4. Estuaries

Figure 4.1: Examples of estuaries in NY NRM Region. (A) Point Davenport. (B) Port Pirie River. Photos © J. Baker (A), and Fairv8 at Wikimedia Commons, CC BY-SA 3.0 Licence (B).

Asset	**Estuaries**
Description	Areas around the NY NRM Region where fresh water courses such as rivers and creeks meet the sea via direct drainage, or where coastal inlets and lagoons under tidal influence are periodically flushed with fresh water. Common habitats associated with estuaries include seagrass, subtidal sand/silt, mangroves, saltmarsh and intertidal mud flats.
Examples of Main Species	***Bony Fishes*** • Yellow-eye Mullet and Sea Mullet • juvenile Australian Herring (Tommy Ruff) • Estuary Catfish • Congolli • Black Bream • post-larval and juvenile King George Whiting, juvenile Yellow-fin Whiting, and Silver Whiting • juvenile Southern Sea Garfish Western Striped Grunter • Flathead species e.g. Southern Sand Flathead • Greenback Flounder and several other flounder species • Blue-spotted Goby, Southern Longfin Goby, Tamar River goby, Bridled Goby, Glass Goby, and other goby species • Smallmouth Hardyhead • Oyster Blenny • Weeping Toadfish • Deepbody Pipefish, juvenile Pugnose Pipefish and several other pipefishes

	Invertebrates • diatoms, and foraminifera • snails (e.g. coniwinks and littorinids, mud-creepers, topshells, conical moon snail, whelks, mussels, mud cockles) • bubble shells • bivalves (e.g. tellin shells, mud cockles, mud-lucines, lantern shells) • small grapsid crabs and pebble crabs • amphipods, isopods, tanaids and other small crustaceans • many kinds of polychaete worms, such as bloodworms, mudworms, threadworms, ragworms, tube-dwelling spionid worms, nereidid worms, phyllodocid worms, and others • peanut worms • nematode worms ***Coastal Birds*** • Cormorant species (e.g. Black-faced, Pied) • Tern species (Caspian, Crested, Fairy) • White-faced Heron • Great Egret • Banded Stilt • Oystercatchers (Sooty and Pied) • Migratory shorebird species (e.g. species of plover, sandpiper, knot, and many others) • Eastern Osprey (rarely, in mangroves near estuaries)
Locations	<u>Northern and North-Eastern Spencer Gulf</u> • Winninowie Conservation Park and Chinaman Creek • Port Pirie River and numbered creeks (1 - 7) and Fisherman Creek near Port Pirie, in eastern Spencer Gulf • Port Davis Creek (estuary of the Broughton River) <u>Southern Yorke Peninsula</u> • Point Davenport <u>Northern Gulf St Vincent</u> • Wills Creek / Price area • Wakefield River, Port Wakefield (Clinton wetland) • Light River delta <u>Western Gulf St Vincent</u> • Coobowie / Salt Creek

Description

Estuaries around Yorke Peninsula are varied in size, salinity, bottom type, and flow regime. They include:

- areas of direct fresh water drainage, where creeks and rivers meet the coast - such as Broughton River estuary at Port Davis in Spencer Gulf, and Wills Creek in Gulf St Vincent;
- coastal inlets flushed by tidal waters, with little substantial fresh water flow from the land - such as Chinaman Creek in northern Spencer Gulf, and some of the Port Pirie Creeks;
- Point Davenport, a stranded, semi-enclosed salt water lagoon, diluted periodically by fresh water.

Common habitats associated with estuaries of the NY NRM region include seagrass, subtidal sand/silt, mangroves, saltmarsh and intertidal sand flats and mud flats.

Ecological Significance of Estuaries

Estuaries are an important nearshore ecosystem, which link terrestrial, freshwater, and marine environments, and they are rich in life. Estuaries are unstable, regularly changing environments which often contain a gradient of salt-tolerant plants and animals. These range from marine species at the mouth, through to estuarine species in the central area (comprising species which can tolerate both saltier and fresher water), and mainly fresh water species upstream, which can withstand occasional periods of higher salinity (Edgar 2001). Some of the truly estuarine species have adaptations which enable them to maintain a particular salt balance, regardless of the amount of salt water inflow from the sea, and fresh water inundation during periods of heavy river flow. Other species adapt to the changing conditions by moving upstream or downstream, depending on whether they are essentially a fresh water or marine animal.

The floor of estuaries is often sandy or muddy, and support fine seagrasses such as *Zostera*. The ecological values of seagrass are discussed in separate chapters of this report. Estuaries around Yorke Peninsula are often associated with surrounding mangrove forests, mudflats and sandflats around tidal channels and on floodplains, and samphires in landward areas further from the estuary. Estuaries are highly productive systems, and those which do not receive substantial inflow of fresh water may have input of mangrove plant material from adjacent habitats. The ecological significance of mangroves, sandflats / mudflats, and samphires are discussed in more detail in other chapters of this report, but one major role is the trapping and binding of sediment and detritus, which builds up the coastline and protects the estuarine system from wave energy and consequent erosion. These areas are also breeding grounds and feeding habitat for fish, birds and invertebrates. From the land side, mangroves soak up and filter fresh water run-off, including water polluted with sediments and chemicals, and thus help to maintain the physical and chemical quality of nearshore marine waters. The samphire marshes adjacent to estuaries provide organic matter to the estuary food chain, and also filter sediment from land-based runoff (Favier et al. 2014). The samphires are influenced periodically by tidal inundation, but also by very occasional river flooding, which brings nutrients, organic matter and silt from the river catchment upstream.

Seasonally, regular or irregular fresh water flows connect the few rivers on Yorke Peninsula to their estuaries, and these flows transport sediment, nutrients and organic matter. The sediment helps to maintain the mudflats that support the mangrove forests adjacent to a number of estuaries on Yorke Peninsula, such as Broughton River estuary (Port Davis Creek), and Wills Creek. The nutrients and organic matter provide a significant food source for estuarine plants and animals. Some estuarine species are adapted to the higher turbidity of estuarine areas due to periods of sediment input (e.g. during after winter rain periods), and others avoid the estuary during such periods of high inflow.

The invertebrates of estuaries have important ecological roles. Filter-feeding / suspension-feeding animals help to keep the water clear, by taking in micro-algae and suspended sediments. They also help to regulate the deposition and storage of nutrients in the estuarine system (Edgar 2001). Both planktonic and benthic invertebrates in estuaries are also important food sources for larger animals such as fish. Some invertebrates maintain their position high in the water column and swim upstream on the incoming tide, and then move back down into calmer water near the estuary floor during the ebbing tide. Invertebrates both in the water column and near the floor of estuaries need to cope not only with changes in the strength of flow, but also with changes in salinity. Those on the floor are also subjected to periodic covering with sediment loads, and many such animals have developed self-cleaning mechanisms to avoid being smothered. The floor of estuaries provides habitats for an abundance of invertebrates which live in the organic-rich mud. Small gastropod and bivalve shells, abundant polychaete worms (including tube worms and blood worms), sea lice and other small crustaceans, insects (including larvae) and other small animals in estuarine systems have are food sources for fishes and some bird species, and they are also important in nutrient recycling, and the maintenance of estuarine health.

Estuaries provided protected environments for larval and juvenile fishes (including recreationally and commercially significant species), as well as larger crustaceans, such as some crab species. The warm, shallow waters of estuaries and the abundant invertebrate food sources promote growth of the young fishes ("fry" or "whitebait"), and the estuarine environment also protects these fishes from larger predators, and from adverse oceanographic conditions which they would experience in open waters. Some of the fishes and crustaceans which use estuaries as nursery areas provide important food sources for the local bird fauna.

Large numbers of birds and crabs feed on the invertebrates and young juvenile fishes in the shallow estuarine waters, and also the adjacent mudflats, sandflats and mangroves. Invertebrates, fishes and birds of the NY NRM region's estuaries are discussed in more detail in separate sections below.

Estuary Distribution in NY NRM Region

There are few estuaries around Yorke Peninsula. The estuaries of the NY NRM Region are low flowing systems, some of which dry up in summer. There are no substantial river systems on Yorke Peninsula, and thus there are no substantial floodplains in NY NRM which are regularly flooded with fresh water outflows.

At the top of Spencer Gulf, the Port Augusta "inverse estuary" complex has no fresh water input from rivers or creeks. Furthermore, rainfall at Port Augusta is reported to be around 236 mm per year, which is less than 10% of the "pan" evaporation rate of 2507 mm annually. Overall, there is no fluvial input of fresh water to upper Spencer Gulf at any time (Gostin et al. 1984, cited by Harris and O'Brien 1998), and thus this highly saline estuarine system is not discussed here, because it does not fit with the concept of estuaries as discussed in this report.

The estuaries of NY NRM region are often associated with mudflats or sandflats, tidal channels, mangrove forests, and landward saltmarsh, the latter of which is less regularly inundated by the tide. These habitats are discussed in more detail in separate chapters of this report.

Estuarine systems in NY NRM region which have some freshwater input from land catchment area and/or groundwater systems include:

- part of far northern Spencer Gulf, including Chinaman Creek in Winninowie Conservation Park on the north-eastern side of Spencer Gulf;
- Port Pirie River and the adjacent numbered creeks (1 - 7), and Fisherman Creek near Port Pirie;
- Port Davis Creek / Broughton River estuary (rarely has fresh water input, during periods of mid and high flow); and
- Wakefield River (NB usually dries up in summer) and Light River in north-eastern Gulf St Vincent.

Further south of Port Davis, Fisherman Bay at Port Broughton contains a number of large, shallow, tidal inlets indenting the coast, but since this area has no significant fresh water input into the bay, Fisherman Bay is not discussed here as an estuary. South of Port Broughton, there are no estuaries with fresh water input along the western side of Yorke Peninsula, but there is a unique stranded lagoon on the south coast of the peninsula, at Point Davenport. Further east, near the "heel" of Yorke Peninsula is Salt Creek at Coobowie, in western Gulf St Vincent. As is the case on the western side of Yorke Peninsula, there are few fresh water inputs on the eastern side, and the Wills Creek and Shag Creek system at Price is the only estuary of note. At the eastern edge of the NY NRM region, are the Wakefield River at Port Wakefield, and the Light River delta. These rivers drain catchment areas in the mid-north of SA, and both rivers open into Gulf St Vincent at their mouths.

The estuaries of NY NRM region are discussed in more detail below, from north to south, and then east to Gulf St Vincent.

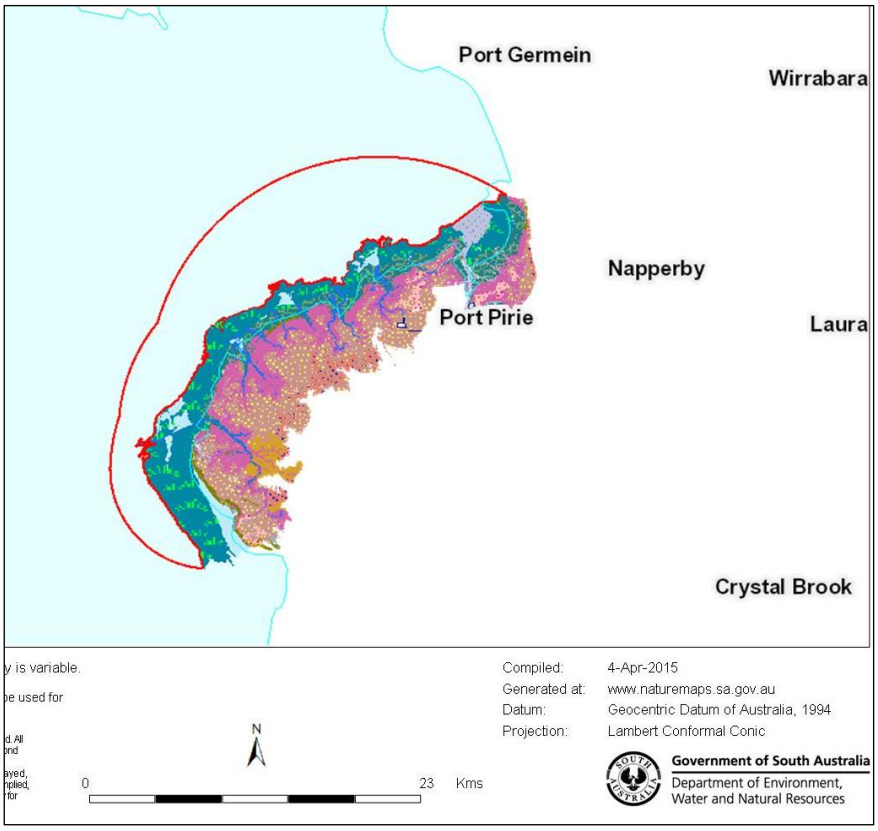
In northern Spencer Gulf, the Redcliff Point to Yatala Harbour area (which includes Winninowie Conservation Park - see below) includes substantial areas of samphire saltmarsh; sandflats both above and between the tides; intertidal mangroves on mudflats, and tidal creeks. Tidal inundation occurs over the low-lying samphires twice daily, while high areas are flooded several times per fortnight (Reilly 1991, cited by DEH 2000). Mangrove forests border the shorelines and tidal channels on the intertidal mud and sand flats. The area of mangroves is intersected by over 60km of tidal creeks, and Chinaman Creek is the largest tidal creek in the reserve (DEH 2000, cited by Baker 2004).

Winninowie Conservation Park includes 28km of the north-eastern Spencer Gulf coastline, and most of the reserve is low-lying coastal plain. The reserve is characterised by a system of tidal creeks, bordered by mangrove forest extending into low lying temporary lakes (playas) and samphire communities (DEH 2000).

Between Winninowie and Port Germein, Mambray Creek meets the coast north-west of Baroota. The Baroota Reservoir has restricted flow of the Mambray Creek to the coast (Deane et al. 2005), and the estuary no longer functions as such.

The coastal section from Germein Bay down to Point Jarrold / Port Davis area comprises an extensive network of tidal creeks (**Map 4.1**). This includes Deep Creek, Port Davis Creek, Fisherman Creek, Seventh, Sixth, Fifth, Fourth, Third, Second and First Creeks (some backed by swamplands), and Port Pirie River. The major habitats include sandflats, mudflats, tidal saltmarsh, extensive mangrove areas, and shallow subtidal seagrass. At Port Davis Creek, Third Creek, Second Creek and First Creek, more than 75% of the original catchment area has been cleared, and an assessment as part of the National Land and Water Resources Audit classified all of these creeks as severely modified (Bucher and Saenger 1989; Barnett 2001). Fisherman Creek and Port Pirie River have also been classified as severely modified estuaries (Barnett 2001).

The Broughton River estuary, known as Port Davis Creek (near Port Davis), comprises mangrove-fringed channels bordered by saline coastal flats under tidal influence. This is a shallow, depositional environment where sediment accumulates (Favier et al. 2004). There is seagrass in the tidal channels, and samphires such as species of *Halosarcia* and *Sarcocornia* on the tidal flats. The Broughton River is connected to its estuary by periods of moderate flow. Under "base flow" conditions, there is no connection. Very occasionally, periods of high flow after significant rains transport sediment and larger volumes of water to the estuary. Only during large flows (which occur very infrequently), does the Broughton River flood onto the low-lying samphire marshes, and discharge through the numerous tidal streams along the coast (Favier et al. 2004).



Map 4.1. Mapped estuarine extent of the Port Pirie and Port Davis area. Map © DEWNR.

Further south along the western side of Yorke Peninsula through to Hardwicke Bay and the "toes" of Yorke Peninsula, there are no freshwater inputs to the coast that are large enough to be classified as estuaries. However, along the southern foot of Yorke Peninsula, facing Investigator Strait, is the rare example of a stranded lagoon - Point Davenport (**Figure 4.3**). This semi-stranded lagoon enters the sea through a tidal inlet that changes shape over short time scales due to the mobile sand spit which separates the lagoon from the sea. Surrounding the tidal lagoon and its billabongs are low, emerging dunes (with open heath vegetation) in some areas, and tidal samphire flats (see chapter on **Saltmarsh and Samphire**). The lagoon of Point Davenport is inundated during extreme high tides, usually once or twice a year). Point Davenport supports stands of Swamp Paperbark *Melaleuca halmaturorum* in low-lying areas, and this open scrubland is not conserved to such an extent in any other Yorke Peninsula location (Morelli and de Jong 1995).

Figure 4.3. Point Davenport estuary, a stranded lagoon system on southern Yorke Peninsula (A); the shallow waters and floor of Point Davenport (B). Photos © J. Baker.

In south-western Gulf St Vincent is the Coobowie Inlet, around 3km long and more than 1km wide, and this is connected to Coobowie Bay by a narrow channel under the Coobowie / Edithburgh coast road (NY NRM 2009). During the mid 2000s, culverts were made under the road to allow for greater exchange of water between the bay and the wetland system associated with the creek, and to help restore the condition of the estuary. The wetland extends west and south-west of the causeway, and is known as Salt Swamp Creek, or Salt Swamp Creek lagoon. In 2014 - 15, the micro-biota (such as protozoa) of Salt Swamp Creek and also Point Davenport (see previous paragraph) were being researched by biologist J.M. Douglas.

Further north from Salt Creek, on the eastern side of Yorke Peninsula, the natural freshwater wells in the beach sand at Tiddy Widdy (located between Ardrossan and Mangrove Point), and James Well are two sources in a region where fresh water near the coast is rare.

On the north-western side of Gulf St Vincent is the estuary near Price, consisting of tidal creeks Wills Creek and Shag Creek, which form shallow estuaries at Mangrove Point (**Figure 4.4**). The Price area consists of saltmarsh both above and between the tide line (with large expanses of samphire in some areas), with associated sand flats / mudflats; intertidal mangroves, and shallow subtidal seagrasses. There are salt evaporation fields adjoining the system, which have ecological significance for wading birds (see section below, on **Coastal Bird Species in Estuarine Areas,** and chapter on **Saltmarsh** and **Samphire**). Mangrove forests up to 1km wide line the sides of Price Creek, and continue along the surrounding coast in a band about 200m wide, up to the head of Gulf St Vincent and around to the eastern side, where the mangrove cover widens. Adjacent to the mangrove fringe, a zone of occasional inundation supports a samphire low shrubland of several species (see chapter on **Saltmarsh and Samphire**). The system at Price is dissected by numerous small tidal channels, which provide effective drainage when the tide recedes. The floor of the estuary is composed of dark, organic-rich muds. Much of the area lies below high tide level, and is therefore subjected to daily inundation (Seager, unpublished, cited by Morelli and de Jong 1995). There is a large sand spit where the creek system meets Gulf St Vincent. North of Mangrove Point, the tidal channels are lined with seagrass.

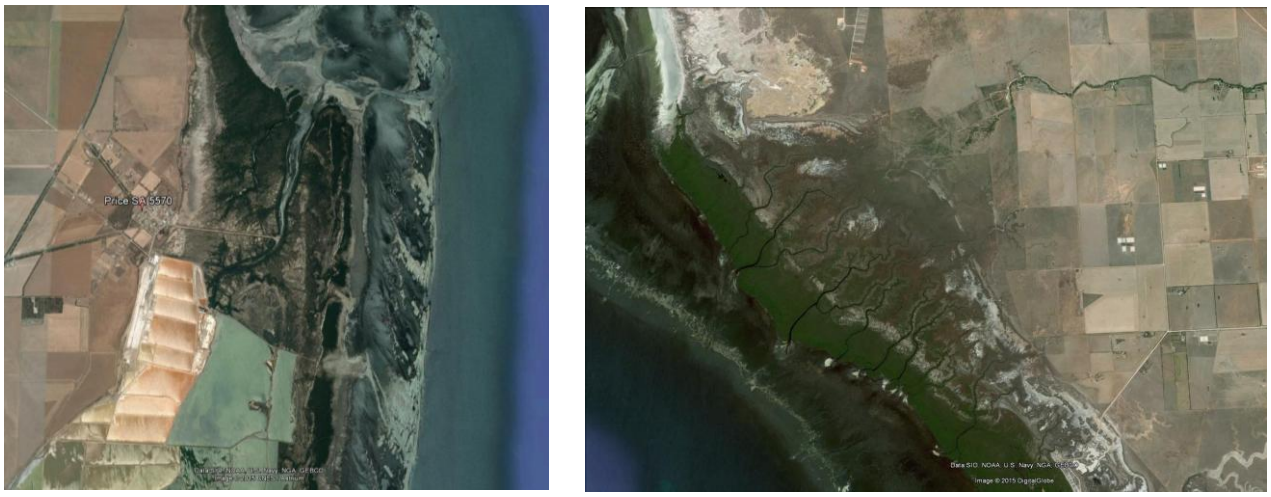


Figure 4.4. Estuarine area at Price, western Gulf St Vincent (A); Light River delta, NE Gulf St Vincent (B). Maps © Google Earth.

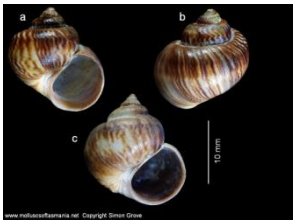
On the north-eastern side of northern Gulf St Vincent, the River Wakefield and the Light River are the major drainage channels in the area, and also the major input of fresh water into the tidal flat system of far northern GSV. At the Wakefield River estuary, water enters the coast from the northern extension of the Mt Lofty Ranges and the Mt Templeton highland (Morelli and de Jong 1995), including 6 creeks. Groundwater also contributes to the river's flow, but in far lesser amount now than prior to European settlement, due to water extraction in the Clare Valley / Mid North area (Favier et al. 2000). There are stranded shell and sand beach ridge deposits in the area above the water line. The hinterland consists of alluvial fan deposits (i.e. a build-up of sediments caused by streams), incised with small creek gullies. These creeks either fan out onto the tidal flats, depositing red clay loam and gravel on the surface, or continue across to the sea. Along the estuarine section of the Wakefield River, bank erosion, degradation of native riverbank vegetation, and reduced flow are significant issues (see Favier et al. 2000).

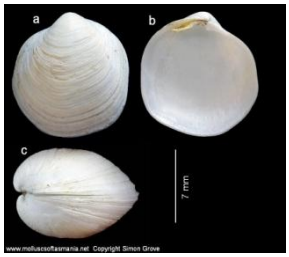
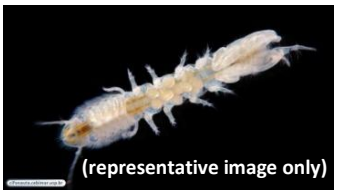
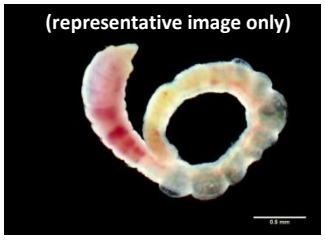
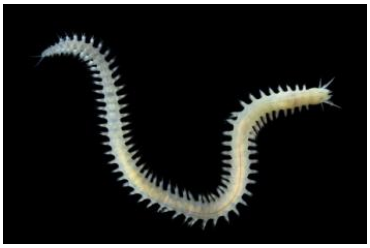
Above the tidal area, stranded samphire at the head of the gulf extends up to 5km inland on the north-eastern side, and is discussed in the chapter on **Saltmarsh and Samphire**. Near the south-eastern edge of the NY NRM region, the Light River delta contains numerous small drainage channels through the near pristine mangrove area, which is up to 1.7km wide in places. The mangroves are backed by intertidal saltmarsh (between around 500m and 1.8 km wide), and saltmarsh above the tide line extends more than 1km inland (DEH data, in DTUP 2003). In the Middle Beach / Light River area, mangrove forests are fronted by sandflats and mudflats, at the southern edge of the NY NRM region. The vulnerable Bead Samphire *Tecticornia flabelliformis*, listed under both South Australian and national legislation as a vulnerable species, occurs around the Light River Delta and Wakefield River estuary (NY NRM 2009).

Marine Invertebrates in Estuaries

Some invertebrates (e.g. polychaete worms) live on in the mud, sand, rocks or seagrass of estuaries, and others (such as small planktonic crustaceans) live in the water column. There are several types of feeding groups, namely deposit-feeders (which take in food with the sediments of the estuary floor), filter-feeders (which filter food particles out of the water column), grazers (which eat films of algae on rocks, or chew through larger algae) and predators (which eat other invertebrates). The distribution and abundance of invertebrates in estuaries is influenced by many physical variables such as water temperature, depth, dissolved oxygen concentrations, pH (i.e. acidity / alkalinity), salinity, and the grain size and organic content of the sediment. Biological factors may also affect the estuarine composition over time too, due to predation and competition (Edgar 2001). There can also be obvious seasonal differences in the invertebrate composition of estuaries, for example after heavy winter rains, and during dry summers. At larger time scales, estuaries can change in their invertebrate composition and abundance, due to influences such as organic enrichment from run-off. This stimulates algal growth and organic detritus, which, upon breaking down, can deoxygenate the water and sediments. This can eventually lead to an increase in opportunistic species which can tolerate low oxygen conditions - such as nematode worms, some polychaetes, and small bivalve shells - and a loss of mobile species which require higher oxygen content to survive (Nielson and Jernakoff 1996). Some of the common invertebrates in estuaries of the NY NRM region include snails, nudibranchs, crabs, small planktonic crustaceans such as copepods, and numerous types of worms. Examples are shown in **Table 4.1** below.

Table 4.1: Some of the invertebrate species which are found in estuaries of the NY NRM region (Hutchings et al. 1993; Morelli and de Jong 1995; Baker 2004 and references therein). ***Note: Photos are labelled "representative image only" when an image of that species is not available. These are included as examples of animals in that family (or genus where possible), and may include species from countries other than Australia.***

Common Name and Latin Name	**Representative Image**	**Common Name and Latin Name**	**Representative Image**
Diatoms, and Foraminifera	**(representative image only)**  **© L. Altoff, MRG**	Snails e.g. *Phallomedusa* (previously *Salinator) solida* and *P. fragilis*	 **© S. Grove www.molluscsoftasmania.net**
Estuarine Conniwink *Bembicium auratum* and other small littorinid snails	 **© D. Beechey www.seashellsofnsw.org.au**	Topshells e.g. *Austrocochlea constricta*	 **© D. Beechey www.seashellsofnsw.org.au**
Conical Moon Snail *Polinices conicus*	 **© National Library of Australia. Image by Dr. I. Bennett**	Impoverished Whelk *Nassarius pauperatus*	 **© T. Alexander www.ausmarinverts.net**
Southern Creeper *Zeacumantus diemenensis*	 **© www.idscaro.net CC Licence**	Bubble shells, such as *Bulla quoyii,* and species in *Retusa*	 **Image: J. Delsing @ Wikimedia Commons**
Tellin shells *e.g. Tellina margaritina / Merisca margaritina*	 **© D. Staples, Museum Victoria. CC Licence**	Mud Cockle *Katelysia* species	 **© D. Staples, Museum Victoria. CC Licence**

Common Name and Latin Name	**Representative Image**	**Common Name and Latin Name**	**Representative Image**
Common Mud-Lucine *Wallucina assimilis*	 **© S. Grove www.molluscsoftasmania.net**	Crecina Lantern Shell *Laternula creccina*	 **© L. Altoff, MRG**
Pebble crabs, such as *Bellidilia laevis*	 **© K. Davey. Image from: Department of the Environment's Species Bank**	*Helograpsus haswellianus* and other small grapsid crabs, such as *Brachynotus spinosus*	 **© M. Breitfuss. Image from www.ozcoasts.gov.au**
amphipods, including a species in *Cymadusa* and *Waldeckia*	 **© Nova Southeastern University**	isopods (such as *Platynympha longicaudata*, and species in genus *Cymodoce*, amongst others)	 **© M. Marmach, Museum Victoria**
tanaid crustaceans	 **© A. Migotto, Cifonauta http://cifonauta.cebimar.usp.br**	Bloodworms in Glyceridae, such as *Glycera* species	 **© NOAH NERR Collection 1995**
Threadworms e.g. *Capitella* sp.	 **© Dr S. Mills @ Flickr CC Attribution Share-Alike 2,0 licence**	Ragworms, such as *Neanthes vaalii*	 **© L. Altoff, MRG**

Common Name and Latin Name	Representative Image	Common Name and Latin Name	Representative Image
Orbiniidae worms (deposit-feeding worms), such *Scoloplos normalis* and *S. simplex*	 **© H. Hillewaert. CC Attribution Share-Alike 4.0 licence**	Tube-dwelling "polydorid" / spionid worms, such as *Pseudopolydora* species	 **© T. Goodman CC licence http://bcbiodiversity.lifedesks.org/sites/all/modules/creativecommons_lite/images/buttons_small/by-nc-sa.png**
Eunicidae mudworms and bloodworms, such as *Marphysa* species	 **© H. Hillewaert. CC Attribution Share-Alike 4.0 licence**	Other polychaete worms, such as nereidids (e.g. *Ceratonereis* species) and phyllodocids (e.g. *Nephtys* species)	 **© 2010 Moorea Biocode**
peanut worms (sipunculids)	 **© K. Puxley**	Nematode worms	 **A. Smyth, Smithsonian TRI http://biogeodb.stri.si.edu/bioinformatics/**

Fishes in Estuarine Habitats

A number of fish species utilise the shallow estuaries of the NY NRM region as nursery habitats, and others spend their entire life in such habitat, feeding and sheltering. **Table 4.2** depicts some of those species, which range from the post-larvae and juveniles of commercially and recreationally significant species such as King George Whiting (e.g. Salt Creek / Coobowie) and Yellow-fin Whiting, through to estuarine residents such as Black Bream, and gobies. Populations of fresh water fishes (such as Common Galaxias *Galaxias maculatus*) which require periods of high flow to connect river to estuaries in order to complete their breeding cycle, do not thrive on Yorke Peninsula, due to the periodic lack of fresh water input. Sea fishes such as species of mullet and whiting can tolerate the reduced salinity levels of estuary mouths, but do not penetrate far upstream. On the floor of estuaries around the NY NRM region, several species of flathead and flounder (such as Greenback) occur, as well as Estuary Catfish, various species of goby (see **Table 4.2** below), Oyster Blenny, and several pipefish species. On the western side of Yorke Peninsula, fish species found in the Broughton River estuary include estuarine species such as Yellow-eyed mullet and Hardyhead, as well as Congolli and Bluespot Goby (Hicks and Sheldon 1999). Congolli is found in both freshwater and estuarine habitats, as well as nearshore marine waters, but reaches highest adult abundance at the interface of fresh and salt water (Hammer et al. 2008). Congolli migrate from fresh water to estuarine waters to spawn (Allen 1989). Bluespot gobies are found in sandy and muddy areas of estuaries and coastal lagoons, and breed in less saline parts of estuaries (Gomon et al. 2008). On the eastern side of Yorke Peninsula, the large tidal creek system of Wills Creek forms a nursery area for various fish species, including whiting and a number of other commercially and recreationally significant fishes. There are few very sharks and rays in South Australia which enter estuarine areas, but the Southern Fiddler Ray *Trygonorrhina dumerilii* is one which has been recorded occasionally in estuaries of Yorke Peninsula.

Table 4.2: Fish species which are associated with estuaries of the NY NRM region (from Jones et al. 1990; Morelli and de Jong 1995; Hicks and Sheldon 1998; Baker 2004, 2014; Gillanders et al. 2008).

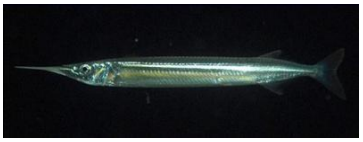
Common Name and Latin Name	Representative Image	Common Name and Latin Name	Representative Image
Congolli *Pseudaphritis urvillii*	 © Australian National Fish Collection CSIRO	Yellow-eye Mullet *Aldrichetta forsteri*	 © Auckland Council
Sea Mullet *Mugil cephalus* and/or Jumping Mullet / Flat-tail Mullet *Liza argentea*	 © FAO of the United Nations	juvenile Australian Herring (Tommy Ruff) *Arripis georgianus*	 © R. Stuart-Smith, RLS
Estuary Catfish *Cnidoglanis macrocephalus*	 © R. Ling, Flickr. CC Licence	Black Bream *Acanopagrus butcheri*	 © S. Speight, CC Licence
post-larval and juvenile King George Whiting *Sillaginodes punctatus*	 © Reef Life Survey	juvenile Yellow-fin Whiting *Sillago schomburgkii*	 © D. Muirhead
Silver Whiting *Sillago bassensis*	 © Australian National Fish Collection CSIRO	Blue-spotted Goatfish / Red "Mullet" *Upeneichthys vlamingii*	 © J. Finn, Museum Victoria
juvenile Southern Sea Garfish *Hyporhamphus melanochir*	 © D. Muirhead	Western Striped Grunter *Pelates octolineatus*	 © R. Stuart-Smith, RLS

Table 4.2 (continued):

Common Name and Latin Name	Representative Image	Common Name and Latin Name	Representative Image
Flathead species e.g. Southern Sand Flathead *Platycephalus bassensis* and other species	 © S. Speight, CC licence	Greenback Flounder *Rhombosolea tapirina* and several other flounder species	 © R. Stuart-Smith, Reef Life Survey
Blue-spotted Goby *Pseudogobius olorum*	 © Aquaculture Council of WA	Southern Longfin Goby *Favonigobius lateralis;* Tamar River Goby *Afurcagobius tamarensis;* Bridled Goby *Arenigobius bifrenatus*, & other gobies	 © A. Green, Reef Life Survey
Glass Goby *Gobiopterus semivestitus*	 © R. Kuiter, Aquatic Photographics	Smallmouth Hardyhead *Atherinosoma microstoma*	 © D. Muirhead
Oyster Blenny *Omobranchus anolius*	 © D. Muirhead	Weeping Toadfish / Common Blowfish / "Blowie" *Torquigener pleurogramma*	 © D. Muirhead
Deepbody Pipefish *Kaupus costatus*	 © D. Muirhead	juvenile Pugnose Pipefish *Pugnaso curtirostris*	 © D. Muirhead

Coastal Bird Species in Estuarine Areas

The few estuaries which occur on Yorke Peninsula provide significant feeding and/or breeding/roosting habitat for a number of coastal bird species, including species of regional and State significance, and species listed under international treaties for migratory birds. This includes JAMBA and/or CAMBA (NPWS 1995; DEH 2009; Commonwealth Department of the Environment 2014), and the Convention on the Conservation of Migratory Species of Wild Animals (known as the Bonn Convention) (UPEP / CMS 2013). The JAMBA and CAMBA international agreements relating to conservation of migratory birds, were formed between Australia and the Government of Japan in 1974, and the People's Republic of China in 1986. The JAMBA and CAMBA agreements include bird species which migrate between Australia and the respective countries. Amongst other agreements, both parties agree to protect and conserve important habitats for shorebirds. The JAMBA agreement also includes provisions for cooperation on the conservation of threatened birds (Commonwealth Department of the Environment 2014). Another international agreement, ROKAMBA, was formed between Australia and the Republic of Korea in 2007. The table below (**Table 4.3**) lists and depicts some of the bird species which utilise estuaries around Yorke Peninsula and the northern part of both gulfs, within the NY NRM region.

In the northern and north-eastern part of Spencer Gulf, near the northern edge of the NY NRM region, the estuarine areas of Chinaman Creek (Winninowie Conservation Park), the Port Pirie Creeks and Port Davis collectively comprise habitat for a large number (around 67) of waterbird species recorded, of which 19 are listed under international migratory bird treaties such as JAMBA, CAMBA and/or ROKAMBA. Examples of birds for which the northern Spencer Gulf wetlands are a migration stop-over include Marsh Sandpiper, Red-necked Stint, Red Knot, Sanderling, Grey Plover, Pacific Golden Plover, Grey-tailed Tattler, Bar-tailed Godwit and Ruddy Turnstone. Some of the coastal bird species in the area are listed under the *National Parks and Wildlife Act* as threatened species, and these include Hooded Plover, White-bellied Sea-Eagle, Osprey, Little Egret, Eastern Curlew, Fairy Tern, Slender- billed Thornbill, Eastern Reef Egret, Spotted Crake, and Australasian Shoveler. Some of the most abundant waterbirds which have been recorded in the northern Spencer Gulf estuarine area include Black-faced and Pied cormorants, and Red-capped Plover. It is noted that in 1992, a single bird of the endangered Orange-bellied Parrot *Neophema chrysogaster* was sighted on several occasions by SAOA / Birds SA observers, at Chinaman Creek amongst a flock of Blue-winged Parrots *N. chrysostoma* and several Rock Parrots *N. petrophila* (Klau and Langdon 1992). At the time, this finding was recorded as a significant extension of range for the species (Morelli and de Jong 1995), but is now considered to be vagrant example of this species, known mainly from south-eastern Australia (ALA 2014; Department of the Environment 2015).

Along the south coast of Yorke Peninsula, the Point Davenport estuary provides habitat for a number of threatened bird species listed under the *National Parks and Wildlife Act*, such as Hooded Plover, Latham's Snipe, Musk Duck, Eastern Curlew and Fairy Tern Sterna (Allen et al. 1982, cited by Morelli and de Jong 1995). It is also a stop-over point for migratory birds listed under international treaties, including Common Greenshank, Ruddy Turnstone, Eastern Curlew, Pectoral Sandpiper, Sharp-tailed Sandpiper, Curlew Sandpiper, Red-necked Stint, Latham's Snipe, and Pacific Golden Plover. In some years, the estuary supports hundreds of Chestnut Teal, Ruddy Turnstone, Sharp-tailed Sandpiper, Red-necked Stint, and Curlew Sandpiper.

Wills Creek / Shag Creek estuary at Price provides habitat for migratory wading birds, and is also a major site of breeding activity for 4 cormorant species (Morelli and de Jong 1995, and references therein), and two species of tern also breed in the area. A number of listed threatened species have been recorded in the area, including Musk Duck, and Slender-billed Thornbill *Acanthiza iredalei rosinae*. The latter species is discussed in more detail in the chapters on **Mangroves**, and **Saltmarsh and Samphire**. Previously, 49 waterbird species were recorded in the Wills Creek area, and 18 of these are listed under international treaties (Morelli and de Jong 1995). Common birds which utilise the estuarine area include Australian Pelican, Sooty Oystercatcher, Crested Tern, 4 species of cormorant (Great, Little Black, Pied and Little Pied), White-faced Heron and Great Egret. Hundreds of breeding pairs of Pied Cormorant occur in the Shag Creek area, and at Mangrove Point. Numbers of bird species on the Price salt fields are discussed in chapter of this report, on **Saltmarsh with Samphire**. Purnell et al. (2012 and 12013) provided figures for counts of birds in the area.

On the other side of northern Gulf St Vincent, the Wakefield River estuary and the Light River delta both support coastal birds, including migratory species. Example of bird species counted in recent years at Light Beach near the Light River estuary and delta include Banded Stilt, Red-necked Stint, Common Greenshank, Eastern Curlew, Sharp-tailed Sandpiper, Pied Oystercatcher, Red-capped Plover, and Grey Plover (Purnell et al. 2012, 2013). Red-necked Stints and Red-capped Plovers roost along the sandy shore of Light Beach, and Eastern Curlews roost on the tide line (Purnell et al. 2013).

Table 4.3: Some examples of bird species which utilise estuarine habitats in NY NRM Region (Close and McCrie 1986; Morelli and de jong 1995; Baker 2004 and references therein; Birdlife Australia records, cited in ALA 2015; Purnell et al. 20012, 2013).

Common Name and Latin Name	**Common Name and Latin Name**
Australian Pelican *Pelecanus conspicillatus*  **© G. Penaluna, CC Licence**	Australasian Gannet *Morus serrator*  **© Matt Binns, CC Attribution 2.0 Generic Licence**
Great Cormorant *Phalacrocorax carbo*  **©D. Daniels (http://carolinabirds.org/), CC Licence**	Little Black Cormorant *Phalacrocorax sulcirostris*  **©D. Daniels (http://carolinabirds.org/), CC Licence**
Black-faced Cormorant *Phalacrocorax fuscescens*  **© J.J. Harrison, CC Licence**	Pied Cormorant *Phalacrocorax varius* and Little Pied Cormorant *Phalacrocorax melanoleucos* (= *Microcarbo melanoleucos*)  **© G. Fergus, CC Licence**  **© C. Liber, CC Licence**

Table 4.3 (continued):

Common Name and Latin Name	Common Name and Latin Name
Fairy Tern *Sterna nereis* (*Endangered*, under *NPW Act* in SA).  **© J.J. Harrison, CC Licence**	Crested Tern *Thalasseus bergii* (JAMBA)  **© G. Fergus, CC Licence**
Caspian Tern *Hydroprogne caspia* (= *Sterna caspia*) (JAMBA and CAMBA)  **© Mdf at Wikimedia Commons. CC Licence**	Pacific Gull *Larus* (*Larus*) *pacificus*  **© J.J. Harrison, CC Licence**
Sooty Oystercatcher *Haematopus fuliginosus* (*Rare*, under the *NPW Act* in SA)  **© J.J. Harrison, CC Licence**	Pied Oystercatcher *Haematopus longirostris* (*Rare*, under *NPW Act* in SA)  **© J.J. Harrison, CC Licence**
White-faced Heron *Egretta novaehollandiae*  **© G. Fergus, CC Licence**	Great Egret *Ardea modesta* (*Ardea alba*) (Bonn, CAMBA, and JAMBA)  **© J.J. Harrison, CC Licence**

Table 4.3 (continued):

Common Name and Latin Name	Common Name and Latin Name
Glossy Ibis *Plegadis falcinellus* (Bonn, CAMBA; *Rare* under *NPW Act* in SA)  **© J.M. Garg, GNU Free Documentation Licence**	Whimbrel *Numenius phaeopus* (Bonn, CAMBA, JAMBA, ROKAMBA; *Rare*, under *NPW Act* in SA)  **© Aviceda, CC Licence**
Hooded Plover *Thinornis rubricollis* (*Vulnerable*, under *NPW Act* in SA)  **© J.J. Harrison, CC Licence**	Red-capped Plover *Charadrius ruficapillus*  **© J.J. Harrison, CC Licence**
Grey Plover *Pluvialis squatarola* (Bonn, CAMBA, JAMBA)  **© G. Buissart, CC Licence**	Pacific Golden Plover *Pluvialis fulva* (Bonn, CAMBA, JAMBA, ROKAMBA; Rare, under *NPW Act* in SA)  **© J.J. Harrison, CC Licence**
Double-banded Plover *Charadrius bicinctus* (Listed under Bonn)  **© J.J. Harrison, CC Licence**	Ruddy Turnstone *Arenaria interpres* (Listed under Bonn, CAMBA, JAMBA, ROKAMBA) (Listed as Rare, under the *NPW Act* in SA)  **© A. Trepte, CC Licence**

Table 4.3 (continued):

Common Name and Latin Name	Common Name and Latin Name
Grey-tailed Tattler *Tringa brevipes* (Bonn, CAMBA, JAMBA, ROKAMBA; *Rare*, under *NPW Act* in SA)  **© J.J. Harrison, CC Licence**	Common Greenshank *Tringa nebularia* (Bonn, CAMBA, JAMBA, ROKAMBA)  **© A. Trepte, CC Licence**
Marsh Sandpiper *Tringa stagnatilis* (Bonn, CAMBA, JAMBA, ROKAMBA)  **© Alnus, CC Licence**	Eastern Curlew *Numenius madagascariensis* (Bonn, CAMBA, JAMBA, ROKAMBA)  **© D. Daniels (http://carolinabirds.org/), CC Licence**
Red-necked Stint *Calidris ruficollis* (Bonn, CAMBA, JAMBA ,and ROKAMBA)  **© J.J. Harrison, CC Licence**	Sharp-tailed Sandpiper *Calidris acuminata* (Bonn Convention, CAMBA, JAMBA, ROKAMBA)  **© Alnus, CC Licence**
Sanderling *Calidris alba* (Bonn, CAMBA, JAMBA, ROKAMBA; *Rare*, under *NPW Act* in SA)  **© I. Sévi @ Wikimedia Commons**	Curlew Sandpiper *Calidris ferruginea* (Bonn, CAMBA, JAMBA, ROKAMBA)  **© J.J. Harrison, CC Licence**

Table 4.3 (continued):

Common Name and Latin Name	Common Name and Latin Name
Red Knot *Calidris canutus* (Bonn, CAMBA, JAMBA, ROKAMBA)  **© J.J. Harrison, CC Licence**	Banded Stilt *Cladorhynchus leucocephalus* (*Vulnerable*, under *NPW Act* in SA)  **© C. Liber, CC Licence**
Masked Lapwing *Vanellus miles*  **© J.J. Harrison, GNU Free Documentation Licence**	Australian Spotted Crake *Porzanza fluminea*  **© Frankzed, CC Attribution 2.0 Generic licence**
Latham's Snipe *Gallinago hardwickii* (*Rare*, under the *NPW Act* in SA)  **© Mdekool, CC BY-SA 3.0 Licence**	Ruff *Philomachus pugnax* (*Rare*, under the *NPW Act* in SA)  **© J.M. Garg, GNU Free Documentation Licence**
Bar-tailed Godwit *Limosa lapponica* (Bonn, CAMBA, JAMBA, ROKAMBA; Rare, under the *NPW Act* in SA)  **© U.S. Fish and Wildlife Service, CC Licence**	Black-tailed Godwit *Limosa limosa* (Bonn, CAMBA, JAMBA, ROKAMBA; Rare, under *NPW Act* in SA)  **© Frebeck, CC Licence**

Table 4.3 (continued):

Common Name and Latin Name	Common Name and Latin Name
Musk Duck *Biziura lobata* (*Rare*, under the *NPW Act* in SA)  **© Mdekool, CC BY-SA 3.0 Licence**	Australian Shelduck *Tadorna tadornoides*  **© DickDaniels (http://carolinabirds.org/)**
Grey Teal *Anas* (*Nettion*) *gracilis*  **© J.J. Harrison, CC BY-SA 3.0 Licence**	Chestnut Teal *Anas castanea*  **© Frankzed, CC Attribution 2.0 Generic licence**
Black Swan *Cygnus atratus*  **© S. Mosdell CC Attribution 2.0 Generic Licence**	Rock Parrot *Neophema petrophila* (*Rare*, under the *NPW Act* in SA)  **© C. Liber, CC Licence**