

3 Fisheries Resources

3.1 Introduction

The Macleay River estuary supports a large recreational fishery, an estuary general fishery with upwards of 12 professional fishers and an oyster aquaculture industry.

3.2 Available Information

NSW Industry and Investment are the primary information source with respect to the fisheries resources of the Macleay River. A wide range of information specific to the Macleay River is available for the Estuary General and Aquaculture fisheries, including total catch/production data for the past 12 years, and the results of studies undertaken on the Macleay system (eg. Macbeth *et al.* 2002, Gibbs *et al.* 1999).

With respect to recreational fishing, the primary sources of information are a statewide survey (NSW Fisheries 2001) and post flood recovery studies (Macbeth *et al.* 2002)

3.3 Macleay Estuary General Fishery

The taking of fish and shellfish for commercial sale from estuarine waters in NSW can only be done under an estuary general or estuary prawn trawl permit. There is no longer an estuary prawn trawl industry in the Macleay but the Macleay River estuary general fishery is, regionally, very important. The Macleay is the largest river with a commercial estuarine fishery between the Clarence and the Manning River. Two of the 3 nearest rivers, the Hastings and the Bellinger, are recreational fishing havens.

3.3.1 Fishery Production

Between 1997/98 and 2008/09 the Macleay River estuary general fishery was worth an average of \$376476 annually. This amounts to slightly less than 2% of the total estuary general value for NSW. The average annual harvest over the same period was 84297kg of product. Total catch has been relatively stable with the exception of years affected by floods (2000/2001 and 2008/2009). The total annual catch for the years between 1997/98 and 2008/09 are shown in **Figure 3.1**. In 2001 the fishery was closed for a period of 3 months, after a catastrophic fish kill. In 2006/2007 the low annual catch was largely a result of a poor sea mullet catch. The most productive months of the year are typically April and May (See **Figure 3.2**). This is explained by the congregation of sea mullet in the lower estuary during these months, prior to their migration to the Coral Sea for breeding. Despite steady catch throughout the other parts of the year the summer months (December-March) are typically more valuable than winter and spring. This is mostly a result of the increased mud crab catch during these months. This highlights the importance of these two species to the overall viability of the estuary general fishery on the Macleay.

3.3.2 Methods Employed

All methods permitted under the estuary general fishery are permissible on the waters of the Macleay River estuary (the methods are listed in **Table 3.1**). A number of closures apply at certain points in time to specific parts of the river. These are described in **Section 3.3.4**.

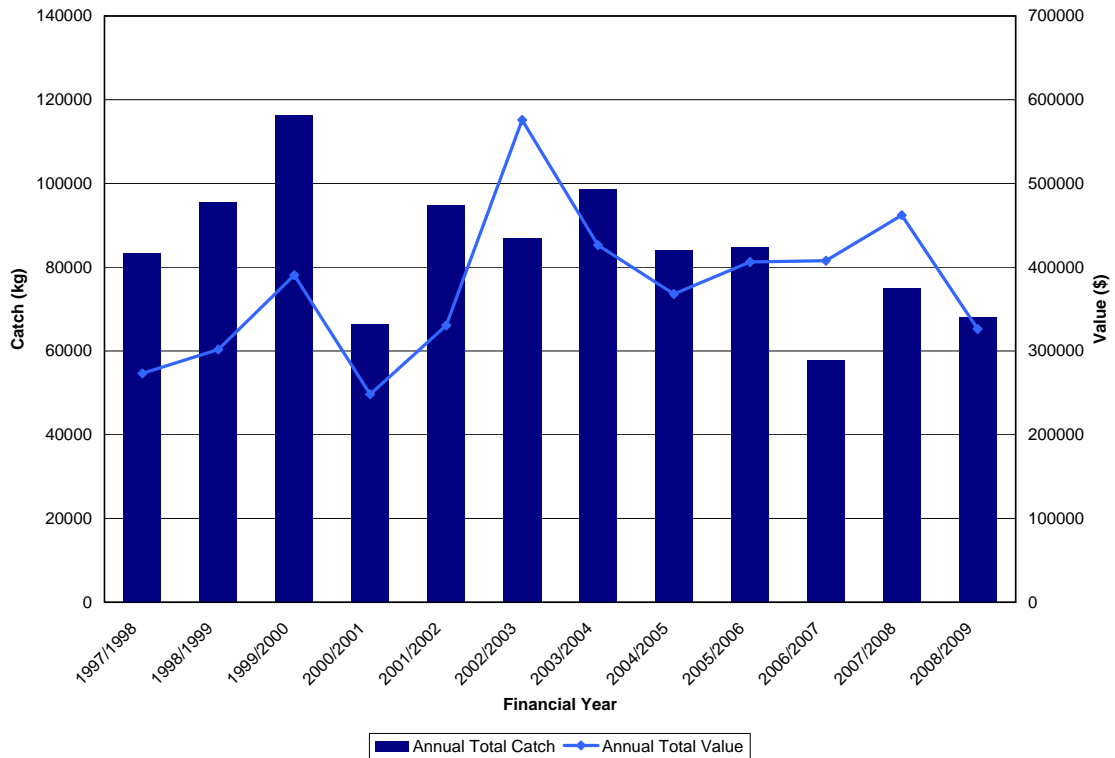


Figure 3.1 Annual Catch and Value for the Macleay River estuary general fishery.

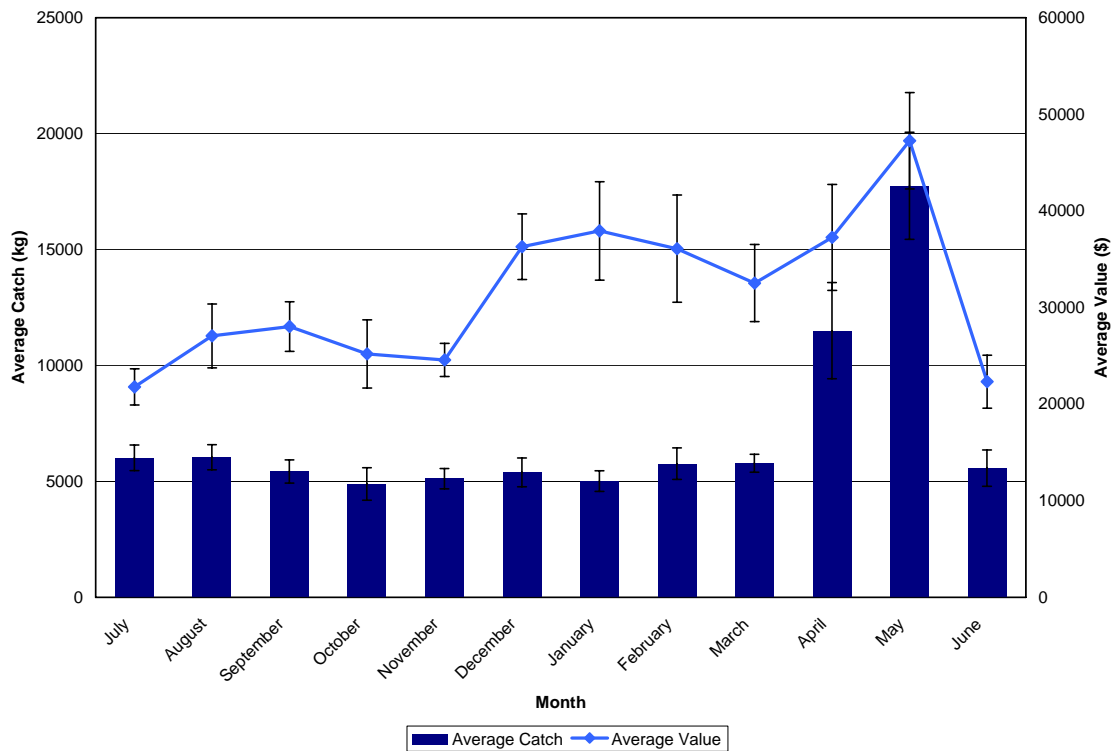


Figure 3.2 Average monthly catch and value (\pm Standard Error) for the Macleay estuary general fishery between 1997/98 and 2008/09.

Table 3.1 Methods employed in the NSW estuary general fishery (Adapted from NSW Fisheries 2003)

<i>Endorsement types</i>	<i>Endorsement description</i>
Meshing	This endorsement authorises the commercial fisher to use a meshing net and a flathead net to take fish for sale from estuary waters.
Prawning	This endorsement authorises the commercial fisher to use a prawn hauling net, prawn seine net, prawn set pocket net, prawn running net, hand-hauled prawn net, push or scissors net and a dip or scoop net to take prawns for sale from estuary waters.
Category 1 hauling	This endorsement authorises the commercial fisher to take fish for sale from estuary waters using any of the following nets: general purpose hauling net, trumpeter whiting net, pilchard, anchovy and bait net, garfish hauling net, garfish bullringing net, bait net.
Category 2 hauling	This endorsement authorises the commercial fisher to take fish for sale from estuary waters using any of the following nets: garfish hauling net, garfish bullringing net, bait net.
Trapping	This endorsement authorises the commercial fisher to use a fish trap and a hoop or lift net to take fish (other than eels or mud crabs) for sale from estuary waters.
Eel trapping	This endorsement authorises the commercial fisher to use an eel trap to take eels for sale from estuary waters.
Mud crab trapping	This endorsement authorises the commercial fisher to use a crab trap to take mud crabs for sale from estuary waters.
Hand gathering	This endorsement authorises the commercial fisher to take beachworms, pipis, cockles, yabbies, mussels and nippers for sale from estuaries and ocean beaches by hand picking.
Handlining & hauling crew	This endorsement authorises the commercial fisher to take fish for sale from estuaries using a hand line or by assisting another commercial fisher with a category one or a category two hauling endorsement (using hauling methods only).

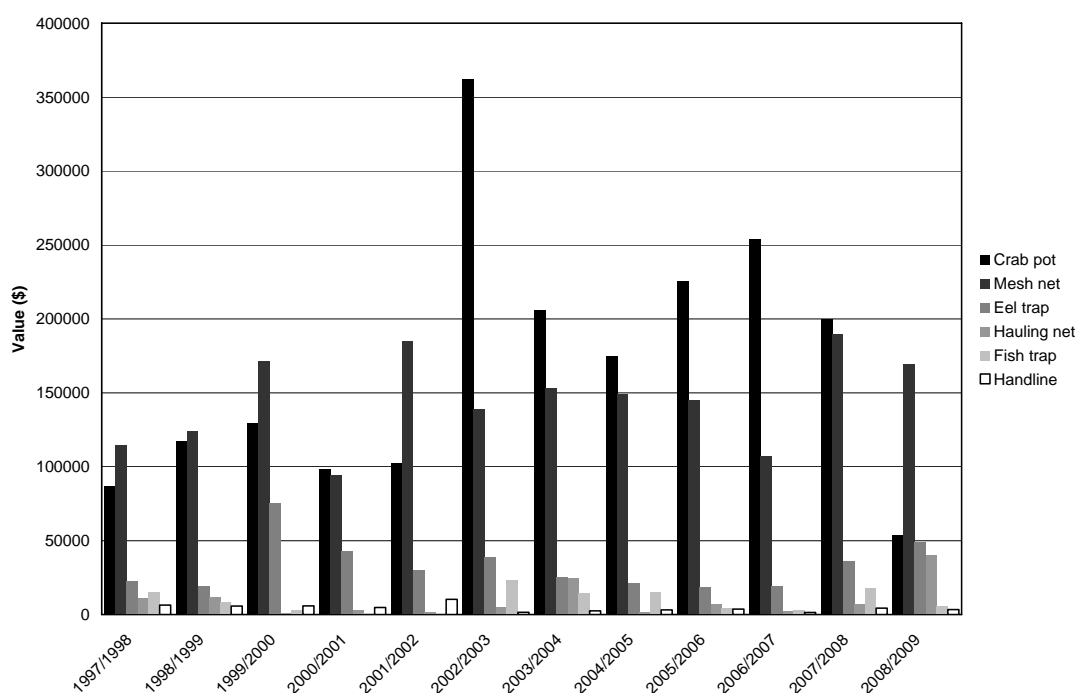


Figure 3.3 The top 6 methods, by value, used in the Macleay River estuary general fishery between 1997/98 and 2008/09.

The methods used to greatest effect in the Macleay are crab traps, meshing nets and eel traps (see **Figure 3.3**). Hauling nets, fish traps and handlines are also regularly used. The application of these methods changes seasonally, as shown in **Figures 3.4 – 3.14**.

Meshing

Meshing nets are nets of mesh size larger than 80mm that can be up to 725m long. They are typically set at night in a location and retrieved later or set and retrieved in one motion following a short period of ‘splashing’ to scare fish into the net. The length of time a meshing net can be set for varies throughout the year. In December and January, the net may only be set whilst splashing occurs and then must be retrieved, from July to August, nets may be set overnight and during the rest of the

year they may be set for a maximum of three hours at a time. Meshing nets on the Macleay catch mostly mullet and luderick, though a variety of other species including bream, flathead, whiting and mullet are also caught (**Figure 3.5**). Meshing is used throughout the year but the largest catches are in April and May when sea mullet gather in the lower estuary prior to their spawning migration (**Figure 3.4**).

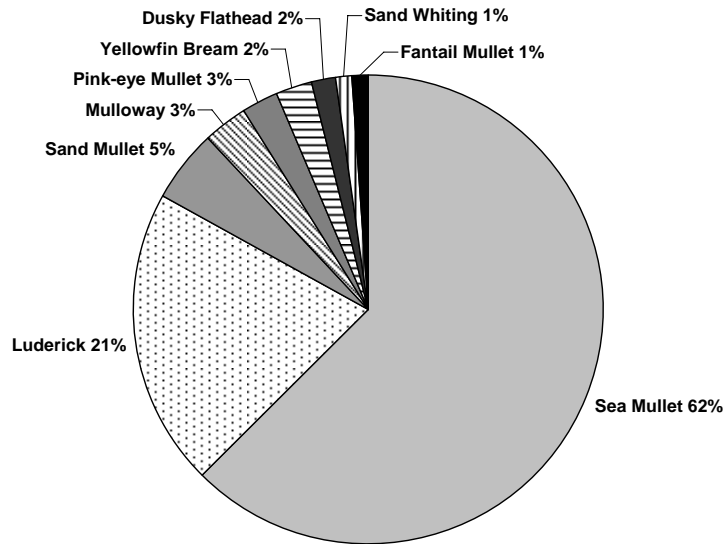


Figure 3.4 Breakdown of species caught in meshing nets on the Macleay River estuary between 1997/98 and 2008/09 (Excludes species accounting for <1%)

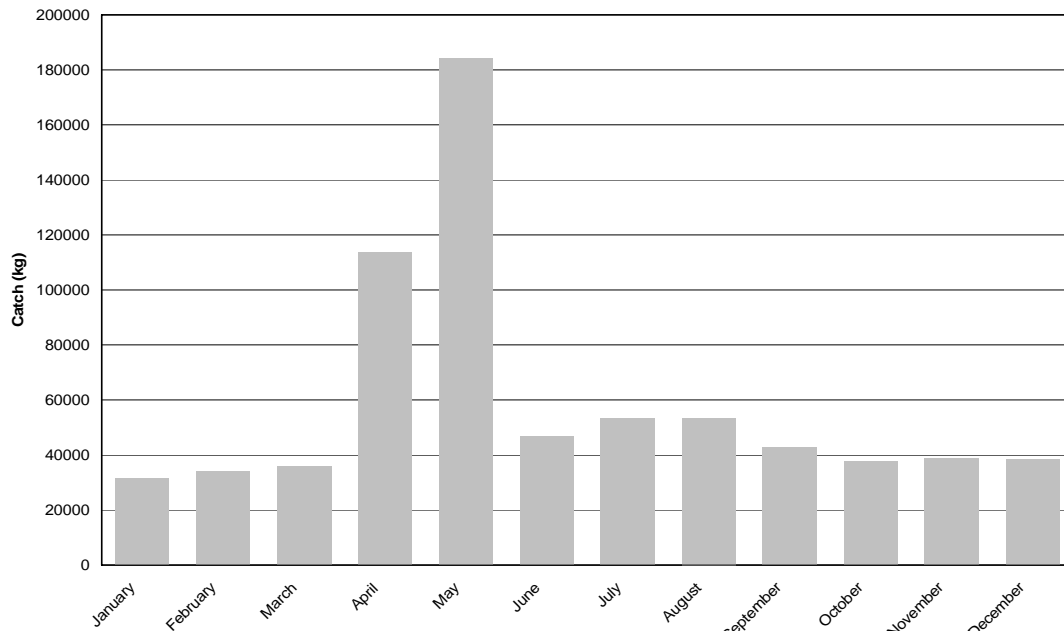
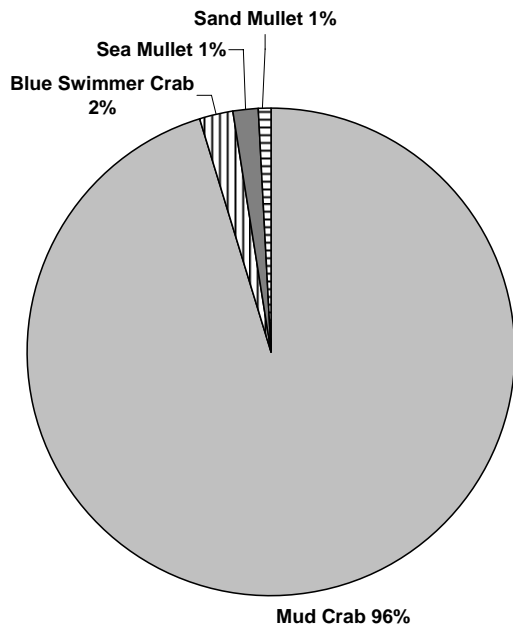


Figure 3.5 The weight of fish caught per month by meshing nets on the Macleay between the years of 1997/98 and 2008/09.

Crab Traps

Crab traps are typically made of solid frames with a mesh outer. The standard size is 1.2m long, 0.5m deep and 1m wide with 50mm or larger mesh. Crab traps are employed throughout the year on the Macleay though the majority of crabs are caught in the warmer months when they are more active (**Figure 3.7**). Crab traps on the Macleay catch mostly mud crabs and few blue swimmer crabs though approximately 5% of the reported catch is saleable bycatch in the form of bream, luderick, mullet and eels (**Figure 3.6**).



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Figure 3.4 Breakdown of species caught in crab traps on the Macleay River estuary between 1997/98 and 2008/09 (Excludes species accounting for <1%)

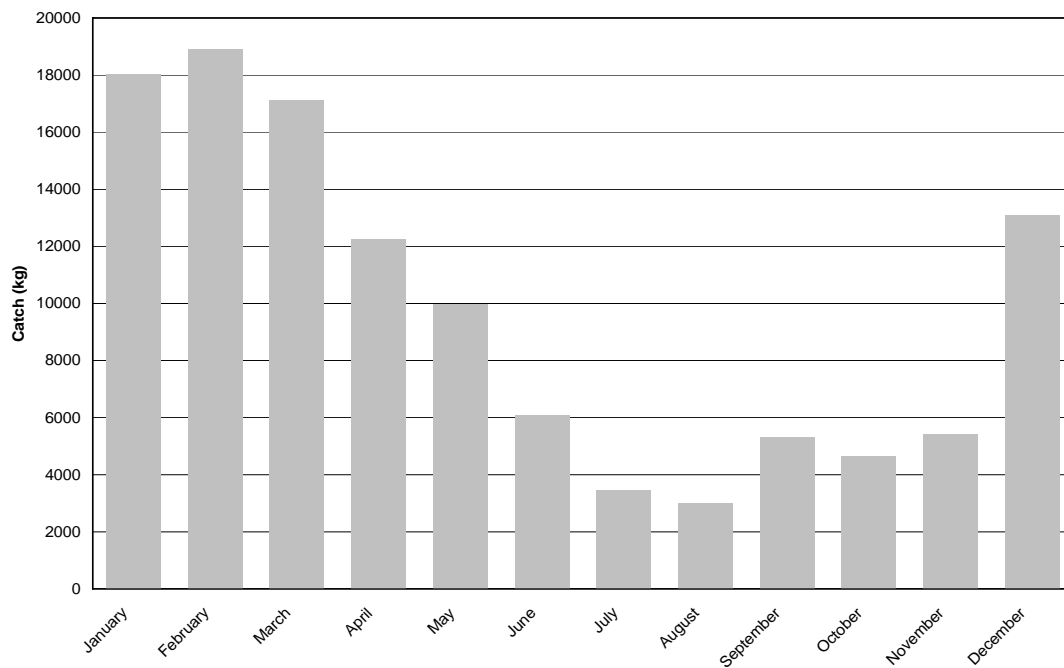
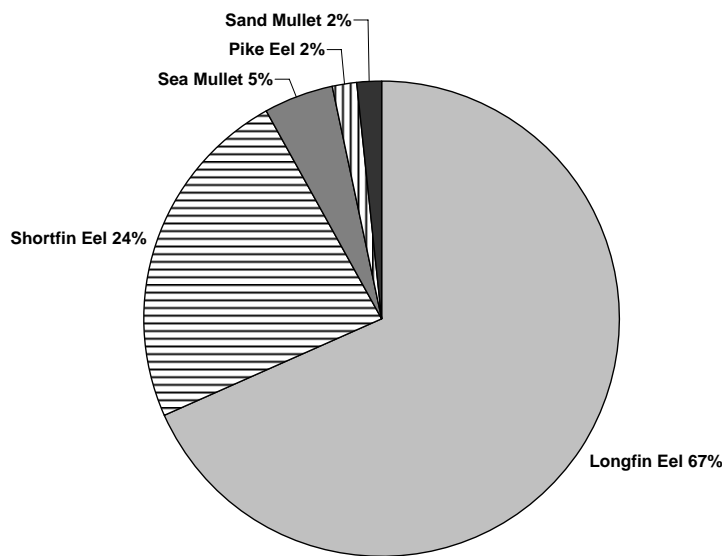


Figure 3.5 The weight of fish caught per month by crab traps on the Macleay between the years of 1997/98 and 2008/09.

Eel Traps

The standard dimensions for an eel trap are either a maximum of 2 m in length, 0.5 m in width and 0.5 m in depth, or 1 m in length, 1 m in width and 0.5 m in depth with



mesh of between 20 mm and 40 mm and an entrance funnel of no more than 100 mm in diameter. Saleable bycatch caught in eel traps on the Macleay is primarily mullet and a small proportion of the total catch (7% by weight, **Figure 3.8**). The catch from eel traps on the Macleay is relatively consistent over time, though larger catches are common in the winter and spring (**Figure 3.9**).

Figure 3.6 Breakdown of species caught in eel traps on the Macleay River estuary between 1997/98 and 2008/09 (Excludes species accounting for <1%)

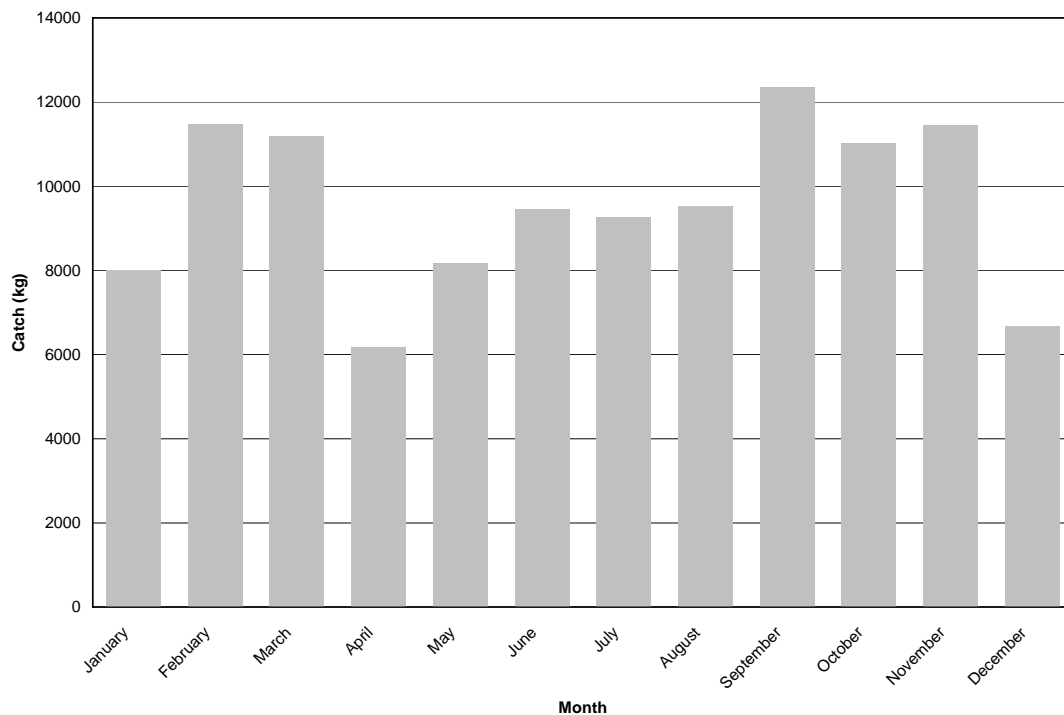


Figure 3.7 The weight of fish caught per month by eel traps on the Macleay between the years of 1997/98 and 2008/09.

Hauling Nets

Hauling nets used in the estuary general fishery can be up to 375m in length, with mesh sizes of 80mm minimum in the wings (sides of the net) and between 30 and 57mm in the bunt (centre) of the net. They are typically launched from boats and pulled up on to the shore where shoreline conditions permit. Hauling nets are

primarily used to target schooling fish such as mullet, luderick and whiting (**Figure 3.10**). The distribution of catch throughout the year shows two distinct peaks, one in the sea mullet season, April/May, and another in the fantail mullet season, November/December (**Figure 3.11**).

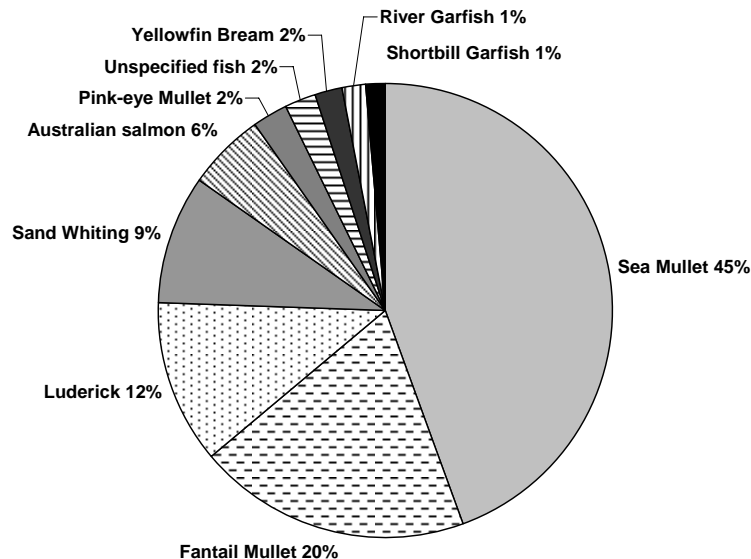


Figure 3.8 Breakdown of species caught in hauling nets on the Macleay River estuary between 1997/98 and 2008/09 (Excludes species accounting for <1%)

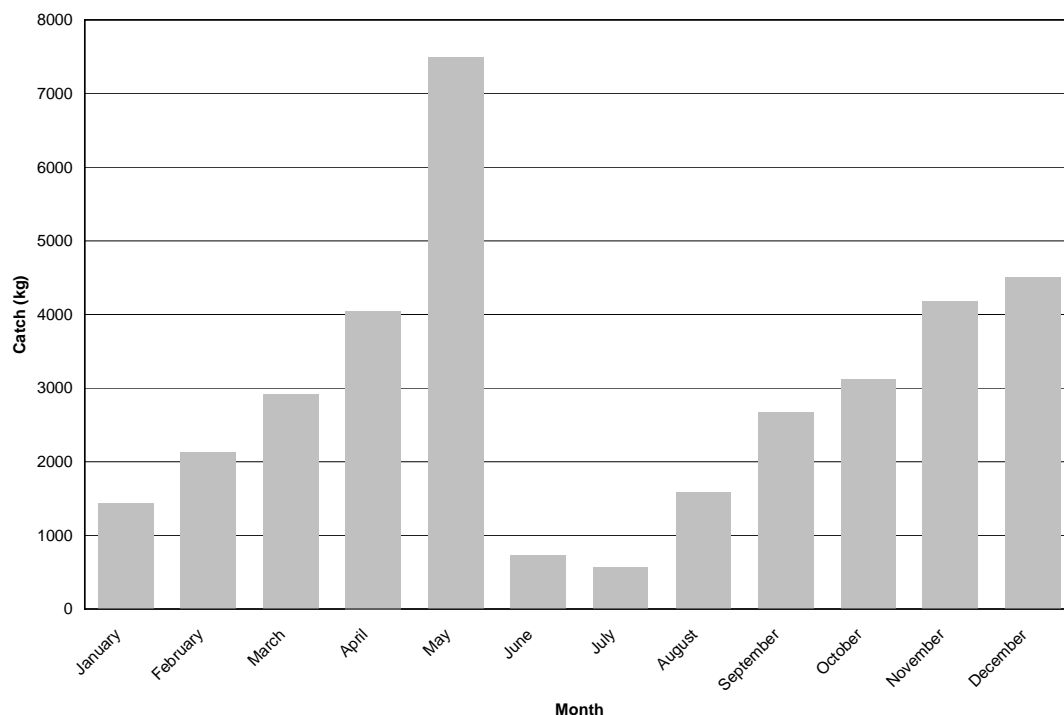
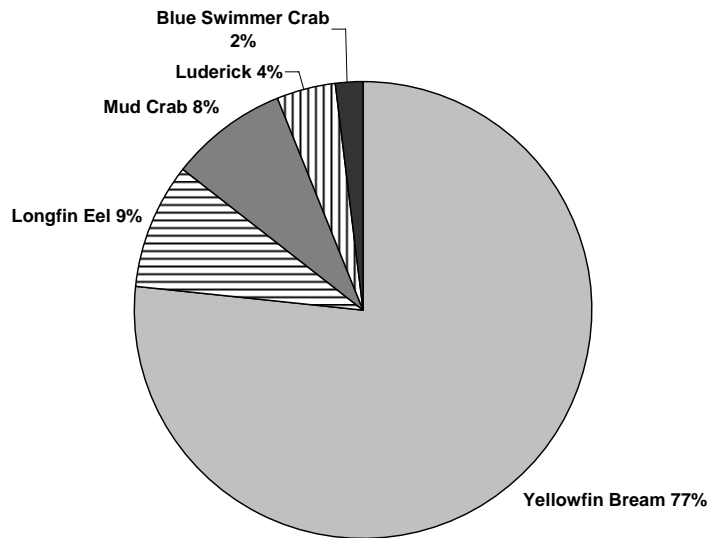


Figure 3.9 The weight of fish caught per month by hauling nets on the Macleay between the years of 1997/98 and 2008/09.

Fish Traps

Fish traps allowed for use in the estuary general fishery have maximum dimensions of 2m long, 1.5m wide and 1m in height. They are usually a solid frame enclosed in wire mesh which must have a minimum mesh size of 50mm. Yellowfin bream account for the majority of fish caught in fish traps on the Macleay (Figure 3.12) and this is reflected in the catch distribution throughout the year with a clear peak in the winter months (Figure 3.13) when bream school in the lower estuary prior to spawning in the ocean. Eels, crabs and luderick are also commonly caught in fish traps.



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Figure 3.10 Breakdown of species caught in fish traps on the Macleay River estuary between 1997/98 and 2008/09 (Excludes species accounting for <1%)

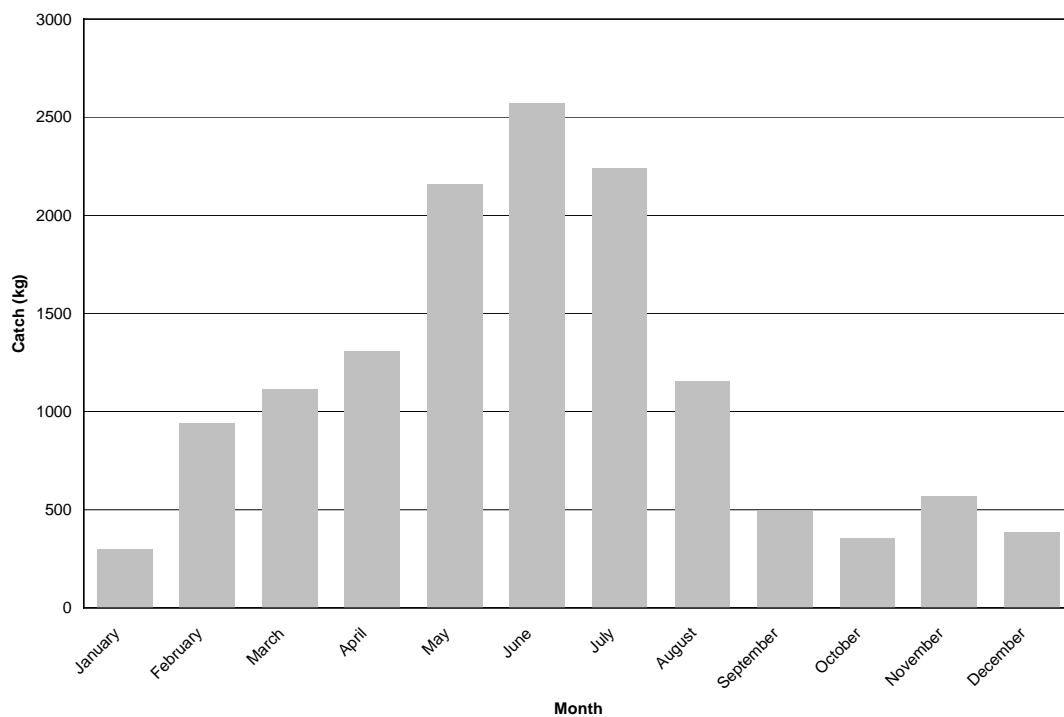


Figure 3.11 The weight of fish caught per month using fish traps on the Macleay between the years of 1997/98 and 2008/09.

Handline

Handlining is responsible for only a small proportion of the total commercial catch for the Macleay. The key species targeted with handlines is mullocky, though bream and kingfish are also caught in significant numbers (**Figure 3.15**). Most of the handlined fish are caught in the winter and spring months (**Figure 3.14**).

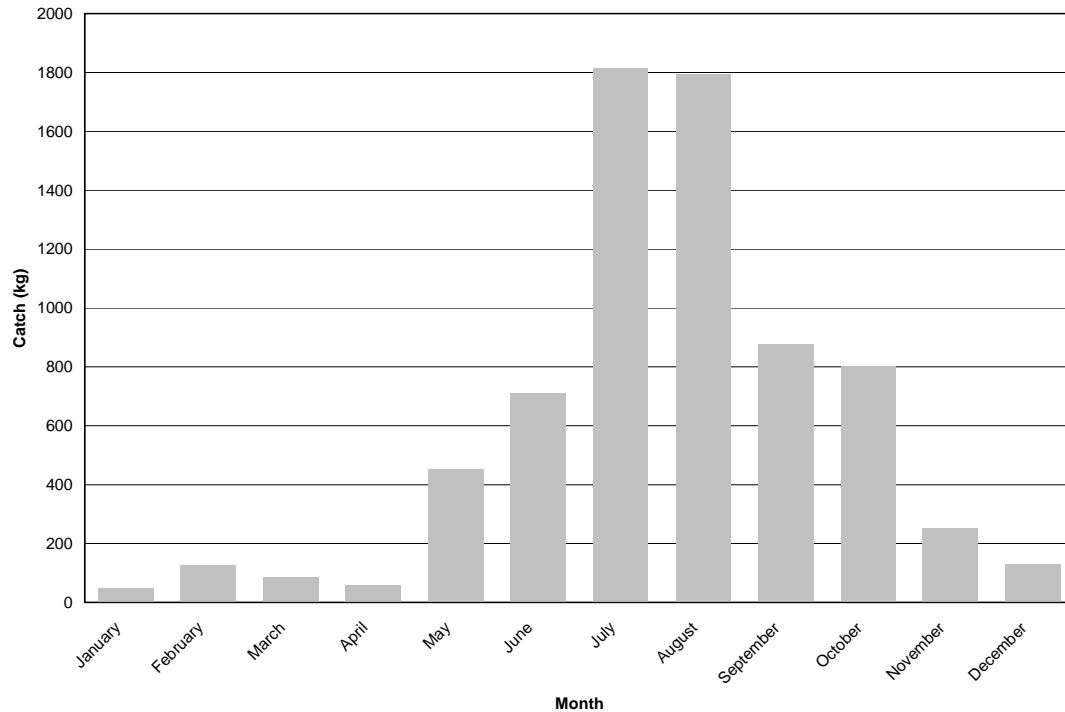


Figure 3.12 The weight of fish caught per month using handlines on the Macleay between the years of 1997/98 and 2008/09.

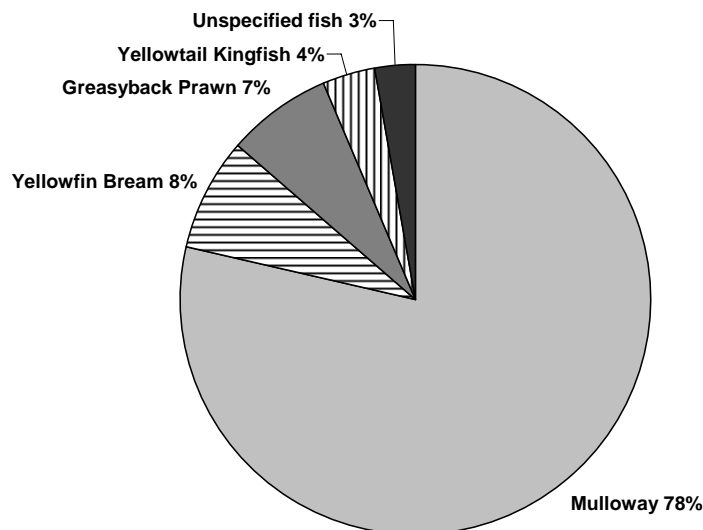


Figure 3.13 Breakdown of species caught using handlines on the Macleay River estuary between 1997/98 and 2008/09 (Excludes species accounting for <1%)

3.3.3 Key Species

The top 11 species with respect to the value of the Estuary General Fishery in the Macleay River are listed in **Table 3.2** along with status information derived from

Scandol *et al.* (2008) which describes the state of the population across NSW from a fisheries management perspective. Their relative value to the fishery, derived from catch returns from between 1997/98 and 2008/09 are displayed in **Figure 3.16**. Species summaries, essentially a review of descriptions from NSW Fisheries (2003) and Scandol *et al.* (2008) follow, along with information about the methods and times of catches.

Table 3.2 Key species targeted in the Macleay River estuary general fishery

<i>Species Name</i>	<i>Common Name</i>	<i>Status</i>
<i>Scylla serrata</i>	Mud crab	Undefined – possibly overfished.
<i>Mugil cephalus</i>	Sea mullet	Fully fished
<i>Anguilla reinhardtii</i>	Longfin river eel	Lightly to fully fished
<i>Acanthopargus australis</i>	Yellowfin bream	Fully fished
<i>Girella tricuspidata</i>	Luderick	Moderately fished
<i>Argyrosomus hololepidotus</i>	Mulloway	Overfished
<i>Sillago bassensis</i>	Sand whiting	Fully fished
<i>Anguilla australis</i>	Shortfin river eel	Lightly to fully fished
<i>Platycephalus fuscus</i>	Dusky flathead	Fully fished
<i>Myxus elongatus</i>	Sand mullet	No status provided
<i>Metapenaeus macleayii</i>	School prawn	Growth overfished

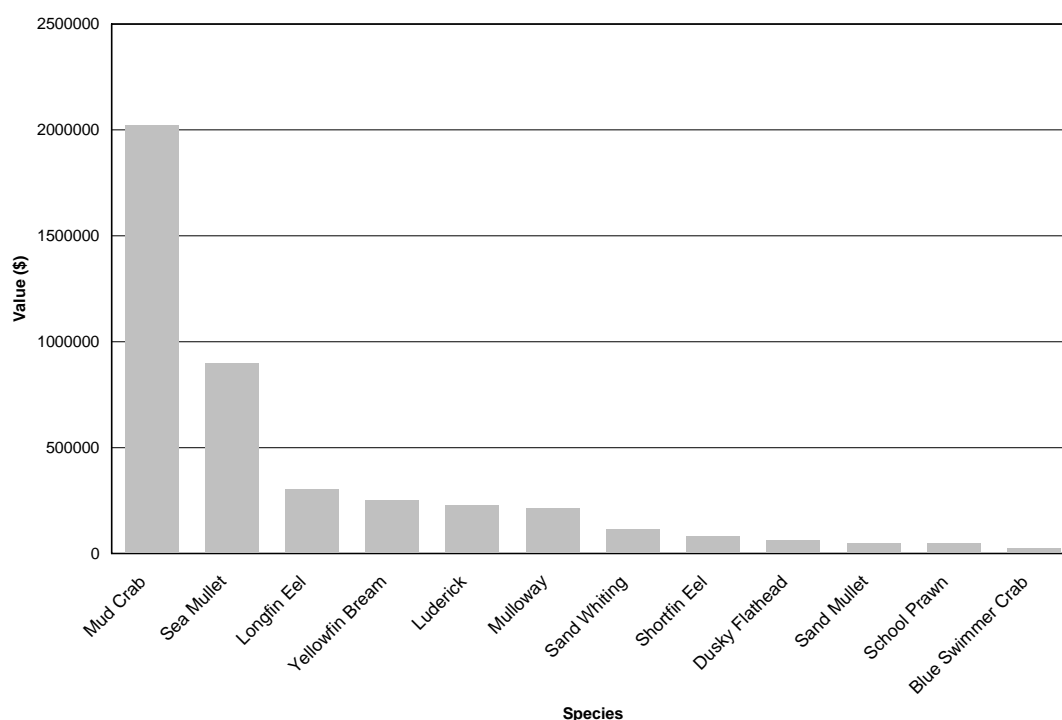


Figure 3.14 Total value of catch between 1997/98 and 2008/09 for 12 major species caught in Macleay Estuary General Fishery



Giant mud crab (*Scylla serrata*)

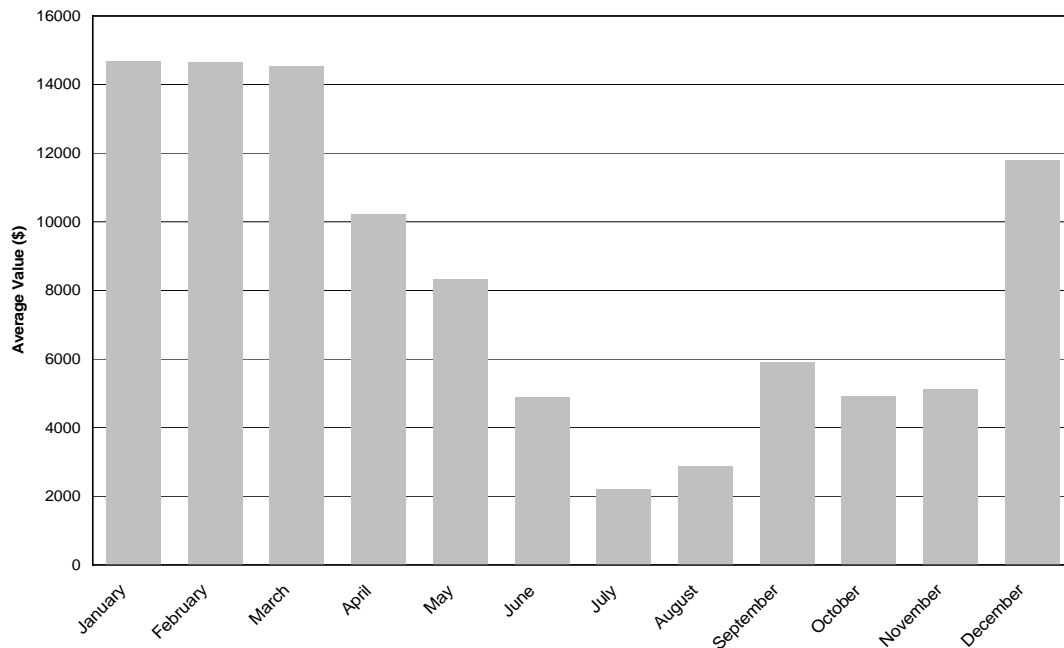
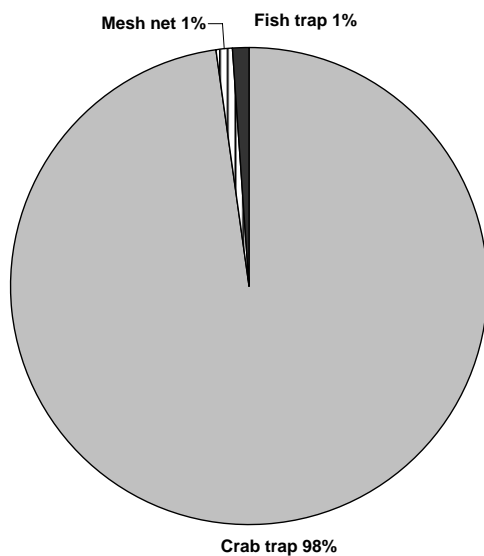


Figure 3.15 Average value of mud crabs caught on the Macleay by month between 1997/98 and 2008/09.

The giant mud crab is the largest of the swimmer crabs (family Portunidae) and is most commonly found in mangroves and on mud flats in estuarine waters. Mud crabs are able to tolerate wide variations in the temperature and salinity of water but are most active and feed most regularly at temperatures above 20°C. This is reflected by higher catch rates from the Macleay between December and March (**Figure 3.17**). Mud crabs forage for food at night, feeding primarily on crustaceans, polychaetes and molluscs. Their life span is thought to be approximately 4 years. Sexual maturity is



reached between 18 and 24 months and mating occurs in the warmer months, with females migrating out to sea to spawn 2 to 5 million eggs. The majority of females are believed to spawn only once. Early life history stages are dependent upon marine water quality and young mudcrabs re-enter estuarine waters after a number of early moulting stages. The current status of the giant mudcrab in NSW is undefined though overfishing is considered a possibility. The great majority of mud crabs on the Macleay River are caught in crab traps, with a small percentage caught in meshing nets and fish traps (**Figure 3.18**).

Figure 3.16 Percentage of mud crabs caught by method on the Macleay River between 1997/98 and 2008/09.



Sea Mullet (*Mugil cephalus*)

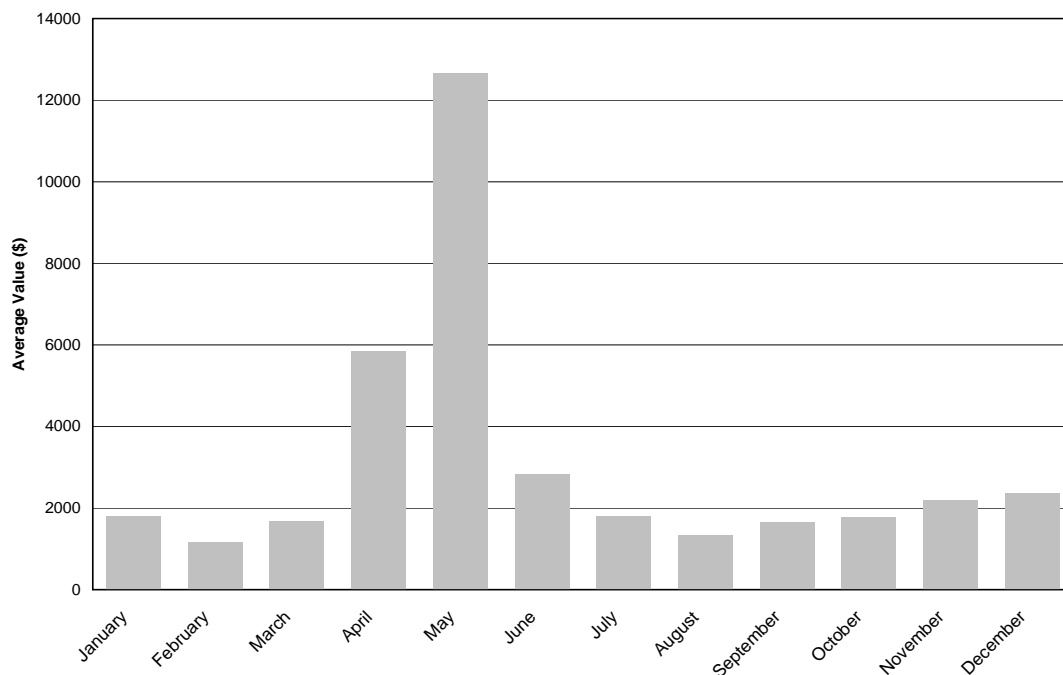
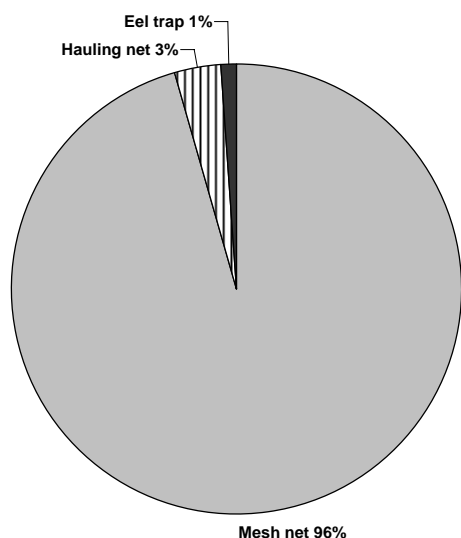


Figure 3.17 Average value of sea mullet caught on the Macleay by month between 1997/98 and 2008/09.

Sea mullet are found throughout estuaries (also utilising fresh water systems) most commonly around shallow weeds and bare substrate. Their diet consists primarily of benthic microalgae, macroalgae and detritus. In the mid to late autumn, adult (>2 years) sea mullet form large schools and migrate into oceanic waters and to the north to spawn. This is widely believed to be a physiological response to strong westerly winds and lower water temperatures and is represented by the higher catch rates during this time (**Figure 3.19**). Sea mullet fry travel south with the east Australian current and enter estuarine waters. Juvenile sea mullet depend heavily on shallow, sheltered estuarine habitats such as seagrass.



The sea mullet stocks of New South Wales are considered 'fully fished'. The numbers of mullet caught in the local area during the breeding migration is frequently raised during consultation. However, the most recent NSW status report indicated no cause for concern with regards to the stock based upon catch rates (NSW DPI 2007). Sea mullet represent the most caught target species of the Macleay estuary general fishery by weight and the second most valuable species. Mullet are included in most fish kill reports from the Macleay estuary system, often in large numbers.

Figure 3.18 Percentage of sea mullet caught by method on the Macleay River between 1997/98 and 2008/09.



Longfin River Eel (*Anguilla reinhardtii*)

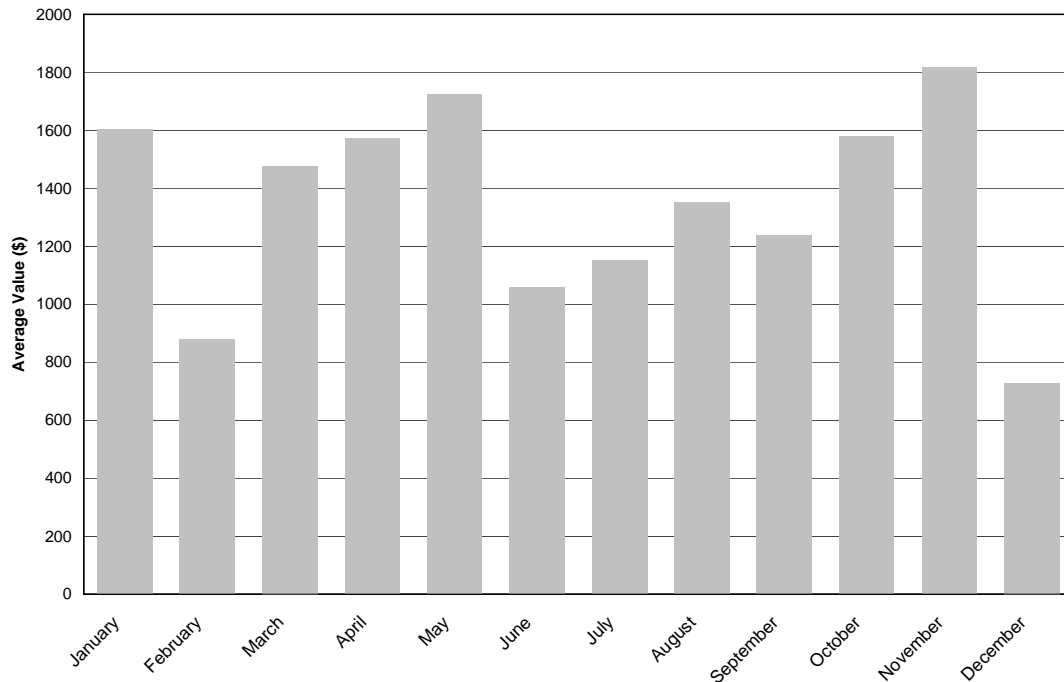
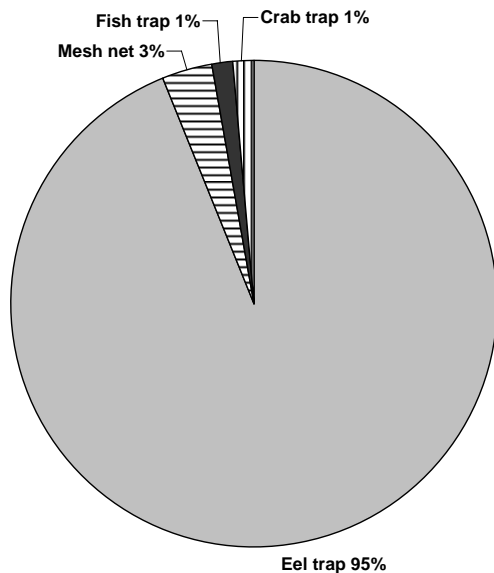


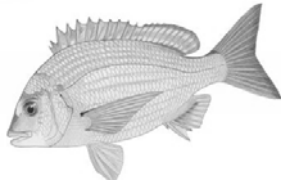
Figure 3.19 Average value of longfin eels caught on the Macleay by month between 1997/98 and 2008/09.

Longfin river eels are found within most estuarine and freshwater environments east of the Great Dividing Range but prefer flowing waters. River eels migrate north to the Coral Sea to spawn, typically during winter. After a long larval stage travelling with ocean currents, the juvenile (glass) eels enter estuarine waters. Here they appear to prefer muddy habitats and utilise seagrass beds. River eels grow slowly and take a long time to reach sexual maturity (10-50 years). Adults are presumed to die after spawning.



Eels are a hardy species that are able to overcome many of the physical barriers that affect most finfish. As an apex predator in some of the environments they occupy they are a key species for ecosystem integrity. No commercial fishing of eels is allowed in freshwaters (where females are most commonly found) and a recreational size and bag limits apply. Eels have been reported in many fish kills on the Macleay system, particularly from the Belmore River and Kinchela Creek. The status of the NSW river eel fishery is listed as lightly to fully fished.

Figure 3.20 Percentage of longfin eels caught by method on the Macleay River between 1997/98 and 2008/09.



Yellowfin Bream (*Acanthopagrus australis*)

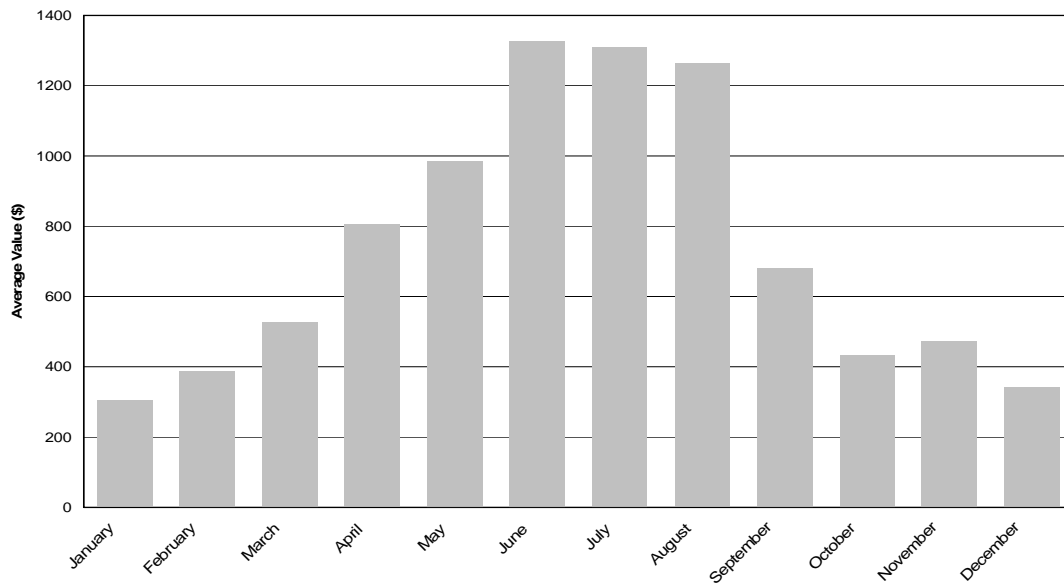
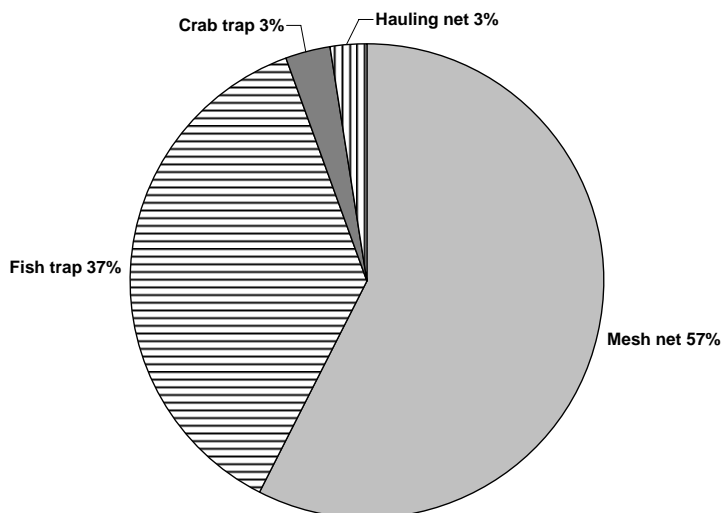


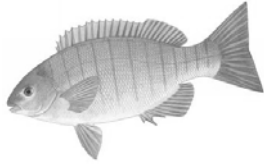
Figure 3.21 Average value of bream caught on the Macleay by month between 1997/98 and 2008/09.

Yellowfin bream are primarily encountered in estuarine and nearshore marine waters though they can be found in the lower freshwater reaches of coastal rivers. Within estuaries bream are found across a wide range of habitats including rocky reefs, seagrass beds, mangroves and sandy substrate. They eat a wide range of foods including other fish, molluscs and crustaceans. Bream are slow growing fish, taking an average of five years to reach maturity. At maturity they undertake extensive migrations to spawn around the mouths of estuaries and in the surf zone in the winter. The schooling and movement associated with spawning events is linked to the larger catch of bream during the winter months (**Figure 3.23**). The larvae re-enter estuaries after a short period where they typically associate with seagrass beds and macroalgae during the early juvenile stages. The exploitation of yellowfin bream stocks in NSW



is listed as ‘fully fished’. The recreational catch of bream across NSW is greater than the commercial catch (NSW Fisheries 2003). Bream are a commonly encountered species in fish kill reports from the Macleay estuary system. The majority of bream on the Macleay are caught in mesh nets and fish traps (**Figure 3.24**).

Figure 3.22 Percentage of bream caught by method on the Macleay River between 1997/98 and 2008/09.



Luderick (*Girella tricuspidata*)

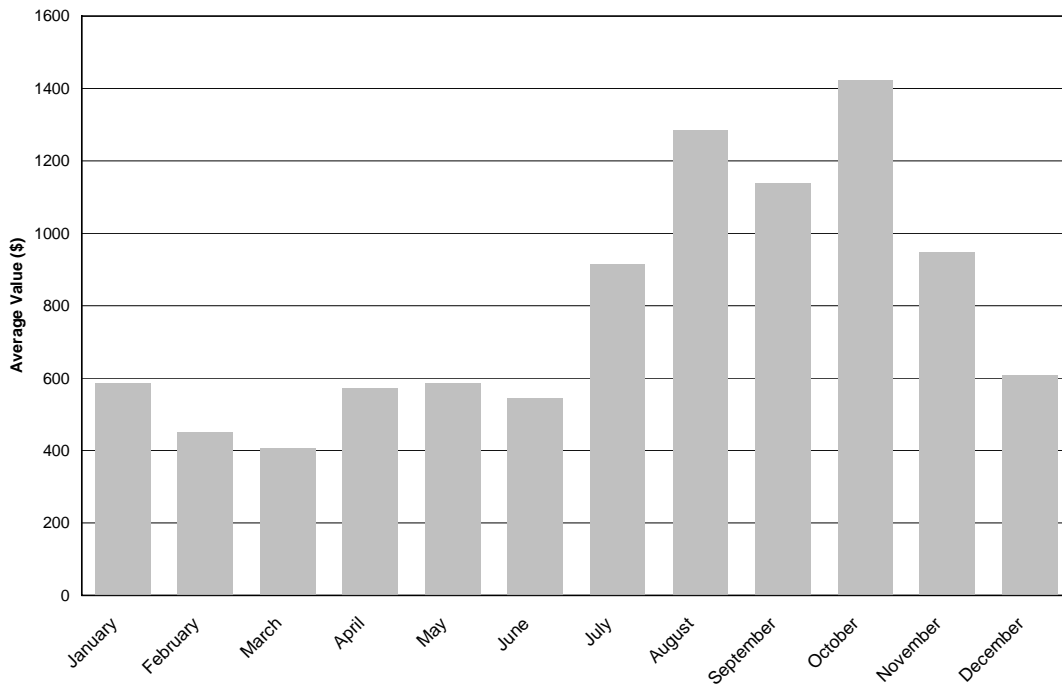
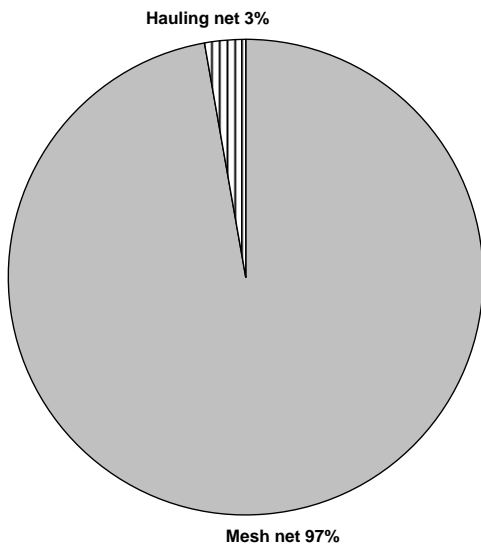


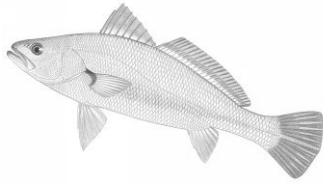
Figure 3.23 Average value of luderick caught on the Macleay by month between 1997/98 and 2008/09.

Luderick are mostly encountered in estuarine and nearshore marine waters. In estuaries, they prefer to be associated with rocky or vegetative habitats. Luderick are primarily herbivores, mostly feeding on green macroalgae, but occasionally include small invertebrates in their diet. Luderick are slow growing, taking 4 to 5 years to reach maturity. Adult fish migrate northwards in large schools to spawn, which occurs in the surf zone around estuary entrances in the winter. Adults return to the estuary. Juvenile luderick, once they reach estuarine waters, are most often associated with aquatic plant life.



The status of luderick is listed as 'moderately fished'. In the Macleay they are most often caught in mesh nets during the months of August – October. Across NSW the recreational catch of luderick is approximately the same size as the commercial catch.

Figure 3.24 Percentage of luderick caught by method on the Macleay River between 1997/98 and 2008/09.



Mulloway (*Argyrosomus japonicus*)

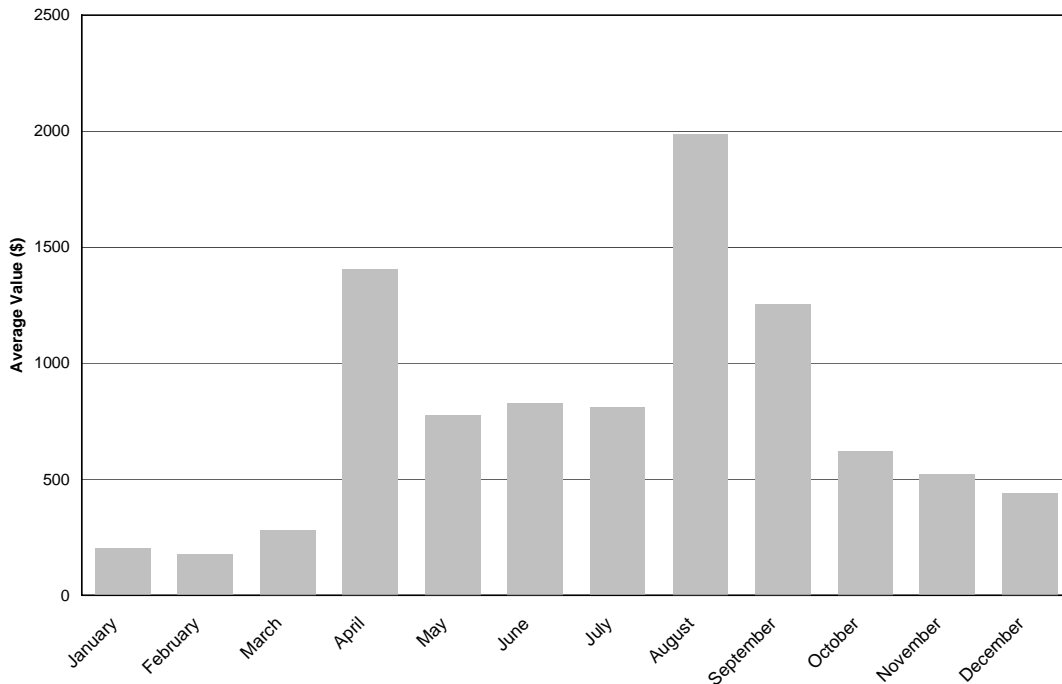
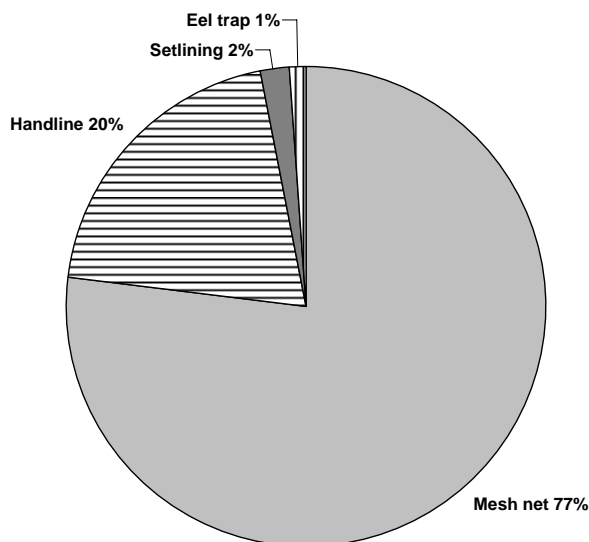


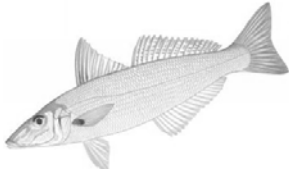
Figure 3.25 Average value of mulloway caught on the Macleay by month between 1997/98 and 2008/09.

Mulloway are a coastal fish species that are found in estuaries as juveniles but also, at times, as adult and sub adults. Large fish are usually only found in lower estuaries. As juveniles, the diet is largely composed of crustaceans but larger fish prefer to consume squid and smaller fish.



Limited information about the life cycle of mulloway is available though spawning is known to occur in the summer. In the Macleay the catch rate for mulloway increases during August and September (**Figure 3.27**). The status of the mulloway for NSW waters is listed as ‘overfished’. The total weight of mulloway caught on the Macleay is relatively low, but the high prices obtained make it a valuable species to the industry.

Figure 3.26 Percentage of mulloway caught by method on the Macleay River between 1997/98 and 2008/09.



Sand Whiting (*Sillago ciliata*)

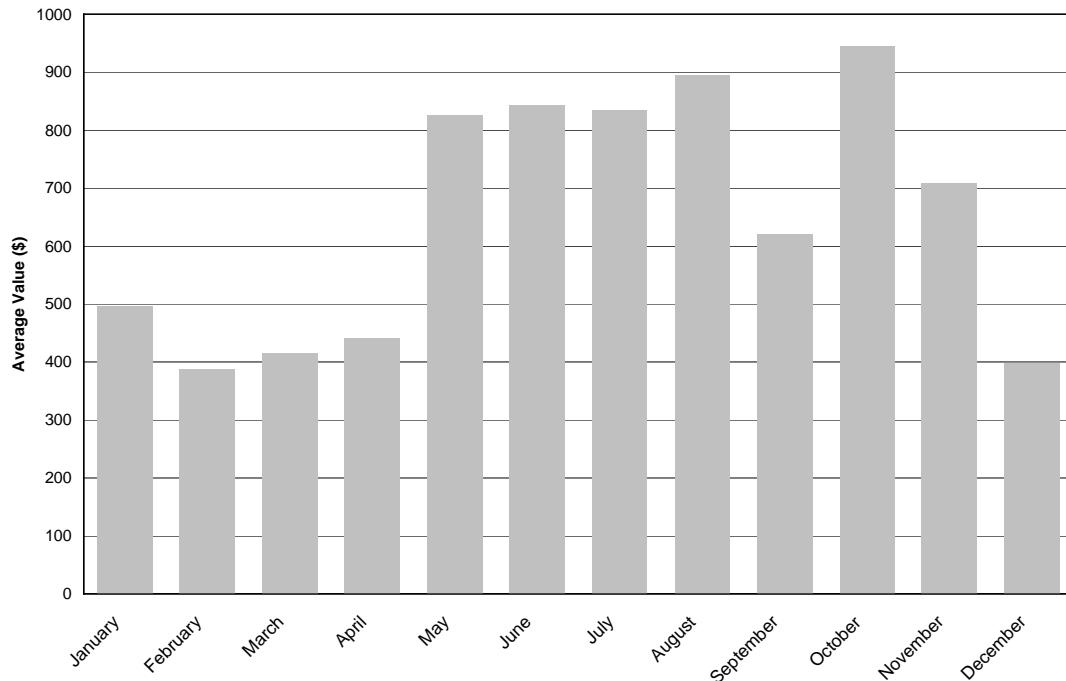


Figure 3.27 Average value of whiting caught on the Macleay by month between 1997/98 and 2008/09.

Sand whiting are found in estuarine and nearshore marine waters. In estuaries they prefer bare sandy habitats and have a diet that consists primarily of polychaetes, crustaceans and molluscs.

Sand whiting spawn during the summer in estuaries and in near shore environments near the mouths of rivers. Juveniles enter estuaries and prefer shallow waters in the vicinity of seagrass beds or mangroves.

The status of sand whiting in NSW is listed as ‘fully fished’.

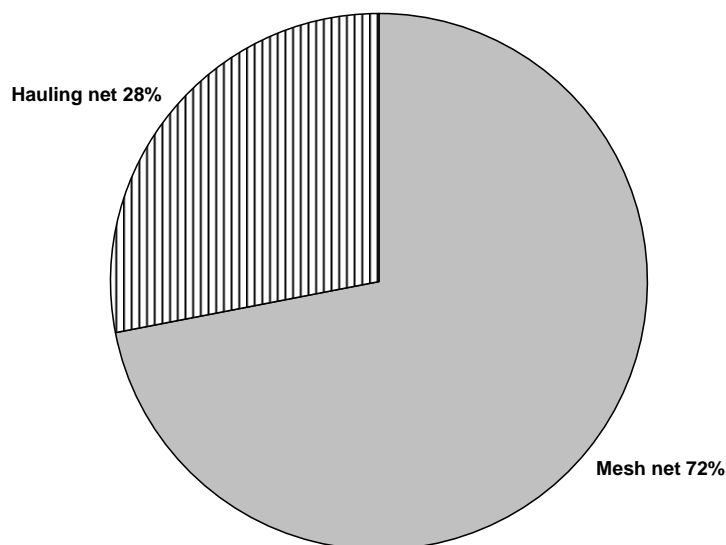


Figure 3.28 Percentage of sand whiting caught by method on the Macleay River between 1997/98 and 2008/09.



Shortfin River Eel (*Anguilla australis*)

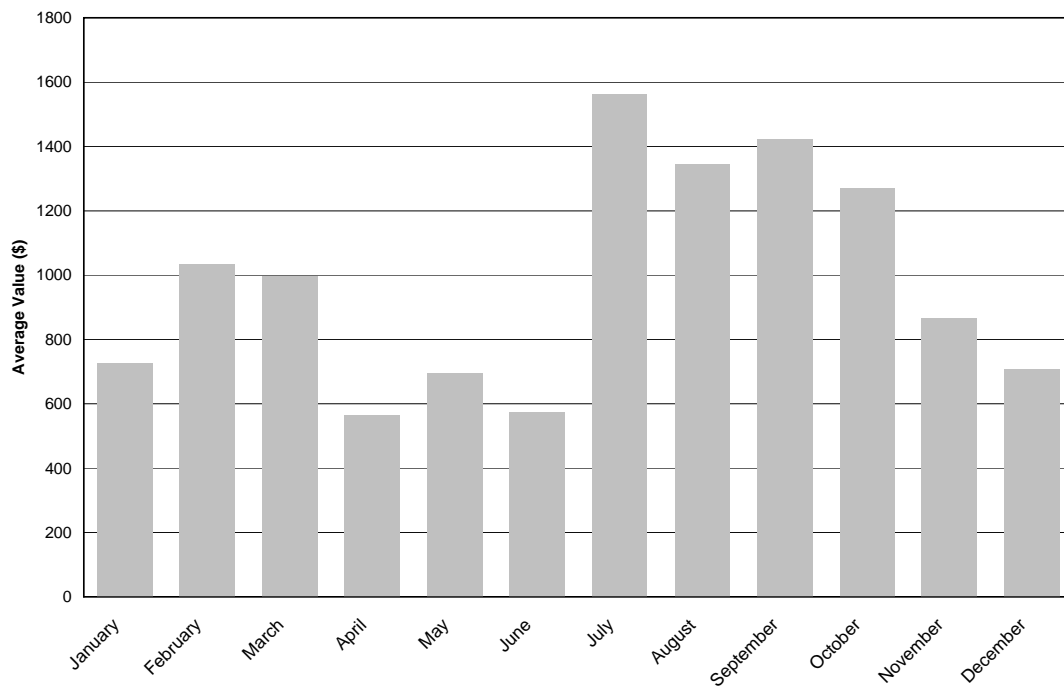


Figure 3.29 Average value of shortfin eel caught on the Macleay by month between 1997/98 and 2008/09.

The shortfin river eel has a very similar biology to the longfin river eel. On the Macleay, shortfin river eels are caught in eel traps (95% of catches) and occasionally in mesh nets. The peak months for capturing shortfin eel on the Macleay appear to be July through October.



Dusky Flathead (*Platycephalus fuscus*)

The dusky flathead is mostly found in estuarine waters and occasionally in nearshore marine waters. In estuaries, they are mostly found on soft muddy or sandy substrates, and in seagrass beds. Their diet consists mostly of small fish and a variety of invertebrates.

Spawning occurs in the lower reaches of estuaries during the summer months. Larvae enter estuaries and prefer the same habitats as adult fish. Overnight setting of mesh nets in the lower estuary is only allowed during the winter, explaining the increase in dusky flathead catches during this time of the year (**Figure 3.32**).

The recreational catch of dusky flathead is much greater than the commercial catch. The stock in NSW is listed as 'fully fished'. On the Macleay River, 97% of commercially caught dusky flathead are caught with meshing nets.

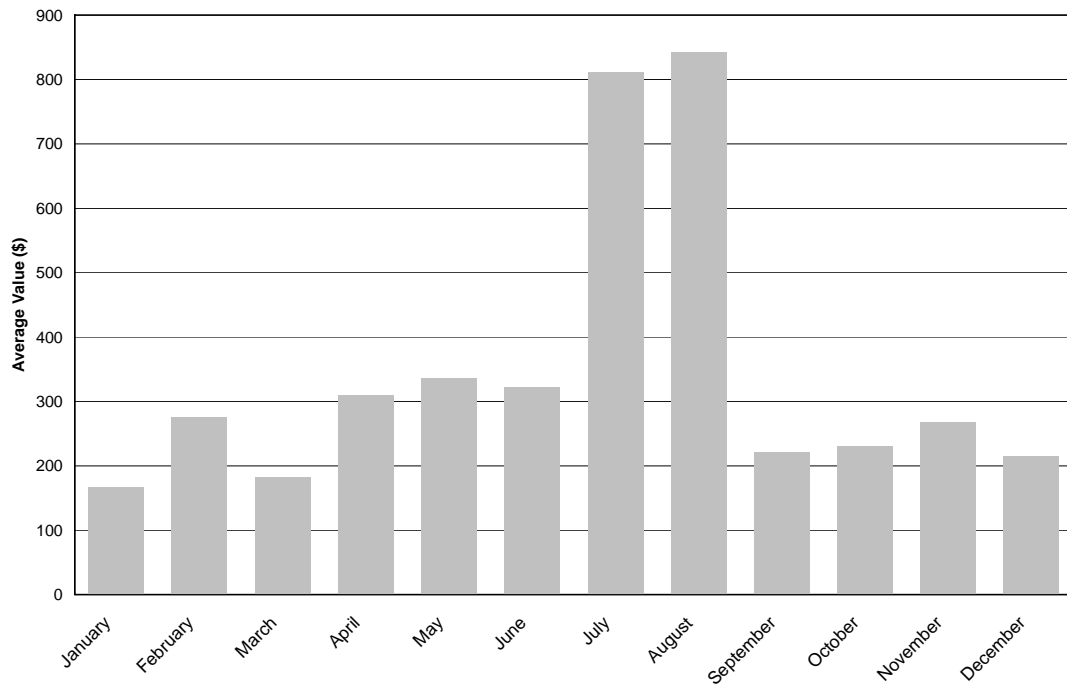


Figure 3.30 Average value of dusky flathead caught on the Macleay by month between 1997/98 and 2008/09.



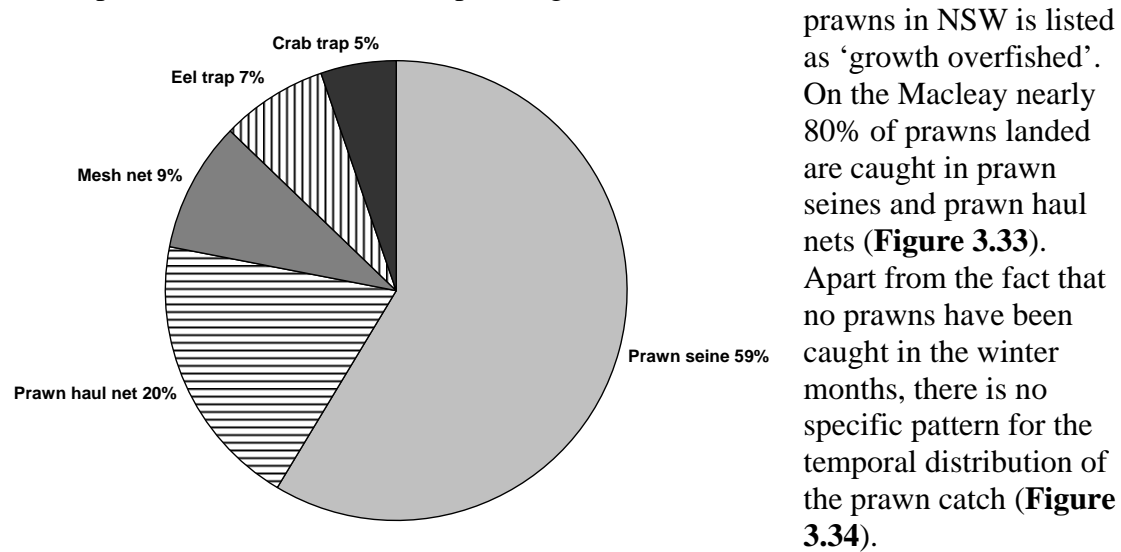
Sand Mullet (*Myxus elongates*)

There is limited available information about the sand mullet. They are understood to be reproductively most active between January and March and spawn in the lower parts of estuaries and nearshore marine waters. Most sand mullet in the Macleay are caught in mesh nets during the peak season for sea mullet, with which they are often associated.

School Prawn (*Metapenaeus macleayii*)

The school prawn inhabits estuarine waters during the juvenile and sub-adult stages of its life cycle. Within estuaries they prefer soft muddy substrates and seagrass beds and are found in brackish and even freshwater environments. Prawns feed on detritus and small invertebrates.

Adult prawns are found in marine environments where they spawn between February and May. School prawns only spawn once. Juvenile prawns return to estuarine waters after a short larval period. Freshwater events are thought to be very important in the life cycle of school prawns, triggering downstream migrations and gonad development and associated with spawning success. The stock assessment for school prawns in NSW is listed as 'growth overfished'.



On the Macleay nearly 80% of prawns landed are caught in prawn seines and prawn haul nets (Figure 3.33). Apart from the fact that no prawns have been caught in the winter months, there is no specific pattern for the temporal distribution of the prawn catch (Figure 3.34).

Figure 3.31 Percentage of school prawns caught on the Macleay River by method between 1997/98 and 2008/09.

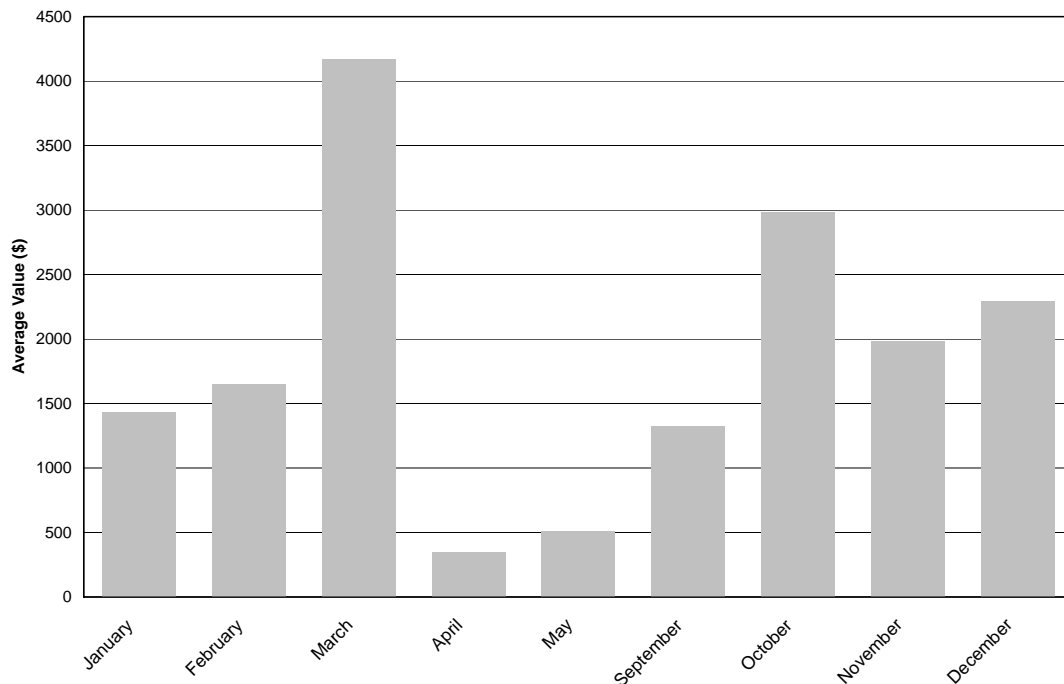


Figure 3.32 Average value of school prawns caught on the Macleay by month between 1997/98 and 2008/09.

3.3.4 Fishing Effort

During consultation for the Macleay River Estuary Management Plan a number of concerns were raised about potential increases in commercial fishing effort on the Macleay River associated with the declaration of recreational fishing havens on the Hastings and Bellinger Rivers.

I&I NSW collect information about fishing effort with the monthly catch returns submitted by all commercial fishers in NSW. The available information can be used to analyse changes in commercial fishing effort over time. The average number of commercial fishers submitting monthly catch returns on the Macleay River has remained relatively stable over the years between 2002 and 2008 at an average of 12-15. The assembled data gives no indication that there has been an increase in the number of commercial fishers utilising the Macleay River as a result of the declarations of nearby Recreational Fishing Havens (**Figure 3.33**).

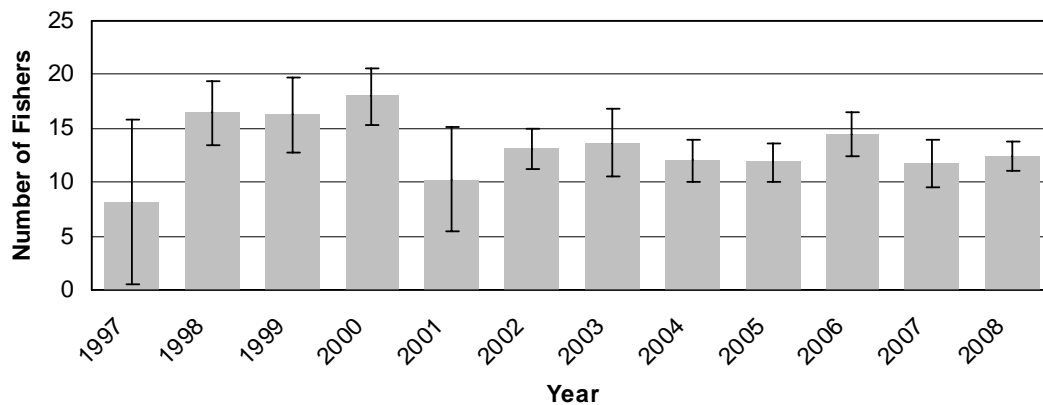


Figure 3.33 Average (\pm SD) number of estuary general permit holders submitting monthly catch returns per year for the Macleay River.

The two most commonly used methods on the Macleay River are meshing and crab trapping. The number of reported days fishing is available for both of these methods on the Macleay. This information is displayed in **Figures 3.34** and **3.35**.

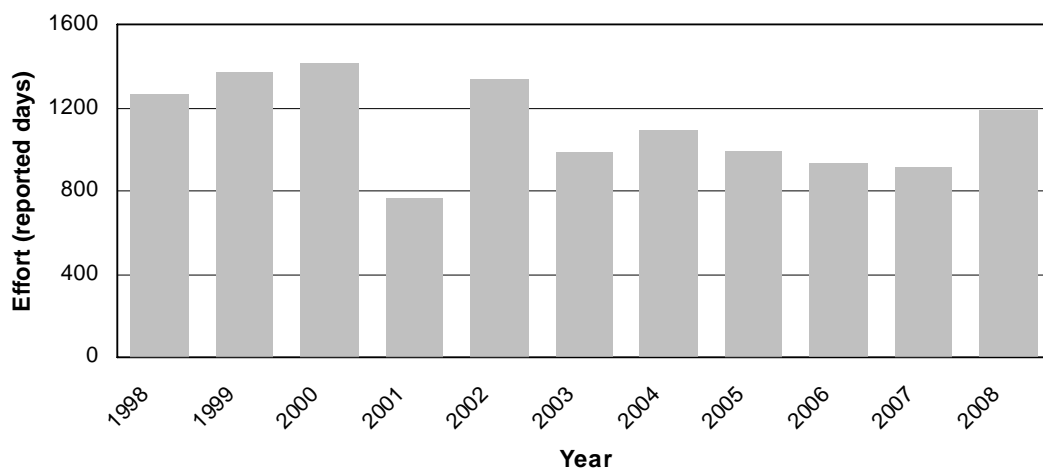


Figure 3.34 Fishing effort for meshing on the Macleay River between 1998 and 2008, displayed as total number of reported fishing days per year.

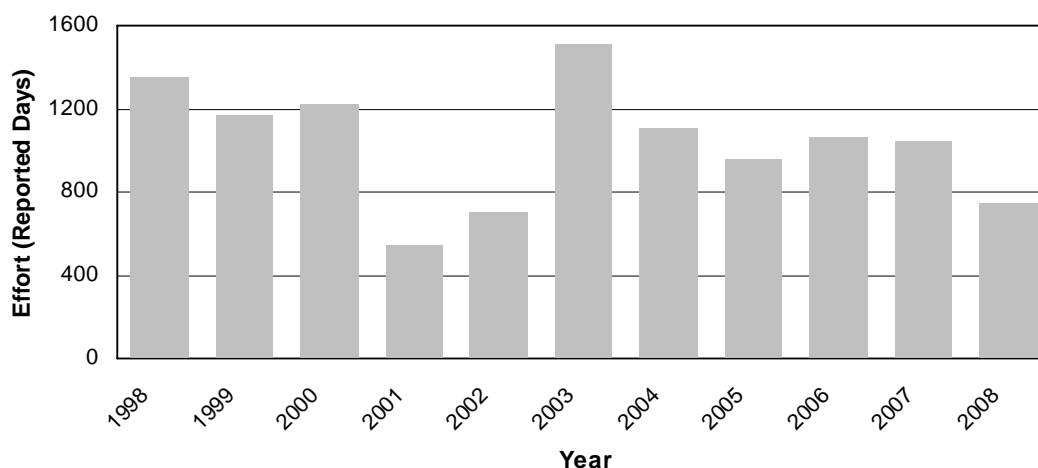


Figure 3.35 Fishing effort for crab trapping on the Macleay River between 1998 and 2008, displayed as total number of reported fishing days per year.

There appears to be no clear pattern of increasing or decreasing effort for commercial fishing on the Macleay River for either meshing or crab trapping activities. Specifically there is no indication of a long term intensification of effort since the declaration of nearby Recreational Fishing Havens in late 2002, despite a peak in the crab trapping effort in 2003.

3.3.5 Fishing Closures Operating on the Macleay River Estuary

NSW I&I administrate a number of fishing closures on the estuary general fishery, some of which apply to the whole fishery, and some of which are specific to individual water bodies, such as the Macleay River. The current closures operating on the Macleay River are listed in **Table 3.3**. Recreational closures are listed in **Section 3.5** of this report.

Table 3.3 Commercial fishing closures operating within the study area.

<i>Area Affected</i>	<i>Species Affected</i>	<i>Methods Affected</i>	<i>Periods</i>
Garfish Netting			
Whole estuary	All fish species	Hauling - Use of a garfish hauling net	Midnight Friday until midnight Sunday each week and any public holiday.
Prawn Count Closure			
Whole estuary	Prawns	All methods	Any time counts are less than 125 king prawns per ½kg or 180 other prawns per ½kg.
Weekend Netting			

<i>Area Affected</i>	<i>Species Affected</i>	<i>Methods Affected</i>	<i>Periods</i>
Whole estuary including tributaries	All fish species	Any method involving the use of a net, other than the following: (a) a dip or scoop net (prawns), (b) a hand-hauled prawn net, (c) a hoop or lift net, (d) a push or scissors net (prawns), (e) a landing net.	6pm Friday to 6pm Sunday in each week, or to 6pm Monday if Monday is a public holiday.
Nets			
All waters upstream of the Kempsey Railway Bridge	All fish species	All nets other than landing nets	All year
Set Meshing Net – Lower Reaches			
All waters lying on the northern side of a line drawn from the northern bank of Spencer's Creek to Kemp's Corner and from a line drawn east/west crossing the southern end of Whiskey Island.	All fish species	Any method involving the use of a meshing net, unless the net is used by the method of splashing.	All year
Set meshing Net – Jerseyville to Smithtown			
Between Smithtown Bridge and the Jerseyville Bridge including tributaries	All fish species	Any method involving the use of a meshing net, other than used by the method of splashing or when set for a period of less than 2 hours.	May 1 st until August 31 st each year.
Set meshing Net – Upper Reaches			
Between Smithtown Bridge and the Kempsey Railroad Bridge including tributaries	All fish species	Any method involving the use of a meshing net, unless the net is used by the method of splashing.	May 1 st until August 31 st each year.
Belmore River			
Belmore River flood gate downstream to the road bridge at Gladstone including tributaries.	All fish species	Any netting or trapping other than an eel trap or landing net.	All year
Belmore River – Upper Reaches			
Waters of the Belmore and tributaries upstream of the flood gates.	All fish species	All nets other than landing nets	All year
Yarrahapinni Wetlands National Park			

<i>Area Affected</i>	<i>Species Affected</i>	<i>Methods Affected</i>	<i>Periods</i>
All waters of the YWNP upstream of the confluence with Andersons Inlet.	All fish species	All methods	All year
South West Rocks Creek			
All waters of South West Rocks Creek.	All fish Species	All nets other than landing nets	All year

3.3.6 Export Approval Conditions

The NSW Estuary General Fishery is subject to a number of conditions for the maintenance of its export approval status under the Federal *Environment Protection and Biodiversity Conservation Act 1999*. The conditions mostly relate to monitoring and stock evaluation strategies to ensure the sustainability of the fishery. In order to maintain export approval the fishery must submit an annual report to DEWHA detailing:

- The nature of the fishery;
- Changes to the management of the fishery;
- New research and monitoring activities;
- The most recent catch data;
- The status of target stock;
- Interactions with threatened species;
- Ecosystem impacts of the fishery;
- Progress in implementing recommendations and conditions of the previous export approval process;

The submissions are a good source of information about the fishery and freely available from the DEWHA website.

3.3.7 Seasonal Variation in the Macleay Estuary General Fishery

A summary of key events affecting the Macleay Estuary General Fishery is provided in **Table 3.4**

Table 3.4 A summary of key events that affect the Macleay River estuary general fishery over the seasons.

<i>Season</i>	<i>Species</i>	<i>Event</i>
Summer	Mud crab	Increased activity as a result of warmer water temperatures leads to increased catch rates. Mating occurs with 'berried' females migrating to ocean waters to release eggs. 'Berried' females are rarely caught in NSW waters.
	Mulloway	Mulloway school to spawn, which occurs in marine waters beyond the surf zone.
	Sand whiting	Spawning occurs in the lower estuary and nearby ocean waters.
	Dusky flathead	Spawning occurs in the lower estuary, typically in seagrass beds.
Autumn	Sea mullet	Fish gather in very large numbers in the lower estuary prior

<i>Season</i>	<i>Species</i>	<i>Event</i>
		to a spawning run north to the coral sea. Catch of sea mullet spikes dramatically in the autumn as they become easier to target in large schools.
	Sand mullet	Highest catches of sand mullet occur during the autumn months, most likely as fish associated with sea mullet schools are caught incidentally.
Winter	Yellowfin bream	Fish migrate out to nearshore marine waters to spawn. Fish gather in large numbers around rocky shores, reefs and in the surf zone. The catch of yellowfin bream spikes dramatically in the winter months.
	Luderick	Fish migrate out to nearshore marine waters to spawn. Fish gather in large numbers around rocky shores, reefs and in the surf zone.
	Mulloway	Highest catches of mulloway occur during the winter months. May be associated with the ability to set meshing nets overnight during this time of the year.
	Dusky flathead	Highest catches of flathead occur during the winter months. May be associated with the ability to set meshing nets overnight during this time of the year.
	All fish	Closures affect the use of set nets upstream of Jerseyville during the winter to reduce the effects on spawning Australian bass in the mid estuary.
Spring	Luderick	Highest catches of luderick occur during the spring months.
	River eels	Highest catches of river eels occur during the spring months.

3.3.8 Threats to Estuary General Productivity

Fish kills

Fish kills are a significant issue affecting the Macleay River Estuary General Fishery. There have been a number of significant fish kills on the Macleay River estuary system. Whilst fish kills are a natural occurrence to a certain extent, it is widely accepted that the majority of kills are triggered by the release of oxygen poor and/or acidic water from the floodplain (eg. Richardson 1980). NSW I&I maintain a database of recorded fish kills. Over the period between 1977 and 2009 42 reports of fish kills were recorded on estuarine waters of the Macleay River. The reports include kills of a few fish up to tens of thousands or tons of fish. The most commonly reported species include bream, mullet, luderick, eels, bass, estuary perch, flathead and prawns. Fish across all size categories occur within the reports. The majority of the reports include a description of the water as 'black' or 'brown' and where water quality measurements were taken they frequently describe low pH and/or low dissolved oxygen readings. As a result of the catastrophic fish kill in 2001 the Macleay Estuary General industry was closed for a period of three months.

Loss of productive fishing grounds

Mechanisms that can reduce the available area for commercial fishing practices include;

- habitat loss (see **Section 2** of this report);

- infilling of deep holes due to increased sediment loads and bank erosion; and
- the development of jetties, wharves and pontoons.

In addition, the construction of floodgates and levee banks resulted in the loss of the Yarrahapinni Wetlands, formerly one of the most productive fishing grounds of the Macleay system.

The *Fisheries Management Act 1994* provides for the declaration of ‘recognised fishing grounds’ (RFGs). These are areas of historical use for net fishers where commercial netting activities can be given priority of access with the aim of reducing conflict between users. At present no RFGs have been defined on the Macleay system.

Loss of productive upstream habitats

The modification of floodplain wetlands has resulted in a great reduction of habitat availability to several species of commercial interest, most notably river eels and mullet species.

Water quality

Poor water quality associated with acidic and deoxygenated water export from drained floodplain wetlands has been demonstrated to cause catastrophic fish kills on the Macleay and elsewhere. In 2001, a flood event resulted in the closure of the estuary general fishery for a period of 3 months.

Overfishing

The combined recreational and commercial fishing activities on the Macleay result in the removal of a significant biomass and number of fish from the system. Whilst recent years have shown relatively regular commercial catches, the overall production has reduced greatly since the 1970s. This may be a result of changes to landuse and catchment management, reduction in the extent of habitat, increased fishing pressure or a combination of all three.

3.4 Macleay Aquaculture Industry

3.4.1 Oyster Aquaculture Production

Aquaculture on the Macleay River estuary is limited to the production of the Sydney rock oyster, *Saccostrea glomerata*. Commercial production of *S. glomerata* is practiced in 41 estuaries throughout NSW. The NSW total average annual production between 1999/2000 and 2007/2008 was more than \$32million or 7.3million dozen oysters (see **Figure 3.36**). Production has been relatively stable over this period but the 2 decades prior to this period had seen oyster production decline from a peak of 146500 bags (approximately 14.7million dozen oysters) in 1976/77 (NSW DPI 2006). Oyster production in NSW is dominated by Wallis Lake. The Macleay River contributed an average of 1.7% of total NSW Sydney rock oyster production (1.55% of dollar value) over the period from 1999/2000 to 2007/2008 and occasionally ranks within the top ten oyster producing estuaries of the state.

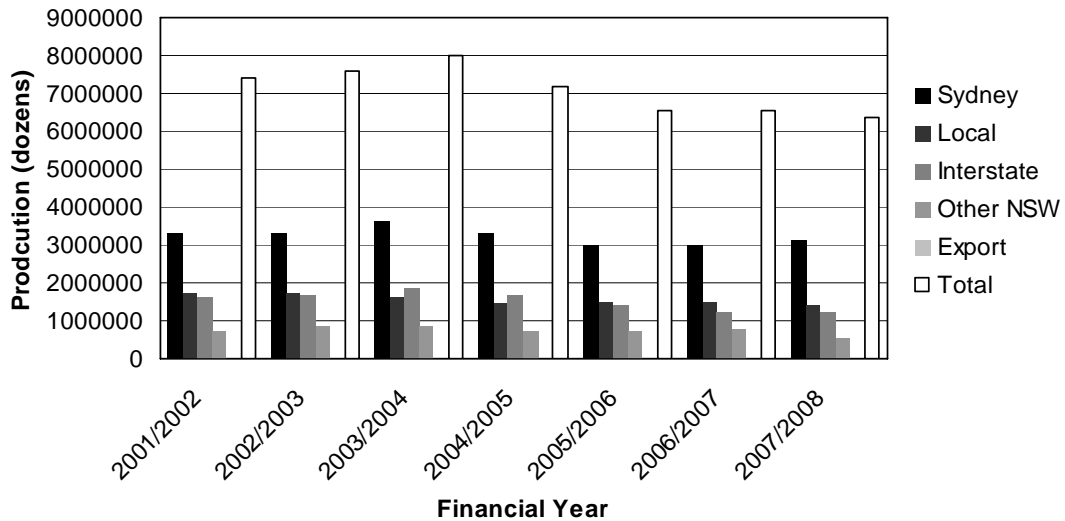


Figure 3.36 Annual Sydney rock oyster production for NSW by market (Source: NSW I&I annual aquaculture reports).

Sydney Rock Oysters are a bivalve mollusc that can live in a variety of habitats, from subtidal sediments up to 3m deep to intertidal rocky shores. They obtain their food by filtering minute particles, including bacteria and algae, from the water column. An individual plate grade oyster can filter up to 60L of water per day. In this way, oyster farming can be beneficial for the clarity of estuarine waters. The Sydney Rock oyster takes approximately 3-4 years to reach maturity, at which time it is ready for sale. Once mature, oysters spawn a number of times throughout their life first as a male and subsequently as a female. During spawning, adult females disperse up to 20 million eggs and males hundreds of millions of sperms into the water when the tide and current are optimal for the widest distribution. Fertilisation takes place in the water column and development continues for up to 3-4 weeks as the larval stages of the oyster swim and grow, ultimately settling on a suitable hard clean surface. Survival rates during this phase are less than 0.1%. The surviving oysters are called "spat" and can be collected, distributed to oyster leases and grown for sale. Oysters are preferentially hunted by some birds, fish, crustaceans and octopus. One benefit of the Sydney rock oyster for aquaculture is its unique ability to stay alive (and therefore fresh) for up to 12 days out of water. This ensures that transported or exported oysters do not require processing or freezing.

Across NSW the most popular production methods are Tray, followed by Raft, Stick and Basket production. In the Macleay, most oysters are grown on trays and baskets, though raft and float methods are also utilised (see **Figure 3.37**). Each individual method has its benefits and drawbacks. In the case of the Macleay, oysters grown using the tray method were most susceptible to mortality during the period from late 2006 to 2008.

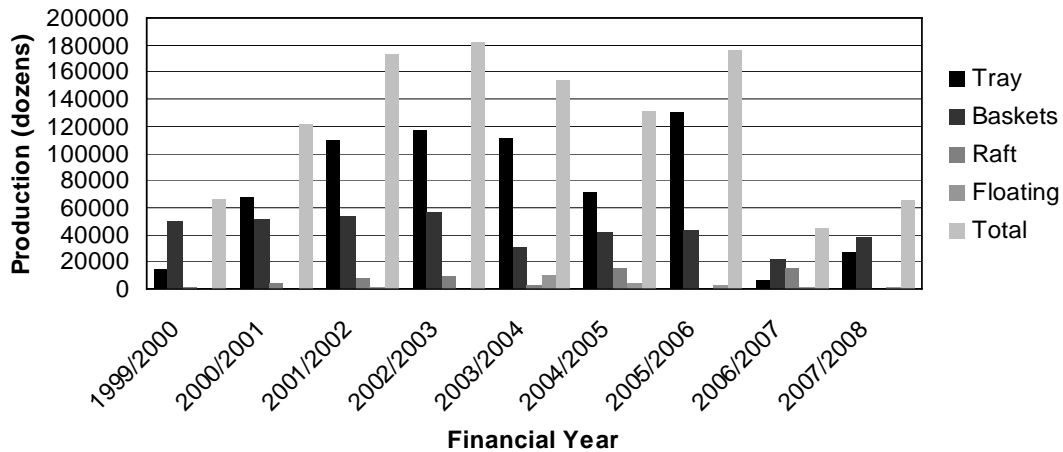


Figure 3.37 Macleay River annual oyster production by method (Source: NSW I&I annual aquaculture reports).

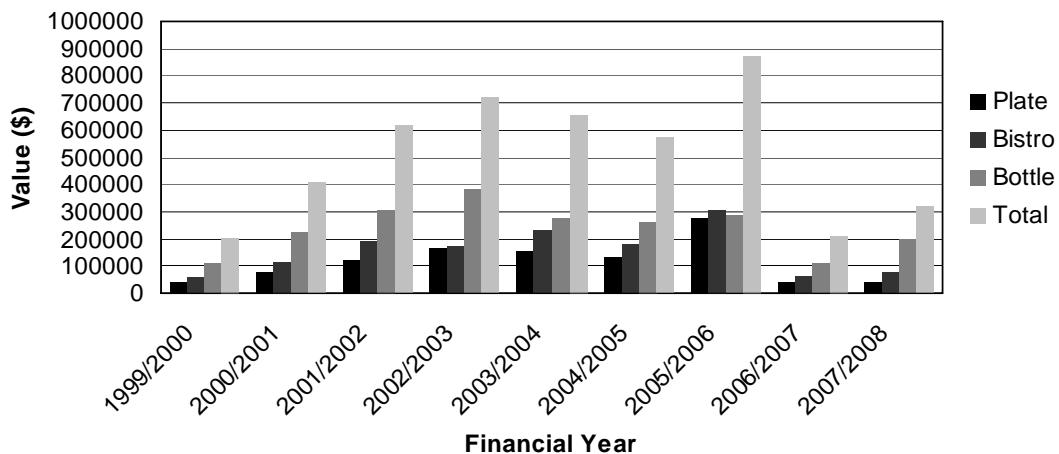


Figure 3.38 Macleay River annual oyster farm gate value by grade (Source: NSW I&I annual aquaculture reports).

The Macleay River oyster industry has suffered a number of severe setbacks in recent years, including an outbreak of QX disease and subsequent NSW Industry and Investment biosecurity restrictions, uncharacteristic losses to an unknown toxin at the end of 2008 and stock losses associated with flooding and the release of acidic deoxygenated water throughout 2009. These factors accounted for the poorest years for oyster growers on the Macleay since 1999/2000 (See **Figure 3.38**). The biosecurity restrictions mean that oyster growers on the Macleay River can no longer supply estuaries that have a lower QX risk classification. The Macleay is considered an excellent catching estuary and this restriction has caused a significant reduction in the overall value of oyster farming in the area. In NSW, oysters are graded by size before sale. The largest saleable grade is plate oysters, followed by bistro and then bottle. Most oysters from the Macleay are sold at the bottle size, followed by bistro and then plate (see **Figure 3.38**). The farm gate value of oysters from the Macleay has averaged at \$509373 over the 9 years to 2007/2008, peaking at \$870894 in 2005/2006.

3.4.2 Threats to Aquaculture Productivity

The primary threats to the productivity of the Macleay River oyster industry are diseases and those that affect water quality.

Diseases affecting oyster production

A variety of diseases can affect oyster production (Neill 2007), including;

- *QX disease* – This disease causes mortality via a widely distributed protozoan parasite, *Marteilia sydneyi*. An outbreak of this parasite, which occurs in the sediments of most NSW oyster growing estuaries, results in the death of large numbers of oysters. The disease appears to be seasonal, with infection usually occurring between January and April and diseased oysters usually losing condition and dying in the winter or early spring. A QX outbreak occurred in the Macleay in 2006, resulting in the classification of the Macleay as high risk under NSW I&I biosecurity protocols. Curiously, the expression of QX in the Macleay was the reverse of the normal trend, having most impact in the New Entrance oyster harvest zone where the tidal flushing is greatest. No significant loss of oysters to QX disease has occurred on the Macleay River since 2006. The trigger for an outbreak is unknown but it is widely thought to be related to:
 - Environmental factors and the resultant impact upon the ability of the agent to infect and the ability of the oyster to resist infection;
 - The availability of other hosts in the disease agents life cycle; and
 - The immune status of the oyster.
- *Mudworm* – Mudworm is the generic name for a range of spionid polychaete worms, the most damaging of which is *Polydora websteri*. Mudworm was accidentally brought into NSW waters from New Zealand, annihilating natural oyster reefs and destroying the dredge bed oyster industry in all but a few locations. The modern oyster farming methods have largely been developed as a response to mudworm, with the best control observed in oysters grown above the mid tide level.
- *Winter mortality* – Winter mortality is a disease that is caused by a protozoan parasite *Bonamia roughleyi*. Winter mortality is generally not a problem in estuaries located to the north of Port Stephens.
- *Flatworm* – Flatworm, *Imogine mcgrathi*, is another parasite capable of causing oyster mortality that appears to have the greatest effect in times of drought, ie when salinities are highest. The status of flatworm in the Macleay River estuary is not known.

In order to assess the potential causes of large mortalities suffered in 2008-2009 a survey was distributed amongst Macleay River oyster growers by John Schmidt (DECCW).

Oyster Grower Survey Results

Introduction

After large mortalities were suffered in isolated oyster leases on the Macleay River in late 2008, DECC staff undertook some testing of oysters, sediment and water to assess the possible role of agricultural pesticides in the oyster kills. No significant pesticide residues were detected. After an interagency meeting

describing the results of the DECC pesticide investigations and further consultation with oyster growers a survey was distributed amongst Macleay oyster growers in an attempt to better understand the factors causing oyster mortality on the Macleay.

The specific aims of the survey were;

- to collect information about the timing, location and severity of kills;
- to prepare a list of possible causes;
- to prepare a list of other problems affecting the oyster industry;
- to define the questions about water quality, runoff and estuary health that might assist in the development of solutions to the problem; and
- to prepare a list of actions the oyster industry would like to see undertaken.

Results

Six surveys were returned. All of the oyster growers that returned surveys suffered significant oyster deaths in stock between September 2008 and May 2009. Four of the growers considered the deaths to be widespread (*ie*, in many leases across a harvest zone.). The percentage of oysters killed ranged from 40% up to 80-90%. 5 of the growers reported deaths among oysters of all age classes. The general results are in **Table 3.5**. The oyster growers were able to identify individual leases where the mortalities were heaviest, in turn allowing for the spatial representation of the information to assess whether any patterns existed. This information is displayed in **Figure 3.39**. No specific trends are immediately obvious but the largest number of leases were affected in the New Entrance harvest area and the most severe losses occurred in the Fishermans Reach harvest area.

Discussion

The survey results, along with other accumulated knowledge point to a number of separate agents causing oyster mortality on the Macleay River;

- The first is the QX disease, though limited sampling and the observations of the oyster growers would indicate that this has not been a major factor since the first outbreak in 2006. The QX disease mortality is compounded by the fact that having a QX quarantine eliminates the option of moving healthy oysters to other areas during times of poor water quality. There appears to be a consensus among the Macleay farmers that QX is dormant or semi-dormant in the estuary but the costs associated with testing for reclassification (Approx \$90000 over 3 years) are prohibitive.

- The second issue is the discharge of 'black water' from the Clybucca floodgates and to a lesser extent from other drained backswamps on the Macleay floodplain. The operation of this factor is most likely to be limited to large, repeated freshwater events that reduce the ability of oysters to feed and/or starve them of oxygen for a prolonged period. Results from DECC pesticide testing indicate that sulphur concentrations associated with the dispersal of MBOs in black water may also be causing mortality.
- The third issue is acid water discharge from the Clybucca floodgates. This acts over a limited time frame and only appears to have affected oysters in the uppermost harvest area (Clybucca harvest area).
- The fourth factor is an unknown, possibly toxic agent that appears to operate in isolated, discrete areas during dry periods.

The results of the survey gave an indication of what future research and management might improve the understanding of the causes of mortality and responses to any future mortality events. They are as follows;

- Management of the operation of floodgates and drainage in the Clybucca, Seven Oaks and Collombatti areas. The discharge of poor quality water from the Clybucca Floodgates negatively affects the Macleay oyster industry. These impacts may escalate in the long term as high intensity rainfall events are predicted to increase in this area under current climate change scenarios.
- Management of the operation of floodgates and drainage throughout the Macleay system. Whilst the impacts of other backswamp systems are unlikely to be as direct as Clybucca/Collombatti/Seven Oaks poor quality water from the Macleay general negatively impacts the oyster industry.
- An investigation into the distribution, source, nature and effects of black oozes around the oyster harvest zones.
- An investigation into the possibility of other toxic agents operating in the oyster harvest zones. If potential agents are found to be operating then an investigation into the source and delivery should be undertaken.

- A clear outline of management responsibilities for undertaking investigations on behalf of Macleay oyster











growers and pointing oyster growers in the direction of available assistance needs to be developed.

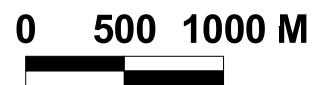
Table 3.5 Results of a survey distributed to Macleay River oyster growers.

Grower	1	2	3	4	5	6
Distribution	Widespread	Localised	Localised	Widespread	Widespread	Widespread
% killed	50 - 70	80 - 90	40	80 - 90	70	40
Age group	All	All	2 years +	All	All	All
First noticed	Dec-08	Dec-08	Sep-08	Oct-08	Dec-08	May-09
Period of mortality	Dec 08 - May 09	Dec 08 - May 09	Sept 08 - Jan 09	Oct 08 - Apr 09	Nov 08 - Jan 09	
Description	Some died due to prolonged blackwater exposure, others died suddenly, no explanation.	Dead oysters.	Noticed oysters dying in early spring.	Unknown kill in late 08, after the floods black water kill.	Dead oysters, lack of food.	Continuous fresh from Feb 09 to May 09.
Conditions around time of mortality	Majority died during flood conditions but some had started dying before that.	Little salt, dirty colour around 20 degrees.	Conditions were good at the time for growth and fattening	Brown to black water.	Sal 32, colour green, temp 23. ie good.	Low salinity, brown water.
Possible Cause	Natural river cycle. Illegal dumping.	Floods and dirty water.	Does not know, had tests done and no QX, no winter mortality no mudworm.	Build-up of chemicals around fishermans reach?	Acid Sulfate?	Prolonged fresh and some contaminants from floodgates.



LEGEND

	None reported		Dec08-May09
	1 - 50 %		Nov08-Jan09
	51 - 60 %		Oct08-Apr09
	61 - 70 %		Sept08-Jan09
	71 - 90 %		Study Area



Spatial distribution of oyster mortality timing and intensity

Water quality factors affecting oyster production

Water quality threats occur via two mechanisms. The first is stock losses and reductions in growth rates and reduction in saleable quality due to very poor water conditions. Most commonly this relates to acidic and or deoxygenated water that directly kill oysters or make them susceptible to mortality from other factors or reduces their ability to feed. However, it can also be associated with toxic agents such as high concentrations of sulfur containing molecules, toxins produced by microalgal blooms or anthropogenic sources such as illegal waste dumping or chemical runoff from urban and agricultural areas. The second mechanism is the closure of harvesting from the Macleay River under the risk based guidelines set by the Foodsafe NSW Shellfish Quality Assurance Program (SQAP).

Oyster growth and production is affected by natural variations in water quality including salinity, temperature and the availability of digestible particulate matter. However, it is also affected by water quality problems caused or worsened by human activity. The most likely factors to negatively affect oyster growth are suspended solid concentration, pH and the presence of toxic substances including aluminium and iron (NSW DPI 2006). Tidal processes, water flow and salinity affect the source of food for oysters, distribution of larvae and the ability of oyster farmers to harvest product. The Macleay River estuary is permanently open to the ocean, allowing oyster farmers the stability of a predictable tidal regime upon which to base their activities. Water quality guidelines for the optimal production of Oysters have been defined (NSW DPI 2006) and are reproduced in **Table 3.6**.

Table 3.6 Water quality guidelines for oyster aquaculture areas. (Source: NSW DPI (2006))

<i>Parameter</i>	<i>Guideline</i>	<i>Source</i>
pH	6.75-8.75	Schumway (1996)
Salinity	20.0-35.0g/L	Australian and New Zealand Environment Conservation Council (ANZECC) Guidelines for Fresh and Marine Water Quality (2000)
Suspended Solids	<75mg/L	
Aluminium	<10µg/L	
Iron	<10µg/L	
Other Parameters	For other parameters refer to Section 4.4 and Section 9.4 of the ANZECC (2000) guidelines	

Available water quality information (WMA 2009) for the Macleay River estuary suggests that Salinity, pH and total suspended solid concentrations are normally within the above parameters in the Macleay Arm (which includes 2 of the 3 harvest zones) and the lower estuary. Measured levels of Aluminium and Iron concentrations, reported in the Macleay River Estuary Processes Study (WMA 2009) regularly exceeded these guideline levels (25/35 samples for Al and 100% of samples for Fe), though no indication is given as to what part of the estuary these samples were taken from.

The ability of oyster growers to harvest oysters is dependent upon salinity and bacterial characteristics of the water as advised under the NSW Shellfish Quality Assurance Program. The NSW Food Authority conduct a thorough review of potential risks to the sanitary safety of oysters in specific harvest areas, as well as a program of bacteriological and microalgal sampling of the water to classify each harvest area individually and to develop a monitoring schedule and recommendations for the harvest areas.

The Macleay River oyster growing areas have been divided into 3 harvest areas, the New Entrance harvest area, the Fishermans Reach harvest area and the Clybucca harvest area. A map of the oyster leases is provided in **Figure 3.39**. The New Entrance harvest area has been classified as 'conditionally approved'. This means that when the harvest area is open, product may be harvested and sold directly for human consumption. It also means that, when open, the area may be used to depurate oysters from restricted areas for a minimum of 14 days (under permit). The New Entrance harvest area will be closed to harvest under the following conditions;

- when *E. coli* in any shellfish sample exceeds 2.3 *E. coli* per gram;
- when salinity of water is below 26ppt;
- when faecal coliform concentrations in the water exceed 14FCU/100mL at any of the sample sites;
- when rainfall exceeds 50mm in a 24 hour period at the Fishermans Reach BOM station.

The Fishermans Reach and Clybucca harvest areas have been classified 'conditionally restricted'. This means that oysters harvested from these areas must be depurated prior to sale. It also means that these areas will be closed to harvest under the following conditions:

- when *E. coli* in any shellfish sample exceeds 10.0 *E. coli* per gram;
- when salinity of water is below 18ppt
- when faecal coliform concentrations in the water exceed 70FCU/100mL at any of the sample sites; or
- when rainfall exceeds 50mm at the Fishermans Reach BOM station.

3.4.3 Black Sediments in the Oyster Aquaculture Area

One of the recommendations following the oyster grower survey described in **Section 3.4.1** of this report is that black sediments found in the vicinity of some oyster leases may be a cause of mortalities and warrant further investigation. A benthic sediment sampling program was considered the best way to characterise and map the extent of these sediments.

Benthic Sediment Sampling 2010

Introduction

Along with QX disease, black water and acid water discharges causing recent mortalities in Macleay River oysters, a yet to be identified toxic agent was responsible for large losses in late 2008. Black, gooey sediments that are present within and upstream of oyster growing areas have been suggested a possible cause. Sediment sampling was undertaken in March 2010 with the aim of mapping the occurrence of black ooze in the estuary, characterising it and assessing the risks it posed to oyster aquaculture. A secondary aim was to assess the benthic macrofauna around specific oyster leases where large mortalities have occurred.

Methods

Prior to sampling, oyster growers were contacted and asked what experiences they have had with 'black ooze' type sediments, where they thought 'black ooze' would be encountered and where else they thought sediment should be analysed. The results of these conversations, in addition to the results of the surveys reported in **Section 3.4.1**, were used to preselect estuarine sampling sites. A number of sites upstream of the Clybucca floodgates in and around the Seven Oaks drain were also sampled. The sampling sites are displayed in **Figure 3.40**.

Sampling was undertaken on the 25th, 26th and 27th of March 2010. At each site a Van-veen grab sampler was used to collect benthic

sediments, which were then collected in two 250mL sample jars and put on ice. Where it was not possible to use the grab sampler, benthic sediments were collected using a sample jar on the end of a pole. A portion of benthic material was field tested for the presence of monosulfidic black ooze (MBO) by mixing it with water in a bucket and monitoring dissolved oxygen for a period of approximately 1 minute. At the end of each day, collected samples were frozen until they could be couriered to the NATA recognised Southern Cross University Environment Analysis Laboratory (EAL) for chemical analysis. At EAL samples were analysed for Reduced Inorganic

sulphur (RIS) and Acid Volatile Sulphur (AVS). At selected sites a further grab sample was taken for biological analysis. This sample was bagged and soaked in 10% formalin in seawater with rose bengal biological dye and returned to the laboratory to be sieved (0.5mm sieve), sorted and characterised for macrofaunal makeup. Additional information collected at each site included physicochemical water quality information, position using a handheld Garmin 12 GPS unit, a brief site description and digital photographs. **Table 3.7** contains a summary of the specific treatments applied at each of the sampling sites.

Table 3.7 Summary of sediment sampling activities

<i>Sample Site</i>	<i>Chemical Analysis</i>	<i>Biological Analysis</i>	<i>MBO Test</i>	<i>GPS Mark</i>	<i>Photo</i>
S01	y		y	y	y
S02	y		y	y	y
S03	y		y	y	y
S04	y		y	y	y
S05	y		y	y	y
S06	y		y	y	y
S07	y		y	y	y
CL1	y		y	y	y
CL2	y		y	y	y
CL3	y		y	y	y
CL4	y		y	y	y
CL5	y		y	y	y
CL6	y	y	y	y	y
NE1	y	y	y	y	y
FR1	y	y	y	y	y
FR2	y	y	y	y	y
CG1	y	y	y	y	y
YH1	y		y	y	y
YH2	y		y	y	y
YB1	y		y	y	y

Results

No surprising results were obtained from water quality investigations. Downstream of the floodgates pH, dissolved oxygen and salinity were all within the normal ranges of estuarine waters. Upstream of the floodgates, dissolved oxygen was high and salinity typical of fresh waters. The water was generally moderately acidic ($4.5 < \text{pH} < 6$) upstream of the floodgates with the exception of site S01 where the pH was recorded as 3.12.

In general, the sediments collected varied greatly in their physical nature. The colour of the samples varied from dark brown to grey in the lower estuarine areas to charcoal and black in the upper estuary and upstream of the floodgates. The sample collected at site S01 was comprised mostly of decaying leaf litter. With the exception of samples collected at sites S07, CL4 and CL5 the samples did not fit the description of MBOs from the literature in texture (eg Bush *et al.* 2004). The samples from these 3 sites also emitted a strong sulphurous odour. None of the samples

responded positively to field testing for the presence of MBOs.

The results of chemical analyses of benthic sediments are reported in **Table 3.8**. The highest concentration of AVS was detected at site S07, a small drain leading into the Clybucca system from the south. Relatively high concentrations of AVS were also detected in the upper Clybucca Ck (site CL3) and in Borigalla Ck (Site YH2) though these are within the ranges found in natural sediments (Bush *et al.* 2004). The highest percentages of RIS were

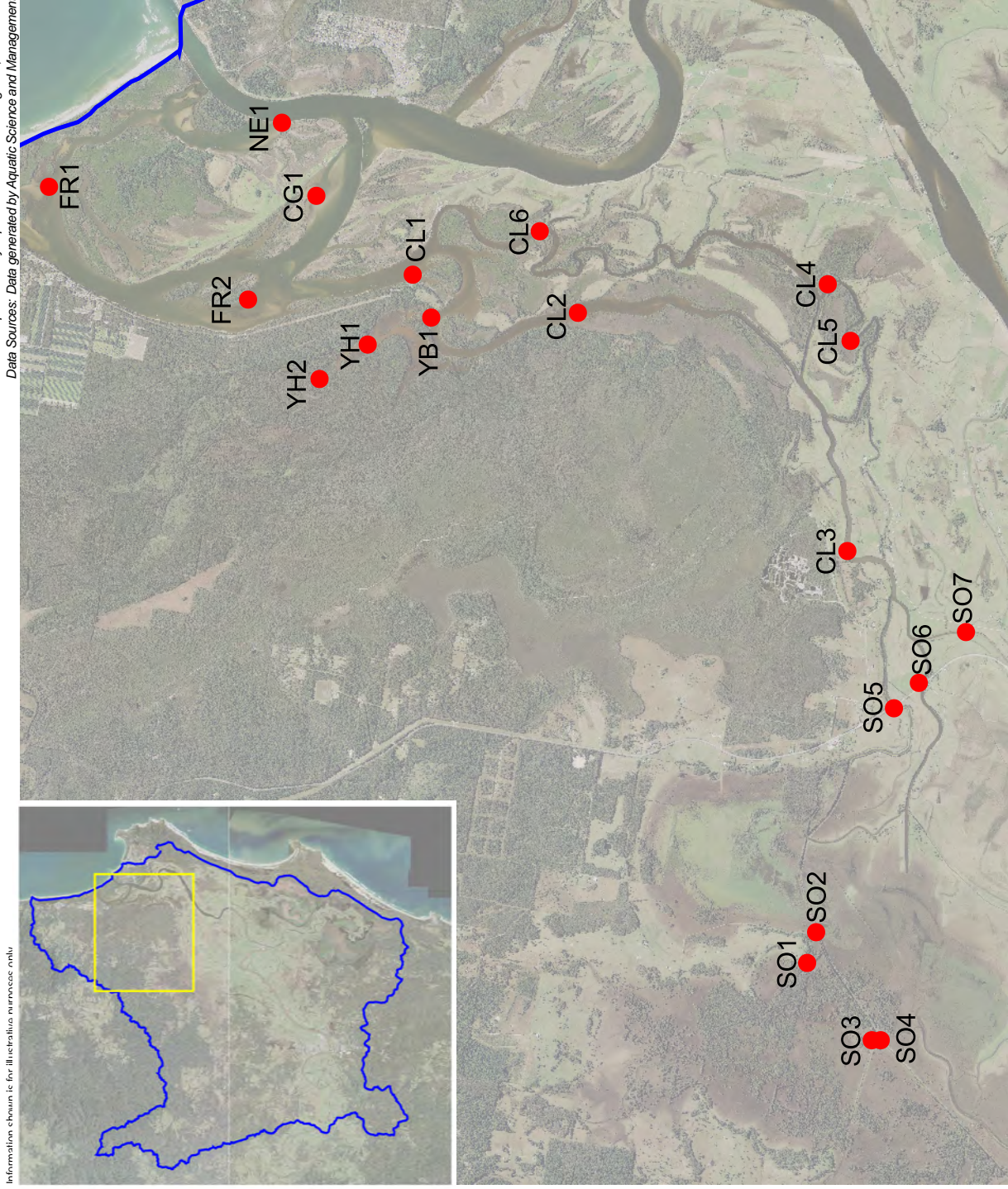
detected in the Seven Oaks (sites S06, S07) and upper Clybucca Creek (sites CL4 and CL5).

Results for the biological analysis of sediments are pending. There is also an oyster growth and mortality experiment being undertaken on the Macleay at the time of writing. The results of both of these studies will be reported to the local oyster industry and to the NSW Aquaculture Research Advisory Committee upon completion.

Table 3.8 Results of chemical analyses of benthic sediment samples from the Macleay River

Sample Site	ACID VOLATILE SULFUR (AVS)		REDUCED INORGANIC SULFUR	
	(% Sav WW)	(% Sav DW)	%Scr	mole H ⁺ /tonne
S01	0.0030	0.0187	0.2400	149.6880
S02	0.0080	0.0233	1.7300	1079.0010
S03	0.0590	0.1147	0.3700	230.7690
S04	0.0470	0.0969	1.3000	810.8100
S05	0.0540	0.1090	0.1900	118.5030
S06	0.0180	0.0400	2.2100	1378.3770
S07	0.5510	2.5873	3.1200	1945.9440
CL1	0.0000	0.0000	0.0600	37.4220
CL2	0.0270	0.0533	0.5000	311.8500
CL3	0.1020	0.2414	0.6800	424.1160
CL4	0.0310	0.0816	2.1600	1347.1920
CL5	0.0210	0.0740	3.3100	2064.4470
CL6	0.0500	0.0923	0.5200	324.3240
NE1	0.0020	0.0028	0.1100	68.6070
FR1	0.0000	0.0000	0.0400	24.9480
FR2	0.0000	0.0000	0.1100	68.6070
CG1	0.0040	0.0063	0.1800	112.2660
YH1	0.0090	0.0129	1.1300	704.7810
YH2	0.1570	0.2395	0.4000	249.4800
YB1	0.0860	0.1465	0.3500	218.2950

Map Created by Aquatic Science and Management, June 2010
Data Sources: Data generated by Aquatic Science and Management



Information shown is for illustrative purposes only.

Sediment Sampling Sites on the lower Macleay
Figure 3.40

Discussion

The potential effects of sulphur containing sediments on shellfish aquaculture or estuarine biota are poorly understood. The ANZECC (2000) guidelines for water quality do not consider sediment quality in relation to shellfish aquaculture. Sediment quality is considered in relation to ecosystem health and acid volatile sulfides are described but only in regards to their function in reducing the toxicity of some metal contaminants under certain conditions. MBOs, specifically, are known to play a significant part in the deoxygenation of floodwaters passing through acid sulfate soil landscapes and the later acidification of these waters (Eyre *et al* circa 2004).

Acid volatile sulphur (AVS) is a component of total reduced inorganic sulphur (RIS). Testing for the AVS portion of RIS is considered useful for the characterisation of MBOs. With the exception of the sample taken at site SO7, the concentrations of AVS in the samples collected for this study are typical of (or lower than) those known to occur in natural sediments of marine, estuarine or brackish waters (a range of 0.06% to 0.39% reported in Bush *et al* 2004). In the areas downstream of the floodgates this result is expected due to the rapid conversion of iron monosulfides to pyrite under in estuarine environments (Bush *et al* 2004) and the likely dispersal of MBOs during transport from drains in floodwaters. However, the result is somewhat surprising for those areas upstream of the Clybucca Floodgates due to the presence of conditions known to facilitate the formation of MBOs, ie acid sulfate soil runoff and a ready supply of organic

material from acid tolerant macrophytes. At site SO7 the AVS concentration is indicative of the presence of MBO's despite the negative result obtained from field testing. Given the dynamic nature of the drains it is likely that the occurrence and distribution of MBOs upstream of the floodgates would change over time in relation to rainfall patterns and localised land management practices.

The total concentration of RIS varied across the study site. The highest concentrations were found in the upper Clybucca Creek sites (CL4 and CL5) and in scattered sites upstream of the floodgates (SO2, SO6 and SO7). High concentrations of RIS were not detected at any of the sites around oyster leases. No conclusions can be drawn about the effects of the RIS concentrations in sediments on sulphur concentrations in overlying waters or about the likely transport pathways of RIS throughout the estuary.

The results of this investigation only provide a snapshot of the distribution of RIS species across the oyster growing areas of the Macleay. At the time of sampling no MBOs were detected downstream of the Clybucca floodgates and none are likely to occur. In addition, the total RIS concentrations around oyster growing areas were not of concern.

Future investigations that may be of value include analysis of other toxins in sediments from around the oyster growing areas and an investigation into the link between RIS concentrations in sediments and sulphur concentrations in overlying waters.

3.5 Recreational Fishing on the Macleay River Estuary

3.5.1 Introduction

The results from a state-wide survey of recreational fishing indicate that recreational fishing could be worth in excess of \$40 million to the mid north coast regional economy (Telfer 2005). Over 74000 recreational fishers, representing almost 30% of the population, operated on the mid-north coast of NSW during the survey period (NSW Fisheries 2001). No data exists for the value of recreational fishing or the number of recreational fishers on the Macleay River estuary though it is likely to represent a significant proportion of the above numbers. The majority of the recreational catch during the survey was taken in estuarine waters and the Macleay is the second largest river system in the mid north coast region. The general survey undertaken as part of the Macleay Estuary Management Study (GeoLINK 2010)

found that recreational fishing ranks as the second most common use of the Macleay River estuary, following boating (103/162 respondents).

In the case of certain species, including flathead, bream, tailor and mulloway, the total state recreational catch is greater than the total state commercial catch. This information may or may not apply to the Macleay River estuary though the proportion of the total catch of these species attributable to recreational fishers is likely to be significant.

Steffe and MacBeth (2002) surveyed recreational fishing on the Macleay between July and October 2001. Their survey was timed to generate information about the recovery of the recreational fishery after catastrophic fish kills resulting from floods earlier that year. They found that over 90% of the fish caught (by weight) were luderick, yellowfin bream and dusky flathead. Limited comparisons with previously collected data indicated that the structure of fish stocks was not noticeably different after the estuary had been recovering from flood impacts for 3.5 months. Over the survey period the average monthly recreational fishing effort was approximately 20000 fisher hours. The most popular area for recreational fishers was the area around the entrance (37.5%), with the Kemps Corner/Clybucca area the second most popular (28.4%). They found that most recreational fishing (60%) was shore based, with the other 40% undertaken from boats. During the survey period, an estimated 25 tons (45300 individuals from 16 taxa) of fish and crustaceans were harvested from the estuary by recreational fishers.

3.5.2 Australian Bass

The Australian Bass (*Macquaria novemaculeata*) is of particular importance to the Macleay River recreational fishery. Bass are an iconic sportfish that occur throughout NSW and the Macleay River is highly regarded for the Bass fishing offered. At least three local tourism operators run specialist bass fishing tours on the greater Macleay River and an annual bass fishing tournament brings up to 100 bass fishers to the local area. Bass populations have declined through most of their natural range highlighting the importance of the healthy populations found on the Macleay. The key threats to bass are overfishing, habitat destruction, stream acidification, flow regulation and artificial obstructions to movement.

Though largely considered to be a freshwater fish estuaries are of particular importance to bass as they require salinities of between 8 and 14ppt to spawn and juveniles remain in brackish or estuarine waters until they are physiologically capable of entering freshwater (Pusey *et al* 2004). In addition to this, during non-reproductive periods males often remain in tidal waters. Adult bass tend to prefer deep pools (>2m) and are generally found in association with instream cover such as overhanging banks or woody debris. Juveniles tend to recruit to macrophyte beds (such as vallisneria or phragmites) for their upstream migration (Pusey *et al* 2004). Well connected habitats facilitate the upstream migration by juveniles. Prior to spawning adult males often congregate in large schools, making them susceptible to capture. This is part of the reason behind commercial netting closures in the upper Macleay estuary during the winter months. River discharge is known to be very important to the reproductive success of bass. Freshwater inflows may act as a cue for downstream migration, as a factor controlling the amount of suitable spawning water available and also as a

pathway for the delivery of nutrients and organic matter which may increase food availability for larvae and juveniles (Pusey *et al* 2004). Flow regulation is thought to have played a large part in the decline of bass populations.

The habitat requirements and movement of bass are well understood. Habitat features such as macrophytes (primarily *Vallisneria sp.* and *Phragmites australis*), snags, overhanging banks and submerged boulder fields are recognised as important (West *et al* 2004). Most adult bass have been shown to successfully negotiate water velocities of 1.85 m/sec and juvenile fish velocities of around 1m/sec. This has important implications for fishway and floodgate design (see Pusey *et al* 2004).

A local recreational fishing club, Bass Kempsey, is centred upon Bass fishing activities. The club runs the annual 'Bass Catch' tournament in September each year with approximately 100 competitors attending and 839 individual Bass caught (and released) in 2009 (Macleay Argus, Nov 10th 2009). Money raised from the tournament is reinjected into the local community. The club also runs kids fishing clinics, has undertaken educational activities such as the erection of signs at river access points and have previously been involved in riverbank stabilisation projects.

Data from the Bass Catch tournament on the Macleay (and other tournaments throughout NSW) has been collected since the year 2000 and was recently summarised (Ghosn 2009). Catches from the Macleay River show the greatest size range of all the rivers assessed and a relatively high catch per unit effort, indicating a resilient Bass population. The results also show a relatively stable overall catch and length frequency distributions.

A study into the fate of caught and released bass indicates that the vast majority (at least 94%) of fish survive in the short term (the study monitored fish for at least 5 days). The study identified angling and handling procedures that improve the chances of survival and minimise trauma to the fish. These are (Dowling *et al* 2004);

- encouraging lures rather than baits (to promote mouth hooking);
- using knotless and/or rubber landing nets and gloves or a towel during handling;
- ensuring live wells have adequate water exchange and aeration;
- using heavy-duty wet plastic bags rather than abrasive containers for weighing; and
- minimising air exposure.

3.5.3 Management of Recreational Fishing on the Macleay

Recreational fishing on the Macleay River is managed mostly through bag and size limits and through closures. The recreational fishing closures operating within the study area are listed in **Table 3.9**.

Table 3.9 Recreational fishing closures operating on the Macleay River estuary system.

<i>Area Affected</i>	<i>Species</i>	<i>Methods Affected</i>	<i>Time of Closure</i>
South West Rocks Creek – Nets			
Whole Creek	All fish species	All nets other than dip or scoop nets for prawns, or landing nets.	All year
Macleay River – Nets			
All waters upstream of the Kempsey Railway Bridge	All fish species	All nets other than landing nets.	All year
Belmore River			
Whole River and tributaries.	All fish species	Any method involving the use of a net or a trap, other than the following: (a) a dip or scoop net (prawns), (b) a landing net, (c) a bait trap.	All year
Yarrahapinni Wetlands National Park			
All waters of the YWNP upstream of Andersons Inlet.	All fish species	All methods	All year
Spearfishing			
All waters of South West Rocks Creek and the waters of the Macleay River downstream of a line drawn from the southernmost extremity of Shark Island to the northern edge of the public boat ramp at Mattys Flat extending out to sea 100m and 100m either side of the breakwalls.	All fish species	Spear fishing.	All year
Spawning Closure			
Whole estuary (all NSW flowing waters)	Australian bass and estuary perch	All methods	June 1 st until August 31 st .

3.6 Fisheries Resources Management Issues

3.6.1 Estuary General Industry

Issue 3.1: Catastrophic fish kills associated with floods

In times of flood, fish kills in the Belmore River, Clybucca Creek and Kinchela Creek can remove tonnes of fish from the system.

Issue 3.2: Loss of productive fishing grounds

Sediment infill and habitat loss are the key drivers for loss of productive fishing grounds. Additional protection of fishing grounds against development pressure could be given by the declaration of some recognised fishing grounds.

Issue 3.3: Habitat loss

The loss of habitats due to the installation of floodgates on major tributaries has significantly reduced the habitat available for some fish species that are commonly harvested by the estuary general fishery.

3.6.2 Oyster Aquaculture Industry

Issue 3.4: Mortality Reporting

During the course of consultation, Macleay River oyster growers have indicated that they are not aware of a clear chain of command for the reporting of mortality and other issues. Fortunately, this is an easy problem to solve as NSW Industry and Investment have a clear, written protocol for required actions resulting from oyster mortality. The policy is a requirement of every Class A Aquaculture Permit and is as follows.

In the event that a significant oyster disease/mortality is observed:

1. Within 48 hours phone either:
 - a. 24 hour hotline 1800 043 536
 - b. Your local NSW DPI Fisheries office, and ask to speak to a Fisheries Officer.
 - c. Manager Aquatic Biosecurity & Risk Management (02) 4982 1232
2. Complete a NSW DPI Fisheries Veterinary Laboratory Specimen Advice form and an Oyster Mortality Report form. Accurate information is required as it will assist in determining the cause of the disease event. Please provide comments on any suspected cause or unusual environmental conditions.
3. Collect and package the samples as directed by NSW DPI.
4. Attach these forms, taped in a plastic bag, to the outside of the container in which the samples are being sent to the laboratory.
5. Arrange freight of samples to laboratory or seek assistance from NSW DPI or your local fisheries officer.
6. Await laboratory diagnosis. While awaiting this result stock movements should be minimised, in case you may be spreading an infectious agent (eg virus, new parasite).

A related, more complicated, problem appears to be that there is no clear protocol for the government response to mortality issues affecting oyster farmers.

Issue 3.5: High Risk QX Rating

The discovery of QX disease in August 2006 and subsequent restrictions on intersystem transport of Macleay oysters has severely impacted the local industry. Added to this is the fact that the oyster growers felt that the rating was based upon an inadequate and non-representative sample. In effect 30 oysters were carefully selected for symptoms of disease from a large number of healthy oysters to send to DPI when a problem was noted. A standard QX test is supposed to involve 200 oysters randomly selected. No oyster mortality related to QX has been reported since the original outbreak and oyster growers feel that the rating for the Macleay should be revised. However, the sampling system for revision involves a great deal of cost (approximately \$90000 over three years) that could not be met after 3 years of poor returns.

Issue 3.6: Derelict Oyster Leases

At any time a number of oyster leases in the three harvest zones on the Macleay River will be fallow. However, there are also a number of derelict leases on the Macleay which, under the NSW Oyster Industry Sustainable Aquaculture Strategy, require cleaning up. The material left on these leased areas includes posts, racks and a conveyor belt. The condition of the signage and posts is poor and some of the material is considered to be a navigation hazard. Two lease areas that have been identified are to the north east of the eastern shore of Whiskey Island and to the south west of the southern tip of Whiskey Island.

3.7 Fisheries Resources Management Options

Option 3.1: Reduce sediment inputs from erosion and runoff into the Macleay River

Reducing sediment inputs has the capacity to slow sediment infill of productive deep holes, reduce smothering of valuable seagrass habitats and improve the productivity of primary producers by improving light penetration. The key mechanisms available for reducing sediment inputs are catchment management approaches. They include;

- Rehabilitation of the riparian zone to improve vegetative cover increasing the sediment trapping capacity and improving bank stability (see **Options 2.1, 2.2 and 2.3**);
- Increase the cover of vegetation catchment wide to improve reduce the erosive capacities of wind and rain;
- Improve floodwater retention times in floodplain wetland areas, allowing improved settlement of flood borne sediment;
- Ensure that the maintenance of dirt roads in the vicinity of waterways is undertaken in line with current best practice (see I&I regulations for maintaining forestry roads); and
- Ensure that sediment control on building sites is undertaken in line with current best practice (see DEC (2006) Guidelines).

Option 3.2: Aim to improve the quality of floodwater discharges

Poor quality flood discharges cause fish kills and oyster mortality. The key mechanisms available to improve floodwater discharge are catchment management approaches. Suitable actions include;

- Neutralising acid sulfate soils;

- Preventing the disturbance and exposure of undisturbed acid sulfate soils;
- Reducing the occurrence of over-drainage;
- Increasing the residence time of floodwaters; and
- Encouraging wetter pasture management in general to improve the cover of water tolerant species on the floodplain.

Option 3.3: Improve the connectivity of aquatic habitats

This is a matter of continuing to alter the management or structure of the many floodgates to allow fish passage and controlled and regular tidal flows. It is also a matter of slowing the discharge of floodwaters from floodplain wetlands to increase the connectivity between individual wetlands pools.

Option 3.4: Incorporate commercial fishing requirements into the planning approvals process for wharves, jetties and pontoons

Prepare a local development control plan in consultation with I&I and NSW Maritime that incorporates commercial fishing requirements with respect to fishing grounds that can be utilised with hauling nets *etc*, into the planning and approval of these structures.

Option 3.5: Identify and clean up derelict oyster leases

Remove signs, posts and racks and any debris from all identified derelict oyster leases, where possible at the expense of the last leaseholder. NSW I&I has developed a strategy for undertaking this.

Option 3.6: Define clear protocols for the reporting of and response to oyster mortality events

Consultation between oyster growers and I&I and subsequent education and correspondence is required to improve the understanding of the rights and responsibilities of both parties in response to oyster mortality events.