MARINE MONITORING PROGRAM

Annual Report for
INSHORE PESTICIDE MONITORING
2018-19

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The Great Barrier Reef Marine Park Authority acknowledges the continuing Sea Country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Island Traditional Owners whose rich cultures, heritage values, enduring connections and shared efforts protect the Reef for future generations.

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Common acronyms, abbreviations and units

Acronym	**Detail**
2,4-D	2,4-dichlorophenoxyacetic acid
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG 2018	Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
Authority	Great Barrier Reef Marine Park Authority
%CV	per cent coefficient of variation
C_W	Concentration in water
DES	Department of Environment and Science (formerly DSITI)
DSITI	Department of Science, Information Technology and Innovation
EC_x	x per cent maximal effective concentration is observed
ED	Empore Disk^{TM} passive sampler
GBRCLMP	Great Barrier Reef Catchment Loads Monitoring Program
GBRMPA	Great Barrier Reef Marine Park Authority
GC-MS	Gas Chromatography-Mass Spectrometry
GPC	Gel Permeation Chromatography
GV	Guideline value
IC_x	x per cent of the maximal inhibitory concentration is observed
IWL	Interim working level
K_{OW}	Octanol-water partition coefficient
LC_x	x per cent of the lethal concentration is observed
LC-MS/MS	Liquid Chromatography-Tandem Mass Spectrometry
LOD	Limit of Detection
LOR	Limit of Reporting
MCPA	2-methyl-4-chlorophenoxyacetic acid
MMP	Marine Monitoring Program
ms-PAF	Multi-substance potentially affected fraction
NOEC	No Observed Effect Concentration
PDMS	Polydimethylsiloxane passive sampler
PFM	Passive/Plaster Flow Monitor
PSII-HEq	Photosystem II Herbicide Equivalent Concentration
PTFE	Polytetrafluoroethylene : Common brand name - Teflon
PWG	Pesticide Working Group
QAEHS	Queensland Alliance for Environmental Health Sciences (formerly Entox)
QA/QC	Quality Assurance/Quality Control
QHFSS	Queensland Health Forensic & Scientific Services
RPF	Relative Potency Factor
Reef 2050 WQIP	Reef 2050 Water Quality Improvement Plan
SOP	Standard Operation Procedure
SSD	Species sensitivity distribution

Note that the term pesticide is used to refer collectively to the group of insecticides, herbicides and fungicides.

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David Boadle	Mission Beach Charters: Bec Rowlands and Jason Shearer	REEF Catchments

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Executive Summary

This component of the Marine Monitoring Program provides an understanding of nearshore pesticide profiles and the exposure risk to marine organisms, as a part of water quality condition on the Great Barrier Reef.

Data are collected from eleven fixed monitoring sites located in four Natural Resource Management regions — the Wet Tropics (five sites: Low Isles, High Island, Normanby Island, Dunk Island and Lucinda), Burdekin (one site: Barratta Creek), Mackay-Whitsundays (four sites: Repulse Bay, Flat Top Island, Sandy Creek and Sarina Inlet) and Fitzroy (one site: North Keppel Island).

The suite of pesticides monitored includes photosystem II (PSII) inhibiting herbicides (such as diuron, atrazine (and its metabolites), ametryn, hexazinone, tebuthiuron), which all affect photosynthesis, and are commonly detected due to their high usage in adjacent catchments, and their high solubility. Other pesticides monitored include those that have non-photosynthetic effects (such as imidacloprid and metolachlor) and knockdown herbicides (such as 2,4-D).

Pesticide concentration data are evaluated in two ways:

- Individual estimates of concentration are checked against relevant water quality guidelines and exceedances noted
- Measured concentrations in a given sample are assessed against a pesticide exposure risk metric which predicts the percentage of species that may be affected by mixtures of pesticides detected. The risk metric used is the multi-substance potentially affected fraction (ms-PAF method).

A range of pesticides were detected at all monitoring sites in 2018–19. In line with previous monitoring years, diuron, atrazine and hexazinone were the most frequently detected and abundant of the pesticides at most sites, reflecting their high usage in sugar cane cultivation, which is located along much of the Great Barrier Reef coastline.

Higher pesticide levels were often observed during the wet season after large river discharges. Maximum concentrations of diuron, atrazine and hexazinone (250 ng L^{-1}, 176 ng L^{-1} and 58 ng L^{-1}) all occurred in the Mackay-Whitsunday region at Repulse Bay and Flat Top Island sites, which typically experience the highest pesticide concentrations within this monitoring program.

Compared to the previous monitoring year, maximum pesticide concentrations at the fixed monitoring sites returned a mixed result. At Flat Top Island (previously referred to as Round Top), the maximum pesticide concentration monitored this year was lower than the record high concentration of last year, e.g. the maximum concentration of diuron this year was 250 ng L^{-1} compared to 778 ng L^{-1} last year. While Repulse Bay site set its new highest concentration since monitoring started at this site. The maximum concentration at Normanby Island was also higher, but this is probably due to more samples being retrieved successfully during the wet season. The variation at other sites was not significant enough to change the corresponding risk category.

There are considerable differences in pesticide concentrations among regions. The Mackay-Whitsundays and Burdekin regions have higher levels of pesticides than the much lower Wet Tropics and Fitzroy regions concentrations (and corresponding risk).

There were no individual exceedances of the current marine trigger values in this monitoring year (i.e. over the water quality guideline values). Assessment against proposed revised aquatic ecosystem protection guideline values would result in one instance of exceedance, from a grab sample collected at the Tully River in the Wet Tropics region for imidacloprid: 68 ng L^{-1} against 57 ng L^{-1}.

For passive sampler data, consistent with historical data, monitoring sites located in the Mackay-Whitsunday region experienced the greatest risk of toxic effects due to pesticide exposure. Conversely, the Wet Tropics and Fitzroy have consistently been at low risk, likely due to sites being located further from intensive use sources (further offshore).

All sites in the Wet Tropics (five sites) and Fitzroy regions (one site) met the target of very low risk: protective of at least 99 per cent of species. One site (Sandy Creek) in the Mackay-Whitsunday region also returned results consistent with this risk level, although three early wet season samplers were lost for this monitoring year.

Sarina Inlet (Mackay-Whitsunday) and Barratta Creek (Burdekin) had a mix of very low risk: protective of at least 99 per cent of species and low risk: protective of 95 to less than 99 per cent of species.

Flat Top Island and Repulse Bay (Mackay-Whitsunday region) returned samples across three risk categories:

- Very low risk: protective of at least 99 per cent of species
- Low risk: protective of 95 to less than 99 per cent of species
- Moderate risk: protective of 90 to less than 95 per cent of species for one sampler at each site.

1. Methods

1.1 Overview

Pesticide monitoring was conducted at fixed (long-term) monitoring sites using passive samplers: a time-integrated sampling technique that provides a time-averaged estimated concentration. The passive samplers accumulate chemicals into a sorbing material from water via passive diffusion over a month or more. The passive samplers used in this program include:

- SDB-RPS Empore^{TM} Disk (ED) polar passive samplers for relatively hydrophilic organic chemicals with relatively low octanol-water partition coefficients (log K_{OW}) such as the PSII herbicides (e.g. diuron).
- Polydimethylsiloxane (PDMS) non-polar passive samplers for organic chemicals that are relatively more hydrophobic (higher log K_{OW}) such as organophosphorus insecticides (e.g. chlorpyrifos).

Using estimates of water flow at each site and uptake rates measured during laboratory calibration experiments, average concentrations in the water for accumulated pesticides are estimated for a deployment period (typically one month during the wet season, and two months during the dry season). Passive sampler extracts are analysed for a suite of thirty pesticides across the two passive sampler types targeting pesticides of varying water solubility.

In addition to the long-term pesticide levels assessment, flood plume monitoring was conducted during the monitoring year using grab sampling to provide a single ‘point in time’ concentration of pesticides in water and capture potential peaks in pesticide concentration. This year sampling was conducted at sites seaward from the Russell-Mulgrave and Tully rivers (Wet Tropics region), and from Barratta Creek (Burdekin region).

Full details regarding these methodologies have been described in the *Marine monitoring program quality assurance and quality control manual 2018–19* (GBRMPA, 2019) and in previous reports (Gallen et al., 2013; Gallen et al., 2014; Gallen et al., 2016; Grant et al., 2017; Kennedy et al., 2012).

1.2 Study area and sampling sites

1.2.1 Fixed monitoring sites (passive samplers)

Sites are selected using several criteria, including being adjacent to areas of high pesticide usage on the catchment area, serviceability, likelihood of intercepting flood plumes during wet season river flow events and the safety of the site from public interference. The long-term monitoring data generated from these sites, aims to link changes in land-based agricultural activities (as a result of management initiatives) and how pressures such as catchment rainfall, river discharge and pesticide loads influence trends in marine pesticide concentrations.

Eleven inshore Reef sites have been monitored since 2014-15, including five sites monitored since at least 2009 (Table 1). Sites are located within the expected extent of flood plumes from rivers that drain a variety of land uses on the adjacent catchment areas and discharge into the Reef lagoon (Table 1). Of the 11 sites monitored for pesticides, three (Low Isles, Dunk Island, and Sarina Inlet) are also seagrass monitoring sites under other elements of the MMP (McKenzie et al., 2017). Five sites (Low Isles, High Island, Normanby Island, Dunk Island and North Keppel Island) are nearby to monitored coral reefs (Thompson et al., 2017).

Fixed sampling sites in the Wet Tropics region in 2018 - 19 were at Low Isles, High Island, Normanby Island, Dunk Island and Lucinda (Figure 1).

There is one sampling site in the Burdekin region in 2018 -19 at Barratta Creek mouth (Figure 1), which was established in 2014.

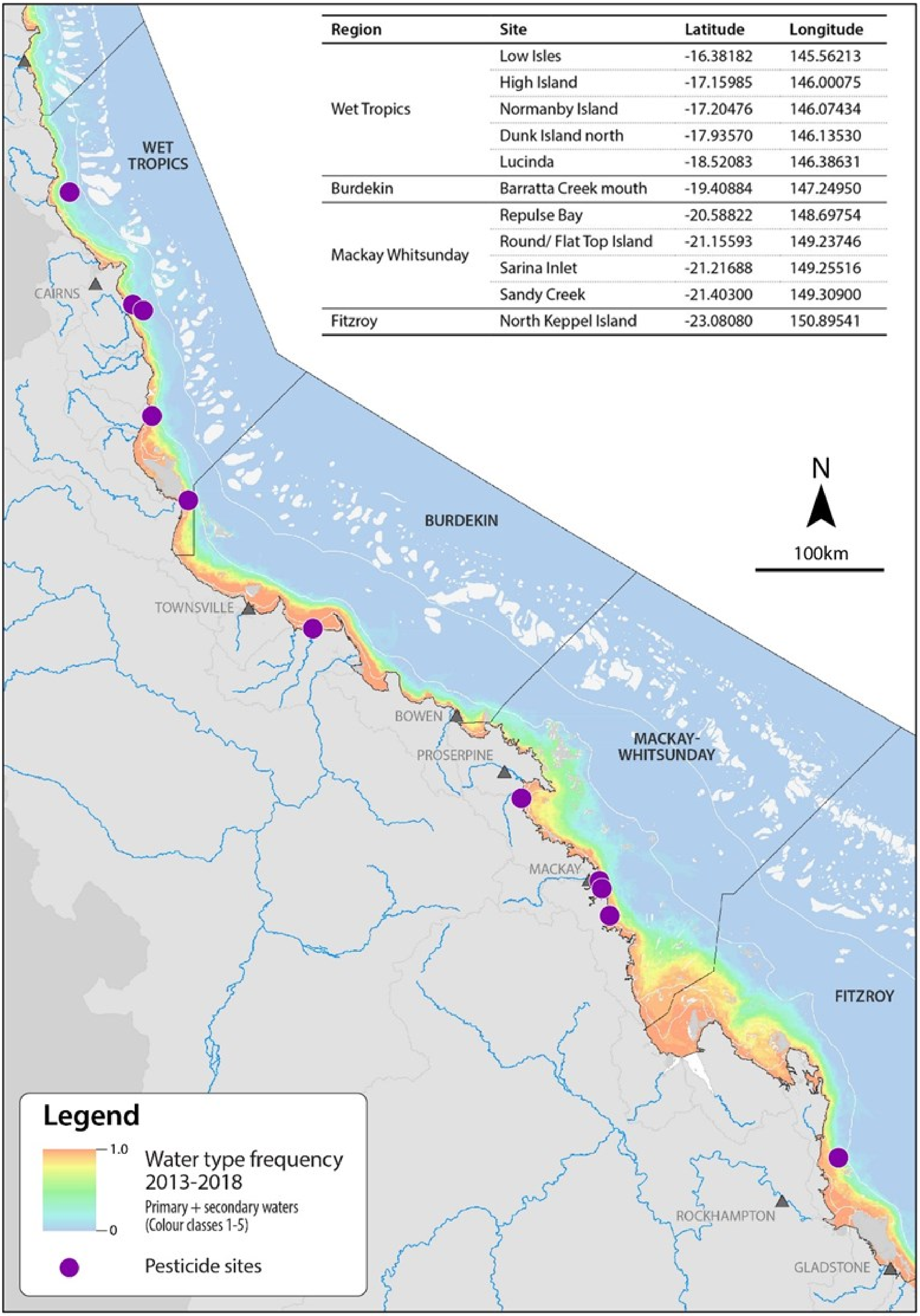
Sampling sites in the Mackay Whitsunday region in 2018 -19 were Repulse Bay, Flat Top Island, Sandy Creek and Sarina Inlet (Figure 1).

The one site in the Fitzroy region is at North Keppel Island (Figure 1).

Table 1: Location of fixed passive sampling sites, closest influencing river and date that sampling first commenced

NRM region	Basin	Major River/ Creek	Fixed site name	Sampled since	Approx. distance from river mouth (km)
Wet Tropics	Mossman	Mossman River	Low Isles	Aug-2005	18
	Mulgrave-Russell	Mulgrave River/ Russell River	High Island	May-2015*	8.0
			Normanby Island	Jul-2005	11
	Tully	Tully River	Dunk Island	Sep-2008	13
	Herbert	Herbert River	Lucinda	Jul-2014	12
Burdekin	Burdekin	Barratta Creek	Barratta Creek mouth	Mar-2014	1.5
Mackay Whitsunday	Proserpine O'Connell	Proserpine River O'Connell River	Repulse Bay	Sep-2014	12 3.3
	Pioneer Plane	Pioneer River Sandy Creek	Flat Top Island	Sep-2014	3.0
	Plane	Sandy Creek	Sandy Creek	Sep-2014	8.6
		Plane Creek	Sarina Inlet	May-2009	2.8
Fitzroy	Fitzroy	Fitzroy River	North Keppel Island	Aug-2005	50

* High Island was reintroduced to the sampling program in 2015–16 after its discontinuation in 2008.



Region	Site	Latitude	Longitude
Wet Tropics	Low Isles	-16.38182	145.56213
	High Island	-17.15985	146.00075
	Normanby Island	-17.20476	146.07434
	Dunk Island north	-17.93570	146.13530
	Lucinda	-18.52083	146.38631
Burdekin	Barratta Creek mouth	-19.40884	147.24950
Mackay Whitsunday	Repulse Bay	-20.58822	148.69754
	Round/ Flat Top Island	-21.15593	149.23746
	Sarina Inlet	-21.21688	149.25516
	Sandy Creek	-21.40300	149.30900
Fitzroy	North Keppel Island	-23.08080	150.89541

Figure 1: Locations of fixed monitoring sites where time-integrated passive sampling of pesticides occurred in 2018 - 19. Sites are overlaid on the 2003 – 2018 water type frequency map for two water types – primary, secondary, corresponding to five colour classes. Grey triangles indicate towns. (Source – Dieter Tracy, James Cook University)

1.2.2 Flood plume (transect) monitoring ('event' passive sampler and grab sampling)

Terrestrial run-off assessments, i.e. flood plume monitoring, have been conducted in past monitoring years along transects extending from river mouths during discharge events in two or three Natural Resource Management regions with a high risk from pesticide exposure. The locations and timing of the flood plume sampling changes annually, as it is event-driven and requires a rapid response.

In 2018–19, flood plume monitoring was undertaken along transects extending from the mouths of two rivers in the Wet Tropics region – the Tully and Russell-Mulgrave rivers (Figure 2). Both transects have been sampled in previous monitoring years, with the Tully transect first sampled in 2010 and the Russell-Mulgrave transect first sampled in 2013.

Grab samples were collected at Burdekin River and Barratta Creek mouth within the Burdekin focus area during discharge events by the James Cook University (JCU) Inshore Marine Water Quality team (Figure 2).

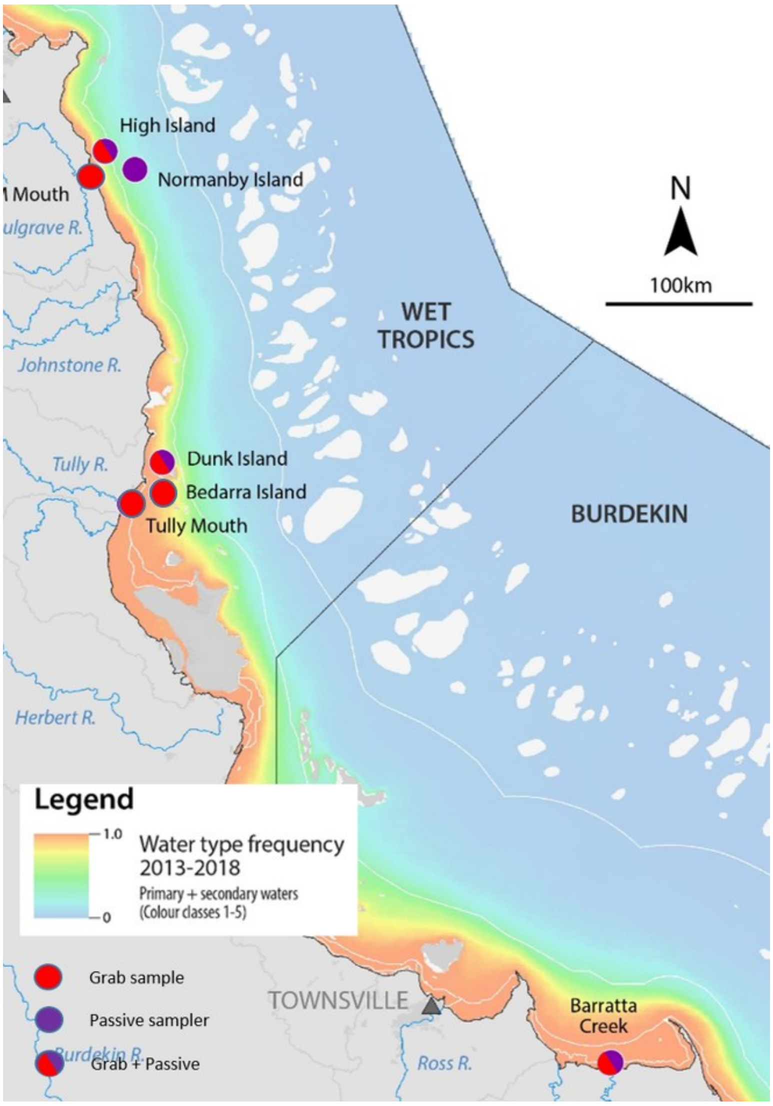


Figure 2: Locations of grab (flood plume monitoring) and passive samplers (fixed monitoring) collected on the Russell-Mulgrave River transect, Tully River transect. Sampling sites are overlaid on a colour-scale representing the water type frequency of flood plumes for 2003-2018. Maps edited from those provided by Dieter Tracey, James Cook University (JCU).

1.3 Sampling approaches

Details of the techniques for passive and grab sampling are given in the *Marine Monitoring Program quality assurance and quality control manual 2018/2019 (GBRMPA, 2019)*. An overview of the sampling periods and types of samples collected is given below, with additional details in Appendix A.

1.3.1 Passive sampling (fixed monitoring sites) to assess long-term trends

Pesticide monitoring at fixed monitoring sites is reported for the year to 30 April 2019. The year is divided into "dry 2018" (May 2018 to October 2018) and "wet 2018 -19" (November 2018 to April 2019) sampling periods for reporting purposes.

During dry sampling periods, passive samplers are typically deployed for two months at a time (maximum of three deployment periods each monitoring year), and for one month at a time during wet sampling periods (maximum of six deployment periods within each monitoring year). Time integrated concentrations are reported that reflect the average concentration over the actual period of deployment. The maximum number of samples obtained from each location in the monitoring year is nine.

Table 2: The types of passive samplers deployed at each fixed monitoring site in 2018 -19.

Region	**Site**	**EDs (polar)**		**PDMS (non-polar)**	
		Dry	**Wet**	**Dry**	**Wet**
Wet Tropics	Low Isles	✓	✓	✗	✗
	High Island	✓	✓	✗	✗
	Normanby Island	✓	✓	✗	✗
	Dunk Island	✓	✓	✗	✗
	Lucinda	✓	✓	✗	✗
Burdekin	Barratta Creek Mouth	✓	✓	✗	✓
Mackay Whitsunday	Repulse Bay	✓	✓	✗	✓
	Flat Top Island	✓	✓	✗	✓
	Sandy Creek	✓	✓	✗	✓
	Sarina Inlet	✓	✓	✗	✓
Fitzroy	North Keppel Island	✓	✓	✗	✗

All eleven fixed sites were monitored in both the dry 2018 and wet 2018-19 sampling periods using EDs (Table 2), targeting polar pesticides (see Table A-2 for a list of the polar pesticides in the passive sampler analysis suite). Five sites also had PDMS samplers deployed during the wet 2018-19 sampling period (Table 2) and one site (Barratta Creek) deployed a PDMS sampler in the dry 2018 period, targeting non-polar pesticides (see Table A-3 for a list of the non-polar pesticides in the passive sampler analysis suite). North Keppel Island wet season samplers (EDs) have not been returned as yet. Contact was lost with deployment personnel for several months. If samplers can be returned for analysis results will be published at a later time.

PDMS samplers were co-deployed with the EDs in the Burdekin region (one site) and the Mackay Whitsunday region (four sites) (Table 2). These two regions were chosen for targeting non-polar pesticides based on their high proportions of sugar cane land use relative to other regions, and the high pesticide risk assigned to these regions (Brodie et al., 2013). The deployment dates and results for each fixed monitoring site are in Appendix D Table D-2 to Table D-12.

1.3.2 Grab sampling to assess flood plume (transect) profiles

Sampling activities targeting discharge events from major Reef basin rivers occurred during the 2018-19 monitoring year, and typically coincided with large rainfall events in the adjacent basin catchment. Grab samples (250 mL) were collected along transects extending from river mouths to capture peak concentrations and establish the presence of any pesticides not adequately sampled by passive samplers (e.g. due to their high water solubility).

Forty-four grab samples were collected in 2018–19. Thirty were collected to monitor terrestrial run-off from the two river transects (the Tully and Russell-Mulgrave rivers) during flood plume events between July 2018 and March 2019 (Figure 2). A further 14 grab samples were collected from the Burdekin focus area at Barratta Creek and Burdekin River mouths during major discharge events in both the dry and wet season. Further details for these samples including the date of collection and results for individual pesticides detected are provided in Appendix E Table F-1.

1.3.3 Sampler deployment data

This monitoring year, 76% of fixed site passive sampler sets sent to volunteers were successfully deployed, returned (undamaged) and analysed (Appendix D Table D-1). This return rate was comparable to the two previous years (75%). The remainder of samplers were unsuccessful for several reasons but were typically because of a lost mooring following bad weather, presumed human interference (e.g. theft of mooring) or *in situ* damage (e.g. membrane lost or fouled). Four sites (Dunk Island, Repulse Bay, Lucinda, and Barratta Creek) returned at least eight sampling kits. Sites located in the Mackay Whitsunday region which had experienced the highest sampler losses in 2017-18 had a much improved return rate of 74%. Four sites (Low Isles, Normanby Island, Sandy Creek and North Keppel Island) had high rates of losses and non-returned samplers.

For sites with lower successful deployment rates, trend comparisons with previous years are generally not possible, and care needs to be taken when comparing between the monitoring sites. Details on deployment procedures and approaches for data interpretation when samplers are not/ cannot be deployed or are lost are given in Appendix A: A-1.

1.4 Pesticide analyses and reporting QA/QC

1.4.1 Target pesticides

The list of target pesticides included in this report and their rationale for inclusion are given in Appendix A: A-2 and Table A-3.

1.4.2 Instrument analyses and quality assurance quality control (QA/QC)

Analysis of non-polar pesticides using Gas Chromatography-Mass Spectrometry (GC-MS) and polar pesticides using Liquid Chromatography-tandem Mass Spectrometry (LC-MS/MS) was conducted at Queensland Alliance for Environmental Health Sciences (formerly Entox) (QAEHS). Further analytical details are given in Appendix A.

1.4.3 Calculating pesticide concentrations

Once the concentrations of pesticides in the extract were measured, they are converted to a time-integrated concentration in water (ng/L) using an in-situ derived sampling rate R_S (L/day). In-situ sampling rates were derived using passive flow monitors (PFMs) deployed in duplicate alongside the passive samplers (O'Brien et al., 2011a). The R_S for atrazine and prometryn were directly predicted from the average in-situ flow velocity (m/s) estimated by the rate of loss of plaster from the PFMs during the deployment period based on data from previous calibration studies (O'Brien et al., 2011a; O'Brien et al., 2011b). The sampling rates of all other contaminants were either predicted from average ratios for the R_S of the target contaminant to that of atrazine based on a number of calibration studies (including for analogous contaminants for which no calibration data exist) or the sampling rate of atrazine was assumed (when no calibration data were available for analogous contaminants).

At present, there are limited passive sampler calibration data available for many pesticides currently in use in Reef basins (e.g. fipronil). Some pesticides (e.g. the herbicide asulam) are highly water soluble and unlikely to accumulate in passive samplers, and therefore grab sampling may increase the probability of detecting them in the marine environment. Calibration studies in the field are labour intensive; however, they may need to be considered in the future to better understand the uptake of these chemicals into passive samplers, and more accurately estimate water concentrations.

1.5 Data analyses and reporting metrics

1.5.1 Water quality guideline values (GVs)

A key aim of this program is to compare measured concentrations of pesticides to current guideline values for chemicals in marine waters.

The Australian and New Zealand water quality guidelines (see Appendix B for more details) for freshwater and marine ecosystems are being revised (DoE, 2016; Warne et al., 2015; Warne et al., 2018). For the purposes of this report, monitoring data are compared against the ANZG guidelines however, pesticide concentrations that exceed the proposed aquatic ecosystem protection guideline values (PGV), which are still undergoing endorsement, are highlighted.

PGVs for 28 pesticides for freshwater and marine ecosystems have been determined using species sensitivity distributions (SSD) by the Department of Environment and Science (DES). All these guidelines will be submitted for consideration for national endorsement and inclusion into the Australian and New Zealand Water Quality Guidelines (King et al., 2017b; King et al., 2017c). If endorsed, they will supersede the current Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA, 2010) In advance of endorsed PGVs being released, ecotoxicity threshold (ET) values for diuron, ametryn, hexazinone and simazine in marine waters (PC99, 95, 90, 80) have recently been published (King et al., 2017a; King et al., 2017c; Warne et al., 2018).

Due to the high ecological value of the Reef, PC99 values are relevant to this ecosystem, and are required by Great Barrier Reef Marine Park Authority water quality guidelines (GBRMPA, 2010). The published ETs and the PGVs for 24 other pesticides submitted for endorsement and relevant to the current monitoring period, are detailed in Appendix B (Table B-1).

1.5.2 Risk assessment metric

Up until the 2016–2017 monitoring year, the Photosystem II Herbicide Equivalent Concentration (PSII-HEq) Index (based on diuron equivalent concentrations) has been used to assess ecological risk of mixtures of 13 PSII herbicides & metabolites for MMP reporting (for detailed information about this method see (Grant et al., 2018b). This index defines ranges of PSII-HEq that equate with different levels of effect (based on published toxicity data using Reef relevant species). The index included only the five priority PSII herbicides – ametryn, atrazine, diuron, hexazinone and tebuthiuron.

Since the 2017–18 report, the ms-PAF method has been used to assess the overall risk of mixtures of pollutants to ecological communities. The ms-PAF method allows the effect of multiple pesticides on an ecosystem to be estimated by determining the potentially affected fraction of species (i.e. percentage of species that will theoretically be affected when exposed to a given mixture) (Warne et al., in prep). The ultimate aim is to report a single assessment end point (PAF) for all monitored pesticides detected in the MMP program (further information on the ms-PAF metric and its application for this report is in Appendix C).

Passive samplers integrate pesticide concentrations over the time of their deployment so they represent a portion of the wet season, not the full season. Given there is a range of risk reported across the deployments, averaging for the season would likely result in a reduced overall score. We highlight the ms-PAF value for the deployment with the highest concentrations (and highest ms-PAF scores).

2. Pesticides detected in marine waters

2.1 Frequency of pesticide detections

Thirteen PSII herbicides and two metabolites of atrazine (DE atrazine and DI atrazine) were included in the sample analysis suite of the polar passive sampler extracts. Of these fifteen compounds, thirteen were detected at one or more of the marine monitoring sites (Figure 3), only terbutryn and DI atrazine were not detected in any sample. The most commonly detected PSII herbicides (indicated in blue) were diuron, atrazine, and hexazinone (each detected in over 90% of samplers), consistent with results of previous years.

Among eleven non-PSII pesticides in the ED analysis suite (indicated in green in Figure 3), nine were detected in the ED samplers with detection frequencies ranging between 2% (fluroxypyr) and 91% (metolachlor). Only 2,4 DB and fluazifop were not detected.

Four non-polar pesticides (indicated in yellow) were detected in the PDMS samplers, with detection frequencies ranging between 45% (pendimethalin) and 90% (propazine) of samplers (Figure 3). Trifluralin was not detected during this monitoring year.

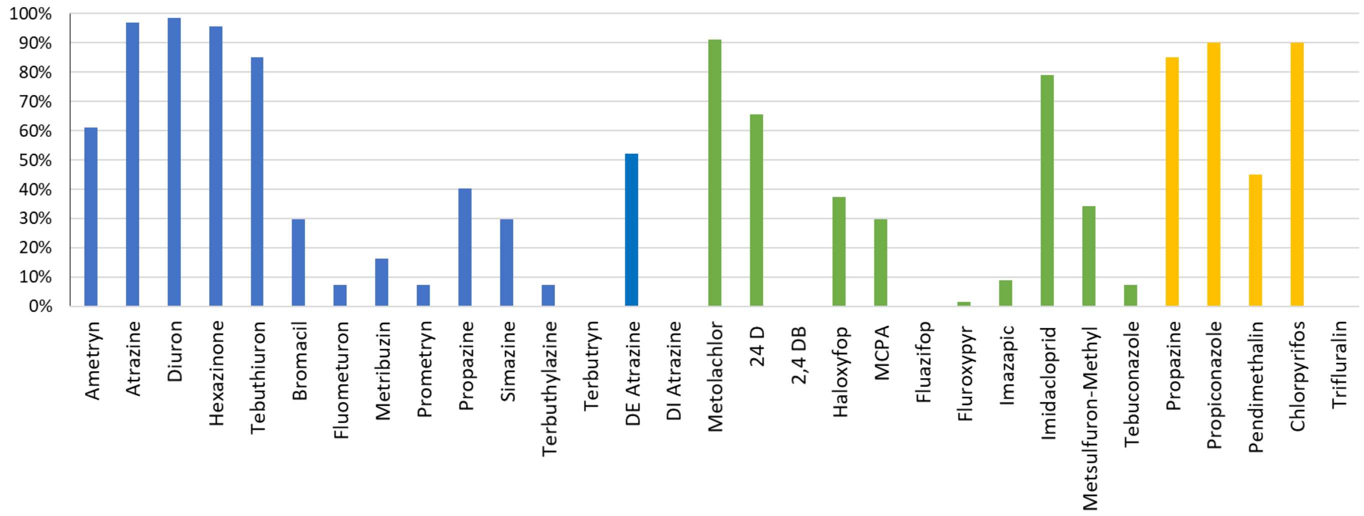


Figure 3 : Percentage of ED and PDMS samplers that had measurable pesticide levels (i.e. above the limit of detection, LOD) for each pesticide included in this study, out of a total of 67 ED samplers and 20 PDMS samplers returned in 2018-19 (**Appendix D** Table D-1). Blue: PSII herbicides; Green: Other pesticides; Yellow: non-polar pesticides

2.2 Summary of pesticide concentrations in 2018–19

The PSII herbicides detected at the highest concentrations in 2018–19 were also the most frequently detected, with maximum concentrations (C_{max}) of:

- diuron 250 ng L^{-1}
- atrazine 176 ng L^{-1}
- hexazinone 58 ng L^{-1}.

These were detected at Flat Top Island (diuron) and Repulse Bay (atrazine, hexazinone), in the Mackay-Whitsunday region. These sites also experienced the highest concentrations of these same PSII herbicides in the previous monitoring years (Grant et al., 2018b).

Other PSII herbicides, including ametryn, tebuthiuron and DE atrazine were also frequently detected (>60% of samplers), although most often at much lower concentrations (typically <5 ng L^{-1}), with the highest concentration being 19 ng L^{-1} of DE atrazine (at Barratta Creek).

Similar to the previous monitoring year, the non-PSII pesticides 2,4-D, imidacloprid and metolachlor were consistently detected across the sampling sites (>60% of samplers), although at lower concentrations compared to the PSII herbicides with the maximum concentrations (C_{max}) of:

- 2,4-D 7.7 ng L^{-1} - Flat Top Island
- imidacloprid 38 ng L^{-1} – Repulse Bay
- metolachlor 6.8 ng L^{-1} – Repulse Bay

When using the risk metrics (ms-PAF) for assessment, all passive sampling sites in the Wet Tropics and at North Keppel Island met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected). Remaining sites, other than Flat Top Island and Repulse Bay, i.e. Barratta Creek, Repulse Bay, Sandy Creek, and Sarina Inlet, had a mix of very low risk: protective of ≥99% of species (i.e. ≤1% of species are affected) - risk category 5; and low risk: protective of 95% to <99% of species (or >1 to 5% of species affected) - risk category 4. No wet season data is available for North Keppel Island for 2018–19.

Flat Top Island and Repulse Bay had samples returned across 3 categories:

- Very low risk: protective of ≥99% of species (i.e. ≤1% of species are affected) - risk category 5: nine
- Low risk: protective of 95% to <99% of species (or >1 to 5% of species affected) - risk category 4: four
- Moderate risk: protective of 90% to <95% of species (or >5 to 10% of species affected) - risk category 3: two

The risk metrics indicate that the Flat Top Island and Repulse Bay sites located in the Mackay-Whitsunday region are exposed to elevated risk of pesticide exposure compared to other sites.

It is noted that results of grab samples showed higher concentrations compared to the passive samplers in the Wet Tropics region, including the high concentration of imidacloprid (67.7 ng L^{-1}) in the Tully River mouth in January 2019. Such observation is reasonable as the grab samples were specifically collected during high flow events early in the wet season, which are often associated with high runoff amounts. The grab samples also avoid the dilution effect of passive sampler integration during deployment. Putting it differently, passive sampler concentrations are an average over time and that likely short periods of high pesticide concentrations in high flow events occur.

2.3 Comparison to guideline values

No individual exceedances of the current marine trigger values (i.e. water quality guideline values) were detected but it is noted these values are undergoing a review. The current ANZG trigger value for diuron is 1,800 ng L^{-1} (a low reliability interim working value) and the Authority's PC99 (protective concentration values that will protect ≥99% of the species) is 900 ng L^{-1} (Table B-1). Under both guidelines, the Flat Top Island and Repulse Bay diuron values are not an exceedance. Note that there are no existing PC99 or trigger values for imidacloprid.

Applying the proposed values under review (levels determined to protect 99% of marine species), there would be one instance of exceedance for imidacloprid in the grab sample collected at Tully River mouth in January 2019 (67.7 ng L^{-1} against the proposed value of 57 ng L^{-1}). However, until endorsed, comparisons with this proposed value are provided only for consideration.

2.4 Comparison to pesticide concentrations from previous years

The 2018–19 C_{max} values for diuron and imidacloprid were in a lower range to those detected in 2017–18 (249 and 38 ng L-1, respectively). With the exception of Sandy Creek (unreliable sampling in 2018–19), the 2018–19 C_{max} were generally similar to the results from 2017–2018.

The ms-PAF values assessments both find Repulse Bay and Flat Top Island the highest risk sites, at a worst assessed risk of moderate (centre column, Table 3). Normanby Island, Repulse Bay and Sarina Inlet experienced an increase in pesticide concentrations compared to 2017–18. Lucinda, Barratta Creek and Sandy Creek returned similar concentrations in 2018–19 compared to 2017–18, with other sites slightly lower. (Note that trend comparisons for sites most recently introduced to the program as well as sites that experience higher than average sampler losses should be interpreted with particular caution due to limited data).

Table 3: Maximum pesticide concentrations, which were colour-coded from lowest to highest percentile, at each fixed passive sampling site.

% of species affected values are colour-coded according to their risk category. Grey shaded pesticides indicate that no calibration data is available and the sampling rate of atrazine was assumed.

		Concentration PSII herbicides (ng/L) (* included in ms-PAF method)													**% Species Affected**	**Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)**												
Region	Passive sampling site	Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron*	Metribuzin*	Prometryn*	Propazine*	Simazine*	Terbuthylazine	Terbutryn*		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
Wet Tropics	Low Isles	0.02	0.7	1.5	0.4	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	n.d.	n.d.	**0.21**	n.d.	n.d.	0.17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.2	n.d.	n.d.
	High Island	0.02	2.8	9	3.0	0.55	n.d.	n.d.	n.d.	0.07	0.04	n.d.	n.d.	n.d.	**0.49**	0.18	n.d.	0.98	0.3	n.d.	0.08	0.09	n.d.	n.d.	n.d.	1.6	0.11	0.13
	Normanby Island	0.05	6.5	18.8	4.7	0.58	0.43	n.d.	n.d.	0.03	0.08	0.10	n.d.	n.d.	**0.55**	0.95	n.d.	1.34	0.23	n.d.	0.10	n.d.	n.d.	n.d.	0.03	3.34	n.d.	0.04
	Dunk Island	0.07	8.5	18	7.1	0.70	0.21	n.d.	0.27	n.d.	0.10	0.1	n.d.	n.d.	**0.44**	0.81	0.00	0.70	0.5	n.d.	0.12	n.d.	n.d.	n.d.	n.d.	3.48	0.08	n.d.
	Lucinda	0.06	4.6	12.7	4.1	1.02	0.60	n.d.	0.00	n.d.	0.06	0.08	0.00	n.d.	**0.42**	0.45	0.00	0.86	0.39	0.00	0.07	0.10	0.00	0.00	n.d.	2.05	0.07	n.d.
Burdekin	Barratta Creek	0.9	53	47	1.74	1.68	8.81	n.d	16.37	0.02	0.7	0.20	0.90	n.d	**1.9**	19	n.d	5	2.9	n.d	0.59	0.8	n.d	n.d	0.43	1.38	0.56	0.14
Mackay Whitsundays	Repulse Bay	0.22	176.0	231	58	1.1	12.04	0.04	1.84	n.d.	1.54	0.46	1.34	n.d.	**7.90**	11.3	n.d.	6.8	5.8	n.d.	0.09	1.62	n.d.	n.d.	0.80	38.0	0.50	n.d.
	Flat Top Island	1.7	69	250	54	0.2	0.22	0.05	5	0.05	0.8	0.1	0.42	n.d.	**7.80**	2	n.d.	3	7.7	n.d.	0.09	2.0	n.d.	n.d.	0.8	11.03	0.34	n.d.
	Sandy Creek	0.14	5.0	17	5.0	0.23	n.d.	0.05	n.d.	n.d.	0.05	0.3	n.d.	n.d.	**0.76**	1.01	n.d.	0.57	0.87	n.d.	0.02	0.23	n.d.	0.12	n.d.	2.15	0.18	n.d.
	Sarina Inlet ^	0.80	59	114	45	0.9	0.95	0.03	0.54	n.d.	0.56	0.34	n.d.	n.d.	**2.8**	5.89	n.d.	0.5	1.82	n.d.	0.03	0.16	n.d.	n.d.	n.d.	5.03	0.37	n.d.
Fitzroy	North Keppel Island	n.d.	0.26	1.4	0.07	0.06	n.d.	0.02	n.d.	n.d.	n.d.	0.12	n.d.	n.d.	**0.25**	n.d.	n.d.	0.26	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.

n.d. = maximum concentration did not esceed the limit of detection

^Note only 2 successful sampling periods

Lowest 50th percentile **Highest**

3. Regional results

3.1 Wet Tropics Region

No exceedances of guideline values were detected in this monitoring year.

Continuing the trend of previous monitoring years, the predominant pesticides detected using EDs in the Wet Tropics region in 2018–19 were atrazine, diuron and hexazinone. All three were detected in wet season samplers (Appendix D Table D2 to Table D-6). Simazine, tebuthiuron and DE atrazine (metabolite) were PSII herbicides that were also frequently detected in at least 50% of samplers at all sites as were the other non-PSII pesticides 2,4-D, imidacloprid and metolachlor.

Ms-PAF values were calculated and no sites in the region are above very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected). It should be noted that the concentrations of some non-PSII pesticides are yet to be integrated into this risk metric and thus the potential risk from all pesticides could be higher in this region than what is reported here.

3.1.1 Low Isles

In 2018–19, there were no exceedances of guideline values at the Low Isles site, although data were only available for four deployment periods, with only one very short deployment early in the wet season, resulting in near zero detection of pesticides.

Maximum concentration of pesticides at Low Isles during the 2018–19 monitoring year was 1.5 ng/L of diuron during May/June 2018. Unfortunately, only one sample in the wet season was received due to site access issues. Diuron is usually the pesticide with the highest concentration among the 26 chemicals analysed for at this site.

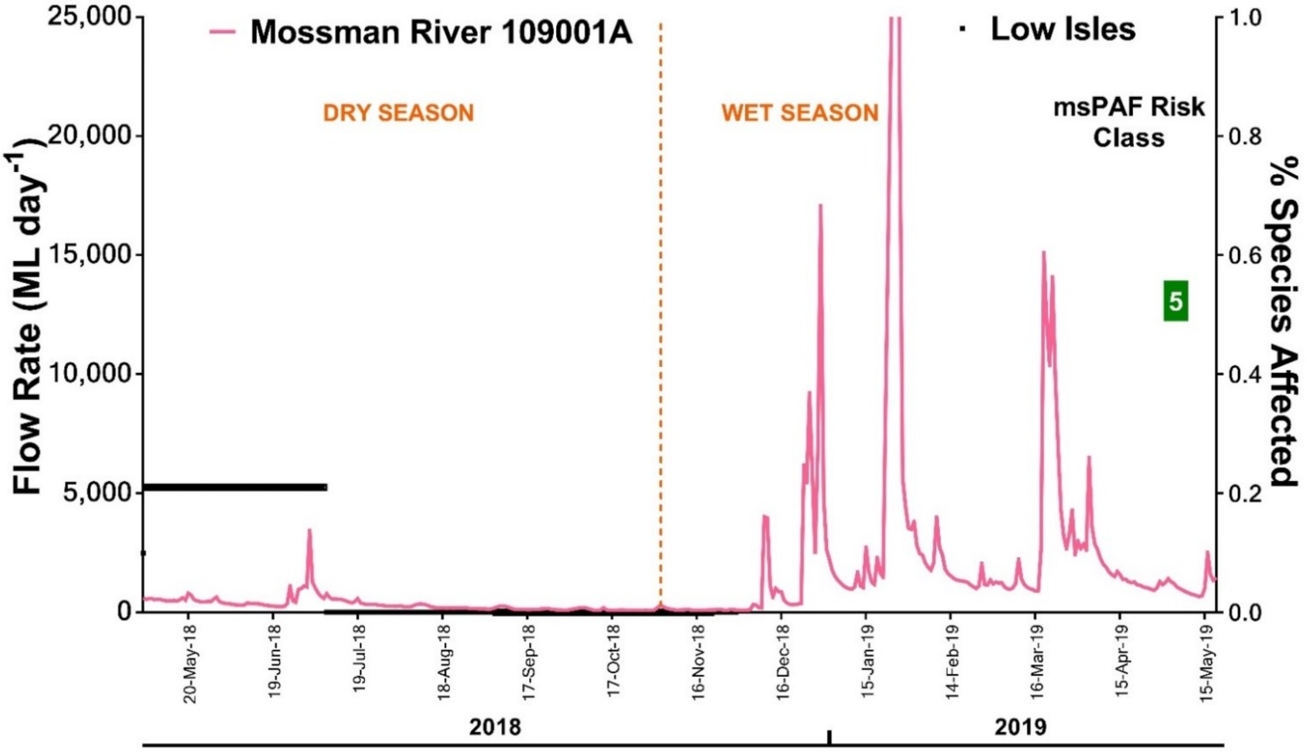


Figure 4: Temporal trends in % of species affected by pesticides (indicated by the black bars) in Low Isles in 2018-19, together with the flow rate of Mossman river (pink line). Flow data from DNRM Stream Gauging Network. Note there is no black bar for the second half of the graph due to samples not being received.

The maximum concentrations of pesticides monitored in 2018–19 were lower than in 2017-18 but similar to the previous monitoring year of 2016-17 (see more details about historic data in Gallen et al., 2019).

The ms-PAF values in 2018–19 at this site met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for all deployments.

3.1.2 High Island

There were no exceedances of guideline values at the High Island site in 2018–19.

i) For passive samplers

The maximum concentration of pesticides at High Island in this monitoring year was 9.2 ng/L of diuron in the first deployment of the wet season in December 2018. Similar to Low Isles, diuron is usually the pesticide with the highest concentration among the pesticides monitored in this site.

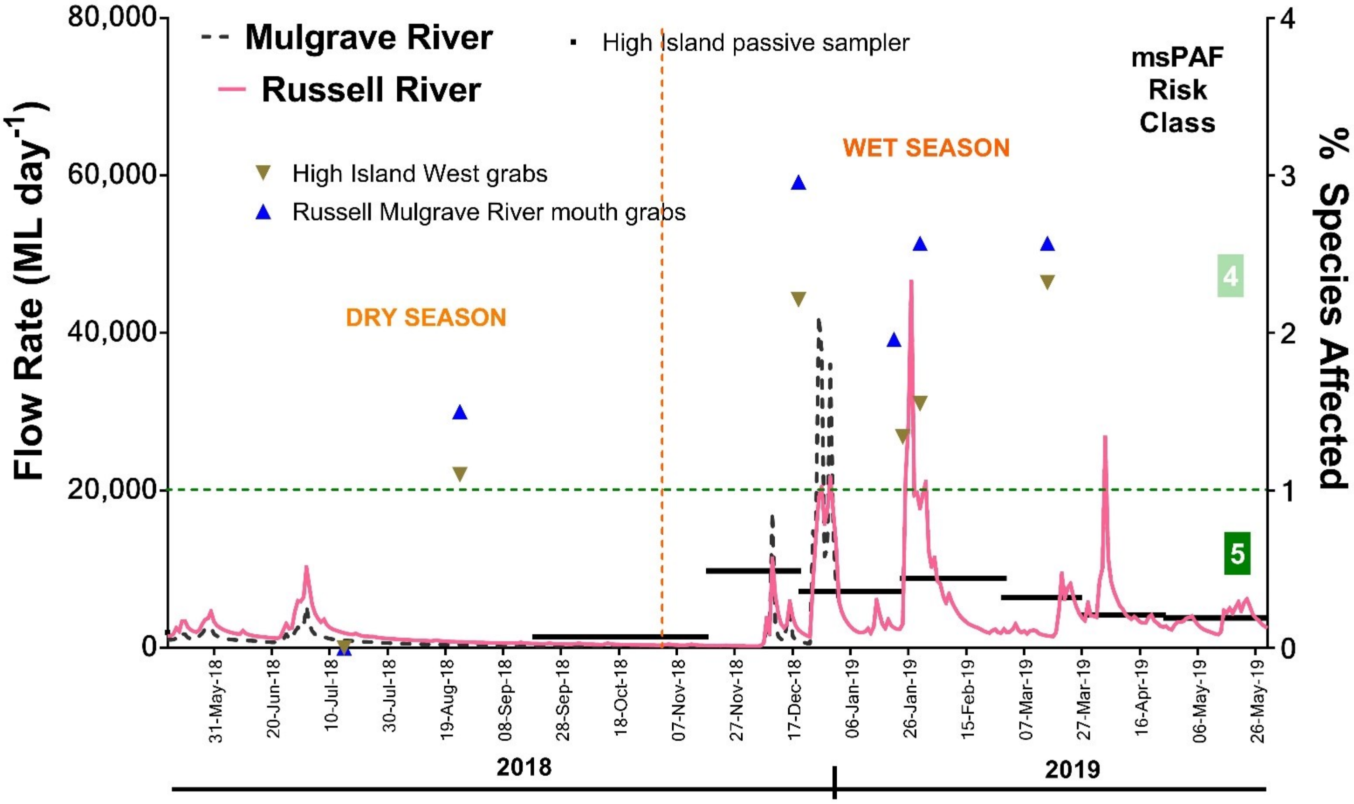


Figure 5: Temporal trends in % of species affected by pesticides by passive (indicated by the black bars) and grab samples (indicated by the spots) in High Island in 2018-19, together with the flow rate of Mulgrave and Russell rivers. Flow data from DNRM Stream Gauging Network.

At High Island, the maximum concentrations of pesticides monitored in 2018–19 were also lower than in 2017-18 and the previous monitoring year of 2016-17 (see more details about historic data in Gallen et al., 2019)**Error! Reference source not found.**.

The ms-PAF values in 2018–19 at this site met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for all deployments, with maximum ms-PAF value of 0.5.

ii) For grab samples along the transect

Grab samples were collected from the Russell-Mulgrave River mouth and High Island (fixed monitoring site) on six occasions (two ambient and four during flow events throughout the wet season).

The highest concentrations of pesticides were detected in a grab sample at the mouth of the Russell-Mulgrave River on 19 December 2018, coinciding with a surge in river discharge. Overall, the pesticide profile at the river mouth site was dominated by (C_{max}):

- diuron 36 ng L^{-1}
- atrazine 70 ng L^{-1}
- hexazinone 35 ng L^{-1}
- imidacloprid 36 ng L^{-1}
- 2,4-D 17 ng L^{-1}
- Metolachlor 12 ng L^{-1}

A similar pesticide profile was observed between the grab and passive samplers at High Island (atrazine, diuron, hexazinone and imidacloprid dominance). Other pesticides such as metolachlor, haloxyfop, MCPA and 2,4-D that were less frequently detected in grabs collected at High Island, were found routinely in most passive samplers, but all at low concentrations near the limit of detection (~1 ng/L).

3.1.3 Normanby Island

There were no exceedances of guideline values at the Normanby Island site in 2018–19 although the data were only available for three deployment periods as a number of samplers were lost due to bad weather.

The maximum concentration of pesticides at Normanby Island in this monitoring year was 18.8 ng/L of diuron in Jan/Feb 2019 during the wet season with diuron as the pesticide with the highest concentration at this site.

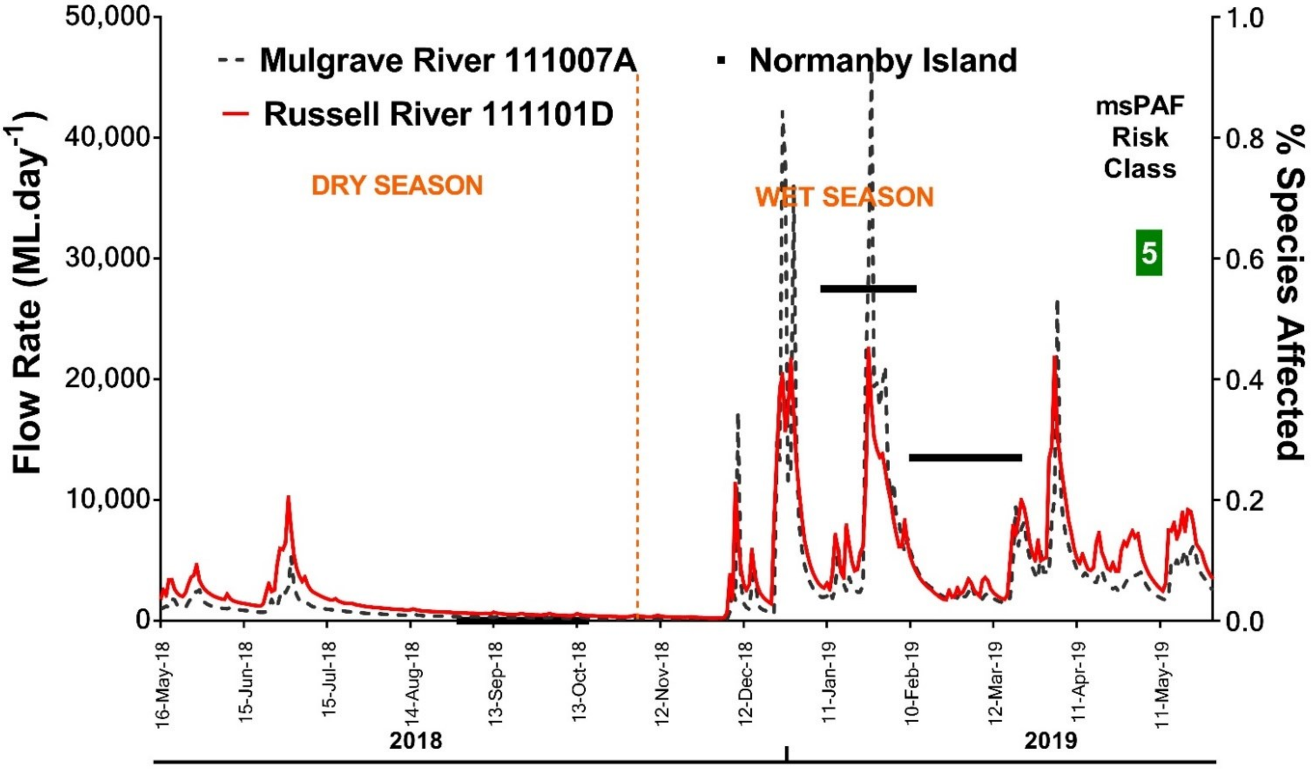


Figure 6: Temporal trends in % of species affected by pesticides (indicated by the black bars) in Normanby Island in 2018-19, together with the flow rate of Mulgrave and Russell rivers. Flow data from DNRM Stream Gauging Network. Note that ms-PAF values were only available for 3 periods due to samplers lost.

At Normanby Island, the maximum concentrations of pesticides monitored in 2018–19 were higher than in 2017–18. There was no data in 2015-16 and 2016-2017 (see more details about historic data in Gallen et al., 2019).

The ms-PAF values in 2018–19 at this site met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for all deployments.

3.1.4 Dunk Island

There were no exceedances of guideline values at the Dunk Island site in 2018–19.

i) For passive samplers

The maximum concentration of pesticides at Dunk Island in this monitoring year was 18.5 ng/L of diuron in February 2018 during the wet season. Diuron is still the pesticide with the highest concentration in this site.

At Dunk Island, the maximum concentrations of pesticides monitored in 2018–19 were lower than in 2017–18 but higher than the previous monitoring years. The concentrations in 2015–2016 and 2014–2015 were the lowest on record since 2009–2010 (see more details about historic data in Gallen et al., 2019).

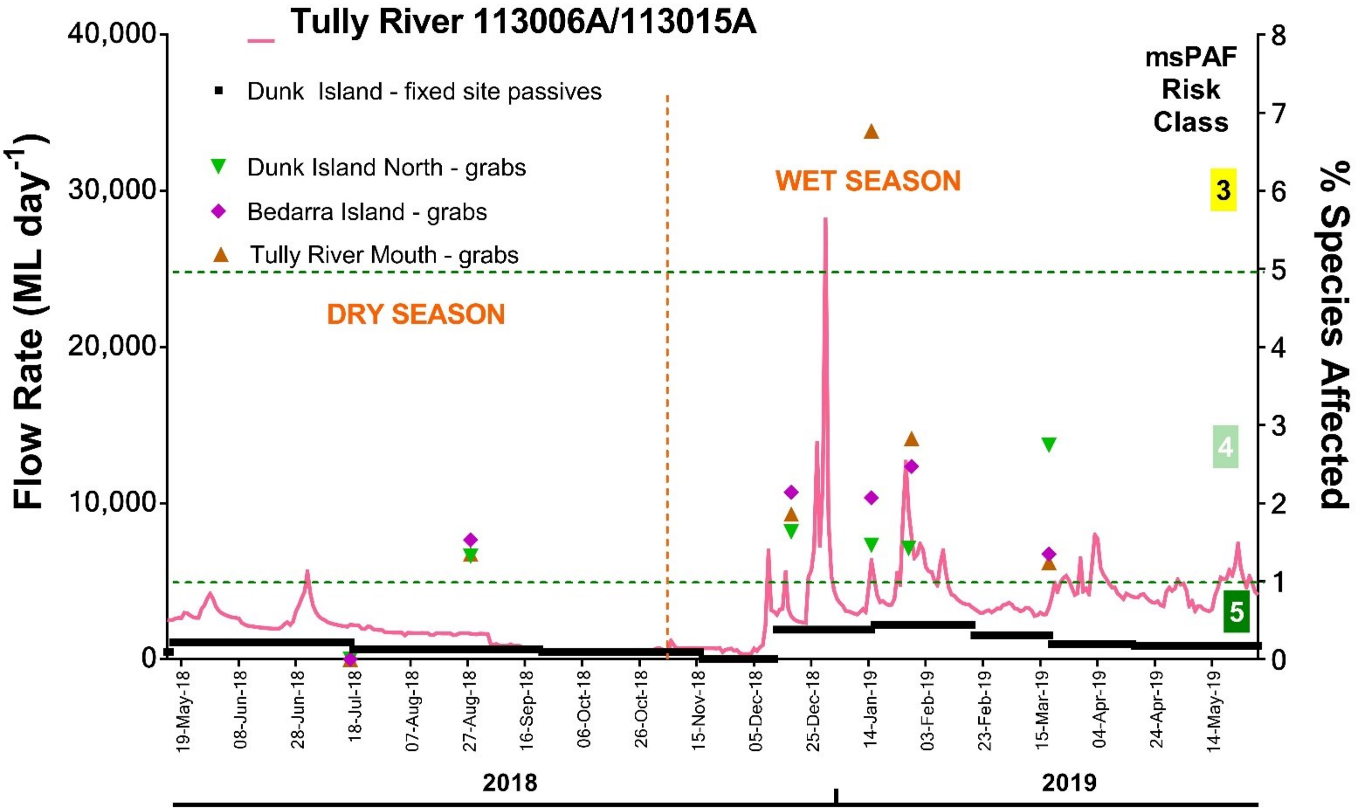


Figure 7: Temporal trends in % of species affected by pesticides (indicated by the black bars) and grab samples (indicated by the spots) in Dunk Island in 2018–19, together with the flow rate of Tully River. Flow data from DNRM Stream Gauging Network.

The ms-PAF values in 2018–19 at this site met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for all passive sampler deployments.

ii) For grab samples along the transect

In the Tully region, six grab sampling campaigns were undertaken during both wet (4 campaigns) and dry seasons (2 campaigns), with samples collected from three sites: Tully River mouth; Bedarra Island directly offshore from the Tully River and Dunk Island, which lies to the north of the Tully (Figure 2).

The samples were collected during base flow in July and August 2018 and during flow events in December 2018, January 2019 and March 2019.

The highest concentrations were detected in a grab sample collected at the Tully River mouth following the mid-January 2019 flow (Table F-1). Similarly to the Russell Mulgrave transect, the pesticide profile at the river mouth site was dominated by (C_{max}):

- diuron 139 ng L^{-1}
- atrazine 95 ng L^{-1}
- hexazinone 77 ng L^{-1}
- imidacloprid 67 ng L^{-1}
- 2,4-D 39 ng L^{-1}
- imazapic 29 ng L^{-1}

The ms-PAF assessment at the Tully River mouth returned a moderate risk of exposure for the grab sample of mid-January with 6.8% of species affected (category 3: protective of 90% to <95% of species (or >5 to 10% of species affected) (Table F-1). Other samples returned low risk (category 4: protective of 95% to <99% of species) or very low risk (category 5: protective of ≥99% of species), respectively. The results of grab samples in this site shows that pesticide concentrations in short-term events (high flow) can have higher risk than those assessed by passive samplers (i.e. average over mid-term period).

All samples at Dunk Island North and Bedarra Island returned low risk (category 4: protective of 95% to <99% of species) except the samples in July 2018 when the risk is very low (category 5: protective of ≥99% of species). Both the Bedarra and Dunk Islands grab samples had a similar pesticide profile but lower concentrations and frequencies of detections than at the river mouth (Table F-1).

3.1.5 Lucinda

There was no exceedance of guideline values at the Lucinda site in 2018–19.

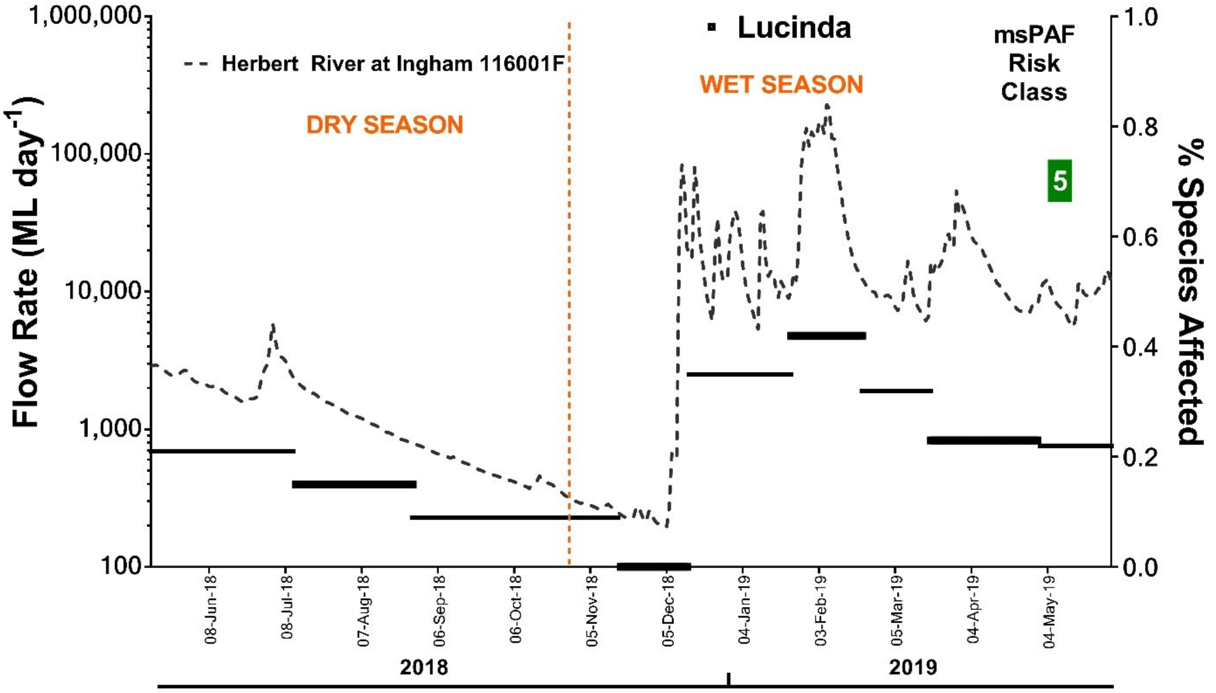


Figure 8: Temporal trends in % of species affected by pesticides (indicated by the black bars) in Lucinda in 2018-19, together with the flow rate of Herbert River. Flow data provided by DNRM Stream Gauging Network.

The maximum concentration of pesticides at Lucinda in this monitoring year was 12.7 ng/L of diuron in January/February 2019 in the middle of the wet season. Similar to the other sites in the Wet Tropics, diuron and atrazine are the two pesticides with the highest concentrations at this site.

At Lucinda, the maximum concentrations of pesticides monitored in 2018–19 were similar to those reported in 2017–18, but at a higher level compared with data from previous monitoring years since 2014–2015.

The ms-PAF values met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for all passive sampler deployments.

There appears to be a seasonal change in herbicide profile across the sites within the region. In the wet season, diuron contributes approximately 50% and atrazine approximately 20% to the total pesticide concentration whereas in the dry season the contribution of diuron drops to between 30 and 40%, and atrazine increases to an average contribution of 35%. Such change could be due to the difference between the half-lives of the two herbicides in the marine environment: diuron 556 days, atrazine 2089 days (Mercurio et al., 2015).

3.2 Burdekin Region

3.2.1 Barratta Creek

No exceedances of pesticide concentrations were detected at Barratta Creek in 2018–19.

i) For passive samplers

At this site, most of the PSII herbicides (and metabolites) monitored in this program (with the exception of fluometuron, prometryn and terbutryn) were detected (Appendix D Table D-7).

Historically, atrazine and atrazine metabolites have typically dominated the pesticide profile at Burdekin sites, including those sites monitored in previous years but no longer in the current program (e.g. Cape Cleveland; (Gallen et al., 2016)), contributing up to 80 per cent of the total pesticide concentration. However, diuron shared the dominance profile with atrazine at Barratta Creek in 2018–19. Other PSII herbicides like ametryn, hexazinone, tebuthiuron, and propazine were consistently detected, albeit at low levels (1-10 ng/L), throughout the year. Bromacil and metribuzin were detected at levels of 10 ng/L in the middle of the wet season.

Of the other pesticides, metolachlor and 2,4-D were also detected, with maximum concentrations of 5.2 and 2.9 ng L^{-1} respectively in January/February 2019. Using PDMS samplers, propazine, chlorpyrifos and pendimethalin were detected but at very low concentrations (Appendix D Table D-7). Total pesticide concentrations in the current year were lower than in 2017–18 but higher those of the previous two monitoring years (see more details about historic data in Gallen et al., 2019).

In 2018–19, high flow during the wet season (January/February 2019) contributed to the highest concentrations in passive samplers detected of this monitoring year (1.9% species affected), which was dominated by atrazine (53 ng L^{-1}) and diuron (42 ng/L).

The ms-PAF values in 2018–19 at this site had a mix of very low risk (category 5): protective of ≥99% of species (i.e. ≤1% of species are affected) and low risk (category 4): protective of 95% to <99% of species (or >1 to 5% of species affected). The ms-PAF level was highest in December 2018 - January 2019 corresponding to the high flow of the wet season, although the risk level remained low.

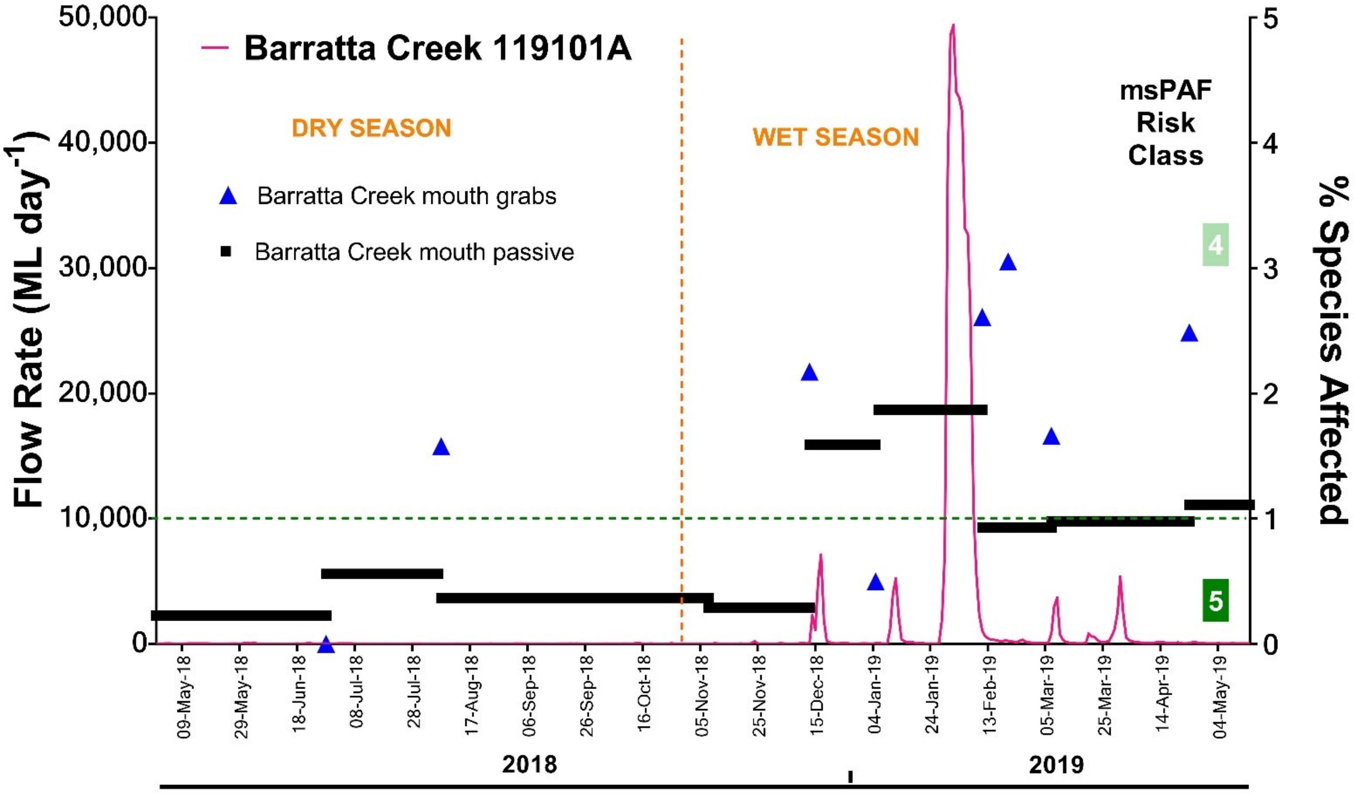


Figure 9: Temporal trends in ms-PAF values at Barratta Creek mouth fixed passive sampling (black bar) and grab samples (blue triangles) relative to the flow rate of the rivers influencing the sampling sites. Flow data from DNRM Stream Gauging Network.

ii) For grab samples along the transect

In addition to passive samplers, grab samples were collected at the Barratta Creek mouth throughout the year. Overall, concentrations and pesticide profiles in both grab and passive samplers reflected one another (Figure 9). But grab sampling provided the opportunity to catch the peak concentrations (which were still low risk) of pesticides during major flow events while passive sampling provided the average concentrations during the sampling period.

All of the grab samples returned low risk (category 4) or very low risk (category 5). Atrazine and its metabolite DE atrazine were dominant in the pesticide profile although at low concentration (Atrazine C_{max} 22 ng L^{-1}). Diuron is the pesticide with second highest concentration in the grab samples from this region (Diuron C_{max} 13 ng L^{-1}).

3.3 Mackay-Whitsunday Region

In 2018–19, there were no exceedances at any sites of this region. This is the first time this region has no exceedance after three consecutive years where the levels of diuron had exceeded the proposed guideline values in a deployment period in Flat Top site. Repulse Bay and Flat Top Island had the highest concentration of most pesticides monitored, compared to other sites.

While the maximum concentrations were lower, the overall profiles of PSII herbicides (and metabolites) detected are similar to previous monitoring years with diuron, hexazinone and atrazine being the most frequent (Table D-8 to Table D-11). Meanwhile, terbuthylazine and propazine were detected at very low concentrations (<2 ng L^{-1}). Other pesticides, imidacloprid, 2,4-D, MCPA and metolachlor, were regularly detected in at least one sampler at all sites.

Pesticides measured from PDMS samplers were mainly detected at low concentrations (< ~5 ng L^{-1}), the highest concentration of pesticides from PMDS were from propazine at concentration of 4.4 ng/L at Repulse Bay and 5.8 ng/L at Flat Top Island.

3.3.1 Repulse Bay

Maximum concentration of pesticides during the 2018–19 monitoring year was 231 ng/L of diuron during the wet season of January/February 2019. Diuron is usually the pesticide with the highest concentration, followed by hexazinone in this site but in this monitoring year atrazine replaced hexazinone as the second highest pesticide with a maximum of 176 ng/L in January/February 2019.

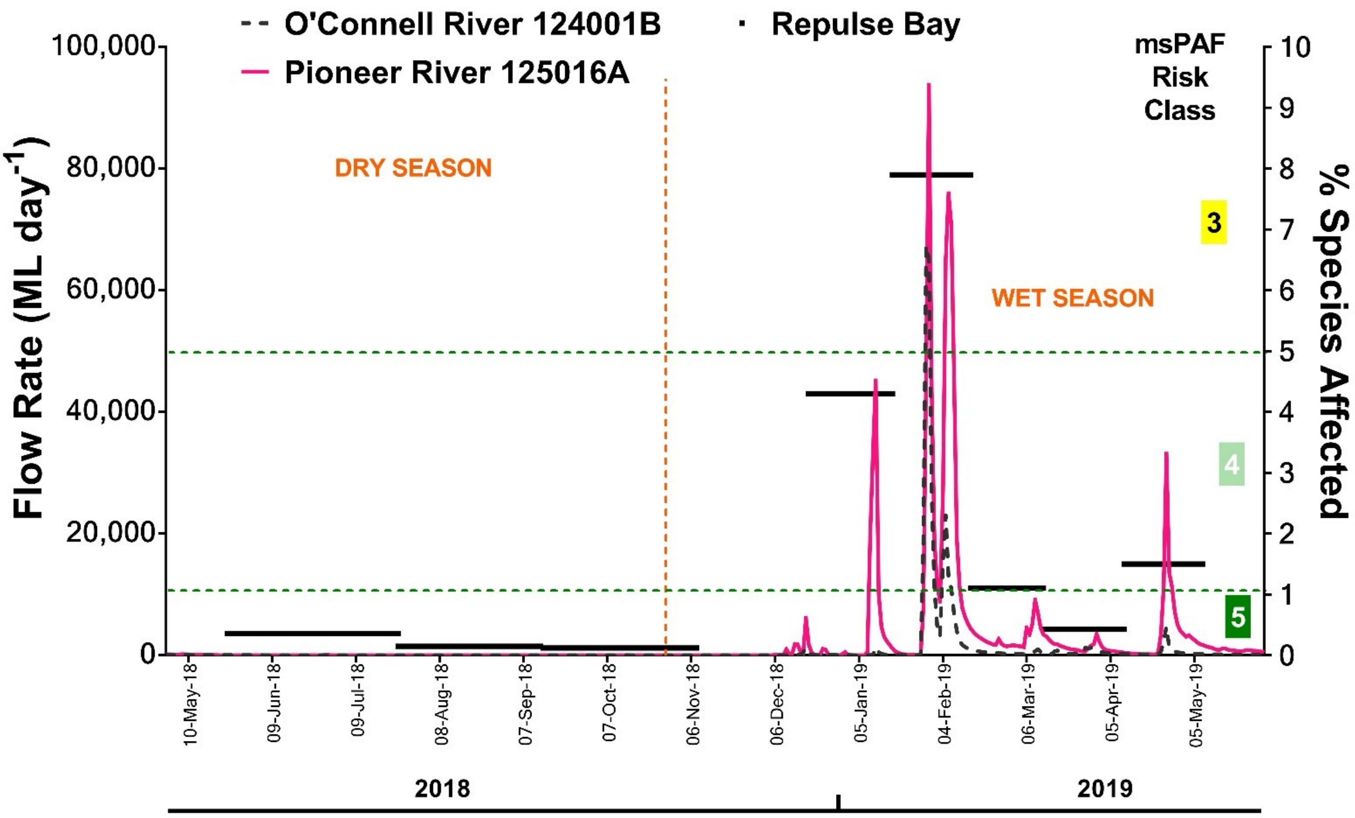


Figure 10: Temporal trends in % of species affected by pesticides (indicated by the black bars) in Repulse Bay in 2018-19, together with the flow rates of adjacent rivers. Flow data provided by DNRM Stream Gauging Network.

The maximum concentrations of pesticides monitored in 2018–19 were much higher than in the previous monitoring year of 2017–18 and were the highest since the monitoring started in 2014-15.

The ms-PAF values in 2018–19 in this site returned samples across three risk categories, and is our highest risk site of this monitoring year:

- Very low risk (category 5): protective of ≥99% of species (i.e. ≤1% of species are affected) - four samples
- Low risk (category 4): protective of 95% to <99% of species (or >1 to 5% of species affected) – three samples
- Moderate risk (category 3): protective of 90% to <95% of species (or >5 to 10% of species affected) – one sample

3.3.2 Flat Top Island

There were no exceedances of guideline values at the Flat Top Island site in this monitoring year compared to two exceedances in the last monitoring year (2017-18) for diuron.

Maximum concentration of pesticides during the 2018–19 monitoring year was 249.7 ng/L of diuron during the wet season of December 2018 - January 2019. Diuron is usually the pesticide with the highest concentration at this site. Atrazine and hexazinone are also usually found at higher concentrations.

Among the other pesticides (non- PSII herbicides) concentrations of imidaclopid were the highest at 11 ng/L in January/February 2019 but not as high as the level of 42 ng/L reached in the last monitoring year (the PGV for imidacloprid is 57 ng/L).

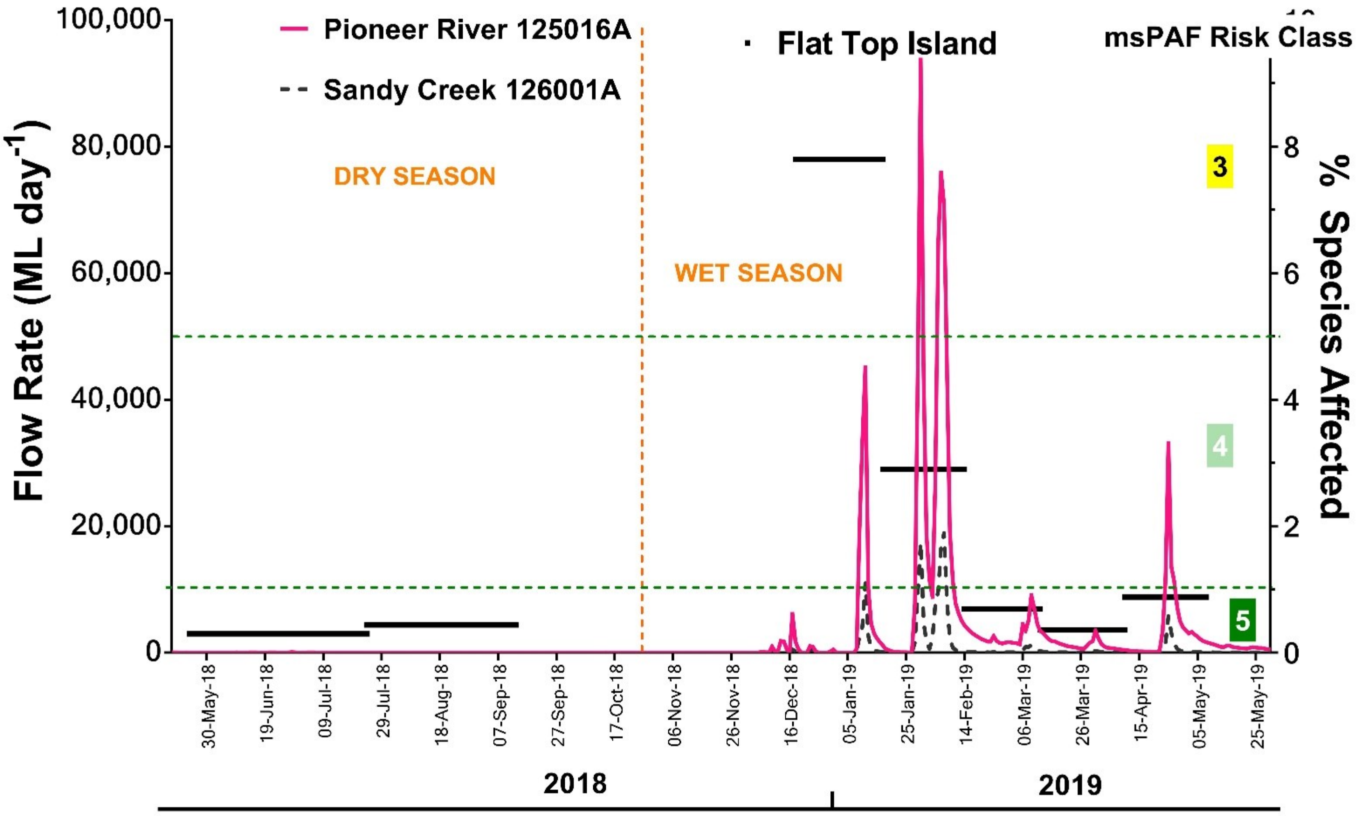


Figure 11: Temporal trends in % of species affected by pesticides (indicated by the black bars) in Flat Top Island in 2018-19, together with the flow rates of adjacent rivers. Flow data from DNRM Stream Gauging Network.

The total concentrations of pesticides monitored in 2018–19 were lower than those of the three previous monitoring years. This is the first time there was no exceedance of the proposed guideline at this site.

Flat Top Island returned samples across three risk categories, and together with Repulse Bay is one of our highest risk sites:

- Very low risk (category 5): protective of ≥99% of species (i.e. ≤1% of species are affected) - five samples
- Low risk (category 4): protective of 95% to <99% of species (or >1 to 5% of species affected) – one sample
- Moderate risk (category 3): protective of 90% to <95% of species (or >5 to 10% of species affected) – one sample

3.3.3 Sandy Creek

There were no exceedances of guideline values at this site although three early wet season samplers were lost for this monitoring year.

Maximum concentration of PSII herbicides during the monitoring year was 17 ng/L for diuron in February/March 2019 during the wet season after high flow in early February 2019. At this site, diuron is the pesticide with the highest concentration, followed by atrazine and hexazinone.

The level of total concentrations of pesticides monitored in this monitoring year were lower than the previous monitoring years of 2016 and 2017, with data not available in 2014 and 2015 (see more details about historic data in Gallen et al., 2019).

All passive sampler deployments in this region returned ms-PAF values that met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected).

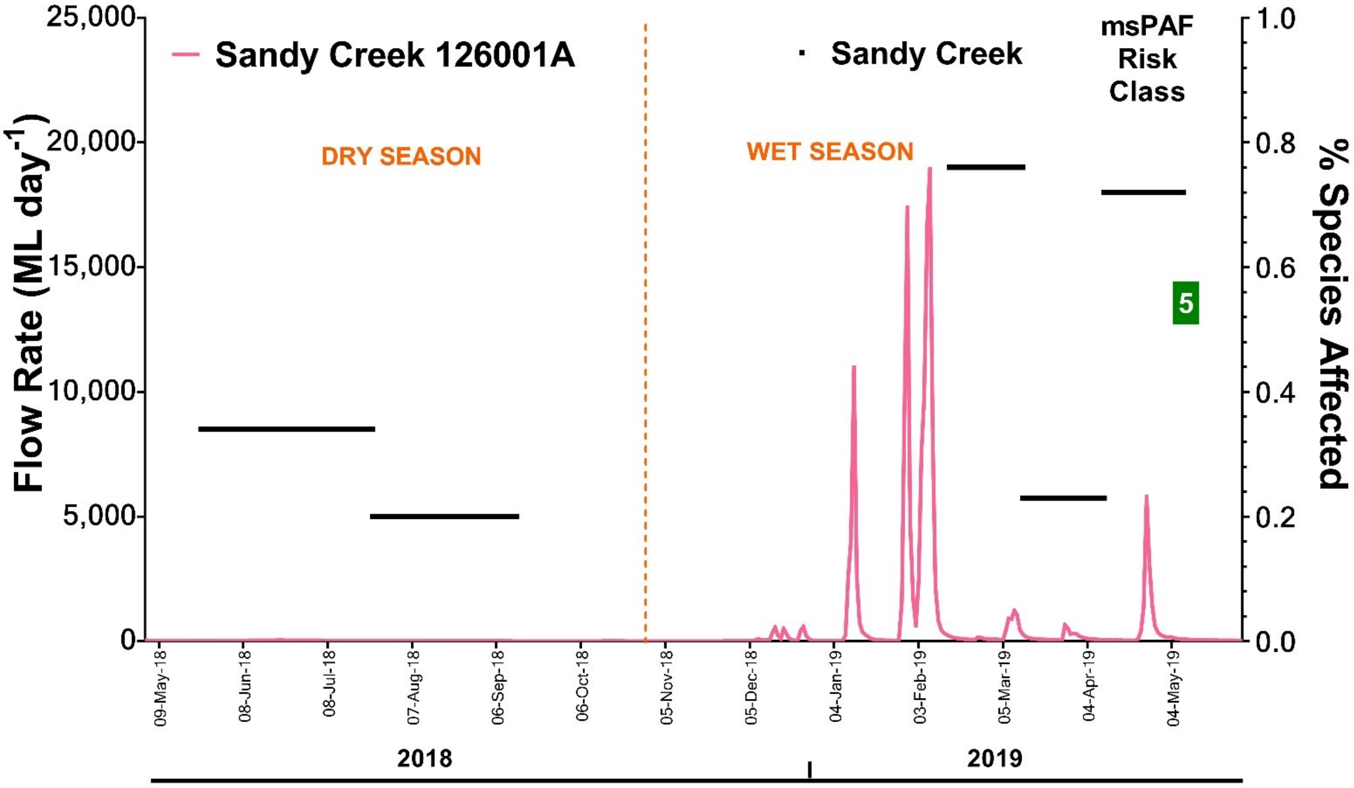


Figure 12: Temporal trends in % of species affected by pesticides (indicated by the black bars) in Sandy Creek in 2018–19, together with the flow rates of adjacent rivers. Flow data from DNRM Stream Gauging Network.

3.3.4 Sarina Inlet

There were no exceedances of guideline values at the Sarina Inlet site.

The maximum concentration of PSII herbicides during the monitoring year was 114 ng/L for diuron in Jan/Feb 2019 in the beginning of the wet season. Similar to the close-by site of Sandy Creek, in Sarina Inlet, diuron is the pesticide with the highest concentration, followed by atrazine and hexazinone.

The ms-PAF values in 2018–19 at this site were similar to those reported in the previous monitoring year (2017–2018) and met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for four deployments, while two deployments in the middle of the wet season (December 2018 to February 2019) returned a low risk, category 4: protective of 95% to <99% of species (or >1 to 5% of species affected) as shown in Fig. 15.

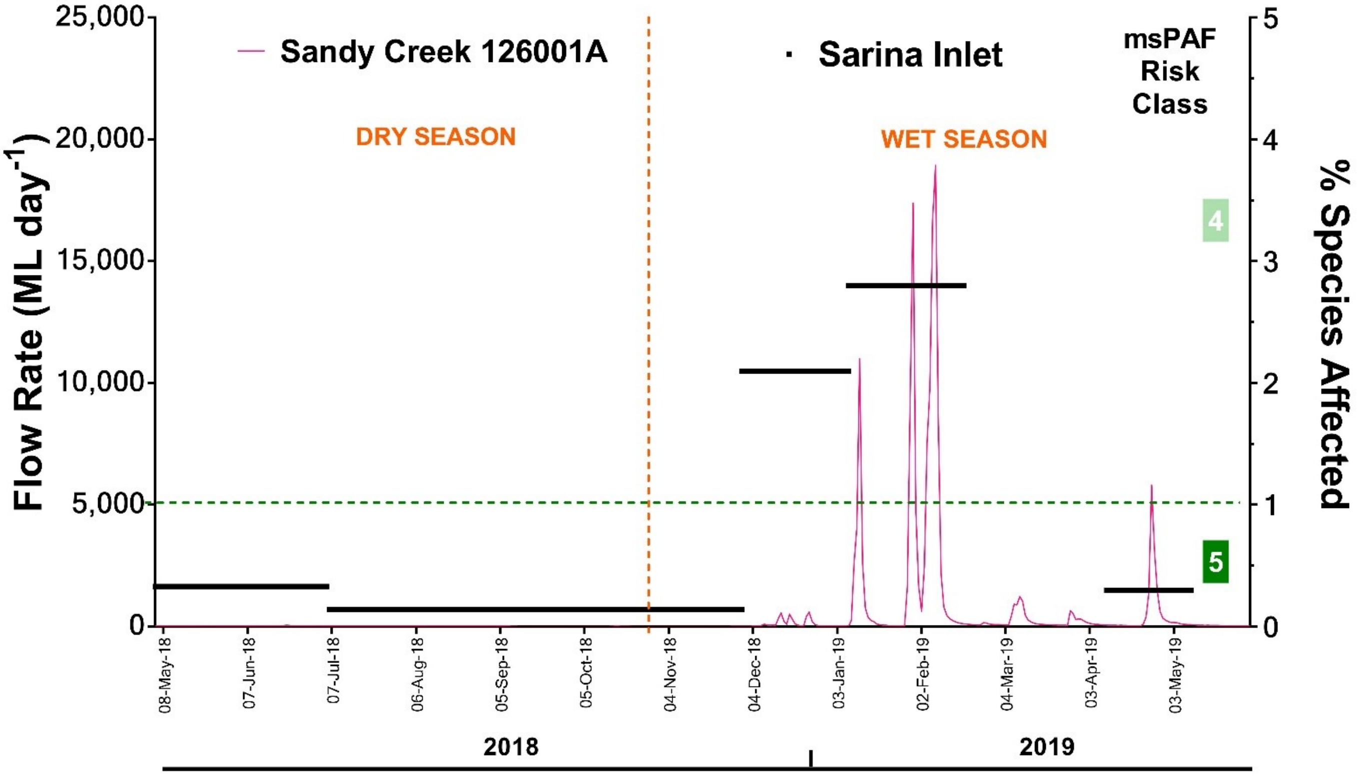


Figure 13: Temporal trends in % of species affected by PSII pesticides (as indicated by the black bars) in Sarina Inlet in 2018–19, together with the flow rates of adjacent rivers. Flow data from DNRM Stream Gauging Network.

3.4 Fitzroy Region

3.4.1 North Keppel Island

There were no exceedances at North Keppel Island in the Fitzroy region during the 2018–19 monitoring year. But the number of samplers recovered for this monitoring period was low with only two retrieved in the dry season.

PSII herbicides detected at North Keppel Island in 2018–19 included atrazine, diuron, hexazinone, simazine and tebuthiuron (Table D-12). Metolachlor and imidacloprid were also detected at very low concentrations. Diuron had the highest concentration at North Keppel Island with the maximum concentration of 1.4 ng/L.

The ms-PAF values met the desired very low risk category 5: protective of ≥99% of species (i.e. ≤1% of species are affected) for all passive sampler deployments. But again, it is noted that there were only two samplers retrieved from this site during the dry (i.e. low risk) season.

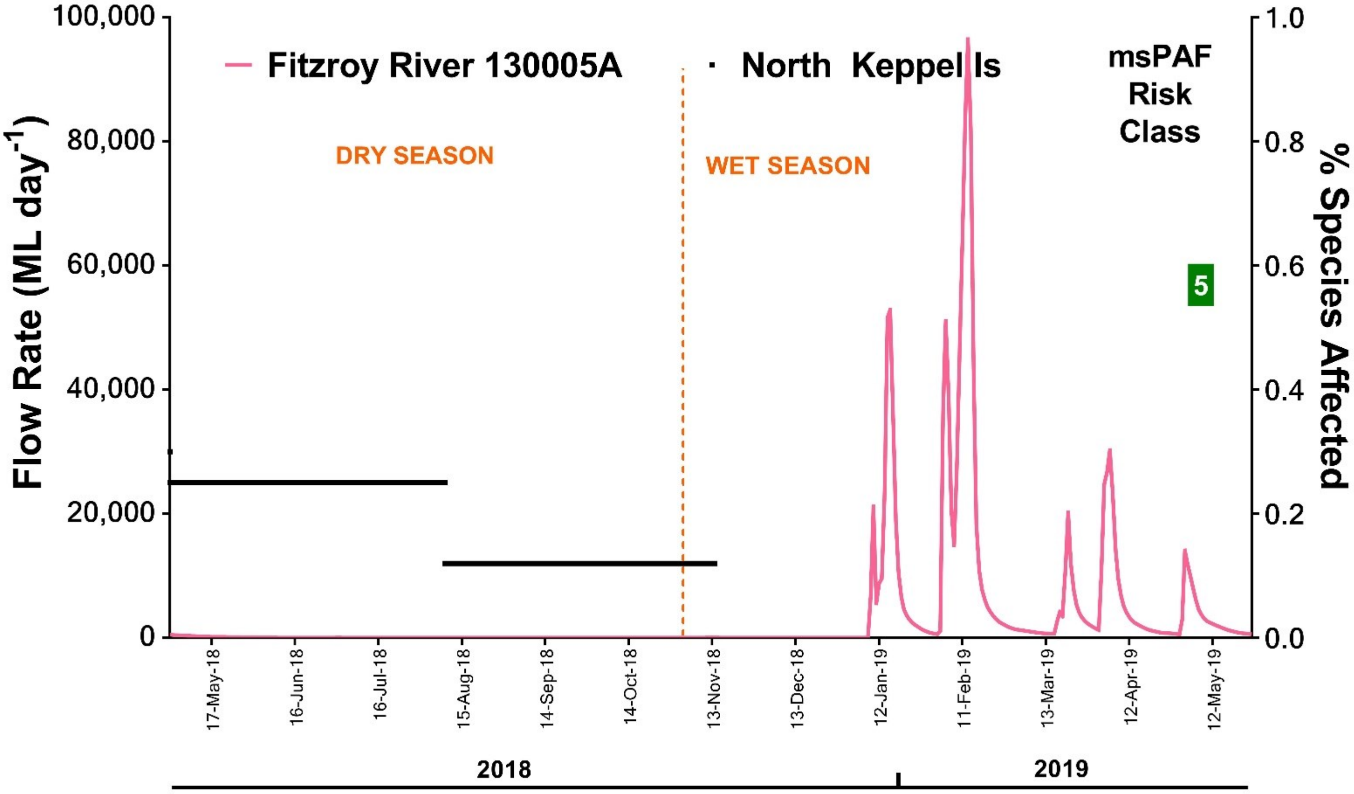


Figure 14: Temporal trends in ms-PAF values in 2018-19, relative to the flow rate of the Fitzroy River influencing North Keppel Island's fixed passive sampler site. Flow data from DNRM Stream Gauging Network.

4. Discussion

Overall trends in pesticide levels at fixed monitoring sites.

Pesticide concentrations at fixed monitoring sites were, in most cases, similar to or lower than the previous monitoring year. No individual exceedances of the current marine trigger values (i.e. water quality guideline values) were detected although some of these values are undergoing a review. Although higher levels of pesticides detected at the Flat Top Island, Repulse Bay and Sarina Inlet in 2018-19 indicate that these are higher risk sites. This is the first year that Flat Top Island did not record any exceedance after several occurrences in the previous monitoring years.

It is challenging to evaluate the long-term trends of the monitored marine pesticide data, especially when changes to multiple pressures occur simultaneously. The end-of-basin loads, seasonal pulses of river flow patterns, discharge volumes, distance from river mouths and other factors (such as timing of pesticide application) affecting the transport of pesticides from the river mouths to the sites all likely contribute to the pesticide concentrations measured at these sites. Historically, the highest pesticide concentrations have been detected at the Mackay-Whitsunday sites.

Whether the slight reduction in pesticide concentrations measured during this monitoring year is due to, for example, climatic variabilities influencing pesticide transport potential from basin to Reef or better land management practices reducing pesticide usage and runoff, or both, requires a detailed understanding of all the factors driving these changes. Quite often the necessary data needed to interpret these changes (particularly pesticide usage and application rates) are either not available or only updated periodically. Since pesticide discharges from land uses occurred mainly during runoff events in the wet season, river discharge is also expected to be a key driver of pesticide concentrations reaching monitoring sites. All these factors make it difficult to quantitatively assess the link between improved land management practices as a direct result of Reef 2050 WQIP initiatives and changes in nearshore marine water quality.

To assess the ability of the monitoring program to trace the effectiveness of Reef 2050 WQIP, a separate statistical investigation of the data is being conducted by the team in collaboration with DES.

PSII herbicide profiles

Similar to previous monitoring years, diuron, atrazine and hexazinone were the most consistently detected and abundant PSII herbicides at most sites (Bentley et al., 2012; Gallen et al., 2013; Gallen et al., 2014; Gallen et al., 2016; Grant et al., 2017; Kennedy et al., 2010; Kennedy et al., 2012). These herbicide residues reflect land-use applications primarily in the sugar cane, horticulture and grain cropping industries (Bainbridge et al., 2009; Devlin et al., 2015; Kroon et al., 2013; Lewis et al., 2009).

Diuron is typically associated with the intensive sugar cane farming in the coastal area of the Tully River, Herbert River, Pioneer River and Sandy Creek basins. Higher concentrations of diuron have been typically measured in sites of these basins since monitoring commenced in 2010.

Atrazine (also registered for use in sugarcane) has historically been used extensively in the Barratta and Burdekin basins, and has been found during recent passive sampling activities in these basins (O'Brien et al., 2016), and previous monitoring years by this MMP (in both passive and grab samples). This herbicide continues to represent the highest proportion of PSII herbicides at the monitoring sites in this region.

Hexazinone has a similar level to atrazine in most of the monitoring sites except in the Barratta and Burdekin basins.

Other pesticide profiles

Monitoring of non-PSII pesticides cover the use of alternative knock-down herbicides (such as 2,4-D, glyphosate) (Reef Plan, 2013; Smith et al., 2015), insecticides, fungicides and other herbicides (i.e. herbicides that are not used as a PSII herbicide alternative weed control, e.g. metsulfuron-methyl) that are known to be used and transported into basins discharging to the Reef (Devlin et al., 2015).

Among the other pesticides monitored, metolachlor, 2,4-D, and imidacloprid were frequently detected in ED passive samplers while propazine, propiconazole and chlorpyrifos were frequently detected in PDMS samplers in the current monitoring year. Compared to PSII herbicides, concentrations of other pesticides were generally very low or non-detected except for imidacloprid.

Although the concentrations of imidacloprid is relatively low, its low proposed PGV value of 57 ng L^{-1} (level determined to protect 99% of marine species) made the risk from imidacloprid higher (C_{max} from passive samplers was 38 ng L^{-1}). There would be one instances of exceedance for imidacloprid in the grab sample collected at Tully River mouth in January 2019 (67.7 ng L^{-1}). However, until endorsed, comparisons with this proposed value are provided only for consideration.

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Appendix A Supplemental information on methodology

A-1 Sampler deployment, approaches for missing data and sources of uncertainty

Sampler deployment and approaches for missing data

Samplers are cleaned, assembled and calibrated by QAEHS but are deployed in the field by a team of volunteers. The participation of volunteers from various community groups, agencies and tourist operations is a key feature of the long-term pesticide monitoring program and integral to the success of maintaining the program in often remote locations. Volunteers receive, deploy, retrieve and return the passive samplers to QAEHS for subsequent extraction and analysis. Volunteers are trained by the Great Barrier Reef Marine Park Authority (GBRMPA) and/or QAEHS staff in the Standard Operating Procedures (SOPs) for deploying and retrieving the passive samplers, ensuring high quality usable data.

Whilst every effort is made to deploy samplers in accordance with the proposed sampling schedule, there are circumstances every year where this is not possible. This may result in periods where passive samplers are not deployed (for example, during bad weather) or samplers are under- or over-deployed, i.e. the period the sampler is left in the water is less than or greater than the preferred period (2 months in dry season, 1 month in wet season). In addition, samplers are regularly lost in extreme weather events or are stolen or otherwise damaged. For periods of non-deployment, gaps between successful deployments are often up to 1-2 weeks at most and have minimum impact on the long-term trends. Longer periods of non-deployment or when samplers are lost can result in uncertainty in the representativeness of the pesticide concentration data for that deployment season and, therefore, may affect the long-term trends (for example, when only one wet season sampler is successfully deployed in one year, but all 6 are deployed for previous years). This can make interpretation of long term trends challenging. Actual dates of deployment are given in Appendix D and average concentrations where only one sampler was received for that season are highlighted in the summary statistics tables in the Results section.

Passive samplers are calibrated for an optimum deployment period and if they are over- or under-deployed, this reduces the confidence in the reported concentrations. If under-deployed, the amount of pesticide taken up into the sampler may be too low to be detected on the analytical instruments, resulting in a non-detect result when in fact the pesticide was present in the marine waters. If over-deployed, the samplers may become saturated, violate the assumptions of pesticide uptake dynamics or become bio-fouled or otherwise contaminated in the field. In these cases, samplers are excluded from the analysis.

Passive samplers that show evidence of inappropriate storage during transportation that may lead to contamination (such as transport lids not attached or EDs returned dry) or damage during deployment (mud underneath membrane or severe biofilm that impedes water flow) are also excluded from analysis.

Sources of uncertainty

To interpret both trends in the long-term data and true changes in concentrations year to year, there must be an understanding of the inherent variability of the data. Possible sources of uncertainty when using the passive samplers may include (but are not limited to) the effects of salinity and water temperature on chemical uptake into the sampler, accurate measurement of exposure time, the integrity of the flow-limiting membrane over the deployment period, degree of biofouling on the surface of the sampler and its effect on the sampling area, analytical error and variability in the dissolution of the PFM used to approximate water flow (and sampling rates).

Salinity (ionic strength) has been found to have a very small effect on the solubility of the gypsum contained in the PFM, which is subsequently used to estimate sampling rates with respect to the water flow at a given site (O'Brien et al., 2011b). The effect of salinity on a hypothetical calculation of water concentration from an ED found that a change in salinity from 5 g L^{-1} (freshwater) to 35 g L^{-1} (marine water) did not change the estimated flow rate (to two significant figures) under either low or high dissolution rate conditions. The effect of water temperature on the dissolution of the PFM is not well understood, but as water temperature remains relatively constant between the wet and dry seasons (20-25°C) it is assumed to have a negligible effect.

Replicate PFMs are deployed at each passive sampler site, and the mass lost per day is used to estimate the sampling rate of chemicals. Normalised difference percentages between duplicate PFMs deployed at each site this monitoring year ranged between <1 and 32% (mean of 9.8%), showing good agreement (this excludes 26 sampler-sets where PFM duplicates were both empty upon retrieval).

Duplicate EDs are deployed at each sampling site and returned to QAEHS. One duplicate sampler is analysed for approximately every 10 samples to determine the variability in the overall performance (chemical uptake) of the EDs. This monitoring year, 24 ED sampler sets were analysed in duplicate, and four grab samples were also analysed in duplicate (results combined). There were 284 pesticide detections in both duplicates and 24 herbicide detections in only one of the duplicates. Mean coefficients of variation (%CVs) for chemicals (which includes detections in both duplicates only) ranged from 3.3% (terbutryn; however only one duplicate detection) to 55% (fluazifop; also only one duplicate detection). Variability for the most frequently detected pesticides (diuron, atrazine, hexazinone) were 26%, 22% and 24% respectively, similar to the previous monitoring year (20%, 23% and 23%).

The objective of most passive sampling field studies is to derive an estimate of the concentration of pollutants present in the environment. However, the environmental concentrations obtained from passive sampling can only be accurate when appropriate calibration data (i.e. sampling or chemical uptake rates usually in units of L day^{-1}) is used to derive these values. Sampling rates are influenced by the prevailing conditions at a sampling site and include temperature, water flow and the degree of sampler biofouling, and cannot be easily predicted based on a chemical's physico-chemical properties. Although there is an ever-increasing amount of calibration data available for commonly detected anthropogenic chemicals, calibration data is still lacking for many, particularly for new and emerging chemicals.

The sampling rates (R_s) of many polar chemicals relevant to the Reef have been reported in both field and laboratory calibration experiments throughout the literature (Booij et al., 2002; Kaserzon et al., 2014; O'Brien et al., 2011a; Shaw et al., 2009; Shaw and Mueller, 2009; Stephens et al., 2005; Stephens et al., 2009; Vermeirssen et al., 2009), although rates vary due to the conditions under which they were conducted. Atrazine was common to all of these studies and was chosen as a reference point to estimate compound specific sampling rates of other herbicides on a proportional basis (i.e. R_s of chemical X / R_s of atrazine).

The relationship between the sampling rate of atrazine and flow effects has been extensively investigated (O'Brien et al., 2011a). Using this relationship, a sampling rate for each herbicide was calculated, specific to the flow conditions encountered at a particular site during each deployment. By inserting the relevant water velocity (estimated from PFM loss rate) into the equation and adjusting the resulting sampling rate by their proportion relative to atrazine, compound specific sampling rates were estimated for other herbicides, to provide estimates of herbicide water concentrations. For herbicides where no calibration data is available, the sampling rate of atrazine has been assumed. Whilst there is always variability in calibration data, regardless of whether calibration data is available or has been assumed, the objectives of the pesticide monitoring component (to monitor trends in pesticide concentrations) of the MMP can be achieved, provided the same calibration data is used year-on-year.

A-2. Target chemicals

Table A-1: QAEHS LC-MS/MS analyte list for positive and negative mode analysis

Positive Ion Mode	Negative Ion Mode
Ametryn	2,4-D
Asulam	2,4-DB
Atrazine	Fluroxypyr
Bromacil	Haloxyfop
Desethyl Atrazine	MCPA
Desisopropyl Atrazine	
Diuron	
Fluazifop	
Fluometuron	
Hexazinone	
Imazapic	
Imidacloprid	
Metolachlor	
Metribuzin	
Metsulfuron-methyl	
Prometryn	
Propazine	
Simazine	
Tebuconazole	
Tebuthiuron	
Terbutryn	

Table A-2: QAEHS GC-MS analyte list for PDMS extracts

Pesticide
Chlorpyrifos
Pendimethalin
Propazine
Propiconazole
Trifluralin

Table A-3: Proposed priority pesticides and herbicides specified under the MMP (proposed by PWG 18 August 2015) and other pesticides of interest for potential inclusion in monitoring and reporting activities (feedback from the Paddock to the Reef program). Instrument limit of detection (LOD) and limit of reporting (LOR) are given (μg L^{-1}), where available.

Chemical	Description	Priority or of interest	LC-MS/MS		GC-MS
			LOD	LOR	LOR
2,4-D	Phenoxy-carboxylic-acid herbicide	Priority	0.03	0.10	
2,4-DB	Phenoxy-carboxylic-acid herbicide	Of interest	5.0	15	
Aciflurofen*	Herbicide: cell membrane disruptor	Of interest			
Ametryn	PSII herbicide – methylthiotriazine	Priority	0.56	1.69	
Asulam	Herbicide: inhibition of DHP – carbamate	Of interest			
Atrazine	PSII herbicide – chlorotriazine	Priority	0.05	0.15	
Atrazine – desethyl	PSII herbicide breakdown product (also active)	Priority	0.005	0.10	

Chemical	Description	Priority or of interest	LC-MS/MS		GC-MS
			LOD	LOR	LOR
Atrazine – desisopropyl	PSII herbicide breakdown product (also active)	Priority	0.02	0.10	
Bromacil	PSII herbicide – uracil	Of interest	0.02	0.10	
Chlorothalonil*	Organochlorine fungicide	Priority			
Chlorpyrifos	Organophosphate insecticide	Priority			0.5
Diazinon*	Insecticide: inhibits acetylcholinesterase	Of interest			
Diuron	PSII herbicide – phenylurea	Priority	0.02	0.10	
Ethametsulfuron methyl*	Herbicide: acetolactate synthase (ALS) inhibition	Of interest			
Fipronil*	Phenylpyrazole insecticide	Priority			
Fluazifop	Herbicide: inhibition of acetyl CoA carboxylase	Of interest	0.02	0.10	
Fluometuron	PSII herbicide – urea	Of interest	0.01	0.10	
Fluroxypyr	Pyridine carboxylic acid herbicide	Priority	0.02	0.10	
Glyphosate*	Broad-spectrum systemic herbicide	Priority			
Haloxyfop	Aryloxyphenoxy-propionate herbicide	Priority	0.04	0.13	
Hexazinone	PSII herbicide – triazinone	Priority	0.01	0.10	
Imazapic	Imidazolinone herbicide	Priority	0.02	0.10	
Imidacloprid	Neonicotinoid insecticide	Priority	0.01	0.10	
Isoxaflutole and DKN*	Isoxazole herbicide	Priority			
MCPA	Phenoxy-carboxylic-acid herbicide	Priority	0.05	0.14	
Mesosulfuron methyl*	Herbicide: acetolactate synthase (ALS) inhibition	Of interest			
Metolachlor	Chloracetanilide herbicide	Priority	0.03	0.10	
Metribuzin	PSII herbicide – triazinone	Priority	0.03	0.11	
Metsulfuron methyl	Sulfonylurea herbicide	Priority	0.03	0.10	
MSMA*	Herbicide: inhibition of cell division	Of interest			
Paraquat*	Herbicide: photosystem-I-electron diversion	Of interest			
Pendimethalin	Dinitroaniline herbicide	Priority			1.0
Prometryn	PSII herbicide – methylthiotriazine	Priority	0.54	1.61	
Propazine	PSII herbicide – chlorotriazine	Priority	0.06	0.18	
Propiconazole*	Conazole fungicide	Priority			2.0
Prothiophos*	Insecticide: inhibits acetylcholinesterase	Of interest			
Simazine	PSII herbicide – chlorotriazine	Priority	0.08	0.24	
Tebuconazole	Conazole fungicide	Priority	0.10	0.31	
Tebuthiuron	PSII herbicide – thiadazolurea	Priority	0.01	0.10	
Terbuthylazine*	PSII herbicide – triazine	Priority			
Terbutryn	PSII herbicide – triazine	Of interest	0.55	1.7	
Triclopyr*	Pyridine carboxylic acid herbicide	Priority			
Trifloxysulfuron*	Herbicide: inhibition of ALS – sulfonyl urea	Of interest			
Trifluralin	Herbicide – dintiroaniline	Priority			0.2

* Not currently analysed by QAEHS
Shaded chemicals are included as part of the Paddock 2 Reef Integrated Monitoring, Modelling and Reporting Program
Red text indicates that the sampling rate of atrazine has been assumed.

A-3. Analytical details

QAEHS undertakes all herbicide analysis of passive and grab samples using Liquid Chromatography-tandem Mass Spectrometry (LC-MS/MS).

ED extracts and grab samples were analysed for herbicides using a Sciex QTRAP 6500+ mass spectrometer (Sciex, Concord, Ontario, Canada) equipped with an electrospray (TurboV) interface coupled to a Shimadzu Nexera HPLC system (Shimadzu Corp., Kyoto, Japan). Separation was achieved using a 2.6 micron 50 x 2.0mm Phenomenex Biphenyl column (Phenomenex, Torrance, CA) run at 45˚C, and a flow rate of 0.3 mL min^{-1} with a linear gradient starting at 5% B, ramped to 100% B in 5.2 minutes then held at 100% for 4.3 minutes followed by equilibration at 5% B for 3.5 minutes. (A = 1% methanol in HPLC grade water, B = 95% methanol in HPLC grade water, both containing 0.1% acetic acid). The mass spectrometer was operated in both positive and negative ion multiple reaction-monitoring mode, using nitrogen as the collision gas and monitoring two transitions for each analyte.

Positive results were confirmed by retention time and by comparing transition intensity ratios between the sample and an appropriate concentration standard from the same run. Samples were reported as positive if the two transitions were present (with peaks having a signal to noise ratio greater than 3), retention time was within 0.15 minutes of the standard and the relative intensity of the confirmation transition was within 20% of the expected value. The value reported was that for the quantitation transition.

Analysis of PDMS extracts for non-polar pesticides was conducted on a Thermo Scientific TSQ Quantum XLS Triple Quadrupole GC-MS/MS. The mass spectrometer was operated in positive ion, multiple reaction monitoring mode, using argon as the collision gas. Prior to introduction into the mass spectrometer, compounds were separated on an Agilent J & W DB5-MS (25m; 0.25mm i.d.; 0.25µm film thickness) column. Samples were injected in splitless mode at 80°C. The GC oven was held at 80°C for 2 minutes and ramped to 180°C at 20°C/minute; held for 0.5 minutes and ramped to 300°C at 10°C/minute and held for 10.5 minutes. The transfer line and ion source were heated at 280°C and 270°C respectively. Helium was used as the carrier gas at a rate of 1.0 mL/minute. A quantitative and qualitative ion transition was monitored for each compound.

Appendix B Supplemental information on water quality guidelines

Water quality in Australia is currently managed in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2018). Trigger values are defined for a range of pesticides and an indication of the reliability of the value (low, moderate, high) is given in Table B-1. The guidelines paid considerable attention to values derived using the assessment factor approach (Batley et al., 2014). For several of the pesticides detected in this current monitoring year, no trigger values were yet available.

The use of species sensitivity distributions (SSDs) is the preferred method of deriving water quality guidelines (Warne et al., 2015). A SSD is a model of the variation in sensitivity of species in an ecosystem to a particular stressor and allows prediction of the percentage of species that is expected to be adversely affected at a given environmental stressor level (e.g. pesticide concentration). Under this approach, protective concentrations can be defined that typically offer four levels of protection: 99, 95, 90 and 80 per cent of species in the ecosystem being protected, referred to as PC99, PC95, PC90 and PC80, respectively (Batley et al., 2014).

Using this approach, marine protective concentrations were derived by the Great Barrier Reef Marine Park Authority (GBRMPA, 2010) for tropical species (Appendix B Table B-1). The Great Barrier Reef is considered as a high ecological value (HEV) ecosystem and, therefore, afforded the highest water quality protection level, i.e. protection of at least ≥99 per cent of species (PC99). This level of protection is judged the most suitable for this World Heritage Area, which is classified as having outstanding universal value and no change in the indicators of biological diversity beyond the natural variation is recommended.

Table B-1: Water quality limits available for pesticides (protective concentration (PC) values, PC95 and PC99, will protect ≥95% and ≥99% of the species in the ecosystem, respectively) (ng L^{-1}).

Chemical	DES proposed guideline values (PGVs)[a]		ANZECC[c]		GBRMPA[e]	
	PGV	Notes	Trigger Value	Notes	PC Value	Notes
2,4-D	1,040,000	PC99; low reliability; Marine water				
Ametryn	100	PC99; moderate reliability; Marine water			500	PC99; Moderate reliability
					1,000	PC95; Moderate reliability
Atrazine	-		700	PC99; Fresh water	600	PC99; Moderate reliability
			1,300	PC95; Fresh water	1,400	PC95; Moderate reliability
			ID	PC99/95; Marine water		
Bromacil	230	PC99; moderate reliability; Marine water				
Chlorpyrifos	-		0.5	PC99; Marine water	0.5	PC99; High reliability

Chemical	DES proposed guideline values (PGVs)[a] PGV	 Notes	ANZECC[c] Trigger Value	 Notes	GBRMPA[e] PC Value	 Notes
			9	PC95; Marine water	9	PC95; High reliability
			0.04	PC99; Freshwater		
Diuron	430[b]	PC99; very high reliability; Marine water	200[d]	IWL; low reliability; Freshwater	900	PC99; moderate reliability
			1,800[d]	IWL; low reliability; Marine water	1,600	PC95; moderate reliability
Fipronil	3.4	PC99; moderate reliability; Marine water				
Fluometuron	20,000	PC99; moderate reliability; Marine water				
Fluroxypyr	87,000	PC99; moderate reliability; Marine water				
Haloxyfop	589,000	PC99; low reliability; Marine water				
Hexazinone	1,800	PC99; low reliability; Marine water			1,200	Low reliability
Imazapic	49	PC99; very low reliability; Marine water				
Imidacloprid	57	PC99; moderate reliability; Marine water				
MCPA	1,000	PC99; low reliability; Marine water				
Metolachlor	Marine data n.a.		20[d]	IWL, low reliability; Freshwater		
	Freshwater: 16		20[d]	IWL, low reliability; Marine water		
Metribuzin	2,000	PC99; moderate reliability; Marine water				
Metsulfuron methyl	Marine data n.a. Freshwater: 4.7					
Pendimethalin	240	PC99; moderate reliability; Marine water				
Prometryn	110	PC99; moderate reliability; Marine water				
Propazine	2,200	PC99; low reliability; Marine water				
Propiconazole	2,100	PC99; moderate reliability; Marine water				

Chemical	DES proposed guideline values (PGVs)[a]		ANZECC[c]		GBRMPA[e]	
	PGV	Notes	Trigger Value	Notes	PC Value	Notes
Simazine	28,000	PC99; low reliability; Marine water	200	PC99; Freshwater	200	PC99; Low reliability
			3,200	PC95; Freshwater		
			ID	PC99/95: Marine water		
Tebuthiuron	4,700	PC99; moderate reliability; Marine water	20	PC99; Freshwater	20	PC99; low reliability
			2,200	PC95; Freshwater		
			ID	PC99/95: Marine water		
Terbuthylazine	400	PC99; moderate reliability; Marine water				
Terbutryn	79	PC99; moderate reliability; Marine water				
Triclopyr	36	PC99; low reliability; Marine water				
Trifluralin	-		2,600	PC99; Freshwater		
			ID	PC99/95: Marine water		

[a] Reported in the 2017 Scientific Consensus Statement (Waterhouse et al., 2017) as proposed ecotoxicity threshold values

[b] Sourced from King et al. (2017a) (King et al., 2017b; King et al., 2017c)(PC99, PC95, PC90 and PC80 are derived, only PC99 relevant to the Reef reported in the table)

[c d] Interim Working Level (IWL) (rather than trigger value) as indicated in f the ANZECC Guidelines (ANZECC, 2018)

[e] Sourced from Table 26 & Table 27 of the Water Quality Guidelines for the Great Barrier Reef Marine Park (GBRMPA, 2010)

ID - insufficient data were available to determine a trigger value

Appendix C Supplemental information on risk assessment metrics

C-1. Overview of risk assessment metric: Multisubstance-potentially affected fraction (ms-PAF) method

Pesticide condition for the 2018 report card was based on the monitored concentrations of up to 19 pesticides (**Table C-** 13) in passive sampler devices and grab samples over the year. This differs from pesticide condition in the catchments, which is based on multiple grab samples over the wet season. Passive samplers provide a single time integrated concentration for each sampler representing the entire deployment time (typically four weeks).

Passive samplers allow for a longer-term ‘average’ concentration to be identified, which suits annual condition reporting. While grab samples have the potential to identify acute, rapid, irregular peaks in pesticide concentration, this is only the case if taken at the opportune time.

Table C- 1: Pesticides detected in passive sampler devices that were assessed using the ms-PAF method for multiple pesticides. Not all of the listed pesticides were necessarily detected in collected water samples.

Name of pesticide	Type	MoA
Chlorpyrifos	Insecticide	Acetylcholine esterase (AChE) inhibitor
Imidacloprid	Insecticide	Nicotinic receptor agonist
Haloxyfop	Herbicide	Acetyl-coenzyme A carboxylase (ACCase) inhibitor
Imazapic	Herbicide	Group 1 Acetolactate synthase (ALS) inhibitor
Metsulfuron-methyl	Herbicide	Group 2 Acetolactate synthase (ALS) inhibitor
Pendimethalin	Herbicide	Microtubule synthesis inhibitor
Metolachlor	Herbicide	Acetolactate synthase (ALS) inhibitor
Ametryn	Herbicide	Group 1 PSII inhibitor
Atrazine	Herbicide	
Terbuthylazine	Herbicide	
Tebuthiuron	Herbicide	
Simazine	Herbicide	Group 2 PSII inhibitor
Diuron	Herbicide	Group 3 PSII inhibitor
Terbutryn	Herbicide	
Hexazinone	Herbicide	Group 4 PSII inhibitor
Metribuzin	Herbicide	Group 5 PSII inhibitor
2,4-D	Herbicide	Group 1 auxins (Phenoxy-carboxylic acid auxins)
MCPA	Herbicide	
Fluroxypyr	Herbicide	Group 2 auxins (Pyridine-carboxylic acid auxins)

In order to express the concentration data for all selected pesticides as a single number that represented the overall risk to aquatic ecosystems, it was necessary to convert all the concentration data into a numerical term that represented the toxicity of the mixture of pesticides in each passive sampler or water sample, and then aggregate all the pesticide concentration data as a single number. In previous reports, the hazard equivalence (HEq) method was used to express the toxicity of PSII herbicides based on their toxicities relative to diuron (Table C- 3).

In this report the multi substance potentially affected fraction (ms-PAF) approach was adopted to bring this metric in line with freshwater catchments (Grant et al., 2018a; Traas et al., 2002). The ms-PAF approach was applied to pesticides with multiple modes of action (Table C- 1). The ms-PAF for pesticides with different modes of action was calculated using the independent action model of joint action (Könemann, 1981; Plackett and Hewlett, 1952). Further details on how the pesticide risk metric calculations were made is provided in Warne et al. ((in prep)).

The result of the ms-PAF analysis provides an estimate of the toxicity of the mixture of pesticides in each passive sampler device or water sample expressed as a percentage of species affected.

The corresponding per cent species protected (calculated for each passive sampler at 11 monitoring sites) were then allocated to the risk categories presented in Table C- 2. These categories are consistent with the ecological condition categories used in the Australian and New Zealand Water Quality Guidelines for Fresh and Marine Waters.

For the 2018 report card onwards, ms-PAF values were used to determine pesticide grades. Values were assessed at one decimal point.

Table C- 2: Grading description for the pesticides indicator.

Risk categories (% species affected)	% species protected	Risk category	Risk Level	Pesticides assessment
≤1.0%	≥99%	5	Very low risk	Very good
>1 – 5%	95 – <99%	4	Low risk	Good
>5 – 10%	90 – <95%	3	Moderate risk	Moderate
>10 – 20%	80 – <90%	2	High risk	Poor
>20.0%	<80%	1	Very high risk	Very poor

Table C- 3: Scientific publications indicating the effect concentrations and the end-points for the reference PSII herbicide diuron used to define specific PSII-HEq Index categories as an indicator for reporting purposes

Category	PSII-HEq Range (ng L^{-1})	Description	Supporting Literature with Respect to the Reference Chemical Diuron				
			Species	**Effects Concentration (ng L^{-1})**	**Endpoint**	**Toxicity measure**	**Reference (see footnotes)**
5	HEq ≤ 10	No published scientific papers that demonstrate any effects on plants or animals based on toxicity or a reduction in photosynthesis. The upper limit of this category is also the detection limit for pesticide concentrations determined in field collected water samples.					
4	10 < HEq ≤ 50	Published scientific observations of reduced photosynthesis for two diatoms.	**Diatoms**				
			D. tertiolecta	50	↓photosynthesis	LOEC	Bengston Nash *et al* 2005
			N. closterium	50	Sensitivity	LOEC	Bengston Nash *et al* 2005
3	50 < HEq < 250	Published scientific observations of reduced photosynthesis for two seagrass species and three diatoms.	**Seagrass**				
			H. ovalis	100	↓photosynthesis	LOEC	Haynes et al 2000
			Z. capriconi	100	↓photosynthesis	LOEC	Haynes et al 2000
			Diatoms				
			N. closterium	100	Sensitivity	IC10	Bengston Nash *et al* 2005
			P. tricornutum	100	Sensitivity	IC10	Bengston Nash *et al* 2005
			D. tertiolecta	110	↓photosynthesis	IC10	Bengston Nash *et al* 2005
2	250≤ HEq ≤ 900	Published scientific observations of reduced photosynthesis for three coral species.	**Coral - Isolated zooxanthellae**				
			S. pistillata	250	↓photosynthesis	LOEC	Jones *et al* 2003
			Coral - Adult colonies				
			A. formosa	300	↓photosynthesis	LOEC	Jones & Kerswell, 2003
			S. hystrix	300	↓photosynthesis	LOEC	Jones *et al* 2003
			S. hystrix	300	↓photosynthesis	LOEC	Jones & Kerswell, 2003
1	HEq > 900	Published scientific papers that demonstrate effects on the growth and death of aquatic plants and animals exposed to the pesticide. This concentration represents a level at which 99 per cent of tropical marine plants and animals are protected, using diuron as the reference chemical.	**Seagrass**				
			Z. capriconi	1000	↓photosynthesis	LOEC	Chesworth *et al* 2004
			Z. capriconi	5000	↓growth	LOEC	Chesworth *et al* 2004
			Z. capriconi	10000	↓photosynthesis	LOEC	Macinnis-Ng & Ralph, 2004
			C. serrulata	10000	↓photosynthesis	LOEC	Haynes *et al* 2000b

Category	**PSII-HEq Range (ng L^{-1})**	**Description**	**Supporting Literature with Respect to the Reference Chemical Diuron**				
			Species	**Effects Concentration (ng L^{-1})**	**Endpoint**	**Toxicity measure**	**Reference (see footnotes)**
			Coral - Isolated zooxanthellae				
			M. mirabilis	1000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			F. fragum	2000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			D. strigosa	2000	↓C^{14} incorporation	LOEC	Owen *et al* 2003
			Larvae				
			A. millepora	300	↓ Metamorphosis	LOEC	Negri *et al* 2005
			Coral recruits				
			P. damicornis	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			P. damicornis	10000	Loss of algae	LOEC	Negri *et al* 2005
			Coral - Adult colonies				
			A. formosa	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			P. cylindrica	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			M. digitata	1000	↓ photosynthesis	LOEC	Jones *et al* 2003
			S. hystrix	1000	↓ photosynthesis	LOEC	Jones *et al* 2003, Jones 2004
			A. millepora	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			P. damicornis	1000	↓ photosynthesis	LOEC	Negri *et al* 2005
			S. hystrix	2300	↓ photosynthesis	EC50	Jones *et al* 2003
			A. formosa	2700	↓ photosynthesis	EC50	Jones & Kerswell, 2003
			M. digitata	10000	Loss of algae	LOEC	Jones *et al* 2003
			P. damicornis	10000	Loss of algae	LOEC	Negri *et al* 2005
			S. hystrix	10000	Loss of algae	LOEC	Jones 2004
			P. cylindrica	10000	GPP* rate, GPP to respiration ration, effective quantum yield	LOEC	Råberg *et al* 2003
			Macro Algae				
			H. banksia	1650	↓ photosynthesis	EC50	Seery *et al* 2006
			Red Algae				
			P. onkodes	2900	↓ photosynthesis	LOEC	Harrington *et al* 2005

Category	PSII-HEq Range (ng L^{-1})	Supporting Literature with Respect to the Reference Chemical Diuron					
		Description	Species	Effects Concentration (ng L^{-1})	Endpoint	Toxicity measure	Reference (see footnotes)
			Diatoms				
			Navicula sp	2900	↓ photosynthesis	IC50 Acute, 6 m	Magnusson *et al* 2006
			P. tricornutum	3300	↓ photosynthesis	I50	Schreiber *et al* 2002
			Mangroves				
			A. marina	1100	Health	NOEC	Duke *et al* 2003, 2005
			A. marina	1500	Reduced health	LOEC	Duke *et al* 2003, Bell & Duke 2005
			A. marina	2000	Dieback/ absence	Mortality	Duke et al 2003, Bell & Duke 2005
			A. marina	1500	Reduced health	LOEC	Duke *et al* 2003, Bell & Duke 2005

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Appendix D Fixed monitoring sites – sampler returns and individual site results

Table D-1: Passive sampling return record for the 2018–19 monitoring year. ED sampler numbers are given with PDMS (non-polar) samplers in brackets after.

NRM Region	Site Name	No of samplers sent	No of samplers returned and analysed	Comments
Wet Tropics	Low Isles	5	4	Access to site affected by boat being in dry-dock for most of wet season.
	Normanby Island	7	3	A number of samplers lost due to bad weather. One 2018-19 kit used in 2018-19
	Dunk Island	9	9	No issues
	High Island	8	7	May/June samplers at High Island lost with moorings. Re-established in September.
	Lucinda Jetty (CSIRO)	9	9	No issues
Burdekin	Barratta Creek	8	8	Overdeployments from 2018-19 pushed back deployments in 2018-19, with April sampler being deployed from June 2018 (2018/19 sampling year). 1 PDMS sample provided for June-July (dry season) and 1 deployed over 2 sampling periods. I ED sampler also lost
Mackay Whitsunday	Repulse Bay	9	8	November samplers lost.
	Flat Top Island	9	7	Sept/Oct and November lost or stolen. 1 ED sampler lost in Feb.
	Sarina Inlet	8	6	PDMS cage lost in Nov, Dec. 1 ED lost in Sept/Oct and Nov. All lost in Feb and March.
	Sandy Creek	9	5	Samplers lost/stolen Sept/Oct, Nov, Dec, Jan (incl buoy). PDMS cage lost in March
Fitzroy	North Keppel Island	8	2	Numerous samplers not returned for analysis. Contact lost with deployment personnel for several months. Further samplers may yet be returned for analysis for addition to later version of this report.
TOTAL 2018-19	11 sites	89 (28)	68 (21)	One cage returned from Barratta Creek from 2018-19 included in return figures. 8 more PDMS cages returned compared to 2018-19.
TOTAL 2017-18	11 sites	89 (27)	67 (13)	

TOTAL 2016-17	**11 sites**	**84 (24)**	**63 (14)**	

Table D-2: Low Isles, Wet Tropics region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)												
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
LOW0518	04-May-18	08-Jul-18	ED	n.d	0.73	1.46	0.44	0.02	n.d	n.d	n.d	n.d	n.d	0.08	n.d	n.d	0.21	n.d	n.d	0.17	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.19	n.d	n.d
LOW0718	08-Jul-18	05-Sep-18	ED	n.d	0.07	0.53	0.07	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.00	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.03	n.d	n.d
LOW0918	05-Sep-18	21-Nov-18	ED	0.02	0.05	0.57	0.03	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.00	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
LOW1118	21-Nov-18	30-Nov-18	ED	n.d	n.d	0.56	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.00	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.04	n.d	n.d
LOW1218	Not deployed		ED																											
LOW0119			ED																											
LOW0219			ED																											
LOW0319			ED																											
LOW0419			ED																											
Summary																														
Samples (n)				4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Detects (n)				1	3	4	3	1	0	0	0	0	0	1	0	0	4	0	0	1	0	0	0	0	0	0	0	3	0	0
% Detects				25	75	100	75	25	0	0	0	0	0	25	0	0	100	0	0	25	0	0	0	0	0	0	0	75	0	0
Minimum concentration				n.d.	n.d.	0.53	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				0.02	0.7	1.5	0.4	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	n.d.	n.d.	0.2	n.d.	n.d.	0.17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.19	n.d.	n.d.

Minimum % Species Affected	0.00
Maximum % Species Affected	0.21
Avg Dry % Species Affected	0.05
Avg Wet % Species Affected	0.00

Table D-3: High Island, Wet Tropics region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)												
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
HIG0518	Samplers lost		ED																											
HIG0718			ED																											
HIG0918	19-Sep-18	17-Nov-18	ED	n.d	0.06	0.27	0.04	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.07	n.d	n.d	0.01	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
HIG1118	17-Nov-18	19-Dec-18	ED	n.d	0.60	3.93	1.11	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.49	n.d	n.d	0.22	0.11	n.d	n.d	0.09	n.d	n.d	n.d	0.40	n.d	n.d
HIG1218	19-Dec-18	24-Jan-19	ED	0.02	0.99	9.23	2.99	0.21	0.17	n.d	n.d	n.d	0.01	n.d	n.d	n.d	0.36	n.d	n.d	0.60	0.20	n.d	0.07	n.d	n.d	n.d	n.d	1.07	0.04	n.d
HIG0119	24-Jan-19	28-Feb-19	ED	0.02	2.77	8.45	2.54	0.55	0.28	n.d	n.d	n.d	0.04	n.d	n.d	n.d	0.44	0.18	n.d	0.98	0.14	n.d	0.05	n.d	n.d	n.d	n.d	1.60	n.d	n.d
HIG0219	28-Feb-19	26-Mar-19	ED	n.d	1.40	5.16	1.64	0.53	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.32	0.15	n.d	0.48	0.24	n.d	0.06	n.d	n.d	n.d	n.d	0.77	0.11	n.d
HIG0319	26-Mar-19	24-Apr-19	ED	n.d	1.64	4.61	1.95	0.26	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.21	n.d	n.d	0.16	0.26	n.d	0.08	n.d	n.d	n.d	n.d	0.86	n.d	0.13
HIG0419	24-Apr-19	29-May-19	ED	n.d	1.26	3.98	1.63	0.12	n.d	n.d	n.d	0.07	n.d	n.d	n.d	n.d	0.19	n.d	n.d	0.13	0.13	n.d	0.02	n.d	n.d	n.d	n.d	0.40	n.d	n.d
Summary																														
Samples (n)				7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Detects (n)				2	7	7	7	5	2	0	0	1	2	0	0	0	7	2	0	7	6	0	5	1	0	0	0	6	2	1
% Detects				29	100	100	100	71	29	0	0	14	29	0	0	0	100	29	0	100	86	0	71	14	0	0	0	86	29	14
Minimum concentration				n.d.	0.06	0.27	0.04	n.d.	0.17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				0.02	2.77	9.23	2.99	0.55	n.d.	n.d.	n.d.	0.07	0.04	n.d.	n.d.	n.d.		0.18	n.d.	0.98	0.26	n.d.	0.08	0.09	n.d.	n.d.	n.d.	1.60	0.11	0.13
								Minimum % Species Affected					0.07																	
								Maximum % Species Affected					0.49																	
								Avg Dry % Species Affected					0.07																	
								Avg Wet % Species Affected					0.33																	

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-4: Dunk Island, Wet Tropics region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	**Deployment Dates**		**Sampler Type**	**Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)**													**% Species Affected**	**Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)**												
	START	**END**		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
DUN0518	16-May-18	17-Jul-18	ED	n.d	0.82	1.45	0.92	0.04	n.d	n.d	n.d	n.d	n.d	0.08	n.d	n.d	**0.22**	0.26	n.d	0.19	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.30	n.d	n.d
DUN0718	17-Jul-18	21-Sep-18	ED	n.d	0.06	0.36	0.12	0.02	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	**0.13**	n.d	n.d	0.05	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
DUN0918	21-Sep-18	16-Nov-18	ED	n.d	0.06	0.32	0.07	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	**0.09**	n.d	n.d	0.02	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
DUN1118	16-Nov-18	12-Dec-18	ED	n.d	n.d	0.59	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	**0.00**	0.12	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
DUN1218	12-Dec-18	15-Jan-19	ED	0.04	0.33	7.82	3.03	0.19	0.21	n.d	n.d	n.d	n.d	n.d	n.d	n.d	**0.38**	n.d	n.d	0.70	0.24	n.d	0.07	n.d	n.d	n.d	n.d	1.50	n.d	n.d
DUN0119	15-Jan-19	19-Feb-19	ED	0.07	8.51	18.49	7.06	0.70	n.d	n.d	0.27	n.d	0.10	0.05	n.d	n.d	**0.44**	0.81	n.d	0.68	0.18	n.d	0.12	n.d	n.d	n.d	n.d	3.48	n.d	n.d
DUN0219	19-Feb-19	18-Mar-19	ED	n.d	1.70	3.42	1.28	0.47	n.d	n.d	n.d	n.d	n.d	0.05	n.d	n.d	**0.31**	0.42	n.d	0.44	0.19	n.d	0.03	n.d	n.d	n.d	n.d	0.24	0.08	n.d
DUN0319	18-Mar-19	16-Apr-19	ED	n.d	0.33	6.43	3.05	0.28	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	**0.20**	n.d	n.d	0.15	0.53	n.d	0.06	n.d	n.d	n.d	n.d	0.55	n.d	n.d
DUN0419	16-Apr-19	30-May-19	ED	n.d	1.52	4.05	1.45	0.12	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	**0.17**	n.d	n.d	0.10	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.13	n.d	n.d
Summary																														
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Detects (n)				2	8	9	8	7	1	0	1	0	1	3	0	0	9	4	0	8	4	0	4	0	0	0	0	6	1	0
% Detects				22	89	100	89	78	11	0	11	0	11	33	0	0	100	44	0	89	44	0	44	0	0	0	0	67	11	0
Minimum concentration				n.d.	n.d.	0.32	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				0.1	8.5	18.5	7.1	0.7	0.2	n.d.	0.3	n.d.	0.1	0.1	n.d.	n.d.		0.8	0.0	0.7	0.5	n.d.	0.1	n.d.	n.d.	n.d.	n.d.	3.5	0.1	n.d.
									Minimum % Species Affected								**0.00**													
									Maximum % Species Affected								**0.44**													
									Avg Dry % Species Affected								**0.15**													
									Avg Wet % Species Affected								**0.25**													

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-5: Normanby Island, Wet Tropics region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)												
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
NOR0518	Samplers lost		ED																											
NOR0718			ED																											
NOR0918	01-Sep-18	16-Oct-18	ED	n.d	0.08	0.18	n.d	n.d	0.10	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.00	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
NOR1118	Samplers lost		ED																											
NOR1218			ED																											
NOR0119	10-Jan-19	11-Feb-19	ED	0.05	6.50	18.78	4.73	0.58	0.43	n.d	n.d	0.03	0.08	0.10	n.d	n.d	0.55	0.95	n.d	1.34	0.23	n.d	0.10	n.d	n.d	n.d	n.d	3.34	n.d	0.04
NOR0219	11-Feb-19	21-Mar-19	ED	n.d	0.82	2.32	0.63	0.37	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.27	0.09	n.d	0.30	0.10	n.d	n.d	n.d	n.d	n.d	0.03	0.09	n.d	n.d
NOR0319	Samplers lost		ED																											
NOR0419			ED																											
Summary																														
Samples (n)				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Detects (n)				1	3	3	2	2	2	0	0	1	1	1	0	0	3	2	0	2	2	0	1	0	0	0	1	2	0	1
% Detects				33	100	100	67	67	67	0	0	33	33	33	0	0	100	67	0	67	67	0	33	0	0	0	33	67	0	33
Minimum concentration				n.d.	0.08	0.18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				0.05	6.50	18.78	4.73	0.58	0.43	n.d.	n.d.	0.03	0.08	0.10	n.d.	n.d.		0.95	n.d.	1.34	0.23	n.d.	0.10	n.d.	n.d.	n.d.	0.03	3.34	n.d.	0.04
												Minimum % Species Affected					0.00													
												Maximum % Species Affected					0.55													
												Avg Dry % Species Affected					0.00													
												Avg Wet % Species Affected					0.41													

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations
Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution
Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate
**Concentration is average of duplicate samplers

Table D-6: Lucinda, Wet Tropics region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)												
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
LUC0518	15-May-18	11-Jul-18	ED	0.02	1.23	2.68	0.87	0.06	n.d	0.04	n.d	n.d	n.d	0.08	n.d	n.d	0.21	n.d	n.d	0.17	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.12	n.d	n.d
LUC0718	11-Jul-18	27-Aug-18	ED	n.d	0.20	0.53	0.14	0.03	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.15	n.d	n.d	0.08	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
LUC0918	27-Aug-18	07-Nov-18	ED	n.d	0.09	0.36	0.10	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.09	n.d	n.d	0.02	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
LUC1118	07-Nov-18	13-Dec-18	ED	n.d	0.10	n.d	0.12	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.27	0.16	n.d	n.d	0.09	n.d	n.d	0.10	n.d	n.d	n.d	n.d	n.d	n.d
LUC1218	13-Dec-18	23-Jan-19	ED	0.06	1.41	10.20	4.15	0.34	0.27	n.d	n.d	n.d	0.04	n.d	n.d	n.d	0.35	n.d	n.d	0.54	0.39	n.d	0.05	n.d	n.d	n.d	n.d	1.21	n.d	n.d
LUC0119	23-Jan-19	20-Feb-19	ED	0.06	1.24	12.68	4.11	1.02	0.60	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.42	0.18	n.d	0.86	0.26	n.d	0.07	n.d	n.d	n.d	n.d	2.05	n.d	n.d
LUC0219	20-Feb-19	19-Mar-19	ED	n.d	0.21	5.89	1.71	0.77	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.32	n.d	n.d	0.48	0.23	n.d	n.d	n.d	n.d	n.d	n.d	0.23	n.d	n.d
LUC0319	19-Mar-19	30-Apr-19	ED	0.05	2.23	5.71	1.91	0.36	n.d	n.d	n.d	n.d	0.03	n.d	n.d	n.d	0.23	0.22	n.d	0.18	0.20	n.d	0.02	n.d	n.d	n.d	0.10	0.17	0.07	n.d
LUC0419	30-Apr-19	12-Jun-19	ED	0.05	4.58	7.08	2.55	0.14	n.d	n.d	n.d	n.d	0.06	n.d	n.d	n.d	0.22	0.45	n.d	0.18	0.10	n.d	n.d	n.d	n.d	n.d	n.d	0.05	n.d	n.d
Summary																														
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Detects (n)				5	9	8	9	7	2	1	0	0	3	1	0	0	9	4	0	8	6	0	3	1	0	0	1	6	1	0
% Detects				56	100	89	100	78	22	11	0	0	33	11	0	0	100	44	0	89	67	0	33	11	0	0	11	67	11	0
Minimum concentration				n.d.	0.09	0.36	0.10	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				0.06	4.58	12.68	4.15	1.02	0.60	n.d.	0.00	n.d.	0.06	0.08	0.00	n.d.		0.45	0.00	0.86	0.39	0.00	0.07	0.10	0.00	0.00	n.d.	2.05	0.07	n.d.

Minimum % Species Affected	0.09
Maximum % Species Affected	0.42
Avg Dry % Species Affected	0.15
Avg Wet % Species Affected	0.30

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-7: Barratta Creek, Burdekin Region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)													Concentration pesticides (ng/L) in PDMS samplers				
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole	Propazine	Propiconazole	Pendimethalin*	Chlorpyrifos*	Trifluralin
BAR0518	27-Apr-18	28-Jun-18	ED	0.29	3.43	1.35	0.34	0.10	n.d	n.d	n.d	n.d	0.04	0.06	n.d	n.d	0.23	1.30	n.d	0.20	0.05	n.d	n.d	n.d	n.d	n.d	n.d	0.02	0.09	n.d					
BAR0718	28-Jun-18	07-Aug-18	ED	0.94	9.62	1.51	0.31	0.16	n.d	n.d	n.d	0.02	0.18	n.d	n.d	n.d	0.56	n.d	n.d	1.69	0.09	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d					
			PDMS																												1.16	0.06	n.d.	n.d.	n.d.
BAR0918	07-Aug-18	08-Nov-18	ED	0.43	2.97	0.84	0.11	0.07	n.d	n.d	n.d	n.d	n.d	0.01	n.d	n.d	0.37	n.d	n.d	0.65	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.04	n.d	n.d					
	PDMS Sampler lost																																		
BAR1118	08-Nov-18	13-Dec-18	ED	0.12	1.45	0.50	0.14	0.01	n.d	n.d	n.d	n.d	0.02	n.d	n.d	n.d	0.29	0.68	n.d	0.06	0.03	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d					
			PDMS																												0.15	n.d.	0.01	0.01	n.d.
BAR1218	13-Dec-18	05-Jan-19	ED	0.54	17.24	47.13	1.74	1.14	8.81	n.d	16.37	n.d	0.32	n.d	0.35	n.d	1.59	n.d	n.d	1.08	1.10	n.d	0.04	0.34	n.d	n.d	0.43	0.31	0.34	n.d					
			PDMS																												2.40	0.39	0.01	0.04	n.d.
BAR0119	05-Jan-19	11-Feb-19	ED	0.35	53.05	42.46	1.16	1.31	7.55	n.d	11.22	0.02	0.74	0.20	0.90	n.d	1.87	18.85	n.d	5.16	2.90	n.d	0.59	0.78	n.d	n.d	0.36	1.38	0.56	0.10					
			PDMS																																
BAR0219	11-Feb-19	07-Mar-19	ED	0.26	3.02	10.22	0.70	1.68	1.77	n.d	0.57	n.d	0.07	n.d	n.d	n.d	0.93	0.54	n.d	1.01	0.33	n.d	0.08	0.16	n.d	n.d	n.d	0.40	0.15	0.06					
			PDMS																												0.20	0.17	0.01	0.02	n.d.
BAR0319	07-Mar-19	24-Apr-19	ED	0.24	3.63	8.20	1.68	0.99	0.77	n.d	0.43	n.d	0.04	n.d	n.d	n.d	0.98	0.91	n.d	0.40	0.33	n.d	0.19	0.09	n.d	n.d	n.d	0.11	0.32	0.14					
			PDMS																												0.27	0.11	0.05	0.09	n.d.
BAR0419	24-Apr-19	23-May-19	ED	0.42	6.89	4.87	1.56	0.53	0.35	n.d	n.d	n.d	0.09	n.d	n.d	n.d	1.11	n.d	n.d	0.85	0.62	n.d	0.08	0.09	n.d	n.d	n.d	0.06	0.24	n.d					
			PDMS																												0.49	0.17	0.23	0.10	n.d.
Summary																																			
Samples (n)				9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	6	6	6	6	6
Detects (n)				9	9	9	9	9	5	0	4	2	8	3	2	0	9	5	0	9	8	0	5	5	0	0	2	7	6	3	6	5	5	5	0
% Detects				100	100	100	100	100	56	0	44	22	89	33	22	0	100	56	0	100	89	0	56	56	0	0	22	78	67	33	100	83	83	83	0
Minimum concentration				0.12	1.45	0.50	0.11	0.01	n.d.	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	n.d	0.23	n.d.	n.d	0.06	n.d.	n.d	n.d.	n.d	n.d.	n.d	n.d.	n.d	n.d.	n.d	0.15	n.d.	n.d	n.d.	n.d
Maximum concentration				0.9	53.1	47.1	1.7	1.7	8.8	n.d	16.4	0.02	0.7	0.2	0.9	n.d	1.9	18.9	n.d	5.2	2.9	n.d	0.6	0.8	n.d	n.d	0.4	1.4	0.6	0.1	2.4	0.4	0.2	0.1	n.d

Minimum % Species Affected	0.23
Maximum % Species Affected	1.87
Avg Dry % Species Affected	0.39
Avg Wet % Species Affected	1.13

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-8: Repulse Bay, Mackay-Whitsunday region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)													Concentration pesticides (ng/L) in PDMS samplers				
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole	Propazine	Propiconazole	Pendimethalin*	Chlorpyrifos*	Trifluralin
REB0518	24-May-18	24-Jul-18	ED	0.08	2.21	10.58	5.05	0.30	n.d	0.04	n.d	n.d	n.d	0.17	n.d	n.d	0.36	n.d	n.d	0.56	n.d	n.d	n.d	n.d	n.d	n.d	n.d	2.85	n.d	n.d					
REB0718	24-Jul-18	13-Sep-18	ED	0.02	0.30	0.98	0.32	0.13	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.15	n.d	n.d	0.07	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.06	n.d	n.d					
REB0918	13-Sep-18	08-Nov-18	ED	n.d	0.08	0.83	0.22	0.05	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.12	n.d	n.d	0.04	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d					
REB1118	Samplers lost		ED																																
			PDMS																																
REB1218	18-Dec-18	17-Jan-19	ED	0.12	68.08	124.98	58.03	0.64	1.88	n.d	1.49	n.d	0.53	0.21	0.48	n.d	4.3	3.68	n.d	6.41	5.76	n.d	0.07	1.62	n.d	n.d	0.80	15.63	0.19	n.d					
			PDMS																												4.42	0.43	n.d.	0.02	n.d.
REB0119	17-Jan-19	14-Feb-19	ED	0.22	175.96	230.96	55.79	1.12	1.66	n.d	1.84	n.d	1.54	0.46	1.34	n.d	7.9	11.32	n.d	6.84	3.68	n.d	0.09	1.12	n.d	n.d	n.d	38.04	0.50	n.d					
			PDMS																												1.36	0.57	0.01	0.01	n.d.
REB0219	14-Feb-19	12-Mar-19	ED	0.16	9.64	35.02	10.79	0.12	0.21	n.d	n.d	n.d	0.10	n.d	n.d	n.d	1.1	1.00	n.d	0.62	0.42	n.d	n.d	0.20	n.d	n.d	n.d	1.59	n.d	n.d					
			PDMS																												0.54	0.23	n.d.	0.01	n.d.
REB0319	12-Mar-19	10-Apr-19	ED	0.12	1.96	12.97	4.13	0.08	0.52	n.d	n.d	n.d	0.03	n.d	n.d	n.d	0.43	0.17	n.d	0.22	0.35	n.d	n.d	n.d	n.d	n.d	n.d	0.28	0.10	n.d					
			PDMS																												0.27	0.24	n.d.	0.02	n.d.
REB0419	10-Apr-19	08-May-19	ED	0.13	3.02	16.35	4.73	0.31	12.04	n.d	n.d	n.d	0.04	n.d	n.d	n.d	1.5	n.d	n.d	5.64	1.65	n.d	0.09	0.42	n.d	n.d	n.d	3.07	n.d	n.d					
			PDMS																												0.82	0.37	n.d.	0.02	n.d.
Summary																																			
Samples (n)				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	5	5	5	5	5
Detects (n)				7	8	8	8	8	5	1	2	0	5	3	2	0	8	4	0	8	5	0	3	4	0	0	1	7	3	0	5	5	1	5	0
% Detects				88	100	100	100	100	63	13	25	0	63	38	25	0	100	50	0	100	63	0	38	50	0	0	13	88	38	0	100	100	20	100	0
Minimum concentration				0.02	0.1	0.8	0.2	0.05	n.d.	n.d.	n.d.	n.d.	n.d.	n.d	n.d.	n.d.		n.d.	n.d.	0.04	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.06	n.d.	n.d.	0.3	0.23	n.d.	0.01	n.d.
Maximum concentration				0.22	175.96	230.96	58.03	1.12	12.04	0.04	1.84	n.d.	1.54	0.46	1.34	n.d.		11.32	n.d.	6.84	5.76	n.d.	0.09	1.62	n.d.	n.d.	0.80	38.04	0.50	n.d.	4.42	0.57	0.01	0.02	n.d.

Minimum % Species Affected	0.12
Maximum % Species Affected	7.9
Avg Dry % Species Affected	0.21
Avg Wet % Species Affected	3.0

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-9: Flat Top Island, Mackay-Whitsunday region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)													Concentration pesticides (ng/L) in PDMS samplers				
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole	Propazine	Propiconazole	Pendimethalin*	Chlorpyrifos*	Trifluralin
RFT0518	24-May-18	24-Jul-18	ED	n.d	1.00	3.94	1.23	0.15	n.d	0.05	n.d	n.d	n.d	0.12	n.d	n.d	0.30	n.d	n.d	0.41	n.d	n.d	n.d	n.d	n.d	n.d	n.d	1.14	n.d	n.d					
RFT0718	24-Jul-18	13-Sep-18	ED	n.d	0.62	2.09	0.42	0.14	n.d	n.d	n.d	n.d	n.d	0.09	n.d	n.d	0.44	0.16	n.d	0.16	0.06	n.d	n.d	0.07	n.d	n.d	n.d	n.d	n.d	n.d					
RFT0918	Samplers lost		ED																																
RFT1118			ED/PDMS																																
RFT1218	18-Dec-18	17-Jan-19	ED	1.72	68.86	249.75	53.78	0.17	0.22	n.d	5.21	0.05	0.77	n.d	0.42	n.d	7.8	2.25	n.d	3.37	7.72	n.d	0.05	1.96	n.d	n.d	0.84	10.46	0.34	n.d					
			PDMS																												5.78	0.71	0.02	0.03	n.d.
RFT0119	17-Jan-19	14-Feb-19	ED	0.65	20.02	99.91	17.06	0.23	n.d	n.d	1.75	n.d	0.27	n.d	n.d	n.d	2.9	1.36	n.d	2.01	2.98	n.d	0.09	0.48	n.d	n.d	n.d	11.03	0.29	n.d					
			PDMS																												1.19	0.52	0.02	0.03	n.d.
RFT0219	14-Feb-19	12-Mar-19	ED	0.07	2.41	9.89	3.02	0.07	n.d	n.d	n.d	n.d	0.03	n.d	n.d	n.d	0.69	0.72	n.d	0.20	0.64	n.d	n.d	0.14	n.d	n.d	n.d	0.48	n.d	n.d					
			PDMS																												0.13	0.10	0.00	0.01	n.d.
RFT0319	12-Mar-19	10-Apr-19	ED	0.04	1.74	6.68	1.71	0.15	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.36	0.50	n.d	0.10	0.28	n.d	n.d	n.d	n.d	n.d	n.d	0.15	0.13	n.d					
			PDMS																												0.08	0.10	n.d.	0.02	n.d.
RFT0419	10-Apr-19	08-May-19	ED	0.06	0.67	11.37	2.30	0.17	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.88	n.d	n.d	0.19	1.04	n.d	n.d	0.42	n.d	n.d	n.d	1.17	0.24	n.d					
			PDMS																												0.10	0.47	n.d.	0.03	n.d.
Summary																																			
Samples (n)				7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	5	5	5	5
Detects (n)				5	7	7	7	7	1	1	2	1	3	2	1	0	7	5	0	7	6	0	2	5	0	0	1	6	4	0	5	5	3	5	0
% Detects				71	100	100	100	100	14	14	29	14	43	29	14	0	100	71	0	100	86	0	29	71	0	0	14	86	57	0	100	100	60	100	0
Minimum concentration				n.d	0.6	2.1	0.42	0.07	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	0.10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.08	0.10	n.d.	0.01	n.d.
Maximum concentration				1.7	68.9	249.7	53.8	0.2	0.22	0.05	5.2	0.1	0.8	0.1	0.4	n.d.		2.3	n.d.	3.4	7.7	n.d.	0.09	1.96	n.d.	n.d.	0.8	11.0	0.34	n.d.	5.8	0.71	0.02	0.03	n.d.

Minimum % Species Affected	0.30
Maximum % Species Affected	7.8
Avg Dry % Species Affected	0.4
Avg Wet % Species Affected	2.5

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcluded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-10: Sarina Inlet, Mackay-Whitsunday region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)													Concentration pesticides (ng/L) in PDMS samplers				
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole	Propazine	Propiconazole	Pendimethalin*	Chlorpyrifos*	Trifluralin
SAR0518	05-May-18	06-Jul-18	ED	0.03	2.42	3.46	2.33	0.50	n.d	0.03	n.d	n.d	n.d	0.34	n.d	n.d	0.33	0.34	n.d	0.50	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.14	n.d	n.d					
SAR0718	06-Jul-18	03-Sep-18	ED	n.d	0.41	0.81	0.32	0.11	n.d	n.d	n.d	n.d	n.d	0.08	n.d	n.d	0.14	0.12	n.d	0.06	0.02	n.d	n.d	n.d	n.d	n.d	n.d	0.04	n.d	n.d					
SAR0918	03-Sep-18	30-Nov-18	ED	0.03	0.41	1.52	0.58	0.07	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.14	n.d	n.d	0.06	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d					
SAR1118	30-Nov-18	07-Jan-19	ED	0.26	26.97	89.26	21.22	0.28	0.95	n.d	0.25	n.d	0.25	0.11	n.d	n.d	2.1	2.55	n.d	0.50	1.82	n.d	n.d	0.16	n.d	n.d	n.d	2.85	0.21	n.d					
	PDMS sampler lost		PDMS																																
SAR1218	07-Jan-19	17-Feb-19	ED	0.80	58.99	113.85	44.62	0.89	0.68	n.d	0.54	n.d	0.56	0.16	n.d	n.d	2.8	5.89	n.d	0.48	0.83	n.d	0.03	0.07	n.d	n.d	n.d	5.03	0.37	n.d					
	PDMS sampler lost		PDMS																																
SAR0119	Samplers lost		ED																																
SAR0219			ED																																
SAR0319			ED																																
SAR0419	09-Apr-19	02-May-19	ED	0.03	1.77	3.54	1.21	0.33	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.30	0.52	n.d	0.04	0.38	n.d	n.d	n.d	n.d	n.d	n.d	0.33	0.24	n.d					
			PDMS																												n.d.	0.04	n.d.	0.02	n.d.
Summary																																			
Samples (n)				6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	1	1	1	1	1
Detects (n)				5	6	6	6	6	2	1	2	0	2	4	0	0	6	5	0	6	4	0	1	2	0	0	0	5	3	0	0	1	0	1	0
% Detects				83	100	100	100	100	33	17	33	0	33	67	0	0	100	83	0	100	67	0	17	33	0	0	0	83	50	0	0	100	0	100	0
Minimum concentration				n.d.	0.41	0.81	0.32	0.07	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	0.06	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.04	n.d.	0.02	n.d.
Maximum concentration				0.80	59	114	45	0.89	0.95	0.03	0.54	n.d.	0.56	0.34	n.d.	n.d.		5.89	n.d.	0.50	1.82	n.d.	0.03	0.16	n.d.	n.d.	n.d.	5.03	0.37	n.d.	n.d.	0.04	n.d.	0.02	n.d.

Minimum % Species Affected	0.14
Maximum % Species Affected	2.8
Avg Dry % Species Affected	0.2
Avg Wet % Species Affected	1.71

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-11: Sandy Creek, Mackay-Whitsunday region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)													Concentration pesticides (ng/L) in PDMS samplers				
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole	Propazine	Propiconazole	Pendimethalin*	Chlorpyrifos*	Trifluralin
SCK0518	24-May-18	24-Jul-18	ED	n.d	0.83	2.31	0.78	0.12	n.d	0.05	n.d	n.d	n.d	0.31	n.d	n.d	0.34	n.d	n.d	0.57	n.d	n.d	n.d	n.d	n.d	0.12	n.d	2.15	n.d	n.d					
SCK0718	24-Jul-18	13-Sep-18	ED	0.03	0.55	2.04	0.59	0.13	n.d	n.d	n.d	n.d	n.d	0.10	n.d	n.d	0.20	0.15	n.d	0.16	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.11	n.d	n.d					
SCK0918	Samplers lost		ED																																
SCK1118			ED																																
			PDMS																																
SCK1218			ED																																
			PDMS																																
SCK0119			ED																																
			PDMS																																
SCK0219	14-Feb-19	12-Mar-19	ED	0.14	4.95	16.58	5.03	0.11	n.d	n.d	n.d	n.d	0.05	n.d	n.d	n.d	0.76	1.01	n.d	0.38	0.87	n.d	n.d	0.10	n.d	n.d	n.d	0.61	0.11	n.d					
			PDMS																												0.17	0.20	n.d.	0.01	n.d.
SCK0319	12-Mar-19	10-Apr-19	ED	0.08	1.50	9.16	2.52	0.23	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.23	0.36	n.d	0.19	0.59	n.d	0.02	n.d	n.d	n.d	n.d	0.27	0.13	n.d					
			PDMS																												n.d.	n.d.	n.d.	n.d.	n.d.
SCK0419	10-Apr-19	08-May-19	ED	0.07	2.26	7.80	1.86	0.23	n.d	n.d	n.d	n.d	0.01	n.d	n.d	n.d	0.72	0.66	n.d	0.14	0.65	n.d	n.d	0.23	n.d	n.d	n.d	0.60	0.18	n.d					
			PDMS																												n.d.	0.34	n.d.	0.02	n.d.
Summary																																			
Samples (n)				5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	3
Detects (n)				4	5	5	5	5	0	1	0	0	2	2	0	0	5	4	0	5	3	0	1	2	0	1	0	5	3	0	1	2	0	2	0
% Detects				80	100	100	100	100	0	20	0	0	40	40	0	0	100	80	0	100	60	0	20	40	0	20	0	100	60	0	33	67	0	67	0
Minimum concentration				n.d.	0.55	2.04	0.59	0.11	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.20	n.d.	n.d.	0.14	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.11	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				0.14	4.95	17	5.03	0.23	n.d.	0.05	n.d.	n.d.	0.05	0.31	n.d.	n.d.	0.76	1.01	n.d.	0.57	0.87	n.d.	0.02	0.23	n.d.	0.12	n.d.	2.15	0.18	n.d.	0.17	0.34	n.d.	0.02	n.d.

Minimum % Species Affected	0.20
Maximum % Species Affected	0.8
Avg Dry % Species Affected	0.27
Avg Wet % Species Affected	0.57

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

**Concentration is average of duplicate samplers

Table D-12: North Keppel Island, Fitzroy Region – Time integrated estimated concentrations in water (ng L^{-1})

Sampling Code	Deployment Dates		Sampler Type	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration of other herbicides/ pesticides (ng/L) (* included in ms-PAF method)												
	START	END		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor *	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl *	Tebuconazole
NKI0518	02-May-18	09-Aug-18	ED	n.d	0.26	1.37	0.06	0.03	n.d	0.02	n.d	n.d	n.d	0.12	n.d	n.d	0.25	n.d	n.d	0.26	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.02	n.d	n.d
NKI0718	09-Aug-18	14-Nov-18	ED	n.d	0.08	0.77	0.07	0.06	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.12	n.d	n.d	0.04	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
NKI0918	Samplers not returned		ED																											
NKI1118			ED																											
NKI1218			ED																											
NKI0119			ED																											
NKI0219			ED																											
NKI0319			ED																											
NKI0419			ED																											
Summary																														
Samples (n)				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Detects (n)				0	2	2	2	2	0	1	0	0	0	1	0	0	2	0	0	2	0	0	0	0	0	0	0	1	0	0
% Detects				0	100	100	100	100	0	50	0	0	0	50	0	0	100	0	0	100	0	0	0	0	0	0	0	50	0	0
Minimum concentration				n.d.	0.08	0.77	0.06	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.		n.d.	n.d.	0.04	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Maximum concentration				n.d.	0.26	1.4	0.1	0.06	n.d.	0.02	n.d.	n.d.	n.d.	0.12	n.d.	n.d.		n.d.	n.d.	0.26	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.
													Minimum % Species Affected				0.12													
													Maximum % Species Affected				0.25													
													Avg Dry % Species Affected				0.18													
													Avg Wet % Species Affected				#DIV/0!													

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

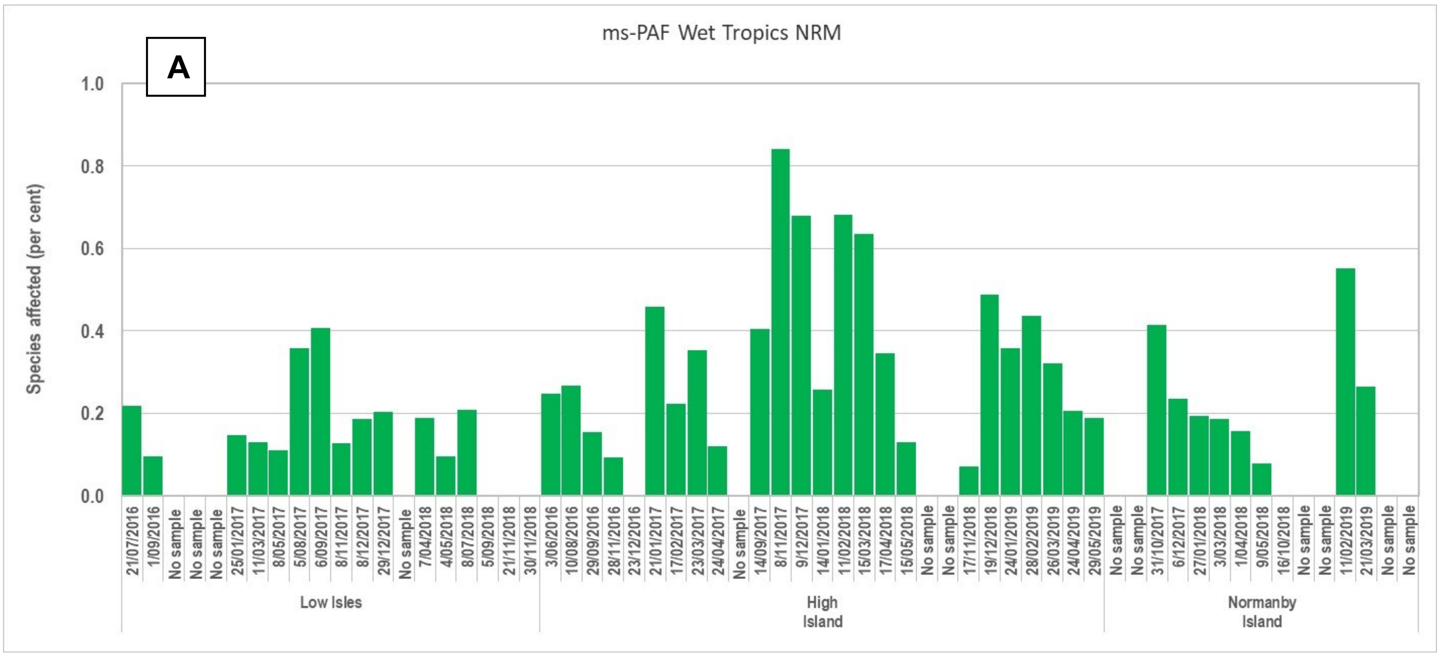
Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

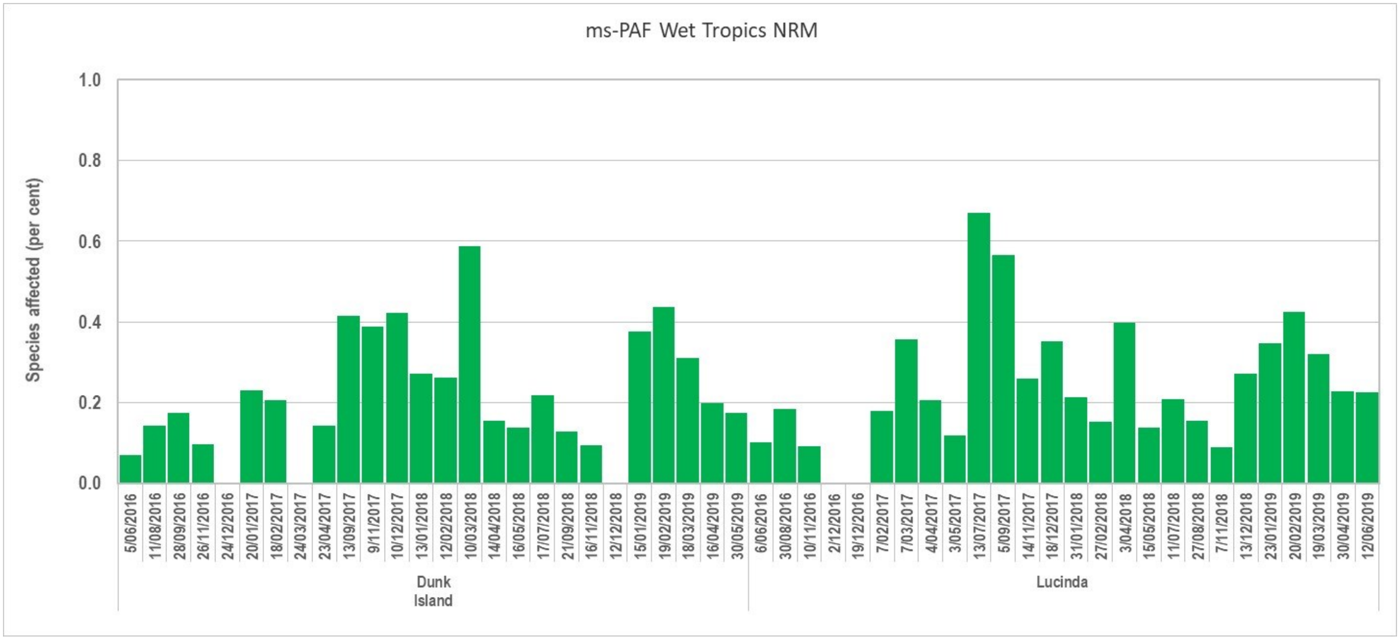
Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with cautior

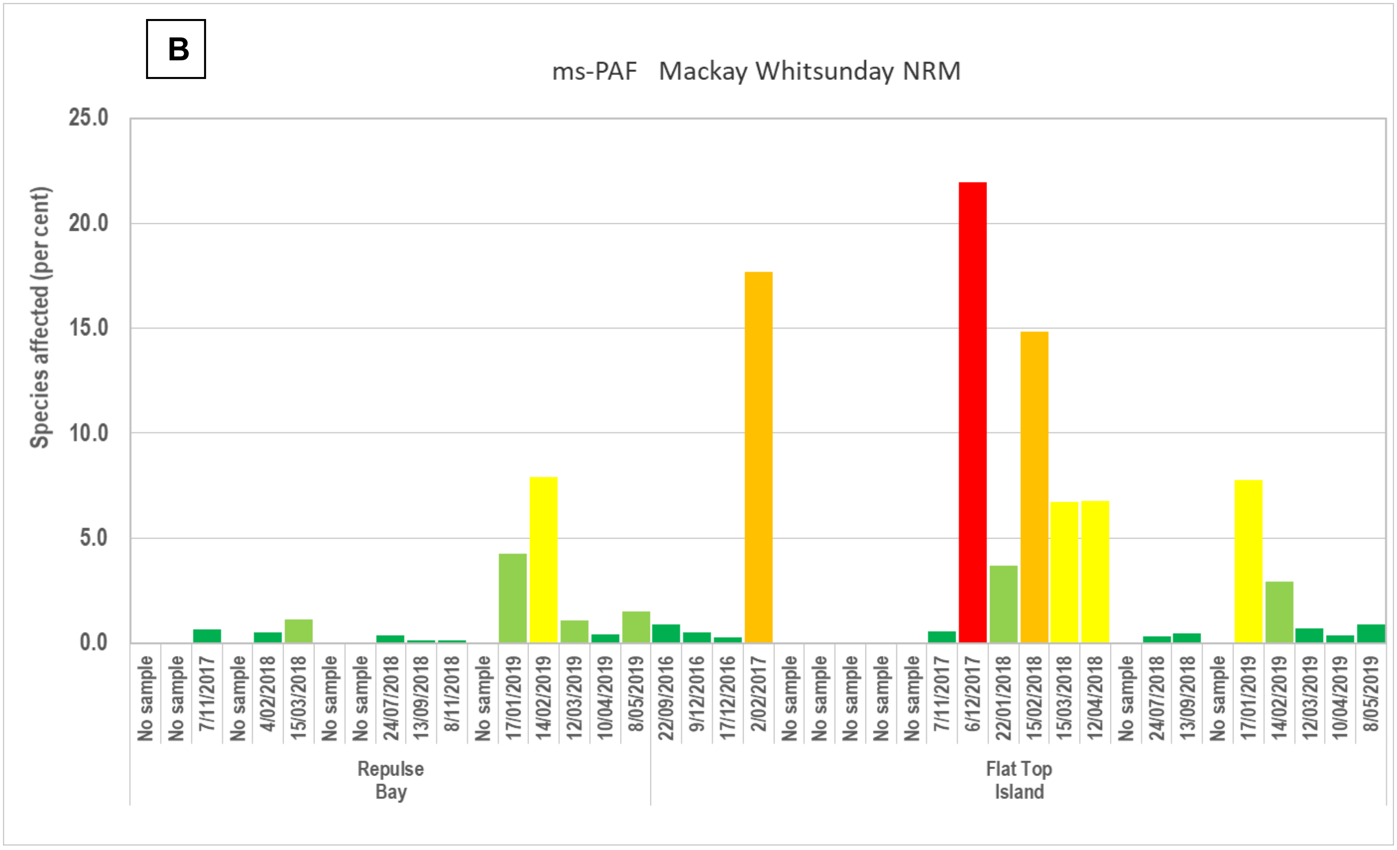
Shaded pesticides and herbicides indicate that no calibration data is available and the sampling rate of atrazine was assumed. Water estimatations are approximate

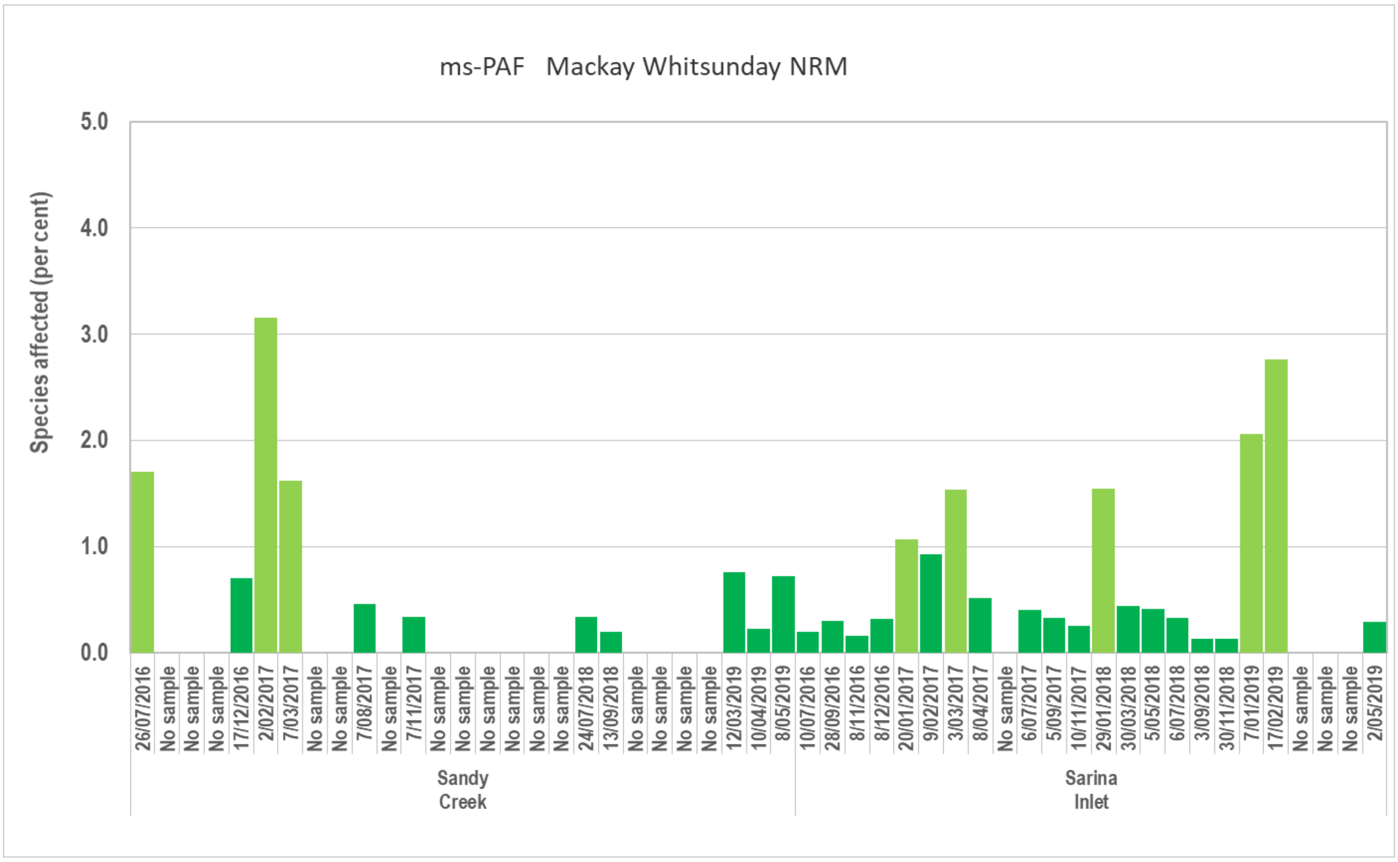
**Concentration is average of duplicate samplers

Appendix E Temporal changes of risk at fixed monitoring sites






B
ms-PAF Mackay Whitsunday NRM
Species affected (per cent)
25.0
20.0
15.0
10.0
5.0
0.0
No sample
No sample
7/11/2017
No sample
4/02/2018
15/03/2018
No sample
No sample
24/07/2018
13/09/2018
8/11/2018
No sample
17/01/2019
14/02/2019
12/03/2019
10/04/2019
8/05/2019
22/09/2016
9/12/2016
17/12/2016
2/02/2017
No sample
No sample
No sample
No sample
No sample
7/11/2017
6/12/2017
22/01/2018
15/02/2018
15/03/2018
12/04/2018
No sample
24/07/2018
13/09/2018
No sample
17/01/2019
14/02/2019
12/03/2019
10/04/2019
8/05/2019
Repulse Bay
Flat Top Island


ms-PAF Mackay Whitsunday NRM
Species affected (per cent)
5.0
4.0
3.0
2.0
1.0
0.0
26/07/2016
No sample
No sample
No sample
17/12/2016
2/02/2017
7/03/2017
No sample
No sample
7/08/2017
No sample
7/11/2017
No sample
No sample
No sample
No sample
No sample
No sample
24/07/2018
13/09/2018
No sample
No sample
No sample
No sample
12/03/2019
10/04/2019
8/05/2019
10/07/2016
28/09/2016
8/11/2016
8/12/2016
20/01/2017
9/02/2017
3/03/2017
8/04/2017
No sample
6/07/2017
5/09/2017
10/11/2017
29/01/2018
30/03/2018
5/05/2018
6/07/2018
3/09/2018
30/11/2018
7/01/2019
17/02/2019
No sample
No sample
No sample
2/05/2019
Sandy Creek
Sarina Inlet

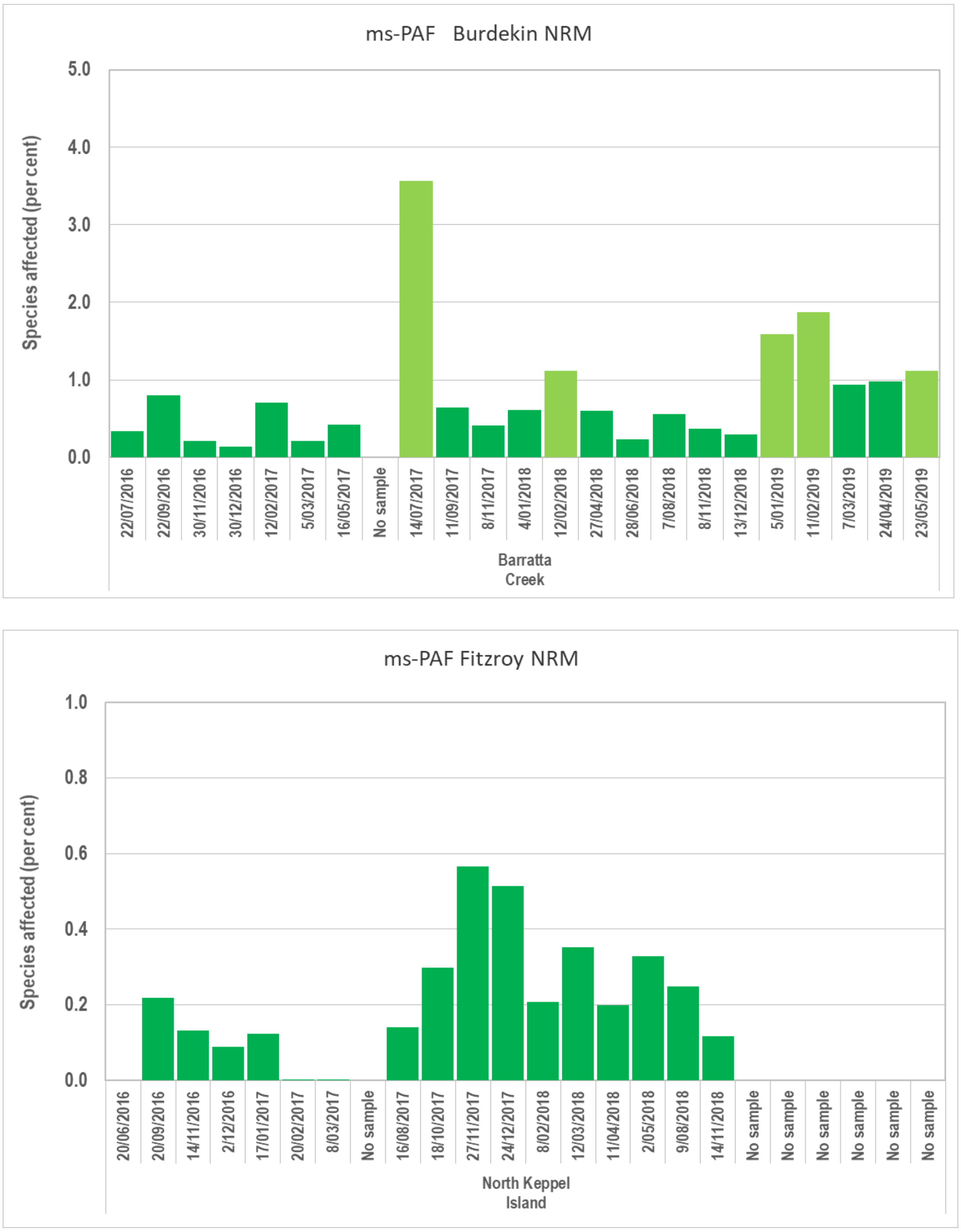


Figure E- 1: Temporal changes of Maximum % of species affected calculated using the ms-PAF method for (A) all Wet Tropic sites and (B) for all other sites. Note the difference in y-axis scale.

Appendix F Terrestrial run-off assessment results

Table F-1: Concentrations in grab water samples (ng L^{-1}) measured at various locations offshore and in river mouths (along transects) during the 2018–19 monitoring year

Sample Description	Date collected	Concentration of PSII herbicides (ng/L) (* included in ms-PAF method)													% Species Affected	Concentration other herbicides/ pesticides (ng/L) (* included in ms-PAF method)												
		Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn		DE Atrazine	DI Atrazine	Metolachlor*	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl	Tebuconazole
BURDEKIN FOCUS REGION																												
Barratta Creek mouth	28-Jun-18	n.d.	1.56	0.18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.06	0.0	0.33	0.11	0.23	0.16	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Barratta Creek mouth	07-Aug-18	0.70	8.99	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	4.01	1.18	1.18	n.d.	n.d.	n.d.	n.d.	n.d.	1.11	n.d.	n.d.	6.82	n.d.
Barratta Creek mouth	13-Dec-18	0.34	9.12	0.87	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.2	3.25	1.27	0.50	n.d.	n.d.	n.d.	1.19	n.d.	n.d.	n.d.	n.d.	7.75	n.d.
Barratta Creek mouth	05-Jan-19	n.d.	0.72	1.65	1.09	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3.66	n.d.
Barratta Creek mouth	11-Feb-19	0.68	22.24	13.02	0.80	4.93	9.83	n.d.	3.51	n.d.	n.d.	n.d.	n.d.	n.d.	2.6	16.28	6.41	4.75	8.48	n.d.	0.81	4.99	n.d.	7.21	8.28	1.62	4.16	n.d.
Barratta Creek mouth	20-Feb-19	n.d.	3.97	3.48	0.63	2.63	0.86	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3.1	2.05	n.d.	0.88	1.22	n.d.	0.15	0.94	n.d.	1.25	0.91	n.d.	12.33	n.d.
Barratta Creek mouth	07-Mar-19	n.d.	4.59	2.90	1.61	0.59	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.7	1.42	n.d.	n.d.	2.25	n.d.	n.d.	2.76	n.d.	n.d.	n.d.	n.d.	5.90	n.d.
Barratta Creek mouth	24-Apr-19	0.86	10.21	5.03	2.31	2.24	1.52	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.5	5.29	1.70	0.61	1.74	n.d.	0.78	2.41	n.d.	2.49	2.46	0.76	7.96	n.d.
Barratta Creek mouth	23-May-19	n.d.	4.91	2.56	1.36	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.0	0.82	n.d.	0.95	0.67	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	4.18	n.d.
Burdekin River	15-Feb-19	n.d.	0.57	0.99	n.d.	0.72	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.48	n.d.	n.d.	n.d.	0.58	3.88	n.d.
Burdekin River	15-Feb-19	n.d.	0.90	1.26	n.d.	0.96	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.69	n.d.	n.d.	n.d.	n.d.	6.91	n.d.
Burdekin River	15-Feb-19	n.d.	0.48	n.d.	n.d.	1.61	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.7	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.93	n.d.	n.d.	n.d.	n.d.	7.04	n.d.
Burdekin River	20-Feb-19	n.d.	2.47	2.34	1.07	1.67	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	0.48	n.d.	n.d.	0.75	n.d.	n.d.	2.23	n.d.	n.d.	n.d.	0.57	5.77	n.d.
Burdekin River	20-Feb-19	n.d.	2.52	4.69	0.99	4.31	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.1	0.64	n.d.	0.73	1.03	n.d.	n.d.	3.30	n.d.	n.d.	n.d.	0.56	5.90	n.d.
RUSSELL-MULGRAVE RIVERS TRANSECT																												
Russell/Mulgrave mouth	15-Jul-18	n.d.	0.15	0.71	0.64	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.16	n.d.	0.0	0.39	n.d.	0.04	0.13	n.d.	0.22	n.d.	n.d.	n.d.	n.d.	2.12	n.d.	n.d.
Russell/Mulgrave mouth	24-Aug-18	n.d.	4.36	2.97	3.92	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.1	2.33	n.d.	3.35	0.57	n.d.	0.38	n.d.	n.d.	n.d.	n.d.	4.87	5.34	n.d.
Russell/Mulgrave mouth	19-Dec-18	n.d.	69.75	35.81	35.49	n.d.	n.d.	n.d.	n.d.	n.d.	0.97	1.37	n.d.	n.d.	2.2	11.20	3.92	6.83	4.78	n.d.	1.07	n.d.	n.d.	1.24	8.20	35.78	6.46	n.d.
Russell/Mulgrave mouth	21-Jan-19	n.d.	10.37	10.53	10.60	1.89	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.3	5.92	n.d.	2.15	17.41	n.d.	0.46	0.54	n.d.	1.37	4.02	19.86	4.78	n.d.
Russell/Mulgrave mouth	30-Jan-19	n.d.	10.39	18.77	11.29	0.93	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	5.72	n.d.	12.45	7.43	n.d.	0.76	1.65	n.d.	4.44	9.27	30.58	2.00	n.d.
Russell/Mulgrave mouth	15-Mar-19	n.d.	4.89	5.79	8.73	1.87	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.3	6.09	n.d.	1.03	24.07	n.d.	0.65	1.28	n.d.	1.94	1.13	10.09	8.96	n.d.
High Island	15-Jul-18	n.d.	2.41	2.35	1.73	0.64	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.0	0.99	n.d.	n.d.	2.88	n.d.	0.16	0.86	n.d.	n.d.	n.d.	n.d.	10.67	n.d.
High Island	24-Aug-18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.1	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
High Island	19-Dec-18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	6.76	n.d.
High Island	24-Jan-19	n.d.	8.28	5.90	2.40	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.3	0.66	n.d.	0.72	1.60	n.d.	n.d.	0.54	n.d.	n.d.	n.d.	n.d.	8.35	n.d.
High Island	30-Jan-19	n.d.	6.71	6.59	3.89	0.32	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	1.20	n.d.	n.d.	3.73	n.d.	0.27	0.82	n.d.	1.32	n.d.	1.30	5.37	n.d.
High Island	15-Mar-19	n.d.	1.41	1.23	0.70	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.3	n.d.	n.d.	n.d.	0.85	n.d.	n.d.	0.51	n.d.	n.d.	n.d.	n.d.	6.89	n.d.

Table F-1 (cont.): Concentrations in grab water samples (ng L^{-1}) measured at various locations offshore and in river mouths (along transects) during the 2018–19 monitoring year

		Concentration PSII herbicides (ng/L)														Concentration other herbicides/ pesticides (ng/L)												
Sample Description	**Date collected**	Ametryn*	Atrazine*	Diuron*	Hexazinone*	Tebuthiuron*	Bromacil*	Fluometuron	Metribuzin*	Prometryn*	Propazine	Simazine*	Terbuthylazine*	Terbutryn	**% Species Affected**	DE Atrazine	DI Atrazine	Metolachlor*	24 D *	2,4 DB	Haloxyfop *	MCPA *	Fluazifop	Fluroxypyr *	Imazapic *	Imidacloprid *	Metsulfuron-Methyl	Tebuconazole
TULLY RIVER TRANSECT																												
Tully River Mouth	17-Jul-18	n.d.	0.11	0.20	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.23	n.d.	0.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Tully River Mouth	28-Aug-18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8.14	n.d.
Tully River Mouth	18-Dec-18	n.d.	3.74	17.60	12.89	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.9	0.77	n.d.	3.23	3.14	n.d.	0.64	0.56	n.d.	1.73	5.28	11.34	3.58	n.d.
Tully River Mouth	15-Jan-19	n.d.	95.12	139.28	77.36	0.36	n.d.	n.d.	17.01	n.d.	1.19	1.70	n.d.	n.d.	6.8	11.85	3.53	2.35	39.00	n.d.	2.69	1.46	n.d.	3.21	28.57	67.70	3.89	n.d.
Tully River Mouth	29-Jan-19	n.d.	23.10	37.62	18.74	0.27	n.d.	n.d.	2.99	n.d.	0.53	n.d.	n.d.	n.d.	2.8	4.27	1.57	1.31	11.84	n.d.	1.61	0.54	n.d.	3.55	5.74	45.90	5.31	n.d.
Tully River Mouth	18-Mar-19	n.d.	4.80	6.38	6.43	0.53	n.d.	n.d.	1.74	n.d.	n.d.	n.d.	n.d.	n.d.	1.2	1.53	n.d.	0.50	5.48	n.d.	0.40	2.18	n.d.	1.88	0.41	2.43	3.89	n.d.
Dunk Island north	17-Jul-18	n.d.	0.12	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dunk Island north	28-Aug-18	n.d.	0.18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7.98	n.d.
Dunk Island north	18-Dec-18	n.d.	2.13	10.76	5.99	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	0.49	n.d.	2.00	1.62	n.d.	0.42	0.51	n.d.	1.30	1.07	2.59	3.96	n.d.
Dunk Island north	15-Jan-19	n.d.	4.20	2.98	1.26	0.54	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.5	0.91	n.d.	n.d.	1.82	n.d.	0.14	0.74	n.d.	0.94	n.d.	n.d.	6.08	n.d.
Dunk Island north	28-Jan-19	n.d.	2.27	2.34	1.63	0.35	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.4	0.63	n.d.	n.d.	1.51	n.d.	0.13	0.48	n.d.	n.d.	n.d.	n.d.	8.53	n.d.
Dunk Island north	18-Mar-19	n.d.	21.88	21.81	17.80	0.31	0.85	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.7	2.86	1.02	0.76	9.62	n.d.	0.52	0.80	n.d.	5.15	2.89	9.35	9.64	n.d.
Bedarra Island	17-Jul-18	n.d.	0.12	0.24	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.0	0.10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Bedarra Island	28-Aug-18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.50	n.d.	n.d.	n.d.	n.d.	6.79	n.d.
Bedarra Island	18-Dec-18	n.d.	4.18	18.01	13.50	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.1	0.79	n.d.	3.79	3.96	n.d.	0.55	n.d.	n.d.	1.40	3.42	9.84	7.47	n.d.
Bedarra Island	15-Jan-19	n.d.	2.60	1.33	n.d.	0.42	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.1	0.68	n.d.	n.d.	0.67	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	12.15	n.d.
Bedarra Island	29-Jan-19	0.21	29.01	45.41	27.24	0.39	0.71	n.d.	n.d.	n.d.	0.49	n.d.	n.d.	n.d.	2.5	5.03	1.68	1.48	14.86	n.d.	0.92	1.03	n.d.	3.78	8.40	30.15	3.83	n.d.
Bedarra Island	18-Mar-19	n.d.	3.48	5.93	4.51	0.54	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.3	1.30	n.d.	n.d.	4.38	n.d.	0.28	0.76	n.d.	1.38	n.d.	n.d.	5.49	n.d.

n.d. - non detect, for these samples the extract concentration was below the instrument LOD. n.d. values are inlcuded as 0 for summary statistics and ms-PAF calculations

Concentrations that did not exceed 3 x blank levels and are shown preceded by "<" in the tables and are included as for n.d. in summary statistics

Concentrations where the extract concentration was above the instrument LOD but below the instrument LOR (see Table A4, Appendix A) are shown in italics. These values are included in the ms-PAF calculations but should be treated with caution

(repl) indicates a replicate sample was extracted