

The Risky Business of ICOLL Entrance Management

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Introduction

Estuaries in NSW with entrance channels that become blocked by the build-up of marine sand are often referred to colloquially as intermittently closed and open lakes and lagoons or ICOLLs. Over 60% of the estuaries in NSW are considered to be ICOLLs (DECCW, 2010a, b, c, d).

Due to the unpredictable nature of rainfall in south-east Australia, the opening behaviour of ICOLLs can be intermittent and erratic and the salinity regime comparatively variable (Roy *et al.* 2001). As the opening and closing of estuary entrances occurs naturally, the aquatic and fringing plant and animal communities have adapted to the accompanying variable environmental conditions.

Artificial entrance management generally involves either opening entrances at a level lower than the natural breakout range or managing the height, location or configuration, of the beach berm to facilitate entrances opening at lower than natural levels.

Intervention in the behaviour of ICOLL entrances has occurred for various reasons and can be accompanied by negative environmental impacts some of which may be directly apparent whereas others may take many years to become evident.

The most common trigger for artificial opening of ICOLL entrances is mitigating potential damage or inconvenience to low-lying properties and assets inundated or threatened by rising water levels. This can often also result in pressure from local communities to maintain permanently open entrances.

In order to consider and balance the often competing issues associated with ICOLL entrance management, including estuary health, community uses of the estuary and the longer term impacts of climate change, entrance management policies are a requirement in the preparation of coastal zone management plans (DECCW, 2010e). Where entrance constriction or closure contributes to the severity of flooding of urban areas and associated public infrastructure entrance management is often considered amongst the suite of options within a floodplain risk management plan (NSW Government, 2005).

Regardless of whether ICOLL entrances are being managed through a coastal zone management plan or through a floodplain risk management plan there are commonalities in the approach, policy framework and environmental assessment requirements leading to the inclusion of adaptive entrance management as a management action.

This presentation will discuss the policy context for entrance management, key physical and ecological processes and impacts and the suggested framework for developing entrance management policies. A review of the entrance management policies developed in NSW over the last 10 years has informed the key considerations around ICOLL entrance management and information around potential environmental and social impacts.

Entrance processes

The interaction between fluvial, tidal and wave processes determines the morphology and entrance condition of NSW estuaries. Put simply, the balance between wave processes and flood tides (moving sediment into estuary entrances) and ebb tide and fluvial processes (moving sediment out of estuary entrances) will determine whether an entrance is open, closed or in a transitional state between the two (see Roy 1984, Dyer 1997, Roy *et al.*, 1997, Hanslow *et al.*, 2000).

When entrances close, rainfall, runoff and wave overtopping increase water levels in the ICOLL and often cause inundation of low-lying foreshore areas. Depending upon the amount, intensity and location of rainfall and catchment size and morphology, water levels will either creep up slowly or rise rapidly until they overtop the level of the entrance berm. When this occurs the berm breaches and high velocity outflows scour an entrance channel (Haines and Thom 2007).

The frequency and duration of entrance opening is known to vary considerably across NSW ICOLLs. The entrances of some ICOLLs with relatively small catchment to waterway ratios can be closed for many years between openings eg. Wallaga Lake (BVSC 2004) and Lake Wollumboola (Kinhill 2000) are documented as regularly closing for periods of between six to eight years. Conversely, water levels in ICOLLs such as Fairy Creek and Towradgi Lagoon with relatively large catchment areas are known to rise rapidly resulting in multiple entrance openings in any year (Cardno Lawson Treloar, 2007 a and b).

The duration of entrance openings can also be highly variable between ICOLLs and for individual ICOLLs. However, there is some evidence that the higher the break out level the longer the duration of the opening as a result of a more efficient scour of the entrance channel (eg. see Spurway *et al.*, 2001).

Triggers for entrance management

The most common reasons given for artificially managing ICOLL entrances are:

- mitigating potential damage or inconvenience to low-lying properties and assets inundated or threatened by rising water levels (eg. homes, yards, jetties, roads, foreshore reserves, caravan and camp sites, and stormwater, septic and sewerage systems),
- pressure from local communities who prefer open entrances (often based on comparison to large river estuaries where entrance works have been installed for navigational purposes),
- alleviating actual or perceived water quality problems, through the introduction of tidal processes, and
- attempts to enhance fish and prawn recruitment.

For about half of the ICOLLs in NSW, artificial opening is undertaken to manage foreshore inundation (Haines 2008). The need to open coastal lakes for this reason is often the result of past land use planning decisions, which have led to development on land vulnerable to inundation. These entrance opening practices have not

necessarily considered the necessary approval and environmental assessment processes (HRC 2002) or the long-term impacts of the activity.

The opening or attempted opening of ICOLL entrances by members of some local communities has also occurred, largely for the above reasons but also in some locations to seek to improve surf breaks.

Whilst water quality is often cited as a trigger for opening ICOLLs, the opening of the ICOLL alone is not likely to significantly improve water quality. The limited tidal flushing and entrance exchange efficiencies whilst entrances are open means that pollutants (particularly those entering from tributaries furthest from the entrance) may be moved around within the system but may not be removed (eg. Spurway *et al.*, 2000). Opening an ICOLL does not address source control of problematic pollutants (eg. sediment and nutrients from diffuse sources), and this remains the most effective way to manage water quality problems.

The certainty of achieving benefits from opening ICOLLs for the purpose of fish and prawn recruitment is unclear. It is virtually impossible to artificially manipulate entrance opening with any certainty of enhancing fish or prawn recruitment and subsequent production without a detailed sampling and analysis of offshore and coastal larval populations (Gibbs, 1997). The artificial opening to promote production of one species or a group of species may in fact disadvantage other species, with the final outcome being no net benefit (NSW Fisheries, 1999).

Environmental impacts of entrance management

Whilst there is evidence that the macroinvertebrate ecology of the beach berm may recover relatively quickly after an artificial opening (Gladstone *et al.*, 2006), ecosystems within and fringing the ICOLL are likely to be subject to more significant and longer lasting impacts.

Potential environmental impacts of artificial entrance management within the ICOLL and its fringing environments include:

- marinisation through increased and more stable salinities leading to changes in aquatic vegetation communities. Specifically, moving to more regular tidal range and inundation periods may also promote the establishment or expansion of mangroves at the expense of other vegetation types.
- the hydrology of fringing wetlands is changed when consistently opening entrances at lower levels through the reduction in inundation levels and periods (Spurway *et al.* 2000). Many coastal lakes in NSW have fringing communities of the endangered ecological community coastal saltmarsh (Creese *et al.* 2009) that rely on periodic inundation.
- fish kills can occur as a result of anoxic conditions in ICOLLs following artificial opening (see Wilson *et al.* 2002 for a description of processes leading to anoxia). Fish kills can be the most immediate environmental impact and have the greatest visual and olfactory impact for local communities (Wilson *et al.* 2002, Arundel 2006 and Stephenson 2011).
- reduced fish habitat and stock (Jones and West 1995). Direct loss of habitat can occur where seagrass beds have established in entrance channels that then change as a result of artificial opening. Whilst the impact of artificial entrance opening on fish communities remains largely unpredictable, Jones and West

(1995) document the short-term visitation of larger economically important fish species to the detriment of the abundance of smaller resident species after artificial entrance opening. The salinity regime of individual lakes contributes to the structuring of fish assemblages on a regional scale (Jones and West 1995, NSW Fisheries, 1999).

- increased sand shoaling at the entrance (Haines 2008) and reduced opening duration (Spurway *et al.* 2000) due to inefficient scour of entrances at low opening levels.

Climate change

In understanding the entrance behaviour of ICOLLS in the longer term, risks associated with climate change will be a major consideration. ICOLL entrance management policies should realistically assess the impacts of, and vulnerabilities to, climate change impacts such as sea level rise. Under projected sea level rise, the level and frequency of asset inundation due to oceanic processes may increase and the ecological character of an estuary may change. Entrance management policies and triggers for opening should therefore be adaptable, or reviewed periodically, to reflect changing circumstances and estuarine behaviour.

Hanslow *et al.*, (2000) describe berm building processes, potential berm level, and berm level variability for ICOLLS, as well as the likely impacts of sea level rise. With increased sea levels, general beach recession is likely to be accompanied by landward and upward translation of the berm resulting in higher ICOLL water levels and in many locations a commensurate increase in flood risk.

The *NSW Sea Level Rise Policy Statement* (NSW Government, 2009) sets out the Government's approach to planning for sea level rise, the risks to property owners from coastal processes and assistance that Government provides to councils to reduce the risks from coastal hazards. The policy and its accompanying guidelines (DECCW 2010f and DECCW 2010g) should be consulted when considering the impacts of sea level rise in preparing ICOLL entrance management policies.

Entrance management - coastal zone management plans or floodplain risk management plans?

In the past there has been some confusion as to whether ICOLL entrance management should be considered as part of a coastal zone management plan (previously referred to as an estuary management plan) or floodplain risk management plan. ICOLL management can be considered as part of either process. For example:

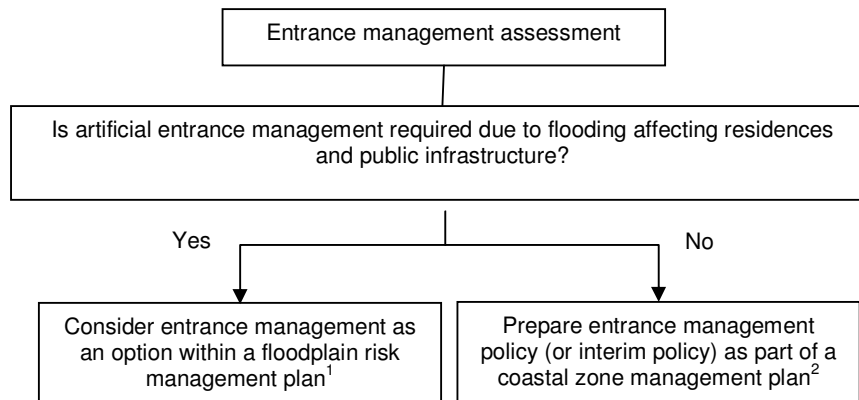
- Where flooding affecting residences and public infrastructure justifies adaptive entrance management it should be considered as one of the suite of options within a floodplain risk management plan, prepared in accordance with the Floodplain Development Manual (NSW Government, 2005).
- Where a coastal zone management plan is being prepared for an ICOLL an entrance management policy is required as part of the plan (DECCW, 2010e). Generally this type of plan will address relatively minor inundation affecting assets such as foreshore reserves, yards, boat ramps, jetties or access roads. Some consideration may need to be given to permanent inundation due to the impacts of projected sea level rise.

Interim entrance management policies may be appropriate where the need for entrance management is apparent but preparation of a floodplain risk management plan or coastal zone management plan is yet to begin, or negotiations regarding critical assets are likely to be lengthy. Where interim policies are being developed they should be placed on public exhibition and the adopted policy made available through council's website. These policies should also be regularly reviewed, as it clearly being developed on an interim basis.

If applicable, where an estuary management plan has been prepared in accordance with the previous Estuary Management Manual (NSW Government, 1992) and does not include an entrance management policy, an interim entrance management policy could be prepared as a stand-alone policy until the estuary management plan is reviewed and revised in line with the current requirements for preparing coastal zone management plans.

A process for preparation of an entrance management policy is shown in Figure 1.

Figure 1: Preparation of an entrance management policy.



¹ consistent with Floodplain Development Manual: the management of flood liable land (NSW Government, 2005).

² consistent with *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010e). Coastal management guide notes to support the guidelines are in preparation and will provide additional guidance on the content of entrance management policies.

Coastal zone management plans

The *Guidelines for Preparing Coastal Zone Management Plans* (DECCW, 2010e) outline the minimum requirements that must be included in a coastal zone management plan. These include an entrance management policy for ICOLLs.

The guidelines have been adopted as a manual for the purposes of section 733 of the *Local Government Act 1993*. The section provides an exemption from liability for certain management actions by councils and the State Government provided the actions were made in good faith. Councils and the State Government are considered to have acted in good faith if the actions were undertaken substantially in accordance with the principles contained in the specified manual.

The entrance management policy is to identify if a council intends to artificially manage the entrance. If so, the policy is to include triggers for actions to manage the opening of the entrance, which were developed considering the impacts of entrance opening on:

- flood levels and tidal inundation,
- estuary health, including inundation of fringing wetlands and water quality, and
- community uses of the estuary.

The policy should achieve a reasonable balance between these considerations, and should also consider the longer term impacts of climate change on entrance management.

In some situations the entrance management policy will support maintaining a natural entrance regime or reducing intervention (eg. Shoalhaven City Council, 2004).

Floodplain risk management plans

There are three ways that communities near an ICOLL can be flooded:

- As anywhere, heavy rain in the catchment can cause the lake and entrance channel to overflow into settled areas.
- As in all coastal areas, storm surge in the ocean can pump up the tidal waterway resulting in flooding of low lying land.
- A closed ICOLL entrance will trap catchment run off, so that adjacent land will stay flooded until evaporation lowers the lake, the berm overtops or the entrance is opened.

In assessing ICOLL entrance management in a floodplain risk management study the fundamental question is: Can it reduce the impact of flooding on the community? The floodplain risk management process tests the impact of all options including entrance management on flood behaviour and risk for each type of flooding. Finding the optimum overall suite of effective options requires balancing the risks, particularly for options like entrance management which might reduce impact from one flooding type but increase it for another.

Flood modelling of ICOLLs in some recent flood studies has incorporated dynamic scouring of the entrance. It has also used open, closed and trained entrance configurations. This modelling has demonstrated that for large floods which cause significant risk to communities, the model is more sensitive to the adopted ocean water level (eg DECCW 2010f) than to the state of the entrance.

The floodplain risk management process may identify alternative flood mitigation measures which, once implemented, adequately address the risks from the full range of catchment or storm surge flooding. Implementation of these alternative measures may result in a small level of residual exposure to the nuisance of persistent flooding and render artificial entrance opening redundant as a floodplain management option. Whilst entrance management may be used to manage existing flood risk, it is generally not desirable to rely on entrance intervention to set flood planning levels for future development particularly where the risk can be otherwise avoided.

Where artificial entrance management is to be included as an option in a floodplain risk management plan, an entrance management policy is an appropriate mechanism to set out the conditions for entrance management (why, when, where and how?). Any such policy needs to adequately consider and address potential environmental and social impacts and the manner in which any impacts are to be managed.

Entrance management framework

An entrance management policy should establish the framework for managers to make informed decisions about the management of an ICOLL entrance. This includes whether or not the entrance should be artificially opened, its frequency and how this should occur.

The following should be considered when developing entrance management policies:

- entrance opening following as natural a regime as possible, taking into account property inundation and flooding of infrastructure,
- a clear decision-making and approval process, based on the best available data and information,
- engaging with local communities so they are aware of any arrangements for entrance management, and deterrence of unauthorised openings.

Considerations should be given to the long-term goal of an entrance management policy being to retain or progressively reinstate natural entrance behaviour. Implementation of policies to meet this goal may require the progressive removal, relocation or modification of assets and activities that are affected by inundation or that may create public health problems when water levels are high (eg. stormwater and sewerage systems). Such an approach may benefit the affected community by reducing their risk exposure under both existing and changed climate conditions in the long term.

Given the pattern of development around some estuaries, this may not be a realistic or cost effective goal in the short term, but policies should consider whether there are opportunities to utilise future asset renewals and development decisions over time to work towards meeting this goal. In circumstances where adaptation is deferred entrance management should take into account critical ecosystem processes and emphasise the need for long-term planning to ensure entrance management does not further compromise estuary health or asset inundation due to oceanic processes.

A high level of debate in the community as to the pros and cons of artificial entrance management usually precedes the adoption of any entrance management policy. The process of developing a clearly set out policy enables the broader community to become more informed about issues associated with entrance management.

Preparing entrance management policies

In order for entrance management policies to provide a useful tool for ongoing adaptive entrance management, an entrance management policy could include:

- the purpose of the policy,

- a description of the entrance management activity/activities to be undertaken, the approval process to be followed and the corresponding level of environmental assessment required. A range of legislation and policies should be considered, the extent of their application will be dependant on the actual location of works and likely impacts, these may include:
 - The *Environmental Planning and Assessment Act 1979* (EP&A Act) is the primary legislation controlling development activity in NSW. Where an ICOLL entrance management policy includes artificial opening the activity will require assessment under either Part 4 or Part 5 of the Act.
 - The *State Environmental Planning Policy (Infrastructure) 2007* specifies a number of activities that may be permitted with or without consent under the EP&A Act when carried out by public authorities. These include for flood mitigation activities. When proposing to open an ICOLL entrance, or maintain an entrance berm at a certain level for the purposes of flood mitigation, a public authority may use the SEPP to assess the activity in accordance with Part 5 of the EP&A Act.
 - The *Crown Lands Act 1989* provides for the administration and management of Crown land, including most beaches and estuaries. Where a local council has care and control of the entrance area of an ICOLL this may only apply to the area above mean high water mark. Dredging on Crown land requires a licence under Part 4, Division 4 of the Act. Where the material dredged will be removed from the system, that is, taken, stockpiled or sold it would generally be undertaken under a licence agreement (s 49).
 - The *Fisheries Management Act 1994* requires a public authority (other than a local government authority) to consult with the relevant Minister prior to carrying out dredging or reclamation (s 199). A local government authority proposing to undertake dredging works is required to obtain a permit (s 200). Dredging works includes excavating and/or the removal of material. However, s 200 does not apply if the dredging is authorised under the *Crown Lands Act 1989* or by another relevant authority (other than a local government). Section 205 (harm to marine vegetation) of the Act could apply if seagrasses were to be damaged in carrying out the entrance opening. Guidelines are available to assist with applications and approvals (NSW Fisheries, 1999).
 - Depending upon local circumstances, including the presence of threatened species and migratory birds, the *Environment Protection and Biodiversity Conservation Act 1999*, *Threatened Species Conservation Act 1995* or *Heritage Act 1977* may be relevant. Similarly, where ICOLL entrances are located within the reserve system the *Marine Parks Act 1997* or *National Parks and Wildlife Act 1974* may also apply.
- a description of the state of the entrance and processes contributing to its state, including water levels, rainfall response, historical opening frequency, location and opening duration,
- a description of the ecological and social values associated with the entrance area (e.g. roosting site of migratory birds etc), ICOLL and fringing areas. Including the likely short and long term impacts of entrance management on estuary health (including inundation of fringing wetlands),
- identification, location and elevation of affected assets and impacts upon the local community,

- consideration of the impacts of climate change on entrance condition and behaviour and inundation of assets,
- any proposed monitoring protocols both before and after opening events, including water levels, berm height, water quality, tidal behaviour and sand egress, channel configuration, presence of threatened species,
- the decision-making process leading to intervention including responsibilities, procedures and accountabilities in relation to entrance management,
- measures to be implemented to avoid or mitigate impacts,
- a communication strategy to increase community understanding and communicate protocols for entrance opening,
- a mechanism for reviewing and updating the policy, including actions required to minimise intervention in the longer term and linking these to a review of opening conditions.

The policy should be accompanied by the necessary environmental assessment addressing the likely impacts of the policy on the relevant environment, social and economic assets.

Relevant agencies, including those from which approvals, licences or permits will be required, should be consulted during formulation of the policy.

Conclusion

Entrance management is an issue that often requires a balance between competing environmental, social and economic drivers. There are a range of considerations to be taken into account in the development of an entrance management policy for ICOLLs, including flood risk, ecosystem health and community amenity.

Implementation of other flood mitigation or environmental improvement measures may have greater potential in addressing the likely cause of a problem for which entrance opening has been proposed as a possible solution. A thorough investigation should be carried out ensure that the most effective management option is being recommended. This may not always include the artificial opening of an entrance.

Most importantly, decisions should be made based on the best available information, and a policy response should be monitored and reviewed to ensure that the most appropriate and cost effective options is being implemented at any given location.

References

Arundel H. (2006) *Estuary Entrance Management Support System (EEMSS) Background Report and User Manual*. Natural Heritage Trust, Parks Victoria, Glenelg Hopkins Catchment Management Authority, Corangamite Catchment, Management Authority and the Environment Protection Authority Victoria. Deakin University, Warrnambool.

Bega Valley Shire Council (2004) *Wallaga Lake Entrance Management Policy Draft Report*. Prepared by Bega Valley Shire Council and Department of Infrastructure, Planning and Natural Resources.

Cardno Lawson Treloar Pty Ltd (2007a) *Fairy Lagoon Entrance Management Policy*. Report prepared for Wollongong City Council.

Cardno Lawson Treloar Pty Ltd (2007b) *Towradgi Lagoon Entrance Management Policy*. Report prepared for Wollongong City Council.

Creese R. G., Glasby T. M., West G. and Gallen C. (2009) *Mapping the habitats of NSW estuaries*. Industry & Investment NSW, Fisheries Final Report Series 113. Port Stephens, NSW, Australia. ISSN 1837-2112. 95 pp.

DECCW (2010a) *State of the Catchments, Estuaries and Coastal Lakes, Northern Rivers Region*. Department of Environment, Climate Change and Water NSW, Sydney South.

DECCW (2010b) *State of the Catchments, Estuaries and Coastal Lakes, Hunter - Central Rivers Region*. Department of Environment, Climate Change and Water NSW, Sydney South.

DECCW (2010c) *State of the Catchments, Estuaries and Coastal Lakes, Hawkesbury–Nepean and Sydney Metropolitan regions*. Department of Environment, Climate Change and Water NSW, Sydney South.

DECCW (2010d) *State of the Catchments, Estuaries and Coastal Lakes, Southern Rivers Region*. Department of Environment, Climate Change and Water NSW, Sydney South.

DECCW (2010e) *Guidelines for Preparing Coastal Zone Management Plans*. Department of Environment, Climate Change and Water NSW, Sydney South.

DECCW (2010f) *Flood Risk Management Guide - Incorporating sea level rise benchmarks in flood risk assessments*. Department of Environment, Climate Change and Water NSW, Sydney South.

DECCW (2010g) *Coastal Risk Management Guide - Incorporating sea level rise benchmarks in coastal risk assessments*. Department of Environment, Climate Change and Water NSW, Sydney South.

Dyer K. R. (1997) *Estuaries: a physical introduction*. John Wiley & Sons Ltd, Chichester.

Gibbs P. (1997) *A Review of Information on NSW South Coast Estuarine Fisheries*. NSW Fisheries Research Institute, Cronulla.

Gladstone W., Hacking N. and V. Owen (2006) Effects of artificial openings of intermittently opening estuaries on macroinvertebrate assemblages of the entrance barrier. *Estuarine, Coastal and Shelf Science* 67 (2006) 708-720.

Haines P.E. and Thom B.G. (2007) Climate change impacts on entrance processes of intermittently open/closed coastal lagoons in New South Wales, Australia. *Journal of Coastal Research*, SI 50 242–246.

Haines P. E. (2008) *ICOLL Management: Strategies for a sustainable future*, BMT WBM Pty Ltd, Broadmeadow NSW.

Hanslow, D. J., Davis, G. A., You, B. Z. and Zastawny, J. (2000) Berm heights at coastal lagoon entrances in NSW. *Proceedings 10th Annual NSW Coastal Conference*. 20 – 24th November 2000, Yamba NSW.

Healthy Rivers Commission (2002) *Independent Public Inquiry into Coastal Lakes: Final Report*. Healthy Rivers Commission of New South Wales, Sydney.

Jones M.V and West R.J. (1995) 'Spatial and temporal variability of seagrass fishes in intermittently closed and open coastal lakes in south-eastern Australia'. *Estuarine, Coastal and Shelf Science* 64(2–3), 277–288.

Kinhill (2000) *Lake Wollumboola Estuary Management Plan*. Report prepared by Kinhill Pty Ltd for Shoalhaven City Council and the Department of Land and Water Conservation.

NSW Fisheries (1999) *Policy and Guidelines Aquatic Habitat Management and Fish Conservation (1999 Update)*. NSW Fisheries, Sydney.

NSW Government (1992) *Estuary Management Manual*. NSW Government.

NSW Government (2005) *Floodplain Development Manual: the management of flood liable land*. Department of Infrastructure, Planning and Natural Resources, Sydney.

NSW Government (2009), *NSW Sea Level Rise Policy Statement*. NSW Department of Environment, Climate Change and Water, Sydney.

Roy, P. S. (1984) New South Wales estuaries—their origin and evolution. In *Developments in Coastal Geomorphology in Australia* (Thom, B. G., ed.). Academic Press, New York, pp. 99–121.

Roy, P. S., Cowell P. J., Ferland M. A. and B. G. Thom (1997) Wave-dominated coasts. In *Coastal Evolution, Late Quaternary Shoreline Morphodynamics* (Carter R. W. and Woodroffe C. D., eds). Cambridge University Press, Cambridge, pp. 121-186.

Roy P. S., Williams R. J., Jones A. R., Yassini I., Gibbs P. J., Coates B., West R. J. Scanes P. R, Hudson J. P. and Nichol S. (2001) Structure and Function of South-east Australian estuaries. *Estuarine, Coastal and Shelf Science* (2001) 53, 351-384.

Shoalhaven City Council (2004) *Swan Lake Entrance Management Policy* (Policy Number: POL05/41), Prepared by Peter Spurway & Associates for Shoalhaven City Council, Nowra.

Spurway P., Roper T. and Stephens K. (2000) Community consultation, conservation, crustaceans, calculations and consents – Entrance Management Policies for ICOLLs. *Proceedings 10th Annual NSW Coastal Conference*. 20 – 24th November 2000, Yamba NSW.

Stephenson J (2011) Email warning - Attack on Lake Wollumboola was planned, *South Coast Register*, 4th April, 2011, accessed at <http://www.southcoastregister.com.au/news/local/news/general/email-warning-attack-on-lake-wollumboola-was-planned/2122667.aspx>.

Wilson J., Evans P. and Kellaheer N. (2002) Fish Kills in Cockrone Lagoon – Implications for Entrance Opening of Coastal Lakes. *Coast to Coast Conference*, November 2002, Tweed Heads.