How healthy is the Moore River Estuary?

Water quality study completed

In 1998 the local community expressed concerns about possible nutrient enrichment of the estuary and reported that there appeared to be an increasing frequency of algal blooms. They were also concerned about salinity levels in the estuary – wanting to know if it was influenced by salinisation of the upper catchment. Concern was also expressed about the impacts of the bar being artificially opened, particularly on the rate of sedimentation in the estuary.

A four-year study of water quality in the lower end of the Moore River system has recently been completed. The project was an initiative of the Guilderton Community Association and the Water and Rivers Commission, supported by the Natural Heritage Trust, and Moore River cruises.

The sampling program began in December 1998 and continued until November 2002. The key aims of this study were to:

1. Determine the nutrient and suspended sediment status of the lower Moore River
2. Determine the dominant areas of nutrient enrichment to the Moore River estuary
3. Determine the dynamics of algal abundance in the Moore River estuary
4. Determine the extent of salinity influence from the catchment to the lower Moore River
5. Provide recommendations for management of the lower Moore River.
Flow conditions during the study

The Moore River system is highly responsive to the prevailing weather conditions, as seasonal rainfall and the dynamics of the bar at the mouth play important roles in determining the nutrient status of the estuary. The study period captured data from a wide range of environmental conditions, including dry and wet summers, dry to extremely wet winters, and unseasonal flooding in March 1999 (Figure 1). Due to these contrasting conditions, no two seasons were similar with respect to river flow.

The length of time the bar remained open decreased with the drier conditions each year, while the number of times the bar opened and closed in a year increased. When the bar opens and closes in a short amount of time (less than 1-2 weeks) the height to which the bar builds up can be reduced. The higher the bar, the greater volume of water contained in the estuary, the greater the flushing of sediments from the estuary basin when the bar is breached.

<table>
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<tr>
<th>Site</th>
<th>NH₃-N</th>
<th>NO₃-</th>
<th>TN</th>
<th>FRP</th>
<th>TP</th>
<th>CHLA</th>
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<tr>
<td>Tidal estuary – S</td>
<td>0.019</td>
<td>0.120</td>
<td>0.84</td>
<td>0.013</td>
<td>0.05</td>
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<td>0.034</td>
<td>0.53</td>
<td>0.015</td>
<td>0.05</td>
<td>0.0014</td>
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<tr>
<td>Upper estuary – S</td>
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<td>0.150</td>
<td>0.92</td>
<td>0.025</td>
<td>0.06</td>
<td>0.0022</td>
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<tr>
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<td>0.205</td>
<td>1.00</td>
<td>0.023</td>
<td>0.06</td>
<td>0.0017</td>
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<tr>
<td>Moore River</td>
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<td>0.070</td>
<td>0.59</td>
<td>0.004</td>
<td>0.03</td>
<td>0.0027</td>
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<td>Gingin Brook</td>
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<td>0.068</td>
<td>0.86</td>
<td>0.12</td>
<td>0.17</td>
<td>0.0006</td>
</tr>
<tr>
<td>ANZECC 1992 Estuarine</td>
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<td>n/a</td>
<td>0.015</td>
<td>n/a</td>
<td>0.01</td>
</tr>
<tr>
<td>ANZECC 1992 Riverine</td>
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<td>n/a</td>
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<td>n/a</td>
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<tr>
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<td>ANZECC 2000 Lowland</td>
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<td>0.15</td>
<td>1.2</td>
<td>0.04</td>
<td>0.065</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Artificial breaching of the bar

Artificial breaching of the bar has been of major concern to the community, and while not many incidents were confirmed during the study, the practice does contribute to decreasing the height of the bar and reducing the flushing capability of the estuary. The bar is mostly breached artificially during the summer and Easter school holidays.

What is the condition of the estuary?

Nutrient status and seasonal nutrient patterns

- Nutrients come from surface flows (mainly in winter), groundwater (year round) and are released from the sediments (associated with low-oxygen conditions in summer and autumn).
- There is a high proportion of soluble nutrients (dissolved inorganic nitrogen and soluble phosphorus) – the forms which are directly available to algae – throughout the system.
- Phosphorus concentrations in Gingin Brook are of greatest concern (Figure 2). Soluble phosphorus levels are elevated year round and median concentrations in the Brook and estuary are considerably higher than ANZECC 2000 trigger values (Table 1).
- Nitrogen concentrations in the estuary show a strong seasonal pattern, increasing with surface flows in winter (Figure 2). Total nitrogen and oxidised nitrogen concentrations also exceeded ANZECC 2000 trigger values in the tidal estuary and upper estuary. Ammonia also marginally exceeded trigger values in bottom waters of the upper estuary.
- Nutrient loads are strongly dependent on flow. In wet years, when flows are much greater in the Moore River, nitrogen loads from the Moore River are much greater than from Gingin Brook, but soluble phosphorus loads are higher in Gingin Brook. When flows are similar in the two catchments, Gingin Brook contributes a greater load of total nitrogen, and a considerably higher phosphorus load than the Moore River, to the estuary.
- The estuary has relatively high concentrations of nutrients compared to other South West estuaries, particularly dissolved inorganic nitrogen and soluble phosphorus.

Salinity

- Salinity values for bottom waters in the tidal estuary varied widely, caused by seawater periodically moving in along the bottom of the estuary when the bar is open (Figure 4).
Salinity in the Moore River is considerably higher than Gingin Brook which is consistently fresh. Surface salinities in the Moore River and estuary often reached brackish levels (>5 parts per thousand) during winter flows.

Salinity in the upper Moore River increased slightly during spring, when flows were declining. The elevated salinities indicate that salinisation of the upper Moore River catchment is having a slight effect on the lower river and estuary.

**Dissolved oxygen**

- The dissolved oxygen status of the Moore River estuary is serious. Nearly 30% of sampling revealed concentrations less than 3mg/L—levels that are lethal to some fish, and stimulates nutrient availability from the sediments.

- Oxygen depletion of bottom waters was often associated with the bar opening and closing, and was often worst after the bar re-established, trapping salty water and algae in the estuary basin, and in stagnant deep holes.

- Low-oxygen conditions were associated with ammonia and hydrogen sulphide release from the sediments during summer and autumn.

- Dissolved oxygen levels were relatively low in Gingin Brook, but were often supersaturated in the Moore River (Figure 5).

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1The point within each box is the median or 50th percentile, meaning that there are equal numbers of samples above and below this value. The box gives an idea of the variation in the data around the median. Half of all sample values fall within the range shown by the box (from the 25th to the 75th percentile).
Colour and suspended solids

- The tea-like colour in the water (gilvin) is highest in Gingin Brook and lowest in the Moore River with the estuary being somewhere in between.
- Total suspended solids were greater in the Moore River than elsewhere, indicating a need for better erosion control as sediment and associated nutrients are being flushed from the catchment during high flows.

Algae

- When the system is warm, calm and shallow, and the bar is closed or close to closing, there is sufficient light and nutrients to allow algal growth to occur. The algal growth in the system is usually associated with mats of green filamentous algae above the "Footy Field" in the upper estuary, however can occur throughout.
- Growth of microscopic algae was not excessive, with only occasional ‘blooms’ of harmless species occurring. Concentrations of chlorophyll $a$ – a commonly used measure of the mass of algae in water – were generally very low, and median levels were well below ANZECC 2000 trigger values throughout the system (see Table 1).
- Potentially toxic blue-green algae have been observed in the estuary, though only in small numbers and not persisting. They have the potential to increase in abundance given the right conditions.

What do these results tell us?

Excessive nutrients pose a threat to the natural attractions of the Moore River Estuary. The monitoring results show that nitrogen and phosphorus concentrations are elevated in the estuary and that phosphorus levels in Gingin Brook are high. Nutrient levels in the estuary are as high as other South West estuaries that have significant algae problems. Luckily, the dark tannin-coloured waters seem to play an important role in limiting algal growth by reducing the light penetration that algae need to grow. However, when conditions are right significant algal mats are able to form in the upper estuary and lower catchment, and occasional “blooms” of phytoplankton do occur – though to date these have consisted of harmless species.

Occasions of very low dissolved oxygen in the water are also cause for concern. Dissolved oxygen is critical for the survival of fish and other aquatic animals. Low dissolved oxygen levels result from the decay of organic matter (such as algae) by bacteria which use oxygen, and are more common in bottom waters where there is restricted exchange of oxygen with the surface water. Low levels of oxygen are a common cause of fish deaths in rivers and estuaries.

A number of catchment characteristics contribute to the nutrient problem. The soils in the lower Gingin Brook catchment consist mainly of leached sands, which have little or no capacity to retain nutrients. When fertilisers and animal wastes are applied to the land they directly affect the groundwater and surface water in the area by leaching and from runoff due to rainfall events. The lower Moore River catchment, in contrast, has less intensive farming. The soils in the area are also mostly sandy but their capacity to retain nutrients is slightly greater than the leached sands. Animal wastes are still a major concern especially when livestock is allowed uncontrolled access to the river. Livestock are also a major cause of riverbank erosion in the catchment, reducing fringing vegetation etc.

The groundwater table around the estuary and lower catchment is very shallow and plays an important part in affecting the elevated nutrient condition of the estuary, particularly during times of low flow. The groundwater aquifers around Gingin Brook and Moore River Estuary contain elevated nutrient concentrations. Although groundwater can take several decades to move through the aquifers underlying the surface, any impact to recharge areas will have a pronounced effect in years to come, so management of the pollution inputs to the groundwater is critical and an important issue.
Summary of nutrient processes in the lower Moore River system

1. Bar open – high flow

Winter rainfall brings nutrients from the surrounding catchment with surface runoff, creating a seasonal pattern where nitrogen concentrations increase during the winter months. The increased flow also means higher loads of phosphorus entering the estuary during winter. Most of this flow comes down the Moore River, though in drier years flows from Gogin Brook can be similar to those from the Moore. The estuary is completely flushed with water from the catchment. Nutrient concentrations are similar throughout the estuary. Erosion in the catchment leads to relatively high levels of suspended sediments and associated nutrients entering the estuary from the Moore River, though most is flushed out to sea. Mobilisation of salt from the upper catchment means that the flow from the Moore, and consequently the estuary, is quite salty, often reaching brackish concentrations (>5 parts per thousand). The waters of Gogin Brook are fresh, nutrient enriched and at their most highly coloured towards the end of winter. Flood events tend to scour out the river channel and estuary basin, washing large amounts of sediment out to sea. During winter it is common for pulses of fresh, nutrient enriched, coloured water to be observed leaving the river mouth as a plume heading out to sea or along the coast. As flow drops away, seawater moves in along the bottom of the estuary and coastal processes cause the bar to form and close. This first closing is usually short-lived, as continued flow causes water levels to rise rapidly and break the bar again.

2. Bar open/closed – low flow

When the bar is open there is an exchange of nutrients, fauna and algae between the estuary and the open ocean. There is also an influx of salt water, which moves in along the bottom of the estuary from the ocean, and sediment that is brought in from the nearshore environment as a consequence of wave action and storm surges. Groundwater (containing dissolved nutrients) contributes to continuing flow from the catchment and also enters the estuary directly. While stagnant salt water remains in the closed system (up to 4 weeks) rotting algae and other organic matter can cause oxygen depletion of bottom waters, which can lead to unpleasant odours due to the production of hydrogen sulphide (rotten egg gas). Low-oxygen conditions can also cause nutrients to be released from the sediments. When water levels are low there is sufficient light and nutrients for algal mats to form in the upper estuary above the "Footy Field", which tend to float as water levels rise. Opening of the bar leads to a sudden decrease in water levels, and mats of green algae are often left exposed along beaches and river edges and in the estuary basin. As water moves out of the estuary it scours some of the sediment brought in while the bar was open previously. If the bar is breached frequently the bar does not have sufficient time to build up to a significant height to enable a good flushing of sediments from the system.
3. Bar closed – low flow

This is the stable summer condition where the bar can remain closed for several months. Groundwater continues to enter the estuary and maintains some flow from the catchment. The bar continues to build up, leading to slowly rising water levels in the estuary. This continued flow dilutes any remaining salt water and, combined with wind mixing, breaks down stratification. Even so, oxygen depletion can still persist in stagnant deep holes, causing ammonia release from the sediments. Gingin Brook continues to contribute high soluble phosphorus concentrations, and dissolved inorganic nitrogen still enters the estuary from the groundwater and catchment. The dark tannin-coloured waters of the system and high water levels reduce light availability, which restricts the growth of algal mats and phytoplankton despite abundant available nutrients.

Conclusions

1. The Moore River Estuary has elevated nitrogen and phosphorus concentrations. Sediments are being washed into the estuary from the catchment during high flows and from coastal processes as the bar builds up during low flows.

2. Phosphorus enrichment (especially soluble phosphorus) to the estuary mainly occurs due to flows from Gingin Brook. Nitrogen enrichment to the estuary is from winter flows throughout the catchment, and from groundwater discharge.

3. Phytoplankton growth is generally dominated by harmless diatoms, chlorophytes and cryptophytes during the warmer months. Potentially toxic blue-green algae have been observed but only at low levels for short periods of time. Algal mats do form in the warmer months and can be both a boating and visual nuisance.

4. Salinity levels in the lower Moore River and estuary during winter flows are affected by salinisation in the upper catchment.

5. Reduction of nutrient levels from Gingin Brook catchment through improved catchment management is essential to prevent long term problems in the Moore River Estuary.

6. Restriction of stock access and improvement of riparian vegetation along the Moore River and estuary is important to reduce nutrients and sediments entering the estuary.

7. The bar should be left alone as artificial breaching (especially during summer) contributes to sedimentation and algal problems in the estuary.

For more information:


Organisations undertaking work in the Moore River Catchment include:

The Water and Rivers Commission
<www.wrc.wa.gov.au>
Midwest/Gascoyne Region
Contact: Ron Shepherd (9964 5978)
Aquatic Science Branch
Contact: Tom Rose (9278 0413)

The Lower Moore River Rehabilitation Working Group
Contact: Elaine McCartin (9577 1735)

Moore River Catchment Council
<www.moorercatch.org>

Northern Agriculture Catchment Council
<www.cacli.org>

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