions within the Region and the catchment are focused on aspects critical to the health of the Reef and restoration, maintenance and enhancement of the Region's values.

To support the agency's outcome-based target-driven management approach, priority will be given to scientific information that informs actions to:

- restore the condition of values and processes in poor and very poor condition (see Appendix A), including critical habitats such as coral reefs and seagrass meadows and ecological processes such as connectivity and recruitment
- maintain and enhance the condition of values and environmental processes in good and very good condition.

Improved scientific knowledge and understanding will also be required to support the agency's major new Reef Recovery Program — implementing regional and local cooperative management approaches to address threats to the Region's values and promote sustainable use. Introduction of this program recognises that, while there is a suite of common issues across the Region, the way these interact is often very localised and varies from place to place. In developing the program, priority will be given to addressing pressures that affect identified at-risk species and habitats. Priority will be given to implementing the program in Keppel Bay, Mackay, and Townsville (Cleveland and Bowling Green bays), as well as Princess Charlotte and Bathurst bays further north.

The agency will also be seeking to better understand and take into account cumulative effects in its management of the Reef, particularly in assessing and deciding on the grant of permits and developing planning arrangements. The need to understand and address cumulative effects is strongest in the inshore areas of central and southern areas of the Region, particularly close to major regional centres.

## 4.2. Themes

There are four overarching themes for the agency's science information needs, based on the DPSIR framework:

- A. Drivers and pressures
- B. Key values
- C. Thresholds and desired condition
- D. Management responses.

The first three themes are interrelated and directly inform understanding of the interactions between the drivers, activities, pressures, state, and effects within the system. The fourth theme concerns the testing of current and possible management responses to identify the most appropriate, cost-effective and feasible options available.



For each of the themes, a set of 'key questions' is provided setting out the broad scope of the agency's science needs. More detailed questions for each theme are described in a web-based [register of detailed knowledge needs](#). This will be regularly updated to address emerging issues and critical information needs for management. For each theme, the science needs are put into context through a discussion of why the theme is important for management and how the scientific information generated will be applied to adaptive management.

Identification and development of individual science projects under each theme should be designed to answer one or more of the questions, taking into account the broader DPSIR framework and the management context.

Table 1 summarises how scientific information generated under each theme will contribute to developing, refining and implementing the various management tools employed by the agency.

**Table 1 Contribution of science information to developing, refining and implementing management tools**

Management tools	Theme A Drivers and pressures	Theme B Key values	Theme C Thresholds and desired condition	Theme D Management responses
Acts and Regulations			●	●
Zoning Plan	●	●	●	●
Plans of management	●	●	●	●
Permits (including environmental impact assessment)	●	●	●	●
Fees and charges	●			●
Traditional Owner agreements	●	●	●	●
Compliance	●	●	●	●
Site infrastructure	●	●	●	●
Policy	●	●	●	●
Partnerships	●			●
Stewardship and best practice	●	●	●	●
Education and community awareness	●	●	●	●
Reporting	●	●	●	●



## Theme A: Drivers and pressures

A better understanding of the cause-and-effect links between drivers, influencing factors and pressures will be an important contribution to improved protection and management of the Great Barrier Reef. In particular it is crucial to better understand the interactions between pressures and the ecological, heritage, cultural, social, economic values of the Region, including having a more dynamic understanding of cumulative effects.

### Key questions — Drivers and pressures

1. What are the current and projected future status and trends of drivers, influencing factors and pressures affecting key ecological, cultural, heritage, economic and social values in the Great Barrier Reef Region?
2. How do pressures act cumulatively on the Great Barrier Reef ecosystem, its biodiversity and heritage values and the community benefits they provide and what would be appropriate decision-support tools and methods for considering this?
3. How do coastal ecosystem functions contribute to poor water quality when altered?
4. What are the consequences of coastal development, including port development, on the Region's values?
5. What are the consequences of climate change (including ocean acidification) on the Region's values?
6. What are the risks to and effects on species of conservation concern, species stocks and habitats from commercial, recreational, Traditional and illegal fishing?
7. What are the time lags for ecosystem responses to changes in the pressures affecting the Reef?
8. What is the quantified cumulative effect of crown-of-thorns starfish outbreaks, and what is the influence of other disturbances on the probability of outbreaks?
9. How do Traditional Owners consider that drivers, influencing factors and pressures have affected Indigenous heritage values?

### Why is this important?

Declining Great Barrier Reef health indicates the need to not only protect and restore the condition of values and processes, but to improve the management of high risks and cumulative effects. The agency's 25-year management program recognises that halting and reversing declines in the health of the Region's values will depend on minimising not only short-term or acute pressures, but also cumulative and chronic pressures, some of which may seem insignificant in isolation. An increased understanding of cumulative effects can improve management decisions, particularly those related to environmental impact assessment. In addition, a better predictive capacity and understanding of effects on particular values or in defined spatial areas allows future scenarios to be more thoroughly explored.

The five key drivers affecting Reef health identified in the strategic assessment and Outlook Report are economic growth, human population growth, societal attitudes (people's relationship with the Reef), technological developments and climate change. The reports highlight an unprecedented decline in the condition of species and habitats within the Great Barrier Reef's southern and central inshore areas over recent decades. Development within the catchment and beyond, including agriculture, urban expansion, industrial development, mining and port activities, is adding further pressure to inshore areas already affected by poor water quality from land-based run-off, recent cyclones and floods. Although considerable gains have been made in reducing pressures from fishing, a number of high risks remain such as overfishing of some predators, incidental catch of species of conservation concern, effects on other discarded species, fishing unprotected spawning aggregations and illegal fishing and poaching (see Appendix B).

Understanding links between these drivers, influencing factors and pressures, including connectivity within and between terrestrial and marine-based systems, is an important part of proactive management. The way these factors interact is often localised and can vary significantly from place to place as do the management responses required to protect and restore the values in each area. It is therefore important to tailor management responses at a regional or local scale.

An understanding of cause-and-effect links between drivers, influencing factors and pressures at the scale of individual catchments and bays will be an important contribution in this shift to more locally specific management actions by the agency and its partners.

## How will it be applied to management?

Results of research, monitoring and modelling undertaken under this theme will be used to inform management activities such as:

- developing and implementing the Reef Recovery Program, with priority on Keppel Bay, Mackay, Townsville (Cleveland and Bowling Green bays), Princess Charlotte Bay and Bathurst Bays
- developing policies, guidelines for assessing cumulative effects
- strengthening guidelines for water quality and hydrodynamic modelling
- developing processes for prioritising potentially at-risk elements of biodiversity and for targeting actions, including the allocation of biodiversity offsets from major developments
- developing an integrated management framework for the detection, control and adaptive management of crown-of-thorns starfish outbreaks, including Reef-wide risk modelling
- estimating the non-retained catch of each fishery in the Great Barrier Reef Region and the level and types of interactions with species of conservation concern by fishing activities
- developing a dredging management strategy, including measures to address dredging-related effects on Reef water quality and ecosystem health
- integrating responses to priority pressures, including cumulative effects affecting land, inshore and coastal terrestrial systems
- predicting future scenarios and identifying emerging issues likely to affect the Region's values
- assessing social resilience in the face of climate change and extreme weather, which contributes to adaptation planning.

## Theme B: Key values

The condition of values is a result of exposure to cumulative effects of multiple pressures through the complex interconnections in the Reef system (Theme A) and the sensitivity of values to those effects (Theme C). Knowledge of the condition and trend of values is consequently critical to understanding vulnerability and managing for resilience.

### Key questions — Key values

1. What are the current condition, trend and projected future condition of the Region's values?
2. Given the assessment of vulnerability for at-risk species and habitats is there any spatial consistency in the effects of pressures that could guide prioritisation and be addressed by targeted actions?
3. What are the Traditional Owner and shared heritage values and community benefits derived from the Great Barrier Reef?
4. What are the connections between community benefits and the natural and heritage values which support them, and how are these connections changing over time?
5. What are the patterns of human use in the Great Barrier Reef and how are these affected by population and economic growth as well as societal attitudes? How will these patterns affect biodiversity and biocultural diversity, including on islands?
6. What long-term social, cultural and economic changes are likely as a result of the effects of climate change on the Great Barrier Reef?
7. How will new biodiversity knowledge and understanding improve management's ability to protect the Region's values, including identification of new values and hotspots?



## Why is this important?

A comprehensive understanding of the condition of the Region's values — encompassing ecological, heritage, social and economic values — is crucial to their ongoing protection and management. It allows management actions to be directed towards matters at highest risk, informs assessments of management effectiveness and is a key component of reporting.

While there is a growing body of information about the condition of some key habitats, species and processes in the Region, for example coral reefs, seagrass meadows, dugongs, marine turtles and water quality, the condition of other key biodiversity components and many ecosystem processes is poorly understood.

Heritage values (including Indigenous and historic) of the Region have previously received limited scientific attention — improving understanding of these values and trends in their condition is a major component of this theme. Priority is also given to understanding the connections between community benefits and the natural and heritage values which support them, and how these connections change over time.

## How will it be applied to management?

Results of monitoring, research and modelling undertaken under this theme will be used to develop and adapt a number of management tools, including:

- developing and refining outcomes and targets for key values, based on their condition and trend over time
- developing an inventory of inshore biodiversity hotspots and identifying places of biocultural diversity, social significance and heritage value to inform management actions regarding offsets and net benefits, as well as decisions to avoid and mitigate impacts
- identifying priority islands in the Great Barrier Reef World Heritage Area, which are strongholds for some vegetation communities and breeding populations of key species
- evaluating the carbon sequestration potential of Great Barrier Reef habitats, such as island ecosystems, mangroves, seagrasses and saltmarshes (blue carbon)
- identifying and prioritising sites that provide and are forecast to keep providing, key ecosystem services (natural, cultural, social and economic) at a regional or local scale, as well as areas where these services have been compromised
- developing more effective methods for early identification of crown-of-thorns starfish outbreaks (including population dynamics, dispersal mechanisms, genetic connectivity and hydrodynamic models), enabling the development of early warning systems to support proactive management actions before outbreaks expand beyond the initiation zone
- characterising degraded habitats and species on the upper continental slope in the southern Great Barrier Reef and updating assessments of their vulnerability to human uses
- identifying priority wetland sites (including freshwater and coastal wetlands, mangroves and estuarine environments) for management intervention, taking into account overall catchment condition and how it affects wetland capacity
- improving identification of Indigenous heritage values
- updating the [Great Barrier Reef Marine Park Heritage Strategy 2005](#) and completing heritage management plans for Low Isles and North Reef light stations
- developing a historic heritage database
- completing conservation management plans for major historic shipwrecks, including updates to existing plans
- improving the capacity to survey potential maritime heritage sites within the Region
- developing impact assessment guidelines for cultural heritage values in the Region
- establishing standards to understand and report on condition and trend of the aesthetic qualities of the Reef, islands and coast.

## Theme C: Thresholds and desired condition

This theme is focused on better understanding the desired condition of the Reef ecosystem and the thresholds beyond which it would no longer sustain natural processes and remain in a healthy condition. Such information is important in future decision making by the agency, particularly in relation to the granting of permits. It is also relevant in defining triggers for management action.

### Key questions — Thresholds and desired condition

1. What constitutes healthy Great Barrier Reef habitats and what is understood by ecosystem health and function?
2. What might be realistic, regionally-specific desired states for the Region's values that management should be directed towards, taking into account social, cultural, heritage and economic aspects, and the cost to manage versus restore?
3. What are suitable proxies of ecosystem health for monitoring and reporting now and into the future?
4. In a given high-impact area (embayment scale) what are the primary causes of cumulative effects? For which of these does management intervention most effectively improve ecosystem health and function?
5. What are critical and early-warning ecosystem thresholds for coral reefs, seagrass meadows and other key coastal habitats such as mangroves?
6. What are ecosystem thresholds from a Traditional Owner perspective and do they compare with western thinking?
7. What are spatially-explicit critical thresholds for dugong abundance?
8. What thresholds can be established for very high risk species such as snubfin dolphin in hotspot habitat areas?
9. How do cumulative disturbances affect the productivity, recovery, fecundity and survival of key habitats and species and ecosystem function?
10. How can recording and mapping of social, heritage and cultural values; community recollections; traditional ecological knowledge; and historical records be used to increase understanding of shifting baselines?
11. What are appropriate levels of fishing if extensive fisheries are ecologically sustainable and viable in the long-term, including consideration of target stocks, bycatch and the broader environment? What management arrangements would support this?
12. How can climate-induced geographic shifts of species and habitats be effectively taken into account in management measures?

### Why is this important?

To achieve its goals of protecting and restoring the Great Barrier Reef and ensuring use is ecologically sustainable, the agency requires a strong understanding of the desired state of the Reef and its vulnerability, including thresholds of unacceptable change for values. This will help guide management actions and decisions, including estimating the residual effects of pressures and determining potential offset mechanisms.

Particularly, science undertaken under this theme will help the agency develop regionally-based ecosystem health standards, incorporating thresholds and management triggers, as part of its Reef Recovery Program. Because many values and processes are currently in poor condition, past standards may no longer be appropriate to the recovery of the ecosystem.

## How will it be applied to management?

Information generated under this theme through monitoring, research and modelling will guide and prioritise management actions including:

- defining regionally-based ecosystem health standards, reflecting the past and current condition of the Region's values and their desired condition
- defining ecological thresholds and tipping points, including for fisheries
- developing management triggers for pressures and values
- improving the agency's water quality guidelines to include cumulative effects and regional scales
- determining regionally appropriate standards for wastewater discharges
- assessing whether or not likely residual effects of pressures from specific developments would exceed critical thresholds in the short, medium or long-term
- developing a net benefit policy
- developing methods for the early detection of ecological stress
- developing monitoring tools and methods for ship noise
- informing cumulative effects assessments.

## Theme D: Management responses

This theme is designed to direct scientific activities towards investigating the effectiveness of actual and potential management responses to protect and manage the Reef. This will assist the agency and its partners in better understanding the most effective options for management and the most appropriate scales for action.

### Key questions – Management responses

1. What are the effects of existing management measures on the condition of the Region's values?
2. What adaptation strategies, including improvements to current management and new strategies, could be used to improve the resilience of the Region's values? Particularly:
  - 2.1. How can management strategies in the catchment and nearshore areas (planning and decision making across all uses) be improved to better protect coastal systems adjacent and connected to the Reef?
  - 2.2. How can environmental offsets be best applied to maintain the condition of the regions values and deliver improvements through net environmental benefit?
  - 2.3. How can fisheries of the Great Barrier Reef and adjacent areas be best managed to protect Great Barrier Reef values and meet future challenges?
  - 2.4. What is the most effective crown-of-thorns starfish control strategy to ensure that coral cover targets are achieved?
  - 2.5. What strategies, approaches and scales of management action can support adaptive management?
3. How do current governance arrangements, including structures and processes of decision making on matters directly or indirectly affecting the Great Barrier Reef, affect management outcomes? What efficiencies could be gained?
4. How can monitoring, targeted research and modelling and innovative science be improved and employed to more efficiently and accurately assess management effectiveness and guide management actions?

## Why is this important?

Understanding the performance of existing management, including the spatial scale of management actions relative to pressures, is critical to an adaptive management strategy. Management agencies need to know if implemented strategies are reducing risks to the marine environment, whether the scale of



management actions is appropriate for the pressures being targeted, and if not, what possible alternative strategies might more effectively reduce risks.

This theme concerns the evaluation of specific management strategies and governance arrangements implemented by the agency and other management agencies, and fosters research into innovations to solve key problems. This will help feed into regular assessments of management effectiveness, including in the agency's Outlook Report and Queensland Parks and Wildlife Services' management effectiveness evaluation.

## How will it be applied to management?

Results of monitoring, research and modelling undertaken under this theme will be used for the following management actions:

- streamlining, harmonising and enhancing the agency's statutory and non-statutory management tools
- testing, evaluating and refining management interventions for building resilience of vulnerable species and habitats
- improving certainty for planning and management
- improving compliance with management arrangements
- supporting best practice and stewardship
- evaluating the cost-effectiveness of management actions, taking into account costs to affected industries and communities
- evaluating the effects of illegal activities, and the ecological benefits of compliance and enforcement
- testing and defining the effectiveness of potential dredge spoil mitigation measures including defining innovative approaches and new treatment technologies for the beneficial reuse of dredge material
- developing robust, cutting-edge restoration methods for habitats affected by shipping incidents
- developing evaluation tools to support effective sea country partnerships with Traditional Owners
- developing operationally efficient and effective techniques for controlling crown-of-thorns starfish outbreaks
- testing the sensitivity and practicality of available sampling and monitoring tools for field assessment of introduced marine pests, and developing better methods for the early detection of outbreaks of significant pest species on islands (for example crazy ants)
- in conjunction with Fisheries Queensland and the fishing industry, identifying innovative approaches to measure and reduce fishery bycatch, minimise habitat damage from fishing gear, and mitigate risks to species of conservation concern
- influencing decisions in other jurisdictions that affect the Great Barrier Reef, including coastal planning and fisheries management responses
- informing the five-yearly assessment of management effectiveness undertaken through the Outlook Report process.



# 5. Strategy implementation

This strategy articulates the science needs of the agency for the next five years. In support of the strategy and to foster maximum use of its outcomes, the agency will support science activities as appropriate, nurture partnerships with science providers, internally coordinate science information and manage its broader dissemination.

With regard to applying knowledge to management, key areas of focus include integrating knowledge, monitoring and reporting into adaptive management; improving alignment and coordination of research priorities; increasing emphasis on the use of modelling approaches; improving spatial mapping capabilities; supporting long-term monitoring programs; and standardising data collection and facilitating sharing.

This section outlines how the agency will deliver the strategy and support the collection and dissemination of scientific knowledge.

## 5.1. Guiding principles

In implementing this strategy, the agency will adopt the following guiding principles:

- A clear adaptive management framework is crucial to facilitating a sound scientific basis for management decisions
- Ongoing engagement with research and information providers maximises the relevance of scientific information to management
- Monitoring data and other information relevant to the Reef will be incorporated into an integrated monitoring and reporting program
- A sustained capacity to synthesise and integrate scientific information into management responses is crucial to strengthening management
- Improved discoverability and access to scientific information facilitates its use by management and other stakeholders
- Effective management outcomes depend on full integration of economic, social and environmental information
- Where there is uncertainty and a lack of knowledge, a risk-based approach will be adopted in management decisions and actions
- Where appropriate, Traditional, community and scientific knowledge should be integrated for broader understanding

## 5.2. Influencing science programs

Although the agency directly funds or manages the acquisition of only a very small proportion of the science information it uses, it endeavours to influence or be a partner in a wide range of monitoring, research and modelling activities related to the Reef. This is made possible through the agency's continued engagement with funding providers and participation in the development and execution of major research programs, such as the National Environment Research Program (NERP), which funded research in the Great Barrier Reef from July 2011 to December 2014. The agency anticipates it will be similarly involved in the development and implementation of the National Environment Science Program (NESP), NERP's successor, with its input based on the contents of this strategy.

The agency's preferred approach to supporting scientific projects and maximising their usefulness to management has been to collaborate with scientists from initial planning through to analysis and reporting. This participatory approach is achieved through:

- articulating problems
- framing specific questions
- assisting in project design
- participating in project teams and steering committees for research projects
- assessing and granting research permits
- providing letters of support for grant applications
- providing funding (although direct funding from the agency is limited)
- advising on the most useful form and timing of delivery of information
- helping interpret science for government and the public
- facilitating the application of science to policy and operational outcomes.

Research undertaken in the Great Barrier Reef Marine Park requires a permit if it can't be undertaken as part of an accreditation of a research institution. Whilst the agency will continue to assess applications in the shortest time possible, changes are being made to the way permit applications are assessed and researchers are encouraged to submit their application for a permit as soon as possible.

### 5.3. Reef integrated monitoring and reporting program

The agency is developing and implementing the Reef Integrated Monitoring and Reporting program (RIMRep) to measure and report progress towards achieving its management program and meeting its commitments under the [Reef 2050 Long-Term Sustainability Plan](#).

The program will improve integration and coordination of existing monitoring programs through the development and implementation of standardised protocols for information collection, collation, analysis, reporting, and data availability. It will improve the scalability of data (from point source or local, to regional and Reef-wide scales) and synthesis of information from different sources. This will provide a more comprehensive and systematic understanding of the condition of values and scale of effects.

Outcomes from the increased use of modelling to improve our understanding of cause-and-effect relationships between drivers, influencing factors, pressures and the Region's values as well as cumulative effects will inform development of the program.

The program will include:

- long-term core monitoring programs — to assess the condition and trend of the Region's values and broadscale effects of pressures, such as water quality, over many years
- short to medium-term, issue-specific monitoring — to examine the condition, extent of pressures on and recovery rate of the Region's values
- compliance monitoring — to measure the effects of a development action (for example, construction of a marina dredging program) in accordance with conditions specified in a permit, licence or approval.

Over time, consistent reporting of information at a regional scale will help further refine and target management actions. Work is already underway between governments, industry and the community to progressively develop regional-scale report cards for priority catchments.

The monitoring program will incorporate the knowledge and information of Traditional Owners, industry and the community. It will draw on existing monitoring systems and datasets and will be progressively developed.

Reports on the program will be provided annually to the Great Barrier Reef Ministerial Forum. The results of the integrated monitoring program will be a major information source for future reporting, including Great Barrier Reef Outlook Reports and annual reports, and Australian and Queensland government state of environment reports, including assessments of the condition and trend of key values and pressures and progress towards achieving outcomes and targets.



## 5.4. Communicating science

The agency seeks to access information relevant to protection and management of the Great Barrier Reef generated by research providers, Traditional Owners and stakeholders to add to the body of knowledge on which its decisions (for example in the consideration of permit applications) and other management actions are based. In addition, the agency strives to provide the information to other decision makers and the public, in clear and plain language.

This translation of data and information to knowledge is important to:

- strengthen debates held nationally and internationally on Great Barrier Reef issues, by illustrating how the agency has taken different scientific viewpoints into account and identified relevant risks, in developing and assessing options and arriving at decisions
- strengthen community confidence in emerging science, including by emphasising the role that science plays in underpinning the work of the agency
- enhance the literacy of the wider community on contemporary Great Barrier Reef science, including by enhancing public access to information resources and assets
- support Traditional Owners in their continuing care and protection of the Great Sea Country.

Through its communication and media strategy, the agency is committed to communicating the value of up-to-date information and knowledge, including traditional ecological knowledge, and the ways best available science has informed decision making.

## 5.5. Managing uncertainty

As highlighted in the agency's 25-year management program, managers are often required to act in the absence of scientific certainty, and timeframes for decision making may differ from the publication of relevant science results. The [APS200 Project Report](#) (2012) acknowledges that policy makers need to be able to manage uncertainty in scientific analysis in the same way it is managed when providing advice on complex issues in the absence of agreement or complete information.

Recognising the complexity of the Region, the agency is committed to using the best available scientific information whilst applying the precautionary principle — that the lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment.

## 5.6. Data and information management

The uptake of scientific evidence and advice into management measures relies on appropriate collection, management, synthesis, communication and accessibility of science.

Science information for the Great Barrier Reef World Heritage Area is generated by a wide range of institutions with their own data storage systems. These systems vary from carefully curated government or institutional data systems to management of individual programs by lead researchers. Although there are efforts to ensure that government-funded research and monitoring data is accessible through the Australian National Data Service portal, enhanced coordination between end users and existing data management systems is needed. The Reef Integrated Monitoring and Reporting Program relies on appropriate data management procedures (for example data management plans established at the beginning of projects, appropriate data storage infrastructure and a metadata repository).

The agency will build on existing systems locally, nationally and internationally to improve discoverability and accessibility of data. The agency will work to enhance the collection, generation, synthesis, use and dissemination of scientific information, both internally and externally. This includes:

- reviewing relevant internal and external procedures, policies and frameworks to ensure the best available scientific information is available for consideration in decision making
- ensuring that information received by agency staff involved in program committees, advisory committees and formal partnerships with external bodies is appropriately disseminated within the agency through the development of formalised internal systems
- monitoring information assets on a regular basis, including timely advance notification of upcoming science publications
- developing and implementing a Creative Commons framework to standardise data and report sharing, including:



- for reports commissioned by industries as part of developments in and adjacent to the Great Barrier Reef Marine Park that have an effect on the Region's values; and
- for data from specific monitoring programs such as the Marine Monitoring Program and the Integrated Eye on the Reef Program.
- investigating the possibility of access to commercial fishery data at regional and local scales, taking into account commercial-in-confidence issues
- ensuring agreements and memoranda of understanding with research partners are in place, including for the conduct of 'as-of-right' scientific research
- supporting Traditional Owners to develop Indigenous Ecological Knowledge management systems
- ensuring information systems and software are relevant, best practice, and provide easily discoverable and accessible paths to research information and data, including through a meta-portal to redirect to main portals where individual datasets are stored
- publishing peer-reviewed reports which synthesise existing knowledge and identify research gaps including through five-yearly publication of the agency's science information needs
- maintaining a web-based, up-to-date register of detailed knowledge needs to drive ongoing improvements and complete the adaptive management cycle
- establishing data sharing agreements, developing protocols and knowledge management systems for culturally sensitive information, and integrating knowledge into management decisions.

All these actions will help the agency efficiently curate, synthesise and incorporate the best available scientific information in policy development and decision-making.

### Key features of good data management

The features of data management systems that improve use of scientific information by managers and add value to investments in data generation include:

- intuitive data discovery, including through metadata
- clearly defined data storage options
- secure data management systems
- distributed and centralised hosting of data
- agreed standards for data storage (including version control)
- an agreed and common vocabulary and key words
- clear definition of terms and conditions of data use, including rules for acknowledging provenance
- options for entry — flexibility in the level of investment for data providers
- regular archiving of data — periodic snapshots of data that are securely stored
- appropriate funding — ideally analysis and reporting should be about 30 per cent of the cost of monitoring programs
- a long-term perspective, including management well beyond the life of the data collection period, recognising that datasets appreciate over the long term, increasing in value as data continue to be added
- treating the data management system as an asset, for example by including the management elements of planning, implementation, maintenance, decommissioning and upgrade.

# Appendix

## Appendix A — Summary of values condition and trend and threats from *Great Barrier Reef Outlook Report 2014*

### Biodiversity — habitats

Assessment component	2014 grade and trend	2014 confidence	
		Grade	Trend
Islands	Good, Deteriorated	Limited	Limited
Mainland beaches and coastlines	Good, Stable	Limited	Limited
Mangrove forests	Good, Stable	Limited	Limited
Seagrass meadows	Poor, Deteriorated	Limited	Limited
Coral reefs	Poor, Deteriorated	Adequate	Adequate
Lagoon floor	Good, Stable	Inferred	Inferred
Shoals	Good, Stable	Limited	Inferred
Halimeda banks	Very good, Stable	Inferred	Inferred
Continental slope	Good, Deteriorated	Inferred	Inferred
Open waters	Good, Deteriorated	Adequate	Adequate

### Biodiversity — population of species and groups of species

Assessment component	2014 grade and trend	2014 confidence	
		Grade	Trend
Mangroves	Very good, Stable	Limited	Inferred
Seagrass	Poor, Deteriorated	Limited	Limited
Macroalgae	Good, Stable	Limited	Limited
Benthic microalgae	Very good, Deteriorated	Inferred	Inferred
Coral	Poor, Deteriorated	Adequate	Adequate
Other invertebrates	Good, Deteriorated	Inferred	Inferred
Plankton and microbes	Very good, Deteriorated	Inferred	Inferred
Bony fish	Good, Deteriorated	Limited	Limited
Sharks and rays	Poor, Deteriorated	Limited	Limited
Sea snakes	Poor, Stable	Limited	Inferred
Marine turtles	Poor, No consistent trend	Adequate	Adequate
Estuarine crocodiles	Good, Improved	Limited	Adequate
Seabirds	Poor, No consistent trend	Limited	Limited
Shorebirds	Poor	Inferred	Not assessed
Whales	Good, Improved	Limited	Limited
Dolphins	Good, Deteriorated	Inferred	Inferred
Dugongs	Poor, Deteriorated	Adequate	Adequate



**Physical processes**

Assessment component	2014 grade and trend	Confidence	
		Grade	Trend
Currents	Very good, Deteriorated	Anecdotal	Anecdotal
Cyclones and wind	Good, Deteriorated	Limited	Limited
Freshwater inflow	Good, Deteriorated	Adequate	Adequate
Sedimentation	Poor, Deteriorated	Adequate	Adequate
Sea level	Good, Deteriorated	Adequate	Adequate
Sea temperature	Poor, Deteriorated	Adequate	Adequate
Light	Good, Deteriorated	Limited	Limited

**Chemical processes**

Assessment component	2014 grade and trend	Confidence	
		Grade	Trend
Nutrient cycling	Poor, Deteriorated	Adequate	Adequate
Ocean pH	Good, Deteriorated	Adequate	Adequate
Ocean salinity	Good, Deteriorated	Adequate	Adequate

**Ecological processes**

Assessment component	2014 grade and trend	Confidence	
		Grade	Trend
Microbial processes	Good, Stable	Anecdotal	Anecdotal
Particle feeding	Good, Deteriorated	Anecdotal	Anecdotal
Primary production	Very good, No consistent trend	Limited	Limited
Herbivory	Good, Deteriorated	Limited	Limited
Predation	Poor, No consistent trend	Anecdotal	Limited
Symbiosis	Good, Deteriorated	Anecdotal	Limited
Recruitment	Poor	Limited	Not assessed
Reef building	Good, Deteriorated	Anecdotal	Anecdotal
Competition	Good, Stable	Anecdotal	Anecdotal
Connectivity	Good, Deteriorated	Limited	Limited

**Terrestrial habitats that support the Great Barrier Reef**

Assessment component	2014 condition	Confidence
		Condition
Saltmarshes	Good	Limited
Freshwater wetlands	Poor	Limited
Forested floodplains	Poor	Limited
Heath and shrublands	Very good	Limited
Grass and sedgeland	Poor	Limited
Woodlands and forests	Poor	Limited
Rainforests	Good	Limited

### Outbreaks of disease, introduced species and pest species

Assessment component	2014 condition and trend	Confidence	
		Condition	Trend
Outbreaks of disease	Good, No consistent trend	Limited	Anecdotal
Outbreaks of crown-of-thorns starfish	Very poor, Deteriorated	Limited	Limited
Introduced species	Good, No consistent trend	Anecdotal	Anecdotal
Other outbreaks	Good, No consistent trend	Anecdotal	Anecdotal

### Indigenous heritage values

Assessment component	2014 grade	Confidence	
		Condition	Grade
Cultural practices, observances, customs and lore	Good	Limited	Limited
Sacred sites, sites of particular significance, places important for cultural tradition	Poor	Limited	Limited
Stories, songlines, totems and languages	Poor	Limited	Limited
Indigenous structures, technology, tools and archaeology	Poor	Limited	Limited

### Historic heritage values

Assessment component	2014 grade	Confidence	
		Condition	Grade
Historic voyages and shipwrecks	Poor	Adequate	Adequate
Historic lightstations	Good	Adequate	Adequate
World War II features and sites	Poor	Limited	Limited
Other places of historic significance	Poor	Inferred	Inferred

### Other heritage values

Assessment component	2014 grade	Confidence	
		Condition	Grade
Social heritage values	Good	Limited	Limited
Aesthetic heritage values	Good	Limited	Limited
Scientific heritage values	Good	Adequate	Adequate

**Economic and social benefits of use**

Assessment component	2014 grade and trend	2014 confidence	
		Grade	Trend
Commercial marine tourism	Very good, Stable	Adequate	Adequate
Defence activities	Good, Stable	Adequate	Adequate
Fishing	Good, Stable	Adequate	Adequate
Ports	Very good	Adequate	Not assessed
Recreation (not including fishing)	Very good, Stable	Limited	Limited
Research and educational activities	Very good, Stable	Adequate	Adequate
Shipping	Very good	Adequate	Not assessed
Traditional use of marine resources	Very good, Stable	Inferred	Inferred

**Impacts of use on the Region's values**

Assessment component	2014 grade and trend	Confidence	
		Impacts	Trend
Commercial marine tourism	Very low impact, Stable	Adequate	Adequate
Defence activities	Very low impact, Stable	Adequate	Adequate
Fishing	High impact, Stable	Limited	Limited
Ports	High impact	Limited	Not assessed
Recreation (not including fishing)	Low impact, Stable	Limited	Limited
Research and educational activities	Very low impact, Stable	Limited	Limited
Shipping	Low impact	Adequate	Not assessed
Traditional use of marine resources	Very low impact, Decreased	Limited	Limited

**Impacts on ecological values**

Assessment component	2014 grade and trend	Future trend	Confidence	
			Grade	Trend
Climate change	Very high impact, Increased	Increasing	Adequate	Adequate
Coastal development	High impact, Increased	Increasing	Adequate	Adequate
Land-based run-off	High impact, Decreased	Decreasing	Adequate	Adequate
Direct use	Low impact, Increased	Increasing	Limited	Limited

## Impacts on heritage values

Assessment component	2014 grade and trend	Future trend	Confidence	
			Grade	Trend
Climate change	Very high impact	Increasing	Limited	Limited
Coastal development	High impact	Increasing	Limited	Limited
Land-based run-off	High impact	Decreasing	Adequate	Limited
Direct use	Low impact	Increasing	Adequate	Limited

## Impacts on economic values

Assessment component	2014 grade and trend	Future trend	Confidence	
			Grade	Trend
Climate change	High impact, Increased	Increasing	Limited	Adequate
Coastal development	Low impact, No consistent trend	No consistent trend	Limited	Limited
Land-based run-off	High impact, Decreased	Decreasing	Limited	Limited
Direct use	Very low impact, Stable	Stable	Adequate	Limited

## Impacts on social values

Assessment component	2014 grade and trend	Future trend	Confidence	
			Grade	Trend
Climate change	High impact, Increased	Increasing	Limited	Limited
Coastal development	Low impact, Stable	Stable	Limited	Limited
Land-based run-off	Low impact, Decreased	Decreasing	Limited	Limited
Direct use	Low impact, Stable	Stable	Limited	Limited



## Appendix B — Assessment of future risks

	Threat	Risk		Timing	Influencing factors			
		Ecosystem	Heritage values		Climate change	Coastal development	Land-based run-off	Direct use
Region-wide	Altered weather patterns	Very high	Very high	Now	●			
	Sea temperature increase	Very high	Very high	Now	●			
	Ocean acidification	Very high	Very high	10+	●			
	Sea level rise	Very high	Very high	10+	●			
	Modifying coastal habitats	Very high	Very high	Now		●		
	Nutrient run-off	Very high	Very high	Now			●	
	Sediment run-off	Very high	Very high	Now			●	
	Outbreak of crown-of-thorns starfish	Very high	Very high	Now			●	
	Illegal fishing and poaching	Very high	Very high	Now				●
	Incidental catch of species of conservation concern	Very high	Very high	Now				●
	Barriers to flow	Medium	Medium	Now		●		
	Marine debris	Medium	Medium	Now			●	●
	Incompatible uses	Low	Medium	Now				●
	Discarded catch	Medium	Medium	Now				●
	Extraction of predators	Medium	Medium	Now				●
	Extraction of particle feeders	Medium	Medium	Now				●
	Altered ocean currents	Medium	Medium	10+	●			
Local or regional	Pesticide run-off	Medium	Medium	Now			●	●
	Disposal of dredge material	Medium	Medium	Now		●		●
	Extraction from spawning aggregations	Medium	Medium	Now				●
	Outbreak of disease	Medium	Medium		Cumulative effect of many factors			
	Outbreak of other species	Medium	Medium		Cumulative effect of many factors			
	Terrestrial discharge	Medium	Medium	Now			●	
	Acid sulphate soils	Medium	Medium	Now		●	●	
	Artificial light	Medium	Medium	Now		●		●
	Damage to reef structure	Medium	Medium	Now				●
	Damage to seafloor	Medium	Medium	Now				●
	Dredging	Medium	Medium	Now		●		●
	Exotic species	Medium	Medium	Now			●	●
	Extraction of herbivores	Medium	Medium	Now				●
	Grounding large vessel	Medium	Medium	Now				●
	Illegal activities — other	Medium	Medium	Now				●
	Noise pollution	Medium	Medium	Now		●		●
	Spill — large chemical	Medium	Medium	Now				●
	Spill — large oil	Medium	Medium	Now				●
	Vessel strike	Medium	Medium	Now				●
	Vessel waste discharge	Medium	Medium	Now				●
	Wildlife disturbance	Medium	Medium	Now				●
	Grounding small vessel	Medium	Medium	Now				●
	Spill — small	Medium	Medium	Now				●
	Atmospheric pollution	Medium	Medium	Now		●		●

A table showing the 41 threats (by abbreviated title) in column one, their level of risk to the Region's ecosystem and heritage values (columns 2 and 3), timing (column 4, is shown as either now or more than ten years) and which influencing factors are causing the threat — climate change, land-based run-off, coastal development and direct use (columns 5 to 8). The associated scale of each threat is indicated as either 'Region-wide' or 'local or regional'. Very high risk threats acting on a region-wide scale now are: altered weather patterns, sea temperature increase, modifying coastal habitats, nutrient run-off, sediment run-off, outbreak of crown-of-thorns starfish, illegal fishing and poaching, and incidental catch of species of conservation concern. Very high risk threats acting on a region-wide scale in more than 10 years' time are: Ocean acidification and sea level rise. High risk threats acting on a region-wide scale now are: Barriers to flow, marine debris, incompatible uses, discarded catch, and extraction of predators. High risk threats acting on a local or regional scale now are: pesticide run-off, disposal of dredge material, extraction from spawning aggregations, and outbreak of disease.

Risk				Timing	
Low	Medium	High	Very high	Now	10+ More than 10 years

## Appendix C — Key values, processes and pressures

Values	Processes	Pressures
<b>Biodiversity</b> <ul style="list-style-type: none"> <li>Islands</li> <li>Beaches and coastlines</li> <li>Mangrove forests</li> <li>Coral reefs and corals</li> <li>Seagrass meadows and seagrasses</li> <li>Open water</li> <li>Supporting terrestrial habitats</li> <li>Other invertebrates</li> <li>Bony fish</li> <li>Sharks and rays</li> <li>Sea snakes</li> <li>Marine turtles</li> <li>Seabirds</li> <li>Shorebirds</li> <li>Dolphins</li> <li>Dugongs</li> <li>Humpback whales</li> </ul>	<ul style="list-style-type: none"> <li>Waves, currents and tides *</li> <li>Cyclones *</li> <li>Sedimentation *</li> <li>Sea level *</li> <li>Sea temperature *</li> <li>Nutrient cycling *</li> <li>Ocean acidity *</li> <li>Freshwater inflow and salinity *</li> <li>Primary production — pelagic</li> <li>Herbivory *</li> <li>Predation *</li> <li>Connectivity</li> <li>Recruitment</li> <li>Reef building *</li> </ul> <p>* addressed via indicators for values or pressures</p>	<b>Climate change</b> <ul style="list-style-type: none"> <li>Altered ocean currents and small scale circulations</li> <li>Cyclone activity</li> <li>Increased sea and air temperature</li> <li>Ocean acidification</li> <li>Rising sea level</li> </ul>
<b>Indigenous heritage</b> <ul style="list-style-type: none"> <li>Cultural practices, observances, customs and lore</li> <li>Indigenous sacred sites, sites of particular significance, places important for cultural tradition</li> <li>Indigenous stories, song lines, totems and languages</li> <li>Indigenous structures, technology, tools and archaeology</li> </ul>		<b>Land-based run-off</b> <ul style="list-style-type: none"> <li>Increased freshwater inflow</li> <li>Nutrients from catchment run-off</li> <li>Outbreak of crown-of-thorns starfish</li> <li>Pesticides from catchment run-off</li> <li>Sediments from catchment run-off</li> </ul>
<b>Historic heritage</b> <ul style="list-style-type: none"> <li>Places of historic significance, including:               <ul style="list-style-type: none"> <li>historic ship wrecks</li> <li>World War II features and sites</li> <li>lightstations</li> </ul> </li> <li>Places of social significance</li> </ul>		<b>Degradation of coastal ecosystems</b> <ul style="list-style-type: none"> <li>Artificial barriers to flow</li> <li>Coastal reclamation</li> <li>Modifying supporting terrestrial habitats</li> </ul>
<b>Community benefits</b> <ul style="list-style-type: none"> <li>Income and employment</li> <li>Understanding of the Great Barrier Reef</li> <li>Appreciation, enjoyment and aesthetics (natural beauty)</li> <li>Access to reef resources</li> <li>Personal connection</li> <li>Health benefits</li> </ul>		<b>Direct use</b> <ul style="list-style-type: none"> <li>Dredging and spoil disposal</li> <li>Extraction – death of discarded species</li> <li>Extraction – fishing in spawning aggregations</li> <li>Extraction – predators</li> <li>Illegal fishing and poaching</li> <li>Marine debris</li> <li>Noise pollution</li> <li>Outbreaks of disease</li> </ul>

These key values, processes and pressures were selected as follows:

- **Biodiversity** (habitats and species): a classification of 'at risk' in the agency's vulnerability assessments; affected by a high or moderate level of single or cumulative effects; a key ecological feature; a source of important community benefits; iconic status; specific reporting obligations (for example, World Heritage listing); or the subject of existing monitoring that is of value to management.
- **Processes:** critical to the functioning of matters of national environmental significance; critical to the recovery of values assessed to be in poor, very poor or declining condition; affected by a high or moderate level of single or cumulative effects; having specific reporting obligations; or not sufficiently informed by the monitoring of biodiversity values (see above) or key pressures (see below).
- **Pressures:** assessed to be of high or very high risk in the strategic assessment due to its effects on multiple values (acute or chronic) or over a broad scale (acute or chronic); or the subject of existing monitoring that is of value to management.

**Heritage values** and **community benefits** values are less well developed than biodiversity values, ecosystem processes and key pressures. Those identified are based on work undertaken for the strategic assessment, expert opinion and legislative requirements. Mechanisms to systematically identify and monitor social, cultural and economic drivers and values across the Region are being developed.

This list will continue to be refined to ensure they represent the best measures of the Great Barrier Reef Region's environment and key environmental pressures.

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