EVALUATION REPORT AUGUST 2016

Monitoring potential impacts of climate change on natural values

OF THE TASMANIAN WILDERNESS WORLD HERITAGE AREA

Department of Primary Industries, Parks, Water and Environment

Tasmanian Government

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Monitoring and Reporting System for Tasmania's National Parks and Reserves

This report is a product of the Tasmanian Government's management effectiveness Monitoring and Reporting System for national parks and reserves. An important component of the system is evaluated case study reports on the monitored effectiveness of significant and selected projects/programs in achieving their objectives. For information about Tasmania's Monitoring and Reporting System see this report on the Parks and Wildlife Service website at www.parks.tas.gov.au/monitoring.

MONITORING AND REPORTING SYSTEM FOR TASMANIA'S NATIONAL PARKS AND RESERVES

EVALUATED CASE STUDY REPORT	
PERFORMANCE ARENA:	3. MANAGMENT OF THREATS, RISKS AND IMPACTS
Key Performance Area:	**3.9. Climate Change Adaptation**
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Cover images: Main image: Monitoring feldmark vegetation on The Boomerang in the far south of Tasmania. Smaller images from top left: Monitoring coastal herbfield in Hannant Inlet, Port Davey. Pencil Pines (*Athrotaxis cupressoides*. Zoanthids (colonial anemones) in Bathurst Harbour (photo: Fred Bavendam; all other images: DPIPWE).

Evaluation report: Monitoring potential impacts of climate change on natural values of the Tasmanian Wilderness World Heritage Area

This report examines the progress, achievements and challenges of an initiative to establish a reliable foundation of knowledge and understanding of the potential impacts of climate change on a range of natural values considered to be at risk in the Tasmanian Wilderness World Heritage Area, and subsequently monitor and document any observed shifts under climate change. The purpose of the program is to provide reliable measured evidence to inform sound decision-making for climate change adaptation through ongoing policy and strategy development. Although too early in the term of this program to provide a full assessment of performance, it is clear that significant progress has been made in delivering the planned outputs. Priority natural values at risk from climate change have been identified and documented; baseline monitoring has been established in selected ecosystems; and five years of weather data have been successfully collected. This evaluation concludes that this initiative has performed very well to date.

Introduction

The world's climate system is warming. The atmosphere and oceans have warmed, sea level has risen, and in a number of regions the frequency of heavy precipitation events has increased, whilst extreme weather events in general are becoming more common (IPCC, 2014). Tasmania, like other parts of Australia, is already showing evidence of these types of changes.

The Australian Government and all Australian State and Territory Governments have recognised the importance of adapting to climate change. There is agreement that while some level of change is unavoidable, adaptation strategies involving governments, business and the community are required to lessen the impacts.

Climate change increasingly presents a major challenge for nature conservation in Tasmania, and for management of the State's world class reserves and unique natural heritage. Gaining an understanding of the specific nature of the threats, risks and impacts posed by climate change to Tasmania's natural environments and values will help inform and guide sound evidence-based strategic planning for appropriate mitigation and adaptation responses to climate change.

Government, natural resource managers, land managers, community organisations and the broader community all stand to benefit from having a reliable foundation of knowledge and understanding of the potential impacts of climate change on natural values at risk in the Tasmanian Wilderness World Heritage Area.

About the threat or issue

The issue of climate change and the threat it poses globally are detailed in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report on Climate Change (IPPC 2014).

The Fifth IPPC Assessment Report states that anthropogenic drivers (largely economic growth and population growth) have increased greenhouse gas emissions (of carbon dioxide, methane and nitrous oxide) to levels that are unprecedented in at least the last 800,000 years. The report concludes: 'Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.'

Climate change is expected to have impacts on many aspects of biodiversity and geodiversity, including impacts on ecosystems, their component species and associated genetic diversity, and on ecological interactions. For Australia and New Zealand, the most vulnerable sector to the impacts of climate change is biodiversity, which faces greater risks than sectors such as agriculture and forestry, health, tourism and major infrastructure (IPCC 2007).

Climate change trends in Tasmania are consistent with global trends (see Figure 1). Much of Tasmania has experienced a warming in average temperatures since the 1950s, accompanied by decreases in average rainfall since 1970 (Grose *et al.* 2010). Sea level has risen 10-20 cm in the last century, with water temperatures off Tasmania's east coast increasing by more than 1°C since the 1940s (DPIPWE 2010). Ocean acidity levels have also increased in recent times, along with atmospheric carbon dioxide levels (DPIPWE 2010).

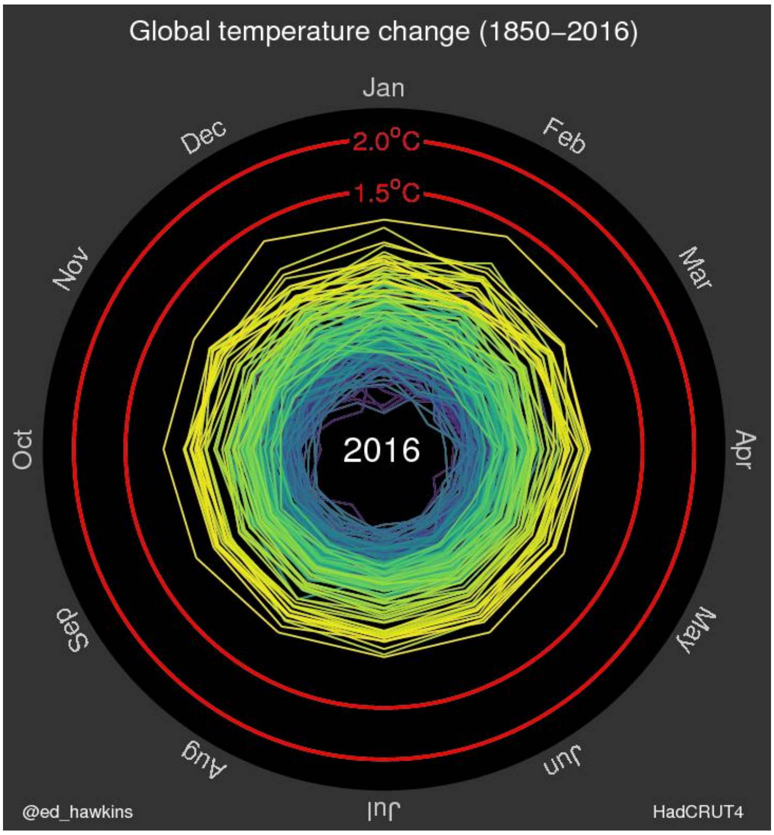

Figure 1. Spiralling global annual temperature records. This graphic shows the recorded global annual temperatures over the past 160-plus years, commencing in 1850 and progressing unbroken until March 2016. The earliest recorded temperatures are represented by the purple line which progresses over time through blue, green and culminates in yellow representing the most recent past. The red circles represent the internationally discussed temperature targets for limiting dangerous climate change. Note the general increase in average temperature over time towards the present and what appears to be a recent change in the rate of increase.

Source: Climate Lab Book (open climate science) at http://www.climate-lab-book.ac.uk/2016/spiralling-global-temperatures/

Climate Futures for Tasmania projections[1] indicate that average temperatures will rise consistently across Tasmania, particularly in central Tasmania and at higher elevations; that increased summer and autumn rainfall is likely in the east, and increased winter rainfall and reduced summer rainfall in the west. Central Tasmania will have reduced rainfall in all seasons (ACE CRC 2010). Over the coming decades, Tasmania is expected to experience increased land and sea temperatures; changes to rainfall patterns and higher evaporation in most areas; wind speed changes; and sea level rises. These factors in combination will lead to a significant increase in the number of days per year when fire sensitive vegetation communities, such as rainforest, will be capable of burning.

In addition, there is mounting evidence that lightning-caused wildfires may be on the increase in Tasmania (Parks and Wildlife Service, 2015). As an example, following an extended period of significantly below average rainfall in the latter half of 2015 and early 2016, a series of dry lightning storms over Tasmania ignited over 80 blazes on the 13th of January 2016. The resulting wildfires burnt over 123,000 ha across Tasmania including 20,100 ha within the TWWHA. The impacts of these fires included the likely permanent loss of some areas of iconic pencil pine vegetation and the degradation of approximately 8,000 ha of other alpine and subalpine vegetation not adapted to fire. Whilst it is not possible to categorically attribute a single event to climate change, it is widely accepted by relevant experts that events such as this are likely to be attributable to changing weather patterns and can be expected to become more common as climate change continues.

Wildfires are a major threat to ancient and fire sensitive vegetation in the TWWHA. This photo shows the aftermath of a recent fire at Lake MacKenzie—one of 80 wildfires across Tasmania ignited by dry-lightning strikes in January 2016. There is mounting evidence that lightning-caused wildfires may be on the increase in Tasmania.

Photo: copyright Rob Blakers

1 Climate Futures for Tasmania was a project undertaken by the Antarctic Climate and Ecosystems Cooperative Research Centre with a range of partners (ACE CRC 2007) that produced fine-scale projections based on six IPCC AR4 climate simulation models to dynamically downscale to a grid resolution of 0.1° (approx. 10km) (Corney *et al.* 2010). The models and projections include information regarding changes in the various regions of Tasmania (Grose *et al.* 2010).

What natural values are likely to be affected?

The effects of climate change are considered likely to exacerbate some existing stressors to natural values—such as fire, weeds, diseases and habitat fragmentation. Cascading impacts through complex and cumulative interactions among multiple system components are likely to occur and are difficult to predict. The following sections outline DPIPWE's current understanding of potential impacts of climate change on natural values with particular reference to the Tasmanian Wilderness World Heritage Area.

Geodiversity

Tasmania contains a wide variety of rock types, landforms and soils with many of these geodiversity resources represented in the TWWHA (Sharples 2003). In addition to their intrinsic values, these features and systems underpin a diverse suite of ecosystems within Tasmania's land-use mosaic of conservation reserves and productive landscapes. Climate change will affect geomorphic processes, landforms and soil systems directly, and also as a consequence of people's adaptation to the changing environment.

Degradation of moorland organic soils and soils on the Central Plateau by desiccation and erosion or by increased fire frequency and intensity has been identified as the most significant climate change related risk to Tasmanian geodiversity (Sharples 2011). Other major geomorphic systems most likely to be affected by climate change are fluvial (rivers, lakes and wetlands) and coastal/estuarine systems. Sandy coasts and muddy estuaries will be critically affected by sea level rise. Changes in key environmental drivers—such as temperature, rainfall, evapotranspiration and storminess—will have varying effects on earth surface processes throughout the State. Those aspects of geodiversity associated with active or recently active land and soil forming processes are considered the most likely to be affected by climate change[2].

Alpine geomorphic processes of solifluction[3], patterned ground[4], alpine lunettes[5], and nivation[6] are likely to become further limited in Tasmania. Other less extensive systems (including karst[7], aeolian[8] and active hillslope processes such as landslips) will also be affected, with locally important effects on landforms and geoconservation values.

Terrestrial biodiversity

Tasmania has globally and nationally significant natural values on several levels, including cultural, scientific, and ecological. Globally significant ecosystems in Tasmania include alpine communities, temperate rainforests, tall eucalypt forests, buttongrass moorlands, high-energy coastal systems (Balmer *et al.* 2004) and the Port Davey marine and estuarine ecosystem (Edgar *et al.* 2010). These ecosystems are largely, or in the case of Port Davey entirely, located within the TWWHA.

Climate change is expected to lead to ecosystem changes, including the emergence of novel ecosystems[9] for which there are no current analogues, and local species extinctions (Dunlop and Brown 2008). There will also be effects on ecosystem processes which will affect ecosystem services

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2 Note also that the sedimentary record of geomorphic response to earlier climatic change could provide valuable input to refining local predictions of what is to come.

3 **Solifluction** is the gradual, downhill movement of soil or other material in areas typically underlain by frozen ground such as periglacial environments.

4 **Patterned ground** is the distinct, and often symmetrical geometric shapes formed by ground material in periglacial regions.

5 **Lunettes** are crescent-shaped dunes bordering a lake.

6 **Nivation** is the collective name for the different processes that occur under a snow patch.

7 **Karst** is the technical term used to describe a region that has underground drainage with many cavities and passages caused by the dissolution of the rock. Limestone cave systems are a familiar example of karst.

8 **Aeolian** means relating to or caused by wind.

9 **Novel ecosystems** are new combinations of species (often including invasive and native species) occurring in places that have been altered in structure and/or function as a result of human activity, especially in the modern era.

provided to society. Changed climatic parameters—including decreased rainfall, increased temperature, and increased occurrence of extreme events such as higher frequency and potentially severity of drought and fire—will impact variably on terrestrial biodiversity across the State. Tasmania's mountainous terrain and ocean-moderated climate provide buffering against some aspects of broadscale predictions of climate change impacts. However, Tasmania's complex geography creates diverse and often localised climatic conditions and gradients which support a variety of ecological communities with comparatively narrow ecological niches, and some of these communities are likely to be affected by climate change locally or across their range.

Many of the ecosystems, species and values of the TWWHA have been identified as being at risk from climate change (Australian National University 2009; Brown 2009; DPIPWE 2010; Sharples 2011; Mallick 2013).

As an example, alpine ecosystems could be transformed by increasing shrub and tree colonisation and growth. Alpine ecosystems are also highly vulnerable, particularly to increased stochastic[10] risk of fire. Tasmanian moorlands and peatlands are potentially vulnerable particularly on steeper, better drained slopes. The Tasmanian alpine ecosystem, like many mountain regions of the world, is distinguished by high vascular plant diversity and endemic richness (Kirkpatrick and Brown 1984). The bolster heaths or cushion communities so characteristic of Tasmania's high country exhibit globally exceptional levels of endemism and diversity, with six endemic species of cushion shrubs. The diversity of Tasmanian alpine conifers (seven species from six genera and two families) is very high, and is rich in primitive, endemic[11] and relict[12] species. These alpine communities support a rich invertebrate community with a very high proportion of endemic and primitive taxa. Many biota taxa are restricted to the alpine zone and modelling suggests that a suite of endemic alpine skinks will likely become extinct by 2085 (Jungalwalla 2010). Highland lakes, tarns and wetlands, which provide a highly diverse array of limnological[13] habitats with few analogues elsewhere in Australia (Fulton and Tyler 1993), are at high risk from climate change. The vertebrate and invertebrate fauna of highland lakes and wetlands have a high component of ancient and relictual[14] taxa of world heritage significance with high levels of endemism. Several rare and endemic fish species have been identified as at high risk from climate change.

Estuarine and marine ecosystems

The globally unique Port Davey–Bathurst Harbour marine ecosystem is at high risk from climate change. Increased water temperatures may lead directly to many estuarine species falling outside their 'climatic envelopes', as well as to the establishment of 'invasive' warm-temperate species which migrate south under a warmer climate (Edgar *et al.* 2010). Reduced summer rainfall would also be likely to cause significant impacts on the Port Davey–Bathurst Harbour system as a result of changes in the depth and transparency of the upper freshwater layer of water (Edgar *et al.* 2010, Barrett *et al.* 2010). Variability in rainfall in response to a changing climate may also be a significant driver of change in the Bathurst Channel invertebrate community over the next century, with this community considered to be particularly sensitive to such changes (Barrett *et al.* 2010).

Background to management

The past decade has seen a significant increase in identification and assessment of the threat of climate change at the international, national and state scales.

10 **Stochastic** means involving a random element, chance or probability and hence unpredictable and without a stable pattern or order. Many natural events are stochastic phenomena.

11 **Endemic** refers to species which are unique to a defined geographic location such as an island or country.

12 **Relict** refers to species which have survived from an earlier period or in a primitive form.

13 **Limnological** means of or pertaining to (the scientific study of the life and phenomena of) fresh water, especially lakes and ponds.

14 **Relictual** refers to a species or population that inhabits a much smaller geographic area than it did in the past, often because of environmental change.

In 2007 the Fourth Assessment of Working Group II of the Intergovernmental Panel on Climate Change (generally referred to as IPCC AR4) completed an assessment of current scientific understanding of the impacts of climate change on natural, managed and human systems and the capacity of these systems to adapt, and their vulnerability. The Climate Change Science Compendium (McMullen and Jabbour 2009), compiled by the United Nations Environment Program, updated and reaffirmed the strong scientific evidence of IPCC AR4, and showed that the pace and scale of climate change is increasing at a greater rate than previously thought by scientists. The assessment identified that biodiversity and other natural values are one of the most vulnerable sectors to the impacts of climate change.

The first national assessment of the vulnerability of Australia's biodiversity to climate change was commissioned in 2007. The final report, *A Strategic Assessment of the Vulnerability of Australia's Biodiversity to Climate Change* (Steffen *et al.* 2009), was released in 2009, along with a technical synthesis and a summary for policy makers. National assessments have also been undertaken to assess the implications of climate change for related issues, including marine life (Hobday *et al.* 2006), Australia's National Reserve System (Dunlop & Brown 2008), natural resource management (Campbell 2008), World Heritage Properties (Australian National University 2009), and fire regimes (Williams *et al*. 2009).

The Tasmanian Government's *Framework for Action on Climate Change* (DPAC 2006) identified four areas where Tasmania should initially focus on adapting to climate change:

1. Ensuring scientific research provides a firm foundation for taking action in different regions and different sectors by measuring and predicting climate change and identifying new approaches;
2. Giving individuals, communities and businesses appropriate information, resources, skills and incentives to plan and adapt to climate change and manage their own risks;
3. Providing an adequate and appropriate emergency response to more frequent and intense events, such as bushfires, floods and storms, and assisting communities recover from such events; and
4. Managing risks to public infrastructure, assets and values (including roads, biodiversity, national parks and reserves), and protecting industry and the community against health and biosecurity risks.

The potential impacts of climate change on Tasmania's natural values, world class reserves and unique natural heritage has been an emerging issue over the past decade.

A preliminary assessment of the implications of climate change for Australia's World Heritage Areas concluded that climate change effects—such as sea level rise, reduced rainfall and higher temperatures—are expected to threaten the resilience of Australia's World Heritage properties, exacerbating issues such as habitat loss and degradation, spread of invasive species and changing fire regimes (Australian National University, 2009).

The Department of Primary Industries Parks Water and Environment (DPIPWE) has carried out a range of investigations in relation to threatening processes and impacts on Tasmania's natural values. This includes an assessment of the vulnerability and potential impacts of climate change on Tasmania's terrestrial, freshwater and marine systems (DPIPWE 2010, Mallick 2013).

An area of ongoing focus for investigations is threats to the internationally recognised natural values of the Tasmanian Wilderness World Heritage Area (TWWHA). The TWWHA program has established a climate change monitoring program which includes documenting climate change impacts on natural values of the TWWHA. As such this report largely outlines the establishment phase of the monitoring program including the documentation of values that are likely to be lost or fundamentally altered under a changing climate.

Overall Management Goal

The overall goal of this program is:

- Establishment of a reliable foundation of knowledge and understanding of the potential impacts of climate change on natural values at risk in the Tasmanian Wilderness World Heritage Area, to monitor change in priority natural assets, including the documentation of values considered at risk of loss from climate change, and to inform sound, evidence-based decision-making for climate change adaptation.

This includes:

(i) compilation of high quality weather data from montane/alpine sites in the TWWHA (to enable assessment of future changes in weather patterns, and increase understanding of altitudinally defined vegetation boundaries and topographic variation in climatic conditions to better inform modelling).
(ii) collection of quantitative biological and environmental data through the establishment of monitoring programs and documenting of natural values (to help understand the impacts of climate change on priority vulnerable ecosystems, species and landforms).

Management actions and significant events

- Contributions by DPIPWE professional specialists in natural resource management and conservation to the State-wide climate change project identifying natural values at risk (DPIPWE 2010).
- Workshops of stakeholders, Parks and Wildlife Service and specialist staff, plus engagement of consultants to review priorities for identification and protection of World Heritage Area natural values (Brown 2009, Sharples 2011, Mallick 2013, DPIPWE 2013).
- Methods and priorities for monitoring dry coastal vegetation in the Tasmanian Wilderness World Heritage Area (TWWHA) identified (Horton *et al.* 2008, Rudman *et al.* 2008).
- Establishment of monitoring of the erosion status of beaches within the TWWHA (Eberhard *et al* 2015)
- Establishment of monitoring of the vegetation development in alpine feldmark vegetation within the TWWHA (Visoiu, 2014)
- Establishment of baseline monitoring for montane conifers in the TWWHA (Fitzgerald 2011).
- Establishment of alpine treeline ecotone monitoring program within the TWWHA (Styger and Balmer 2009) and resurveying of alpine plots at Mt Rufus one decade after their establishment (Harrison-Day *et al*. in press).
- Establishment of baseline monitoring for snowpatches in the TWWHA (Parry 2016).
- Identification of TWWHA fauna values and habitats at risk from climate change and options for management and a framework for monitoring (Mallick 2013)
- Re-survey of vegetation communities and invertebrates along a 1300 m altitudinal gradient at Warra–Mt Weld in 2011–12 which was first established and surveyed in 2001–02 (Doran *et al.* 2003, Grove 2004, Fitzgerald 2012, Driessen and Mallick 2013).
- Re-survey of marine ecosystem, including invasive species, in Port Davey in 2010 and 2011 (Barrett *et al* 2002, Barrett *et al.* 2010, Aquenal *et al* 2003, Aquenal 2011).
- Documentation of the geomorphological evolution of the Prion Beach and New River Lagoon beach barrier system (Cullen and Dell 2013).
- Following major wildfires in Tasmania, in March 2016 the Tasmanian government instigated the TWWHA Bushfire and Climate Change Research Project—a research initiative to investigate the impact of climate change on Tasmania's wilderness areas and strengthen techniques to prepare for and respond to bushfires in wilderness areas.

Monitored results for performance indicators

Table 1: Performance indicators, targets, results

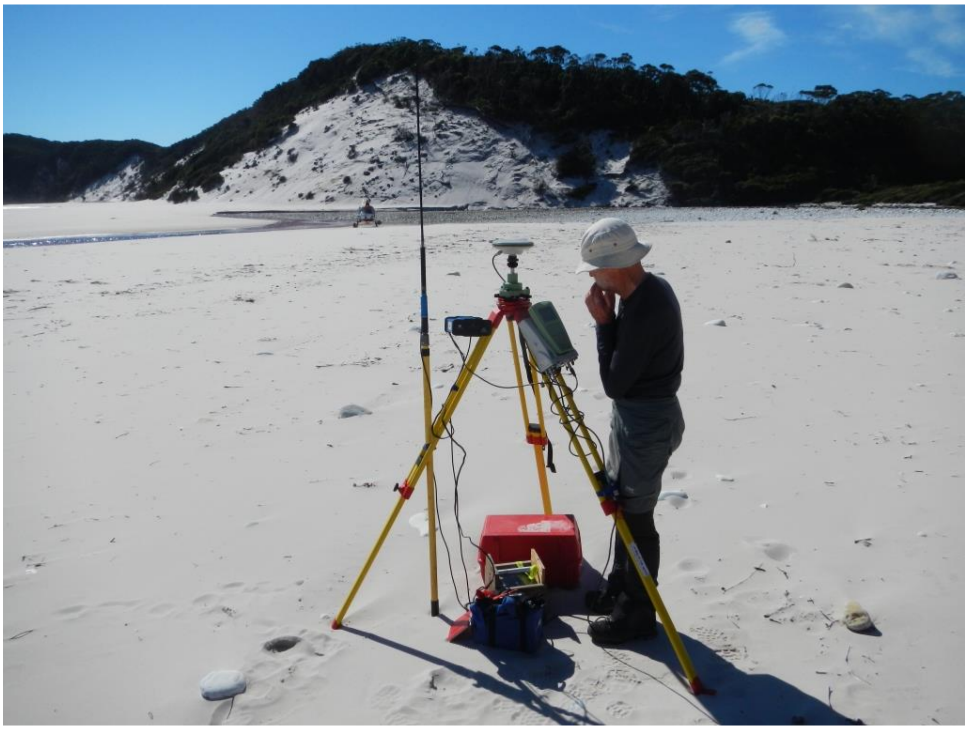
Performance Indicators (and how they are monitored)	**Targets and/or Limits** (and how performance is assessed)	**Monitored Results** (detected over the management period)
PRESSURE INDICATORS[15]		
1. Changes in the climatic parameters that determine the altitude of the alpine vegetation transition		
Monitoring	*Target*	*Results*
Establishment of Automated Weather Stations near the alpine zone on mountains in the TWWHA (an identified priority; previous weather data collected has been from low elevations, with higher altitude conditions modelled).	Collection of a minimum of five years of high quality weather observations from two widely separated sites in the TWWHA as: *a)* a baseline against which any future data can be compared; and *b)* to better inform climate modelling. *Assessment of performance* Successful collection of weather data.	Two weather stations have been established at the Mt Sprent site—one each below and above the alpine/sub-alpine interface. Vegetation monitoring has been established, utilising data from previous work undertaken 20 years ago. The weather station at the Cradle Plateau site provides a comparison with weather data collected in Cradle Valley. Currently, five years of data are available from Mt Sprent and four years of data from Cradle Plateau.
CONDITION INDICATORS[16]		
2. Monitored biological condition of communities in environments which are under immediate threat from changing climatic conditions		
(a) Priority flora values		
Monitoring	*Target or limit*	*Results*
• Monitoring of coastal verge vegetation zonation on soft sediment coasts. • Monitoring of alpine vegetation interfaces on remote mountains. • Monitoring of exposure dependent high altitude communities (Feldmark and snowpatch). • Monitoring of montane conifer health. • Survey of wet forest, subalpine, and alpine vegetation communities along Warra-Mt Weld altitudinal transect.	No targets or limits established—tracking only. *Assessment of performance* Successful establishment and collection of monitoring data. Baseline surveys and establishment reports have been prepared. Re-monitoring is proposed to occur at 10 year intervals, unless there is a major event that indicates a need for earlier reassessment.	Observational and re-photographic evidence indicates that there has been a general decline in montane conifer health in the several decades leading up to 2010. This has been largely observed as a decrease in foliage, browning of trees and decline in vigour. The monitoring component of this study and most other baseline studies have only been established during this management period. A variety of floristic changes occurred in the alpine vegetation on Mt Rufus but there was no evidence of a shift in the treeline in the first decade of monitoring (Harrison-Day 2016). Warra-Mt Weld altitudinal plots were resurveyed in 2011, ten years following establishment with analysis of data not

15 'Pressure indicators' relate to activities, processes and/or agents that are considered to pose a threat of degradation to reserves or reserve values (either directly or indirectly).

16 Condition indicators relate to the condition of reserves or reserve values (e.g. natural or cultural resource assets and features).

Performance Indicators (and how they are monitored)	**Targets and/or Limits** (and how performance is assessed)	**Monitored Results** (detected over the management period)
• Capturing of high resolution aerial imagery within the TWWHA to enable detection of future vegetation and landform change.		yet completed. Conifer monitoring plots within areas burnt by 2016 wildfires were resurveyed in 2016. Extensive areas of high resolution aerial imagery have been captured on the Central Plateau. Imagery has also been captured of soft sediment coastal environments on the South and West Coasts.
(b) Priority fauna values		
Monitoring • Survey invertebrate communities by pitfall trapping along Warra-Mt Weld altitudinal transect.	*Target or limit* No targets or limits established—tracking only *Assessment of performance* Results of surveys using pitfall trappings in 2011-12. Detected changes from the baseline data established in 2001-2002; in particular changes in distribution of species that are restricted by altitude.	*Results* The invertebrate sampling, sorting and identification has been completed. Final analyses and reporting are due to be completed in 2017.
Monitoring • Survey marine community in Port Davey-Bathurst harbour using digital photo-quadrats.	*Target or limit* No targets or limits established—tracking only *Assessment of performance* Changes from the baseline data established in 2010. Results of surveys using digital photo-quadrats in 2010.	*Results* Survey of community types within Bathurst Channel in 2010 showed that this system has remained inherently stable over the time frame since the 2002 survey (Barret *et al*. 2002). One notable change was an apparent 50% decline in sea whip abundance at both Munday Island and Forrester Point at 5m depth. This was interpreted as being a probable consequence of drought conditions leading up to the 2010 survey reducing the water tannin concentration to a point where algal growth became possible in this depth zone, smothering components of the invertebrate fauna (Barrett *et al*. 2010).
Monitoring • Survey of introduced marine pests in Port-Davey Bathurst Harbour using diver video transects, infauna cores, plankton cores, plankton tows, crab traps and beach wrack surveys.	*Target* No nationally listed target marine pest species detected. *Assessment of performance* Results of surveys using diver video transects, infauna cores, plankton cores, plankton tows, crab traps and beach wrack surveys conducted in 2011.	*Results* No nationally listed target pest species or other new introduced marine species were detected during the 2011 survey (Aquenal 2011).

Performance Indicators (and how they are monitored)	**Targets and/or Limits** (and how performance is assessed)	**Monitored Results** (detected over the management period)
(c) Priority geoconservation values		
Monitoring • Documentation of beach barrier system at Prion Beach and New River Lagoon	*Target or limit* No targets or limits established—tracking only. *Assessment of performance* Results from re-measurement of coastal erosion transects.	*Results* Initial geomorphological evolution of the Prion Beach and New River Lagoon beach barrier system was documented by Cullen and Dell (2013) including 10 erosion transects established.
• Erosion monitoring of Port Davey estuaries	*Target or limit* No targets or limits established—tracking only *Assessment of performance* Periodic transect re-measurement and reporting	*Results* Low rates of erosion have been detected in the sheltered and normally depositional environments of Port Davey estuaries. This erosion has been attributed to sea level rise (Bradbury 2011).
OTHER INDICATORS (E.G. SOCIAL OR ECONOMIC)		
No other indicators identified for this project		



Monitoring coastal sand erosion and accretion requires accurate measurement. Here, surveyor Nick Bowden establishes a temporary survey base station to provide an accurate reference for a survey transect across the face of this beach-backing dune.

Photo: R. Eberhard

Supporting evidence

Changes in the climatic parameters that determine the altitude of the alpine vegetation transition

Nearly five years of weather observations have been collected from Cradle Plateau. Fig 2 below shows average daily temperatures from 1286m asl[17] on Cradle Plateau from October 2011 until April 2016. 24 hour rain accumulation is also included. The heat wave recorded in January/February 2014, which was the most severe recoded in high altitude areas of southeastern Australia was able to be correlated with localised vegetation death on Cradle Plateau (Visoiu and Whinam 2015).

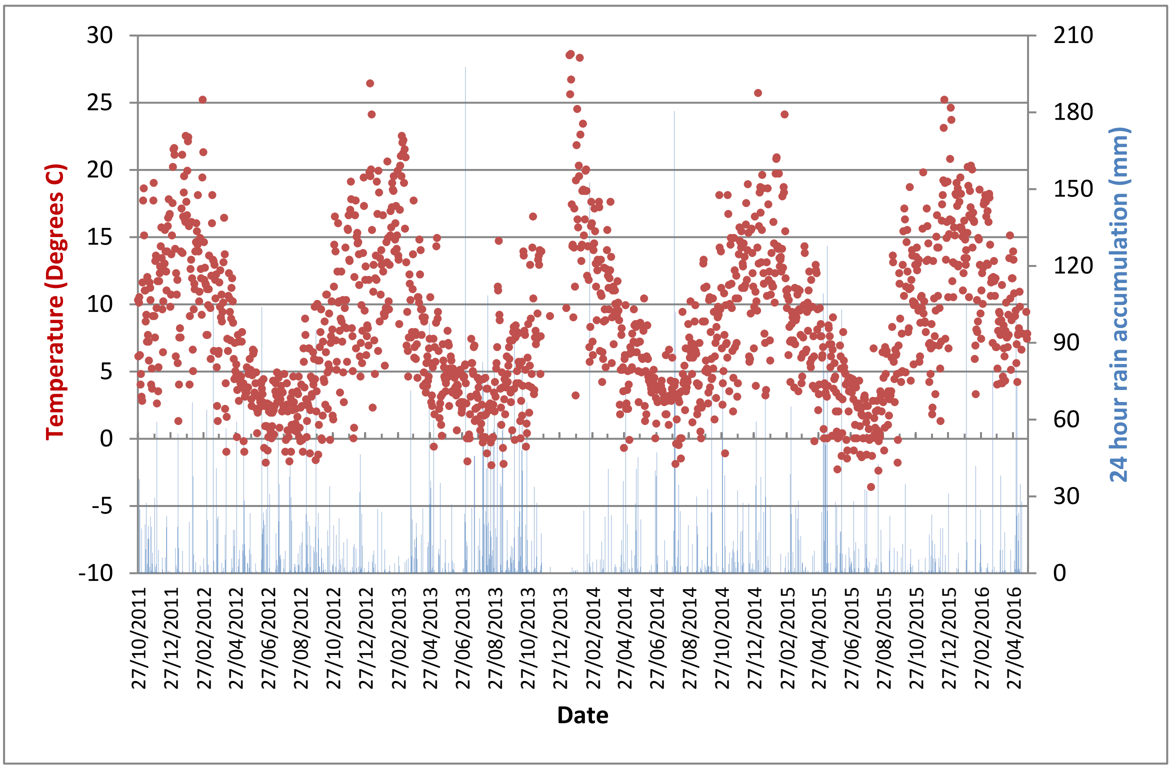


Figure 2. Maximum daily temperatures at 1286m above sea level on Cradle Plateau, as measured at 2m above ground level (red dots) and 24 hour rain accumulation (blue bars). This Automated Weather Station commenced operation in October 2011. Note the five days over 25°C in January 2014 during one of the most extreme high altitude heat waves on record in South Eastern Australia.

Monitored changes in the Bathurst Channel marine invertebrate community

Baseline monitoring of the benthic marine community of Bathurst Channel was established in 2002 and repeated in 2010 to detect any changes over time in species composition and species distribution. Comparisons between 2002 and 2010 show a consistent distribution of representative and characteristic macroalgae and marine invertebrate species over the years at the sites monitored (Barrett *et al.* 2010). The most notable change detected was a significant decline in average abundance of sea whips at Munday Island and Forrester Point, representing an average decline of around 50% in the cover of sea whips at the 5m depth category (see Fig. 3). This decline is considered to be almost certainly related to a prolonged period of drought leading up to the 2010 survey, which resulted in reduced tannin levels via less river runoff, and hence less protection of the invertebrate assemblages against algal overgrowth.

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17 asl stands for 'above sea level'

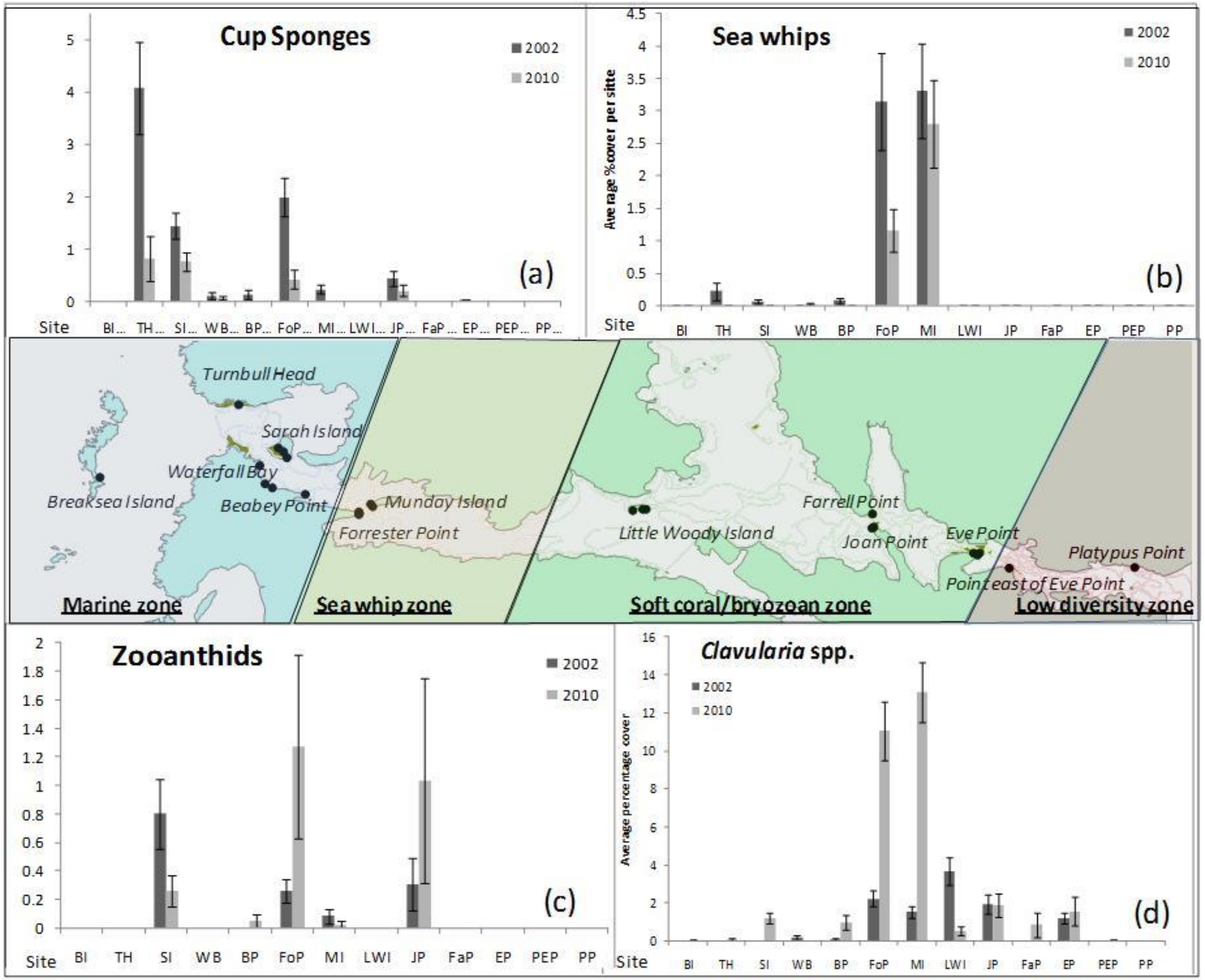

Figure 3. The average percentage cover in 2002 and 2010 at each site surveyed in Bathurst Channel of: a) cup sponges, b) sea whips, c) zooanthids and d) the soft coral *Clavularia* spp. Site codes are as follows: BI= Breaksea Island, TH= Turnbull Head, SI= Sarah Island, WB= Waterfall Bay, BP= Beabey Point, FoP= Forrester Point, MI= Munday Island, LWI= Little Woody Island, JP= Joan Point, FaP= Farrell Point**, EP=Eve Point.

** Farrell Point was not surveyed in 2002.

(Source: Barrett *et al.* 2010)

Outcomes

Table 2: Expected and actual outcomes of this project

Expected outcomes	Actual outcomes/outputs
A. GOAL AND KEY DESIRED OUTCOMES	
Overall Management Goal: • Establishment of a reliable foundation of knowledge and understanding of the potential impacts of climate change on natural values at risk in the TWWHA, to monitor change in priority natural assets, including the documentation of values considered at risk of loss from climate change, and to inform sound, evidence-based decision-making for climate change adaptation. This includes: (i) compilation of high quality weather data from montane/alpine sites in the TWWHA (to enable assessment of future changes in weather patterns, and increase understanding of altitudinally defined vegetation boundaries and topographic variation in climatic conditions to better inform modelling) (ii) Collection of quantitative biological and environmental data through the establishment of monitoring programs and documenting of natural values (to help understand the impacts of climate change on priority vulnerable ecosystems, species and landforms).	• Priority natural values at risk from climate change have been identified and baseline monitoring has been established in selected ecosystems as planned. As at July 2016: o Five years of weather data have been successfully collected from montane/alpine sites in the TWWHA. o Establishment reports and values assessments have been published. o The planned monitoring programs are underway and results are being progressively analysed. o Preliminary findings indicate: - there has been a general decline in montane conifer health in the several decades leading up to 2010. This has been largely observed as a decrease in foliage, browning of trees and decline in vigour. - floristic changes have occurred in the alpine vegetation on Mt Rufus over the past decade of monitoring, although there is no evidence of a shift in the treeline over this period, - a 50% decline in the abundance of seawhips occurred at the 5m depth zone in particular areas of Port Davey-Bathurst Harbour following drought conditions leading up to the 2010 survey. This change is attributed to reduced water tannin concentrations allowing algal growth to occur which smothered some bottom-dwelling invertebrate fauna. - No nationally listed target marine pest species or other new introduced marine species were detected during the 2011 survey of Port Davey-Bathurst Harbour. - Low rates of erosion have been detected in the sheltered and normally depositional environments of Port Davey estuaries, and this is attributed to sea level rise.
B. OTHER ANTICIPATED OUTCOMES/IMPACTS	
Nil identified	
C. UNANTICIPATED OUTCOMES AND/OR LEGACY	
Nil to date	

Assessment and commentary on management performance

Table 3: Assessment of management performance*

LEVEL OF PERFORMANCE	EFFECTIVENESS *To what extent did the project achieve its objectives?*	EFFICIENCY *To what extent was the project delivered on time and on budget? Were resources, including time and effort, used wisely and without wastage?*
Great result		
Satisfactory/Acceptable result	●	●
Unsatisfactory/Unacceptable result		

* This is an interim assessment of the program's performance at this early stage of the program. More informed assessments will be undertaken and reported in future editions of this report.

Comments on management performance

Summary statement on performance: This program is progressing as planned and is on-track to delivering the anticipated outputs in the expected timeframe and budget.

Key factors contributing positively to management performance

- Large, undisturbed natural areas with a minimum of additional stressors have the best opportunity to adjust to an altered climate without catastrophic loss of natural values and ecosystem services such as maintenance of soils and water quality. In this context, the TWWHA provides an excellent example of a large, contiguous reserve system with a high level of legislative protection which is largely free of the most common environmental stressors.
- Funding and staff time have been allocated to this program and it is seen as a priority for TWWHA research supported by the agency executive.

Key factors limiting or threatening management performance

- Difficulty in predicting impacts of climate change on complex systems with limited information on the components of these systems.
- Management of the effects of climate change on values of the TWWHA is likely to be severely limited or impossible given the magnitude of shifts envisaged in terms of both spatial scale and the number of species/values affected.
- Potential for reallocation of program funding and/or staff time to respond to other emerging issues or whole of government priorities.

Suggestions for improving management performance

None provided

Lessons learnt/ additional comments

None provided

Investment in this project

A substantial component of the Natural and Cultural Heritage Division's funding for the TWWHA has been allocated to undertake this project, both through permanent staff and contracted services. The establishment of weather stations has been undertaken with assistance from the Parks and Wildlife Service Fire Management Branch. The identification of natural values at risk from climate change has been undertaken with agency specialists, University of Tasmania personnel, consultants and the National Parks and Wildlife Advisory Council (NPWAC).

Significant funding for this program comes from the Australian Government through joint arrangements with the Tasmanian Government for management of the TWWHA. Direct funding for specific TWWHA Climate Change related projects in the 2015-16 financial year totalled $239,000 and for the 2016-17 financial year, an allocation of $135,000 has been made.

Note also that following the major wildfires in January 2016, the Tasmanian Government announced funding for a new independent research initiative: the TWWHA Bushfire and Climate Change Research Project. This initiative has a focus on investigating the impacts of climate change in the TWWHA, its influence on wildfire, and investigation of techniques for fighting wildfires in remote wilderness areas. The initiative is managed by an independent committee chaired by consultant Tony Press. DPIPWE is represented on the Steering Committee. Research funds are being allocated to various institutions.

Sources

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Micah Visoiu is an ecologist with the Department of Primary Industries, Parks, Water and Environment (DPIPWE). He has authored publications related to botany, ecology and conservation management. His particular area of interest and expertise is biogeography.

Photo: Quinn Visoiu

Dr Jennie Whinam (retired) was formerly DPIPWE's Senior Ecologist for World Heritage Areas and was responsible for establishing this long-term monitoring program. Dr Whinam continues to pursue her professional interests as a world-renowned expert in sphagnum peatland ecology.

Photo: Nick Fitzgerald

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Glenys Jones (PWS Coordinator, Evaluation) guided the preparation of this report.

Dixie Makro (PWS Interpretation Officer – Publications) assisted with graphic design.

References and further information

For more information on the following topics, click on the links below to the DPIPWE website:

- Tasmanian Wilderness World Heritage Area
- Performance monitoring, evaluation and reporting for Tasmania's national parks and reserves

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Photo gallery

Installation of an Automated Weather Station at 941m asl on Mt Sprent in the Tasmanian Wilderness World Heritage Area in October 2010. This station and another below the climatic 'alpine zone' at 849m asl have now provided five years of observations for future use in monitoring and modelling of finer scale interactions of climate with vegetation than has previously been possible.

Photo Nick Fitzgerald

Katie Mulder (a BookEnd Trust student) emptying invertebrate pitfall traps on Mt Weld.

Photo Michael Driessen/DPIPWE

Malaise traps are used to collect flying insects. Insects fly into the black mesh barrier hanging down from the apex of the white canopy sheet. They then crawl upwards towards the sunlight and enter a collecting bottle where they fall into the alcohol-filled container. The trap was set up at 800m on Mt Weld.

Photo, Michael Driessen

Staff walking up Mt Weld to undertake invertebrate sampling.

Photo, Michael Driessen

A permanent photo-point established at upper Mickies Creek on the northern Central Plateau. Similar sites with multiple replicates have been set up across the range of Tasmania's unique montane conifer flora. These extremely long lived species are thought to be at risk of increasing environmental stresses and this monitoring program will allow the detection of any loss in condition on a multi-decadal time scale.

Photo, Nick Fitzgerald

Establishment of photo-plot transects on The Boomerang in the far south of Tasmania will detect any fine scale changes in the geographically restricted Feldmark* communities at this location. Feldmark is highly dependent on macroclimatic conditions including intensity and severity of freeze thaw cycles and intensity, velocity and directionality of winds. Any changes in these parameters are likely to affect changes in the vegetation.

Photo: Tim Rudman

*Feldmark (from Norwegian, meaning 'mountain field') is a plant community characteristic of sites where plant growth is severely restricted by extremes of cold and by exposure to wind, typical of alpine tundra and subantarctic environments.

Examples of condition classes of King Billy pine (*Athrotaxis selaginoides)*: top=4, middle=3, bottom = 2.

Source: Fitzgerald (2011, page 29)

Oblique aerial photograph, Mount Anne: King Billy pine (*Athrotaxis selaginoides)* trees are the bright green crowns, some crown dieback is evident in the lower left.

Source: Fitzgerald (2011, Photo 10, page 37)

Stepped feldmark vegetation on the summit of The Boomerang in the far south of Tasmania. Vegetation such as this is heavily dependent on wind speed and direction as well as freeze thaw cycles and is highly vulnerable to climate change.

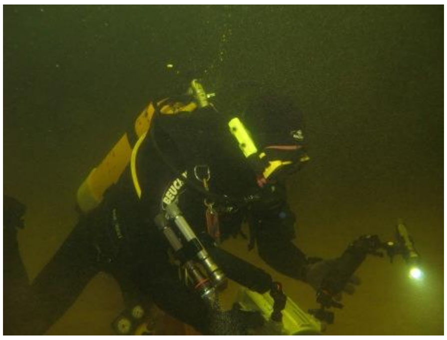
Photo: Tim Rudman/DPIPWE

Establishment of monitoring at low energy coastal sites in Port Davey's Hannan Inlet will provide information on how these precariously placed vegetation communities cope with increased storm surge and king tide intensity and severity. Already these marsupial lawn communities are showing signs of contraction.

Photo: Tim Rudman/DPIPWE

Establishment of coastal transects at Prion Beach on the south coast will help provide information on projected regression of sandy beach systems on the TWWHA coastline.

Photo: Michael Comfort/DPIPWE



Diver undertaking a video monitoring survey of marine invertebrates.

Photo: Courtesy Aquenal

The photos below show some of the extraordinary species that make up the unique bottom-dwelling community of Bathurst Harbour in the Tasmanian Wilderness World Heritage Area. The species shown are all colonial invertebrates and, despite a superficial resemblance to plants, are all actually animals.

Zoanthids (a type of colonial anemone)

Photo: Fred Bavendam

Sea fan in Bathurst Channel

Photo: Fred Bavendam

Sea pens. This species of sea pen normally occurs at much greater depths off-shore but also lives in the shallow dark tannin-stained waters of Bathurst Channel.

Photo: Fred Bavendam

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