SECTION 4

A Survey of Daytime Recreational Fishing Following a Large Fish-kill Event in the Lower Reaches of the Macleay River, New South Wales, Australia

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April 2002
ACKNOWLEDGEMENTS

We would like to thank the following persons:

- Doug Chapman for his invaluable work in creating the database and designing the machine-readable data collection sheets used during the survey.

- John Matthews for providing assistance with maps.

- Tracey McVea for formatting the final report.

- Kerry Grezl, Victor Grezl and Allan Lyons for their help in co-ordinating the work of field staff and for providing technical support during the project.

- Heath Baker, Glen Barriskill, Reece Barriskill, Graham Beach, Glen Beers, Philip Bennett, Carol Bourne, Ian Cross, Kerry Grezl, Victor Grezl, Allan Lyons, Ken Lyons, Amanda Martin, Jenny M’Caskie, Jeff Murphy, Dale Rigney, Colin Rowsell, Ethel Rowsell, Wayne Williams and Mathew Yalouris. The excellent work of this group of people during the data collection phase of the survey ensured a high level of data integrity.

- Steve Kennelly and Geoff Liggins for reviewing the draft manuscript and providing comments which improved the final report.

- Finally, we would like to thank all of the fishers that participated in the survey. The successful completion of this work was made possible by their continual co-operation and support.
EXECUTIVE SUMMARY

Major flooding in the upper reaches of the Macleay River occurred during the second week of March 2001. The flood water inundated large areas of the floodplain which led to the decay of large amounts of vegetation and the mobilisation of highly reactive acid sulphate soils and sediments in the area. These two processes contributed directly to the marked reduction in dissolved oxygen levels in the river which in turn are believed to have been the cause of a small fish-kill in the upper reaches of the Macleay system during the time of flooding and a much larger fish-kill in the lower reaches of the Macleay River which occurred during the period 15 to 19 March 2001. The main species that were killed were yellowfin bream, Australian bass, sea mullet, sand whiting, eels, dusky flathead, luderick, silver biddy, estuary cod, gudgeons, gobies, toadfish, mosquitofish, school prawns and mud crabs.

The NSW government responded to the fish-kill by: (a) closing the tidal waters of the Macleay River (approximately 54 km upstream of the entrance) and adjacent inshore ocean waters to all forms of fishing; (b) initiating biological monitoring of commercial fish and crustaceans; and (c) forming a Recovery Working Group to provide advice to the Minister on actions to be taken to enhance the recovery of fish stocks in the river, particularly with respect to river closures. In June 2001, the government decided to re-open part of the lower Macleay River, downstream of the township of Kinchela and including the Stuarts Point arm and the Clybucca Creek area, to limited recreational and commercial fishing. This decision was taken after extensive consultation with the public and after detailed analysis of available biological and water quality information. Thus, when this recreational fishery re-opened on the 1st July, 2001 there was a need to collect quantitative information to describe the recreational fishery of the lower Macleay River. These data were essential for assessing the status of the recreational fisheries resources, the quality of the recreational fishery and to provide additional information regarding the rate of recovery of the populations of fish in the river since the fish-kill. The partial river closures were removed at the end of September 2001 to allow for the resumption of recreational and commercial fishing throughout the Macleay River.

Recreational fishing surveys of sound statistical design are essential for the collection of statistically unbiased information. We used stratified random sampling procedures as the basis of the survey design and integrated many data quality checks into the survey. Complemented survey methods were used to estimate the fishing effort; harvest and discard rates; and total harvest and discard for both the boat-based and shore-based fisheries in the Macleay River over a four-month survey period (July to October 2001 inclusive). The successful planning, organisation and execution of a large on-site survey of recreational fishing is a demanding and costly task. A community-based approach to the survey work, relying heavily on the support and involvement of local interest groups during all phases of the survey, proved highly successful.

We found that the recreational fishing population of the lower Macleay River was dominated by males - 82% of the boat-based fishers and 79% of the shore-based fishers interviewed were male. We also found that approximately 48% of the fishers interviewed were of local origin, ranging from approximately 43% from the local area in the boat-based fishery to approximately 51% in the shore-based fishery.

We estimated that approximately 78,800 fisher hours of daytime recreational effort was expended in the lower Macleay River during the survey period - July to October 2001 inclusive. The level of daytime recreational fishing effort showed a distinct monthly pattern with the highest levels of effort recorded during July and August, and the lowest levels of effort recorded during September and October. This monthly pattern of effort was similar to that recorded in the Richmond River, suggesting that these effort data are showing a seasonal trend.
We estimated that the daytime recreational harvest from the Macleay River fishery during the survey period consisted of approximately 45,300 fish and crabs (± 4,205 individuals - approximate SE) from 16 taxa. The bulk of this harvest was made up of luderick (=29,110 fish - ≈ 16.5 tonnes), yellowfin bream (=9,250 - ≈ 4.7 tonnes), dusky flathead (=3,760 - ≈ 1.9 tonnes), striped seapike (=1,220 - ≈ 0.1 tonnes), tailor (=670 - ≈ 0.3 tonnes), and sand mulet (=600 - < 0.1 tonnes). These six taxa, by number, accounted for 98.5% of the daytime recreational harvest during the survey period. A limited comparison made between these data and a summary of information collected during a five month recreational fishing survey in 1990 in the lower Macleay River indicated that there have not been any major changes in the structure of the recreational fishery since that time. Recreational anglers are still targeting and harvesting much the same species in the river. Further comparisons made between this study, a concurrent survey in the lower Richmond River and data collected during 1988-1989 from the Richmond River suggest strongly that the monthly patterns of targeting and harvesting that we have documented are consistent with normal seasonal changes in this fishery.

The size of the recreational harvest taken during the four month survey period can be put in context by considering the relative sizes of the estimated recreational harvest with respect to the relative magnitude of the fish mortality caused by the fish-kill event of March 2001.

Westlake and Copeland (2002) have estimated the number of dead fish in a 1.5 km stretch of the lower Macleay River, near the town of South West Rocks, at approximately 180,000 individual fish of various species. In comparison, the number of fish and crabs harvested by recreational fishers during the survey period were estimated as approximately 45,300 individuals which is approximately one quarter of the size of the estimated mortality for a 1.5 km stretch of the lower Macleay River during the mid-March fish-kill event.

We estimated that daytime recreational fishers (boat-based and shore-based) discarded approximately 34,310 fish and crabs (± 2,060 individuals - approximate SE) from 26 taxa whilst fishing in the lower Macleay River during the survey period. The six most commonly discarded taxa, by number, during the survey period were yellowfin bream (=22,260 - 64.8%), luderick (=5,200 - 15.2%), dusky flathead (=3,590 - 10.5%), sand whiting (=1,250 - 3.6%), tailor (=1,040 – 3.0%), and silver batfish (=470 - 1.4%) (Table 23). These six taxa, by number, accounted for 98.5% of the total daytime recreational discard. Recreational fishers indicated that the great majority of discarded yellowfin bream (94.7%), sand whiting (97.6%), luderick (82.9%), dusky flathead (76.7%) and tailor (75.0%) were below the legal minimum length. Although these discard data should be viewed with some caution because they are self-reported and less accurate than harvest data (which are collected by direct observation), they show that recreational fishers were catching and returning to the water large numbers of juvenile fish.

The four indicators of recreational fishing quality considered in this study were the proportion of unsuccessful fishing parties, non-directed harvest rates for the boat-based and shore-based fisheries, non-directed discard rates for the boat-based and shore-based fisheries and size-frequency distributions for some important taxa harvested by the recreational sector. The proportion of unsuccessful boat-based fishing parties ranged from approximately 22% to 51% on a monthly basis whilst the proportion of unsuccessful shore-based fishing parties was relatively higher ranging from approximately 54% to 74% on a monthly basis. In both fisheries the lowest proportion of unsuccessful fishing trips was recorded during July, immediately after the river was re-opened to recreational fishing, and higher proportions of unsuccessful fishing parties were recorded in the following months. These data suggest that the quality of recreational fishing was best in July after the river had been re-opened to recreational fishing and that there had been a gradual decline in fishing quality in the following months. The reason for these trends in the boat
and shore fisheries was probably a combination of seasonal fish abundances and the large amount of fishing effort that occurred immediately after the fishery was re-opened.

The harvest rates and discard rates we calculated and presented are based on the total non-directed fishing effort. The harvest rates of the main angling species measured during this four month survey were similar, and in some cases higher, than comparable harvest rate data collected in other estuarine fisheries in NSW. These findings suggest that the quality of recreational fishing was quite good for boat-based and shore-based fishers during the survey period in the lower Macleay River. A similar conclusion is reached when examining discard rate data. High rates of discard were reported for the main species of recreational interest during the survey period indicating that juvenile fish were abundant in the lower Macleay River during the survey period.

The size-frequency distributions presented are important baseline indicators which can be used to monitor future changes (if any) in the size structure of these species in the fishery. Overall, the proportions of undersized fish retained by recreational fishers in the lower Macleay River fishery (boat and shore-based) were comparable to rates measured in some other estuarine fisheries in NSW, suggesting a comparable availability of legal-sized fish in the population in the Macleay River. In addition, large individuals that were highly-prized by fishers were common in the recreational harvests, indicating that the quality of recreational fishing opportunities in this fishery were quite good.

In summary, the question of whether the recreational fishery (shore and boat-based) in the Macleay River has recovered from the impact of the March fish-kill event cannot be answered directly because we do not have any detailed information describing the status of riverine fish stocks or the recreational boat and shore fisheries in the Macleay River immediately before the fish-kill event nor do we have information about other non-impacted estuarine recreational fisheries in the region that could be used as controls or reference sites. Therefore, we are restricted to making inferences about the recovery of estuarine fish stocks and the status of the recreational fisheries from limited comparisons with previous studies and by examining a number of indicators of recreational fishing quality that have been derived from the current survey. The interpretation of the available evidence strongly suggests that the recreational fisheries in the lower Macleay River are still productive and providing quality recreational fishing opportunities despite the adverse impacts of the March 2001 fish-kill event.
1. **INTRODUCTION**

Major flooding in the upper reaches of the Macleay River occurred during the second week of March 2001. The flood water inundated large areas of the floodplain which led to the decay of large amounts of vegetation and the mobilisation of highly reactive acid sulphate soils and sediments in the area. These two processes contributed directly to the marked reduction in dissolved oxygen levels in the river (Westlake and Copeland 2002) which in turn are believed to have been the cause of a small fish-kill in the upper reaches of the Macleay system during the time of flooding and a much larger fish-kill in the lower reaches of the Macleay River which occurred during the period 15 to 19 March 2001 (Macbeth *et al.* 2002, Westlake and Copeland 2002). The main species that were killed were yellowfin bream, Australian bass, sea mullet, sand whiting, eels, dusky flathead, luderick, silver biddy, estuary cod, gudgeons, gobies, toadfish, mosquitofish, school prawns and mud crabs (Macbeth *et al.* 2002, Westlake and Copeland 2002).

The NSW government responded to the fish-kill by: (a) closing the tidal waters of the Macleay River (approximately 54 km upstream of the entrance) and adjacent inshore ocean waters to all forms of fishing; (b) initiating biological monitoring of commercial fish and crustaceans; and (c) forming a Recovery Working Group to provide advice to the Minister on actions to be taken to enhance the recovery of fish stocks in the river, particularly with respect to river closures. In June 2001, the government decided to re-open part of the lower Macleay River, downstream of the township of Kinchela and including the Stuarts Point arm and the Clybucca Creek area, to limited recreational and commercial fishing. This decision was taken after extensive consultation with the public and after detailed analysis of available biological and water quality information. Thus, when this recreational fishery re-opened on the 1st July, 2001 there was a need to collect quantitative information to describe the recreational fishery of the lower Macleay River. These data were essential for assessing the status of the recreational fisheries resources, the quality of the recreational fishery and to provide additional information regarding the rate of recovery of the populations of fish in the river since the fish-kill. The partial river closures were removed at the end of September 2001 to allow for the resumption of recreational and commercial fishing throughout the Macleay River.

1.1. **Limitations of recreational fishing surveys for detecting environmental impacts**

The assessment of environmental disturbance or impacts is difficult because it is often uncertain whether a causal relationship exists between the detrimental environmental event that has occurred (e.g. a flood followed by a fish-kill) and any changes that are measured at a later time. The changes in the recreational fishery detected after the fish-kill event include a component attributable to the detrimental flood event and a component due to natural fluctuations of fish populations that occur at various spatial and temporal scales. An appropriate experimental design is needed to discriminate between changes in the recreational fishery due to the fish-kill event and changes caused by natural fluctuations in fish abundance and catchability. Ideally, an experiment designed to test for the impacts of the fish-kill event would have included spatial replication at the level of rivers (i.e. other riverine fisheries would be used as controls or reference sites) and these multiple riverine fisheries would have been surveyed before and after the fish-kill event. This type of experimental design is referred to as a Before-After-Control-Impact (BACI) design in the scientific literature. Underwood (1991) provides a detailed description of this type of experimental design.

The recreational fishing survey we have done does not meet the rigorous requirements of a BACI experimental design. We do not have any data describing the recreational fishery immediately before the unexpected fish-kill event nor do we have data describing the status of other riverine...
recreational fisheries in the region that could be used as control sites. Thus, the current survey data can only be used to describe the status of the recreational fishery in the lower Macleay River after the fish-kill event. We are restricted to making inferences about the recovery of the fish stocks in the lower Macleay River from limited comparisons with some previous recreational fishing studies and by examining a number of indicators of recreational fishing quality derived from the present study.

1.2. Site description

The Macleay River (30°52’S 153°01’E) is a large river on the mid-north coast of New South Wales (NSW) on the east coast of Australia (Fig. 1). The Macleay River has a water area of approximately 18.2 km² and a total catchment area of approximately 11385 km² (Roy et al. 2001). The Macleay River is open permanently to the ocean with twin training breakwaters at its entrance. Roy et al. (2001) have classified the Macleay River as wave-dominated, barrier estuary. This type of estuary is characterised by having a tidal inlet that is constricted by wave deposited beach sand and a flood-tidal delta that is usually smaller than those found in tide-dominated estuaries (Roy et al. 2001). Wave dominated estuaries are more strongly influenced by river discharge than by tide with tidal ranges being approximately 5-10% less than in the ocean (Roy et al. 2001). The main river arm is approximately 150 km in length and the tidal limit is approximately 54 km from the ocean (DLWC website). The river contains approximately 5.2 km² of mangroves, approximately 1.1 km² of seagrass and approximately 3.7 km² of saltmarsh vegetation (Roy et al. 2001). The survey area in the lower Macleay River consisted of a relatively large and convoluted part of the river system, the water distance from the entrance to Kinchela being approximately 23 km, the water distance from Kemps Corner and including a single circuit of the Clybucca Creek/Andersons Inlet loop being approximately 20 km and the Stuarts Point arm being approximately 8.5 km in length (Figure 1).

1.2.1. Access for recreational fishers

The lower Macleay River, waters downstream of the township of Kinchela to the river mouth including the Stuarts Point arm and the Clybucca Creek area, was re-opened to limited recreational fishing on July 1, 2001. Additional new management measures were implemented during the following three month period which provided temporary restrictions to the recreational access to the fishery. Recreational fishing was allowed only between 06:00 to 21:00 hours. Each recreational fisher was permitted to have a daily bag limit of ten fish of any mix of species but with no more than five bream and one mulloway and not more of any species of finfish than allowed by an existing bag limit. Mullet taken for live bait were excluded from this personal bag limit with an additional 20 mullet less than 15 cm total length allowed. Recreational crab trapping was allowed in the re-opened area of the river. Existing legal size limits for all species remained the same.

The recreational fishery in the lower Macleay River can be readily accessed by fishers from boats and from the shore (Fig. 1). Boat-based fishers have access to the recreational fishery from four public boat ramps within the survey area (Fig.1) and from many other ramps located further upstream and outside the survey area. Private access to the fishery is quite restricted. There is extensive rural use of properties adjacent to the shoreline upstream of the survey area and large wetlands exist throughout the system which preclude access for recreational fishers. There are very few moorings in the river. Shoreline access to the recreational fishery is diffuse within the survey area, even though there are large areas of shoreline which are not very accessible because of the dense vegetation (e.g. mangroves in the Clybucca Creek area and along most of the Stuarts Point arm). Easy access to the fishery is available along the southern shoreline of the main river and along the length of the breakwater. The shoreline area beneath the Jerseyville bridge was also a popular fishing spot.
Figure 1. Map of the lower Macleay River showing the spatial extent of the survey and the boundaries used to divide the fishery into four areas: (1) the Main River area; (2) the Entrance area; (3) the Kemps Corner/Clybucca area; and (4) the Stuarts Point area. The location of public boat ramps and training walls (break-waters) have been marked.
1.2.2. Access for commercial fishers

The lower Macleay River was also re-opened to limited commercial fishing on July 1, 2001. Stringent management measures were implemented during the following three month period to hasten the recovery of fish stocks in the river. Commercial hauling operations on the ocean beaches to the north and south of the river mouth were restricted to travelling schools of fish such as sea mullet so as not to directly affect the recovery of the river. Commercial mesh netting (minimum mesh size 95mm) by the method of “splashing” which requires that the shooting of the net, splashing of water in the vicinity of the net and the retrieval of the net be done in a continuous operation, was permitted in the re-opened part of the river at night between 18:00 and 06:00 hours. A further condition associated with this commercial mesh netting was that no flathead were to be retained. Commercial crab and eel trapping was allowed within the re-opened area of the river. Existing legal size limits for all species remained the same.

1.3. Aims

The principal aims of this project were:

1. To estimate the level of daytime recreational fishing effort in the lower reaches of the Macleay River during the four month period, July to October 2001 inclusive.
2. To estimate daytime recreational harvest rates and discard rates in the lower reaches of the Macleay River.
3. To estimate the amount of daytime harvest and discarding by recreational fishers in the lower reaches of the Macleay River.
4. To describe the status of the shore-based and boat-based recreational fisheries in the lower reaches of the Macleay River following a major fish-kill event in mid March 2001.
2. METHODS

2.1. General

We seek to communicate the findings of this work to a very diverse audience which includes recreational and commercial fishers, scientists, managers and interested members of the general public. The published texts describing the many different types of survey designs and methods, their relative strengths and limitations, and their statistical treatment, all contain a considerable quantity of technical terms. Unfortunately, it is not possible to eliminate the use of this technical language without compromising the scientific meaning of the report. We provide a glossary of the technical terms used in this report (see Appendix 1) to assist any layperson in his/her attempt to read and understand the findings of this work. Wherever possible, we also try to define terms in the text when they are used for the first time. The term “catch” is used to refer to the number or weight of fish caught (kept and discarded), whilst the term “harvest” refers to that part of the catch that is retained, usually measured as the number or weight of fish kept. The term “discard” is used to refer to that part of the catch that is not kept, usually measured as the number of fish discarded. The reasons for discarding fish, crabs and cephalopods vary among fishers and include: (a) the small size of the animal (many species that are targeted by recreational fishers have minimum legal lengths specified in legislation, whereas, for all other species the discard size is determined by the judgement of individual fishers); (b) the animal is regarded by fishers to be of low edible quality or has poisonous flesh; (c) the bag limit has been achieved but the fisher wants to continue fishing; (d) the fishing ethic adopted by individual fishers (many fishers are involved in “catch and release” fishing).

Accurate and precise information which describes and quantifies the fishing effort, harvests, and harvest rates of recreational fishers is needed to understand changes in recreational fisheries throughout time. Recreational fishing surveys that have multiple objectives usually involve complex survey designs and these types of surveys can be very costly (Pollock et al. 1994). The choice of survey design is constrained by practical considerations which are often site-specific, and by the limited finances available to the project. Thus, when decisions on sample sizes are made at the start of a survey, they are always influenced by the trade-off between desired levels of precision and the limited resources allocated to the survey. A statistically sound survey design based on the principles of stratified random sampling is essential to enable the cost-efficient collection of reliable survey data.

2.2. Survey design

We follow the terminology of Pollock et al. (1994) to describe the survey designs and estimation methods used to calculate harvest and discard rates, estimates of total fishing effort, total harvest and discard. We used on-site survey methods (surveys conducted at the fishing sites) because most of the information collected on-site can be verified by field staff. In contrast, off-site methods (surveys conducted away from fishing sites), such as telephone or diary surveys, depend largely on self-reported information which cannot be verified (Pollock et al. 1994). Another major advantage of on-site surveys is that the non-response or refusal rates recorded are usually much lower than the non-response rates recorded during off-site surveys (Pollock et al. 1994).

A complemented survey combines two or more contact methods for collecting effort and catch information from fishers (Pollock et al. 1994). Complemented survey methods were used to assess separately the shore-based recreational fishery and the boat-based recreational fishery. The shore-based fishery was assessed by using a roving(effort)-roving(harvest and discard) design.
combination. The boat-based fishery was assessed by using a roving(effort)-access(harvest and discard) design combination.

The sampling frame is a complete list of possible sampling units in the whole population and a clear and unambiguous definition of the sampling frame is needed to determine the scope of a survey (Cochran 1953, Yates 1965, Pollock et al. 1994). The sample frame can be divided into non-overlapping strata and a random sampling protocol is usually applied to select a sample from each stratum (Cochran 1953, Yates 1965, Pollock et al. 1994). This survey work is based on the principles of stratified random sampling. Pollock et al. (1994) summarised the advantages of stratification as:

(a) improving the overall precision of population estimates. An increase in precision (i.e. a reduction in variance) will occur when a relatively heterogeneous population is divided into non-overlapping strata of known size, that are relatively more homogeneous than the whole population;
(b) making the administration of the survey work easier because strata can be used to partition large frames that are difficult to sample into multiple, smaller units that can each be sampled more easily; and
(c) providing greater information yield. The creation of strata allows us to calculate population estimates for each separate stratum, thereby providing important information at a smaller scale, as well as providing overall estimates of population parameters for the entire population by combining the separate stratum totals and their associated variances.

2.3. Spatial sampling frame and stratification

The spatial sampling frame (geographical boundary) of this survey is illustrated in Figure 1. All excluded areas shown in Figure 1 are regarded as being outside the spatial sampling frame. The lower Macleay River survey area (Fig. 1) was stratified into four distinct areas: (a) the Entrance area; (b) the Main River area; (c) the Kemps Corner/Clybucca area; and (d) the Stuarts Point area.

2.3.1. Entrance area

The eastern extremity of the Entrance area (Fig. 1) was defined as being a line drawn between the seaward-most extremities of the North and South breakwaters at the river mouth. The boundary between the Entrance area and the Main River area (Fig. 1) was defined as a line originating from the downstream edge of the mouth of Spencers Creek and extending across the river to the western bank (Fig. 1). The boundary between the Entrance area and the Kemps Corner/Clybucca area was defined as a line extending from the tip of the breakwater at Kemps Corner to the southern edge of Shark Island (Fig. 1). The popular fishing spots located along the southern breakwater were included in this area.

2.3.2. Main river area

The seaward boundary of this area was defined as a line originating from the downstream edge of the mouth of Spencers Creek and extending across the river to the western bank (Fig. 1). The upstream boundary of this area was defined as a line originating from the downstream edge of the mouth of Kinchela Creek and extending across the river to the western bank (Fig. 1). The waters of Kinchela Creek, the non-navigable parts of Spencers Creek and the small waterway behind the town of Jerseyville were excluded from this area.

2.3.3. Kemps Corner/Clybucca area

The boundary between the Kemps Corner/Clybucca area and the Entrance area was defined as a line extending from the tip of the breakwater at Kemps Corner to the southern edge of Shark Island (Fig. 1). The shallow sandbar near Fishermans Reach formed a natural barrier to boat traffic near
the bottom of the tide. The southern edge of this sandbar was used as the boundary between the Kemps Corner/Clybucca area and the Stuarts Point area (Figure 1). All navigable waters around Shark Island and the Clybucca Creek/Andersons Inlet loop were included in this area. All waters behind the floodgates and behind the causeway at the end of Clybucca Creek were excluded from this area (Figure 1).

2.3.4. **Stuarts Point area**

The southern edge of the sandbar near Fishermans Reach was used as the boundary between the Kemps Corner/Clybucca area and the Stuarts Point area (Figure 1). The Stuarts Point area was characterised by extensive stands of mangroves, the small township of Stuarts Point and the caravan park located adjacent to the shoreline at Stuarts Point.

2.4. **Temporal sampling frame and stratification**

The temporal sampling frame of the survey spanned a four month period, commencing in July and concluding at the end of October 2001. We stratified the four month survey period into months (July, August, September and October), and day-types within each month (Weekdays and Weekend days). Public holidays were classified as weekend days. Days were regarded as the primary sampling unit for all strata. By definition, a survey day started at sunrise and ended at sunset, however the fishery closure in place during July, August and September restricted the legally permitted fishing day to the period between 06:00 to 21:00 hours. When sunrise occurred before the start of the legally permitted fishing day we defined the length of the fishing day as being from 06:00 to sunset.

Basic sampling theory dictates that the accuracy and precision of overall population estimates can be improved by allocating more sampling units to a stratum that contains a large part of the recreational fishing effort and/or harvest (see Cochran 1953, Pollock *et al.* 1994). It has long been known that surveys will usually be most efficient (have least variance) when the distribution of sampling effort coincides with the distribution of fishing effort (Best and Boles 1956, Pollock *et al.* 1994). If effort and harvest are strongly correlated then it follows that by weighting sampling effort in proportion to the fishing effort there will also be an improvement in the precision of harvest estimates. We already knew from previous angler surveys that a disproportionate amount of the recreational fishing effort and harvest occurs on weekend days (Steffe *et al.* 1996a & 1996b, Steffe and Chapman 2002, Steffe unpublished data) thus it was logical to allocate proportionally more sampling units to the weekend day-type stratum than to the weekday day-type stratum.

2.5. **Collecting data for the boat-based and shore-based recreational fisheries**

Two independent datasets were collected and used to estimate recreational fishing effort, harvest rates and discard rates. These datasets consisted of: (1) progressive counts of recreational fishing effort; and (2) interviews with recreational fishing parties. These two datasets were used to obtain estimates of boat-based and shore-based recreational harvest and discard.

2.5.1. **Progressive counts of recreational fishing effort**

Estimates of recreational fishing effort for the boat-based fishery and the shore-based fishery were made with progressive counts on randomly selected survey days. Progressive counts were made separately of all boats and all shore-based persons that were observed to be involved in some type of recreational fishing activity. These recreational fishing activities included all forms of angling and the setting, checking and retrieval of crab nets, but excluded activities such as spearfishing, bait collecting and prawning. We specifically excluded boats traveling across the river and anglers moving along the shore from the counts (even when recreational fishing gear was visible) when it was not possible to determine their destination nor their intent to engage in any recreational fishing.
activity. In contrast, we included boats in the counts when they were engaged in drift fishing and they were observed traveling to start another “drift” upstream. Drift fishing was common in the river.

We divided the survey area into two circuits for making progressive counts by boat: (a) the Entrance area, the Main River area and the Kemps Corner/Clybucca area; and (b) the Stuarts Point area (see Figure 1). This division of the fishery into two separate circuits was necessary because a large shallow expanse near Fishermans Reach was navigable only near the top of the tide. The time needed to complete progressive counts in each of the two circuits was determined during a series of runs. Two replicate progressive counts were scheduled on each of the randomly selected survey days. The starting times for the replicate progressive counts were scheduled by picking one of a set of discrete possible starting times as recommended by Hoenig et al. (1993). The starting location and direction of travel were randomly selected for each scheduled progressive count. This progressive count method will, under very general conditions, provide unbiased estimates of fishing effort during the day (Hoenig et al. 1993). The collection of recreational effort data by means of these progressive counts was done on the same days as the interviews with recreational fishing parties. Importantly, the collection of progressive count and interview data were treated as separate jobs, meaning that scheduled progressive counts were not interrupted to interview fishers and that other survey staff were assigned to conduct interviews throughout the fishery during the entire fishing day which included the periods during which replicate progressive counting of fishing effort was done. This small organisational change in staff deployment effectively eliminated the “shadow bias” (see Wade et al. 1991) that occurs when progressive counts are interrupted so that interviews with fishers can be done. The number of replicate days sampled for each day-type stratum within each month is summarised in Table 1. The level of daily replication achieved represents sampling fractions of approximately 64% for the weekend day-type stratum and approximately 28% for the weekday stratum during the period of the survey (Table 1).
Table 1. Sample sizes (number of days spent interviewing and the number of replicate progressive counts of effort), number of interviews, number of refusals and refusal rates for the boat and shore recreational fisheries in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>No. Days in Stratum</th>
<th>Effort Counts</th>
<th>Interviews</th>
<th>Number of Interviews</th>
<th>Number of Refusals</th>
<th>Refusal Rate (%)</th>
<th>Number of Interviews</th>
<th>Number of Refusals</th>
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<td></td>
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2.5.2. Interviews with recreational fishing parties

All interviews were done between 09:00 hours and sunset. We chose to restrict the interview coverage because data from a previous study had showed that less than 4% of recreational fishing trips were completed between sunrise and 09:00 hours making it cost-effective to start interviewing after 09:00 hours (Steffe et al. 1996a). It is important to note that most recreational fishing trips that begin in the period between sunrise and 09:00 hours are completed later in the day and would be covered by the sampling regime. Machine-readable interview forms were used to collect information from boat-based and shore-based fishing parties. Fishing parties were approached and asked to participate in the survey by providing information about their fishing trip, harvest and discard. Attempts were made to interview all recreational fishing parties encountered (shore-based and boat-based), however, during periods of high recreational activity it was necessary to systematically subsample every second or third fishing party (depending on the number of fishing parties available for interview). Refusals to provide information, or to show the fish retained, were recorded. We asked co-operative recreational fishers about their targeting preferences during their current fishing trip, the time they started fishing and their fishing locations. We also recorded the number of fishers in the fishing party (non-fishers were not included as part of a fishing party) and the sexes of all fishing party members. Home postcode information for all persons (fishers and non-fishers) in a fishing party was requested and the following five home postcodes (2431, 2440, 2447, 2448, 2449) were used to identify local fishers in the lower Macleay River. The retained catch was identified by field staff and, whenever possible, measurements of all fish (fork length), crabs (carapace length) and squid (mantle length) were taken to the nearest whole centimetre. When fishers were in a hurry to leave the ramp and it was not possible to measure all fish, crabs and squid, the survey personnel were instructed to record counts of the identified harvest and attempt to measure a sub-sample of the harvest. Fishers were also asked to recall the quantity and identity of all fish, crabs and cephalopods that they had caught and discarded during their trip. Whenever the nominated discard was a species that had a minimum legal length the fishers were asked additional questions to assess whether the discards had been larger or smaller than the minimum legal length.

Sampling effort was concentrated at the boat ramps used by recreational fishers within the survey area. This approach was adopted to maximise the number of interviews with boat-based fishing parties during late Winter and early Spring when low recreational effort levels were expected. The use of a bus-route method during this survey (see Robson and Jones 1989 for a description of this method) was considered but proved to be impractical because of the seasonal timing of the survey. We wanted to remove the possibility on low effort survey days of missing interviews with the few available boat-based fishing parties because the survey staff were waiting at another access point or in the process of traveling between boat ramps.

Boat-based fishing parties were approached at boat ramps when they returned from their fishing trip. The harvest rate and discard rate information collected during these access point interviews is based on completed trips (Malvestuto 1983, Hayne 1991, Pollock et al. 1994, Pollock et al. 1997). The access point survey method works best when there are few, well-defined, access sites (Pollock et al. 1994). The survey area contained four boat ramps which were all sampled but there are also many other access points further upstream that could have been used to provide access to the fishery. Similarly, private jetties and moorings could also have been used to access the fishery, however, there are relatively few private access points for boats along the lower Macleay River. Holidaymakers and residents from the Stuarts Point caravan park often store their small fishing boats on the adjacent beach. These recreational fishers were surveyed by the person covering the boat ramp at Stuarts Point. Therefore, we assumed that the fishing activities of recreational fishers using the public boat ramps were representative of recreational fishing parties that used private access points and other boat ramps further upstream to enter and leave the fishery. Although we did not test this important assumption, we have no reason to expect that fishers using private
access points and other upstream boat ramps would have behaved differently to those fishers that
used the public boat ramps within the survey area because these populations of fishers (regardless
of where they access the fishery) use the same methods to target the same species in the same
fishing areas within the survey area.

The diffuse access across large stretches of shoreline and breakwater compelled us to use roving
survey methods to assess the shore-based fishery. The shore-based fishery within the survey area
was searched entirely at least once (usually many times) during each survey day by interviewers,
thus providing coverage of the entire shore-based fishery on each survey day. Shore-based fishing
parties were approached during their fishing trips by field staff. Therefore, the harvest rate and
discard rate information collected during these interviews was based on incomplete trips which
documented only part of the total effort, harvest and discard for these fishing trips (Robson 1961 &
1991, Pollock et al. 1994). The use of a roving survey design introduced a sampling bias because
the probability of interviewing a group is proportional to the duration of their fishing trip. That is,
parties that fish for longer time periods are more likely to be encountered by field staff moving
through the fishery, termed the “length-of-stay” bias (Robson 1991, Pollock et al. 1994, Pollock et
al. 1997, Hoenig et al. 1997), which means that harvest rates and discard rates derived from roving
survey methods tend to be based on samples that contain an over-representative number of longer
trips and an under-representative number of short trips. Roving survey methods require the
following assumptions be made: (a) the harvest rate and discard rate for the portion of fishing trip
documented is the same as the harvest rate and discard rate for the entire trip; and (b) the harvest
rate and discard rate of interviewed fishing parties is representative of the whole fishing
population, which is the expected outcome for estimates derived from randomly selected samples

2.6. Estimation methods

We follow the general equations used by Pollock et al. (1994) for estimating total recreational
fishing effort, recreational harvest and discard rates, and total recreational harvest and discard for
the boat-based and shore-based fisheries and refer the reader to this book for worked examples.
More detailed explanations of the statistical procedures used can be found in Cochran (1953),
& 1997) and Pollock et al. (1997).

2.6.1. Basic notation

\( j \) denotes the stratum being considered \( (j = 1, \ldots, J) \);

\( J \) denotes the total number of strata;

\( i \) denotes the sample day unit within the stratum \( (i = 1, \ldots, N_j) \);

\( N_j \) is the total population size (all possible sampling days) in stratum \( j \);

\( n_j \) is the sample size in stratum \( j \);

\( x_{ij} \) denotes the value of the \( i \)th unit of stratum \( j \);

\( \bar{x}_j \) is the sample mean for stratum \( j \);

\[
\sigma_j^2 = \frac{\sum_{i=1}^{n_j} (x_{ij} - \bar{x}_j)^2}{(n_j - 1)}
\]

is the sample variance for stratum \( j \).
2.6.2. **Effort estimation for the boat-based and shore-based recreational fisheries**

Estimation of total effort was done separately for the boat-based fishery (units of boat hours) and the shore-based fishery (units of fisher hours). The base level of effort estimation was a day-type stratum within a month for each of the four areas in the lower Macleay River (Entrance area, Main River area, Kemps Corner/Clybucca area; and Stuarts Point area – see Figure 1). The effort estimates for each of the four river areas were combined to give separate day-type and monthly totals for the whole lower Macleay River survey area. A description of the equations used for estimating stratum totals, variances and standard errors are provided below.

Step 1 - The progressive counts of recreational fishing boats and shore-based fishers were expanded separately to estimate the daily effort for each fishing day that was sampled.

\[ \hat{e}_i = \bar{P}_i \times T \]  
(Equation 1)

where:
- \( \hat{e}_i \) is the estimate of fishing effort for the \( i \)th sample day.
- \( \bar{P}_i \) is the mean value for replicated progressive counts done on the \( i \)th sample day. The mean number of boats per progressive count is used for the boat-based fishery. The mean number of shore fishers per progressive count is used for the shore-based fishery.
- \( T \) is the length of the fishing day. We used the mean daylength period (units are hours) for each month (sunrise to sunset) whenever this period was contained within the legally permitted fishing day (06:00 to 21:00). When sunrise occurred before the start of the legally permitted fishing day we defined the length of the fishing day as being from 06:00 to sunset.

Step 2 - These daily effort estimates were then expanded for each day-type stratum within each month. This was done by multiplying the number of possible sample days in each base level stratum with the mean of the daily estimates of effort.

\[ \bar{\bar{e}}_j = \frac{\sum \hat{e}_{ij}}{n_j} \]  
(Equation 2)

where:
- \( \bar{\bar{e}}_j \) is the estimated mean daily fishing effort for the \( j \)th day-type stratum within a month, in units of boats per day for the boat fishery and fishers per day for the shore fishery.
- \( \hat{e}_{ij} \) is the estimate of fishing effort for the \( i \)th sample day in the \( j \)th day-type stratum within a month.
- \( n_j \) is the number of days sampled in the \( j \)th day-type stratum within a month.

\[ \hat{E}_j = N_j \times \bar{\bar{e}}_j \]  
(Equation 3)

where:
- \( \hat{E}_j \) is the estimate of total effort for the \( j \)th day-type stratum within a month. In the boat fishery the units are boat hours and for the shore fishery the units are fisher hours.

See Basic notation and Equation 2 for definitions of the other terms.

Step 3 - Calculate the precision of the effort estimates. This is done for each fishery by estimating variances and standard errors for each stratum.
\[ Var(\bar{e}_j) = \frac{s_j^2}{n_j} \] (Equation 4)

where:
\[ Var(\bar{e}_j) \] is the estimated variance of the mean daily fishing effort for the \( j \)th day-type stratum within a month. This is calculated separately for each fishery.
\[ s_j^2 \] is the sample variance of the daily estimates of fishing effort for the \( j \)th day-type stratum within a month.
\[ n_j \] is the sample size as described in Equation 2.

\[ SE(\bar{e}_j) = \sqrt{Var(\bar{e}_j)} \] (Equation 5)

where:
\[ SE(\bar{e}_j) \] is the estimated standard error of the mean daily fishing effort.
\[ Var(\bar{e}_j) \] is the estimated variance of the mean daily fishing effort as described in Equation 4.

\[ Var(\hat{E}_j) = N_j^2 \times Var(\bar{e}_j) \] (Equation 6)

where:
\[ Var(\hat{E}_j) \] is the estimated variance of total effort for a stratum, and is calculated separately for each day-type within each month for each fishery.
See Basic notation and Equation 4 for definitions of the other terms.

\[ SE(\hat{E}_j) = \sqrt{Var(\hat{E}_j)} \] (Equation 7)

where:
\[ SE(\hat{E}_j) \] is the estimated standard error of total effort for a stratum.
\[ Var(\hat{E}_j) \] is the estimated variance of total effort for a stratum as described in Equation 6.

Step 4 - Calculate total fishing effort separately for the boat-based and shore-based fisheries. This was done by adding the effort estimates of the day-type strata together to obtain monthly totals.

\[ \hat{E}_{Tot} = \sum_{j=1}^{J} \hat{E}_j \] (Equation 8)

where:
\[ \hat{E}_{Tot} \] is the total monthly effort calculated by combining the effort estimates for each day-type stratum. The general form of the same equation was used when adding effort estimates for the four survey areas.
\[ \hat{E}_j \] is the estimate of total effort for the \( j \)th day-type stratum as defined in Equation 3.

Step 5 - Calculate the precision of effort estimates obtained by adding stratum totals. This is done by simply adding the estimated variances for each stratum and calculating a standard error for the estimates of monthly effort totals.
\[ \text{Var}(\hat{E}_{\text{Tot}}) = \sum_{j=1}^{J} \text{Var}(\hat{E}_j) \]  
(Equation 9)

where: 
\( \text{Var}(\hat{E}_{\text{Tot}}) \) is the estimated total monthly variance calculated by combining the estimated effort variances for each day-type stratum. The general form of the same equation was used when adding variance estimates for the four survey areas.

\[ \text{SE}(\hat{E}_{\text{Tot}}) = \sqrt{\text{Var}(\hat{E}_{\text{Tot}})} \]  
(Equation 10)

where: 
\( \text{SE}(\hat{E}_{\text{Tot}}) \) is the estimated standard error for monthly effort totals when adding day-type strata. The general form of the same equation was used when adding effort estimates for the four survey areas and calculating the standard error for the combined effort estimate. 
\( \text{Var}(\hat{E}_{\text{Tot}}) \) is the estimated total variance as described in Equation 9.

Step 6 - Calculate total fishing effort (boat-based plus shore-based) for the entire survey area. The initial step in these calculations was to convert the effort estimates for the boat-based fishery into units of fisher hours. As before, the base level of effort estimation was for a day-type stratum within a month for each of the four survey areas (Entrance area, Main River area, Kemps Corner/Clybucca area; and Stuarts Point area).

Please note: to simplify the notation in the following equations we have stopped adding the suffix \( j \) (which denotes the \( j \)th stratum) to all terms in the general equations even though these terms still refer implicitly to the \( j \)th stratum.

\[ \hat{E}_{\text{new}} = \hat{E}_{\text{old}} \times \tilde{f} \]  
(Equation 11)

where:
\( \hat{E}_{\text{new}} \) is the new estimate of effort for the boat-based fishery in units of fisher hours. 
\( \hat{E}_{\text{old}} \) is the old estimate of effort for the boat-based fishery in units of boat hours. 
\( \tilde{f} \) is the mean number of fishers per boat in that stratum.

Step 7 - Calculate the variance and standard error of the new estimate of effort for the boat-based fishery.

\[ \text{Var}(\hat{E}_{\text{new}}) = \left[ \hat{E}_{\text{old}}^2 \times \text{Var}(\tilde{f}) \right] + \left[ \tilde{f}^2 \times \text{Var}(\hat{E}_{\text{old}}) \right] - \left[ \text{Var}(\tilde{f}) \times \text{Var}(\hat{E}_{\text{old}}) \right] \]  
(Equation 12)

where:
\( \text{Var}(\hat{E}_{\text{new}}) \) is the estimated variance of the new estimate of effort for the boat-based fishery. 
\( \text{Var}(\tilde{f}) \) has been calculated by using the general form of Equation 4. 
\( \text{Var}(\hat{E}_{\text{old}}) \) has been calculated by using the general form of Equation 6. 
The terms \( \hat{E}_{\text{old}} \) and \( \tilde{f} \) are described in Equation 11.
\[ SE(\tilde{E}_{\text{new}}) = \sqrt{Var(\tilde{E}_{\text{new}})} \] (Equation 13)

where:
- \( SE(\tilde{E}_{\text{new}}) \) is the estimated standard error of the new estimate of effort for the boat-based fishery.
- \( Var(\tilde{E}_{\text{new}}) \) is described in Equation 12.

Step 8 - When estimates of effort totals for the boat-based fishery had been converted into the same units as those in the shore-based fishery, it was possible to combine stratum totals for the boat and shore fisheries to give estimates of monthly effort totals. Monthly effort estimates for the four spatial strata (Entrance area, Main River area, Kemps Corner/Clybucca area; and Stuarts Point area) were then combined to give effort estimates for the whole survey area. This procedure of adding stratum estimates has already been described and calculations were done using the general form of Equation 8.

Step 9 - Calculate monthly estimates of variance and standard errors for the total fishery. This procedure has already been described and calculations are done using the general form of Equations 9 and 10.

2.6.3. Harvest rate and discard rate estimators for the boat-based fishery

When the objective is to estimate total harvest, and the interview data are based on completed trips, the correct harvest rate estimator to use is the “ratio of means” (Jones et al. 1995, Pollock et al. 1997). This estimator is essentially the ratio of mean harvest to mean effort on a given day. The “ratio of means” was used for estimating the harvest of the boat-based fishery. Pollock et al. (1997) have shown that this estimator has a statistical expectation that is equal to total harvest divided by total effort for the population of fishers when it is applied to completed trip interviews taken at access points to the fishery.

\[ \hat{R}_{\text{II}} = \frac{\sum_{k=1}^{n} H_k}{\sum_{k=1}^{n} L_k} \] (Equation 14)

where:
- \( \hat{R}_{\text{II}} \) is the “ratio of means” an estimated daily harvest rate based on complete trips. The units used to estimate recreational harvest for the boat-based fishery were the number of fish per boat hour (see Appendices 2.1 to 2.6), and the weight of fish per boat hour (which are not presented). We also converted harvest rates for the boat-based fishery to numbers of fish per fisher hour so that comparisons could be made with the shore-based fishery.
- \( H_k \) is the complete harvest for the \( k \) th fishing unit. These fishing units can be boats, fishing parties, or fishers.
- \( L_k \) is the complete trip length for the \( k \) th fishing unit.
- \( n \) is the number of fishing units in the daily sample.

The explanation given above for harvest rate estimation is also valid for the estimation of discard rates.
\[
\hat{R}_{\text{d}} = \frac{\sum_{k=1}^{n} D_k}{\sum_{k=1}^{n} L_k}
\]

(Equation 15)

where:

\(\hat{R}_{\text{d}}\) is the “ratio of means” an estimated daily discard rate based on complete trips. The units used to estimate recreational discard for the boat-based fishery were the number of fish discarded per boat hour (see Appendices 2.1 to 2.6). We also converted discard rates for the boat-based fishery to numbers of fish discarded per fisher hour so that comparisons could be made with the shore-based fishery.

\(D_k\) is the complete discard for the \(k\)th fishing unit. These fishing units can be boats, fishing parties, or fishers.

\(L_k\) is the complete trip length for the \(k\)th fishing unit.

\(n\) is the number of fishing units in the daily sample.

We calculated mean daily harvest rates \(\overline{R}_{\text{h}}\) and mean daily discard rates \(\overline{R}_{\text{d}}\) for each day-type stratum within a month. The estimated variances of the mean daily harvest rates \(\text{Var}(\overline{R}_{\text{h}})\) and the estimated variances of the mean daily discard rates \(\text{Var}(\overline{R}_{\text{d}})\) were calculated by using the general form of Equation 4, and the estimated standard errors of the mean daily harvest rates \(\text{SE}(\overline{R}_{\text{h}})\) and the estimated standard errors of the mean daily discard rates \(\text{SE}(\overline{R}_{\text{d}})\) were calculated using the general form of Equation 5.

### 2.6.4. Harvest rate and discard rate estimators for the shore-based fishery

When the objective is to estimate total harvest, and the interviews are based on incomplete trips, the correct harvest rate estimator to use is the “mean of ratios” (Jones *et al.* 1995, Pollock *et al.* 1997, Hoenig *et al.* 1997). This estimator is essentially the mean of the individual harvest rates for all fishers interviewed on a given day. The “mean of ratios” was used for estimating the harvest of the shore-based fishery. Hoenig *et al.* (1997) used simulation procedures to show that the “mean of ratios” estimator has a large variance caused by the inclusion of high harvest rates resulting from very short, incomplete trips that have harvested some fish already. These authors found that the truncation (exclusion) of all short incomplete trips reduced the variance greatly without inducing an appreciable bias. Hoenig *et al.* (1997) recommended the truncation of short trips less than 20-30 minutes but noted that there was a trade-off between the level of truncation used and the number of interviews that were discarded. We examined the relationship between the harvest rate and the duration of the fishing trip for shore-based interviews to determine the most appropriate level of truncation. We found that by discarding all incomplete trips that had been in progress for less than 30 fisher minutes, we were able to remove the interviews with the most extreme harvest rates and hence minimise the variance of the harvest rate estimator. The adoption of this truncation criterion resulted in the loss of 90 shore-based interviews (approximately 6.8% of the usable shore-based interviews) from harvest calculations. We had routinely asked shore-based fishing parties about the intended finishing time for their current trip. We retained and used shore-based interviews with fishing parties that had completed their trips but had fished for less than 30 fisher minutes. We believe it is logical to keep and use the data from these complete short trips, regardless of the small amount of time fished or the amount of harvest taken, because it is these short trips that are under-represented in roving surveys due to “length-of-stay” bias.
Hoenig et al. (1997) showed that the mean of ratios estimator has an approximate statistical expectation of total harvest divided by total effort for the population of fishing units when it is applied to incomplete trip interviews with a truncation of short trips, taken by roving through the fishery. Thus, the mean of ratios estimator (\( \hat{R}_2 \)) used on incomplete trips with a truncation of short trips, provides an equivalent measure of fishing success to the ratio of means estimator (\( \hat{R}_1 \)) used on complete trips (Pollock et al. 1997, Hoenig et al. 1997).

\[
\hat{R}_{2(u)} = \frac{1}{n} \sum_{k=1}^{n} \frac{H_k}{L_k} \quad \text{(Equation 16)}
\]

where:
\( \hat{R}_{2(u)} \) is the “mean of ratios” an estimated daily harvest rate with truncation of short incomplete trips. The units used to estimate recreational harvest for the shore-based fishery were the number of fish per fisher hour, and the weight of fish per fisher hour.
\( H_k \) is the incomplete harvest (the harvest recorded at the time of interview for the incomplete trip) for the \( k \) th fishing unit. These fishing units can be boats, fishing parties, or fishers.
\( L_k \) is the incomplete trip length (the length of the incomplete trip at the time of interview) for the \( k \) th fishing unit.
\( n \) is the number of fishing units in the daily sample.

The explanation given above for harvest rate estimation is also valid for the estimation of discard rates.

\[
\hat{R}_{2(d)} = \frac{1}{n} \sum_{k=1}^{n} \frac{D_k}{L_k} \quad \text{(Equation 17)}
\]

where:
\( \hat{R}_{2(d)} \) is the “mean of ratios” an estimated daily discard rate with truncation of short incomplete trips. The units used to estimate recreational discard for the shore-based fishery were the number of fish discarded per fisher hour.
\( D_k \) is the incomplete discard (the discard recorded at the time of interview for the incomplete trip) for the \( k \) th fishing unit. These fishing units can be boats, fishing parties, or fishers.
\( L_k \) is the incomplete trip length (the length of the incomplete trip at the time of interview) for the \( k \) th fishing unit.
\( n \) is the number of fishing units in the daily sample.

We calculated mean daily harvest rates \( \bar{R}_{2(u)} \) and mean daily discard rates \( \bar{R}_{2(d)} \) for each day-type stratum within a month. The estimated variances of the mean daily harvest rates \( \text{Var}(\bar{R}_{2(u)}) \) and the estimated variances of the mean daily discard rates \( \text{Var}(\bar{R}_{2(d)}) \) were calculated by using the general form of Equation 4, and the estimated standard errors of the mean daily harvest rates \( SE(\bar{R}_{2(u)}) \) and the estimated standard errors of the mean daily discard rates \( SE(\bar{R}_{2(d)}) \) were calculated using the general form of Equation 5.
2.6.5. **Monthly harvest rate estimation for boat and shore fisheries**

The same logic and general equations are applied in the estimation of monthly harvest rates, monthly discard rates and their associated variances and standard errors. The contribution of each day-type stratum to the estimated monthly harvest rate and monthly discard rate was weighted by the relative size of each day-type stratum within the month (Pollock et al. 1994). This means that a greater weighting was given to the weekday stratum because there are more weekdays in a month than there are weekend days in a month.

\[
\overline{R}_{Month} = \left( \frac{N_{wd}}{N_{Month}} \times \overline{R}_{wd} \right) + \left( \frac{N_{we}}{N_{Month}} \times \overline{R}_{we} \right) \quad (\text{Equation 18})
\]

where:

- \(\overline{R}_{Month}\) is a stratified mean daily rate (harvest or discard) for a month. The \(\hat{R}_1\) estimators described in Equations 14 and 15 were used for the boat-based fishery, and the \(\hat{R}_2\) estimators described in Equations 16 and 17 were used for the shore-based fishery. The units are the number of fish per fisher hour for the boat and shore fisheries.
- \(N_{wd}\) is the number of weekdays in the month.
- \(N_{we}\) is the number of weekend days (includes public holidays) in the month.
- \(N_{Month}\) is the total number of days in the month (weekdays \(N_{wd}\) plus weekend days \(N_{we}\)).
- \(\overline{R}_{wd}\) is a mean daily rate (harvest or discard) for the weekday stratum. The \(\hat{R}_1\) estimators described in Equations 14 and 15 were used for the boat-based fishery, and the \(\hat{R}_2\) estimators described in Equations 16 and 17 were used for the shore-based fishery. The units are the number of fish per fisher hour for the boat and shore fisheries.
- \(\overline{R}_{we}\) is a mean daily rate (harvest or discard) for the weekend day stratum. The \(\hat{R}_1\) estimators described in Equations 14 and 15 were used for the boat-based fishery, and the \(\hat{R}_2\) estimators described in Equations 16 and 17 were used for the shore-based fishery. The units are the number of fish per fisher hour for the boat and shore fisheries.

The estimates of variance for the stratified mean daily harvest rates and stratified mean daily discard rates for each month were calculated using the following general equation.

\[
\text{Var}(\overline{R}_{Month}) = \left( \frac{N_{wd}}{N_{Month}} \right)^2 \times \text{Var}(\overline{R}_{wd}) + \left( \frac{N_{we}}{N_{Month}} \right)^2 \times \text{Var}(\overline{R}_{we}) \quad (\text{Equation 19})
\]

where:

- \(\text{Var}(\overline{R}_{Month})\) is an estimated variance for the stratified mean daily rate (harvest or discard) for a month.
- \(\text{Var}(\overline{R}_{wd})\) is an estimated variance for the mean daily rate (harvest or discard) for the weekday stratum in a month. This variance of a mean can be calculated by using the general form of Equation 4.
- \(\text{Var}(\overline{R}_{we})\) is an estimated variance for the mean daily rate (harvest or discard) for the weekend day stratum in a month. This variance of a mean can be calculated by using the general form of Equation 4.

The other terms used have been described in Equation 18.
The estimates of standard errors for the stratified mean daily harvest rates and stratified mean daily discard rates for each month were calculated using the following general equation.

\[ SE(\bar{R}_{Month}) = \sqrt{Var(\bar{R}_{Month})} \]  

(Equation 20)

where:
- \( SE(\bar{R}_{Month}) \) is the standard error of a stratified mean daily rate (harvest or discard) for a month.
- \( Var(\bar{R}_{Month}) \) is the variance of a stratified mean daily rate (harvest or discard) for a month. This term has been described in Equation 19.

### 2.6.6. Harvest and discard estimation for the boat-based and shore-based fisheries

The complemented survey designs used to assess the recreational fisheries used different on-site, contact methods to estimate effort and catch. Harvest and discard estimation in the boat-based fishery used interviews of completed trips, whereas the shore-based fishery used interviews of incomplete trips. The text in this section provides a detailed explanation of harvest estimation and the calculation of variances and standard errors. The same logic and general equations are also applied in the estimation of discard and its associated estimates of precision.

**Step 1** - Daily harvest calculations are made for each survey day within each day-type stratum in a month. These daily harvest calculations are done because effort counts were done on the same days as interviews with recreational fishing parties.

\[ \hat{H}_i = \hat{e}_i \times \hat{R}_i \]  

(Equation 21)

where:
- \( \hat{H}_i \) is an estimate of harvest for the \( i \) th sample day. The base level of estimation was for each day-type stratum within a month. Harvest units are either numbers of fish, or the weight of fish.
- \( \hat{e}_i \) is an estimate of fishing effort for the \( i \) th sample day. Units are in boat hours for the boat-based fishery and in fisher hours for the shore-based fishery.
- \( \hat{R}_i \) is an estimate of harvest rate for the \( i \) th sample day. The \( \hat{R}_{1(i)} \) estimator (see Equation 14) is used for the boat-based fishery and units are either numbers of fish per boat hour, or the weight of fish per boat hour. The \( \hat{R}_{2(i)} \) estimator (see Equation 16) is used for the shore-based fishery and units are either numbers of fish per fisher hour, or the weight of fish per fisher hour.

**Step 2** - These daily harvest estimates were then expanded for each day-type stratum within each month. This was done by multiplying the number of possible sample days in each base level stratum with the mean of the daily estimates of harvest.

\[ \bar{H}_j = \frac{\sum \hat{H}_{ij}}{n_j} \]  

(Equation 22)

where:
- \( \bar{H}_j \) is the estimated mean daily harvest for the \( j \) th day-type stratum within a month, in units of numbers of fish per day or weight of fish per day.
\( \hat{H}_{ij} \) is the estimate of harvest for the \( i \)th sample day in the \( j \)th day-type stratum within a month.

\( n_j \) is the number of days sampled in the \( j \)th day-type stratum within a month.

\[
\hat{H}_j = N_j \times \overline{H}_j \quad (\text{Equation 23})
\]

where:

\( \hat{H}_j \) is the estimate of harvest for the \( j \)th day-type stratum within a month, in units of numbers of fish or weight of fish.

See Basic notation and Equation 22 for definitions of the other terms.

Step 3 - Calculate the precision of the harvest estimates for each day-type stratum in a month. This is done for each fishery by estimating variances and standard errors for each stratum.

\[
\text{Var}(\overline{H}_j) = \frac{s_j^2}{n_j} \quad (\text{Equation 24})
\]

where:

\( \text{Var}(\overline{H}_j) \) is the estimated variance of the mean daily harvest for the \( j \)th day-type stratum within a month. This is calculated separately for each fishery.

\( s_j^2 \) is the sample variance of the daily estimates of harvest for the \( j \)th day-type stratum within a month.

\( n_j \) is the sample size as described in Equation 2.

\[
\text{SE}(\overline{H}_j) = \sqrt{\text{Var}(\overline{H}_j)} \quad (\text{Equation 25})
\]

where:

\( \text{SE}(\overline{H}_j) \) is the estimated standard error of the mean daily harvest.

\( \text{Var}(\overline{H}_j) \) is the estimated variance of the mean daily harvest as described in Equation 24.

\[
\text{Var}(\hat{H}_j) = N_j^2 \times \text{Var}(\overline{H}_j) \quad (\text{Equation 26})
\]

where:

\( \text{Var}(\hat{H}_j) \) is the estimated variance of total harvest for a stratum, and is calculated separately for each day-type within each month for each fishery.

See Basic notation and Equation 24 for definitions of the other terms.

\[
\text{SE}(\hat{H}_j) = \sqrt{\text{Var}(\hat{H}_j)} \quad (\text{Equation 27})
\]

where:

\( \text{SE}(\hat{H}_j) \) is the estimated standard error of total harvest for a stratum.

\( \text{Var}(\hat{H}_j) \) is the estimated variance of total harvest for a stratum as described in Equation 26.
We did not attempt to make expanded estimates of harvest for any taxa that were considered to have been “rare” throughout the survey period - defined as any taxon that had been recorded from three or less interviews during the survey period, regardless of the number of individuals harvested in those trips. This definition of rarity was applied separately to the boat-based and shore-based fisheries. All taxa which did not meet the criterion for rarity were classified as common taxa and expanded estimates of harvest were made for these taxa.

Survey personnel had, where possible, measured all identified fish, crabs and cephalopods that were seen during interviews with fishing parties. It was not always possible to obtain measurements, usually because fishers were in a hurry to leave the ramp. Thus, during many interviews, survey personnel were only able to collect measurements for a sub-sample of the entire harvest, or were only able to record counts of identified fish, crabs and cephalopods.

We did not measure the weight of fish during interviews but converted the length measurements into weights using length to weight conversion keys. This was done for all taxa for which we had suitable length to weight conversion keys (Appendix 3). The remaining unmeasured component of the harvest (i.e. those fish seen during interviews but only counted) were assigned the median weight for that taxon as calculated from the pooled interview data. We used a median weight rather than a mean weight (as is traditionally done in angler surveys) because many of the estimated weight frequency distributions were highly skewed, making the median a better estimate of the centre of the population (Sokal and Rohlf 1969). In some cases, the use of a mean would have resulted in higher estimates of harvest. We calculated medians separately for the boat-based and shore-based fisheries. When no measurements had been made for a taxon in a particular fishery (e.g. the boat fishery), we used the available measurements from the other fishery (e.g. the shore fishery). In some cases, measurements were not available for some taxa and so we could not estimate weights.

Harvest estimates for the weekday and weekend day strata were combined to give monthly totals. A description of the equations used for estimating stratum totals, variances and standard errors is provided for effort estimation. The general form of the equations used in the estimation of effort and the associated variances and standard errors has been used for harvest estimation.

2.7. Comparisons with other recreational fishing studies done in NSW

Fisheries managers and the general public have a reasonable expectation that meaningful comparisons should be made between the current study and previous work done on other estuarine recreational fisheries in NSW. We have compared harvest rate data collected during: (a) this survey (monthly estimates for boat and shore fisheries); (b) a concurrent recreational fishing survey in the lower Richmond River (monthly estimates for shore and boat fisheries); (c) a survey of recreational fishing in Lake Macquarie done during 1999/2000 (seasonal estimates for boat and shore fisheries); and (d) a survey of boat-based recreational fishing in Tuross Lake done during 1999/2000 (seasonal estimates for the boat fishery only). The different survey designs used during these four surveys has precluded more detailed comparisons.

A five month recreational fishing survey was done in the lower Macleay River during March to July 1990 (NSW Fisheries unpublished data). Unfortunately, the different seasonal timing and the much smaller spatial coverage of that survey allows only limited comparisons to be made between that study and the current survey. The previous survey excluded the Stuarts Point area, most of Clybucca Creek and Andersons Inlet and most of the navigable waters behind Shark Island (NSW Fisheries unpublished data). The limited data summaries from the 1990 survey are aggregated for the entire five month period of the survey and no measure of precision is given (NSW Fisheries unpublished data), thereby precluding any detailed comparison.
2.8. Quality assurance

A survey can be useless if the data collected are of poor quality (Yates 1965, Pollock et al. 1994). We incorporated important quality assessment and control procedures into all phases of the survey so that the highest possible level of data quality and integrity could be attained. A brief description of these procedures are provided below.

2.8.1. Survey preparation phase

2.8.1.1. Design and pre-testing of survey forms

We had previously used similar data collection forms and interview procedures in other recreational fishing surveys. A feature of the previous surveys was the extensive field testing of survey forms that was done to ensure clearly worded, unambiguous questions and the development of a simple survey protocol. The forms used in this current survey were based on the previously used form designs. The old data collection forms were simplified to meet the needs of the current survey. We pre-tested the new data collection forms to confirm the logic of the questions and their functionality by conducting a series of mock interviews with persons having no involvement in this project. This pre-testing step was useful for further improving the form designs and was completed prior to the start of staff training.

2.8.1.2. Training of survey personnel

There were 21 people involved in data collection during this survey. NSW Fisheries staff provided comprehensive training to all persons involved in the survey, which included detailed documentation of survey protocols, procedures and fish identification. All persons were provided with explanations of the aims of the survey and the importance of the information that was being collected. Field staff were provided with work rosters which specified survey dates and work times and all persons involved in interviewing recreational fishing parties were provided with clear instructions on standard interview procedures, protocols for recording data on the interview forms, and on the use of the fish identification kit. Additional training based on hypothetical examples likely to be encountered during the course of the survey was also provided to all interviewers. The importance of using a systematic sampling procedure to subsample recreational fishing parties during busy periods was stressed to all interviewers and strict instructions were given to them to not preferentially interview fishers known to them or parties that were known to be cooperative.

2.8.1.3. Field identification kit for fish, crabs and cephalopods

We developed a detailed field identification kit for fish and invertebrates that were likely to be caught by recreational fishers during the survey. This kit was used to standardise the level of taxonomic precision among interviewers working at different sites in the Macleay River. The use of the identification kit also facilitated the conduct of interviews and as such was an important part of the interview procedure.

2.8.1.4. Information leaflets

Information leaflets which stated the objectives of the study and provided a brief explanation of the need for collecting survey data were distributed by field staff. These leaflets generated much local interest and were useful for informing the general public about the importance of the survey work. The distribution of these information leaflets helped gain the support and cooperation of the local fishing community and thereby were critical in improving the integrity of the survey data.
2.8.2. Survey operation phase

2.8.2.1. Supervision of survey personnel

Random checks of survey personnel were carried out during the survey period to provide a cost-effective way of ensuring data quality. We also maintained regular contact with nominated group leaders by telephone. In this way we were able to provide a regular flow of information to all field staff.

2.8.2.2. Preliminary scrutiny of data collection forms

Preliminary checks of progressive count data sheets and interview forms were made as they were received and we identified any missing or unusual data, such as, large numbers of fishing boats in particular areas of the river, very large harvests, fish having very small or very large sizes, and the occurrence of uncommon species. The individuals that had collected the unusual data were then contacted and asked to confirm or explain them. This scrutiny helped to maintain high levels of data integrity by identifying and correcting data problems at the earliest possible time.

2.8.3. Data entry, checking and manipulation phase

2.8.3.1. Data entry and data checking procedures

Machine-readable data forms were designed and used during this project. After the initial vetting of the data forms, the sheets were scanned and the digital images of the forms were examined using Intelligent/Optical Character Recognition (ICR/OCR) software (Teleform Elite Version V - Cardiff software). A trained operator checked and either verified or corrected all data that were queried by the ICR/OCR data entry process. Random checks of data subsets were then done to validate the effectiveness of the data entry system. Prior to any analyses, the data were subjected to a wide range of data outlier checks to identify any unusual data and detect any reading or logic errors which had been missed during the preliminary checks.

2.8.3.2. Data manipulation procedures

We verified the correctness of the computations used to derive the estimates of harvest rates, discard rates, weights of fish, effort, harvest, discard and their associated measures of precision by undertaking random checks on some subsets of the data.
3. RESULTS

3.1. Recreational fishing effort

3.1.1. Whole fishery (boat and shore fisheries combined)

We estimated that approximately 78,800 fisher hours of daytime recreational effort was expended in the lower Macleay River during the survey period - July to October 2001 inclusive (Table 2). Most recreational fishing effort, approximately 29,600 fisher hours representing 37.5% of total effort, occurred in the Entrance area (Table 3). The Kemps Corner / Clybucca area received approximately 22,400 fisher hours representing 28.4% of the total effort (Table 4), while the Stuarts Point area received approximately 16,400 fisher hours representing 20.8% of the total effort (Table 5), and approximately 10,500 fisher hours of effort representing 13.3% of total effort were recorded for the Main River area (Table 6). The level of daytime recreational fishing effort showed a distinct monthly pattern (Table 2). The highest level of effort was found in July (approximately 26,900 fisher hours representing 34.1% of the total effort), while a similarly high level of effort was also recorded in August (approximately 23,900 fisher hours representing 30.3% of the total effort). The lowest levels of effort were recorded in September (approximately 12,800 fisher hours representing 16.3% of the total effort), and October (approximately 15,200 fisher hours representing 19.3% of the total effort). Tables 2 to 6 also provide estimates of daytime effort for each day-type stratum within each month.

Table 2. Estimates of daytime recreational fishing effort (fisher hours) for the four areas in the Macleay River (Main River, Entrance, Kemps Cnr / Clybucca and Stuarts Point) combined. Data are presented for all temporal strata and for the boat-based and shore-based fisheries.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Boat Effort (fisher hrs)</th>
<th>SE</th>
<th>Shore Effort (fisher hrs)</th>
<th>SE</th>
<th>Total Effort (fisher hrs)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>6,502 ± 1,027</td>
<td></td>
<td>11,422 ± 1,366</td>
<td></td>
<td>17,924 ± 1,709</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>3,758 ± 443</td>
<td></td>
<td>5,178 ± 562</td>
<td></td>
<td>8,936 ± 716</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>10,260 ± 1,118</td>
<td></td>
<td>16,600 ± 1,477</td>
<td></td>
<td>26,860 ± 1,853</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>4,854 ± 572</td>
<td></td>
<td>12,141 ± 1,476</td>
<td></td>
<td>16,995 ± 1,583</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>2,444 ± 358</td>
<td></td>
<td>4,487 ± 506</td>
<td></td>
<td>6,931 ± 620</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>7,298 ± 675</td>
<td></td>
<td>16,629 ± 1,561</td>
<td></td>
<td>23,927 ± 1,700</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>2,328 ± 554</td>
<td></td>
<td>3,792 ± 546</td>
<td></td>
<td>6,120 ± 778</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>3,096 ± 404</td>
<td></td>
<td>3,626 ± 499</td>
<td></td>
<td>6,722 ± 642</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5,424 ± 686</td>
<td></td>
<td>7,418 ± 740</td>
<td></td>
<td>12,842 ± 1,009</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>5,528 ± 897</td>
<td></td>
<td>4,964 ± 696</td>
<td></td>
<td>10,492 ± 1,136</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>2,898 ± 388</td>
<td></td>
<td>1,829 ± 236</td>
<td></td>
<td>4,727 ± 454</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8,426 ± 978</td>
<td></td>
<td>6,793 ± 735</td>
<td></td>
<td>15,219 ± 1,223</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>19,212 ± 1,579</td>
<td></td>
<td>32,320 ± 2,197</td>
<td></td>
<td>51,532 ± 2,706</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>12,196 ± 799</td>
<td></td>
<td>15,121 ± 936</td>
<td></td>
<td>27,317 ± 1,231</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>31,408 ± 1,770</td>
<td></td>
<td>47,440 ± 2,388</td>
<td></td>
<td>78,848 ± 2,973</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Estimates of daytime recreational fishing effort (fisher hours) for the Entrance area of the Macleay River. Data are presented for all temporal strata and for the boat-based and shore-based fisheries.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Boat Effort (fisher hrs)</th>
<th>Shore Effort (fisher hrs)</th>
<th>Total Effort (fisher hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>1,729 ± 454</td>
<td>6,329 ± 1,197</td>
<td>8,058 ± 1,280</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>786 ± 147</td>
<td>2,434 ± 395</td>
<td>3,220 ± 421</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2,515 ± 477</td>
<td>8,762 ± 1,260</td>
<td>11,277 ± 1,348</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>1,107 ± 287</td>
<td>5,912 ± 1,263</td>
<td>7,019 ± 1,295</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>514 ± 74</td>
<td>2,416 ± 399</td>
<td>2,930 ± 406</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,621 ± 297</td>
<td>8,329 ± 1,325</td>
<td>9,950 ± 1,357</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>238 ± 106</td>
<td>1,575 ± 364</td>
<td>1,813 ± 379</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>482 ± 102</td>
<td>1,799 ± 328</td>
<td>2,281 ± 343</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>720 ± 147</td>
<td>3,374 ± 490</td>
<td>4,094 ± 511</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>744 ± 230</td>
<td>2,612 ± 556</td>
<td>3,356 ± 602</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>365 ± 136</td>
<td>558 ± 63</td>
<td>923 ± 150</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,109 ± 268</td>
<td>3,170 ± 560</td>
<td>4,279 ± 620</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>3,818 ± 594</td>
<td>16,428 ± 1,863</td>
<td>20,246 ± 1,955</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>2,147 ± 236</td>
<td>7,207 ± 653</td>
<td>9,354 ± 695</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5,965 ± 639</td>
<td>23,634 ± 1,974</td>
<td>29,599 ± 2,075</td>
</tr>
</tbody>
</table>

Table 4. Estimates of daytime recreational fishing effort (fisher hours) for the Kemps Corner / Clybucca area of the Macleay River. Data are presented for all temporal strata and for the boat-based and shore-based fisheries.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Boat Effort (fisher hrs)</th>
<th>Shore Effort (fisher hrs)</th>
<th>Total Effort (fisher hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>2,317 ± 676</td>
<td>2,072 ± 302</td>
<td>4,389 ± 741</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,386 ± 319</td>
<td>731 ± 157</td>
<td>2,117 ± 356</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,703 ± 748</td>
<td>2,802 ± 341</td>
<td>6,505 ± 822</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>2,248 ± 436</td>
<td>3,167 ± 449</td>
<td>5,415 ± 625</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,000 ± 315</td>
<td>933 ± 258</td>
<td>1,933 ± 407</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,248 ± 537</td>
<td>4,100 ± 517</td>
<td>7,348 ± 746</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>749 ± 227</td>
<td>972 ± 292</td>
<td>1,721 ± 369</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,318 ± 304</td>
<td>593 ± 204</td>
<td>1,911 ± 366</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2,067 ± 379</td>
<td>1,565 ± 356</td>
<td>3,632 ± 520</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>2,712 ± 843</td>
<td>588 ± 176</td>
<td>3,300 ± 861</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,301 ± 265</td>
<td>298 ± 108</td>
<td>1,599 ± 286</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4,013 ± 884</td>
<td>887 ± 207</td>
<td>4,900 ± 908</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>8,026 ± 1,187</td>
<td>6,799 ± 639</td>
<td>14,825 ± 1,348</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>5,005 ± 603</td>
<td>2,555 ± 380</td>
<td>7,560 ± 713</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13,031 ± 1,331</td>
<td>9,354 ± 744</td>
<td>22,385 ± 1,525</td>
</tr>
</tbody>
</table>
Table 5. Estimates of daytime recreational fishing effort (fisher hours) for the Stuarts Point area of the Macleay River. Data are presented for all temporal strata and for the boat-based and shore-based fisheries.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Boat Effort (fisher hrs)</th>
<th>SE</th>
<th>Shore Effort (fisher hrs)</th>
<th>SE</th>
<th>Total Effort (fisher hrs)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>2,179 ± 617</td>
<td>1,368 ± 436</td>
<td>3,547 ± 755</td>
<td>2,258 ± 347</td>
<td>5,805 ± 831</td>
<td>1,368 ± 436</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,309 ± 250</td>
<td>949 ± 240</td>
<td>2,258 ± 347</td>
<td>1,045 ± 68</td>
<td>3,303 ± 417</td>
<td>1,045 ± 68</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,488 ± 665</td>
<td>2,317 ± 498</td>
<td>5,805 ± 831</td>
<td>3,208 ± 271</td>
<td>9,013 ± 1,120</td>
<td>3,208 ± 271</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>1,213 ± 230</td>
<td>950 ± 126</td>
<td>2,163 ± 262</td>
<td>1,464 ± 224</td>
<td>3,627 ± 346</td>
<td>1,464 ± 224</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>597 ± 49</td>
<td>448 ± 47</td>
<td>1,045 ± 68</td>
<td>544 ± 95</td>
<td>1,591 ± 243</td>
<td>544 ± 95</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,810 ± 236</td>
<td>1,398 ± 134</td>
<td>3,208 ± 271</td>
<td>2,011 ± 217</td>
<td>5,019 ± 565</td>
<td>2,011 ± 217</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>1,183 ± 480</td>
<td>583 ± 195</td>
<td>1,766 ± 519</td>
<td>1,464 ± 224</td>
<td>3,247 ± 414</td>
<td>1,464 ± 224</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>920 ± 203</td>
<td>544 ± 95</td>
<td>1,464 ± 224</td>
<td>1,464 ± 224</td>
<td>2,384 ± 328</td>
<td>1,464 ± 224</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2,103 ± 522</td>
<td>1,128 ± 217</td>
<td>3,208 ± 271</td>
<td>2,831 ± 366</td>
<td>5,039 ± 685</td>
<td>2,831 ± 366</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>1,860 ± 174</td>
<td>800 ± 267</td>
<td>2,660 ± 319</td>
<td>1,502 ± 263</td>
<td>4,162 ± 413</td>
<td>1,502 ± 263</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,050 ± 224</td>
<td>452 ± 138</td>
<td>1,502 ± 263</td>
<td>1,502 ± 263</td>
<td>2,552 ± 336</td>
<td>1,502 ± 263</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2,910 ± 283</td>
<td>1,252 ± 300</td>
<td>4,162 ± 413</td>
<td>3,004 ± 326</td>
<td>6,966 ± 649</td>
<td>3,004 ± 326</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>6,435 ± 833</td>
<td>3,702 ± 561</td>
<td>10,137 ± 1,005</td>
<td>6,095 ± 635</td>
<td>16,406 ± 1,120</td>
<td>6,095 ± 635</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>3,876 ± 395</td>
<td>2,393 ± 297</td>
<td>6,269 ± 494</td>
<td>1,120 ± 1,120</td>
<td>7,389 ± 976</td>
<td>1,120 ± 1,120</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>10,311 ± 922</td>
<td>6,095 ± 635</td>
<td>16,406 ± 1,120</td>
<td>7,215 ± 875</td>
<td>17,616 ± 1,241</td>
<td>7,215 ± 875</td>
</tr>
</tbody>
</table>

Table 6. Estimates of daytime recreational fishing effort (fisher hours) for the Main River area of the Macleay River. Data are presented for all temporal strata and for the boat-based and shore-based fisheries.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Boat Effort (fisher hrs)</th>
<th>SE</th>
<th>Shore Effort (fisher hrs)</th>
<th>SE</th>
<th>Total Effort (fisher hrs)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>277 ± 103</td>
<td>1,653 ± 389</td>
<td>1,930 ± 403</td>
<td>1,930 ± 403</td>
<td>3,783 ± 706</td>
<td>1,930 ± 403</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>277 ± 101</td>
<td>1,065 ± 279</td>
<td>1,342 ± 297</td>
<td>1,342 ± 297</td>
<td>2,687 ± 594</td>
<td>1,342 ± 297</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>554 ± 145</td>
<td>2,719 ± 479</td>
<td>3,273 ± 500</td>
<td>3,273 ± 500</td>
<td>6,027 ± 1,000</td>
<td>3,273 ± 500</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>286 ± 46</td>
<td>2,112 ± 606</td>
<td>2,398 ± 608</td>
<td>2,398 ± 608</td>
<td>4,596 ± 1,216</td>
<td>2,398 ± 608</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>333 ± 145</td>
<td>690 ± 167</td>
<td>1,023 ± 221</td>
<td>1,023 ± 221</td>
<td>1,956 ± 342</td>
<td>1,023 ± 221</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>619 ± 152</td>
<td>2,802 ± 629</td>
<td>3,421 ± 647</td>
<td>3,421 ± 647</td>
<td>6,240 ± 1,289</td>
<td>3,421 ± 647</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>158 ± 117</td>
<td>661 ± 208</td>
<td>819 ± 239</td>
<td>819 ± 239</td>
<td>1,038 ± 358</td>
<td>819 ± 239</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>376 ± 138</td>
<td>690 ± 301</td>
<td>1,066 ± 331</td>
<td>1,066 ± 331</td>
<td>1,442 ± 462</td>
<td>1,066 ± 331</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>534 ± 181</td>
<td>1,351 ± 366</td>
<td>1,885 ± 408</td>
<td>1,885 ± 408</td>
<td>3,219 ± 870</td>
<td>1,885 ± 408</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>212 ± 107</td>
<td>965 ± 269</td>
<td>1,177 ± 289</td>
<td>1,177 ± 289</td>
<td>2,344 ± 578</td>
<td>1,177 ± 289</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>182 ± 110</td>
<td>520 ± 145</td>
<td>702 ± 182</td>
<td>702 ± 182</td>
<td>2,526 ± 470</td>
<td>702 ± 182</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>394 ± 153</td>
<td>1,484 ± 306</td>
<td>1,878 ± 342</td>
<td>1,878 ± 342</td>
<td>5,362 ± 990</td>
<td>1,878 ± 342</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>933 ± 195</td>
<td>5,391 ± 797</td>
<td>6,324 ± 820</td>
<td>6,324 ± 820</td>
<td>15,715 ± 1,640</td>
<td>6,324 ± 820</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,168 ± 250</td>
<td>2,966 ± 466</td>
<td>4,134 ± 529</td>
<td>4,134 ± 529</td>
<td>15,715 ± 1,640</td>
<td>4,134 ± 529</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2,101 ± 317</td>
<td>8,356 ± 923</td>
<td>10,457 ± 976</td>
<td>10,457 ± 976</td>
<td>21,568 ± 2,264</td>
<td>10,457 ± 976</td>
</tr>
</tbody>
</table>
3.1.2. **Boat-based fishery**

We estimated that approximately 31,400 fisher hours of daytime recreational boat-based effort was expended in the lower Macleay River during the survey period - July to October 2001 inclusive (Table 2). This represented 39.8% of the effort for the total fishery (boat and shore combined). The highest amounts of boat-based effort were recorded from the Kemps Corner / Clybucca area (approximately 13,000 fisher hours representing 41.5% of the boat-based effort - Table 4) and the Stuarts Point area (approximately 10,300 fisher hours representing 32.8% of the boat-based effort - Table 5), while relatively low levels of boat-based effort were recorded from the Entrance area (approximately 5,965 fisher hours representing 19.0% of the boat-based effort - Table 3) and the Main River area (approximately 2,100 fisher hours representing 6.7% of the boat-based effort - Table 6). The level of daytime boat-based fishing effort showed a distinct monthly pattern (Table 2). The highest level of effort was found in July (approximately 10,300 fisher hours representing 32.7% of the total boat effort). Intermediate levels of effort were recorded in August (approximately 7,300 fisher hours representing 23.2% of the total boat effort) and October (approximately 8,400 fisher hours representing 26.8% of the total boat effort), while the lowest level of effort was recorded in September (approximately 5,400 fisher hours representing 17.3% of the total boat effort). Tables 2 to 6 also provide estimates of daytime boat-based effort for each day-type stratum within each month. Supplementary daytime effort information for the boat-based fishery is provided in units of boat hours, the original units used to in the calculations of boat-based effort and harvest (see Appendix 4).

3.1.3. **Shore-based fishery**

We estimated that approximately 47,400 fisher hours of daytime recreational shore-based effort was expended in the lower Macleay River during the survey period - July to October 2001 inclusive (Table 2). This represented 60.2% of the effort for the total fishery (boat and shore combined). The highest amount of shore-based effort was recorded from the Entrance area - approximately 23,600 fisher hours representing 49.8% of the shore-based effort (Table 3). Substantially lower levels of shore-based effort were recorded from the Kemps Corner / Clybucca area (approximately 9,400 fisher hours representing 19.7% of the shore-based effort - Table 4), the Main River area (approximately 8,400 fisher hours representing 17.6% of the shore-based effort - Table 6) and the Stuarts Point area (approximately 6,100 fisher hours representing 12.8% of the shore-based effort - Table 5). The level of daytime shore-based fishing effort showed a distinct monthly pattern (Table 2). The highest levels of effort were found in July (approximately 16,600 fisher hours representing 35.0% of the total shore effort) and August (approximately 16,600 fisher hours representing 35.1% of the total shore effort), while much lower levels of effort were recorded in September (approximately 7,400 fisher hours representing 15.6% of the total shore effort), and October (approximately 6,800 fisher hours representing 14.3% of the total shore effort). Tables 2 to 6 also provide estimates of daytime shore-based effort for each day-type stratum within each month.
3.2. Demography of the fishing population

The populations of boat-based and shore-based fishers were dominated by males (Table 7). Over the survey period, we found that 82.0% of the boat-based fishers that had been interviewed were males. Similarly, we found that 79.0% of the shore-based fishers that had been interviewed were males. There was an apparent increase in the proportion of female fishers during the final two months (September and October) of the survey period in the boat-based fishery, and the final three months (August, September and October) of the survey period in the shore-based fishery (Table 7). In the shore-based fishery a consistent pattern was evident when comparing the sex-based composition of the fishing populations between day-type strata. A higher proportion of female fishers were observed in the fishing population on weekend days. A similar pattern was found in the boat-based fishery except for the month of October during which the proportion of female fishers observed during weekend days was slightly lower than the proportion of female fishers recorded during weekdays (Table 7).

Over the survey period, we found that around half of the fishers in the shore-based fishery (51.3%) were of local origin (Table 8). In contrast, slightly less than half of the boat-based fishers (42.8%) were of local origin (Table 8). The proportion of visiting fishers in the boat-based fishing population ranged between 52.4% and 65.0% on a monthly basis (Table 8). In the boat fishery, the lowest proportion of visiting fishers was recorded during August and the highest proportion of visiting fishers was recorded during October (Table 8). The proportion of visiting fishers in the shore-based fishing population ranged between 45.7% and 62.6% on a monthly basis (Table 8). In the shore fishery, the highest proportion of visiting fishers was recorded during October, while the proportions recorded during the three preceding months were similar (Table 8).
Table 7. Numbers and percentages of male and female fishers for the boat and shore recreational fisheries in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>BOAT FISHERY</th>
<th></th>
<th>SHORE FISHERY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. Male</td>
<td>% Male</td>
<td>No. Female</td>
<td>% Female</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>217</td>
<td>87.9</td>
<td>30</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>293</td>
<td>81.6</td>
<td>66</td>
<td>18.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>510</td>
<td>84.2</td>
<td>96</td>
<td>15.8</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>141</td>
<td>85.5</td>
<td>24</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>277</td>
<td>83.7</td>
<td>54</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>418</td>
<td>84.3</td>
<td>78</td>
<td>15.7</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>105</td>
<td>82.0</td>
<td>23</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>202</td>
<td>78.9</td>
<td>54</td>
<td>21.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>307</td>
<td>79.9</td>
<td>77</td>
<td>20.1</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>146</td>
<td>75.6</td>
<td>47</td>
<td>24.4</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>157</td>
<td>79.7</td>
<td>40</td>
<td>20.3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>303</td>
<td>77.7</td>
<td>87</td>
<td>22.3</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>609</td>
<td>83.1</td>
<td>124</td>
<td>16.9</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>929</td>
<td>81.3</td>
<td>214</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,538</td>
<td>82.0</td>
<td>338</td>
<td>18.0</td>
</tr>
</tbody>
</table>
Table 8. Numbers and percentages of local and visiting fishers for the boat and shore recreational fisheries in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>BOAT FISHERY</th>
<th></th>
<th></th>
<th>SHORE FISHERY</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. Local</td>
<td>% Local</td>
<td>No. Visitors</td>
<td>% Visitor</td>
<td>No. Local</td>
<td>% Local</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>97</td>
<td>39.6</td>
<td>148</td>
<td>60.4</td>
<td>185</td>
<td>45.6</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>174</td>
<td>48.9</td>
<td>182</td>
<td>51.1</td>
<td>411</td>
<td>59.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>271</td>
<td>45.1</td>
<td>330</td>
<td>54.9</td>
<td>596</td>
<td>54.0</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>60</td>
<td>36.1</td>
<td>106</td>
<td>63.9</td>
<td>88</td>
<td>40.9</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>177</td>
<td>53.3</td>
<td>155</td>
<td>46.7</td>
<td>228</td>
<td>58.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>237</td>
<td>47.6</td>
<td>261</td>
<td>52.4</td>
<td>316</td>
<td>52.5</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>39</td>
<td>30.2</td>
<td>90</td>
<td>69.8</td>
<td>48</td>
<td>44.9</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>116</td>
<td>46.2</td>
<td>135</td>
<td>53.8</td>
<td>110</td>
<td>59.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>155</td>
<td>40.8</td>
<td>225</td>
<td>59.2</td>
<td>158</td>
<td>54.3</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>48</td>
<td>24.9</td>
<td>145</td>
<td>75.1</td>
<td>58</td>
<td>29.4</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>89</td>
<td>44.9</td>
<td>109</td>
<td>55.1</td>
<td>67</td>
<td>48.9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>137</td>
<td>35.0</td>
<td>254</td>
<td>65.0</td>
<td>125</td>
<td>37.4</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>244</td>
<td>33.3</td>
<td>489</td>
<td>66.7</td>
<td>379</td>
<td>41.0</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>556</td>
<td>48.9</td>
<td>581</td>
<td>51.1</td>
<td>816</td>
<td>58.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>800</td>
<td>42.8</td>
<td>1,070</td>
<td>57.2</td>
<td>1,195</td>
<td>51.3</td>
</tr>
</tbody>
</table>
3.3. Targeting preferences

The main targeting preferences nominated by boat-based fishing parties over the survey period were grouped into 8 categories (Table 9). Fishing parties nominating “luderick” as their main target were ranked highest overall during the survey period (Table 9). Many boat-based fishing parties indicated that they did not have any specific target preference, with fishing parties nominating “anything” as their main target ranked second during the survey period (Table 9). Flathead, bream and mulloway were other popular main targets of boat-based fishing parties. Fishing parties that had nominated any of these five main target categories, including the generalist category “anything”, made up 99.1% of the boat-based fishing population during the survey period (Table 9). Whiting, tailor and crabs were also nominated as main target categories by boat-based fishing parties. These three target categories accounted for 0.9% of the boat-based fishing population during the survey period (Table 9). Some monthly trends in the targeting preferences of boat-based fishing parties were evident. There was a steady, yet substantial decrease in the proportion of fishing parties targeting “luderick” during the course of the survey (Table 9). In contrast, the proportion of generalist fishing parties in the boat fishery was lowest in July, the month in which the fishery was re-opened, with relatively higher proportions recorded during the other months, the highest being recorded in September (Table 9). There was an increase in the proportion of fishing parties targeting “flathead” during the course of the survey period, with by far the highest being recorded in October (Table 9). The proportion of fishing parties targeting “bream” were highest during July, while relatively lower proportions of “bream” targeting were recorded during August, September and October (Table 9). The proportion of boat-based fishing parties targeting “mulloway” were relatively low throughout the survey period (Table 9).

The main targeting preferences nominated by shore-based fishing parties over the survey period were grouped into 11 target categories (Table 10). A large proportion of shore-based fishing parties indicated that they did not have any specific target preference. Fishing parties nominating “bream” as their main target were ranked highest overall during the survey period (Table 10). Many shore-based fishing parties indicated that they did not have any specific target preference, with fishing parties nominating “anything” as their main target ranked second during the survey period (Table 10). Luderick, flathead and mulloway were other popular main targets of shore-based fishing parties. Fishing parties that had nominated any of these five main target categories, including the generalist category “anything”, made up 99.0% of the shore-based fishing population during the survey period (Table 10). Mullet, whiting, tailor, garfish, seapike and tarwhine were also nominated as main target categories by shore-based fishing parties. These six target categories accounted for 1.0% of the shore-based fishing population during the survey period (Table 10). Some monthly trends in the targeting preferences of shore-based fishing parties were evident. There was a steady decrease in the proportion of fishing parties targeting “bream” during the survey period (Table 10). In contrast, the proportion of generalist fishing parties in the shore fishery was lowest in July, steadily increasing during the course of the survey period (Table 10). The proportion of shore-based fishing parties targeting “luderick” were relatively high during July and August, with a marked decline in the proportion of “luderick” targeting recorded during September and October (Table 10). The proportion of fishing parties targeting “flathead” showed the opposite, with the lowest proportions recorded during July and August, while the highest proportions were recorded during September and October (Table 10). The proportions of shore-based fishing parties targeting “mulloway” were highest in July and October, and very low in August and September (Table 10).
### Table 9. Main target categories nominated by boat-based fishing parties in the Macleay River fishery during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Boat-Based Target Category</th>
<th>July 2001 No. %</th>
<th>August 2001 No. %</th>
<th>September 2001 No. %</th>
<th>October 2001 No. %</th>
<th>Total No. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luderick</td>
<td>171 54.1</td>
<td>115 42.8</td>
<td>42 23.2</td>
<td>11 6.5</td>
<td>339 36.3</td>
</tr>
<tr>
<td>Anything</td>
<td>31 9.8</td>
<td>57 21.2</td>
<td>74 40.9</td>
<td>56 33.3</td>
<td>218 23.3</td>
</tr>
<tr>
<td>Flathead</td>
<td>40 12.7</td>
<td>52 19.3</td>
<td>36 19.9</td>
<td>68 40.5</td>
<td>196 21.0</td>
</tr>
<tr>
<td>Bream</td>
<td>64 20.3</td>
<td>39 14.5</td>
<td>25 13.8</td>
<td>24 14.3</td>
<td>152 16.3</td>
</tr>
<tr>
<td>Mulloway</td>
<td>9 2.8</td>
<td>6 2.2</td>
<td>2 1.1</td>
<td>4 2.4</td>
<td>21 2.2</td>
</tr>
<tr>
<td>Whiting</td>
<td>1 0.3</td>
<td>-</td>
<td>2 1.1</td>
<td>1 0.6</td>
<td>5 0.5</td>
</tr>
<tr>
<td>Tailor</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2 1.2</td>
<td>2 0.2</td>
</tr>
<tr>
<td>Crabs</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>316</strong></td>
<td><strong>269</strong></td>
<td><strong>181</strong></td>
<td><strong>168</strong></td>
<td><strong>934</strong></td>
</tr>
</tbody>
</table>

### Table 10. Main target categories nominated by shore-based fishing parties in the Macleay River fishery during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Shore-Based Target Category</th>
<th>July 2001 No. %</th>
<th>August 2001 No. %</th>
<th>September 2001 No. %</th>
<th>October 2001 No. %</th>
<th>Total No. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bream</td>
<td>269 43.7</td>
<td>137 38.9</td>
<td>60 35.5</td>
<td>34 19.3</td>
<td>500 38.1</td>
</tr>
<tr>
<td>Anything</td>
<td>133 21.6</td>
<td>111 31.5</td>
<td>73 43.2</td>
<td>105 59.7</td>
<td>422 32.1</td>
</tr>
<tr>
<td>Luderick</td>
<td>170 27.6</td>
<td>85 24.1</td>
<td>15 8.9</td>
<td>4 2.3</td>
<td>274 20.9</td>
</tr>
<tr>
<td>Flathead</td>
<td>13 2.1</td>
<td>10 2.8</td>
<td>17 10.1</td>
<td>19 10.8</td>
<td>59 4.5</td>
</tr>
<tr>
<td>Mulloway</td>
<td>28 4.5</td>
<td>6 1.7</td>
<td>3 1.8</td>
<td>8 4.5</td>
<td>45 3.4</td>
</tr>
<tr>
<td>Mullet</td>
<td>-</td>
<td>1 0.3</td>
<td>1 0.6</td>
<td>2 1.1</td>
<td>4 0.3</td>
</tr>
<tr>
<td>Whiting</td>
<td>1 0.2</td>
<td>-</td>
<td>-</td>
<td>3 1.7</td>
<td>4 0.3</td>
</tr>
<tr>
<td>Tailor</td>
<td>2 0.3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2 0.2</td>
</tr>
<tr>
<td>Garfish</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 0.6</td>
<td>1 0.1</td>
</tr>
<tr>
<td>Striped seapike</td>
<td>-</td>
<td>1 0.3</td>
<td>-</td>
<td>-</td>
<td>1 0.1</td>
</tr>
<tr>
<td>Tarwhine</td>
<td>-</td>
<td>1 0.3</td>
<td>-</td>
<td>-</td>
<td>1 0.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>616</strong></td>
<td><strong>352</strong></td>
<td><strong>169</strong></td>
<td><strong>176</strong></td>
<td><strong>1,313</strong></td>
</tr>
</tbody>
</table>

### 3.4. Indicators of recreational fishing quality

An assessment of a recreational fishery can be improved if reliable indicators of fishing quality are available. We present four indicators of recreational fishing quality for the boat-based and shore-based fisheries in the lower Macleay River. These are: (1) the proportion of unsuccessful fishing parties; (2) recreational harvest rates; (3) recreational discard rates; and (4) the size-frequency distributions for some important taxa harvested by the recreational sector.

#### 3.4.1. Proportion of unsuccessful fishing parties

We found that quite a high proportion of boat-based fishing parties were unsuccessful during their fishing trips. That is, these fishing parties failed to catch any fish, crab or cephalopods that they regarded as being worthy of keeping. The proportion of unsuccessful boat-based fishing parties ranged from approximately 22% to 51% on a monthly basis (Fig. 2). The proportion of unsuccessful boat-based fishing parties was approximately 36% over the entire survey period. The proportion of unsuccessful boat-based fishing parties was lowest during July, higher in August and the highest proportions were recorded during September and October (Fig. 2).
Shore-based fishing parties were less successful than boat-based parties. The proportion of unsuccessful shore-based fishing parties ranged from approximately 54% to 74% on a monthly basis (Fig. 2). The proportion of unsuccessful shore-based fishing parties was approximately 61% over the entire survey period. The proportion of unsuccessful shore-based fishing parties was lowest during July, higher in August and the highest proportions were recorded during September and October (Fig. 2).

![Figure 2](image.png)

**Figure 2.** The proportion of unsuccessful boat-based and shore-based fishing parties ($\pm 95\%$ C.I.) for each month of the survey period (July 1 - October 31, 2001). Sample sizes are presented in Table 1.

### 3.4.2. Recreational harvest rates

The harvest rates reported in this document are based on calculations made using total fishing effort (non-directed effort) for a stratum. We present harvest rates for six important species. The harvest rate information is presented separately for the boat-based and shore-based fisheries, for each day-type stratum and for each month. In this way, temporal trends within the whole fishery can be examined. We also provide supplementary harvest rate information for the boat-based fishery in units of number of fish per boat hour (see Appendices 2.1 to 2.6). These appendices report the harvest rates for the boat-based fishery in the original units that were used in the calculations of boat-based effort and harvest, and are useful for other workers that may want to make comparisons between boat-based fisheries from other locations and/or survey periods.
3.4.2.1. Yellowfin bream

Bream were an important component of the harvest for both boat-based and shore-based fishing parties. The highest harvest rates for bream taken by boat-based fishers were recorded during July (Table 11). A decline in bream harvest rates in the boat fishery was observed throughout the remainder of the survey (Table 11). Similarly, bream harvest rates in the shore fishery were highest during July and there was a steady decline in harvest rate recorded during the next three months (Table 11). The bream harvest rates were generally higher in the shore-based fishery than in the boat-based fishery (Table 11).

Table 11. Recreational harvest rate and discard rate estimates (fish per fisher hour ± standard error) for Yellowfin bream (*Acanthopagrus australis*) taken by (a) boat-based fishers, and (b) shore-based fishers, in the Macleay River during the survey period (July 1 - October 31, 2001).

### a. BOAT FISHERY

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.080 ± 0.029</td>
<td></td>
<td>0.157 ± 0.045</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.136 ± 0.038</td>
<td></td>
<td>0.271 ± 0.075</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.096 ± 0.023</td>
<td>0.190 ± 0.039</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.088 ± 0.039</td>
<td></td>
<td>0.143 ± 0.050</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.073 ± 0.014</td>
<td></td>
<td>0.229 ± 0.066</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.084 ± 0.029</td>
<td>0.165 ± 0.041</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.014 ± 0.010</td>
<td></td>
<td>0.102 ± 0.028</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.059 ± 0.013</td>
<td></td>
<td>0.117 ± 0.022</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.029 ± 0.008</td>
<td>0.107 ± 0.020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.031 ± 0.014</td>
<td></td>
<td>0.172 ± 0.014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.010 ± 0.005</td>
<td></td>
<td>0.227 ± 0.046</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.025 ± 0.010</td>
<td>0.188 ± 0.017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### b. SHORE FISHERY

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.168 ± 0.013</td>
<td></td>
<td>0.495 ± 0.074</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.229 ± 0.018</td>
<td></td>
<td>0.529 ± 0.110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.186 ± 0.011</td>
<td>0.505 ± 0.061</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.153 ± 0.035</td>
<td></td>
<td>0.274 ± 0.100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.150 ± 0.029</td>
<td></td>
<td>0.270 ± 0.065</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.152 ± 0.027</td>
<td>0.273 ± 0.076</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.106 ± 0.014</td>
<td></td>
<td>0.296 ± 0.052</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.154 ± 0.045</td>
<td></td>
<td>0.362 ± 0.052</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.122 ± 0.018</td>
<td>0.318 ± 0.039</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.090 ± 0.027</td>
<td></td>
<td>0.320 ± 0.073</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.089 ± 0.045</td>
<td></td>
<td>0.313 ± 0.089</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.090 ± 0.023</td>
<td>0.318 ± 0.058</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.2. **Luderick**

High harvest rates of luderick were achieved in both the shore and boat fisheries during the first two months of the survey period with particularly high harvest rates recorded in the boat-based fishery during July (Table 12). The high harvest rates for luderick in July and August were followed by a marked decline in harvest rates during September and October. This trend was the same for both the boat and shore fisheries (Table 12).

**Table 12.** Recreational harvest rate and discard rate estimates (fish per fisher hour ± standard error) for Luderick (*Girella tricuspidata*) taken by (a) boat-based fishers, and (b) shore-based fishers, in the Macleay River during the survey period (July 1 - October 31, 2001).

a. **BOAT FISHERY**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>1.081 ± 0.137</td>
<td></td>
<td>0.170 ± 0.050</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.709 ± 0.140</td>
<td></td>
<td>0.160 ± 0.055</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.973 ± 0.106</td>
<td></td>
<td>0.167 ± 0.039</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.575 ± 0.144</td>
<td></td>
<td>0.062 ± 0.020</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.545 ± 0.102</td>
<td></td>
<td>0.058 ± 0.021</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.567 ± 0.110</td>
<td></td>
<td>0.061 ± 0.015</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.187 ± 0.048</td>
<td></td>
<td>0.017 ± 0.008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.255 ± 0.049</td>
<td></td>
<td>0.032 ± 0.016</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.210 ± 0.049</td>
<td></td>
<td>0.022 ± 0.007</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.066 ± 0.038</td>
<td></td>
<td>0.003 ± 0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.092 ± 0.037</td>
<td></td>
<td>0.026 ± 0.022</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.074 ± 0.029</td>
<td></td>
<td>0.009 ± 0.006</td>
<td></td>
</tr>
</tbody>
</table>

b. **SHORE FISHERY**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.350 ± 0.050</td>
<td></td>
<td>0.108 ± 0.036</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.352 ± 0.103</td>
<td></td>
<td>0.131 ± 0.030</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.350 ± 0.046</td>
<td></td>
<td>0.118 ± 0.027</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.526 ± 0.175</td>
<td></td>
<td>0.037 ± 0.034</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.159 ± 0.069</td>
<td></td>
<td>0.048 ± 0.035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.431 ± 0.131</td>
<td></td>
<td>0.040 ± 0.027</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.008 ± 0.006</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.071 ± 0.038</td>
<td></td>
<td>0.091 ± 0.073</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.029 ± 0.013</td>
<td></td>
<td>0.030 ± 0.024</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.037 ± 0.027</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td>0.020 ± 0.020</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.026 ± 0.019</td>
<td></td>
<td>0.006 ± 0.006</td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.3. **Dusky flathead**

Dusky flathead harvest rates in the boat fishery showed no apparent trend in the first three months of the survey, while the harvest rate increased substantially during October (Table 13). The highest harvest rate for dusky flathead in the shore fishery was recorded during September, with lower harvest rates being recorded in the other three months of the survey period (Table 13).

**Table 13.** Recreational harvest rate and discard rate estimates (fish per fisher hour ± standard error) for Dusky flathead (*Platycephalus fuscus*) taken by (a) boat-based fishers, and (b) shore-based fishers, in the Macleay River during the survey period (July 1 - October 31, 2001).

### a. BOAT FISHERY

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.053 ± 0.030</td>
<td>0.050 ± 0.019</td>
<td>0.019</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.039 ± 0.010</td>
<td>0.057 ± 0.013</td>
<td>0.013</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.049 ± 0.022</strong></td>
<td><strong>0.052 ± 0.014</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.036 ± 0.014</td>
<td>0.084 ± 0.018</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.061 ± 0.012</td>
<td>0.084 ± 0.033</td>
<td>0.033</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.042 ± 0.011</strong></td>
<td><strong>0.084 ± 0.016</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.045 ± 0.019</td>
<td>0.071 ± 0.022</td>
<td>0.022</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.066 ± 0.015</td>
<td>0.093 ± 0.011</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.052 ± 0.014</strong></td>
<td><strong>0.078 ± 0.015</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.117 ± 0.035</td>
<td>0.134 ± 0.064</td>
<td>0.064</td>
<td>0.064</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.119 ± 0.022</td>
<td>0.108 ± 0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.118 ± 0.026</strong></td>
<td><strong>0.126 ± 0.046</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### b. SHORE FISHERY

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.029 ± 0.006</td>
<td>0.013 ± 0.006</td>
<td>0.006</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.020 ± 0.010</td>
<td>0.021 ± 0.011</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.026 ± 0.005</strong></td>
<td><strong>0.016 ± 0.005</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.017 ± 0.008</td>
<td>0.001 ± 0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.034 ± 0.012</td>
<td>0.002 ± 0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.022 ± 0.007</strong></td>
<td><strong>0.001 ± 0.001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.053 ± 0.020</td>
<td>0.048 ± 0.036</td>
<td>0.036</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.079 ± 0.035</td>
<td>0.027 ± 0.018</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.062 ± 0.018</strong></td>
<td><strong>0.041 ± 0.025</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.014 ± 0.006</td>
<td>0.040 ± 0.018</td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.051 ± 0.024</td>
<td>0.070 ± 0.032</td>
<td>0.032</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.025 ± 0.008</strong></td>
<td><strong>0.048 ± 0.016</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.4.  **Sand whiting**

Relatively few sand whiting were taken by boat-based fishers during the survey period and accordingly the harvest rates recorded were relatively low (Table 14). There was no apparent monthly trend in these harvest rate data for the boat fishery. The harvest rates for the shore fishery were very low during July, while no sand whiting were recorded in the harvest of boat-based fishers during August and September (Table 14). Interestingly, the sand whiting harvest rate recorded in the shore fishery during October was markedly higher (Table 14).

**Table 14.**  Recreational harvest rate and discard rate estimates (fish per fisher hour ± standard error) for Sand whiting (*Sillago ciliata*) taken by (a) boat-based fishers, and (b) shore-based fishers, in the Macleay River during the survey period (July 1 - October 31, 2001).

**a. BOAT FISHERY**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.006 ± 0.005</td>
<td></td>
<td>0.010 ± 0.005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.001 ± 0.001</td>
<td></td>
<td>0.014 ± 0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.004 ± 0.003</td>
<td></td>
<td>0.011 ± 0.004</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.001 ± 0.001</td>
<td></td>
<td>0.011 ± 0.005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>&lt;0.001 ± &lt;0.001</td>
<td></td>
<td>0.003 ± 0.001</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.001 ± 0.001</td>
<td></td>
<td>0.002 ± 0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.005 ± 0.003</td>
<td></td>
<td>0.016 ± 0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.003 ± 0.001</td>
<td></td>
<td>0.007 ± 0.003</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>0.020 ± 0.011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.011 ± 0.007</td>
<td></td>
<td>0.007 ± 0.004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.003 ± 0.002</td>
<td></td>
<td>0.016 ± 0.008</td>
<td></td>
</tr>
</tbody>
</table>

**b. SHORE FISHERY**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.001 ± 0.001</td>
<td></td>
<td>0.006 ± 0.004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td>0.007 ± 0.006</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.001 ± 0.001</td>
<td></td>
<td>0.007 ± 0.003</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>0.005 ± 0.005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td>&lt;0.001 ± &lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-</td>
<td></td>
<td>0.004 ± 0.004</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td>0.011 ± 0.011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-</td>
<td></td>
<td>0.004 ± 0.004</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.032 ± 0.016</td>
<td></td>
<td>0.101 ± 0.052</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.047 ± 0.036</td>
<td></td>
<td>0.013 ± 0.005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.036 ± 0.015</td>
<td></td>
<td>0.075 ± 0.037</td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.5. **Tailor**

The harvest rates for tailor taken by boat-based fishers were relatively low in the boat fishery during each month of the survey period, with no apparent monthly trend in these data (Table 15). The highest harvest rates for tailor taken by shore-based fishers were recorded during July, while very few tailor were caught by shore-based fishers during August (Table 15). No tailor were recorded in the harvest of shore-based fishers during September and October (Table 15).

**Table 15.** Recreational harvest rate and discard rate estimates (fish per fisher hour ± standard error) for Tailor (*Pomatomus saltatrix*) taken by (a) boat-based fishers, and (b) shore-based fishers, in the Macleay River during the survey period (July 1 - October 31, 2001).

### a. BOAT FISHERY

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.001 ± 0.001</td>
<td>0.007 ± 0.006</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.005 ± 0.003</td>
<td>0.017 ± 0.011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.002 ± 0.001</td>
<td>0.010 ± 0.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.006 ± 0.006</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.003 ± 0.001</td>
<td>0.007 ± 0.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.001 ± &lt;0.001</td>
<td>0.006 ± 0.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.002 ± 0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.004 ± 0.003</td>
<td>0.011 ± 0.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.001 ± 0.001</td>
<td>0.005 ± 0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.005 ± 0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.002 ± 0.002</td>
<td>0.010 ± 0.006</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.001 ± 0.001</td>
<td>0.006 ± 0.003</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### b. SHORE FISHERY

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.005 ± 0.002</td>
<td>0.012 ± 0.009</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.067 ± 0.063</td>
<td>0.021 ± 0.015</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.023 ± 0.018</td>
<td>0.015 ± 0.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.020 ± 0.016</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.003 ± 0.002</td>
<td>0.028 ± 0.028</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.001 ± &lt;0.001</td>
<td>0.022 ± 0.014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.006 ± 0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-</td>
<td>0.004 ± 0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.2.6. **Mulloway**

Relatively few mulloway were taken by boat-based fishers during the survey period and accordingly the harvest rates recorded were relatively low (Table 16). There was no apparent monthly trend in these harvest rate data for the boat fishery. Similarly, few mulloway were taken by shore-based fishers during the survey period, with no apparent monthly trend in the harvest rate data (Table 16). No mulloway were recorded in the harvest of shore-based fishers during September (Table 16).

**Table 16.** Recreational harvest rate and discard rate estimates (fish per fisher hour ± standard error) for Mulloway (*Argyrosomus hololepidotus*) taken by (a) boat-based fishers, and (b) shore-based fishers, in the Macleay River during the survey period (July 1 - October 31, 2001).

**a. BOAT FISHERY**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.008 ± 0.005</td>
<td></td>
<td>Total 0.002 ± 0.001</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.003 ± 0.002</td>
<td></td>
<td>Total 0.001 ± &lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>See</td>
<td></td>
<td>note</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.004 ± 0.002</td>
<td></td>
<td>Total 0.001 ± 0.001</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.004 ± 0.004</td>
<td></td>
<td>Total 0.003 ± 0.003</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

**b. SHORE FISHERY**

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>SE</th>
<th>Discard Rate (fish/fisher hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.015 ± 0.008</td>
<td></td>
<td>0.002 ± 0.002</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>Total 0.011 ± 0.006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.005 ± 0.005</td>
<td></td>
<td>Total 0.004 ± 0.004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>-</td>
<td></td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.003 ± 0.003</td>
<td></td>
<td>Total 0.001 ± 0.001</td>
<td></td>
</tr>
</tbody>
</table>

Note: Mulloway were classified as a rare taxon with respect to discards in the boat and shore fisheries and as such we did not estimate discard rates for this species in the boat or shore fishery.
3.4.3. **Recreational discard rates**

The discard rates reported in this document are based on calculations made using total fishing effort (non-directed effort) for a stratum. We present discard rates for six important species. The discard rate information is presented separately for the boat-based and shore-based fisheries, for each day-type stratum and for each month. In this way, temporal trends within the whole fishery can be examined. We also provide supplementary discard rate information for the boat-based fishery in units of number of fish per boat hour (see Appendices 2.1 to 2.6). These appendices report the discard rates for the boat-based fishery in the original units that were used in the calculations of boat-based effort and discard, and are useful for other workers that may want to make comparisons between boat-based fisheries from other locations and/or survey periods.

3.4.3.1. **Yellowfin bream**

Bream were regularly discarded by both boat-based and shore-based fishing parties. Recreational boat-based fishers indicated that 6.5% of the estimated 1300 discarded bream had been of legal size. Similarly, recreational shore-based fishers indicated that 3.8% of the estimated 1100 discarded bream had been of legal size. The highest discard rates for bream taken by boat-based fishers were reported during July and October (Table 11). There were slightly lower bream discard rates in the boat fishery during August, while the lowest monthly bream discard rate was reported during September (Table 11). Bream discard rates in the shore fishery were highest during July, while lower discard rates were reported during August, September and October (Table 11).

3.4.3.2. **Luderick**

Recreational boat-based fishers indicated that 18.0% of the estimated 530 discarded luderick had been of legal size. Similarly, recreational shore-based fishers indicated that 14.0% of the estimated 150 discarded luderick had been of legal size. The reported discard rates were lower than the harvest rates achieved for luderick for all strata in the boat fishery and most strata in the shore fishery (Table 12). Discard rates exceeded harvest rates in the shore fishery during the weekend day-type stratum in both September and October (Table 12). The highest discard rates for luderick reported by boat-based fishers occurred during July (Table 12). A decline in luderick discard rates in the boat fishery was apparent throughout the remainder of the survey (Table 12). Similarly, luderick discard rates in the shore fishery were highest during July and there was a steady decline in the monthly discard rates reported during the next three months (Table 12).

3.4.3.3. **Dusky flathead**

Recreational boat-based fishers indicated that 24.7% of the estimated 570 discarded dusky flathead had been of legal size. In contrast, recreational shore-based fishers indicated that 12.1% of the estimated 70 discarded dusky flathead had been of legal size. Dusky flathead monthly discard rates in the boat fishery were lowest during July, intermediate during August and September and highest during October (Table 13). The shore fishery was characterised by relatively lower discard rates than those reported for the boat fishery. The discard rates reported by shore-based fishers were higher during the second half of the survey period (Table 13).

3.4.3.4. **Sand whiting**

Recreational boat-based fishers indicated that none of the estimated 80 discarded sand whiting were of legal size, while shore-based fishers indicated that 6.4% of the estimated 50 discarded sand whiting in the shore fishery had been of legal size. The sand whiting discard rates reported by boat-based fishers were relatively low during the survey period and there was no apparent
monthly trend in these discard rate data for the boat fishery (Table 14). The monthly discard rates reported by shore-based fishers during the first three months of the survey were as low as those recorded for the boat-based fishery, while a relatively higher discard rate was reported during October (Table 14).

3.4.3.5. **Tailor**

Recreational boat-based fishers indicated that 31.7% of the estimated 60 discarded tailor had been of legal size. In contrast, recreational shore-based fishers indicated that 15.0% of the estimated 40 discarded tailor had been of legal size. The monthly discard rates for tailor reported by boat-based fishers were relatively low during the survey period and there was no apparent monthly trend in these discard rate data for the boat fishery (Table 15). The tailor discard rates reported by shore-based fishers during July and August were higher than all of the monthly discard rates reported in the boat fishery (Table 15). Shore-based fishers reported lower discard rates during September, while no tailor were reported as being discarded in the shore-based fishery during October (Table 15).

3.4.3.6. **Mulloway**

Boat-based fishers caught relatively few mulloway during the survey period and the number of reported discards was also extremely low. For example, none of the 5 mulloway reported as discard in the boat-based fishery were of legal size, while no mulloway were reported as being discarded in the shore-based fishery. As a consequence, mulloway were classified as a rare taxon with respect to discards in the shore fishery and as such we did not estimate discard rates or make expanded estimates of discard for this species in the shore fishery (Table 16).

3.4.4. **Size-frequency distributions**

Appendix 5 contains descriptive statistics of all measurements taken for each taxon by boat-based and shore-based fishers during the survey period. Here, we present length frequency distributions for the five main taxa in the recreational fishery, aggregated for the whole fishery (boat and shore combined). The size-frequency distributions presented here are important baseline indicators which can be used to monitor future changes (if any) in the size structure of these species in the fishery. There are some noteworthy features evident in these size-frequency distributions (Figures 3a to 3e). First, large individuals that were highly-prized by recreational fishers were present in the recreational harvests indicating that the quality of recreational fishing opportunities during the survey period were quite good. Second, the proportions of under-sized yellowfin bream, luderick, tailor and mulloway in the recreational harvest were extremely low indicating good compliance with fisheries regulations. Finally, the proportions of under-sized dusky flathead and sand whiting in the recreational harvest were less than 15% which is comparable to rates measured in other NSW estuarine fisheries.
**Figure 3.** Length frequency distributions for: (a) Yellowfin bream (*Acanthopagrus australis*); (b) Luderick (*Girella tricuspidata*); (c) Dusky flathead (*Platycephalus fuscus*); (d) Sand whiting (*Sillago ciliata*); and (e) Tailor (*Pomatomus saltatrix*); taken by recreational fishers in the lower Macleay River during the survey period (July 1 to October 31, 2001). The length frequency data for the boat and shore fisheries have been pooled. The dashed line indicates the minimum legal length.
3.5. **Recreational harvest**

3.5.1. **Whole fishery**

We recorded 16 taxa in the retained catch of recreational fishers accessing the lower Macleay River fishery by boat and from the shore during the survey period (Table 17). We estimated that approximately 45,300 fish and crustaceans (± 4,205 individuals - approximate SE) were harvested by daytime recreational fishers from the lower Macleay River during the survey period (Table 17) and that this recreational harvest consisted almost exclusively of finfish (>99% of harvest) - (Table 17). The six most commonly harvested taxa, by number, during the survey period were luderick (=29,110 – 64.2%), yellowfin bream (=9,250 - 20.4%), dusky flathead (=3,760 - 8.3%), striped seapike (=1,220 - 2.7%), tailor (=670 - 1.5%), and sand mullet (=600 – 1.3%) - (Table 17). These six taxa, by number, accounted for 98.5% of the daytime recreational harvest during the survey period (Table 17).

We estimated that approximately 25.2 tonnes of fish and crustaceans (± 2.4 tonnes - approximate SE) were harvested by daytime recreational fishers from the lower Macleay River during the survey period (Table 18) and that this recreational harvest consisted almost exclusively of finfish (>99% of harvest) – (Table 18). The six most commonly harvested taxa, by weight, during the survey period were luderick (=16.5 tonnes – 65.4%), yellowfin bream (=4.7 tonnes – 18.8%), dusky flathead (=1.9 tonnes – 7.5%), mulloway (=1.6 tonnes – 6.3%), tailor (=0.3 tonnes – 1.0%), and striped seapike (=0.1 tonnes - 0.6%) - (Table 18). These six taxa, by weight, accounted for 99.6% of the daytime recreational harvest during the survey period (Table 18).
Table 17. Monthly and total harvest estimates (number of individuals) and standard errors for taxa taken by recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001). The daytime harvest data for the boat and shore fisheries have been pooled.

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<tbody>
<tr>
<td>Luderick</td>
<td>15,167 ± 2200</td>
<td>11,676 ± 3320</td>
<td>1,428 ± 283</td>
<td>837 ± 269</td>
<td>29,108 ± 4002</td>
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<tr>
<td>Girella tricuspidata</td>
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<tr>
<td>Yellowfin bream</td>
<td>4,201 ± 500</td>
<td>3,120 ± 459</td>
<td>1,078 ± 145</td>
<td>848 ± 208</td>
<td>9,247 ± 724</td>
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<tr>
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<tr>
<td>Dusky flathead</td>
<td>1,048 ± 340</td>
<td>684 ± 162</td>
<td>911 ± 205</td>
<td>1,118 ± 195</td>
<td>3,761 ± 471</td>
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<tr>
<td>Platyccephalus fuscus</td>
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<tr>
<td>Striped seapike</td>
<td>46 ± 41</td>
<td>5 ± 5</td>
<td>637 ± 637</td>
<td>535 ± 340</td>
<td>1,223 ± 723</td>
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<tr>
<td>Sphyraena obtusata</td>
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<tr>
<td>Tailor</td>
<td>631 ± 503</td>
<td>21 ± 11</td>
<td>12 ± 10</td>
<td>8 ± 8</td>
<td>672 ± 503</td>
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<tr>
<td>Sand mullet</td>
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<td>598 ± 338</td>
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<tr>
<td>Mulloway</td>
<td>219 ± 88</td>
<td>89 ± 81</td>
<td>10 ± 6</td>
<td>41 ± 34</td>
<td>359 ± 124</td>
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<tr>
<td>Argyrosomus japonicus</td>
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<tr>
<td>Sand whiting</td>
<td>66 ± 39</td>
<td>5 ± 5</td>
<td>27 ± 16</td>
<td>212 ± 90</td>
<td>310 ± 100</td>
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<td><em>Portunus pelagicus</em></td>
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<td>Sea mullet</td>
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# Expanded estimates of harvest have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
Table 18. Monthly and total harvest estimates (kilograms) and standard errors for taxa taken by recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001). The daytime harvest data for the boat and shore fisheries have been pooled.

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<th>Taxon</th>
<th>July 2001</th>
<th>August 2001</th>
<th>September 2001</th>
<th>October 2001</th>
<th>Total</th>
<th>% total</th>
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<tr>
<td></td>
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<td>kg</td>
<td>SE</td>
<td>kg</td>
<td>SE</td>
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<tr>
<td><strong>Luderick</strong></td>
<td>8,614 ± 1,312</td>
<td>6,496 ± 1,776</td>
<td>838 ± 173</td>
<td>511 ± 146</td>
<td>16,459 ± 2,219</td>
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<td><em>Girella tricuspidata</em></td>
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<tr>
<td><strong>Yellowfin bream</strong></td>
<td>1,964 ± 231</td>
<td>1,665 ± 261</td>
<td>561 ± 95</td>
<td>548 ± 182</td>
<td>4,738 ± 404</td>
<td>18.8</td>
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<td><em>Acanthopagrus australis</em></td>
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<tr>
<td><strong>Dusky flathead</strong></td>
<td>549 ± 171</td>
<td>362 ± 98</td>
<td>399 ± 95</td>
<td>588 ± 111</td>
<td>1,898 ± 245</td>
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<tr>
<td><strong>Mulloway</strong></td>
<td>877 ± 384</td>
<td>457 ± 409</td>
<td>70 ± 53</td>
<td>173 ± 153</td>
<td>1,577 ± 584</td>
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</tr>
<tr>
<td><strong>Tailor</strong></td>
<td>244 ± 194</td>
<td>8 ± 4</td>
<td>3 ± 3</td>
<td>6 ± 6</td>
<td>261 ± 194</td>
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<td>6 ± 5</td>
<td>1 ± 1</td>
<td>75 ± 75</td>
<td>63 ± 19</td>
<td>145 ± 85</td>
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<tr>
<td><strong>Sand whiting</strong></td>
<td>16 ± 9</td>
<td>1 ± 1</td>
<td>8 ± 4</td>
<td>48 ± 19</td>
<td>73 ± 22</td>
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<td>#7 - - - -</td>
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<tr>
<td><strong>Sea mullet</strong></td>
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<td><strong>Australian bass</strong></td>
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<td>&lt; 0.1</td>
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<tr>
<td><em>Macquaria novemaculeata</em></td>
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<tr>
<td><strong>Blue-swimmer crab</strong></td>
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<td><em>Portunus pelagicus</em></td>
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<tr>
<td><strong>Flat-tail mullet</strong></td>
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<tr>
<td><em>Liza argentea</em></td>
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Table 18 (continued)

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<tr>
<td>Gerres subfasciatus</td>
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</table>

# Expanded estimates of harvest have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
3.5.2. **Boat fishery**

We recorded 12 taxa in the retained catch of boat-based recreational fishers during the survey period (Table 19). We estimated that for boat-based recreational fishers, approximately 20,180 fish and crustaceans (± 2,230 individuals - approximate SE) were harvested in the daytime from the lower Macleay River during the survey period (Table 19). This represents 44.5%, by number, of the daytime harvest for the total fishery (boat and shore combined). The recreational harvest for the boat fishery consisted almost exclusively of finfish (>99% of harvest) - (Table 19). The six most commonly harvested taxa by boat-based fishers, by number, during the survey period were luderick (=15,400 – 76.3%), yellowfin bream (=2,260 – 11.2%), dusky flathead (=2,260 – 11.2%), sand whiting (=110 – 0.5%), mulloway (=80 - 0.4%) and tailor (=50 – 0.3%) - (Table 19). These six taxa, by number, accounted for 99.9% of the daytime recreational harvest of the boat-based fishery during the survey period (Table 19).

We estimated that for boat-based recreational fishers, approximately 11.4 tonnes of fish and crustaceans (± 1.3 tonnes - approximate SE) were harvested in the daytime from the lower Macleay River during the survey period (Table 20). This represents 45.3%, by weight, of the daytime harvest for the total fishery (boat and shore combined). The recreational harvest for the boat fishery consisted almost exclusively of finfish (>99% of harvest) - (Table 20). The six most commonly harvested taxa by boat-based fishers, by weight, during the survey period were luderick (=8.7 tonnes – 76.3%), dusky flathead (=1.1 tonnes – 9.8%), yellowfin bream (=1.1 tonnes – 9.7%), sand whiting (0.4 tonnes – 3.6%), mulloway (<0.1 tonnes – 0.2%) and tailor (<0.1 tonnes – 0.2%) - (Table 20). These six taxa, by weight, accounted for 99.9% of the daytime recreational harvest of the boat-based fishery during the survey period (Table 20).
Table 19. Monthly and total harvest estimates (number of individuals) and standard errors for taxa taken by boat-based recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>July 2001 No.</th>
<th>SE</th>
<th>August 2001 No.</th>
<th>SE</th>
<th>September 2001 No.</th>
<th>SE</th>
<th>October 2001 No.</th>
<th>SE</th>
<th>Total No.</th>
<th>SE</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luderick</td>
<td>9,150 ± 1,774</td>
<td></td>
<td>4,398 ± 1,183</td>
<td></td>
<td>1,238 ± 272</td>
<td></td>
<td>610 ± 200</td>
<td></td>
<td>15,396 ± 2,159</td>
<td></td>
<td>76.3</td>
</tr>
<tr>
<td><em>Girella tricuspidata</em></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Yellowfin bream</td>
<td>1,105 ± 255</td>
<td></td>
<td>693 ± 249</td>
<td></td>
<td>215 ± 56</td>
<td></td>
<td>249 ± 126</td>
<td></td>
<td>2,262 ± 382</td>
<td></td>
<td>11.2</td>
</tr>
<tr>
<td><em>Acanthopagrus australis</em></td>
<td></td>
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</tr>
<tr>
<td>Dusky flathead</td>
<td>635 ± 325</td>
<td></td>
<td>294 ± 43</td>
<td></td>
<td>376 ± 117</td>
<td></td>
<td>951 ± 188</td>
<td></td>
<td>2,256 ± 395</td>
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<td>11.2</td>
</tr>
<tr>
<td><em>Platycephalus fuscus</em></td>
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<td></td>
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</tr>
<tr>
<td>Sand whiting</td>
<td>51 ± 36</td>
<td></td>
<td>5 ± 5</td>
<td></td>
<td>27 ± 16</td>
<td></td>
<td>27 ± 17</td>
<td></td>
<td>110 ± 43</td>
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<tr>
<td><em>Sillago ciliata</em></td>
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<td></td>
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<tr>
<td>Mulloway</td>
<td>32 ± 18</td>
<td></td>
<td>8 ± 5</td>
<td></td>
<td>10 ± 6</td>
<td></td>
<td>33 ± 33</td>
<td></td>
<td>83 ± 39</td>
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<td><em>Argyrosomus japonicus</em></td>
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<tr>
<td>Tailor</td>
<td>29 ± 15</td>
<td></td>
<td>5 ± 3</td>
<td></td>
<td>12 ± 10</td>
<td></td>
<td>8 ± 8</td>
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<td>54 ± 20</td>
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<td><em>Pomatamus saltatrix</em></td>
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<tr>
<td>Striped seapike</td>
<td>#5</td>
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<td><em>Sphyrana obtusata</em></td>
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<td>#4</td>
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<td>Australian salmon</td>
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<td><em>Arrhipis trutta</em></td>
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<tr>
<td>Small-toothed flounder</td>
<td>-</td>
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<td></td>
<td></td>
<td>#2</td>
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<td></td>
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<tr>
<td><em>Pseudorhombus jenynsii</em></td>
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<tr>
<td>Silver biddy</td>
<td>#1</td>
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<td>&lt;0.1</td>
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<tr>
<td><em>Gerres subfasciatus</em></td>
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<tr>
<td>Blue-swimmer crab</td>
<td>-</td>
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<td></td>
<td></td>
<td>#1</td>
<td></td>
<td>&lt;0.1</td>
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<tr>
<td><em>Portunus pelagicus</em></td>
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</tbody>
</table>

# Expanded estimates of harvest have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
Table 20. Monthly and total harvest estimates (kilograms) and standard errors for taxa taken by boat-based recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>July 2001 kg</th>
<th>SE kg</th>
<th>August 2001 kg</th>
<th>SE kg</th>
<th>September 2001 kg</th>
<th>SE kg</th>
<th>October 2001 kg</th>
<th>SE kg</th>
<th>Total kg</th>
<th>SE kg</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Luderick</strong></td>
<td>5,113 ± 1,059</td>
<td></td>
<td>2,401 ± 594</td>
<td></td>
<td>750 ± 170</td>
<td></td>
<td>428 ± 130</td>
<td></td>
<td>8,692 ± 1,233</td>
<td></td>
<td>76.3</td>
</tr>
<tr>
<td><em>Girella tricuspidata</em></td>
<td></td>
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</tr>
<tr>
<td><strong>Dusky flathead</strong></td>
<td>292 ± 155</td>
<td></td>
<td>152 ± 28</td>
<td></td>
<td>172 ± 58</td>
<td></td>
<td>501 ± 105</td>
<td></td>
<td>1,117 ± 198</td>
<td></td>
<td>9.8</td>
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<td><em>Platyecephalus fuscus</em></td>
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<tr>
<td><strong>Yellowfin bream</strong></td>
<td>492 ± 113</td>
<td></td>
<td>333 ± 114</td>
<td></td>
<td>111 ± 31</td>
<td></td>
<td>174 ± 109</td>
<td></td>
<td>1,110 ± 197</td>
<td></td>
<td>9.7</td>
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<tr>
<td><em>Acanthopagrus australis</em></td>
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</tr>
<tr>
<td><strong>Sand whiting</strong></td>
<td>137 ± 80</td>
<td></td>
<td>49 ± 31</td>
<td></td>
<td>70 ± 53</td>
<td></td>
<td>152 ± 152</td>
<td></td>
<td>408 ± 182</td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td><em>Sillago ciliata</em></td>
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<tr>
<td><strong>Mulloway</strong></td>
<td>12 ± 8</td>
<td></td>
<td>1 ± 1</td>
<td></td>
<td>8 ± 4</td>
<td></td>
<td>7 ± 4</td>
<td></td>
<td>28 ± 10</td>
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</tr>
<tr>
<td><em>Argyrosomus japonicus</em></td>
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<tr>
<td><strong>Tailor</strong></td>
<td>12 ± 6</td>
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<td>3 ± 1</td>
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<td>3 ± 3</td>
<td></td>
<td>6 ± 6</td>
<td></td>
<td>24 ± 9</td>
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<tr>
<td><em>Pomatomus saltatrix</em></td>
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<tr>
<td><strong>Australian salmon</strong></td>
<td>#7</td>
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<td></td>
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<td>#14</td>
<td></td>
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<tr>
<td><em>Arripis trutta</em></td>
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<td></td>
</tr>
<tr>
<td><strong>Blue-swimmer crab</strong></td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>#1</td>
<td></td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Portunus pelagicus</em></td>
<td></td>
<td></td>
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<tr>
<td><strong>Small-toothed flounder</strong></td>
<td>#&lt;1</td>
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<td></td>
<td></td>
<td></td>
<td>#1</td>
<td></td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Pseudorhombus jenynsii</em></td>
<td></td>
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</tr>
<tr>
<td><strong>Striped seapike</strong></td>
<td>#1</td>
<td></td>
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<td></td>
<td>#1</td>
<td></td>
<td>&lt;0.1</td>
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<tr>
<td><em>Sphyraena obtusata</em></td>
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</tr>
<tr>
<td><strong>Silver biddy</strong></td>
<td>#&lt;1</td>
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<td></td>
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<td>#&lt;1</td>
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<tr>
<td><em>Gerres subfasciatus</em></td>
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</tr>
<tr>
<td><strong>Southern herring</strong></td>
<td>#&lt;1</td>
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<tr>
<td><em>Herklotsichthys castelnau</em></td>
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</tbody>
</table>

# Expanded estimates of harvest have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
3.5.3. **Shore fishery**

We recorded 13 taxa in the retained catch of shore-based recreational fishers during the survey period (Table 21). We estimated that for shore-based recreational fishers, approximately 25,120 fish (± 3,570 individuals - approximate SE) were harvested in the daytime from the lower Macleay River during the survey period (Table 21). This represents 55.5%, by number, of the daytime harvest for the total fishery (boat and shore combined). The recreational harvest for the shore fishery consisted exclusively of finfish (Table 21). The six most commonly harvested taxa by shore-based fishers, by number, during the survey period were luderick (≈13,710 - 54.6%), yellowfin bream (≈6,990 - 27.8%), dusky flathead (≈1,510 - 6.0%), striped seapike (≈1,220 – 4.8%), tailor (≈620 – 2.4%), and sand mullet (≈600 – 2.4%) - (Table 21). These six taxa, by number, accounted for 98.0% of the daytime recreational harvest of the shore-based fishery during the survey period (Table 21).

We estimated that for shore-based recreational fishers, approximately 13.8 tonnes of fish (± 2.0 tonnes - approximate SE), were harvested in the daytime from the lower Macleay River during the survey period (Table 22). This represents 54.7%, by weight, of the daytime harvest for the total fishery (boat and shore combined). The recreational harvest for the shore fishery consisted exclusively of finfish (Table 22). The six most commonly harvested taxa by shore-based fishers, by weight, during the survey period were luderick (≈7.8 tonnes – 56.3%), yellowfin bream (≈3.6 tonnes – 26.3%), mulloway (≈1.2 tonnes – 8.5%), dusky flathead (≈0.8 tonnes – 5.7%), tailor (≈0.2 tonnes – 1.7%), and striped seapike (≈0.1 tonnes – 1.0%) - (Table 22). These six taxa, by weight, accounted for 99.5% of the daytime recreational harvest of the shore-based fishery during the survey period (Table 22).
Table 21. Monthly and total harvest estimates (number of individuals) and standard errors for taxa taken by shore-based recreational fishers in the Macleay River by shore-based recreational fishers in the Macleay River.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>July 2001</th>
<th>August 2001</th>
<th>September 2001</th>
<th>October 2001</th>
<th>Total</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>SE</td>
<td>No.</td>
<td>SE</td>
<td>No.</td>
<td>SE</td>
</tr>
<tr>
<td>Luderick</td>
<td>6,017</td>
<td>± 1,301</td>
<td>7,278</td>
<td>± 3,103</td>
<td>190</td>
<td>± 78</td>
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<tr>
<td>Girella tricuspidata</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellowfin bream</td>
<td>3,096</td>
<td>± 430</td>
<td>2,427</td>
<td>± 386</td>
<td>863</td>
<td>± 134</td>
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<tr>
<td>Acanthopagrus australis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusky flathead</td>
<td>413</td>
<td>± 102</td>
<td>390</td>
<td>± 156</td>
<td>535</td>
<td>± 168</td>
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<tr>
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</tr>
<tr>
<td>Tailor</td>
<td>602</td>
<td>± 503</td>
<td>16</td>
<td>± 11</td>
<td>-</td>
<td>-</td>
</tr>
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<td>Pomatomus saltatrix</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Sand mullet</td>
<td>160</td>
<td>± 106</td>
<td>295</td>
<td>± 288</td>
<td>143</td>
<td>± 143</td>
</tr>
<tr>
<td>Myxus elongatus</td>
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<td></td>
</tr>
<tr>
<td>Mulloway</td>
<td>187</td>
<td>± 86</td>
<td>81</td>
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</tr>
<tr>
<td>Sand whiting</td>
<td>15±15</td>
<td>± 15</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Sillago ciliata</td>
<td></td>
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<td></td>
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<tr>
<td>Flat-tail mullet</td>
<td>-</td>
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<td>#1</td>
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<td>Arripis trutta</td>
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<tr>
<td>Sea mullet</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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</tr>
<tr>
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<td>Small-toothed flounder</td>
<td>#1</td>
<td>-</td>
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<td>Total Taxa</td>
<td>11</td>
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# Expanded estimates of harvest have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
Table 22.  Monthly and total harvest estimates (kilograms) and standard errors for taxa taken by shore-based recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001).

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<tr>
<th>Taxon</th>
<th>July 2001 kg</th>
<th>SE</th>
<th>August 2001 kg</th>
<th>SE</th>
<th>September 2001 kg</th>
<th>SE</th>
<th>October 2001 kg</th>
<th>SE</th>
<th>Total kg</th>
<th>SE</th>
<th>% total</th>
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<tr>
<td>Luderick</td>
<td>3,501 ± 774</td>
<td></td>
<td>4,095 ± 1,674</td>
<td></td>
<td>88 ± 34</td>
<td></td>
<td>83 ± 66</td>
<td></td>
<td>7,767 ± 1,845</td>
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<tr>
<td><em>Girella tricuspidata</em></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellowfin bream</td>
<td>1,472 ± 201</td>
<td></td>
<td>1,332 ± 235</td>
<td></td>
<td>450 ± 90</td>
<td></td>
<td>374 ± 145</td>
<td></td>
<td>3,628 ± 353</td>
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<td>26.3</td>
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<td></td>
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<tr>
<td>Mulloway</td>
<td>740 ± 375</td>
<td></td>
<td>408 ± 408</td>
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<td></td>
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<td>21 ± 21</td>
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<td>1,169 ± 555</td>
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<tr>
<td>Dusky flathead</td>
<td>257 ± 73</td>
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<td>210 ± 94</td>
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<td>227 ± 75</td>
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<td>87 ± 36</td>
<td></td>
<td>781 ± 145</td>
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<tr>
<td>Tailor</td>
<td>232 ± 194</td>
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<td>5 ± 4</td>
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<td>237 ± 194</td>
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<tr>
<td>Striped seapike</td>
<td>5 ± 5</td>
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</tr>
<tr>
<td>Sand whiting</td>
<td>4 ± 4</td>
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<td>41 ± 19</td>
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<td>45 ± 19</td>
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<tr>
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<td>4 ± 3</td>
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<td>2 ± 2</td>
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<tr>
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<td>Flat-tail mullet</td>
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<td></td>
<td>#1</td>
<td></td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Liza argentea</em></td>
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<td>-</td>
<td></td>
<td>#&lt;1</td>
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</tr>
</tbody>
</table>

# Expanded estimates of harvest have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
3.5.4. Monthly trends in recreational harvest

Information describing monthly trends in the pattern of recreational harvesting for the whole fishery are provided in Tables 17 and 18. Here we provide a brief description of the monthly trends evident for the six main species in the harvest, by number, for the whole fishery. The largest monthly harvest of luderick was taken during July, the month after the river was re-opened (Table 17). Harvests of luderick remained high during August, although the harvests recorded during September and October were considerably lower (Table 17). Similarly, the largest monthly harvest of yellowfin bream was taken during July, which was followed by a steady decrease in harvest during each of the following three months of the survey period (Table 17). The smallest levels of harvest for luderick and yellowfin bream were recorded during October (Table 17). A different monthly pattern was evident for dusky flathead (Table 17). The largest harvests of dusky flathead were taken during July and October, while decreased levels of harvest were recorded during August and September (Table 17). In contrast, the largest harvests of striped seapike were taken during September and October, while much lower levels of harvest were recorded during the first two months of the survey (Table 17). As was the case for luderick and yellowfin bream, the largest harvest of tailor was taken during July (Table 17). However, relatively few tailor were harvested during August, September and October (Table 17). The harvest of sand mullet showed no apparent trend with the largest harvest level recorded during August, relatively lower amounts of harvest taken during July and September, and no sand mullet recorded during October (Table 17). We also present information describing monthly trends in the pattern of recreational harvesting for the boat-based fishery (Tables 19 and 20), and the shore-based fishery (Tables 21 and 22). In this way, the reader may extract monthly information for particular species of interest.

3.6. Recreational discard

3.6.1. Whole fishery

Recreational fishers (boat-based and shore-based) reported discarding 26 taxa whilst fishing in the lower Macleay River during the survey period (Table 23). We estimated that approximately 34,310 fish and crustaceans (± 2,060 individuals - approximate SE) were discarded by daytime recreational fishers in the lower Macleay River during the survey period (Table 23) and that this recreational discard consisted almost exclusively of finfish (>99% of harvest) - (Table 23). The six most commonly discarded taxa, by number, during the survey period were yellowfin bream (≈22,260 - 64.8%), luderick (≈5,200 - 15.2%), dusky flathead (≈3,590 - 10.5%), sand whiting (≈1,250 – 3.6%), tailor (≈1,040 – 3.0%), and silver batfish (≈470 - 1.4%) - (Table 23). These six taxa, by number, accounted for 98.5% of the total daytime recreational discard during the survey period (Table 23). The great majority of discarded yellowfin bream (94.7%) and sand whiting (97.6%) were below the legal minimum length. Interestingly, lower proportions of discarded luderick (82.9%), dusky flathead (76.7%) and tailor (75.0%) were below the legal minimum length.
Table 23. Monthly and total discard estimates (number of individuals) and standard errors for taxa taken by recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001). The daytime harvest data for the boat and shore fisheries have been pooled.

<table>
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<tr>
<th></th>
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<tbody>
<tr>
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<td>SE</td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellowfin bream Acanthopagrus australis</td>
<td>9,878 ± 1,451</td>
<td>5,708 ± 1,327</td>
<td>3,015 ± 618</td>
<td>3,660 ± 781</td>
<td>22,261 ± 1,715</td>
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</tr>
<tr>
<td>Luderick Girella tricuspidata</td>
<td>3,643 ± 1,065</td>
<td>1,029 ± 473</td>
<td>380 ± 227</td>
<td>150 ± 118</td>
<td>5,202 ± 877</td>
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<tr>
<td>Dusky flathead Platycephalus fuscus</td>
<td>923 ± 294</td>
<td>585 ± 118</td>
<td>867 ± 314</td>
<td>1,215 ± 412</td>
<td>3,590 ± 477</td>
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<tr>
<td>Sand whiting Sillago ciliarata</td>
<td>264 ± 119</td>
<td>112 ± 99</td>
<td>84 ± 57</td>
<td>786 ± 422</td>
<td>1,246 ± 361</td>
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</tr>
<tr>
<td>Tailor Pomatomus saltatrix</td>
<td>441 ± 241</td>
<td>445 ± 293</td>
<td>97 ± 70</td>
<td>58 ± 28</td>
<td>1,041 ± 329</td>
<td>3.0</td>
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<tr>
<td>Silver batfish Monodactylus argenteus</td>
<td>342 ± 217</td>
<td>30 ± 28</td>
<td>-</td>
<td>95 ± 87</td>
<td>467 ± 221</td>
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<td>Mullet Mugilidae</td>
<td>60 ± 60</td>
<td>69 ± 44</td>
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<td>69 ± 52</td>
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<tr>
<td>Stingrays &amp; stingarees Dasyatidae &amp; Urolophidae</td>
<td>18 ± 15</td>
<td>85 ± 85</td>
<td>43 ± 40</td>
<td>6 ± 4</td>
<td>152 ± 87</td>
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<tr>
<td>Tarwhine Rhabdosargus sarba</td>
<td>62 ± 33</td>
<td>-</td>
<td>3 ± 3</td>
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<td>Large-toothed flounder Pseudorhombus arsius</td>
<td>20 ± 15</td>
<td>20 ± 13</td>
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<td>11 ± 11</td>
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<td>#4</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#5</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Longtom BELONIDAE</td>
<td>-</td>
<td>#4</td>
<td>-</td>
<td>-</td>
<td>#4</td>
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<tr>
<td>Estuary cod Epinephelus spp.</td>
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<td>-</td>
<td>-</td>
<td>#1</td>
<td>#3</td>
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### Table 23 (continued)

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<tr>
<th>Taxon</th>
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<th>August 2001</th>
<th>September 2001</th>
<th>October 2001</th>
<th>Total</th>
<th>% total</th>
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<td>Black trevally (spinefoot)</td>
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<td>SE No.</td>
<td>SE No.</td>
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<td>#1</td>
<td>#2</td>
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<td>Painted grinner</td>
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<td>SE No.</td>
<td>SE No.</td>
<td>No.</td>
<td>SE %</td>
</tr>
<tr>
<td>Acanthistius ocellatus</td>
<td></td>
<td>#1</td>
<td>#1</td>
<td>#1</td>
<td>&lt; 0.1</td>
<td></td>
</tr>
<tr>
<td>Unidentified fish</td>
<td>No.</td>
<td>SE No.</td>
<td>SE No.</td>
<td>SE No.</td>
<td>No.</td>
<td>SE %</td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#3</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>

*TOTAL DISCARD FOR WHOLE FISHERY*  
July 2001 | August 2001 | September 2001 | October 2001 | Total | % total
---|---|---|---|---|---|
No. | SE | No. | SE | No. | SE | No. | SE | No. | SE |
---|---|---|---|---|---|---|---|---|---|---|
17 | | 12 | | 15 | | 14 | | 26 | |

*# Expanded estimates of discard have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.*
3.6.2. **Boat fishery**

Recreational fishers in the boat-based fishery reported discarding 24 taxa whilst fishing in the lower Macleay River during the survey period (Table 24). We estimated that approximately 11,860 fish and crustaceans (± 1,040 individuals - approximate SE) were discarded by daytime boat-based recreational fishers in the lower Macleay River during the survey period (Table 24) and that this recreational discard consisted almost exclusively of finfish (>99% of harvest) - (Table 24). This boat-based discard represents 34.6%, by number, of the daytime discard for the total fishery (boat and shore combined). The six most commonly discarded taxa, by number, during the survey period were yellowfin bream (=5,670 - 47.8%), dusky flathead (=2,750 - 23.2%), luderick (=2,650 - 22.4%), sand whiting (=370 - 3.1%), tailor (=300 - 2.6%) and silver batfish (=40 - 0.4%) - (Table 24). These six taxa, by number, accounted for 99.5% of the daytime recreational discard for boat-based fishers during the survey period (Table 24).
Table 24. Monthly and total discard estimates (number of individuals) and standard errors for taxa taken by boat-based recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>July 2001</th>
<th>August 2001</th>
<th>September 2001</th>
<th>October 2001</th>
<th>Total</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellowfin bream</td>
<td>2,402 ± 573</td>
<td>1,117 ± 241</td>
<td>660 ± 174</td>
<td>1,489 ± 201</td>
<td>5,668 ± 676</td>
<td>47.8</td>
</tr>
<tr>
<td>Acanthopagrus australis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusky flathead</td>
<td>660 ± 195</td>
<td>564 ± 105</td>
<td>561 ± 136</td>
<td>965 ± 335</td>
<td>2,750 ± 424</td>
<td>23.2</td>
</tr>
<tr>
<td>Platycephalus fuscus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luderick</td>
<td>1,909 ± 624</td>
<td>443 ± 102</td>
<td>177 ± 83</td>
<td>124 ± 92</td>
<td>2,653 ± 645</td>
<td>22.4</td>
</tr>
<tr>
<td>Girella tricuspidata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand whiting</td>
<td>136 ± 50</td>
<td>23 ± 11</td>
<td>56 ± 29</td>
<td>156 ± 100</td>
<td>371 ± 116</td>
<td>3.1</td>
</tr>
<tr>
<td>Silago ciliata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailor</td>
<td>135 ± 71</td>
<td>40 ± 28</td>
<td>70 ± 53</td>
<td>58 ± 28</td>
<td>303 ± 97</td>
<td>2.6</td>
</tr>
<tr>
<td>Pomatomus saltatrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver batfish</td>
<td>17 ± 13</td>
<td>19 ± 17</td>
<td>-</td>
<td>7 ± 7</td>
<td>43 ± 23</td>
<td>0.4</td>
</tr>
<tr>
<td>Monodactylus argenteus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stingrays &amp; stingarees</td>
<td>3 ± 3</td>
<td>4 ± 4</td>
<td>30 ± 27</td>
<td>6 ± 4</td>
<td>43 ± 28</td>
<td>0.4</td>
</tr>
<tr>
<td>Dasyatidae &amp; Urolophidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large-toothed flounder</td>
<td>-</td>
<td>-</td>
<td>#7</td>
<td>#1</td>
<td>-</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Pseudorhombus arsius</td>
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<td></td>
</tr>
<tr>
<td>Mulloway</td>
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<td>#1</td>
<td>-</td>
<td>-</td>
<td>#5</td>
<td>&lt;0.1</td>
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<tr>
<td>Argyrosomus japonicus</td>
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</tr>
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<td>Longtom</td>
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<td>-</td>
<td>#3</td>
<td>-</td>
<td>#3</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>BELONIDAE</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Estuary cod</td>
<td>#2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#2</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Epinephelus spp.</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Painted grinner</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#2</td>
<td>#2</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Trachinocephalus myops</td>
<td></td>
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</tbody>
</table>
### Table 24 (continued)

<table>
<thead>
<tr>
<th>Taxon</th>
<th>July 2001</th>
<th>August 2001</th>
<th>September 2001</th>
<th>October 2001</th>
<th>Total</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black trevally (spinefoot)</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Siganus spp.</em></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bullrout</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Notesthes robusta</em></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Giant trevally</td>
<td>#1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Caranx ignobilis</em></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hammerhead shark</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Sphyrna spp.</em></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Moses perch</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Lutjanus russelli</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mud crab</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Scylla serrata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver trevally</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Pseudocaranx dentex</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Striped catfish</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Plotosus lineatus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tarwhine</td>
<td>#1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Rhabdosargus sarba</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toadfish</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Tetraodontidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wirrah</td>
<td>#1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td><em>Acanthistius ocellatus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unidentified fish</td>
<td>#2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#2</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>

Total Taxa: 13, 10, 14, 9, 24

# Expanded estimates of discard have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
3.6.3. Shore fishery

Recreational fishers in the shore-based fishery reported discarding 18 taxa whilst fishing in the lower Macleay River during the survey period (Table 25). We estimated that approximately 22,440 fish and crustaceans (± 1,780 individuals - approximate SE) were discarded by daytime shore-based recreational fishers in the lower Macleay River during the survey period (Table 25) and that this recreational discard consisted almost exclusively of finfish (>99% of harvest) - (Table 25). This shore-based discard represents 65.4%, by number, of the daytime discard for the total fishery (boat and shore combined). The six most commonly discarded taxa, by number, during the survey period were yellowfin bream (≈16,590 – 73.8%), luderick (≈2,550 - 11.4%), sand whiting (≈880 – 3.9%), dusky flathead (≈840 – 3.7%), tailor (≈740 – 3.3%) and silver batfish (≈420 - 1.9%) - (Table 25). These six taxa, by number, accounted for 98.0% of the daytime recreational discard for shore-based fishers during the survey period (Table 25).
Table 25. Monthly and total discard estimates (number of individuals) and standard errors for taxa taken by shore-based recreational fishers in the Macleay River for the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>July 2001</th>
<th>August 2001</th>
<th>September 2001</th>
<th>October 2001</th>
<th>Total</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>SE</td>
<td>No.</td>
<td>SE</td>
<td>No.</td>
<td>SE</td>
</tr>
<tr>
<td>Yellowfin bream</td>
<td>7,476 ± 878</td>
<td>4,591 ± 1,086</td>
<td>2,355 ± 444</td>
<td>2,171 ± 580</td>
<td>16,593 ± 1,576</td>
<td>73.8</td>
</tr>
<tr>
<td><em>Acanthopagrus australis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luderick</td>
<td>1,734 ± 441</td>
<td>586 ± 371</td>
<td>203 ± 144</td>
<td>26 ± 26</td>
<td>2,549 ± 594</td>
<td>11.4</td>
</tr>
<tr>
<td><em>Girella tricuspidata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand whiting</td>
<td>128 ± 69</td>
<td>89 ± 88</td>
<td>28 ± 28</td>
<td>630 ± 322</td>
<td>875 ± 342</td>
<td>3.9</td>
</tr>
<tr>
<td><em>Sillago ciliata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusky flathead</td>
<td>263 ± 99</td>
<td>21 ± 13</td>
<td>306 ± 178</td>
<td>250 ± 77</td>
<td>840 ± 218</td>
<td>3.7</td>
</tr>
<tr>
<td><em>Platicephalus fuscus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailor</td>
<td>306 ± 170</td>
<td>405 ± 265</td>
<td>27 ± 17</td>
<td>-</td>
<td>-</td>
<td>738 ± 315</td>
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<tr>
<td><em>Pomatomus saltatrix</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver batfish</td>
<td>325 ± 204</td>
<td>11 ± 11</td>
<td>-</td>
<td>-</td>
<td>88 ± 80</td>
<td>424 ± 219</td>
</tr>
<tr>
<td><em>Monodactylus argenteus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mullet</td>
<td>60 ± 60</td>
<td>69 ± 44</td>
<td>-</td>
<td>-</td>
<td>69 ± 52</td>
<td>198 ± 90</td>
</tr>
<tr>
<td><em>Mugilidae</em></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stingrays &amp; stingarees</td>
<td>15 ± 12</td>
<td>81 ± 81</td>
<td>13 ± 13</td>
<td>-</td>
<td>-</td>
<td>109 ± 82</td>
</tr>
<tr>
<td><em>Dasyatidae &amp; Urolophidae</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tarwhine</td>
<td>61 ± 33</td>
<td>-</td>
<td>3 ± 3</td>
<td>-</td>
<td>-</td>
<td>64 ± 33</td>
</tr>
<tr>
<td><em>Rhabdosargus sarba</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large-toothed flounder</td>
<td>20 ± 15</td>
<td>13 ± 13</td>
<td>-</td>
<td>11 ± 11</td>
<td>44 ± 23</td>
<td>0.2</td>
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<tr>
<td><em>Pseudorhombus arius</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estuary cod</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>#1</td>
</tr>
<tr>
<td><em>Epinephelus spp.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black trevally (spinefoot)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>#1</td>
</tr>
<tr>
<td><em>Siganus spp.</em></td>
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</tbody>
</table>

SHORE-BASED DISCARD
Table 25 (continued)

<table>
<thead>
<tr>
<th>Taxon</th>
<th>BELONIDAE</th>
<th>Scylla serrata</th>
<th>Hyphorhamphus regularis</th>
<th>Pseudocaranx dentex</th>
<th>Tetraodontidae</th>
<th>Toadfish</th>
<th>Unidentified fish</th>
<th>Total Taxa</th>
</tr>
</thead>
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<tr>
<td>Longtom</td>
<td>-</td>
<td>#1</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>#1</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>Mud crab</td>
<td>#1</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>#1</td>
<td>#1</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>River garfish</td>
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<td>-</td>
<td>#1</td>
<td>#1</td>
<td>-</td>
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</tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>#1</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>#1</td>
<td>#1</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

# Expanded estimates of discard have not been calculated. This observation was classified as a rare event during this time period and its occurrence is simply noted.
4. DISCUSSION

4.1. Overview of survey design

Recreational fishing surveys of sound statistical design are essential for the collection of statistically unbiased information. In the absence of reliable information, usually the result of flawed survey designs, the interpretation of survey data can become equivocal and management decisions cannot be justified scientifically. The theoretical framework for valid survey designs has been readily available for a long time (see Cochran 1953, Yates 1965) and these texts provide detailed descriptions of the logistic and statistical issues that need to be addressed when planning and running surveys. Detailed recommendations concerning the reporting of survey findings were published in 1948 by The United Nations Sub-Commission on Statistical Sampling (Yates 1965 reproduces the recommendations). These recommendations clearly identify many important issues that need to be addressed in order to evaluate the validity of survey findings. These issues include detailed descriptions of: (a) the survey aims; (b) the survey design, which includes the method of sample selection and the designation of sampling units; and (c) the survey frame (spatial and temporal). Further, it was recommended that when reporting survey results, the authors should provide sufficient information for an assessment of: (1) the survey accuracy - which can be done by minimising bias with good survey design, by providing evidence of the completeness of frame coverage and by quantifying the level of non-response errors such as refusal rates; (2) the survey precision - which can be done by reporting the precision of estimates derived from data; and (3) the integrity of survey data - which can be done by providing information about various quality assurance issues.

An assessment of a recreational fishery requires a specialised type of survey design but such assessments still require that randomly selected samples from a population of known size are used to estimate parameters for the entire population. Whilst, there have been recent advances in the theoretical understanding of recreational fishing survey designs and the statistical analysis of survey data (Robson and Jones 1989, Hoenig et al. 1993 and 1997, Pollock et al. 1994 and 1997, Jones et al. 1995), the theoretical basis of roving survey and access point survey designs, the most commonly used on-site survey methods, have been readily available for many years (Robson 1960 and 1961).

The use of complemented survey methods to estimate separately the effort, harvest and discard of the boat-based and shore-based fisheries separately in the lower Macleay River recognised that important differences existed between these two fisheries. We used stratified random sampling procedures as the basis of the survey design and integrated many data quality checks into the survey work (see Methods). In summary, this survey provides valuable baseline information about the boat-based and shore-based recreational fisheries in the lower Macleay River, collected using statistically sound survey methods which, if repeated, can be used to assess future changes in the fishery.

4.2. Demography of the recreational fishing population

We found that the recreational fishing population of the lower Macleay River was dominated by males - 82% of the boat-based fishers and 79% of the shore-based fishers interviewed were male (Table 7). It is a well established fact that recreational fishing is a male dominated activity in Australia (see McGlennon 1995 for a review of national and statewide demographic characteristics of recreational fishing populations). A national study and all six statewide studies completed during the period 1978 to 1987 show that the proportion of male participants in the recreational
fishing population ranged from approximately 67% to 75% (McGlennon 1995). The slightly higher proportions recorded during our on-site survey in the lower Macleay River were probably a reflection of the avidity of male fishers. It is well known that fishers are sampled in proportion to their avidity during on-site surveys and that off-site surveys, such as the telephone surveys used to collect statewide participation rates and demographics, sample fishers with equal probability (Pollock et al. 1994).

We found that approximately 48% of the fishers interviewed were of local origin, ranging from approximately 43% from the local area in the boat-based fishery to approximately 51% in the shore-based fishery (Table 8). It is not possible to use these data to assess whether the closure of the river to recreational fishing had an impact on tourist numbers in the area. However, these data are useful as a baseline for assessing future changes in the fishery.

4.3. Recreational effort, harvest and discard

We estimated that approximately 78,800 fisher hours of daytime recreational effort was expended in the lower Macleay River during the survey period - July to October 2001 inclusive (Table 2). The highest levels of effort were found in July (approximately 26,900 fisher hours) and August (approximately 23,900 fisher hours), while the lowest levels of effort were recorded in September (approximately 12,800 fisher hours) and October (approximately 15,200 fisher hours). This monthly pattern of effort is similar to the monthly effort trend found in the Richmond River. A concurrent survey in the lower Richmond River found highest monthly effort in July, an intermediate level of effort in August and the lowest levels of effort were recorded during September and October 2001 (Steffe and Macbeth 2002). Similarly, West and Gordon (1994) surveyed a much larger part of the Richmond River during 1988 and 1989 and reported monthly estimates of angling effort of approximately 21,500 angler hours for July, approximately 20,000 angler hours for August, approximately 9,500 angler hours for September and approximately 18,000 angler hours for October. The apparent similarities in monthly effort patterns in all three studies suggests that these effort data are showing a seasonal trend.

We recorded 16 taxa in the retained catch of recreational fishers accessing the lower Macleay River fishery by boat and from the shore during the survey period (Table 17). We estimated that approximately 45,300 fish and crustaceans (± 4,205 individuals - approximate SE) were harvested by daytime recreational fishers from the lower Macleay River during the survey period (Table 17) and that this recreational harvest consisted almost exclusively of finfish (>99% of harvest) - (Table 17). The six most commonly harvested taxa, by number, during the survey period were luderick (≈29,110 fish - ≈ 16.5 tonnes), yellowfin bream (≈9,250 - ≈ 4.7 tonnes), dusky flathead (≈3,760 - ≈ 1.9 tonnes), striped spadefish (≈1,220 - ≈ 0.1 tonnes), tailor (≈670 - ≈ 0.3 tonnes), and sand mullet (≈600 - < 0.1 tonnes) - (Tables 17 and 18). These six taxa, by number, accounted for 98.5% of the daytime recreational harvest during the survey period (Table 17). The species composition and the selective nature of the recreational harvest (i.e. six species making the bulk of the harvest) in the current study are consistent with the findings of other surveys (West and Gordon 1994, Steffe and Macbeth 2002, NSW Fisheries unpublished data). The six main species in the recreational harvest of the lower Richmond River during the same period were luderick, yellowfin bream, dusky flathead, sand mullet, tailor and sand whiting and these six taxa, by number, accounted for 97.3% of the daytime recreational harvest (Steffe and Macbeth 2002). The six main species in the recreational harvest during the Richmond River survey in 1988 and 1989 were yellowfin bream, southern herring, dusky flathead, sand whiting, tailor and luderick and these species, by number, accounted for approximately 95% of the harvest (West and Gordon 1994). The six main species in the recreational harvest during the March to July 1990 period were yellowfin bream, luderick, dusky flathead, mulloway, southern herring and sand whiting and these species, by number, accounted for 98.3% of the harvest (NSW Fisheries unpublished data).
These comparisons indicate that great similarities exist between the recreational fisheries in the Richmond and Macleay Rivers. The limited comparison between the 1990 survey data and the current study suggests that there have not been any major changes in the structure of the recreational fishery in the lower Macleay River. Recreational anglers are still targeting and harvesting much the same species in the river and the monthly patterns of targeting and harvesting that we have documented are consistent with normal seasonal changes observed in the lower Richmond River.

The size of the recreational harvest taken during the four month survey period can be put in context by considering the relative sizes of the fish mortality caused by the major flooding and subsequent deoxygenation of the lower reaches of the Macleay river during the middle of March 2001. Westlake and Copeland (2002) consulted local Fisheries officers, local council staff, commercial and recreational fishers and members of the general public to determine the size of the fish-kill in the lower Macleay River. Westlake and Copeland (2002) have estimated the number of dead fish in a 1.5 km stretch of the lower Macleay River, near the town of South West Rocks, at approximately 180,000 individual fish of various species. The Macleay River fish-kill event was apparently smaller than that in the Richmond River which was estimated to have killed over two million fish, prawns, crabs and bloodworms (Westlake and Copeland 2002). Anecdotal accounts provided by local fishers indicate that the fish-kill event was concentrated in the main reach of the Macleay River and that some other areas in the river were not affected greatly. For example, local fishers observed large schools of apparently healthy fish, mainly mullet and luderick, in the Stuarts Point arm during the time of the major fish-kill in the lower Macleay River.

In comparison, the number of fish and crabs harvested by recreational fishers during the survey period were estimated as approximately 45,300 individuals (Table 17) which is approximately one quarter of the size of the mortality estimate provided by Westlake and Copeland (2002) for a 1.5 km stretch of the lower Macleay River in mid-March 2001. The two main species taken by recreational fishers, by number, during the survey period were luderick (64.2% of total harvest) and yellowfin bream (20.4% of total harvest) – (Table 17). The highest monthly estimates of harvest for luderick and yellowfin bream were recorded during July with harvest levels declining in the subsequent months. This suggests that large populations of luderick and yellowfin bream were resident in the lower Macleay River when it was re-opened to limited recreational fishing. A combination of factors which are not mutually exclusive may explain the apparent abundance of luderick and yellowfin bream in the river following the flood event. First, it is common for large schools of luderick and yellowfin bream to migrate between estuaries on the mid-north coast during the Winter and Spring seasons. Second, it is possible that the water quality remained good in some areas within the Macleay river system during the time of the major fish-kill in the main arm of the river and that these areas of good water quality were used by fish as refuges. Fish surviving in these refuge areas could have recolonised the main river channel as soon as there was an improvement in water quality. The anecdotal accounts provided by local fishers of large schools of fish in the Stuarts Point arm support this refuge area hypothesis. Third, the availability of food was not a limiting factor for luderick in the lower Macleay River after the flood event. Luderick are mainly herbivorous and it is believed that the algal food source of luderick in the lower Macleay River was not reduced greatly following the flood event. In contrast, the benthic food source of carnivorous and omnivorous fish such as yellowfin bream and dusky flathead may have been reduced by the fish-kill event and this in turn could have had an adverse effect on localised fish abundance. Westlake and Copeland (2002) provided evidence of mass mortality of prawns and blood worms, important food sources for many species of fish, during the Richmond River fish-kill. We believe it is plausible to suggest that the populations of prawns and worms would also have been impacted adversely in the lower Macleay River during the time of the large fish-kill (see Macbeth et al. 2002), however, the magnitude of any potential reduction in the populations of these taxa remains unknown.
Recreational fishers (boat-based and shore-based) reported discarding 26 taxa whilst fishing in the lower Macleay River during the survey period (Table 23). We estimated that approximately 34,310 fish and crabs (± 2,060 individuals - approximate SE) were discarded by daytime recreational fishers in the lower Macleay River during the survey period (Table 23) and that this recreational discard consisted almost exclusively of finfish (>99% of harvest) - (Table 23). The six most commonly discarded taxa, by number, during the survey period were yellowfin bream (=22,260 - 64.8%), luderick (=5,200 - 15.2%), dusky flathead (=3,590 - 10.5%), sand whiting (=1,250 – 3.6%), tailor (=1,040 – 3.0%), and silver batfish (=470 - 1.4%) - (Table 23). These six taxa, by number, accounted for 98.5% of the total daytime recreational discard during the survey period (Table 23). The great majority of discarded yellowfin bream (94.7%), sand whiting (97.6%), luderick (82.9%), dusky flathead (76.7%) and tailor (75.0%) were below the legal minimum length. Discard data should be viewed with some caution because they are self-reported and less accurate than harvest data, which are collected by direct observation. Consequently, discard data suffer from additional biases such as rounding errors when reporting discard numbers, fish identification errors when reporting the species that were discarded, and recall problems when providing information about their discards. Even so, these discard data show that recreational fishers were catching and returning to the water large numbers of juvenile fish which suggests that the juveniles of these popular angling species were abundant in the lower Macleay River during the time of the survey.

4.4. Indicators of recreational fishing quality

Reliable indicators of recreational fishing quality for estuarine fisheries can provide a cost-effective means for monitoring and comparing the relative quality of important recreational fisheries. We have presented four indicators in this study: the proportion of unsuccessful fishing parties, non-directed harvest rates for the boat-based and shore-based fisheries, non-directed discard rates for the boat-based and shore-based fisheries and size-frequency distributions for some important taxa harvested by the recreational sector. The proportion of unsuccessful fishing parties is a measure of “lack of success” and it is believed that a strong positive correlation exists between the experience of fishers and the size of their harvests. That is, the least experienced fishers tend to catch fewer fish and the more experienced fishers tend to have larger harvests. Therefore, changes in the proportion of unsuccessful fishing parties through time would provide an indication of changes in a fishery (beneficial or detrimental) because they affect the largest and most inexperienced group of fishers in the recreational fishing population. The proportion of unsuccessful boat-based fishing parties ranged from approximately 22% to 51% on a monthly basis (Fig. 2) whilst the proportion of unsuccessful shore-based fishing parties was relatively higher ranging from approximately 54% to 74% on a monthly basis (Fig. 2). In both fisheries the lowest proportion of unsuccessful fishing trips was recorded during July, immediately after the river was re-opened to recreational fishing, and higher proportions of unsuccessful fishing parties were recorded in the following months (Fig. 2). These data suggest that the quality of recreational fishing was best in July after the river had been re-opened to recreational fishing and that there had been a gradual decline in fishing quality in the following months. The reason for these trends in the boat and shore fisheries was probably a combination of seasonal fish abundances and the large amount of fishing effort that occurred immediately after the fishery was re-opened.

The harvest rates and discard rates we calculated and presented are based on the total non-directed fishing effort. We provide harvest rate comparisons for luderick (Table 26), yellowfin bream (Table 27) and dusky flathead (Table 28) taken by boat-based and shore-based recreational fishers during this study, a concurrent survey done in the Richmond River (Steffe and Macbeth 2002), the recreational shore and boat fisheries in Lake Macquarie during the 1999 Winter and Spring seasons (Steffe and Chapman 2002), and the recreational boat-based fishery in Tuross Lake during the 1999 Winter and Spring seasons (Steffe and Chapman in prep.). It should be noted that seasonal harvest rate estimates will tend to be lower than the peak monthly harvest rate estimate...
because seasonal harvest rates incorporate any variability that occurs on smaller temporal scales (e.g. monthly or weekly variability). Even so, these seasonal harvest rates provide a general baseline that can be used to evaluate the relative size of the monthly harvest rates.

The harvest rates observed during this four month survey are similar to the comparable harvest rate data collected in other estuarine fisheries in New South Wales (see Tables 26, 27 and 28). The boat-based harvest rate for luderick in the lower Macleay River during July 2001 is the highest harvest rate for this species among the tabulated comparisons for the boat-based fisheries (Table 26). The monthly harvest rates for yellowfin bream and dusky flathead taken by boat-based fishers in the lower Macleay River all fall within the range of harvest rates recorded from other estuaries (Tables 27 & 28). The monthly harvest rates for luderick taken by shore-based fishers in the lower Macleay were relatively high but within the range of harvest rates recorded from other estuaries (Table 26). The boat-based harvest rate for yellowfin bream during July 2001 in the lower Macleay River is the highest harvest rate for this species among the tabulated comparisons for the boat-based fisheries (Table 26). The monthly harvest rates for luderick taken by shore-based fishers in the lower Macleay were relatively high but within the range of harvest rates recorded from other estuaries (Table 26). The shore-based harvest rate for yellowfin bream during July 2001 in the lower Macleay River is the highest harvest rate for this species among the tabulated comparisons for the shore-based fisheries (Table 27), however, this harvest rate was only marginally higher than that recorded in the Richmond River during the same month. Dusky flathead harvest rates for shore-based fishers tended to be relatively low across all estuaries (Table 28). The highest shore-based harvest rate for dusky flathead among the tabulated comparisons was recorded during September 20001 in the lower Macleay River (Table 28). The harvest rate similarities among estuarine fisheries suggest that the quality of recreational fishing was quite good for boat-based and shore-based fishers during the survey period in the lower Macleay River. A similar conclusion is reached when examining discard rate data. High rates of discard were reported for the main species of recreational interest during the survey period (Tables 10 to 15) indicating that juvenile fish were abundant in the lower Macleay River. The use of harvest rates and discard rates as indicators of recreational fishing quality would be improved by using the directed fishing effort that is targeted at a particular species of interest. In this way, a multi-species fishery could be partitioned according to the targeting preferences of fishers and more accurate harvest rate comparisons could be made among sites and through time (Steffe and Murphy 1995).

The use of size-frequency distributions complements the interpretations made from harvest rate data. For example, it is conceivable that the harvest in a fishery, measured in terms of the number of fish taken, could remain constant through time but that the average size of the fish has become smaller. The regular monitoring of size-frequency distributions taken from the recreational fishery would allow the detection of this type of change in the fishery. The size frequency distributions of luderick, yellowfin bream, dusky flathead, sand whiting and tailor (Fig. 3) that were harvested by recreational fishers during the survey period are similar to size frequency distributions found in other NSW estuarine fisheries at the same time of year (West and Gordon 1994, Steffe and Chapman 2002). It is noteworthy that large individuals that were highly-prized by fishers were commonly observed in the recreational harvest indicating that the quality of recreational fishing opportunities in this fishery were quite good (Fig. 3).

Size-frequency distributions of species having minimum legal length restrictions are also useful for evaluating compliance rates for the fishery. The proportion of undersized fish in the recreational harvest could also be used as an important indicator of fishing quality because the rate of compliance with regulations may be directly linked to the availability of legal sized fish to the recreational fishing population. For example, the proportion of undersized fish retained would be expected to be low when legal sized fish are abundant in a fishery, and conversely, in fisheries that contain relatively low numbers of legal sized fish it should be expected that compliance rates would be lower and that the proportion of undersized fish retained would be higher. The proportions of undersized fish retained by recreational fishers in the lower Macleay River fishery (boat and shore-based) were comparable to rates measured in some other estuarine fisheries in NSW (West and Gordon 1994, Steffe and Chapman 2002). We found that the proportions of under-sized yellowfin bream and luderick in the recreational harvest were extremely low (2.1% and 1.0% respectively), indicating good compliance with fisheries regulations (Fig. 3a & 3b). We
did not record any under-sized tailor in the recreational harvest but this figure is based on a small number of fish (Fig. 3e). The proportions of under-sized dusky flathead and sand whiting in the recreational harvest were around 8% (Fig. 3c & 3d).

The use of these indicators is not intended to be an exhaustive analysis of the recreational survey data. We recommend that further analyses be done on the survey data to provide additional indicators, which could be used to assess future changes in the lower Macleay River fishery.
Table 26. Recreational harvest rate estimates (fish per fisher hour ± standard error) for Luderick (*Girella tricuspidata*) taken by: (a) boat-based fishers in the northern Lake, southern Lake, and Swansea Channel areas of Lake Macquarie and in Tuross Lake during Winter and Spring 1999; (b) boat-based fishers in the Richmond River and Macleay River during the period July to October 2001; (c) shore-based fishers in the northern Lake, southern Lake, and Swansea Channel areas of Lake Macquarie during Winter and Spring 1999; and (d) shore-based fishers in the Richmond River and Macleay River during the period July to October 2001.

### A. BOAT FISHERY - LUDERICK

<table>
<thead>
<tr>
<th>Season/Year</th>
<th>LAKE MACQUARIE</th>
<th>TUROSS LAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NORTHERN LAKE</td>
<td>SOUTHERN LAKE</td>
</tr>
<tr>
<td>Winter 1999</td>
<td>0.052 ± 0.039</td>
<td>-</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>0.115 ± 0.113</td>
<td>-</td>
</tr>
</tbody>
</table>

### B. BOAT FISHERY - LUDERICK

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>RICHMOND RIVER</th>
<th>MACLEAY RIVER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Harvest Rate</td>
<td>Harvest Rate</td>
</tr>
<tr>
<td></td>
<td>(fish/fisher hr)</td>
<td>(fish/fisher hr)</td>
</tr>
<tr>
<td>July 2001</td>
<td>0.272 ± 0.052</td>
<td>0.973 ± 0.106</td>
</tr>
<tr>
<td>August 2001</td>
<td>0.200 ± 0.051</td>
<td>0.567 ± 0.110</td>
</tr>
<tr>
<td>September 2001</td>
<td>0.316 ± 0.088</td>
<td>0.210 ± 0.036</td>
</tr>
<tr>
<td>October 2001</td>
<td>0.004 ± 0.003</td>
<td>0.074 ± 0.029</td>
</tr>
</tbody>
</table>

### C. SHORE FISHERY - LUDERICK

<table>
<thead>
<tr>
<th>Season/Year</th>
<th>LAKE MACQUARIE</th>
<th>SWANSEA CHANNEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NORTHERN LAKE</td>
<td>SOUTHERN LAKE</td>
</tr>
<tr>
<td>Winter 1999</td>
<td>-</td>
<td>0.688 ± 0.114</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>0.016 ± 0.016</td>
<td>0.736 ± 0.116</td>
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<tr>
<td></td>
<td></td>
<td>0.128 ± 0.039</td>
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<tr>
<td></td>
<td></td>
<td>0.184 ± 0.062</td>
</tr>
</tbody>
</table>

### D. SHORE FISHERY - LUDERICK

<table>
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<th>Month/Year</th>
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<th>MACLEAY RIVER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Harvest Rate</td>
<td>Harvest Rate</td>
</tr>
<tr>
<td></td>
<td>(fish/fisher hr)</td>
<td>(fish/fisher hr)</td>
</tr>
<tr>
<td>July 2001</td>
<td>0.246 ± 0.053</td>
<td>0.350 ± 0.046</td>
</tr>
<tr>
<td>August 2001</td>
<td>0.263 ± 0.032</td>
<td>0.431 ± 0.131</td>
</tr>
<tr>
<td>September 2001</td>
<td>0.311 ± 0.070</td>
<td>0.029 ± 0.013</td>
</tr>
<tr>
<td>October 2001</td>
<td>0.066 ± 0.020</td>
<td>0.026 ± 0.019</td>
</tr>
</tbody>
</table>

1 Steffe and Chapman (2002)
2 Steffe and Chapman (in preparation)
3 Steffe and Macbeth (2002)
4 This study
Table 27. Recreational harvest rate estimates (fish per fisher hour ± standard error) for Yellowfin Bream (*Acanthopagrus australis*) taken by: (a) boat-based fishers in the northern Lake, southern Lake, and Swansea Channel areas of Lake Macquarie and in Tuross Lake during Winter and Spring 1999; (b) boat-based fishers in the Richmond River and Macleay River during the period July to October 2001; (c) shore-based fishers in the northern Lake, southern Lake, and Swansea Channel areas of Lake Macquarie during Winter and Spring 1999; and (d) shore-based fishers in the Richmond River and Macleay River during the period July to October 2001.

### A. BOAT FISHERY - YELLOWFIN BREAM

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<th>Season/Year</th>
<th>Lake Macquarie</th>
<th>Tuross Lake</th>
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</tr>
<tr>
<td></td>
<td>(fish/fisher hr)</td>
<td>(fish/fisher hr)</td>
</tr>
<tr>
<td>Winter 1999</td>
<td>0.058 ± 0.032</td>
<td>0.002 ± 0.001</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>0.025 ± 0.011</td>
<td>0.036 ± 0.022</td>
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### B. BOAT FISHERY - YELLOWFIN BREAM

<table>
<thead>
<tr>
<th>Month/Year</th>
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<th>Macleay River</th>
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<td>Harvest Rate</td>
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<tr>
<td></td>
<td>(fish/fisher hr)</td>
<td>(fish/fisher hr)</td>
</tr>
<tr>
<td>July 2001</td>
<td>0.113 ± 0.021</td>
<td>0.096 ± 0.023</td>
</tr>
<tr>
<td>August 2001</td>
<td>0.073 ± 0.011</td>
<td>0.084 ± 0.029</td>
</tr>
<tr>
<td>September 2001</td>
<td>0.031 ± 0.023</td>
<td>0.029 ± 0.008</td>
</tr>
<tr>
<td>October 2001</td>
<td>0.059 ± 0.014</td>
<td>0.025 ± 0.010</td>
</tr>
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### C. SHORE FISHERY - YELLOWFIN BREAM

<table>
<thead>
<tr>
<th>Season/Year</th>
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</thead>
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<tr>
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<td>Harvest Rate</td>
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<tr>
<td></td>
<td>(fish/fisher hr)</td>
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<tr>
<td>Winter 1999</td>
<td>0.010 ± 0.005</td>
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<tr>
<td>Spring 1999</td>
<td>0.022 ± 0.008</td>
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<table>
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<tr>
<th>Season/Year</th>
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<td>Harvest Rate</td>
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<tr>
<td></td>
<td>(fish/fisher hr)</td>
</tr>
<tr>
<td>Winter 1999</td>
<td>0.014 ± 0.008</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>0.024 ± 0.009</td>
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### D. SHORE FISHERY - YELLOWFIN BREAM

<table>
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<tr>
<th>Month/Year</th>
<th>Richmond River</th>
<th>Macleay River</th>
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<tbody>
<tr>
<td></td>
<td>Harvest Rate</td>
<td>Harvest Rate</td>
</tr>
<tr>
<td></td>
<td>(fish/fisher hr)</td>
<td>(fish/fisher hr)</td>
</tr>
<tr>
<td>July 2001</td>
<td>0.177 ± 0.035</td>
<td>0.186 ± 0.011</td>
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<tr>
<td>August 2001</td>
<td>0.132 ± 0.028</td>
<td>0.152 ± 0.027</td>
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<tr>
<td>September 2001</td>
<td>0.064 ± 0.026</td>
<td>0.122 ± 0.018</td>
</tr>
<tr>
<td>October 2001</td>
<td>0.033 ± 0.010</td>
<td>0.090 ± 0.023</td>
</tr>
</tbody>
</table>

1 Steffe and Chapman (2002)
2 Steffe and Chapman (in preparation)
3 Steffe and Macbeth (2002)
4 This study
Table 28. Recreational harvest rate estimates (fish per fisher hour ± standard error) for Dusky Flathead (*Platycephalus fuscus*) taken by: (a) boat-based fishers in the northern Lake, southern Lake, and Swansea Channel areas of Lake Macquarie and in Tuross Lake during Winter and Spring 1999; (b) boat-based fishers in the Richmond River and Macleay River during the period July to October 2001; (c) shore-based fishers in the northern Lake, southern Lake, and Swansea Channel areas of Lake Macquarie during Winter and Spring 1999; and (d) shore-based fishers in the Richmond River and Macleay River during the period July to October 2001.

### A. BOAT FISHERY - DUSKY FLATHEAD

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<tr>
<th>Season/Year</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LAKE MACQUARIE¹</td>
<td>SOUTHERN LAKE</td>
<td>SWANSEA CHANNEL</td>
<td>TUROSS LAKE²</td>
</tr>
<tr>
<td>Winter 1999</td>
<td>0.006 ± 0.002</td>
<td>0.001 ± 0.001</td>
<td>-</td>
<td>0.027 ± 0.014</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>0.021 ± 0.011</td>
<td>0.022 ± 0.015</td>
<td>0.031 ± 0.017</td>
<td>0.133 ± 0.034</td>
</tr>
</tbody>
</table>

### B. BOAT FISHERY - DUSKY FLATHEAD

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RICHMOND RIVER³</td>
<td>MACLEAY RIVER⁴</td>
</tr>
<tr>
<td>July 2001</td>
<td>0.084 ± 0.018</td>
<td>0.049 ± 0.022</td>
</tr>
<tr>
<td>August 2001</td>
<td>0.084 ± 0.020</td>
<td>0.042 ± 0.011</td>
</tr>
<tr>
<td>September 2001</td>
<td>0.066 ± 0.019</td>
<td>0.052 ± 0.014</td>
</tr>
<tr>
<td>October 2001</td>
<td>0.081 ± 0.016</td>
<td>0.118 ± 0.026</td>
</tr>
</tbody>
</table>

### C. SHORE FISHERY - DUSKY FLATHEAD

<table>
<thead>
<tr>
<th>Season/Year</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LAKE MACQUARIE¹</td>
<td>SOUTHERN LAKE</td>
<td>SWANSEA CHANNEL</td>
<td></td>
</tr>
<tr>
<td>Winter 1999</td>
<td>0.011 ± 0.009</td>
<td>&lt;0.001 ± &lt;0.001</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Spring 1999</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.003 ± 0.002</td>
</tr>
</tbody>
</table>

### D. SHORE FISHERY - DUSKY FLATHEAD

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Harvest Rate (fish/fisher hr)</th>
<th>Harvest Rate (fish/fisher hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RICHMOND RIVER³</td>
<td>MACLEAY RIVER⁴</td>
</tr>
<tr>
<td>July 2001</td>
<td>0.033 ± 0.008</td>
<td>0.026 ± 0.005</td>
</tr>
<tr>
<td>August 2001</td>
<td>0.022 ± 0.007</td>
<td>0.022 ± 0.007</td>
</tr>
<tr>
<td>September 2001</td>
<td>0.021 ± 0.006</td>
<td>0.062 ± 0.018</td>
</tr>
<tr>
<td>October 2001</td>
<td>0.018 ± 0.006</td>
<td>0.025 ± 0.008</td>
</tr>
</tbody>
</table>

¹ Steffe and Chapman (2002)
² Steffe and Chapman (in preparation)
³ Steffe and Macbeth (2002)
⁴ This study
4.5. Status of the recreational fisheries in the lower Macleay River

Fisheries managers and the general public will inevitably ask whether the recreational fishery (shore and boat-based) in the Macleay River has recovered from the impact of the March fish-kill event. This important question cannot be answered directly because we do not have any detailed information describing the status of estuarine fish stocks or the recreational boat and shore fisheries in the Macleay River immediately before the fish-kill event nor do we have information about other non-impacted estuarine recreational fisheries in the region that could be used as controls or reference sites. Therefore, we are restricted to making inferences about the recovery of estuarine fish stocks and the status of the recreational fisheries from limited comparisons with previous studies and by examining a number of indicators of recreational fishing quality that have been derived from the current survey.

The available information indicates that a major flood in March 2001 led to deoxygenation of the water in the lower Macleay River and this was the direct cause of a large fish-kill event in the river (Westlake and Copeland 2002). We know that: (a) large numbers of important recreational and commercial fish species such as yellowfin bream, dusky flathead, luderick, sand whiting and Australian bass were killed by the anoxic conditions; (b) large numbers of hardy species such as mullet, eels and mudcrabs were also killed; (c) large numbers of important prey animals such as school prawns were killed. The evidence strongly suggests that most fish of recreational importance were flushed from the river system, migrated actively away from areas of poor water quality or were killed by the anoxic water during the period of the fish-kill. The government responded to this fish-kill event by closing the river to recreational and commercial fishing for a period of approximately three and a half months. The lower Macleay River was re-opened to limited recreational and commercial fishing at the start of July 2001.

The recreational fishing survey data indicate that: (a) the levels of monthly fishing effort recorded were similar to effort estimates recorded during a concurrent survey in the lower Richmond River and to estimates reported from 1988 and 1989 data in a much larger part of the Richmond River system; (b) the levels of monthly effort showed a seasonal pattern; (c) the monthly patterns of targeting and harvesting by boat-based and shore-based recreational fishers were consistent with expected seasonal changes in these fisheries; (d) the quality of recreational fishing was best during July after the river had been re-opened presumably because of a combination of seasonal fish abundances and a high level of recreational fishing effort after a long period of fishery closure; (e) the species composition and the selective nature of the recreational harvest were consistent with the findings of previous survey work; (f) the harvest rates of the main angling species were similar, and in some cases higher, than comparable data from other estuarine fisheries in NSW; (g) large populations of luderick and yellowfin bream were resident within the lower Macleay River when the fishery was re-opened; (h) highly-prized, large individuals were commonly observed in the recreational harvest of luderick, dusky flathead and yellowfin bream indicating that the quality of recreational fishing opportunities in this area were quite good; (i) large numbers of juvenile fish were caught and returned to the water by recreational fishers which suggests that the juveniles of these popular angling species were abundant in the lower Macleay River during the survey period; and (j) for the main angling target species, the proportions of under-sized fish retained by recreational fishers were similar to the rates measured in some other NSW estuarine fisheries.

The interpretation of the available evidence strongly suggests that the recreational fisheries in the lower Macleay River are still productive and providing quality recreational fishing opportunities despite the adverse impacts of the March 2001 fish-kill event. We recommend that statistical power analyses be done on the dataset collected during this study before starting any future surveys or monitoring of the recreational fishery in the lower Macleay River. Power analyses are based on four parameters of statistical inference: power, significance criterion, sample size, and effect size (Cohen 1988). The use of appropriate power analyses that specify the values of power,
significance criterion and effect size should be done to determine, in a scientifically defensible way, the necessary sample size needed to detect future changes in the lower Macleay River fishery.

5. RECOMMENDATIONS

When based on statistically valid survey designs, on-site surveys of recreational fishing are valuable tools for collecting information to describe the status of a recreational fishery. We recommend the use of such surveys in conjunction with fishery-independent population assessment techniques should future fish-kill events occur.

On-site recreational fishing surveys should be repeated periodically to monitor the recreational fishery in the lower Macleay River. The intervals between surveys should be relatively short. It is our opinion that intervals of 3-5 years between surveys would be sufficient for monitoring changes in the recreational fishery.

Before future surveys or monitoring programmes are done in the lower Macleay River, it is recommended that statistical power analyses should be done of the recreational fishing dataset collected during this study. Power analyses are vital for determining scientifically defensible and cost-effective survey designs that have sufficient statistical power to detect changes in the recreational fishery throughout time.

The development of robust and reliable indicators of recreational fishing quality would lead to more cost-effective ways of monitoring estuarine fisheries throughout NSW. We recommend that additional work be done to develop robust and reliable indicators of fishing quality for all recreational fisheries in NSW. This would require more detailed analyses of: (a) the data collected during this survey; and (b) the survey data collected during previous recreational fishing surveys done in NSW.
6. REFERENCES


7. **APPENDICES**

**Appendix 1.** Glossary of technical terms. This is a modified version of the glossary provided by Pollock *et al.* (1994).

The terms in this glossary are defined in the context of recreational fishing, the focus of this report. Some terms may have slightly different (but analogous) meanings for recreational and commercial fishing.

**Access point design:** an on-site, intercept design that is used when fishers use defined access points to enter and leave the fishery. This method works best when there are few access points (e.g. boat ramps, wharves, breakwalls) and most fishers use these defined access points. The access point design can be used to estimate fishing effort, harvest rates and harvest and relies on complete trip interviews. (Compare *Roving design.*)

**Accuracy:** Degree of conformity to a true value. An accurate estimator has a small mean squared error, implying little or no bias and small standard error. (Compare *Precision.*)

**Angler:** Person participating in a line fishing activity. Recreational line fishing activities include trolling, drifting, fishing with lures or bait. (Compare *Fisher.*)

**Angler survey:** General term for any survey of anglers by an off-site method (mail, telephone, door-to-door) or an on-site method (access, roving, aerial). (Compare *Creel survey.*)

**Avidity bias:** Bias arising in on-site surveys when anglers are sampled in proportion to their fishing avidity (time spent fishing or frequency of fishing), not with equal probability.

**Biased estimator:** Estimator whose average value over many hypothetical repetitions of a study deviates from the true parameter value.

**Catch rate:** Number or weight of all fish caught (kept or released) per trip, per angler hour, or per some other unit of fishing effort. The catch per unit effort can be used as a measure of success rate. (Compare *Harvest rate.*)

**Catch:** Number or weight of all fish caught, whether the fish are kept or released. Sometimes the term is also used (less precisely) to mean harvest. (Compare *Harvest.*)

**Census:** Sampling of every unit in the sampled population.

**Complemented survey:** Survey combining two or more contact methods (e.g., a telephone survey to estimate effort and an access survey to estimate catch rate).

**Complete trip interview:** Interview conducted as an angler leaves the water at the end of fishing. (Compare *Incomplete trip interview.*)

**Consistent estimator:** Estimator that gets closer and closer to the true parameter value as the size of the sample increases.

**Contact method:** Any method used to contact fishers for a survey (mail, telephone, door-to-door, access, roving, or aerial).
Creel survey: On-site angler survey during which the harvests of fishers are examined by the survey agent.

Direct impact of fishing: The immediate, main effect caused by fishers on a population or stock. In any extractive fishery (recreational or commercial) this main, immediate impact can be assessed by estimating the harvest. (Compare Indirect impact of fishing.)

Directed fishing effort: Fishing effort directed at a particular species or group of species. (Compare Non-directed fishing effort.)

Directed harvest rate: A harvest rate that has been calculated using directed fishing effort and the associated harvest from that directed effort. (Compare Non-directed harvest rate.)

Discard: That part of the catch that is not kept. (Compare Catch, Harvest.)

Discard rate: Number of fish released (fish kept are not included) per trip, per angler hour, or per some other unit of fishing effort. The discard per unit effort can be used as a measure of success rate for the released component of the catch. (Compare Catch rate, Harvest rate.)

Effort: See Fishing effort.

Estimate: Realised value of an estimator calculated from a particular sample.

Estimation methods: General term to describe the methods used to calculate estimates of population parameters (e.g. effort, harvest rate, and harvest) and estimates of their precision (e.g. variances and standard errors). (Compare Survey methods.)

Estimator: Formula or sample statistic used to estimate a population parameter.

Fisher: Person participating in any fishing activity. Recreational fishing activities include all forms of line fishing, bait collecting, and the setting of crab traps. (Compare Angler.)

Fishing effort (fishing pressure): A measure of resource use by anglers or fishers. Typical units of effort are number of trips on the water, angler hours, party hours, and boat hours.

Fishing party: A group of anglers or fishers participating in a recreational fishing activity. A fishing party can consist of a single individual or a large number of persons fishing together.

Frame: See Sampling frame.

Harvest: Number or weight of the fish caught that are kept, not released. (Compare Catch.)

Harvest rate: Number or weight of fish retained (fish released are not included) per trip, per angler hour, or per some other unit of fishing effort. The harvest per unit effort can be used as a measure of success rate. (Compare Catch rate.)

Incomplete trip interview: Interview conducted before an angler has finished fishing. (Compare Complete trip interview.)

Indirect impact of fishing: An incidental, secondary effect caused by fishers on a population or stock. In any extractive fishery (recreational or commercial) these secondary impacts may include physical and genetic changes in population structures, post-release mortality of discards, and numerous effects on fish and fish habitats caused by factors such as pollution.
from outboard motors, anchoring in seagrass beds, loss of lead sinkers and fishing lines. (Compare Direct impact of fishing.)

**Independence:** See Statistical independence.

**Instantaneous count:** Count of anglers/fishers or boats made quickly from an aeroplane, a vantage point (bridge, hilltop, etc.), a fast-moving boat, or an automobile. (Compare Progressive count.)

**Large individual:** Being of more than common size.

**Length-of-stay bias:** Bias arising in roving surveys when anglers are interviewed with probability proportional to the length of their fishing trip, not with equal probability.

**Mean:** The arithmetic mean or average is calculated by summing all the individual observations (sampling units) of a sample and dividing this sum by the number of observations in the sample.

**Median:** The value of a variable (in an ordered array) that has an equal number of observations on either side of it. The median is used to divide a frequency distribution into two halves.

**Non-directed fishing effort:** The combined fishing effort regardless of targeting preferences. This term refers to the amalgamation of directed effort for different species and species groups and the effort of generalist fishers that had no specific target species. (Compare Directed fishing effort.)

**Non-directed harvest rate:** A harvest rate that has been calculated using non-directed fishing effort and the associated harvest from that non-directed effort. (Compare Directed harvest rate.)

**Non-response bias:** Bias arising when people refuse or are unable to answer a survey question. (See Refusal rate.)

**Off-site survey:** A recreational fishing survey that is carried out away from the fishing sites of a defined fishery. Off-site survey methods include mail, telephone, door-to-door, logbooks, diaries and catch cards. (Compare On-site survey.)

**On-site survey:** A recreational fishing survey that is carried out at the fishing sites within a defined fishery. On-site survey methods include access point, roving, and aerial surveys. (Compare Off-site survey.)

**Parameter:** Characteristic of the population under study.

**Precision:** Degree of variation. A precise estimator has a small standard error (or variance). (Compare Accuracy.)

**Probability sampling:** Sampling in which all possible samples have known probabilities of being drawn.

**Progressive count:** Count of anglers/fishers or boats made over time as a survey agent moves through a fishery area. Within each small subarea, the count may be instantaneous. (Compare Instantaneous count.)
Quality assurance: A continual process of checks and refinements aimed at maximising data integrity and hence also improving the credibility of survey results.

Random sampling: Independent sampling in which the replicate sampling units were selected at random for inclusion in the sample.

Recall bias: Bias arising when anglers/fishers inaccurately remember past events or the time in which they occurred.

Recreational fishing survey: General term for any survey of fishers by an off-site or on-site method. (Compare Angler survey.)

Refusal rate: The proportion of fishers or fishing parties that refused or were unable to answer survey questions. The refusal rate is an important measure of the non-response error within a survey. (See Non-response bias.)

Response error: Error arising because of recall, prestige, or rounding bias, or because an angler lied, misinterpreted a question, misidentified a species, or measured fish incorrectly.

Roving design: an on-site, intercept design that is used when access to a fishery is diffuse, occurring at too many points for the use of an access point survey. The roving design can be used to estimate fishing effort, harvest rates and harvest but relies on incomplete trip interviews. (Compare Access point design.)

Sample: Group of sampling units drawn from the sampled population.

Sample size: The number of sampling units in the sample.

Sampled population: Actual population from which information is collected. (Compare Target population.)

Sampling error: Error arising from improper sample selection, an incomplete sampling frame, duplications within the frame, avidity bias, or length-of-stay bias.

Sampling frame: Complete set or list of all sampling units.

Sampling unit: Basic unit of sampling (e.g., an angler/fisher, a fishing party, a fishing day or a particular combination of space and time).

Standard error: Square root of an estimator's variance.

Statistic: Characteristic of the sample drawn.

Statistical independence: The inherent assumption in all survey work that the sampling error associated with each sample is independent of the other samples. Random sampling is the mechanism used to safeguard against lack of independence problems.

Stratified sampling: Independent sampling within two or more defined subgroups of a sampled population. (See Stratum).

Stratum: A defined subgroup of a sampled population that does not overlap with any other subgroups and is of known size (See Stratified sampling.)
Survey error: General term embracing sampling, response, and non-response errors.

Survey methods: General term to describe the sampling methods used to survey the fishery (e.g. frame definition, levels of stratification, contact methods used, definition of basic sampling units, sample size). (Compare Estimation methods.)

Target population: Population about which information is desired. (Compare Sampled population.)

Unbiased estimator: Estimator whose average (or expected) value over many hypothetical repetitions of a study is the true parameter value.

Variance: The average (or expected) value of the squared deviations of an estimator from its expected value.
### Appendix 2.1. Recreational harvest rate and discard rate estimates (fish per boat hour ± standard error) for yellowfin bream (*Acanthopagrus australis*) taken by boat-based fishers in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate</th>
<th>Discard Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(fish/boat hr)</td>
<td>(fish/boat hr)</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.148 ± 0.053</td>
<td>0.287 ± 0.079</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.265 ± 0.071</td>
<td>0.531 ± 0.132</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.182 ± 0.043</td>
<td>0.358 ± 0.068</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.161 ± 0.072</td>
<td>0.236 ± 0.078</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.142 ± 0.027</td>
<td>0.443 ± 0.129</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.157 ± 0.054</td>
<td>0.290 ± 0.067</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.029 ± 0.021</td>
<td>0.213 ± 0.057</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.125 ± 0.025</td>
<td>0.250 ± 0.043</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.061 ± 0.016</td>
<td>0.225 ± 0.041</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.065 ± 0.027</td>
<td>0.391 ± 0.019</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.026 ± 0.012</td>
<td>0.544 ± 0.120</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.054 ± 0.020</td>
<td>0.435 ± 0.037</td>
</tr>
</tbody>
</table>

### Appendix 2.2. Recreational harvest rate and discard rate estimates (fish per boat hour ± standard error) for luderick (*Girella tricuspidata*) taken by boat-based fishers in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate</th>
<th>Discard Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(fish/boat hr)</td>
<td>(fish/boat hr)</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>1.924 ± 0.195</td>
<td>0.307 ± 0.089</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1.345 ± 0.206</td>
<td>0.305 ± 0.098</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1.756 ± 0.151</td>
<td>0.306 ± 0.098</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>1.014 ± 0.286</td>
<td>0.104 ± 0.032</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1.056 ± 0.195</td>
<td>0.110 ± 0.038</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1.025 ± 0.218</td>
<td>0.106 ± 0.026</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.390 ± 0.095</td>
<td>0.037 ± 0.017</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.563 ± 0.112</td>
<td>0.074 ± 0.039</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.448 ± 0.073</td>
<td>0.050 ± 0.017</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.171 ± 0.106</td>
<td>0 ± 0</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.190 ± 0.075</td>
<td>0.049 ± 0.039</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.177 ± 0.078</td>
<td>0.018 ± 0.012</td>
</tr>
</tbody>
</table>
### Appendix 2.3.
Recreational harvest rate and discard rate estimates (fish per boat hour ± standard error) for dusky flathead (*Platycephalus fuscus*) taken by boat-based fishers in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/boat hr)</th>
<th>SE</th>
<th>Discard Rate (fish/boat hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.098 ± 0.053</td>
<td></td>
<td>0.092 ± 0.035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.076 ± 0.020</td>
<td></td>
<td>0.112 ± 0.024</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.091 ± 0.038</td>
<td></td>
<td>0.098 ± 0.026</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>0.058 ± 0.018</td>
<td></td>
<td>0.137 ± 0.027</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.119 ± 0.022</td>
<td></td>
<td>0.164 ± 0.065</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.074 ± 0.015</td>
<td></td>
<td>0.144 ± 0.026</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.093 ± 0.043</td>
<td></td>
<td>0.149 ± 0.047</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.146 ± 0.031</td>
<td></td>
<td>0.207 ± 0.029</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.111 ± 0.030</td>
<td></td>
<td>0.168 ± 0.033</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>0.259 ± 0.066</td>
<td></td>
<td>0.291 ± 0.125</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.276 ± 0.056</td>
<td></td>
<td>0.264 ± 0.068</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.264 ± 0.050</td>
<td></td>
<td>0.283 ± 0.091</td>
<td></td>
</tr>
</tbody>
</table>

### Appendix 2.4.
Recreational harvest rate and discard rate estimates (fish per boat hour ± standard error) for sand whiting (*Sillago ciliata*) taken by boat-based fishers in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/boat hr)</th>
<th>SE</th>
<th>Discard Rate (fish/boat hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.011 ± 0.008</td>
<td></td>
<td>0.018 ± 0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.001 ± 0.001</td>
<td></td>
<td>0.028 ± 0.013</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.008 ± 0.006</td>
<td></td>
<td>0.021 ± 0.008</td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.002 ± 0.002</td>
<td></td>
<td>0.022 ± 0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.002 ± 0.001</td>
<td></td>
<td>0.006 ± 0.002</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>0.003 ± 0.003</td>
<td></td>
<td>0.004 ± 0.004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.012 ± 0.008</td>
<td></td>
<td>0.034 ± 0.014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.006 ± 0.003</td>
<td></td>
<td>0.014 ± 0.006</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td></td>
<td>0.047 ± 0.025</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.027 ± 0.017</td>
<td></td>
<td>0.018 ± 0.012</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.008 ± 0.005</td>
<td></td>
<td>0.039 ± 0.018</td>
<td></td>
</tr>
</tbody>
</table>
**Appendix 2.5.** Recreational harvest rate and discard rate estimates (fish per boat hour ± standard error) for tailor (*Pomatomus saltatrix*) taken by boat-based fishers in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/boat hr)</th>
<th>Discard Rate (fish/boat hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>0.002 ± 0.002</td>
<td>0.012 ± 0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.009 ± 0.005</td>
<td>0.031 ± 0.019</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.004 ± 0.002</strong></td>
<td><strong>0.018 ± 0.009</strong></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.010 ± 0.010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.005 ± 0.003</td>
<td>0.015 ± 0.009</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.001 ± 0.001</strong></td>
<td><strong>0.011 ± 0.008</strong></td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.005 ± 0.005</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.009 ± 0.006</td>
<td>0.029 ± 0.026</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.003 ± 0.002</strong></td>
<td><strong>0.013 ± 0.008</strong></td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td>0.010 ± 0.007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.005 ± 0.005</td>
<td>0.025 ± 0.016</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.001 ± 0.001</strong></td>
<td><strong>0.014 ± 0.007</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Appendix 2.6.** Recreational harvest rate and discard rate estimates (fish per boat hour ± standard error) for mulloway (*Argyrosomus japonicus*) taken by boat-based fishers in the Macleay River during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>Harvest Rate (fish/boat hr)</th>
<th>Discard Rate (fish/boat hr)</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.016 ± 0.010</td>
<td>0.007 ± 0.006</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.005 ± 0.003</strong></td>
<td><strong>0.002 ± 0.002</strong></td>
<td></td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.006 ± 0.004</td>
<td>0.001 ± 0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.001 ± 0.001</strong></td>
<td>&lt;0.001 ± &lt;0.001</td>
<td></td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.009 ± 0.004</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.003 ± 0.001</strong></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>0.007 ± 0.007</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>0.005 ± 0.005</strong></td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 3.

Length to weight conversion keys \[ W(\text{grams}) = a \times L(\text{cm})^b \] used to estimate weights for various taxa. Relevant details which describe the sample material used to calculate the length to weight key is provided. In all length to weights keys the sexes have been combined.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Taxon</th>
<th>Sample Size</th>
<th>Size Range (cm)</th>
<th>Length to Weight Key [ W(\text{grams}) = a \times L(\text{cm})^b ]</th>
<th>Adjusted ( r^2 )</th>
<th>Region of Sample</th>
<th>Source of Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bass, Australian</td>
<td><em>Macquaria novemaculeata</em></td>
<td>845</td>
<td>5.0 – 47.6</td>
<td>[ W = 0.01122 \times L^{3.091} ]</td>
<td>0.971</td>
<td>Sydney Basin, NSW</td>
<td>Harris (1987)</td>
</tr>
<tr>
<td>Biddy, Silver</td>
<td><em>Gerres subfasciatus</em></td>
<td>Unpublished</td>
<td>NSW Fisheries data used to estimate weights</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bream, Yellowfin</td>
<td><em>Acanthopagrus australis</em></td>
<td>758</td>
<td>15.0 – 40.5</td>
<td>[ W = 0.024787915 \times L^{3.956} ]</td>
<td>0.980</td>
<td>NSW</td>
<td>Steffe et al. (1996a)</td>
</tr>
<tr>
<td>Crab, Blue swimmer</td>
<td><em>Portunus pelagicus</em></td>
<td>186</td>
<td>1.3 – 9.3</td>
<td>[ W = 0.9219 \times CL^{2.855} ]</td>
<td>0.967</td>
<td>NSW</td>
<td>Steffe et al. (1996a)</td>
</tr>
<tr>
<td>Flathead, Dusky</td>
<td><em>Platycephalus fascus</em></td>
<td>589</td>
<td>20.3 – 88.0</td>
<td>[ W = 0.00526864577 \times L^{3.2210} ]</td>
<td>0.992</td>
<td>NSW</td>
<td>Steffe et al. (1996a)</td>
</tr>
<tr>
<td>Flounder, Small-toothed</td>
<td><em>Pseudohombus jenynsi</em></td>
<td>138</td>
<td>15.0 – 33.4</td>
<td>[ W = 0.0014768963 \times L^{3.62935} ]</td>
<td>0.961</td>
<td>Botany Bay, NSW</td>
<td>Steffe et al. (1996a)</td>
</tr>
<tr>
<td>Herring, Southern</td>
<td><em>Herklatschthys castelnaui</em></td>
<td>557</td>
<td>5.2 – 18.1</td>
<td>[ W = 0.0119 \times L^{3.106} ]</td>
<td>0.962</td>
<td>Botany Bay, NSW</td>
<td>SPCC (1981)</td>
</tr>
<tr>
<td>Luderrick</td>
<td><em>Girella tricuspisata</em></td>
<td>186</td>
<td>10.0 – 38.8</td>
<td>[ W = 0.0099659797 \times L^{3.32212} ]</td>
<td>0.990</td>
<td>Botany Bay, NSW</td>
<td>SPCC (1981)</td>
</tr>
<tr>
<td>Mullet, Flat-tail</td>
<td><em>Liza argentea</em></td>
<td>657</td>
<td>10.5 – 35.8</td>
<td>[ W = 0.0291 \times L^{3.7951} ]</td>
<td>0.837</td>
<td>Botany Bay, NSW</td>
<td>SPCC (1981)</td>
</tr>
<tr>
<td>Mullet, Sand</td>
<td><em>Myxus elongatus</em></td>
<td>336</td>
<td>10.0 – 39.5</td>
<td>[ W = 0.0097 \times L^{2.997} ]</td>
<td>0.963</td>
<td>Botany Bay, NSW</td>
<td>SPCC (1981)</td>
</tr>
<tr>
<td>Mullet, Sea</td>
<td><em>Magil cephalus</em></td>
<td>216</td>
<td>6.9 – 43.8</td>
<td>[ W = 0.0078 \times L^{3.2097} ]</td>
<td>0.970</td>
<td>Botany Bay, NSW</td>
<td>SPCC (1981)</td>
</tr>
<tr>
<td>Mulloway</td>
<td><em>Argyrosomus japonicus</em></td>
<td>141</td>
<td>21.7 – 139.0</td>
<td>[ W = 0.01355 \times L^{2.34} ]</td>
<td>Not Given</td>
<td>S. A.</td>
<td>Hall (1986)</td>
</tr>
<tr>
<td>Salmon, Australian</td>
<td><em>Arrius trutta</em></td>
<td>8232</td>
<td>4.0 – 77.0</td>
<td>[ W = 0.0132678 \times L^{3.0845} ]</td>
<td>Not Given</td>
<td>Australia</td>
<td>Malcolm (1966)</td>
</tr>
<tr>
<td>Seapike, Long-finned</td>
<td><em>Dinoletes levini</em></td>
<td>87</td>
<td>13.0 – 43.5</td>
<td>[ W = 0.0024688595 \times L^{3.30752} ]</td>
<td>0.995</td>
<td>NSW</td>
<td>Steffe et al. (1996a)</td>
</tr>
<tr>
<td>Seapike, Striped*</td>
<td><em>Sphyraena obtusata</em></td>
<td>-</td>
<td>-</td>
<td>Long-finned Seapike Key Used</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailor</td>
<td><em>Pomatomus saltatrix</em></td>
<td>1028</td>
<td>10.0 – 58.5</td>
<td>[ W = 0.0075039512 \times L^{3.15755} ]</td>
<td>0.994</td>
<td>NSW</td>
<td>Steffe et al. (1996a)</td>
</tr>
<tr>
<td>Whiting, Sand</td>
<td><em>Silago ciliata</em></td>
<td>1198</td>
<td>10.0 – 39.5</td>
<td>[ W = 0.0040 \times L^{3.3137} ]</td>
<td>0.973</td>
<td>Botany Bay, NSW</td>
<td>SPCC (1981)</td>
</tr>
</tbody>
</table>

This study - refers to additional material collected during the survey.  
Steffe et al. (1996a) - refers to the amalgamation of material from a variety of sources and the recalculation of a length to weight key. These sources include material from market measuring, ramp measuring, and unpublished material taken from the Botany Bay project (SPCC 1981), the Northern Rivers project and the Deep Ocean Outfall Monitoring project.  
* Length to weight equation for this taxon was not available. Estimates of weight were obtained by using a length to weight key for a closely related taxon.  
FL - Fork Length, ML - Mantle Length, CL - Carapace Length.
Appendix 4. Estimates of daytime recreational fishing effort (boat hours) for the boat-based fishery in the four areas in the Macleay River (Main River, Entrance, Kemps Cnr / Clybucca and Stuarts Point). Data are presented for all temporal strata and have also been combined to provide total effort estimates for the whole survey area.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Day-Type</th>
<th>ENTRANCE</th>
<th>KEMPS/CLYBUCCA</th>
<th>STUARTS POINT</th>
<th>MAIN RIVER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boat Effort (boat hrs)</td>
<td>SE</td>
<td>Boat Effort (boat hrs)</td>
<td>SE</td>
<td>Boat Effort (boat hrs)</td>
</tr>
<tr>
<td>July 2001</td>
<td>Weekday</td>
<td>950 ± 248</td>
<td>1,273 ± 369</td>
<td>1,197 ± 337</td>
<td>152 ± 56</td>
<td>3,572 ± 561</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>397 ± 73</td>
<td>700 ± 160</td>
<td>661 ± 125</td>
<td>140 ± 51</td>
<td>1,898 ± 221</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1,347 ± 258</td>
<td>1,973 ± 402</td>
<td>1,858 ± 359</td>
<td>292 ± 76</td>
<td>5,470 ± 603</td>
</tr>
<tr>
<td>August 2001</td>
<td>Weekday</td>
<td>655 ± 168</td>
<td>1,330 ± 253</td>
<td>718 ± 134</td>
<td>169 ± 27</td>
<td>2,872 ± 333</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>272 ± 38</td>
<td>529 ± 166</td>
<td>316 ± 24</td>
<td>176 ± 76</td>
<td>1,293 ± 188</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>927 ± 172</td>
<td>1,859 ± 302</td>
<td>1,034 ± 136</td>
<td>345 ± 81</td>
<td>4,165 ± 382</td>
</tr>
<tr>
<td>September 2001</td>
<td>Weekday</td>
<td>224 ± 46</td>
<td>613 ± 139</td>
<td>428 ± 92</td>
<td>175 ± 64</td>
<td>1,440 ± 184</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>117 ± 52</td>
<td>369 ± 110</td>
<td>583 ± 235</td>
<td>78 ± 58</td>
<td>1,147 ± 271</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>341 ± 70</td>
<td>982 ± 177</td>
<td>1,011 ± 253</td>
<td>253 ± 86</td>
<td>2,587 ± 328</td>
</tr>
<tr>
<td>October 2001</td>
<td>Weekday</td>
<td>329 ± 101</td>
<td>1,200 ± 369</td>
<td>823 ± 67</td>
<td>94 ± 47</td>
<td>2,446 ± 392</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>154 ± 57</td>
<td>549 ± 109</td>
<td>443 ± 93</td>
<td>77 ± 46</td>
<td>1,223 ± 161</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>483 ± 116</td>
<td>1,749 ± 385</td>
<td>1,266 ± 115</td>
<td>171 ± 66</td>
<td>3,669 ± 424</td>
</tr>
<tr>
<td>Total</td>
<td>Weekday</td>
<td>2,158 ± 319</td>
<td>4,416 ± 597</td>
<td>3,166 ± 380</td>
<td>590 ± 101</td>
<td>10,330 ± 783</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>940 ± 113</td>
<td>2,147 ± 278</td>
<td>2,003 ± 283</td>
<td>471 ± 118</td>
<td>5,561 ± 429</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,098 ± 339</td>
<td>6,563 ± 658</td>
<td>5,169 ± 474</td>
<td>1,061 ± 155</td>
<td>15,891 ± 892</td>
</tr>
</tbody>
</table>
Appendix 5. The number of individuals observed (N), the number of individuals measured (n), size range (cm), median length (cm), and mean length (cm) for all taxa measured during interviews with boat-based and shore-based recreational fishers in the Macleay River fishery during the survey period (July 1 - October 31, 2001).

<table>
<thead>
<tr>
<th>Common Name</th>
<th>BOAT FISHERY</th>
<th></th>
<th>SHORE FISHERY</th>
<th></th>
<th>TOTAL FISHERY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n</td>
<td>Range</td>
<td>Median</td>
<td>Mean</td>
<td>N</td>
</tr>
<tr>
<td>Bass, Australian</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Biddy, Silver</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>12.0</td>
<td>12.0</td>
<td>1</td>
</tr>
<tr>
<td>Bream, Yellowfin</td>
<td>481</td>
<td>443</td>
<td>20 – 40</td>
<td>26.0</td>
<td>26.4</td>
<td>476</td>
</tr>
<tr>
<td>Crab, Blue Swimmer</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>10.0</td>
<td>10.0</td>
<td>1</td>
</tr>
<tr>
<td>Herring, Southern</td>
<td>4</td>
<td>4</td>
<td>5 – 8</td>
<td>7.0</td>
<td>6.8</td>
<td>1</td>
</tr>
<tr>
<td>Longtom, Stout</td>
<td>1</td>
<td>1</td>
<td>70</td>
<td>70.0</td>
<td>70.0</td>
<td>1</td>
</tr>
<tr>
<td>Luderick</td>
<td>3234</td>
<td>2970</td>
<td>20 – 48</td>
<td>29.0</td>
<td>29.5</td>
<td>634</td>
</tr>
<tr>
<td>Mullet, Flat-tail</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Mullet, Sand</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>Mullet, Sea</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Mulloway</td>
<td>22</td>
<td>20</td>
<td>52 – 105</td>
<td>71.0</td>
<td>75.0</td>
<td>12</td>
</tr>
<tr>
<td>Salmon, Australian</td>
<td>4</td>
<td>4</td>
<td>50 – 75</td>
<td>52.0</td>
<td>57.3</td>
<td>1</td>
</tr>
<tr>
<td>Seapike, Striped</td>
<td>5</td>
<td>5</td>
<td>21 – 30</td>
<td>26.0</td>
<td>26.4</td>
<td>27</td>
</tr>
<tr>
<td>Tailor</td>
<td>15</td>
<td>14</td>
<td>27 – 40</td>
<td>31.0</td>
<td>31.9</td>
<td>28</td>
</tr>
<tr>
<td>Whiting, Sand</td>
<td>25</td>
<td>24</td>
<td>25 – 33</td>
<td>27.0</td>
<td>27.9</td>
<td>13</td>
</tr>
</tbody>
</table>
SECTION 5

Survey of Prawn Trawl By-catch in the Richmond River Oceanic Fishing Closure
(April – July 2001)

Marcus Miller

NSW Fisheries
P.O. Box 21, Cronulla, NSW, 2230
Australia

April 2002
EXECUTIVE SUMMARY

At the beginning of February 2001 a flood event occurred in the Richmond River Catchment causing a severe fish kill in the lower reaches of the estuary. The river and adjacent off-shore waters were closed to all fishing following this fish kill.

As a component of the overall surveys done by NSW Fisheries to examine at the recovery of the river after such a large kill, investigations into the abundances of recreational and commercial species in the offshore fishing closure outside the mouth of the estuary were done using an ocean prawn trawler during the months of April, June and July.

Survey sites were chosen throughout the entire closure area, with the results indicating high by-catch to school prawn ratios. The main recreational and commercial species observed in high numbers were juvenile mulloway with lesser numbers of juvenile and small adults of tarwhine, silver biddy and large-toothed flounder.

Overall there were not a large proportion of estuarine fish species captured at these sites during each of the months surveyed, but the closure did seem to be beneficial in protecting juvenile mulloway after the flood and for the spawning of school prawns before they migrated away from the system and became susceptible to capture outside the closure.

In conclusion, it appears as though this oceanic closure subsequent to the fish kill may have had benefits to future stocks of mulloway and school prawns in the region.
1. INTRODUCTION

At the beginning of February 2001, a severe flooding event occurred in the upper reaches of the Richmond River Catchment. Runoff from the surrounding flood plains brought with it a large body of de-oxygenated water, resulting in a major fish kill which occurred in the lower reaches of the river approximately a week later, peaking on or around 9 February.

The river and adjacent inshore waters were closed to all fishing following this event fish kill for an initial period of three weeks from 9 February 2001. This was extended to a three month fishing closure from Ballina Bar upstream to Coraki Junction and the mean high water mark at Lennox Head, extending 5km seaward off the Ballina Bar, then southwards 16.5km to the northern tip of South Riordan Shoals, and finally back to the mean high water mark at the southern end of South Ballina Beach (see Map 1, for exact coordinates see Appendix 1).

During the period of this closure, NSW Fisheries regularly surveyed the river to determine the recovery of fish and crustacean stocks in the system, providing the necessary biological and water quality information required to make fisheries management decisions as to when or if the closure on this river and adjacent ocean waters should be lifted. During April, June and July, as part of the post-fish kill investigations, a survey using a commercial prawn trawler was conducted in the ocean closure area located off the Richmond River to examine the relative abundances of commercial and recreational fish and crustacean species present within this area. This report outlines this latter work.
2. MATERIALS AND METHODS

The prawn trawler LFB ‘Kiama’, based at Ballina, was used to survey fish and crustacean abundances in the ocean closure located off the mouth of the Richmond River (refer to Map 1).

Scientific observers were placed on board the prawn trawler during April, June and July 2001 to conduct these surveys. The April and July trips were performed during daylight hours and the June trip was performed at night. A May survey was not possible as the prawn trawler was unavailable. It was, in fact, catching school prawns outside the closure at Evans Head and Lennox Head, which were then experiencing large catches of school prawns – thought by fishers to be a consequence of the flooding.

Sites in the survey were chosen so that they were spread evenly throughout the area from the northern to the southern-most part of the closure (see Maps 2, 3 and 4). Details of each shot, including sampling time, shot duration, coordinates, at the start and finish of each shot, depth, and number of codends used were recorded (see Tables 1, 2 and 3). After hauling each shot on board and emptying the contents onto the sorting tray, the catch was sorted by the crew and observers according to retained commercial / recreational fish and crustacean species as well as discarded by-catch (see Photos 1, 2, 3 and 4). If the entire catch of a particular species could not be counted, data were collected from a representative sample, with the total weight taken to enable a total count to be estimated. Data being collected from each tow were: the total weight of retained and discarded by-catches, and the numbers and weights of retained commercial / recreational species and their sizes (total lengths).

A species list was generated from the overall catch. Length frequency information for each of the most abundant commercial and recreational fish species captured was generated as % frequencies.
for those species in the catch from each shot. A ratio of school prawn to total by-catch weight in the catch was calculated.

**Photo 1.** Preparation for the first shot of the day Ballina Bar.

**Photo 2.** A collection of species captured from a shot made during the survey.
Photo 3. Hauling the catch aboard the ‘Kiama’.

Photo 4. Sorting of the catch into species.
2.1. April survey operational information

Map 2. Sites sampled during the April survey within the Ocean Closure.

Table 1. Sites 1 to 4 – time, shot duration, and start / finish coordinates of each shot, number of codends used and depth range for each site.

<table>
<thead>
<tr>
<th>Site</th>
<th>Time (am)</th>
<th>Shot Duration (mins)</th>
<th>Start</th>
<th>Finish</th>
<th>No. of Codends Used</th>
<th>Depth (fathoms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.15am</td>
<td>24</td>
<td>28°52'.92 S, 153°35'.59 E</td>
<td>28°53'.52 S, 153°34'.99 E</td>
<td>3</td>
<td>7 - 11</td>
</tr>
<tr>
<td>2</td>
<td>9.30am</td>
<td>10</td>
<td>28°50'.35 S, 153°36'.90 E</td>
<td>28°50'.75 S, 153°36'.80 E</td>
<td>1</td>
<td>10 - 12</td>
</tr>
<tr>
<td>3</td>
<td>10.30am</td>
<td>15</td>
<td>28°56'.46 S, 153°32'.09 E</td>
<td>28°57'.00 S, 153°31'.66 E</td>
<td>3</td>
<td>6 - 8</td>
</tr>
<tr>
<td>4</td>
<td>11.30am</td>
<td>20</td>
<td>28°58'.94 S, 153°30'.80 E</td>
<td>28°59'.83 S, 153°29'.75 E</td>
<td>1</td>
<td>10 - 12</td>
</tr>
</tbody>
</table>
2.2. June survey operational information

Map 3. Sites sampled during the June survey within the Ocean Closure.

Table 2. Sites 1 to 6 - time, shot duration, and start / finish coordinates of each shot, number of codends used and depth range for each site.

<table>
<thead>
<tr>
<th>Site</th>
<th>Time (am)</th>
<th>Shot Duration (mins)</th>
<th>Start</th>
<th>Finish</th>
<th>N° of Codends Used</th>
<th>Depth (fathoms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>22.30pm</td>
<td>30</td>
<td>28<em>53’.99 S,153</em>34’.75 E</td>
<td>28<em>54’.95 S,153</em>33’.83 E</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>
2.3. **July survey operational information**

**Map 4.** Sites sampled during the July survey within the Ocean Closure.

**Table 3.** Sites 1 to 8 - time, shot duration, and start / finish coordinates of each shot, number of codends used and depth range for each site.

<table>
<thead>
<tr>
<th>Site</th>
<th>Time</th>
<th>Shot Duration</th>
<th>Start</th>
<th>Finish</th>
<th>N° of Codends Used</th>
<th>Depth (fathoms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.45am</td>
<td>30</td>
<td>28°58'.21 S, 153°30'.49 E</td>
<td>28°57'.20 S, 153°31'.28 E</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>9.45am</td>
<td>30</td>
<td>28°59'.70 S, 153°29'.81 E</td>
<td>28°58'.72 S, 153°30'.59 E</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>11.00am</td>
<td>30</td>
<td>28°57'.16 S, 153°31'.61 E</td>
<td>28°56'.10 S, 153°32'.29 E</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>12.30pm</td>
<td>30</td>
<td>28°55'.84 S, 153°32'.49 E</td>
<td>28°54'.90 S, 153°33'.27 E</td>
<td>3</td>
<td>3 - 4</td>
</tr>
<tr>
<td>5</td>
<td>13.15pm</td>
<td>30</td>
<td>28°55'.09 S, 153°33'.80 E</td>
<td>28°54'.11 S, 153°34'.64 E</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>14.30pm</td>
<td>30</td>
<td>28°53'.31 S, 153°35'.12 E</td>
<td>28°52'.29 S, 153°36'.00 E</td>
<td>3</td>
<td>8 - 9</td>
</tr>
<tr>
<td>7</td>
<td>15.45pm</td>
<td>30</td>
<td>28°50'.67 S, 153°36'.86 E</td>
<td>28°49'.53 S, 153°36'.98 E</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>16.30pm</td>
<td>30</td>
<td>28°51'.47 S, 153°37'.27 E</td>
<td>28°52'.70 S, 153°37'.02 E</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>
2.4. LFB ‘Kiama’ gear information

The 48ft prawn trawler ‘Kiama’ uses a Caterpillar 3306, 230hp engine. The otter boards used throughout the survey were rectangular ‘Humphrey Boards’, of dimensions 7ft by 3 ft. Triple-trawl gear was used, with the outside nets comprised of 1 3/4” mesh and the middle part of the net comprising of 2” mesh. The total headrope length was 43.8m, with the middle net measuring 16.5m and the outer nets both measuring 13.65m, respectively. Positioned in each of the codends was a by-catch reduction device (BRD) measuring 210mm by 297mm, with a minimum diagonal measurement of 55mm. The ground gear used was 8mm stainless ground chain (see Photo 5).

Photo 5. The prawn trawler LFB ‘Kiama’.
3. RESULTS

A complete species list for the three surveys from the Ocean Prawn Trawl Closure is given in Table 4. From the three surveys the majority of the catch was identified to species, but those organisms for which identification or handling was difficult were assigned to higher taxonomic groupings.

Table 4. List of species sampled from the Ocean Closure.

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific Name</th>
<th>Common Name</th>
<th>April</th>
<th>June</th>
<th>July</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Finfishes:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APOGONIDAE</td>
<td>Apogon atripes</td>
<td>Bulls-eye cardinalfish</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>APOGONIDAE</td>
<td>Vincenzia novaehollandiae</td>
<td>Eastern gobbleguts</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARACANIDAE</td>
<td>Anoplocapros inermis</td>
<td>Eastern smooth boxfish</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOTHIDAE</td>
<td>Pseudorhombus arius</td>
<td>Large-toothed flounder</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>BOTHIDAE</td>
<td>Pseudorhombus jenynsii</td>
<td>Small-toothed flounder</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARANGIDAE</td>
<td>Gnathanodon speciosus</td>
<td>Golden trevally</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARANGIDAE</td>
<td>Pseudocaranx dentex</td>
<td>Silver trevally</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARANGIDAE</td>
<td>Trachurus novaezelandiae</td>
<td>Yellowtail</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARCHARHINIDAE</td>
<td>Rhizoprionodon acutus</td>
<td>Milk shark</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHAETODONTIDAE</td>
<td>Chaetodon guentheri</td>
<td>Gunther’s butterflyfish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLupeidae</td>
<td>Herklotsichthys castelnaui</td>
<td>Southern herring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CYNOGLOSSIDAE</td>
<td>Paraplagusia unicolor</td>
<td>Lemon tongue sole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DASYATIDAE</td>
<td>Dasyatis fluviorum</td>
<td>Estuary stingray</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DINOLETIDAE</td>
<td>Dinolestes lewini</td>
<td>Longfin pike</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIODONTIDAE</td>
<td>Dicotomycthus punctulatus</td>
<td>Three-bar porcupinefish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENOPLOSIDA</td>
<td>Enoplosus armatus</td>
<td>Old wife</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FISTULARIIDAE</td>
<td>Fistularia commersonii</td>
<td>Smooth flutemouth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GERRIDAE</td>
<td>Gerres subfuscatus</td>
<td>Silver biddy</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HARPODONTIDAE</td>
<td>Saurida undosquamis</td>
<td>Large-scaled grinner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEMIRAMPHIDAE</td>
<td>Hyporhamphus australis</td>
<td>Eastern garfish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HYPNIDAE</td>
<td>Hypons monopterygium</td>
<td>Coffin ray</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MICROCANTHIDAE</td>
<td>Microcanthus striatus</td>
<td>Stripey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MONACANTHIDAE</td>
<td>Meuschenia sp.</td>
<td>Leatherjacket</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MONODACTYLIDAE</td>
<td>Schuettea scalaripinnis</td>
<td>Ladder-finned pomfret</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUGILIDIDAE</td>
<td>Parapercis sp.</td>
<td>Grubfish</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MULLIDAE</td>
<td>Upeniechthys lineatus</td>
<td>Blue-lined goatfish</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MULLIDAE</td>
<td>Upeneus tragula</td>
<td>Bar-tail goatfish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORECTOLOBIIDAE</td>
<td>Oreotolbus maculatus</td>
<td>Spotted wobegong</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEPHERIDIDAE</td>
<td>Pempheris sp.</td>
<td>Bullseye</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATYCEPHALIDAE</td>
<td>Platyccephalus caeruleopunctatus</td>
<td>Eastern blue-spotted fladhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATYCEPHALIDAE</td>
<td>Platyccephalus endrachtensis</td>
<td>Bar-tail fladhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATYCEPHALIDAE</td>
<td>Platyccephalus arenarius</td>
<td>Northern sand fladhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLATYCEPHALIDAE</td>
<td>Platyccephalus fuscus</td>
<td>Dusky fladhead</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLOTOSIDAE</td>
<td>Cnidoglanis macrocephalus</td>
<td>Estuary catfish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLOTOSIDAE</td>
<td>Ploitosus lineatus</td>
<td>Striped catfish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POMATOMIDAE</td>
<td>Pomatomus saltatrix</td>
<td>Tailor</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>RHINOBATIDAE</td>
<td>Aptychotremus rostrata</td>
<td>Shovelnose ray</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIAENIDAE</td>
<td>Argyrosomus japonicus</td>
<td>Mulloway</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIAENIDAE</td>
<td>Atractaciom acuidens</td>
<td>Teraclin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCOMBRIDAE</td>
<td>Scomber australasicus</td>
<td>Slimy mackerel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCORPENAIDAE</td>
<td>Centropros australis</td>
<td>Fortesque</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCORPENAIDAE</td>
<td>Notesthes robusta</td>
<td>Bullot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCORPIDAE</td>
<td>Scorpa lineolata</td>
<td>Silver sweep</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILLAGINIDAE</td>
<td>Sillago flinders</td>
<td>Red spot whiting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILLAGINIDAE</td>
<td>Sillago robusta</td>
<td>Stout whiting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPARIDAE</td>
<td>Rhabdosargus sarba</td>
<td>Tarwhine</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>SOLEIDAE</td>
<td>Aesopia microcephalus</td>
<td>Black sole</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOLEIDAE</td>
<td>Zebras scalaris</td>
<td>Many-banded sole</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TETRAODONTIDAE</td>
<td>Arothron manillensis</td>
<td>Narrow-lined puffer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TETRAODONTIDAE</td>
<td>Tetractenos glaber</td>
<td>Smooth toadfish</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>TERAPONTIDAE</td>
<td>Pelates sexlineatus</td>
<td>Striped trumpet</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>TRICHIURIDAE</td>
<td>Trichiurus lepturus</td>
<td>Hairtail</td>
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<tr>
<td>TRIGLIDAE</td>
<td>Chelidonichthys kumu</td>
<td>Red gurnard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UROLOPHIDAE</td>
<td>Trygonoptera testacae</td>
<td>Common stingaree</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4 (continued)

![Table 4](image)

3.1. **April survey**

Weights of the total by-catch, retained commercial catch and discarded by-catch are shown in Table 5.

Table 5. **Weights (kg) of the catch taken from all sites.**

<table>
<thead>
<tr>
<th>Catch</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Total (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retained Commercial Catch (kg)</td>
<td>80.8</td>
<td>4.75</td>
<td>94.15</td>
<td>12.95</td>
<td>192.65</td>
</tr>
<tr>
<td>Discarded By-catch (kg)</td>
<td>59.8</td>
<td>13.63</td>
<td>85.86</td>
<td>34.25</td>
<td>193.54</td>
</tr>
<tr>
<td>Total Weight of Catch (kg)</td>
<td>140.6</td>
<td>18.38</td>
<td>180.01</td>
<td>47.2</td>
<td>386.19</td>
</tr>
</tbody>
</table>

The commercial species retained from Sites 1 – 4 included School Prawns (*Metapenaeus macleayi*), Tiger Prawns (*Penaeus esculentus*), Eastern King Prawns (*Penaeus plebejus*), Blue Swimmer Crabs (*Portunus pelagicus*), Stout Whiting (*Sillago robusta*), Yellowtail (*Trachurus novaezelandiae*) and Bottle Squid (*Loliolus sp.*).

The total amount of prawns caught from all sites was 19.65 kg. The total amount of by-catch amounted to 366.54 kg, a prawn to by-catch ratio (from all sites) of:

**1 kg of prawns to 18.65 kg of by-catch.**

Stout Whiting (*Sillago robusta*), Yellowtail (*Trachurus novaezelandiae*), Northern Sand Flathead (*Platyccephalus arenarius*), Mulloway (*Argyrosomus japonicus*) and Silver Biddy (*Gerres subfasciatus*) were recorded as the most abundant retained fin-fish captured from each shot. Each species was measured and weighed, with results for their size ranges given as % frequency of the total catch for that species from each site. School Prawns (*Metapenaeus macleayi*) and Bottle
Squid (*Loliolus sp.*) were the two most abundant retained crustaceans and molluscs. The length frequencies for these species are shown in Figures 1 - 4.

Total weight and % of total catch was calculated for the five most abundant fin-fish species from all sites. This is shown in Table 6.

**Table 6.** The seven most abundant commercial species as a % of the total catch.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Weight (kg)</th>
<th>Numbers</th>
<th>Total Catch Weight (kg)</th>
<th>% of total catch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stout whiting</td>
<td><em>Sillago robusta</em></td>
<td>157.2</td>
<td>3934</td>
<td>386.19</td>
<td>40.71</td>
</tr>
<tr>
<td>Mulloway</td>
<td><em>Argyrosomus japonicus</em></td>
<td>13.7</td>
<td>774</td>
<td>386.19</td>
<td>3.55</td>
</tr>
<tr>
<td>Northern sand flathead</td>
<td><em>Platypus arenarius</em></td>
<td>9.1</td>
<td>392</td>
<td>386.19</td>
<td>2.36</td>
</tr>
<tr>
<td>Yellowtail</td>
<td><em>Trachurus novaezelandiae</em></td>
<td>7.0</td>
<td>201</td>
<td>386.19</td>
<td>1.81</td>
</tr>
<tr>
<td>Silver biddy</td>
<td><em>Gerres subfasciatus</em></td>
<td>6.42</td>
<td>173</td>
<td>386.19</td>
<td>1.66</td>
</tr>
<tr>
<td>School prawns</td>
<td><em>Metapenaeus macleayi</em></td>
<td>19.65</td>
<td>-</td>
<td>386.19</td>
<td>5.09</td>
</tr>
<tr>
<td>Bottle squid</td>
<td><em>Loliolus sp.</em></td>
<td>8.8</td>
<td>-</td>
<td>386.19</td>
<td>2.28</td>
</tr>
</tbody>
</table>

**Figure 1.** Length frequencies for the most abundant fin-fish from Site 1.
Figure 2. Length frequencies for the most abundant fin-fish from Site 2.

Figure 3. Length frequencies for the most abundant fin-fish from Site 3.
3.2. **June survey**

The total by-catch, retained commercial catch and discarded by-catch were measured and weighted (kg), and are shown in Table 7.

**Table 7.** Weights (kg) of the catch from all sites.

<table>
<thead>
<tr>
<th>Catch</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Total (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retained Commercial Catch (kg)</td>
<td>37.05</td>
<td>58.2</td>
<td>69.12</td>
<td>34.9</td>
<td>55.05</td>
<td>62.4</td>
<td>316.72</td>
</tr>
<tr>
<td>Discarded By-catch (kg)</td>
<td>65.42</td>
<td>36.67</td>
<td>50.39</td>
<td>23.45</td>
<td>50.31</td>
<td>109.7</td>
<td>335.94</td>
</tr>
<tr>
<td>Total Weight of Catch (kg)</td>
<td>102.47</td>
<td>94.87</td>
<td>119.51</td>
<td>58.35</td>
<td>105.36</td>
<td>172.1</td>
<td>652.66</td>
</tr>
</tbody>
</table>

The commercial species retained from Sites 1 – 6 included School Prawns (*Metapenaeus macleayi*), Blue Swimmer Crabs (*Portunus pelagicus*), Stout Whiting (*Sillago robusta*), Red-spot Whiting (*Sillago flinderi*), Yellowtail (*Trachurus novaezelandiae*), Eastern Garfish (*Hyporhamphus australis*), Bottle Squid (*Loliolus sp.*), and Octopus (*Octopus sp.*).
The total quantity of prawns caught from all sites was 7.65 kg. The total by-catch amounted to 645.01 kg giving a prawn to by-catch ratio (from all sites) of:

1 kg of prawns to 84.32 kg of by-catch.

Stout Whiting (*Sillago robusta*), Eastern Blue-spot Flathead (*Platycephalus caeruleopunctatus*), Mulloway (*Argyrosomus japonicus*), Large-toothed Flounder (*Pseudorhombus arsius*) were recorded as the most abundant retained commercial / recreational fin-fish captured from each shot. A non-commercial / non-recreational species, the Many-banded Sole (*Zebrias scalaris*), represented 2.09% of the catch. Each species was measured and weighed, with results for their size ranges being given as % frequency of the total catch for that species from each site. School Prawns (*Metapenaeus macleayi*) and Bottle Squid (*Loliolus sp.*) were the two most abundant retained crustaceans and molluscs. The length frequencies for the fin-fish species are shown in Figures 5 - 8.

Total weights and % of total catch were calculated for the four most abundant retained fin-fish species from all sites. This is shown in Table 8.

### Table 8. The four most abundant commercial species as a % of the total catch.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Weight (kg)</th>
<th>Numbers</th>
<th>Total Catch Weight (kg)</th>
<th>% of total catch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stout whiting</td>
<td><em>Sillago robusta</em></td>
<td>295</td>
<td>8991</td>
<td>652.66</td>
<td>45.20</td>
</tr>
<tr>
<td>Eastern blue-spotted flathead</td>
<td><em>Platycephalus caeruleopunctatus</em></td>
<td>20</td>
<td>430</td>
<td>652.66</td>
<td>3.06</td>
</tr>
<tr>
<td>Many-banded sole</td>
<td><em>Zebrias scalaris</em></td>
<td>13.65</td>
<td>396</td>
<td>652.66</td>
<td>2.09</td>
</tr>
<tr>
<td>Large-toothed flounder</td>
<td><em>Pseudorhombus arsius</em></td>
<td>7.2</td>
<td>40</td>
<td>652.66</td>
<td>1.10</td>
</tr>
<tr>
<td>Mulloway</td>
<td><em>Argyrosomus japonicus</em></td>
<td>7.07</td>
<td>145</td>
<td>652.66</td>
<td>1.08</td>
</tr>
<tr>
<td>Bottle squid</td>
<td><em>Loliolus sp.</em></td>
<td>9.5</td>
<td>1571</td>
<td>652.66</td>
<td>1.46</td>
</tr>
<tr>
<td>School prawns</td>
<td><em>Metapenaeus macleayi</em></td>
<td>7.65</td>
<td>1286</td>
<td>652.66</td>
<td>1.17</td>
</tr>
</tbody>
</table>

**Figure 5.** Length frequencies for the most abundant fin-fish from Site 1.
Figure 6. Length frequencies for the most abundant fin-fish from Site 2.

Figure 7. Length frequencies for the most abundant fin-fish from Site 3.
Figure 8. Length frequencies for the most abundant fin-fish from Site 4.

Figure 9. Length frequencies for the most abundant fin-fish from Site 5.
Figure 10. Length frequencies for the most abundant fin-fish from Site 6.

3.3. July survey

The total by-catch, retained commercial catch and discarded by-catch were measured and weighted (kg), and are shown in Table 9.

Table 9. Weights (kg) of the catch from all sites.

<table>
<thead>
<tr>
<th>Catch</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Site 7</th>
<th>Site 8</th>
<th>Total (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retained Commercial Catch (kg)</td>
<td>33.35</td>
<td>173.72</td>
<td>44.37</td>
<td>0.96</td>
<td>19.4</td>
<td>1.98</td>
<td>25.45</td>
<td>0.15</td>
<td>299.378</td>
</tr>
<tr>
<td>Discarded By-catch (kg)</td>
<td>12.7</td>
<td>37.92</td>
<td>19.46</td>
<td>22.16</td>
<td>25.16</td>
<td>25.16</td>
<td>16.36</td>
<td>179.425</td>
<td></td>
</tr>
<tr>
<td>Total Weight of Catch (kg)</td>
<td>46.05</td>
<td>211.64</td>
<td>63.83</td>
<td>23.12</td>
<td>44.56</td>
<td>22.49</td>
<td>50.61</td>
<td>16.51</td>
<td>478.803</td>
</tr>
</tbody>
</table>

The commercial species retained from Sites 1 – 8 included Stout Whiting (*Sillago robusta*), Red-spot Whiting (*Sillago flindersi*), Slimy Mackeral (*Scomber australasicus*), Yellowtail (*Trachurus novaezelandiae*), Bottle Squid (*LolIolus sp.*), Octopus (*Octopus sp.*), Cuttlefish (*Sepia sp.*) and Blue Swimmer Crabs (*Portunus pelagicus*).

One School Prawn (*Metapenaeus macleayi*) measuring a carapace length of 21mm was captured in Site 7, from a total catch amounting to 487.81 kg. It was unnecessary to determine a prawn to by-catch ratio.

Stout Whiting (*Sillago robusta*), Eastern Blue-spot Flathead (*Platycephalus caeruleopunctatus*), Silver Biddy (*Gerres subfasciatus*), Mulloway (*Argyrosomus japonicus*), Large-toothed Flounder (*Pseudorhombus arsius*), Tarwhine (*Rhabdosargus sarba*), Red-spot Whiting (*Sillago flindersi*) and Yellowtail (*Trachurus novaezelandiae*) were recorded as the most abundant retained commercial / recreational fin-fish captured from each shot. Each species was measured and
weighed, with results for their size ranges being given as % frequency of the total catch for that species from each site. School Prawns (*Metapenaeus macleayi*) and Bottle Squid (*Loliolus sp.*) were the two most abundant retained crustaceans and molluscs. The length frequencies for these species are shown in Figures 11 - 18.

Total weight and % of total catch was calculated for the eight most abundant fin-fish species from all sites. This is shown in Table 10.

### Table 10. The eight most abundant commercial species as a % of the total catch.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Weight (kg)</th>
<th>Numbers</th>
<th>Total Catch Weight (kg)</th>
<th>% of total catch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stout whiting</td>
<td><em>Sillago robusta</em></td>
<td>293.1</td>
<td>6616</td>
<td>478.80</td>
<td>61.22</td>
</tr>
<tr>
<td>Eastern blue-spotted flathead</td>
<td><em>Platyccephalus caeruleopunctatus</em></td>
<td>17.78</td>
<td>295</td>
<td>478.80</td>
<td>3.71</td>
</tr>
<tr>
<td>Silver biddy</td>
<td><em>Gerres subfasciatus</em></td>
<td>7.15</td>
<td>213</td>
<td>478.80</td>
<td>1.49</td>
</tr>
<tr>
<td>Mulloway</td>
<td><em>Argyrosomus japonicus</em></td>
<td>5.94</td>
<td>49</td>
<td>478.80</td>
<td>1.24</td>
</tr>
<tr>
<td>Large-toothed flounder</td>
<td><em>Pseudorhombus arsius</em></td>
<td>5.76</td>
<td>44</td>
<td>478.80</td>
<td>1.20</td>
</tr>
<tr>
<td>Tarwhine</td>
<td><em>Rhabdosargus sarba</em></td>
<td>4.72</td>
<td>68</td>
<td>478.80</td>
<td>0.99</td>
</tr>
<tr>
<td>Red spot whiting</td>
<td><em>Sillago flindersi</em></td>
<td>2.23</td>
<td>106</td>
<td>478.80</td>
<td>0.47</td>
</tr>
<tr>
<td>Yellowtail</td>
<td><em>Trachurus novaezelandiae</em></td>
<td>2.01</td>
<td>50</td>
<td>478.80</td>
<td>0.42</td>
</tr>
</tbody>
</table>

**Figure 11.** Length frequencies for the most abundant fin-fish from Site 1.
Figure 12. Length frequencies for the most abundant fin-fish from Site 2.

Figure 13. Length frequencies for the most abundant fin-fish from Site 3.
Figure 14. Length frequencies for the most abundant fin-fish from Site 4.

Figure 15. Length frequencies for the most abundant fin-fish from Site 5.

Figure 16. Length frequencies for the most abundant fin-fish from Site 6.

Figure 17. Length frequencies for the most abundant fin-fish from Site 7.
Figure 18. Length frequencies for the most abundant fin-fish from Site 8.
4. DISCUSSION

The oceanic closure implemented off the Richmond River following the 2001 flood event was found to contain a large number of fin-fish species and relatively few prawns. A total of 54 fin-fish, 8 crustaceans and 5 molluscs were captured from the three surveys, of which 52% species are regarded as potential commercial or recreational species (see Table 1). The difference between the discarded by-catch and retained commercial catch from the April and June surveys was 4.21 kg and 19.22 kg respectively. In July however, the opposite occurred where the retained commercial catch exceeded the discarded by-catch by 119.95 kg (see Tables 5, 7 and 9).

The most abundant fin-fish species caught in April were Stout Whiting (*Sillago robusta*) and Mulloway (*Argyrosomus japonicus*), making up 42.93% and 3.74% of the total catch respectively. School Prawns and Bottle Squid made up 5.37% and 2.4% of the catch respectively. In June, Stout Whiting (*S. robusta*) and Eastern Blue-spot Flathead (*Platycephalus caeruleopunctatus*) made up 45.19% and 3.06% of the catch respectively, whilst School Prawn and Bottle Squid numbers dropped significantly to 1.17% and 1.46% of the total catch respectively. The July results indicated that Stout Whiting (*S. robusta*) numbers rose significantly to 61.22% of the total catch, an increase of 18.29% of the catch compared with April. Eastern Blue-spot Flathead (*P. caeruleopunctatus*) remained steady in numbers, only increasing slightly to 3.71%. Both School Prawn and Bottle Squid numbers decreased to insignificant numbers, where only one individual school prawn and 97 Bottle Squid were captured throughout the closure (together representing just 0.0012% of the total catch in July.

The prawn to by-catch ratio proved to be large during the entire survey. April results indicated over one and half times the ratio found during studies done in an earlier study by Kennelly et al. (1998) where the by-catch to prawn ratio was found to be 1 kg of prawns to 10.4 kg of by-catch for the off-shore Eastern King Prawn fishery. The June results showed over eight times the prawn to by-catch ratio in comparison to the earlier work. A similar ratio was unable to be calculated in July due to a lack of prawns.

Length frequencies were derived for the total lengths of the individual most abundant commercial and recreational fin-fish species from each site surveyed. In April, Sites 1 – 3 showed a large proportion of the population of Stout Whiting (*S. robusta*) ranged from 120 – 170mm, but catches at Site 4 indicated that a larger cohort of fish of lengths 170 – 240mm inhabited the lower southern region of the closure. Mulloway (*Argyrosomus japonicus*) catches showed that the greatest portion of the catch were in the size range from 70 – 140mm at all sites. Silver Biddy catches contained a large proportion of fish between 110 – 170mm. Yellowtail catches showed a cohort of fish from all sites between 110 – 150mm. June results indicated that the majority of the Stout Whiting (*S. robusta*) captured were from a cohort that ranged from 100 up to 200mm. Eastern Blue-spot Flathead (*P. caeruleopunctatus*) showed a steady range of sizes of fish from 160 to 280mm. Mulloway (*A. japonicus*) numbers declined, but those captured showed the greatest numbers in the size range between 140 – 240mm. Large-toothed Flounder (*Pseudorhombus arsius*) ranged from 160 – 260mm from the small number of fish sampled. The July survey showed three size cohorts of Stout Whiting (*S. robusta*) from the very large sample that was captured. The smaller cohort of fish measured 85mm – 130mm, the medium sized fish measured 160 – 210 mm and the large cohort measured 275 – 340mm. Red-spot Whiting (*Sillago flindersi*) were captured for the first time in July and displayed two cohorts of fish. Smaller fish measured between 95 and 125mm and medium sized fish measured 150 – 190mm. A small population of larger fish were captured measuring 210 – 240mm. Two sizes of Yellowtail (*Trachurus novaezelandiae*) were captured, smaller fish measured between 50 – 70mm and larger fish ranged from 145 – 265mm. Eastern blue-spot flathead (*P. caeruleopunctatus*) showed a range of sizes
from 110 – 230mm, with a few larger specimens being taken at Site 8, in the deeper water. The only large catches of Mulloway (*A. japonicus*), Tarwhine (*Rhabdosargus sarba*) and Silver Biddy (*Gerres subfasciatus*) were captured in the far southern region of the closure from Site 2. Fish were between 200 – 260mm for the Mulloway. The main part of the population of Tarwhine was between 130 – 155mm, and the Silver Biddy ranged from 120 to 145mm.

From this survey, the extension of the already existing juvenile Eastern King Prawn closure located off the Richmond River Bar showed that only a low percentage of high value commercial species, namely School Prawns, inhabited this closure during the period of the study. The water turbidity at the time of the survey was much clearer within the closure than outside it. This may have implications for School Prawn and Bottle Squid populations as they may have been buried in the sand, thus producing lower numbers in our samples compared with what may have been present. Over the months, as water clarity improved, a decrease in the quantities of high value species occurred, while populations of other low value species, such as Stout Whiting and Eastern blue-spot flathead, increased.

The night survey in June showed no significant differences in fin-fish catches from the previous survey that had occurred in April, although, as mentioned above, a drop in the percentage of the total catch of School Prawns and Bottle Squid had occurred.

It is worth noting that during the period of 17 April to 15 May, the Prawn Trawl Fleet was working the ocean closure borders outside Evans Head and Lennox Head, capturing a total of 46,944 kg of School Prawns (Pers. Comm – Ballina Fishermans Co-operative March 2002).
5. CONCLUSION

The survey reported here has several limitations, the most important being the fact that only three individual days of sampling were done, one in each month. This precludes any definitive statements about temporal trends in the data. Despite this, however, the data clearly show very low catches of School Prawns made inside the closure, and relatively high by-catch to prawn catch ratios. This leads one to conclude that the ocean closure off the mouth of the Richmond River was a beneficial management tool during this flood event and should be considered during future such events.

This closure, which protected those commercial / recreational (especially by-catch) species present in this area, should have helped to facilitate the redistribution and recovery of the fish stocks in the lower Richmond River estuary, especially in the case of the juveniles of estuarine species such as Mulloway, Tarwhine, Silver biddy and Large-toothed flounder. In addition, the existence of this closure should have allowed for the spawning of school prawns before they migrated to areas where they could be captured outside the protective closure zone.
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No. 28 Otway, N.M., 1999. Identification of candidate sites for declaration of aquatic reserves for the conservation of rocky intertidal communities in the Hawkesbury Shelf and Batemans Shelf Bioregions. Final report to Environment Australia for the Marine Protected Areas Program (Project No. OR22).


