



Wilson Inlet



Report to the Community

DEPARTMENT OF ENVIRONMENT

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Ruppia in Wilson Inlet



Figure 1: The shoreline of Wilson Inlet.

Ben Boardman

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This newsletter is the seventh in the series of community reports on Wilson Inlet produced by the Department of Environment, incorporating the Water and Rivers Commission. This newsletter describes our present understanding of the roles, life history and distribution of the seagrass *Ruppia* and its epiphytes in Wilson Inlet. The information in this report largely derives from studies carried out by the University of Western Australia's Department of Botany with funding partially provided by the National Eutrophication Management Program and the Water and Rivers Commission. A list of references and a glossary of terms are included at the back of this report.

Introduction

Wilson Inlet is a seasonally closed estuary on the south coast of Western Australia. There is ongoing concern that as a consequence of land use changes in its catchment, Wilson Inlet is becoming increasingly eutrophied (i.e. nutrient enriched). An increase in the abundance of aquatic plants and algae has been the major symptom of eutrophication in the Inlet.

The seagrass *Ruppia megacarpa* has been observed in the river mouths leading into Wilson Inlet for decades. In fact, at least some small amount of *Ruppia* is likely to have been present in the Inlet even in its pristine state – as some *Ruppia* can be found in the nearby, near pristine Broke Inlet. However, in the 1970s a large increase in the biomass and distribution of *Ruppia* was observed in Wilson Inlet (see Figure 2). *Ruppia* now grows extensively in Wilson Inlet and has become the dominant aquatic plant in the Inlet. Many community members are concerned that *Ruppia* grows prolifically and becomes a nuisance by it inhibiting boat movement and decomposing along the shoreline. The *Ruppia* may also carry a large load of epiphytic algae, which further contribute to beach fouling.

However, *Ruppia* cannot be viewed in isolation from broader changes to the Inlet, nor in an entirely negative light. It is now an important component of the Wilson Inlet ecosystem. In particular it supports a diverse and productive community of aquatic animals that underpin the Inlet's fishery, and it plays a large and very important role in nutrient cycling in the Inlet.



Figure 2: Series of aerial photos of the Wilson Inlet delta, dated March 1946, January 1971 and December 1992 respectively, illustrating the increase in aquatic vegetation in the Inlet over time. The clean sands present in the 1946 photo in the back of the delta (centre of photos), adjacent to Poddyshot Point (top right of photos) and on the southern shore of the Inlet (bottom right of photos) have become increasingly vegetated in the 1971 and 1992 photos.

Ruppia megacarpa

The seagrass *Ruppia megacarpa* is a type of flowering plant that grows under water in saline conditions. Similar to grasses that grow on land, *Ruppia* grows from 'rhizomes' or runners. These are underground stems from which roots and branches grow. *Ruppia* rhizomes grow just beneath the sediment surface (a few centimetres deep), its roots grow downward from the rhizome, and its branches and leaves grow upward and protrude from the sediment into the water column (Figures 3-9). The branches and leaves are usually submerged but float on the surface at times (especially when water levels fall). *Ruppia* branches may be up to 2.5 metres long with a zigzag branching pattern. The leaves are long and very narrow.

The plant grows by extension and branching of its rhizome, similar to the way grasses grow on land. It flowers and sets seed, from which a new individual can grow. *Ruppia* produces tiny (3 to 5 mm) yellow-greenish flowers, during summer, that float on the surface of the water at the end of a long, thin, coiled stalk (a 'peduncle'). *Ruppia* may also reproduce from specialised branches, called vegetative propagules, which break off from a parent plant and are transported to another location by water currents, where

they settle and grow. *Ruppia* grows in water depths down to three metres in Wilson Inlet.

Ruppia megacarpa is widely distributed in Australia and similar species are found throughout the world.

Ruppia, like other plants and like algae, takes up nutrients from the water and undertakes photosynthesis and produces oxygen. Because it has roots *Ruppia* is able to stabilise and oxygenate the sediments (which is important for sediment nutrient recycling and is discussed in report eight of this series).

Physical factors affecting *Ruppia* growth

The distribution and abundance of *Ruppia* is highly variable within a year and from year to year. It is a robust plant that can live in an environment with large variations in the physical conditions.

This adaptability of *Ruppia* to different physical conditions is important for its growth in Wilson Inlet as there are strong seasonal variations in the salinity, temperature, and turbidity in the Inlet. High winter rainfall and river flow brings cold, fresh water into the inlet over the winter and

	Winter	Spring	Summer	Autumn	Comment
Salinity (ppt)	22 (range of 6 to 35)	17 (range of 1 to 35)	24 (range of 18 to 36)	27 (range of 17 to 37)	Maximum in summer, minimum in spring.
Temperature (°C)	12 (range of 9 to 17)	16 (range of 12 to 23)	22 (range of 18 to 26)	18 (range of 13 to 23)	Maximum in summer, minimum in winter.
Secchi depth (m) proxy for turbidity	2.9 (minimum of 1.7)	1.8 (minimum of 0.6)	3.9 (minimum of 1.9)	3.5 (minimum of 1.8)	Maximum in summer, minimum in spring.
Ammonium (mg/L)	0.025 (maximum of 0.25)	0.025 (maximum of 1.6)	0.006 (maximum of 0.14)	0.013 (maximum of 0.15)	Maximum in spring, minimum in summer.
Nitrate (mg/L)	0.028 (maximum of 0.63)	0.022 (maximum of 0.22)	0.005 (maximum of 0.04)	0.005 (maximum of 0.086)	Maximum in winter, minimum in summer.
Orthophosphate (mg/L)	0.003 (maximum of 0.095)	0.003 (maximum of 0.13)	0.003 (maximum of 0.055)	0.003 (maximum of 0.033)	Maximum in spring, minimum in autumn.
Chlorophyll a (mg/L)	0.0010 (maximum of 0.014)	0.0022 (maximum of 0.065)	0.0011 (maximum of 0.031)	0.0015 (maximum of 0.009)	Maximum in spring, minimum in winter.

Table 1: Seasonal medians of 1995-2001 water quality data (surface and bottom samples for all sites).

Ruppia plants

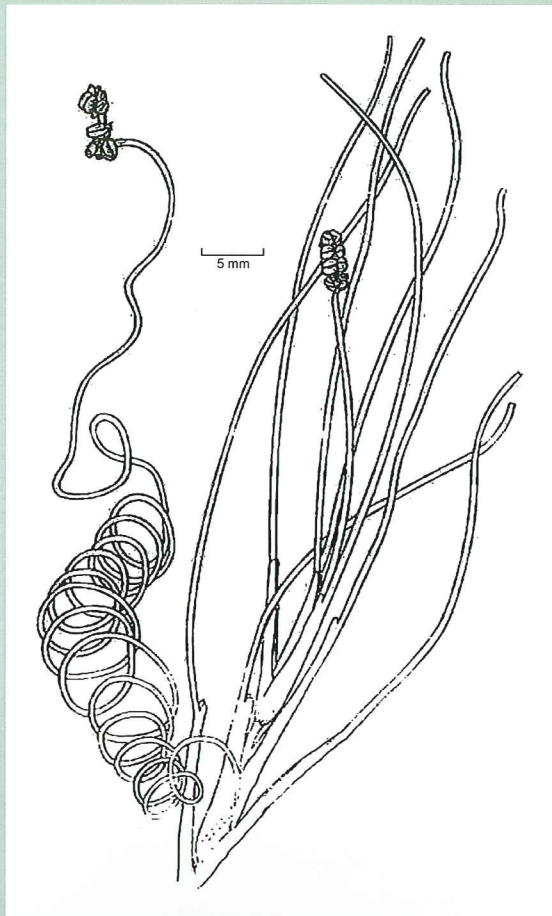


Figure 3: A diagram of a *Ruppia megacarpa* plant showing the above ground parts (from Wolmersley, 1984). On the right hand side of the diagram are portrayed the branches and leaves of a small *Ruppia* plant. On the left hand side a mature flower at the end of its coiled peduncle is shown.



Figure 4: *Ruppia* flower at surface.

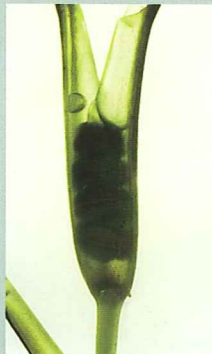


Figure 5: A *Ruppia* flower developing in a leaf sheath.
Tim Carruthers



Figure 6: *Ruppia* rhizome.

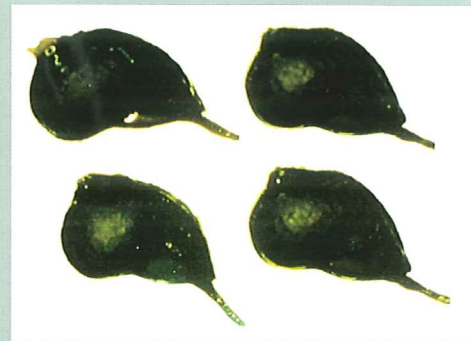


Figure 7: *Ruppia* seeds. Tim Carruthers

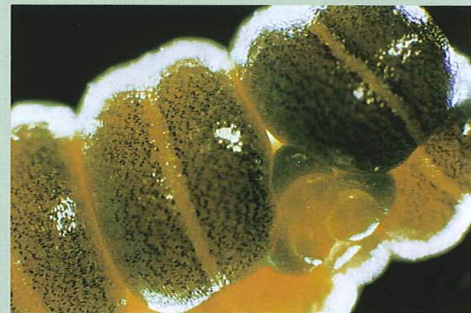


Figure 8: Close up of *Ruppia* flower.
Tim Carruthers



Figure 9: *Ruppia* shoots. Ron Phillips

early spring. There is also high turbidity during this period from the suspended material carried in by the rivers. The opening of the bar in later winter or early spring brings in warmer, more saline oceanic water. In summer and autumn, there is low rainfall, high evaporation and strong solar radiation, which cause the temperature and salinity in the Inlet to increase and the turbidity to decrease. Reports number two and five in this series of reports describe the water quality of Wilson Inlet in more detail. The seasonal water quality parameters are summarised in Table 1.

Water quality parameters are a major determinant of *Ruppia* distribution. Forty per cent of the variation in the distribution and abundance of *Ruppia* in the Inlet between seasons is explained by variations in the turbidity and salinity of the Inlet. Other factors that may effect the distribution and abundance of *Ruppia* include the availability of nutrients, physical uprooting by storms and overgrowth by epiphytes.

Salinity

While adult *Ruppia* plants can cope with a wide range of salinity, short periods of low salinity are important in the establishment of new populations, as *Ruppia* seeds require

fresh water for germination. Without a period of low salinities very few *Ruppia* seeds will germinate. Therefore, a seasonal variation in salinity is required to maintain the distribution and biomass of *Ruppia* in the Inlet. Six months after a drop in salinity, *Ruppia* biomass increases to a maximum between January to March.

Turbidity

Like all plants, *Ruppia* requires light to grow. The deeper parts of Wilson Inlet that contain seagrass are susceptible to loss of seagrass cover with decreased light. Reductions in the availability of light in the water column occur with increases in water turbidity. High turbidity results from conditions such as river flow carrying silt into the Inlet, phytoplankton blooms clouding the water column, or resuspension of silt and mud from the bottom of the Inlet. If there are long periods of time with high turbidity a direct large-scale reduction in *Ruppia* is likely. However, if some *Ruppia* remains, the seagrass can regrow rapidly when the conditions become favourable.

Macroalgal epiphytes of *Ruppia*

Macroalgal epiphytes are large algae that grow on *Ruppia*, they are a significant contributor to the wrack that fouls the beaches of Wilson Inlet, and have the potential to reduce the growth and distribution of the *Ruppia* itself by smothering it.

Figure 10 (right top): *Ruppia* shoots smothered by the macroalgae *Polysiphonia*, *Cystoseira* and *Spyridia*.

Bernie Dudley

Figure 11 (right middle): Some macroalgal epiphytes (*Chondria*, *Polysiphonia*, *Ceramium* and *Enteromorpha*).

Anna Gahnstrom

Figure 12 (right bottom): *Ruppia* shoots smothered by the macroalgae *Polysiphonia*, *Cystoseira* and *Spyridia*.

Bernie Dudley

Figure 13 (below): The macroalgae *Cladophora* growing on a *Ruppia* bed along the southern shore of Wilson Inlet (Eden Bank).

Tim Carruthers



Nutrients

Ruppia plants require a number of nutrients in order to maintain their growth. Two of the most important of these are nitrogen and phosphorus. Although it has roots, and could theoretically obtain some nutrients from the sediments, it has been found that *Ruppia* in Wilson Inlet relies on the uptake of nutrients from the water column, through its leaves, to sustain its growth. *Ruppia* takes up nutrients in winter and early spring when nutrient concentrations in the Inlet are high due to catchment runoff. The *Ruppia* stores these nutrients for later use when light conditions are favourable for growth.

Other factors

The physical uprooting of plants, particularly by wave action during storm activity, is also a mechanism that effects *Ruppia* distribution in the Inlet. Areas on the south side of Wilson Inlet are more susceptible to damage by early winter northerly storms. Reductions in seagrass cover are also found at Poddyshot Point possibly due to scour by currents, and throughout the Inlet due to grazing by Black Swans.

The other major factor that can impact on the distribution of *Ruppia*, is the overgrowth of *Ruppia* by macroalgal and microalgal epiphytes, these are described in the next section. Macroalgal epiphytes, in particular, smother the *Ruppia* and restrict the light that is available for it to use.

Macroalgae and *Ruppia*

Macroalgal epiphytes are large algae that grow on *Ruppia* (see Figures 10 to 13). Most of the macroalgal epiphytes in Wilson Inlet are of marine origin. More than a dozen species of macroalgae have been recorded in Wilson Inlet (see Table 2). Most of the species found grow as epiphytes on *Ruppia*, some may also grow floating freely in the water column. The most abundant macroalgae recorded in the Inlet are the marine red algae *Polysiphonia* and *Chondria*.

The biomass of the macroalgae in Wilson Inlet varies between seasons due to temperature, salinity and turbidity. Higher macroalgal epiphyte biomass is associated with high salinity, moderate temperature and low turbidity; i.e. more marine conditions. The green algae *Cladophora*, *Enteromorpha* and *Chaetomorpha* have the most seasonal distribution with their maximum biomass in late summer and minimum in winter. *Cladophora* in particular has been associated with eutrophic conditions in other estuaries in WA.

Unlike the seagrass, macroalgae do not have roots and have to obtain all of their nutrients from the water column. Their lack of roots means they do not play a role in oxygenating the sediments (well oxygenated sediments have been identified as an important component of 'healthy' sediment nutrient cycling, see the eighth report in this series on the sediments in Wilson Inlet). They also have the potential to grow faster than seagrass and decompose more rapidly, and



Microalgal epiphytes of *Ruppia*

Microalgal epiphytes are microscopic algae that grow on Ruppia, they form a yellow brown slime over the Ruppia.

Figure 14 (left): *Ruppia* shoots covered in diatomaceous slime.

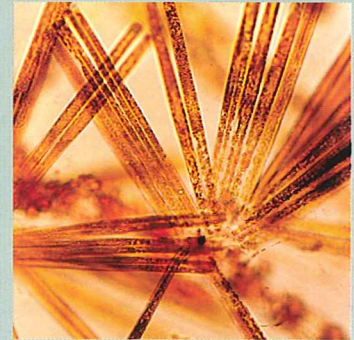
Tim Carruthers

Figure 15 (below left): Micrograph of diatomaceous slime.

Jane Wilshaw

Figure 16 (below right): Detail of epiphytic diatoms, *Melosira*.

Jane Wilshaw



it is generally accepted that they provide less ecological amenity (in terms of habitat) for higher parts of the food chain, such as invertebrates and fish, than seagrasses do, although are a preferred food to *Ruppia*.

In Wilson Inlet the biomass of macroalgal epiphytes is not dependent on the biomass of *Ruppia* – in other words the macroalgae are able to overgrow and smother the *Ruppia*. Macroalgal biomass per unit seagrass, and percentage seagrass coverage, are highest at Poddyshot Point and lowest close to the Hay River, the total biomass is the reverse. The increased coverage of macroalgae in the western end of the Inlet compared to the eastern is most

likely due to its proximity to the ocean, and therefore increased opportunities for the recruitment of macroalgae from the ocean. The high total biomass of macroalgal epiphytes in the eastern end of the Inlet may reflect the contribution of nutrients to the Inlet from the catchment.

Microalgae and *Ruppia*

Microalgal epiphytes are microscopic plants that grow on the *Ruppia* (see Figures 14 to 16). The microalgal epiphytes in Wilson Inlet are mostly diatoms. Diatoms are a type of single celled plant that have an intricate casing, somewhat

Algal Division	Name	Common name	Description
Phaeophyta or 'brown algae'	<i>Cystoseira</i> (e) <i>Dictyota</i> (e,b,f)		<ul style="list-style-type: none"> • brown with branches, rounded areas on ends of branches • distinctive thin flattened branches that grow from tips of blade, one becomes two, becomes four etc, in an even manner, brown
Chlorophyta or 'green algae'	<i>Polyphysa</i> (b) <i>Enteromorpha</i> (e,f) <i>Cladophora</i> (e,f) <i>Ulva</i> (b) <i>Chaetomorpha</i> (b,f)	'goat weed' 'sea lettuce' 'rope weed'	<ul style="list-style-type: none"> • green, stands like a stalk with a lobed 'hat', to 10 cm high • long thin bright green filaments, to 40 cm • tangled mass of fine green filaments over seagrass, may form 'mats' • leafy lettuce like appearance, bright green, to 30 cm • long tangled green filaments, forms a loose lying mass on other plants or the sea bed, length of filaments to 3 m
Rhodophyta or 'red algae'	<i>Spyridia</i> (e,f) <i>Polysiphonia</i> (e,f) <i>Gracilaria</i> (b,f) <i>Ceramium</i> (e,f) <i>Chondria</i> (e,f) <i>Audouinella</i> (e) <i>Callithamnion</i> (e,f)	possibly 'pink snot'	<ul style="list-style-type: none"> • filamentous, filaments decrease in size away from main body of alga • thin delicate filaments to 15 cm, pink to red in colour, forms large tufts • red to brownish yellow, firm fleshy branching species to 15 cm • thin delicate filaments, often wraps round itself to form clumps, red • branching, with small (< 1 cm) terminal branches, rubbery texture, red
Charophyta	<i>Lamprothamnium</i> (b)	'whiting grass'	<ul style="list-style-type: none"> • spiky appearance, green, forms red coloured berry like reproductive spores

Table 2: A list of macroalgae known to grow in Wilson Inlet. These macroalgae either grow on the *Ruppia*, freely on the sediment or floating in the water (e = epiphytic i.e. growing on the *Ruppia*, b = benthic i.e. growing on the sediments, f = floating i.e. growing freely in the water column).

like a delicate skeleton, that is made from silica and is called a 'frustule'. Dozens of species of diatoms have been found in Wilson Inlet. These include species that are found freely floating (i.e. planktonic), growing on the sediments (i.e. benthic) or growing on the *Ruppia* (i.e. epiphytic).

Most epiphytic diatoms in Wilson Inlet occur in a slime that coats *Ruppia* plants. The slime is composed of diatom cells, mucous excreted by the diatoms, bacteria, fungi, and fine particulate matter that becomes entrapped in the slime. This diatomaceous slime is typically yellow to brown in colour depending on the amount of particulate matter trapped in it.

Diatoms are abundant and important primary producers in aquatic environments. They grow fast, take-up nutrients from the water column rapidly, decompose rapidly and can respond quickly to changes in the environmental conditions. In Wilson Inlet their growth is favoured by low temperatures, around 13°C, and high salinity of 25 to 40 parts per thousand. The epiphytic diatom distribution in Wilson Inlet is dependent on the amount of *Ruppia* leaf area available to colonise.

Abundance of *Ruppia* in Wilson Inlet

As we have seen a number of factors control the growth of *Ruppia* in the Inlet. In summary those factors are:

- Nutrients. Growth is limited by the availability of nutrients, phosphorus in particular.
- Light. Growth is limited by the availability of light due to water turbidity and epiphyte overgrowth.
- Salinity. Seed germination is limited by salinity as freshwater is required for germination.
- Storm damage. Storm damage reduces *Ruppia* coverage and forces constant regrowth.
- Herbivores. Herbivores reduce *Ruppia* coverage (e.g. Black Swans consume a quarter of the *Ruppia* in the Inlet) and force constant regrowth.

Variability of *Ruppia* growth between and within years

Ruppia pursues different life strategies (annual versus perennial growth) in different parts of the Inlet. For example, *Ruppia* beds in exposed locations may need to re-grow from seed each year, whereas those in more sheltered locations maybe able to maintain year around growth. In the 1995 to 1996 period *Ruppia* plants on Eden Bank and near Poddyshtot Point grew as annuals from seed, whereas those at Bails Jetty and near the Hay River mouth maintained perennial populations growing from rhizomes.

Even in sheltered locations, there tends to be a net loss of whole or partial plants from *Ruppia* beds in the late summer through to winter period. However, unlike many other seagrasses, *Ruppia* responds rapidly to changes in conditions and there may be a regeneration of those *Ruppia* beds in spring and summer. This pattern of loss and regrowth is reflected in annual changes in the *Ruppia* biomass in the Inlet; the summer biomass is estimated to be twice the winter biomass.

At the same time that there are changes in the biomass of *Ruppia* beds, there are also considerable changes in the appearance of *Ruppia* beds. The *Ruppia* canopy is more likely to be dense and relatively short in summer months when water levels and turbidity are low, whereas in winter and spring the *Ruppia* canopy will include a mix of much longer branches when water levels and turbidity are high (see Figure 17).

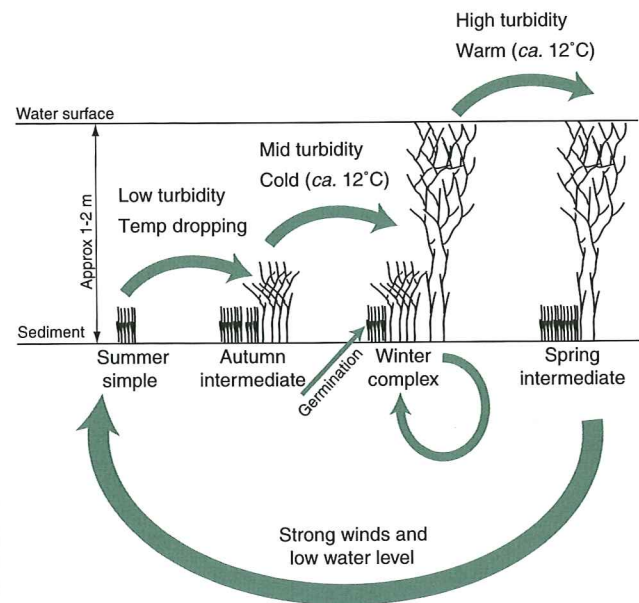


Figure 17: The variation in *Ruppia* canopy complexity throughout the year.

In many places, such as Albany Harbours or Cockburn Sound, changes in seagrass coverage are used as a measure of long-term water quality changes and 'health' of the system. Unlike other seagrasses though, the biomass of *Ruppia* is not stable over time. As we have already noted, its summer biomass is perhaps twice its winter biomass and its canopy changes dramatically over the same period, while it uses different life strategies in different parts of the Inlet, and it is highly adaptable and able to respond rapidly to changes in conditions. This all means that the variability of *Ruppia* abundance between sites and years is very high.

Its high variability means that a one off snap shot of *Ruppia* abundance and distribution is not a good indicator of long-term water quality changes or the 'health' of the Inlet. Its high short-term variability has to be integrated over time, requiring many snapshots. Figure 18 shows data from 50 m long transects in the Inlet that we have been using to track the *Ruppia* abundance and variability over time and between sites.

Where a long-term change in *Ruppia* abundance or distribution does occur, it needs to be interpreted in a context that explains the change, as it could signal both improvements or deteriorations in the 'health' of the Inlet. For example, the presence of *Ruppia* where there had been little before is an indicator of long-term deterioration of Inlet 'health'. However a reduction in *Ruppia* from the present state could represent a 'health improvement' if it occurred because catchment nutrient loads had fallen, or could represent a 'health deterioration' if it occurred because algae had replaced *Ruppia*.

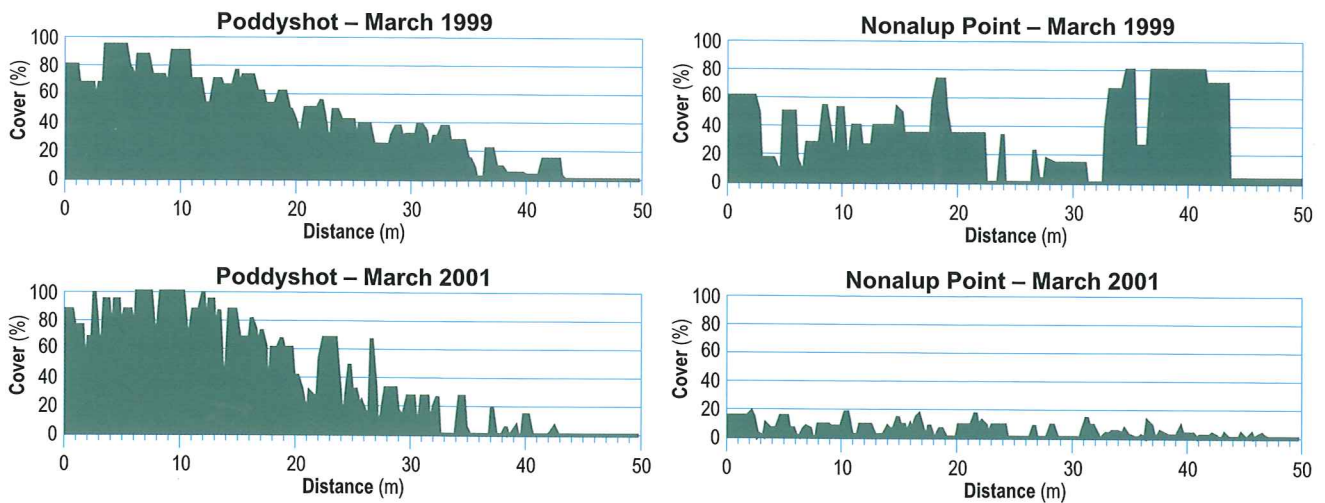


Figure 18: These four plots all represent the % coverage of *Ruppia* along 50 m composite transects at Poddyshot Point and Nonalup Point. A comparison of the coverage of seagrass at Poddyshot in March of 1999 and 2001 to that at Nonalup gives some idea of the variability of the seagrass coverage in the Inlet. While the coverage at Poddyshot has stayed roughly the same (10% decrease) between the two years, that at Nonalup has decreased significantly (80% decrease).

How much *Ruppia* is there in the Inlet?

The last effort to survey the biomass of *Ruppia* in the Inlet was made in December 1994 (see Figure 21). Since that time surveys have focused on trying to measure the variability between sites, seasons and years rather than trying to estimate total biomass. However in December 1994 it was estimated that there were about 1700 tonnes of *Ruppia* (dry weight) and 1100 tonnes of macroalgae in the Inlet. This estimate was a substantial reduction on estimates made following the previous set of surveys between July 1982 and April 1985 (see figure 19). Anecdotal evidence also suggests a possible reduction in *Ruppia* biomass in the 1990s compared to the 1980s. It is not clear what has caused this possible reduction. However, given the high variability we have observed and commented on, this possible reduction in *Ruppia* shouldn't be taken as a sign that we can be complacent about managing the Inlet.

For the purpose of comparison to other estuaries, biomass estimates from Wilson Inlet can be standardised as 'areal loads' of macroalgae and seagrass. The comparison shows, for example, that the areal loads of seagrass and

macroalgae in Wilson Inlet are less than those in the Peel Inlet were in the decade leading up to the opening of the Dawesville Channel and less than the present condition of the Peel Inlet post Dawesville (see Figure 20).

The Impact of *Ruppia* on the Inlet

The presence of *Ruppia* in Wilson Inlet has both positive and negative impacts on the amenity of the estuary. On the positive side, the *Ruppia* is an important component of the Inlet's highly productive fishery and provides a crucial role as a 'nutrient buffer' for the Inlet preventing macroalgal and microalgal problems from being much worse. On the negative side, the decomposition of the *Ruppia* and its associated macroalgal and microalgal epiphytes fouls beaches.

Ruppia and the food web of Wilson Inlet

The '*Ruppia* complex', which includes the *Ruppia* and its macroalgal and microalgal epiphytes, is a principal component of the food web that sustains Wilson Inlet's highly productive fishery and its abundant bird life.

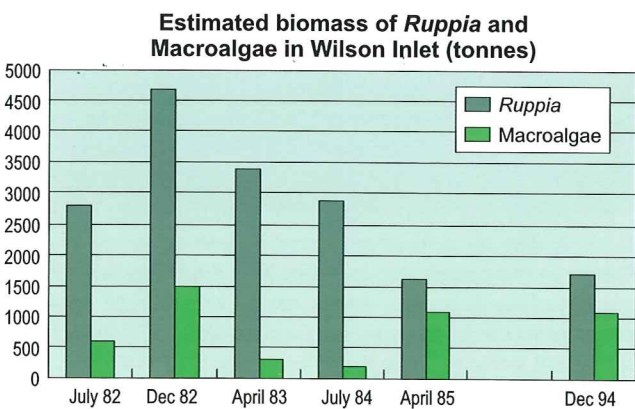


Figure 19: Total estimated biomass (dry weight in tonnes) of *Ruppia* and macroalgae in Wilson Inlet. Note that because of calculation problems associated with the original biomass estimates for the surveys held between July 1982 and April 1985, the biomass numbers presented here have been revised downward from the numbers that were published immediately after those surveys in the 1980s.

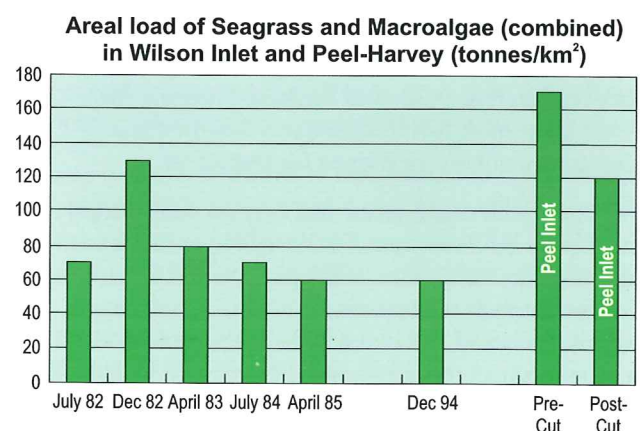
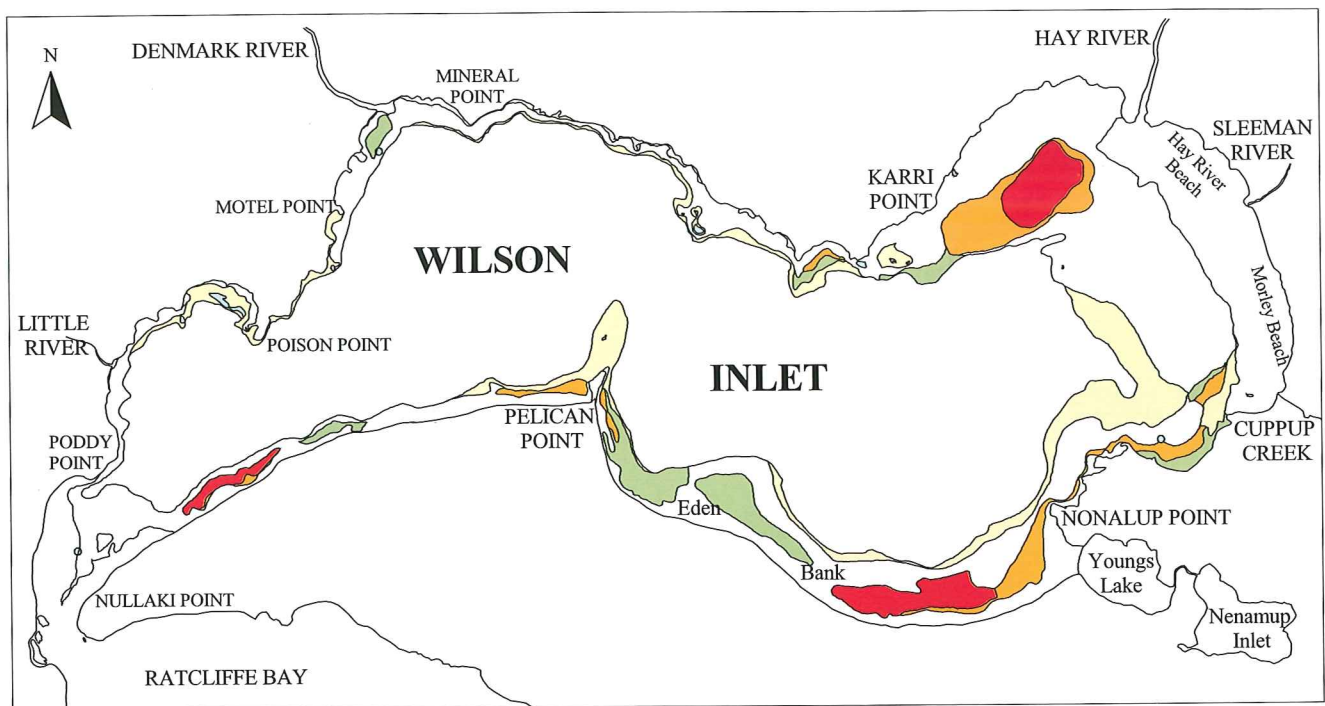


Figure 20: Estimated areal loads (dry weight in tonnes per km²) of seagrass and macroalgae (these have been combined to make an easier comparison) for Wilson Inlet compared to the average of the Peel Inlet for the ten years prior to the opening of the Dawesville Channel and the five years after.



Wilson Inlet *Ruppia* Distribution

1 0 1 2 3 4 5 kilometres

Ruppia abundance

Greater than 400 g/m² 10 ≥ 100 g/m²
 200 ≥ 400 g/m² Less than 10 g/m²
 100 ≥ 200 g/m²

Figure 21: The distribution of *Ruppia* in Wilson Inlet in December 1994.

While the *Ruppia* itself is an important food source for only a few species (e.g. Gardie and Black Swans), the *Ruppia* plays a crucial role in providing the physical framework for the macroalgal and microalgal epiphytes that are a critical food source for a large number of species. The *Ruppia* complex is a food source, either directly or indirectly (through its contribution to the detritus in the Inlet), for an array of crustaceans, molluscs, polychaete worms, some adult and juvenile fish. Further, the *Ruppia* complex is also an important source of habitat and shelter for them.

Most fish species in the Inlet, including all of the commercially and recreationally important species except Gardie, either feed on the crustaceans, molluscs and worms that rely on the *Ruppia* complex for food and shelter, or prey on other fish that do so. This includes open bottom feeders such as mature King George Whiting; the worms they feed on rely on detritus for food. Similarly the juveniles of most fish species spend their first years sheltering amongst the *Ruppia* for protection.

Fisheries catch data indicate that over the same period that the *Ruppia* has flourished fish catches have substantially increased. In the absence of *Ruppia* it would be expected that the numbers of crustaceans, molluscs, polychaete worms, and small fish living in the Inlet would decline, with subsequent reductions in the biomass of larger fish in the Inlet.

Nutrient buffering capacity of *Ruppia* in Wilson Inlet

The *Ruppia* in Wilson Inlet plays an important role as a 'nutrient buffer' for the estuary. What this means is that the *Ruppia* absorbs a significant proportion of the nutrients entering the Inlet from the catchment, shortly after they

enter the Inlet, and then stores them over the summer, preventing other plants and algae from using them and proliferating during the summer maximum growth period. If the *Ruppia* was not present in the Inlet and this important buffer function was therefore not fulfilled, the nutrients entering the Inlet from the catchment could instead be used by other plants and algae.

Nutrient uptake by *Ruppia* occurs year round, although the uptake rate varies throughout the year. It is at its lowest in winter, when water temperatures and light are at minimum, and highest in summer when water temperatures and light are at maximum. If we multiply the uptake rates by the biomass we can estimate the mass of nutrients that the *Ruppia* and its epiphytes can theoretically take up (see Table 3).

	Phosphate	Nitrate	Ammonium
Summer	700 kg/day	1200 kg/day	4800 kg/day
Winter	200 kg/day	800 kg/day	1800 kg/day

Table 3: The theoretical uptake of different nutrients by the *Ruppia* (and its epiphytes) in Wilson Inlet (in kg per day). These are based on 6 hourly uptake rates (with longer duration experiments the rates would fall) and assume full contact of the catchment water with the *Ruppia* – so are high estimates.

These theoretical daily nutrient uptakes by the *Ruppia* are generally greater than the daily nutrient inputs from the catchment. This explains why, despite the nutrient loads we measure entering the Inlet, we usually only measure very low nutrient concentrations in the Inlet itself for most of the year. The *Ruppia* is taking up the nutrients from the Inlet faster than the rate at which they are entering the Inlet.

If there were no *Ruppia*, and the nutrient loads from the catchment remained as they presently are, we would expect to see the greater proliferation of macroalgae (that are ecologically less functional than *Ruppia*) and more frequent and intense algal blooms (including potentially toxic microalgae) in the spring and summer period. We often see an increase in macroalgae in particular, and sometimes microalgae, in the late summer or autumn period; what we call a 'late summer' bloom. This may be a response to the *Ruppia* dying off (or 'senescing') and the nutrients it had trapped finally becoming available to other plants and algae – but too late in the season for a significant bloom like those that occur in spring due to sediment recycled nutrients.

The 1994 data illustrates the important nutrient buffering role of *Ruppia*. In December 1994 it was estimated that the *Ruppia* and its epiphytes retained 50 tonnes of nitrogen and three tonnes of phosphorus; perhaps half of which had been derived from that seasons catchment inflow. This nutrient retention accounted for most of the nitrogen and phosphorus that entered the Inlet from the catchment in a form available for use by plants and algae. Intense algal blooms, such as that in the spring of 1995, require about 30 tonnes of nitrogen and four tonnes of phosphorus – if there were no *Ruppia* to trap nutrients we could expect to see more intense spring and summer algal blooms. With the *Ruppia* present algae are unable to rely on catchment nutrients in spring and summer and must instead rely on nutrients recycled from the sediments (see report five of this series).

It is also important to note that the nutrients that are stripped from the water column by the *Ruppia* in one season, are eventually added to the sediments from where they have the potential to be recycled in following years. Therefore, while *Ruppia* is a nutrient buffer for the Inlet, protecting it from more intense spring and summer algal blooms, its presence is not an alternative to reducing the nutrient input from the catchment.

Decomposition of *Ruppia*

A recent study of the sediment geochemistry of Wilson Inlet (to be published in report eight of this series) demonstrated that the *Ruppia* comprises only 10% of the organic matter that is found accumulating in the Inlet. This is despite the fact that *Ruppia* plants have the most abundant biomass of any of the primary producers in the Inlet at any time. It turns out that there are two reasons for this. Firstly, the microalgae, which are less conspicuous than the *Ruppia*, have a total productivity throughout the year in the order of five times greater than the *Ruppia* – because they grow and decompose much faster than *Ruppia*. The other major reason is that much of the *Ruppia*, rather than immediately sinking to the floor of the Inlet when it dies or breaks off of the parent plant, floats and is washed ashore, where it rots on beaches. The wrack that accumulates on beaches contains not only *Ruppia* but may also contain large amounts of macroalgae (see Figure 22).

The wind roses in Figure 23 help to explain why the accumulation of *Ruppia* is exacerbated on beaches in the western end of the Inlet, particularly over the summer and early autumn periods. At the same time that *Ruppia* is

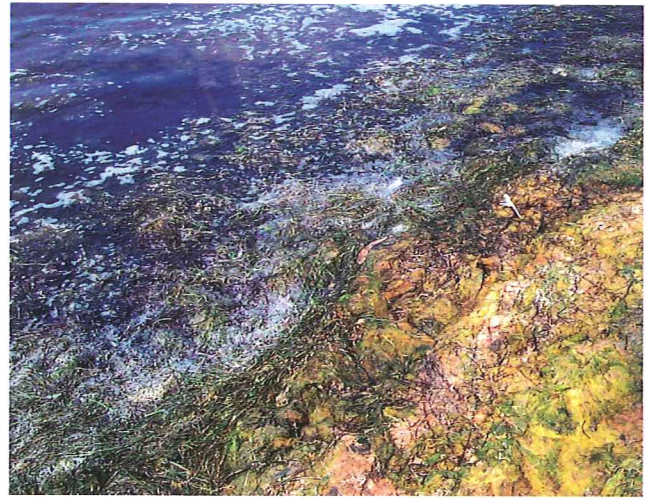


Figure 22: Rotting seagrass and macroalgal wrack containing *Ruppia* and a large amount of *Enteromorpha*. W. Hosja

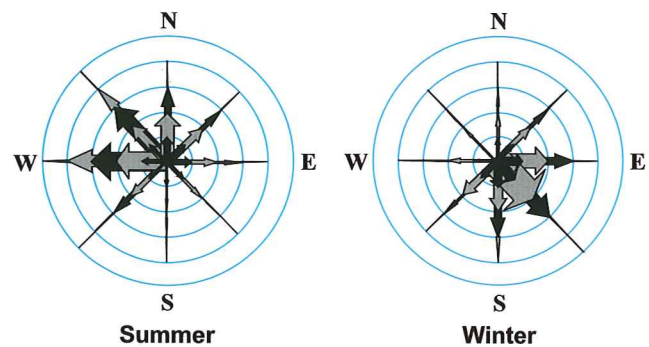


Figure 23: Wind roses for summer and winter indicating the direction winds are blowing toward (Albany data for 1995 to 2001, knots, each concentric circle represents 5 knots). In summer the predominant winds are from the east and south-east blowing to the west and north-west, in winter the predominant winds are from the west and north-west blowing to the east and south east. This illustrates why, in summer, decaying *Ruppia* and algae accumulates in the western end of the Inlet – it is blown there by the prevailing wind.

dying off in late summer the winds are blowing toward the western end of the Inlet. Consequently decaying *Ruppia* (and its macroalgal and microalgal epiphytes) is concentrated in the western end of the Inlet. The problem becomes more acute in years when late summer or early autumn storms uproot *Ruppia* beds, or in years when there are more prolonged and stronger easterly winds than usual.

Ruppia typically takes one to four months to break down on beaches. As it decomposes it may form a black organic 'ooze', with foul smelling hydrogen sulfide gas ('rotten egg gas') and sickly-sweet smelling di-methyl sulfide gas.

Management implications

As we have seen, while the presence of *Ruppia* has some negative consequences for the Inlet's amenity, these are almost certainly outweighed by positive facets of its presence. In summary, although the decomposition of *Ruppia* may foul beaches and snag boats and fishing nets, it provides the basis for the Inlet's food web, and it protects the Inlet from macroalgal and microalgal blooms that

would foul beaches to a far greater extent and potentially wipe out the productive fishery. Management actions must therefore consider the positive utility of the *Ruppia* as well as the problems it causes.

The *Ruppia* protects the Inlet by buffering the nutrient loads that enter the Inlet. Therefore, a significant loss of *Ruppia*, without a reduction in the nutrient loads from the catchment could spell disaster for the Inlet. In short, if nutrients are present some form of plant or algae will utilise them, be it *Ruppia*, ecologically less functional macroalgae or potentially toxic microalgae. Seagrasses in other estuaries in south-west WA have been lost or are in decline as a result of eutrophication. In many cases, such as the Albany Harbours, seagrasses were largely replaced by macroalgae, which in the case of the Peel-Harvey, were in turn replaced by toxic blue-green algae. In these cases, ongoing nutrient loading from the catchment at unsustainably high levels tipped the ecosystem out of balance. Without controlling nutrient loads from the catchment this could also occur in Wilson Inlet.

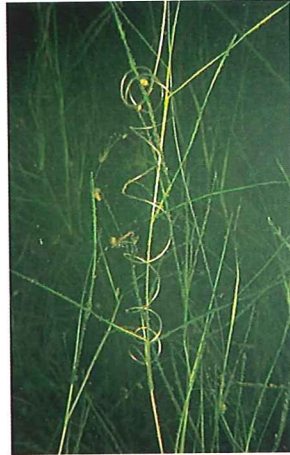


Figure 24: *Ruppia*.
Sue Scott (MarLIN)

Management actions must therefore address catchment nutrient loads. In turn, a reduction in catchment nutrient loads is expected to translate into a reduction in the *Ruppia* abundance in the Inlet – without jeopardising the Inlet's 'health'.

While it has been noted that the sediments deliver more nutrients to the water column than the catchment, sediment

nutrients are ultimately sourced from the catchment, and in the long term reductions in catchment nutrient loads may reduce sediment nutrient fluxes. See report eight in this series.

Other management options for the community's concerns with *Ruppia* fouling beaches have also been considered. Harvesting *Ruppia* and removing wrack from beaches were two options considered. Efforts to harvest macroalgae in the Albany Harbours proved to be exceedingly inefficient, expensive, had little impact on the growth and abundance of macroalgae and in fact created more ecological damage than they solved. Considering this experience, and the fact that destruction of *Ruppia* beds could be disastrous for the Inlet, we do not advocate any effort to harvest the *Ruppia* or the macroalgae in the Inlet. On the other hand we do support the idea of removing rotting *Ruppia* and macroalgal wrack from beaches (see Figure 27) – this is after all one of the major negative consequences for the amenity of the Inlet due to the presence of *Ruppia*.

As an alternative or an addition to reducing catchment nutrient loads, permanent opening of the Inlet, akin to the Peel-Harvey, has been suggested as a means to reduce the nutrient retention in the Inlet. Reviews of coastal processes and marine exchange suggest that this would result in higher Inlet salinities, and subsequently, loss of *Ruppia* may be a risk. Higher salinities or increased periods of saline water retention may limit *Ruppia* germination and favour the growth of further marine macroalgal and microalgal epiphytes. If *Ruppia* were lost without catchment nutrient reductions, or without significant reductions in nutrient retention times in the Inlet, then we would expect an increased proliferation of macroalgae and microalgae with potentially negative effects for the amenity of the Inlet. Furthermore there are no other marine seagrass species of similar structure, function and life history that could take over the niche of *Ruppia* and support a similar food web so essential to the productive fishery of the Inlet.

Ruppia ecology in Wilson Inlet

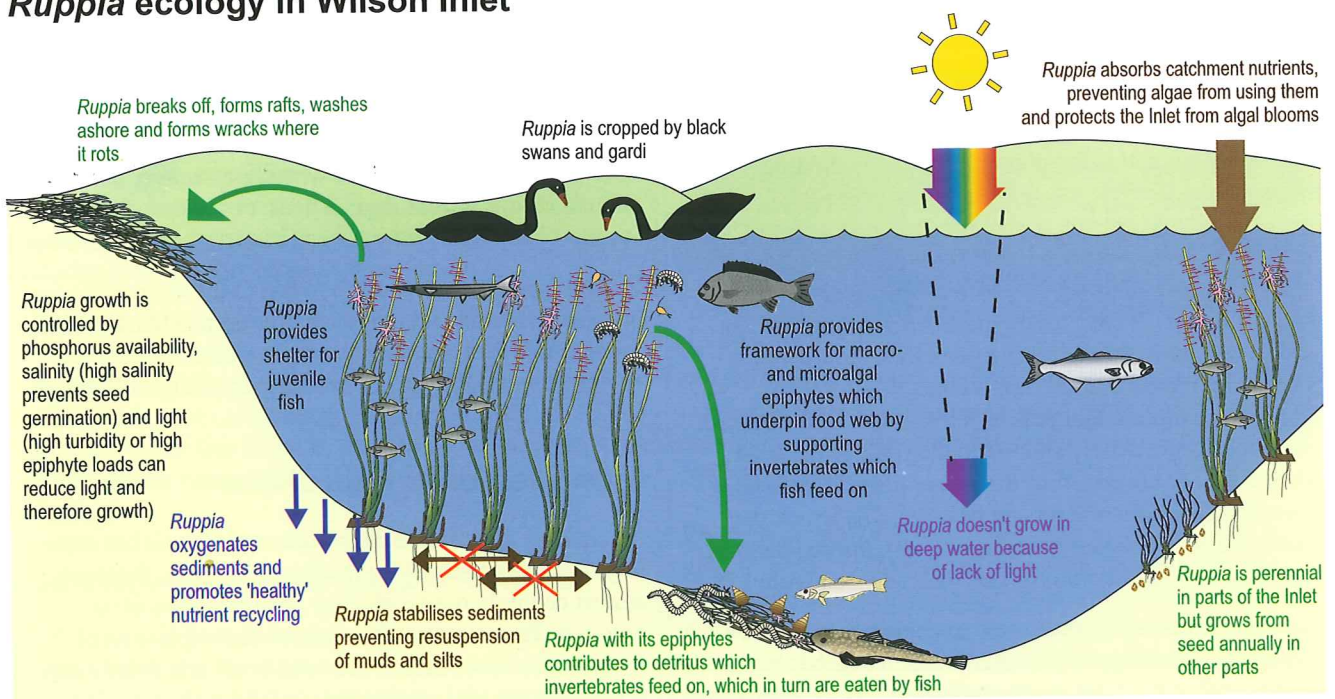


Figure 25: A schematic summary of the ecology of *Ruppia* in Wilson Inlet.



Figure 26: *Ruppia* – while some consider it to be the scourge of the Inlet, it is also the Inlet's saviour.

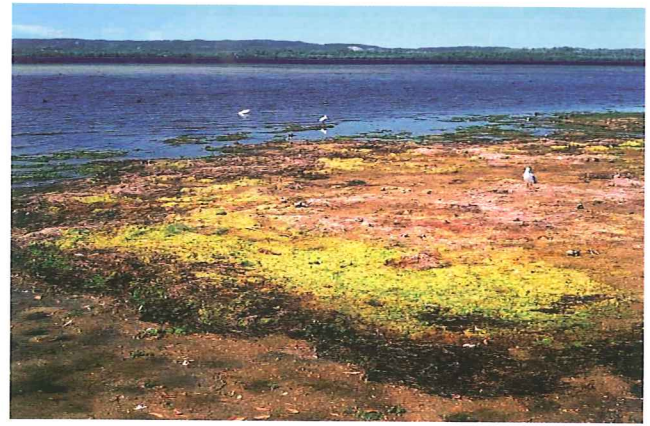


Figure 27: *Ruppia* (brown colour) and macroalgae (yellow-green colour) on the shore of Wilson Inlet. While this is the only view that most people get of *Ruppia* in Wilson Inlet, there is much more to its role and function than simply fouling beaches.

Emma van Looij

The situation in Wilson Inlet is not as dire as the Peel-Harvey. While the nutrient load to Wilson Inlet per unit area is at least twice that of the near pristine Broke Inlet it is about half of that to Oyster Harbour and almost a quarter of that to the Peel-Harvey. If nothing is done, Wilson Inlet may eventually reach a stage of eutrophication like the Peel-Harvey requiring drastic solutions, but if we take actions in the catchment now it will never reach that stage. To prevent further eutrophication, controlling the nutrients entering the Inlet from the catchment must be a major priority for management.

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Glossary of terms

Algae – Essentially simple plants with few, if any, of the differentiated structures usually associated with plants (e.g. leaves, stems, roots etc). Algae may be microscopic, single celled organisms (microalgae) or larger multi-celled organisms (macroalgae). Like more complex plants algae undertake photosynthesis.

Annual – A plant that grows from seed each year and then dies off before the next year.

Bacteria – A class of microscopic organisms which in Wilson Inlet are responsible for consuming and decomposing much of the decaying organic matter.

Benthic – Close to or in the sediments.

Biomass – The amount of living material in an organism usually measured as dried weight.

Crustaceans – A type of animal with a hard, segmented outer shell, many branched legs and antennae, e.g. crabs, prawns, shrimp and many similar microscopic creatures.

Diatom – A type of microalgae, the most common in Wilson Inlet, that has an intricate silica skeleton called a frustule. Diatoms may be epiphytic, benthic or planktonic.

Epiphyte – A plant that lives by growing on another plant, but does not take nutrients directly from that plant like a parasite does.

Eutrophication – The process of increasing nutrient enrichment in a waterway. Eutrophication is a natural process but is accelerated by human activities.

Flowering plant – A classification of plants that produce true flowers. This includes *Ruppia* but not algae.

Fungi – A class of organisms which in Wilson Inlet are, along with the bacteria, responsible for consuming and decomposing much of the decaying organic matter.

Germination – The process where a seed from a plant begins to grow and develop.

Macroalgae – Large multi-celled algae that can be seen with the naked eye. The macroalgae include groups of red, brown and green macroalgae that are commonly referred to as seaweeds.

Macrophyte – A plant that is visible with the naked eye including flowering plants and macroalgae.

Mollusc – A type of animal which has, among other characteristics, a hard shell and is without legs but has tentacles or a foot, e.g. cockles, mussels, oysters, snails and scallops. About 25% of the organisms living in the sediments of Wilson Inlet are molluscs.

Perennial – A type of plant that grows year around.

Phytoplankton – Microscopic, usually single celled free floating or weakly mobile aquatic plants, e.g. diatoms.

Photosynthesis – The process in which light energy is used for biosynthesis of organic cell materials.

Plankton – Organisms that float in the water.

Polychaete worms – Segmented worms that live in the sediments of a water body and may resemble earthworms found on the land. About 60% of the organisms living in the sediments of Wilson Inlet are polychaete worms.

Primary producers – A term that refers to all organisms that are able to undertake photosynthesis; i.e. all of the plants and algae.



Figure 28: UWA Department of Botany students measuring *Ruppia* nutrient uptake in Wilson Inlet. Bernie Dudley

Rhizome – An underground stem usually serving as a means of elongation and growth in plants.

Salinity – The salt content of water, measured as total dissolved salts in the water, expressed in parts of salt per thousand parts of water (ppt). South coast WA seawater has a salinity in the range 34 to 37 ppt.

Seagrass – Marine flowering plants that are usually rooted in the sediment and are found in coastal rivers, estuaries and embayments.

Secchi disk depth – A measure of the turbidity of water equal to the depth where a 30 cm disk painted in alternate quarters of black and white is no longer visible.

Senescence – The seasonal die off of plants in response to changing seasonal factors such as water temperature or light.

Turbidity – A measure of the suspended particles in water which cause a reduction in light entering and penetrating through the water. In low turbidity water, the water is clearer than highly turbid water.

Wrack – The name used to describe accumulations of algae and seagrass that are washed ashore onto beaches.

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