STOKES INLET

WATER QUALITY SAMPLING TECHNICAL REPORT 2020 – 2021

SOUTHCOAST NATURAL RESOURCE MANAGEMENT INC.

esperance regional fund

AN ACTIVITY SUPPORTED BY THE ESPERANCE REGIONAL FORUM (ERF) LEGACY FUNDS
PREPARED BY SOPHIE WILLSHER WITH ASSISTANCE FROM KATE PICKERING, SOUTH COAST NATURAL RESOURCE MANAGEMENT INC.

Stokes Inlet, Esperance Western Australia

Kate Pickering sampling water quality at Stokes Inlet

communities caring for their environment

South Coast NRM is an incorporated not for profit natural resource management organisation on the South Coast of WA. It is the peak regional body that brings, people, organisations and information together so that the regional community can drive sustainable management of natural resources with positive environmental and economic outcomes.

We acknowledge the Noongar/Nyungar peoples of the South Coast region as the traditional custodians of this land and we pay our respects to their Elders past and present.

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CONTENTS

1. Abstract

Stokes Inlet is an important ecological feature in Esperance's landscape, a region characterised by its rare and unmatched biodiversity and scenic landscapes. Nestled within the Stokes National Park, the inlet has immense social, ecological, cultural, and economic value. Periodic sampling of the inlet since the 1970's shows extreme nutrient enrichment of the catchment, hyper salinity, and a dominance of phytoplankton, growing with the expansion of agricultural activity in the region.

South Coast Natural Resource Management (NRM) conducted water quality sampling at Stokes Inlet between June 2020 and April 2021. This data and report contribute to sampling of the inlet by the Department of Water and Environmental Regulation (DWER) that had been conducted from the 1970s to 2010. Results from the 2020 - 2021 sampling period indicate the system remains a hypersaline and nutrient enriched environment since the mid-seventies. The effects of the El Nino event in late 2020 altered natural stratification of the inlet and therefore water quality parameters vary slightly to historic records. The inlet can also be oversaturated with oxygen, with levels consistently sitting at 80 – 140% dissolved oxygen throughout the year. Nutrient enrichment has continued to rise, and chlorophyll a levels in autumn suggests an algal bloom may have occurred. Nutrient input into the inlet should be investigated further to understand the relationship between land management practises and inlet health.

Overall, the 2020 – 2021 sample round suggests that the inlet has remained at a similar degree of health to historic sampling rounds, with no immediate threats to the ongoing condition of the inlet. This will need to be verified by a more complete sampling regime in the future that addresses the low sample size and high variability in results observed in this sample round.

Image 1. Stokes Inlet, Esperance, Western Australia

2. Figures

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4. Introduction

Stokes Inlet lies 80km west of Esperance, within the Stokes National Park (Figure 1). The inlet is attributed by two catchments, the Lort and Young rivers, (Figure 2) which cover a total of 4,575km^2 between the Shires of Esperance and Ravensthorpe.

Figure 1. Stokes National Park located approximately 80km from the town of Esperance

The land surrounding the catchments is largely agricultural, encompassing the rural communities of Munglinup, Cascade and Coomalbidgup. As of 2008, approximately 65 – 70% of the catchments had been cleared, with the dominant farming practises now being grains (wheat, barley & canola), lupins and some livestock.

The inlet and its encompassing National Park have broad social, cultural, and environmental values, with the area frequently used for recreational fishing, camping, bush walks and bird watching. Stokes Inlet is also known to be an important habitat for many native and internationally protected migratory shorebirds, frequently sought after by local bird watching enthusiasts including the Esperance Bird Observers Group. Further, the inlet hosts a significant population of black bream which is fished commercially and is a strong driver for recreational fishing in the area.

The purpose of this report is to inform on the overall condition of Stokes Inlet and its tributaries, building from historic knowledge across three previous sample rounds (1974, 2006 and 2010). This report will investigate changes to the inlet based on historic data and their subsequent implications. The findings of this report will go on to inform future management actions for the inlet to maintain its ecological function and integrity.

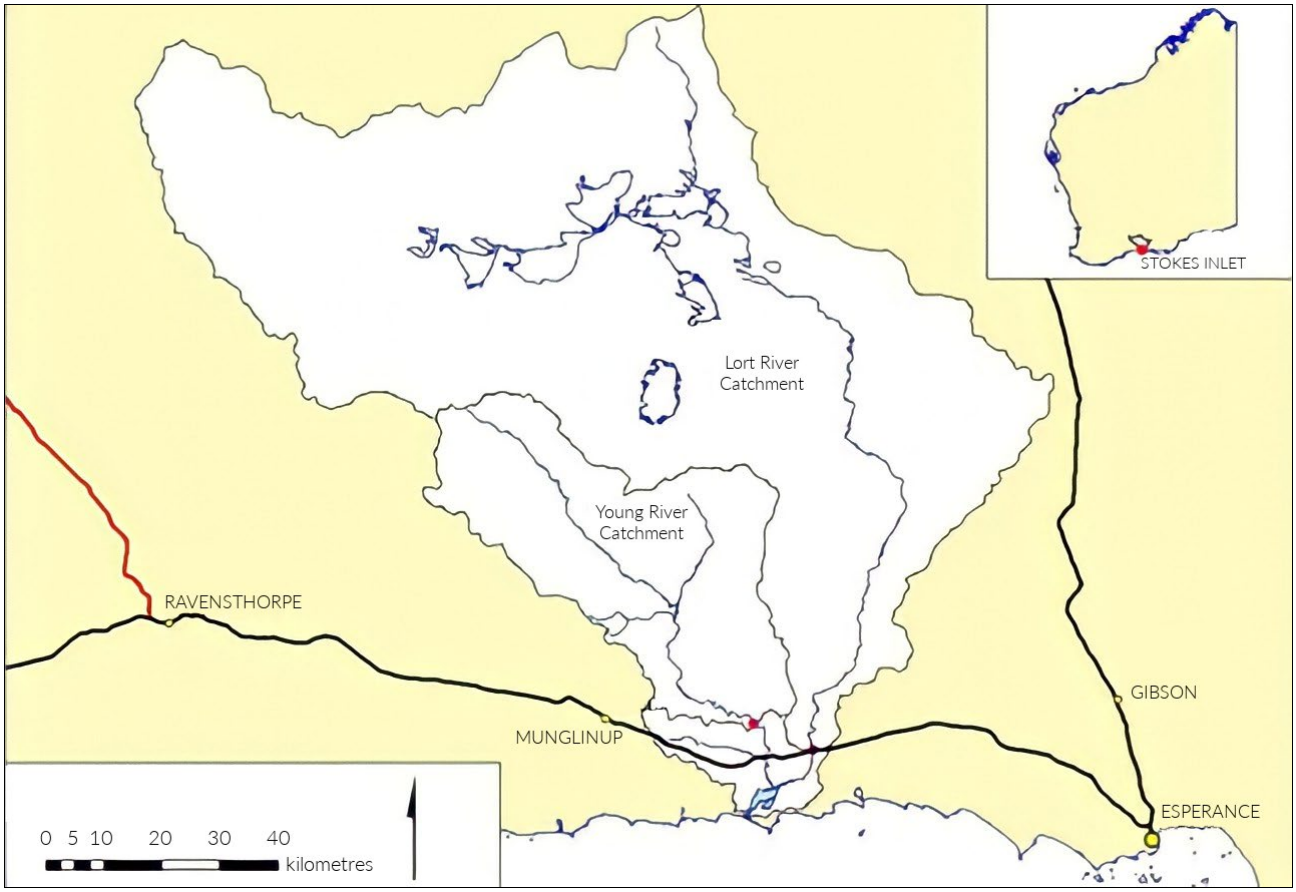

Figure 2. Catchment area of Stokes inlet extending 100km inland from the southern coastline west of Esperance. Image source: Department of Water and Environmental Regulation, 2007

5. Methods

5.1 Data Collection

Data was collected in field over a single day (sample dates were: 03/06/2020, 18/09/2020, 05/01/2021 & 07/04/2021) once every season, following sampling methods used in previous sample runs by DWER. There were five selected sample sites within the inlet itself, one site in each river and one site in the ocean (Figure 3).

At each site, surface and bottom samples were collected and sent to the Australian Laboratory Services (ALS) for discrete analysis of major nutrients, as listed below:

- Turbidity (NTU)
- Ammonia as N (mg/L)
- Nitrite + Nitrate as N (NOx) (mg/L)
- Dissolved Total Kjeldahl Nitrogen (TKN) as N (mg/L)
- Total Nitrogen as N (TKN + NOx) (mg/L)
- Total Phosphorus as P (mg/L)
- Reactive Phosphorus (mg/L)
- Chlorophyll a, b, c + Pheophytin a with Volume (mg/m^3)

Physiochemical parameters were recorded in-situ, as listed below:

- Temperature (degrees Celsius)

- Depth (m)
- Dissolved Oxygen (% DO)
- pH
- Salinity (µm/cm)

Samples sent to ALS were collected using laboratory provided containers, with bottom samples collected with the use of a bilge pump. In-situ data was attained by testing with a pH meter, conductivity and DO probe from South Coast NRM's WTW Water Quality Meter.

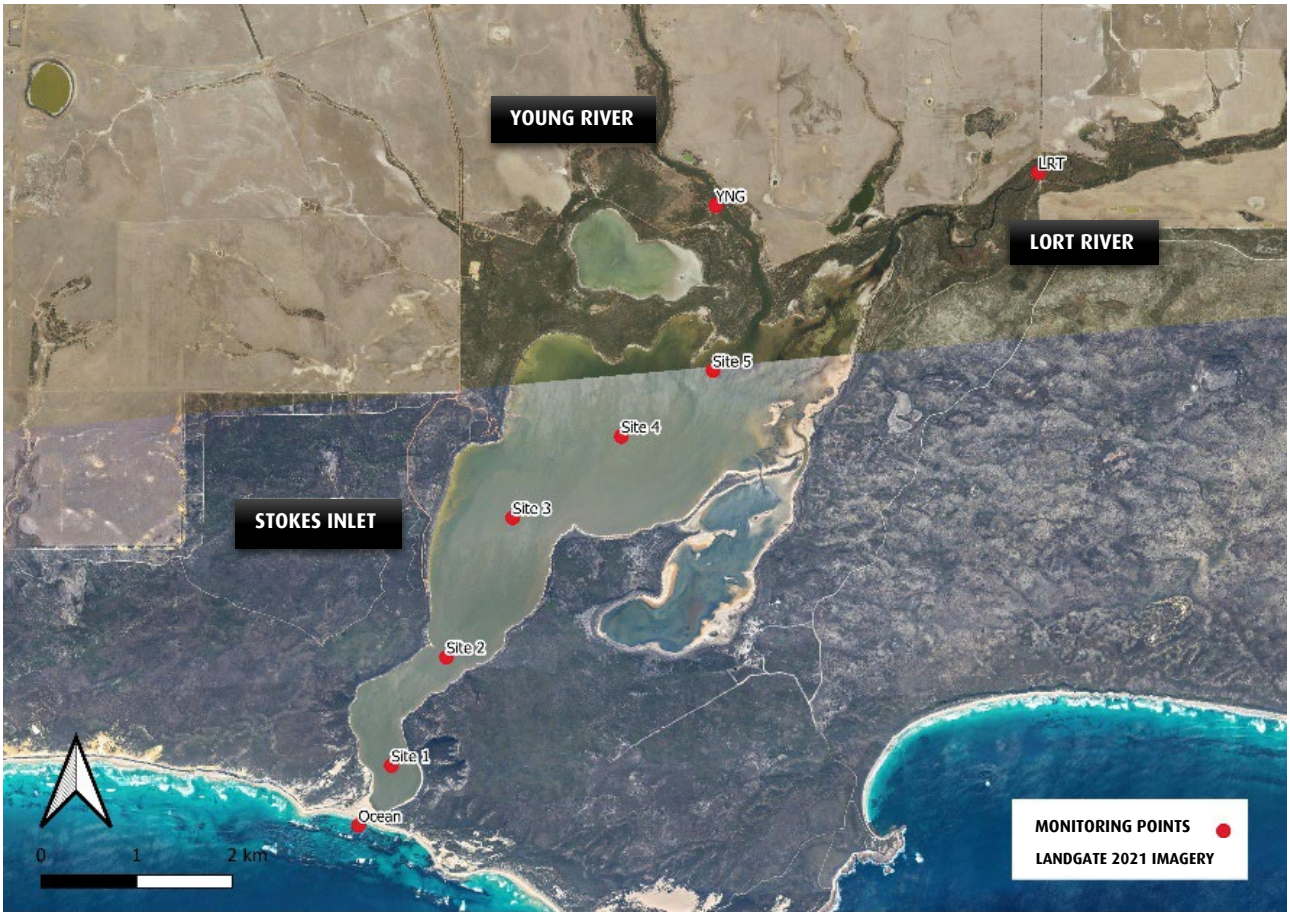

Figure 3. Sample points for the Stokes Inlet Water Quality Sampling Project 2020 – 2021

5.2 Data Interpretation

To produce meaningful results from this sample round, interpretation of the 2020/21 data followed the methodology developed in previous sampling rounds, ensuring continuity and comparability between historic data, and the 2020/2021 sample round. Results were then examined against the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) baseline values. These figures are described as "low-risk guideline trigger values," that determine the risk of negative consequences to an aquatic ecosystem.

Rainfall data collected at the Bureau of Meteorology's Stokes Inlet Weather Station (BoM, 2021) was used to provide context to the data collected (Figure 4) and will be referred to throughout the results and discussion sections below. Rainfall over the sample period was generally above average, attributed to the El Nino event that occurred globally from September 2020 to February 2021 .

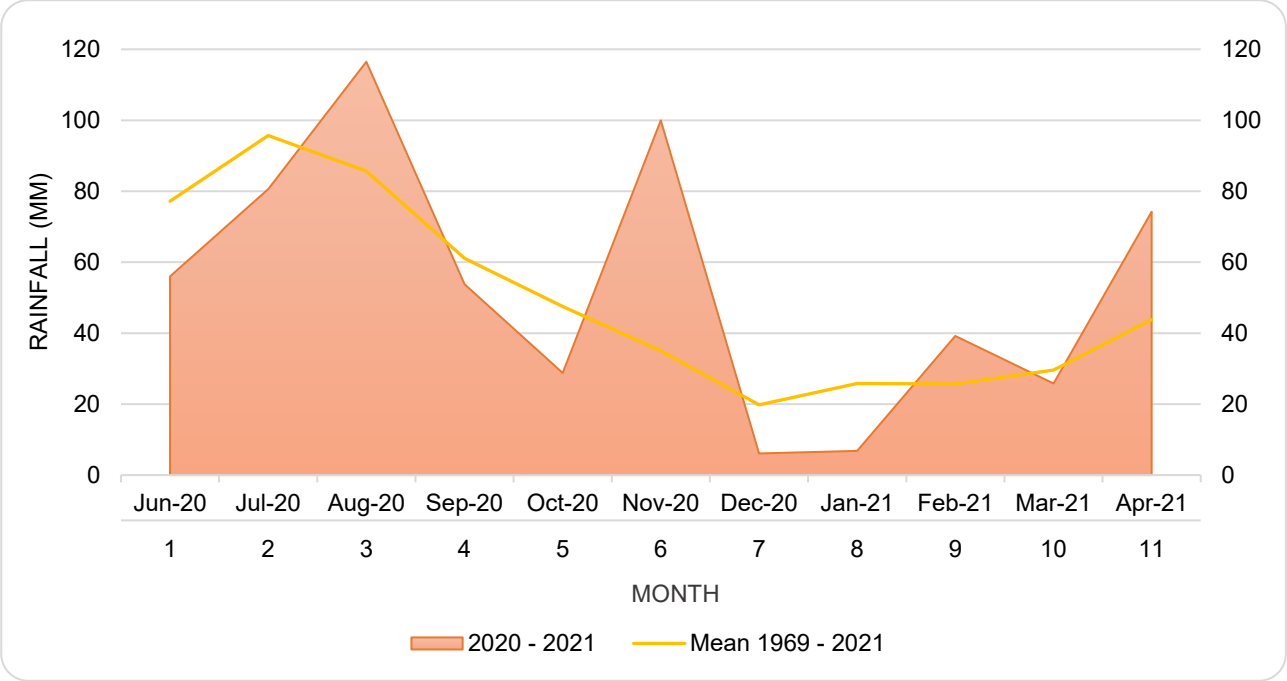

Figure 4. Monthly rainfall (mm) from 2020 – 2021 collected at the Stokes Inlet Weather Station compared to the average monthly rainfall for the Esperance region from 1969 to 2021, data sourced from the Bureau of Meteorology (2021)

6. Results

6.1 Parameters

Temperature

Water temperature (Figure 5) varied from an average of 14°C in winter to 22°C in autumn, there was very little variation between sites, or surface and bottom temperatures.

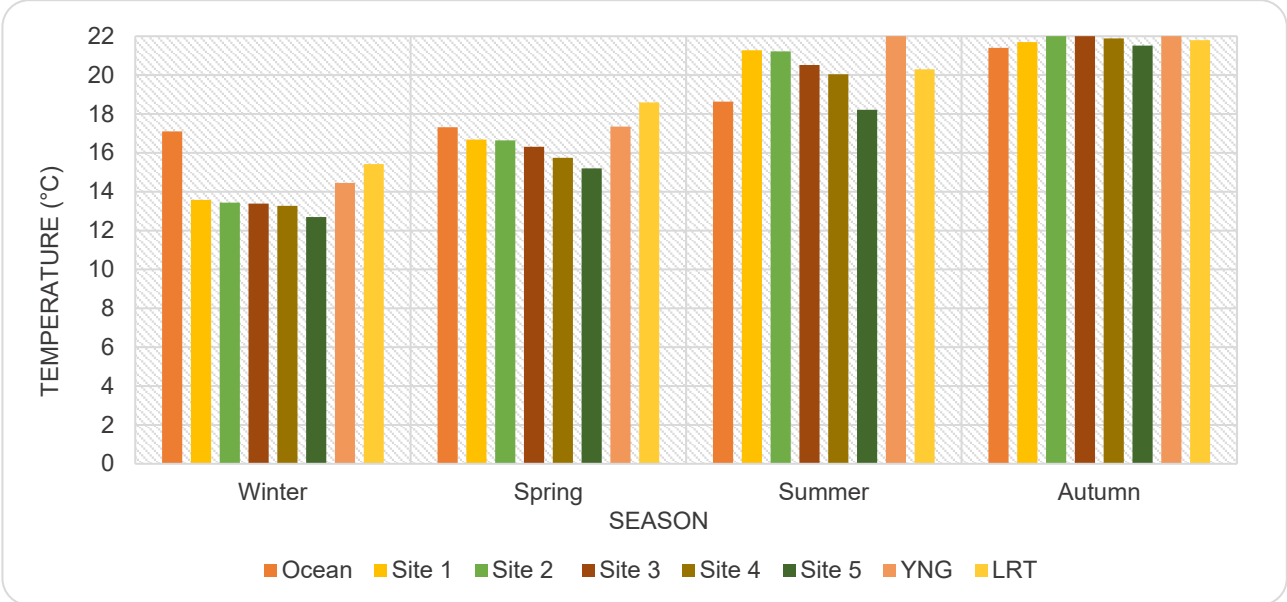

Figure 5. Water temperatures sampled across the Stokes Inlet from June 2020 – April 2021 as a part of the Stokes Inlet Water Quality Sampling Project

Depth

The estuary is deepest at its mouth (Site 1), averaging 8.4m across the sample period, and shallowest closest to the tributaries at Site 5, averaging 0.53m (Figure 6). There is little seasonal variation, however summer depths were deeper than winters, by an average of 15% across each site. These summer depths may be a result of the extended wet weather the Esperance region experienced during the El Nino event (Figure 4).

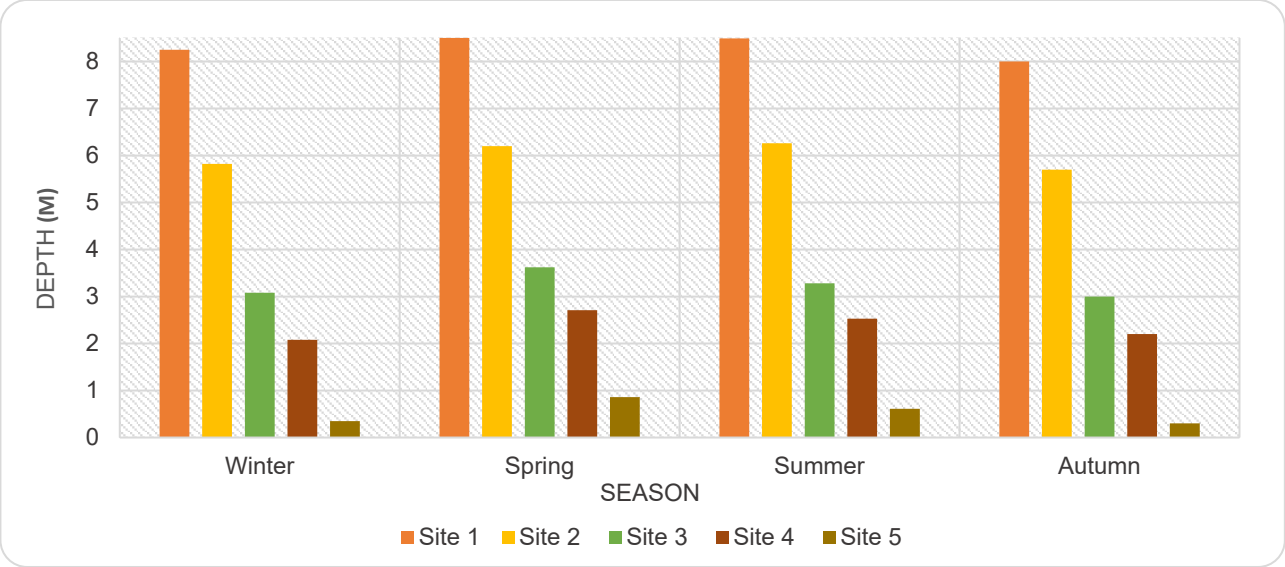

Figure 6. Depth of sample sites at Stokes Inlet from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project

pH

The inlet remains alkaline with pH levels between 7.5 – 8.5 (Figure 7). Autumn was significantly more alkaline than other seasons, exceeding the ANZECC guidelines upper limit of a pH of 8.5 for estuaries, for all sites within the inlet. All other seasons remained within the ANZECC guidelines.

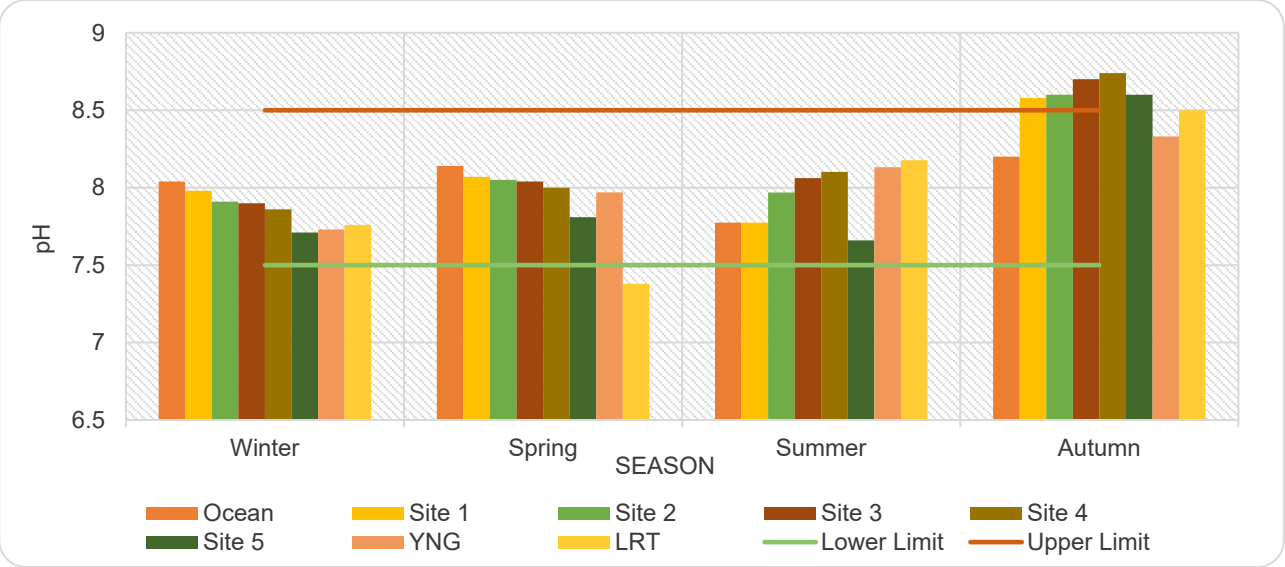

Figure 7. pH of sample sites at Stokes Inlet from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project

Dissolved Oxygen

Dissolved Oxygen (DO) fluctuated between 80 – 140% (7 – 12 Mg/L) across the year, but remained relatively consistent between winter, spring and summer (Figure 8). Lower DO readings from Site 5 in summer and autumn may be attributed to the shallowness of the site at less than 1 metre deep (Figure 6). DO in autumn exceeded 130% saturation on five sample occasions and showed strong variation between surface and bottom DO levels. This is acutely demonstrated at Site 1 in autumn where the surface DO was 87% while its bottom DO was 29.4%, strongly indicating stratification occurred at the inlets mouth. The Lort River had the lowest DO levels of all survey sites averaging 85% DO across the sample period.

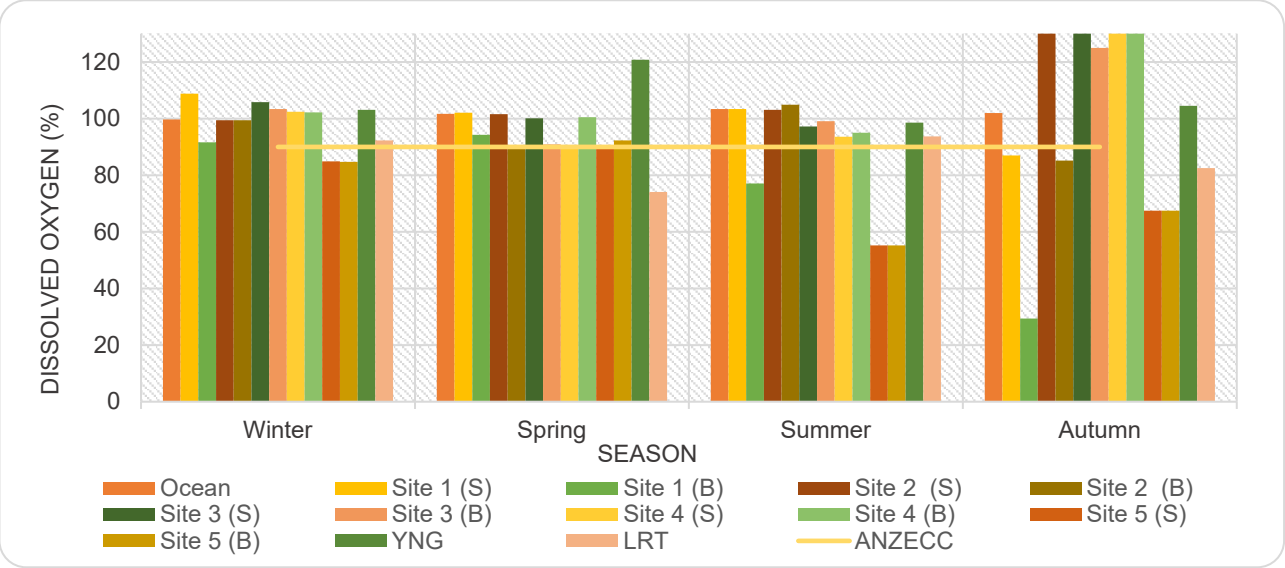

Figure 8. Graph of dissolved oxygen levels at the surface (S) and bottom (B) of each site at Stokes inlet from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project.

Image 1. Kate Pickering (South Coast NRM Ramsar Project Officer) and Sophie Willsher (South Coast NRM Regional Agricultural Landcare Facilitator – East) taking water samples at Stokes Inlet, Esperance WA.

Turbidity

Significant variation in turbidity exists across seasons, sample sites and surface and bottom turbidity (Figure 9). Spring was the most turbid season, with Sites 2, 3 & 4 having high bottom recordings up to 30 nephelometric turbidity units (NTU). A general trend shows a sharp peak in turbidity for spring and a dramatic fall following in the summer before turbidity rises slightly in autumn.

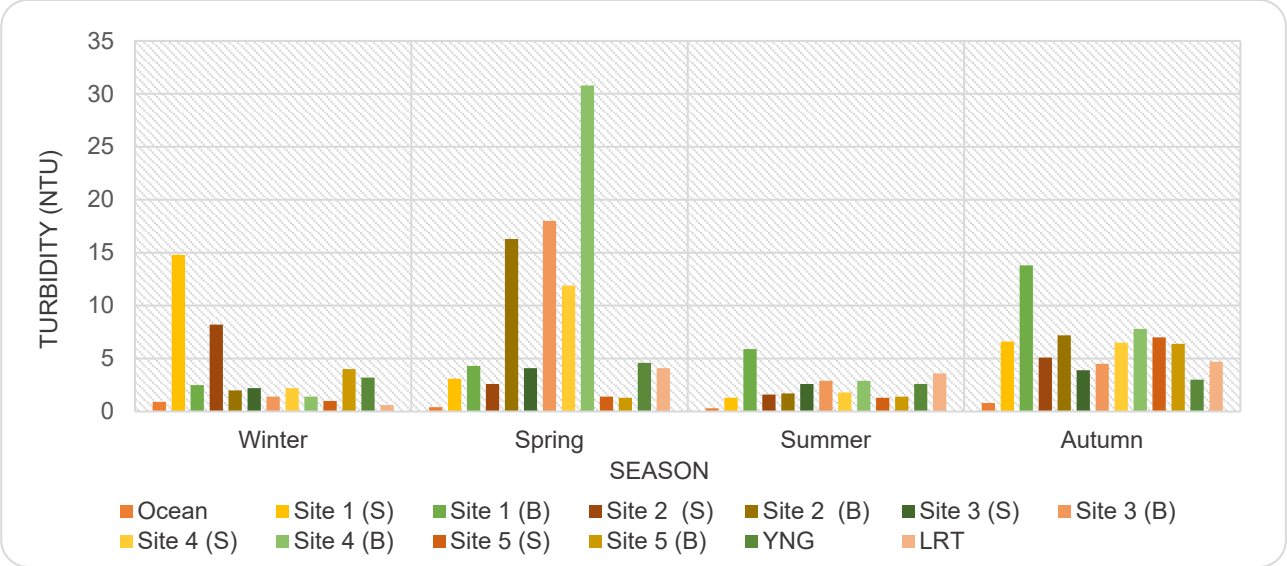

Figure 9. Turbidity (NTU) at the surface (S) and bottom (B) of each site at Stokes from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project

Salinity

Salinity was measured in conductivity (microSiemens per centimetre or µc/cm). This parameter was consistent across sites but showed seasonal variation (Figure 10). Winter was significantly more saline than the other seasons with most sites recording 80 µm/cm. Summer was the least saline and the only season to meet the salinity of seawater at 53.85µm/cm. Salinity decreased further up the catchment with the tributaries less saline than the inlet specifically, the Lort River was less saline than ocean water for all seasons, but winter and the Young River mirrored the variation seen in the inlet.

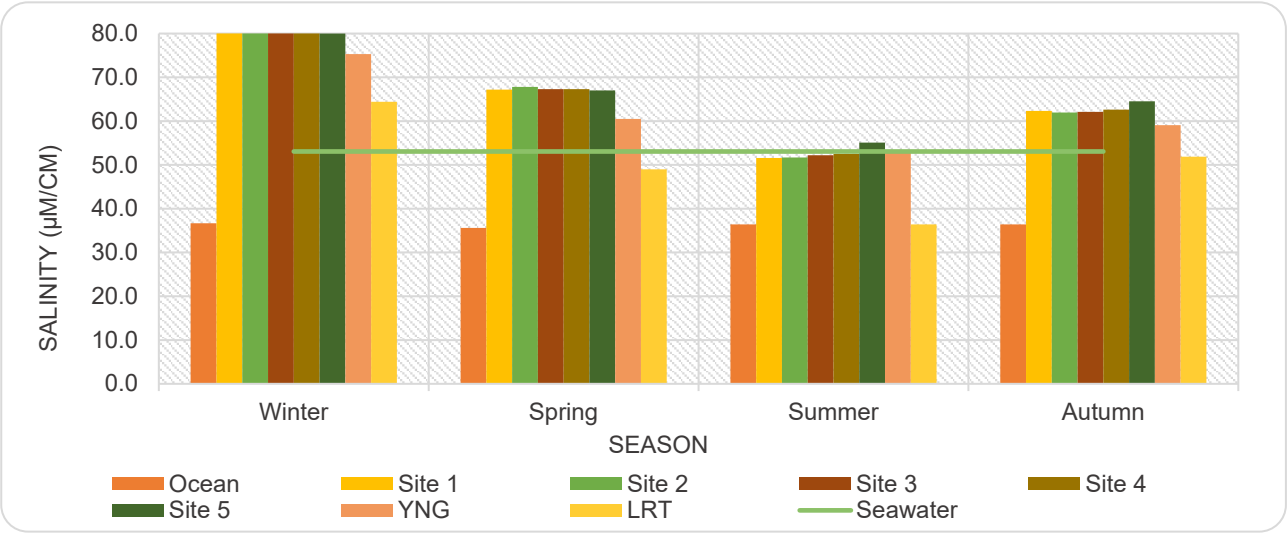

Figure 10. Salinity at the surface (S) and bottom (B) of each site at Stokes Inlet, measured in conductivity (µm/cm) from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project

6.2 Nutrients

Ammonia

Ammonia breached the ANZECC guidelines of 0.004mg/L on all but four sample occasions all occurring in spring (Figure 11). In winter, ammonia in the inlet was far higher than the Young & Lort Rivers, reaching a high of 0.14mg/L at Site 3, and only 0.04mg/L at the Lort River. This relationship reversed in spring with the Lort recording 0.19mg/L and Site 2 only 0.02mg/L. Summer showed some variance with levels between 0.02mg/L and 0.09mg/L. Autumn showed a strong spike at Site 5 up to 0.17mg/L. Relative to total nitrogen, the variance in ammonia is not significant between sites or over the sample year.

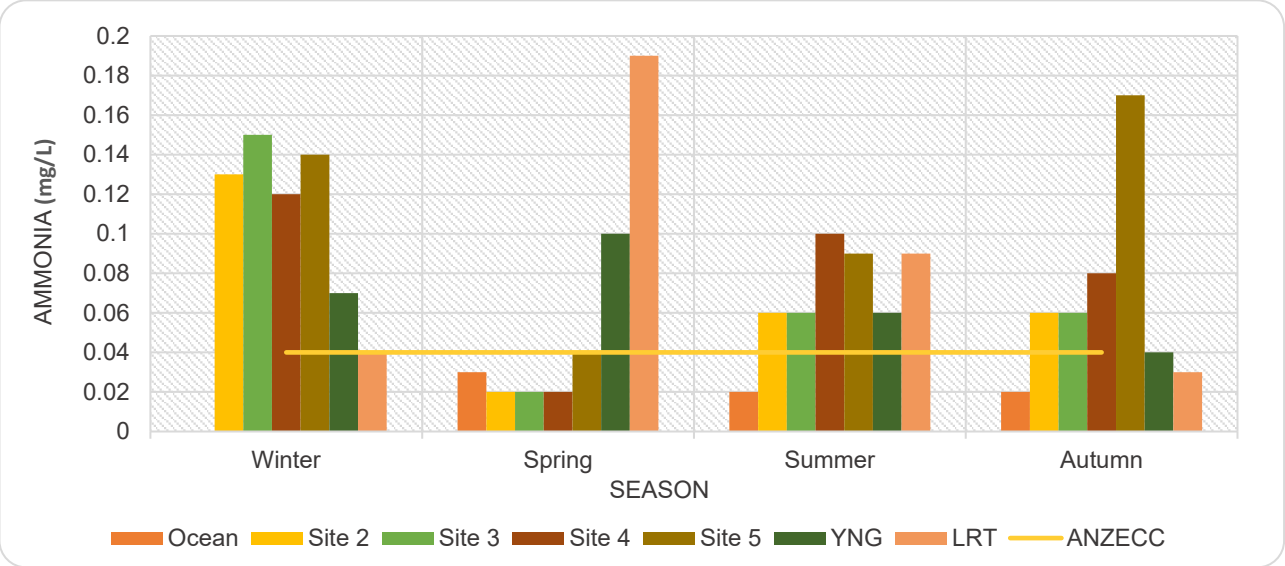

Figure 11. Ammonia levels (mg/L) for each site at Stokes Inlet from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project

Image 2. Stokes Inlet, Esperance, Western Australia

Phosphorus

Total Phosphorus (TP) exceeded the ANZECC guidelines for all seasons (Figure 12). TP was lowest in summer, remaining below the ANZECC guidelines within the estuary, but still exceeding the guidelines in the Lort and Young Rivers. Autumn and winter recorded extreme levels of TP, reaching 0.23mg/L in winter (Site 1, surface) and 0.21mg/L in summer (Site 4, surface). Soluble Reactive Phosphorus (SRP) and SRP were only observed once at site 4 & 5 in summer (0.04mg/L).

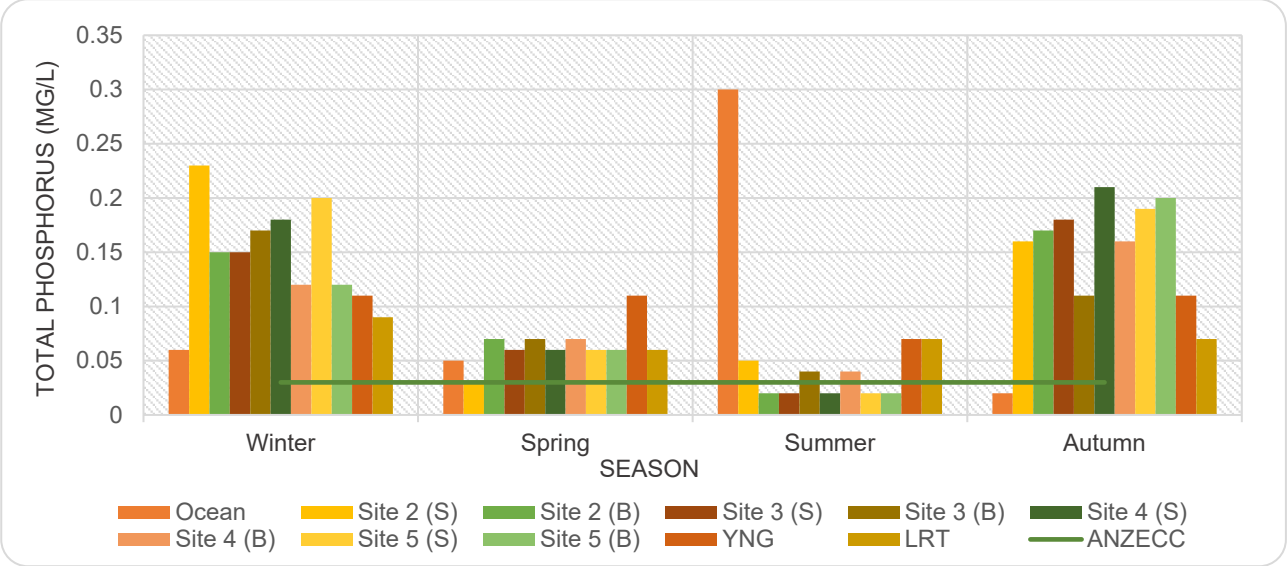

Figure 12. Total Phosphorus recorded at surface (S) and bottom (B) of each site at Stokes Inlet from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project.

Total Nitrogen

Total Nitrogen (TN) exceeded the ANZECC guidelines of 0.75mg/L across the 2020/21 sample year (Figure 13). Autumn recorded the highest levels of TN, up to 4mg/L, three times the ANZECC guidelines, while all other seasons generally increased their TN levels further towards the catchments. NOx was only detected twice, in summer (Site 4, 0.04mg/L) and spring (Young River, 0.02 mg/L).

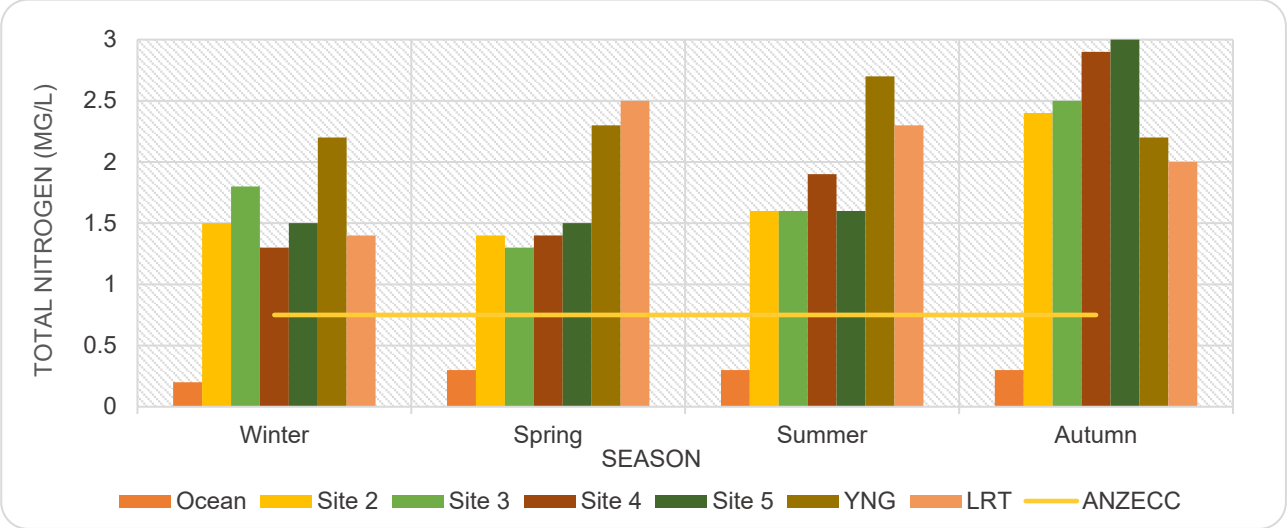

Figure 13. Total Nitrogen of each site at Stokes inlet from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project.

Chlorophyll a was above the ANZECC guidelines of 3mg/m^3 in all but one sample case (Site 4, surface, summer) (Figure 14). There was no distinct pattern between surface and bottom samples, however, autumn's data was distinctly high averaging 72.75mg/m^3 compared to 6.5, 9 and 5.25mg/m^3 of the other seasons (winter, spring, summer).

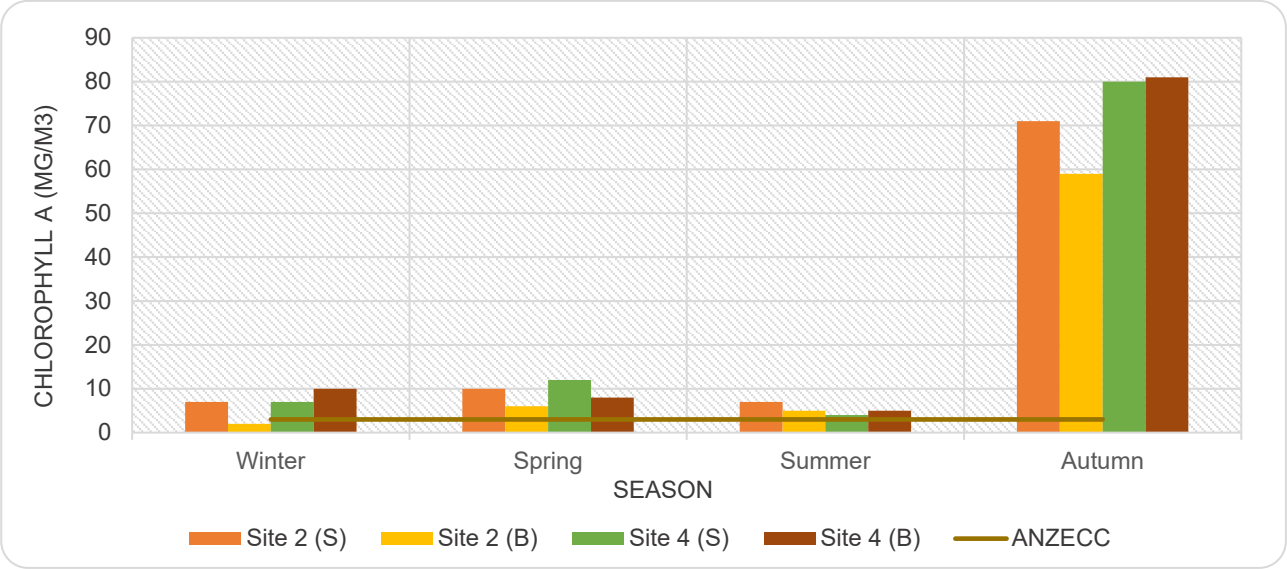

Figure 14. Chlorophyll a at surface (S) and bottom (B) of each site at Stokes Inlet, from June 2020 – April 2021 for the Stokes Inlet Water Quality Sampling Project.

7. Discussion

Historic data found water temperature of the inlet to follow a seasonal trend, with significant decline of 3 - 5°C at depths below 5.5m due to stratification and poor light penetration. Thermal stratification was not observed in the 2020/21 sampling run, and as a result, there was insignificant differences in temperature between surface and bottom samples. Summer temperatures were lower than autumn which is uncharacteristic for the region and influenced by the El Nino event which ran from September 2020 to March 2021. Rainfall to June 2021 was 273 mm, compared to just 91.5 mm for the same period in 2020.

Depths are consistent with historic data dating to 1974, with the profile decreasing in depth towards the catchments. Winter depths were less than that of summer, reflecting the late summer rainfall associated with El Nino. Stokes Inlet is consistently hypersaline, rarely below 53µc/cm, the salinity of seawater (equivalent of 35ppt). The extreme salinities observed in the 2020/21 sample run are within historic bounds of which the system is adapted to, and therefore are not considered a management threat (DWER, 2007).

Dissolved oxygen (DO) findings are not consistent with historic data. In the Department of Water's 2007 report, surface waters maintained a DO of 5 - 8 mg/L while bottom samples were anoxic, at 0 – 7 mg/L. The report indicated the inlet became increasingly oxygenated in the direction of the catchments. Findings from the 2020/21 sample round reveal insignificant differences between surface and bottom DO, with the inlet becoming less oxygenated further toward the catchment. Water temperature, salinity, and conductivity provide further supporting evidence that stratification did not occur in the inlet throughout 2020/21. This is a notable change from 2006, which acknowledged that stratification was brief due to high wind mixing, but still a very present phenomenon.

pH remains consistent with historic data; the inlet is an alkaline system ranging in pH from 7.5 – 8.6. As a phytoplankton dominated and iron rich sediment system, the 2020/21 sample run saw significant variation in turbidity across the inlet. Elevated turbidity was observed in spring, likely due to increased sediment run off following winter, and greater off farm inputs. Stokes Inlet has remained nutrient enriched since its first sample round in 1974, well over the ANZEEC guidelines. Table 1 demonstrates the significant increase in nutrient concentrations over time since 1974, with the exception of Soluble Reactive Phosphorus (SRP).

Nutrient	1974/75	2006	2010	2020/21	ANZECC
TN (mg/L)	0.99	2.5	1.58	1.6	0.75
NH4 (mg/L)	0.02	0.06	-	0.06	0.004
SRP (mg/L)	0.01	0.015	0.015	<0.01	0.005
TP (mg/L)	0.03	0.09	0.05	0.1	0.005

Table 1. Average of nutrient concentrations at the Stokes inlet across 4 sampling events 1974/5, 2006, 2010 and 2020/21, in comparison to ANZECC guidelines for the Stokes Inlet Water Quality Sampling Project.

The nutrient enriched environment of Stokes Inlet may be attributed to the heavy agricultural practises surrounding the catchment, with chemicals, fertilisers and other on farm inputs entering the catchments and influencing the nutrient balance of the system. The increase in nutrient values since the 1970's reflects the gradual intensification of farming practises over the decades. However, changes to farming practises, including the increased precision of chemical application, may have also led to a reduced excess of SRP entering the catchment, and these influences should be investigated further.

Total Nitrogen (TN) more than doubled in 2006, before reducing to 1.6mg/L in 2020/21. Ammonia remained consistent with 2006 levels, although this is three times the levels of 1974 (Table 1). Extremely elevated levels of ammonia pose a serious threat to the population of black bream in the inlet, which are a less tolerant species to ammonia toxicity than most. The bream was reported to be vulnerable across the south coast of WA due to fertiliser run-off, and so further investigation into the process of ammonia breaking down in the inlet from the surrounding agricultural land should be explored.

Results from the 2020/21 sample run indicate Total Phosphorus (TP) concentrations in Stokes Inlet are continuing to increase despite negligible SRP in the water column. High TP, but low SRP may indicate a substantial proportion of TP is being absorbed by the iron rich sedimentation, and therefore is not available to plant and aquatic life.

Chlorophyll a for autumn was extremely high. Accompanied with oversaturated DO, warm water temperatures, and turbid conditions, this report concludes an algal bloom was likely to have occurred in April 2021. Algal blooms have occurred in the inlet in the past, resulting in a fish kill incident in 2007. In the 2010 sample run, chlorophyll a exceeded the ANZECC guidelines on 20 occasions with a range from 0.001 – 0.067 mg/L. DWER attributed this to the nature of Stokes Inlet as a phytoplankton dominated system, characterised by non-lethal dinoflagellates and diatoms. Phytoplankton analysis from the 2020/21 sample run concur with the dominate phytoplankton, and no direct implications of the suspected bloom were reported by Stokes National Park Ranger Dave Thornburg.

8. Conclusion

Stokes Inlet remains a hypersaline, nutrient enriched, phytoplankton dominated environment. Results of the 2020/21 sample run indicate the system has had little variance in the past decade and concurs there are no immediate threats to the systems health. However, the limited sample size and high variation in results (both temporally and spatially) limit the confidence of this data, and a more complete sampling regime is necessary to conclusively assess the health of the inlet. The El Nino event in September 2020 – March 2021 significantly altered the usual stratification of the inlet, shown by differences in temperatures, freshwater inputs and salinity which are not reflective of historic sample results.

The inlet has become increasingly nutrient enriched since the 1970's, although levels have not varied significantly since 2006. Nutrient input from agricultural practises is the greatest threat to the ecosystem's health, with ammonia toxicity highlighted through this report as the major concern, especially for the viability of the black bream population. Further analysis into the relationship between current farming practises within the catchment and the health of the estuary are necessary to understand the role agriculture has in nutrient enrichment, and what the implications of this are.

9. Acknowledgements

South Coast NRM would like to thank the Esperance Regional Forum for funding this activity and DBCA, specifically Stokes National Park Ranger, Dave Thornburg for his assistance throughout the sample year.

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