LANDSCAPE LOGIC
LINKING LAND AND WATER MANAGEMENT TO RESOURCE CONDITION TARGETS

Fact sheet for managers and policy-makers #16
March 2011

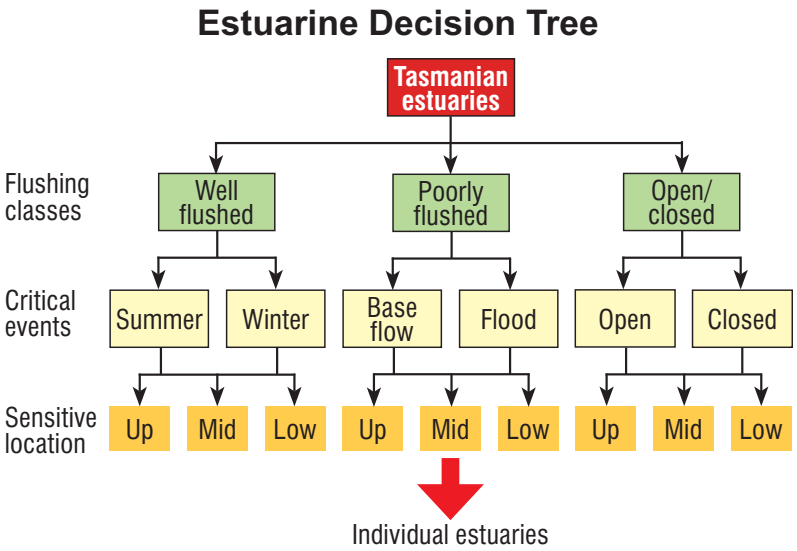
A decision tree for monitoring and management of Tasmanian estuaries

What we found

Estuarine environments around Tasmania are highly variable in their geomorphology, their physical and chemical characteristics, and the levels of human activity to which they are exposed. In addition, climatic conditions vary around the state and add to the complexity of estuarine environments. This has made generalization about the management of estuaries very difficult.

By examining data collected from estuaries around Tasmania over the last two decades and more detailed studies of 31 estuaries as part of Landscape Logic, we have developed an Estuarine Decision Tree based on the vulnerability of Tasmanian estuaries to human-induced change. The decision tree aims to support management of Tasmanian estuaries by standardizing and simplifying condition assessments and their interpretation.

We have concentrated on the sensitivity of estuaries to eutrophication as a result of increased concentrations of nutrients, especially N and P, and organic matter. These stressors are derived from diffuse sources in the catchment such as agriculture and urban settlement, and are significant in many estuaries. The decision treeis also applicable to other diffuse pollutants such as agricultural chemicals.

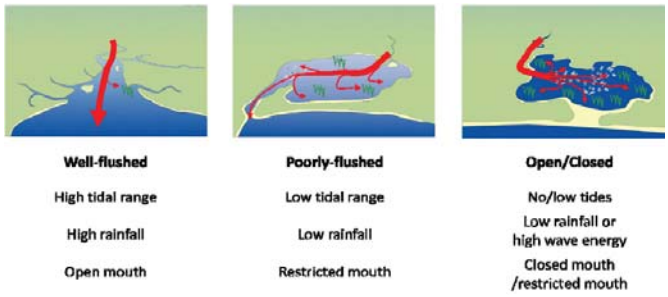


Flushing class

The estuaries most susceptible to degradation are those that have a limited ability to dilute or flush out pollutants. Consequently, we have used the key hydrologic influences (river flow and tidal range) and physical characteristics (volume and entrance geomorphology) that determine flushing time as the first level for classifying the vulnerability of estuaries to human impacts.

Estuaries were classified as either well flushed and therefore the least susceptible to degradation, poorly flushed and moderately vulnerable or intermittently open and closed and highly susceptible. The distribution of these groups around Tasmania is relatively consistent.

Well flushed estuaries are mostly located on the north coast whereas estuaries of the east coast are predominately poorly flushed or intermittently open/closed. West coast estuaries have low tidal range but high river input due to heavy rainfall in the catchment. Sand movement along the coast is an important factor controlling the entrances to these estuaries and those with small catchment areas and/or long riverine estuaries tend to be poorly flushed or intermittently open.



Critical events

The second level in the decision tree is based on the critical events when estuaries are most sensitive to anthropogenic impact. Well flushed estuaries generally show strong seasonal patterns, with the largest freshwater flows in winter and spring and low flows in summer. These estuaries are most vulnerable during summer

low flows when pollutants take longer to be flushed from the system, temperatures are higher and there are more hours of daylight, resulting in greater biological activity. Although poorly flushed estuaries receive less freshwater flow, flooding can be extensive and at any time of year. Thus the greatest contrast in the condition of poorly flushed estuaries is between base flows and flood events.

Following floods, if nutrients introduced to these estuaries are retained for extended periods, eutrophication can result, especially in summer. Conversely, a reduction in base flows, such as during drought and through water extraction, can have the opposite effect of reducing nutrient input and hence the productivity of an estuary. Intermittently open and closed estuaries are clearly most vulnerable when they are closed as any nutrient or pollutant entering the estuary cannot be flushed out by tidal activity.

Sensitive locations

The response to anthropogenic inputs will also vary depending on location within an estuary. In well flushed estuaries the greatest impact has been observed in the upper estuary where dilution of pollutants by oceanic waters is lowest. Similarly, in poorly flushed estuaries vulnerability increases with distance upstream due to decreasing dilution, whereas in open/closed estuaries human influences are generally evident across the entire lagoon.

Estuary-specific information

Although we have classified estuaries into broad types, the key drivers of flushing time and ecological characteristics will vary from estuary to estuary, and as such estuary specific information should be used when available. Data on estuarine condition has been compiled and summarized in fact sheets for a number of Tasmanian estuaries (www.landscapelogicproducts.org.au) and should be used where available. The generic information for the relevant estuary class is intended for estuaries where no data has been previously collected,

Implications for managers and policy-makers

Managers can use this decision tree to inform planning and management and the design of monitoring programs for estuaries around Tasmania. In particular, this information can be used to prioritise monitoring effort to the most vulnerable times and locations within the focus estuary/s.

For example, well flushed estuaries are the least vulnerable to high nutrient loads. Even so they can be susceptible to eutrophication in the upper estuary when temperatures are high and hours of daylight are longest. For example, Duck Bay which has the highest nutrient concentrations of all Tasmanian estuaries has not had any major phytoplankton blooms to date, but some high chlorophyll a levels in summer suggest that this estuary is nearing its tolerance limit. Using the decision tree, monitoring in the upper estuary over summer is recommended if further developments in the catchment increase the nutrient load to the estuary. Poorly flushed estuaries on

Example: Leven Estuary

Here we examine a hypothetical management scenario, a major agricultural development upstream of the Leven estuary. The decision tree is used to assess where and when the estuary is likely to be most vulnerable to potential changes in the quantity and quality of freshwater entering the estuary

STEP 1: Flushing Class

The estuary is on the north west coast where rainfall and the tidal range are relatively high. It is classed as well flushed, and therefore has low vulnerability to anthropogenic changes to river inputs.

STEP 2: Critical Event

As a northwest coast estuary where the natural flow regime is highly seasonal, the estuary is most vulnerable during summer low flow periods when biological activity is greatest.

STEP 3: Sensitive Location

Well flushed estuaries are likely to be most vulnerable to changes in condition in the upper estuary because exchange with the ocean becomes progressively reduced moving upstream.

STEP 4: Individual Estuary Data

Monitoring data for the Leven estuary in 2006 - 2008 show that the upper estuary is already indicating signs of eutrophication with high chlorophyll a levels over summer. This implies that the upper region of the estuary is sensitive to high nutrient loading and any increase in nutrients could have a significant impact on the estuary.

Monitoring design

If this hypothetical development was to proceed with an increase in nutrient delivery to the river, monitoring would be recommended at a minimum of two sites in the upper estuary (LU1 and LU3 in picture above) three times over summer and once over winter, starting before the development is operational to provide a before and after comparison. Important indicators to be monitored include dissolved oxygen (profiled through the water column), turbidity, salinity and chlorophyll a. A site image library should be established with photographs taken at each site on each sampling occasion from a fixed point and clearly showing the intertidal zone at low tide. As the stressor identified as having the highest risk of impacting the estuary is nutrient concentration, it is recommended that nitrate, phosphate and ammonia concentrations are measured when funds are available. A more comprehensive monitoring program would include an assessment of the composition of invertebrate fauna in the sediment at least every three years.

the other hand, such as Little Swanport, are most susceptible to change during and after floods and when base flows are reduced. Water Management Plans that have 'cease-to flow' environmental water requirements, which stop the extraction of water when river flow drops below a predefined level, are important for protecting the health of estuaries and rivers.

Indicator choice and trigger levels are discussed in a companion fact sheet and the Decision Tree is described in more detail in a technical report at:
www.landscapelogicproducts.org.au

How we did it

Flushing class

The northern coastline is mesotidal, with tides ranging from 2.5 to 3.5 m, whereas the rest of the Tasmanian coastline has tides of less than 1.5.m, with much of the coast having tides of less than 1 m. Estuaries flowing into Bass Strait on the northern coastline are thus routinely better flushed than those elsewhere in the State, and so are generally less susceptible to anthropogenic impacts.

Freshwater flow into estuaries is determined by rainfall and the size and geomorphology of catchments. The western half of the state has the highest rainfall, from 1000 to 3000 mm, especially in summer and spring. On the east coast rainfall if more variable both in annual quantity and time of year, with annual rainfall ranging from 500 to 1000 m. Thus rivers in the east of the state show greater flow variability between base flows and flood events, and floods can occur at any time of the year. The morphology of the estuary entrance also influences the flushing rate. This is affected by longshore sand transport and tidal activity. In areas of relatively low tidal activity and strong longshore currents, sand build up can restrict flow through the entrance or completely close it.

Critical Events and Sensitive Locations

An examination of data from previous studies and from our own investigations has shown clear differences in environmental characteristics between summer and winter in well flushed estuaries and between floods and base flows in poorly-flushed estuaries. Extensive studies in the Little Swanport estuary have also revealed that a reduction in base flows affects the condition of poorly flushed estuaries (Crawford et al 2010). The most sensitive location to human impacts in both well flushed and poorly flushed estuaries have been identified as the upper estuary where there is reduced flushing by oceanic waters (Hirst et al 2007, Beard et al 2008). In open/closed estuaries, however, degradation is likely to be greatest when they are closed to flushing and spread across the entire estuary.

References

Crawford, C., Hundloe, T. & Ross, J. (2010) Water use across a catchment and effects on estuarine health and productivity. Draft Report to FRDC, Project No. 2005/72

Hirst, A. J., Kilpatrick, R., Mount, R., Guest, M. A. & Crawford, C. (2007) Determining the ecological health of of estuaries in NW Tasmania: A case study assessing the status of the Duck, Montagu, Detention and Black river estuaries. Tasmania Aquaculture and Fisheries Institute.

Beard, J., Crawford, C. & Hirst, A. (2008) Developing a monitoring program for six key estuaries in north-west Tasmania. Tasmanian Aquaculture and Fisheries Institute.

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It is a partnership between:
six regional organisations – the North Central, North East and Goulburn–Broken Catchment Management Authorities in Victoria and the North, South and Cradle Coast Natural Resource Management organisations in Tasmania;
five research institutions – University of Tasmania, Australian National University, RMIT University, Charles Sturt University and CSIRO; and
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