

The fish fauna of the Swan–Canning Estuary

Fish in estuaries

Estuaries play a crucial role in the life cycle of numerous fish species. Although many fish species either enter estuaries during a particular period of their life or use them as a migratory route for moving between their spawning and main feeding areas, a few species spend the whole of their life in this type of environment.

The fish species that are found in estuaries can be allocated to one of a number of ‘life cycle categories’, according to how they use these environments. Estuaries play an important role as a nursery area for numerous marine fish species, referred to as ‘estuarine-dependent’. Such species typically enter estuaries from marine waters as larvae or juveniles, and often in large numbers. They remain for a period in the estuary, exploiting the rich food reserves and shelter it provides, before eventually migrating back to sea where they mature and spawn (Fig 1a).

Nearshore marine waters also provide a similar nursery function for various marine species, and thus their juveniles are not necessarily dependent on estuaries for the completion of this phase of their life cycle. Consequently, marine species that often, but not exclusively, use estuaries as a nursery area were termed ‘marine estuarine-opportunists’. Examples of fish species that belong to this life history category in south-western Australian estuaries include Yelloweye Mullet (*Aldrichetta forsteri*), Sea Mullet (*Mugil cephalus*), Eastern Striped Grunter or Trumpeter (*Pelates sexlineatus*), King George Whiting (*Sillaginodes punctata*), Tarwhine or Silver Bream (*Rhabdosargus sarba*) and Weeping Toadfish or Blowfish (*Torquigener pleurogramma*).

In contrast, some other marine species are found usually only in the lower reaches of estuaries and in low numbers, e.g. Old Wife (*Enoplus armata*), Blue Sprat (*Spratelloides robustus*), Southern School Whiting (*Sillago bassensis*) and Rough Leatherjacket (*Scobinichthys granulatus*) (Fig 1b). For this reason, they have been termed ‘marine stragglers’.

A few fish species complete their entire life cycles in estuaries and have thus been categorised as ‘estuarine’. Some of these are restricted entirely to these environments in south-western Australia and are thus termed ‘solely estuarine’, e.g. Black Bream (*Acanthopagrus butcheri*), Yellowtail Grunter (*Amniataba caudavittata*), Bluespot goby (*Pseudogobius olorum*) and Western Hardyhead (*Leptatherina wallacei*). In contrast, other species in this estuarine category are also represented by separate populations in coastal marine waters, and, in some cases, have been shown to be genetically distinct from their counterparts in estuaries. These latter species have thus been termed ‘estuarine and marine’, e.g. Estuary Cobbler (*Cnidoglanis macrocephalus*), Southern Bluespotted Flathead (*Platycephalus speculator*) and Western Gobbleguts (*Apogon rueppellii*) (Figs 1c, d).

Other fish species use estuaries as a migratory route between rivers and the sea and are termed ‘diadromous’. These species comprise two main groups. The first are the ‘anadromous’ species, which are born in freshwater but feed

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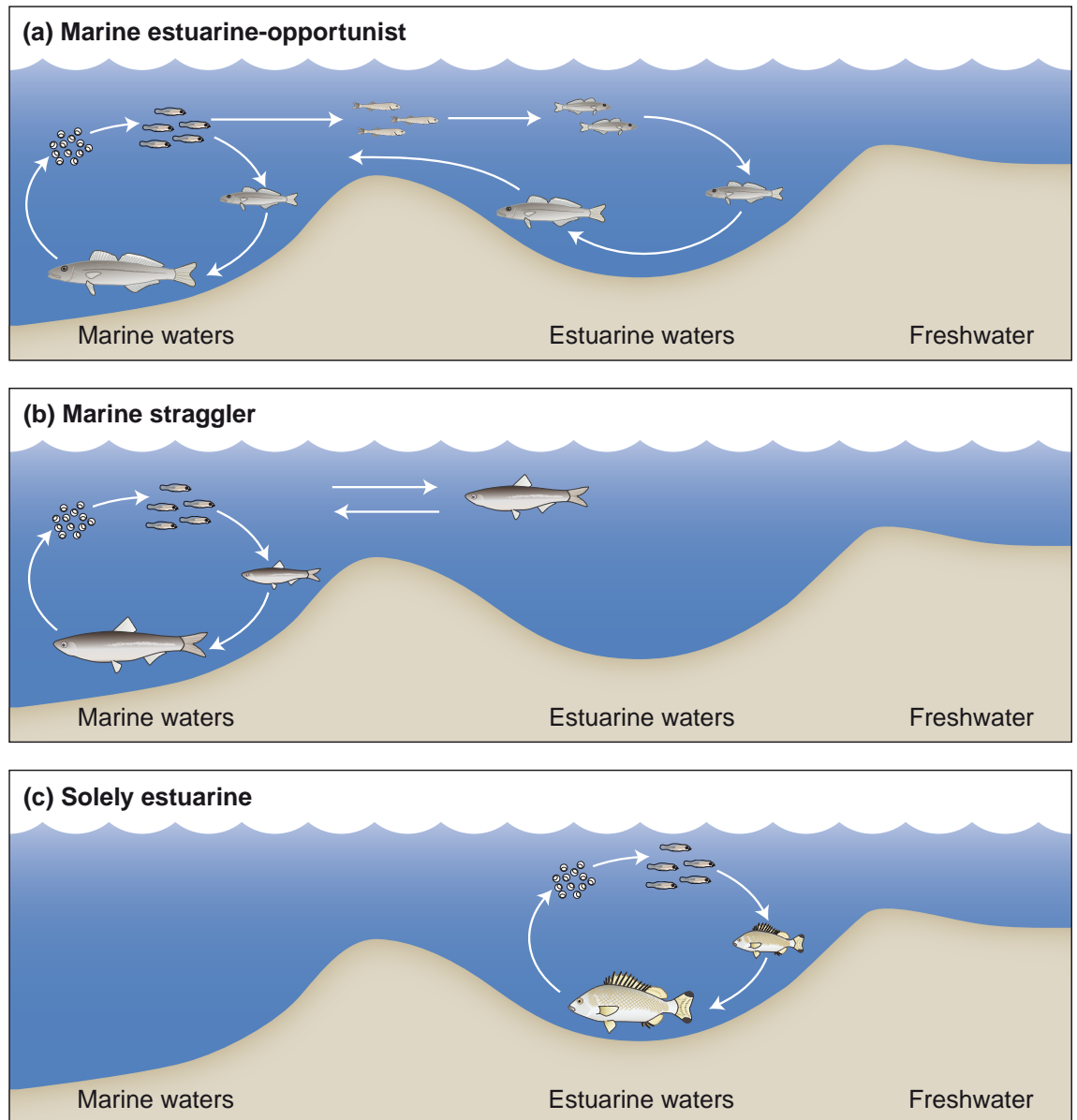


Figure 1a–c Illustration of the various ways in which various fish species use estuaries, and thus belong to one of the following 'life cycle categories'. (a) Marine estuarine-opportunist, (b) marine straggler, (c) solely estuarine, (Potter & Hyndes 1999).

and grow mainly in marine waters and migrate back through estuaries and into rivers to spawn. The Pouched Lamprey (*Geotria australis*) is the only anadromous species in south-western Australia. Semi-anadromous species also live and feed mainly in marine waters, but migrate only as far as the upper reaches of estuaries to spawn (Fig. 1e). The endemic Perth Herring (*Nematalosa vlaminghi*) is the sole representative of this category in south-western Australia. The second main group of diadromous fish are the 'catadromous' species, which live and feed in fresh water, but migrate through estuaries to the sea to spawn (Fig. 1f). There are no representatives of this category in south-western Australia, but it is represented in eastern Australia by the eels *Anguilla australis* and *A. reinhardtii*. Finally, freshwater species, which are normally found in rivers and lakes, are occasionally present in the upper reaches of estuaries, but generally in relatively low numbers,

e.g. the introduced Mosquitofish (*Gambusia holbrooki*) and Freshwater Cobbler (*Tandanus bostocki*).

Although the fish assemblages of estuaries in temperate regions of the northern and southern hemisphere contain representatives of most or all of the above life-history categories, the relative contributions of such categories to both the overall number of fish species and total numbers of fish can vary markedly among systems. This is attributable to many factors including, in particular, the extent of tidal exchange between the estuary and local seas and whether the estuary is closed from the sea by a sand bar at its mouth and, if so, for how long. Many estuaries in south-western Australia are microtidal (i.e. tidal range less than 2 m), and the energy of these tidal currents is often substantially less than that of waves on the adjacent coastline.

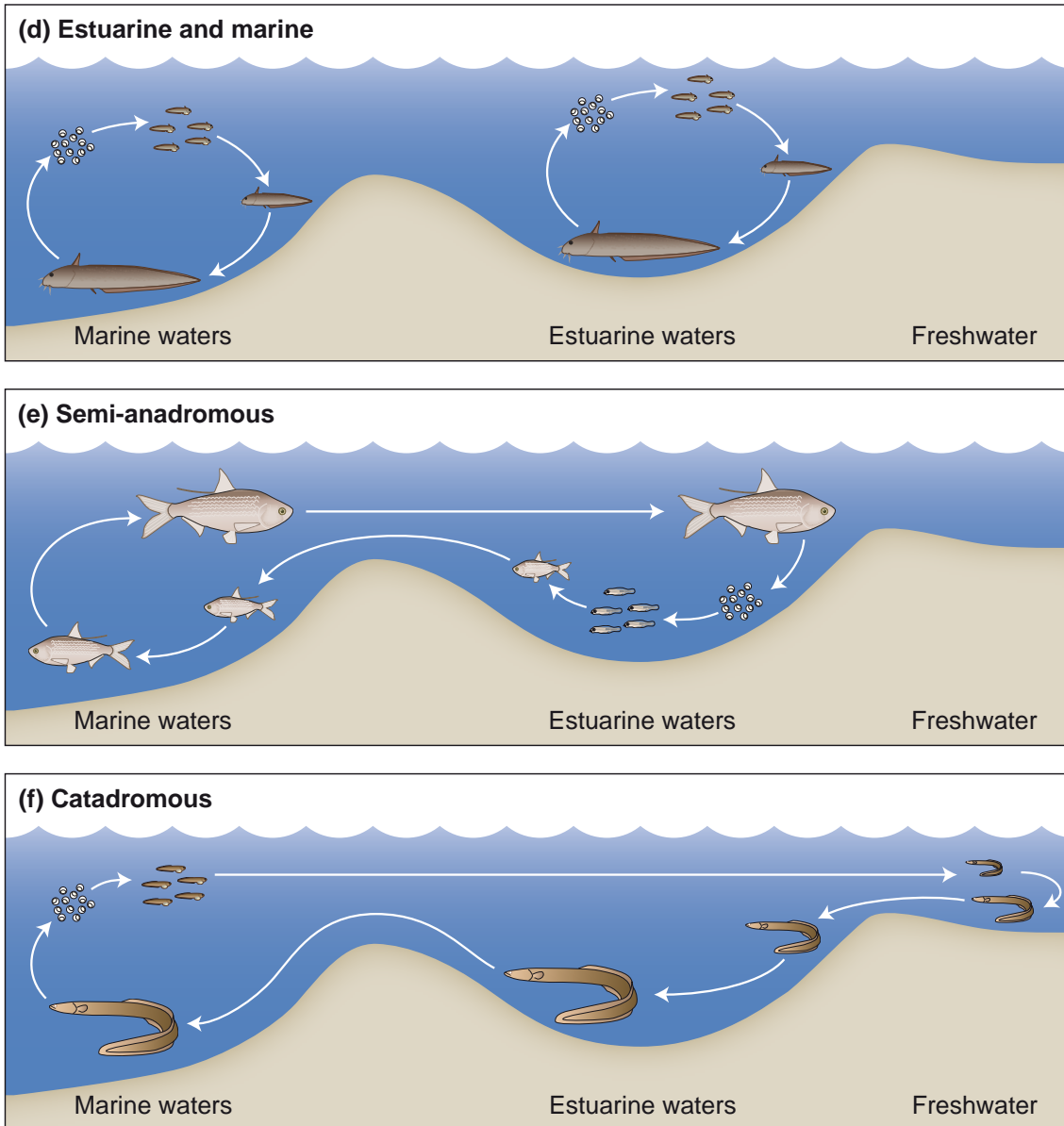


Figure 1d–f Illustration of the various ways in which various fish species use estuaries, and thus belong to one of the following 'life cycle categories'. (d) estuarine and marine, (e) semi-anadromous and (f) catadromous (Potter & Hyndes 1999).

The relatively high oceanic wave energy often leads to the inshore transport of marine sands, which accumulate as sand bars at the mouths of many of these microtidal systems. These so-called 'bar-built' estuaries may be blocked off from the sea for varying periods, depending on the timing and extent of river flow and the degree of oceanic wave energy. Thus, while the entrances of some of these estuaries remain permanently open, due either to sufficient river flow or human influence (e.g. dredging or construction of ports at their mouths), others are seasonally, intermittently or even normally closed. In south-western Australia, the Swan and Peel–Harvey estuaries provide examples of permanently open systems, whereas the Wilson and Broke inlets are seasonally open and the Stokes Inlet and Wellstead estuary are normally closed. In the case of permanently open estuaries, this probably reflects a combination of the presence of far more stable

conditions for spawning and a much smaller chance of eggs and larvae being flushed to sea on ebb tides. With seasonally open and normally closed estuaries, it will also reflect selection pressures which, over geological time, favour species that can complete their life cycle in estuaries when these water bodies become closed off from the sea.

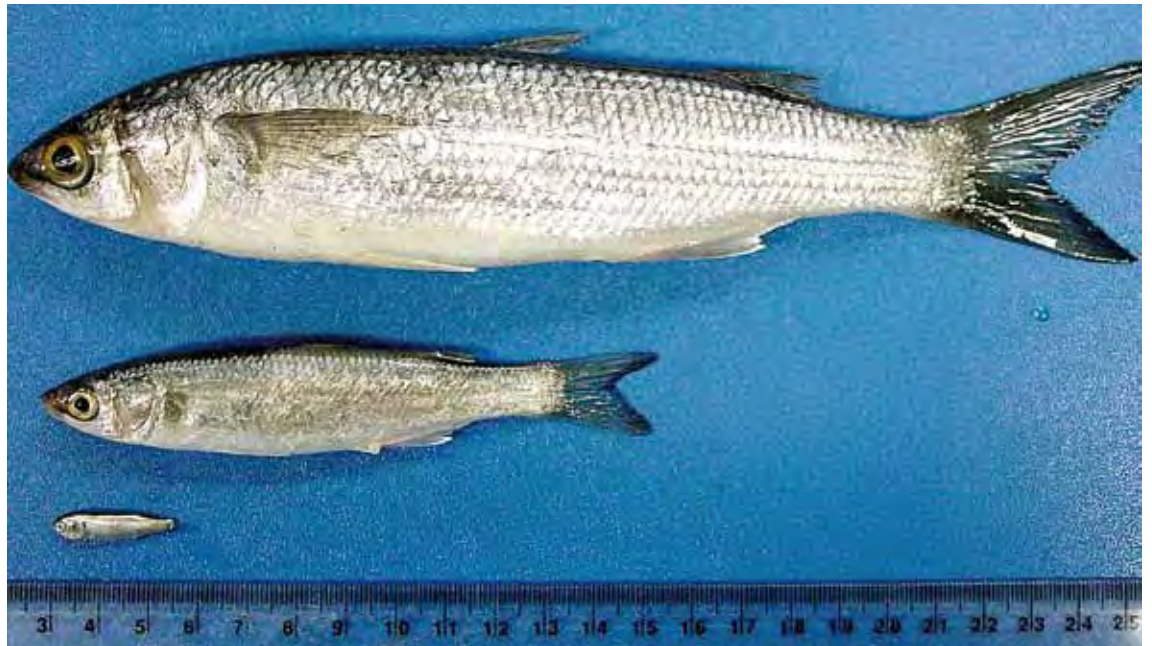


Figure 2 Different stages in the life cycle of Yelloweye Mullet (photograph by F. Valesini, Murdoch University).

Swan estuary

Physical characteristics

The Swan estuary remains permanently open to the sea via an international shipping port constructed at its mouth, which has been artificially deepened to 11–13 m and widened to 400 m. This microtidal system experiences a mean spring tidal range of only 0.4 m, which is often exceeded by storm surge and changes in barometric pressure. The mean significant height of offshore waves in nearby marine waters, which includes both swell and seas, is 1.8 m in summer and 2.8 m in winter

The body of the Swan estuary, which extends c. 50 km inland and occupies an area of c. 55 km², contains the following three distinct regions. (i) The tidal and saline lower reaches of the Swan and Canning rivers, (ii) two wide open basins, namely Perth Water and the far larger Melville Water and (iii) a narrow entrance channel. The depth of each of these regions varies markedly, from c. 0.5–5 m in its rivers, c. 0.5–16 m in its main basin and c. 0.5–20 m in its channel.

Each of the above three main regions of the Swan estuary contains a variety of different habitats for fish, not only in terms of the characteristics of the water (e.g. salinity, temperature, turbidity, level of dissolved oxygen), but also in the extent of exposure to wave activity, the types of substrate and the extent of any submerged plants or snags. This accounts for the presence of marked differences in the compositions of the fish fauna of both the different regions and of their various habitat types

(Loneragan et al. 1989, Loneragan & Potter 1990). The environmental characteristics of the Swan estuary also undergo pronounced changes during the year, due mainly to the marked seasonality of rainfall and thus of river discharge. These seasonal environmental changes, in combination with differences in the time of the year at which different fish species either migrate into or emigrate from the estuary, lead to the composition of the fish fauna in this system also undergoing pronounced temporal change.

Fish fauna

Marine species

The Sea Mullet *Mugil cephalus* and Yelloweye Mullet *Aldrichetta forsteri*

The Sea and Yelloweye mullets are marine estuarine-opportunists, and both spawn at sea over a protracted period from early autumn to early spring (Chubb et al. 1981). Their juveniles are found in large numbers in the Swan estuary, emphasising that this system plays an important role as a nursery area for these two relatively large marine species (Fig. 2). The juveniles of these two mullet species gradually move upstream as they grow older. The Sea Mullet penetrates further upstream than the Yelloweye Mullet and, in some estuaries, even enters fresh water. Both species occupy the shallow waters along the banks during their early part of life, but later move into deeper waters as they become larger.



The majority of individuals of the two mullet species found in the estuary are in their first or second year of life, although some older individuals are also present (Chubb et al. 1981). Both species, and particularly the Sea Mullet, grow rapidly in the productive waters of the Swan estuary, especially during the warmer months of the year. Consequently, by the end of their first year of life, the Sea Mullet has reached lengths of 180–220 mm and weights of 65–120 g, compared with the lesser but still substantial lengths of 135–155 mm and weights of 20–30 g attained by the Yelloweye Mullet. The majority of individuals of both mullet species leave the Swan estuary before they reach 350 mm in length, which is close to the size at which this species typically becomes mature.

The Weeping Toadfish *Torquigener pleurogramma* (blowfish)

The Weeping Toadfish is very abundant in the Swan estuary. Large numbers of toadfish were collected in the nets of recreational fishers who used to fish for River Prawn when these crustaceans were still abundant. The toadfish from these nets were commonly deposited on the estuary banks, where they attracted flies and thus became a public nuisance. Some idea of the large numbers often present in the shallows of certain regions of the Swan estuary can be gauged by the fact that, at times, their densities in these waters were estimated to be as high as five fish per metre.

Toadfish can ingest large volumes of water, resulting in a great increase in their body size and the erection of the numerous small spines on their body surface. These defence mechanisms protect toadfish against predators.



Figure 3 (a) Juvenile and (b) adult of the Mullet (photographs by B. Farmer, Murdoch University).



Figure 4 Tarwhine (photograph by F. Valesini, Murdoch University).

Although toadfish spawn in coastal marine waters in December and January, its juveniles do not typically start entering the Swan estuary in numbers until July and August. This species starts to mature during its second year of life, but it is not until the end of that year, when it reaches approximately 130 mm in length and 40 g in weight, that it moves out of the estuary to spawn. The maximum length and weight recorded for toadfish in the Swan estuary is 230 mm and 220 g.

Two 'atypical' marine species

The Mulloway *Argyrosomus japonicus*

The estuaries of south-western Australia do not regularly provide as important a nursery function for this iconic recreational species. However, some large mulloway do start entering the Swan estuary as adults in the spring, and can subsequently be found in various parts of the lower and middle estuary (Fig. 3). They move into the deeper waters of those regions, where they reach maturity and form spawning aggregations.

Formation of their spawning aggregations is aided by the 'croaking' noises that the mature individuals of

this species produce. The detection of these sounds by mulloway is facilitated by their possession of very large otoliths (earbones). Spawning aggregations are typically found at night between late spring and late summer. The eggs and larvae are swept out to sea on ebb tides and settle in nearshore marine waters, which thus act as a nursery area. The use by mulloway of deep waters of the Swan estuary as an ancillary spawning area to its more typical breeding areas, such as those near reefs and other structures in coastal marine waters, is unusual.

The Tarwhine *Rhabdosargus sarba*

This marine species typically enters estuaries either as larvae or post-larvae, as occurs in south-eastern Australian estuaries, or as juveniles, as in some south-western Australian estuaries (Fig. 4). Although Tarwhine, like Mulloway, almost invariably breed at sea, some individuals do spawn in the lower reaches of the Swan estuary. Spawning in the Swan estuary occurs in spring, and thus later than in marine waters where it occurs in winter. The delayed spawning in the estuary enables breeding to take place when salinities have increased from their winter minima and are more likely to be conducive to spawning

success and survival of their eggs and larvae (Hesp & Potter 2003). This spawning activity occurs at night, prior to the commencement of the ebb tide, and at times when those tides are particularly strong (Hesp et al. 2004). The eggs are transported out of the estuary and the resultant larvae settle in protected, nearshore marine waters.

Tarwhine typically becomes mature at two years, by which age it has reached a length of just over 200 mm. The oldest and largest tarwhine caught in the Swan estuary were seven years and 370 mm, respectively.

Estuarine species

The Black Bream *Acanthopagrus butcheri*

The Black Bream, which is one of the most important angling fish species in the Swan estuary, is also fished commercially in this system. The capture of individuals of this species at all stages of its life cycle in the Swan estuary provides overwhelming evidence that it completes its whole life in this environment (Figs 5a, b). The Black Bream has been extremely successful in south-western Australia and is now found in substantial numbers in most estuaries of this region. This success reflects its remarkable ability to cope with the wide range of environmental conditions found in these systems and being a highly opportunistic feeder.

This species typically becomes mature at the end of the second year of life, when, on average, it has reached about 215 mm in length. Spawning occurs predominantly in the upper reaches of the Swan estuary between the middle of spring and middle of summer, with individuals spawning on more than one occasion in that period (Sarre & Potter 1999). The resultant juveniles are found in the upper estuary, but some of these and older individuals are sometimes swept down into Perth and Melville waters during heavy fresh water discharge, and occasionally also out of the estuary into nearby marine waters. Many of the black bream that are flushed down into the lower reaches of the estuary move back into the upper estuary during the spring and early summer as freshwater discharge slackens.

Black Bream have been found to grow faster in the Swan estuary than in any other estuary which has been attributed to differences in factors, such as food availability, fish density or certain environmental conditions.



Figure 5 (a) Juvenile and (b) adult Black Bream (photographs by D. Morgan and S. de Lestang, respectively, Murdoch University).



Figure 6 Juvenile Yellowtail Grunter (photograph by D. Morgan, Murdoch University).

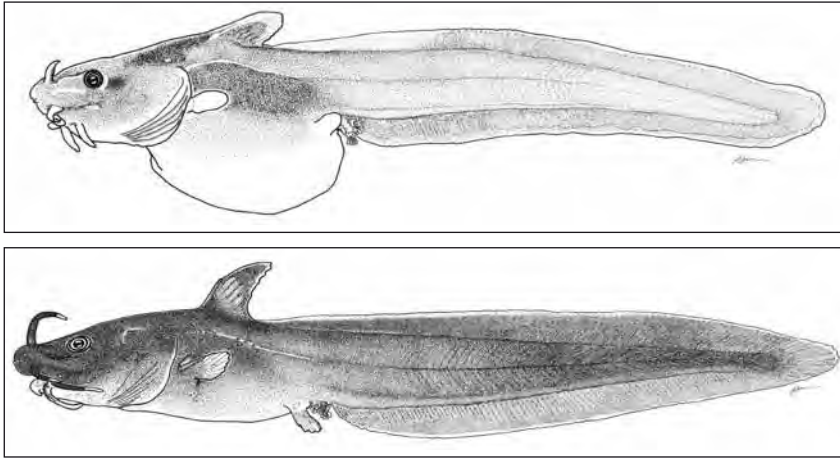


Figure 7 (a) Larva and (b) juvenile of Estuary Cobbler (from Neira et al. 1998).

The oldest Black Bream recorded in the Swan estuary was a female of 21 years, which measured nearly 500 mm and weighed 2200 g. The percentage contribution of fish greater than five years old to the catches of this species in the Swan estuary was the lowest recorded in any of the estuaries studied, a feature that may reflect the substantial fishing pressure to which this species is subjected in this system.

The Yellowtail Grunter *Amniataba caudavitta*

Yellowtail Grunter (Fig. 6) is typically found in marine waters throughout most of its wide distribution, which includes the northern and western coasts of Australia. In contrast to the situation in most other regions of Australia, the Yellowtail Grunter is confined to estuaries in south-western Australia. In the Swan estuary, the adults move into the upper reaches, where they spawn between mid-spring and late summer, and the resultant juveniles disperse throughout the upper and middle parts of the system (Wise et al. 1994). In the winter, the larger individuals of this species move offshore into deeper areas, and particularly to the more saline bottom-waters that lie below the upper freshwater layer that forms during heavy fresh water discharge.

The males and females of the Yellowtail Grunter typically become mature at the end of their second year of life, when they are about 150 mm in length. The maximum length recorded for this species in the Swan estuary is 290 mm.

The Estuary Cobbler *Cnidoglanis macrocephalus*

The Estuary Cobbler (Fig. 7), which spawns from October to December in the Swan River estuary, has an exceptionally large egg due to its possession of a

very substantial amount of yolk. This large egg size accounts for individual females of Estuary Cobbler producing only between 530 and 21 000 eggs, which is relatively very low for a species of its size.

During reproduction, this species excavates a large hole in the estuary substrate within which the eggs and, after hatching, the larvae, are guarded by the adult male. The Estuary Cobbler has not fully re-sorbed its yolk until it has reached a length of about 40 mm.

Although the oldest Estuary Cobbler recorded during an early study in the Swan estuary was only about seven years in age, much older individuals have been found in Wilson Inlet. In the Swan estuary, this species reaches a length of about 185 mm after one year of life and 440 and 650 mm at the end of its third and six years of life, respectively (Nel et al. 1985). The majority of individuals have become mature by the end of their third year of life.

The Estuary Cobbler has large, barbed and venomous spines associated with the dorsal (back) and pectoral (side) fins, which become erect and lock when the fish is threatened. These spines are capable of inflicting painful injuries. Puncture wounds from such spines usually cause an immediate throbbing pain and then local swelling, which may subsequently spread further. The toxin produced by Estuary Cobbler, like those of most other catfishes, are deactivated by temperatures higher than about 45°C. Immersion of the stung area in water as hot as can be tolerated is thus the most effective first aid measure for the majority of injuries from these spines.

Migratory species

The Perth Herring *Nematalosa vlaminghi*

Perth Herring, which is endemic to Western Australia, is the only fish species found in the Swan estuary that spends much of its life feeding in coastal marine waters and then migrates into the low salinity areas in the upper reaches of the estuary where it becomes mature and spawns (Chubb & Potter 1984). This species used to be fished commercially in both the Swan estuary and nearby coastal waters to provide bait for the Western Rock Lobster fishery. The numbers of Perth Herring in the Swan estuary have clearly declined markedly over the last 30 years, probably due to deleterious environmental changes, e.g. phytoplankton blooms and associated effects, in the upper reaches of this system.

Spawning occurs between late spring and the middle of summer. During the ensuing months, the young

juveniles become dispersed throughout the upper and middle estuary, while the older individuals move out to sea.

Perth Herring reaches a length of about 100 mm by the end of its first year of life and does not typically reach maturity until it is at least 160 mm in length. It is estimated that Perth Herring present in this system are up to eight years in age. The largest Perth Herring caught in the Swan estuary was just over 350 mm in length.

The abundant small species

The Western Gobbleguts *Apogon rueppellii*

The Western Gobbleguts, which is abundant in the Swan estuary and some protected nearshore marine waters, rarely exceeds 100 mm in length (Fig. 8). The possession of a relatively large mouth facilitates oral-brooding by this species, whereby the males brood the eggs in their mouths. Most individuals of this species probably do not live for more than two years.

As freshwater discharge into the Swan estuary increases in winter, this species, and particularly its larger and older individuals, tend to move offshore into deeper waters where salinities are generally greater than in the shallows. This offshore migration would be likely to benefit this species, as it belongs to an essentially marine family that would thus be adapted to living in salinities typically found in marine waters.

During spring, the Western Gobbleguts migrates into the shallows, where it becomes mature and then spawns between late spring and the middle of summer. The eggs are relatively large, having a diameter of about 2.4 mm. The number of eggs produced ranges from about 70 by the smallest females to about 350 by the largest females. Most of the eggs produced by the females are collected in the mouths of males and develop there for just over two weeks, before hatching at a length of about 8 mm (Chrystal et al. 1985).

Hardyheads/silversides and gobies

The atherinids (otherwise known as hardyheads or silversides), together with the gobies, are the most abundant fish in the Swan estuary and contain a greater number of species than any other fish family found in this system (Figs 9 and 10). In fact, the gobies are the most speciose of all families of vertebrates found in the world. Atherinids and gobies typically live in shallow waters near the shore, and the former

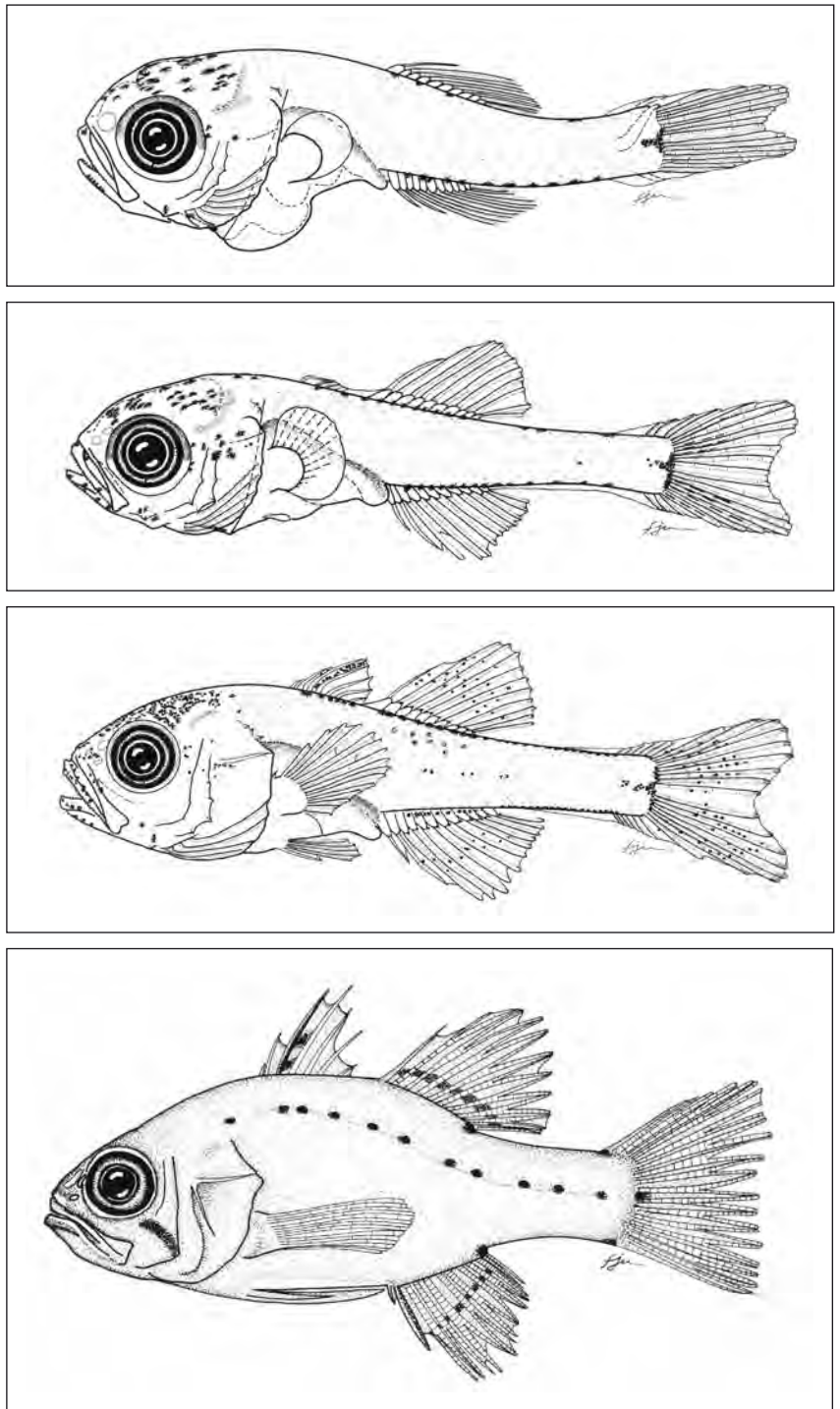


Figure 8 (a) Newly hatched larva and (b) and (c) developing larva and (d) juvenile of the Western Gobbleguts (from Neira et al. 1998).



Figure 9 Wallace's Hardyhead (photograph by D. Morgan, Murdoch University).

can often be seen swimming in large schools. The various species of both families in the Swan estuary are either marine estuarine-opportunists, solely estuarine or estuarine and marine.

The atherinid and goby species in the Swan estuary are small and have short life cycles. Thus, four of the five atherinid species commonly found in the Swan estuary generally have a maximum length of less than 110 mm and live for only a year and, while the fifth species lives for two years, its largest individuals still only reach a length of about 150 mm (Prince & Potter 1983). Likewise, the seven species of gobies commonly found in the Swan estuary rarely attain lengths greater than 150 mm and live for only one or two years. Their small size and large numbers make the atherinids and gobies an important source of prey for carnivorous fish and piscivorous (fish eating) birds, such as cormorants.

The five species of atherinids are distributed in different ways among the lower, middle and upper regions of the Swan estuary. Thus, Oglybyi's Hardyhead (*Atherinomorbus ogilbyi*) and the Silverfish (*Lepatherina presbyteroides*) are largely found in the lower reaches, whereas the Elongate Hardyhead (*Atherinosoma elongata*) and Mugil's Hardyhead (*Craterocephalus mugiloides*) mainly occupy the wide central basins of the middle estuary and the Western Hardyhead (*Lepatherina wallacei*) lives predominantly in the upper reaches.

The differences in the pattern of distribution of the five species of atherinid in the Swan estuary has the advantage of spreading spatial resources among these abundant species and thereby reducing the potential for competition for space.

Gobies tend to be most abundant in the lower and upper reaches of the Swan estuary, in which nearshore shallow waters are not as exposed to wind action as those of the wide basins in the middle estuary. However, they are also abundant in the more protected areas of the middle estuary, such as in sheltered embayments or areas with deeper waters.

Four of the goby species found in the Swan estuary occur mainly in just one of the three main regions of the estuary. Thus, the Southern Longfin Goby (*Favonigobius lateralis*) occupies predominantly the lower estuary, while the Bluespot, Southwestern and Redspot gobies (*Pseudogobius olorum*, *Afurcagobius suppositus* and *Papillogobius punctatus*) are found mainly in the upper estuary. The Bridled Goby (*Arenigobius bifrenatus*) is the only species of goby found in the Swan estuary that burrows, a habit which helps protect it from the effects of turbulence caused by wind action in the more exposed middle estuary. However, this goby is ubiquitous in that it also occurs in the lower and upper estuaries and in nearshore marine waters along the coast. The Trident Goby (*Tridentiger trionocephalus*) is found



Figure 10 Long-headed goby (photograph by D. Morgan, Murdoch University).

in unusual habitats like beer bottles and discarded cans, and was probably introduced via bilge water from visiting cargo ships.

Summary

This estuary clearly plays an important nursery role in the life cycle for many marine estuarine-opportunists, a group which, by definition, enters estuaries in large numbers as juveniles. However, individuals of some of these marine species, such as Toadfish, may leave the estuary to spawn but then return after breeding. The data also emphasise that some species complete their life cycle within the estuary, and among these are species that are also represented by discrete populations in the local marine environment. The success of the estuarine-spawning species in the Swan estuary reflects the presence of good conditions for spawning and recruitment that prevail during the late spring and summer, when fish species typically breed in south-western Australian estuaries. The Swan River contains no entirely diadromous species, i.e. species which use the estuary as a migratory route between their main feeding and spawning areas. The Perth Herring does, however, spend some time feeding at sea and then, as an adult, migrates into the upper estuary to spawn.

The data acquired on the length and age compositions, growth and size at maturity of recreationally and commercially important fish species are of value, as they enable managers to develop plans for conserving the stocks of these species. Current and ongoing studies in the Swan estuary will highlight the habitat requirements of these and other fish species, and thus provide the potential for ensuring that key habitats will be conserved.

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For more information

More information on water quality in the Swan–Canning estuary and catchment is available from the Swan River Trust. The complete list of Swan–Canning Cleanup Program and Healthy Rivers Action Plan publications are available on the Internet at <www.swanrivertrust.wa.gov.au>. River Science publications can be obtained from the Swan River Trust or downloaded in PDF format through the same website. More information on estuaries and water quality can be found at <<http://www.water.wa.gov.au/Waterways+health/default.aspx>> and River Science publications are also available from the same website under publications

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