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Chapter1
Introduction

What is an estuary? Is there a wetland on or near my property? Is boat wash really a problem? What are the non-toxic alternatives for pest control in my house and garden? Does dredging work? How clean is the river water? This kit has been designed to inform you about the water catchment in which you live, and the rivers and creeks that feed it. The mid-north coast is comprised of three major catchments, the Nambucca, Macleay and Hastings. If you live, work, holiday or have recently moved here, this kit is an easy to use guide on how to live and work in ways that preserve our coastal environment. As coastal populations continue to grow, we all have a responsibility toward protecting our estuaries, which support our livelihoods, lifestyle choices and recreational pursuits. Estuaries and the systems they support are live organisms. If we don't care for them, they will die!

The kit explains what a catchment is, its various components and what is meant by an environmental impact. It outlines various environmental parameters that can affect water quality and oyster production. The oyster industry is perhaps the most susceptible to the health of the estuary and is included here as an indicator of estuarine health. Estuarine processes that determine the viability of the oyster industry are explained; although they are dealt with individually, they should not be perceived in isolation. Estuaries are highly dynamic, complex environments in a constant state of flux with phenomena like turbidity, salinity and pollutants all acting on the system at once. Practical

solutions and examples of how local people are tackling the problems that can impact on waterways are included in Chapter 6.
To help you understand where you sit in relation to the estuaries, maps are included showing the rivers and creeks in each catchment. The catchments lie in what is called the north coast or northern rivers region. This area covers approximately 50,000 square kilometres from the Camden Haven River in the south to the Queensland border and 160 kilometres inland. The mid-north coast region encompasses the traditional lands of the Gumbaynggir, Dunghutti, Birpai and Worimi people, and extends into Bundjalung country in the north.
While all attempts have been made to provide up to date information, this kit provides a general introduction to the topics and can be read in conjunction with the Resource Kit for Rural Landholders. This was written for the mid-north coast and is available free from Landcare offices. It should be noted that since the time of publication some of the government department names have changed. This restructuring and adjustment of names is common practice and can make it extremely confusing for anyone looking for assistance. Always seek professional advice using the list of contacts for each topic in the contacts section of the kit.

The northern rivers region (Northern Rivers CMA)

Chapter 2
Know your estuary
What is an estuary?

Estuaries are places of transition, where water from the land meets and mixes with the open sea. They are found at the lower end of rivers and may be large systems, like the Nambucca, Macleay and Hastings Rivers, or small systems like Back Creek at South West Rocks.
Estuaries are often referred to as the “nurseries of the sea” because they are the breeding grounds for many fish, crustaceans, and other marine life. NSW has more than 130 estuaries of varying sizes that are of immense environmental, social and economic importance. They all contain diverse ecosystems that support vegetation, wildlife, and the coastal food-chain. Estuaries located close to towns, are a mecca for tourists and the preferred location for coastal development.
However, concern is growing about the negative effect that increasing coastal urbanisation is having on our environment including estuaries. Population growth and urbanisation are stressing and degrading our fragile coastal ecosystems. Habitat degradation, declining water quality, resource depletion, loss of amenity, and restricted access are just some of the issues of concern to local communities. Nutrients, sediments and toxins created by urbanisation, agricultural activities, vegetation clearing and industry, eventually end up in an estuary affecting the water quality and life within. In this way estuaries can be considered as the report cards of the catchments. Dams and water extraction for irrigation and water supply, alters the hydrology of estuaries and may lead to increased salinity in the upper reaches of the tidal pool increasing sedimentation, closed entrances, altered freshwater flows and changes in tidal flushing. These changes can have profound impacts on estuarine and coastal ecosystems (http://www.dnr.nsw.gov.au/estuaries/index, 2006).
The physical, chemical and biological processes of an estuary are highly integrated, each component acting on the other to determine the type of ecological conditions. For example, inputs into the system and tidal processes directly affect physical processes within the estuary which affect the chemical processes which then determine the existing ecology. Nature adapts to these changes. Our perceptions of what rivers, creeks and estuaries should look like as well as our expectations for using these areas may need to accommodate the fact that these natural environments have been modified over time by human activity. Their sensitivity to changes should be a guiding factor in how we treat them.
The Nambucca Estuary

The special characteristics of the Nambucca Estuary make it a popular recreational river, with marine sands giving it an aquamarine colour perfect for swimming and snorkelling. The main arm of the river is approximately 76 km long, with the tidal limit 28 km from the entrance. Despite extensive clearing to the river edge, there are remnants of diverse riparian vegetation. The major estuarine tributaries feeding into the Nambucca River are Taylors Creek, Newee Creek, Watt Creek, Taylors Arm, Swampy Creek and Warrell Creek. The town of Nambucca is located at the entrance and Macksville is approximately 13 km upstream of the entrance. The estuary extends up the Nambucca River from Nambucca Heads to the town of Bowraville, and along Warrell Creek past Scotts Head out to the Pacific Highway. The area it covers is approximately 7.74 km2 and drains a catchment of 1,460 km2.

Nambucca River mouth. © DECC

The river is navigable to approximately 5 km upstream of Macksville. The permanent entrance at Nambucca Heads is trained with a single northern wall and is shallow and very hazardous. 55% of the catchment is zoned rural, 40% State Forest and of the remainder 1.6% Environmental Protection and 1.9% National Park. The river is used for small oyster and commercial fish enterprises (WBM Oceanics, 2000). There are three sewage treatment plants located in close proximity to the estuary at Macksville, Scotts Head and Bowraville. Only the Macksville plant discharges directly into the Nambucca River estuary, at the confluence of Newee Creek.

The upper catchment contains the steep and rugged eastern edges of the New England Plateau and the lower catchment includes the fertile floodplains of the Nambucca River and Taylors Arm. These and adjacent undulating lands have been cleared extensively for agriculture, predominantly beef and dairy cattle with some cropping and horticulture including banana and macadamia nut production. The floodplains of the Nambucca River are characterised by gravel soils with high permeability, low water holding capacity, high top soil fertility, localised poor drainage and seasonal waterlogging, resulting in localised flood hazards (Eddie, 2000). Where the riparian vegetation has been removed, severe stream bank erosion has occurred causing large areas of floodplain to be eroded into the river (Eddie, 2000; WBM Oceanics, 2000). Extensive, inappropriate sand and gravel extraction has also been cited as a contributing factor to degradation of the waterway. Sydney Rock Oyster production for 2004 – 2005 in the Nambucca was 64,657 total dozens (NSW DPI, 2004-2005).

The Macleay Estuary

The Macleay River is fed by the waters flowing from the tablelands. It has an interesting history due to the flood mitigation works that began in the 1950s. The approximate length of the main arm of the river is 150 km. The town of South West Rocks is located at the entrance. The ocean mean spring tidal range at the entrance is 1.28 m. Tidal influence up the Macleay River terminates at Belgrave Falls, approximately 5 km upstream of Aldaville or 54 km from the entrance. The coastal floodplain of the Macleay extends over an area of 400 km2, and is comprised of semi-permanent back swamps. The unique characteristics of this river system include a floodplain that contains over 150 km2 of wetland, aquatic bird habitat and 5.0 km2 of mangroves which is equivalent to 5% of the NSW estuarine total. Draining the floodplain has created a number of water quality problems. Exposure and the subsequent oxidisation of the sulfidic estuarine clays, has meant acid leachate has been washed into the waterways; land slumping and accelerated bank erosion have also deteriorated water quality (Telfer, 2005). Other significant tributaries that feed the Macleay River are the Macleay Arm, Yarrahappini, Broadwater, Clybucca Creek, Belmore River, Collombatti Creek and Kinchela Creek. It is an intensive oyster producing estuary at 20 t/km2 per year, and a commercial and recreational fishing mecca with parts of Hat Head, New England and Apsley Gorge National Parks all located in the catchment. Sydney Rock Oyster production for 2004 – 2005 in the Macleay was 130,998 total dozens.

Macleay River mouth. © DECC

The Hastings Estuary

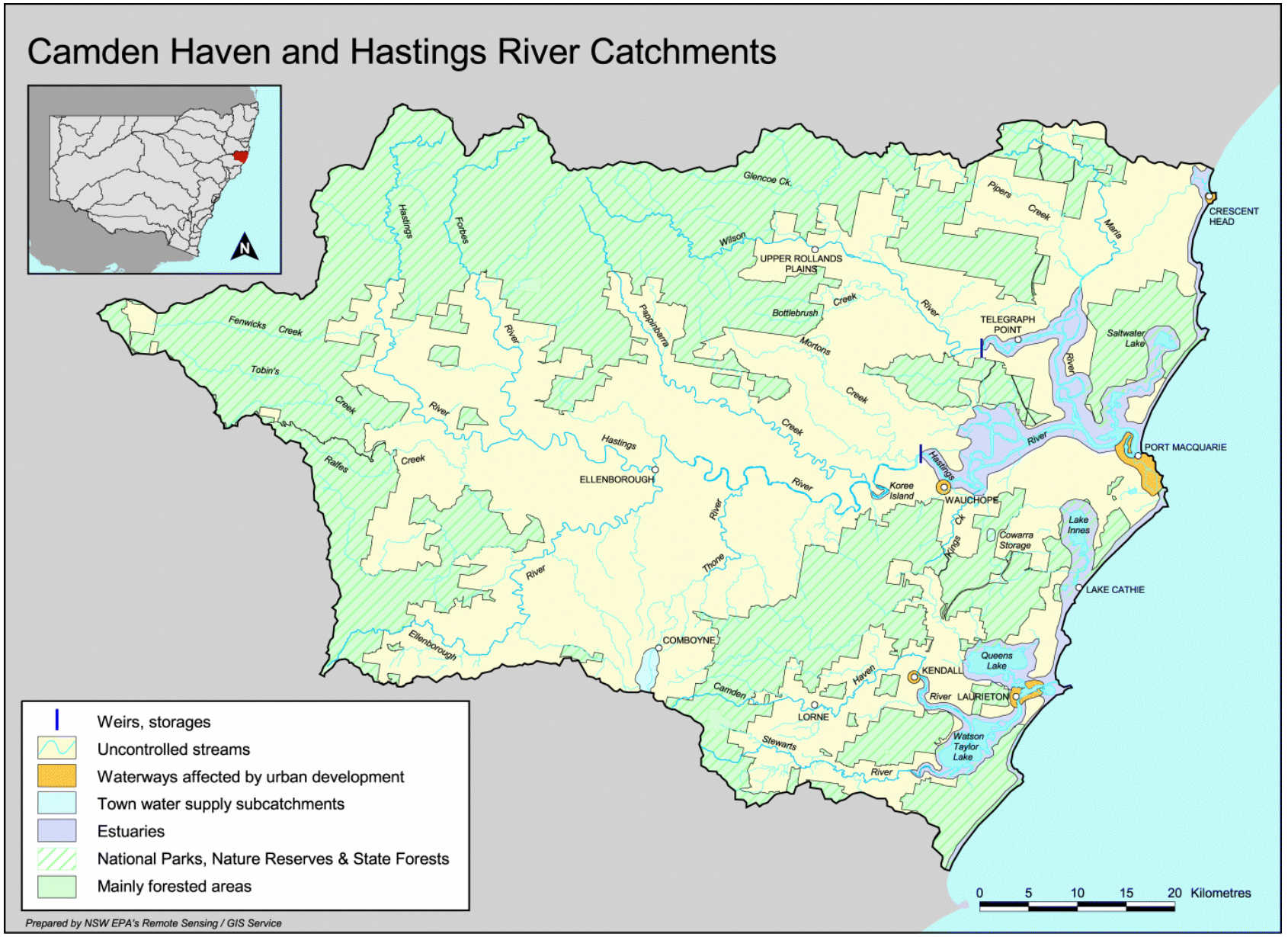
The Hastings River is south of the Nambucca and Macleay. The main arm of the river is approximately 120 km long. It was first charted by European explorers in 1818 after its discovery by John Oxley who named the river for the then Governor-General of India, Francis Rawdon-Hastings.

The river shares its name with the endangered Hastings River Mouse. The large town of Port Macquarie is located south of the entrance. The area of the catchment is 3,595 km2.. The lower Hastings River is under tidal influence for some 32 km from the entrance to a point just upstream of Bains Bridge, about 8 km above Wauchope. Although no tidal gradient data is available, the tidal range is believed to be fairly constant up to Wauchope. Significant estuarine tributaries that feed this catchment include Fernbank Creek, Carecorara Inlet, Twin Rivers, Balyngara Creek, Tommy Owens Creek, Rawdon Creek, Munns Channel, Rawdon Channel, Caswell Channel, Hughes Inlet, Pipers Creek, Wilson River, Kooloonbung Creek, Limeburners Creek, Saltwater Lake, Maria River, Fernbank Creek and Rawdon Creek. It is an important tourist area with good amateur fishing opportunities, however, it is closed to all commercial fishing. There is large oyster producing, 250 tonnes per year. The estuary has extensive enclosed waters for boating. A trained river entrance provides ocean access in all but extreme storm weather conditions. Sydney Rock Oyster production for 2004 – 2005 in the Hastings was 300,255 total dozens* (*Production records do not include spat production and inter-estuarine transfers. The actual biomass produced from some estuaries greatly exceeds the DPI data records).

Where do you live in the catchment?

Perhaps your property has a creek or gully running through it or you live in town with gutters and drainage infrastructure. Wherever you live, your activities and daily choices can have an impact on the water flowing out to the sea. If you look at the maps of each catchment you can locate where you live in relation to the waterways running to the main river. It is important to remember that every dry gully or slope is part of the spider web network of water running off the land and out to sea. Although they have no water in them for periods of time, they are connected and it’s important to be aware of what is entering them in wet periods and where this is flowing to.

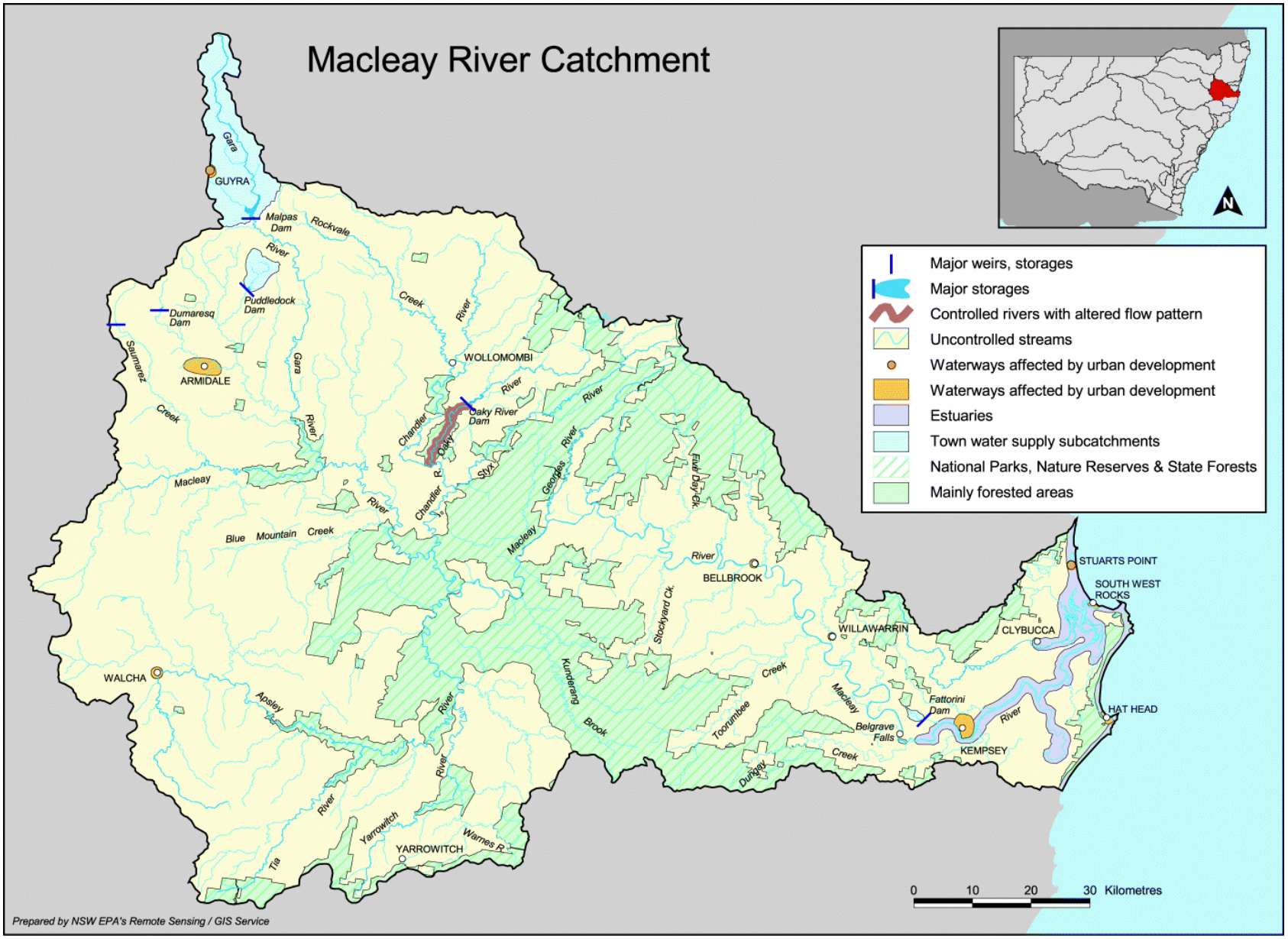
Nambucca River running through the landscape. © John Schmidt



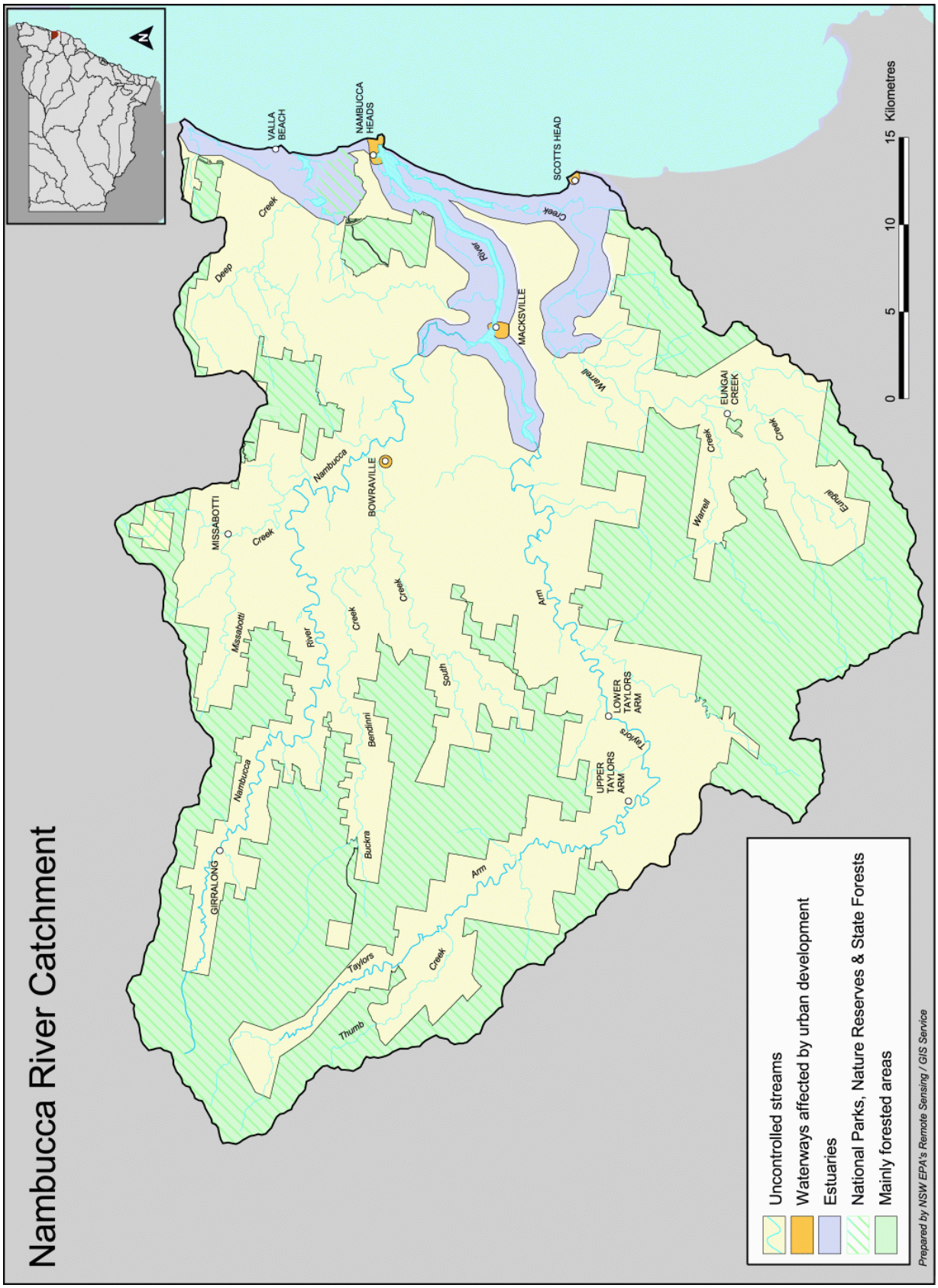
Mid-north coast catchments and subcatchments © Damon Telfer

Mis-north coast catchments and subcatchments © Damon Telfer

Camden Haven and Hastings River Map © DECC



Macleay River Map© DECC



Nambucca River Map © DECC

Chapter
3

The world is your oyster so look after it!

The general conditions required for growing healthy oysters are well oxygenated, clear, brackish to saline waters, with pH in the range 6.75 to 8.75, suitable tidal exchange, adequate phytoplankton supplies and control of upstream sources of runoff and pollution (see ANZECC and ARMCANZ 2000 for further details). In addition to the threats presented by human modifications to land and water, natural conditions, including climatic patterns, can have a major influence on the suitability of a site for oyster cultivation (HRC 2003, p.5).

The oyster is a native crustacean that is farmed and enjoyed all over the world. Increasing coastal populations are a direct threat to oyster cultivation. There is a feeling that if the oyster industry goes, so do the watchdogs of estuary health, oyster farmers. They are the ones looking out for water quality as it is in their best interest to keep their oysters healthy. In its lifetime, an average oyster can remove up to 1 million tonnes of suspended material from the water. They have an important role as purifiers of estuaries (White, 2001).

Extraction of freshwater upstream in periods of low flow, agricultural and industrial chemical runoff, land reclamation, boating, storm-water, leaky or faulty sewage systems, clearing of riparian land, acid sulfate soils and general urban and industrial development are just some of the activities contributing to a decline in oyster health and increased mortality rates.

The oyster as an indicator of catchment health

Estuaries support a diverse range of functions and uses, and no use is more dependent on clean water and susceptible to pollution, than oyster cultivation and harvest. The oyster has been referred to as the canary of the waterways because its health is determined by the health of the water in which it grows. As a living organism, it can take two to four years to mature and in that time can filter large volumes of estuarine river water, taking up everything that is dissolved or not in the water column. When oysters, clams, and other bivalve molluscan shellfish filter feed, they can accumulate disease-causing microorganisms (pathogens) and other contaminants that may be present in the near-shore environment.

A productive and healthy oyster industry is therefore closely linked to a healthy coastal waterway (HRC, 2003). All three estuaries featured in this kit produce significant quantities of the Sydney Rock Oyster, considered to be a delicacy throughout Australia.

The local oyster farmer

Oyster farmers are like any farmers, they have good years and bad, but what sets them apart is the area in which they farm, the estuary. Their paddocks are water, their livestock are hidden beneath and it is sometimes difficult to appreciate what they are producing until it appears on your plate. What follows are some insights on their industry and what they see happening to the estuaries in which they farm.

In the Hastings, there are a number of leases operating. One particular third generation oyster farmer has been cultivating oysters for 25 years or more. He likes the lifestyle that goes with oyster farming and working with the environment. ‘Being born into it, you have a bit of a passion for it, it’s no different to any other type of farming and it’s better than the rat race’. However, he has noticed a decline in oyster production over a period of years. ‘It was cleaner (the water) for my father and grandfather. We probably produce no more or not as many oysters as they did back in those days. Even using the archaic methods they produced a lot of oysters. They grew oysters like you wouldn’t believe. We don’t get anywhere near those growth rates anymore.’

Talking about oysters, he says ‘they’re just a little pump and filter basically and they can’t help but filter that sediment load out. That’s what they do in an estuary. A lot of toxic material is filtered and it either kills them or makes them very sick. Oysters can actually loose size (if the water quality becomes degraded) because an oyster is continually doing shell work, doing the housework, sweeping the shell out, forming new shell. When they get sick that’s the first thing they stop doing, they stop the house work.

Acid waters creating holes in maturing oyster shells. ©John Schmidt

When salinity levels go up what happens is cunjie, octopus, sea-squirts, stuff that lives out in the ocean starts to move into the estuary. They compete with the oysters for food, they foul our oysters, they are just extra weeds in the garden. High salinity is not an immediate impact, it’s a slow process.

Oysters will continue to grow, but not grow as well as they should. A rain event helps flush this away, rain fills up the wetlands which start producing algae's and stuff that oysters love to eat. Oysters start growing like crazy, everything is just blooming like an aquatic garden. You interfere with those wetlands you're in trouble. They are critical for not only oysters but the health of the estuary. Wetlands are the starting point, all that food that is produced in there is vital for the aquatic organisms in the estuary. Some leases are positioned near the wetland areas when oysters are just starting out, and then the oysters are moved to an area nearer the ocean with more food variety. It's like taking them off the baby food and putting them on solids. We work out leases according to the size of the oyster to take advantage of what's available for the various stages of their growth. We can't pasture improve like a cattle farmer who moves his cattle to spring pasture, so we move the oysters according to the environment. Aesthetically, we are not the best looking industry going. I can go to farms and say oh he's got a huge investment there, look at the money he's spent, other people see something different they say 'we've gotta clean this up'. According to this farmer, this has posed a problem with developers on the coast wanting to clean up the oyster leases. Usually developments involve expensive houses with an expectation that they should have pristine water views.

The main issue for this farmer, like most of them, is water quality. The deadly QX disease (caused by a protozoan parasite) can be triggered by any deterioration in water quality.

We discussed the concept of pH. 'Our normal background level of pH in this area is 8.2, we're fairly alkaline. High loads of acid tip this out of the normal range. Some of the creeks around here can deposit a total of 40 tonne of acid a week, which has a major effect. As acid travels through the floodplain it dissolves heavy metals, it creates flocs (sediment particles with a very open structure) which enter the estuary water. We know that impacts happening here, are being caused miles away, coming through in those sediment loads which are carrying toxic materials. The oysters, they're pumping and filtering, they can't be selective, after they filter the material out they select what they want to eat. There is a naturally occurring algae growing on the estuary bed, this flowers at certain times of year, the algae float, oysters love them. What's happening is those flocs are settling on the algae, the algae's transporting aluminium and iron flocs, food for the oysters is made toxic from these suspended heavy metals. In its peak here we had oysters that were actually rusting, sediment building up on the outside of the oyster. Oysters were drawing their food through these rust crystals. There's not a lot you can do when things like this happen.'

The onus always seems to be on the oyster farmer to prove that oyster mortality is a consequence of human activity, whether it is detrimental dredging methods or potentially toxic runoff from agricultural enterprises.

A Macleay oyster farmer has been farming oysters in the Macleay Arm for twenty years. Here he talks about the effect of acid sulfate soils on his oyster production. 'I guess we didn't really become aware of just how bad it was until about five years ago, now whether that's because we've had dry times since then or whether its because there has been changes in practice up above the gates, we don't quite know why. All of a sudden we started to notice, especially on our little oysters, holes in the backs of them. In the first year I noticed these holes when we pulled all the trays out there were just masses of crabs on the trays and what have you. I put it down to the crabs punching holes in the oysters. And in the next year it happened there were no crabs and I thought that's a bit strange. We got on to a scientist down at the research station at Port Stephens and he came and had a look (in about 2000) he had done his thesis on acid sulfate soils. He said "Oh it's acid sulfate", but he couldn't do much for us other than identify what it was.'

'When the river goes fresh, we have to stop harvesting, he says, this happens from a heavy rain period further up the catchment which washes down into the estuary, a 'salinity drop' occurs. Rain in Armidale affects the estuary. There are also potential problems from point source pollution from septic systems in the Macleay which can overflow in peak periods. The difficulty is to be able to pinpoint where the faecal contamination might be coming from since the leases are situated some distance from the source.'

It is important to realize that the industry itself is heavily regulated by the NSW Shellfish Program and leases can be shut down if there is any perceived threat.

Indigenous Australians connection to the waterways

"The river systems of New South Wales have been a focus of life and central to the identity of many Aboriginal peoples for thousands of generations. Many person-hours are spent fishing by Aboriginal people along the river systems of NSW. For Aboriginal people fishing is much more than a 'recreational' activity. It is a family activity and provides an opportunity for older people to reveal places, knowledge and ideas to younger people. It is a time when young people can admire the skills, knowledge and wisdom of their elders.
Fishing places a person in a direct relationship with the environment, with the cultural practice of fishing mediating that relationship. This situation validates culture. It is a time when all the experience and knowledge and wisdom of the Aboriginal practitioner have value. It is a time when literacy is irrelevant. A time when the whole sweep of colonial history is irrelevant. In this way, fishing is a decolonised experience. Fishing produces highly valued food for the autonomous Aboriginal economy. The fish produced enable individuals to give, exchange and share within the kinship network or in accordance with other interpersonal obligations. It enhances a person's ability to fully participate in their social duties as an Aboriginal citizen. The sum of many such enhanced personal abilities aggregates to enhance the functioning of Aboriginal society. In this way fishing is a critical right for Aboriginal people. Aboriginal people have a duty to practice and defend this right' (Behrendt. et al. 2003)."

Marcia Langton has described the Aboriginal world view in relation to country in the following manner.
'In the Aboriginal world, there is an established body of laws that allocate rights and interests among particular people to water sources such as lakes, rivers springs. These laws derive from the sacred ancestral past that imbues the present, shaping and forming the world we inhabit with its distinctive features, and, notably, emplacing individual and group entities and polities in landscapes and waterscapes with jural - such as property - rights and responsibilities, according to religious principles. These property relations are then expressed metaphorically in the Aboriginal discourse of possession and stewardship symbolised in a variety of ways, ...

These Aboriginal waterscapes are construed not only as physical domains, but also as spiritual, social and jural spaces, according to the same fundamental principles as our affiliations to places in the landscapes. The dialogic relationship in indigenous thought between the ancestral past and its effect on human existence derives from the Aboriginal understanding of the transformative powers of the spiritual beings that inhabit those places. Their legacy to us is both the nature of our being and the nature of our relationship to place, be it a waterscape or a landscape' (Langton, 2002).

Aboriginal middens along the coast contain vast quantities of oyster shells carbon dated back to 6000 BC. Clybucca, in the Macleay, harbours one of the oldest and largest shell middens on the eastern sea board. The Aboriginal use of the estuaries and waterways of the mid-north coast is maintained traditionally by peoples of Aboriginal nations from the Gumbaynggirr, Dunghutti and Biripai. These nations extend from Port Macquarie to Coffs Harbour. A local indigenous person says the Aboriginal use of the estuaries for their food is alive and well today, however, the quality and abundance of certain food has declined significantly. Typical estuary foods include oysters, cockles, fish and cobra or guguur. Guguur is a type of woodworm that feeds inside timber. The guguur is used both as a traditional food source and for medicinal purposes. Ceremony ensures that the cobra continues to proliferate. In the past, water quality was surmised by intuition. European settlement and farming have impacted the water quality over time.
For a better understanding of the Aboriginal connection to the water, please refer to the paper by Behrendt that has been partially quoted above. There are a number of excellent papers that give a more in depth discussion of cultural use and stories from the traditional inhabitants of this coastline, check the resource section of this kit.

As non-indigenous Australians we are able to acknowledge indigenous places particularly when contemplating the development of land. For more information contact the Cultural Sites Officer at the Department of Environment and Climate Change, Parks and Wildlife division in Coffs Harbour.

Chapter 4
What is an impact?

Nature deals with the continuing flux of uncertainty mostly by processes of feedback and readjustment that seem to extend from the molecular to the global level (Lyle, 1999).
An 'environmental impact' in this resource kit refers to the positive or negative result of an action on the coast and estuarine environments and their resources. An 'impact' does not necessarily have to be detrimental, however, this chapter places an emphasis on the potentially negative effects that can result from natural events and human activity. Human pressure on natural environments increases dramatically with population growth, disrupting natural processes and degrading natural assets. Urbanisation is perhaps the most significant of all land use changes, dramatically altering the natural capacity of watersheds to absorb and attenuate flows and contaminants. The imprint of urbanisation is generally permanent and many of the related environmental impacts, including the contamination of oyster areas, are difficult to mitigate or reverse. The continued fragmentation of landscapes and habitat that has resulted from urbanisation, recreation, industrialisation and agriculture, has created an increased uniformity in landscapes and consequential reduction, disappearance, fragmentation or isolation of the natural landscape (Christy et al., 2004). Coastal urbanisation means that sensitive and dynamic estuarine ecosystems are continually readjusting to a variety of impacts, both natural and anthropogenic.
It's not what you do but how you do it. We've all heard this before, but its implications for our environment are critical in terms of whether our activities will have a positive or negative impact. One way to consider your actions on or near waterways is in terms of the environments natural limits. A river has natural controls, checks and balances keeping the system healthy, in other words it has a limited range of environmental conditions within which it can survive. Any impacts that breach this range of conditions will ultimately upset the balance of the system creating a detrimental outcome. This should dictate what we impose upon it. Certain size rivers should only carry certain size vessels, for example.
Pollution impacts can be prevented and mitigated using a variety of approaches and techniques, but there are practical limits to our ability and willingness to preserve coastal habitats and resources as development progresses. There is no replacement for sound land use planning and personal stewardship that recognize and preserve the inherent qualities of natural systems for buffering impacts and preserving clean water and healthy aquatic habitats (Christy et al., 2004).
Natural impacts (estuarine processes)
Natural phenomena such as tidal flushing and heavy rain events are critical for maintaining good water quality. Many of the estuarine processes like tides, wind-waves, ocean-waves and sediment movement will be impacting on the estuary continually. In the event of extreme weather like flooding or drought, these processes will be interrupted, changing the dynamics of the estuary. To be able to preserve our estuaries it helps to have some understanding of how these ecosystems work. Some of the main land and estuarine processes are discussed here in relation to oyster health.
Soil erosion and turbidity
While soil erosion is a natural process, the rate at which it occurs has been accelerated by land clearing, road construction, mining and other land use practices (HRC, 2000). Large volumes of material enter the waterways increasing nutrient levels and turbidity. Turbidity refers to the ability of water to transmit light. The more particulate or floating matter (suspended solids) within the water column, the less light is able to penetrate. This has major implications for the photosynthetic activity of aquatic plants because sunlight is needed for photosynthesis to occur, and if this is reduced a plant

will die off. High sediment loads are often equated with large catchment areas that have been cleared of native vegetation and support high urban development and or intensive agriculture.

Sediment plume, Nambucca River. © John Schmidt

How does it affect the oyster?

Water clarity is a major determinant of the condition and productivity of an aquatic system. Suspended sediment can smother oysters as well as promote the growth of pathogens and waterborne diseases, and lead to dissolved oxygen depletion in the water column if the sediment is comprised of organic matter. Even a thin film of silt can reduce oyster settling and it is well known that oyster clearance rates decrease once a critical concentration of total suspended matter has been reached. Oyster eggs and larvae are particularly sensitive to silt. Silt clogs sensitive feeding apparatus in larvae and can lead to infestations of mudworm which kill large numbers of oysters. In general, oysters feed more efficiently in reasonably clear water with some nutrients. When nutrient levels get too high, aquatic life can be starved of oxygen in a process called eutrophication (see eutrophication).

An oyster farmer scraping sediment off spat collecting tube. © John Schmidt

What causes soil erosion and turbidity

Turbidity is created in part from fine sediment travelling from building sites, gully and streambank erosion. Storm-water runoff carrying a high sediment load into estuaries is one of the deleterious impacts that is characteristic of urbanisation and cultivation of landscapes. Natural land cover is turned into impervious surfaces, this means that water runs off hard non-absorbing ground surfaces. Impervious cover is the most widely researched landscape indicator for gauging the effects of development on aquatic ecosystems. Impervious cover degrades aquatic habitats of all kinds, including shellfish growing areas, and the degradation increases as development intensifies. Actions that protect natural hydrologic functions and that promote connectivity can help mitigate development impacts (Christy, 2004).

One of the most potentially damaging activities to estuarine health, directly or indirectly, is development or building of any kind. You could potentially contribute to the sediment load in your local waterways without realising it. The loss of sediment that can move from the building site to the waterways can be quite significant. Shire councils will require you to have a sediment/erosion control plan in place before commencing works. Another consideration is the soil landscape of a development. Certain types of soils may have qualities and limitations that make them unsuitable for septic waste-water systems, in particular sodic and dispersive soils. These are often highly erodible and have low wet bearing strengths. They require careful management. ‘The transport of pathogenic viruses from land into waterways varies with the soil type into which the effluent is discharged. Fine soils are prone to movement during rain, and carry associated viruses’ (Schaub & Oshiro, 2000). Highly dispersive soils stay in suspension and require additional management and design considerations during construction. Ensuring that there is adequate storage capacity and systems in place to settle out the fine material before it is discharge into waterways, is paramount. Another potentially damaging activity is burning off. Fire can reduce ground cover creating soil erosion. The Resource Kit for Rural Landholders deals with fire management. Options for minimising sediment load are discussed in Chapter 6.

The pH story

Oysters will spawn in the pH range 6 to 10. Outside that range, oyster eggs and sperm lose their viability within a few hours. The optimal pH range for oysters appears to be between 6.75 to 8.75 (Shumway, 1996) with growth rates rapidly declining at either side of this range. The pH of estuaries is of major concern to oyster growers because of the drainage of acid waters from large areas of acid sulfate soils in coastal floodplains of the state (Sammut et al., 1996; White, 1997; Wilson et al., 1999). The pH of the estuary is therefore closely tied to acid discharge into estuaries in high rainfall events. The acidic discharge tips the alkaline balance. Holes appear in the oyster shell due to shell dissolution and eventually the oyster dies. Farmers locally have noted large volumes of iron oxyhydroxide flocs that are produced and transported with the acid discharge.

What are acid sulfate soils?
Acid sulfate soils (ASS) are soils that contain iron sulfides. They were formed in low-lying coastal floodplains over the past 10,000 years as the sea level rose. When acid sulfate soils are exposed to air, they oxidise forming sulphuric acid. If the soils are buried or waterlogged they are known as potential acid sulfate soils (PASS). There are maps available of all the ASS and PASS areas along the NSW Coast. These risk maps are available from the Department of Environment and Climate Change, Natural Resources Division.

Acid plume. © Glenn Atkinson

What is their impact?
Acid sulfate soils, when exposed, can produce acid for well over 100 years. Water moving through an acid soil strips the soil of iron and aluminium and dissolves heavy metals such as cadmium. The iron flocculates out of acid water when it reaches less acid water producing iron oxide (red) scums. The acidification of waterways disturbs many natural ecological processes by interfering with normal chemical reactions and reacting with organisms such as fish and oysters. Water affected by ASS can drop from a pH of 7.8 down to 2.4. The pH of your local waterways can be simply tested with a pH strip that can be purchased from any pool supply or hardware store.
Acidity, and especially sudden (after rainfall) changes in acidity, is stressful to fish and may result in a fish kill. Plants and other organisms in the food chain (e.g. small crustaceans and plankton) can die from exposure to acid runoff. Oysters are particularly vulnerable to acid sulfate runoff as they are sedentary beings.
The best way of reducing the impact of ASS is to stop PASS from being exposed to the air. The ASS/PASS maps produced by the Department of Environment and Climate Change are useful for identifying which areas are most likely to be ASS. These maps are a guide to deciding which areas are best left undisturbed and waterlogged. ASS are dark grey in colour, very wet and have a sulphuric odour. Exposed or drained ASS unfortunately are common in the Nambucca, Macleay and Hastings. Land which has been reclaimed by flood mitigation works, drained for farming and urban development are all prime contenders for ASS. Farmland that has been exposed can be re-flooded with the consent of the landholder and will form extremely productive pastures. Reforming drains, so they are wide and shallow rather than deep and narrow, avoids exposing ASS (Dixon, 1999). The Yerbury's property featured in Chapter 6 is an example of this approach.
Salinity
The presence of soluble salts, that is salinity, is essential to coastal waterways. As an ecological parameter, salinity gives many aquatic organisms the ability to regulate their internal ion concentration. Salinity is an important control in certain types of pathogenic organism and invasive species. Most aquatic organisms function optimally within a specific range of salinity. Estuaries are saline by nature but loss of water due to drought or poor flushing can result in hypersaline conditions, where the saline content is higher than the ocean water. Dissolved oxygen falls as water temperature and salinity increase. Measures of dissolved oxygen refer to the amount of oxygen contained in water. Many processes, like photosynthesis require a certain amount of dissolved oxygen.
Salinity regimes
The salinity regime of estuaries is directly affected by the influx of freshwater supplied by rivers and marine water supplied by the ocean. Salinity levels fluctuate with the penetration of tidal flows, and with mixing of freshwater and marine water by wind and currents. Freshwater discharges to Australia's coastal waterways are mainly episodic, and are primarily controlled by conditions in the catchment including rainfall patterns, vegetation type and cover, topography, catchment area and geology. Entrance size of the river mouth and sea level dictate marine water exchange, and the extent to which salinity can build up within the coastal waterway due to evaporation during times of low river flow (http://www.ozestuaries.org, 2006).
Climate change

Human activity, particularly the burning of fossil fuels, has made the blanket of greenhouse gases around the earth "thicker." The resulting increase in global temperatures is changing the complex web of systems that allow life to thrive on earth, such as cloud cover, rainfall, wind patterns, ocean currents, and the distribution of plant and animal species. More of the sun's energy is being trapped in the atmosphere, and much more of the world's carbon (in the form of carbon dioxide) is resting in the air rather than in trees, soil, and subterranean deposits.
Some consequences of global warming are already apparent. The complexity of the climate system means predictions vary widely, but even the minimum changes forecast could mean frequently flooded coastlines, disruptions to food and water supplies, and the extinction of many species (UNFCC Climate Change Science at http://unfccc.int/essential_background/feeling_the_heat/items/2902.php).
The future climate of the Northern Rivers catchment is likely to be warmer and drier. Changes in rainfall and higher evaporation rates are likely to lead to less water for streams and rivers in the Northern Rivers catchment, which will have downstream consequences for storages and place strains on the catchment's water resources. However, given increases in extreme rainfall events that periodically deliver large volumes to storages, the effects of long-term reductions in average rainfall on storages may be moderate (CSIRO, 2006).
Drought and flood
Drought can be catastrophic for most biological systems and nowhere is this more apparent than in the estuary. Generally, low levels of water mean there is less flushing with freshwater. Salinity increases and there is often an invasion of marine disease organism in the oyster leases. Rain events can increase the risk of sewage spills or seepage associated with reticulation systems, particularly in times of heavy use like during peak holiday periods in a caravan park. These climatic conditions will be exacerbated if current climate change predictions transpire. Estuaries will potentially take longer to recover if at all after drought events.
Water movement
Water moves along an estuary under the influence of two primary forcing mechanisms, freshwater inflows draining out to sea and the regular tidal movement of seawater into and out of the estuary. In addition, tidal and salinity behaviour within the estuary generate a number of secondary currents, which while of low velocity, are of considerable significance with respect to mixing (see mixing) and sediment transport. Nutrient and pollutants are dispersed by both tidal and freshwater inflows and the relative importance of these dispersive processes will change in relation to the level of freshwater flow.
Deposition and sediment movement
Different types of sediment are supplied to an estuary by a variety of sources; in general, natural riverbank erosion and general catchment runoff produce large quantities of sand, silt and clay. Wind action on dunes and intertidal sandbanks can also carry fine sand into the estuary. However the majority of sand in the lower reaches of estuaries in NSW comes generally from infilling with marine sand gained from the beach system. The waves and currents mobilise and carry the sediment into the entrance from where there is a general net upstream transport of sand into the lower estuary. It is generally well accepted for northern NSW (north of Seal Rocks) that there is a net northward littoral drift of sand with transport rates of approximately 500,000 cubic metres per year (Carley et al. 2005).
The Nambucca River estuary is an example of a wave dominated inter-barrier estuary that typically has a tidal inlet constricted by wave deposited beach sand (WBM 2006) and whose lower estuary is characterised by continually shifting sands and shoals formed by currents interacting between tidal forces, fluvial flow and littoral processes of adjacent beaches. Any efforts to manage shoaling, via dredging, within the lower estuary must acknowledge these macro coastal processes and interactions (Schmidt, pers. comm., 2007).
Mixing
Mixing refers to the intermingling of parcels of water as they are moved along the estuary under the influence of freshwater flows, tidal flows and secondary currents. Mixing, not only involves an exchange of water mass, but also of any substance dissolved in it, such as salinity, dissolved

pollutants, etc. Hence, mixing processes are critical to the distribution of salinity and water quality levels throughout the estuary.

Eutrophication

Eutrophication occurs naturally in a water body as it receives inputs of nutrients, mostly nitrates and phosphates from erosion and runoff from surrounding lands. An overload of nutrients into the water can increase the incidences of harmful algal blooms, shellfish contamination and dissolved oxygen depletion which can cause fish kills.

Pests and weeds

Stormwater enables weeds to spread, some of which literally choke waterways or displace native flora. Alligator weed is one example of an aquatic weed that behaves this way. Similarly Bitou Bush from South Africa, has invaded coastal habitats, forming thickets on sand dunes that smother native plants. For more on weeds visit the Weeds Australia website http://www.weeds.org.au/natsig.htm.

Invasive marine pests degrade the environment and cost millions of dollars in damage to shipping and maritime infrastructure and losses to aquaculture. Early recognition of pests, like the Black-striped Mussel and the Pacific Oyster is critical. You can report the location of pests by phoning the NSW DPI on 4916 3877. More details about these marine pests and others can be found on CSIRO's National Introduced Marine Pests website at http://www.marine.csiro.au/crimp/nimpis or visit the NSW DPI website listed in the resources section.

Not to be confused with this issue is the explosion of red macroalgae blooms (red weed) and Sea Hares that can occur at certain times of the year on the mid-north coast beaches. Kempsey Shire Council has been closely monitoring these mass stranding events and they have produced an excellent fact sheet. Visit

http://www.kempsey.nsw.gov.au/pdfs07/red_weed_sea_hares.pdf (2007).

Human impacts

Everyone who lives in the estuarine area will place a degree of stress on the aquatic environment. Being mindful of how we go about our tasks and leisure pursuits is imperative if we want to continue to enjoy and use these unique areas. Every time humans interrupt the natural water cycle there will be an effect. Our impact on water pathways occurs in two main ways, withdrawing and discharging. We extract water out of the system to irrigate crops, provide water for our daily lives and for industry. When it rains, the water falling on the ground gushes into roadside kerbs, gullys, and rivers picking up all kinds of pollutants. These may constitute agricultural pesticides, herbicides and fertilisers, waste from faulty septic systems, loose soil from building sites and in urban areas, the mix can include petrol, oil, and animal waste. What follows is a description of some of the ways humans impact on estuaries as outlined on the Australian Government Natural Resources website. As you read, consider how the natural estuarine processes will be affected.

Faecal contamination

Faecal contamination poses a risk for humans and animals within an estuary. One of the more common reasons an oyster lease is closed is due to high levels of recorded bacteria. Most waterborne pathogens originate in human and animal faeces and include a wide variety of viruses, bacteria, and protozoa (Rose et al. 1999 in Christy, 2004). The transmittal of viral disease is a key health concern associated with the consumption of shellfish. Sanitation surveys conducted by the NSW Shellfish Program suggest that storm-water runoff, failure of local septic sewage systems, sewage reticulation system malfunctions, sewage treatment plant outfall and possibly pollution from passing vessels are all potential causes of contamination in the mid-north coast estuaries.

Other Water Pollution

It is an offence for any person to pollute waters. Pollution includes introducing anything (litter, wash water, soil, debris, detergent, paint, cement slurry, building materials, etc.) into water.

Some of the most critical types of water pollution include heavy metals, biotoxins, organic contaminants and sewage. In the Nambucca, for example, the potential pollution risks to the estuary tend to be dominated by discharge from reticulated sewage systems, septic sewage systems and runoff from intensive and extensive agriculture, all of which are substantially exacerbated under conditions of heavy rainfall.

Acid drainage from ASS can contain dissolved heavy metals, leached from minerals in the soil. Although there is no documented evidence of bioaccumulation of heavy metals in oysters grown locally, heavy metal contamination has occurred as a by-product of acid discharge, the black ooze. Monosulfidic black ooze (MBO) refers to sulfur and iron enriched organic sediments that commonly form in drainage channels in acid sulfate soil (ASS) landscapes. These sediments are highly mobile and easily incorporated into the water column during floods, where they can rapidly deoxygenate and acidify water (ASSAY, 2004).

Black Water at Gumma Gumma, Nambucca River . © John Schmidt

River impoundments

The construction of dams and management of water resources to meet town water supply, irrigation, riparian, environmental and other demands has influenced the magnitude and variability of freshwater inflows to estuaries. Dams and weirs have varying effects on downstream estuarine ecosystems, depending on the size and location of the structures and the uses made of the impounded water. Impacts include sediment and nutrient inputs; altering freshwater flow and flooding pattern; water quality, and barriers to fish migration. Impoundments generally trap a high proportion of bed load and suspended sediments.

Floodgates as a barrier to fish. © Scott Johnson

Whilst input of nutrients is important in maintaining estuarine productivity, excessive nutrients may lead to eutrophication. Nutrients are affected by impoundments in different ways, depending on whether they are in the form of organic detritus, bound to sediment particles or dissolved in the water. The reduction in freshwater flow depends on how much of the catchment is impounded, the storage capacity, and what proportion is diverted to off-stream uses. Reduced freshwater flow affects the hydrology of an estuary, and allows greater penetration of saline water. Impoundments tend to restrict both the size and frequency of floods. Flooding is important to many freshwater wetlands, and is a stimulus to the breeding and migration of many fish species inhabiting coastal rivers and estuaries (Harris, 1984). Larger floods also flush accumulated sediments out of estuaries. Larger impoundments can cause significant water quality changes in their own right, such as lowered temperature and oxygen levels, together with related changes in chemical balances. Toxic substances such as hydrogen sulphide may also be generated. As well as affecting the physiology of aquatic organisms, temperature and chemical changes can also affect breeding and migration behaviour (Harris, 1984). Many fish species use both estuarine and freshwater habitats. Weirs may be barriers to migration, although species differ in their abilities to swim, leap or even climb over barriers. Some low weirs may be passable to most fish when the river is in flood. A large number of NSW coastal rivers have weirs built around the tidal limit to limit saline intrusion. These are potential barriers to estuarine organisms which require access to fresh water for part of their life cycle (Harris, 1984). Drinkwater & Frank (1988) claim that ‘a decline in some coastal fisheries with an overall impact on the biota is generally associated with reductions in freshwater inflow.’

Groundwater use

Groundwater is an important, but hidden, component of the water balance of an estuary. Groundwater reserves can exist in both wind and water deposited sediments, i.e. in wind-built sand dunes and in sand and gravel beds deposited by freshwater and the action of coastal waters. Groundwater can be an essential source of water in the coastal environment: freshwater lakes and streams surrounding an estuary are often sustained by natural groundwater discharges from beach and dune sands. Some coastal rainforests and wetlands are dependent on groundwater, especially during drought periods. A number of coastal towns in NSW are supplied with groundwater from estuarine areas. Stuarts Point and South West Rocks draw water from wind deposited (aeolian) sandbeds; Bellinger and Nambucca draw water from water deposited (fluviatile) sandbeds just above

the tidal limit. The integrity and quality of the groundwater resources of an estuary can be compromised in a number of ways. Over pumping can lead to the intrusion of saltwater into the aquifer; high-rise residential buildings and tourist complexes may require permanent de-watering of the water table to enable construction of basement carparks; sewage effluent from septic tanks and seepage from landfill sites can contaminate aquifers; mineral sand-mining and extractive industries, including irrigation, can also influence the recharge behaviour and quality of groundwater reserves.

Fishing

Commercial fishing occurs in the Nambucca and Macleay estuaries. Methods of fishing include netting for prawns and fish as well as line fishing, fish and crab trapping. Recreational fishing is a popular pass time in the Macleay, Nambucca and Hastings with more than 74,000 anglers living on the mid-north coast and many more visiting the area during holiday periods (NSW Fisheries, 2002). There are a number of guidelines published on fishing responsibly, whether it be from a boat or on land. Over-fishing and habitat degradation adversely affect fish stocks. Fishing hooks and bait packaging are frequently left in waterways. Plastic bags are mistakenly swallowed by some marine animals suffocating them and fish hooks imbed into the beaks and bodies of marine birds and animals.

Agriculture and grazing

Changes to estuarine draining catchments by clearing, burning, cropping and grazing all increase the rate of sediment production and the amount of sediment transported into estuaries. These activities also alter habitats to the detriment of both aquatic and terrestrial wildlife.

The clearing of riverbank areas commonly causes banks to erode. Clearing also affects the hydrological balance of catchments: the frequency and severity of flooding increases; the distribution and duration of surface runoff across the catchment is altered; and changes to the groundwater table may occur.

Burning can lead to highly increased nutrient levels in surface runoff, which may result in eutrophication and possible oxygen depletion in receiving waters.

Cropping increases sediment runoff because ploughing and tilling operations both destabilise the upper soil mass and expose it to the elements. Agricultural runoff, apart from sediment load, can also contain high levels of toxic materials (pesticides and herbicides) and nutrients.

Grazing causes a progressive loss of tree cover because seedlings are eaten by stock. Other detrimental effects include trampling of flora, the compaction of soils, increased nutrient levels in runoff (from faecal matter) and the destabilisation of river banks (unless these areas are fenced off) causing erosion and sediment input.

Another adverse effect of agriculture is the exposure to the atmosphere of acid sulfate soils, which are common along the lower floodplains of the Hastings and Macleay. Leachate from these soils can be strongly acidic and contain high concentrations of aluminium (leached from clay soils). This runoff can severely affect estuarine water quality for short periods of time (if the runoff drains to an estuary) see ‘What are acid sulfate soils?’ for more information.

Forestry

Unless they are well managed, forestry operations adjacent to estuaries or in upstream catchment areas have the potential to cause significant soil erosion, with consequent increases in turbidity and sedimentation within an estuary. Forestry activities can also result in the loss of scenic amenity around an estuary. While forest roads can provide access for recreational activities, they can also act as wildlife barriers, preventing or inhibiting the movement of certain native animals in estuarine catchments, and exacerbate the spread of exotic animals and plants.

Recreational and commercial boating

The estuarine waterways of the mid-north coast are used extensively for recreational and commercial boating. Recreational uses include fishing, sailing, rowing, canoing, sailboarding and water-skiing. Commercial uses include various forms of commercial fishing, charter-vessel cruises and vessel hire. Boating brings considerable recreational and commercial benefit, not only to the users themselves, but to the wider community.

Normally waterways are freely used for all forms of boating, but in limited situations, the NSW Maritime Authority can apply restrictions on the type of boating allowed. Conflicts of use can occur

between different types of boats and between boating users and the local community. Such conflicts are best managed by the NSW Maritime Authority through the 'Boating Users Groups' which exist for all major waterways.
Some adverse effects of boating include pollution by unburnt exhaust gases from power boats, fuel spills and litter; disturbance to fish stocks; bank erosion, bank undercutting and increased turbidity levels caused by power-boat wash; and damage to seagrass beds caused by propellers, anchors and digging for bait. As a boat user, you are in a position to make a valuable contribution to positive environmental practices. You can contact the Waterways Authority on 131256 or visit http://www.bia.org.au/environment/boat-users.html for more on the Boating Industry Association and user groups.

Wake up? Slow Down: True or False? Some facts many people get wrong
1. Boat wake can't cause any more damage then wind-driven waves.
YES IT CAN
Wind driven waves tend to travel along the length of the waterway and directly approach the shore only at bends in the channel. But boat wake may travel almost directly towards the bank and can cause erosion along the entire length of the waterway.
2. Most 'tinnies' are small and light enough not to cause any wake problems. NO THEY'RE NOT.
Speed is just as important as size, and both factors must be considered together. For their size, most outboard powered boats can travel much faster than almost anything else on the water.
3. On the plane, the smaller wake causes less damage. NO IT DOESN'T.
Even though a wake reduces in height as the boat planes, the waves are moving faster, further and travelling outwards from the vessel track. When a planing vessel travels parallel to a sheltered shore, the wave energy is directed towards that shore.
4. You can see what your wake's doing from the boat. NO, YOU CAN'T.
Even if you're fairly close to the bank (say 50 metres away) the peak wake impact of a boat traveling at 20 knots only occurs as the first 5-10 waves hit. By that time, you're half a minute and 300 metres away. The only way to really observe the impact of wake is to stand on a soft shore and watch the impact of wake in all three phases of boat speed. Every boat driver should do this sometime- you may be surprised at what you see (DPI, TAS).

Extractive industries
The extraction of sand, gravel or other materials from an upstream catchment area or from the floodplains or bed and banks of an estuary can have a number of adverse impacts on the estuarine environment. Extractive industries located around the fringes or within the waterbody of an estuary can cause major damage to estuarine habitats. The tailings associated with sand and gravel extraction, whether windblown from land or discharged back to the estuary, may smother seagrass beds. Sand and gravel mining alter the cross-sectional area and storage characteristics of affected reaches of the estuary. This results in changes to the hydrodynamic, salinity and sediment transport processes of the estuary. In turn, these changes can lead to habitat degradation and bank erosion. Other possible adverse effects of sand and gravel extraction include the release of nutrients and changes to water levels. Extractive industries have wrought much damage and destruction to estuarine habitats in the past. These days, such industries require planning approval under the Environmental Protection and Assessment Act, 1979. This procedure is aimed at limiting detrimental effects to acceptable levels.
Reclamation and dredging
Reclamation is the most damaging activity associated with the development of estuarine foreshores. More often than not, mangrove and seagrass areas, which are amongst the most productive and most important habitats of an estuary are destroyed or severely degraded. The existing foreshore is buried; intertidal areas may be smothered by fill operations, or destroyed if used as a source of fill. Reclamation of intertidal areas reduces the tidal prism (a volume of water exchanged between an estuary or a lagoon and the open sea during one tidal period), significantly at times. This in turn may alter the salinity regime and exacerbate water quality problems through reduced flushing.
Dredging can have a number of adverse effects on an estuary. Seagrass beds may be destroyed by mining the underlying sediment or degraded by increased levels of turbidity and sedimentation. Any deep holes and channels created by dredging can become stagnant or may adversely affect current patterns and can trigger bank instabilities nearby. Offshore dredging and sand-mining near the mouth of an estuary can significantly affect tidal hydraulics and the movement of water and sediment into and out of the estuary. Of special concern is the reclamation and dredging of acid sulfate soils, which can generate acid runoff containing high levels of aluminium.
Training walls

Training walls are commonly used to stabilise an estuary entrance or to confirm the location of a main channel. Whilst training walls improve the navigability of an estuary, they may have a number of adverse effects on estuarine habitats and ecosystems. If training walls are constructed along foreshores, there is a loss of foreshore habitat and the disturbance and probable loss of intertidal habitat. Training walls may significantly alter the ebb and flood current patterns within an estuary. This may lead to certain backwater areas being poorly flushed. Altered current patterns may cause fish larvae to settle in inhospitable areas. Notwithstanding these adverse effects, training walls can increase the overall flushing of the estuary by promoting increased flows through deep channels and also provide rock substrate habitat.

Aquaculture

Oyster farming, with the oysters raised on racks in shallow estuarine waters, can have a number of adverse effects on the estuarine environment. First, oyster leases are 'out of bounds' to other waterway users (boaters, fishermen, etc.). Second, if oyster racks are poorly aligned to the prevailing currents, the flushing of lease areas is restricted. Realignment of oyster racks in sympathy with ebb and flood-tide currents promotes both the flushing of lease areas and oyster growth.

One potential advantage of aquaculture is that the adverse effects of this form of fishing are much more controllable, because of their concentrated nature and close proximity to land, compared to 'open water' fishing. The shifting of fishing operations from the water to the land may allow more stringent fishing controls to be imposed in the estuary itself, and thereby hasten its recovery, whilst preserving the commercial 'catch'.

Waterfront developments

Waterfront land is a valuable commodity. Past demand for waterfront land has led to the piecemeal reclamation of extensive foreshore areas. In turn, this has led to the destruction of natural foreshore and intertidal habitats, and has resulted in restricted public access to foreshores. In addition, significant pollution of estuarine waters has occurred from sullage, other domestic wastes and urban runoff from waterfront developments. Waterside caravan parks with septic tank and absorption trench facilities are also common sources of pollution.

Waterfront developments can have a detrimental effect on wader populations: important habitat areas may be lost or reduced; nesting birds may be disturbed.

Well-designed and sympathetic waterfront developments can increase public access to estuarine foreshores and enhance both passive and active recreational amenity.

Canal estates

Two common and often major adverse impacts of canal estates on an estuary are the initial destruction of estuarine habitat, often wetlands or saltmarsh, and the subsequent continuing pollution and disturbance of estuarine waters by urban runoff, boating activities, etc. Canal estates, like waterfront developments in general, may have adverse effects on wader populations (loss of habitat, disturbance of nesting birds).

Conversely, well-designed and constructed canal estates can facilitate the flushing of nearby estuarine areas because of the greater tidal prism associated with the canal development.

Canal estates are generally constructed on low-lying land adjacent to estuaries. Material from canal areas is excavated and used as fill to raise the residual land area. In the past, the dimensions and layout of canals were governed largely by commercial dictates: the need to maximise the number of waterfront blocks and the need to obtain sufficient fill to raise blocks above flood level.

These days, it is recognised that canal dimensions and layout should be governed by the following considerations: retention of wetlands; minimisation of adverse effects on the adjacent estuary, including sedimentation and pollution; adequate tidal flushing of canals; and provision of public access to foreshores.

The construction of canals in acid sulfate soils is of concern because of the high acidity and elevated aluminium levels in runoff from such areas.

Not to mention that most development includes tar seal roads, curb and gutters creating impervious surfaces which aids in the increase and velocity of runoff.

Marinas and recreational facilities

Estuaries are popular areas for active recreational pursuits, such as swimming, boating, water skiing and fishing. These activities require various shore based facilities, such as marinas, boat ramps and car parks. Often, these structures are built along the foreshore at the expense of mangroves and the natural fringing vegetation. In addition, dredging is sometimes required to improve boat access to marinas.

Marinas and recreational facilities can disturb the roosts and beach nesting areas of wader populations as well as damage feeding areas, and potentially reduce food availability through the collection of bait and delicacies such as oysters.

Marinas and recreational facilities provide a focus for boating and recreational activities. As such, they are a valuable management tool that can be used to shepherd these activities into appropriate areas of the estuary. By providing a focus for these activities they also facilitate the control of any resulting pollution, e.g. litter, fuel spills.

Road and bridge construction

Roads and bridges across estuaries can have a number of adverse effects on estuarine habitats and ecosystems. Causeways across an estuary can severely restrict tidal flows and reduce the tidal prism. This in turn can lead to increased rates of siltation and deterioration in water quality, with consequent degradation of seagrass beds and other habitats around the obstruction.

From an economic point of view, long causeways with limited waterway openings are desirable. However, the smaller the waterway opening, the greater the loss of tidal prism and the greater the adverse effects described above. In addition, limited or unsuitable waterway openings may restrict the passage of fish past the structure.

Road construction along and across estuaries often involves wetland reclamation with dredge spoil and the destruction of foreshore vegetation. These activities result in the loss of foreshore, wetland, tidal and possibly intertidal habitat.

The long-term adverse consequences of road and bridge construction can be dramatic. The reduced fluctuation in tidal water levels and velocities, together with highly reduced salinity levels, can lead to a progressive, but ultimately marked change to upstream habitat areas, including the loss of mangroves and the smothering of any upstream seagrass beds.

Again, careful and sensitive design that recognises the interactions between the various estuary processes can minimise these adverse effects.

Flood mitigation works

Killick Creek , Back Swamp. © Kempsey Council archives

In the past, a variety of flood mitigation works were constructed along estuaries to protect agricultural and urban areas from freshwater and coastal flooding. The Macleay is an example of this. Such works included levees, drains and floodgates, together with the clearing and lining of stream channels to facilitate the passage of flood-waters.

Creek, river and channel improvements aimed at facilitating the flow of flood-waters, quite apart from destroying habitat, can lead to erosion problems and downstream siltation.

Perhaps the most critical effect of flood mitigation works is the loss of wetland areas. In the past, many agricultural areas on floodplains were won by draining wetlands and restricting saltwater inflows to tidal creeks. In addition, levee banks were constructed to exclude floodwaters. All of these activities resulted in the loss of wetland areas or in markedly altered wetland regimes because of reduced replenishment by floodwaters. In addition, the loss of tidal storage led to a reduction in tidal prism with its accompanying detrimental effects of increased siltation and exacerbation of water quality problems.

The construction of tidal barriers, such as weirs and floodgates, eventually converts upstream reaches from a brackish to a freshwater environment. In addition, these barriers impede or prevent the movement of fish and prawns and can lead to prolific weed growth upstream of the barriers. This weed growth is caused by nutrient build up in the largely stagnant waters upstream of the barrier.

Some floodgates are designed to store flood-waters for release after main channel water flood levels have fallen. Although such gates can be left open to allow tidal flushing in non-flood times, this is

generally not done. Gates tend to be kept permanently closed and are only opened when a release of water is to be made. Any residual water trapped in upstream flood channels tends to become stagnant and polluted by organic matter, with accompanying low levels of dissolved oxygen.
Such releases consist of a concentrated slug of poor quality water that persists for a short period of time before being diluted by the receiving waters. Nevertheless, in a number of cases, such releases have caused disease and death to downstream fish and other aquatic organisms.
These days, the potential adverse impacts of flood mitigation works are clearly recognised. It is unlikely that new areas of biologically significant wetlands will be drained for agricultural or other purposes. The appropriate design of new works can preserve existing wetland areas whilst providing flood protection. Where possible, the sympathetic operation of existing works can reduce their detrimental effects. For assistance in restoring or protecting your floodplain property, contact your local council and/or the Landcare office.

Pest control

Mosquitoes, sandflies and other insects are an irritation to humans. At times they can pose a health hazard, e.g. Ross River Fever, which is caused by an arbovirus carried by mosquitoes whose numbers can increase to epidemic proportions in stagnant accumulations of brackish water.
Insects breed in the wetland areas, saltmarshes and tidal fringes of an estuary and are an important component of a healthy and balanced estuarine ecosystem. Often there is pressure on the local council to eliminate or reduce insect nuisance by filling or draining breeding areas or by use of pesticides. All of these activities have adverse effects on the estuarine environment. Some pesticides can decimate estuarine organisms.
The management of insect populations in important or sensitive estuarine areas such as wetlands and saltmarshes should be a compromise between the expectations of the community and the requirements of the ecosystem. Healthy wetlands can actually reduce or keep mosquito populations in check. For further information visit the Wetland Care website at http://www.wetlandcare.com.au.

An oyster farmer relates this story: 'some residents in a new housing development near the coast, were complaining about the lack of fish due to the professional fisherman catching the fish. But these people were possibly having a bigger impact on the river than the professional fishermen, they were spraying their lawns for army worms. New development, with lush green grass and lots of rain saw a proliferation of army worms in their lawns. The whole street decided to spray for these worms in a brief moment of no rain. Trying to beat the rain their comment was 'well it's only going to be on there for an hour so before it rains and it will kill the army grubs'. They got the result they were after, but all that chemical goes down the drain which runs into a lake. They can't see it so they don't realize what is being washed off. Councils are busy installing storm water drains and gross pollutant traps and that's great because it gets rid of visual pollution but so much of what is toxic is not obvious to the community. Some sub-divisions have all the storm-water drains running into a wetland, so runoff is filtered before it hits the estuary. These are the kinds of things sub-divisions should be looking at. Nature will do a better job than we ever can.'

Caring for the coast

The beach and coastal dune system is also connected to the health of the estuarine environment. They supply the sand that is the basis for unique dune plant and animal communities. The coastal dunes are a buffer for wave attack on the land inward. They too require protection. Many are highly degraded due to residential development, grazing, mining, weeds and recreational activities. This has resulted in increased sand drift inland and decreased coastal sediment budget needed to replenish frontal dunes after waves have eroded them away. You can help protect these areas by sticking to designated beach tracks and parking areas as well as staying off dune vegetation. There are a variety of excellent organizations and information on protecting the beach and its ecology. There are plenty of ways to take an active role in caring and restoring beach systems if you live or holiday near the beach. Local councils, coast and estuary committees, Coastcare, World Wide Fund for Nature, Australian Seabird Rescue, OceanWatch and the Surfrider Foundation are just a few of the entities that can assist the community with protecting these unique areas and the habitats within, remember a habitat is a home.

Middle Head Beach in the Macleay. © Natasha English

Chapter 5

The importance of native vegetation

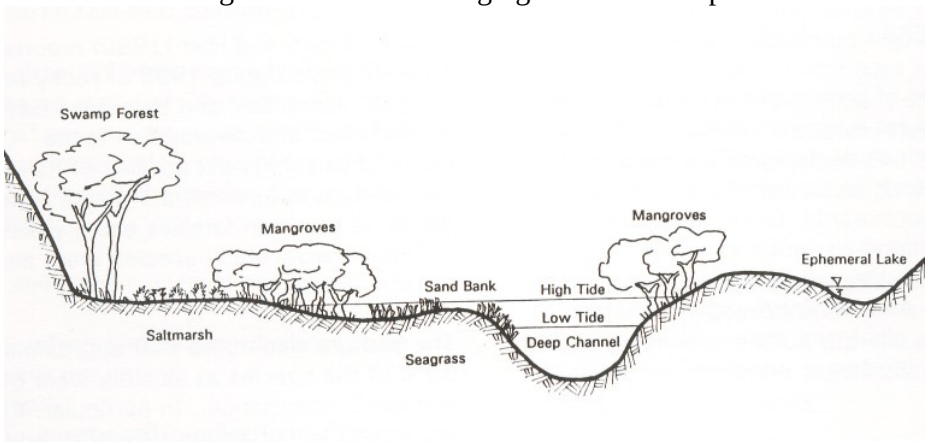
The vegetation communities of the three catchments

The entire coastline and inner areas of the Nambucca, Macleay and Hastings have been cleared extensively since early settlement. To gain an understanding of the changes in vegetation that have occurred, there are a number of descriptions by the surveyor Clement Hodgkinson of how the north coast rivers looked in the 1800s. It puts into context why restoring and protecting the vegetation that is left is so important for the health of the catchments.

The different types of vegetation communities which grow in the mid-north coast range from a variety of rainforests, wet sclerophyll forest, dry sclerophyll forest, grassy woodlands, heathland, swamp sclerophyll forest, wetlands, estuarine and grasslands. A good description of the types of native vegetation can be found in the Resource Kit for Rural Landholders. Native vegetation in estuarine environments is critical to bank stability considering the constant wind and wave action that washes against the banks. It also provides habitat for fish by providing structures and shading the water. Where banks have little or no vegetation the rate of erosion is accelerated, especially during floods. There is often a perception that if riparian areas are fenced off it automatically contributes to a profit loss because the land can't be used. However, if left unfenced the impact from stock can eventually lead to a greater loss as land slumps and washes into the estuary. There are many examples of landholders altering land management practices that benefit river health and increase farm profitability (increased production and/or reduced costs). Measures have included rotational grazing, stock exclusion from riparian zones for a period of time, which can result in increased pasture growth, increased dominance of perennial species, reduced weeds, reduced erosion and runoff and increased stock carrying capacity (Douglas, 2002).

Habitats of the estuary

What follows is a description of some of the critical estuary habitats, found here on the mid-north coast. These habitats are important because they help maintain the health of the estuary. Many coastal properties contain these ecosystems and it is important that they are protected from stock by fencing and periodic weed control as the existence of some of these habitats is already threatened, for example littoral rainforest and seagrass beds. The Northern Rivers Catchment Management Authority, DPI Fisheries, Wetland Care Australia and Landcare, can all provide advice and sometimes funding assistance for managing these areas as part of a sustainable farming enterprise.



Estuarine habitats. © NSW Government, Estuary Management Manual (1992)

Mangroves

Mangroves grow along the shores of the Nambucca, Macleay and Hastings estuaries, and in some places form extensive forests. All mangroves are land-plants which have adapted to the harsh environment at the terrestrial-marine interface. In such circumstances, the species had to overcome an unstable and low oxygen environment, cope with potentially toxic levels of dissolved sodium (either by excluding its uptake or by developing mechanisms to secrete it efficiently). Mangroves play an important role in estuarine ecology. They provide organic matter to estuaries through the decomposition of leaf litter. They provide habitat for fish, birds, molluscs, crustacea, butterflies and other insects, and worms. Mangroves protect and stabilise the shoreline; maintain water quality by

filtering land based runoff; and provide recreational and educational opportunities. Mangrove habitats are important to both juvenile and adult fish. At low tides fish are confined to drainage channels, but move out into the mangrove forest on the high tide (http://www.dnr.nsw.gov.au/estuaries/index, 2005) . There are five species of mangroves in NSW. The Grey Mangrove and the River Mangrove are the most common on the NSW coast. The River Mangrove is a shrub found from the Tweed River south to the Merimbula River. The Grey Mangrove is a large tree found along the entire coast. Three others, the Red Mangrove, the Large-leaved Mangrove and the Milky Mangrove, are located only in the northern estuaries of NSW (http://www.fisheries.nsw.gov.au/aquatic_habitats/aquatic_habitats/fishcare_-_our_mangrove_forests, n.d.).

Mangroves and salt marsh on a property in the lower Macleay. © Natasha English

Saltmarshes

Saltmarshes occur on the landward side of mangroves, where tidal inundation is regular but infrequent. In the mid-north coast, saltmarshes are characteristically dominated by only a few plant species, including Red Samphire and Salt Couch. The plant communities of saltmarshes often occur in distinctive zones, determined by a complex interplay of factors, which include tidal scour on seedlings in the lower limit of the saltmarsh, competition with mangroves for light, competition between species, soil type, salinity gradient and inputs of freshwater (Clarke and Hannon, 1967; 1969; 1970; 1971). A recent study found that nineteen species of estuarine fish used the saltmarsh habitat, eleven of these being of commercial importance (Morton et al, 1987). The most common fish were Yellowfin Bream, Flat-Tail Mullet and Fantail Mullet. Saltmarshes provide organic matter to estuarine food chains, but are not as productive as seagrass or mangrove areas. They also help maintain estuarine water quality by filtering sediment from land based runoff. Saltmarshes may harbour important insect communities. Some rare butterfly species depend on saltmarshes and associated vegetation for completion of certain life phases, e.g. the larvae of the Saltpan Blue and Painted Skipper butterflies.

The presence of insects and small vertebrates in saltmarshes attracts waterbirds, such as herons, bitterns and egrets, and waders to these areas, e.g. Bush Stone Curlew, Double-banded Plover, Greenshank, Bar-tailed Godwit and Sharp-tailed, Pectoral and Curlew Sandpipers (Kingsford, 1991). Some bush birds, such as the White-fronted Chat, also feed and nest within saltmarsh vegetation. Perhaps the greatest threat to the saltmarsh areas is land reclamation. Saltmarshes are often naively viewed as unproductive, unsightly and untidy areas that can "be put to better use". Many previous saltmarshes now lie buried beneath sports fields (Adam, 1984).

Poor practice-fencing in the sensitive salt marsh. Note where the pasture stops. © John Schmidt

Swamp forests

Swamp forests, which are generally located adjacent to wetland areas, represent the most inland habitat directly connected to an estuary. Swamp forests provide organic matter to the estuary (as detritus) and contain many terrestrial species of wildlife, as well as aquatic organisms. They also form buffer strips between the hinterland and the water. Swamp forest trees consist principally of paperbark and casuarina, e.g. Broadleaf Paperbark and Swamp Oak. Eucalypts such as Swamp Mahogany are also common. A number of other ground dwelling mammals, aerial feeders such as bats, and reptiles such as Redbellied Black Snake, Carpet Python and Land Mullet also live in swamp forests. A number of birds and bats winter in Swamp Forests. The Broadleaf Paperbark provides a significant food source for these animals. It is likely that northern NSW stands of Paperbark are extremely important over-wintering sites (Nix, 1976).

The ephemeral lakes and dune lake systems

The ephemeral lakes associated with estuaries, are temporary water bodies created by overflow from the main drainage channels. Because they are only intermittently filled, the waters of these temporary reservoirs experience extreme physical and chemical variations. This does not necessarily mean that

they are devoid of fauna. In studies of temporary streams within Australia, species richness amongst macro-invertebrates was found to be extremely high, often with considerable species overlap between permanent and temporary water bodies (Boulton and Suter 1986). Therefore ephemeral water bodies may be of considerable importance to vertebrates seeking food, and an integral part of the ecology of the floodplain as a whole.

The geomorphology of coastal dune wetlands is diverse: they can occur in deflation hollows in swales (mainly on the older inner barrier); and as lagoons infilled to varying degrees, between the inner and outer barriers or enclosed within bedrock spurs. Some of these dunal wetlands have extensive catchments on bedrock: some lagoons and swales are perched above the water table on accumulated humic material, and others intercept the water-table. Dune lakes vary in terms of their connection with the sea. Heavy rains and flooding can lead to overflow from most lakes and semi-permanent connections with the sea. Salinity is usually low within these lakes and the water is typically acidic and humic. The biological communities are usually simple. Energy pathways appear to rely on the input of organic matter and are therefore at risk of pollution (Timms 1986).

Seagrass beds

Generally, seagrass meadows occur in the intertidal and sub-tidal zones of relatively shallow, sheltered in-shore areas, typically in bays, estuaries, saline lagoons and lakes. The substratum in which seagrasses grow is typically soft sediments consisting of any combination of sand and mud. The distribution of seagrasses is influenced by light intensity, which is required for photosynthesis. Therefore, depth and turbidity play an important role in the local extent of seagrass meadows. Seagrass beds serve a number of important and basic ecological roles (see Poiner & Roberts, 1986): they are a source of significant amounts of detrital material, they are an important mechanism for nutrient cycling, they facilitate substrate stabilisation, they provide a variety of animal habitats, and they provide substrate for epibiota (small plant and animals living on the stems and leaves of seagrass). Seagrass beds produce large amounts of organic matter. Depending on species and location, 1 ha of seagrass meadow may produce 3-20 tonnes of dried leaf matter per year. Seagrass beds provide juvenile fish with shelter and protect them from predation (Bell & Pollard, 1989). Most of the estuarine fish species of commercial importance spawn offshore, with larval and juvenile stages spent in seagrass beds. Hence, the maintenance and well being of seagrass beds are of fundamental importance to the success of commercial fisheries in NSW.

The cycling of organic matter and nutrients by seagrasses, especially via the detrital food chain, is crucial to biological productivity and population numbers within estuaries. The presence of seagrass beds reduces current flows and water turbulence, thereby facilitating the deposition of suspended sediments and limiting erosion and sediment transport and providing a safe haven for fauna. Seagrass beds are quite fragile and are susceptible to many of the modern pressures on estuaries. Point sources of pollution, such as effluent outfalls, may cause excessive algal growths that smother seagrass areas. Dredging, large scale removal of seagrass beds or their periodic harvesting to "clear the waterway" can have drastic effects on their viability and the biological productivity of the marine organisms living in amongst them. Once seagrass beds are lost, they do not necessarily recolonise quickly (http://www.dnr.nsw.gov.au/estuaries/index, 2006).

Wetlands

Besides serving as important habitat for wildlife, the wetlands that fringe many estuaries also perform other valuable services. Water draining from the catchment carries sediments, nutrients, and other pollutants. As the water flows through the marshes, much of the sediments and pollutants are filtered out. This filtration process creates cleaner and clearer water, which benefits both people and marine life. Wetland plants and soils also act as a natural buffer between the land and ocean, absorbing flood-waters and dissipating storm surges. This protects land based organisms as well as valuable real estate from storm and flood damage.

What is riparian vegetation and why is it important?

Riparian vegetation grows next to a waterway, whether it is a gully, creek, swamp, wetland, river, fresh or saline. Stock impacts and diminished vegetation in these areas, cause banks to erode. This creates problems for water quality, generating sediment and the loss of land as banks accrete. Good vegetation on the waterways would include a mix of plant heights and species, one or two trees in a

section of the bank is not sufficient for stabilising it. There are many excellent publications and fact sheets about riparian vegetation but for specific assistance on management of your riparian areas it is best to contact the Northern Rivers Catchment Management Authority and/or the Landcare office in your area. Funding is sometimes available to assist landholders with riparian works, in the form of fencing, weed control, alternate watering points for stock and native plants. There are free species lists available for each catchment to assist you in replanting, however, allowing an area to regenerate if possible is often the best option. Plants used for revegetation should come from a reliable source hopefully propagated from seed collected in your area. Please seek advice.

Warrell Creek riparian vegetation. © John Schmidt

Protecting, maintaining or restoring native vegetation

There are numerous incentives for protecting vegetation on your property. Maintaining ground-cover and riparian buffers, increases soil productivity, water retention capacity and maintains soil nutrients and means less chemicals are required for productivity or to suppress weeds. The Native Vegetation Act 2003 regulates all land clearing activities and The Fisheries Management Act 1994 and Rivers Foreshore Act regulate any activity in the riparian zone, refer to Chapter 7.

Rural landholders who wish to clear native vegetation on their land must apply for a Property Vegetation Plan (PVP) or Development Consent (DC) from the Northern Rivers Catchment Management Authority (NRCMA). These will outline plans for the clearing of native vegetation on your property for up to 15 years. Staff from the NRCMA can provide advice to landholders on their obligations under the Act. Clearing any land can have major effects on the catchment. You must also consult your local DECC officer about lodging for places of Aboriginal significance and/or fauna and flora before applying for a permit to clear.

Trees within the Hastings Local Government area and Kempsey Shire are protected by a Tree Preservation Order (TPO). This order prohibits the removing, poisoning, killing, clearing, ringbarking or knocking over of trees and the cutting, pruning, lopping or topping of living branches of a tree, its canopy or roots. A copy of the complete Tree Preservation Order and Policy can be obtained from council websites.

Planting natives in your garden or on your property is the best way to ensure exotic weeds don't spread into estuaries and riparian vegetation, like littoral rainforest. The Bushland Friendly Nursery Scheme has produced an excellent booklet on alternatives for introduced species which can potentially flourish in the warmer climate of the mid-north coast (BFNS, n.d). The 'Nambucca Valley Vegetation and Planting Guide 2007', is also a great resource that can be obtained from the Nambucca Valley Landcare office.

Chapter
6

Lessening the impacts-what you can do

Turbidity: How to manage soil run-off

Extreme rainfall events carry runoff from the land to the estuary, lakes and lagoons, causing oysters and other aquatic life to be inundated with high nutrient and sediment loads. This has major implications for areas on the mid-north coast where high climate variability, heavy rainfall events and prolonged periods of drought are common. Depending on the type of activity there are a number of ways to stop soil and other material washing off into waterways. Whilst erosion and deposition of sediment are natural river processes, the accelerated rates of erosion today have resulted primarily from the removal of native vegetation over time. The examples presented here are directly related to the section on riparian vegetation but can extend to any exposed or vulnerable areas of bare earth.

If you are building, a sediment and erosion control plan can include a number of practical on site measures to stop runoff into waterways. You can limit the entry points on the building site to one point and stabilise this area. Strip and stockpile topsoil; install sediment fences below the site; re-spread topsoil and vegetation on all bare areas are just a few of the components that should be included in an erosion control plan. Contact your local shire council for information on erosion control plans.

Example of uncontrolled development site. © John Schmidt

Example of a sound demarcation barrier between the development and the surrounding environment. © John Schmidt

Dumping unauthorised material into a river in an attempt to prevent bank erosion, can lead to friable material being washed away causing pollution and damage to natural ecosystems (pers. comm. Hurst in James, 2003). It is important to ensure that the design of bank stabilisation works is appropriate for the site and that you obtain all relevant approvals before undertaking any work. It is always advisable to seek advice from the DECC, the DPI and the NRCMA before proceeding with any kind of stabilisation project as a wrong approach can cause worse problems. On farm: there are a number of successful and simple techniques that have been trialed in the estuarine environment for stabilising the river bank such as the following example.

Silt curtain, Macksville, example of controlling runoff from bank stabilisation works. © Natasha English

A project example: stabilising farm riverbanks

Accelerated riverbank erosion is a common problem in many of our estuaries. One of the main causes of this is the loss of the riparian forests that once fringed these waterways. These forests performed many functions including: providing a wind-break effect that reduced wind-generated wave action; and providing roots that physically reinforced the banks. Perhaps most importantly, forests were a continuous source of large woody debris whereby whole trees and large limbs falling into the water created a screen of protecting 'snags' that absorbed wave energy in front of the bank and created the microhabitat required for mangrove seedling establishment. In 2000 a demonstration site was established at Dumaresq Island on the Manning River estuary near Taree on the NSW lower-north coast that aimed to recreate some of the functions provided by these forests. This site demonstrated a technique of bank protection that provides a greater range of environmental benefits to those methods used previously. At this high energy site (i.e. the site is very exposed to wind-generated wave action) large quarry rock (median diameter of 500 mm) was used to build wave energy dissipation walls, sometimes known as rock fillets. These walls were constructed to the height of the mean high-water mark about 3–5 m in front of the eroding bank. The walls absorb wind-generated wave action and create an area of still water that mimics the microhabitat created by large woody debris. Within months of the installation thousands of mangroves had self-seeded behind the walls. The upper bank was also planted with native rainforest pioneer trees and shrubs to create a minimum 10 m buffer. This method of estuarine river bank protection is cheaper than traditional methods, effectively stops accelerated bank erosion and, where a seed source exists, mangroves will self-seed. The inclusion of upper bank planting underlines the importance of aiming at full riparian rehabilitation, not just physical bank protection. The final result provides habitat for a range of aquatic and terrestrial fauna (James, 2003).

Managing ASS in the floodplain: a project example

A property on the Lower Macleay that was covered in large areas of acid scald has been successfully rehabilitated by introducing water back into the system using a ponding technique; during the recovery period, stock were kept off. When Russell and Georgina Yerbury purchased their property back in 1992 they had very little farming experience and had never heard of acid sulfate soils. 'Two thirds of our 365 hectare cattle property is lowland back swamp country, dissected by a major flood mitigation drain which had been extended and deepened in the late 1970s to 2 metres below mid-tide level. In 1993-94 through the combined effects of severe drought and deep drainage the water table was lowered excessively. This exposed the potential acid sulfate soils to oxygen and acid formed.' Approximately 120 hectares of the property became an acid scald with virtually no vegetation, low productivity and soil flying off onto the Pacific Highway almost 2 km away. Introducing water back into the system over the scald was the beginning of modifying and in some cases dispensing with traditional management techniques. As Russell explains, 'this entailed closing off all the inlets to the

drain to maintain artificial ponding. Wetland pastures (water couch and soft rushes) began to return to the former drained swamp area and with this new growth came a completely unexpected bonus. The water pH began to rise with the thickening of the ponded vegetation from readings of pH 2.5 to current readings of up to pH 7. This was due, we believe, to anaerobic bacterial activity in the root zone'.

The Yerbury's use of passive acid sulfate scald management techniques, has had some amazing results. Dense coverage of native ponded pasture over a large area has been reinstated. Trials at the property show water couch growth at 150 kg per hectare per day, equal to the growth and quality of irrigated Lucerne. The water runoff which was previously acidic, is now recorded at a pH of 6+. Frogs, fish and birds are thriving in the water that was previously toxic; and fat cattle graze lush country that had been devoid of any pasture. The Yerbury's management regime closely resembles the natural wetting and drying cycle of the swamp country. This property is an excellent example of a landholder working with the natural elements whilst successfully farming.

Acid scald on the Yerbury's property, 1992. © Russell Yerbury

Yerbury's property following passive ASS management techniques. © Russell Yerbury

Who to call if ASS are a problem

Your first contact should be with your local council to request some advice as to how to proceed if you believe you are dealing with an acid scald. You may also need to contact the NRCMA or the DECC for management advice.

Managing salinity

Human activities in the upstream reaches of coastal catchments can alter critical components of the marine and freshwater flows which are essential for maintaining healthy estuaries. Reservoirs and diversion structures such as dams, weirs and barrages, and direct pumping of water from the stream channel for domestic, industrial and agricultural use, can directly alter the magnitude and variation of water flows. The removal of riparian buffers, clearing of native trees and expansion of urban areas can also change the rainfall runoff. These are the elements which can contribute to high salinity levels within the estuary. Good farm management makes sense; protecting the systems that support the estuary, help to nurture your land and protect the health of the environment.

A project example: a sustainable farming enterprise

Eggert Agripartners began the conversion to organic dairy farming in 2000, after deregulation and at the start of the drought. Previous to this, they ran a high-input, high production conventional dairy. The conversion to the organic farming system was virtually overnight. This required a lot of hard work and trial and error. Full certification was gained in 2003 and Chris and his family now milk approximately 160 cows and produce 1 million litres of milk per year.

A number of changes have been made on the farm with a large focus on recycling nutrients and improving the soil. In 2003, after having mixed success with composting chicken manure, Chris put sawdust on the dairy yard and collected the manure and urine to make his own compost, saving water from hosing down and recycling the nutrients from the farm. As the health of the cows has improved, so has the manure, which in turn improves the compost; the compost improves the soil and the pasture which the cows eat. This further improves the manure for the cycle to begin again. 'As far as we know, no one else has tried this revolutionary but simple method.' Chris and his family now produce about 1000 tonnes of compost each year, which is put back on the farm. A compost turner and trommel have been purchased which makes the process more efficient and produces a superior product. They also have the beginnings of a worm farm.

What follows is some of the other improvements which Chris and his family have made. Water efficiency has been improved. A new K-line irrigation system was installed in 2006, ground cover has increased and there is an increased diversity of pasture species with differing water requirements. Using a combination of soil tests; compost; compost tea; and foliar sprays, organic matter increased from 2 to 5 %. Calcium to nitrogen ratio improved and CEC increased (CEC stands for cation exchange capacity, it is essentially a measure of the ability of the soil to hold onto cations for example nutrients such as hydrogen, potassium, calcium, magnesium etc. and make these available

for use by plants). Nutrients (including trace elements) have become more available naturally; soil structure has improved and soil biodiversity (including worms) has increased.
Since converting to organic production and implementing time control grazing, the pastures are exhibiting greater longevity (some paddocks last up to five years), and they are showing greater diversity and increased legume percentage. The pastures also exhibit better recovery from animal impact and climatic influences, and there are fewer weeds.
Vet bills have been reduced from $18-20,000 to less than $1,000 per year. Conception rates have increased and there are fewer calving problems and less mastitis.

Preventing water pollution

'Pollution, the difference is you' and 'the drain is just for rain' are familiar government slogans for what appears to be self-evident. But perhaps you have not considered whether all your daily activities are sound.

What you can do

Wash your car on the grass. If you wash your car in the street or on your driveway, detergents, mud, oil and grease can wash directly into the storm-water system. Many detergents contain phosphates which over- fertilise waterways, altering the pH, and can lead to a build up of toxic algae which is harmful to fish and humans too. Try and use environmentally friendly products in the household and dispose of household chemicals correctly. Check your council's website or phone them for advice, or visit http://www.cleanout.com.au.
Sweep them up before they wash away. Even natural things like leaves, garden clippings and soil in large amounts can harm our waterways. In bushland or in our gardens, leaves are scattered and decay where they fall. But when they are washed into the storm-water system they become concentrated. Imagine the impact of all the leaves and dirt in all the streets from 5 kilometres around washing directly into your local waterway. When leaves and clippings decay in water, they use up oxygen. Taking oxygen away from the water can kill plants, fish and other animals that live in our waterways. Soil is a problem too. It makes waterways cloudy and can silt them up. Silt can suffocate fish by clogging their gills, see the section on turbidity.
Put leaves in the compost or on the garden as mulch. Rake up grass clippings then mulch or compost them. Cover piles of soil, sand or mulch to stop them washing into drains. Build barriers around your garden beds to contain the soil (and any fertilisers you are using). Plant grass where soil is exposed (DECC).

Making your business fish friendly

As a local business owner, it is imperative to dispose of wastewater in the correct manner to reduce the risk of pollution and give your business a cleaner, greener image. Under the Protection of the Environment Operations Act 1997, you can receive an on-the-spot fine of $1,500, if you allow anything other than rainwater to enter a gutter or storm-water drain. Portable bunds can be used to direct wastewater away from storm-water drains. Bunds are textile tubes filled with sand or other impermeable material. For suppliers see under 'Oil and Chemical Spill Recovery or Dispersal' in the Yellow Pages.
Biodegradable products, like certain detergents, are designed to breakdown in the sewage treatment process. They should never be allowed to run into the storm-water drain.
To use a mobile dog washing business as an example, flea rinse containing diazinon, chlorpyrifos or any anticholinesterase compound should never be used. These do not break down in the sewage treatment process and will kill aquatic organisms. Half a teaspoon of these compounds can kill everything in an area the size of an Olympic swimming pool. It pays to be informed about all chemicals that you use in your garden, home on your pets or your business.

Wastewater management

Wastewater enters rivers and estuaries from many different sources. It includes runoff from urban and agricultural areas, overflows from septic systems, discharges from sewage treatment plants and

sewage overflows, sewage discharges from boats (HRC, 2000). On-site effluent management in urban areas of the Nambucca, Macleay and Hastings, often involves a septic tank and absorption trench located below ground level. Solids settle to the base of the tank and oils and fats float to the top in a scum layer. Anaerobic (absence of oxygen) bacterial digestion of the stored solids produces sludge, which accumulates in the bottom of the tank. This sludge needs to be removed every few years. Partly treated effluent flows from the tank to either a holding tank for pump out, or directly to a soil absorption trench. This effluent soaks into the soil, ideally pollutants are safely retained, transformed or taken up by plants, and water is safely released to the water cycle through groundwater movement or evapotranspiration. The on-site soil and landscape conditions are critical to the influence of harmful pollutants entering the waterways. On-site sewage management systems need to be maintained, this is imperative when you consider that the entire population of Stuarts Point, Grassy Head and Fishermans Reach on the Macleay Arm, are on septic systems and there are approximately 400 septic systems known to be located in close proximity to the Nambucca River.
If you are intending to install or upgrade an existing system there are a number of factors that need to be considered. These include soil type for potential dispersability and permeability; soil depth due to shallow soils limiting soil residence time and ability to absorb, adsorb, transform and promote vegetation uptake of nutrients; soil sodicity and reactivity; slope; flooding frequency; and water table depth, amongst other things (Chapman, 2004). Seek advice from your local council.

Something to consider when developing land

The science of ecology teaches that all living organisms are connected via a network of trophic relationships. Internal mechanisms of an ecosystem will evolve to maintain life by managing fluctuations and perturbations with unique phenomena, like predator/prey relationships. Change in one part of an ecosystem will alter other parts of that system over different spatial and temporal scales. Human planning and management strategies could attempt to emulate these natural processes in order to ensure the health of the ecosystem under developmental pressures. The principles of Landscape Ecology as described by Lyle (1999) are based primarily on this concept of interconnectedness and scale combining the disciplines of landscape architecture and ecology. Lyle proposes that humans emulate the natural processes as closely as possible in their construction designs and management plans to create the 'human ecosystem'. The human ecosystem concept recognises the 'merging and interacting of human and natural processes' (Lyle 1999, p. 15). Humans have been designing and altering the landscape without considering how and to what extent the natural ecosystems are altered. Controls are required when the land is being used for intensive large-scale development, but the controls put in place should attempt to follow natural contours of the land and work with the existing topography wherever possible. An example might be aquaculture ponds built in the path of a natural watershed filtering runoff before it flows into a water-body. Designers or planners should intentionally incorporate natural processes, (water flows; planting trees that reflect solar radiation) into the design plans. This type of approach will tend to protect ecological relationships at different scales.

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Chapter
7

Local government and legislation

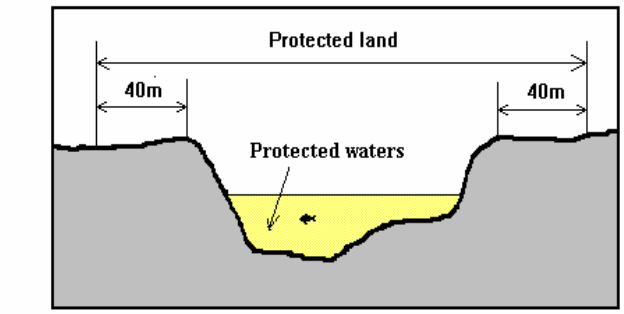
You should be aware of the role of local government and the existing broader legislation that governs management of the coasts and estuaries in NSW and the policies that relate directly to development of any kind in the coastal zone. Whether it is clearing trees or moving soil, there are strict guidelines set out in the development application process available from your local council.

The role of local government

Local government has a prominent role in the management of the estuary. In recognition of the need for future sustainable use of high value public assets, the NSW Government is implementing a

number of key strategic initiatives, one of which is the Estuary Management Program. The Estuary Management Program commenced in 1992 to assist local government to better manage estuaries through a strategic process outlined in the NSW Estuary Management Manual. The Department of Environment and Climate Change, coast and estuaries division, worked with local councils to establish an Estuary Management Committee, which includes representatives from the local community, industry, environmental interest groups, researchers, and state and local government. The committee work together to identify problems in the estuary and create and implement a formal management plan. These plans aim to: improve the environmental health and condition of estuaries; protect important coastal habitats, features and heritage items; rehabilitate degraded areas; improve public access and amenity; accommodate sustainable population growth and resource utilisation. Estuary Management Committees and plans have been developed by the Hastings, Macleay and Nambucca councils than and are now at the implementation stage.

Catchment Action Plan for the Northern Rivers
The Catchment Management Authorities Act 2003 provides for the establishment of thirteen Catchment Management Authorities in NSW. Each Catchment Management Authority (or CMA) is required to prepare a catchment action plan. To view this plan for the Northern Rivers region go to www.northern.cma.nsw.gov.au or visit your local Landcare office.
Environment Protection and Biodiversity Conservation Act 1999
This act governs protection of the environment especially in relation to matters of national significance (e.g. World Heritage Areas). It also lists threatened species and prohibits the export of native species without a permit.
Environmental Planning and Assessment Act 1979 and the associated State Environmental Planning Policies or SEPPS of which there are a number that are specific to the coastal/estuary environment, including SEPP 14 'Wetlands' and SEPP 71 'Coastal Protection'. This Act specifically controls the extent and conditions of development on all land in NSW. Administered by local councils, this is your first port of call to discuss any kind of building, structure or activity that will alter the condition of a piece of land.
Rivers and Foreshores Improvement Acts 1948
DECC administers the R&FI Act on all land in NSW except that controlled by Port Authorities. Part 3A of the R&FI Act is designed to control activities in or near rivers and lakes that have the potential to cause instability, obstruct or detrimentally affect the flow of protected waters. Part 3A of the Act applies to 'protected land', which includes the bed and banks of these water bodies and adjacent land within 40 metres of the top of bank or shore.
Local councils and other government authorities do not need 3A permits for activities under their direct supervision (they have the power to do works under their own legislation). However, part 3A gives DECC the power to order remediation works if it considers an activity has damaged, or is likely to detrimentally affect a river or lake, or cause a river to change its course.



Under section 22B of the RF&I Act
(1) A person must not:
(a) make an excavation on, in or under protected land; or
(b) remove material from protected land: or

(c) do anything which obstructs, or detrimentally affects, the flow of protected waters or is likely to do so, unless the person is either authorised to do so by a permit under this Part and does so in accordance with any conditions to which the permit is subject, or is authorised to do so by the regulations.

A part 3A permit is required for any excavation, removal of material such as rock or soil, or anything that might obstruct or detrimentally affect water flow (e.g. structures or fill). Each permit has conditions that are specific to the type of activity being undertaken. Typical developments include:
sand and gravel extraction from a river or floodplain;
stream restoration (bank erosion stabilisation works)
stream crossings (e.g. bridges, culverts, causeways);
subdivisions involving roads, stormwater control measures, drainage or earthworks, dams or weirs;
laying of cables or pipelines across streams; and
foreshore structures on freehold land (e.g. seawalls, boat ramps, boat sheds, marinas).

To apply for a 3A Permit contact the Senior Natural Resource Officer Coast & Floodplain Management, Department of Environment & Climate Change. Ph 02 65614975, fax 0265614981, mob 0417428571. Address: PO Box 6 Kempsey, NSW 2440, The Harrinton Building, 41 Belgrave Street Kempsey.

Fisheries Management Act 1994
This act is administered by NSW DPI Fisheries and aims to ensure that fishing activities remain sustainable. Permits may be required for a number of fishing activities. A recreational fishing licence is required for recreational fishing (including bait gathering) in all public waterways-some exemptions apply. There are fishing guides available for recreational fishers which outline rules including: size limits, bag limits, allowable methods, gear and areas. Contact the fisheries office Port Macquarie phone: 6581 4084, and for recreational fishing licences phone: 1300 369 365.
The Fisheries Ecosystems branch of the Department of Primary Industries based at Wollongbar (NSW) are concerned with the protection and conservation of marine habitat such as marine vegetation like macroalgae, mangroves and seagrass beds as well as the protection of fish passage. Certain species of fish need to be able to migrate up stream to breed. The Fisheries Ecosystems branch deal with Part 7 of the Fisheries Management Act which deals with any activities that may destroy marine vegetation and or block fish passage. Such activities might include, dredging, reclamation, placing materials in the water way, building jetties or boat ramps. Any riparian works or activities that may inhibit fish passage or potentially harm habitat require a permit under this Act. The Act covers all waterways in NSW and includes water-lands, areas that are conducive to water inundation like salt marshes which are extremely sensitive. DPI Fisheries has a concurrence role with the Department of Environment and Climate Change who administer the Rivers and Foreshore Act. Bank stabilisation or bed control activities are primarily the jurisdiction of DECC but DPI Fisheries will have some say in the project proposal.
It is advisable to contact the Senior Conservation Manager at Wollongbar to discuss any preliminary plans that may impact on aquatic vegetation or fish passage or visit www.dpi.nsw.gov.au for best practice guidelines for the design of certain structures. Phone: 662 61269.
Coastal Protection Act 1979
This act is to provide protection to the coastal environment of NSW, including the natural environment, benefits to urban communities, fisheries, industry and recreation, culture and heritage and benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water. Certain coastal developments will need the approval of the Minister for Planning and is governed by State Environmental Planning Policy No. 71. More information can be obtained from the NSW Department of Planning-regional office North Coast: 76 Victoria Street, Locked Bag 10, Grafton NSW 2460. Phone 02 6641 6600.

Protection of the Environment Operations Act 1997

This legislation administered by the Environment Protection Authority which is part of DECC, issues licences to control air, noise, water and waste impacts primarily to large industrial operations. Local council can issue Clean-up notices, Prevention notices and prohibition notices if private individuals are in breach of the pollution laws. The EPA can be contacted on 131555. Under the Protection of the Environment Operations Act 1997 (POEO Act), it is an offence to pollute any waters unless permitted under a licence issued by the DECC. Waterways Authority officers can issue on-the-spot infringement notices of $750 for an individual or $1500 to a corporation where cases of pollution from vessels are detected.
The POEO Act is complemented by the Marine Pollution Amendment (Waste Discharge and Oil Spill Response Plans) Regulation 2003, which became effective on 1 July 2003. This Regulation prohibits the discharge of untreated sewage from vessels into navigable waters, requires that treated sewage not be discharged within 500 meters of aquaculture and includes a requirement for the installation of sewage holding tanks in certain types of vessels. There are no specific requirements for private recreational vessels other than a general requirement to avoid polluting the waterway. Of the commercial vessels, only specific types of class
1 (passenger carrying) and class 4 vessels (hire and drive, e.g. houseboats) are required to have holding tanks for sewage effluent. A publicly available pump-out facility is provided at the Macksville Wharf on River Street, East Macksville. This facility is administered by Nambucca Shire Council and is available 24 hours a day.
(www.maritime.nsw.gov.au).

Native Vegetation Act 2003
Native vegetation on rural property can only be cleared as part of a defined routine agricultural management activity or in accordance with a property vegetation plan (PVP) or via development approval under the Environmental Planning and Assessment Act 1979. Contact the Northern Rivers Catchment Management Authority for more information.

North Coast Regional Environmental Plans 1988
Several Clauses within the NCREP address specific considerations relating to developments near waterways or environmentally important or culturally significant areas, for example Clauses 15, 29A, 32B, 33, 36A and others.

Water Management Act 2000
This act sets out landholders' entitlements and obligations regarding water use, covering streams, lakes, dams, bores and harvesting runoff. Contact water licensing in the Department of Water and Energy or the Northern Rivers Catchment Management Authority for more information.
Resources
Know your estuary
Reading
For a historical perspective on river settlement and life:
Hodgkinson, C. (1884) "Australia from Port Macquarie to Moreton Bay; with descriptions of the natives, their manners and customs; the geology, natural productions, fertility and resources of that region". T. and W. Boone, London.
Neil, M. H. (1972) "Valley of the Macleay, the History of Kempsey and the Macleay River District", Wentworth Books, Sydney.
Townsend, Norma (1993) "Valley of the crooked river: European settlement on the Nambucca", New South Wales University Press, Kensington, Australia
Online
Telfer, D. (2005) "Macleay River Estuary Data Compilation Study": A report reviewing the existing data adequacy and data and information needs for the Macleay River Estuary Management Plan, available online at: www.kempsey.nsw.gov.au (has a good historical overview of the Macleay River).

Draft Nambucca River Estuary Management Plan and Macleay River Estuary Management Plan are both available on the respective council websites.
Hastings Estuary Management Plan is available by contacting the council directly.
Web Sites
Technical information about Australia's estuaries and coasts can be found at: www.ozestuaries.org
DNR, NSW Government Department of Natural Resources web site:
www.dnr.nsw.gov.au/estuaries/index
The world is your oyster so look after it!
(HRC) Healthy Rivers Commission (2003) "Oysters: Independent Review of the Relationship between Healthy Oysters and Healthy Rivers", Final Report, available as a PDF at:
www.bookshop.nsw.gov.au/search.jsp?keyword=Healthy+River+Commission&submit.x=16&submit.y=8
NSW Oyster Industry (2006) "Sustainable Aquaculture Strategy", by the NSW Department of Primary Industries, ISBN 0 7347 1776 8.
Indigenous Australians connection to the water ways
Reading
Behrendt, J. and Thompson, P. (2003) "The recognition and protection of Aboriginal interests in NSW Rivers", Occasional Paper prepared for the NSW Healthy Rivers Commission by Chalk and Fitzgerald, Lawyers and Consultants, Sydney.
English, A. (August, 2000) "The sea and the rock gives us a feed": Mapping and managing Gumbaingirr wild resource use places. NSW National Parks and Wildlife Service, Bibliography. ISBN 0 7313 6880 0.

National Parks and Wildlife Service (May, 2003) "Aboriginal Women's Heritage: Nambucca", available online.
What is an impact?
Natural impacts (estuarine processes)
Soil erosion and turbidity
Contacts
General information about local soil types:
Agronomists, NSW DPI (agriculture) at Kempsey and Taree
Soil erosion control measures:
Northern Rivers Catchment Management Authority at Kempsey and Coffs Harbour
Landcare Community Support Officers at Bowraville, Kempsey and Wauchope
NSW DPI Wollongbar or Kempsey
Soil Conservation Services in the Department of Lands:
Senior Environmental Officer (Consult)
Soil Conservation Service
Department of Lands, 36 Marina Drive
PO Box 291J, Coffs Harbour Jetty NSW 2450
Phone: (02) 6691 9617
Fax: (02) 6651 1001

Reading
'Soils' section in the Resource Kit for Rural Landholders in the Nambucca, Macleay and Hastings Valley (available from the DPI and Landcare offices)
Lines-Kelly, R. (ed) 2000, "Soil Sense-Soil Management for NSW North Coast Farmers", 2nd edition, ISBN 07347 1210 3. Available from NSW DPI (agriculture) bookshop.
NSW Department of Primary Industries (2006) "Soil Erosion Solutions: Helping North Coast landholders reduce soil erosion, a booklet covering soil erosion projects completed in the Northern Rivers, NSW 2005/06", copies available from the DPI Wollongbar office or your Landcare office.
Web Sites

NSW EPA Controlling erosion and sediment fact sheet at:
www.environment.nsw.gov.au/small_business/landscaping
www.naturalresources.nsw.gov.au/care/soil/
Septic safe website and Australian New Zealand Standards No. 1547
NSW Department of Local Government (2000) "The Easy Septic Guide". Developed by Social Change Media for the New South Wales Department of Local Government. "The Easy Septic Guide" may be downloaded in PDF format from the SepticSafe web site: www.dlg.nsw.gov.au/ssfpub.htm
Human impacts: www.naturalresources.nsw.gov.au/estuaries/factsheets (Dept. of Natural Resources, NSW Government)

Acid sulfate soils
Online
Johnston, S. et al (November 2003) "Restoring the balance: Guidelines for Managing Floodgates and Drainage Systems on Coastal Floodplains", NSW Agriculture, Wollongbar, NSW, A report prepared for Land and Water Australia, online at: www.fisheries.nsw.gov.au
Contacts
Location of acid sulfate soils and planning controls:
local shire council and Department of Natural Resource maps.
Management of acid sulfate soils:
environmental officers at Nambucca, Kempsey and Port Macquarie/Hastings Shire Councils
Reading
Kempsey Shire Council Development Control Plan No 27 – Acid Sulfate Soils

Tulau, M. J.(1999) "Acid Sulfate Soil Management Priority Areas in the Lower Hastings-Camden Haven Floodplains", Report, Department of Land and Water Conservation, Sydney.

Climate change
Reading
Australian Government Bureau of Rural Sciences, Climate Change Adaptation in Agriculture, "Science for Decision Makers" series, available at: www.brs.gov.au or phone 02 6272 4282
CSIRO (2006) "Climate Change in the Northern Rivers Catchment", Prepared for the New South Wales Greenhouse Office on behalf of CSIRO.
Online
For ideas on how to make a difference or further information on the cause, impacts and solutions to climate change, visit the following websites:
www.greenhouse.gov.au/science/index..html
www.greenhouse.nsw.gov.au
Australian Conservation Foundation www.acfonline.org.au
Beyond Nuclear Initiative www.foe.org.au/bni.htm
Climate Action Network Australia www.cana.net.au
Business Council for Sustainable Energy www.bcse.org.au
Clean Energy Future Group wwf.org.au/ourwork/climatechange/cleanenergyfuture
Pests and weeds
The Weeds Australia website contains further information regarding bitou bush, boneseed and other Weeds of National Significance (WONS) www.weeds.org.au/natsig.htm
National Introduced Marine Pests (NIMPIS) website www.marine.csiro.au/crimp/nimpis
Human Impacts
Other water pollution
Two excellent fact sheets on Chemical Pollutants and Plant & Organic Impacts have been produced by Coffs Harbour Council. These include tips on what you can do to minimise these impacts.
www.coffsharbour.nsw.gov.au/resources/documents/FINAL_chemical_pollutants_fact_sheet_21.pdf
www.coffsharbour.nsw.gov.au/resources/documents/FINAL_organic_pollutants_fact_sheet_31.pdf
Groundwater use

Groundwater is a poorly understood resource and yet we rely heavily on this virtually unseen reservoir. For more in-depth discussion visit: www.epa.nsw.gov.au/soe/95/11_1.htm. For more on how you can protect and conserve groundwater at home or on the farm visit: www.tweed.nsw.gov.au/Education/w_14_protectandconservewaterhints.htm

Fishing

When fishing in NSW waters, both fresh and saltwater, you are required by law to pay the NSW Recreational Fishing Fee and carry a receipt showing the payment of the fee. This applies when spear fishing, hand lining, hand gathering, trapping, bait collecting and prawn netting or when in possession of fishing gear in, on, or adjacent to waters.

All money raised by the NSW Recreational Fishing Fee is placed into the Recreational Fishing Trusts and spent on improving recreational fishing in NSW. These trusts are regulated by law and overseen by two committees made up of recreational fishers - one for saltwater and one for freshwater.

How to pay the NSW Recreational Fishing Fee visit: www.dpi.nsw.gov.au/recreational and for any of the following:

Find out how your licence fees are spent

To apply for funds for projects that will improve recreational fishing?

Listening to recreational fishers - Recreational Fishing Trusts & Committees

"Recreational Fisher's Info Kit", A summary of rules regulations information & tips for saltwater & freshwater fishers.

"New South Wales Freshwater Fishing Guide 2006-07"

"Hastings River recreational fishing guide"

Saltwater Fishing

Freshwater Fishing

Fish Aggregating Devices (FADs)

Artificial Reefs

Gamefish Tagging Program

Charter Boats

Fishing Workshops - teaching responsible fishing to children

Fishcare Volunteer Program - Get involved!

Recreational Fishing Publications - Poster, reports, leaflets including local fishing information & guides

Fishing Closures

Fishing Safety Advice

Recreational Fishing Havens - Details, locations and downloads.

Ferris, L & R (2004) "The impact of recreational fishing on estuarine birdlife on the far north coast of New South Wales", Australian Seabird Rescue Inc. located at: www.seabirdrescue.org/downloads.html

The National Code of Practice for Recreational and Sport Fishing is available at: www.recfish.com.au/best_practice/national_code.html

Coffs to Nambucca fishing guide available at: www.dpi.nsw.gov.au/data/assets/pdf_file/89672/coffs-harbour-to-nambucca-recreational-fishing-guide.pdf

Agriculture and grazing

Rose, H. (2006) "A Resource kit for Rural Landholders in the Nambucca, Macleay and Hastings Valleys", printed with funding from the Australian Government Department of Agriculture, Fisheries and Forestry, National Landcare Program, available free from Landcare offices in Nambucca, Macleay and Hastings.

This is an excellent source of information for everything to do with property management.

Recreational and commercial boating

Websites:

Boat Users Guide to the Environment + more, online at: www.bia.org.au/boat-users/index.html

NSW Maritime is the State's maritime regulator and administers the following Acts of Parliament and the Regulations made thereunder:
Ports Corporatisation and Waterways Management Act 1995
Marine Safety Act 1998
Maritime Services Act 1935
Navigation Act 1901
Marine Pilotage Licensing Act 1971
Commercial Vessels Act 1979
Marine Safety Legislation (Lakes Hume and Mulwala) Act 2001
Marine Pollution Act 1987
NSW Maritime also has responsibilities relating to the marine environment under:
Rivers and Foreshores Improvement Act 1948
Environmental Planning and Assessment Act 1979
Protection of the Environment Operations Act 1997
Visit: www.waterways.nsw.gov.au/listoff1.html
Flood mitigation works
Many farmers have improved grazing productivity, amongst other farm operations, by conserving their wetlands and their natural functions and processes. Like the Yerbury's property, the water regime should be managed to mimic the natural conditions if possible. You can check with your local council for the existence of a floodplain management plan for your area and find out how it might affect where you live.
NSW Government Department of Natural Resources (2006) "An introduction to coastal and floodplain management", ISBN 0734757026. Online at: www.dnr.nsw.gov.au/nr/p/coast_flood_4pp_broch.pdf. For more information, or for specific advice contact the Senior Natural Resource Officer Coast & Floodplain Management, Department of Environment & Climate Change. Phone 02 65614975, fax 0265614981, mob 0417428571. Address: PO Box 6 Kempsey, NSW 2440, The Harrinton Building, 41 Belgrave Street Kempsey.

Macleay River Floodplain Project 2007, contact Kempsey Shire Council. Phone 02 6566 3200
Pest control
Natural pyrethrum insecticides visit: www.pestech.com.au
Caring for the coast
Reading
"50 ways to care for our coast". A pdf document located at : http://www.parkweb.vic.gov.au/education/marinekit/resources,. Although this is located at a Victorian Government address, the information is pertinent to all coastlines.

Fiedler M. and Glover R. (2003) "CPR Coastal Plant Regeneration", NSW Department of Infrastructure, Planning and Natural Resources, Coastal Unit, Newcastle, and Coastcare, Sydney. ISBN 0 7347 5315 2.

NSW Department of Land and Water Conservation (2001) "Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques", Coastal Unit, DLWC, Newcastle.

Web Sites
Australian Seabird Rescue located at: www.seabirdrescue.org

Coastcare: www.coastcare.com.au

OceanWatch Australia Ltd is a national environmental, not-for-profit company that works to achieve sustainability in the Australian seafood industry by protecting and enhancing fish habitats, improving

water quality and advancing the sustainability of fisheries through action based partnerships with the Australian seafood industry, government, natural resource managers, private enterprise and the community. www.oceanwatch.org.au

Surfrider Foundation is a not for profit organisation dedicated to the protection and enjoyment of the world's oceans, waves and beaches for all people. Visit: www.surfrider.org.au

World Wide Fund for Nature at: wwf.org.au
The importance of vegetation
Contacts
Vegetation identification: Coffs Harbour Botanic gardens herbarium; NRCMA if it is part of a property vegetation plan; private consultants (see "natural resource" or "environmental and or pollution" consultants in the Yellow Pages)
Wetland management: agronomists, NSW DPI (agriculture) at Kempsey and Taree; NRCMA; Wetland Care Australia; environmental officers at Kempsey and Port Macquarie Hastings Shire Councils.
Reading
BFNS (n.d.) "BFNS Environmental weeds and native alternatives, Taree to Tweed, A guide to identification control & replacement", Initiative of the NSW North Coast Weeds Advisory Committee [Online] Available from: www.bfns.org.au or your local council or Landcare office.
Nambucca Valley Landcare Inc. "Riverbank Restoration for the Nambucca River Estuary, A Decision Making Guide", available from the Landcare office in Bowraville,. Phone 02 65647838 and Nambucca Shire Council.
Riparian Management: J. & O'Sullivan, J. (2006) "Stock and waterways: a manager's guide". Land & Water Australia, Canberra (Phone: 02 6263 6000/internet: www.rivers.gov.au)
Spearpoint, J. (2006) "Striking the balance: a family's quest for a sustainable future in agriculture", ISBN: 0731305973. Copies of this booklet may be obtained from the Hunter-Central Rivers Catchment Management Authority. Phone: 02 4930 1030.
Websites
Vegetation clearing: www.naturalresources.nsw.gov.au
Wetland management: www.wetlandcare.com.au and
www.naturalresources.nsw.gov.au/care/wetlands
Lessening the impacts-what you can do
Preventing water pollution
What you can do
Reading and Websites
Green Pages Australia is a comprehensive directory of environmental services, businesses, products covering everything imaginable, find it at: www.greenpagesaustralia.com.au or buy it at the newsagency.
Department of Environment and Climate Change (NSW) website (landscaping fact sheet)
www.environment.nsw.gov.au/small_business/landscaping/factsheet8.htm

Total Environment Centre, "Detox your home: easy steps you can take for a safer and healthier home", part of the Safer Solutions project at: www.safersolutions.org.au or Phone: 02 92613437 or visit www.healthyhabitat.com.au for friendly products for your home.

Don't send your garden and food waste to landfill. Department of Environment and Climate Change (NSW) "The easy composting guide, how to start one and how to fix common composting problems". This brochure is available at: www.environment.nsw.gov.au
Worm farming: General information on worm farming is available from local council libraries and newsagents (gardening section) and in Gardening Australia (an ABC publication).
Contacts
Agriculture, Fisheries and Forestry, Department of the Australian Government – DAFF

Responsible for agriculture, fisheries and forestry at the national level.
GPO Box 858, Canberra, ACT, 2601
Agriculture enquiries (02) 62725680
Fisheries enquiries (02) 62725777
Forestry enquiries (02) 62724679
Web site: www.affa.gov.au

Birpai Local Aboriginal Land Council
PO Box 876, Port Macquarie NSW 2444
Phone: 65849066
Fax: 65838172
Email: birpailalc@midcoast.com.au
Services include: Land acquisition, claims and community

Booroongen Djugun Aboriginal Corporation
Aboriginal Community Support Officer
Locked Bag 3, Kempsey NSW 2440
Phone: 65621572
Services include: Accommodation, Cultural Education & Training, Health & Welfare and
Aboriginal Community Support Officer: Birpai, Dunghutti and Thungutti communities
Phone: 65621729
Email: acso@booroongencollege.nsw.edu.au

Bowraville Aboriginal Land Council
Phone: 6564 7812

Bunyah Local Aboriginal Land Council
PO Box 90, Wauchope NSW 2446
Phone: 65853882

Department of Environment and Climate Change (DECC-see National Parks and Wildlife)
Incorporating the EPA

Department of Environment and Climate Change. Natural Resources.
Phone: 02 65614975, fax : 0265614981.
Address: PO Box 6 Kempsey, NSW 2440, The Harrington Building, 41 Belgrave Street Kempsey.

Department of Primary Industries NSW – Fisheries division
Port Macquarie Office
Contact for fisheries and aquaculture
16 Jindalee St, Port Macquarie, 2444
Phone: 6581 4084

Dunghutti Elders Council Aboriginal Corporation
2 John Street, Kempsey, PO Box 179, Kempsey
Phone: 6562 2855

Environment Protection Authority – EPA
Contact for information on the regulations regarding pesticide usage (Pesticides Act 1999) and water pollution. 59 Goulburn St, Sydney, 2000
Information line 131 555
Email: info@environment.nsw.gov.au

Web site: www.epa.nsw.gov.au

Environmental Defender's Office (NSW) Ltd Northern Rivers – EDO
A not-for-profit community legal service specializing in public interest law, assisting individuals and community groups working to protect the natural and built environment. Provides easy to read fact sheets and other publications on environmental law.
10 Club Lane, Lismore NSW 2480
Postal Address: PO Box 212, Lismore NSW 2480
Phone: 1300 369 791
Fax:: 02 6622 6404
Web site: www.edo.org.au/edonsw

To subscribe to their free eBulletin, or for more information on fact sheets, publications, subscriptions or on becoming a member, please contact: edonsw@edo.org.au mailto:edonsw@edo.org.au>.

(Hastings Shire Council)
Port Macquarie-Hastings Shire Council
Community services in the shire are listed by the Port Macquarie Neighbourhood Centre at: www.pmncinfo.org.au/community-directory.htm
Burrawan St. (cnr. Lord St.) Port Macquarie, 2444
Phone: 6581 8111
Email: council@hastings.nsw.gov.au
Web site: www.hastings.nsw.gov.au

Kempsey Local Aboriginal Land Council
PO Box 540 Kempsey NSW 2440
Phone: 65628688

Kempsey Shire Council
Community services available in the shire are listed at: www.kempsey.nsw.gov.au/shireserv.htm
Elbow St. (cnr Tozer St.) West Kempsey, 2440
Phone: 6566 3200
Email: ksc@kempsey.nsw.gov.au

Nambucca Heads Local Aboriginal Land Council
2/3 Sussex Street, PO Box 358, Nambucca Heads NSW 2448
Phone: 65689281
Fax:: 65689161
Email: nhlalc@bigpond.com
Services include: Land acquisition, claims and community housing

Nambucca Shire Council
Princess St, Macksville, 2447
Phone: (02) 6568 2555
Email: council@nambucca.nsw.gov.au
Web site: www.nambucca.nsw.gov.au

National Parks & Wildlife Division – Department of Environment and Climate Change (DECC)
Mid North Coast Regional Office
152 Horton Street, Port Macquarie NSW 2444
Ph: 65868300

Services: Cultural Heritage Officers to assist with identifying whether your land has places of importance to Aboriginal people and how you can manage them.

Ngurrala Aboriginal Corporation
PO Box 62
Macksville NSW 2447
Phone: 6568 4400
Services include: Cultural, Education & Training, Land Councils

Northern Rivers Catchment Management Authority
Aboriginal NRM Facilitator
PO Box 1417, Coffs Harbour NSW 2450
Phone: 6653 0150

Northern Rivers Catchment Management Authority
Regional office-Grafton
49 Victoria Street, Grafton NSW 2460 (PO Box 618)
Phone: 6642 0622
District office-Kempsey
The Harrinton Building, 41 Belgrave Street Kempsey (PO Box 228)
Phone: 6561 4960

NSW Maritime Office
Port Macquarie Office (Mon-Friday, 8.30am-4.30pm, Closed 12.30pm-1pm, Open 2nd Saturday of each month 8.30am-12.30pm)
Shop 1, cnr Uralla and Merrigal Roads, 2444
Phone: 6583 1007
South West Rocks Office
1/1 Livingstone Street, 2431
Phone: 6566 7204

Regional Land Council Office
Suite 7, 2nd Floor
54 Belgrave Street, PO Box 305, Kempsey NSW 2440
Phone: 6562 6395
Fax: 65627322
Service include: Servicing local Aboriginal Land Councils and providing administrative support

Thungutti Local Aboriginal Land Council
c/- Bellbrook Post Office, Bellbrook NSW 2440
Phone: 6567 2050
Fax:: 6567 2169Services include: Land acquisition and claims

Unkya Local Aboriginal Land Council
Suite 7, 17-19 Wallace Street
PO Box 319
Macksville NSW 2447
Phone: 65682786
Fax: 65682610
Email: unkyalalc@tsn.cc
Services include: Land acquisition, claims & Housing for Aboriginal People

Wetland Care Australia

A non-profit organization that aims to improve the value of wetland environments. Contact for information on wetlands and their management; technical advice; guidance on on-ground works; and funding assistance for priority areas. PO Box 114, Ballina NSW 2478
Phone: 6681 6069
Website: www.wetlandcare.com.au

References

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