NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Maximising the survival of bycatch discarded from commercial estuarine fishing gears in NSW.

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NON-TECHNICAL SUMMARY

2005/056 Maximising the survival of bycatch discarded from commercial estuarine fishing gears in NSW

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OBJECTIVES:

(1) To identify deleterious operational procedures and post-capture handling practices and quantify their effect on the immediate and short-term mortalities of unwanted, discarded bycatch throughout NSW key commercial estuarine fisheries.

(2) To examine simple, but appropriate, operational and/or handling practices that improve the immediate and short-term post-capture survival of unwanted bycatch.

(3) To determine the most appropriate strategies from (2) and assist commercial fishers and managers in their implementation, adoption and eventual legislation.

NON TECHNICAL SUMMARY:

Outcomes achieved
The project resulted in the quantification of immediate and short-term mortalities and contributing factors for key bycatch species discarded from the main estuarine fishing gears in NSW and simple mitigation strategies. While mortalities varied considerably, irrespective of the fishing method, these could be mitigated by using selective gears, choosing when and where to fish (to avoid high temperatures and jellyfish abundances and low salinities), minimising the duration of gear deployments, changing the methods by which fish and crabs are removed from nets and sorting in water. Commercial adoption of the recommended handling protocols should ultimately contribute towards the sustainability of commercial fishing in NSW estuaries.

The mortality of large quantities of bycatch from commercial fishing throughout the world has attracted considerable attention during the past 20 years and led to management strategies designed to alleviate the negative impacts that such wastage may have on populations. Excluding closures to fishing, bycatch management options can be divided into two general categories that include: (1) specific physical modifications to gears to improve species and/or size selectivity and (2) changes to operational and/or post-capture handling procedures that reduce the mortality of those organisms that are caught and then discarded.

The first option has been the most commonly adopted in net-based fisheries. Depending on the gears and their specific problems, improvements to selection have been achieved via alterations to the sizes and configurations of mesh used, and more commonly for towed gears, the development of bycatch reduction devices (BRDs). These sorts of modifications have been introduced in many

trawl and seine fisheries throughout Australia and, based on research to show that the majority of escaping organisms survive, they should positively benefit stocks of bycatch species.

In NSW, a range of BRDs and other technical modifications have been designed to improve the selectivity of problematic fishing gears, including prawn trawls and boat-based seines and fish beach seines and gillnets. While some of these designs have reduced the bycatches of unwanted species by up to 95%, rates of reduction more commonly range between 30 and 70%. Such reductions have obvious benefits for the stocks of bycatch species. But considering the magnitudes of bycatches in many estuarine fisheries, and especially those targeting prawns (i.e., sometimes 100s of fish per deployment), it is apparent that, despite the use of modified gears, in nearly all cases there still remains some capture and mortality of unwanted bycatch.

This three-year project sought to mitigate the above remaining component of unwanted fishing mortality for NSW estuarine trawls, seines and gillnets by investigating the utility of changes to operational and/or onboard handling methods (i.e., second option above). The work was done using chartered commercial fishers working in those areas (and times) traditionally characterised by potentially problematic bycatches. A total of 152 conventional and modified gear deployments/experiments were completed, during which more than 81 000 individuals comprising 30 species were assessed for their immediate mortalities onboard the vessels, while almost 4000 organisms of 13 species were subsequently caged and monitored along with controls (previously collected during non-invasive techniques) for their short-term (three to 10 days) fate. Estimates of total discard mortalities and formal analyses of the key contributing factors and the identification of resolution strategies were restricted to these latter species.

In general, there was considerable variability among the immediate and short-term fate of the various bycatch species after being trawled, seined or gillnetted, and then discarded according to conventional practices. Irrespective of the gear, some species, including school prawns (*Metapenaeus macleayi*), blue swimmer crabs (*Portunus pelagicus*), blue catfish (*Neoarius graeffei*), luderick (*Girella tricuspidata*) and black sole, (*Synaptura nigra*) consistently incurred fewer than 50% mortalities and moderate stress (measured by blood physiology parameters for some species). Yellowfin bream (*Acanthopagrus australis*) were also quite resilient to all fishing methods, with typically considerably more fish surviving than dying. In contrast, the impacts to other more fragile fish, such as silver biddy (*Gerres subfasciatus*), southern herring (*Herklotsichthys castelnaui*), Port Jackson glassfish (*Ambassis jacksoniensis*) and dusky flathead (*Platycephalus fuscus*) were more dramatic with mortalities often approaching 100%. Much of the variability among fatalities was attributed to the inherent ability of organisms to withstand key deleterious technical, environmental and operational factors that included, but probably were not limited to (1) the deployment duration of the gear, (2) catch weight, (3) salinity and (4) temperature of the fished river/estuary, (5) presence of jellyfish, and the (6) duration of air exposure and (7) extent of sunlight/cloud cover during sorting. Often, the impacts of these factors were significantly exacerbated in smaller individuals.

Many of the negative impacts to bycatch species associated with the above factors occurred during the fishing process (especially for towed gears), often causing widespread mortalities before catches were landed onboard. Some of these fatalities can be mitigated via simple operational strategies, such as choosing when and where to fish (to avoid high water temperatures and jellyfish abundances and low salinities), using BRDs (where appropriate) and appropriate mesh sizes and configurations to reduce catch weights and jellyfish, and deploying all gears for the minimum practical duration. Once catches are brought onboard, the most effective handling strategy was to limit air exposure by sorting in water. In particular, a purpose-built water sorting system, termed the ‘water tray’, was developed for trawlers which reduced air exposure from up to 25 minutes to less than three minutes, and also eliminated unwanted changes in temperature caused by direct sunlight. Using the water tray contributed towards a reduction in total mortalities by up to almost one quarter and a third for key fish (e.g., yellowfin bream, silver biddy and Port Jackson glassfish) and school prawns, respectively. The same benefits might be achieved for beach seines, by sorting catches in the bunt in shallow water.

Other handling-related impacts that appeared to influence the fate of discards included the methods by which they were removed from nets. For example, simply untangling meshed yellowfin bream, luderick and black sole backwards, rather than pushing them forwards through meshes, has the potential to reduce scale loss, compression and subsequent mortality. Similarly, avoiding the forceful removal of limbs from meshed blue swimmer crabs can limit the frequency of open wounds, blood loss and death.

In many cases, coherent combinations of the protocols mentioned above should significantly reduce the mortality of bycatch discarded in NSW estuaries. However, the often high observed mortalities attributable to the actual fishing mechanisms support the supposition that modifications to operational and/or post-capture handling procedures should not form the basis of bycatch mitigation strategies. Rather, a strategy that involves the appropriate regulation of effort in space and time and the mandatory use of the most efficient selective mechanisms (e.g., BRDs and appropriate mesh sizes and configurations) that allow organisms to escape (with high associated survival) soon after they encounter the gears should be the main priority. Once gear selectivity has been maximised, the ancillary operational and onboard handling procedures proposed and discussed above may be introduced and regulated to help improve the survival of the remaining component of discarded bycatch.

KEYWORDS: collateral mortality, discard mortality, penaeids, beach seines, prawn trawls, prawn seines; gillnets; selectivity

1. INTRODUCTION

1.1. Background

The mortality of large quantities of bycatch from commercial fishing throughout the world has attracted considerable attention during the past 20 years, and led to the development of various strategies to alleviate the potentially negative impacts that such wastage may have on populations. Excluding temporal and spatial closures, bycatch management options can be divided into two general categories of input controls that include: (1) physical modifications to gears to improve their species and/or size selectivity and (2) changes to operational and/or handling procedures that reduce the post-capture fishing mortality of key species.

The first option has been the most commonly adopted in net-based fisheries. Depending on the gears and their specific problems, improvements to selection have been achieved via alterations to the sizes and configurations of mesh used, and more commonly for towed gears, the development of bycatch reduction devices (BRDs). These modifications have been introduced in many trawl and seine fisheries throughout Australia and, based on research done in NSW to show that the majority of escaping organisms survive, they should positively benefit stocks of bycatch species.

Much less attention has been directed towards the utility of the second category of input controls listed above. In Australia, several studies have been done to quantify the fate of organisms discarded from prawn trawlers working in tropical areas (Wassenberg and Hill, 1989; 1993; Hill and Wassenberg, 1990). The general conclusion from this work was that, owing to the stress and damage incurred during trawling (according to conventional procedures), most discarded fish die. Very few studies have examined the fate of bycatch discarded after capture from other commercial fishing gears and methods. Research was recently initiated to examine the effectiveness of industry-developed, water-filled sorting systems (termed ‘hoppers’) for promoting the survival of bycatch discarded from prawn trawlers working in tropical areas (Dell et al. 2003). But this work did not investigate the various operational parameters that contributed towards mortalities, and was limited to a single fishing method.

Quantification of the key factors influencing the mortality of discarded bycatch must be done on a fishery- and gear-specific basis and is a prerequisite for developing effective changes to operational and/or handling procedures that maximise post-release survival. Recognition of the need for these data in NSW main estuarine fisheries justified the funding for the present study which aimed to identify deleterious operational procedures and post-capture handling practices and, where required, examine simple but appropriate modifications that improve the immediate and short-term post-capture survival of unwanted bycatches.

1.2. Need

Eight hundred and thirty commercial fishers are legally endorsed to use a range of active and passive fishing gears (Table 1) to target various teleosts, crustaceans and molluscs throughout 76 estuaries in NSW. Between 2004 and 2007, these fishers landed up to almost 5000 t of catch valued at \$A 25 million per annum. Several fishing methods are used, although 75 to 85% of the total catch is harvested using four general categories of active and passive gears that include small-meshed trawls (Fig. 1) and boat seines (Figs 2 and 3) to target mainly prawns, and larger-meshed beach seines (Fig. 4) and gillnets (Fig. 5) to target fish. Each of these gear categories and their general operating methods are discussed separately below.

Table 1. Summary of the fishing gears used in NSW estuaries and the annual retained catch weight (tonnes) and value (‘000) between 2004 and 2007. The gears marked in bold indicate those examined in this study.

	2004		2005		2006		2007	
Fishing Gear	**Wt**	**$**	**Wt**	**$**	**Wt**	**$**	**Wt**	**$**
Gillnets (fish)	**2130**	**6880**	**2053**	**7148**	**2178**	**8279**	**1849**	**7523**
Beach seines (fish)	**954**	**3062**	**720**	**2730**	**974**	**3557**	**764**	**2999**
Hand gathering (pipis)	625	3484	428	3380	234	2672	121	1884
Trawls (prawn)	**427**	**2770**	**360**	**2227**	**492**	**3480**	**463**	**3494**
Traps (fish and crabs)	351	3109	315	3574	337	4179	297	3792
Boat seines (prawn)	**171**	**904**	**116**	**756**	**170**	**1145**	**150**	**1256**
Boat seines (fish)	98	252	44	165	45	175	19	113
Stow nets (prawns)	67	557	72	654	70	827	88	994
Trap nets (prawns)	34	510	22	318	14	230	32	632
Trawls (squid)	35	984	24	788	29	104	33	125
Hook and line (fish)	15	75	11	58	22	126	17	111
Other (fish)	0.7	1.5	1	2.3	4.6	15	1.4	3.3
Total	4908	22589	4166	21800	4570	24789	3834	22927

Trawls are among the most high-profile of the estuarine fishing gears, with up to 204 vessels predominantly targeting school prawns (*Metapenaeus macleayi*) during the day in summer throughout the Clarence (114 vessels), Hunter (29) and Hawkesbury (61) rivers. Clarence River trawlers are permitted to tow twin-rigged nets (Fig. 1B) each with a maximum headline length of 7.3 m, while trawlers in the other two rivers mostly are restricted to single gear (headline length of 10.9 m – Fig. 1C).

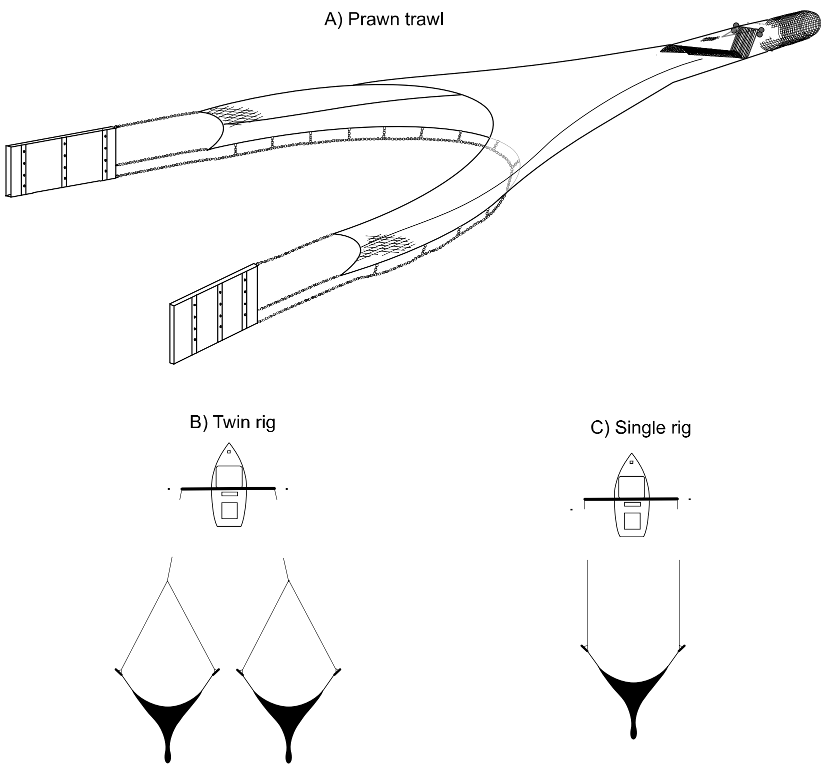

Figure 1. NSW estuarine A) prawn trawl, configured in a B) twin and C) single rig.

Boat-based prawn seines are the second most common prawn-catching gear, used by more than 190 fishers to target (1) school prawns in rivers, or (2) eastern king (*Penaeus plebejus*) and greasyback (*Metapenaeus bennettae*) prawns in coastal lagoons. Both categories of boat seines have comparable designs (Fig. 2A), but differ slightly in their size and operation (Figs 2B and 3). The configurations used to catch school prawns have headline lengths typically shorter than 40 m, and are set by securing one end of a hauling rope to an anchor, and deploying the entire seine around the area to be fished before it is retrieved (Fig. 2B). Eastern king and greasyback prawn seines are much longer (e.g., approximately 140 m headline), and while their initial deployment remains similar to that for school prawn seines (Fig. 3A and B), instead of immediate retrieval, fishers tow the entire seine for up to 10 minutes until the wings come together (Fig. 3B). A buoy is then secured to one wing, while the other is towed and repositioned so that both wings are stretched apart (Fig. 3C). The fisher then retrieves the opposite wing, dragging it in an arc back to the buoy (Fig. 3D and E). The entire seine configuration is then towed for another 10 minutes as above. This process can be repeated again before the codend is eventually hauled onboard.

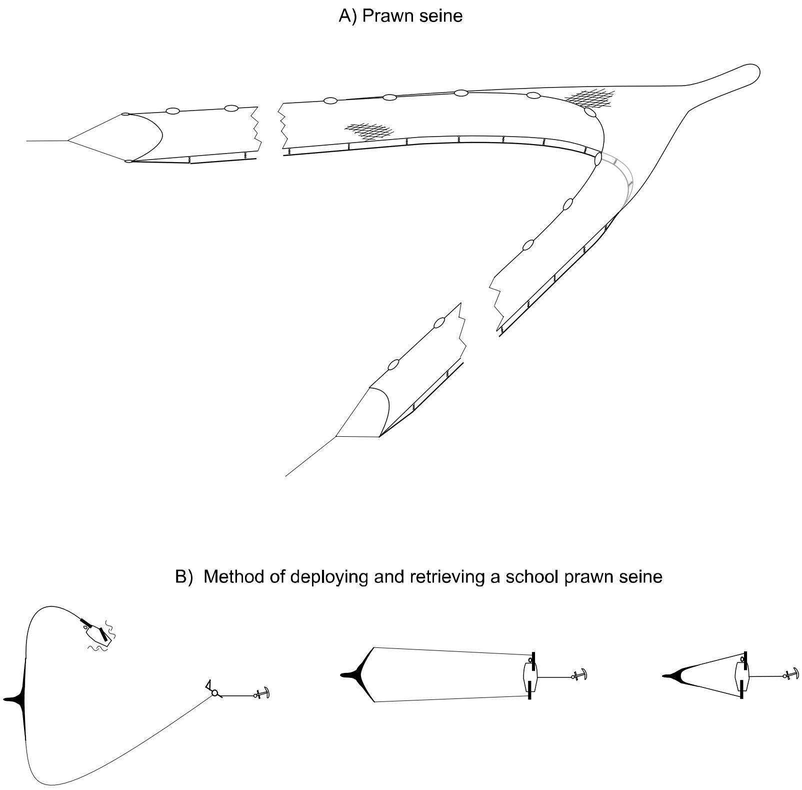

Figure 2. Typical NSW estuarine A) prawn seine and B) method of deployment to target school prawns (*Metapenaeus macleayi*).

Like trawls and boat seines, beach seines are active gears designed to herd catches towards a centrally located bunt (Fig. 4A). Beach seines are deployed by 139 fishers in 40 estuaries to catch up to 70 species, although the main targets comprise fewer than 10 mugulids, sparids, sillaginids, gerreids, girellids and platycephalids (Gray et al. 2001; Gray and Kennelly 2003). Most gears have a headline length less than 500 m and comprise 80-mm mesh throughout their wings (< 400 m), and between 30- and 57-mm mesh in the bunt (< 90 m in length; Broadhurst et al. 2007). Two hauling ropes (up to 2000 m) are attached to the ends of each wing (Fig. 4A). Fishing typically involves securing one hauling rope at the beach, while a fisher deploys the entire hauling rope/seine configuration from a dory around the area to be fished and back to the beach (Fig. 4B). The seine is then retrieved manually, or by using winches, and the catch concentrated into the bunt (often in shallow water – Fig. 4B), where it can be sorted.

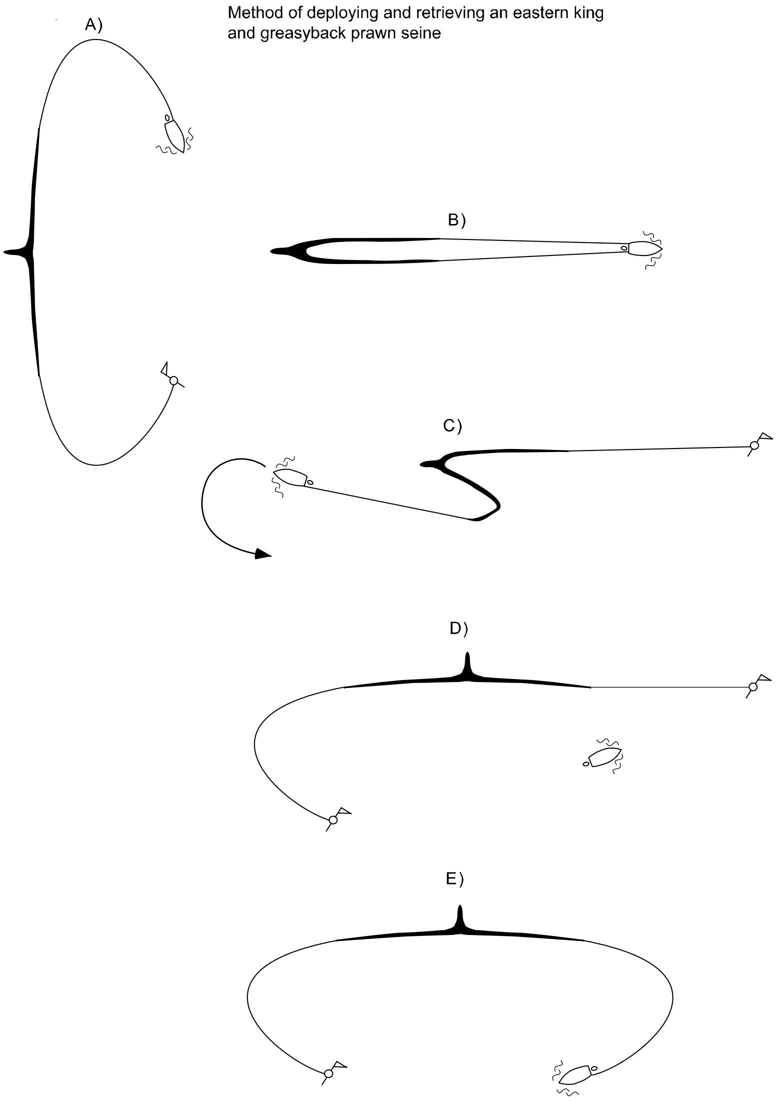

Figure 3. Deployment of a eastern king (*Penaeus plebejus*) and greasyback (*Metapenaeus bennettae*) prawn seine involving A) setting the seine round the area to be fished, B) towing the seine to close the wings, C) and D) repositioning each wing, before E) resetting the gear around the area to be fished.

Gillnets (Fig. 5) are classified as a passive gear, and are used by more than 480 fishers in 35 estuaries according to four broad categories. These include (1) those with low fishing heights (< 0.8 m) set overnight on the bottom to target dusky flathead (*Platycephalus fuscus*), and other, deeper-walled (typically > 2 m) gillnets to mostly catch more vertically distributed species that are either (2) deployed and immediately retrieved (on the surface) at any time of the day, or nocturnally deployed for up to (3) three or (4) 12 hours (overnight). In general, the immediate and three-hour retrieval of gillnets (two and three above) are permitted throughout the year to mainly target sea mullet (*Mulgil cephalus*), while overnight deployments (one and four above) are restricted to winter; when the deeper-walled configurations are used to catch both species above, but also luderick (*Girella tricuspidata*) and yellowfin bream (*Acanthopagrus australis*). Irrespective of their deployment, nearly all gillnets are between 375 and 1450 m long, and typically fished by one person from a powered dory.

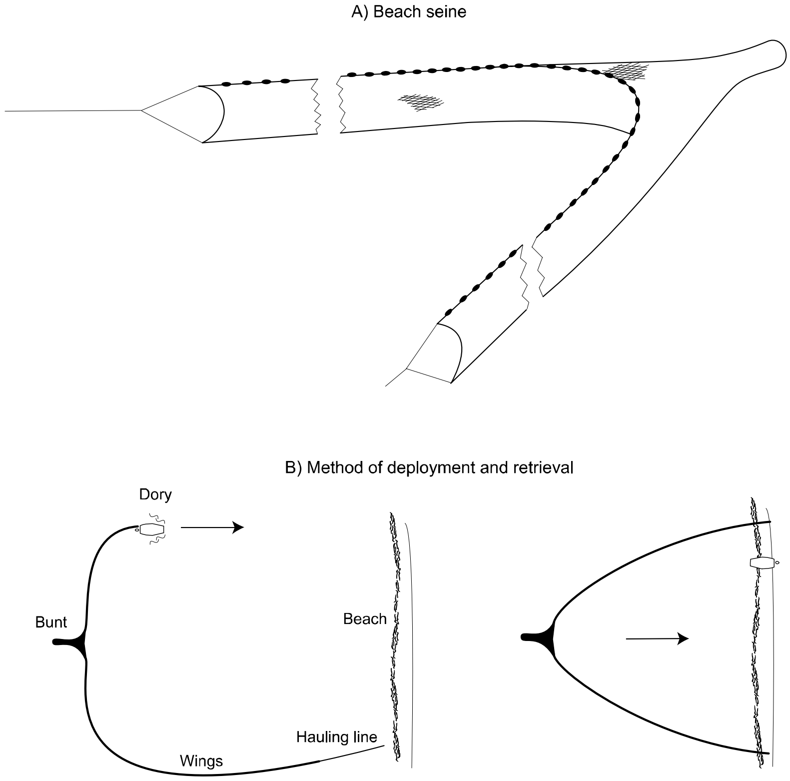

Figure 4. Estuarine A) beach seine and B) method of deployment.

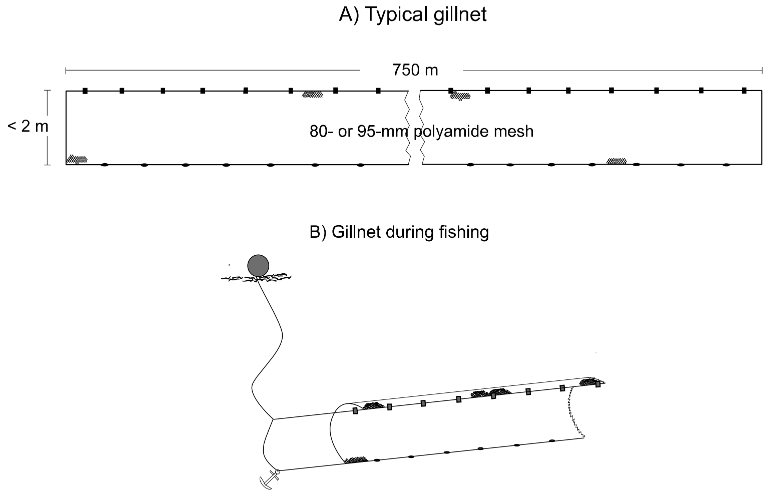

Figure 5. Typical A) gillnet used in NSW estuaries and B) orientation during fishing.

In addition to accounting for most of the commercial harvest from NSW estuaries, seines, gillnets and especially trawls are also the least selective of the various gears, with fishers often discarding some bycatch, including individuals of the targeted species that are smaller than minimum legal (MLTL) or commercial total lengths (MCTL) (Liggins et al. 1996; Liggins and Kennelly 1996; Gray 2001; 2002, Gray et al. 1990; 2001; 2004; 2005a; Gray and Kennelly 2003). For example, as part of an observer-based study, Liggins and Kennelly (1996) estimated that up to 177 t of bycatch comprising 77 species, was discarded each year (between 1990 and 1992) by prawn trawlers working in the Clarence River. During a similar 12-month study of beach seiners in three estuaries, Gray et al. (2001) and Gray and Kennelly (2003) calculated that between 85 and 269 t of bycatch

(38 and 59% of the total catches) were discarded at each location. Comparable 10- and three-month fishery-dependant research with gillnetters in six and three estuaries, respectively showed that while the average volumes of bycatch were considerably less than those observed for beach seiners and trawlers, extrapolated annual estimates were up to 65 t for some estuaries (Gray 2002; Gray et al. 2004). All of these bycatches comprised large numbers of juveniles of commercially- and recreationally-important species.

Concerns over the potential for wide scale, unaccounted fishing mortalities of key discards precipitated attempts at improving the selectivity of estuarine trawls, seines and gillnets. Most of this work has involved gear-based technical modifications, such as alternative rigging configurations and materials for gillnets (Gray et al. 2005b), increases in the sizes of mesh for beach seines (Kennelly and Gray 2000; Broadhurst et al. 2006; 2007) and gillnets (Broadhurst et al. 2003), BRDs for beach seines (Gray et al. 2000) and prawn trawls (Broadhurst and Kennelly 1994; 1996), and square-mesh codends for prawn trawls (Broadhurst et al. 2004) and boat seines (Macbeth et al. 2005).

While most of the above technical modifications have significantly improved gear selectivity for a range of species and their sizes, none are close to 100% effective and so, for all gears, at least some unwanted organisms are still caught and discarded. Excluding temporal and spatial closures, a remaining strategy that might be used to address this unnecessary wastage is to refine operational and/or post-capture handling techniques that maximise the survival of discards (e.g., Trumble et al. 1995; Gamito and Cabral 2003).

Relevant previous studies indicate that there is considerable variability in the mortality of bycatch discarded from commercial fishing gears, which can be attributed to the cumulative effects of a range of factors associated with the catching-and-handling processes (e.g., Wassenberg and Hill 1989; 1993; Hill and Wassenberg 1990; Kaiser and Spencer 1995; Colura and Bumguardner 2001; Gamito and Cabral 2003). Identifying the key mechanisms causing mortalities is a necessary prerequisite to developing solutions that improve survival. However, one problem that we faced at the start of the project was that there were no definitive reviews of the available literature for particular fisheries, and few attempts at using this information to propose appropriate methodologies for accurately obtaining the required data. As a prelude to the core work in the project, therefore, we formulated and published such a framework for towed gears (Appendix 3); which are recognised as being one of the most problematic in terms of collateral fishing mortality.

This review revealed that for many towed gears, discard mortalities were often attributed to the interactive effects of a restricted suite of dominant technical (e.g., gear design and deployment methods), environmental (e.g., temperature, air exposure, salinity and light) and biological (e.g., physiology, size, and catch volume and/or composition) factors. Variation among the influence of these factors means that in any study which seeks to quantify the fate of discarded bycatch and then develop appropriate mitigation strategies, most of the focus should be directed towards field-based studies across the range of commercial conditions; during which it is necessary to collect as much information as possible and then to monitor the health and mortality of discards, along with adequate controls, over typically between at least three and 10 days. Because aquaria experiments are done under simulated conditions, their benefits are limited to examining hypotheses formulated using *a priori*, field-based information about the likely influence of specific mechanisms on damage and mortality.

Given the above, the majority of research in this project was done during field-based studies with appropriate fishers at those locations and times known to have problematic bycatches (based on previous observer-based studies – Liggins et al. 1996; Liggins and Kennelly 1996; Gray 2001; 2002, Gray et al. 2001; 2004; 2005a; Gray and Kennelly 2003). The specific hypotheses tested during each individual experiment are included in the eight manuscripts submitted and published in international journals, and attached here as Appendices 4 – 11. All of this work encompassed the three general objectives listed below.

1.3. Objectives

1. To identify deleterious operational procedures and post-capture handling practices and quantify their effect on the immediate and short-term mortalities of unwanted, discarded bycatch throughout NSW key commercial estuarine fisheries.

2. To examine simple, but appropriate, operational and/or handling practices that improve the immediate and short-term post-capture survival of unwanted bycatch.

3. To determine the most appropriate strategies from (2) and assist commercial fishers and managers in their implementation, adoption and eventual legislation.