CSIRO Submission 19/683

Identification of leading practices in ensuring evidence-based regulation of farm practices that impact water quality outcomes in the Great Barrier Reef

Senate References Standing Committee on Rural and Regional Affairs and Transport

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Introduction

CSIRO welcomes the opportunity to provide input to the inquiry into *Identification of leading practices in ensuring evidence-based regulation of farm practices that impact water quality outcomes in the Great Barrier Reef* by the Senate References Standing Committee on Rural and Regional Affairs and Transport.

As Australia's national science agency, a key purpose for CSIRO is to provide robust science-based advice to governments on issues of national significance, including major environmental challenges. A key feature of this advice is that it is underpinned by peer-reviewed science. Earning and retaining public trust in the rigour of its science-based advice is critical to CSIRO and its reputation. This is achieved through adherence to the most stringent standards of science quality assurance which involves internal CSIRO review processes plus external peer review as part of journal publication processes (see **Appendix 1,** page 20). The quality of CSIRO's science is demonstrated by CSIRO's international standing as measured by science citation metrics (see **Appendix 1**) as well as CSIRO's long history of working effectively with the Australian and State governments on key environmental issues of national significance.

With respect to the Great Barrier Reef (GBR) and the issue of water quality (WQ), CSIRO has materially contributed to a wide range of government-instigated science review and/or synthesis activities on WQ science, such as GBR taskforces and science consensus statements, and government convened committees. This involvement by CSIRO builds on decades of significant research activity and investment in the GBR, spanning land use practices, catchment and marine science, systems modelling and science integration. The breadth and history of CSIRO activity in the GBR is demonstrated by the publications listed in the References section of this submission (see page 14).

The GBR is a highly complex socio-ecological system – economically vital for many industries, environmentally diverse and unique, but threatened, and a living and livelihood space for many Queenslanders, including its Traditional Owners. Understanding the cause and effect of key ecological processes (e.g. the impact of pollutants on marine ecosystems) in such a complex system is very challenging and inevitably characterised by varying levels of uncertainty. Scientific endeavour in complex systems supports the generation of sufficient information for relevant end users to form a view about policy, but rarely achieves absolute certainty. Rather, as research improves our understanding and knowledge, we continually reduce the levels of uncertainty and increase our level of confidence in system understanding, until we reach scientifically accepted levels of confidence that allow us to provide robust policy advice (noting it is the end users that decide when science has reached a point upon which a decision can be made). In aggregate, the building of knowledge and understanding of complex systems delivers a deeper understanding of the system itself, providing greater confidence in the science and its ability to be relevant to policy makers. This process applies to the issues raised as part of this inquiry (e.g. impacts on WQ in the GBR).

In 2001, sixteen lead scientists from seven leading research organisations concluded that there was a continued urgency to work towards a reduction in the runoff of sediments, nutrients and pesticides and other pollutants into the Great Barrier Reef World Heritage Area [1]. Since the above initial assessment, CSIRO and other research organisations, supported by funding from the Australian and Queensland governments, have continued to refine our understanding and knowledge through multiple lines of evidence. This has significantly increased our confidence about where and under what circumstances poor WQ can have detrimental impacts on freshwater and marine ecosystems, and how land use practices affect WQ.

This gradual process of building knowledge has been successively synthesised and documented in subsequent scientific consensus statements, reef science reviews and the Great Barrier Marine Park Authority's Outlook reports, to which CSIRO has provided substantive inputs. In the case of the 2015-2016 Queensland Government's Great Barrier Reef Water Science Taskforce, the scope of these earlier researcher-led assessments was broadened, and the Taskforce also consulted widely with key stakeholders and industry bodies to result in a broad-based consensus of the issues, interventions and policy recommendations, including the implementation of reef WQ regulations[2].

Based on the above, we focus this submission on providing a response to Terms of References a), b) and e). In responding to these ToRs, we primarily focus on the contribution CSIRO science has made, pointing to other key research organisations for domains that have not been covered by CSIRO research. ToRs c) and d) are beyond the scope of CSIRO's mandate as a research organisation and are not addressed in this submission. We note that there is a degree of overlap between ToRs a) and b), and while we attempt to address them separately, the separation is somewhat arbitrary.

CSIRO response to the Terms of Reference (ToR)

ToR a): The existing evidence-base on the impact of farm water runoff on the health of the Great Barrier Reef and catchment areas

Suspended sediments and nutrients play an important role in freshwater and marine biogeochemical processes and food webs. However, once sediments and nutrients exceed certain thresholds in water bodies, they can trigger adverse ecological impacts, making them pollutants. Pollutants also comprise materials that do not occur naturally (e.g. pesticides). Generally, impacts can be separated into those occurring onsite (or on-farm, e.g. soil loss and land degradation) or offsite (or off-farm, e.g. nutrient enrichment, contamination with pesticides, or greater water turbidity). While pollutants are typically associated with offsite impacts, onsite impacts can also be substantial and need to be taken into account when considering catchment health.

For natural thresholds of nutrients and sediments to be exceeded in receiving freshwater or marine environments there needs to be a change in hydrology (e.g. more surface runoff and/or increased groundwater flows), removal or disturbance of vegetation by livestock or agricultural machinery, and/or more of these materials being introduced into the environment (e.g. fertilisers; pesticide applications). Determining when sediments and nutrients become 'excessive', and hence ecologically detrimental, depends on where they come from ('source'), how they are propagated through landscapes, and the ecological sensitivity of where they end up being accumulated ('sinks').

Untangling the above processes and defining 'excessive' against the backdrop of poorly quantified pre-European conditions and high background climate variability is scientifically complex and has required collaboration between different research organisations, specialising in certain aspects of the entire runoff – pollutant – impact continuum. However, there is now considerable evidence that the amount of pollutants generated from the catchments is greater than natural or background levels and that these levels cause ecological impacts. CSIRO's contribution has focussed on understanding sources and sinks of sediments and nutrients, how they are propagated across landscapes, through rivers, estuaries and then distributed within the GBR lagoon, and subsequently, how mobilisation of sediments and nutrients can be managed at the source (refer to our response to ToR b) and e)).

To investigate the complexity of the processes and their quantification in space and time, a suite of interconnected methods and approaches have been undertaken. These can broadly be characterised as:

- *Direct measurements*, e.g. sediment and nutrient loss from paddocks or hillslopes [3-5], sediment and nutrient concentrations [6] or loads at the outlet of individual sub-catchments [7-9];
- *Indirect measurements*, to hindcast to pre-European settlement [10, 11], identify hot-spot areas and processes that are delivering excess sediment and nutrients (e.g. tracing and dating methods) [12-16] or remote sensing [17, 18];
- *Modelling*, e.g. using point source models such as APSIM [19, 20] or GRASP [21], sediment and nutrient budget models such as SedNet [22, 23] or marine biogeochemical models such as eReefs [24-28]; models are the primary means by which we can extrapolate spatially and temporally. Models developed by CSIRO are thoroughly calibrated using long term datasets and grounded in rigorous testing with research collaborators and next users.

Key conclusions from CSIRO research

The key conclusions emanating from this body of CSIRO work are summarised below.

Onsite impacts

- There is strong evidence that post-European land use has eroded soils in catchments, primarily in grazing lands [29], where sheet erosion has led to loss of pasture productivity [30-32], and gully and stream bank erosion has led to loss of productive land. To a lesser extent this is also true for cane lands [33], although sheet erosion has been significantly reduced since the introduction of green trash blanket harvesting.
- In the long run, nitrogen is discharged from fields in direct proportion to the rate at which nitrogen has been applied to crops, so fertilisation of crops is a primary cause of nutrient discharge from GBR catchments [6,32,33].

Offsite impacts - catchments

- There is some evidence that reductions in the amount of vegetation (trees and grasses) will result in increased peak stream flows [36] (which provides further energy for erosion) as well as higher gully and stream bank erosion rates.
- Sediment source tracing and dating methods in the Burdekin and Fitzroy basins provide evidence that the amount of sediment generated from grazing areas is considerably higher today than under pre-agricultural conditions and is the main source of sediments exported to the GBR World Heritage Area (GBRWHA). Within grazing lands across the GBR catchments, spatially confined hotspots contribute the vast majority of sediments, where the dominant processes delivering sediment are gully erosion or erosion from hillslopes with low or no ground cover [12-16].
- Modelling provides evidence that increased amounts of coarse sediments are being deposited in streams and rivers [37], filling in perennial water holes and affecting in-stream habitats (refer to work by James Cook University).
- CSIRO work corroborates the work of others (James Cook University; AIMS) that there is strong evidence that on a per unit area basis, cane lands are the main source of dissolved inorganic nitrogen (DIN). Grazing can also contribute to DIN supply through biologically active nitrogen bound to sediment originating from increased hillslope and gully erosion [38].

Offsite impacts – GBRWHA

- The sediment transported greater than 1 km offshore is generally the clay to fine silt (~4–16 µm) size fraction [39]. However, land-derived suspended particulate matter in larger size fractions (i.e. particulate organic matter and mineral sediment) can be transported over long distances through transformation into large and easily re-suspensible organic-rich sediment flocs. These flocs may lead to prolonged reductions in water clarity [40].
- There is also considerable potential for other terrestrially-derived sediment fractions (~63 µm) to be stored in the near-shore zone and remobilised during wind and tide driven re-suspension [41].
- The CSIRO-led marine modelling using the eReefs platform (https://ereefs.org.au/ereefs) provides evidence of how frequently and to what spatial extent freshwater flood plumes from GBR catchments, and sediments and nutrients suspended in the plumes, reaches marine habitats (sea grasses, inshore coral reefs, mid- and outer-shelf coral reefs) [24, 25, 42]. Major floods, primarily as a result of cyclones, or very wet seasons, drive the majority of events in which some portion of the mid-shelf and outer-shelf reefs can be exposed to sediments and nutrients (or sediment-nutrient flocs) [25].
- Catchment modelling estimates that river loads of nutrients that are readily biologically available, such as dissolved inorganic nitrogen (DIN), have increased 1.2–6.0-fold relative to their pre-colonization levels [9, 28, 43].
- These modelling results are both an independent quantification of impacts produced using field observations by other science teams; and have been combined with observational studies to provide a more complete assessment of water quality impacts.

ToR b): The connectivity of farm practices throughout the Great Barrier Reef catchment areas to water quality outcomes in the Great Barrier Reef Marine Park

As agricultural land use represents about 85% of the catchment area draining to the GBR, water runoff, and the pollutants within the runoff, are primarily generated from agricultural areas. While urban and industrial land use also lead to pollutant discharge, this is much less than the agricultural contribution to pollutant loads leaving catchments [64]. As a result, CSIRO has invested a significant effort over three decades into understanding how agricultural practices affect sediment and nutrient loss, as well as developing practical solutions for land managers to reduce these losses.

Most of the CSIRO research focusing on improving practices has been conducted in partnership with graziers in the Burdekin and Bowen basins, with cane farmers in the Herbert, Wet Tropics and the Lower Burdekin districts, and with other land managers such as the Australian Department of Defence in the Upper Burdekin. The research has predominantly been carried out on-farm, where possible over more than a decade to cater for climate variability. While one objective of this research was to determine the relative contribution of different land management practices on sediment and nutrient loss, a strong emphasis has also been on the farm productivity aspects, both in terms of crop yields and beef cattle turn-off, but also in terms of farm economics (refer to our response under ToR e)).

Most of the land practices research has been conducted at the paddock scale and therefore relates to onsite impacts as defined in the previous section. Methods used in determining nutrient loss are like those outlined in the previous section but have traditionally been a mix of direct measurements and modelling.

Key conclusions from CSIRO research

The key conclusions from CSIRO's research into the relationship between conventional and improved farm practices and losses of sediments and nutrients are summarised below, separately for sediment loss reduction (predominantly grazing management) and nutrient management (predominantly cane farming):

Grazing management

- There is strong evidence that end of dry-season ground cover levels directly affect hillslope soil loss and runoff from grazed paddocks. Minimum ground cover thresholds levels to significantly filter sediment out of hillslope runoff are 40% [3]. However, to also significantly reduce runoff, long term levels of 90% end-of-dry season ground cover are required [29, 44].
- Increased runoff from over-grazed hillslopes is a major driver of hillslope gully erosion [45].
- There is strong evidence that improved grazing management practices involving wet season spelling, reduced pasture utilisation rates and strategic cattle management not only can revert degraded pastures and recover soil health, over time reducing paddock runoff and sediment export, but in the long term can also be more profitable for the grazing enterprises [46, 47].
- CSIRO has developed a range of cost-effective hillslope gully remediation techniques with graziers and land remediation service providers[48], and implementation of these measures under the Australian Government's Reef Trust program is leading to reductions in gully erosion [49].
- Controlling and reducing livestock access to gullies results in reduced gully erosion rates [45].

Cane farming

- In many areas of the Wet Tropics drainage of cane lands has altered hydrology, increasing peak flows and triggering soil erosion, nutrient and sediment export from other landscape elements in cane lands (e.g. drains, headlands) beyond discharge from just the cane paddocks [50-52].
- Reduction in wetland areas in the Wet Tropics to accommodate cane expansion and drainage have altered the capacity of wetlands to act as a buffer and filter for sediments and nutrients leaving cane lands [53, 54].

- There are a range of practical options that cane farmers can adopt to mitigate the effects of excessive drainage on flows and nitrogen export that are economically beneficial [55-57].
- There is strong observed and modelled evidence that nitrogen fertiliser rates are in excess of or mismatched to plant uptake, contributing to leaching losses [58].
- In areas with excess rainfall or irrigation, leaching of nitrogen into ground water is an important loss pathway. In instances where the groundwater then contributes to base flow in streams, this leads to elevated nitrogen concentrations in waterways [20, 59].
- CSIRO, in partnership with sugar mills and cane farmers, has been at the forefront of developing a wide suite of solutions to reduce nitrogen loss, ranging from optimising fertiliser rates and timing of application [20, 58], to precision agriculture applications to better target fertiliser management [60, 61], and developing new generation slow release nitrogen fertilisers [62, 63]. Some of these practices represent win-wins, in other case there is a cost associated with adoption of some of the practices.

Comments on key CSIRO conclusions

Summarising the above conclusions and those under ToR a), CSIRO research has determined that poor farm practices can result in degraded water quality frequently reaching inshore, and less frequently, mid and outer reef ecosystems on the GBR. The extent to which this happens is strongly driven by rainfall variability and varies considerably between catchments. Importantly, studies have shown that improved farm practices can result in improved water quality at plot and paddock scales, however, longer term (>10 year) stream measurement data will be required to statistically validate these trends at large property and catchment scales. Nonetheless, on balance there is strong evidence at a range of scales that grazing and cane farming leads to increases in nutrient and suspended sediment concentrations in water ways draining grazed rangelands and cane lands, and sediment and nutrient loads leaving GBR catchments and entering the GBRWHA. These findings were confirmed in the most recent Water Quality Science Consensus Statement[64].

CSIRO research has also offered a wide range of options for graziers and cane farmers to improve farming practices in a way that leads to better soil health and farm productivity outcomes on their farms, while at the same time contributing to measurable reductions in sediment and nutrient export to downstream freshwater and marine ecosystems.

The above conclusions derived from CSIRO research are corroborated by similar research conducted by State research departments, Sugar Research Australia, James Cook University and the Australian Institute of Maren Science (AIMS) amongst others, and have been extensively documented in the various science consensus statements[64]. These findings are also in line with experience and observation overseas, where intensive agriculture is associated with nutrient enrichment in downstream waterways and marine environments [65, 66].

The degree to which the observed and modelled pollutant loads affect marine ecosystems and species is a question that CSIRO has not been at the forefront of investigating. This is, and continues to be, the focus of other research organisations and universities such as AIMS, James Cook University and The University of Queensland. Again, we refer to the findings of the Water Quality Science Consensus Statement[64].

ToR e): The wider economic and social impact of proposed regulations to restrict farm practices

Practice changes can impact on farm costs and production and therefore enterprise viability. Hence, CSIRO has also invested a significant effort into understanding how agricultural practice changes affect enterprise profitability. CSIRO research has not been calibrated to the proposed regulations and therefore our response is indicative of the range of practice changes under consideration by the industry rather than the limited subset encompassed in the proposed regulations.

The heterogeneity in physical settings and agricultural enterprise structures requires that a suite of methods and approaches is applied to the problem. These can broadly be characterised as:

- *Direct measurements*, e.g. surveys and similar, directly asking landholders about the cost and profitability impacts of practice change [67, 68];
- *Indirect measurements*, such as expert elicitation [69];
- *Integrated modelling*, which typically uses direct or indirect cost estimates combined with biophysical models to determine efficacy in pollutant reduction and estimate overall costs and effectiveness of practice change [70-74].

Consistent with our biophysical research, most of the research focusing on costing improving practices has been conducted either in partnership with, or with the direct input graziers in the Burdekin and Bowen basins, with cane farmers in the Herbert, Wet Tropics and the Lower Burdekin districts, and in collaboration with other researchers. The above research has been conducted primarily at the paddock level and scaled to the enterprise level in order to identify the impacts on both day to day management decisions and whole of farm profitability. The research has also encompassed up-front costs of practice change (transition costs) and other costs of changing practice (transaction costs) in order to identify where other cost and profitability impacts may occur in changing practices [67, 68].

CSIRO's research has predominantly focused on the economic impact of farm practice change from which we are able to infer some, but not all, elements of restricting farm practices. Our research shows that economic costs and benefits are heterogeneous [70, 73] both across landholders and across the range of practice changes examined.

Key conclusions from CSIRO research

The key conclusions from CSIRO's research into the economic impacts of farm practice changes are summarised below for grazing management and cane farming.

Grazing management

- As stated in the previous section, there is strong evidence that improved grazing management practices can revert degraded pastures and recover soil health, over time reducing paddock runoff and sediment export. In the long term these practices, involving wet season spelling, reduced pasture utilisation rates and strategic cattle management, can also be more profitable for the grazing enterprises [46, 47, 75].

Cane farming

- A number of practices have been near universally accepted and adopted, such as reduced tillage and sub-surface fertiliser application across cane growing regions, and green trash blanketing in the wet tropics. These practices are generally accepted as economically and environmentally beneficial and CSIRO research has not focused on these.
- Reducing nitrogen fertiliser rates in excess of, or mismatched to plant uptake towards recommended application rates on average results in improved profitability, but at a declining rate the closer the applied rate is to the recommended rates [58, 70, 71]. Similarly, additional practice changes will have a diminishing marginal impact on nutrient export.

- Transition and transaction costs (those costs required to implement proposed practice change) reduce the economic benefits from practice change, in some instances, causing otherwise economically beneficial changes to become costly [67, 68].
- All costs are likely to be heterogeneous across landholders in practice, meaning that there will be variability in the actual costs incurred in landscapes depending on individual landholder attributes [69, 70, 72-74, 76]. For example, smaller scale cane growers are likely to experience larger transition costs than larger cane farmers, thus having a longer payoff period to practice changes with larger costs.
- Spatial and practice change targeting can increase the potential for cost-effective outcomes for individuals and the cane industry [70, 76].
- In aggregate, practice change that leads to substantive reductions in cane yield can have regional economic impacts on sugar mill viability[72]. This scale of change is well beyond that envisaged by regulations.

Comments on key CSIRO conclusions

Note that these conclusions apply generally to practice change and have not been specifically calibrated to the enacted regulations to restrict farm practices. The overall conclusions for reducing fertiliser rates towards plant uptake suggest a beneficial economic impact subject to any transition or transaction cost in implementing practice change (and complying with regulations).

The above conclusions derived from CSIRO research are corroborated by similar research conducted by State research departments (noting that we have collaborated with state departments on much of our work), BSES/SRA, and others, and have been extensively documented in the various science consensus statements. Similar findings have been found in overseas settings with relatively similar contexts such as intensive cropping and extensive grazing settings. Nevertheless, climatic and other farm economic settings deliver different conclusions in some other settings; hence, context remains important.

Consistent with the above socio-economic research, CSIRO has also invested social research effort into understanding how proposed agricultural practice changes are perceived by land managers, how these perceptions affect their willingness to participate in practice improvement programs, and, in turn, what social implications might arise for them and their industry representative bodies from that participation.

Through in-depth research interviews and focus groups with farmers, their representative organisations and industry and government extension staff working in reef catchments, consistent themes have emerged. Farmers report that participation in voluntary grant-based reef programs can provide several benefits, including funding for farming equipment that brings forward in time their decision to trial or adopt practices that improve water quality outcomes, and this addresses some concerns about equity [77]. Also, programs that provide farmers an opportunity to maintain or improve their reputational standing with their peers, and avoid blaming farmers for environmental harm, are more likely to succeed [77, 78].

Extension officers and farmers also report that participation in these programs relies on having trusted local intermediaries that can work between government funders and farmers, as trust in government amongst farmers is often low, and local intermediaries reduce the burden of participation for farmers [77, 79]. This work has also highlighted that improving practices of individual growers can often be hindered if the accepted practices used amongst their local or peer-based networks, or by the contractors they employ, do not fit with the changes proposed. That is, practice change can be inhibited by the accepted norms that exist in the context of farmers' immediate social and economic farming relationships [77].

Agricultural peak industry bodies have also been engaged in GBR program and policy debates for some time and entered into formal partnership arrangements with regional bodies and other entities to deliver reef programs to their farmer membership base [78, 80]. These industry groups have reported that this creates both opportunities to improve the design and effectiveness of GBR programs by tailoring it to members' needs, but at the same time can create social and political risks for those organisations if they are seen to be conceding ground to government or not acting in accordance with their members expectations [80]

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APPENDIX 1: CSIRO science metrics, policies and procedures that are applicable to the publication of scientific journal articles

Science excellence

As described in the *CSIRO Annual Report 2018-19* (pp. 41-42):

> Science excellence is intrinsic to CSIRO and measured in several ways. One measure is the frequency with which our publications are cited by other research, normalised for subject patterns and the age of the material. This Normalised Citation Impact (NCI) is a standard indicator and allows for global comparison. CSIRO's NCI of 1.49 is 49 per cent higher than the global average, based on publications produced from 2014 to 2018, compared to NCI results of 50 per cent higher than global average for publications from 2013 to 2017 and 51 per cent higher for the prior cycle.
>
> Journal articles are CSIRO's main type of research publication, followed by conference papers and client reports. The number of refereed CSIRO journal articles and reviews published is more than 3,000 per year and in 2018, the last full calendar year on record, CSIRO produced 784 refereed conference papers, 663 client reports and 270 technical reports.
>
> CSIRO publications cover a range of research fields. Fifty-one per cent of its publications are in the four research fields, (Plant and Animal Science, Environment/Ecology, Geoscience and Agricultural Science), for which it is most strongly ranked for total citations, appearing in the top 0.1 per cent of institutions globally. CSIRO has held this position in these four fields for the 14 years since it has tracked this performance.

CSIRO has a high-level Policy, supplemented by Procedures, that collectively cover the conduct of CSIRO's research and development activities and the distribution of that scientific knowledge including publication in learned scientific journals. The policies and procedures that are applicable to the publication of scientific journal articles are as follows:

CSIRO Science and Delivery Policy

The full policy is publicly available on CSIRO's website, and was revised in June 2019, https://www.csiro.au/en/About/Policies-guidelines/Our-core-policies/Science-and-Delivery-Policy. The policy content has been substantially continuous over the past decade – the following is an extract from the policy relevant to publication:

> CSIRO is committed to conducting world class scientific and industrial research consistent with its roles and functions as outlined in the *Science and Industry Research Act 1949***.** As described in the CSIRO Science and Delivery Policy, in conducting its research CSIRO maintains processes and practices to:
>
> - Adopt and effectively implement the *Australian Code for the Responsible Conduct of Research, 2018* (https://www.nhmrc.gov.au/about-us/publications/australian-code-responsible-conduct-research-2018) and related guidance in our activities, including in relation to collaborative work;
> - Publish quality scientific information based on robust peer review, in papers, reports and otherwise, and high integrity data sets;
> - Provide independent, expert, technical advice to government and community as appropriate to inform relevant policy processes and program activities.

As noted in the **CSIRO Public Comment Procedure** (https://www.csiro.au/en/About/Policies-guidelines/Working-with-CSIRO/Public-comment-policy), when providing public comment or submissions to government, CSIRO staff are expected consult widely within the organisation, and where diversity of scientific views exists make reference to the range of scientific perspectives held within CSIRO.

Australian Code for the Responsible Conduct of Research, 2018

As described above, CSIRO has adopted the *Australian Code for the Responsible Conduct of Research, 2018* in the conduct of its science. That code requires:

P1 Honesty in the development, undertaking and reporting of research.

- Present information truthfully and accurately in proposing, conducting and reporting research.

P2 Rigour in the development, undertaking and reporting of research.

- Underpin research by attention to detail and robust methodology, avoiding or acknowledging biases.

P3 Transparency in declaring interests and reporting research methodology, data and findings.

- Share and communicate research methodology, data and findings openly, responsibly and accurately.
- Disclose and manage conflicts of interest.

P4 Fairness in the treatment of others.

- Treat fellow researchers and others involved in the research fairly and with respect.
- Appropriately reference and cite the work of others.
- Give credit, including authorship where appropriate, to those who have contributed to the research.

P5 Respect for research participants, the wider community, animals and the environment.

- Treat human participants and communities that are affected by the research with care and respect, giving appropriate consideration to the needs of minority groups or vulnerable people.
- Ensure that respect underpins all decisions and actions related to the care and use of animals in research.
- Minimise adverse effects of the research on the environment.

P6 Recognition of the right of Aboriginal and Torres Strait Islander peoples to be engaged in research that affects or is of particular significance to them.

- Recognise, value and respect the diversity, heritage, knowledge, cultural property and connection to land of Aboriginal and Torres Strait Islander peoples.
- Engage with Aboriginal and Torres Strait Islander peoples prior to research being undertaken, so that they freely make decisions about their involvement.
- Report to Aboriginal and Torres Strait Islander peoples the outcomes of research in which they have engaged.

P7 Accountability for the development, undertaking and reporting of research.

- Comply with relevant legislation, policies and guidelines.
- Ensure good stewardship of public resources used to conduct research.
- Consider the consequences and outcomes of research prior to its communication.

P8 Promotion of responsible research practices.

- Promote and foster a research culture and environment that supports the responsible conduct of research.

CSIRO Authorship and Publications Procedure

The following is an extract from the CSIRO Authorship and Publications Procedure, that is relevant to the peer review process that CSIRO seeks to conduct in relation to scientific publications initiated from within CSIRO, noting that this internal peer review step is applied in addition to the external peer review processes required by scientific journals:

> An internal review process applies to any publication that notes a CSIRO staff member, student or other associate of CSIRO as Author or lists any CSIRO entity as an affiliation. This review process, which is conducted by CSIRO, is separate from and precedes any external peer review process, such as that organised by the journal to which a manuscript of a paper is submitted. CSIRO considers the following review process to be 'best practice' and ideally to be applied uniformly across CSIRO:
>
> - The publication must be reviewed by two internal peer reviewers before a publication can be approved.
> - External colleagues may also be used as 'internal' reviewers where deemed appropriate (and there are no intellectual property sensitivities that preclude disclosure).
> - In determining appropriate reviewers, issues of sensitivity and confidentiality need to be considered.
> - For conference abstracts and less substantial publications, the number of reviewers may be reduced to one at the discretion of the CSIRO Approver.
>
> Participants in the peer review process must:
>
> - be fair and timely in their review
> - ensure that they are informed about, and comply with, the criteria to be applied
> - act in confidence and not disclose the content or outcome of any process in which they are involved
> - declare any conflicts of interest
> - give proper consideration to research that challenges or changes accepted ways of thinking.
>
> Participants in the peer review process must not:
>
> - permit personal prejudice to influence the peer review process
> - introduce considerations that are not relevant to the review criteria
> - take undue or calculated advantage of knowledge obtained during the peer review process
> - agree to participate in peer review outside their area of expertise.

Peer review

The internal peer review process described above, is conducted by CSIRO as a preliminary activity prior to submission to the Editor of a learned scientific journal for publication in their journal*. All scientific articles that are submitted to a learned scientific journal for publication will, following submission, then go through the peer review process that is used by the Editorial Board of that journal as advice to the editor as to whether to:

* There are some circumstances that can lead to individual manuscripts not being submitted to this internal review process prior to submission to the Editor of a journal, for example where the primary author of the manuscript is not a CSIRO author and that primary author commences the process with the journal. CSIRO's analysis of publications on the topic of the Great Barrier Reef over the past decade time period is that 80% of these publications were actioned through the CSIRO internal review process.

- accept the manuscript for publication;
- or alternatively - whether to advise the authors that a revised version of the manuscript would be further considered for acceptance and publication (commonly – this would be a situation where the authors are advised of issues raised by referees in their advice to the Editor regarding the manuscript and invited to respond to those issues including in proposing a modified manuscript); or
- whether the Editor might inform the authors that the paper is not suitable (for one reason or another) for publication in that journal.

That is, papers accepted for publication in scientific journals have been considered through the Editorial and peer review process conducted by the scientific journal prior to publication. CSIRO's scientific publications, once accepted for publication, are made available publicly in the scientific journals and these papers may also be searched through the Repository that may be accessed via the CSIRO website.