Mapping Change In Inshore Ecosystems Around Australia

A Final Report to The Ian Potter Foundation

REEF LIFE SURVEY

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Final report to The Ian Potter Foundation.

The Reef Life Survey Foundation is a non-profit environmental organisation. Donations to the RLSF are tax-deductible and support ongoing monitoring of the marine environment around Australia.

Tryon Island, Capricorn-Bunker, Great Barrier Reef.

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The ‘Lap of Aus’ Project

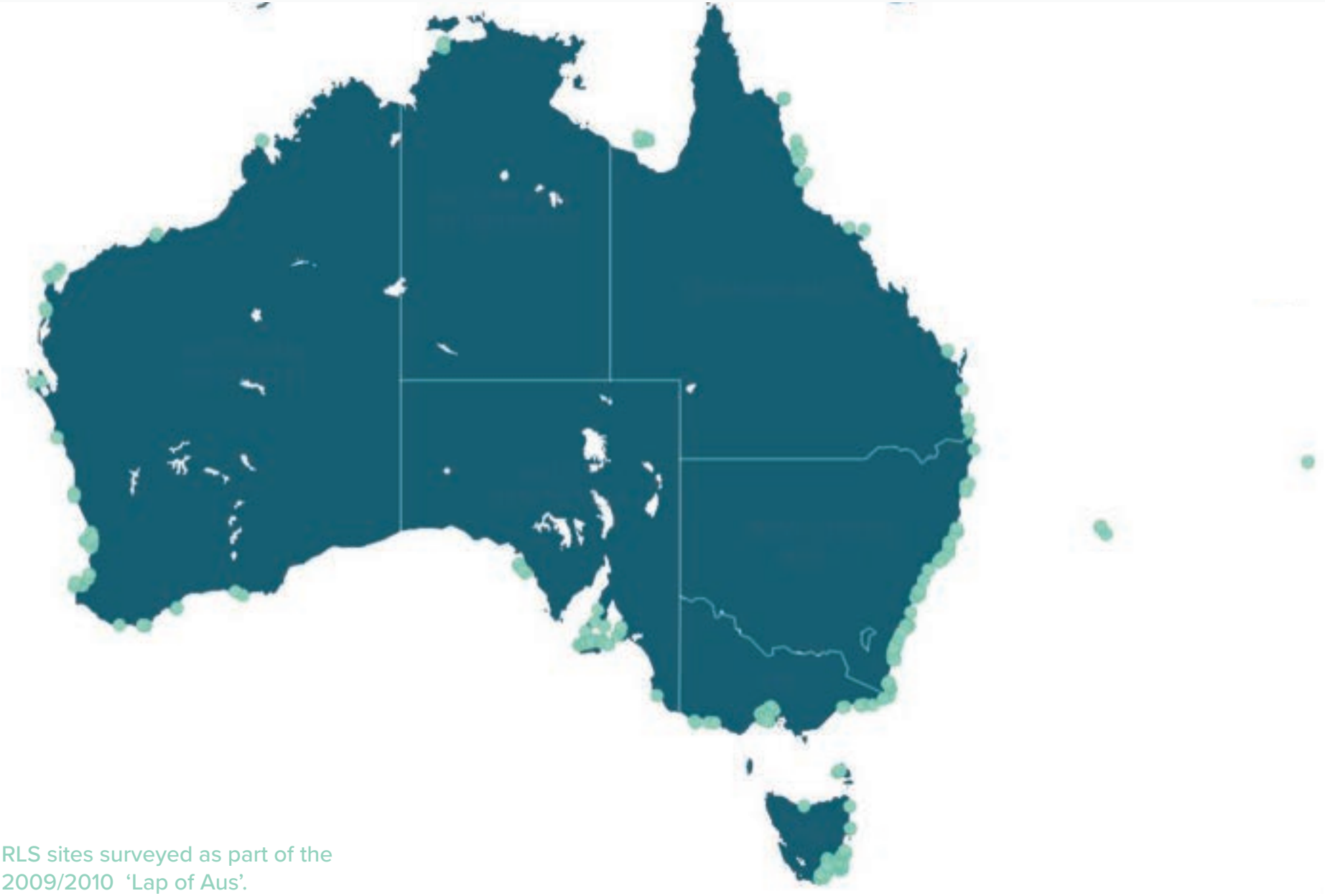
Mapping Change in Inshore Ecosystems Around Australia

In 2009 & 2010, a team of SCUBA divers from the Reef Life Survey program circumnavigated Australia by land, collecting baseline biodiversity data on the condition of more than 500 reef sites, spanning the full Australian coastline and the diverse inshore marine ecosystems found along it.

Since that first ‘Lap of Aus’, the condition of Australia’s marine environment has declined in many locations, potentially as a result of a variety of human pressures, such as climate change, exploitation, pollution, coastal development, introduced species and land runoff. These changes are, however, occurring out-of-sight. Which of these pressures are having the greatest impacts, and the full extent of change across Australia’s unique marine ecosystems is not understood.

While the Reef Life Survey program has continued to collect biodiversity data over the last decade from primary monitoring locations across Australia, the ‘Mapping Change in Inshore Ecosystems Around Australia’ project has allowed a concerted effort towards a comprehensive resurvey of reef sites spanning the continent, to assess change at sites first surveyed in the 2009 & 2010 ‘Lap of Aus’. The project has directly enabled the engagement of 94 skilled SCUBA divers acting in a voluntary capacity, to collect detailed and standardised data on environmental condition at 681 sites

The information has directly fed into a national assessment of reef biodiversity for the State of the Environment report, an assessment of population trends for >1000 marine species, online interactive indicator reports and distribution maps and images of >2,000 reef species found in Australian waters.



RLS sites surveyed as part of the 2009/2010 'Lap of Aus'.

Geographe Bay, WA.

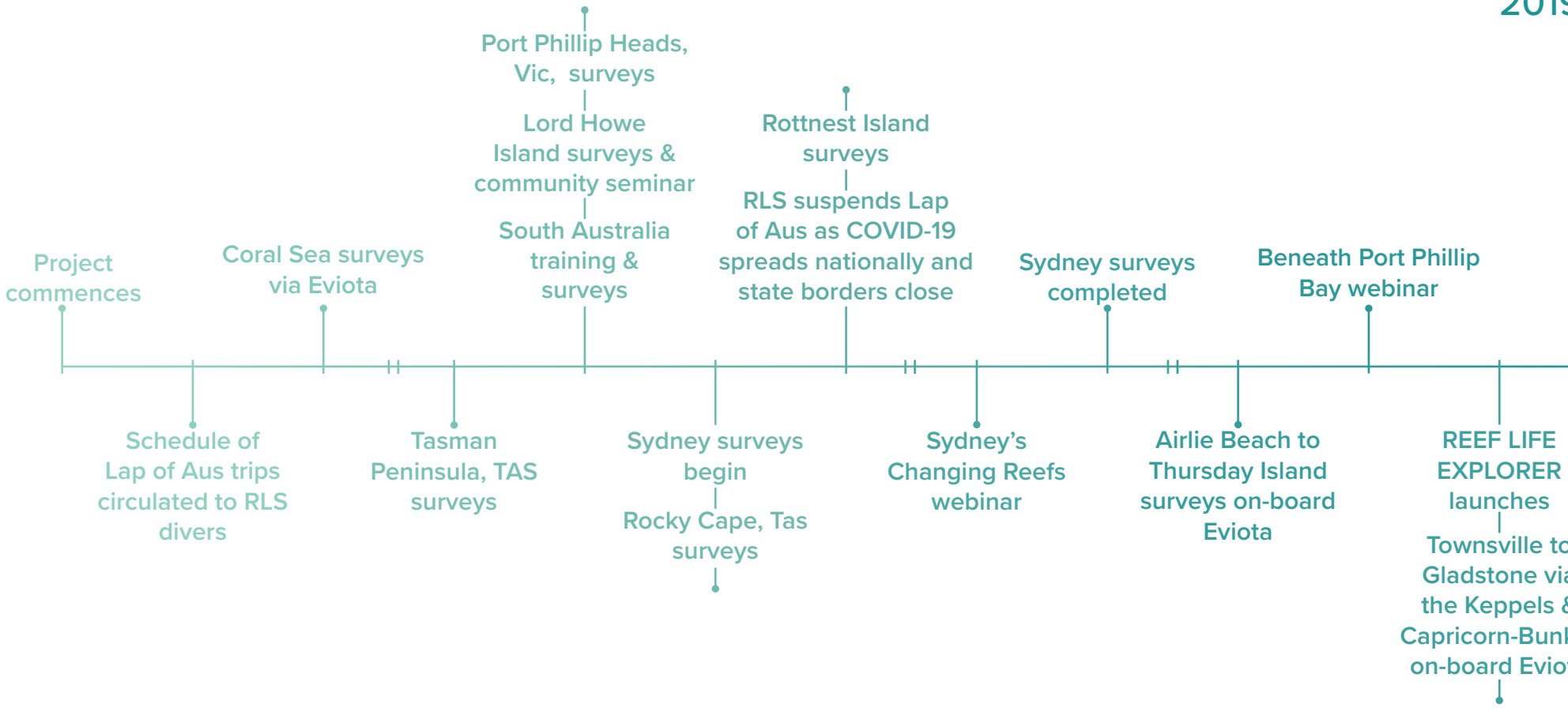
Project Goals

The 2020 ‘Lap of Aus’ project aimed to:

1. Resurvey over 500 sites around Australia’s coast and offshore islands, including: the Great Barrier Reef, Coral Sea, Kimberley, Pilbara, Ningaloo, Abrolhos Islands, Jurien Bay, Rottnest Island, Geographe Bay, South Australian Gulfs, Port Phillip Bay, Wilsons Promontory, northern and southeastern Tasmania, Jervis Bay, Sydney, Port Stephens, Solitary Islands and Lord Howe Island.
2. Provide ready-to-use access to all survey data online.
3. Describe changes over the past decade in the distribution and abundance of >1,000 inshore marine fish, coral, sea urchin, mollusc and crustacean species around Australia.
4. Better understand how reef biodiversity change relates to impacts of global warming.
5. Disseminate findings to management agencies and the public.

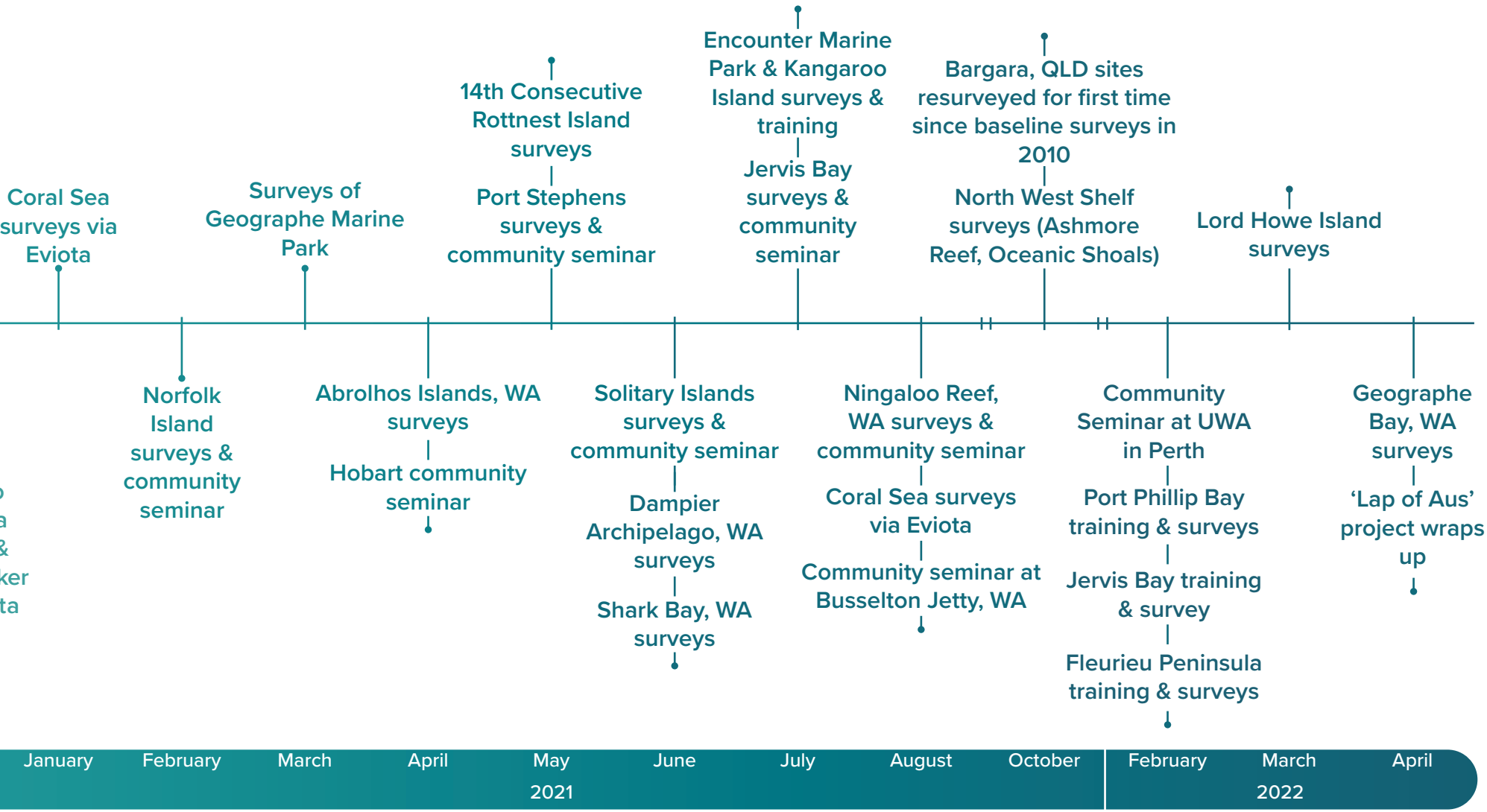
‘Lap of Au

2019



us' Timeline

9-2022



681
Reef sites resurveyed

1,920
Surveys conducted across Australia

2,006
Species counted, sized & recorded

Diver in Port Phillip Bay, VIC.

Collecting Data on Inshore Ecosystems around Australia

Over the course of the 2020 ‘Lap of Aus’ project, 94 RLS divers, including 20 newly trained divers, conducted a staggering 1,920 biodiversity surveys across 681 shallow reef sites. This survey effort represents more than 9,600 hours of volunteered time from the divers alone, or more than $442,000 in in-kind contributions to the project. Across the 675 sites surveyed, divers recorded the size, abundance and presence of 1,343 fish, reptile and mammal species, and 663 species of mobile macro-invertebrates.

Surveys were conducted in all Australia states & territories (bar the ACT), including off-shore Norfolk Island and the Coral Sea.
These surveys provide an important window into the state of Australia’s inshore reefs, and, in conjunction with the data collected during the original ‘Lap of Aus’, will allow for a comprehensive assessment of decadal trends in reef communities across the continent.

Map of RLS sites surveyed as part of the 2020 ‘Lap of Aus’, with light blue lines representing tracks from the sailing catamaran, Eviota through additional support from The Minderoo Foundation.

NT
78 Surveys
5 Divers
43 Sites

QLD & Coral Sea
543 Surveys
23 Divers
253 Sites

Other territories
32 Surveys
5 Divers
15 Sites

NSW
438 Surveys
32 Divers
109 Sites

VIC
138 Surveys
17 Divers
56 Sites

TAS
27 Surveys
14 Divers
18 Sites

SA
340 Surveys
11 Divers
65 Sites

WA
286 Surveys
18 Divers
122 Sites

Communicating Decadal Population Trends to the Scientific Community

Publicly-Available Data

Quality-checked data collected as part of the 'Mapping Change in Inshore Ecosystems Across Australia' project have been made immediately accessible to the scientific community and the wider public through the National Reef Monitoring Network (NRMN) database. The NRMN database brings together long-term monitoring data from the Reef Life Survey Foundation (RLSF), the Australian Temperate Reef Collaboration (ATRC) and Parks Victoria in a single standardized dataset. The data management systems and access are supported by Australia's Integrated Marine Observing System (IMOS) – IMOS is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS).

This project builds on and adds enormous value to the NRMN dataset, which now contains quantitative, standardized data from more than 30,000 reef surveys from 53 countries, and up to 3 decades of monitoring at some Australian locations.

NRMN datasets are the second most downloaded data collection in the IMOS Australian Ocean Data Network (AODN) Portal. Since going live in November 2021, these data records have been accessed over 500 times, which equates to over a third of all AODN downloads, amongst 280 available collections of marine oceanographic and ecological data.

The NRMN dataset is also publicly and freely available through the Atlas of Living Australia (ALA) and the Global Biodiversity Information Facility (GBIF). Since the commencement of this project, records from the NRMN dataset have been downloaded more than 27,900 times from the ALA and GBIF websites, with these downloaded records contributing to 71 scientific journal articles since 2020.

27.9K
Data downloads from ALA & GBIF

Broomfield Reef, Great Barrier Reef

Engaging with a diverse global & local research community

Data collected through this project have fed into a diverse range of research projects, including by the project team at UTAS (including by 6 PhD students) and collaborations with The Smithsonian Institution (USA), University of Victoria (Canada), University of Montpellier (France), Department for Environment and Water South Australia, Deakin University (VIC), University of NSW and the Sydney Institute for Marine Science. Over 500 scientific documents cite RLS data (based on Google Scholar), with 180 of these published during the course of the project (at least 80 of these peer-reviewed scientific papers).

Although in-person conferences were not possible in 2020-21, 'Lap of Aus' project data and findings have contributed to a number of presentations at online conferences and scientific seminars/webinars, including the World Congress on Marine Biodiversity (invited plenary at international conference by Professor Graham Edgar, Dec 2020), James Cook University (webinar by Associate Professor Rick Stuart-Smith April 2021), EuroGOOS (invited plenary at international conference, by Rick Stuart-Smith, May 2021), Smithsonian Institution's MarineGEO (webinar by Rick Stuart-Smith, July 2021) & Australian Government's DAWE Innovation Hub (webinar by Rick Stuart-Smith, Aug 2021).

The First Continental-scale Assessment of Population Trends in Reef Species around Australia

By combining new 'Lap of Aus' data with older RLS records and data from other long term ecological monitoring programs with similar methodology (the Australian Institute of Marine Science and the Australian Temperate Reef Collaboration), we assessed the changing nature of reef populations around Australia over the past decade.

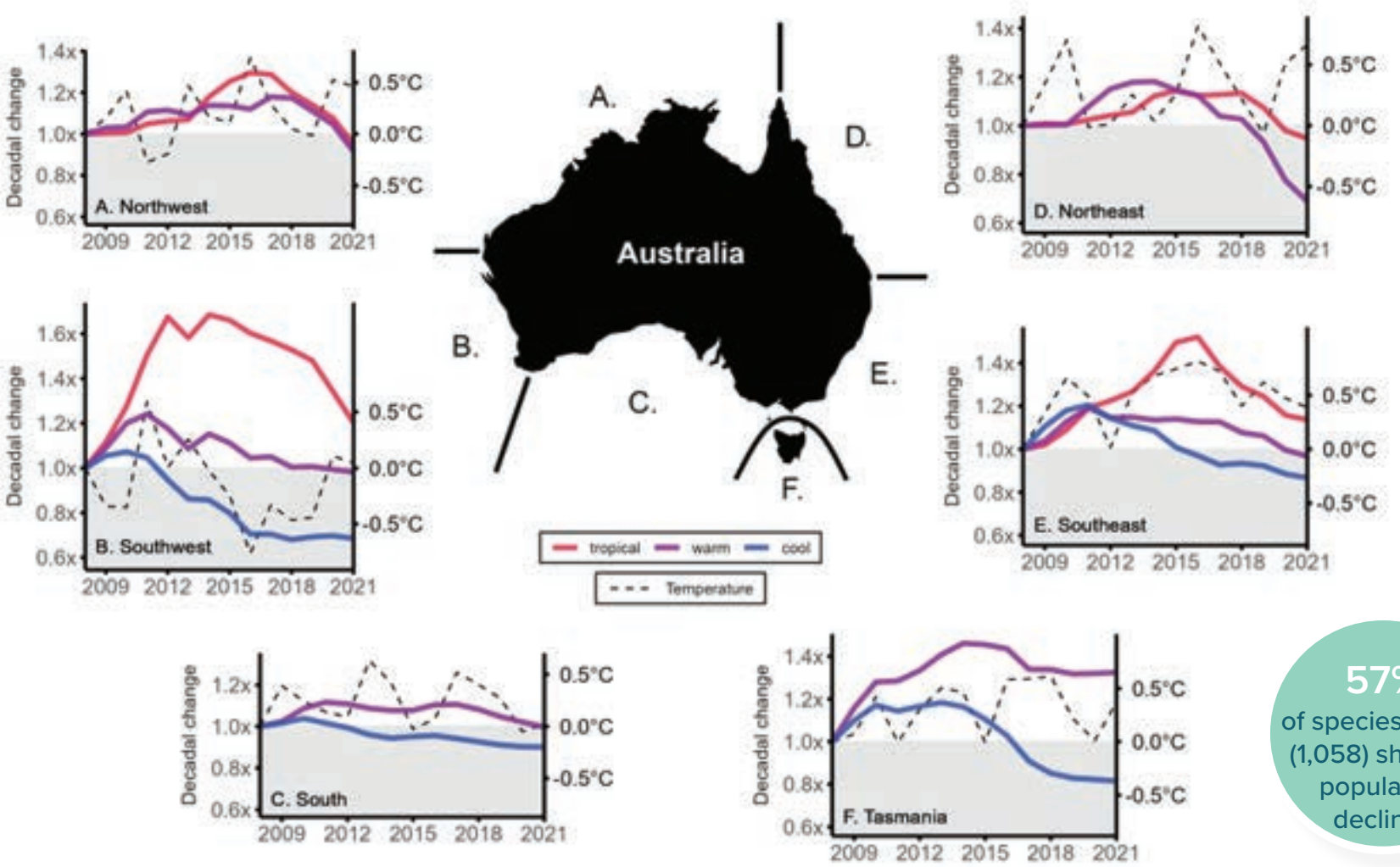
This analysis included 1,058 common shallow reef fishes, corals, echinoderms, molluscs, crustaceans and seaweeds observed at 1,642 sites around the continent since Reef Life Surveys commenced in 2008. We found more species (57%) with populations declining than increasing. Populations of many tropical fishes, temperate invertebrates (particularly echinoderms), and southwestern macroalgae decreased, while, contrary to expectations, coral populations remained relatively stable.

Population declines of cooler water species typically followed years when water temperatures exceeded ~0.5°C above long-term average.

Over 30% of invertebrate species are trending towards extinction along the southern Australian coast and Tasmania, with rapidly declining populations, rising sea temperatures, and nowhere poleward to retreat.

We conclude that greater conservation effort is needed to safeguard temperate marine ecosystems, which are disproportionately threatened and possess a very large proportion of species (~80%) restricted to the Australian continent.

30%
of invertebrates in southern Australia trending toward extinction



57%
of species tested (1,058) showing population declines

Average population trends relative to 2008 for species categorised within three biogeographic groupings for six regions around Australia. Cool water species (which prefer mean water temperatures below 17.5°C) are declining in all regions where present, while tropical species (which prefer mean water temperatures above 23°C) increased greatly in the Southeast and Southwest. Change in mean temperature from 2008 values for each year is overlaid as a dashed line, highlighting a huge increase in tropical species in the Southwest following a heatwave in 2011, and in the Southeast following a heatwave in 2016.

Digitising Photo Quadrats

A significant component of the RLS Underwater Visual Census (UVC) methodology involves collection of a series of photographs of the reef substrate along the transect line. These photos, commonly referred to as Photo Quadrats or PQs, provide an opportunity for scientists and marine managers to assess changes in the condition of the reef habitat at a site. Changes in the cover of living corals or kelp canopies can be measured, for example. Changes in the condition of reef habitats can have profound impacts on the larger reef ecosystem.

Since the project began, over 85,720 images from 4,286 surveys have been digitised for coral and macroalgal densities in Squidle+. RLSF engaged one of the world's most experienced coral experts, Dr Emre Turak (with funding support from the NESP Marine Biodiversity Hub and Parks Australia), to 'annotate' (score the % cover of corals) a large number of photoquadrats from tropical Australian locations such as the Great Barrier Reef, Lord Howe Island, Norfolk Island, the North-West shelf and Coral Sea.

In addition to these tropical images, intensive training in image processing, using the online annotation platform Squidle+, has allowed an additional 14 researchers and volunteers to annotate a further 2.5k surveys from other locations around Australia such as Port Phillip Bay, Wilsons Promontory, Cape Howe, Rocky Cape, Gulf of Carpentaria, Sydney, Jervis Bay and the Derwent Estuary.

These additional researchers engaged in scoring belong to universities in the USA, Canada, France and Australia, and are providing avenues for data flow into large international working groups (including the Reef Futures project led by David Mouillot in France and involving >15 global experts in reef ecology, social sciences, nutrition and climate modelling, from >10 countries).

The habitat data provided through this was also critical in supporting the State of the Environment report (see page 24).

85.7K
Images digitized for coral & macroalgal densities

Ningaloo Reef, WA.

Norfolk Island.

24
Scientific papers published using project data

Scientific Outputs Using ‘Lap of Aus’ Data

A total of 24 scientific papers have been published that use data collected throughout the ‘Lap of Aus’ project. While not a comprehensive list, the publications presented below demonstrate the variety and utility of the data collected throughout this project and more broadly through the RLS Foundation.

Establishing the ecological basis for conservation of shallow marine life using Reef Life Survey.
Edgar, GJ et al., 2020.
Biological Conservation, 252, p.108855.

Direct and indirect effects of heatwaves on a coral reef fishery.
Brown, CJ et al., 2021.
Global Change Biology, 27(6), pp.1214-1225.

Cross-ocean patterns and processes in fish biodiversity on coral reefs through the lens of eDNA metabarcoding.
Mathon et al., 2022.
Proc. R. Soc. B. 289: 20220162.

The aesthetic value of reef fishes is globally mismatched to their conservation priorities.
Langlois, et al., 2022.
PLOS Biology 20 (6).

Global COVID-19 lockdown highlights humans as both threats and custodians of the environment.
Bates et al., 2022.
Biological Conservation: 263.

Ningaloo Reef, WA.

Tracking the ‘Lap of Aus’ Online

In order to track progress toward the 2020 ‘Lap of Aus’ goals, a dedicated page on the RLS website was developed to present statistics, an interactive map of progress, provide a catalogue of relevant blog and social media posts, and display photos captured along the way (see: 2020-21 Lap of Aus Tracking.

Blog Posts

Blog posts for organised 'Lap of Aus' trips are available on the Reef Life Survey website, and are frequently shared to the RLS social media platforms.
In total, **23 blog posts** relating to the 2020 'Lap of Aus' were shared on the RLS website and social media accounts, which have been **viewed over 3,700 times.**
A full list of all blog posts and videos relating to the 'Lap of Aus' can be found on the 'Lap of Aus' tracking page.

Social Media Engagement

Activities, stories and photos from the 'Lap of Aus' were shared widely across the RLS social media channels, which have a combined following of over 6,000 users.
In total, **61 Twitter posts**, viewed over 100,000 times; **93 facebook posts**, with a lifetime total reach of nearly 60,000 people, and; **44 instagram posts** with a lifetime reach of more than 15,000, relating to the 'Lap of Aus' and using the #LapofAus hashtag were shared online.

Video Content

Over the course of the project, **video content reached over 15,000** people through the RLS Facebook page alone.

These numbers primarily relate to the following posts: Launch of the REEF LIFE EXPLORER: 2,800 reach; Port Phillip Bay webinar: 2,100 reach; Sydney's Changing Reefs webinar: 900 reach; Sydney Diver video: 1,700 reach; Port Phillip Bay Beneath the Bay video: 900 reach; 360 Degree South Australia video: 2,000 reach; Norfolk Island video: 7,400 reach.

23
'Lap of Aus' blog posts, viewed >3.7K times

198
Social Media posts, with a reach of >175K users

15K
Views on 'Lap of Aus' video content


Great Barrier Reef.

Engaging & Educating the Wider Community

A significant focus for the 2020 'Lap of Aus' was the engagement and education of local communities across Australia through the presentation of a series of community seminars. These community seminars, presented by RLS coordinators and scientists, discussed the state of local and national reefs, the threats reefs face, and the work RLS does to record changes in reef condition through time.

The 'Lap of Aus' community seminars officially kicked off on Lord Howe Island in February 2020, with a complement of over 40 participants - a great turnout on an island with less than 400 residents.

Unfortunately, six other public meetings, which were originally scheduled between March and June, were canceled due to Covid-19 gathering restrictions. In their place, RLS coordinators developed and produced several educational videos (see: RLS - Spotlight in South Australia and RLS 'Lap of Aus' & Sydney Surveys: Monitoring trends in marine life through citizen science) and hosted a number of online webinars, that were live streamed on Zoom, Facebook and Youtube (see also: Beneath Port Phillip Bay: A decade of change in reef condition, and Sydney's Changing Reefs: Monitoring trends in marine life through citizen science).

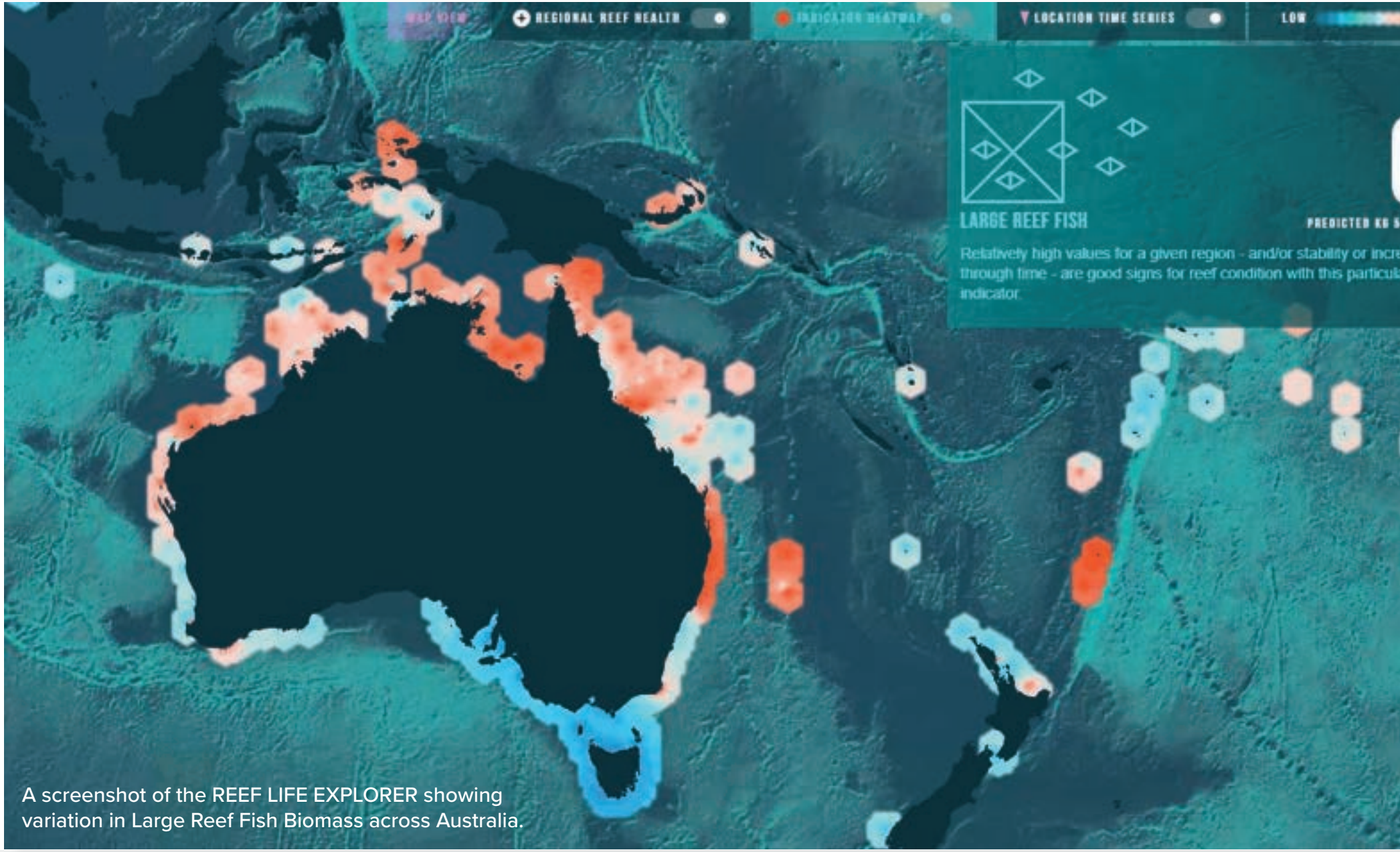
These videos and webinars have since been viewed over 2,800 times.

Since August, 2020, RLS coordinators and researchers have hosted a further 11 community seminars across the country at many of the core RLS monitoring locations, including Port Stephens (top-left photo), Hobart, Jervis Bay (middle-left photo), Ningaloo Reef, Perth, Stradbroke Island, Coffs Harbour and Norfolk Island (bottom-left photo).

1
In-per
online co
semi

3
rson &
ommunity
inars

Lord Howe Island.



A screenshot of the REEF LIFE EXPLORER showing variation in Large Reef Fish Biomass across Australia.

Digital Outcomes & Online Resources

The RLS Website

The data collected by Reef Life Survey underpins a number of web-based products designed to reach different user groups, from government managers and scientists to recreational divers and marine enthusiasts.

Reef Species of the World

The data and photographs collected by RLS divers during this project contribute toward the Reef Species of the World feature on the RLS website.

Reef Species of the World is the most comprehensive online search engine for shallow reef-dwelling species, driven by RLS data on over 4,500 species, and with photographs of animals taken by RLS divers during surveys. Photographs often cover the range of variation in each species across their distribution and life stages.

REEF LIFE EXPLORER

Data collected through this project are now included in the REEF LIFE EXPLORER - a data exploration tool developed by Reef Life Survey to make the underwater world and the challenges it is facing visible to scientists, marine managers and the public.

REEF LIFE EXPLORER launched in December 2020, and has since grown to become an powerful and interactive way to immerse users in the RLS dataset and explore trends in reef biodiversity over both space and time.

The REEF LIFE EXPLORER was also recently the focus of an invited webinar given by RLS President Rick Stuart-Smith to the Australian Government's DAWE Innovation Hub, with an audience of over 100 Australian Government representatives.

Communicating Management-Relevant Outcomes

National State of the Environment Report

The RLS data collected through this project has allowed reef biodiversity change over the last decade to be analysed at the scale of the entire Australian continent. The results of this unprecedented analysis fed into a national case study on reefs for the 2021 State of the Environment Report (SoE 2021; not yet released at the time of preparation of this report). When the SoE 2021 is released, the case study Australia's Changing Reefs will provide one of the primary mechanisms by which the Australian Government reports to the Australian public on the status and changes in reef biodiversity that have been occurring around Australia's coastlines and offshore reef systems and islands.

Management Collaborations

Through the engagement of representative marine managers sitting on the RLSF Steering Committee, the data and reports generated by the 2020 'Lap of Aus' project influences the day-by-day management descicisions of Parks Australia, NSW DPI, Parks Victoria, SA DEWNR and WA DBCA. Most notably, Lap of Aus data and reports contributed to planning for the Australian Marine Parks network (see Parks Australia), and to threatened marine species assessments (e.g., red handfish).

Tasman Peninsula, TAS.

Lonsdale Reef, Port Phillip Bay VIC

Management Reports Using Project Data

Reef Life Survey Assessment of Marine Biodiversity in the Norfolk Marine Park.
Heather, FJ et al., 2022. Reef Life Survey Foundation Incorporated, Hobart, Tasmania (2022).

Biodiversity change across the Coral Sea Marine Park over the past decade including impacts of severe heatwaves.
Heather, FJ et al., 2022. Reef Life Survey Foundation Incorporated.

Reef Life Survey Assessment of Coral Reef Biodiversity in the North-west Marine Parks Network.
Edgar, GJ et al., 2020. Reef Life Survey Foundation Incorporated.

Reef Life Survey Assessment of Marine Biodiversity in Geographe Bay.
Stuart-Smith, RD et al., 2020. Report to Parks Australia, Department of the Environment 2020, Hobart, Tasmania (2020).

Divers at Geographe Bay, WA.

Partners, Supporters & Volunteers

Many thanks to the following organisations & individuals for their contribution to the 2020 ‘Lap of Aus’.

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