POST-FIRE MONITORING REPORT

Post-fire monitoring of wetlands, threatened species and threatened ecological communities on K'gari (Fraser Island) and Great Sandy Strait Ramsar site

Authors

Sydney Collett, Luke Carpenter-Bundhoo, Eva Ford, Butchulla Aboriginal Corporation (BAC), Linda Behrendorff, Julieanne Blake & Mark Kennard

This report should be cited as 'Collett S, Carpenter-Bundhoo L, Ford E, Butchulla Aboriginal Corporation, Behrendorff L, Blake J & Kennard M (2023). "Post-fire monitoring of wetlands, threatened species and threatened ecological communities on K'gari (Fraser Island) and Great Sandy Strait Ramsar site". Burnett Mary Regional Group, Bargara'.

Cover Photo: Wathumba swamp. Credit: Eva Ford.

Acknowledgements

This report was created through a consortium of members from the Burnett Mary Regional Group (Sydney Collett, James Thorley), Griffith University (Mark Kennard, Luke Carpenter-Bundhoo), Mary River Catchment Coordinating Committee (Eva Ford), Butchulla Aboriginal Corporation (Darren Blake, John Green, Conway Burns, Chantel Van Wamelen, Tessa Waia, Troy Broome, Bob Broome, Myles Broome, Christine Royan, Blayde Foley, Rachel Killer), Queensland Parks and Wildlife Service and Partnerships (Rhonda Melzer, Linda Behrendorff, Andrew Meiklejohn), and Department of Environment and Science (Mike Ronan, Julieanne Blake, Lyn Wallace, Adam Musial, Toni Thwaites). We thank the consortium for their contribution and knowledge sharing in this report.

We would also like to thank the many fieldwork assistants for this project.

All sampling was completed in accordance with relevant permits: NSW scientific licence SL102473, NSW section 37 miscellaneous permits P20/0031-1.0 and OUT20/14429, QLD general fisheries permit 208075, 209192 and 253255, QLD P-PTUKI 100024138-3, PTUKI PTU18-001245 and WA0009692, AEC approvals ENV/16/20/AEC, ENV/12/21/AEC, and CA 2020/06/1381.

This project was funded by the Australian Government.

Contents

Glossary

BAC	Butchulla Aboriginal Corporation
BMRG	Burnett Mary Regional Group
DES	Department of Environment and Science
E	Endangered
EPBC	Federal *Environment Protection and Biodiversity Conservation Act 1999*.
FBP	Freshwater Biogeographic Province
GU	Griffith University
IUCN	International Union for Conservation of Nature
KGSS	K'gari World Heritage and adjacent Great Sandy Strait Ramsar site
MRCCC	Mary River Catchment Coordinating Committee
NCA	Queensland *Nature Conservation Act 1992.*
NIAFED	National Indicative Aggregated Fire Extent Datasets
NT	Near threatened
OUV	Outstanding Universal Value of a World Heritage Area.
QPWS	Queensland Parks and Wildlife Service.
V	Vulnerable
WHA	World Heritage Area.
ΔNBR	Differenced Normalised Burn Ratio

Executive Summary

This report aims to identify the impacts of the 2019-2020 bushfires on two internationally significant conservation areas – K'gari (Fraser Island) World Heritage area and the Great Sandy Strait Ramsar site.

In 2019 and 2020, K'gari experienced two extreme fire seasons, which impacted >60% of its landmass (Meiklejohn et al., 2023; Neldner and Ngugi, 2021). In 2020, the area of wetlands (including melaleuca communities, swamps, lakes, mangroves, and saltmarshes) impacted by the Duling fire was 7083.5 ha. This included 2490.6 ha and 815.7 ha that experienced high and extreme relative fire severity, respectively (Table 2; Meiklejohn et al., 2023). Although coastal wallum and dune systems are regularly burnt, the resilience of these habitats and resident species depends on the conditions at the timing and severity of the burn. The extent of fire-related habitat degradation and impacts on threatened species populations from the 2019-2020 fire season is unknown.

Rapid on-ground surveys were conducted across 100 sites within known and historic distribution of priority threatened species on K'gari. Three species of fish and four species of frog that inhabit wallum wetlands are primarily considered in this report: Oxleyan pygmy perch (*Nannoperca oxleyana*), honey blue-eye (*Pseudomugil mellis*), ornate rainbowfish (*Rhadinocentrus ornatus*), wallum froglet (*Crinia tinnula*), wallum sedgefrog (*Litoria olongburensis*), Cooloola sedgefrog (*Litoria cooloolensis*) and wallum rocketfrog (*Litoria freycineti*). Information on additional species of interest including the native freshwater crustaceans (sand crayfish *Cherax robustus*) and introduced fish and cane toads was opportunistically collected during field sampling. Historic data for these species was also compiled to assess their persistence at these sites.

Overall, there was a broad distribution of both native and introduced species across the 100 sites surveyed in 2023 for this project. Despite this, there was a concerning number of instances of potential localised extinctions where wallum frog and fish species had been recorded historically, but not after the 2019-2020 fires.

This project determined that the abundance of native wallum fish species (*N. oxleyana, P. mellis and R. ornatus*) varied with fire and the presence of introduced species. These species were more abundant in areas that were not burnt in the 2019-2020 fires when compared with areas that were. In contrast, introduced fish species, including eastern gambusia and platy, were found to be more abundant in fire-affected waterbodies. However, at sites where a localised extinction was highly likely (e.g., Deep Lake), connectivity in hydrology seemed to be the most important factor influencing fish population dynamics. The complex interactions between hydrology, fire and species suggest that there are numerous factors that directly and indirectly impact the distribution and abundance of wallum fish species.

While wallum frog species generally did not show such pronounced patterns in mean abundance of frequency of occupancy as fish, Wallum froglets were found to increase in abundance with fire severity, suggesting a possible benefit of burning in regard to habitat reinvigoration (Table 6). As with fish, wetland hydrology also served an important role in wallum frog population dynamics.

This study provides evidence that while these wallum species have some resilience to such extreme fire events, predicted drought and increased fire risk due to climate change and associated threats still pose a risk to these species.

Response to a disturbance event such as a bush fire on K'gari should be considered across two time scales – rapid response (days and weeks following event) and long-term response (2-5 years post

event). The monitoring that are recommended to be conducted immediately after a disaster include rapid WetCAT or Health checks. These should be conducted across a sub selection of sites based on:

1. Monitoring goal of the surveys (see Section 3.2.1).
2. Susceptibility of the site to weed invasion, pathogen transmission and trampling.
3. Known extent of the burn.
4. Adaptive management needs arising from surveys (e.g. new invasive pest found or pathogen/disease identified).

These surveys should also be conducted at least annually to monitor the recovery of these habitats and to monitor weed invasions. A full suite of the sites from this study (and potentially new nominated sites) should be thoroughly surveyed every 2-5 years post fire using WetCAT or Health checks. Fish and Frog surveys, and cultural assessments should also be carried out at lest every 2-5 years.

1 Introduction

To understand the impacts of the 2019-2020 bushfire on the Outstanding Universal Value of the K'gari World Heritage area, this project monitored the ecological character of a range of wetlands falling within the boundaries of both K'gari and the Great Sandy Strait Ramsar wetland.

Little is known about how these fires impacted K'gari's wetlands, and their water-dependent fauna, both directly and indirectly. This project focussed on establishing a baseline population estimate and bushfire impact measure to fill key knowledge gaps regarding the impact of bushfire on several wetland species that are currently listed under state and national legislation. The species of interest and their conservation status are listed in Table 1.

Table 1: Species of interest in this study and their conservation status according to state and national legislations.

Group	Scientific Name	Common Name	NCA listing	EPBC listing	IUCN Red list
Frog	*Litoria cooloolensis*	Cooloola sedgefrog	NT		E
Frog	*Litoria freycineti*	wallum rocketfrog	V		V
Frog	*Litoria olongburensis*	wallum sedgefrog	V	V	V
Frog	*Crinia tinnula*	wallum froglet	V		V
Fish	*Nannoperca oxleyana*	oxleyan pygmy perch	E	E	E
Fish	*Pseudomugil mellis*	honey blue eye	E	V	E
Fish	*Rhadinocentrus ornatus*	ornate rainbowfish			V
Crustacean	*Cherax robustus*	sand yabby	V		

NT – Near Threatened; V – Vulnerable; E – Endangered. NCA – *Nature Conservation Act 1992* (Qld); EPBC – *Environment Protection and Biodiversity Conservation Act 1999* (Aus); IUCN – International Union for the Conservation of Nature.

1.1 K'gari and it's World Heritage listing

At 122km long, K'gari is the world's largest sand island covering a total of 181,851ha (Wardell-Johnson et al., 2015). It is located off the east coast of Australia within the Southeast Queensland Bioregion, approximately 250 km north of Brisbane. K'gari has been designated as a World Heritage site for three of the ten Outstanding Universal Values:

- Containing a diverse range of features that are of exceptional beauty, some of which are unique in the world (UNESCO, 1992).
- The property represents significant on-going ecological and biological processes, including the dynamic interrelationship between the coastal dune sand mass, aquifer hydrology and the freshwater dune lakes provides a sequence of lake formation both spatially and temporally (UNESCO, 1992).
- The property represents an outstanding example of significant ongoing biological processes. These processes, acting on a sand medium, include biological adaptation (such as unusual rainforest succession), and biological evolution (such as the development of rare and biogeographically significant species of plants and animals) (UNESCO, 1992).

Much of the western coast of K'gari is also included in the Great Sandy Strait Ramsar site (Ramsar 1999).

The K'gari (Fraser Island) World Heritage Area and the adjacent Great Sandy Strait Ramsar site (hereafter collectively referred to as KGSS) are located within the sub-tropical region of eastern Australia, containing a wide variety of habitats including wallum swamps, window lakes and approximately half of the world's perched freshwater lakes (Wardell-Johnson et al., 2015). These habitats are often nutrient-poor, with some also having acidic 'soft' water, which has given rise to unique flora and fauna that are adapted to such conditions (Department of Environment and Science, 2013).

The majority of the island falls within the Great Sandy National Park including small sections of the island protected as State Forest and the Sandy Cape Conservation Park. Freehold and Unallocated State Land adjoin the National Park and more recently sections of land have been returned as Aboriginal Freehold land declared under the *Aboriginal Land Act 1991*. Similarly, much of the water surrounding K'gari is protected as the Great Sandy Marine Park. K'gari has not always been protected for its natural beauty, with sand mining and forestry operations taking place on the island until 1976 and 1991 respectively.

1.2 Key threats and threatening processes

1.2.1 Human impacts

It is currently estimated that 400,000 tourists visit K'gari each year (Walker *et al.,* 2022). These visitors contribute to the reduction of plant vigour due to trampling, compaction of soil, drainage of wetlands, biosecurity issues, and human waste toxicants in wetlands. When access is increased, the invasion of pest plant and predator species is increased and associated rubbish, trampling water input and fire risk (arson or unintentional). However, the remoteness of some of the wetlands on K'gari reduces the amount of human traffic. K'gari has already significant amounts of people pressure of the significant areas on the island, and the only way to prevent this pressure from spreading is not to promote and create further access.

1.2.2 Pest species

Extensive pest management actions have been conducted on K'gari to mitigate the impacts of common pests on the island's unique flora, fauna, and ecosystems. Continuous management has led to several mainland pests either no longer found on the island (e.g. feral horses) or at low levels where the local wongari (dingo) population can maintain numbers (e.g. feral pigs). There are still several terrestrial vertebrate pests found on the island including feral cat (*Felis catus*), fox (*Vulpes vulpes*). Aquatic, and semi-aquatic pests including cane toad (*Rhinella marina*), platy (*Xiphophorus maculatus*) and Eastern gambusia (*Gambusia holbrooki*) have also been found in K'gari's wetlands and waterways, posing a significant threat to the unique aquatic fauna on the island through competition and predation.

Weedy pest plants have also found their way to the island through various routes. Groundsel (*Baccharis halimifolia*), easter cassia (*Senna pendula var. glabrata*) and bitou bush (*Chrysanthemoides monilifera*) can form large thickets that prevent native species from establishing, while some groundcover species such as Singapore daisy (*Sphagneticola trilobata*) and madeira vine (*Anredera cordifolia*) rapidly outcompete native species (Harvey, 2011). These weeds also have drastic implications for the fire regime on the island as several species promote and exacerbate the spread of fire such as lantana (*Lantana camara*) and African love grass (*Eragrostis curvula*) (Harvey, 2011). Many weeds that have been identified on K'gari have had extensive long-term management

and monitoring programs, and as such, they are only restricted to the few townships and roads on the island.

As well as the extensive populations of vertebrate pests and weeds, there are several highly contagious pathogens such as *Phytophthora*, chytrid fungus (*Batrachochytrium dendrobatidis*) and myrtle rust (*Austropuccinia psidii*) which may not currently occur on the island but are also of concern for K'gari's flora and fauna (Walshe et al., 2021).

1.2.3 Climate change

Climate change is a key threatening process that affects the globe and is interlinked with several other threatening processes within the KGSS. Increased incidences of extreme events including floods, droughts, severe storms and heatwaves, are predicted for K'gari and these changes to the weather processes are the most prominent climate change threats for the island (Queensland Government, 2021).

Sea level rise will have many implications for K'gari, although the rate is amongst the slowest in Australia (Hobday & Lough, 2011). Saltwater encroachment into low lying freshwater environment such as patterned fens and window lakes will have significant impacts on the fauna and may lead to mangrove encroachment into other key wetland environments such as saltmarsh (Moss et al., 2012; Wardell-Johnson et al., 2015).

Similarly, reduced rainfall will have dramatic impacts for the groundwater and rain-fed lakes that are characteristic of the island (window lakes and perched lakes). Below average rainfall will likely also lead to more drying out of peat in these wetlands, making them more susceptible to bushfire damage.

1.3 Aims and objectives of this project:

The aim of this project was to assess the impacts of the recent bushfires on two internationally significant conservation areas – K'gari World Heritage Area and the Great Sandy Strait Ramsar site.

The specific objectives of the project were to:

- Establish a baseline understanding of aquatic ecosystems, species (wetland flora and fauna) and threats on K'gari and Great Sandy Strait Ramsar site.
- Identify the direct and indirect impacts of the fires on species of freshwater wetlands (flora, fauna) and ecosystems and their processes (water purification, runoff of ash deposits, sedimentation, deoxygenation).
- Identify sites, indicators, and procedures for long-term monitoring of the impacts of fire and associated climate change on the ecological character of the Ramsar site and the OUV of the World Heritage property.
- Develop a protocol to assess short-term post-fire impacts and monitor long-term recovery of wetlands, ecological communities, and threatened species on K'gari and Great Sandy Strait Ramsar site.

2 Synthesis of Baseline data

This project set out to better understand the condition of the wetlands and the current extent and abundance of key threatened species. Baseline data on fish and frog populations, vegetation condition, weed infestations, and water quality were collected at 100 sites across K'gari. The data gathered will serve as a baseline dataset for the wetland ecosystems and the fauna surveyed.

2.1 K'gari bushfires and fire impacts

In 2019 and 2020, K'gari experienced two extreme fire seasons, which impacted >60% of its landmass (Meiklejohn *et al.*, 2023; Neldner and Ngugi, 2021). A combination of accumulated fuel load, extreme temperatures, ongoing drought, and erratic wind conditions contributed to one of the worst fire seasons seen on K'gari in recent history.

K'gari contains both fire-adapted and fire sensitive ecosystems across the island. The wetland systems are generally very well adapted to fire, with sediment core samples suggesting these have been subject to fire over many millennia (Moss et al., 2012; 2013). Many species native to these systems have multiple methods for regenerating, for example, through epicormic shoots, lignotubers, rootstock and seed banks (Meiklejohn et al., 2023).

Wetlands on the south-west (2019) and mid-west of K'gari (2020) were subject to the highest fire severity, while no fires occurred within the mainland Ramsar boundaries (Figure 1). In 2020, the area of wetlands (including melaleuca communities, swamps, lakes, mangroves, and saltmarshes) impacted by the Duling fire was 7083.5ha. This included 2490.6 ha and 815.7 ha that experienced high and extreme relative fire severity, respectively (Table 2; Meiklejohn et al., 2023).

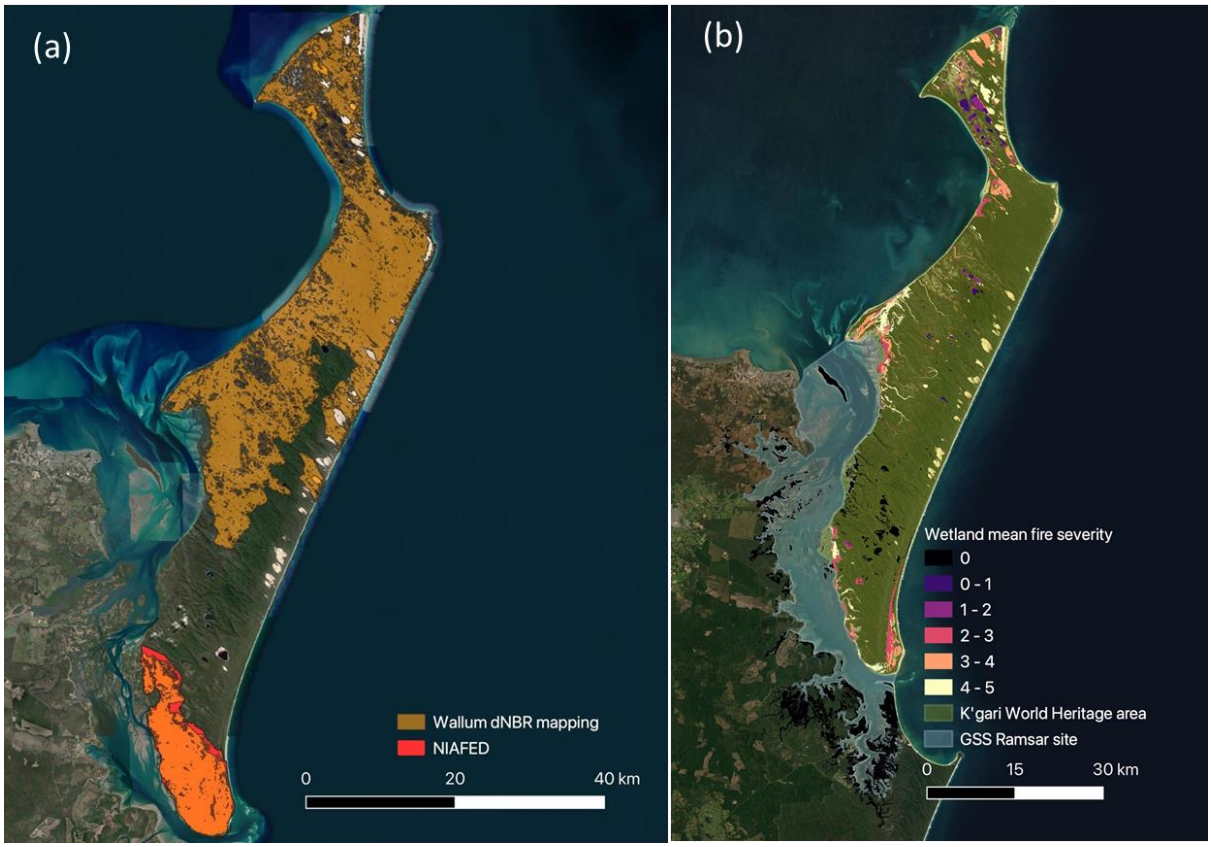

Figure 1. (a) spatial extent of 2019/2020 fires on K'gari. (b) Distribution and mean fire severity score of wetlands on K'gari and within the GSS Ramsar site. Wetlands data modified Department of Environment and Science (2020). Stream data modified from Bureau of Meteorology (2015). Fire extent and severity scores derived from Kennard et al. (2022). dNBR (ΔNBR) is the differenced normalised burn ratio and was used to determine fire perimeters and severity. NIAFED is the National Indicative Aggregated Fire Extent Datasets.

Table 2: Area burnt within each fire severity class, by Broad Vegetation Group, within QPWS estate extracted from Appendix 3 of Meiklejohn et al. (2023).

BVG 5M	Relative fire severity class (ha)				
	Low	Mod	High	Ext	Total
1. Rainforests, scrubs^	13.1	4.7	1.9	0.4	20.1
2. Wet eucalypt open forests	634.9	340	103.3	29.4	1107.6
3. Eastern eucalypt woodlands to open forests	8787.1	7037.1	3395.9	602	19822.1
8. Melaleuca open woodlands on depositional plains	764	586.4	346.3	142.5	1839.2
12. Other coastal communities or heaths[%]	10275.8	14672.9	16818.5	5290.5	47057.7
15. Wetlands (swamps and lakes)	1098.7	1206.9	2143.5	673.2	5122.3
16. Mangroves and tidal saltmarshes	100.2	21	0.8	0	122
Total	21673.8	23869	22810.2	6738	

Mod = moderate; Ext = Extreme fire severity.
Broad Vegetation Groups (BVGs) as described by Neldner *et al.* (2023).
^ Rainforests, scrubs are a total for two 2M BVGs defined by Neldner *et al.* (Neldner et al., 2023) – #3. Notophyll vine forest/ thicket (sometimes with sclerophyll and/or *Araucarian emergents*) on coastal dunes and sand masses & #4. Notophyll and mesophyll vine forest with feather or fan palms on alluvia, along streamlines and in swamps on ranges or within coastal sand masses.
[%] Other coastal communities or heaths are a total for two 2M BVGs defined by Neldner *et al.* (Neldner et al., 2023) – #28. Open forests to open woodlands in coastal locations. Dominant species such as *Casuarina* spp., *Corymbia* spp., *Allocasuarina* spp., *Acacia* spp., L*ophostemon suaveolens, Asteromyrtus* spp., *Neofabricia myrtifolia* & #29. Heathlands and associated scrubs and shrublands on coastal dune fields and inland/ montane locations.

One critical aspect of wetlands that was not measured post-fire was the area of peat in these wetlands that burnt. Peat is usually too wet to burn, however the years leading up the 2019-2020 fires, K'gari had experienced drought, causing concerns for these peat systems. Peat fires occur because of the drying out of the typically moist-wet ecosystem and subsequent consumption of soil organic matter (Smith et al. 1998). In the 12 months prior leading up to the *Duling* fires there was above average rainfall, but well below average rain in the months of October and November 2020. The areas of peat that did burn in the 2019-2020 fires were too small to detect using satellite imagery and were mostly on the higher margins of swamps or in parts of small swamps that had likely been very dry at the time of the fire. The rain in the earlier part of the year may have contributed to the generally limited ecological impact likely limited the impact of these fires on the peat systems.

There was significant impact to large areas of modelled potential habitat for vulnerable frog species that inhabit wetlands estate reported in Meiklejohn et al. (2023) (Table 3).

Table 3. Modelled potential frog habitat impacted by the 2019-2020 fires. Extracted from Appendix 5 in Meiklejohn et al. (2023).

Scientific Name	Common Name	Relative fire severity class (ha)				Potential habitat (ha)
		Low	Mod	High	Ext	Total burnt
Litoria olongburensis	wallum sedgefrog	1668	1489	1221	263	4641
Litoria freycineti	wallum rocketfrog	566	685	719	181	2152
Crinia tinnula	wallum froglet	3070	5108	8015	2559	18752

Mod = moderate; Ext = Extreme fire severity.

2.2 Impact of the 2019-2020 fires

The impact of fire on the four frog and three fish species surveyed for this project are summarised below from Carpenter-Bundhoo, Kennard and Ford (2023).

Overall, there was a broad distribution of both native and introduced species across the 100 sites surveyed in 2023 for this project. Despite this, there was a concerning number of instances of potential localised extinctions where wallum frog and fish species had been recorded historically, but not after the 2019-2020 fires (Table 4).

Table 4. Summary of local population status, abundance/catch-per-unit-effort (CPUE) and frequency of occurrence (FOC) for target species at all sites across the KWHR, denoting those which were affected or not by the 2019-2020 fires. Sampling effort was uniform at each site. Sites with 'new records' did not have historic records for a target species, 'not recorded' sites had historic records, but the species was not recorded in this study, and 'sustained' sites have both historic records and records from the current study.

			Population			CPUE (mean ± s.e.)		FOC	
Group	**Scientific Name**	**Common Name**	**New record**	**Not recorded**	**Sustained population**	**Fire affected**	**Non-fire affected**	**Fire affected**	**Non-fire affected**
Frog	*Litoria cooloolensis*	Cooloola sedgefrog	24	6	12	19.79 ± 7.49	26.82 ± 9.24	18	20
Frog	*Litoria freycineti*	wallum rocketfrog	16	4	5	1.26 ± 0.46	1 ± 0.72	12	9
Frog	*Litoria olongburensis*	wallum sedgefrog	37	6	9	4.82 ± 0.98	4.64 ± 1.53	28	22
Frog	*Crinia tinnula*	wallum froglet	31	4	16	17.74 ± 4.81	4.88 ± 1.72	29	23
Toad	*Rhinella marina*	cane toad#	19	4	5	0.74 ± 0.17	0.52 ± 0.15	15	12
Fish	*Nannoperca oxleyana*	oxleyan pygmy perch	3	1	5	0.01 ± 0.01	0.17 ± 0.13	4	4
Fish	*Pseudomugil mellis*	honey blue eye	2	8	5	1.07 ± 0.65	1.57 ± 1.19	5	2
Fish	*Rhadinocentrus ornatus*	ornate rainbowfish	9	6	15	2.22 ± 0.53	4.53 ± 1.85	17	7
Fish	*Gambusia holbrooki*	Eastern gambusia#	3	3	0	0.01 ± 0.01	2.63 ± 2.63	2	1
Fish	*Xiphophorus maculatus*	platy#	4	0	0	0.09 ± 0.06	2.63 ± 2.63	3	1

# denotes alien species.

This project determined that the abundance of native wallum fish species (*N. oxleyana, P. mellis* and *R. ornatus*) varied with fire and the presence of introduced species (Table 5). These species were more abundant in areas that were not burnt in the 2019-2020 fires when compared with areas that were. In contrast, introduced fish species, including eastern gambusia and platy, were found to be more abundant in fire-affected waterbodies. However, at sites where a localised extinction was highly likely (e.g., Deep Lake), connectivity in hydrology seemed to be the most important factor influencing fish population dynamics. The complex interactions between hydrology, fire and species

suggest that there are numerous factors that directly and indirectly impact the distribution and abundance of wallum fish species.

Table 5. Coefficients of negative binomial mixed effects models predicting electrofishing fish abundance (offset by sampling unit) as a function of environmental predictors. All continuous predictors are scaled. Models could not be fitted for other priority fish species.

	Oxleyan pygmy perch		**Ornate rainbowfish**	
Fixed effect	**Est. ± SE**	**p**	**Est. ± SE**	**p**
Historic OPP record	2.44 ± 0.88	0.006*		
Historic ORF record			2.11 ± 0.61	0.001*
Mean fire score	-1.46 ± 0.57	0.011*	0.36 ± 0.28	0.197
Alien species record			-2.07 ± 0.65	0.001*
Site type: palustrine	-13.47 ± 223.5	0.952	-3.26 ± 1.21	0.007*
Site type: riverine	-0.35 ± 0.92	0.701	1.82 ± 0.67	0.006*
Random effect	Site ID		Site ID	
Observations	146		146	
N(groups)	113		113	
SD	2.246		2.231	
R^2c	0.848		0.825	
R^2m	0.739		0.451	
* indicates significant value ($p < 0.05$).				

While wallum frog species generally did not show such pronounced patterns in mean abundance of frequency of occupancy as fish, Wallum froglets were found to increase in abundance with fire severity, suggesting a possible benefit of burning in regard to habitat reinvigoration (Table 6). As with fish, wetland hydrology also served an important role in wallum frog population dynamics.

Table 6. Coefficients of negative binomial mixed effects models predicting abundance per standardised aural transect of acid frogs and cane toads as a function of environmental predictors. All continuous predictors are scaled.

	Wallum froglet		**Cooloola sedgefrog**		**Wallum sedgefrog**	
Fixed effect	**Est. ± SE**	**p**	**Est. ± SE**	**p**	**Est. ± SE**	**p**
Days since fire	1.37 ± 0.43	0.002*	1.35 ± 0.47	0.004*		
Mean fire score	0.83 ± 0.24	<0.001*				
Days since fire: Mean fire score	1.63 ± 0.4	<0.001*				
Cane toad record			-1.28 ± 0.84	0.127	-0.54 ± 0.29	0.066
Mean open water cover			1.98 ± 0.5	<0.001*	0.40 ± 0.2	0.04*
Random effect (Site)						
Observations	109		109		110	
N(groups)	95		95		95	

SD	1.857	3.894	1.654
R^2c	0.897	0.834	0.844
R^2m	0.143	0.216	0.048

* indicates significant value ($p < 0.05$).

3 Discussion

The 2019-2020 bushfire season resulted in a substantial area of wetlands being impacted. This project was developed to assess impacts on wetland ecosystems and wetland-dependent threatened fauna and flora and identify long-term monitoring sites and indicators of fire and climate change to inform future management.

3.1 The communications engagement strategy

This project involved a consortium of key stakeholder groups to encourage knowledge sharing and to ensure a wide range of expertise is included. This consortium included stakeholders that already conducting surveys on K'gari (QPWS, GU, MRCCC) as well as experts in wetlands processes (DES – Wetlands Branch) and Traditional Owner groups for K'gari – Butchulla.

The communications and engagement strategy involved the following:

- Regular meetings involving all delivery partners to plan fieldwork, present results, refine and develop monitoring protocols, and
- Dissemination of project aims and ongoing results including Facebook posts, consortium members newsletters, website updates and annual report updates.
- Production of a report to be used by stakeholders for
- Further dissemination of results post-project including publication of this report on consortium member's websites and to other interested stakeholders (e.g. K'gari World Heritage Advisory Committee)

Along with the baseline data that was collected for these species, there was also a significant improvement in the knowledge of the consortium through workshops and training. QPWS, BMRG, BAC and Butchulla Land and Sea Rangers participated in several training days where the monitoring protocols discussed in this report (WetCAT and fauna protocols) were taught. This upskilling will facilitate the rapid response surveying required post-fire by those already on the island.

3.2 Monitoring and Evaluation framework

Managers of high conservation value areas such as the K'gari World Heritage Area and the Great Sandy Strait Ramsar site must achieve a balance between taking conservation action, evaluating the effectiveness of actions taken, and monitoring the general status of biodiversity values and the threats they face (Possingham et al. 2001; Nichols & Williams 2006; Salzer & Salafsky 2006).

The design of a monitoring program requires careful consideration of candidate species and processes (including threats) for measurement. It is important however, to distinguish between different types of monitoring programs for conservation, namely targeted (or focused) monitoring and surveillance monitoring (Nichols & Williams 2006). Selection of indicators should therefore be made in light of the overall goals and underlying conceptual models of the ecosystem of interest.

3.2.1 Identify monitoring goals:

In developing a monitoring program for priority aquatic species and their critical wetland habitats on K'gari and the Great Sand Strait Ramsar site, consideration must be given to informative, reliable and cost effective monitoring goals. Monitoring programs designed and embedded in an active adaptive management framework offer the best chances of using limited conservation management funds effectively, including how and where monitoring could be implemented, and of how the outcomes of the monitoring could feed into adaptive management. Wetland monitoring goals for K'gari and the Great Sand Strait could include (but are not necessarily limited to):

1. Tracking persistence of healthy populations of priority species in representative wetlands unaffected by recent fires
2. Tracking post-fire responses of priority species populations in fire-affected wetlands to confirm ongoing persistence and/or continued recovery.
3. Tracking natural recolonisation of priority species in fire-affected wetlands where localised extinctions are suspected to have occurred.
4. Detecting new incursions of introduced aquatic species (including eastern gambusia, platy, cane toad)
5. Identify emerging threatening processes (e.g. weed invasion, saltwater intrusion, etc)
6. Improving understanding of responses to management interventions (e.g. riparian weed control, fire management) intended to protect or restore wetland values.

Candidate locations to implement monitoring activities related to monitoring goals I through to IV are listed in Table 7. See Appendix 1 for a full list.

Table 7. Example locations of candidate wetlands from Carpenter-Bundhoo, Kennard & Ford (2023) that could be targeted for monitoring to achieve monitoring goals I to IV. See Appendix 1 for full list of candidate monitoring sites. Note: for Goal III, species are listed that formerly occurred, but may now be locally extinct. **Mordacia praecox* were also recorded in Rocky and Bogimbah Creek. As of 2023, *M. praecox* are listed as Endangered under the EBPC Act.

Fire affected	Priority species occurrence	Introduced species presence	Candidate location	Latitude	Longitude
Goal I: Track persistence of priority species in wetlands unaffected by recent fires					
No	*P. mel.*	No	Lake Wabby	-25.459	153.131
No	*N. oxl., R. orn.**	No	Rocky Creek	-25.472	153.010
No	*N. oxl., R. orn.*	No	Seary's Creek	-25.975	153.073
No	*C. tin., L. coo., L. olo.*	No	Wetland south of Lake Boomanjin	-25.574	153.062
No	*C. tin., L. fre., L. coo., L. olo.*	No	Beeliwa Lagoon	-25.566	153.030
No	*C. tin., L. fre., L. coo., L. olo.*	No	Wetland south of lake Birrabeen	-25.526	153.054
Goal II: Track post-fire responses of priority species to confirm ongoing persistence and/or continued recovery					
Yes	*N. oxl., R. orn.**	Yes	Bogimbah Creek	-25.303	153.058
Yes	*P. mel., R. orn.*	No	North Yindeering	-24.902	153.241
Yes	*P. mel., R. orn.*	No	Ocean Lake	-24.925	153.278
Yes	*C. tin., L. fre., L. coo., L. olo.*	No	Wetland off Great Walk Jabiru Feeder	-25.775	153.061
Yes	*C. tin., L. fre., L. coo., L. olo.*	Yes	Wetland south end of Bowarrady Rd	-25.160	153.170
Yes	*C. tin., L. fre., L. coo., L. olo.*	No	White Lake area	-25.141	153.224
Goal III: Track natural recolonisation of priority species in fire-affected wetlands where localised extinctions are suspected to have occurred					
Yes	*P. mel., R. orn.*	No	Deep Lake	-25.216	153.216

Yes	*N. oxl., P. mel.*	No	Yidney Creek	-25.221	153.066
Yes	*P. mel.*	No	Lake Allom	-25.196	153.208
Yes	C. tin.	Yes	Boomerang Lake	-25.228	153.135
Yes	L. coo., L. olo.	Yes	Wathumba Wetland - north	-24.931	153.280
Yes	L. olo.	No	Boon Boon Creek tributary	-25.411	153.086
Goal IV: Detect new incursions of introduced aquatic species					
Yes	*P. mel., R. orn.*	No	Ocean Lake	-24.925	153.278
Yes	*P. mel., R. orn.*	No	Bool Creek Lagoon	-24.746	153.175
No	*N. oxl., R. orn.**	No	Rocky Creek	-25.472	153.010
Yes	C. tin., L. fre., L. coo., L. olo.	No	Wetland NE of Boomerang Lakes	-25.215	153.152
No	*C. tin., L. coo., L. olo.*	No	Wetland south of Lake Boomanjin	-25.574	153.062
Yes	*C. tin., L. fre., L. coo., L. olo.*	No	White Lake area	-25.141	153.224

C. tin. = *Crinia tinnula* (wallum froglet); *L. coo.* = *Litoria cooloolensis (*Cooloola sedge frog); *L. fre.* = *Litoria freycineti* (Freycinet's frog); *L. olo.* = *Litoria olongburensis* (wallum sedge frog); *N. oxl.* = *Nannoperca oxleyana* (oxleyan pygmy perch); *P. mel.* = *Pseudomugil mellis* (honey blue-eye); *R. orn.* = *Rhadinocentrus ornatus* (ornate rainbowfish)

3.2.2 Identify sites and indicators for monitoring:

Response to a disturbance event such as a bush fire on K'gari should be considered across two time scales – rapid response (days and weeks following) and long-term response (2-5 years post event).

The immediate loss of habitat and food resources following a fire poses a great risk for wetland fauna, particularly frogs. The lack of shelter and food resources makes them more vulnerable to predation, and ash the settles on wetlands affects their capacity to thermoregulate and perform cutaneous gas exchange. Serious consideration needs to be given to sites that are surveyed in the rapid response surveys. The areas that have been impacted by fire will be vulnerable to human disturbance and weed invasion post-fire. Immediately following a fire, human activity to these sites should be limited, and where it cannot be limited, strict measures should be adhered to in order to limit damage to these ecosystems.

Longer-term impacts may include a loss of hydrological connectivity and drying of wetlands. These also have impacts on these wetland species including localised extinctions, loss of genetic connectivity and overall declines in populations.

It is therefore recommended that the monitoring of these wetlands is ongoing to keep track of these impacts and implement adaptive management actions when necessary. The recommended surveys for these time scales including monitoring tools, and indicators are presented in Figure 2 (rapid response) and Figure 3 (long-term response).

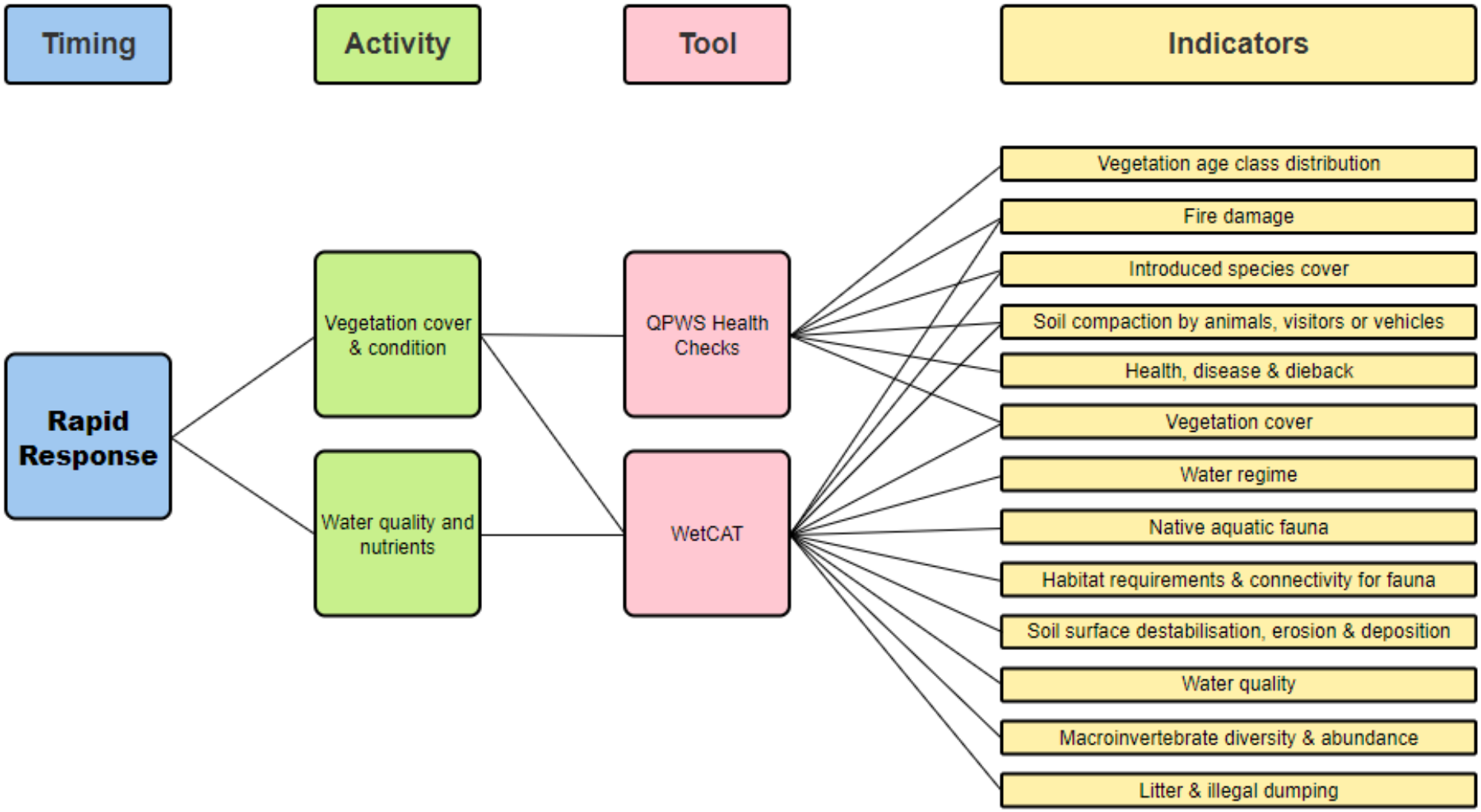

Figure 2. Flow chart outlining the monitoring tools (pink) and indicators (yellow) that should be measured immediately after a fire, where possible.

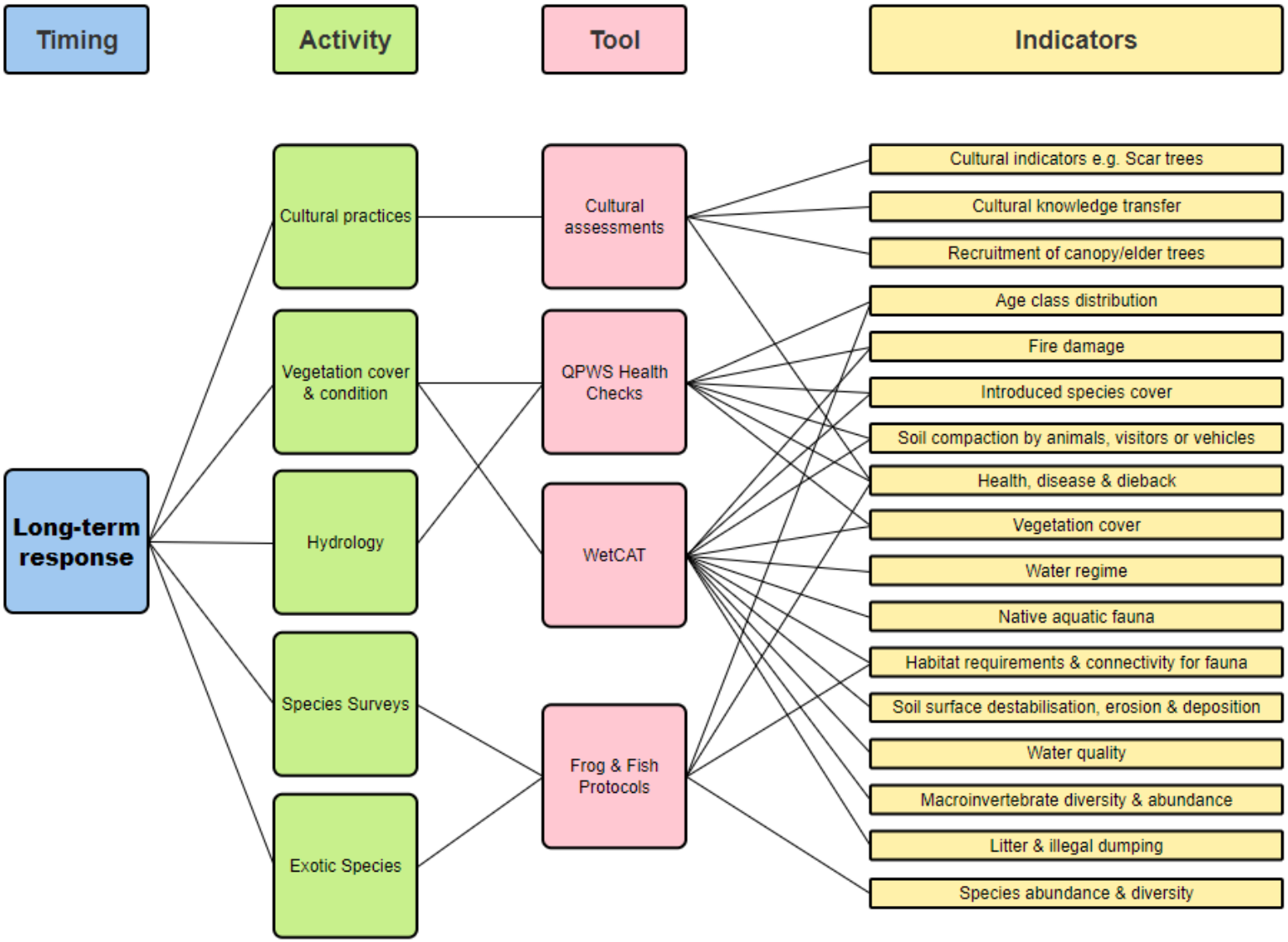

Figure 3. Flow chart outlining the monitoring tools (pink) and indicators (yellow) that should be measured in the months following a fire and every 2-5 years post-fire, where possible.

3.2.3 Develop protocols to assess impacts:

This project has demonstrated protocols for assessing the short-term post-fire impacts and monitor long-term recovery of wetlands and threatened species. The fish and frog field protocols add to the base of monitoring tools that should be used to monitor the impact of and recovery after a fire event. The recommended monitoring tools are included in the Appendix of this document (Appendix 2-4) and provided in full if they are not yet publicly available.

Health checks

QPWS health checks (as per Melzer, 2019) have been conducted on K'gari in recent years. They are a qualitative monitoring tool that uses simple visual 'cues' to assess condition and trend over time. Health Checks, in conjunction with other basic monitoring associated with routine on-ground actions (e.g., planned burning and pest management), are designed to help determine whether current management approaches are appropriate. These health checks are currently conducted annually by QPWS.

These protocols were developed by Queensland Parks, Wildlife and Partnerships Service and a link to the related resources are included in Appendix 2.

WetCAT

Wetland Condition Assessment Tool (WetCAT) protocols have been designed as a rapid assessment method to measure the change in condition of wetlands. These assessments are designed to assess whether a management intervention has achieved an intended outcome, particularly in response to a disturbance event such as bushfires or adaptive management actions. These assessments should be conducted annually with additional surveys conducted in areas impacted by key events e.g., bushfires.

These were developed by the Department of Environment and Science and a link to the related resources are included in Appendix 3.

Wallum frog & fish sampling

Frogs are particularly susceptible to disease due to their ability to absorb elements and breathe via their skin. As such, strict hygiene protocols (as per Murray *et al.*, (2011)) must be adhered to. These surveys are designed to provide a detailed estimate of life stage, distribution between and within wetlands, and habitat assessment for frogs. These include both aural and visual surveys across an approximate 0.8 ha per survey. Frog protocols were developed by MRCCC frog experts and are detailed in Appendix 4.

A combination of box trapping and electro fishing surveys were conducted to determine the fish and crustacean diversity on K'gari. These surveys were intended to be comparable with historic records and followed a standardised protocol outlined in Knight *et al*., (2007). This enabled a direct comparison with historic population distributions to highlight any local extinctions. Fish sampling protocols were developed by Griffith University and are detailed in Appendix 5.

Extensive frog, fish and crustacean surveys should be conducted every few years to ensure that any population declines, and disease can be identified early, and management actions can be implemented. The format of these surveys also enables an accurate measure of the pest and introduced species abundance including the *Rhinella marina* (cane toad) and *Gambusia holbrooki* (mosquitofish) to ensure management actions can be put in place to limit the spread and impact of these species.

In this project, frog and fish surveys were used in conjunction with water quality and WetCAT protocols.

Additional Protocols: Fire monitoring

There exists an array of fire-related protocols and policies that detail collaborative fire management across Queensland. As the majority of K'gari is managed by QPWS, fire monitoring, management hazard reduction burns on the island tend to fall within the South-eastern Queensland Bioregion Planned Burn Guidelines (Department of Environment and Science, 2022). These guidelines outline the timing, considerations, prioritisation, and assessment of an ecosystem's suitability for prescribed hazard reduction burning. Alongside QPWS's fire management guidelines, BAC have drafted a Cultural fire management plan. This plan outlines the desires of the Butchulla people to restore cultural fire management practices to improve connection to Country, knowledge sharing, and understanding of the regional ecosystem's fire needs. With the return of parcels of land on K'gari to Butchulla people, the management of fire on these blocks will fall under the management of Butchulla Land and Sea Rangers through this Cultural management plan. Both frameworks promote and support collaborative management and should be used in conjunction with each other to ensure the best outcome for K'gari.

Additional Protocols: Cultural Assessment

The Butchulla People have a long history of occupation and environmental management on K'gari. Walking through Country, not only enables the two-way knowledge sharing, but can provide an opportunity to pass on cultural knowledge to younger and future generations. Although these annual assessments are typically focussed on the suitability of an ecosystem for cultural fire practices, they can also provide an insight into the overall health of a community including the wetlands and waterways on the island. By understanding cultural indicators, environmental 'cues' and what each ecosystem should look like in 'healthy' conditions, cultural assessments can help to identify areas that require management actions such as weed and pest removal. With ongoing partnerships, these cultural assessments can be used in conjunction with, and build on already ongoing ecosystem assessments.

3.3 Recommendations for future monitoring

This study focused on the impacts of fires on the acid frog and fish species on K'gari. However, it did highlight the need for continued monitoring for these species and ecosystems. There are many aspects of the species ecologies for which there is limited understanding. Ongoing monitoring will help to fill these critical gaps in the knowledge of these species and increase our knowledge of the ecosystems on K'gari as a whole.

Response to a disturbance event such as a bush fire on K'gari should be considered across two time scales – rapid response (days and weeks following event) and long-term response (2-5 years post event). The monitoring that are recommended to be conducted immediately after a disaster include rapid WetCAT or Health checks. These should be conducted across a sub selection of sites based on:

1. Monitoring goal of the surveys (see Section 3.2.1).
2. Susceptibility of the site to weed invasion, pathogen transmission and trampling.
3. Known extent of the burn.
4. Adaptive management needs arising from surveys (e.g. new invasive pest found or pathogen/disease identified).

These surveys should also be conducted at least annually to monitor the recovery of these habitats and to monitor weed invasions. A full suite of the sites from this study (and potentially new nominated sites) should be thoroughly surveyed every 2-5 years post fire using WetCAT or Health checks. Fish and Frog surveys, and cultural assessments should also be carried out at lest every 2-5 years.

3.4 Key learnings, insights, and improvements

This project has achieved what it set out to do by developing a protocol for assessing the short and long-term impacts on K'gari. The monitoring protocols developed and included in this report (e.g. WetCAT, wallum frog & fish sampling) will guide land managers in post-fire prioritisation and monitoring so that these systems and fauna can be monitored with limited detrimental impacts.

Beyond this objective, the consortium involved and integrated expertise from those most knowledgeable in the fields of wetland ecosystems, frog and fish ecology, and management on K'gari. This consortium also included those with on-ground knowledge of these systems and who are responsible for current monitoring programs through QPWS and Butchulla Traditional Owners.

4 Conclusions

This study sought to assess the impact of the 2019-2020 fires on wallum fish and frog species, and how other environmental factors may interact with the impact of fires. The relatively few statistically significant relationships between wallum wetland fauna and environmental variations that were found are likely attributable to the highly idiosyncratic nature of wallum wetlands. Wallum systems are characterised by a wide variation in waterbody habitat and size (Marshall et al. 2011), which may make the physical, chemical and biological impacts of fire highly context dependent (McCullough et al. 2019).

Fire plays an integral role in the ecology of wallum wetlands that are likely to be inherently resilient to fire disturbances (Specht 1981). However, increasing severity and frequency of bushfires may result in considerable damage to systems that are naturally adapted to fire. The effect of fire disturbance, in conjunction with invasive species, drought, riparian degradation, lowering water tables and other factors, on the abundance and distribution of native wallum fauna has not yet been fully elucidated.

5 References

Bureau of Meteorology. (2015). *Australian Hydrological Geospatial Fabric*. http://www.bom.gov.au/water/geofabric/download.shtml

Carpenter-Bundhoo, L., Kennard, M. J., & Ford, E. (2023). *Post fire monitoring of wetlands, threatened species and threatened ecological communities on K'gari (Fraser Island) and GSS Ramsar site. Final Report for Burnett Mary Regional Group*.

Department of Environment and Science. (2013). *Wallum Freshwater Biogeographic Province*. WetlandInfo Website. https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/riverine/wallum/

Department of Environment and Science. (2020). *Wetland data - version 5 - wetland areas - Queensland*. https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid=%7B135EB151-D406-4094-9E9F-40ABC5AA0C7B%7D

Harvey, J. P. (2011). *Landscape weed management plan for Fraser Island*.

Hobday, A. J., & Lough, J. M. (2011). Projected climate change in Australian marine and freshwater environments. *Marine and Freshwater Research*, *62*(9), 1000–1014. https://doi.org/10.1071/MF10302

Kennard, M., Carpenter-Bundhoo, L., & Ford, E. (2022). *Threatened species assessment and recovery in burnt coastal wallum wetlands*.

Meiklejohn, A. M., Melzer, R. I., Hines, H. B., Laidlaw, M. J., Toyne, M., McPherson, K., Behrendorff, L., & MacDonald, S. (2023). *Post-fire Assessment Report – Natural Values: 2020 Duling bushfire, K'gari (Fraser Island), Great Sandy National Park, South East Queensland Bioregion*. https://parks.des.qld.gov.au/__data/assets/pdf_file/0022/265540/post-fire-evaluation-2020-duling-kgari-fraser-gsnp.pdf

Moss, P., Tibby, J., Shapland, F., Barr, C., & Fairfax, R. (2012). *A report into the fire history of the patterned fens of the Great Sandy Region, South East Queensland*.

Neldner, V. ., & Ngugi, M. (2021). *Vegetation recovery after the 2019 and 2020 bushfires on K'gari (Fraser Island), Great Sandy National Park, Southeast Queensland Bioregion*.

Neldner, V. J., Niehus, R. E., Wilson, B. A., McDonald, W. J. F., Ford, A. J., & Accad, A. (2023). *The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Version 6.0*.

Queensland Government. (2021). *Fraser Coast Regional Future Climate Dashboasrd*. Future Climate Predictions. https://www.longpaddock.qld.gov.au/qld-future-climate/dashboard/

UNESCO. (1992). *"Fraser Island" UNESCO, Culture, World Heritage Centre, The List, World Heritage List*. https://whc.unesco.org/document/153916

Walshe, T., Davis, M., de Brie, K., & Kompas, T. (2021). *Environmental Biosecurity Risk Assessement for Conservation Areas*.

Wardell-Johnson, G., Schoeman, D., Schlacher, T., Wardell-Johnson, A., Weston, M. A., Shimizu, Y., & Conroy, G. (2015). Re-framing values for a World Heritage future: what type of icon will K'gari-Fraser Island become? *Https://Doi.Org/10.1080/14486563.2014.985267*, *22*(2), 124–148. https://doi.org/10.1080/14486563.2014.985267

6 Appendices

Appendix 1: Complete list of site selection

Citation

Carpenter-Bundhoo, L., Kennard, M. J., & Ford, E. (2023). Post fire monitoring of wetlands, threatened species and threatened ecological communities on K'gari (Fraser Island) and GSS Ramsar site. Final Report for Burnett Mary Regional Group.

Site number	Site name	Date	Fire score^	Latitude	Longitude	Monitoring goals*
GU58	K'gari 3	30/03/2021	3.2585	-25.7114	153.0744	2, 4
GU61	Southern Rd	31/03/2021	1.0191	-25.5678	152.9730	2, 4
GU62	Govi Ck	1/04/2021	0.1773	-25.5855	153.0986	2, 4
GU63	Lake Wabby	19/04/2021	0	-25.4595	153.1306	1, 4
GU64	Yidney Creek	20/04/2021	2.7881	-25.2214	153.0656	2, 3
GU65	Bogimbah Ck	20/04/2021	3.0823	-25.3030	153.0577	2
GU66	Deep Lake	21/04/2021	2.0295	-25.2158	153.2160	3
GU67	Lake Allom	21/04/2021	2.0295	-25.1963	153.2082	3
GU68	Woralie Creek	21/04/2021	3.2003	-25.1811	153.1476	2
GU69	Ocean Lake	22/04/2021	2.4154	-24.9253	153.2781	2, 4
GU77	Seary's Ck	31/08/2021	0	-25.9744	153.0726	1, 4
GU76	Snapper Ck	13/09/2021	0	-25.9409	152.9746	1, 4
GU66	Deep Lake	15/09/2021	2.0295	-25.2158	153.2160	3
GU67	Lake Allom	15/09/2021	2.0295	-25.1963	153.2082	3
GU64	Yidney Creek	16/09/2021	2.7881	-25.2214	153.0656	2, 3, 4
GU85	Bogimbah Ck 2	16/09/2021	3.0823	-25.3081	153.0617	2
GU72	Rocky Creek	17/09/2021	0	-25.4725	153.0097	1, 4
GU77	Seary's Ck	21/03/2022	0	-25.9746	153.0727	1, 4
GU201	Seary's Ck 2	24/03/2022	0	-25.9429	153.0510	1, 4
GU202	Cooloola Ck	24/03/2022	0	-25.9721	153.0374	1, 4
GU107	Poverty-Point Rd	4/05/2022	0	-25.9808	153.0392	1, 4
GU117	Wanggoolba Ck	25/05/2022	0	-25.4738	153.0646	1, 4
GU129	Coongul Ck	25/05/2022	3.3014	-25.1968	153.1107	2, 4
GU62	Govi Ck	27/05/2022	0.1773	-25.5855	153.0986	2, 4
GU61	Southern Rd	31/05/2022	1.0191	-25.5678	152.9730	2, 4
GU72	Rocky Ck	31/05/2022	0.0000	-25.4725	153.0098	1, 4
GU115	Poyungan Ck #2	1/06/2022	2.8722	-25.3553	153.0859	2, 4
GU130	Poyungan Ck #1	1/06/2022	2.2219	-25.3675	153.1029	2
GU66	Deep Lake	2/06/2022	2.0295	-25.2143	153.2153	3
GU127	North Yindeering	18/06/2022	2.5731	-24.9023	153.2409	2, 4
GU123	Bool Ck Lagoon	20/06/2022	2.5916	-24.7460	153.1746	2, 4
GU310	Bool Ck West	20/06/2022	2.5916	-24.7537	153.1681	2, 4
GU69	Ocean Lake	22/06/2022	2.4154	-24.9253	153.2781	2, 4
GU131	Orange Ck	22/06/2022	2.7071	-24.9156	153.2774	3
GU313	Semaphore Ck	18/07/2022	3.4474	-25.7888	153.0731	2, 4
GU68	Woralie Ck	19/07/2022	3.2003	-25.1810	153.1477	2, 3
GU314	Garowweea Ck	20/07/2022	0.1773	-25.5663	153.1046	2, 4
GU315	Dilli Village	20/07/2022	0	-25.5997	153.0904	1, 4

GU63	Lake Wabby	25/07/2022	0	-25.4595	153.1306	1, 4
GU65	Bogimbah Ck	26/07/2022	3.0823	-25.3030	153.0577	2, 3
GU85	Bogimbah Ck 2	26/07/2022	3.0823	-25.3080	153.0617	2, 3
GU64	Yidney Creek	28/07/2022	2.7881	-25.2214	153.0656	2, 3, 4
GU67	Lake Allom	28/07/2022	2.0295	-25.1963	153.2082	3
GU126	Lake Wanhar	2/08/2022	1.8751	-24.8443	153.2333	2, 4
GU125	Bool Lake	3/08/2022	2.2578	-24.7620	153.1836	3
GU402	North Bool Lagoon	3/08/2022	2.2578	-24.7583	153.1834	3
GU403	Upper Bool Ck	3/08/2022	2.5916	-24.7490	153.1767	2, 4
GU404	Bool Lagoon North West	4/08/2022	2.2578	-24.7654	153.1708	3
MRCCCKU1	NA	25/03/2021	0.1010	-25.6888	153.0658	2, 4
MRCCCKU2	NA	25/03/2021	0	-25.6405	153.0767	1, 4
MRCCCKU5a	NA	26/03/2021	0	-25.5983	153.0799	1, 4
MRCCCKU8	Beeliwa Lagoon	24/03/2021	0	-25.5655	153.0302	1, 4
MRCCCKU9	Wetland South of Lake Birrabeen	24/03/2021	0	-25.5361	153.0478	1, 4
MRCCCKU12	NA	27/03/2021	0	-25.5258	153.0543	1, 4
MRCCCKU14	NA	28/03/2021	0	-25.5130	153.0572	1, 4
MRCCCKB3	Wetland off Great Walk Jabiru Feeder	26/03/2021	3.4845	-25.7749	153.0613	2
MRCCCKB4a	NA	25/03/2021	2.2917	-25.7121	153.0637	2, 4
MRCCCKB4b	NA	26/03/2021	4.3333	-25.7882	153.0404	2, 4
MRCCCKB9	NA	24/03/2021	0	-25.5158	152.9881	1, 4
MRCCCKB13	NA	19/04/2021	4.9596	-25.6541	152.9924	2, 4
MRCCCKB16	NA	27/03/2021	0.0000	-25.6015	153.0350	1, 4
MRCCCKB21a	Poyungan Creek	3/04/2022	4.4516	-25.3452	153.0679	2
MRCCCKB22	Urang Creek/Bogimbah Airstrip	3/04/2022	3.7143	-25.3333	153.0653	2
MRCCCKB22a	Lake Garrawongera	7/03/2022	0.0619	-25.3262	153.1546	2
MRCCCKB27	Boomerang Lake	11/03/2022	2.6082	-25.2278	153.1349	2, 3
MRCCCKB27a	Nr The Declivity	11/03/2022	2.9898	-25.2441	153.1334	2
MRCCCKB28	Moon Point fens	9/03/2022	4.2959	-25.2146	153.0688	2
MRCCCKB28	Moon Point fens	9/03/2022	4.5978	-25.2175	153.0643	2
MRCCCKB30	Wetland NE of Boomerang Lakes	11/03/2022	1.5155	-25.2152	153.1520	2, 4
MRCCCKB32	Wetland nth of Woralie/Northern Rd intersection	8/03/2022	3.7400	-25.1888	153.1947	2, 4
MRCCCKB32a	Wetland west of Lake Allom	8/03/2022	1.9898	-25.1939	153.2002	2, 4
MRCCCKB33	Wetland sth end of Bowarrady Rd	10/03/2022	2.8763	-25.1603	153.1703	2
MRCCCKB34	Wetland on Woralie Rd nr Bowarrady Rd intersection	7/04/2022	4.6667	-25.1514	153.1616	2, 4
MRCCCKB35	Wetland on Woralie Rd nr Bowarrady Rd intersection	7/04/2022	1.4124	-25.1569	153.1575	2, 4
MRCCCKB37	Bowarrady Creek	10/03/2022	4.3367	-25.1452	153.1704	2, 4
MRCCCKB37	Bowarrady Creek	5/03/2022	4.2268	-25.1399	153.1682	2, 4
MRCCCKB39	White Lake area	5/03/2022	2.1134	-25.1389	153.2276	2, 4
MRCCCKB39a	White Lake area	4/03/2022	3.4021	-25.1406	153.2239	2, 4
MRCCCKB41a	White Lake	4/03/2022	2.5155	-25.1218	153.2006	2
MRCCCKB41b	Wetland southern end of White Lake	5/04/2022	3.9697	-25.1367	153.2195	2
MRCCCKB41c	Wetland southeast of White Lake	4/03/2022	2.6596	-25.1307	153.2107	2, 4
MRCCCKB41d	Lake Gnarann	4/03/2022	2.3636	-25.1144	153.1995	2
MRCCCKB74	Wathumba Wetland - south	3/03/2022	3.2062	-24.9823	153.2549	2, 3

MRCCCKB74	Wathumba Wetland - south west	3/03/2022	3.8687	-24.9831	153.2443	2, 3
MRCCCKB77	Wathumba Wetland - north	3/03/2022	3.3900	-24.9311	153.2801	2, 3
MRCCCKB77	Ocean Lake - east	2/03/2022	2.2222	-24.9289	153.2776	2, 3
MRCCCKB80	Orange Creek	2/03/2022	2.0521	-24.9156	153.2778	2, 3, 4
MRCCCKU20	Garry's Anchorage nth	24/03/2022	0	-25.6206	152.9757	1, 4
MRCCCKU20b	Lake Garry	24/03/2022	0.0206	-25.6198	152.9844	2, 4
MRCCCKU23	Dilli waterhole - south of bridge	6/04/2022	0	-25.5995	153.0928	1, 4
MRCCCKU24	Wetland south of Lake Boomanjin	6/04/2022	0	-25.5741	153.0619	1, 4
MRCCCKU25	Wetland NW end of Red Lagoon system	8/04/2022	0	-25.5525	153.0429	1, 4
MRCCCKU44	Wetland west of Lake Mackenzi	4/04/2022	0	-25.4521	153.0493	1, 4
MRCCCKU46	Unnamed	20/03/2022	0	-25.4458	153.0728	1, 4
MRCCCKU48c	Boon Boon Ck trib	4/04/2022	3.3776	-25.4107	153.0863	2, 3, 4
MRCCCKU49a	Black Lagoon	9/03/2022	0	-25.2673	153.1454	1, 4
MRCCCKU60	Waddy Point beach wetland	5/03/2022	0.4898	-24.9651	153.3340	2

^ Fire score denotes mean fire score for the contributing catchment for GU sites and fire score for the immediate 200 m surrounding a site for MRCCC site. Fire scores were generated for contributing catchments derived from the Australian Hydrological Geospatial Fabric (AHGF) Geofabric dataset. They range between 0 (none) and 5 (very major).

* Monitoring Goals are taking from Section 3.3 Recommendations for Future monitoring:

1. Tracking persistence of healthy populations of priority species in representative wetlands unaffected by recent fires
2. Tracking post-fire responses of priority species populations in fire-affected wetlands to confirm ongoing persistence and/or continued recovery**.**
3. Tracking natural recolonisation of priority species in fire-affected wetlands where localised extinctions are suspected to have occurred**.**
4. Detecting new incursions of introduced aquatic species (including eastern gambusia, platy, cane toad)
5. Identify emerging threatening processes (e.g. weed invasion, saltwater intrusion, etc)
6. Improving understanding of responses to management interventions (e.g. riparian weed control, fire management) intended to protect or restore wetland values

Appendix 2: QPWS Health Check Sheets

This publication outlines the Natural Values Health Checks and details Health check indicator definitions, field sheets, and methodology for this tool.
https://parks.des.qld.gov.au/__data/assets/pdf_file/0027/168093/natural-values-health-check-guide.pdf

Citation

Melzer R. 2019. Natural Values Health Checks. A guide to undertaking Health Checks for key natural values. Version 1.8, August 2021. Ecological Assessment Unit, Queensland Parks and Wildlife Service & Partnerships, Department of Environment and Science, Queensland Government.

Appendix 3: WetCAT Record Sheets

This publication outlines the Wetland Condition Assessment Tool (WetCAT) and details equipment required, field sheets, indicators and Condition Assessment Monitoring Plans using this tool.
https://wetlandinfo.des.qld.gov.au/resources/sta?c/pdf/assessment-monitoring/wetcat/wetcat-final.pdf

Citation

Department of Environment and Science, 2022, WetCAT: A Condition Assessment Tool for Measuring Event Recovery and Rehabilitation in Palustrine and Lacustrine Wetlands in Queensland, Version 1.0, June 2022, Queensland Wetlands Program, Queensland Government, Brisbane.

Appendix 4: Frog survey methodology – Researchers 2022

Prepared by the Mary River catchment Coordinating Committee, Gympie, Queensland.
Author: Eva ford, Catchment Officer (eva.ford@mrccc.org.au)
February 2022

The following methodology is designed for frog surveys and wetland assessments of wallum wetlands on K'gari and Great Sandy Strait Ramsar sites for the '*Post fire monitoring of wetlands, threatened species and threatened ecological communities on K'gari (Fraser Island) and GSS Ramsar site*' program funded by the Australian Government and the Queensland Department of Environment and Science. The methodology is designed for visual and aural frog encounter surveys that are conducted on foot within wallum wetland ecosystems. The methodology also includes a WetCAT (Wetland Condition Assessment Tool as per Department of Environment and Science, 2022) assessment.

Site selection and categorisation

Survey sites are determined using imagery, wetland mapping and fire intensity information for the 2021 wildfire. As wetland type is difficult to determine from imagery, daylight ground-truthing is carried out to make a final site selection.

Wallum wetland types of interest to this project are defined by the Queensland Government WetlandInfo resource as follows (Department of Environment and Science, Queensland, 2013):

- Coastal and subcoastal non-floodplain grass, sedge, herb swamp
- Coastal and subcoastal non-floodplain wet heath swamps
- Coastal and subcoastal non-floodplain tree swamp
- Coastal/ Sub-coastal non-floodplain sand lakes (Perched)

From this guide we utilise the following derivations for wetland vegetation group based on dominant floristic assessment:

- Sedge wetland
- Heath wetland
- Melaleuca wetland (specify understory)
- Other

WetCAT assessment

WetCAT is a wetland assessment tool in developmental stage and is used in conjunction with the draft manual (Department of Environment and Science, 2022). The assessment is conducted during the day on a 10 by 10 metre quadrat within the wetland that is representative of the frog survey transect (see following section for frog survey methodology). A flora assessment is also carried out for the quadrat based on aerial extent of cover provided by the various species and/or flora groups that are present. The area is photographed to the north, south, east and west. To record surrounding threats that may impact the wetland a 100m buffer is also assessed from the wetland edge into the surrounding ecosystem/s.

The record sheets for these assessments are attached to this document.

Frog survey methodology

Target frog species are:

- *Crinia tinnula* (Wallum Froglet)
- *Litoria cooloolensis* (Cooloola Sedge Frog)
- *Litoria freycineti* (Wallum Rocket Frog)
- *Litoria olongburensis* (Wallum Sedge Frog)

The Department of Environment and Heritage Protection hygiene protocols (Murray et al, 2011) are adhered to in order to avoid the spread of anuran diseases between sites.

A field record form has been developed for use in the field and is provided as an attachment.

Where possible sites are visited during the typical breeding season from October to February (Department of the Environment, Water, Heritage and the Arts, 2010), unless weather conditions allow for an extension either side of this period. Surveys are conducted after dark and typically continue for 40 minutes. The distance covered is 50 metres into the wetland, or alongside if site accessibility is limited due to deep water, impenetrable vegetation or site sensitivity to disturbance.

Daytime selection and assessment of a site will include:

- Suitability of the site as a wetland
- Acceptable risk assessment
- Accessibility to the site under nigh time conditions

Information collected during the frog survey:

- Location identifier
- Date
- Start and end time
- Surveyors names
- Latitude and longitude of the transect
- Distance travelled
- Recent rainfall history

- Cloud cover
- Moon phase
- Ground moisture
- Water observations - colour, odour, physical appearance etc
- Frog observations
- Incidental fauna observations
- Wetland vegetation type assessment
- Extent of bare ground (%)
- Extent of water present (area % and maximum depth)
- Evidence of feral animals (also carried out at night during the survey)
- Distance from human structure
- Feral animals observed at the site or nearby
- Assessment of fire (flame height, tree death)
- Evidence of recent flooding

Surveys are conducted using headlamp illumination (less than 300 lumens) to aid the detection of eyeshine. Surveys are conducted in 3 stages to cover a circular area of wetland that is 100 metres in diameter (~0.8 hectare) as shown in Figure 1:

1. Five minutes listening for frogs at the start of the transect with headlamp/s off. The radius of detection is 5 metres around this point.
2. Slow progression along the transect recording all frogs heard and observed for one metre each side of the transect, ensuring vegetation layers are inspected by gentle adjustment of the foliage.
3. Five minutes listening for frogs at the end of the transect with headlamp/s off. The radius of detection is 50 metres around this point.

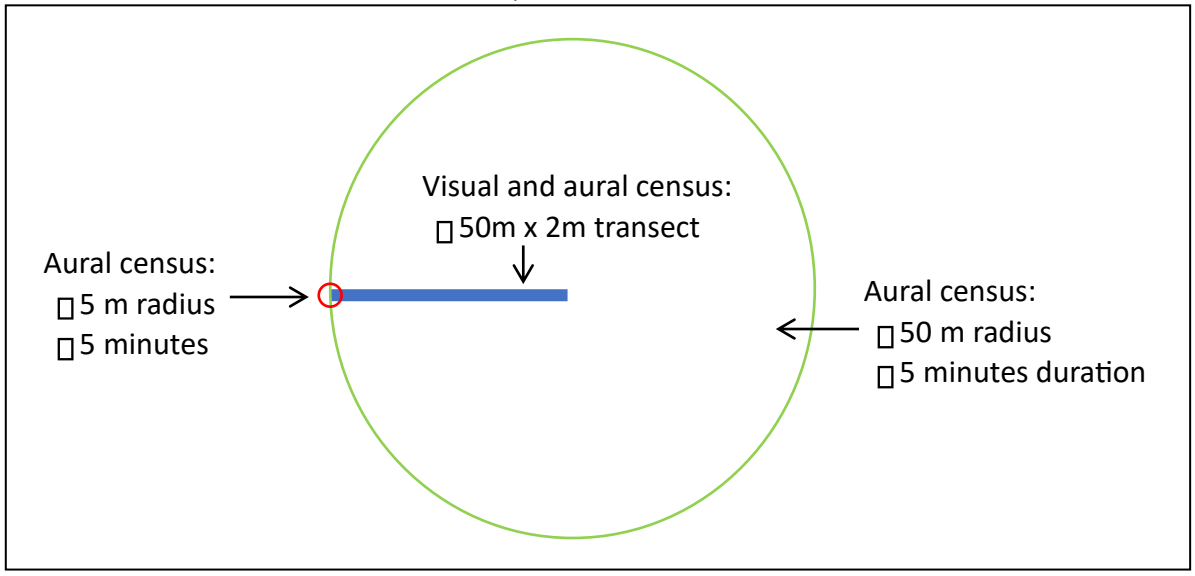

Figure 1. On-site survey design

All frogs are accurately counted or an estimate of numbers is made. Where possible, additional information of each observation is collected as to the life stage (metamorph, juvenile, adult) and sex of the frog/s. A record of the observation method is made (e.g. seen, heard, photographed, audio recording). Frogs detected outside the area of survey are recorded separately as incidental records.

Other fauna, such as ground and arboreal mammals, roosting birds, reptiles, fish and microbats may be detected by sound, dip-netting, Anabat recorder or headlamp during the survey. These are recorded as incidental records.

No fauna is handled or captured unless by incidental dip netting whereupon they are inspected for identification and released at the site. Fauna may be photographed.

Identification of frogs is by call recognition and visual observation by an observer/s with substantial experience in frog survey and identification.

Water quality testing

A TPS FLT90 unit is used to measure Dissolved oxygen, pH, electrical conductivity, turbidity and temperature. The probes are placed within a water body for measurement along or in close proximity to the frog survey transect. If the water is too shallow then sufficient water is collected for testing in a container. If it is too hazardous or too cumbersome to deliver the unit to the site, a water sample is collected for testing upon return to the unit.

Weather parameters

Weather conditions are collected using a hand-held Kestrel 5500 on site at the start and end of the frog survey. Measurements collected are

- Air temperature – wet and dry bulb
- Relative humidity
- Air pressure
- Wind speed

Equipment list

- Storage containers (e.g. nally bins)
- Reference books – frogs, tadpoles, mangroves to Mountains, Stephanie H's Wallum book, water bug books, grasses book, water plants, Wildlife of Greater Bris, …
- Local frog reference sheets (adults/tadpoles)
- Data sheets – MRCCC incidental, Frog survey and WetCAT
- Herbarium plant specimen forms
- Clipboards, pens and pencils, rubber, nikko pens
- Sign-on/emergency contact sheet
- Personnel/volunteer contact list
- Induction material
- Incident report forms
  Maps
- iPad with Avenza maps
- Offline maps on phone with satellite layer
- Laptop and chords
- Risk assessment
- Drone if needed
- Permit/s
- Reflectors and wire
- Headlamps, spare batteries and charger
- Anabat
- Batteries AA for Anabat
- Gas stove and cylinders
- Billy
- Camera
- Phone
- Phone/charging chords
- Powerboard and extension chord

- USB multi-charger ports
- Backpack - frogs
- 1st aid kit
- Snake kits
- Insect repellent
- Sunscreen
- Disinfectant – frog hygiene, foot bath, bottles of water, funnel
- Waders, wellies
- Puncture repair kit for waders
- Sewing kit
- Pocket knife
- FLT90
- Bucket
- Clipseal bags
- Distilled water
- Macroinvertebrate net or fine-meshed fish net (strong)
- 3 dingo poles
- Small scoop net
- Clipseal bags
- Hand-held weather station - Kestrel
- Maxitracks x 4
- Rope
- Shovel
- Snatch-strap
- Chainsaw, spare battery and charger
- Tools - assorted
- Water bottle
- Air compressor for tyres
- Tyre gauge

Field sampling datasheets

Vegetation assessment record sheet

Project:	**Assessed by:**
Date:	**Site ID:**
Site condition/comments:	

This assessment is to be conducted in the area surveyed for the WetCAT assessment. Use the site ID used in the WetCAT assessment.

Species Name	**Approximate abundance (% cover of the WetCat sample area):**	**Visual extent (e.g. patchy, large stacks, everywhere etc.)**	**Photo ID:**

Frog survey record sheet

WALLUM FROG SURVEY
Visual assessment form

WildNet Site ID #	Data entered by:
	Data checked by:

Location:		Waterway/water body name:
Start time: am/pm	End time: am/pm	Date:
Start lat/long or waypoint:	End lat/long or waypoint:	Estimated distance surveyed (m):
Personnel:		
Volunteers:		

Weather			
	Start		End
Air temp. (wet bulb)		Air temp. (wet bulb)	
Air temp. (dry bulb)		Air temp. (dry bulb)	
Relative humidity (%)		Relative humidity (%)	
Air pressure (hPa)		Air pressure (hPa)	
Cloud cover (eighths)		Cloud cover (eighths)	
Wind speed/strength (m/s)		Wind speed/strength (m/s)	
Last rainfall:	☐ More than 1 week ago ☐ During the last week	☐ During the last 24 hours ☐ Raining now	Moon phase (full, ¼, ½, ¾)

Water parameters			
Water temp.		pH	
EC		Turbidity	
Dissolved oxygen (%sat)			
Other obs. (colour, odour, surface condition, flocks, algal blooms)			

Vegetation group	Incidental fauna records
Sedge swamp	
Heath	
Melaleuca (describe understory?)	
Other	

Aural census – START of transect (5 minutes, 5 metres radius)				
Species heard (all HEA, all Male) (write NIL if nothing heard)	Number calling	Notes	Vetting (C, U)	By whom

Transect observations						
Species	Life stage	Obs. type	Number	Notes	Vetting (C, U)	By whom

Life stage = Adult (A), Juvenile (J), Metamorph (MM), Tadpole (TP), Unknown (U) Vetting = Confirmed (C)
Observation type = Seen (SEE), Heard (HEA therefore Male), Photographed (PHT), Recorded (AUD) Unconfirmed (U)

Aural census – DURING traverse of transect (50 metres radius around end point)				
Species heard (all HEA, all Male) (write NIL if nothing heard)	Number calling	Notes	Vetting (C, U)	By whom

Transect notes	
Percentage of transect with free water (%):	
Maximum depth of water along transect (m):	
Distance from human structure (m) (road, track, building, illumination source)	
Evidence of feral animals (pig, fox, fish – Gambusia, Platy, Swordtail)	
Evidence of fire • Presence of burnt trees and shrubs • Flame height • Evidence of tree death	
Evidence/knowledge of recent flooding	

References

Department of Environment and Science, (2022). *WetCAT - A Condition Assessment Tool for Palustrine and Lacustrine Wetlands in Queensland. Version 1.0. In Draft. Queensland Government.*

Department of the Environment, Water, Heritage and the Arts, (2010). *Survey guidelines for Australia's threatened frogs.* Australian Government.

Department of Environment and Heritage Protection, Queensland (date unknown). *Technical manual Interim hygiene protocol for handling amphibians.* Queensland Government.

Department of Environment and Science, Queensland (2013) Palustrine ecology, Wetland*Info* website, accessed 19 November 2021. Available at: https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/palustrine/

Meyer, E. and Hines, H. (2020). *Proposed post-fire frog survey methodology for wallum habitats.* Unpublished.

Murray, K., Skerratt, L., Marantelli, G., Berger, L., Hunter, D., Mahony, M. and Hines, H. 2011. *Hygiene protocols for the control of diseases in Australian frogs.* A report for the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Appendix 5: Fish sampling Field Protocol

Field Manual

Including protocols for quantitative sampling of fish, crayfish, habitat and water quality in Wallum wetlands.

To be used in conjunction with Australian Rivers Institute field sampling data sheets

Mark J Kennard

Luke Carpenter-Bundhoo

16 June 2022

Introduction

The following methodology is designed for the quantitative sampling of fish, crayfish, habitat and water quality in wallum wetlands along the Queensland and new South Wales coastal zone. Target species include: Oxleyan pygmy perch (*Nannoperca oxleyana*), honey blue-eye (*Pseudomugil mellis*), ornate rainbowfish (*Rhadinocentrus ornatus*) and crayfish species including sand crayfish (*Cherax robustus*).

Fish and crayfish

Box trapping

Fish sampling methodology is based on a standardised protocol described in Knight et al. (2007)[1], to align with the sampling efforts of prior records. At each site, 20 unbaited collapsible box traps are set in a variety of habitat types at varying depths (ranging between 20 and 100 cm) for 30 minutes (Figure 1). Leaving traps deployed for longer than 30 minutes can result in predation of smaller individuals. Including bait in the box traps only serves to soil the traps, as studies have shown equal efficacy of baited and unbaited traps for this type of sampling[1]. After retrieval, fish and crustacea should be retained in aerated ~20 L containers with clean water from the sampling site. Standard box traps bought at recreational fishing stores are sufficient for this purpose and should measure 250 x 250 x 450 mm with 3 mm nylon mesh and inverted funnel entrances at each end with 40 mm openings.

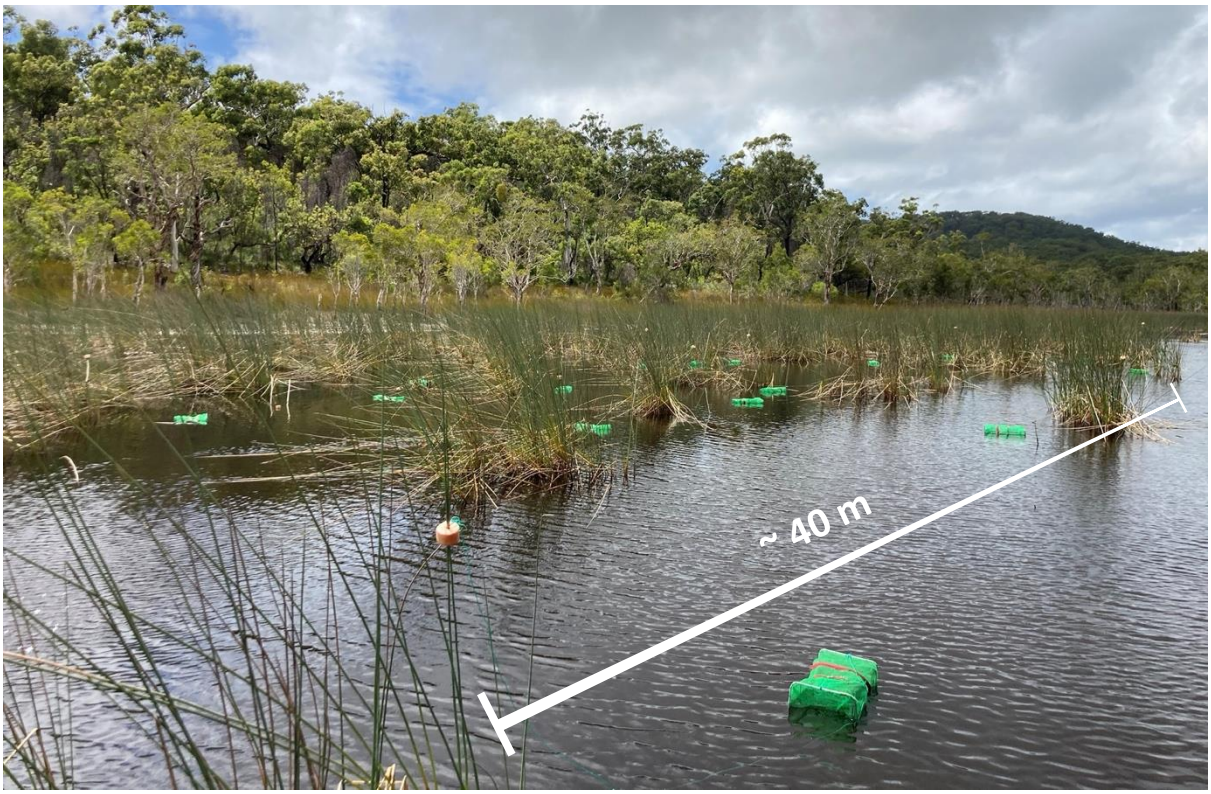

Figure 1. Collapsible box traps deployed at a shallow wetland site in Cooloola National Park, Qld.

*Electrofishing**

When conditions allow, electrofishing should also be used as a complimentary sampling method to capture a broader range of habitats, depths and sampling conditions. In Figure 2 below, electrofishing was done with a Smith- Root model LR24, battery powered, backpack electrofisher, using a 280 mm diameter aluminium anode ring attached to a fibreglass handle, and a steel cable cathode. The electrofisher was set to pulsed direct current

[1] Knight, J., T. Glasby, and L. Brooks. 2007. A sampling protocol for the endangered freshwater fish, Oxleyan Pygmy Perch *Nannoperca oxleyana* Whitley. Australian Zoologist 34:148-157.

* Optional - requires specialist equipment.

(DC) at 120 Hz, with outputs of 250 to 400 volts depending on water conductivity. Multiple 150 second on-time shots should be conducted in all accessible habitats, up to a maximum of 8 shots (total 1200 seconds on-time). All fish and crustacea caught during electrofishing should be retained in aerated ~20 L containers with clean water from the sampling site.

Figure 2. L. Carpenter-Bundhoo and M. Mallet electrofishing a wallum wetland using a Smith- Root model LR24.

Identifying and measuring fish after capture

After collection of fish and crustacea from box traps and electrofishing, each individual should be identified to the species level and recorded, also noting capture method. All Oxleyan pygmy perch (*Nannoperca oxleyana*), honey blue-eye (*Pseudomugil mellis*), ornate rainbowfish (*Rhadinocentrus ornatus*) and sand crayfish (*Cherax robustus*) should be measured as shown in figure 3. After this, all individuals should be released unharmed to their point of capture.

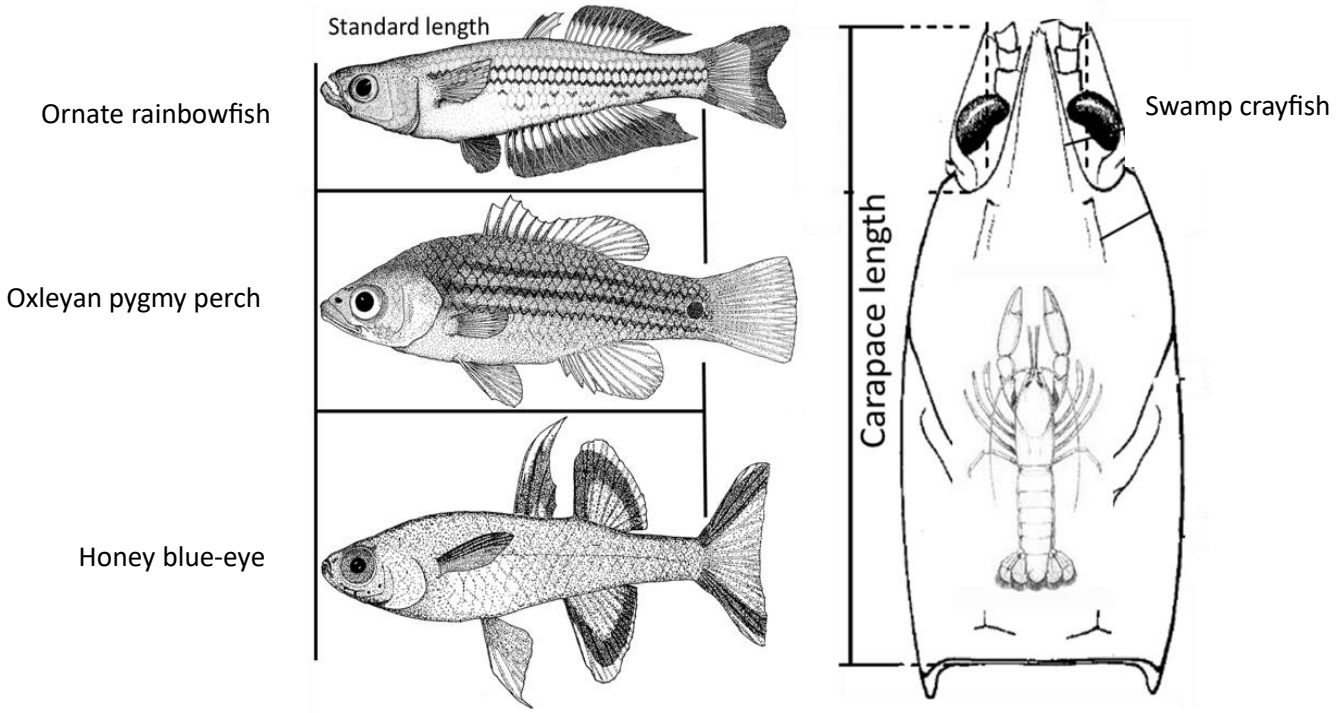

Figure 3. Guide to standard length carapace length measurement for Oxleyan pygmy perch (*Nannoperca oxleyana*), honey blue-eye (*Pseudomugil mellis*), ornate rainbowfish (*Rhadinocentrus ornatus*) and sand crayfish (*Cherax robustus*).

Further information on identifying wallum wetland fish and crayfish species can be found at:

Pusey, B. J., Kennard, M. J. & Arthington, A. H. 2004, *Freshwater fishes of north-eastern Australia*. CSIRO Pub Collingwood, Victoria.

Allen, G. R., Midgley, S. H. & Allen, M. 2002, *Field guide to the freshwater fishes of Australia*, Western Australian Museum Perth, W.A.

Page, T.J. (2021). Nomination to change the conservation class of Cherax robustus under the Queensland Nature Conservation Act 1992 (minor revision of 2020 version). Department of Environment and Science, Brisbane. https://www.dcceew.gov.au/sites/default/files/documents/cam-assessment-cherax-robustus.pdf

Habitat and environmental sampling

*Physiochemical water sample**

A YSI ProDSS instrument, or similar water physiochemical sampling unit, should be used to measure the following water physiochemistry at each site: temperature (°C), dissolved oxygen (DO; mg/L and % saturation), pH, conductivity (µS/cm) and turbidity (NTU).

*Water nutrients sample**

Triplicate grab water samples are collected at each sites to assess nutrient concentrations using 50 mL sterile conical polypropylene tubes, pre-rinsed three times with sample water (Sigma-Aldrich Australia). Samples for

* Optional - requires specialist equipment.

dissolved inorganic nitrogen (DIN; NO3-N and NH4-N), phosphate (PO4-P), total dissolved nitrogen (TDN) and phosphorus (TDP) analysis are filtered through 0.45 µm PVDF filters. An unfiltered water sample should also be collected at each site for the measurement of total nitrogen (TN) and phosphorus (TP) concentrations. All grab water samples are to be kept refrigerated at <4°C while being transported and must be stored frozen at -20°C thereafter. A domestic freezer will be a sufficient temperature for preservation of the samples. Samples can be processed at the Department of Environment and Science water chemistry centre in Dutton Park, Qld.

Habitat survey

Meso- and microhabitat are recorded at ten random points of each site and fire impact is assessed for both riparian and aquatic zones (for categories, see Section 4.0 Field sampling datasheets). At each point, a handheld GPS unit is used to record the position. Water depth is measured using a portable depth probe and mean water velocity is recorded with a portable flow meter (eg. Swoffer, WA, USA). Riparian vegetation canopy cover is estimated using a spherical densiometer.

Field sampling datasheets

Location	
Site name	
Site number	
Site type (riverine, lacustrine, palustrine, spring)	

Date	
Time	

	Latitude	**Longitude**
Start / Downstream		
End / Upstream		

Fire and other impacts: Ratings: 1=none, 2=minor, 3=moderate, 4=major, 5=very major

Factor	**Rating**
Riparian zone	
Riparian vegetation degradation/loss	
Bankside erosion	
Vertebrate pest damage (e.g. pig digging, trampling)	
Invasive plant encroachment	
Aquatic zone	
Ash / Sediment / debris deposition	
Vertebrate pest damage (e.g. pig digging, trampling, wallowing)	
Invasive plant encroachment	

Water chemistry:

Parameter	**Dissolved oxygen (mg/l)**			**Dissolved oxygen (% sat)**			**pH**			**Conductivity (*us*.cm^{-1})**			**Temperature (°C)**			**Turbidity (NTU's)**			**Secchi depth (cm)**
Depth (m)	Rep. #1	Rep. #2	Rep. #3	Rep. #1	Rep. #2	Rep. #3	Rep. #1	Rep. #2	Rep. #3	Rep. #1	Rep. #2	Rep. #3	Rep. #1	Rep. #2	Rep. #3	Rep. #1	Rep. #2	Rep. #3	
0																			
1																			
2																			
3																			
4																			
5																			
6																			

Riparian cover:

Densiometer	**Rep. #1**	**Rep. #2**	**Rep. #3**
1			
2			
3			
4			
% Cover			

SITE MAP DATA SHEET

Include the following details:

- access point
- direction of flow
- location where photos taken
- WQ collection sites
- approximate fish sampling locations for each method (ES, Box trap, etc)
- basic mesohabitat features (i.e. riffle, run, pool, etc)
- basic microhabitat features (i.e. LWD, macrophyte beds, etc)

Total site length (m) = ……

Nutrients:

ELECTROFISHING CATCH DATA SHEET #1

Date:		Site #:		Site name:	

Shot No.	E1	E2	E3	E4	E5
EF Power On time					
Time Start (sec)					
Time End (sec)					
EF Elapsed time					
Time Start (24 hr)					
Time End (24 hr)					
Shot length (m)					
Electrofisher settings					
AC/DC					
Volts					
Pulses per sec.					
% duty cycle (range)					
Amps					

Fish Species	# caught	# obs	# caught	# obs	# caught	# obs	# caught	# obs	# caught	# obs
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										
11.										
12.										
13.										
14.										
15.										
16.										
17.										
18.										
19.										

BOX TRAP CATCH DATA SHEET #1

Date:		**Site #:**		**Site name:**	

Sample No.	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
Total water depth (cm)										
Trap position (upper, mid, bottom)										
Habitat type (Pool, Mac bed, etc.)										
Fish Species	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										
11.										
12.										
13.										
14.										
15.										
16.										
17.										
18.										
19.										
20.										

OTHER CATCH DATA SHEET

Date:		**Site #:**		**Site name:**	

Method										
Sample No.										
Habitat type (Pool, Mac bed, etc.)										
Fish Species	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**	**# caught**
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										
10.										
11.										
12.										
13.										
14.										
15.										
16.										
17.										
18.										
19.										
20.										

LENGTH DATA SHEET #1

Date:		**Site #:**		**Site name:**	

Sample method (ES, BT, etc)	**Species:** *Rhadinocentrus ornatus* (Ornate rainbowfish) *Nannoperca oxleyana* (Oxleyan pygmy Perch) *Pseudomugil mellis* (Honey blue eye) *Cherax robustus* (Sand crayfish)	**mm Standard Length (fish) or mm Carapace Length (crayfish)**	**Health Codes:** D - Deformity (skeletal, eye, fins, asymmetric etc.) P - Other parasites (leech, lamprey, isopod) F - Fin condition poor (broken, eroded) S - Lesions (raised or reddish skin or scales) G – Fungus T - Tumour (localised abnormal growth) L - Lernaea U - Ulcer (skin is broken, crater like, redness) O - Other (describe) W - Wounds (e.g. bird strikes, hook wounds)

		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

HABITAT DATA SHEET

Date		Site #:		Site name:	

Total reach length (m)		

Sample No.	E-Shot length (m)	Wetted width (m)	Mesohabitat type (% shot)					Depth (cm)					Velocity (cm.sec^{-1})					Substrate (% shot)								Microhabitat type (% shot)									
			Riffle	Run	Glide	Pool	Backwater	Rep. # 1	Rep. # 2	Rep. # 3	Rep. # 4	Rep. # 5	Rep. # 1	Rep. # 2	Rep. # 3	Rep. # 4	Rep. # 5	Ash / organic ooze	Mud (<0.06mm)	Sand (0.06-2mm)	Fine Gravel (2-16mm)	Coarse Gravel (16-64mm)	Cobble (64-128mm)	Rock (>128mm)	Bedrock	Aq. macrophytes	Leaf litter	Submerged marginal veg. (e.g. grasses, weeds)	Sub. overhanging veg. (e.g. tree branches / leaves)	Emergent veg. (e.g. sedges, rushes)	Root masses	Undercut banks	Large woody debris (>15cm stem diameter)	Small woody debris (<15cm stem diameter)	Algae
1																																		
2																																		
3																																		
4																																		
5																																		
6																																		
7																																		
8																																		
9																																		
10																																		