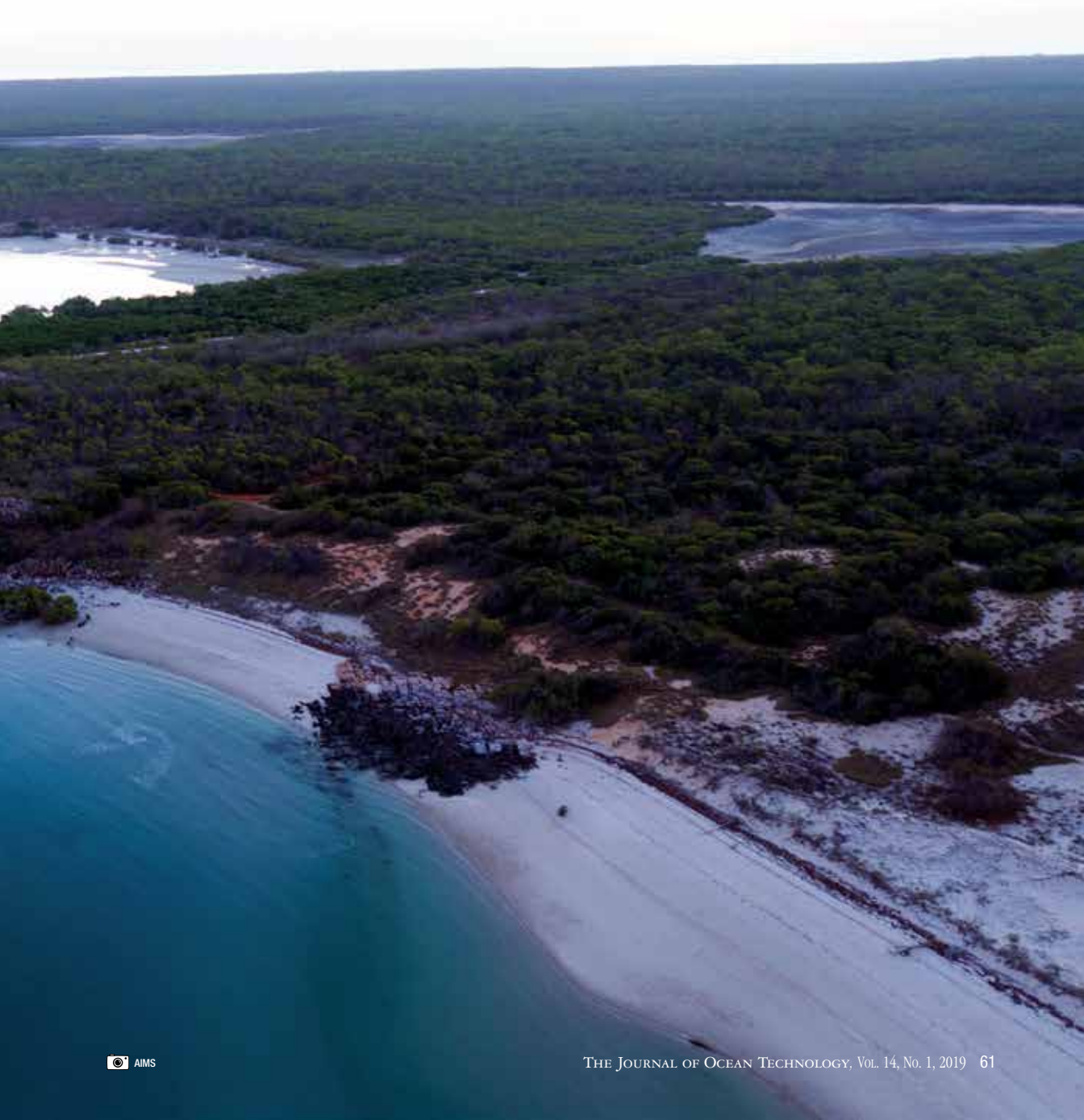
Marine Monitoring of Australia's Indigenous Sea Country using Remote Technologies

by Martial Depczynski, Kylie Cook, Katherine Cure, Harriet Davies, Libby Evans-Illidge, Traceylee Forester, Kevin George, Jackie Gould, Azton Howard, Daniel Oades, Jim Underwood, and Mathew Wyatt

A Case Study in Integrating —Traditional and Scientific— Knowledge



AIMS

Australia's Indigenous Aboriginal and Torres Strait Islander Peoples have been managing their Sea Country for many thousands of years. Examples of traditional sea resource management practices include seasonal closures, community sharing of food resources to minimize waste, protocols governing who may take and consume particular species from certain areas, and agreements on total allowable catches in an effort to avoid overexploitation. These practices have adequately preserved the biodiversity and abundance of marine food resources throughout history under the low-population environment of Australia's pre-colonial times (i.e., before 1788).

Unlike pre-colonial times, however, Australia's marine environments are now under increasing cumulative pressures from many modern-day sources. Potential threats include coastal and offshore development; shipping, mining, recreational and commercial fishing; and the complex ever-evolving effects of global climate change. In reply, modern marine science has developed technologies and methods to accurately track and monitor some of these impacts on the marine environment as an aid to management agencies, but while scientists may have a unique set of tools and technologies at their disposal, this is often coupled with a limited understanding of the local significance (both cultural and ecological) of different flora and fauna, tides, currents, seasons, places, and the links among them. In essence, scientists new to an area lack the sort of detailed place-based perspectives which Indigenous Australians have gained through a deep connection to country that only an enduring history can provide.

Acknowledging the value of both scientific and Indigenous management cultures has led to a desire to address issues of Indigenous sea management by integrating traditional ecological knowledge (TEK) with modern marine ecological science technologies. This integration has great potential to provide a unique, powerful, and inclusive perspective for managing today's environmental issues, but comes with significant challenges. The marine environment seen through the eyes of local Indigenous People is very different to how a visiting scientist views it. TEK is based on experiential knowledge passed down orally and is therefore qualitative and subjective. In contrast, scientific methodologies are based on a philosophy of objectivity that utilizes quantitative data to narrate a story. Moreover, science tends to compartmentalize each component of an ecosystem (i.e., reductionism) and then reassemble these components (usually through a mathematical model) based on ecological concepts and principles. This process is science's way of gaining a more holistic understanding of how the natural world works. This is in striking contrast to that of Indigenous Peoples who relate to, think about, and engage with the natural world through a sense of their inclusive place within it. Because of this, the identity of Aboriginal and Torres Strait Islander Peoples is inextricably linked with the surrounding environment and the way it functions, marking Indigenous People as natural holistic ecologists.

Despite these stark differences, the combination of TEK and scientific ecological knowledge (SEK) can make for informative bedfellows where marine environmental management is concerned. Each perspective can lead to insightful and holistic research questions which may sit outside the paradigm of the other's perspective. TEK provides powerful insights into ecological relationships, and can direct research efforts towards producing impactful science that is culturally-important and has utilitarian and tangible management benefits for local residents. In return, science can provide technologies and methodologies sensitively attuned to monitoring environmental change in today's rapidly-changing and complex marine environment.

"Monitoring" by its very definition is a unifying thread that is familiar to TEK and SEK because they both use direct

observation to identify changes through time in environmental conditions. Such observations detect departures from expected or past environmental trends and biological conditions. Those seen as negative, and which illicit some level of alarm, prompt discussion and management responses to redress the issue. Although the paradigms through which ecological function, ecological change, and environmental management are understood vary significantly across cultures, monitoring even in its most basic form is an intuitive and familiar concept to all communities whose survival is dependent upon being able to observe, explain, predict, and adapt to their environment.

The Australian Institute of Marine Science (AIMS) has been at the forefront of marine scientific monitoring of Australia's tropical marine ecosystems for decades. AIMS maintains some of the largest, longest, and most comprehensive marine monitoring programs and databases in the world. Although AIMS makes significant efforts to monitor Australia's marine estate, the extensive remote nature of Australia's coastline virtually guarantees that there are large geographic areas with little or no scientific information. The vast majority of these areas are found in Australia's remotest regions, many of which are inhabited by Indigenous communities that exercise a strong right to self-determination and internal governance. As recognition of the rights of Indigenous Peoples to their traditional lands and seas becomes more widely accepted in western society, governments are trying to include Indigenous Australians in the governance of their marine estates.

Indigenous Saltwater Peoples' systems of law and governance, while locally diverse, all involve a responsibility to manage Sea Country effectively and sustainably, and are exemplified by a deep spiritual relationship with nature. Although government management frameworks universally fall short of allowing for the full enactment of management responsibilities as conferred under Indigenous systems of law and governance, there has over recent decades been a strong and welcomed investment in supporting a very successful Indigenous Land and Sea Ranger program in Australia through Commonwealth Government funding. There are now over one hundred and twenty ranger groups operating across Australia's vast land and seascapes (Figure 1). These Ranger groups deploy a range of traditional and scientific management tools to plan and implement works which protect the cultural and ecological values of Country in the context of contemporary threatening processes.

AIMS has a long history of working side-by-side with Indigenous Australians in the marine arena in monitoring, mariculture, and pure research science projects. Recently, the creation of a new strategy document (AIMS Strategy 2025) has led to a charter to develop and enhance new capabilities. In recognition of the long historical role in managing Sea Country and the vast wealth of knowledge held by Indigenous Australians, a major objective of the AIMS Strategy 2025 is to grow meaningful science collaborations and partnerships with Traditional Owners (TOs) of Sea Country that carefully considers their management aspirations. Within this, a primary goal is to develop insightful ways to incorporate both SEK and TEK into research and monitoring projects. An important part of realizing this goal involves the joint production of a dedicated marine monitoring manual called *Listening to Sea Country: A Monitoring Manual for Indigenous Marine Rangers*. In this manual, robust and scientific standard operating procedures (SOPs) for marine monitoring are co-developed with Indigenous Marine Ranger groups throughout northern Australia. The written manual is supplemented by: 1) a series of freely available, online instructional videos for each monitoring SOP to increase accessibility to those with limited formal education; and 2) on-country workshops where TEK is articulated through participatory mapping and planning exercises, to ensure that a marine monitoring program is developed

Commonwealth Funded I

NORTHERN TERRITORY
1.Anangu Rangers on Angas Downs
2.Anangu Luritjiku Rangers
3.Anmatyerr Rangers
4.Maru-Warinyi Ankkul Rangers
5.Tjuwanpa Rangers
6.Tjuwanpa Women Rangers
7.Kaltukatjara Rangers
8.Warlpiri Rangers
9.North Tanami Rangers
10.Bulgul Land and Sea Rangers
11.Malak Malak Land Management
12.Wagiman Guwardagun Rangers
13.Thamarrurr Rangers
14.Waanyi Garawa Rangers
15.Garawa Rangers
16.Li-Anthawirriyarra Sea Rangers
17.Tiwi Islands Land and Sea Management
18.Anindilyakwa Rangers
19.Warnbi Rangers
20.Werenbun Rangers
21.Crocodile Islands Rangers
22.Yirralka Rangers - Laynhapuy IPA
23.Dhimurru IPA Rangers
24.Djelk Rangers
25.Warddeken Rangers
26.Garngi Rangers
27.Gumurr Marthakal Rangers
28.Yugul Mangi Rangers
29.Arafura Swamp Ranger Groups (3)
30.Mardbalk Marine Rangers
31.Mimal Rangers
32.Numbulwar Numburindi Amalagayag Inyung Rangers
33.Jawoyn Rangers
34.Njanjma Rangers
35.Mangarrayi Rangers

SOUTH AUSTRALIA
1.Anangu Land Management Rangers
2.Warru Kaninytjaku APY Rangers - Musgrave Ranges
3.Warru Kaninytjaku APY Rangers - Tomkinson Ranges
4.Gawler Ranges Rangers
5.Nantawarrina Rangers
6.Ngarrindjeri Rangers
7.Raukkan Rangers
8.Riverland Rangers
9.Yalata IPA Rangers

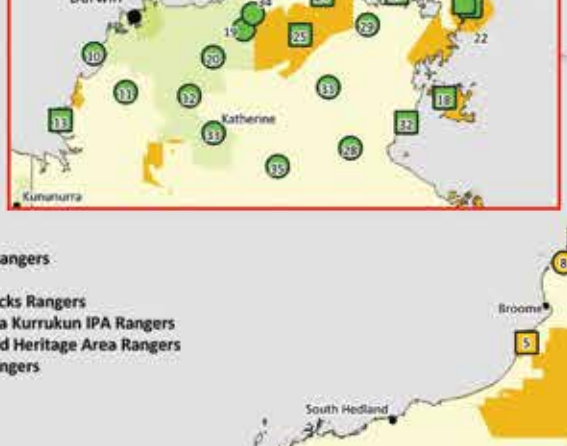
WESTERN AUSTRALIA
1.Miriuwung Gajerrong Rangers for Reserve 31165
2.Balanggarra Rangers
3.Bardi Jawi Rangers
4.Gooniyandi Rangers
5.Karajarri Rangers
6.Ngurrara Rangers
7.Nyikina Mangala
8.Nyul Nyul Rangers
9.Paruku Rangers
10.Uunguu Rangers
11.Wunggurr Rangers
12.Jigalong Rangers
13.Punmu Rangers
14.Parngurr Men Rangers
15.Parngurr Women Rangers
16.Warburton Women Rangers
17.Warburton Men Rangers
18.Blackstone Rangers
19.Warakurna Rangers
20.Kija Rangers

NEW SOUTH WALES
1.Githabul Aboriginal Rangers
2.TIDE Rangers
3.Ngulingah Nimbin Rocks Rangers
4.Wattleridge & Tarriwa Kurrukun IPA Rangers
5.Willandra Lakes World Heritage Area Rangers
6.Barkindji Maraura Rangers

VICTORIA
1.Budj Bim Rangers

QUEENSLAND
1.Bunya Mountain Murri Rangers
2.Gidarjil Rangers
3.Queensland Murray Darling Rangers
4.Gangalidda Garawa Rangers
5.Girringun Rangers
6.Kalan Rangers
7.Kowanyama Land Office Rangers
8.Lama Lama Rangers
9.Mapoon Land and Sea Rangers
10.Mandingalbay Yidinji Rangers
11.Lamalgal Rangers
12.Erubam Rangers
13.Malu Kiai Rangers
14.Mura Badagal Rangers
15.Mabuygiw Rangers
16.Warraber Rangers
17.Wugagal Rangers – Saibai
18.Masig Rangers
19.Poruma Rangers
20.Mualagal Rangers
21.Ugar Rangers
22.Meriam Rangers
23.Dauan Rangers
24.Kaiwalagal Rangers
25.Nanum Wungthim Land and Sea Rangers
26.Apudthama Rangers
27.Eastern Kuku Yalanji Rangers
28.Chuulangun Rangers
29.Yuku-Baja-Muliku Rangers
30.Gunggandji Rangers
31.Normanton Rangers
32.Yirrganydji Rangers

TASMANIA
1.Tasmanian Aboriginal Centre Rangers –milaythina pakana
2.Tasmanian Aboriginal Trainee Rangers (statewide)
3.truwana rangers



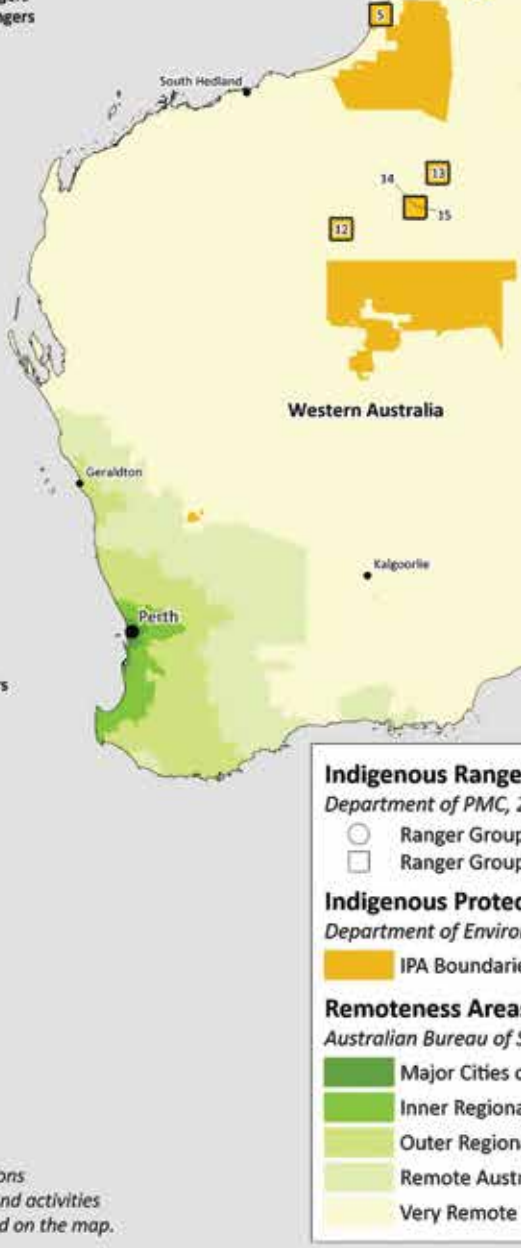
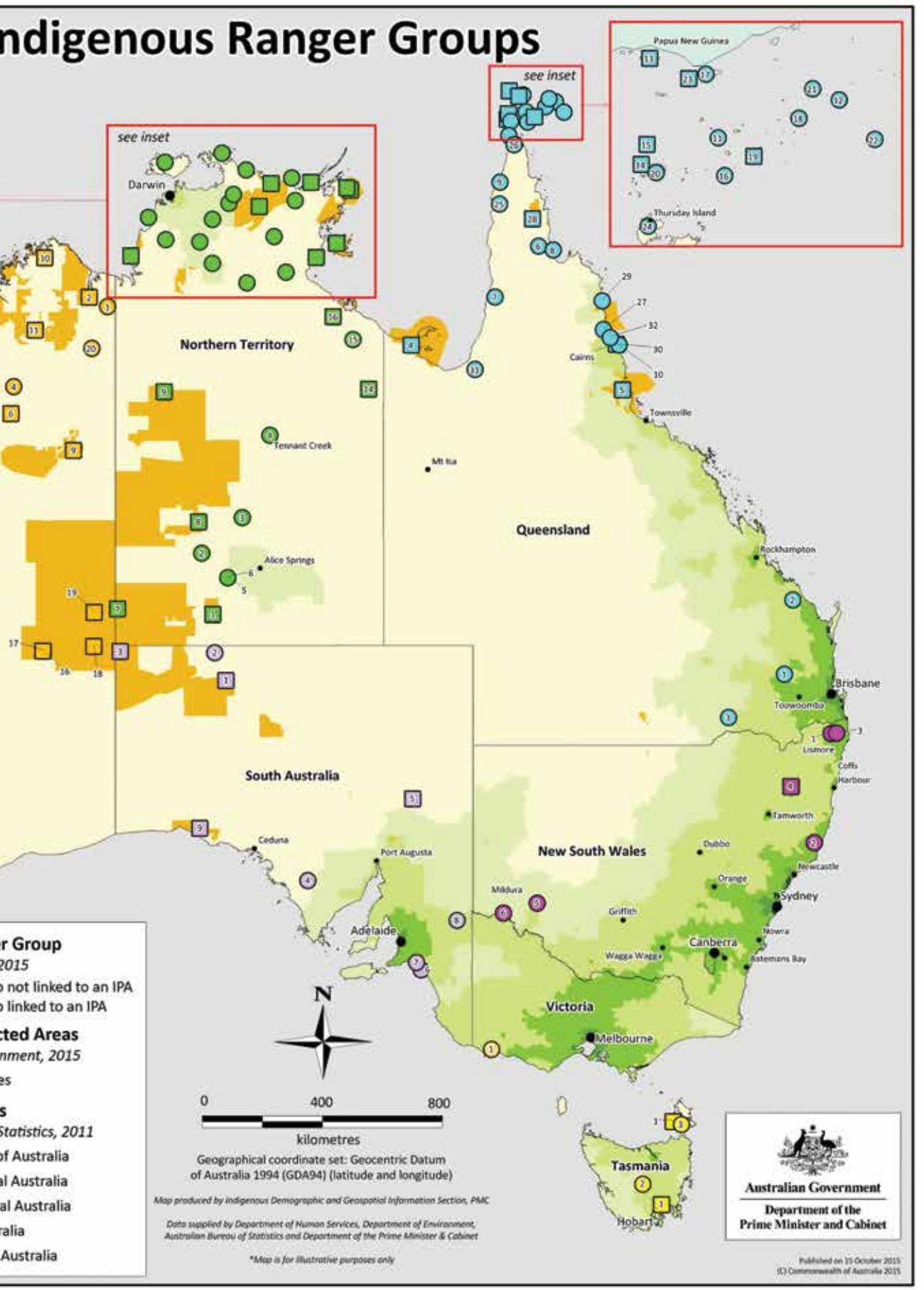


Figure 1: Indigenous Ranger Groups funded by the Commonwealth of Australia as of 2015. Map taken from the Department of Prime Minister and Cabinet.

Note: Indigenous Ranger Group locations are approximate only and the on-ground activities may extend beyond the point identified on the map.


Indigenous Ranger Groups
see inset
see inset
Papua New Guinea
Darwin
Northern Territory
Cairns
Townsville
Tennant Creek
Mt Isa
Queensland
Alice Springs
Rockhampton
Brisbane
Toowoomba
Lismore
Coffs Harbour
Tamworth
South Australia
Ceduna
Port Augusta
New South Wales
Dubbo
Newcastle
Orange
Sydney
Mildura
Griffith
Adelaide
Canberra
Nowra
Batemans Bay
Wagga Wagga
Victoria
Melbourne
Tasmania
Hobart
Thursday Island
N
0
400
800
kilometres
Geographical coordinate set: Geocentric Datum of Australia 1994 (GDA94) (latitude and longitude)
Map produced by Indigenous Demographic and Geospatial Information Section, PMC
Data supplied by Department of Human Services, Department of Environment, Australian Bureau of Statistics and Department of the Prime Minister & Cabinet
*Map is for illustrative purposes only
Australian Government
Department of the Prime Minister and Cabinet
Published on 15 October 2015
(C) Commonwealth of Australia 2015
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2015
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linked to an IPA
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Statistics, 2011
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ralia
Australia

which incorporates the specific ecological settings and management goals of local communities. The SOPs thus aim to make scientific monitoring methodologies available to Rangers to utilize where and when they and their communities identify they may usefully complement local knowledge and management practices.

Joint development of marine monitoring SOPs by AIMS and Indigenous Marine Ranger groups is intentionally focused on new technological advances to provide enhanced and rapid resolution of ecological patterns. These monitoring technologies are partly captured through the use of modern off-the-shelf data logging instruments for physical and chemical parameters (e.g., temperature, turbidity, salinity, pH, dissolved oxygen) and partly through the use of underwater still and video imagery to quantify ecological patterns in biological communities through time (e.g., fish or benthic monitoring). However, the choice and development of each technology has to meet two additional criteria for inclusion in the manual. Firstly, data produced from the methods must be able to be interrogated at various levels of sophistication to increase utility by the full range of custodians and stakeholders (i.e., for monitoring, research, management). An example might be underwater videos that can be easily and quickly analyzed by local ranger groups to derive up-to-date estimates of the stock health for a handful of fish species that are culturally important; but the entire fish assemblage and surrounding habitat could also be quantified by a team of scientists as part of a more detailed regional or global scientific program. Secondly, because scientific monitoring is fundamentally aimed at quantifying changes through time, SOPs must provide a permanent, standardized and unbiased historical record that can be revisited at any time to ensure data quality and integrity. Here we concentrate on two ecological marine monitoring SOPs that meet these criteria to illustrate the process of how we draw on traditional knowledge and scientific monitoring methodologies to provide a powerful and effective platform for adaptively managing Australia's marine environment: 1) Baited Remote Underwater Video Stations (BRUVS) for the quantification of fish abundance and diversity; and 2) DropCam to map and survey the living and non-living components of the seafloor.

Integrating Traditional and Scientific Knowledge for Effective Marine Monitoring

Remote Indigenous communities in Australia have long been involved in scientific surveys, the results of which have produced a range of outcomes. Through observation and discussions with Indigenous People, our personal thoughts on this process (from a marine scientists' perspective) can be summarized as: 1) many local communities are unsure how science translates into looking after country (i.e., there is no obvious link between science and traditional management); and 2) the difference between research and monitoring is not clear (i.e., there is no distinction between what type of information research provides as opposed to the way in which monitoring data can contribute to management decision making). This is because 3) Indigenous participants on research projects are often only a part of one or two of the many steps involved in executing a scientific project from start to finish (often during the field-based data gathering phase – less commonly in the research design stage or data analysis and interpretation phase); and 4) scientists often do not follow through on returning results to communities in a way that coherently explains the relevance of their findings for Sea Country management.

Similarly, as scientists we often struggle to understand: 1) the kinds of TEK held by local communities; 2) how to approach eliciting this information in a culturally appropriate way (recognizing that different knowledge is owned by different members within Indigenous communities); 3) how to understand this knowledge given the very different language and cultural constructs through which it is explained; and 4) the research or monitoring priorities of local communities.

Figure 2: The participatory mapping process in action with members of the Bardi Jawi Rangers.

These shortfalls in cross-cultural understanding need to be addressed if we are to understand what we can achieve together. In terms of co-developing a monitoring framework, a vital first step is a shared understanding of the monitoring process (as a scientific construct), what it can (and cannot) deliver, and the appropriate science tools to use for developing a clear, targeted long-term monitoring strategy. Equally important is understanding what ecosystems/species need to be monitored and why – particularly in the context of local management priorities that value the cultural as well as ecological functions of each environmental resource. So the question arises – how can we utilize the vast but very different knowledge base of each group in a way that enhances our combined capacities to better manage Australia's marine environment?

The Australian Institute of Marine Science and the Bardi Jawi people of the southern Kimberley region of northwest Australia (see Area 3 in Western Australia in Figure 1) embarked on a project that began by developing a strong working relationship built on mutual trust, respect, and knowledge over a number of years. From this position, we co-developed an individually-tailored marine monitoring program during a week-long on-country workshop which first and foremost acknowledged the extensive and valuable traditional ecological knowledge of the community. To do this, project teams consisting of scientists, Indigenous Rangers, and Traditional Owners collaboratively adapted participatory mapping methodologies to document the spatial ecological knowledge of Bardi Jawi Sea Country. Initially using large paper maps and coloured pens to denote various ecological attributes of their Sea Country (Figure 2), these maps were then digitized using standard geographic information system (GIS) software. Local

Bardi Jawi language names were used and confirmation of what each name specifically related to was critical to ensure everyone was talking about the same ecological item(s). For example, a local community may have a number of names in their language for mangroves which differentiate between cohorts of species based on different characteristics in comparison to those used in scientific and common English nomenclature. On the produced electronic GIS map, various layers can be added or taken away as needed (e.g., those containing ecological, cultural or spiritual information) and the appropriate information layers used to inform the development of a marine monitoring sampling regime which directly addressed Bardi Jawi management objectives.

Once mapping was complete, we collectively identified which ecological attributes were most important and what resources were available to the rangers to monitor these in the long term. In this case, particular targets (on this occasion, reefs and fish) were already clearly outlined in the Bardi Jawi Indigenous Protected Area Management Plan 2013-2023. Prioritizing sampling effort to align with Ranger resource availability is a crucial component to the long-term success of any monitoring program. A major focus here was to develop a program which was practically achievable, while still meeting scientific monitoring objectives. Too onerous and the work may not be completed, too limited and the utility of the data rapidly diminishes. This trade-off required discussion, understanding, and agreement among the key workshop participants. Other considerations included fieldwork logistics, Traditional Owner inclusiveness (the responsibility to take care of particular areas of Country are usually designated to different clans or family groups), the avoidance of sacred and culturally restricted areas, and agreement on who would analyze and store the data. Once the ecological assets, geographic locations, and number of monitoring sites were identified against resource availability, a well-informed, culturally appropriate and considered sampling design was able to be generated (Figure 3).

Enabling Culturally Appropriate Marine Monitoring On-Country

The next step was for the scientists to provide scientific training (drawing on the SOPs) in the correct marine monitoring techniques to quantify fish and characterize the seafloor. Monitoring of fish through the use of BRUVS (Figure 4) and the seafloor through DropCam (Figure 5) has proven to be of particular interest for our Indigenous co-researchers in projects undertaken to date. The techniques combine simplicity with the latest camera and video technology which provides for an economical and efficient way to capture data that meets our criteria for monitoring (as outlined above). Practical experience of these two techniques is gained through hands-on practice in setup and use of equipment on land before actual sampling at the chosen monitoring locations. Personalized training provided during monitoring workshops is supplemented by the monitoring manual and accompanying instructional videos which provide step-by-step instructions on the process and can be used as a checklist and refresher in the future.

Using these practiced methods, fieldwork using the sampling design generated in the classroom commenced on Sea Country. In our experience, Indigenous Marine Rangers are highly skilled seamen and women and this step rarely brings practical challenges, but working side-by-side on Sea Country does reinforce the scientific principles of accuracy and repeatability, correct use of equipment and technology, and provides a realistic evaluation of how much time is needed to execute the entire marine monitoring sampling design that we developed together. By the end of the first day of sampling, the first year of the Bardi Jawi long-term marine monitoring program had begun, and the rangers were confident in their abilities to complete our co-developed program. On return from the field, the scientists demonstrated appropriate methods of downloading data, data storage

Figure 3: Sampling design for the long-term monitoring of aarli (fish) and marnany (reefs) in Bardi Jawi Sea Country. The figure shows the location and map of Bardi Jawi Country in the western Kimberley region of Australia; the different benthic (seafloor) categories are overlaid onto the map alongside the locations of fish and benthic sampling sites. The 10 species of fish deemed culturally important to monitor are shown. The bottom shows the sampling design itself is made up of successive years of monitoring at prescribed places alongside the replication necessary to provide solid data.

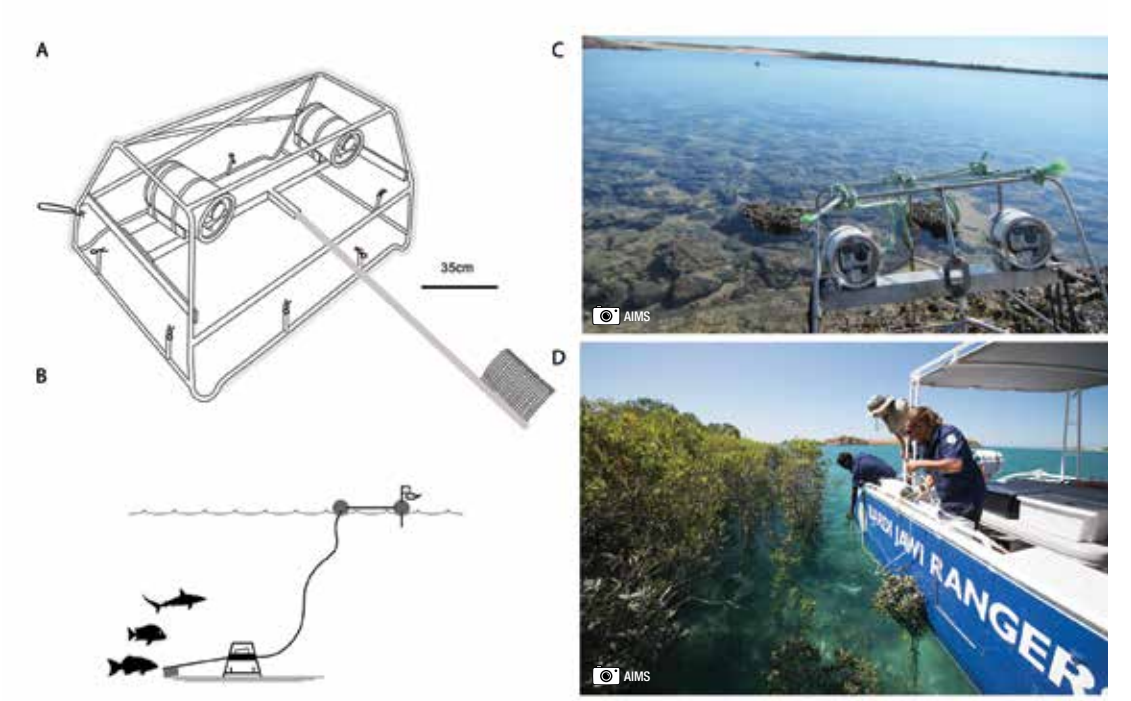


Figure 4: Diagram showing the design (A), functioning (B), and deployment of Baited Remote Underwater Video Station units used here at a large inter-tidal rockpool (C) and in a sub-tidal mangrove habitat from a small vessel (D) in Bardi Jawi Sea Country in the remote southern Kimberley region of Australia.

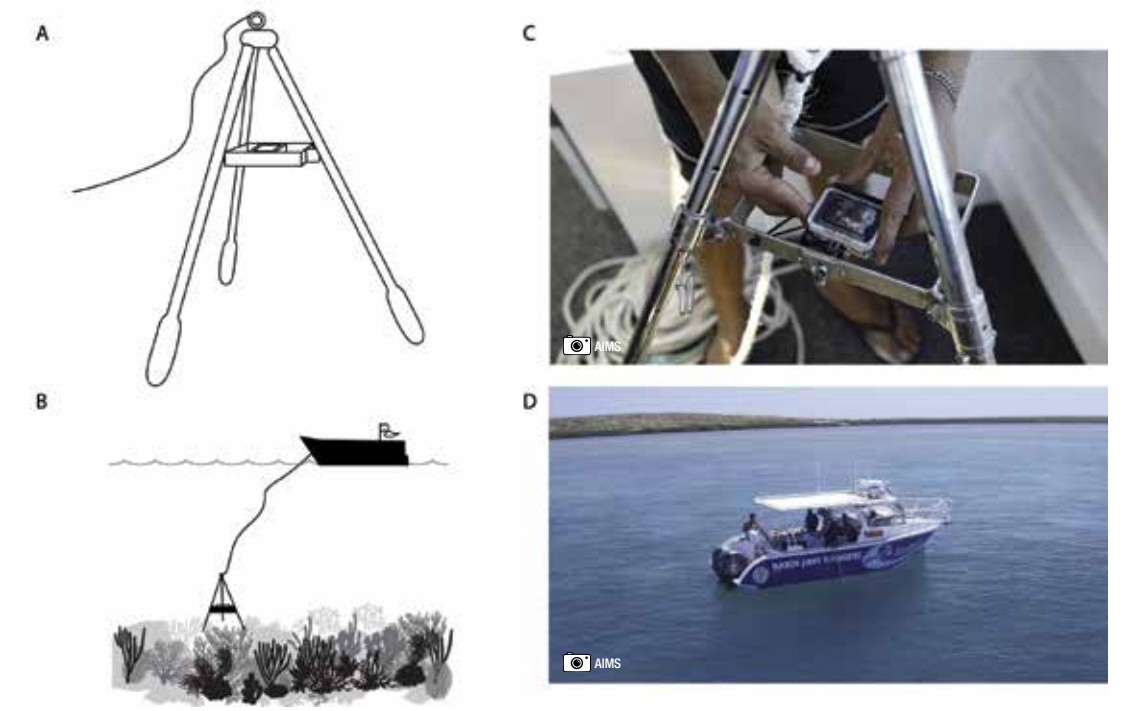


Figure 5: Diagram showing the design (A), functioning (B), camera mount setup (C), and deployment of DropCam unit (D) used here on a coral reef site in Bardi Jawi Sea Country in the remote southern Kimberley region of Australia.

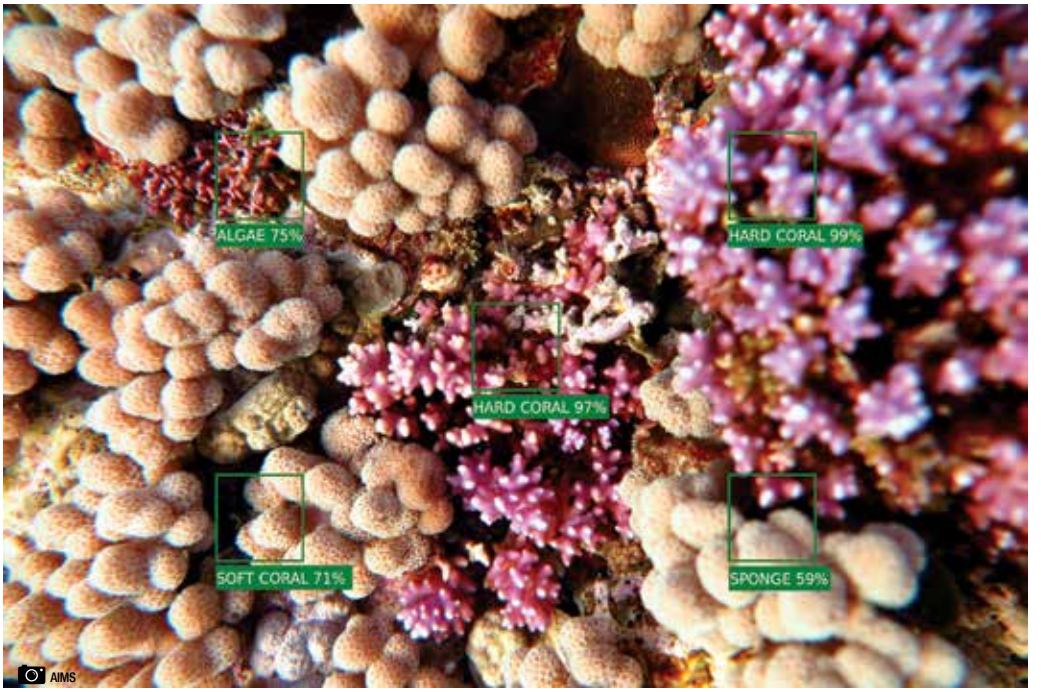


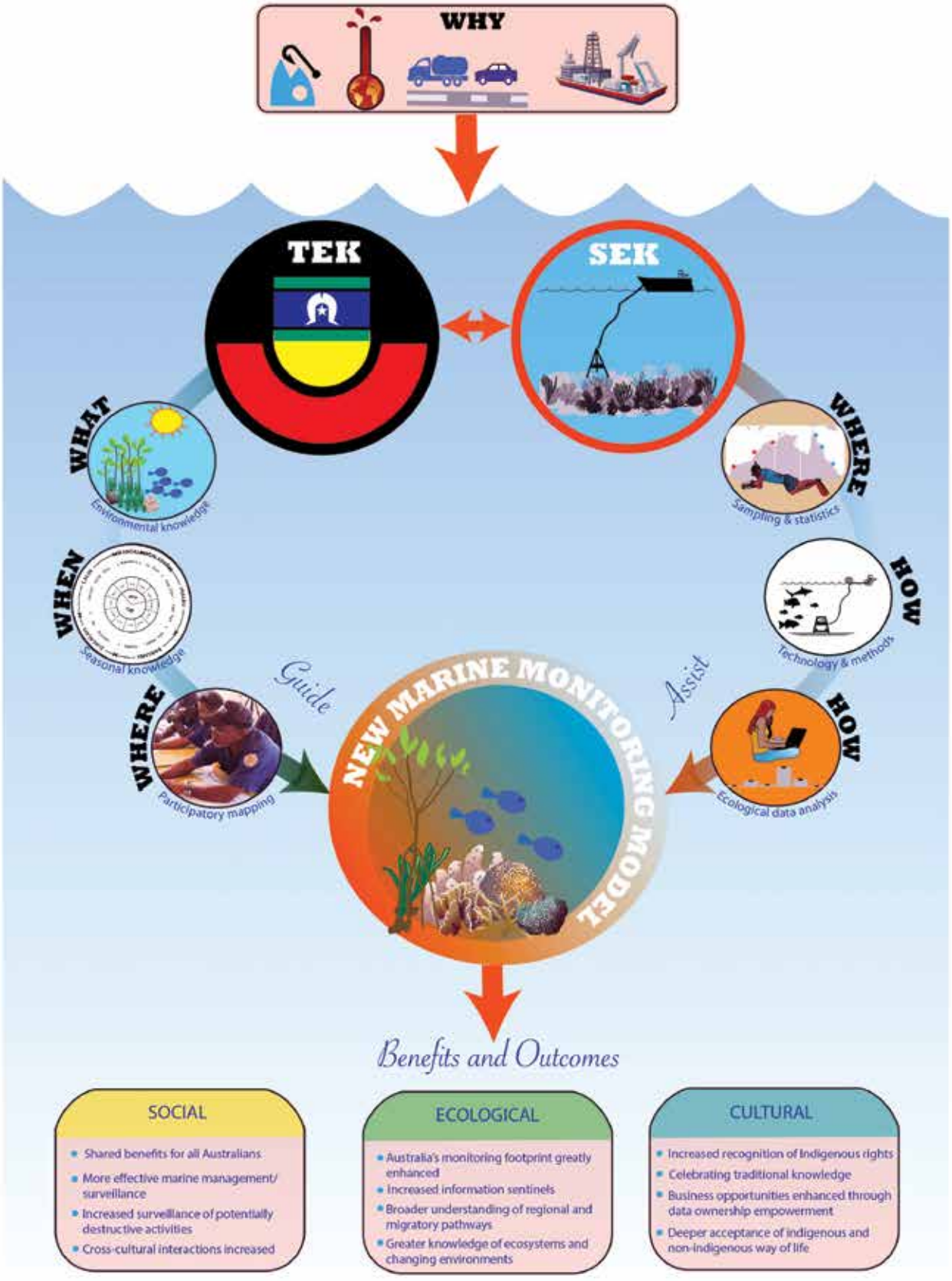
Figure 6: The auto-classification of DropCam images automates the production of data on the composition of the seafloor by identifying the items from five randomly placed squares. As the images are "scored," a data-rich picture that characterizes the seafloor at each site and location in the monitoring design develops from hundreds of images. This general picture, unique to each sampling location, can be compared in successive years to indicate changes from year to year in seafloor components (e.g., coral cover). The auto-classification method employs artificial intelligence to "teach" itself, in essence gaining a higher degree of accuracy as more and more images are scored. In this image, the degree of confidence in the benthic classification for each square is given a percentage.

and backup, alongside preparations by the rangers for the following day's fieldwork.

The final step took us back to the classroom to extract actual data from DropCam and BRUVS imagery for analysis and interpretation. In our experience, this is the most difficult part of the monitoring process for rangers and represents a major hurdle to the success of monitoring programs. Analysis of imagery can be time-consuming and laborious, requires consistency of operation, detailed taxonomic knowledge, as well as computer software skills. In many cases, these tasks are outside the area of interest of Indigenous Marine Rangers and successive years provide further opportunities to gain familiarity with this part of the monitoring process.

Thankfully, new cutting-edge technology is being developed that will overcome this current issue. The adoption of artificial intelligence (AI) in the marine monitoring space is being pioneered by scientists at AIMS and looks a strong candidate. Auto-classification of biological components in still (DropCamera) and video (BRUVS) imagery will enable Traditional Owners to better participate/engage in image analysis and streamline the monitoring process. The computer-driven auto-classification process extracts data from imagery rapidly and accurately, continually improving as images are assessed and data gathered (Figure 6). An obvious advantage is the time-saving potential of having this job automated.

Given image analysis is the greatest bottleneck in the current Indigenous Monitoring Program, computer-driven auto-classification technology would allow expansion of monitoring programs and higher



IAN-INTEGRATION AND APPLICATION NETWORK FOR SYMBOLS; SEASON WHEEL FROM THE BARDI JAWI COMMUNITY.

Figure 7 (left): Conceptual diagram showing the contributions of traditional ecological knowledge (TEK) and scientific ecological knowledge (SEK) to a new Marine Monitoring Model in support of Indigenous Sea Country management. This new model stems from a need to confront increased pressures on remote Indigenous Saltwater communities in Australia such as increased fishing, warming oceans, road infrastructure development, and seabed mining (i.e., the Why). TEK is instrumental in the design of the monitoring program and underlies What to monitor, When (from observed seasonal patterns in aquatic plants and animals), and Where (from intimate Sea Country knowledge). SEK, in turn, contributes to the Where by way of statistical considerations in replication and sampling locations and How through training and knowledge of standard operating procedures. This interactive stepped process, which develops a strong marine monitoring program tailored to individual community needs, respects and unites the strengths of both streams of knowledge to guide and manage monitoring Sea Country while still allowing sustainable use of marine resources. The benefits and outcomes of a strong Indigenous-led monitoring program go beyond ecological monitoring and has positive social and cultural outcomes for all Australians.

replication of sampling units to increase confidence of results or reduce the amount of time (and therefore costs) associated with implementing a monitoring program. The next stage of development of the auto-classification system encompasses taking the extracted data and analyzing it in a format that provides a "report card" on the status of fish and benthos relative to the previous year(s). This is still a little way off; however, computer programs are currently being developed towards this goal, and AIMS anticipates it will be able to provide simple automated report cards containing changes in benthic coverage of simple components like seagrass, hard and soft coral, sand, algae, rubble, etc. in the next 12 months. In the meantime, AIMS scientists are working with Rangers to analyze and interpret data from current marine monitoring activities manually.

Here we have provided one example of how scientists and traditional owners can work together towards a shared future that values all marine knowledge, marries scientific and Indigenous capabilities to monitor Sea Country, and ultimately better protects marine ecosystems for all Australians. We look forward to an exciting future as we continue to walk down this path with our existing and new Indigenous co-researchers and partner organizations. The "Old Way" has cared for Country for thousands of years; however, the "New Way" problems associated with the Anthropocene era are creating new challenges for traditional management. We are still at the beginning of the journey, but the lessons learned here have shown us that we can effectively work towards genuine cross-cultural monitoring and management practices. We are confident that adopting this two-way approach, which enables traditional knowledge and western science to enhance each other, will provide the best outcomes for the sustainable management of Australia's marine environment (Figure 7).

Acknowledgments
We wish to acknowledge the Bardi Jawi Community for entrusting their knowledge which made this essay possible. We would also like to extend a deep thank you to the Bardi Jawi and Oorany Land and Sea Rangers for their enthusiastic participation in the workshop and monitoring process. The Rangers are funded through the Kimberley Land Council. We would also like to thank Andrew Heyward and James Gilmour for their aid in the development of the DropCam benthic monitoring technique.

Further Reading

www.pmc.gov.au/indigenous-affairs/environment/indigenous-rangers-working-country

www.youtube.com/watch?v=npxhUJpK2aQ

Martial Depczynski is a research scientist in ecology with the Australian Institute of Marine Science based at the University of Western Australia in Perth, Australia. His current research interests include the functional role of plant and animal biodiversity in marine ecosystems and working with Indigenous communities in remote areas in support of Sea Country management. Dr. Depczynski's research includes over 60 published works and reports on a wide range of topics including algae, coral and fish recruitment, octopus, lobsters, coral bleaching, and plant learning and behaviour. He is currently working on fish recruitment processes in the World Heritage listed Ningaloo Reef and in setting up marine monitoring with Indigenous marine rangers across Australia's vast tropical coastline. He is also passionate about travelling the planet, meeting people from all walks of life, experiencing new challenges, surfing, hiking, and his dog Picasso.

Kylie Cook is a marine ecologist at the Australian Institute of Marine Science. She has worked on a range of research and monitoring projects around Western Australia with extensive experience in long-term monitoring, data collection, and data management. Ms. Cook has research interests in science communication, coral reef management, and coral bleaching, as well as developing partnerships with Indigenous Ranger groups.

Katherine Cure is a fish ecologist at the Australian Institute of Marine Science. She is originally from Colombia and has worked with fish, fisheries, and monitoring in coral reefs across the Indo-Pacific and Caribbean. She is passionate about fish, science, arts, people, and conservation. Her work to date has centred around the responses of reef fishes to changing environments, focusing on invasive fish species and the impacts of climate change on fish distributions. Currently, Dr. Cure is looking at the depth distribution of herbivorous fishes and their potential impacts on ecosystem health, as well as using Baited Remote Underwater Video Systems (BRUVs) as a tool for monitoring fish populations across Australia's Indigenous Sea Country.

Harriet Davies is a marine spatial scientist at the University of Western Australia and Australian Institute of Marine Science. Her research interests include bridging the gap between Indigenous and western science systems within the marine environment, mapping habitats and environmental change, and anticipative marine spatial planning. She has worked with communities across Australia, Indonesia and Fiji, supporting community driven marine spatial planning projects. Recently, Ms. Davies has been developing a participatory mapping methodology to capture traditional ecological knowledge in a manner that can support Australia's Indigenous communities in developing marine management and monitoring plans.

Libby Evans-Illidge is a marine scientist from the Australian Institute of Marine Science (AIMS) who has worked on and around the Great Barrier Reef and Torres Strait for 35 years. Research interests include biodiscovery and chemical ecology of marine sponges, the potential of aquaculture as an economic opportunity for remote Indigenous communities, and other science-Indigenous collaborations. She is currently the Director of AIMS@JCU – a joint venture with James Cook University – and she is part of a team facilitating research partnerships between AIMS and Traditional Owners of the Sea Country where AIMS works. She enjoys listening to and working with Traditional Owners to find synergies in Sea Country aspirations, knowledge, capacity, and science priorities. Dr. Evans-Illidge deeply loves the reef, is mother to three young adults, and is motivated by the need for a brighter reef future for generations to come.

Traceylee Forester is currently working with the Australian Institute of Marine Science (AIMS) as its first Indigenous Partnerships Coordinator. She is assisting in the building of partnerships between AIMS and Aboriginal and Torres Strait Islander Peoples of Northern Australia, particularly in regards to the collaboration of western science and Traditional Owner science. She is a member of two Traditional Owner groups in Australia's state of Northern Queensland. On her mother's side, she is from the Lama Lama Clan of Princess Charlotte Bay, Cape York, and on her father's side, she is from the Nywaigi Clan located near Ingham. Ms. Forester is passionate about assisting Traditional Owners to share their knowledge, experience and wisdom of the natural environment with others.

Jackie Gould is an anthropologist with Charles Darwin University and the Australian Institute of Marine Science based in Darwin. Her work focuses on supporting Traditional Owners and Indigenous Rangers to document their rich knowledge of Sea Country, and develop management strategies to care for the cultural and ecological values of their coastal and marine estates. Dr. Gould has 15 years of experience working with Traditional Owners across the Arnhem Land coast, and is currently working on several Sea Country Indigenous Protected Area planning projects and participatory mapping projects.

Daniel Oades works for the Bardi Jawi People of the Dampier Peninsula in the Kimberley region of Western Australia. He is employed by the Kimberley Land Council (KLC) in its Land and Sea Management Unit and is the Coordinator of the Bardi Jawi Indigenous Protected Area (IPA) working to implement their own Traditional Owner directed plan of management with Indigenous Rangers. Bardi Jawi country is his traditional country and he works to improve local outcomes in land and sea management while engaging with the community and creating ownership and governance around the projects the IPA and Rangers can facilitate.

Azton Howard (left) and Kevin George are Bardi Jawi Land and Sea Rangers working on country for the Kimberley Land Council (KLC). Mr. Howard heads up the marine monitoring branch for the rangers and Mr. George is the senior cultural ranger and a respected elder of the Bardi Jawi community.

Jim Underwood is primarily a molecular ecologist at the Australian Institute of Marine Science who explores genetic diversity and the resilience of coral reef communities in north-west Australia. Dr. Underwood has been lucky enough to visit Bardi Jawi country several times since 2014, and recently wanted to extend this work and relationships to see if he could help Indigenous mob manage for healthy Sea Country. This has involved helping set up long-term monitoring sites on the Kimberley coral reefs to assess whether corals, algae, or seagrass are getting better or worse over time.

Mathew Wyatt is a data scientist with the Australian Institute of Marine Science, based at the University of Western Australia in Perth. Having a background in software development, he is a fish out of water among marine ecologists. He spends most of his time getting computers to do the boring work for ecologists so they can spend more time in the field. Mr. Wyatt is now putting his computers to work analyzing imagery collected by Indigenous Ranger groups.