Biodiversity and Conservation Science

Annual Swan Canning Estuarine Data Report 2019-20

July 2019 – June 2020

Technical Report of the Rivers and Estuaries Science program.
Biodiversity and Conservation Science, DBCA.

September 2021

GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: (08) 9219 9000
Fax: (08) 9334 0498

www.dbca.wa.gov.au

September 2021

This report was prepared by Josh Baker and Jeff Cosgrove

Questions regarding the use of this material should be directed to:
Program Leader
Rivers and Estuaries Science
Department of Biodiversity, Conservation and Attractions
Locked Bag 104
Bentley Delivery Centre WA 6983
Phone: 08 92780900
Email: rescience@dbca.wa.gov.au

The recommended reference for this publication is:

Baker, J. D., and Cosgrove J. J. (2021) Swan Canning catchment data report January – December 2019, Department of Biodiversity, Conservation and Attractions, Perth.

This document is available in alternative formats on request.

Cover image: Rocky Bay, North Fremantle. Josh Baker.

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Acknowledgements

This project was funded by the Government of Western Australia through the Department of Biodiversity, Conservation and Attractions (Rivers and Estuaries Science) and the Department of Water and Environmental Regulation.

Data for this report was collected with the operational support of the Marine and Riverpark unit of the Swan Coastal District, DBCA. The authors appreciate the efforts of the following persons that contributed to the collection and processing of data: Kerry Trayler, Steeg Hoeksema, Peter Novak, Suzanne Thompson, Jo Gregory, Sam Robinson, Jake Watsham, Peter Howie, Veronica Wilson, Nikita Quartermaine, Rich Tunnicliffe, John Snowden, Sam Cain, Maitlyn Hansen, Mitch Borgogno, Josh Lasscock, Blas Serra, Lisa West, Cen Zamudio, Adrian Ferguson, Joel Chick, Marco Warmt-Murray, Tom Ryan, Mark Bretnall and Ben Cunningham.

Phytoplankton analyses was conducted by the Phytoplankton Ecology Unit, Department of Water and Environmental Regulation and by Dalcon Environmental.

Review of this report was undertaken Steeg Hoeksema, Peter Novak and Kerry Trayler.

1. Preface

The Swan Canning Environmental Monitoring and Reporting Project consists of long-term monitoring of the estuaries of the Swan and Canning Rivers and selected tributaries within their catchments. This has allowed for the regular reporting on water quality and the annual reporting on estuarine and catchment compliance against long and short-term management targets.

The project was initially designed in 1994 by the Swan River Trust and Department of Water and Environment Regulation (DWER) (then Water and Rivers Commission). The project currently falls under the Department of Biodiversity, Conservation and Attractions' (DBCA) River Protection Strategy with management transitioning in July 2019 from being jointly managed by the Aquatic Science Branch at DWER and the Rivers and Estuaries Science Program at DBCA to being managed solely by the Rivers and Estuaries Science Program at DBCA.

The estuarine monitoring project falls under two main Water Information Network (WIN) management projects; the Swan River Estuary sampling (SG-E-SWANEST) and the Canning River Estuary sampling (SG-E-CANEST).

Monitoring of both projects occurs on a weekly basis with the SG-E-SWANEST project typically occurring every Monday and SG-E-CANEST occurring every Tuesday (subject to weather conditions and excluding weeks commencing on a public holiday). The SG-E-SWANEST project comprises twenty-four fixed monitoring sites spanning from Blackwall Reach (BLA) in Bicton in the Lower Swan Canning Estuary upstream to Power Line Crossing (POL) in West Swan in the Swan River (Table 1 and Figure 1.). Due to the extensive sampling area and speed restrictions within the river, the monitoring is split into two monitoring runs, the "lower run" and "upper run". The lower run is usually conducted from the DBCA vessel *DK Coughran* and commences at BLA heading upstream to Maylands (MAY), thus covering the Lower Swan Canning Estuary and much of the Middle Swan Estuary estuarine ecological management zones. The upper run is usually conducted from the DBCA vessel *Kepa*, commencing at the upmost site POL and heading downstream towards Ron Courtney Island (RON). The monitoring of the lower Swan sites commenced on an intermittent basis in October 1994 and became part of the weekly monitoring routine in 1999. The monitoring of the upper Swan sites was included in this routine from November 2006.

The SG-E-CANEST project comprises eight fixed monitoring sites spanning from the South Canning Bridge (SCB2) in Applecross to Ellison Parade (ELL) in Langford. Due to the extensive sampling area and restrictions with vessel draught and speed within the Canning Estuary and Lower Canning River, the monitoring is split into two runs that are conducted simultaneously using the DBCA vessels *Kepa* and *Trekker*. The shallower sample sites between Riverton (RIV) and Castledare (CASMID) are monitored using the *Trekker*. The monitoring of the SG-E-CANEST sites commenced on an intermittent basis in January 1995 and became part of the weekly monitoring routine in 1999.

The closure of two historic projects is also of note; The Upper Swan River Estuary Sampling sub-project (SG-E-UPPERSWAN) was closed in July 2010 with all sites being incorporated into the SG-E-SWANEST project. The Swan River Compliance Sampling (SG-E-SWANCOMP) was closed in June 2019. This sub-project consisted of weekly sampling at a randomly selected sample point within a grid matrix of Melville Waters (site codes were prefixed SWL) and at two randomly selected sites from the SG-E-SWANEST lower Swan run and at RIV from the SG-E-CANEST sub-projects for compliance reporting. With the closure of this sub-project, the sites sampled in their respective sub-projects remain, but the randomly selected site in Melville Waters is no longer sampled. These SWL sites all remain registered with WIN as they serve as effective sample sites during algal bloom response sampling.

Notable recent changes to the estuarine monitoring project:

- The analysis of phytoplankton composition to present the ratio of diatoms to dinoflagellates was incorporated into the 2019-20 report. This ratio provides an insight into shifts in ecological state of marine/brackish waters throughout the reporting period, with a low ratio potentially indicating silicate limitation linked to eutrophication. Diatoms are generally considered better grazing material for zooplankton and planktivorous fish, and a low diatom/dinoflagellate ratio may reflect a poorer ecological status.
- From May 2020, the monitoring site SHELL was added to the suite of sites comprising SG-E-CANEST. This site is downstream from Shelley Bridge and has not previously been reported. Due to an incomplete data set for this reporting period, the available data for this site has been omitted from the analyses in this report. The preliminary data is however detailed within Appendix 1.
- From April 2020, samples collected from the SG-E-CANEST sites RIV and CASMID (and SHELL from May 2020) using *Trekker* were filtered on site and allocated their own chain of custody (COC) to allow them to be taken directly to Chem Centre to improve time efficiencies.
- On 01/06/2019 the sampling for SWANCOMP ceased.
- On 16/01/2019 the run was again reorganised as refurbishment works at Kent Street Weir had been completed and the water levels returned to normal allowing *Kepa* to pass under Greenfield Bridge. The site order was changed to RIV and CASMID being sampled by *Trekker* and SCB2, SAL, KEN to ELL being sampled by *Kepa*.

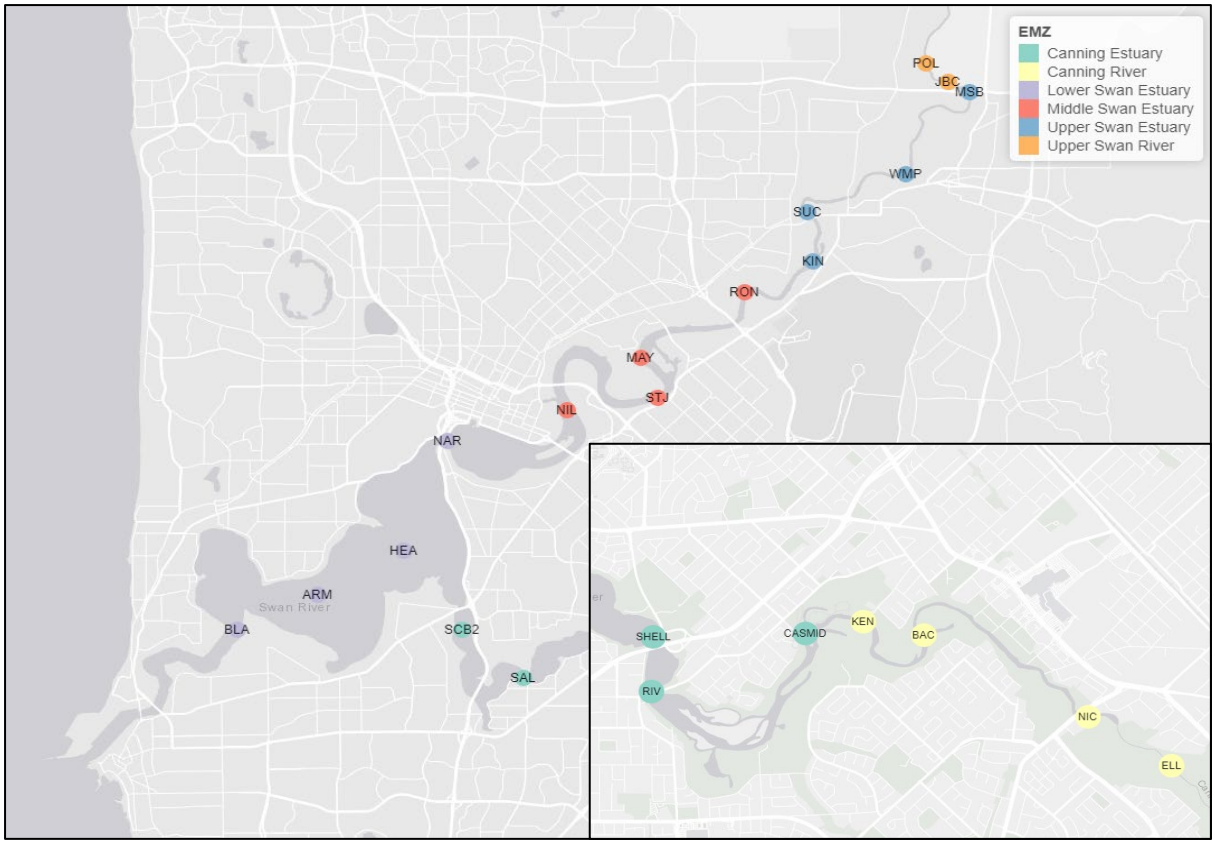
Notable recent events likely to affect the estuarine monitoring project:

- On 13/08/2019 there were strong flood conditions in the Swan River. Only profile data for surface waters were obtained.
- On 06/08/2019 there were strong flood conditions in the Swan River. Only a single surface sample from STJ was collected. No samples or profile data were collected on the upper run.

Table 1 Monitoring site information and coordinates in the Swan Canning Estuary.

Project	Site	Site Code	EMZ	Easting	Northing	Longitude	Latitude	Expected Depth (m)
SG-E-SWANEST	Blackwall Reach	BLA	Lower Swan Canning Estuary	385081	6456807	115.784129	-32.017126	16-17
	Armstrong Spit	ARM		387504	6458161	115.808950	-32.007069	12-13
	Heathcote	HEA		389983	6459538	115.835349	-31.994892	6-8
	Narrows Bridge	NAR		391215	6463014	115.848780	-31.963657	5-6
	Nile Street	NIL	Middle Swan Estuary	394660	6464027	115.885341	-31.954845	2-3
	St John's Hospital	STJ		397308	6464439	115.913400	-31.951372	5-6
	Maylands Pool	MAY		396801	6465716	115.908173	-31.939807	3-4
	Ron Courtney Island	RON		399802	6467786	115.940132	-31.921404	4-5
	Kingsley	KIN	Upper Swan Estuary	401768	6468783	115.961026	-31.912582	5-6
	Success Hill	SUC		401585	6470349	115.959250	-31.898440	4-5
	West Midland Pool	WMP		404439	6471549	115.989456	-31.887859	4-4.8
	Middle Swan Bridge	MSB		406263	6474166	116.009083	-31.864404	2-3
	Jane Brook Confluence	JBC	Swan River	405656	6474493	116.002700	-31.861400	2-2.5
	Power Line Crossing	POL		404979	6475053	115.995600	-31.856300	1.5-2.5
SG-E-CANEST	South Canning Bridge	SCB2	Upper Canning Estuary	391698	6457081	115.853225	-32.017219	3.5-5
	Salter Point	SAL		393509	6455593	115.872233	-32.030813	~2
	Shelley Bridge*	SHELL		396251	6456511	115.901366	-32.022782	~1.5
	Riverton Bridge	RIV		396239	6455988	115.901182	-32.027504	~1.5
	Castledare	CASMID		397599	6456555	115.915643	-32.022513	2-3
	Kent Street Weir	KEN	Lower Canning River	398104	6456676	115.921002	-32.021468	2-3
	Bacon Street	BAC		398643	6456556	115.926700	-32.022600	5-6
	Nicholson Road Bridge	NIC		400105	6455782	115.942100	-32.029700	3-4
	Ellison Parade	ELL		401012	6455148	115.949901	-32.033900	2-3

*SG-E-CANEST site SHELL at Shelley Bridge was added to the monitoring project in summer of 2020. Due to insufficient data at this site, it has not been reported for this reporting period.



*SG-E-CANEST site SHELL at Shelley Bridge was added to the monitoring project in summer of 2020. Due to insufficient data at this site, it has not been reported on in this reporting period.

Figure 1 Map of Swan and Canning routine estuarine monitoring sites within each ecological management zone as presented in Table 1.

Table 2 Swan Canning Estuary sampling regimes. Weekly sampling represented by black ticks and fortnightly sampling represented by red ticks.

Analyte	Sample type					Project
	Surface (S)	**Bottom (B)**	**Integrated (ID)**	**Net**	**In-situ profile**	
TN	✓	✓				All **SG-E-SWANEST** sites (excl. JBC and POL) and all **SG-E-CANEST** sites
NH_3-N	✓	✓				
NO_x-N	✓	✓				
DOrgN	✓	✓				
TP	✓	✓				
FRP	✓	✓				
SiO_2*	✓	✓				
DOC	✓					
TSS	✓					All **SG-E-SWANEST** sites (excl. JBC and POL)
ALK	✓					
Chl-a	✓		✓			All **SG-E-SWANEST** sites and All **SG-E-CANEST** sites
Phytoplankton			✓	✓		
DO					✓	
Sp. Cond.					✓	
Temperature					✓	
pH					✓	
Secchi depth	✓					

*SiO_2 collected from Surface and Bottom **SG-E-SWANEST** and surface sample only in **SG-E-CANEST**

*YSI profile (*in situ*) includes dissolved oxygen (mg/L), temperature (ºC), salinity (specific conductivity) and pH.

S = Surface sample (0.5m depth)

B = Bottom sample (0.5m form bottom depth)

ID = Integrated depth sample.

2. Introduction

The annual Swan Canning Estuarine Data Report presents historical data from 2013-14 to 2018-19 seasons and the current season's data. The data is collected from a total of twenty-two sites (excluding SHELL) from the Swan and Canning Estuarine Monitoring program. Data has been tabulated and presented graphically for thirteen key analytes (Table 2); total nitrogen (TN), ammonia nitrogen (NH3), total oxidised nitrogen (NOx), dissolved organic nitrogen (DOrgN), total phosphorus (TP), filterable reactive phosphorus (FRP), silica (Si), dissolved organic carbon (DOC), total suspended solids (TSS), alkalinity (ALK), chlorophyll-a (Chl-a), secchi depth, phytoplankton and in-situ physico-chemical profile data for dissolved oxygen (DO), salinity, temperature and pH. These data are grouped into six Ecological Management Zones (EMZs) as follows:

- **Lower Swan Canning Estuary**: BLA, ARM, HEA and NAR
- **Middle Swan Estuary:** NIL, STJ, MAY and RON
- **Upper Swan Estuary:** KIN, SUC, WMP and MSB
- **Swan River:** JBC and POL
- **Canning Estuary:** SCB2, SAL, RIV and CASMID
- **Lower Canning River:** KEN, BAC, NIC and ELL

Nutrient analyte and *in-situ* physico-chemical analyte concentration data are presented as background boxplots that detail the monthly median (dark central band), 25th, and 75th percentiles (box) and the 10th and 90th percentiles (as the whiskers) for the previous five years' worth of data (2014-15 to 2018-19) overlain with the monthly medians (solid black circle) for the current year's (2019-20) data for each of the EMZs. The data is presented over a financial year (July-June) so that the summer and autumn months are kept together in the same report. Any data that are recorded as below the laboratory limit of reporting (LoR) is presented and analysed as half the LoR value. The data are also tabulated, detailing the number of monthly samples (n) and the monthly minimum, maximum and median values for each analyte for the current reporting period.

Phytoplankton cell density (cells/mL) data are presented for total phytoplankton, diatoms and dinoflagellates. The graphical presentation includes background boxplots that detail the monthly mean (dark central band), 25th and 75th percentiles (box) and the 10th and 90th percentiles (whiskers) for the previous seven years' worth of data (2012-13 to 2018-19) overlain with the monthly mean (solid black circle) for the current year's (2019-20) data for each of the EMZs. The ecological shift in community composition between diatoms and dinoflagellates is also presented as a ratio over the reporting period. The data is presented over a financial year (July-June) so that peak phytoplankton growth over summer and autumn months are kept together in the same report.

Occurrence and duration of Harmful Algal Bloom (HAB) species within the system are tabulated. Focus has been given to the HAB species belonging to the genus *Alexandrium* as over the reporting year it has been the primary species of concern

(see Section 3 HAB species for detail). Monthly mean cell densities with standard error for the 2018-19 reporting period are overlain with the 2019-20 data along with monthly maximum cell densities for each period.

3. Key observations from 2019-20 reporting period

The total rainfall for the 2019-20 reporting period was 561.8 mm which is below the mean annual rainfall of 713.9 mm recorded at Perth Airport between 1979-2018 (Bureau of Meteorology). Seasonality in rainfall followed historic trends with high rainfall generally experienced in the winter months and low rainfall in the summer months (Figure 2). Perth experienced below average rainfall for most of the year except for February, March and May where above average monthly rainfall was recorded.

Daily rainfall data for the 2019-20 reporting period are presented in Figure 3. Above average rainfall in May was likely a result of a storm system that hit Western Australia towards the end of May where 70.2 mm was recorded between 25/05/20 and 31/05/20.

On 25/05/2020, a strong storm surge, resulting from of a cyclone in the northwest, forced saline water over Kent Street Weir. This resulted in higher water levels and a salt wedge upstream of the weir in the Lower Canning River. As a management response, the weir was opened on the evening of 25/05/2020 to flush the saline water back downstream of the weir. Consequently, increased stratification of the water column was observed in the Canning Estuary during the monitoring run undertaken on 27/05/2020.

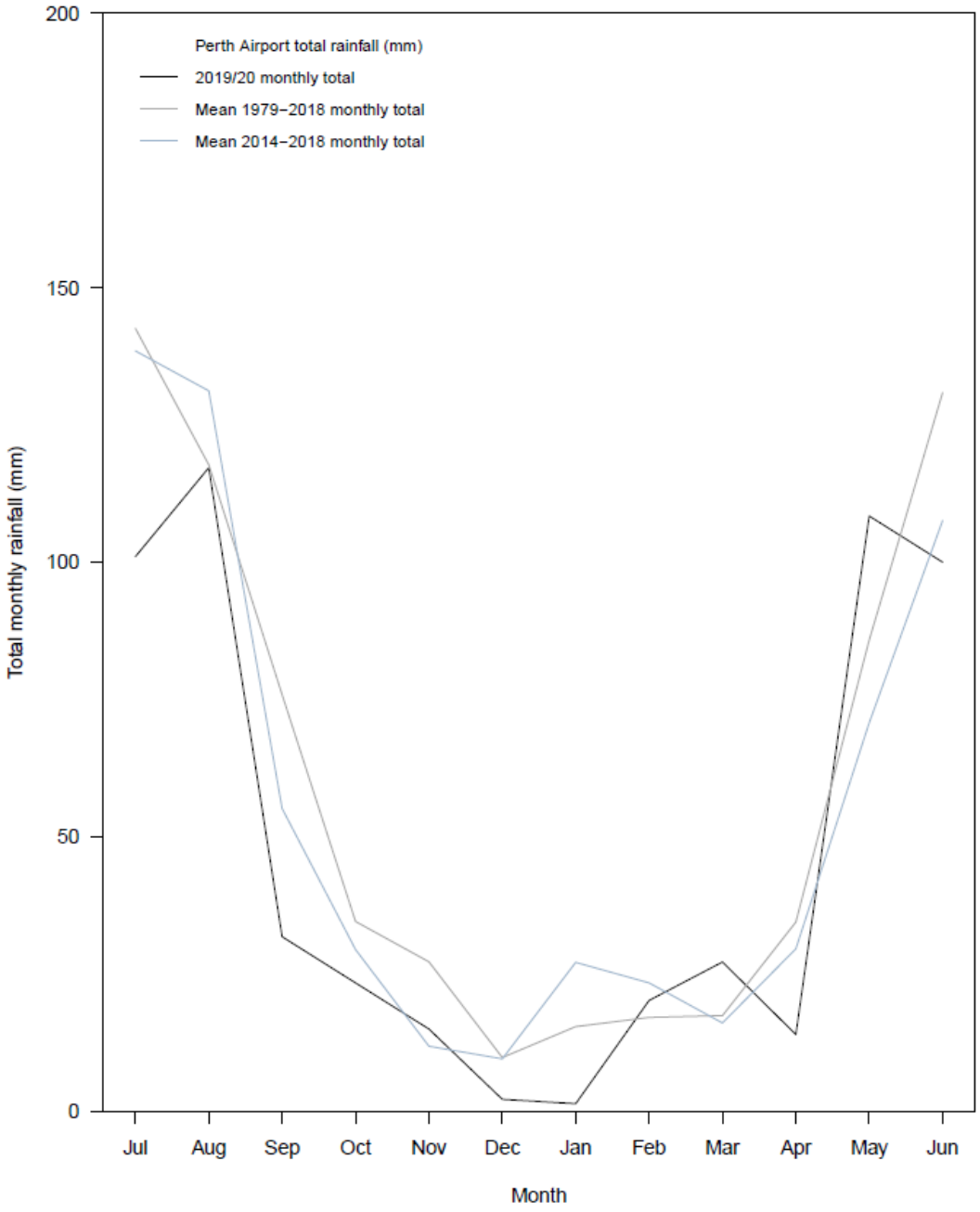


Figure 2 Total monthly rainfall (mm) recorded at Perth Airport (station number 009021 provided by the Bureau of Meteorology) for the 2019-20 reporting period, compared to the mean total monthly rainfall (mm) for the last 40 years (1979-2018) and the historical five year reporting period (2014-2018).

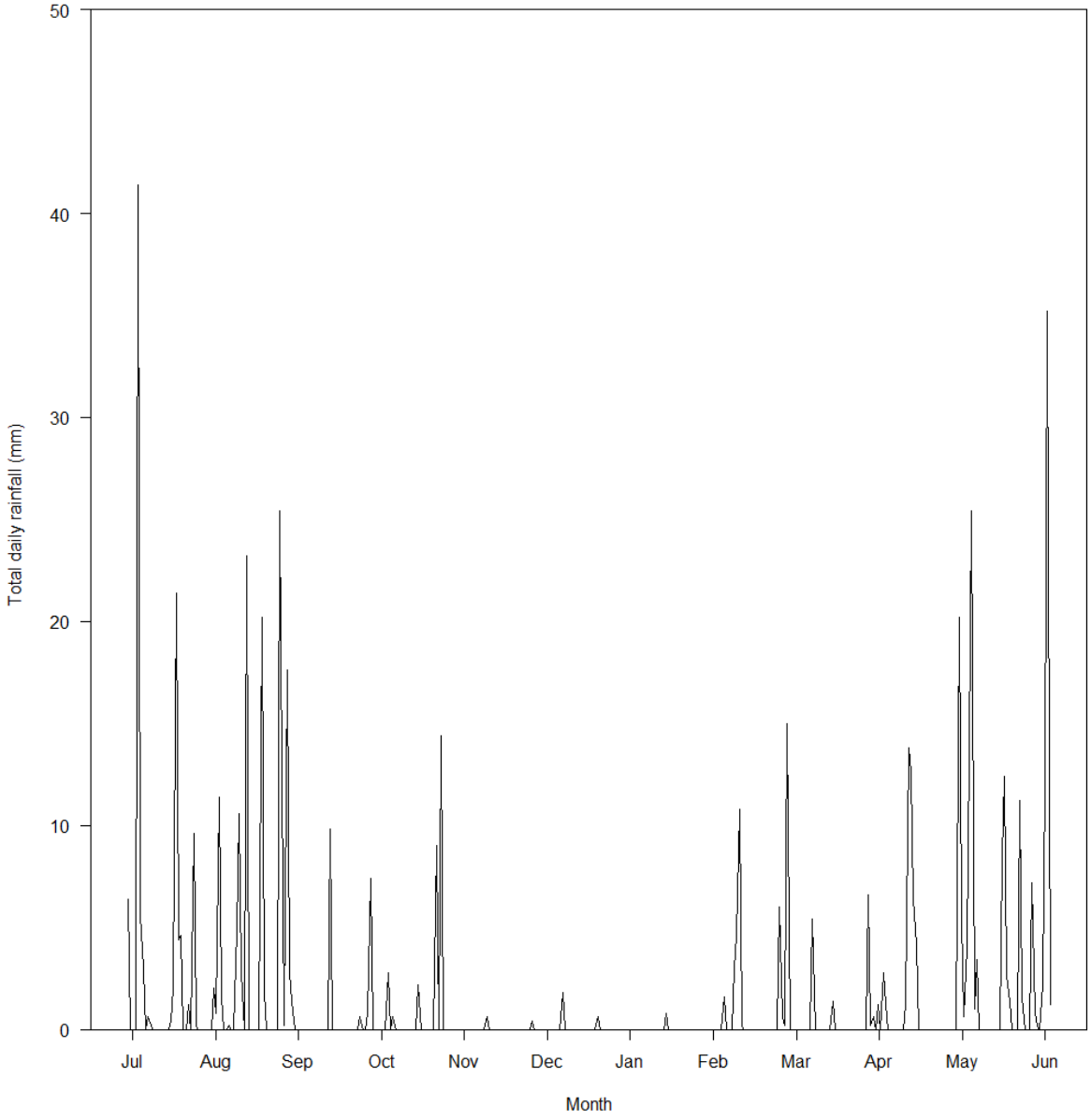


Figure 3 Daily total rainfall (mm) for the 2019-20 reporting period recorded at Perth Airport (station number 009021 provided by the Bureau of Meteorology).

3.1 Swan Estuary physico-chemical

The monthly median TN concentrations for the 2019-20 reporting period largely followed the historic trends and remained within the historic range (Figure 4). In the Lower Swan Canning Estuary, for both surface and bottom samples, TN concentrations remained below the ANZECC trigger value of 0.75 mg/L for estuaries. Slight elevations of TN concentrations above the ANZECC trigger were recorded in the Middle and Upper Swan Estuary between July and October. These were likely a response to rainfall events and seasonal winter flow (Figures 2 and 3). TN concentrations in the Upper Swan Estuary however, continued to exceed the ANZECC trigger values throughout the reporting period.

The higher TN concentrations in the first quarter of the reporting period is likely attributable to concentrations of NH_3 (Figure 6) in the bottom waters and NO_x (Figure 8) and, to a lesser extent, DOrgN (Figure 10) in the surface and bottom waters, which displayed a similar response to the winter rains and seasonal flow. Variability is more apparent in the Middle and Upper Swan Estuary, where the influence of the salt wedge and flow from the catchment is more pronounced.

The concentration of NO_x exceeded the ANZECC trigger value of 0.045 mg/L for estuaries in July in surface waters of the Lower Swan Canning Estuary, in surface and bottom waters of the Middle Swan Estuary between July and September and in surface and bottom waters in between July and October in the Upper Swan Estuary (Figure 8).

The monthly median TP concentrations in 2019-20 were within the range and pattern of the historic data (Figure 12). In the Lower Swan Canning Estuary these concentrations remained below the ANZECC trigger value of 0.03 mg/L for estuaries and showed minimal seasonal response. Concentrations of TP in the Middle Swan Estuary and Upper Swan Estuary (surface and bottom water) exceeded the ANZECC trigger value for the entire reporting period except for October in surface waters of the Upper Swan Estuary and showed a seasonal increase in TP concentrations during the summer months Middle Swan Estuary (Figure 12).

Throughout the Swan Estuary, FRP concentrations (Figure 14) are likely to be the predominant influence on TP concentrations, particularly for bottom waters within the system. Within the Lower Swan Canning Estuary, FRP in the bottom waters comprised 62- 89% of TP concentrations in the first quarter of the reporting period. FRP comprised between 53% and 68% of TP concentrations in the bottom waters of the Middle Swan Estuary for most of the reporting period except August, October and November where concentrations were less than 50%. This influence was less in the bottom waters of the Upper Swan Estuary, but still ranged from 53-66% in the last quarter of the reporting period. There appeared to be a seasonal response exhibited by FRP within surface and bottom waters of the Lower Swan Canning Estuary in the summer and autumn months. During this time concentrations were seen to exceed the ANZECC trigger value of 0.005 mg/L for estuaries. A similar seasonal response to TP was exhibited in the Middle Swan Estuary and Upper Swan Estuary, where concentrations exceeded the trigger value for the entire reporting period.

Concentrations of silica appeared to exhibit variability in response to flow, particularly in the Middle Swan Estuary and Upper Swan Estuary (Figure 16). In general, values fell within the range of the background data.

A seasonal response was also observed in the concentrations of DOC (Figure 18) within the surface waters of the Swan Estuary. They showed highest concentrations in the winter months at the start of the reporting period and continued to decline through the sampling period. This decline was more pronounced in the Middle Swan Estuary and Upper Swan Estuary compared to the Lower Swan Canning Estuary.

The concentrations of TSS (Figure 20) and ALK (Figure 21) reflected those of TP and FRP, with a decline in concentrations in the winter months followed by a peak in concentrations over the summer and early autumn months. Historically, TSS exhibits higher levels of variability which are often associated with high rainfall events, as turbidity increases with entrained solids in runoff from the catchment. The concentrations of ALK remain close to the background data and exhibit a more consistent change throughout the year (Figure 21).

Concentrations of chlorophyll exceeded the ANZECC trigger value of 0.003 mg/L for the first quarter within the Lower Swan Canning Estuary and for most of the reporting period within Middle Swan Estuary and Upper Swan Estuary (Figure 22). Within the Lower Swan Canning Estuary, the trigger value was exceeded between July and October. In November median Chl-a concentrations fell below the trigger value to 0.0018 mg/L and remained below the trigger value until June, when the trigger value was met. In the Middle Swan Estuary and Upper Swan Estuary, the trigger value was greatly exceeded, with concentrations being six times greater than the trigger in August and October in the Middle Swan Estuary and December in the Upper Swan Estuary. Concentrations only fell below the trigger value in September and October in the Upper Swan Estuary (0.0021 mg/L and 0.002 mg/L, respectively) (Figure 22). The increased presence of chlorophyll over the summer months is expected as water clarity (due to decreased tannins and suspended sediments), photoperiods, temperature and nutrient availability, such as FRP, increase.

Median concentrations of DO (Figure 24) in the surface waters of the Lower Swan Canning Estuary were >6 mg/L (well oxygenated) throughout the year and closely resembled those of the background data. Bottom waters in the Lower Swan Canning Estuary were oxygenated (4-6 mg/L) or well oxygenated throughout the year. Median concentrations within the Middle Swan Estuary remained well oxygenated in the surface waters and low in oxygen (>2-4 mg/L) to oxygenated in bottom waters. Median concentrations in the surface waters of the Upper Swan Estuary were oxygenated or well oxygenated and ranged from low in oxygen to well oxygenated in bottom waters. Bottom waters of the Middle Swan Estuary were often higher than background levels, particularly in the summer months. This could possibly be an influence of increased daytime microalgal activity (Figure 22) and of the oxygenation plants in these zones of the estuary.

Specific conductivity (Figure 26) and temperature (Figure 28) display a typical seasonal response, with an increase in median specific conductivity and temperature values in the summer months and a reduction in autumn and winter. Specific

conductivity also increased in bottom waters of the Middle Swan Estuary and Upper Swan estuary during spring and summer as the salt wedge propagated through the estuary and then receded following the onset of winter flows. Temperature followed the patterns in background data closely, whereas specific conductivity varied more from the background data, except within the bottom waters of the Lower Swan Canning Estuary.

Within the Lower Swan Canning Estuary and surface waters of the Middle Swan Estuary, pH concentrations remained within the upper and lower ANZECC trigger values for pH in estuaries (lower trigger value of 8.5 and upper trigger value of 7.5) (Figure 30). There was a slight dip below the lower trigger value at the beginning of the reporting period in bottom waters of the Middle Swan Estuary and towards the end of the reporting period in the Upper Swan Estuary. Overall, pH values remained close to the range of the background data.

The increased depth of sites within the Lower Swan Canning Estuary permits greater median secchi depth within this zone. Secchi depth was however more variable in the Lower Swan Canning Estuary and is likely attributable to a reduction in visible depth during the summer months when chlorophyll concentrations are increased and during periods of peak flow where visibility is reduced due to suspended solids and tannins being washed downstream (Figure 32). Within the shallower waters of the Middle Swan Estuary and Upper Swan Estuary there is an increased level of turbidity and TSS.

3.2 Canning Estuary physico-chemical

Similar trends in concentrations of TN to that of the Swan Estuary were exhibited within the Canning Estuary and Lower Canning River (Figure 5). Higher TN concentrations at the beginning of the reporting period were likely a response to increased seasonal flow, the concentrations then lessen over the summer months. There appeared to be greater variability around this trend in the Canning Estuary, which is tidally influenced. Upstream of Kent Street Weir in the Lower Canning River, there appeared to be more stability and the historic trends were more closely followed.

In both EMZ's, the ANZECC trigger values for TN (0.75 mg/L for estuaries in the Canning Estuary and 1.2 mg/L for lowland rivers in the Lower Canning River) were exceeded at the beginning of the reporting period in July. Later exceedances also occurred in the surface waters in the Canning Estuary in August, September, December and January. The Lower Canning River remained below the respective ANZECC trigger value in both the surface and bottom waters for the remaining sample events.

These exceedances are likely attributable to the concentrations of NH_3 (Figure 7) and particularly NO_x (Figure 9), which show corresponding peaks in data that are typical when compared to the background data for these times of year. The exceedances appear to be less attributable to DOrgN (Figure 11) which displayed less variation throughout the reporting period. The median concentrations of NO_x within the Canning Estuary and Lower Canning River also exceeded the respective ANZECC trigger values of 0.045 mg/L for estuaries and 0.15 mg/L for lowland rivers

at the beginning of the reporting period (between July and September in the surface waters of the Canning Estuary and July and August in the bottom waters of the Canning Estuary, and between July and October and May and June in the waters of Lower Canning River). Greater stability in the background data can be observed within the Canning River and is likely due to the minimal tidal influence encountered within these waters.

The concentrations of TP (Figure 13) display typical seasonal response within both zones and, like that of the Swan Estuary, peaks were reported in the summer months. The ANZECC trigger values for TP of 0.03 mg/L for estuaries and 0.065 mg/L for lowland rivers were exceeded for much of the reporting period in the surface and bottom waters of the Canning Estuary and the bottom waters of the Lower Canning River. A higher level of variability in the background data was observed between the bottom waters of the Canning Estuary and the bottom waters of the Lower Canning River over the summer months.

In the Canning Estuary, concentrations of FRP reflect the seasonal trends observed in TP (Figure 15). This is less apparent in the Lower Canning River, where concentrations reduce over the summer months. Within the Canning Estuary, the concentration of FRP exceeded the ANZECC trigger value of 0.005 mg/L between July and May in the surface waters and between December and February in bottom waters. Median FRP concentrations remained below the ANZECC trigger vale of 0.04 mg/L for lowland rivers was within the Lower Canning River throughout the monitoring period.

Concentrations of Si (Figure 17) remained within the range of the background data within surface waters of both the Canning Estuary and Canning River. Concentrations in both zones decreased leading into the summer months and then tended to increase through summer to autumn. In both zones, the decline of Si concentrations in May is likely attributable to the sampling following the atypically large storm surge event (see Section 3 of this report).

Overall concentrations of DOC (Figure 19) generally followed the trend of the background data within the surface waters of the Canning Estuary for the duration of the reporting period. The trend is likely a response to increased seasonal flow, where concentrations appeared to increase following the winter months and decline leading into summer. This trend also occurs within the surface waters of the Canning River, but the association with the background data was less apparent, particularly between November and March.

Chlorophyll-a concentrations in the Canning Estuary and Lower Canning River also displayed a similar trend to the seasonal conditions exhibited in the background data. Over the spring and summer months (October to March) concentrations increased likely as a result of increased nutrient availability, such as FRP. Median concentrations within the Canning Estuary exceeded the ANZECC trigger value of 0.003 mg/L for Chl-a in estuaries throughout the entire reporting period (Figure 23). Within the Lower Canning River, median concentrations remained below the ANZECC trigger value of 0.003 mg/L for lowland rivers for the first quarter of the reporting period. Between September and October concentrations rose from 0.0015

mg/L to 0.0109 mg/L and median concentrations continued to exceed the trigger value for the rest of the reporting period. Concentrations peaked in March with a median concentration of 0.017 mg/L, which exceeded the trigger value five-fold.

Within the Canning Estuary, concentrations of DO (Figure 25) closely followed the trends of the background data. Increased variability in the background data and some seasonality, can be seen in the surface waters and, to a lesser extent, the bottom waters. Surface waters were oxygenated or well oxygenated throughout the reporting period with median DO concentrations in excess of 5 mg/L. Bottom waters were also typically oxygenated or well oxygenated throughout the reporting period, except for July which were low in oxygen with median concentrations falling to 3.1 mg/L. Greater variability and less apparent seasonality were exhibited by the background data of the Lower Canning River. Median concentrations are likely influenced by the operation of the oxygenation plants when natural concentrations drop below or surpass thresholds in the Lower Canning River. Despite the historical variability, surface waters within the Lower Canning River were well oxygenated throughout the reporting period and ranged from oxygenated to well oxygenated in bottom waters.

Specific conductivity (Figure 27) data also exhibits seasonality in the Canning Estuary. Concentrations increase over the summer months as winter flows subside and the tidal influence moves further upstream. Specific conductivity of surface waters in August exceeded the upper 75th percentile of the background data and were elevated in the bottom waters. This is likely a response to a drier than average August (111.7 m recorded at Gosnells City station 0009106). Upstream of Kent Street Weir, the Lower Canning River closely followed the background data. These background data are less variable through most of the year, except in autumn and early winter as flows increase.

Temperature (Figure 29) in both zones closely followed the seasonality of the background data which peaked during the summer months and cooled during winter.

Within the Canning Estuary and Canning River, the pH (Figure 31) remained within or slightly below the ANZECC upper and lower trigger values (pH 8.5 and 7.5 respectively). A slight seasonal response, likely associated with increased periods of photosynthesis, can be seen with increased pH values being recorded over the summer months and those below the lower trigger value occurring in autumn and winter.

Median secchi depths (Figure 32) were greater in the Canning Estuary, as only waters during periods of peak flows and increased chlorophyll concentrations reduced visibility through the water column. As to be expected, there is also high variability within the background data that is likely associated to the sampling events around those periods. Lower median secchi depths were observed in the Canning River suggesting limitations in visibility by factors including turbidity, tannins and TSS associated with catchment runoff.

4. Total nitrogen analysis

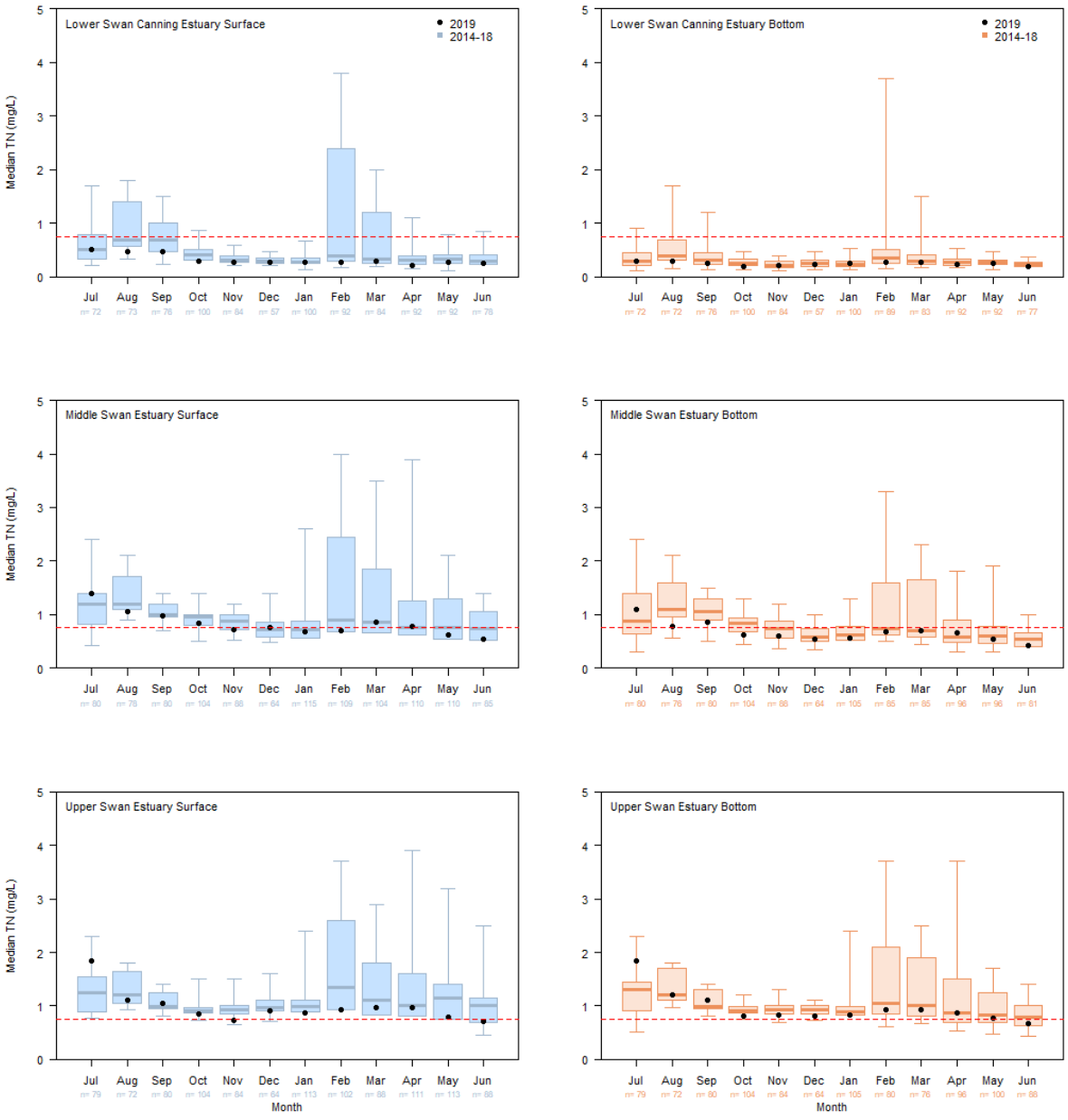


Figure 4 Median total nitrogen (TN) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median TN data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary and the ANZECC trigger values (0.75 mg/L) for Estuaries.

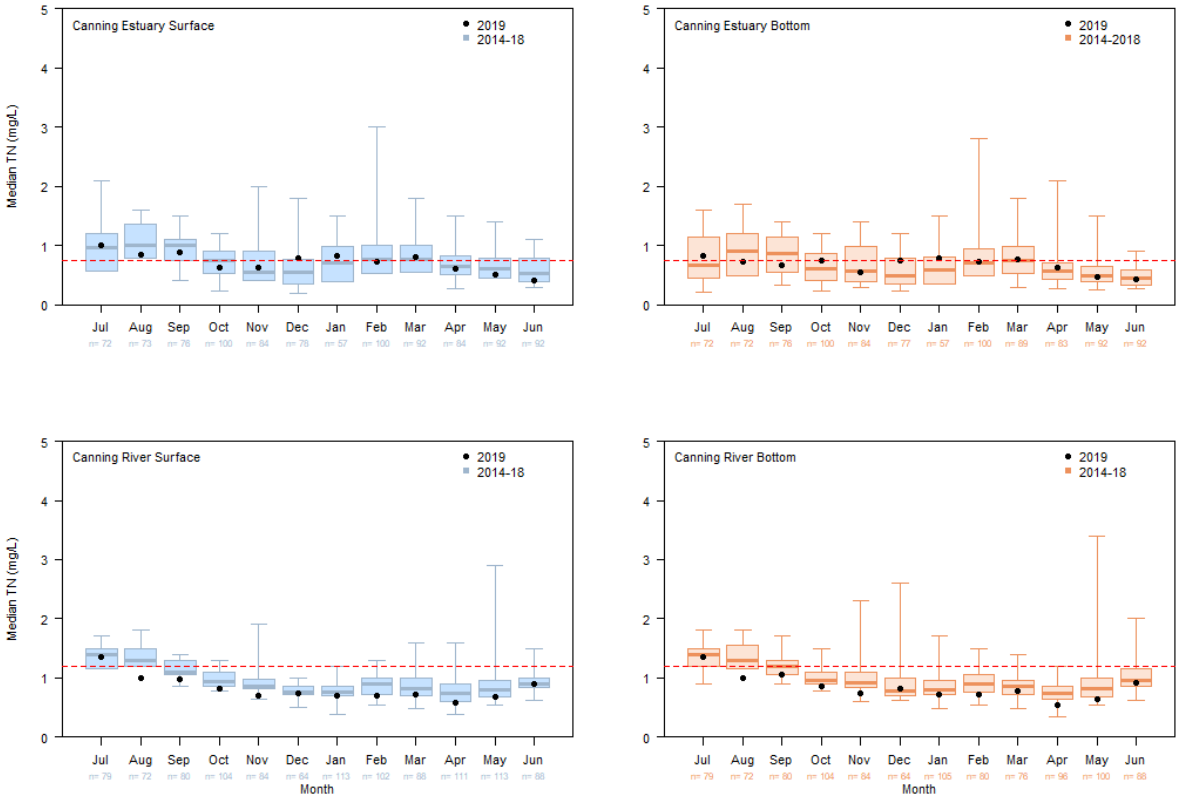


Figure 5 Median total nitrogen (TN) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median TN data in the Canning Estuary and Lower Canning River and the ANZECC trigger values (0.75 mg/L for the Canning Estuary and 1.2 mg/L for the Lower Canning River).

5. Ammonia nitrogen analysis

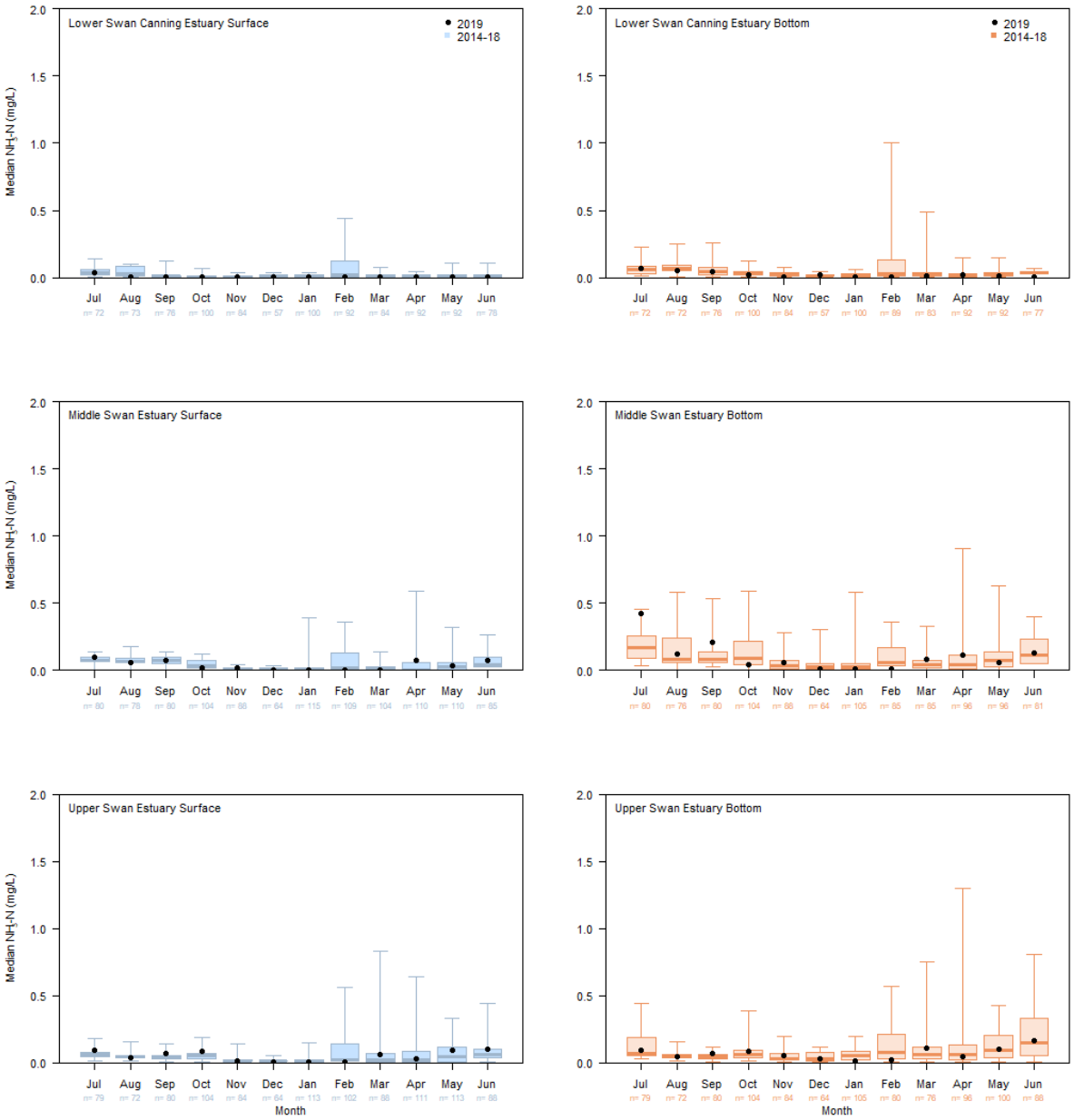


Figure 6 Median ammonia nitrogen (NH3-N) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median NH3-N data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

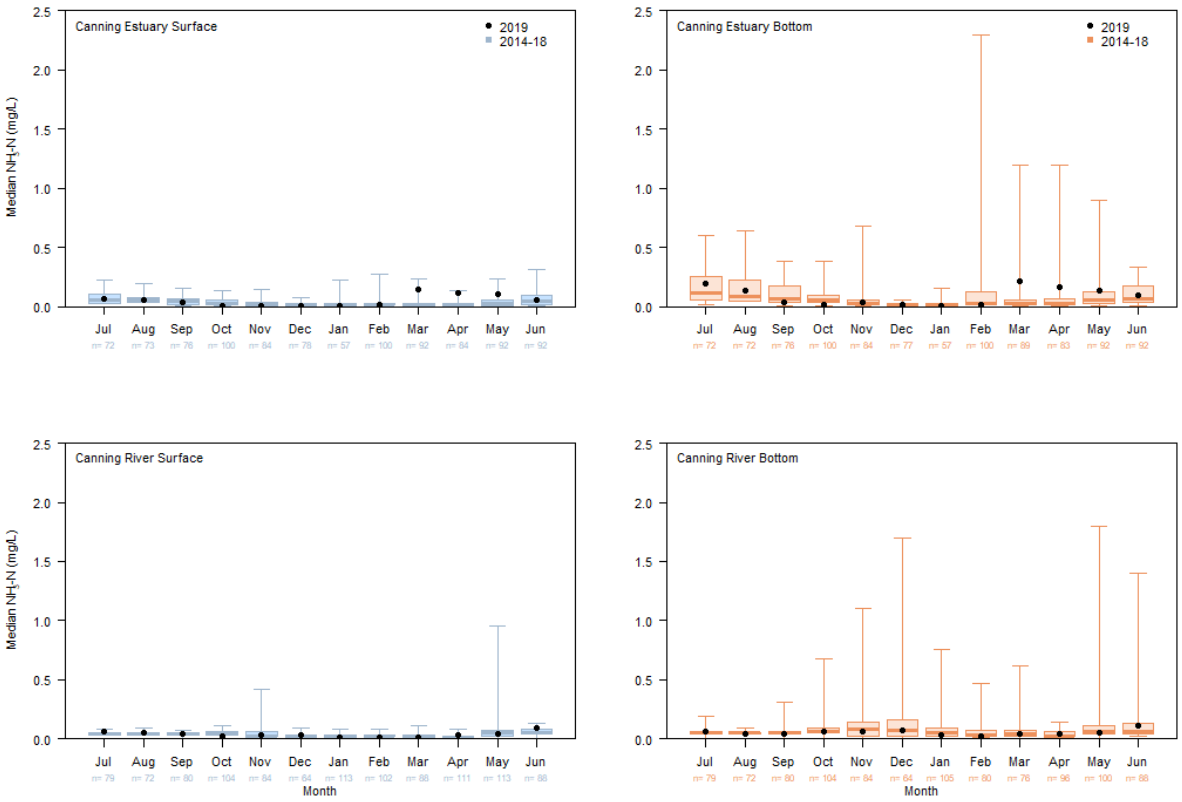


Figure 7 Median ammonia nitrogen (NH3-N) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median NH3-N data in the Canning Estuary and Lower Canning River.

6. Total oxidised nitrogen analysis

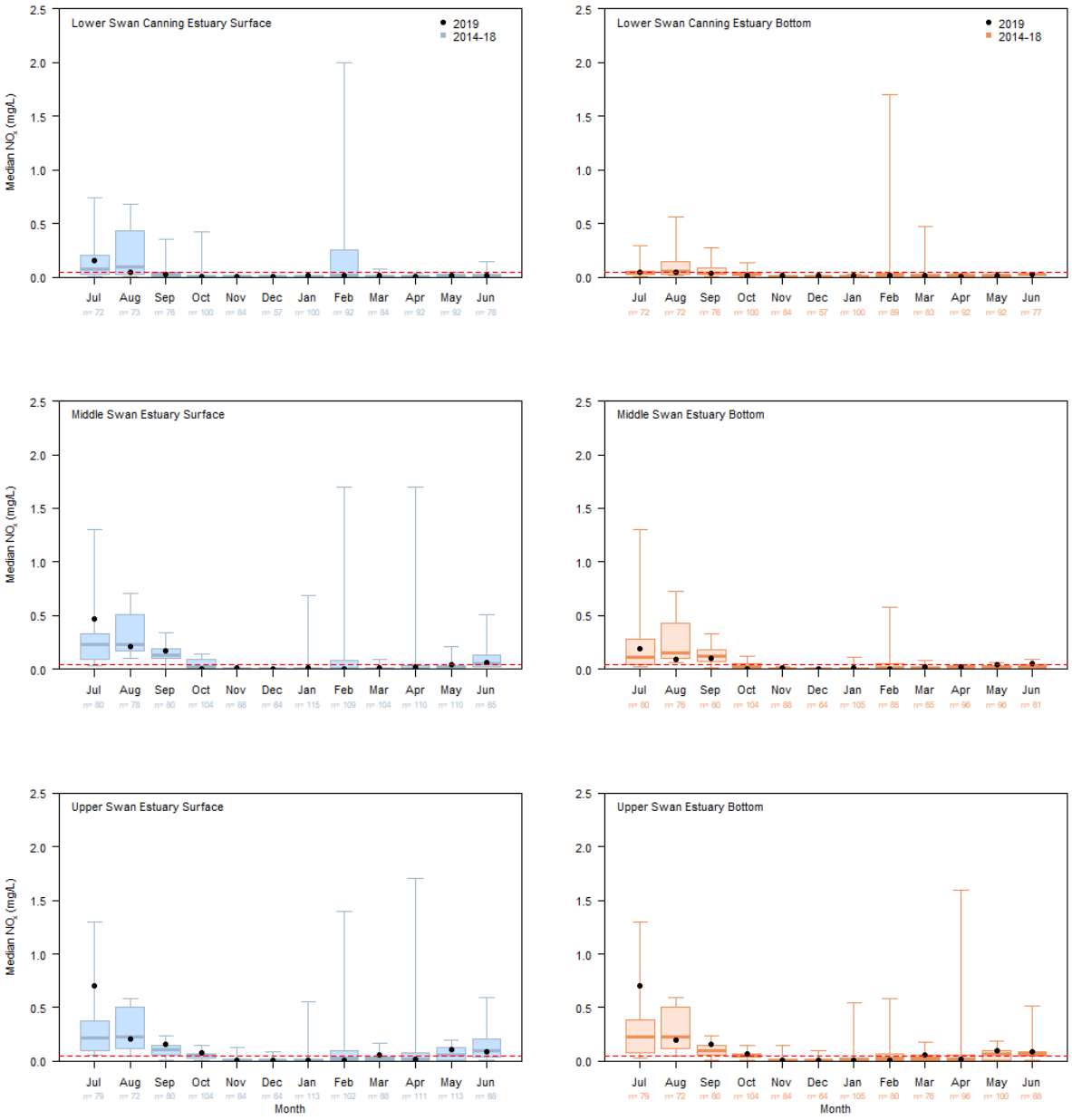


Figure 8 Median total oxidised nitrogen (NOx) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median NOx data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary and the ANZECC trigger value (0.045 mg/L) for Estuaries.

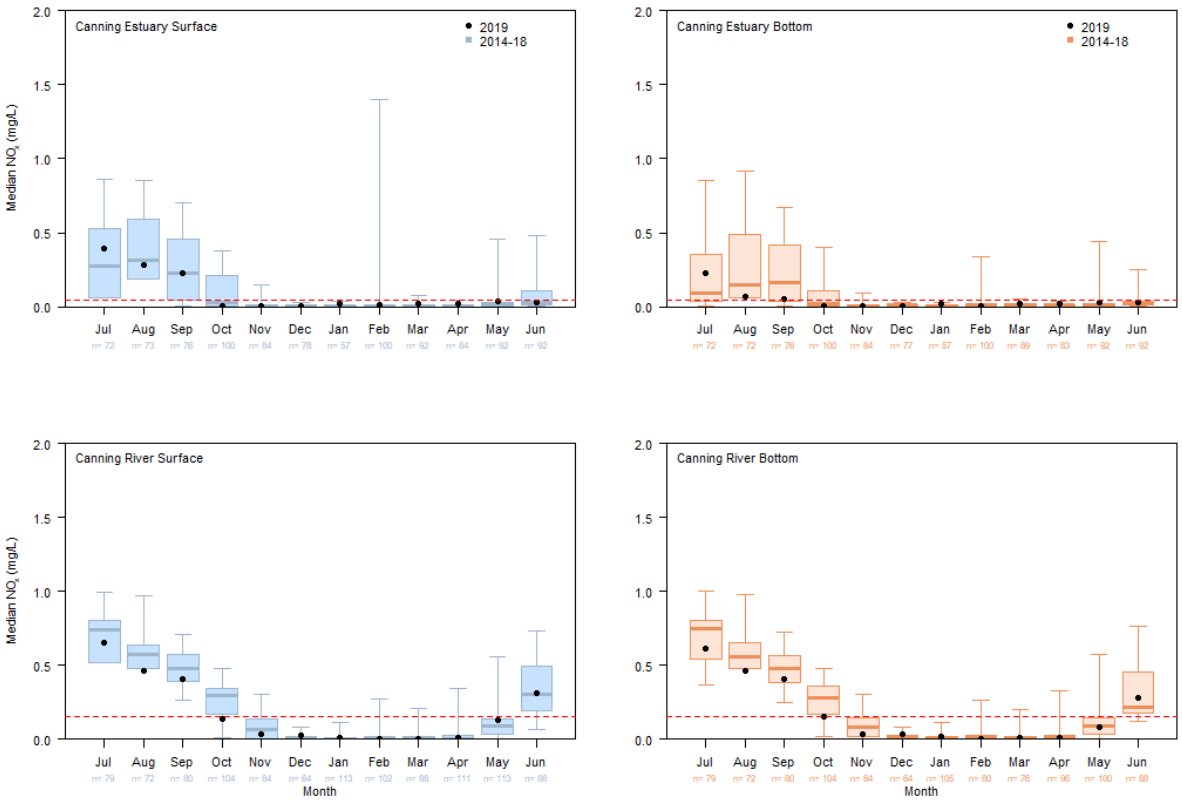


Figure 9 Median total oxidised nitrogen (NOx) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median NOx data in the Canning Estuary and Lower Canning River and the ANZECC trigger values (0.045 mg/L for the Canning Estuary and 0.15 mg/L for the Lower Canning River).

7. Dissolved organic nitrogen analysis

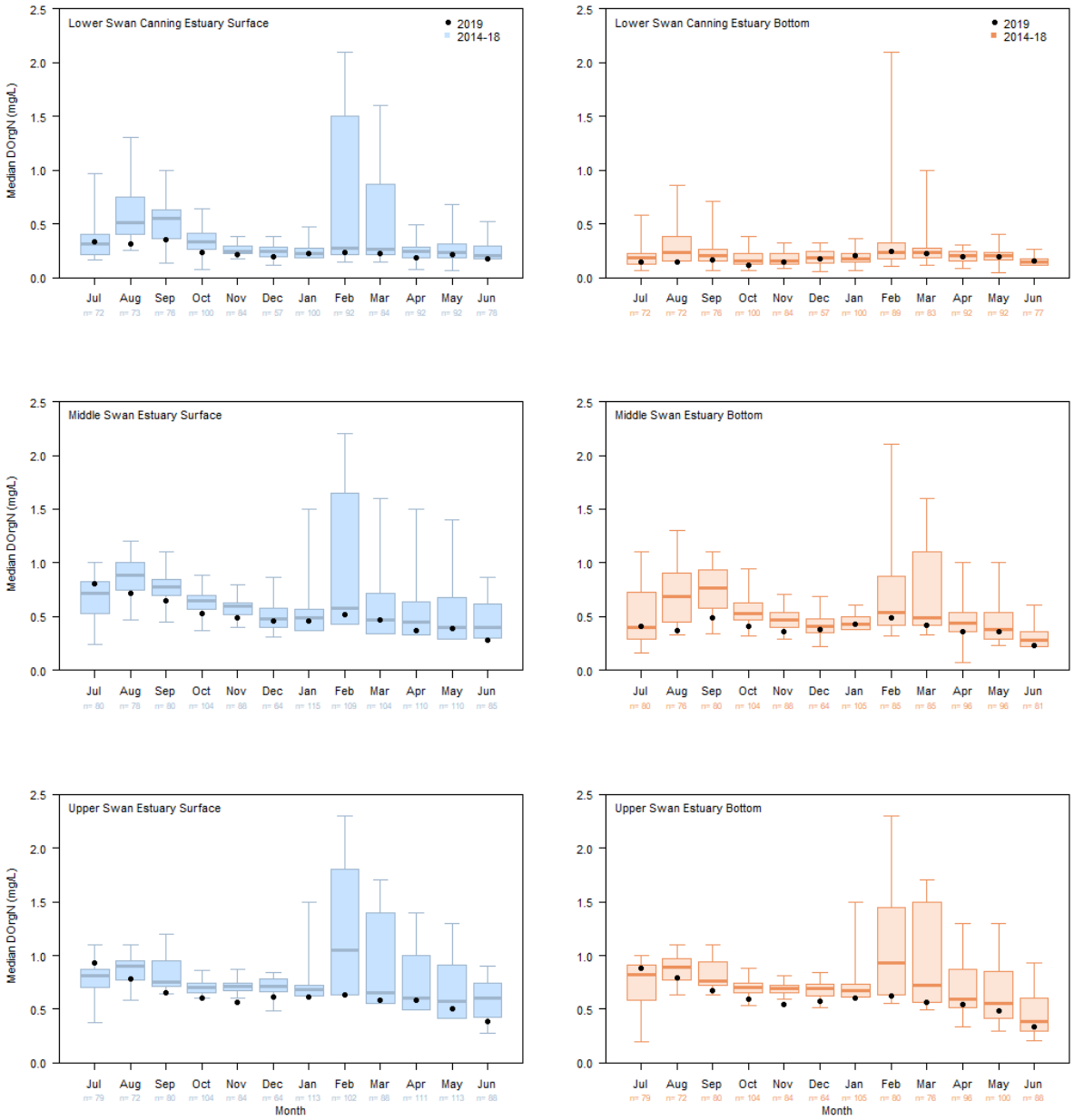


Figure 10 Median dissolved organic nitrogen (DOrgN) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median DOrgN data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

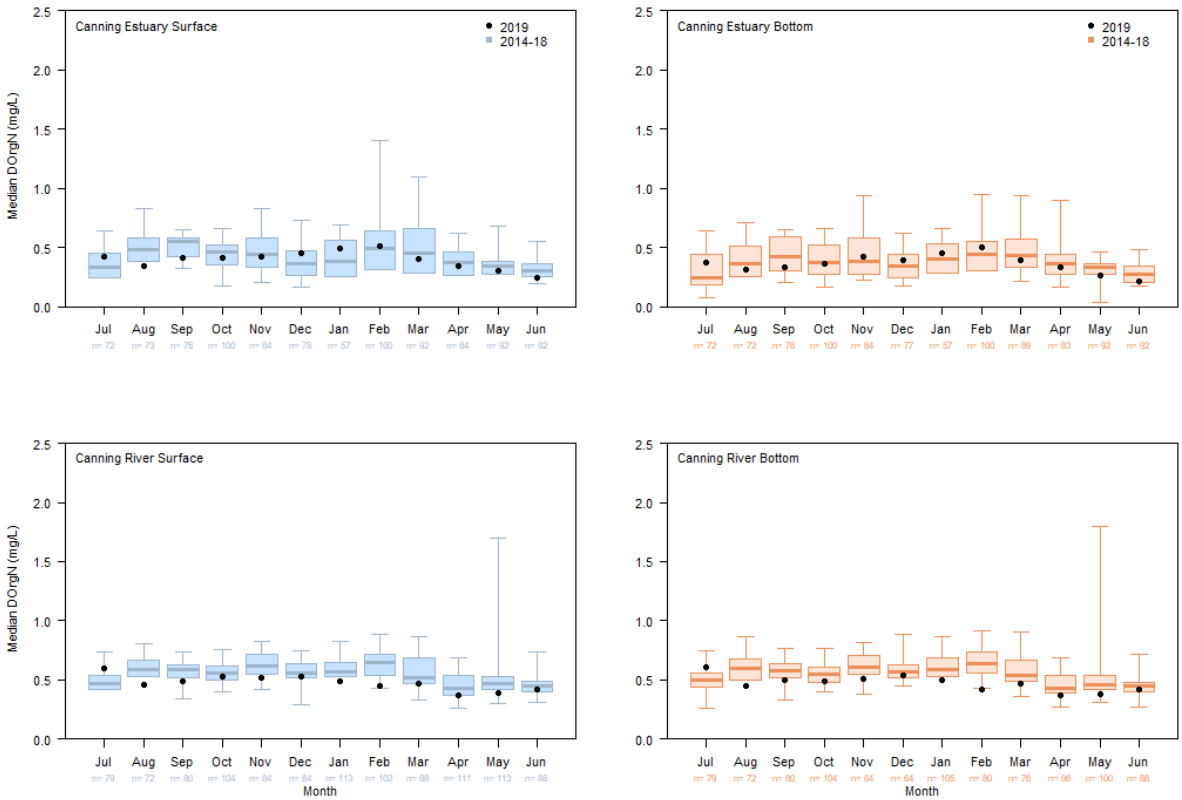


Figure 11 Median dissolved organic nitrogen (DOrgN) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median DOrgN data in the Canning Estuary and Lower Canning River.

8. Total phosphorus analysis

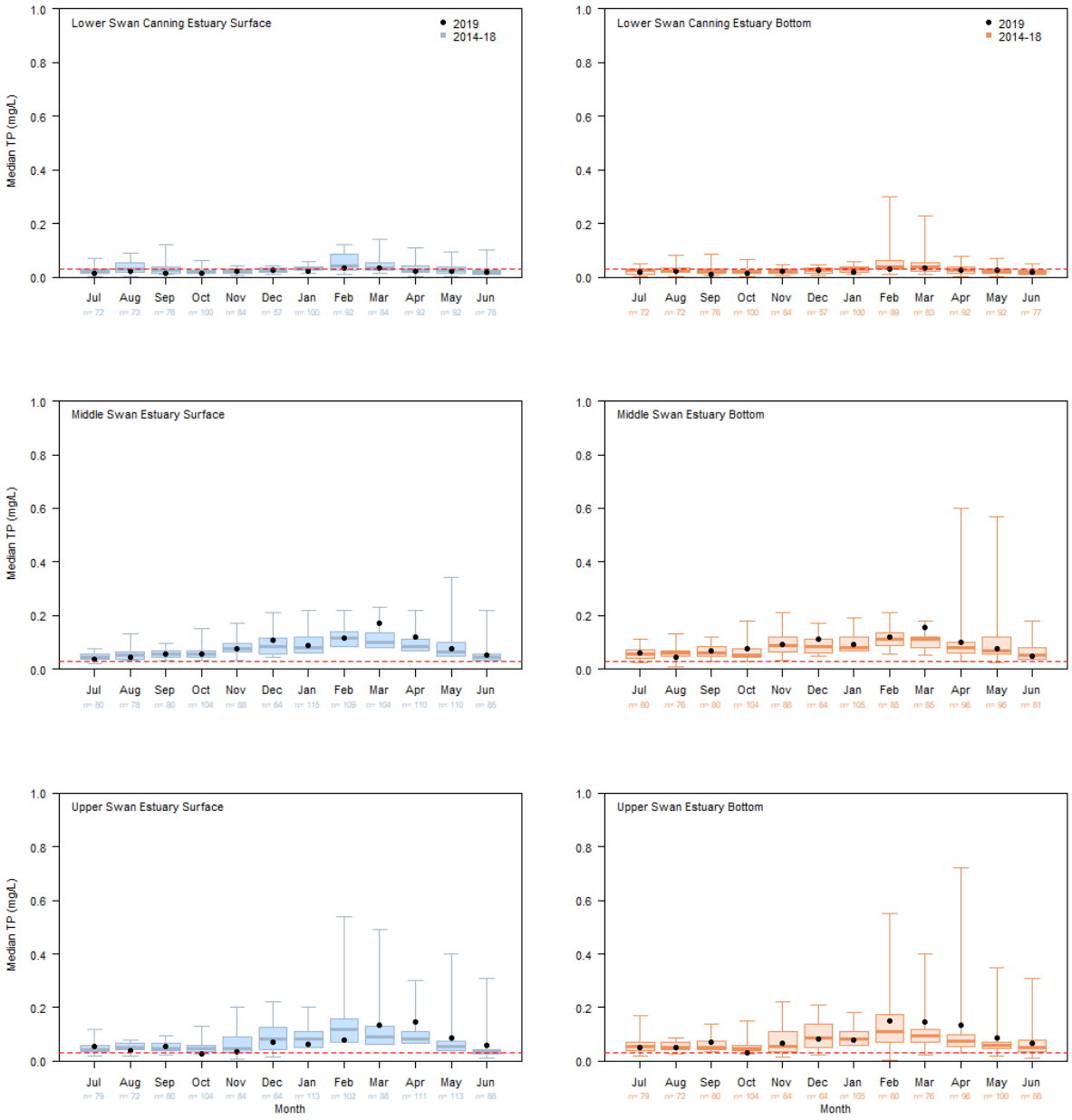


Figure 12 Median total phosphorus (TP) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014- June 2018) median TP data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary and the ANZECC trigger level (0.03 mg/L) for Estuaries.

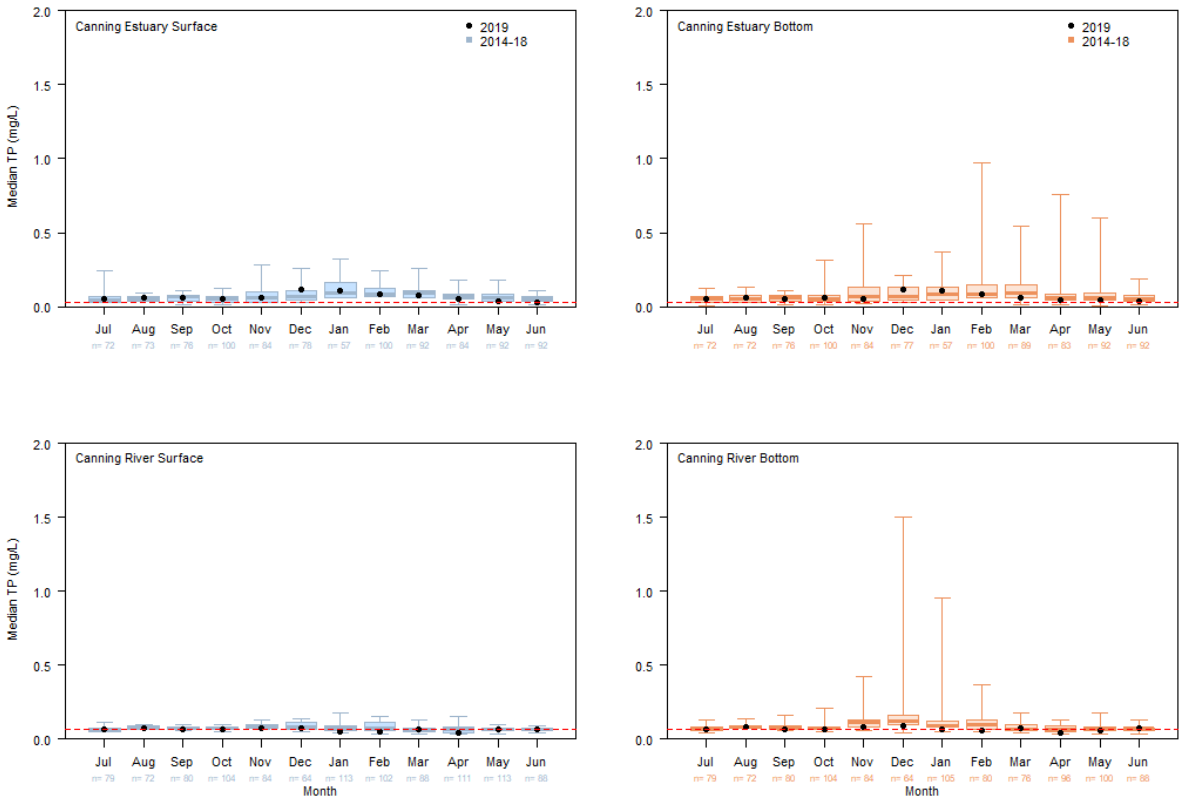


Figure 13 Median total phosphorus (TP) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median TP data in the Canning Estuary and Lower Canning River and the ANZECC trigger values (0.03 mg/L for the Canning Estuary and 0.065 mg/L for the Lower Canning River).

9. Filterable reactive phosphorus analysis

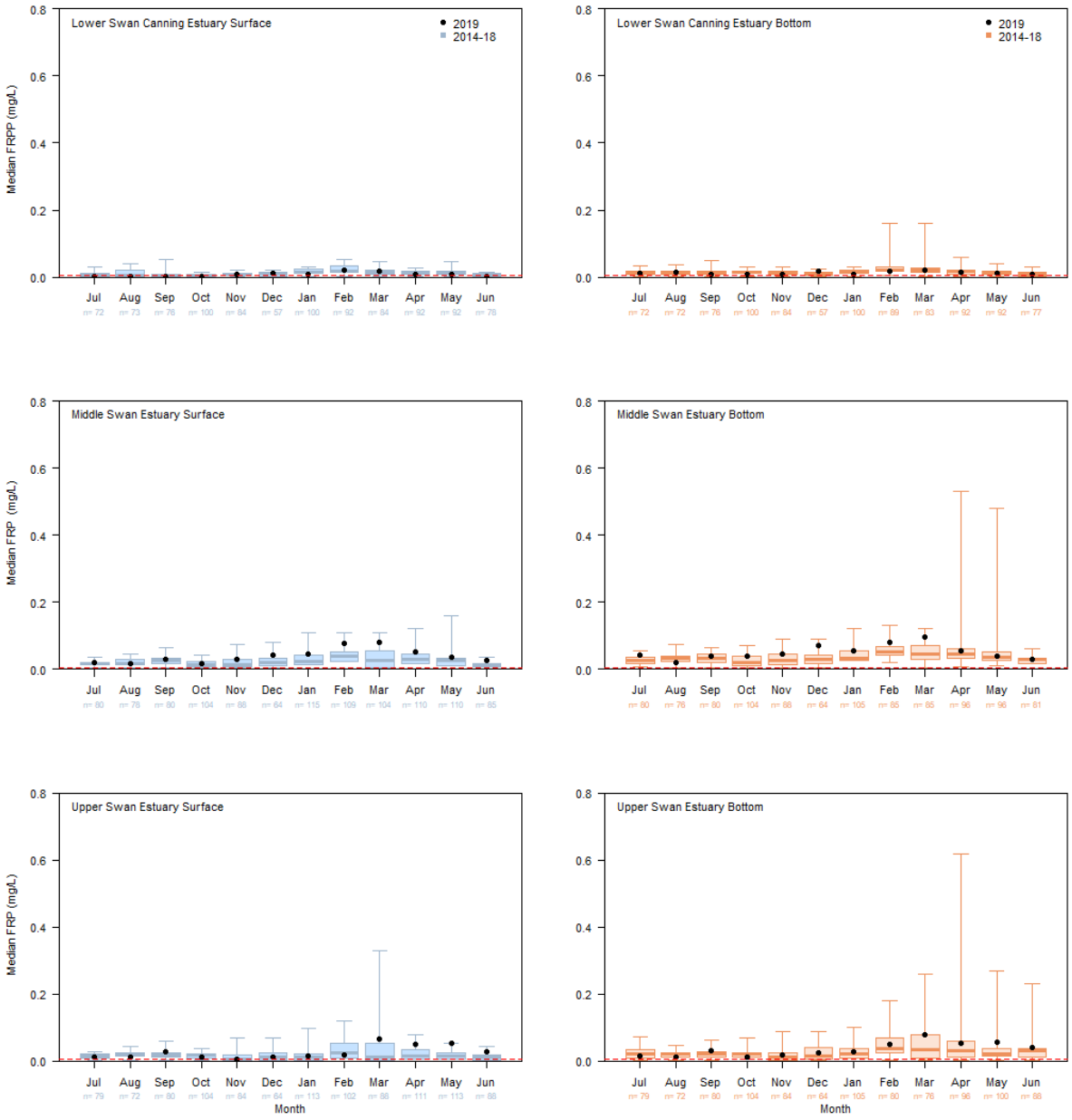


Figure 14 Median filterable reactive phosphorus (FRP) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median FRP data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary and the ANZECC trigger value (0.005 mg/L) for Estuaries.

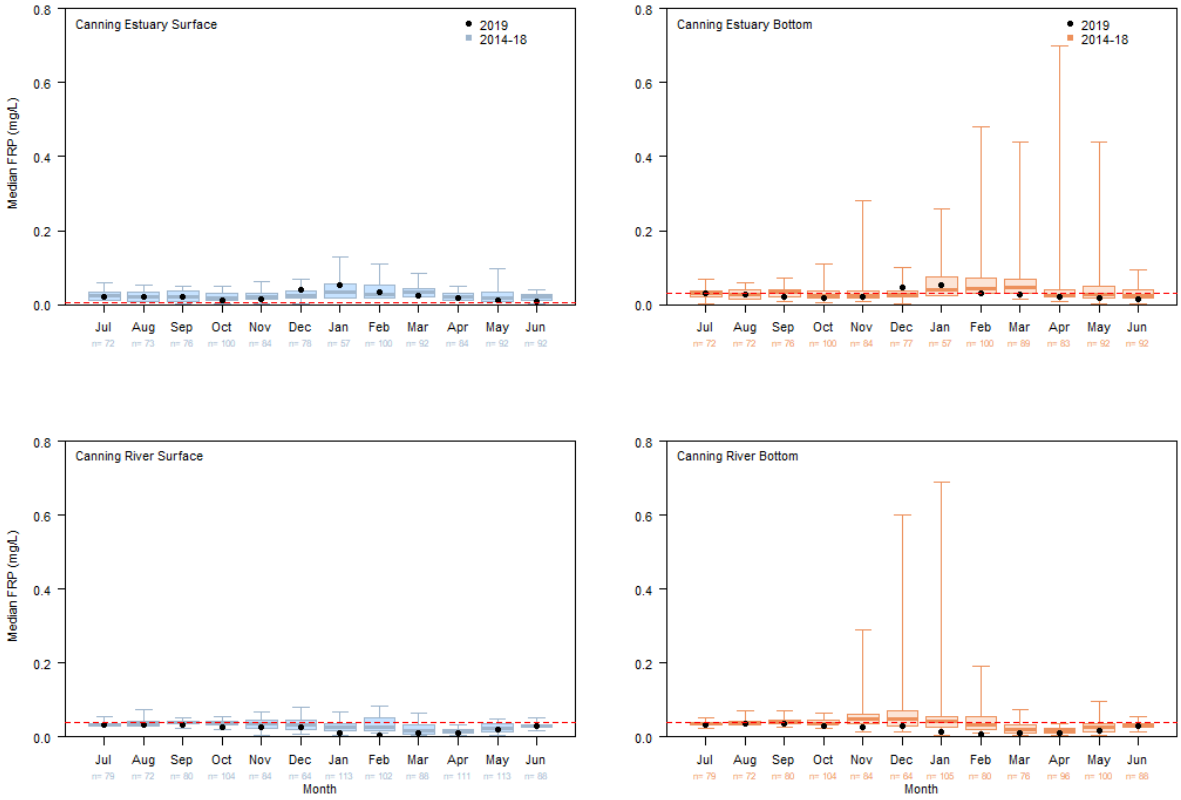


Figure 15 Median filterable reactive phosphorus (FRP) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median FRP data in the Canning Estuary and Lower Canning River and the ANZECC trigger values (0.005 mg/L for the Canning Estuary and 0.04 mg/L for the Lower Canning River).

10. Soluble reactive silica analysis

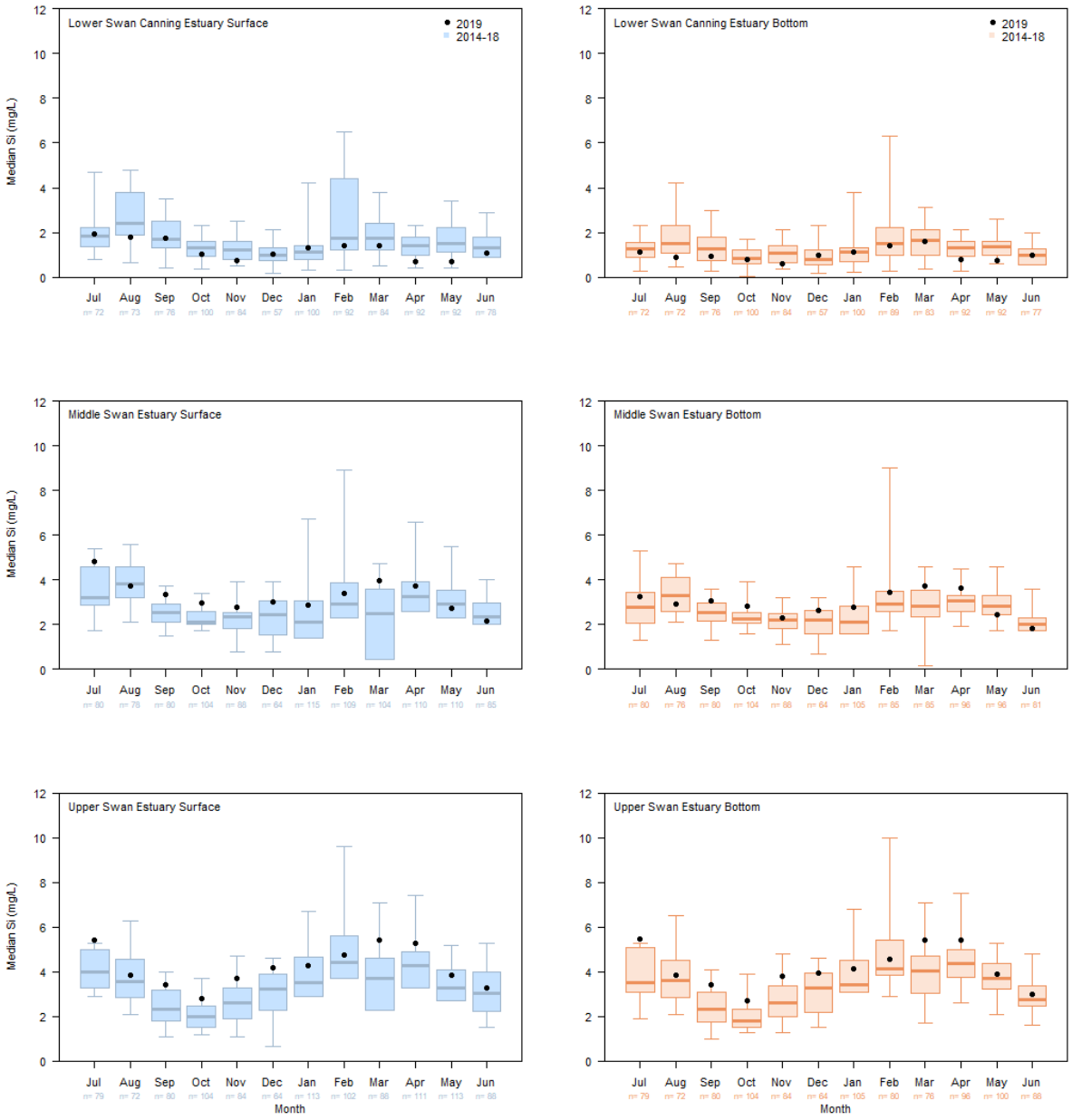


Figure 16 Median soluble reactive silica (Si) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median Si data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

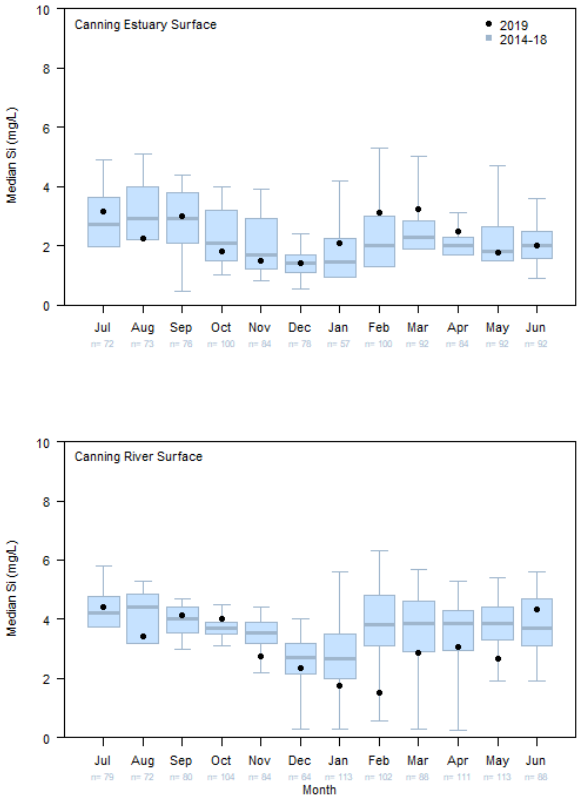


Figure 17 Median soluble reactive silica (Si) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median Si data in the Canning Estuary and Lower Canning River.

11. Dissolved organic carbon analysis

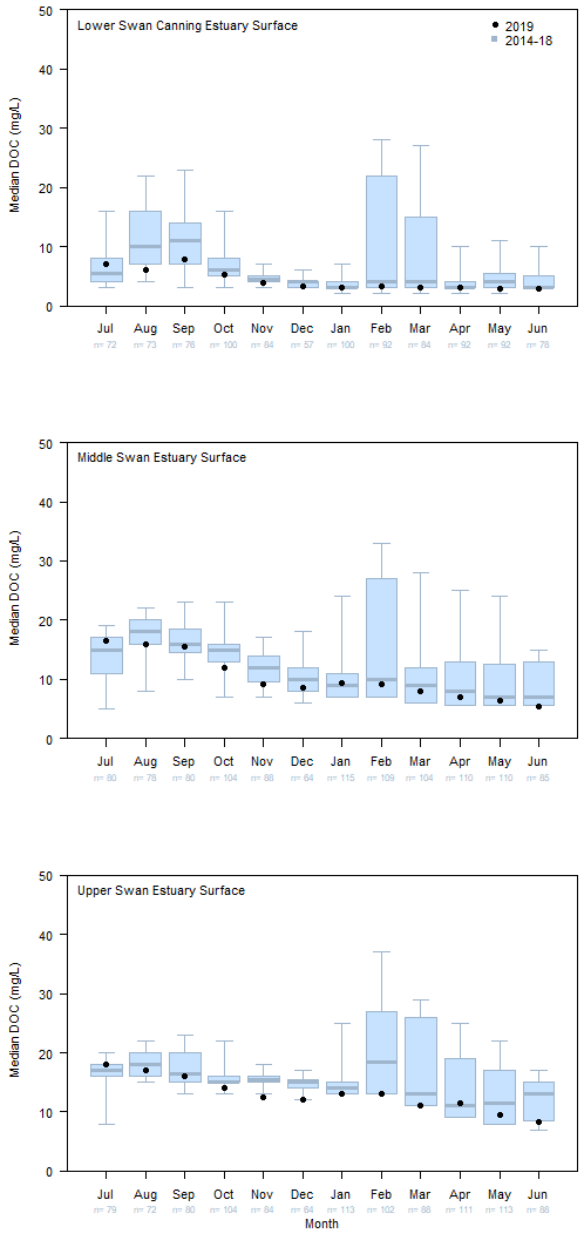


Figure 18 Median dissolved organic carbon (DOC) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median DOC data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

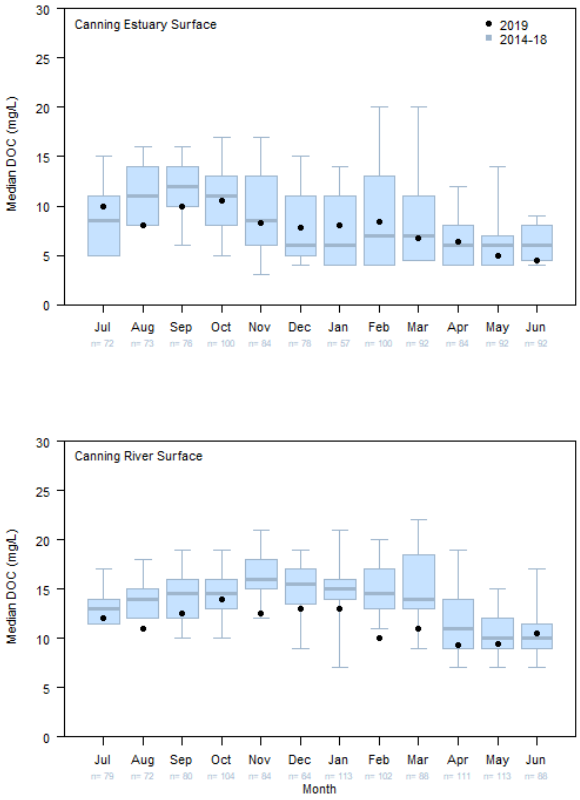


Figure 19 Median dissolved organic carbon (DOC) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median DOC data in the Canning Estuary and Lower Canning River.

12. Total suspended solids analysis

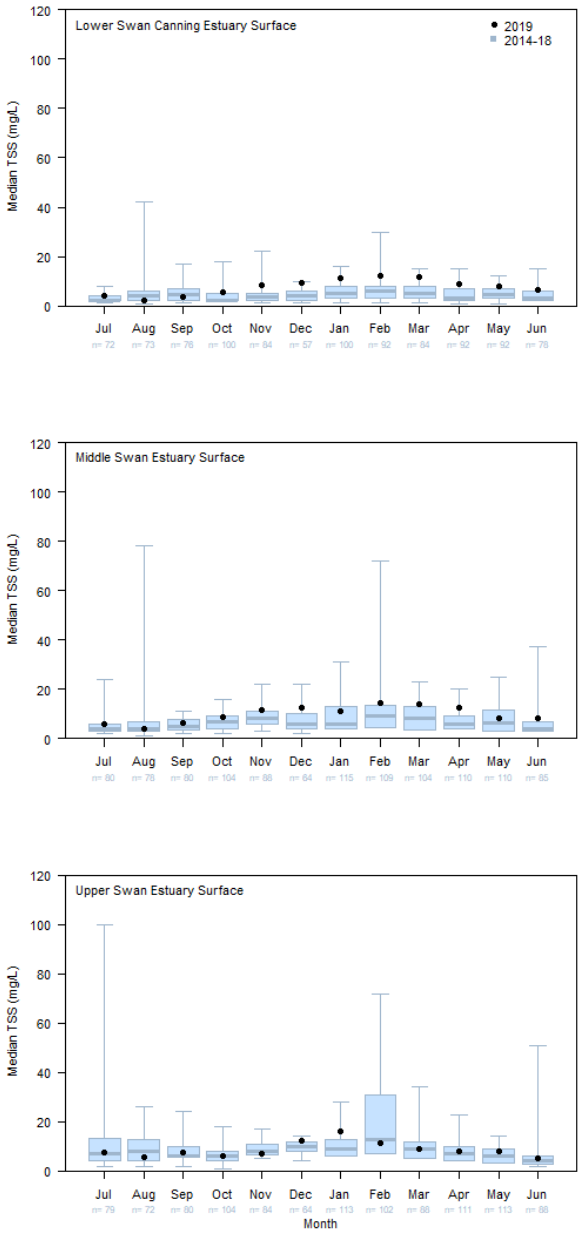


Figure 20 Median total suspended solids (TSS) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median TSS data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

13. Alkalinity (total $CaCO_3$) analysis

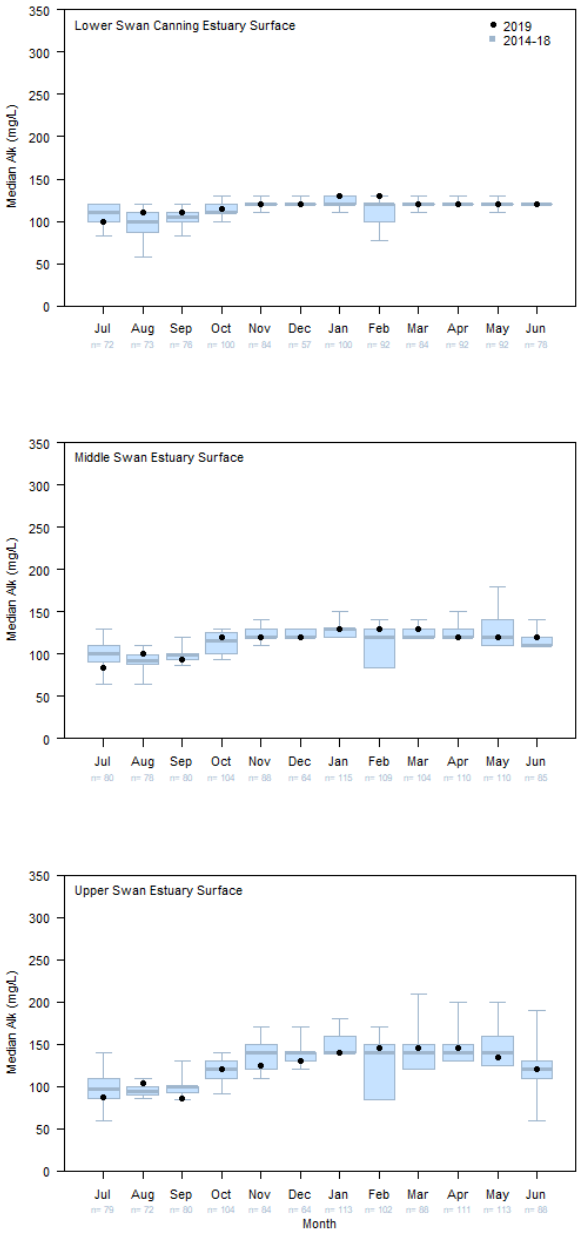


Figure 21 Median alkalinity (total CaCO3) (ALK) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median ALK data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

14. Chlorophyll *a* analysis

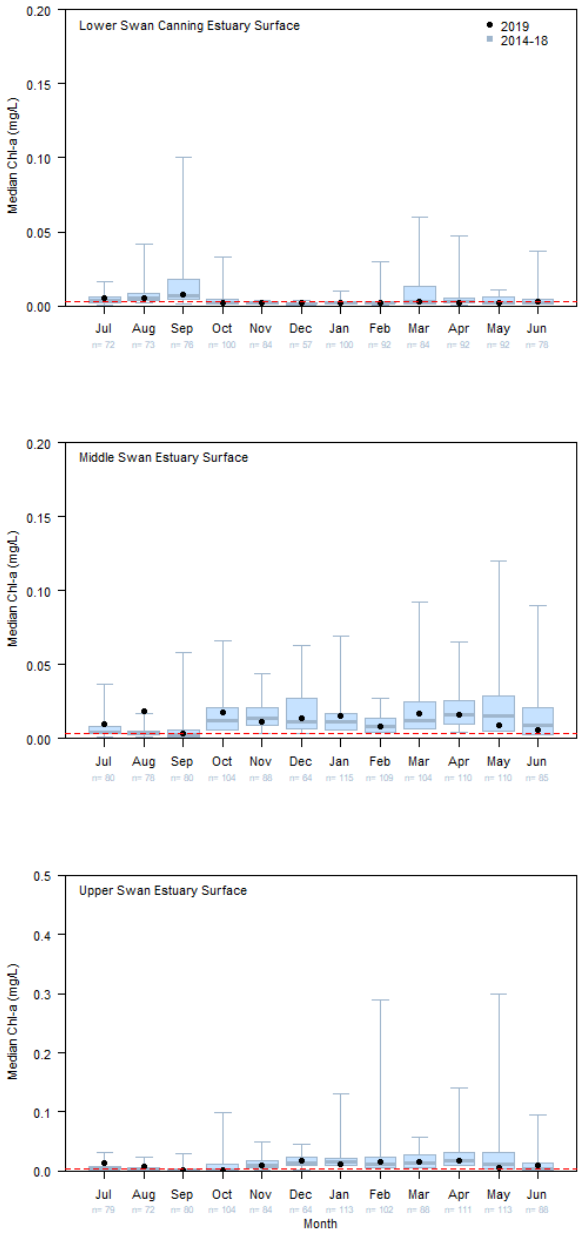


Figure 22 Median chlorophyll a (Chl-a) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median Chl-a data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary and the ANZECC trigger value (0.003 mg/L) for Estuaries. Note the y-axis scaling differs for the Upper Swan Estuary.

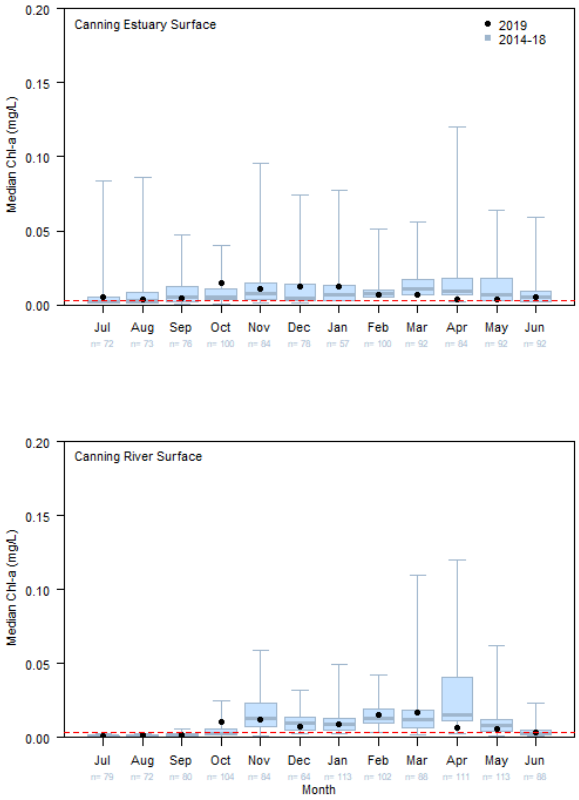


Figure 23 Median chlorophyll a (Chl-a) (mg/L) for the 2019-20 reporting period in surface waters over the historic (July 2014 - June 2018) median Chl-a data in the Canning Estuary and Lower Canning River and the ANZECC trigger value (0.003 mg/L) for Estuaries and lowland rivers.

15. Dissolved oxygen analysis

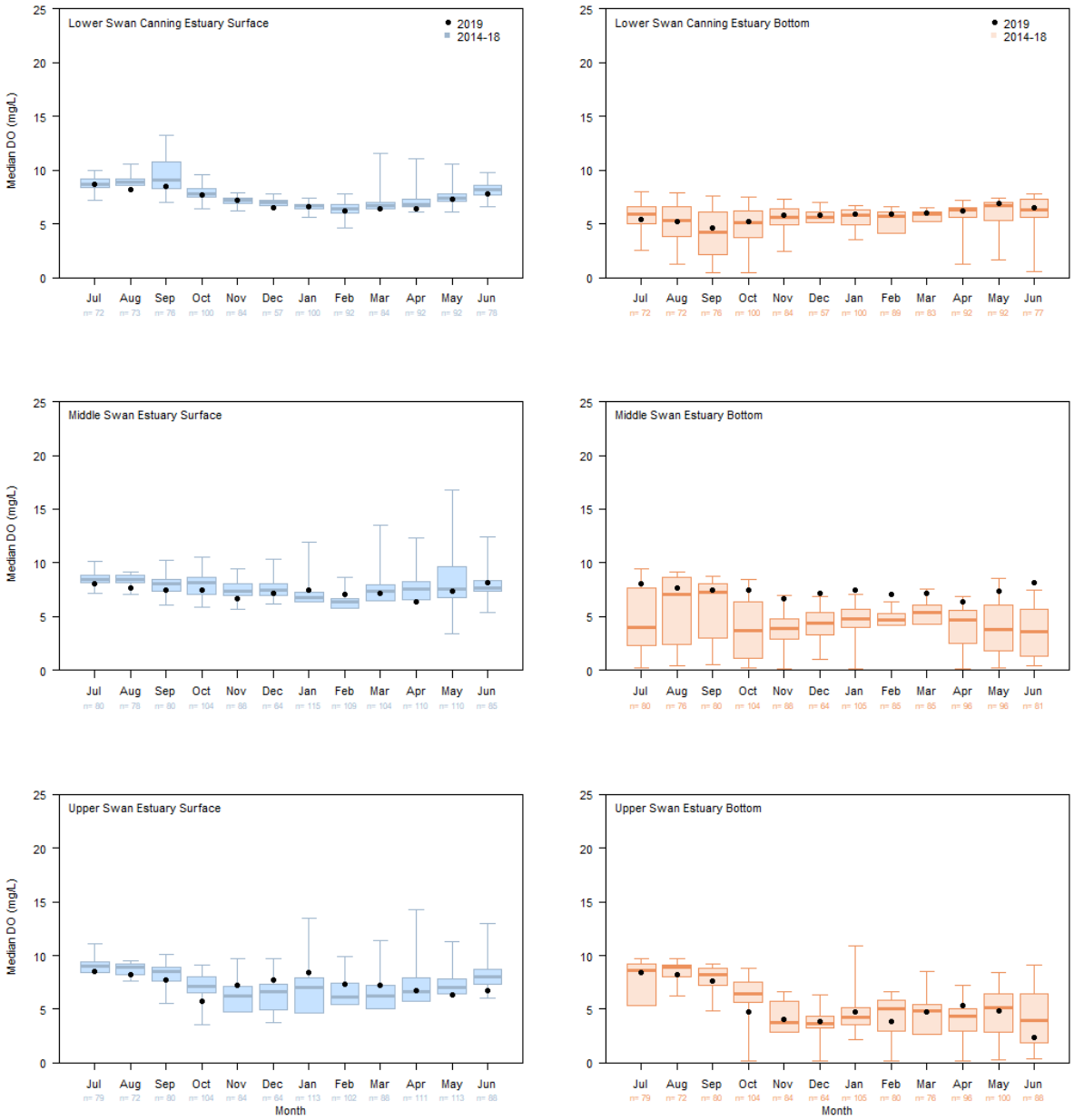


Figure 24 Median dissolved oxygen (DO) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median DO data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

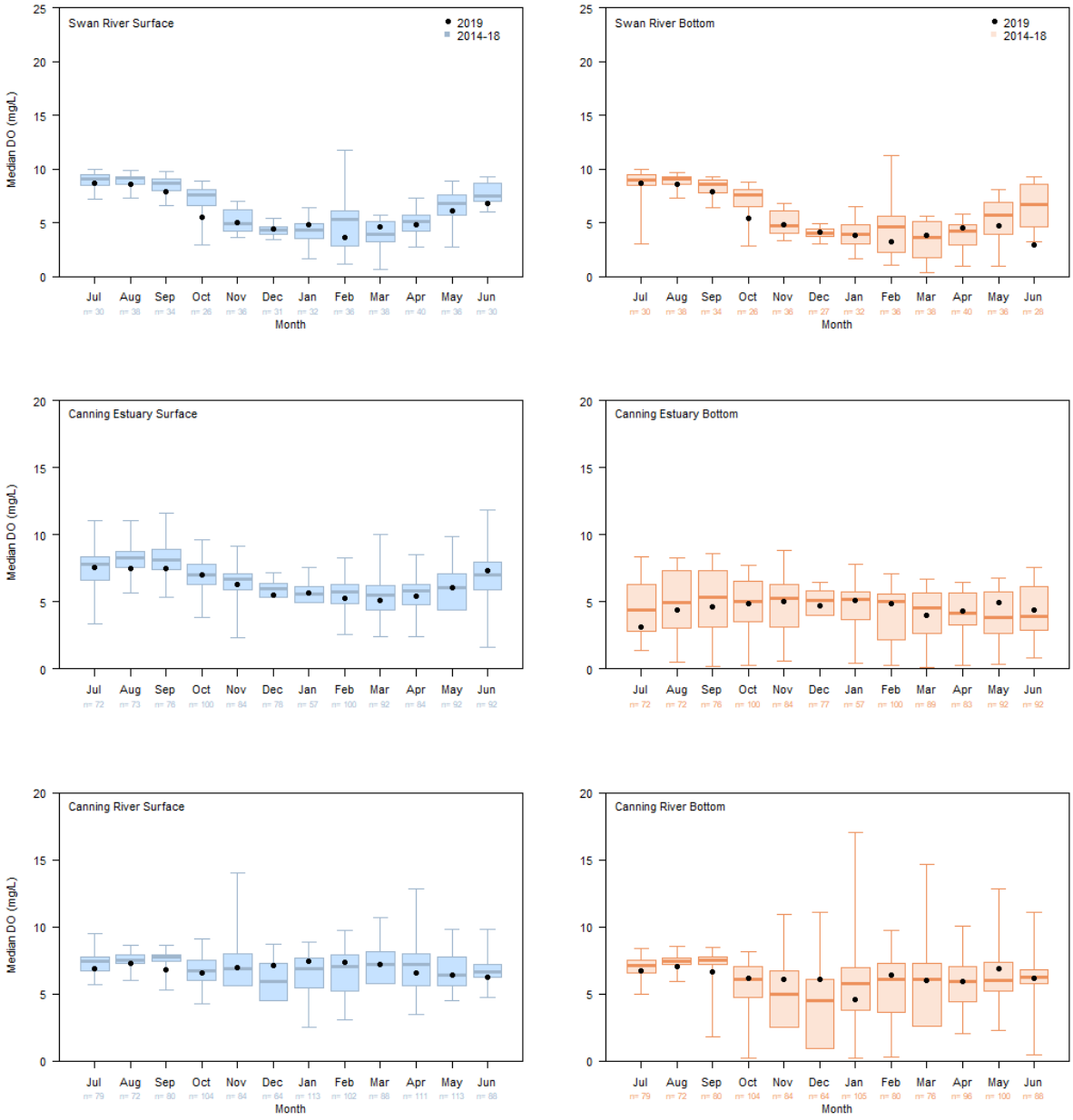


Figure 25 Median dissolved oxygen (DO) (mg/L) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median DO data in the Swan River (top left and top right), Canning Estuary (middle left and middle right) and Lower Canning River (bottom left and bottom right).

16. Specific conductivity analysis

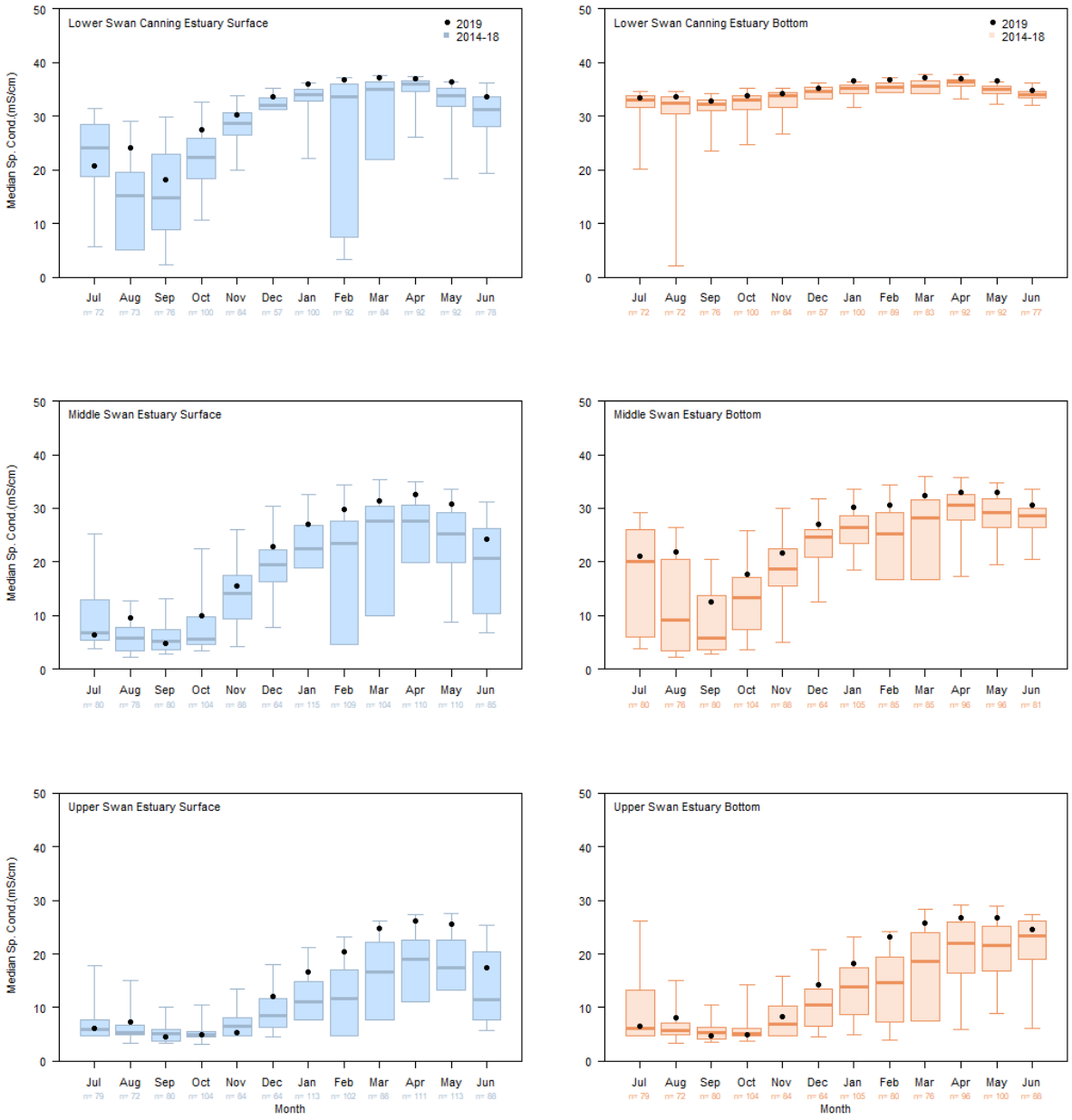


Figure 26 Median specific conductivity (Sp. Cond.) (mS/cm) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median Sp. Cond. data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

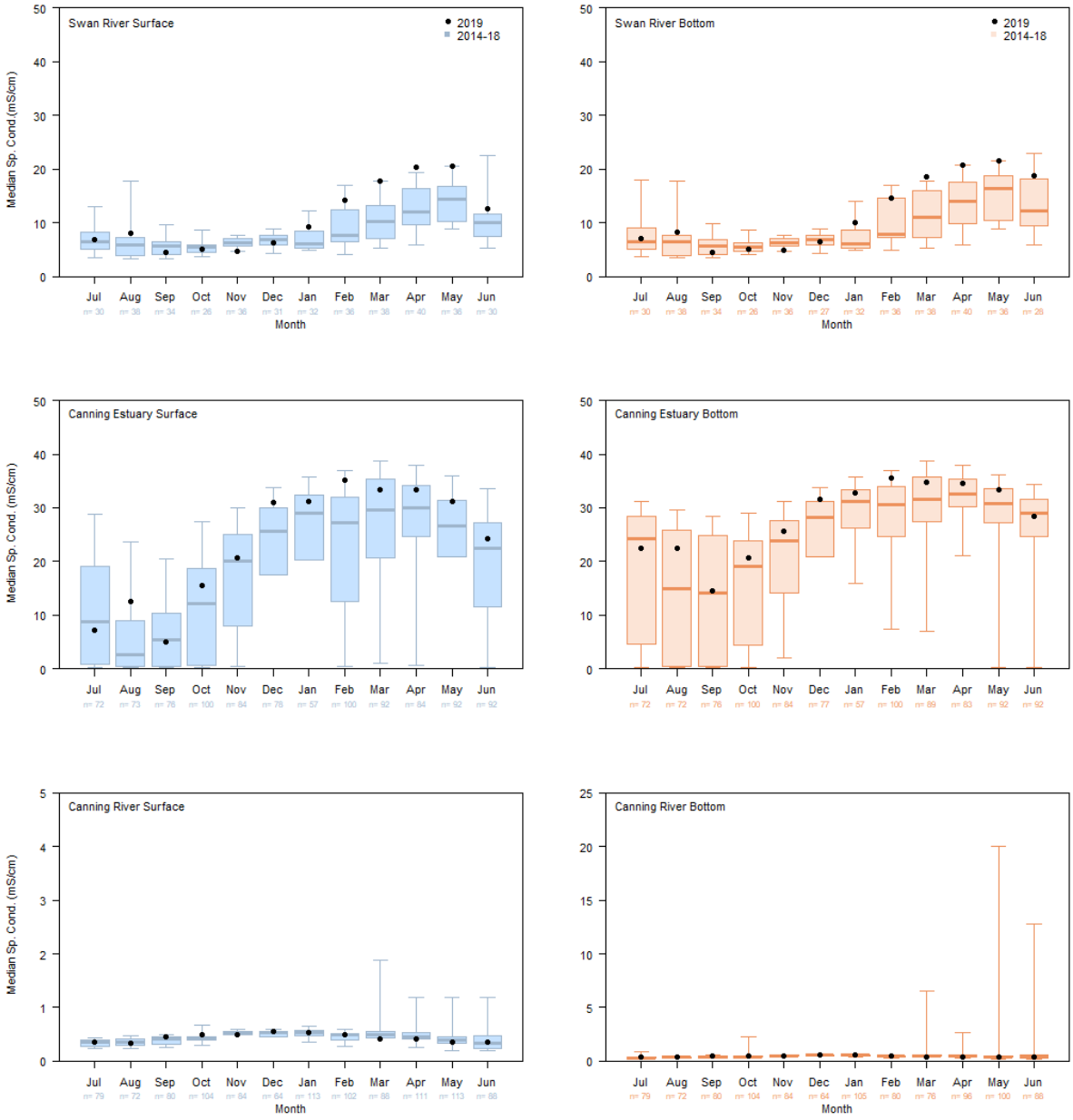


Figure 27 Median specific conductivity (Sp. Cond.) (mS/cm) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median Sp. Cond. data in the Swan River (top left and top right), Canning Estuary (middle left and middle right) and Lower Canning River (bottom left and bottom right). Note the y-axis scaling differs for the Canning River.

17. Temperature analysis

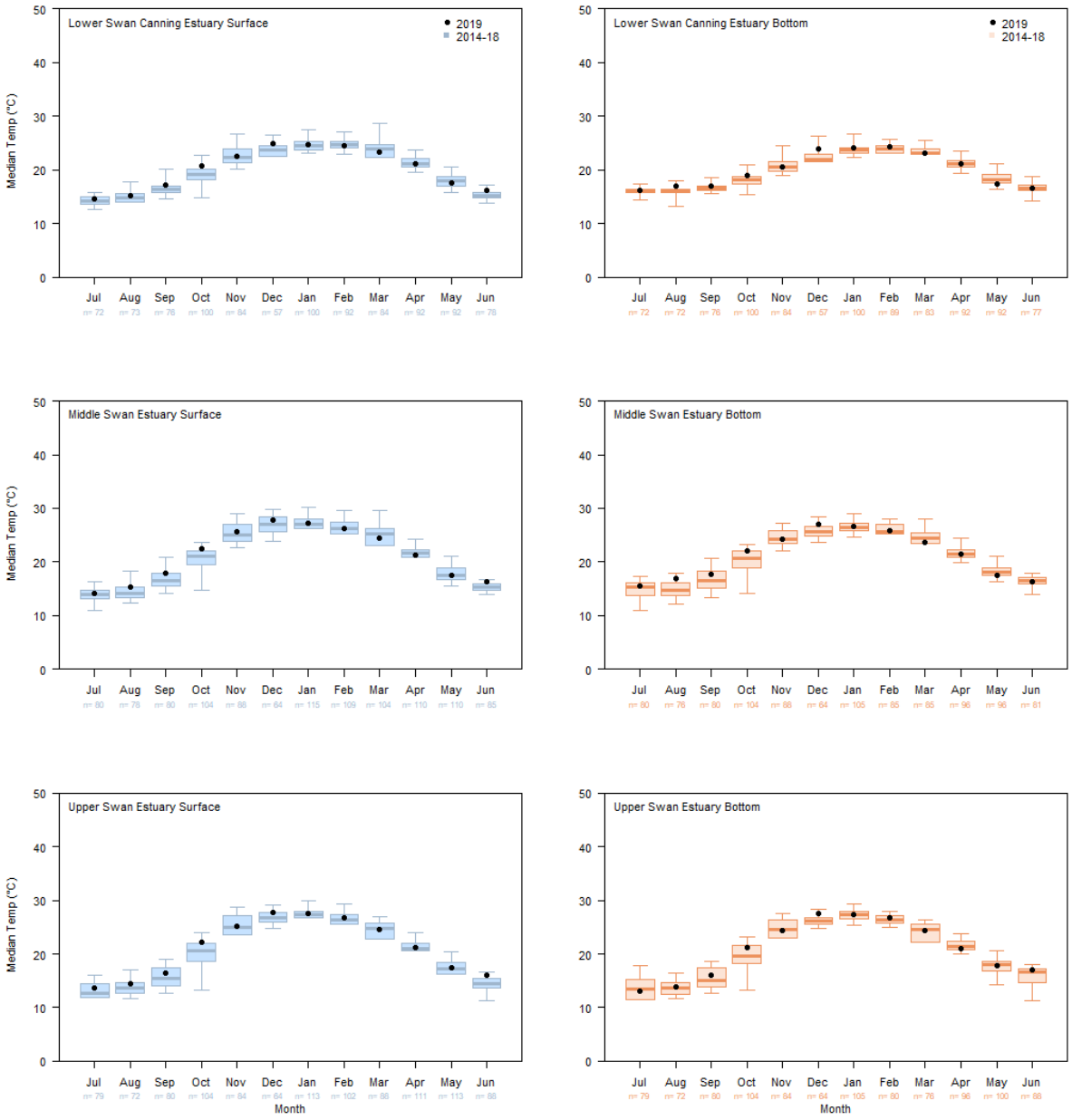


Figure 28 Median temperature (Temp °C) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median Temp °C data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary.

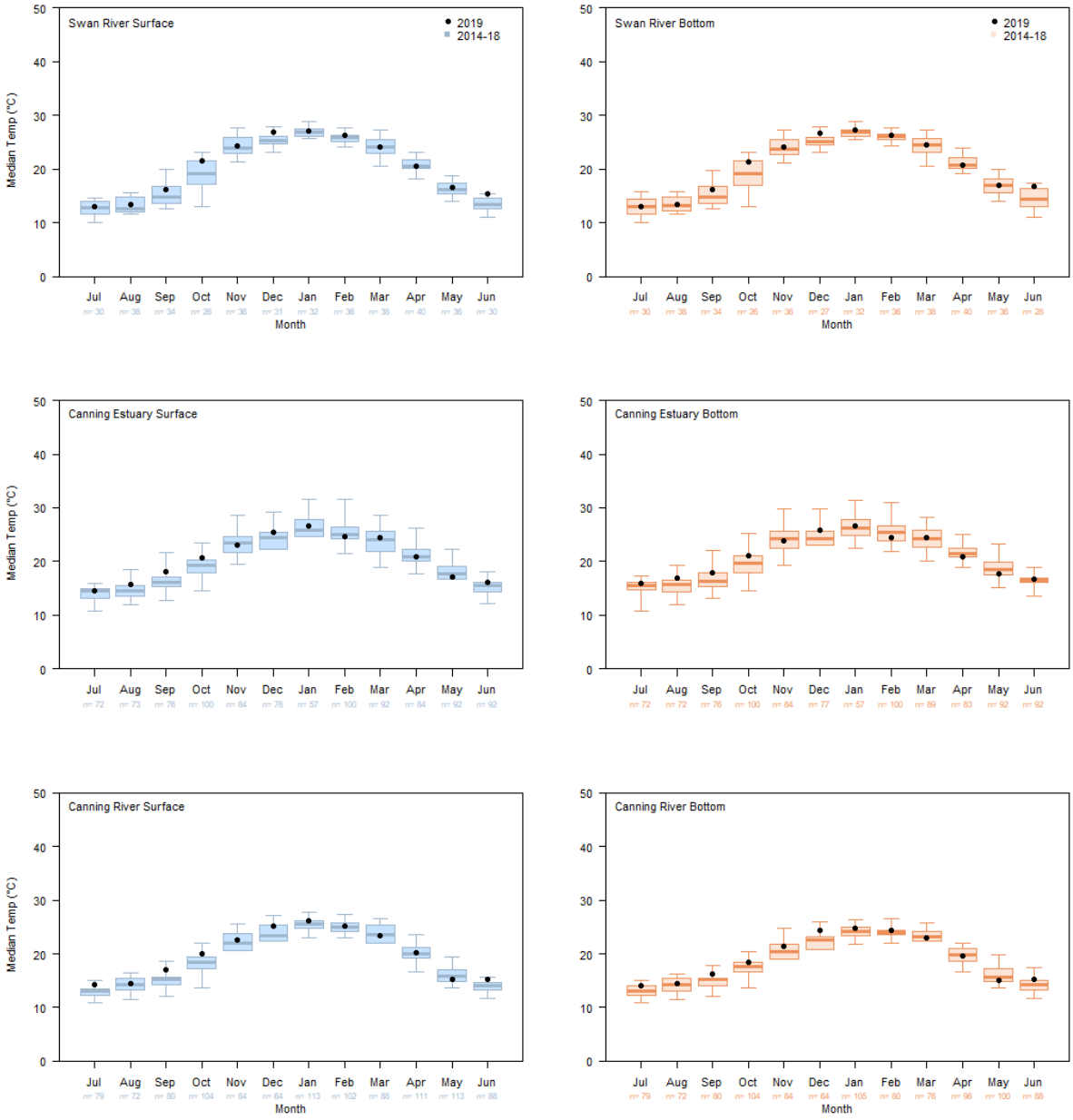


Figure 29 Median temperature (Temp °C) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median Temp °C data in the Swan River (top left and top right), Canning Estuary (middle left and middle right) and Lower Canning River (bottom left and bottom right).

18. pH analysis

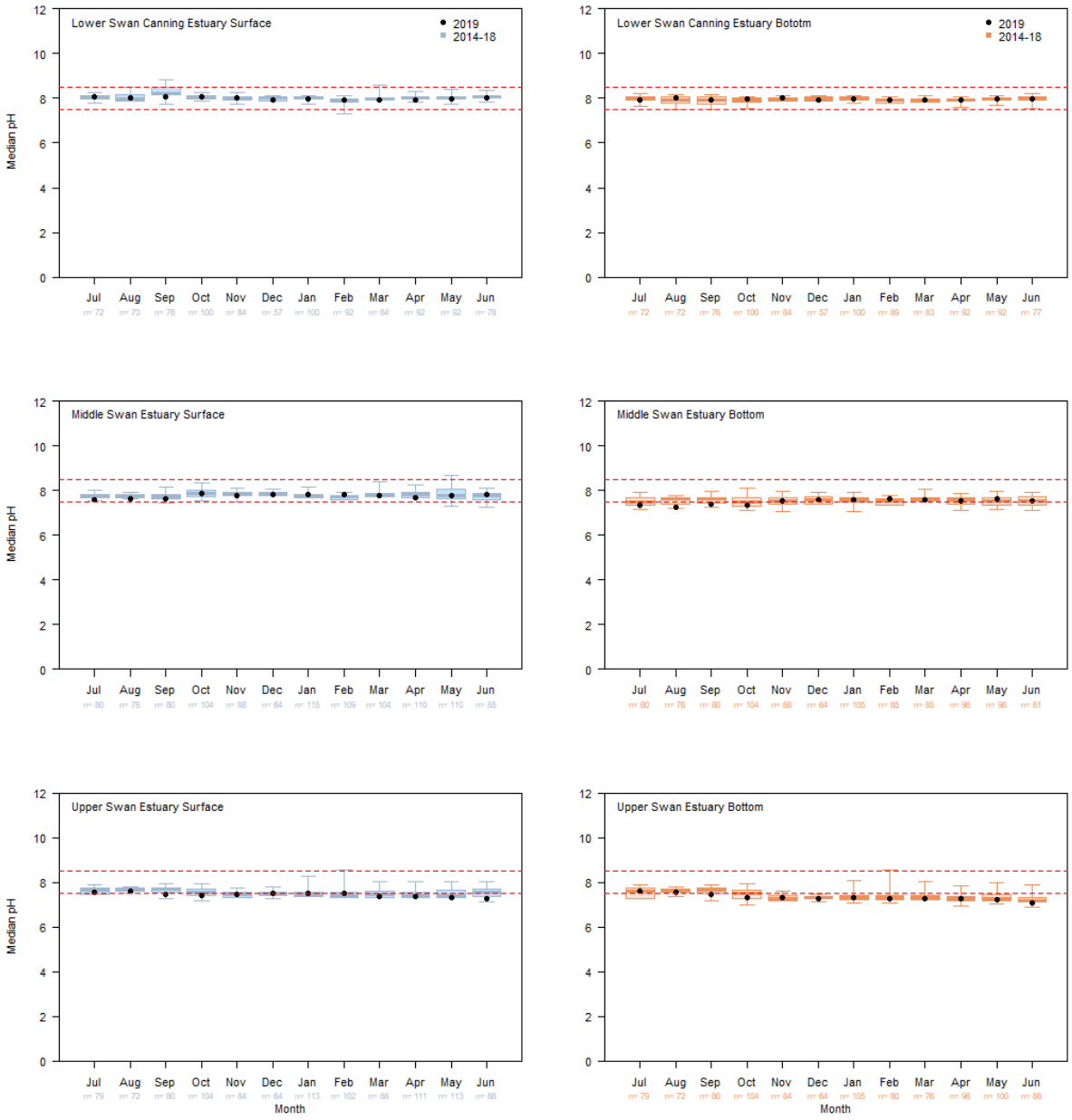


Figure 30 Median pH (in-situ) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median pH data in the Lower Swan, Middle Swan Estuary and Upper Swan Estuary and ANZECC upper and lower trigger values (7.5-8.5) for estuaries.

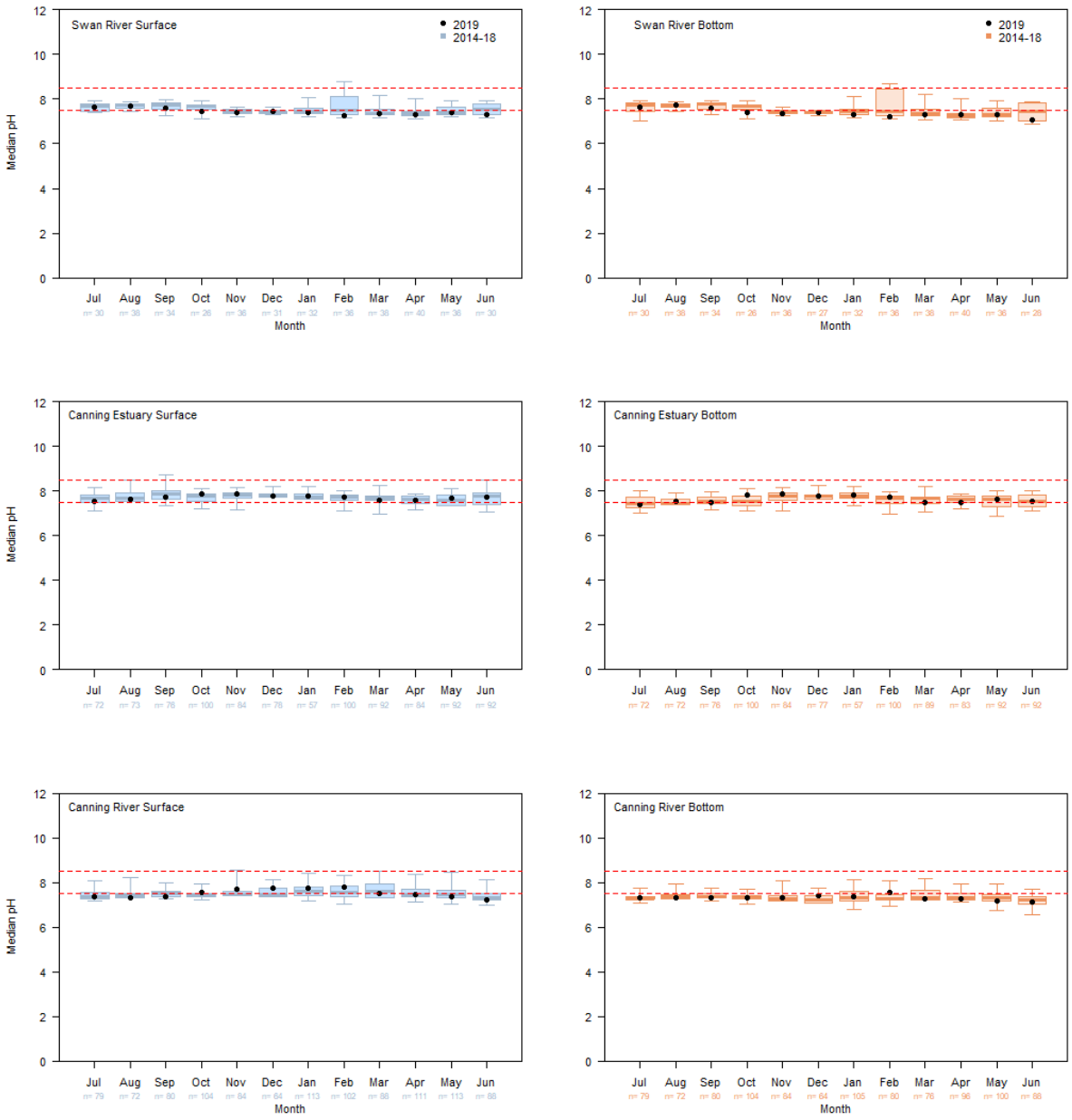


Figure 31 Median pH (in situ) for the 2019-20 reporting period in surface and bottom waters over the historic (July 2014 - June 2018) median pH data in the Swan River (top left and top right), Canning Estuary (middle left and middle right) and Lower Canning River (bottom left and bottom right) and ANZECC upper and lower trigger values (7.5 – 8.5) for estuaries.

19. Secchi depth analysis

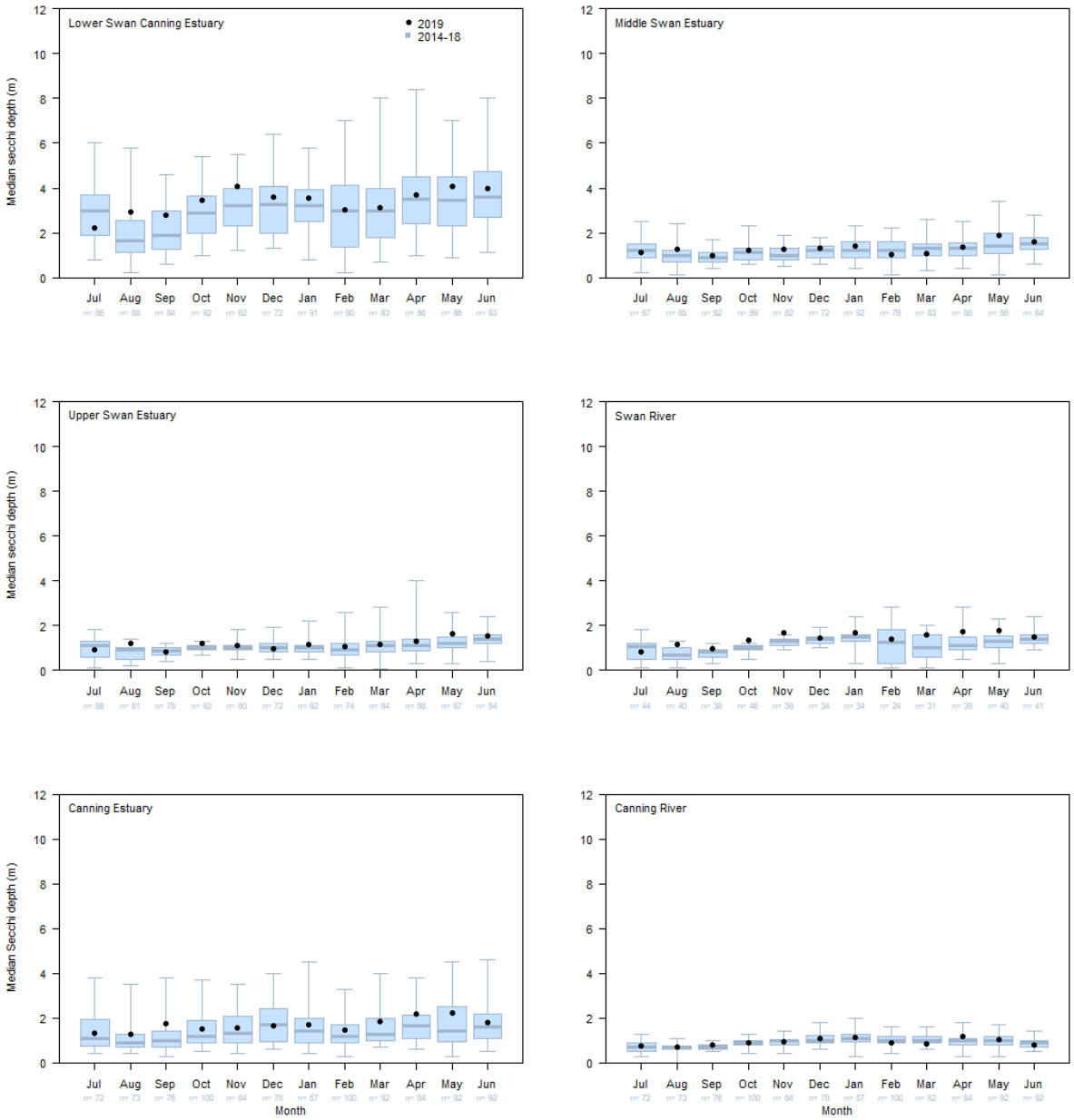


Figure 32 Median secchi depth (m) for the 2019-20 reporting period over the historic (July 2014 - June 2018) median pH data in the Lower Swan Canning Estuary (top left), Middle Swan Estuary (top right), Upper Swan Estuary (middle left), Swan River (middle right), Canning Estuary (bottom left) and Lower Canning River (bottom right).

20. Key phytoplankton observations

20.1 Swan Estuary phytoplankton

Recent historical patterns in total phytoplankton density, represented here as July 2012 – June 2019 background data, show differing activity periods in each of the EMZs (Figure 33). Lower Swan Canning Estuary peak densities and variability are observed in August – October, when diatoms become abundant as flows and run-off alleviate silicate limitation and additional macronutrients are available. The Lower Swan Canning Estuary is not as impacted by tannin staining and suspended solids as other the EMZ's and light limitation is not as significant at this time of the year. The Middle Swan Estuary typically experiences peak phytoplankton densities in summer, however extremes have occurred in July-August (*Karlodinium* dinoflagellate bloom in 2012) and March. The latter extreme was largely due to diatom and chlorophyte influence in the aftermath of the February 2017 flood event. The median background phytoplankton data in the Upper Swan Estuary shows less pattern throughout the year, being more easily impacted by recent weather conditions, however a slight peak is seen in March. Extreme events have been observed in the Upper Swan Estuary in November 2017 (due to a chlorophyte bloom possibly linked to median October water temperatures being well above the historical average) and February-March 2016 (due to a combined dinoflagellate / cyanobacteria bloom).

The overall phytoplankton activity for the 2019-20 reporting period in the Swan River Estuary appeared within range of the background 2012-13 to 2018-19 data (Figure 33) except for a peak in mean cell density in the Lower Swan Canning Estuary in July.

The July peak in the Lower Swan Canning Estuary exceeded the 90th percentile of the background data for this month however this peak in cell densities (Figure 33), largely due to the diatoms *Skeletonema* spp. (Figure 35), was not matched by a similar peak in chl-a concentrations (Figure 22). While diatom growth was likely encouraged by good rainfall on 23-28 June 2019 (Figure 3) bringing nutrients, including silicates, into the system, the cells were small and the July peak was therefore of lesser biological significance than densities alone would suggest.

Mean cell densities in the Lower Swan Canning Estuary remained within the range of the background data for the rest of the reporting period, with subsequent peaks in October, between January and February and then again in June. The October, January and February peaks were also attributable to increased cell densities of diatoms, being dominated by *Skeletonema costatum.* To a lesser extent, mean cryptopyhte cell density was attributable to the peaks in July, October, January and February, but played a more dominant role in the June peak.

Middle Swan Estuary peak mean cell densities occurred in October and June, while August densities were also higher than typical for that month (Figure 33). The August anomaly was likely attributable to a peak in cell density of *Pyramimonas* spp. (Chlorophyta) at the STJ monitoring site, equalling 17,069 cells/mL. These motile species yielding higher than normal surface chlorophyll values (Figure 22). The October peak in total cell density was associated with a peak in cell density of

Pseudopedinella sp. (Ochrophyta; Dictyochophyceae) at 16,210 cells/mL at the STJ monitoring site and *Karlodinium* sp. (Miozoa, Dinophyceae) at 9,696 cells/mL at the NIL monitoring site. This higher cell density yielded similar average surface chlorophyll *a* concentrations to those observed in August. Although October chlorophyll *a* was not as far above the historical median because during this time the salt-wedge propagates through the Middle Swan Estuary (Figure 26). The arrival of the salt wedge results in rapidly increasing water temperatures (Figure 28) and increased light levels (bom.gov.au). Historically, this elevated activity lasts until May/June, when water temperatures drop below October values (22.5 ^{o}C) and fresh water flow significantly influences the Middle Swan Estuary. The peak at the end of the reporting period in June was due to densities of *Heterosigma akashiwo* (Ochrophyta, Raphidophyceae) reaching 12,044 cells/mL at the STJ monitoring site and of cryptophyte species peaking at 9,191 cells/mL at the NIL monitoring site. This peak was not reflected in the surface chlorophyll data (Figure 22) as phytoplankton was likely less abundant in the colder, fresher surface waters compared to near the halocline in the middle of the water column. Despite being a drier than average end to the reporting period (Figure 2), the early rainfall events in April, May and June in the 2019-20 period (Figure 3) may have contributed to lower mean cell density data than the background data. Early inputs to the system may have increased the availability of nutrients, such as silica (Figure 16), that make conditions favourable for the cryptophytes, *Pyramimonas* chlorophytes and *Skeletonema* diatoms that were prevalent at this time.

Mean total cell densities within the Upper Swan Estuary appeared to peak between July and August and then again in April (Figure 33 & 35). The July peak was likely influenced by a peak (20,200 cells/mL) in the diatom species *Cylindrotheca closterium* at the MSB monitoring site. At the same site in August, cell densities of the diatom species belonging to the genus *Cyclotella* peaked at 21,513 cells/mL. Both of these peaks are likely a result of significant nutrient inputs during the large flow events at this time. The peak in April (Figure 33) was a result of cell densities of *Karlodinium* spp. reaching 16,513 cells/mL at WMP and 18,962 cells/mL at MSB on 14 April and 20 April, respectively. Historically, *Karlodinium* spp. have bloomed most commonly in the stratified water column conditions experienced in Autumn. In 2020 this bloom occurred, largely in the Upper Swan Estuary, from 30 March to 20 April with sharp declines in density seen on 28 April. The peak in April is earlier than those observed in the Lower Swan Canning Estuary and Middle Swan Estuary, however may be a similar response to early rainfall events where increased nutrient availability creates favourable conditions for the growth of these species before being flushed downstream.

The ratio of diatom to dinoflagellates within each of the Swan Estuary ecological management zones has been detailed in Figure 33. This ratio provides an insight into shifts in ecological state throughout the reporting period, with a low ratio (<0.5) indicating silicate limitation linked to eutrophication. Diatoms are generally considered better grazing material for zooplankton and planktivorous fish and a low diatom/dinoflagellate ratio is considered to reflect a poorer ecological status. A shift in this composition from a diatom to a dinoflagellate dominated system will indicate key periods of dinoflagellate activity and potentially blooms in HAB species. The

diatom/ dinoflagellate ratio was consistently well above 0.5 in the Lower Swan Canning Estuary (Figure 33), suggesting reasonable to good ecological condition and little silicate limitation. In the Middle Swan Estuary, the ratio dropped to low levels from October to December and then again in February. This reflected a moderate abundance of *Karlodinium* spp. and *Heterocapsa* spp. in October, November and December while diatom densities were very low and dominance alternated between others (generally *Pseudopedinella* or *Heterosigma*), cryptophytes and occasionally dinoflagellates. In February, the low ratio was largely due to the influence of the *Alexandrium* spp. bloom and diatom densities remaining low. A diatom (*Skeletonema* spp.) bloom in January and then returning elevated densities of this species in March, April, May and parts of June worked to elevate the diatom/dinoflagellate ratios from earlier lows, despite continued moderate densities of *Karlodinium* spp. in April and then a transition to *Heterocapsa rotundata* between May and June. A similar trend in the ratio of diatoms to dinoflagellates to that of the Middle Swan Estuary can be seen within the Upper Swan Estuary (Figure 33). A transition in the dominance of diatoms to dinoflagellates occurs from October and, except for January, the system remains dominated by dinoflagellates for the remainder of the reporting period. The reverse in this trend in January back to a diatom dominant system was a response to the increased presence of the diatoms *Thalassiosira* spp. and *S. costatum*.

20.2 Canning Estuary Phytoplankton

Historical patterns in total phytoplankton density, represented by July 2012 – June 2019 data, are represented as bar graphs in Figure 34 and show peak activity across the summer months of January and February for both the estuary and river. Both zones also have lowest phytoplankton mean densities from June to September. Historically, peak phytoplankton densities in the Canning Estuary, observed in October and January through to March, have primarily been a result of short-lived blooms of either of the small diatoms *Chaetoceros minimus* or *C. tenuissimus*. The March peaks are of more variable composition, with other diatoms like *Cyclotella* spp. and *Skeletonema* sp. being (co)dominant in some years. In the Lower Canning River, a mix of chlorophytes and diatoms often dominate during the summer peak in mean phytoplankton densities. The extreme values in July-August in the Canning River historical data are a result of high cyanobacteria densities (*Pseudanabaena* sp. and *Oscillatoria* spp.) recorded between late July and mid-August 2016 after heavy rains (106 mm over 10 days from 8th July) likely washed cyanobacterial into the system from the catchment.

The 2019-20 data for the Canning Estuary exhibits an increased seasonal response relative to the background data, throughout the spring and summer months, peaking in February (Figure 34). This increase in seasonality compared to the background data may be a response to a drier than average start to the reporting period (Figure 2), allowing the salt wedge to propagate further upstream and remain in that part of the system for longer (Figure 27). The change in conditions from a fresh/brackish system to a brackish/marine system may have favoured the growth of brackish/marine phytoplankton taxa. Concentrations of available nutrients also appeared to reflect this seasonal trend. Depletion of silica (Figure 17), TN (Figure 5)

and NO_x (Figure 9) occurred in October which corresponds with the first peak in mean phytoplankton cell density. This peak was the result of a spike in chrysophytes (34,946 cells/mL for mixed chrysophyte spp. at the CASMID monitoring site) and diatoms (12,372 cells/mL for *Skeletonema costatum* at the SCB2 monitoring site). This depletion in nutrient availability continues through to December where a peak in the diatom *Chaetoceros tenuissimus* occurred (22,321 cells/mL at the RIV monitoring site). Nutrient levels (Si, TN and NO_x) increase again around January coinciding with the migration of the salt wedge upstream to the Kent Street Weir (Figure 27), bringing in nutrients from marine waters and the summer and autumn rainfall events in February and March (Figure 2), washing in nutrients from the catchment. The transition of a fresh/brackish system to a brackish/marine system coincides with the January spike in dinoflagellates belonging to the genus *Karlodinium* (30,350 cells/mL at the monitoring site CASMID and detected as far downstream at the SCB2 monitoring site with 25 cells/mL; Figure 36).This transition in specific conductivity and replenishment of nutrient availability is also likely responsible for the most notable peak in mean phytoplankton cell density in February, which was largely attributable to the small diatom species *Chaetoceros minimus* (87,365 cells/mL at the CASMID monitoring site).

Seasonality is also exhibited throughout both the 2019-20 data and the background data within the Canning River (Figure 34). Mean cell densities increased throughout the spring and summer months and peaked in February. This transition may be associated with the closure of the weir in spring through to the following winter, likely resulting in an increase in water residence time, along with increasing temperatures and water clarity. The first notable peak in mean phytoplankton cell density in October was dominated by chrysophyte spp (43,430 cells/mL at the KEN monitoring site). Mean phytoplankton cell densities continued to increase to a peak in February, which was dominated by cyanophytes (25,249 cells/mL for *Anabaena* spp. at the KEN monitoring site), chrysophytes (20,301 cells/mL for mixed chrysophyte spp. at the KEN monitoring site) and diatoms (15,402 cells/mL for *Aulacoseira granulata* at the NIC monitoring site). The reduction in TN (Figure 5), NO_x (Figure 9) and Si (Figure 17) over the October-February growth period was likely due to uptake by phytoplankton.

The diatom to dinoflagellate ratio within the Canning Estuary is only considered during periods of predominantly marine influence (October – April) and is not considered for the Canning River (Figure 34). From late spring to mid-autumn there was a general trend of increasing diatom to dinoflagellate ratio, with highest ratios observed from February to April, largely due to the dominance of the diatom *Skeletonema* spp., with other diatoms such at *Thalassiosira* spp. and *Chaetoceros minimus* also having more transient density peaks. While this period could be considered to a more “ecologically functional” phytoplankton population, it should be noted that small *Cheatoceros* species, especially those with secondary spines on their setae, may cause mechanistic damage to fish gills when in moderate to high densities. The ratio was offset and quite low during January due to blooms of *Karlodinium* spp., *Alexandrium* spp. and *Heterocapsa* spp.

21. Total phytoplankton analysis

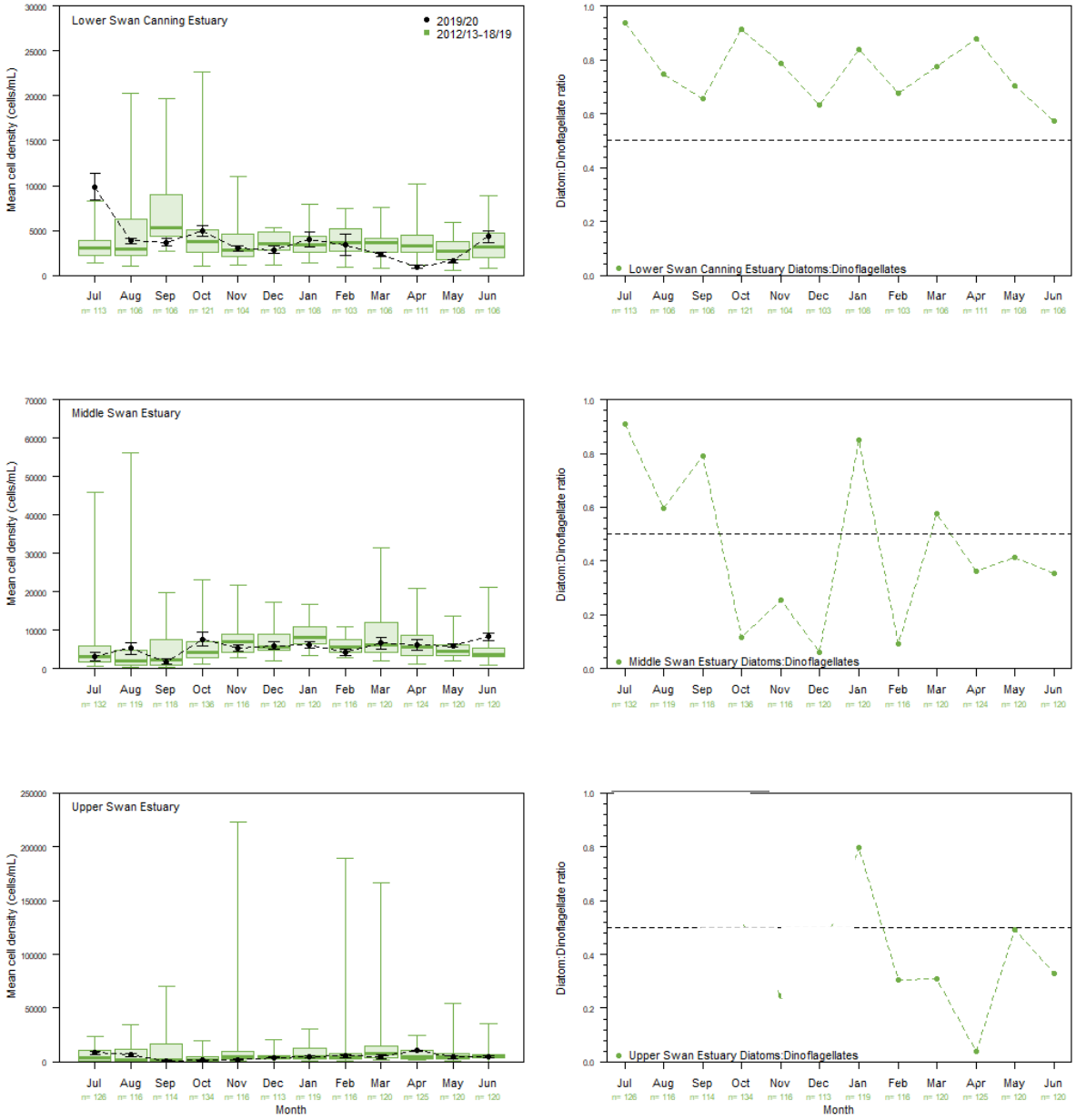


Figure 33 2019-20 mean total phytoplankton (cells/mL) over historic (July 2012 – June 2019) mean phytoplankton data in the Lower Swan Canning Estuary (top left), Middle Swan Estuary (middle left) and Upper Swan Estuary (bottom left) alongside 2019-20 diatom to dinoflagellate ratios in the Lower Swan Canning Estuary (top right), Middle Swan Estuary (middle right) and Upper Swan Estuary (bottom right) during months where specific conductivity exceeded 20 mS/cm (as this is to be considered a marine metric). Note that the y-axis varies between EMZs.

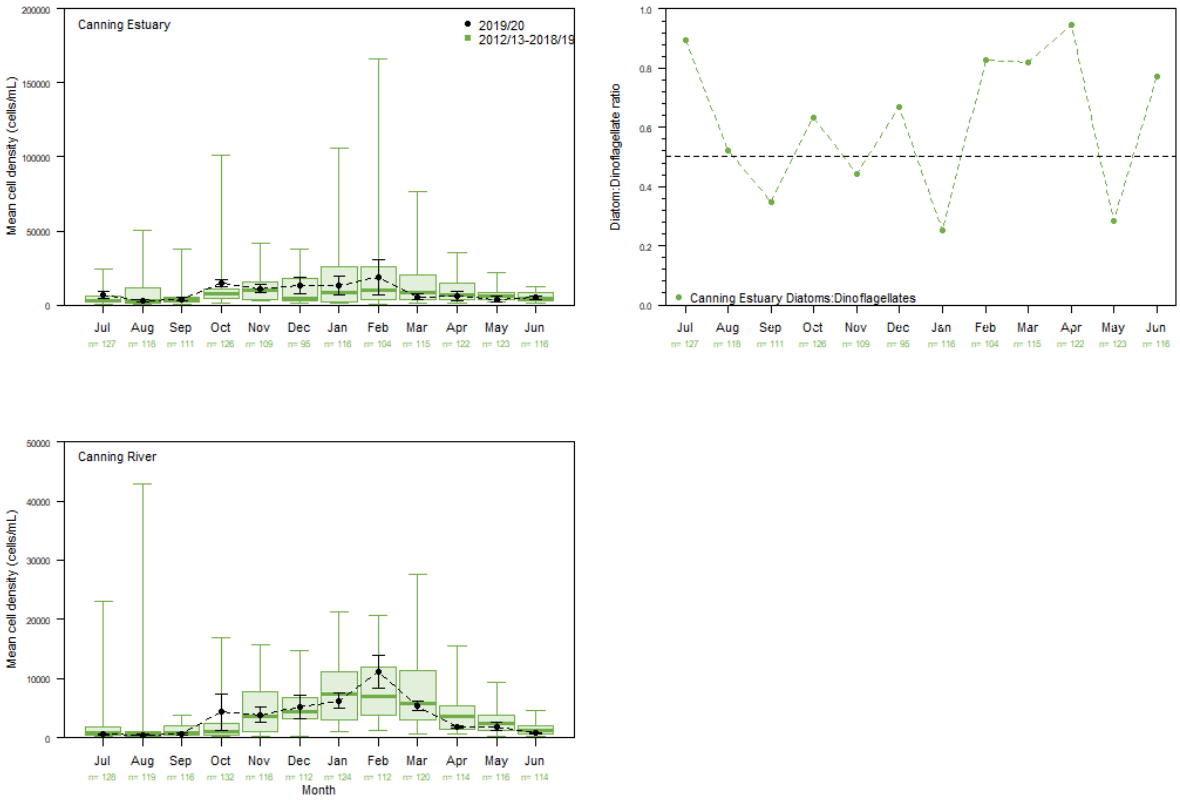


Figure 34 2019-20 mean total phytoplankton (cells/mL) over historic (July 2012 – June 2019) mean phytoplankton data in the Canning Estuary (top left), and Canning River (bottom left) alongside 2019-20 over 2012-13 diatom to dinoflagellate ratios in the Canning Estuary (top right) during months where specific conductivity exceeded 20 mS/cm (as this is to be considered a marine metric). Note that the y-axis varies between EMZs.

22. Diatom and dinoflagellate analysis

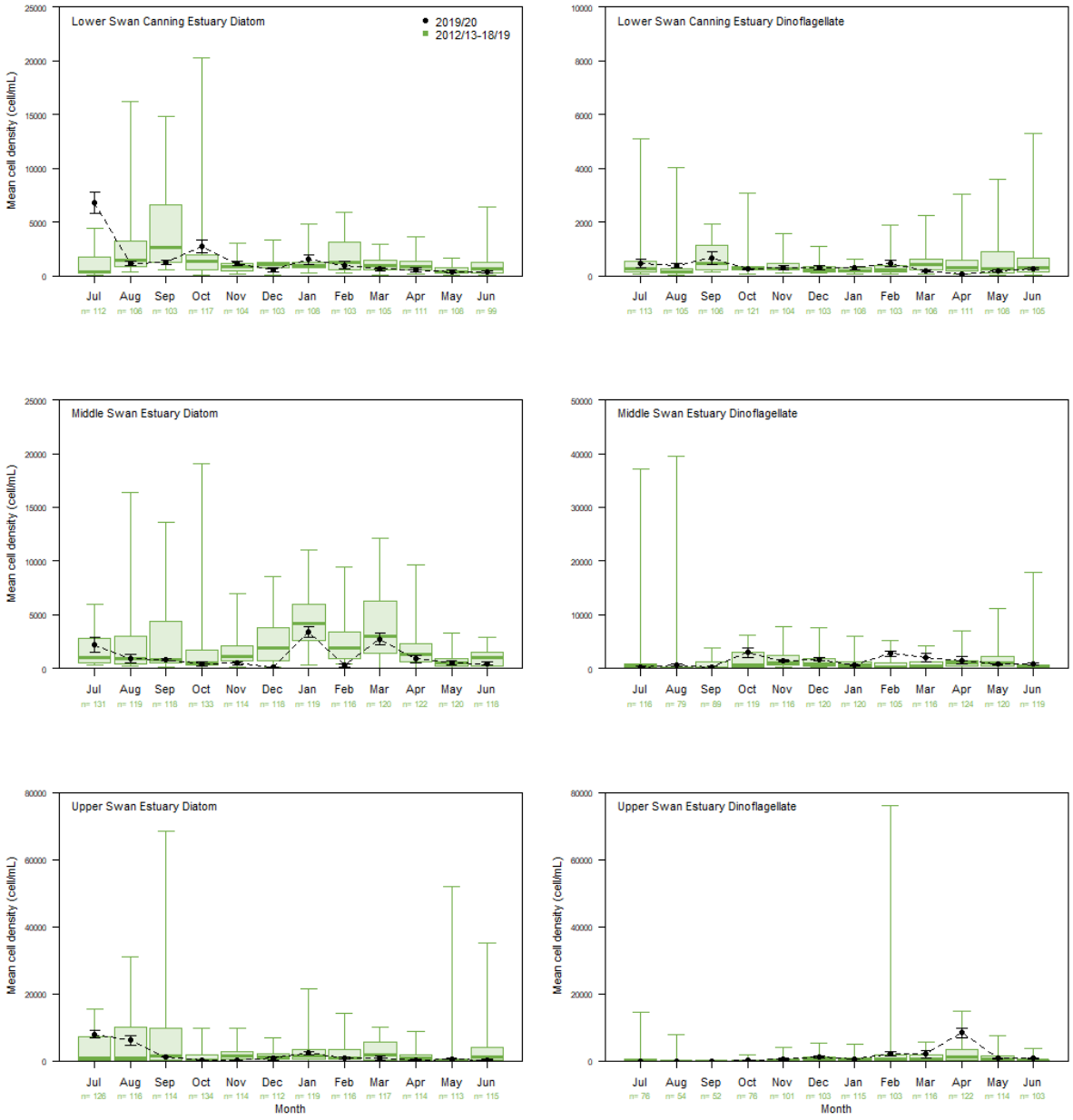


Figure 35 2019-20 mean diatom and dinoflagellate cell densities (cells/mL) over historic (July 2012 – June 2019). Mean diatom and dinoflagellate data in the Lower Swan Canning Estuary (top left and top right), Middle Swan Estuary (middle left and middle right), and Upper Swan Estuary (bottom left and bottom right). Note that the y-axis varies between EMZs.

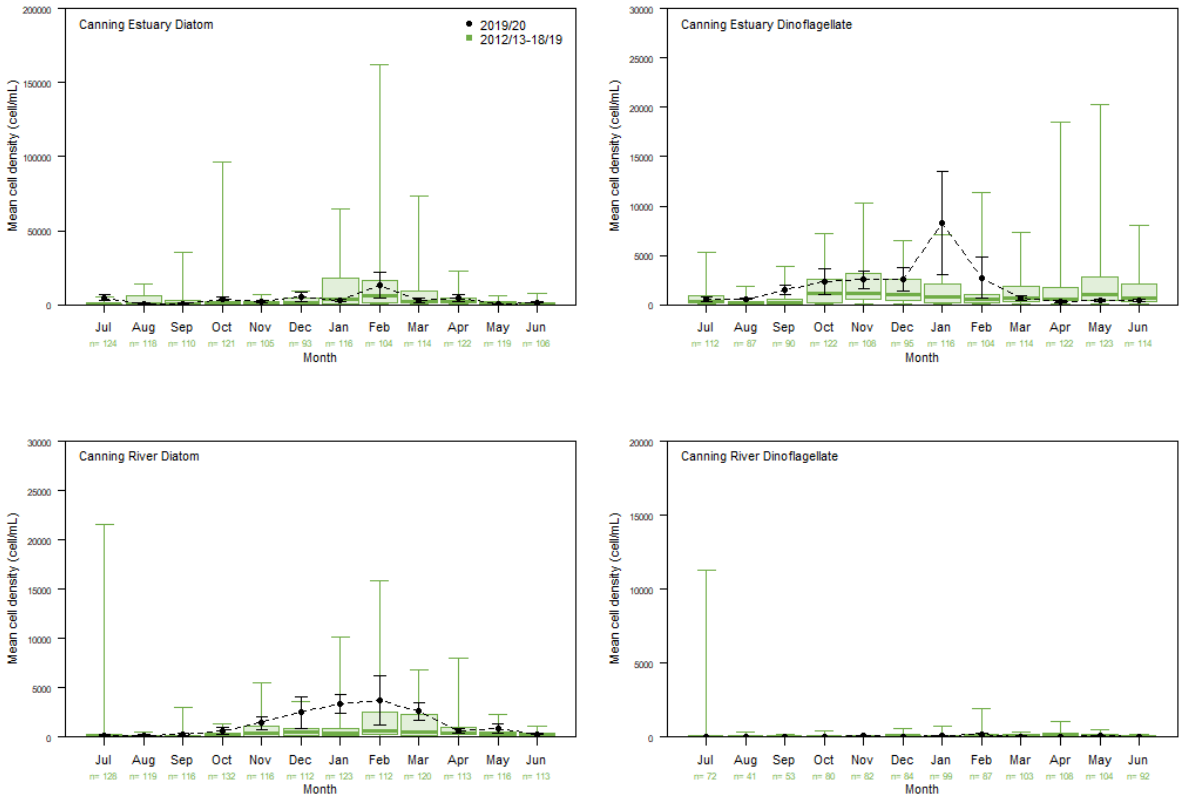


Figure 36 2019-20 mean diatom and dinoflagellate cell densities (cells/mL) over historic (July 2012 – June 2019). Mean diatom and dinoflagellate data in the Canning Estuary (top left and top right), Canning River (bottom left and bottom right). Note that the y-axis varies between EMZs.

23. Key observations of harmful algal bloom (HAB) species

Harmful algal bloom (HAB) species exist within all aquatic systems and, within the Swan Canning system, fall within four main phytoplankton classes: dinoflagellates, raphidophytes, cyanobacteria and diatoms. The prevalence of such taxa should be closely monitored, as blooms can be toxic and pose a significant threat to human health and/or the health of the broader aquatic ecosystem and can have socio-economic implications.

In recent years, within the brackish and marine dominated areas of the Swan Canning Estuary, the species belonging to the dinoflagellate genera *Alexandrium* and *Karlodinium* have been of most concern.

Alexandrium spp. can rapidly produce significant sizable blooms when germinating from cyst-beds in favourable conditions and, through the consumption of affected shellfish or crustacea, can lead to paralytic shellfish poisoning (PSP) in humans. From 2012 to the 2017-18 season, *Alexandrium* was detected only 13 times and only exceeded the Department of Health notification guideline of 10 cells/mL once (16 cells/mL in March 2014). The first bloom of *Alexandrium* spp., impacting >30 km of the Swan Estuary upstream from Perth CBD occurred in Autumn 2019 (2018/19 reporting period; Figure 37), reaching maximum cell density of 6,994 cells/mL at the MSB monitoring site in the Upper Swan Estuary (Table 3). A second *Alexandrium* spp. bloom was observed in the 2019-20 reporting period, beginning in early December 2019 and impacting both the Swan and Canning estuaries, with maxima of 5151 cells/mL and 15453 cells/mL observed in the Swan and Canning, respectively (Figure 37). It is likely that *Alexandrium* cysts are now present withing the sediment throughout much of the Swan and Canning estuaries and this species poses an ongoing risk to the Swan Canning Estuary ecosystem and users. The Department of Biodiversity, Conservation and Attractions (DBCA) has worked with the Department of Health (DoH) and the Department of Primary Industries and Regional Development (DPIRD) to generate advice and resources to the public to manage risk of PSP for fishers.

The presence of *Karlodinium* spp. within the system poses less risk to humans but can be a significant threat to fish species and indirectly affect the broader system through increased biological oxygen demands associated with large fish-kill events. Historically, *Karlodinium* spp. has been recorded in the system at concentrations that have exceeded the DBCA investigation guidelines of 15,000 cells/mL. In 2012-13 concentrations reached a maximum cell density of 75,649 cells/mL at the NIL (Middle Swan Estuary) monitoring site, 2013-14 a maximum of 52,318 cells/mL at the CASMID (Canning Estuary) monitoring site and 2016-17 a maximum of 20,023 cells/mL at the MAY monitoring site (Middle Swan Estuary). Within the last two reporting periods cell densities have still exceeded the DBCA investigation guidelines with a maximum of 29,828 cells/mL at the CASMID monitoring site in 2018-19 and 19,897 cells/mL at the WMP (Upper Swan Estuary) monitoring site in the 2019-20 reporting period (Table 3).

Where freshwater has a more dominant role in the system in the upper Swan and Canning River, the HAB species shift away from being predominantly dinoflagellates to cyanobacteria. The National Health and Medical Research Council (NHRMC) guidelines focusing on combined biovolumes rather than cell counts are applied by DBCA for management response to cyanobacteria. Within this reporting period, *Dolichospermun circinale* and *Anabaenopsis* spp. exceeded the amber alert mode trigger at the KEN and BAC monitoring sites in the Canning River on 4 February 2020 but had reduced to green surveillance mode levels by the following week. The greatest number of detections were low levels during winter and early spring when flow from the catchment flushes cyanobacteria into the system.

Table 3 Duration of key HAB species cell densities exceeding DBCA investigation trigger values in the Swan Canning Estuary.*

Harmful (H) / Nuisance (N) Species	**Durations of Event (Dates Sampled)**	**Zones**
***Alexandrium* spp. (H)**	**6 weeks in total**: From week commencing 27/01/2020 - week commencing 24/02/2020 and a final exceedance in the week commencing 16/03/2020	Lower Swan Canning Estuary Middle Swan Estuary
	3 weeks in total: From week commencing 10/02/2020- week commencing 24/02/2020	Upper Swan Estuary
	3 weeks in total: From week commencing 20/01/2020 – week commencing 03/02/2020	Canning Estuary
***Karlodinium* spp.**	**2 weeks in total**: From week commencing 14/04/2020 – week commencing 20/04/2020	Upper Swan Estuary
	2 weeks in total: From week commencing 14/01/2020 and week commencing 21/01/2020	Canning Estuary

* Species trigger values are set by DBCA in consultation with DWER and DoH and are reviewed annually. The trigger values are intended to inform management actions for the Swan Canning River system. Phytoplankton cell densities are determined from depth-integrated samples. Note that the *Alexandrium* event response was largely based on the DoH trigger level for that species and the actual “event duration” was roughly double that outlined in the table.

24. Key harmful algal bloom (HAB) analysis

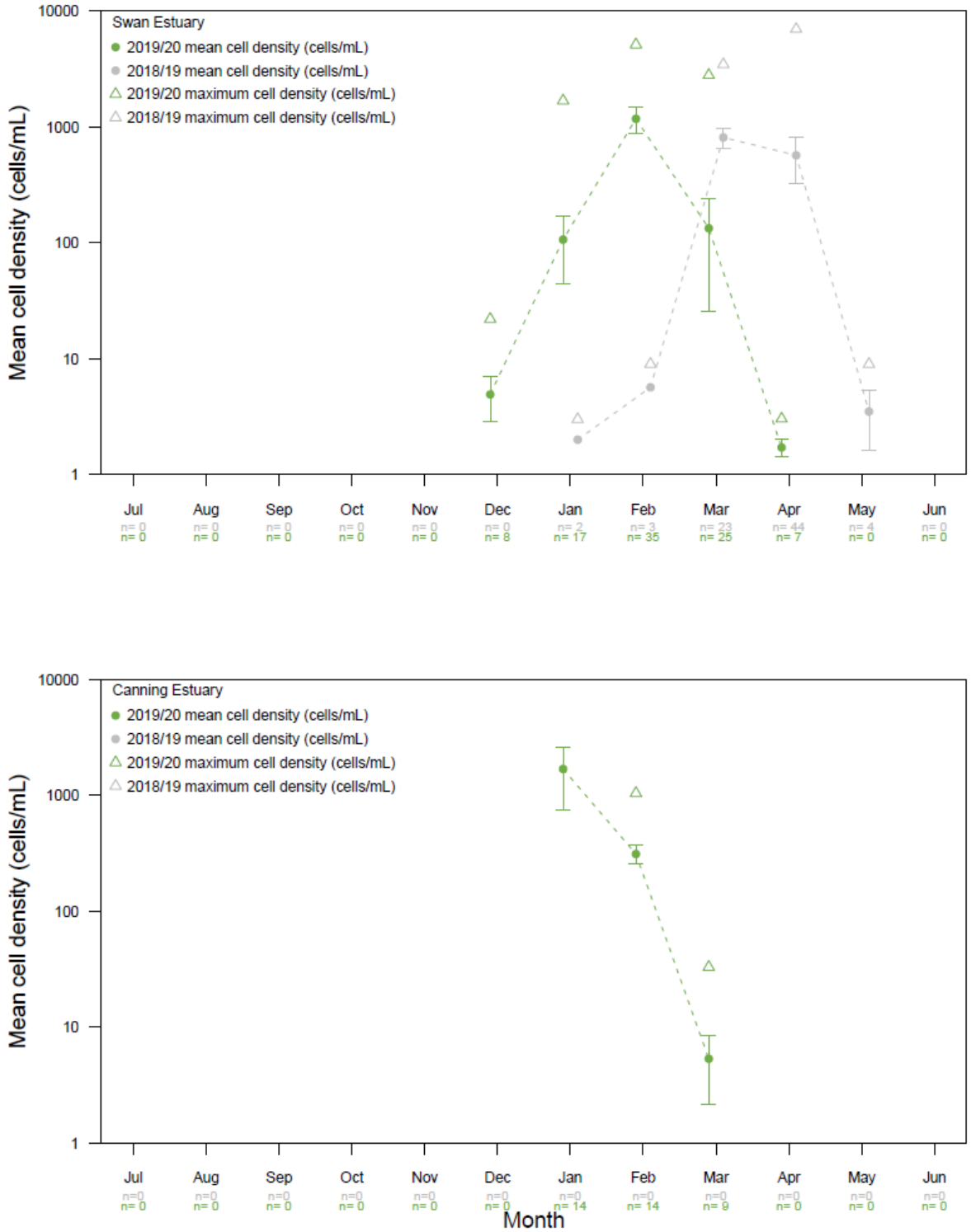


Figure 37 Mean cell densities with standard error of Alexandrium spp. for the 2018/19 and 2019-20 reporting periods within the Swan Estuary (combined Lower, Middle Swan Estuary and Upper Swan Estuary) and the Canning Estuary (downstream of Kent Street Weir). Maximum cell densities recorded for each month are overlain for both reporting periods. Cell densities are reported in log-scale.

Appendices

Appendix 1 Preliminary SHELL physico-chem data

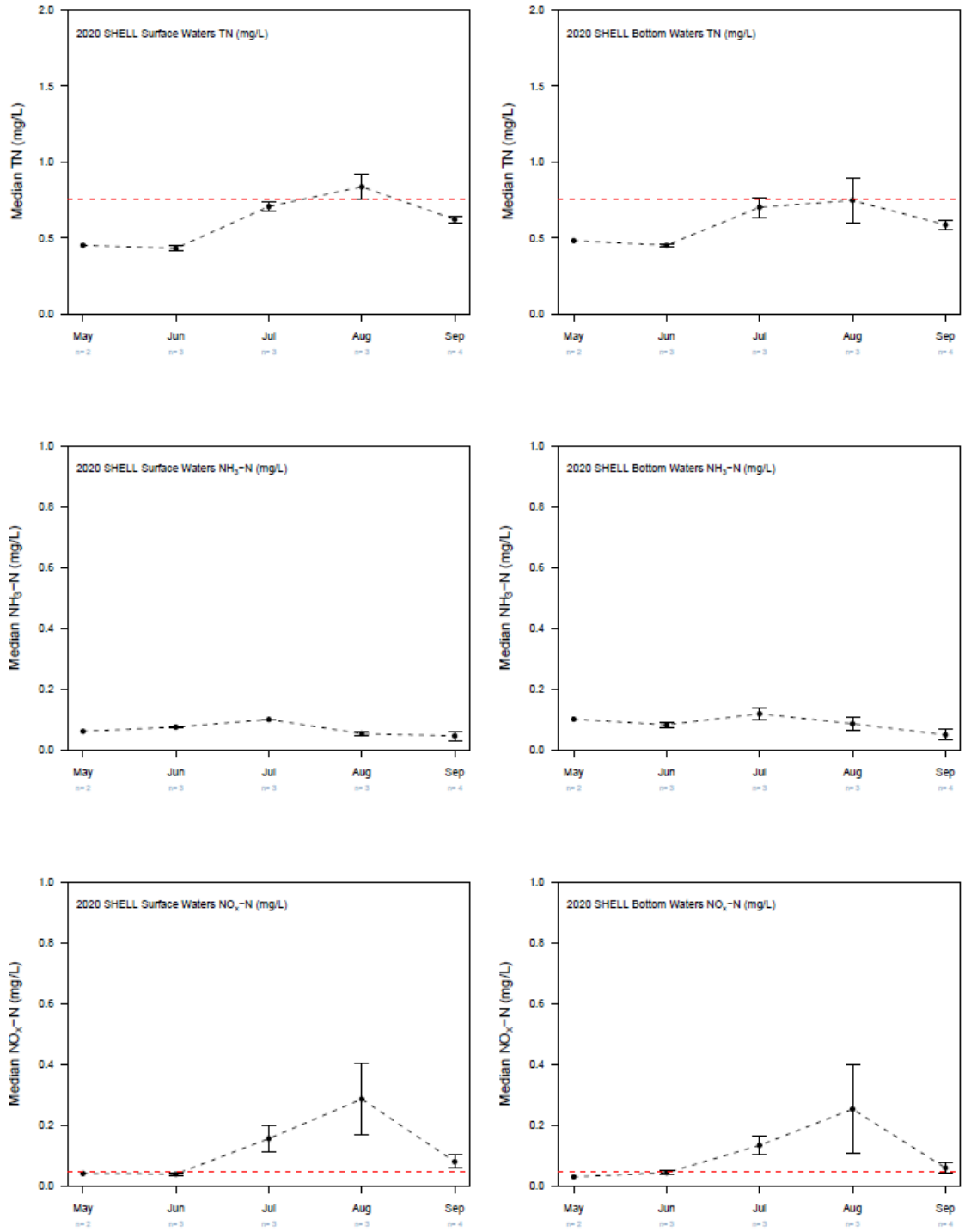


Figure 38 2020 Preliminary data for the new monitoring site SHELL sampled between May – September 2020. TN data for the surface (top left) and bottom (top right) waters, NH3 data for surface (middle left) and bottom (middle right) waters, and NOx data for surface (bottom left) and bottom (bottom right) waters with respective ANZECC trigger values for estuaries as the dashed red line.

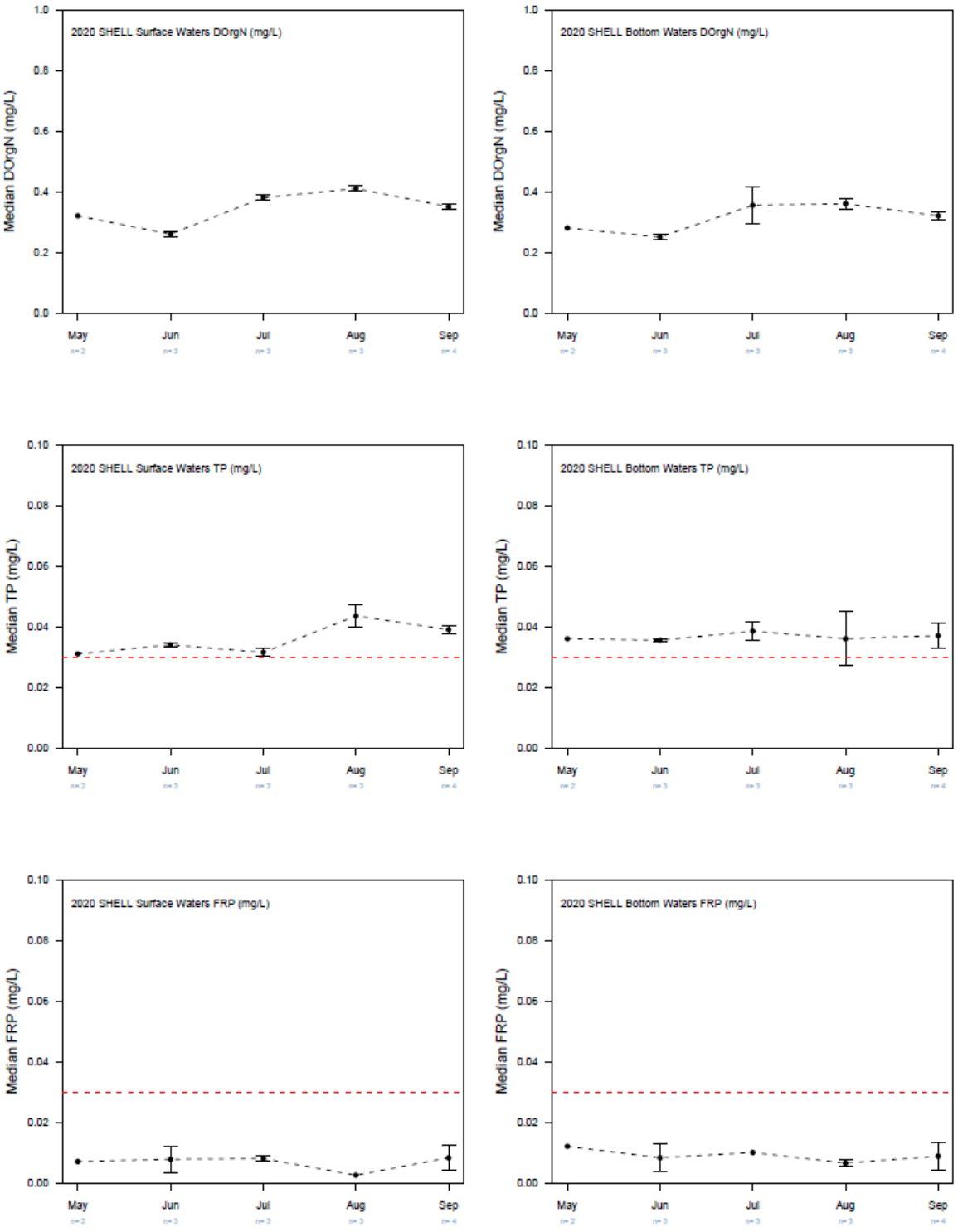


Figure 39 2020 Preliminary data for the new monitoring site SHELL sampled between May – September 2020. DOrgN data for the surface (top left) and bottom (top right) waters, TP data for surface (middle left) and bottom (middle right) waters, and FRP data for surface (bottom left) and bottom (bottom right) waters.

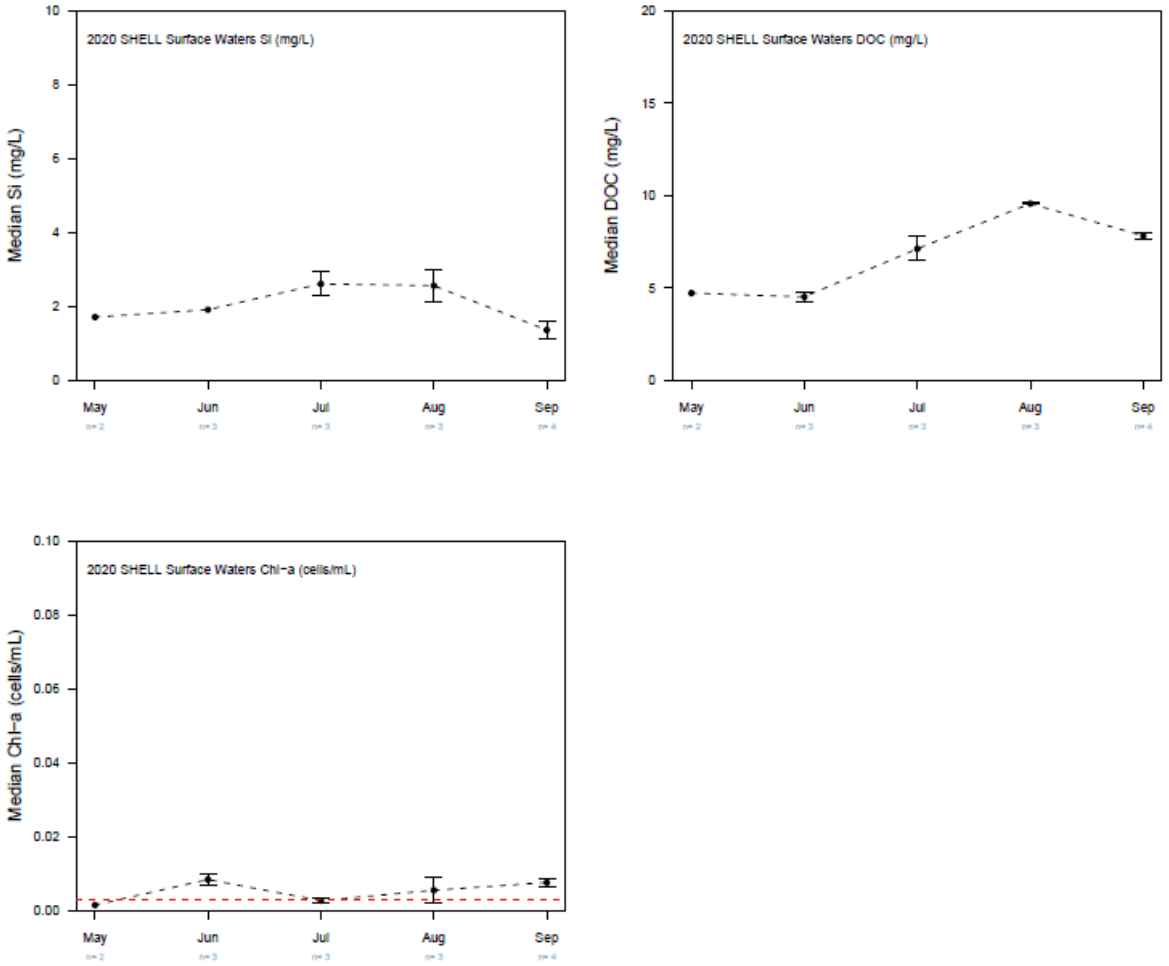


Figure 40 2020 Preliminary data for the new monitoring site SHELL sampled between May – September 2020. Surface Si data (top left), surface DOC data (top right) and surface Chl-a data (bottom left).

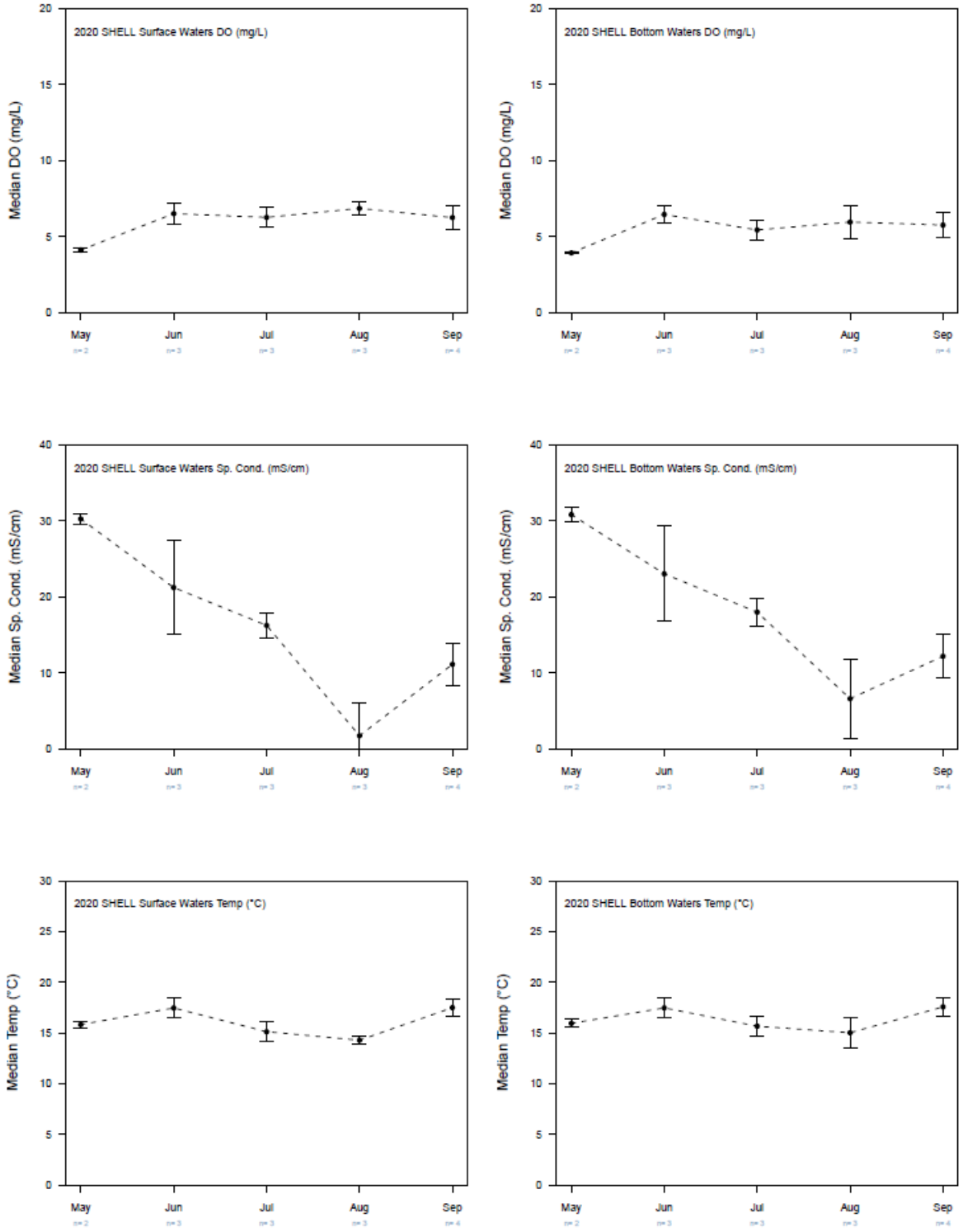


Figure 41 2020 Preliminary data for the new monitoring site SHELL sampled between May – September 2020. DO data for the surface (top left) and bottom (top right) waters, Specific Conductivity (Sp. Cond.) data for surface (middle left) and bottom (middle right) waters, and Temperature data for surface (bottom left) and bottom (bottom right) waters.

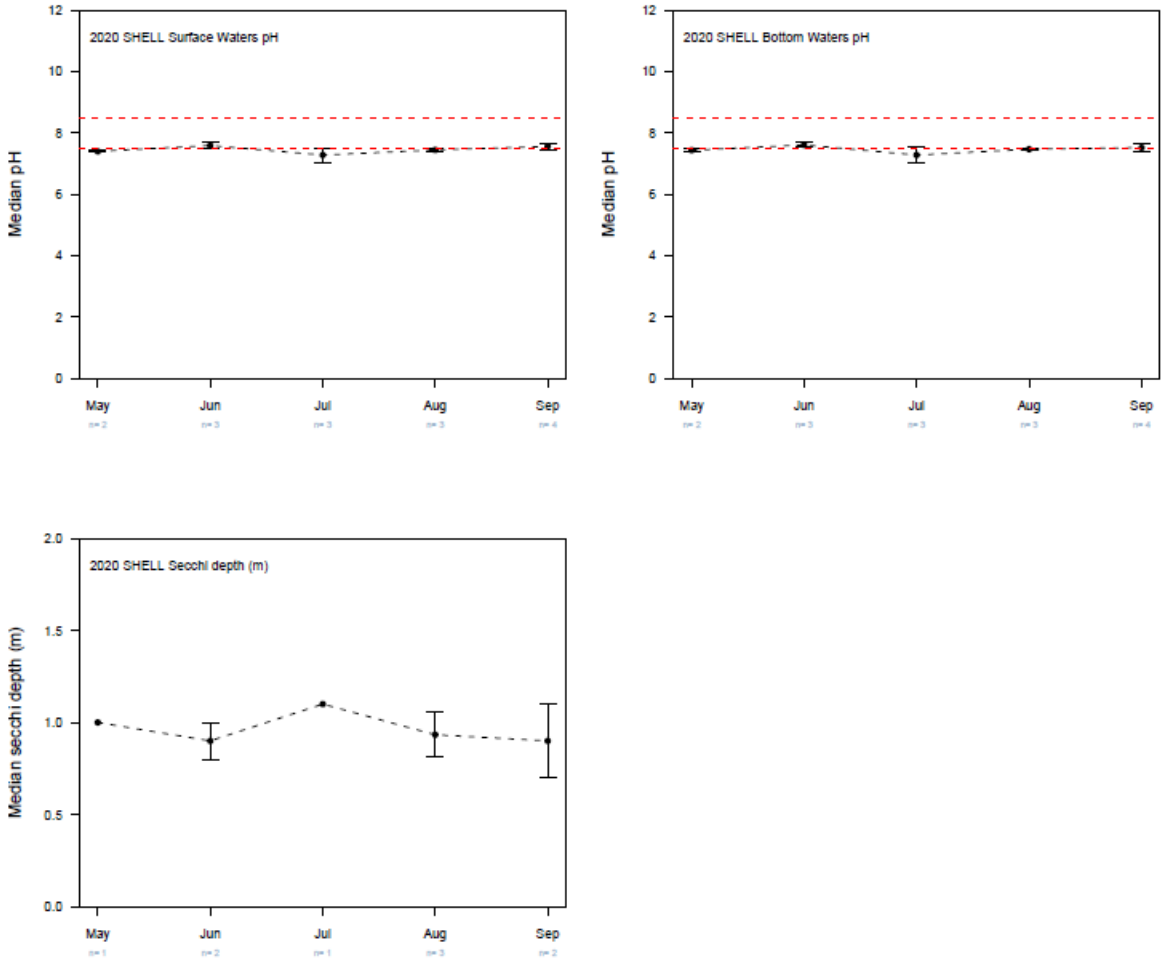


Figure 42 2020 Preliminary data for the new monitoring site SHELL sampled between May – September 2020. Surface pH data (top left), bottom pH data (top right) and Secchi depth data (bottom left).

Appendix 2 Physico-chem concentration tables.

Table 4 Total nitrogen (TN) (mg/L) for Lower Canning Swan Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
TN Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.36	0.36	0.25	0.22	0.22	0.16	0.18	0.23	0.18	0.17	0.3	0.32
max	1.4	0.87	0.77	0.56	0.34	0.29	0.35	0.52	0.51	0.31	0.2	0.12
median	0.51	0.465	0.47	0.285	0.26	0.26	0.26	0.27	0.28	0.21	0.26	0.24
TN Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.19	0.17	0.13	0.15	0.14	0.091	0.16	0.2	0.21	0.19	0.2	0.12
max	0.46	0.45	0.3	0.33	0.29	0.29	0.34	0.45	0.37	0.31	0.32	0.25
median	0.285	0.295	0.255	0.19	0.21	0.235	0.255	0.275	0.275	0.235	0.245	0.195
TN Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.1	0.99	0.81	0.6	0.55	0.53	0.44	0.55	0.6	0.46	0.4	0.35
max	2.4	1.3	1.1	1	1.1	1.3	0.99	1	1.4	0.96	0.8	0.69
median	1.4	1.05	0.985	0.83	0.715	0.75	0.67	0.69	0.86	0.785	0.61	0.53
TN Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.79	0.53	0.61	0.43	0.43	0.44	0.42	0.47	0.44	0.43	0.34	0.27
max	2.4	1	1.1	0.97	0.85	0.69	0.69	0.86	0.83	0.83	0.65	0.63
median	1.1	0.77	0.855	0.62	0.595	0.535	0.565	0.68	0.695	0.66	0.53	0.415
TN Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.1	1.1	0.87	0.75	0.63	0.7	0.74	0.81	0.85	0.87	0.71	0.59
max	2.5	1.2	1.1	0.91	1.1	1.2	1.1	1.1	1.1	1.3	0.98	0.77
median	1.85	1.1	1.05	0.845	0.735	0.91	0.875	0.93	0.965	0.96	0.8	0.705
TN Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.1	1.1	0.9	0.73	0.62	0.69	0.74	0.86	0.7	0.69	0.59	0.6
max	2.6	1.6	1.2	0.95	1.4	0.9	0.97	1.1	1.1	0.96	1	0.75
median	1.85	1.2	1.1	0.815	0.84	0.805	0.83	0.93	0.93	0.88	0.77	0.68

Table 5 Total nitrogen (TN) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
TN Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.61	0.5	0.54	0.3	0.3	0.31	0.33	0.38	0.37	0.33	0.33	0.3
max	1.6	1.1	1.1	1	1.3	1.6	1.7	1.3	1	0.79	0.89	0.78
median	1	0.85	0.88	0.635	0.62	0.78	0.815	0.72	0.805	0.61	0.515	0.405
TN Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	
min	0.52	0.43	0.29	0.26	0.27	0.3	0.35	0.38	0.39	0.34	0.31	0.29
max	1.5	1.1	1	1.1	1.1	1.1	1.4	1.3	1.5	1.4	0.96	0.79
median	0.825	0.73	0.66	0.735	0.55	0.735	0.775	0.73	0.76	0.63	0.46	0.435
TN Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.1	1	0.92	0.71	0.68	0.56	0.53	0.52	0.59	0.45	0.51	0.86
max	1.6	1.1	1.1	0.93	0.83	1.2	0.87	1.3	1	0.71	0.95	0.94
median	1.35	1	0.985	0.82	0.7	0.74	0.695	0.69	0.715	0.575	0.67	0.89
TN Lower Canning River (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.1	1	0.95	0.73	0.67	0.64	0.5	0.52	0.51	0.4	0.51	0.87
max	1.6	1.1	1.1	1.1	1.4	1.1	0.97	0.83	1.1	1.1	0.8	1.8
median	1.35	1	1.05	0.855	0.735	0.81	0.715	0.715	0.77	0.53	0.64	0.915

Table 6 Ammonia nitrogen (NH3-N) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
NH_3 Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
max	0.13	0.074	0.005	0.027	0.005	0.005	0.005	0.019	0.031	0.042	0.024	0.005
median	0.0345	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
NH_3 Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.031	0.022	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
max	0.12	0.16	0.086	0.069	0.03	0.039	0.015	0.025	0.029	0.05	0.032	0.038
median	0.067	0.0495	0.0445	0.024	0.005	0.0165	0.005	0.005	0.013	0.0165	0.012	0.008
NH_3 Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.07	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.016
max	0.15	0.076	0.15	0.11	0.088	0.011	0.013	0.005	0.069	0.13	0.073	0.19
median	0.0995	0.0575	0.0695	0.015	0.02	0.005	0.005	0.005	0.005	0.071	0.0355	0.0745
NH_3 Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.11	0.025	0.005	0.01	0.005	0.005	0.005	0.005	0.005	0.014	0.005	0.036
max	0.63	0.48	0.36	0.2	0.25	0.022	0.082	0.014	0.27	0.2	0.091	0.18
median	0.42	0.12	0.205	0.0445	0.0595	0.0095	0.0075	0.008	0.079	0.112	0.06	0.125
NH_3 Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.057	0.016	0.051	0.025	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.034
max	0.13	0.083	0.13	0.12	0.038	0.018	0.011	0.019	0.13	0.23	0.24	0.18
median	0.0915	0.0375	0.069	0.09	0.0135	0.005	0.005	0.005	0.059	0.034	0.098	0.1025
NH_3 Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.056	0.016	0.053	0.057	0.005	0.005	0.005	0.005	0.005	0.005	0.02	0.12
max	0.13	0.19	0.16	0.23	0.57	0.13	0.045	0.27	0.22	0.23	0.24	0.29
median	0.093	0.043	0.071	0.09	0.0535	0.0295	0.0185	0.0235	0.11	0.044	0.0995	0.165

Table 7 Ammonia nitrogen (NH3-N) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
NH_3 Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.014	0.034	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.018	0.005	0.005
max	0.12	0.11	0.095	0.054	0.025	0.014	0.026	0.066	0.3	0.21	0.25	0.2
median	0.069	0.0515	0.0355	0.009	0.01	0.005	0.005	0.0185	0.14	0.111	0.104	0.0505
NH_3 Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.071	0.045	0.005	0.005	0.005	0.005	0.005	0.005	0.037	0.019	0.03	0.005
max	0.34	0.24	0.25	0.56	0.047	0.019	0.029	0.069	0.67	0.73	0.43	0.5
median	0.194	0.135	0.039	0.0175	0.033	0.0125	0.005	0.017	0.215	0.16	0.135	0.093
NH_3 Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.041	0.035	0.027	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.014	0.07
max	0.063	0.073	0.066	0.062	0.23	0.078	0.054	0.1	0.15	0.13	0.07	0.12
median	0.0575	0.049	0.0405	0.017	0.03	0.035	0.0155	0.0155	0.0145	0.029	0.0435	0.0935
NH_3 Lower Canning River (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.042	0.037	0.019	0.016	0.015	0.011	0.014	0.012	0.005	0.005	0.014	0.077
max	0.074	0.074	0.14	0.39	0.47	0.22	0.14	0.11	0.33	0.41	0.19	1.1
median	0.057	0.045	0.041	0.0645	0.066	0.0685	0.03	0.0175	0.0425	0.0375	0.0505	0.115

Table 8 Total oxidised nitrogen (NOx) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
NO_x Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.049	0.035	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
max	0.41	0.15	0.085	0.031	0.021	0.025	0.035	0.035	0.023	0.015	0.034	0.033
median	0.15	0.0455	0.021	0.008	0.005	0.005	0.0165	0.011	0.017	0.005	0.0175	0.016
NO_x Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.03	0.02	0.013	0.005	0.005	0.005	0.011	0.005	0.005	0.005	0.011	0.013
max	0.078	0.065	0.053	0.049	0.018	0.023	0.022	0.017	0.023	0.014	0.035	0.028
median	0.042	0.0435	0.032	0.02	0.0125	0.016	0.018	0.011	0.017	0.005	0.018	0.0235
NO_x Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.28	0.16	0.073	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.011	0.025
max	1.1	0.27	0.19	0.12	0.036	0.015	0.022	0.012	0.035	0.06	0.13	0.093
median	0.47	0.21	0.175	0.005	0.0125	0.005	0.0125	0.005	0.013	0.0225	0.0465	0.0655
NO_x Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.095	0.051	0.031	0.005	0.005	0.005	0.005	0.005	0.005	0.013	0.022	0.023
max	1.1	0.17	0.17	0.093	0.026	0.013	0.021	0.02	0.03	0.06	0.1	0.077
median	0.19	0.087	0.105	0.005	0.01	0.005	0.0125	0.005	0.0255	0.024	0.0435	0.052
NO_x Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.25	0.15	0.14	0.023	0.005	0.005	0.005	0.005	0.005	0.005	0.064	0.037
max	1.2	0.27	0.17	0.1	0.038	0.005	0.005	0.021	0.12	0.13	0.18	0.13
median	0.705	0.205	0.16	0.074	0.011	0.005	0.005	0.005	0.06	0.023	0.105	0.0855
NO_x Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.26	0.14	0.14	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.083	0.073
max	1.2	0.27	0.16	0.099	0.039	0.011	0.013	0.041	0.13	0.11	0.19	0.14
median	0.705	0.2	0.16	0.0715	0.008	0.005	0.005	0.005	0.0555	0.019	0.1	0.0865

Table 9 Total oxidised nitrogen (NOx) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
NO_x Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.14	0.056	0.017	0.005	0.005	0.005	0.012	0.005	0.011	0.005	0.016	0.015
max	0.82	0.51	0.49	0.13	0.017	0.025	0.022	0.016	0.041	0.036	0.24	0.21
median	0.395	0.28	0.23	0.005	0.005	0.005	0.017	0.01	0.021	0.0235	0.0325	0.0275
NO_x Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.053	0.034	0.019	0.005	0.005	0.005	0.014	0.005	0.015	0.005	0.022	0.017
max	0.81	0.5	0.48	0.062	0.021	0.037	0.024	0.017	0.045	0.059	0.056	0.06
median	0.228	0.0695	0.05	0.005	0.005	0.0075	0.0165	0.005	0.0225	0.0225	0.031	0.0265
NO_x Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.42	0.38	0.33	0.005	0.005	0.005	0.011	0.005	0.005	0.005	0.044	0.27
max	0.84	0.51	0.5	0.27	0.098	0.053	0.016	0.022	0.068	0.033	0.29	0.32
median	0.65	0.465	0.41	0.135	0.0315	0.026	0.0135	0.005	0.005	0.011	0.13	0.31
NO_x Lower Canning River (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.39	0.38	0.34	0.005	0.005	0.005	0.011	0.005	0.005	0.005	0.045	0.22
max	0.83	0.51	0.51	0.27	0.1	0.06	0.029	0.022	0.067	0.031	0.23	0.35
median	0.61	0.465	0.41	0.15	0.035	0.03	0.016	0.005	0.008	0.013	0.0805	0.28

Table 10 Dissolved organic nitrogen (DOrgN) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
DOrgN Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.25	0.25	0.2	0.18	0.16	0.11	0.15	0.17	0.14	0.11	0.14	0.086
max	0.87	0.52	0.49	0.42	0.3	0.25	0.27	0.33	0.27	0.27	0.25	0.26
median	0.33	0.315	0.35	0.23	0.21	0.195	0.22	0.235	0.22	0.185	0.21	0.175
DOrgN Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.11	0.11	0.093	0.067	0.11	0.045	0.13	0.16	0.17	0.12	0.15	0.083
max	0.27	0.27	0.21	0.24	0.28	0.22	0.26	0.4	0.27	0.25	0.24	0.19
median	0.145	0.145	0.16	0.11	0.145	0.17	0.2	0.245	0.22	0.19	0.195	0.155
DOrgN Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.66	0.6	0.59	0.42	0.37	0.36	0.34	0.39	0.33	0.27	0.31	0.23
max	1.1	0.77	0.76	0.64	0.55	0.56	0.57	0.6	0.56	0.49	0.44	0.35
median	0.81	0.72	0.645	0.525	0.485	0.46	0.46	0.52	0.465	0.365	0.385	0.28
DOrgN Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.29	0.28	0.4	0.31	0.28	0.29	0.32	0.39	0.29	0.27	0.27	0.18
max	1	0.74	0.75	0.57	0.49	0.47	0.53	0.58	0.53	0.45	0.41	0.3
median	0.405	0.37	0.485	0.41	0.36	0.38	0.43	0.49	0.415	0.355	0.36	0.23
DOrgN Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.71	0.75	0.56	0.57	0.51	0.57	0.55	0.59	0.55	0.5	0.45	0.32
max	1.1	0.8	0.76	0.66	0.61	0.63	0.67	0.75	0.63	0.61	0.57	0.53
median	0.935	0.78	0.655	0.6	0.565	0.61	0.61	0.635	0.585	0.58	0.505	0.39
DOrgN Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.69	0.74	0.55	0.52	0.47	0.51	0.52	0.58	0.5	0.48	0.35	0.32
max	1.1	0.82	0.78	0.64	0.6	0.65	0.68	0.7	0.66	0.62	0.42	0.47
median	0.88	0.79	0.675	0.59	0.545	0.57	0.6	0.62	0.565	0.545	0.375	0.42

Table 11 Dissolved organic nitrogen (DOrgN) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
DOrgN Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.34	0.31	0.29	0.24	0.23	0.25	0.26	0.27	0.27	0.24	0.23	0.18
max	0.62	0.49	0.53	0.56	0.57	0.61	0.63	0.69	0.52	0.49	0.39	0.33
median	0.425	0.345	0.41	0.415	0.425	0.455	0.49	0.51	0.4	0.345	0.3	0.24
DOrgN Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.16	0.23	0.17	0.18	0.24	0.21	0.3	0.29	0.27	0.23	0.23	0.16
max	0.63	0.53	0.53	0.53	0.56	0.55	0.64	0.65	0.53	0.47	0.35	0.24
median	0.37	0.315	0.335	0.36	0.42	0.395	0.455	0.5	0.395	0.335	0.265	0.215
DOrgN Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.49	0.37	0.43	0.47	0.16	0.48	0.39	0.35	0.4	0.32	0.35	0.34
max	0.68	0.47	0.55	0.58	0.53	0.55	0.55	0.55	0.59	0.43	0.41	0.45
median	0.6	0.46	0.49	0.525	0.52	0.53	0.49	0.445	0.465	0.365	0.385	0.415
DOrgN Lower Canning River (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.56	0.35	0.41	0.44	0.46	0.5	0.34	0.35	0.4	0.3	0.35	0.32
max	0.66	0.51	0.53	0.58	0.54	0.63	0.54	0.58	0.59	0.41	0.42	0.47
median	0.61	0.45	0.495	0.49	0.51	0.535	0.5	0.415	0.465	0.37	0.375	0.42

Table 12 Total phosphorus (TP) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
TP Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.008	0.011	0.0025	0.0025	0.016	0.012	0.0025	0.02	0.016	0.017	0.014	0.01
max	0.036	0.035	0.051	0.023	0.034	0.037	0.037	0.074	0.063	0.037	0.034	0.026
median	0.016	0.021	0.016	0.013	0.022	0.026	0.02	0.034	0.0355	0.0215	0.022	0.0185
TP Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.013	0.013	0.0025	0.0025	0.011	0.01	0.0025	0.016	0.023	0.017	0.014	0.009
max	0.029	0.027	0.015	0.023	0.034	0.037	0.035	0.065	0.056	0.04	0.041	0.024
median	0.0175	0.0215	0.009	0.014	0.0205	0.024	0.017	0.031	0.0355	0.0275	0.025	0.019
TP Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.022	0.041	0.032	0.032	0.057	0.064	0.06	0.075	0.1	0.062	0.049	0.033
max	0.064	0.058	0.065	0.085	0.13	0.21	0.12	0.24	0.26	0.17	0.094	0.062
median	0.037	0.045	0.055	0.0555	0.0745	0.1075	0.0885	0.115	0.17	0.12	0.0765	0.052
TP Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.031	0.02	0.023	0.035	0.062	0.057	0.059	0.11	0.088	0.06	0.043	0.029
max	0.078	0.091	0.075	0.15	0.13	0.13	0.1	0.29	0.2	0.16	0.08	0.069
median	0.06	0.046	0.0685	0.0775	0.092	0.11	0.092	0.12	0.155	0.1	0.0755	0.048
TP Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.036	0.026	0.028	0.016	0.022	0.024	0.034	0.043	0.047	0.11	0.061	0.038
max	0.073	0.058	0.072	0.075	0.11	0.12	0.091	0.17	0.21	0.21	0.13	0.081
median	0.055	0.039	0.054	0.0275	0.036	0.0725	0.0625	0.079	0.135	0.145	0.0865	0.0595
TP Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.035	0.028	0.031	0.018	0.02	0.017	0.034	0.048	0.078	0.08	0.057	0.046
max	0.078	0.061	0.12	0.08	0.21	0.13	0.095	0.2	0.2	0.15	0.096	0.079
median	0.051	0.0495	0.0695	0.0305	0.0675	0.0815	0.0805	0.15	0.145	0.135	0.085	0.0655

Table 13 Total phosphorus (TP) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
TP Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.026	0.024	0.032	0.017	0.028	0.023	0.031	0.042	0.041	0.031	0.031	0.02
max	0.076	0.082	0.079	0.1	0.16	0.32	0.31	0.3	0.21	0.098	0.088	0.066
median	0.053	0.0595	0.0565	0.049	0.0605	0.1145	0.109	0.081	0.073	0.0485	0.0375	0.0305
TP Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.027	0.022	0.017	0.025	0.028	0.028	0.024	0.044	0.04	0.031	0.031	0.022
max	0.091	0.087	0.075	0.15	0.18	0.29	0.22	0.27	0.44	0.46	0.14	0.19
median	0.0535	0.059	0.0485	0.0635	0.0525	0.1115	0.111	0.0825	0.062	0.0475	0.041	0.0335
TP Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.057	0.065	0.058	0.049	0.057	0.044	0.035	0.045	0.047	0.038	0.042	0.058
max	0.08	0.095	0.072	0.07	0.084	0.14	0.058	0.082	0.12	0.07	0.092	0.072
median	0.0665	0.076	0.0645	0.0635	0.07	0.074	0.05	0.0515	0.0635	0.041	0.064	0.0615
TP Lower Canning River (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.056	0.065	0.056	0.053	0.064	0.067	0.046	0.039	0.055	0.031	0.043	0.05
max	0.082	0.096	0.084	0.11	0.16	0.14	0.12	0.1	0.15	0.12	0.076	0.16
median	0.0635	0.0785	0.068	0.0635	0.083	0.087	0.062	0.058	0.071	0.043	0.0585	0.0695

Table 14 Filterable reactive phosphorus (FRP) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
FRP Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.006	0.008	0.005	0.0025	0.0025
max	0.022	0.013	0.005	0.01	0.016	0.023	0.022	0.039	0.04	0.025	0.016	0.009
median	0.0025	0.0025	0.0025	0.0025	0.008	0.0125	0.007	0.02	0.019	0.0085	0.0075	0.0025
FRP Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.007	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.008	0.011	0.006	0.0025	0.0025
max	0.023	0.02	0.014	0.014	0.016	0.022	0.024	0.039	0.041	0.026	0.017	0.013
median	0.012	0.0135	0.008	0.007	0.009	0.017	0.007	0.019	0.022	0.0135	0.01	0.0085
FRP Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.008	0.008	0.0025	0.0025	0.014	0.029	0.026	0.041	0.047	0.026	0.021	0.01
max	0.033	0.026	0.035	0.031	0.045	0.062	0.052	0.12	0.11	0.067	0.049	0.038
median	0.02	0.0165	0.029	0.016	0.029	0.0425	0.0455	0.0755	0.079	0.052	0.0355	0.026
FRP Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.02	0.0025	0.0025	0.012	0.023	0.029	0.026	0.066	0.045	0.027	0.019	0.011
max	0.053	0.054	0.067	0.11	0.07	0.083	0.063	0.15	0.14	0.074	0.054	0.04
median	0.0405	0.0185	0.0375	0.038	0.045	0.069	0.0535	0.08	0.0945	0.0545	0.04	0.0295
FRP Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.008	0.008	0.019	0.006	0.0025	0.0025	0.0025	0.005	0.025	0.026	0.025	0.009
max	0.024	0.013	0.037	0.018	0.019	0.028	0.031	0.084	0.092	0.083	0.058	0.036
median	0.013	0.0115	0.028	0.011	0.00575	0.012	0.016	0.018	0.0665	0.049	0.0545	0.029
FRP Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.008	0.008	0.025	0.007	0.0025	0.0025	0.0025	0.019	0.046	0.03	0.029	0.023
max	0.022	0.028	0.035	0.032	0.081	0.053	0.045	0.1	0.11	0.084	0.06	0.049
median	0.015	0.011	0.0305	0.0115	0.0185	0.025	0.0275	0.049	0.0775	0.0545	0.0565	0.041

Table 15 Filterable reactive phosphorus (FRP) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
FRP Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.0025	0.0025	0.0025	0.0025	0.009	0.017	0.016	0.024	0.011	0.009	0.005	0.0025
max	0.034	0.035	0.035	0.023	0.029	0.12	0.13	0.12	0.1	0.029	0.028	0.022
median	0.022	0.0205	0.0215	0.012	0.0155	0.04	0.053	0.032	0.0235	0.0175	0.0125	0.008
FRP Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.018	0.011	0.0025	0.006	0.013	0.021	0.02	0.026	0.017	0.011	0.011	0.0025
max	0.044	0.04	0.039	0.032	0.041	0.17	0.093	0.12	0.39	0.34	0.077	0.11
median	0.03	0.026	0.021	0.019	0.0215	0.047	0.051	0.0315	0.027	0.0195	0.018	0.0135
FRP Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.03	0.02	0.031	0.016	0.012	0.009	0.0025	0.0025	0.006	0.0025	0.013	0.028
max	0.035	0.038	0.041	0.04	0.044	0.066	0.018	0.008	0.065	0.013	0.032	0.035
median	0.0315	0.0325	0.0335	0.027	0.027	0.0245	0.011	0.005	0.0115	0.009	0.0195	0.0305
FRP Lower Canning River (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.031	0.022	0.03	0.015	0.012	0.011	0.008	0.0025	0.006	0.0025	0.012	0.017
max	0.038	0.039	0.043	0.041	0.047	0.08	0.041	0.013	0.073	0.014	0.027	0.035
median	0.0335	0.0355	0.035	0.0285	0.026	0.028	0.0135	0.006	0.0115	0.009	0.017	0.0285

Table 16 Soluble reactive silica (Si) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Si Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.3	1.4	1.2	0.57	0.19	0.46	0.68	0.67	0.67	0.28	0.22	0.39
max	4.5	2.9	2.8	2.2	1.6	1.6	1.9	3	2.4	1.6	1.1	1.6
median	1.95	1.8	1.75	1.04	0.725	1.03	1.3	1.4	1.4	0.67	0.67	1.05
Si Lower Swan Canning Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.57	0.41	0.5	0.4	0.16	0.45	0.37	0.75	0.81	0.32	0.23	0.41
max	1.7	1.7	1.4	1.3	0.82	1.4	1.9	2.8	2.4	1.5	1.1	1.1
median	1.1	0.87	0.93	0.77	0.605	0.995	1.12	1.4	1.6	0.795	0.73	0.985
Si Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	4.3	3	3	2.5	2.2	2	2.4	3.2	3.1	2.7	1.6	1.7
max	5.9	4.2	3.9	3.4	3.5	3.5	3.7	4.2	4.7	4.7	4	2.7
median	4.8	3.7	3.35	2.95	2.75	3	2.85	3.4	3.95	3.7	2.7	2.15
Si Middle Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	2.4	2.4	2.7	1.9	1.7	1.8	2.1	3.2	2.9	2.7	1.3	1.3
max	5.9	3.6	4	3.5	3.2	3.4	3.2	4.2	4.6	4.6	3.7	2.4
median	3.25	2.9	3.05	2.8	2.3	2.65	2.75	3.45	3.7	3.65	2.45	1.8
Si Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	4.6	3.8	2.3	2.5	2.7	3.6	3.4	3.7	4.4	4.9	3.2	2.9
max	6.3	4.1	4	3.5	4	5	5.5	5.2	5.9	5.7	5.1	3.6
median	5.4	3.85	3.4	2.8	3.7	4.2	4.3	4.75	5.4	5.3	3.85	3.3
Si Upper Swan Estuary (Bottom)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	4.5	3.6	2.4	2.5	2.7	3.4	3.4	3.6	4.8	4.9	3.2	2.5
max	6.3	4.4	4	3.6	4	5.1	5.3	5.4	5.9	5.7	5	3.7
median	5.45	3.85	3.4	2.7	3.8	3.95	4.15	4.55	5.4	5.4	3.9	3

Table 17 Soluble reactive silica (Si) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Si Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	1.6	1.8	1.9	0.78	0.76	0.57	1.7	2.2	1.6	0.99	1.1	1.2
max	4.4	4	4.2	4	2.3	2.5	2.9	3.8	3.7	2.9	2.5	3.1
median	3.15	2.25	3	1.8	1.5	1.4	2.1	3.1	3.25	2.5	1.75	2
Si Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	4.1	2.5	3.8	3.1	2.6	0.26	0.24	0.71	1.7	2.2	2.4	3.8
max	4.7	4.5	4.6	4.4	3.2	2.8	2.8	2.6	3.4	3.7	3.1	5.1
median	4.4	3.4	4.15	4	2.75	2.35	1.75	1.5	2.85	3.05	2.65	4.35

Table 18 Dissolved organic carbon (DOC) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
DOC Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	5	5	4.4	3.4	2.8	2.6	2.5	2.4	2.1	2.2	1.9	1.8
max	15	12	12	9.8	5.6	4	3.9	5	4	4.1	3.7	3.4
median	7	6	7.9	5.2	3.95	3.25	3.15	3.3	3	3.05	2.9	2.9
DOC Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	15	13	14	8.4	7.3	6	6.1	6.3	5.3	5.2	4.2	4
max	19	17	17	14	12	11	12	11	9.9	9.1	8	6.5
median	16.5	16	15.5	12	9.25	8.55	9.35	9.1	7.95	7	6.4	5.3
DOC Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	16	17	16	13	12	11	11	12	10	9.6	7.8	7.1
max	20	18	17	15	13	13	14	14	13	13	12	9.7
median	18	17	16	14	12.5	12	13	13	11	11.5	9.5	8.3

Table 19 Dissolved organic carbon (DOC) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
DOC Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	7	7	9	4.6	3.8	3.7	3.8	4.4	3.9	4.2	3.7	2.8
max	12	12	13	14	12	11	12	12	9.9	9.2	9.4	7.7
median	10	8	10	10.5	8.3	7.85	8.05	8.35	6.7	6.35	5	4.5
DOC Lower Canning River (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	11	9	11	13	11	12	9.4	8.2	10	8.6	9	9.7
max	13	13	15	16	14	14	14	13	13	11	9.7	13
median	12	11	12.5	14	12.5	13	13	10	11	9.3	9.4	10.45

Table 20 Total suspended solids (TSS) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
TSS Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	0.5	1	0.5	2	5	2	7	3	6	8	4	1
max	8	3	12	10	15	16	14	25	17	15	17	16
median	4	2	3.5	5.5	8.5	9.5	11	12	11.5	9	8	6.5
TSS Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	2	2	3	4	7	9	8	9	8	9	5	6
max	9	7	8	13	27	23	21	30	18	17	11	20
median	6	4	6.5	8.5	11.5	12.5	11	14.5	14	12.5	8	8
TSS Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	4	3	3	3	5	6	7	9	7	6	6	3
max	22	10	27	11	16	17	39	16	12	13	10	9
median	7.5	5.5	7.5	6	7	12.5	16	11.5	9	8	8	5

Table 21 Alkalinity (total CaCO3) (ALK) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
ALK Lower Swan Canning Estuary (surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	68	100	100	110	120	120	120	120	120	120	120	120
max	110	300	110	120	120	130	130	130	140	130	130	120
median	100	110	110	115	120	120	130	130	120	120	120	120
ALK Middle Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	67	85	67	110	120	120	120	120	120	120	120	110
max	96	300	110	130	130	130	140	140	140	130	120	120
median	83	100	94	120	120	120	130	130	130	120	120	120
ALK Upper Swan Estuary (Surface)												
n	8	8	8	12	8	8	8	8	12	8	8	8
min	75	89	67	110	110	130	130	140	130	130	120	120
max	94	110	110	130	140	140	160	170	170	160	160	140
median	87	104.5	86.5	120	125	130	140	145	145	145	135	120

Table 22 Chlorophyll a (Chl-a) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Chl-a Lower Swan Canning Estuary (surface)												
n	20	16	16	20	16	20	16	16	16	16	16	20
min	0.0006	0.0031	0.002	0.001	0.001	0.002	0.0012	0.0018	0.0012	0.001	0.0007	0.0009
max	0.017	0.016	0.026	0.006	0.0025	0.004	0.0026	0.0073	0.0038	0.004	0.0041	0.0051
median	0.0049	0.0052	0.0075	0.002	0.0018	0.002	0.0017	0.0022	0.0025	0.002	0.002	0.003
Chl-a Middle Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	16	16	16	20
min	0.0019	0.0035	0.0008	0.005	0.0046	0.006	0.0041	0.0035	0.0089	0.007	0.0034	0.0025
max	0.012	0.04	0.018	0.037	0.073	0.029	0.029	0.03	0.072	0.034	0.016	0.01
median	0.0097	0.0185	0.0036	0.018	0.011	0.014	0.015	0.0084	0.0165	0.016	0.0091	0.0054
Chl-a Upper Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	16	16	16	20
min	0.011	0.0033	0.0019	0.001	0.0037	0.004	0.0083	0.01	0.0043	0.002	0.0017	0.0025
max	0.016	0.017	0.0041	0.021	0.053	0.044	0.05	0.038	0.038	0.045	0.011	0.016
median	0.0135	0.0076	0.0021	0.002	0.0097	0.018	0.0115	0.016	0.0155	0.017	0.0052	0.0105

Table 23 Chlorophyll a (Chl-a) (mg/L) for Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Chl-a Canning Estuary (surface)												
n	20	16	16	20	16	20	16	16	20	16	16	16
min	0.001	0.0015	0.0008	0.0023	0.0027	0.0021	0.0019	0.0025	0.0028	0.0012	0.0017	0.0026
max	0.012	0.011	0.03	0.027	0.042	0.066	0.03	0.031	0.012	0.013	0.0096	0.0097
median	0.006	0.0033	0.0044	0.015	0.0104	0.0123	0.0122	0.0067	0.0067	0.0036	0.0036	0.0052
Chl-a Lower Canning River (Surface)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	0.001	0.0011	0.0013	0.0011	0.0015	0.0057	0.0044	0.0056	0.0017	0.0023	0.0025	0.0015
max	0.003	0.0053	0.006	0.023	0.019	0.012	0.039	0.059	0.023	0.029	0.02	0.0058
median	0.001	0.0018	0.0015	0.0109	0.012	0.0077	0.0089	0.015	0.017	0.0064	0.0059	0.0032

Table 24 Dissolved oxygen (DO) (mg/L) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
DO Lower Swan Canning Estuary (surface)												
n	15	15	16	20	16	20	16	16	20	16	16	20
min	7.56	7.21	7.73	6.92	6.35	5.94	5.98	5.88	5.52	5.52	6.37	6.88
max	11.37	8.97	9.23	8.23	7.84	7.03	6.99	6.52	6.93	7.07	7.63	9.13
median	8.69	8.17	8.515	7.655	7.15	6.495	6.59	6.165	6.41	6.45	7.275	7.79
DO Lower Swan Canning Estuary (Bottom)												
n	12	15	16	20	16	20	16	16	20	16	16	20
min	1.67	1.45	1.37	2.37	3.92	2.21	4.63	5.48	4.88	3.75	6.18	4.52
max	7.55	7.53	8.01	7.13	6.92	6.88	6.58	6.21	6.52	6.86	7.28	7.72
median	5.395	5.25	4.585	5.17	5.84	5.85	5.935	5.865	6	6.205	6.865	6.54
DO Middle Swan Estuary (Surface)												
n	19	16	16	20	16	20	16	16	20	15	16	20
min	7.15	6.26	5.27	5.98	5.11	5.73	5.48	5.41	5.15	4.73	5.72	4.83
max	8.96	10.49	9.58	10.03	10.83	10.06	10.88	8.78	9.93	8.5	12.21	15.25
median	8.04	7.635	7.485	7.42	6.675	7.195	7.5	7.09	7.2	6.4	7.36	8.135
DO Middle Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	15	20	15	16	20
min	0.28	0.24	0.25	0	0.74	0.75	4.21	4.01	2.25	3.16	2.35	0.56
max	8.55	8.31	7.6	6.11	7.24	6.55	6.66	7.47	6.93	7.09	7.11	7.5
median	1.02	1.345	3.54	1.5	2.745	4.11	4.925	4.94	4.66	4.91	5.815	3.605
DO Upper Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	7.75	6.85	5.23	4.47	3.88	3.37	3.94	3.46	3.45	2.92	3.45	4.52
max	9.33	9.16	8.55	8.45	9.24	9.98	11.34	9.41	9.82	9.45	14.46	9.02
median	8.515	8.215	7.725	5.785	7.185	7.705	8.455	7.375	7.23	6.695	6.33	6.755
DO Upper Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	7.48	1.32	4.11	0.23	0.23	0.29	2.54	0.24	2.58	2.47	1.95	0.48
max	9.12	9.14	8.53	7.93	7.7	5.98	7.28	7.27	8.15	7.88	6.93	5.37
median	8.45	8.25	7.65	4.78	4.08	3.87	4.735	3.9	4.705	5.32	4.88	2.345

Table 25 Dissolved oxygen (DO) (mg/L) for the Swan River, Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Swan River (Surface)												
n	10	8	8	8	8	10	8	6	10	6	8	10
min	8.06	7.79	6.7	4.71	3.62	3.34	3.69	2.94	2.86	4.09	4.59	4.12
max	9.23	9.28	8.64	7.78	6.44	5.56	6.23	4.21	6.13	5.15	7.08	8.73
median	8.642	8.57	7.90	5.54	4.97	4.38	4.79	3.60	4.66	4.83	6.07	6.778
Swan River (Bottom)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	8.05	7.74	6.46	4.54	3.53	3.17	2.06	2.99	2.78	3.46	2.86	1.75
max	9.21	9.27	8.63	7.41	6.35	5.58	5.49	3.45	5.23	5.07	6.76	4.64
median	8.632	8.54	7.85125	5.38	4.86	4.14	3.83	3.25	3.83	4.51	4.76	2.89
DO Canning Estuary (surface)												
n	20	16	16	20	16	16	16	16	20	16	16	20
min	4.76	4.7	6.22	3.66	4.21	4.12	1.5	3.81	1.29	2.25	1.9	3.63
max	12.55	9.4	12.39	8.34	7.94	6.48	10.8	11.33	7.07	6.67	7.23	9.82
median	7.525	7.43	7.485	7	6.265	5.525	5.66	5.26	5.085	5.39	6.035	7.32
DO Canning Estuary (Bottom)												
n	20	16	16	20	16	16	16	16	20	16	16	20
min	0.44	1.69	0.36	0	1.65	0.23	0.23	0.12	0.22	0.27	0.65	0.4
max	7.02	8.4	7.44	6.73	7.03	5.72	6.06	11.14	6.38	6.67	6.79	7.77
median	3.085	4.35	4.59	4.835	5.04	4.705	5.105	4.855	4.02	4.295	4.915	4.38
DO Lower Canning River (Surface)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	6.04	6.89	5.36	4.36	4.05	2.42	4.54	4.32	4.86	5.39	4.74	4.97
max	7.54	7.94	7.4	9.36	8.29	9.59	9.3	10.1	10.04	7.97	8.38	6.94
median	6.88	7.26	6.85	6.595	6.955	7.11	7.42	7.37	7.195	6.61	6.38	6.295
DO Lower Canning River (Bottom)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	5.58	4.91	4.2	0.05	2.48	1.07	0.22	0.85	1.98	2.58	5.1	2.45
max	7.48	7.92	7.39	10.83	15.33	9.22	9.77	8.13	8.09	7.24	10.88	14.24
median	6.75	7.075	6.66	6.155	6.1	6.07	4.62	6.435	6.01	5.96	6.87	6.18

Table 26 Specific conductivity (Sp. Cond.) (mS/cm) for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Sp. Cond. Lower Swan Canning Estuary (surface)												
n	16	16	16	20	16	20	16	16	20	16	16	20
min	9.43	11.96	8.25	16.39	23.18	30.33	34.95	35.97	36.65	35.37	35.54	29.92
max	28.67	27.08	27.54	31.15	32.78	35.74	37.3	37.09	38.15	37.38	37.06	35.61
median	20.65	24.06	18.235	27.455	30.275	33.725	36.01	36.74	37.15	37	36.395	33.635
Sp. Cond. Lower Swan Canning Estuary (Bottom)												
n	12	16	16	20	16	20	16	16	20	16	16	19
min	25.99	28.14	27.21	26.85	29.26	30.86	35.06	36.14	36.8	36.66	35.91	33.04
max	34.7	35.11	34.61	35.1	35.08	36.6	37.49	37.08	38.18	37.45	37.15	35.79
median	33.345	33.7	32.93	33.86	34.175	35.245	36.615	36.86	37.24	37.015	36.52	34.87
Sp. Cond. Middle Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	15	16	20
min	4.05	4.87	2.87	4.43	5.26	13.74	20.23	24.09	27.85	29.25	27.69	12.78
max	10.36	17.04	7.9	18.81	23.01	29.54	33.1	34.64	34.86	35.37	34.83	30.42
median	6.43	9.61	4.84	9.925	15.56	22.84	27.08	29.835	31.355	32.58	30.85	24.21
Sp. Cond. Middle Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	15	20	15	16	20
min	4.53	5.77	2.89	8.93	13.44	17.84	24.12	26	28.41	29.71	29.14	26.98
max	29.75	27.22	19.5	23.13	26.38	31.67	34.53	34.66	35.77	36.01	36.35	32.92
median	21	21.955	12.5	17.61	21.645	27.085	30.27	30.57	32.295	33.06	33.02	30.585
Sp. Cond. Upper Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	4.77	4.44	2.97	4.33	4.02	5.1	8.63	11.27	16.04	19.83	21.11	2.95
max	10.38	10.59	5.02	7.3	10.57	18.05	21.89	26.76	28.08	28.98	28.94	26.12
median	6.09	7.305	4.52	4.915	5.38	12.12	16.715	20.42	24.755	26.08	25.56	17.385
Sp. Cond. Upper Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	4.81	4.81	3.1	4.41	4.44	5.09	10.46	13.78	18.57	20.98	21.97	18.83
max	10.5	16.75	7.69	12.55	27.71	19.75	24.12	28.5	29.33	29.45	30.06	28.23
median	6.49	8.08	4.785	5.015	8.35	14.24	18.135	23.135	25.69	26.71	26.71	24.605

Table 27 Specific conductivity (Sp. Cond.) (mS/cm) for the Swan River, Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Sp. Cond. Swan River (Surface)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	4.71	5.21	3.30	4.79	4.45	4.98	6.77	11.80	14.59	18.16	19.56	6.77
max	10.72	10.78	5.13	5.26	4.98	8.31	11.50	16.64	19.52	22.35	21.72	19.30
median	6.91	7.98	4.43	4.98	4.75	6.22	9.27	14.13	17.72	20.33	20.56	12.57
Sp. Cond. Swan River (Bottom)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	5.55	5.43	3.30	4.88	4.51	4.98	6.87	11.86	16.71	18.20	19.67	14.40
max	10.74	10.80	5.15	5.18	4.99	8.39	13.32	18.44	20.59	22.49	23.00	21.40
median	7.14	8.21	4.48	5.00	4.77	6.43	10.12	14.61	18.58	20.72	21.53	18.82
Sp. Cond. Canning Estuary (surface)												
n	20	16	16	20	16	16	16	16	20	16	16	20
min	0.33	0.22	0.27	0.39	0.32	14.19	23.13	27.68	24.72	21.86	4.32	0.23
max	18.01	20.91	17.94	28.00	30.25	34.23	36.12	37.24	38.91	37.05	36.37	32.88
median	7.28	12.45	5.02	15.49	20.67	30.98	31.28	35.22	33.39	33.38	31.27	24.32
Sp. Cond. Canning Estuary (Bottom)												
n	20	16	16	20	16	18	16	16	20	16	16	20
min	0.34	0.21	0.27	0.40	0.33	19.88	26.71	30.79	30.17	29.65	23.24	0.23
max	31.54	30.23	28.49	28.89	31.23	34.31	36.14	37.25	38.95	37.06	36.61	34.87
median	22.42	22.54	14.46	20.68	25.56	31.56	32.84	35.49	34.71	34.54	33.46	28.43
Sp. Cond. Lower Canning River (Surface)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	0.32	0.19	0.25	0.37	0.30	0.50	0.38	0.40	0.35	0.38	0.31	0.22
max	0.86	0.60	0.48	0.56	0.53	0.60	0.60	0.58	0.46	0.44	0.83	0.49
median	0.35	0.34	0.45	0.49	0.50	0.55	0.54	0.50	0.41	0.41	0.35	0.35
Sp. Cond. Lower Canning River (Bottom)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	0.32	0.19	0.25	0.37	0.31	0.50	0.38	0.40	0.34	0.38	0.30	0.22
max	0.96	8.49	0.48	0.55	0.53	0.60	0.60	0.58	0.46	0.44	26.03	6.35
median	0.36	0.34	0.45	0.49	0.47	0.55	0.55	0.50	0.41	0.41	0.36	0.38

Table 28 Temperature (Temp oC) for Lower Swan Canning Estuary, Middle Swan and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temperature Lower Swan Canning Estuary (surface)												
n	16	16	16	20	16	20	16	16	20	16	16	20
min	13.50	14.84	16.09	17.88	18.96	21.82	23.58	23.56	22.18	19.93	14.90	14.85
max	15.44	17.02	20.75	22.31	26.81	28.00	27.96	25.27	24.68	23.47	19.62	18.42
median	14.50	15.25	17.24	20.68	22.52	24.90	24.67	24.52	23.22	21.11	17.50	16.20
Temperature Lower Swan Canning Estuary (Bottom)												
n	12	16	16	20	16	20	16	16	20	16	16	19
min	15.32	16.48	16.28	17.58	18.89	21.34	22.79	23.29	22.17	20.05	15.06	15.62
max	16.81	17.08	17.86	22.20	25.90	26.70	26.80	24.77	24.70	23.43	19.09	17.64
median	16.25	16.89	17.01	19.04	20.55	23.95	24.08	24.33	23.03	21.09	17.41	16.53
Temperature Middle Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	15	16	20
min	13.12	14.37	15.67	19.76	21.52	24.61	25.45	24.99	22.78	20.33	15.04	14.99
max	15.30	16.80	21.12	24.85	28.80	29.78	30.64	27.68	26.33	24.18	19.14	17.52
median	14.06	15.23	17.94	22.53	25.57	27.73	27.26	26.17	24.50	21.30	17.59	16.30
Temperature Middle Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	15	20	15	16	20
min	13.11	12.75	15.39	20.39	20.72	23.80	24.84	25.04	22.04	20.09	15.02	15.34
max	16.36	17.21	20.36	24.02	27.58	28.56	29.08	26.62	25.72	23.85	19.20	17.67
median	15.57	16.81	17.74	22.06	24.32	26.99	26.71	25.92	23.70	21.38	17.52	16.37
Temperature Upper Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	12.40	12.26	14.75	19.19	21.46	25.24	25.80	25.69	22.36	20.23	15.03	15.06
max	15.08	15.14	20.42	24.43	28.54	29.54	30.70	27.36	26.15	21.55	19.18	17.73
median	13.67	14.43	16.38	22.12	25.08	27.83	27.55	26.70	24.64	21.19	17.42	16.00
Temperature Upper Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	12.38	12.27	14.75	19.06	20.75	24.75	25.55	26.15	23.12	20.47	15.62	16.43
max	14.54	16.00	19.62	24.00	27.59	28.67	29.37	27.91	25.76	21.53	19.20	17.67
median	13.07	13.79	16.02	21.28	24.40	27.53	27.31	26.76	24.36	21.08	17.80	17.02

Table 29 Temperature (Temp oC) for the Swan River, Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Temp ºC Swan River (Surface)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	12.31	12.08	14.67	19.13	20.70	25.27	24.94	26.09	22.08	20.10	14.75	14.53
max	13.86	14.78	19.35	23.11	27.36	28.68	28.82	26.65	25.48	20.90	18.81	16.21
median	13.05	13.44	16.25	21.48	24.32	26.82	27.04	26.30	24.01	20.52	16.48	15.45
Temp ºC Swan River (Bottom)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	12.31	12.23	14.67	19.25	20.42	25.14	24.94	26.07	22.62	20.18	15.24	16.14
max	13.86	14.75	19.31	23.05	27.30	28.57	28.79	26.69	25.46	21.16	18.93	17.15
median	13.04	13.43	16.23	21.42	24.15	26.71	27.25	26.37	24.43	20.69	17.02	16.68
Temp ºC Canning Estuary (surface)												
n	20	16	16	20	16	16	16	16	20	16	16	20
min	13.17	12.39	15.28	18.28	18.90	23.04	24.03	22.43	20.82	16.97	14.64	14.52
max	15.57	16.96	20.48	23.83	27.59	30.07	32.75	27.98	28.79	24.71	20.14	18.66
median	14.57	15.72	18.08	20.76	23.08	25.37	26.53	24.55	24.48	20.83	17.08	16.01
Temp ºC Canning Estuary (Bottom)												
n	20	16	16	20	16	18	16	16	20	16	16	20
min	13.73	12.21	15.27	17.71	18.43	22.98	24.15	21.89	21.60	17.74	15.20	14.83
max	16.86	18.22	21.49	25.75	29.55	30.51	31.17	28.92	27.82	24.77	20.51	19.02
median	15.82	16.95	17.98	21.12	23.75	25.84	26.53	24.43	24.52	20.94	17.75	16.73
Temp ºC Lower Canning River (Surface)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	13.15	12.82	15.40	17.95	19.07	24.22	23.78	24.14	20.78	17.64	14.20	14.01
max	14.62	15.12	19.53	22.83	25.38	27.62	27.85	26.26	24.97	22.30	18.52	15.91
median	14.25	14.55	16.95	19.93	22.51	25.22	26.11	25.07	23.40	20.23	15.18	15.33
Temp ºC Lower Canning River (Bottom)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	13.02	12.79	15.32	15.94	18.19	22.03	22.89	23.65	19.62	17.19	14.00	14.00
max	14.53	15.74	19.26	20.96	24.39	26.28	26.26	25.62	24.45	21.71	18.03	16.24
median	14.06	14.41	16.30	18.43	21.40	24.43	24.78	24.47	22.89	19.67	15.07	15.25

Table 30 pH for Lower Swan Canning Estuary, Middle Swan Estuary and Upper Swan Estuary during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
pH Lower Swan Canning Estuary (surface)												
n	16	16	16	20	16	20	16	16	20	16	16	20
min	7.64	7.76	7.84	7.86	7.93	7.83	7.80	7.82	7.85	7.81	7.84	7.88
max	8.39	8.10	8.35	8.17	8.10	8.08	8.06	8.06	8.02	8.01	8.10	8.17
median	8.06	8.00	8.08	8.06	8.05	7.95	7.97	7.91	7.95	7.95	8.00	8.03
pH Lower Swan Canning Estuary (Bottom)												
n	12	16	16	20	16	20	16	16	20	16	16	19
min	7.60	7.65	7.56	7.70	7.85	7.69	7.81	7.79	7.85	7.80	7.85	7.84
max	8.12	8.13	8.13	8.13	8.12	8.07	8.06	8.06	7.99	7.97	8.08	8.11
median	7.95	8.00	7.92	7.99	8.00	7.94	7.97	7.91	7.94	7.92	7.99	7.99
pH Middle Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	15	16	20
min	7.50	7.42	7.40	7.44	7.58	7.67	7.57	7.66	7.60	7.47	7.38	7.25
max	7.72	8.04	8.16	8.16	8.05	8.07	8.02	7.95	8.01	7.78	7.94	8.40
median	7.58	7.61	7.62	7.85	7.77	7.82	7.82	7.82	7.78	7.67	7.77	7.80
pH Middle Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	15	20	15	16	20
min	7.15	7.12	7.21	7.14	7.27	7.30	7.42	7.53	7.31	7.41	7.25	7.13
max	7.73	7.64	7.93	7.89	8.00	7.89	7.86	7.88	7.85	7.77	7.93	7.91
median	7.34	7.26	7.38	7.36	7.53	7.58	7.59	7.65	7.60	7.54	7.64	7.53
pH Upper Swan Estuary (Surface)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	7.45	7.38	7.40	7.35	7.33	7.29	7.29	7.23	7.24	7.19	7.23	7.12
max	7.74	7.93	7.67	7.64	7.63	7.89	7.83	7.77	7.61	7.67	7.86	7.59
median	7.59	7.60	7.49	7.41	7.47	7.50	7.53	7.50	7.38	7.39	7.33	7.30
pH Upper Swan Estuary (Bottom)												
n	20	16	16	20	16	20	16	16	20	12	16	20
min	7.53	7.09	7.32	7.22	7.20	7.10	7.11	7.00	7.12	7.16	7.15	6.96
max	7.74	7.90	7.67	7.54	7.53	7.52	7.55	7.56	7.53	7.50	7.39	7.27
median	7.61	7.59	7.49	7.34	7.32	7.30	7.35	7.29	7.28	7.30	7.25	7.09

Table 31 pH for the Swan River, Canning Estuary and Lower Canning River during the 2019-20 reporting period in surface and bottom waters; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Swan River (Surface)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	7.46	7.52	7.46	7.33	7.34	7.29	7.30	7.19	7.26	7.25	7.30	7.16
max	7.73	7.93	7.69	7.57	7.46	7.58	7.58	7.29	7.50	7.37	7.49	7.54
median	7.62	7.71	7.59	7.43	7.39	7.44	7.41	7.25	7.37	7.32	7.38	7.32
Swan River (Bottom)												
n	10	8	8	8	8	10	8	6	9	6	8	10
min	7.56	7.52	7.51	7.35	7.30	7.26	7.05	7.18	7.22	7.16	7.21	7.00
max	7.74	7.94	7.70	7.52	7.47	7.56	7.54	7.25	7.44	7.36	7.47	7.19
median	7.65	7.73	7.60	7.40	7.37	7.39	7.32	7.22	7.29	7.29	7.31	7.09
pH Canning Estuary (surface)												
n	20	16	16	20	16	16	16	16	20	16	16	20
min	7.19	6.82	7.34	7.39	7.37	7.63	7.65	7.47	7.06	7.11	7.08	7.23
max	8.38	8.04	8.63	8.01	8.05	8.10	8.20	8.03	7.83	7.88	7.88	8.02
median	7.52	7.64	7.72	7.87	7.87	7.78	7.79	7.74	7.57	7.57	7.66	7.72
pH Canning Estuary (Bottom)												
n	20	16	16	20	16	18	16	16	20	16	16	20
min	7.00	6.70	7.28	7.19	7.31	7.06	7.65	7.15	6.95	7.16	7.06	7.12
max	7.63	7.83	7.83	7.98	8.03	7.86	8.00	8.04	7.84	7.88	7.91	8.00
median	7.37	7.51	7.47	7.80	7.85	7.77	7.84	7.74	7.50	7.51	7.62	7.55
pH Lower Canning River (Surface)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	7.20	7.19	7.25	7.36	7.35	7.30	7.37	7.45	7.18	7.29	7.08	7.01
max	7.58	7.62	7.75	7.97	8.02	8.01	8.10	8.14	7.94	7.82	8.01	8.57
median	7.35	7.33	7.37	7.55	7.70	7.78	7.73	7.82	7.52	7.45	7.36	7.25
pH Lower Canning River (Bottom)												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	7.06	7.17	7.23	7.01	6.92	7.06	7.04	7.16	7.05	7.02	7.01	6.75
max	7.49	7.41	7.57	7.73	7.71	7.72	7.81	7.82	7.65	7.70	7.80	7.99
median	7.31	7.31	7.31	7.32	7.32	7.41	7.36	7.55	7.26	7.28	7.20	7.13

Table 32 Secchi depth (m) for the Lower Swan Canning Estuary, Middle Swan Estuary, Upper Swan Estuary, Swan River, Canning Estuary and Lower Canning River during the 2019-20 reporting period; monthly sample size (n), minimum, maximum and median values.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Secchi (m) Lower Swan Canning Estuary												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	0.50	1.70	1.00	1.60	2.00	1.20	1.60	0.90	2.10	2.90	2.90	2.00
max	5.40	4.40	4.90	6.00	6.40	5.80	5.10	4.20	4.40	4.70	6.00	7.20
median	2.20	2.92	2.79	3.45	4.06	3.60	3.54	3.04	3.14	3.68	4.07	3.98
Secchi (m) Middle Swan Estuary												
n	19	16	16	20	16	20	16	16	20	16	12	20
min	0.40	0.80	0.60	0.80	0.70	0.70	0.90	0.80	0.60	0.80	1.30	0.90
max	1.70	1.60	1.30	2.00	2.20	2.50	1.90	1.40	1.70	2.10	2.80	2.40
median	1.12	1.25	0.97	1.22	1.25	1.33	1.41	1.04	1.09	1.36	1.88	1.59
Secchi (m) Upper Swan Estuary												
n	16	16	16	20	16	20	16	16	20	16	16	20
min	0.40	0.70	0.50	0.80	0.60	0.60	0.90	0.70	0.70	0.90	1.00	0.50
max	1.10	1.70	1.30	1.60	1.80	1.40	1.60	1.30	1.90	2.00	2.20	2.60
median	0.91	1.20	0.83	1.21	1.09	0.96	1.18	1.06	1.16	1.30	1.61	1.54
Secchi (m) Swan River												
n	8	8	8	8	7	10	8	8	10	8	8	10
min	0.50	0.80	0.50	1.10	1.30	0.90	1.50	1.10	1.30	1.30	1.50	0.70
max	1.10	1.60	1.30	1.60	2.00	1.80	1.80	1.50	1.90	2.60	2.40	2.40
median	0.83	1.17	0.95	1.35	1.69	1.41	1.68	1.38	1.58	1.73	1.78	1.49
Secchi (m) Canning Estuary												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	0.60	0.45	0.60	0.70	0.45	0.70	0.70	0.60	0.90	1.20	1.00	0.60
max	2.80	2.40	9.00	3.20	3.60	4.10	3.40	3.20	3.70	3.80	4.50	3.20
median	1.31	1.28	1.74	1.53	1.56	1.68	1.69	1.47	1.87	2.20	2.23	1.82
Secchi (m) Lower Canning River												
n	20	16	16	20	16	20	16	16	20	16	16	20
min	0.60	0.50	0.60	0.70	0.60	0.80	0.80	0.60	0.50	0.90	0.70	0.40
max	0.90	1.00	1.00	1.30	1.20	2.00	1.60	1.10	1.10	1.50	1.60	1.00
median	0.77	0.71	0.79	0.92	0.95	1.11	1.13	0.89	0.86	1.16	1.04	0.80

Appendix 3 Historic changes to the estuarine monitoring project

On 09/05/2017 the Canning run site order was changed due to Kent Street Weir refurbishment works increasing water levels prohibiting *Kepa* from getting under Greenfields Bridge. SCB2, SAL and KEN upstream to PO2 are sampled by *Kepa* and RIV, CASMID and GRE upstream to ELL are sampled by *Trekker*. All filtering is carried out in the wet lab at Ellam Street after the monitoring runs.

On 01/05/2017 the analytical laboratory was changed from NMI to Chem Centre for all parameters.

From 26/07/2016 the SG-E-CANEST site order was changed to try and improve the time efficiency of the sampling run. The order of sites sampled using *Kepa* was BAC, KEN, SAL then SCB2 and using *Trekker* was ELL, NIC, CASMID and then RIV.

On 17/08/2015 sampling at HEA was expanded to include grab samples (surface and bottom), integrated depth (ID) samples and phytoplankton samples.

In November 2014 the ecological management zones (EMZ) within the Swan Canning River Estuary were re-classified to align this report with others published by the Department of Biodiversity, Conservations and Attractions (formally SRT) and DOW. Please refer to page 14 of this report for current EMZ classifications. It should therefore be noted that the monitoring sites within each zone have changed with respect to quarterly data reports published before November 2014.

The SG-E-CANEST site CAS in Castledare originally sampled from 23/01/1995 to 23/6/1998 and then re-added on 1/11/2005 was repositioned to mid-channel (CASMID) on 19/01/2010. This was then repositioned back to CAS on the 27/11/2012 and then again back to CASMID on 19/03/2013.

The SG-E-CANEST project was divided into two runs on the 19/03/2013; the lower Canning (SCB2, SAL, RIV and CASMID) sampled using the *Trekker* and the upper Canning (KEN, BAC, NIC and ELL) sampled using *Kepa*.

The SG-E-CANEST site SCB was repositioned 100m west as SCB2 on 29/01/2013.

Sampling of the SG-E-SWANEST sites; SCS01, LLH and WBRP ceased on the 28/05/2012.

The SG-E-CANEST site SCB was introduced to the project in July 2010.

The frequency of grab sample collection across both projects was reduced from a weekly to fortnightly basis.

The collection of chlorophyll was changed from a surface and bottom grab samples to a surface grab sample and ID sample on the 10/12/2001 for SG-E-SWANEST and 15/10/2005 for SG-E-CANEST.

The SG-E-SWANEST site HEA was added to the project on 09/10/2000.

Silica and dissolved organic nitrogen were included in the suite of analytes sampled from 14/07/2008 for SG-E-SWANEST and SG-E-CANEST and from 08/09/2008 for the SG-E-UPPERSWAN.

The analytical laboratory was changed from SGS to NMI from 05/09/2005 for chlorophyll *a* and from 19/09/2005 for all other parameters.

Appendix 4 Historic events likely to affect the estuarine monitoring project:

In February 2017 there was strong flooding in the Swan River which made it difficult to obtain full profiles and samples at all required sites.

On 10/01/2017 *Trekker* was used to sample the SG-E-CANEST project sites, SCB2, SAL, RIV and CASMID and *Kepa* was used to sample ELL, NIC, BAC and KEN due to access issues upstream of Greenfields Bridge being rectified.

On 14/10/2014 the SG-E-CANEST site order was amended due to access issues upstream of Greenfields Bridge. The sites SCB2, SAL, KEN and BAC were sampled using *Kepa* and RIV, CASMID, NIC and ELL were sampled using *Trekker*.