Mesh selectivity in the NSW demersal trap fishery

J. Stewart and D.J. Ferrell

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

FRDC Project No. 98/138
September 2001

NSW Fisheries Final Report Series
No. 35
ISSN 1440-3544

Mesh selectivity in the NSW demersal trap fishery

J. Stewart and D. J. Ferrell

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

FRDC Project No. 98/138
September, 2001

NSW Fisheries Final Report Series
No. 35
ISSN 1440-3544

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

We would like to thank the 34 commercial fishers who participated in the voluntary log-book program. John Scutts and Glen Cuthbert measured fish at the Wooli and Coffs Harbour fishermens' co-operatives. Daniel Johnson and Glen Cuthbert measured fish at sea onboard commercial vessels.

Geoff Gordon provided support in generating selectivity curves in SAS.

Drs Kevin Rowling, Matt Broadhurst and Steve Kennelly provided comments on draft manuscripts of this report.

NON TECHNICAL SUMMARY

98/138 Mesh selectivity in the New South Wales demersal trap fishery

PRINCIPAL INVESTIGATOR: Mr Doug Ferrell

ADDRESS:
Cronulla Fisheries Centre
NSW Fisheries
P. O. Box 21
Cronulla NSW 2230
Telephone: 02 9527 8411 Fax: 02 9527 8576
Email: ferrelld@fisheries.nsw.gov.au

OBJECTIVES:

(1) Document throughout NSW, the current usage patterns of the various mesh types used in demersal fish traps.

(2) Describe the size composition of retained and returned catch for species common in the NSW trap fishery for all mesh types as they are currently used.

(3) Describe the size composition of retained and returned catch for commercially available mesh and wire products in areas where they are not currently fished.

(4) Determine the likely utility of possible mesh configurations not currently in use.

NON TECHNICAL SUMMARY:

Outcomes achieved

This study has resulted in the voluntary use of escape panels in demersal fish traps by many commercial fishers in order to reduce their levels of bycatch. The information on current levels of discarding and the mesh selectivity operating within the fishery will be used by fishery managers in developing a management strategy for the Trap & Line fishery in New South Wales.

The New South Wales demersal trap fishery is a complex, multi-species fishery. The most valuable species in the fishery is snapper, worth approximately half the value of the fishery, with bream, rubberlip morwong, ocean leatherjacket, silver trevally, sweep and pigfish accounting for a further 36% of the fishery. Current regulations specify that traps must be covered with mesh having a measurement from one plain wire to the opposite plain wire of not less than 50 mm, and a 50 mm hexagonal fencing wire is the most commonly used trap mesh. We know that 50 mm hexagonal wire mesh retains undersized snapper and some fishers advocate using panels of 50 x 75 mm welded mesh in their traps to reduce the catch of small, unwanted fish. We needed knowledge concerning discarding of fish in the trap fishery, because it was apparent that the mesh selectivity of the currently used 50 mm hexagonal wire is inappropriate for snapper, and probably also for many other species captured in traps.

A survey of all commercial fishers with endorsements to use fish traps identified that 32% of

respondents used 50 x 75 mm welded mesh panels somewhere in their traps to reduce the catch of small fish. The survey showed that fish trapping businesses varied enormously with respect to targetted species both along the coast and with seasons. This complexity and variation within the fishery suggests that any changes in trap mesh selectivity may impact different businesses in very different ways.

Fisheries observers onboard commercial vessels and a voluntary industry log-book were used to quantify the sizes of retained and discarded fish captured in fish traps with both 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh panels. We chartered commercial fishers to compare the sizes of fish captured in traps with panels of these standard meshes, with those captured in traps covered entirely with small, 37 mm, mesh, and calculated selectivity models for the major species in the fishery. These results indicated that the selectivities of currently used trap meshes were inappropriate for all species with minimum legal size limits, with large numbers of undersized fish being discarded with unknown mortality. Approximately 30% of all snapper observed captured in fish traps were below the minimum legal size of 28 cm total length.

In an attempt to minimize the catch of undersized fish we designed and tested 4 novel mesh types. We used a prototype 40 x 100 mm welded mesh to test the hypothesis that we could design a trap mesh to select snapper at a pre-determined size. This mesh confirmed that the selection size of snapper (and most important species in the fishery) could be estimated from the fishes body depth and the maximum aperture of the trap mesh. We designed a novel 'parlour' trap which enabled us to test the selectivity of various experimental meshes without losing any marketable fish. We used these parlour traps to test a novel 50 x 87 mm welded mesh and two commercially available hexagonal meshes whilst chartering a commercial fisher. Estimates of the selectivity of these novel mesh types showed that reductions in the numbers of undersized and discarded fish can be achieved, but that corresponding losses of important species without minimum legal lengths may be damaging to some fishing businesses.

This study has provided a better understanding of mesh selectivity in fish traps. We conclude that mesh selectivity occurs mostly through the back panels of fish traps and that fish body depth and behaviour are major factors in determining selection sizes. There is a need for more appropriate trap mesh selectivity in order to reduce the catch of undersized fish for all species which have minimum legal size limits on them. The potential losses of some species by using larger mesh sizes suggests that uptake of the newly tested meshes should be voluntary. We encourage fishers to build the newly designed parlour traps to estimate for themselves potential losses of other important species as a result of increases in mesh sizes.

There is a need for species assessments to be done on all the major species in the NSW demersal trap fishery. There have been large declines in the landings of snapper, rubberlip morwong and sweep and most species are harvested close to their minimum legal lengths. We require an understanding of the basic biology of all the major species in the fishery so that appropriate size limits and selection sizes for traps can be set. The size distributions of catches reported in this study should be used as the basis for ongoing monitoring of the fishery. Where possible this monitoring should be done onboard commercial vessels so that discarded and retained catches can be documented.

KEYWORDS: Selectivity, fish trap, by-catch, commercial catches

1. INTRODUCTION

1.1. Background

Reduction of by-catch has been an active area for research in Australia and around the world. The initial focus for research and management has been demersal trawl fishing, where the perception of waste and potential impact has been the greatest. However, the reasons for seeking to reduce unwanted catch apply to all fisheries, including those using demersal traps.

The use of demersal fish traps is an established method of fishing in NSW. Traps are generally rectangular, timber framed, measure approximately 2 x 1 x 1 m and are covered with wire mesh. Most traps have single entrance funnels on one side, and are baited and set on or near reefs at depths from 10 to 150 m. The NSW demersal trap fishery is a multi-species fishery targetting mainly snapper, rubberlip morwong, silver trevally, yellowfin bream, leatherjackets and a range of less valuable species. Snapper is by far the most valuable species in the fishery accounting for around half of its value, however the importance of different species to fishing businesses is known to vary with latitude, season and depth.

Demersal fish traps in NSW must be covered with mesh no smaller than 50 mm, and a galvanized hexagonal fencing wire is the most commonly used material. Prior to this study, we had little knowledge of the selectivity of fish traps in the fishery, but we knew that the 50 mm hexagonal wire currently used retained fish well below their minimum legal sizes, which were subsequently discarded by fishers with unknown mortality rates. Landings of snapper declined steadily from around 600 tonnes in 1992/93 to around 280 tonnes in 1998/99, with most fish harvested being very close to the minimum legal size of 28 cm total length. The continued decline in landings prompted a push to reduce the by-catch of undersized snapper across all fisheries in New South Wales (NSW).

Some fishers use mesh larger than the 50 mm hexagonal wire in at least one panel of their traps, the most common being a 50 x 75 mm welded mesh. Fifty mm hexagonal wire is small enough to retain undersized fish and Ferrell and Sumpton (1997, FRDC 93/074) found a state-wide average of 2.6 undersized snapper were returned from each lift of a fish trap, but gathered no information on other species. Fishers using and advocating the larger mesh have done so to reduce the catch of small fish (mainly snapper), and to decrease sorting times. Other commercial fishers are concerned that the catch of valuable species such as wrasses, leatherjackets, bream etc. (which have no minimum legal lengths (MLL's) or have MLL's smaller than snapper) would be adversely affected by using mesh larger than 50 mm hexagonal mesh.

1.2. Need

Minimum legal length regulations for all species have recently been reviewed in NSW. One of the outcomes of this review, largely as a result of the recent FRDC funded project in NSW and Queensland (FRDC 93/074) was to recommend an increase in the MLL for snapper. Trap fishers have made the point, however, that increasing the MLL on snapper would force them to change the way they currently work, to reduce by-catch (e.g. fishing certain depths only at some times of year). Changes in mesh regulations have been strongly favoured by some, but have also been a cause for concern for many because the amount of loss of species without MLL's was unknown. Some trap fisheries target fish with relatively small MLL's, such as bream, and it was not known what effect changes in trap mesh regulations would have on such fisheries.

The processes effecting the selectivity of wire meshed fish traps are poorly understood. There have been relatively few studies estimating the selectivity of traps compared to studies on towed gears, gillnets and hooks. A few studies have estimated the selectivity of escape gaps in lobster and crab fisheries (Xu and Millar, 1993; Treble et al., 1998; Jeong et al., 2000), while the selectivity of fish traps has really only been studied in the Antilles region (e.g. Ward, 1988; Gobert, 1988; Gobert, 1998). The selectivity of fish traps has not been documented in Australia and there is a need for the processes effecting fish retention in traps to be described.

An understanding of the differences in selectivity of different sizes of mesh on the species caught in fish traps will have a number of uses. This information is essential to determine the cost and benefit to fishers of changing mesh sizes. The selection probabilities for existing meshes can also be used to improve the assessments using age and length composition data collected for snapper and bream in NSW. This is particularly important for snapper, where a very large proportion of the fishery is caught close to the MLL. Finally, because wire mesh can be made in a diversity of shapes and sizes, it may be possible to achieve desirable changes in selectivity for some species with minimal changes in selectivity patterns for others.

1.3. Objectives

The objectives of this study were:

(1) To document throughout NSW the various mesh types currently used in demersal fish traps.

(2) To describe the size composition of retained and returned catch for species common in the NSW trap fishery.

(3) To describe the size composition of retained and returned catch for commercially available mesh and wire products in areas where they are not currently fished.

(4) To determine the likely utility of possible mesh configurations not currently in use.

1.4. Achievement of objectives

Objective 1. A survey of all commercial fishers with endorsements to use fish traps was done to document the various trap mesh sizes used in the fishery. The survey revealed that 98% of fishers who responded to the survey (n = 108) used 50 mm hexagonal wire mesh to cover their traps, however 32% also used panels of 50 x 75 mm welded mesh somewhere in their traps. Fishers using these panels of 50 x 75 mm welded mesh did so to reduce their catch of small, unwanted fish. The survey showed that most fishers using the larger 50 x 75 mm welded mesh were in the north of the state. Our survey included a question about species considered important to individual fishers businesses. The respondants listed 28 species which they considered to be important at certain times and places. The survey was used to initiate consultation with industry and to identify fishers who were willing to participate in the study. The data covering this objective are included in chapter 2.

Objectives 2 & 3. We achieved objectives 2 & 3 through several methods: (i) measuring fish at fishermens' co-operatives and the Sydney Fish Markets; (ii) measuring retained and returned fish onboard commercial vessels using fisheries observers; (iii) a voluntary fishers log-book of measurements of retained and discarded fish, and; (iv) through charter work fishing traps with various mesh sizes. Our estimates of the size compositions of retained and returned fish captured in standard 50 mm hexagonal wire traps showed that the selectivity of this mesh was inappropriate for all species with minimum legal lengths, (snapper, rubberlip morwong, bream and tarwhine) as well as pearl perch, with large numbers of undersized fish being captured and subsequently discarded with unknown mortality. The selectivity of this mesh appeared suitable for all other important species without minimum legal lengths in the fishery.

The size composition of retained and returned catch captured in traps with 50 x 75 mm welded mesh panels showed that fewer undersized fish were retained than in standard 50 mm hexagonal mesh, however large numbers of undersized snapper and rubberlip morwong were still captured in this mesh. Estimates of the retained catch of fish captured in 50 x 75 mm welded mesh showed that catches of marketable snapper, rubberlip morwong, bream, silver trevally, sweep, tuskfish, pearl perch, carpet shark and conger eels were virtually unaffected when using this larger mesh. Estimates of catches of some other important species in the fishery suggest substantial losses of marketable fish i. e. ocean jackets (30% by weight), tarwhine (25% by weight), pigfish (65% by weight) and goatfish (42% by weight). These estimates are based on statewide averages and will therefore vary significantly for individual fishing businesses. The importance of these species will also vary with location and season. We estimated that 32% of fishers used 50 x 75 mm welded mesh somewhere in their traps at the start of this study suggesting that potential losses of some marketable fish were acceptable to these businesses. The data covering these objectives are included in chapters 3 and 4.

Objective 4. We tested the selectivity of 4 novel mesh types for important species in the fishery. We established that the selection properties of a trap mesh could be estimated for many important species from the maximum mesh aperture and the fishes height. We used this relationship to design 2 experimental welded meshes aimed at selecting snapper at pre-determined sizes. We also tested the selectivity of 2 commercially available wire products, 60 x 80 mm and 80 x 100 mm hexagonal gabion wire mesh used in rock retaining walls. These 4 novel meshes were trialed in 2 ways: (i) by chartering commercial fishers to fish traps with novel meshes with fisheries observers onboard, and; (ii) by distributing novel wire to commercial fishers to use in their own traps. The results have shown the difficulty, or impossibility, of designing trap meshes with appropriate selectivities for all important species in such a multi-species fishery. We conclude that some of the novel meshes trialed may be appropriate for snapper, but potential losses of species either with minimum legal lengths smaller than snapper or with no minimum legal lengths may be large, and that uptake of these mesh types should initially be on a voluntary basis. The data covering this objective are included in chapter 5.

2. SURVEY OF MESH TYPES USED IN FISH TRAPS IN NEW SOUTH WALES

2.1. Introduction

This chapter addresses the first objective in the project, to document the current usage patterns of mesh types in the New South Wales demersal fish trap fishery.

Current regulations in NSW specify that fish traps must be covered with mesh having a measurement from one plain wire to the opposite plain wire of not less than 50 mm. The most commonly used wire mesh has been a 50 mm galvanised hexagonal fencing wire, but some fishers have reported advantages using larger mesh sizes in their traps. Prior to this study, we had limited knowledge, and had not quantified, what mesh types were actually used in the demersal trap fishery.

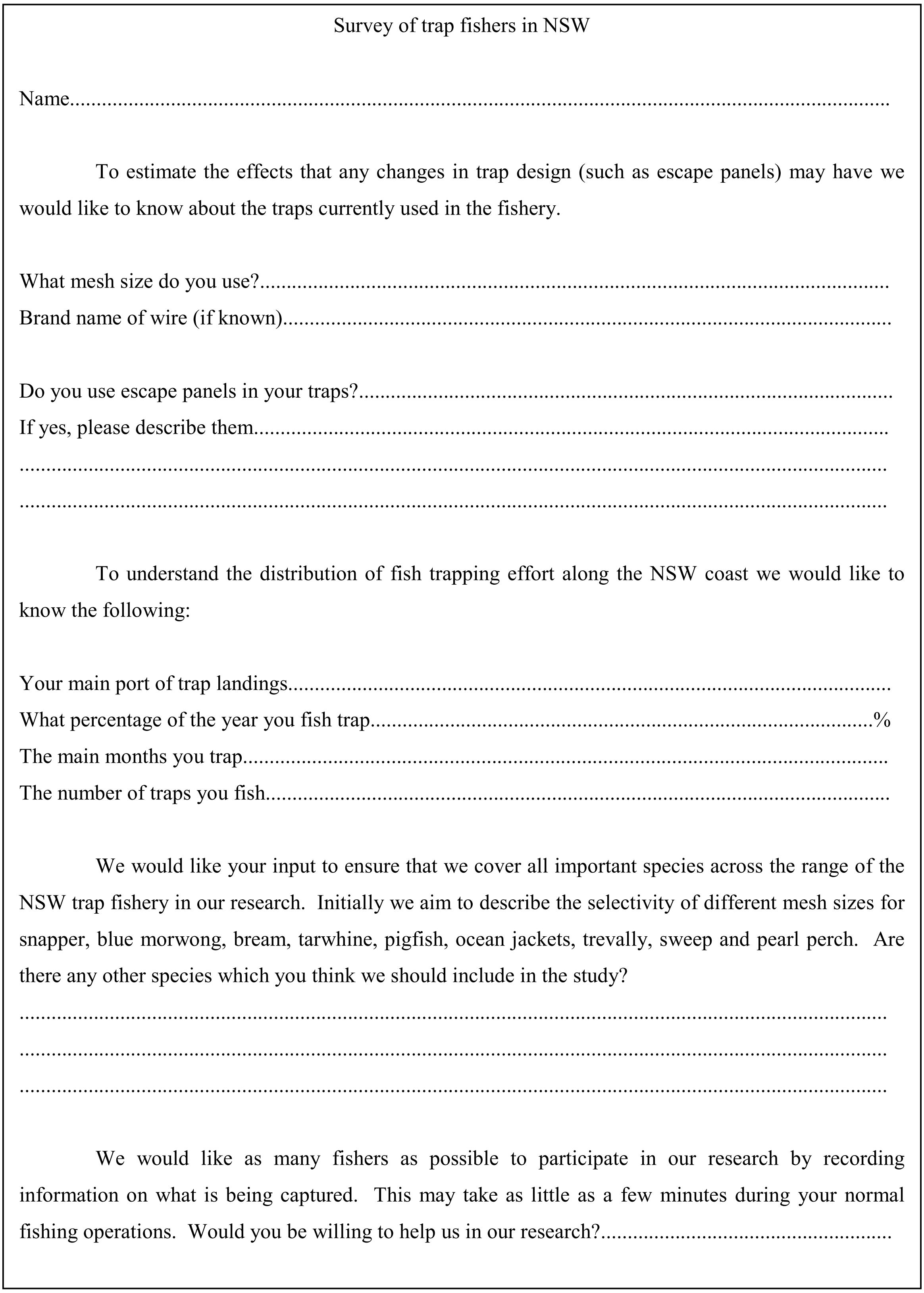
The demersal trap fishery in NSW is a multi-species fishery. We know the major species landed in the fishery (e. g. snapper, rubberlip morwong, bream, silver trevally etc.), but are aware that there are many lesser species which may only be important to some fishers and in some parts of the coast. Any changes in the mesh selectivity of fish traps are likely to impact on the catch of these lower valued species, and we need to be able to estimate potential impacts throughout the fishery.

To estimate the impact of changing the selectivity of fish traps by introducing different mesh sizes into the fishery, we need to know the spatial and temporal distributions of: (i) mesh sizes currently used; (ii) fish trapping effort, and; (iii) species of fish considered important. We considered that the most effective method of determining these factors, and to promote the study, was to directly survey each fisher in the fishery.

2.2. Materials and methods

We designed a survey to identify: (i) the different types of wire mesh used in the NSW demersal trap fishery; (ii) the distribution of effort, and; (iii) species which industry considered important. All commercial fishers with an endorsement to use fish traps (400 fishers) were mailed a letter detailing the objectives of the project and the survey questionnaire at the beginning of January, 1999 (Figure 2.1). We kept the survey form as short and as simple as possible. We asked for the brand name of wire used to help us in sourcing other mesh types and in developing novel meshes later in the study. The final question identified fishers who were willing to assist us during the study. Postage paid envelopes were provided for fishers to return the survey forms.

To identify the distribution of fishing effort along the NSW coast we divided survey returns into three arbitrary regions, the northern (Tweed Heads to South West Rocks), central (Port Macquarie to Sydney) and southern (Wollongong to Eden). For each region we were able to identify the main months of trapping, the average number of traps per fisher, the average number of months spent trapping per year, species of importance and the types of mesh used by fishers.



Survey of trap fishers in NSW

Name...

To estimate the effects that any changes in trap design (such as escape panels) may have we would like to know about the traps currently used in the fishery.

What mesh size do you use?...
Brand name of wire (if known)...

Do you use escape panels in your traps?...
If yes, please describe them..
....
....

To understand the distribution of fish trapping effort along the NSW coast we would like to know the following:

Your main port of trap landings..
What percentage of the year you fish trap..%
The main months you trap..
The number of traps you fish..

We would like your input to ensure that we cover all important species across the range of the NSW trap fishery in our research. Initially we aim to describe the selectivity of different mesh sizes for snapper, blue morwong, bream, tarwhine, pigfish, ocean jackets, trevally, sweep and pearl perch. Are there any other species which you think we should include in the study?
....
....
....

We would like as many fishers as possible to participate in our research by recording information on what is being captured. This may take as little as a few minutes during your normal fishing operations. Would you be willing to help us in our research?..

Figure 2.1. Survey form sent to all trap fishers.

2.3. Results

Of the 400 fishers we sent survey forms to, 108 (27%) completed and returned them to us. There were only 206 licensed fish trappers working in the 98/99 financial year, so this represented 52% of active fish trappers.

Mesh types

Of the 108 fishers who returned a survey form, almost all (106) used 50 mm hexagonal galvanised wire (diameter 1.6 mm), however 35 fishers (approximately 32% of respondants) also used 50 x 75 mm galvanised welded mesh (wire diameter 2.5 mm) somewhere in their traps. Most wire and welded mesh was sourced from BHP Wire products or Smorgon-ARC. The 50 x 75 mm welded mesh was commonly used in the north of the state where more than half of the trappers claimed to use it (see Table 1 for a summary). The welded mesh was commonly placed in the backs of traps, with the rest of the trap being normal 50 mm hexagonal wire mesh, however some fishers used welded mesh in their trap doors (either at the front or sides) and 2 fishers constructed their entire traps of welded mesh. Many survey returns were accompanied by letters detailing the effectiveness of using larger mesh in reducing unwanted catch.

Spatial and temporal activity

Trapping activity varied from south to north and was governed by species availability. In general, trapping south of Wollongong was done almost exclusively during the summer months, north of Wollongong trapping was done throughout the year (but mainly autumn to spring) and in the north of NSW the main months were during the winter and autumn. Reasons for this distribution in effort are complex, for example trapping is mostly done in autumn/winter in the north because of a run of snapper at this time and because of strong currents during the summer months. Other species such as ocean jackets are available to trappers on the south coast during the summer/autumn period with the season becoming progressively later the further north they go and it is a winter fishery on the far north coast. Similarly, for bream the main trapping months are during summer in the central region and during winter around the Clarence River.

Table 2.1. Summary of the survey questionnaire results on fish trapping in the New South Wales demersal trap fishery.

Region	Number of survey returns	Fishers using 50 x 75 mm welded mesh (%)	Mean number of traps per fisher	Mean number of months spent trapping per fisher year
Tweed Heads to South West Rocks	44	24 (55%)	12	7.3
Port Macquarie to Sydney	35	8 (23%)	19	8.8
Wollongong to Eden	27	3 (11%)	23	5.5

Important species

Some fishers were concerned that the catch of all currently landed species would be adversely affected by using mesh larger than 50 mm hexagonal. In addition to the snapper, blue morwong, bream, tarwhine, pigfish, ocean jackets, trevally, sweep and pearl perch we mentioned on the survey form, other species identified by fishers were octopus, ling, tasmanian trumpeter, maori wrasse, all leatherjacket species, wirrah, conger eel, boarfish, redfish, goatfish, red morwong, jackass morwong, teraglin, parrotfish (venus tuskfish), yellowtail kingfish, bar cod, foxfish and mulloway. Some fishers returned copies of their catch histories with their survey forms to emphasize the importance of some of these species to their businesses. In particular, it was revealed in the survey that the catch of octopus is very important to a small number of fishers on the south coast of NSW.

Industry consultation

Of the 108 fishers who returned survey forms, 67 volunteered to assist us further in the project, either by way of keeping log-books, trialing novel mesh designs or by charters. All fishers who indicated that they were willing to help us with our research were phoned to discuss the project. These discussions resulted in a close working relationship with industry and have assisted us in designing our sampling protocols and experimental trap meshes. Following being made aware of the project several fishers requested, and were supplied with, 50 x 75 mm welded mesh to trial in some of their traps, and many others indicated that they were keen to use it when they next built traps.

2.4. Discussion

We received survey returns from 52% of active fish trappers from all areas in NSW. We consider this to be an adequate representation of the fishery in NSW. Only 2 mesh types were reported, the 50 mm hexagonal wire and the 50 x 75 mm welded mesh. Some fishers indicated that they had previously used a 75 mm hexagonal mesh but that the mesh was no longer available. The use of 50 x 75 mm welded mesh in at least some parts of the trap is more widespread in the north of the state. While most fishers using the welded mesh to reduce the catch of small unwanted fish place the welded mesh in the backs of their traps, others find it easier to construct their doors from it. Most fish are thought to escape through the back of the trap as it is winched to the surface, and the effectiveness of larger mesh in the doors at the sides of a trap is unknown. The fact that 32% of fishers who returned the survey already used 50 x 75 mm welded mesh suggests that a change in legal mesh size to 50 x 75 mm would not have a major impact in some sectors of the fishery.

The survey revealed some informative spatial patterns in trapping effort along the NSW coast. Fishers north of South West Rocks tended to target snapper, fished mostly in autumn and winter, averaged 12 traps each and trapped an average of 7.3 months of the year. It was these northern fishers who mostly used the 50 x 75 mm welded mesh to reduce their catch of undersized snapper. Fishers in the central region averaged 19 traps and 8.8 months of effort, mostly from autumn to spring but were also active during the rest of the year. These fishers tended to target different species depending on the season. Finally, fishers on the south coast tended to trap during the summer months and averaged 23 traps each. These southern fishers also relied on species other than snapper and only a few (11%) used 50 x 75 mm welded mesh somewhere in their traps.

The survey revealed a long list of species which industry considered important (see above). This list of species, together with consultation with fishers, has helped us to identify extra species to study. Unfortunately, most of the species listed are not trapped in large quantities and as such it is difficult to get information on sizes currently captured in fish traps. However, the survey identified fishers who were willing to take log-books and to measure these less common species for us. Specifically, we identified velvet leatherjackets, 6-spine leatherjackets, red morwong, goatfish and parrotfish/tuskfish as species which we needed to collect information on in addition to the species mentioned on the survey form.

Several fishers, but one in particular from the south coast of NSW, detailed the importance of octopus to their trapping businesses. The problem raised was that they claim the current minimum of 50 mm hexagonal mesh is already too large and allows many octopus to escape. Any increase in mesh size would potentially allow many larger octopus to escape which would have a negative effect on their businesses. After discussions with these fishers it became clear that traps with 3 entrance funnels captured octopus more effectively, and that much of the catch was actually captured in lobster traps. There is a need for the development of a specific octopus trap, probably using smaller than 50 mm mesh and designed to prevent the capture of finfish and lobsters.

This survey was an excellent way to start the study. Apart from the information on mesh types currently used in the fishery, it enabled us to initiate consultation with industry. Every fisher with an endorsement to use fish traps received details of the study and was given the opportunity to comment on it. The fact that approximately 48% of active fish trappers did not return the survey is disappointing, however most of these were only part-time trappers. We are confident that the survey responses reflected the major fishers, with 9 of the top 10 snapper trappers between 1997 and 1999, and 18 of the 25 who averaged 3000 kg or more per year during the same period, returning the survey.

The spatial and temporal variations in targetted species and mesh types used in the fishery have revealed many complexities involved in any management changes concerning trap mesh selectivity. The survey has identified areas where changes would be welcomed and areas where changes would be considered deleterious to fishing businesses.

3. Size composition of the catch of species important in the New South Wales demersal trap fishery

3.1. Introduction

The demersal fish trap fishery in New South Wales is a multi-species fishery. New South Wales Fisheries catch statistics show that during the 3 most recent financial years (1997/98 to 1999/00) that snapper was the most important species in the fishery, being worth 48% of the value of the entire fishery (Fig. 3.1). The next most important species by value were bream (9%), rubberlip morwong (9%), leatherjacket (7.5%), silver trevally (7%), sweep (2%), pigfish (2%), carpet shark (1%), and parrotfish/tuskfish (1%). The remaining 13.5% of the fishery was composed largely of octopus, jackass morwong, tarwhine, red morwong, pearl perch and conger eel.

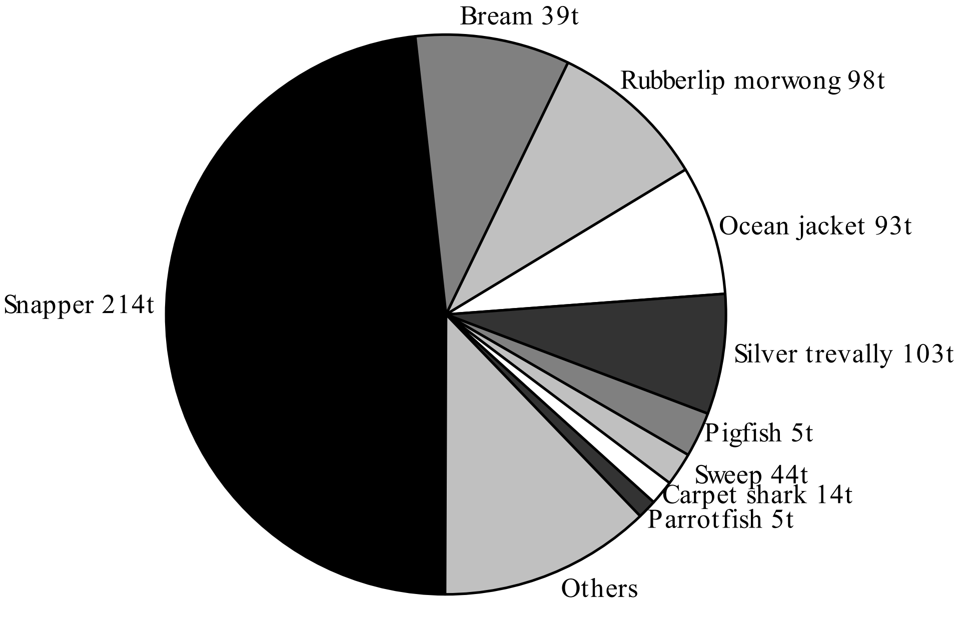


Figure 3.1. Relative value of species within the New South Wales demersal fish trap fishery. Mean landings per year from 1997/98 to 1999/00 are shown in tonnes (t).

While these catch statistics describe the statewide fish trap fishery, individual businesses rely on very different mixes of species. The results of the survey in chapter 2, together with recent catch statistics, reveal the variation in importance of different species to fishers in different places and times. Apart from snapper, which was studied as part of FRDC project 93/074, and silver trevally FRDC project 97/125, we have no information on the sizes of any other species retained in fish traps. This basic information is essential in understanding the dynamics of the fishery and for future fishery assessments. In regards to this study, knowledge of the sizes of fish captured in fish traps is needed if we are to make comment on the suitability of current fish trap selectivity and to estimate the impacts of any changes in mesh size.

The results of the survey described in chapter 2 show that many fishers use 50 x 75 mm welded mesh in their traps. This complicates any estimates of the sizes of fish retained in fish traps because traps with normal 50 mm hexagonal mesh will have different selection properties to traps with 50 x 75 mm welded mesh in them.

Many fish retained in fish traps are discarded at sea, either because they are below their minimum legal size or because they are too small to be marketed. Consequently, what is retained in fish traps can only be quantified at sea during normal fishing operations. Two ways in which this can be done are: (i) by using trained observers onboard trap vessels to measure and count the total retained and discarded catch, and; (ii) by asking fishers to keep logs of what they retain and discard.

This chapter describes the sizes of important species captured in the New South Wales demersal trap fishery. We provide estimates of the statewide catch for these species and where possible quantify the sizes discarded and retained in different mesh types.

3.2. Materials and methods

Estimates of the size composition of retained and discarded fish captured in fish traps were made using several methods. Fish retained for sale were measured (to the nearest 0.5 cm rounding down) at the Sydney fish markets and at fishermen's co-operatives. Wherever possible we assigned a mesh type (either 50 mm hexagonal mesh or 50 x 75 mm welded mesh backs) to catches, however this was not always possible as fishers often used a range of mesh sizes in a day. Estimates of the sizes of silver trevally landed in the fishery were also drawn from the previous comprehensive FRDC project (number 97/125).

Fish were also measured at sea by NSW Fisheries observers, and by commercial fishers as part of a voluntary log-book. These measurements made at sea provided estimates of both retained and discarded catch. We assumed that fishers decisions to discard fish were unaffected by the presence of onboard observers. 34 fishers from Kingscliff to Tathra voluntarily measured nearly 7,000 fish for us. Fishers volunteering to keep a log-book were provided with measuring boards and data sheets. To make data collection easy, fishers were asked to choose 1 species to measure as a part of their normal trapping operations. Fishers were asked to measure fish whenever they were able to, the only stipulation was that all fish of their chosen species had to be measured from each trap chosen. Fishers measured fish as fork length (FL) to the nearest whole cm rounding down. Because fishers had to slightly change the way they worked when measuring fish for us, there was a delay in the fishes normal fate, i.e. the time taken to measure fish delayed either the release of unwanted fish or the killing of fish in an ice slurry. We gained approval from the Animal Care and Ethics Committee (ACEC) to do this research (ACEC 98/13).

We plotted the sizes of fish retained in 50mm hexagonal mesh with the sizes of fish retained in 50mm x 75mm welded mesh. This data provided information on the selectivity already operating within the fishery and was also used in calculating selectivity curves in chapter 4.

3.3. Results

The voluntary log-book was a good way to obtain information on the sizes of less common species captured in the fishery, the sizes of discarded fish and the sizes of leatherjacket species which have their heads cut off at sea (Table 3.1). Where possible we validated the voluntary log-book data with observers onboard commercial vessels. We considered the log-book data to be unbiased and combined these measurements with those from observer days onboard commercial vessels.

Table 3.1. Summary of the numbers of fish measured onboard commercial vessels as part of the voluntary log-book and by NSW Fisheries observers.

Species	No. measured as part of the voluntary log-book	No. measured by NSW Fisheries observers onboard commercial vessels
Snapper	1932	6790
Rubberlip morwong	143	1069
Ocean jackets	1150	3528
Silver trevally	1082	4943
Pigfish	211	109
Tuskfish/Parrotfish	90	none
Pearl perch	587	1
Velvet jackets	1654	234

Snapper (Pagrus auratus)

Landings of snapper caught using traps in NSW have remained stable at around 200 tonnes per year since 1997/98. During the present study we used observers and the voluntary fishers log-book to measure 5365 snapper onboard commercial trap vessels using standard trap meshes. These measurements allowed us to quantify the numbers and sizes of retained and discarded snapper in the fishery. While snapper over 60 cm FL were captured during the study the bulk of the fishery was of fish less than 50 cm FL and we have only presented data for fish less than 50 cm FL. The sizes of fish captured varied between fishers, locations and seasons, but overall approximately 30% of all snapper caught in fish traps using all mesh sizes were below the minimum legal size of 28 cm TL (Fig. 3.2) and were discarded with unknown mortality. Observer data from 501 trap lifts showed an average of 2.78 undersized and 5.8 legal sized snapper captured per trap lift.

While onboard commercial trap vessels and during the charter work described in chapter 4 we measured 6016 snapper from traps covered with 50 mm hexagonal wire and 1338 snapper from traps with 50 x 75 mm welded mesh backs. It was apparent from these measurements that while both mesh types retained significant numbers of undersized snapper (approximately 23.5 cm FL), that the size distributions of undersized snapper differed between mesh types. Traps with 50 x 75 mm welded mesh backs retained almost no snapper < 20 cm FL, while those with 50 mm hexagonal wire backs caught relatively large numbers of snapper smaller than this (Fig. 3.3).

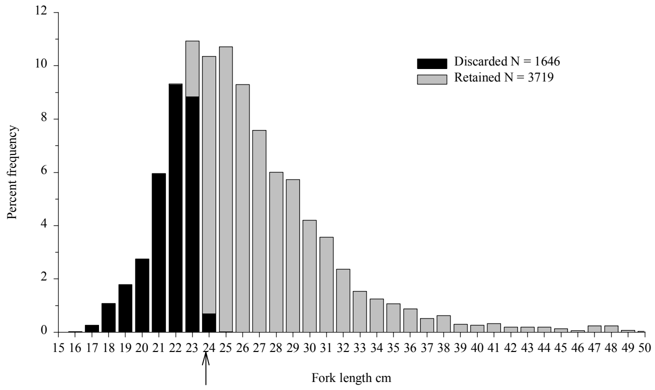


Figure 3.2. Length frequency distributions for retained and discarded snapper in the New South Wales demersal fish trap fishery. Minimum legal limit MLL is 28 cm total length (approximately 23.5 cm fork length).

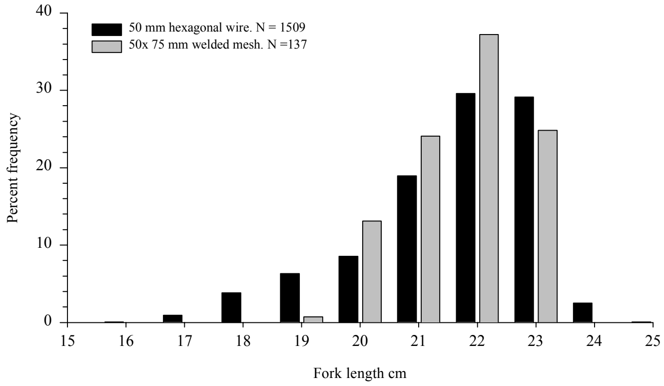


Figure 3.3. Length frequency distributions of undersized snapper captured in 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh back traps.

Bream (Acanthopagrus australis)

Bream are targeted using traps in both oceanic (43% of landings) and estuarine (57% of landings) waters. Most bream trapped in oceanic waters are captured between Forster and Sydney Harbour (78% of landings), while the most important estuaries are Sydney Harbour (30% of estuarine trap landings) and the Clarence River (25% of estuarine trap landings). Landings of trap caught bream have been relatively stable during the previous 3 years being 38 tonnes in 1997/98, 42 tonnes in 1998/99 and 35 tonnes in 1999/00. The trap fishery for bream targets what appear to be spawning aggregations of fish. The fishery is strictly a summer one around the Sydney region and a winter one in the Clarence River. Fishers catch little else when targetting bream with traps. Bream are highly priced, averaging $7.80 at the Sydney fish markets since 1997, with large and extra large fish commonly being sold at between $13 and $16 per kg.

We measured bream using observers onboard commercial vessels to estimate the retained and discarded catch. All fishers used 50 mm hexagonal wire on their traps. We measured a total of 815 bream trapped in oceanic waters and 2150 bream trapped in estuary waters during 1999/00 (Figs. 3.4 and 3.5). These figures show that 50 mm hexagonal wire mesh selects bream below their current minimum legal size of 25 cm total length (approximately 22 cm FL). Approximately 22% of estuary trapped bream were undersized while approximately 15% of oceanic trapped bream were undersized. Oceanic landings tended to have more large fish than estuary landings. The fishery targets fish in relatively shallow waters (less than 20 m) and undersized bream returned to the water appeared to swim away. However, even in relatively shallow water discarded undersized bream are susceptible to predation from pelicans, cormorants, sharks, seals and dolphins.

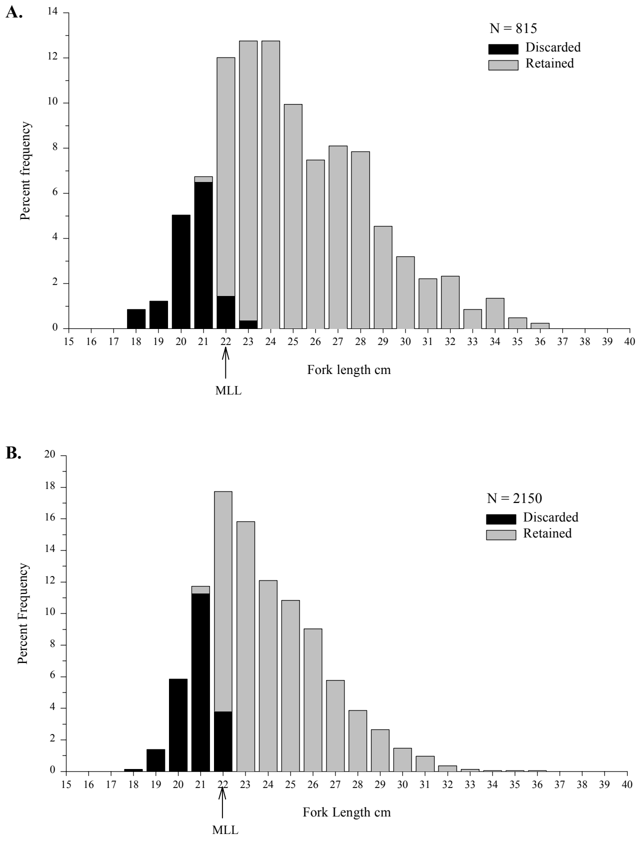


Figure 3.4. Length frequency distributions for retained and discarded bream trapped in **A**. ocean waters and **B**. estuary waters. Minimum legal limit MLL is 25 cm total length (approximately 22 cm fork length).

Rubberlip morwong (Nemadactylus douglasi)

Landings of trap caught rubberlip morwong have declined during the previous 3 years from 124 tonnes in 1997/98 to 93 tonnes in 1998/99 and to 72 tonnes in 1999/00. During this period they represented approximately 13% of the total trap fishery landings by weight but only approximately 9% by value. Rubberlip morwong are landed along the entire NSW coast but the largest landings have been in the central region (ocean zones 5 and 6, 32°S to 34°S) with more than 52% being landed there.

We measured 3854 rubberlip morwong at fishermen's co-operatives between July 1998 and November 2000 (Fig. 3.5). There were no apparent differences in sizes landed between years and it was clear that the size distribution was not knife-edged against the minimum legal size of 28 cm total length (approximately 23 cm FL).

Measurements made at sea as part of the voluntary log-book and observer days provided information on the sizes of rubberlip morwong discarded at sea (Fig. 3.6). These data showed that rubberlip morwong as small as 18 cm FL were retained in fish traps and that many fishers discarded legal sized fish, possibly because of poor market acceptability of small fish.

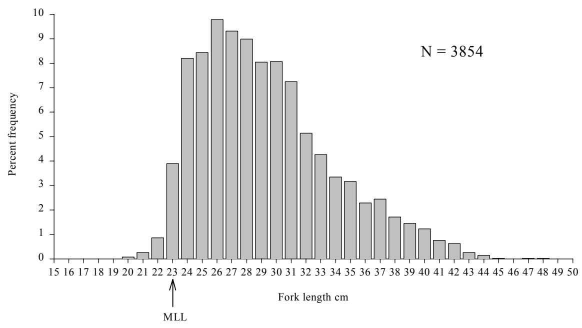


Figure 3.5. Length frequency distribution of rubberlip morwong measured at fishermen's co-ops and the Sydney fish market from all trap mesh types. Minimum legal limit MLL is 28 cm total length (approximately 23 cm fork length).

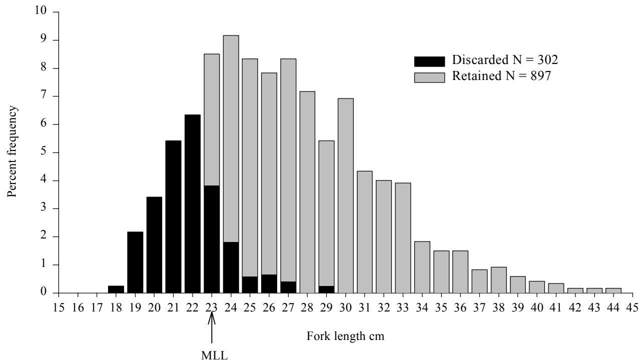


Figure 3.6. Length frequency distributions of discarded and retained rubberlip morwong measured onboard commercial trap vessels. Minimum legal limit MLL is 28 cm total length (approximately 23 cm fork length).

We measured 1032 rubberlip morwong from traps covered with 50 mm hexagonal wire and 529 rubberlip morwong from traps with 50 x 75 mm welded mesh backs (Fig. 3.7). The figure shows that traps with 50 x 75 mm welded mesh backs catch few undersized rubberlip morwong compared to those using 50 mm hexagonal wire mesh backs. We observed an average of 0.8 undersized rubberlip morwong per trap lift using 50 mm hexagonal wire and an average of 0.3 undersized rubberlip morwong per trap lift using 50 x 75 mm welded mesh backs.

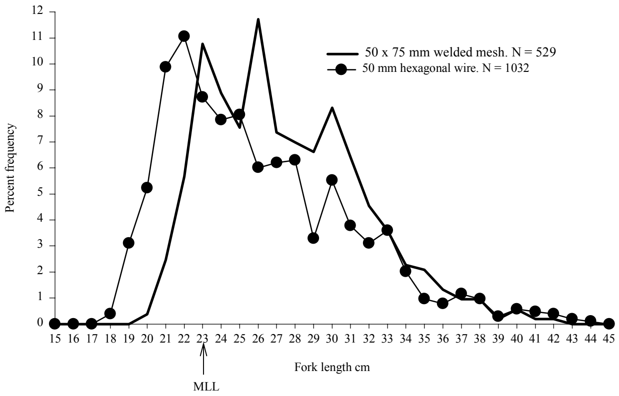


Figure 3.7. Length frequency distributions of rubberlip morwong captured in 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh back traps. Minimum legal limit MLL is 28 cm total length (approximately 23 cm fork length).

Ocean leatherjacket (Nelusetta ayraudi)

Ocean leatherjackets (or jackets) are the fourth most important species by value in the NSW trap fishery. Landings during the previous few years have been relatively stable at around 100 tonnes per year. Historically, ocean jackets were fished for intensively in New South Wales using traps, with landings peaking at 1000 tonnes per year during the 1950's. These landings were apparently not sustainable and declined markedly, suggesting that this species can be fished down by trapping. The ocean jacket trap fishery in New South Wales can be considered as a discrete fishery within the demersal trap fishery. When targetting ocean jackets trappers work specific jacket grounds and catch very little else in their traps. The ocean jacket trap fishery extends the length of the New South Wales coast, with the season varying with latitude. Ocean jackets are targetted off the south coast during summer/autumn with the season becoming progressively later in the north where it is a winter fishery. The season in any one place may extend from a few weeks to a couple of months.

Ocean jackets are beheaded at sea and we obtained estimates of the sizes captured using observer days at sea and voluntary log-books kept by fishers. We observed that the sizes of ocean jackets captured were highly variable between fishers, locations, depths and years (Fig. 3.8).

This variability in sizes, coupled with the requirement to measure fish at sea prior to beheading, meant that it was difficult to gain a statewide estimate of the sizes of ocean jackets captured within the limits of this study. However, our best estimate of the total size distribution for the state was made by determining the proportion of the total catch from each of those areas sampled during the study (i.e. 1997/98 to 1999/00 using catch records) and multiplying the size distribution from each region by its proportion of the total catch (Fig. 3.9).

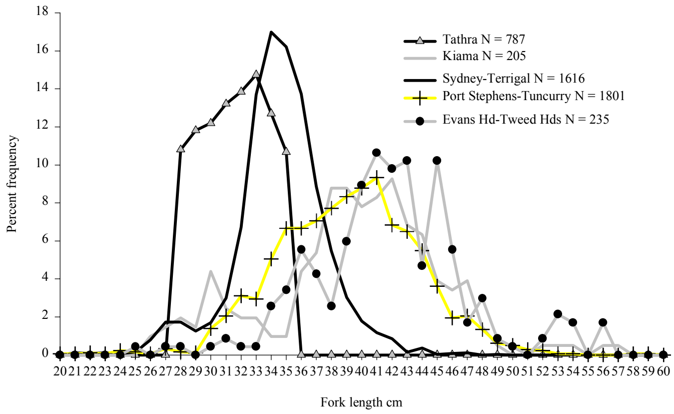


Figure 3.8. Length frequency distributions of trap caught ocean jackets from 5 areas along the New South Wales coast.

We observed very few ocean jackets being discarded by fishers. Ocean jackets which were discarded were smaller than 25 cm FL.

We were able to gain estimates of the sizes of ocean jackets retained in 50 mm hexagonal wire mesh traps and those with 50 x 75 mm welded mesh backs through observer days onboard boats out of Tuncurry, where fishers were using a combination of mesh types (Fig. 3.10). During the period sampled (June/July 2000) there was little difference in the size distributions retained in either mesh type, although traps with 50 mm hexagonal wire backs did retain larger numbers of ocean jackets smaller than 33 cm FL.

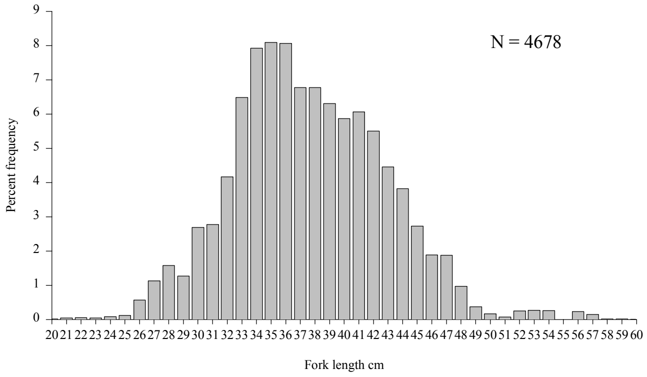


Figure 3.9. Weighted length frequency distribution of ocean jackets in the New South Wales demersal trap fishery. There is no minimum legal size limit for ocean jackets.

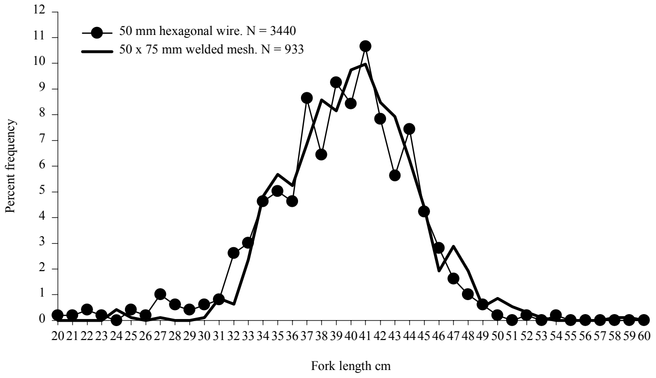


Figure 3.10. Length frequency distributions of ocean jackets captured in 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh back traps.

Silver trevally (Pseudocaranx dentex)

Landings of trap caught silver trevally have remained stable during the previous 3 years at 97 tonnes in 1997/98, 96 tonnes in 1998/99 and 110 tonnes in 1999/00. While silver trevally are ranked the fifth most valuable species in the fishery behind snapper, bream, rubberlip morwong and ocean jackets, there are some trap fishers whose businesses rely heavily on silver trevally. There are now valuable export markets for ice-slurried silver trevally. Silver trevally are landed along the entire NSW coast but since 1998 more than 80% of the states trap catch has come from the area between Forster and Jervis Bay.

There is no legal minimum size on trevally and while fishers claim to discard very small fish we did not observe any discarding during the study. The sizes of silver trevally observed in fish traps ranged from 16 cm FL to 61 cm FL (Fig. 3.11).

The length frequency distributions of silver trevally captured in traps using 50 mm hexagonal wire backs and traps using 50 x 75 mm welded mesh backs were estimated from observer trips onboard commercial vessels and are presented in Fig. 3.12. Most samples from 50 mm hexagonal wire back traps were taken from Sydney while most samples from 50 x 75 mm welded mesh backs were taken from Tuncurry. Fig. 3.12 suggests that the fisheries were targeting fish of different size distributions (i.e. fewer large and small fish at Tuncurry) and that determining the selectivity of the different mesh types is not possible with these data.

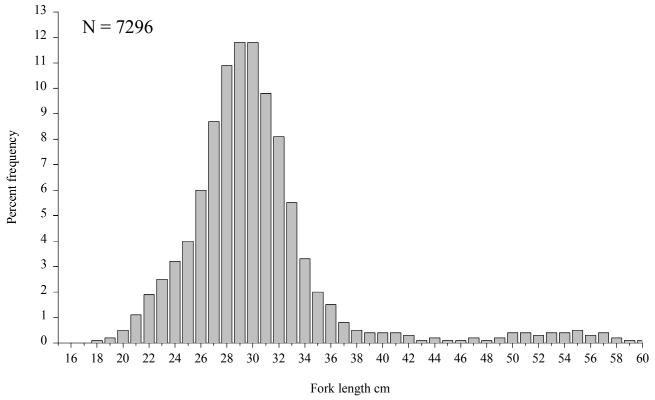


Figure 3.11. Length frequency distribution of silver trevally in the New South Wales demersal trap fishery. There is no minimum legal size limit for silver trevally.

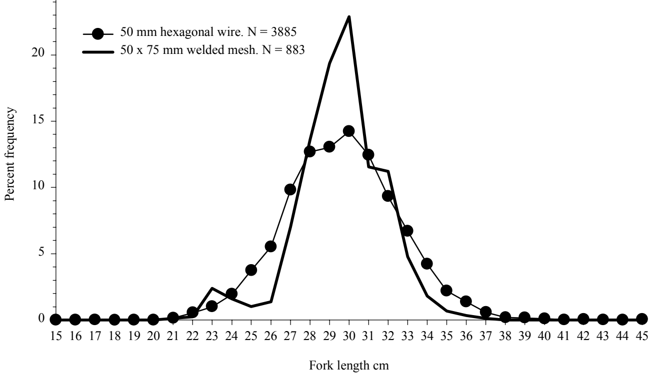


Figure 3.12. Length frequency distributions of silver trevally captured in 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh back traps.

Sweep (Scorpis lineolatus)

Landings of sweep caught in traps have declined rapidly during the previous 3 years from 75 tonnes in 1997/98 to 40 tonnes in 1998/99 and to 15 tonnes in 1999/00. Despite this decline sweep are still a valuable bycatch for many trap fishers. We measured a total of 2234 sweep at co-ops and fish markets, and 393 during observer days onboard commercial vessels. It was apparent that sweep captured on the north coast were on average smaller than those captured on the south coast, and our best estimate of a statewide size distribution was made by weighting measurements made north and south of Coffs Harbour by the total landings north and south of Coffs Harbour. (Fig. 3.13). There is no minimum legal size limit on sweep, however fishers tended to discard smaller fish as they have low market value.

Measurements made at sea onboard commercial vessels provided information on the sizes of sweep discarded at sea (Fig. 3.14). This figure shows that some fishers discard even quite large sweep and that sweep as small as 15 cm FL are retained in standard fish traps.

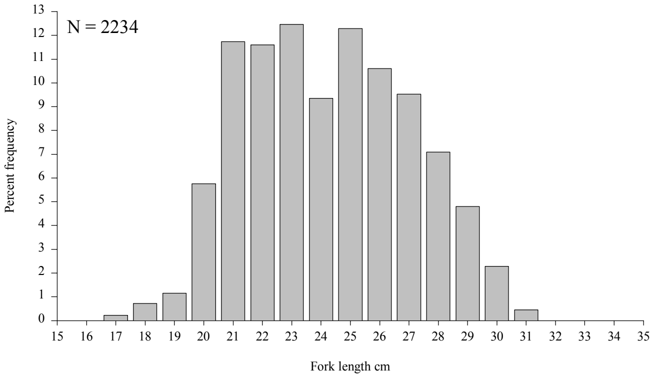


Figure 3.13. Weighted length frequency distribution of retained sweep in the New South Wales demersal trap fishery. There is no minimum legal size limit for sweep.

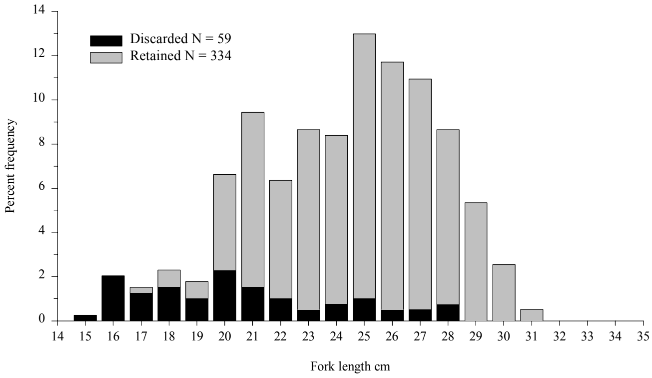


Figure 3.14. Length frequency distributions for retained and discarded sweep in the New South Wales demersal fish trap fishery. There is no minimum legal size size limit for sweep.

Pigfish (Bodianus vulpinus)

Pigfish are captured in small numbers by trap fishers but are the most highly valued species within the fishery, commonly bringing more than $20/kg. Landings have been steady at between 4 and 6 tonnes during the previous 3 years. There is no minimum legal size on pigfish and, because of their high value, they are never discarded. We measured 898 pigfish during the study (Fig. 3.15) and observed fish ranging in sizes from 24 cm to 43 cm FL.

Fig. 3.15 shows lengths of fish captured in traps with both 50 mm hexagonal wire and 50 x 75 mm welded mesh backs. When we plot the sizes of pigfish retained in 50 mm hexagonal wire and 50 x 75 mm welded mesh back traps separately (Fig. 3.16) it suggests that 50 x 75 mm welded mesh selects pigfish at larger sizes than 50 mm hexagonal wire. It should be noted, however, that the sizes may be confounded with latitude as almost all pigfish measured from traps with 50 x 75 mm welded mesh were from north of Coffs Harbour.

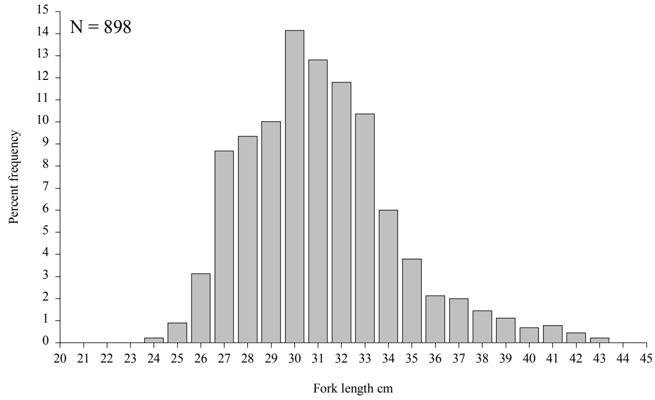


Figure 3.15. Length frequency distribution of pigfish in the New South Wales demersal trap fishery. There is no minimum legal size limit for pigfish.

Pigfish are sexually dimorphic, and if similar to other species of wrasse, probably change sex from female to male. Males were on average larger than females (Fig. 3.17) suggesting that sex change may occur and that this may have important implications when estimating the impact of any increases in mesh selectivity in traps. It will be the smaller female pigfish which are selected against and which will grow and change to males before being selected into the fishery. The numbers of males and females measured in Fig. 3.17 should be proportional to the numbers throughout the fishery, indicating that approximately 70% of the fishery is based on male pigfish.

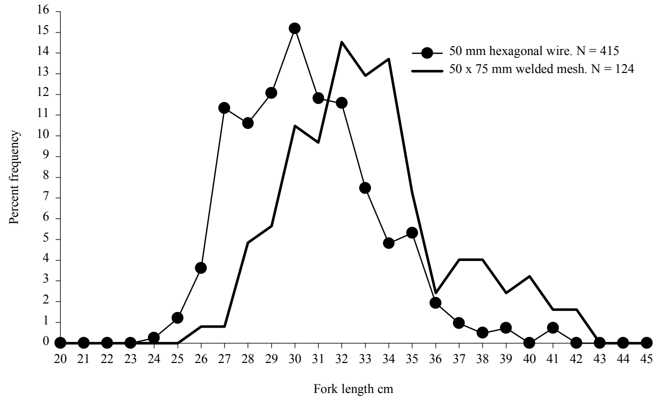


Figure 3.16. Length frequency distributions for pigfish retained in 50 mm hexagonal wire traps and 50 x 75 mm welded mesh back traps.

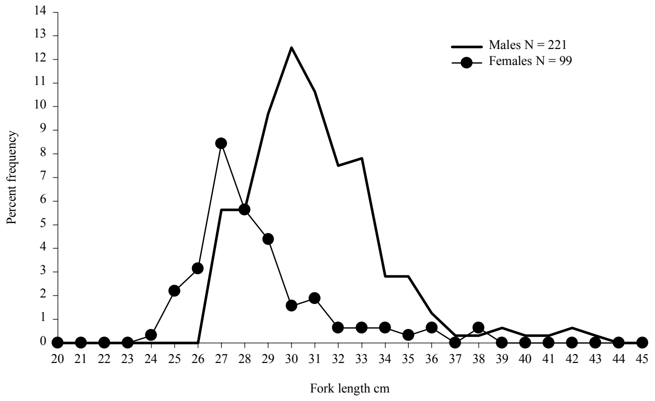


Figure 3.17. Length frequency distributions of male and female pigfish captured in 50 mm hexagonal wire traps.

Tuskfish (Choerodon spp.)

Tuskfish are commonly marketed as parrotfish and are a valuable bycatch in the trap fishery. Landings have been steady at between 39 and 47 tonnes during the previous 3 years. More than 90% of tuskfish are landed on the far north coast of New South Wales (north of South West Rocks). 719 tuskfish were measured at co-ops and onboard commercial vessels as part of the voluntary log-book system (Fig. 3.18). There is no minimum legal size on tuskfish and we did not observe any discarding of small fish. The sizes observed retained in traps were relatively large and ranged between 24 cm and 52 cm FL.

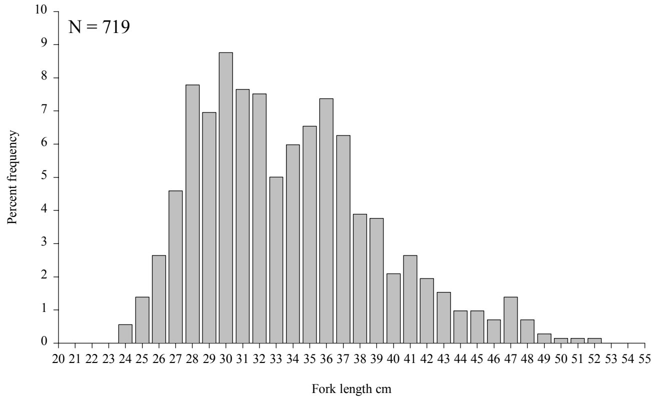


Figure 3.18. Length frequency distribution of tuskfish in the New South Wales demersal trap fishery. There is no minimum legal size limit for tuskfish and we observed no discarding.

Tarwhine (Rhabdosargus sarba)

Landings of trap caught tarwhine have been steady at between 27 and 29 tonnes during the previous 3 years. There is a minimum legal size of 20 cm TL (approximately 17.5 cm FL) for tarwhine. We measured 1359 tarwhine at co-ops (Fig. 3.19) and 206 tarwhine onboard commercial vessels (Fig. 3.20). These figures indicate that: (i) the size distribution of retained tarwhine is not knife-edged against the minimum legal size of 20 cm total length (approximately 17.5 cm FL); (ii) that tarwhine as small as 15 cm FL are retained in traps; and (iii) that some fishers discard legal sized tarwhine because of their small size and low value.

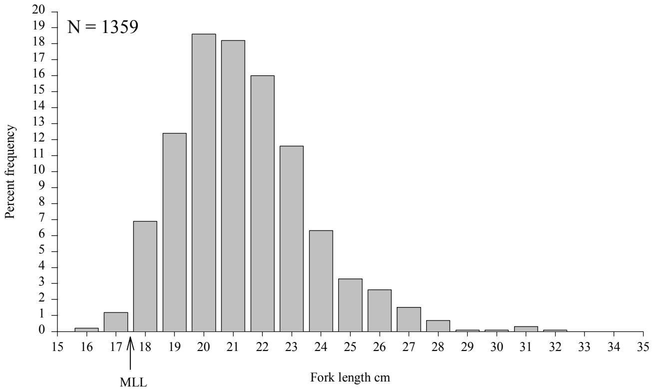


Figure 3.19. Length frequency distribution of tarwhine in the New South Wales demersal trap fishery. There is a minimum legal limit of 20 cm total length (approximately 17.5 cm fork length) for tarwhine.

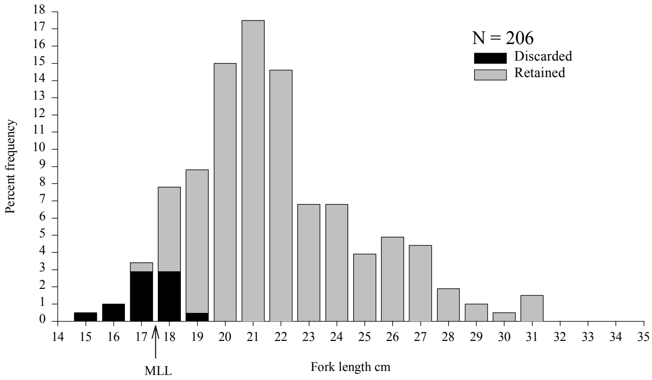


Figure 3.20. Length frequency distributions for retained and discarded tarwhine in the New South Wales demersal fish trap fishery. There is a minimum legal limit of 20 cm total length (approximately 17.5 cm fork length) for tarwhine.

Pearl perch (Glaucosoma scapulare)

Landings of pearl perch caught in traps have varied from 22 tonnes in 1997/98 to 13 tonnes in 1998/99 and 17 tonnes in 1999/00. The fishery is based on the north coast of New South Wales with more than 86% of landings being taken north of South West Rocks. There is no minimum legal size limit on pearl perch. We measured 734 pearl perch at co-ops (Fig. 3.21) and 587 as part of the voluntary log-book (Fig. 3.22). Figure 3.21 shows that fishers have a self imposed policy to not retain pearl perch under approximately 27 cm FL. Figure 3.22 shows that at some times and places large numbers of very small (down to 12 cm FL) pearl perch are retained in fish traps and are subsequently discarded with unknown mortality.

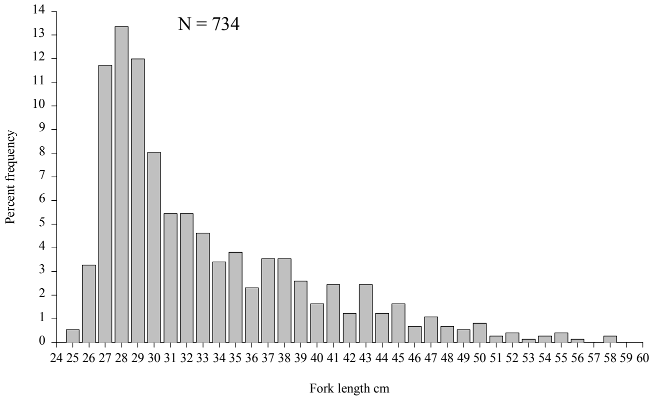


Figure 3.21. Length frequency distribution of retained pearl perch in the New South Wales demersal trap fishery. There is no minimum legal size limit for pearl perch.

We have little data on the selectivity of pearl perch captured in traps with 50 mm hexagonal wire mesh compared to those with 50 x 75 mm welded mesh backs, however we do have good log-book data from 2 fishers from Coffs Harbour who were fishing the same areas during the same period. One fisher used 50 x 75 mm welded mesh on the backs of his traps and the other used 50 x 75 mm welded mesh on his doors on the forward side of the trap (Fig. 3.23). This figure shows that while both fishers captured large numbers of small pearl perch, the fisher using 50 x 75 mm welded mesh on the backs of his traps captured far fewer fish less than 24 cm FL. This result suggests that most mesh selectivity is occurring at the back of the trap and that using larger mesh on the side of traps is not effective at allowing small pearl perch to escape.

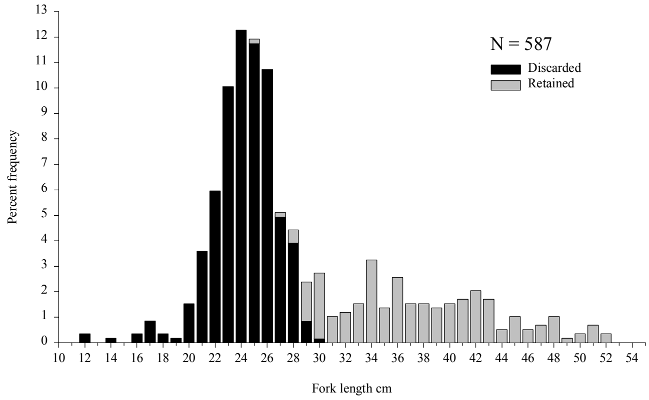


Figure 3.22. Length frequency distributions for retained and discarded pearl perch in the New South Wales demersal fish trap fishery. There is no minimum legal size limit for pearl perch.

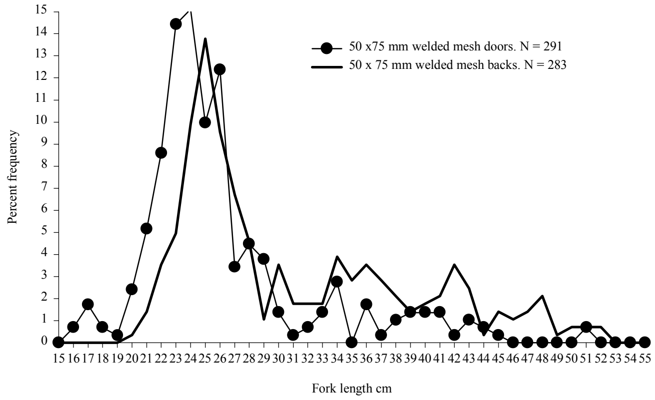


Figure 3.23. Length frequency distributions for pearl perch captured in traps with 50 x 75 mm welded mesh backs and 50 x 75 mm welded mesh side doors.

Velvet and 6-spine leatherjackets (Parika scaber & Meuschenia freycineti)

During this study we observed 8 species of leatherjacket including the ocean jackets described above. Apart from the ocean jackets the 2 most abundant species were the velvet (or army) leatherjacket and the 6-spined leatherjacket. Unfortunately fishers do not differentiate between many species of leatherjackets on their catch returns and catch records for these species are poor. They are, however, of limited commercial value to the trap fishery. All leatherjacket species are beheaded at sea, and we measured them onboard commercial vessels as part of the voluntary log-book and observer work. We measured 1888 velvet jackets (Fig. 3.24) and 414 6-spine jackets (Fig. 3.25) during the study. Fig. 3.24 shows that traps using 50 mm hexagonal wire mesh retained velvet jackets as small as 13 cm FL and that most of these very small fish are discarded. Fig. 3.25 shows that no 6-spine jackets were observed to be discarded during the study and that they were of a larger average size than velvet jackets.

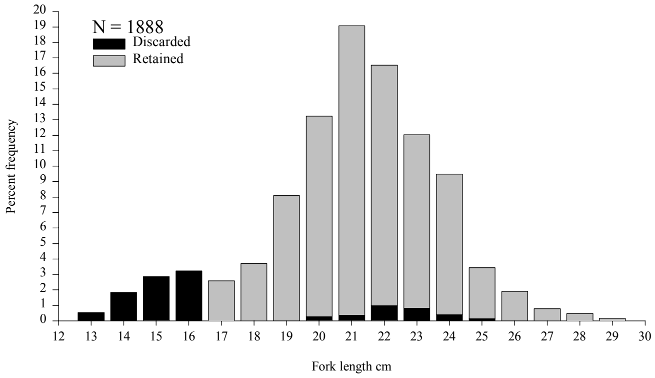


Figure 3.24. Length frequency distributions of retained and discarded velvet jackets in the New South Wales demersal trap fishery. There is no minimum legal size limit for velvet jackets.

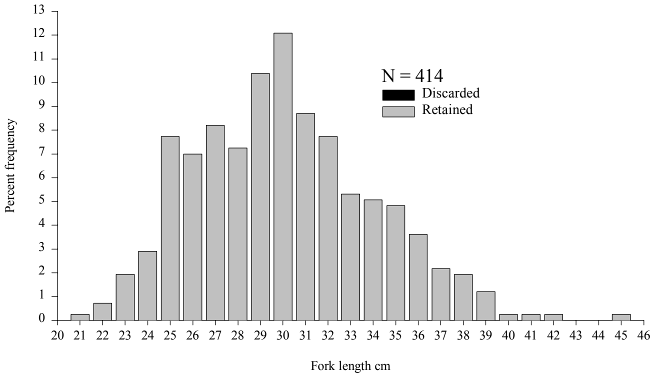


Figure 3.25. Length frequency distribution of 6-spine jackets in the New South Wales demersal trap fishery. There is no minimum legal size limit for 6-spine jackets.

3.4. Discussion

This chapter provides, for the first time, a description of the sizes of the most important species captured in the New South Wales demersal trap fishery. Measuring fish at sea onboard commercial vessels has provided us with information on what is discarded and the means to discuss the suitability of current mesh selectivity in the fishery. The simple voluntary industry log-book worked well and provided information on retained and discarded fish which could otherwise only be obtained using fisheries observers which are relatively expensive. It also enabled us to gain measurements at sea along the length of the coast which would otherwise have been difficult in a limited study such as this.

The data in this chapter indicate that the selectivity of the current legal sized mesh (50 mm hexagonal wire – used by almost all fish trappers to wrap their traps – chapter 2) is inappropriate for all the important species with minimum legal lengths (snapper, bream, rubberlip morwong and tarwhine) and also for pearl perch, with large numbers of undersized fish being captured and subsequently discarded with unknown mortality. The selectivity of 50 mm hexagonal wire mesh appears to be appropriate for almost all important species without minimum legal lengths, such as ocean jackets, trevally, sweep, pigfish and tuskfish.

Those fishers already using 50 x 75 mm welded mesh panels in their traps caught fewer undersized fish than those using 50 mm hexagonal wire mesh on the backs of their traps (Figs. 3.3, 3.7), however these traps still retained undersized fish. The fact that some fishers use 50 x 75 mm welded mesh in the backs of their traps when targetting species such as snapper, rubberlip morwong, ocean jackets and trevally suggests that losses due to an increase in mesh selectivity are small and are acceptable to these businesses. Our estimate of 2.78 undersized snapper per trap lift (estimated by NSW Fisheries observers onboard commercial vessels) is close to the estimate of 2.5 obtained by Ferrell & Sumpton (1997) who used a voluntary log-book study. Ferrell & Sumpton (1997) found that catches of undersized snapper varied by location and season, but that catches were always greatest in water depths less than 25 fathoms. A conservative estimate of trapping effort is 12,000 days/year (from catch returns) and an average of 15 traps per day (from our survey in chapter 2). Based on 2.78 undersized snapper per trap lift this trapping effort results in an estimated 500,400 snapper discarded per year.

While we have quantified the numbers and sizes of discarded undersized snapper, bream, rubberlip morwong and tarwhine, as well as those species with no minimum legal size limits, we have no information on the mortality of these discards. Henry (unpublished data) tagged snapper at various depths and had decreasing rates of recaptures as depth increased, suggesting some form of depth related mortality. Observations onboard commercial vessels show that many species suffer gas embolisms when lifted from deep water and discarded fish float and appear dead. It is likely that the mortality of trap caught fish is low when captured in shallow water. Most fishers winch the trap onboard, remove the trap door and immediately discard undersized or unwanted fish species overboard by hand. While these discarded fish appear to swim away there is likely to be some later, unobserved mortality from factors such as stress, physical damage and predation from seals, dolphins, sharks and pelicans which follow trap boats. Even if the mortality rate of discarded fish is low, large numbers of fish will be killed as a result of being trapped and discarded, e.g. if the mortality rate is only 5% then an estimated 25,000 discarded snapper will die each year, which equates to approximately 8.3 tonnes at recruitment into the fishery.

Information on the major species in the New South Wales demersal trap fishery will benefit fisheries managers when assessing the implications of different management strategies. We have shown that the minimum legal size limits for rubberlip morwong and tarwhine may be inappropriate in this fishery as many legal sized fish are discarded (Figs. 3.6 & 3.20). Fishers have self imposed size limits for species such as pearl perch (Fig. 3.22) and sweep (Fig. 3.14) which have no minimum legal size limits. Setting the appropriate size limits for these species in the trap fishery can be done by minimum legal limits and also by changing the selectivity of the trap mesh. The following chapters will address the suitability of changes in mesh size on the selectivity of the major species in the fishery.

The length frequency distributions for the important species in the fishery will be used in chapters 4 and 5, in which the selectivity of different mesh types are estimated, to estimate potential losses (loss of currently retained fish) and potential gains (reduction in by-catch) by changing the mesh selectivity of fish traps. Unfortunately, in a limited study such as this, it was not possible to quantify landings from all fish trapping businesses, or even from all areas, seasons or species. However, we have compiled enough data to estimate the impacts of any changes in trap mesh selectivity on the most important species in the fishery. We observed large variations in species composition and sizes which were important to individual fishers, and it will be up to individual fishers to document their own fishing businesses and to estimate the impacts that changes in mesh selectivity may have on them.

The log-book records kept by 2 fishers at Coffs Harbour of pearl perch captured in traps (Fig. 3.23) suggest that using 50 x 75 mm welded mesh in traps is more effective in reducing the catch of small fish when used in the back of the trap. This is an important result as in this study we use the mesh on the back of the trap to estimate the traps selectivity. We believe that fish are most likely to escape through trap meshes at the back of the trap while on the sea floor and, primarily, while being hauled to the surface.

Summarizing the sizes of important species and their landings in the New South Wales demersal trap fishery during the previous few years allows an overall assessment of the status of the fishery. Catch statistics for the previous 3 years (1997/98 to 1999/00) show that landings of most of the important species have been stable, however there have been large declines in the landings of rubberlip morwong and sweep caught in traps. This suggests that an assessment of these stocks is urgently needed. No assessments have been done on these species in New South Wales. Despite the fact that landings of all other important species have been relatively stable during the previous 3 years, the size frequency distributions of landings for those species with minimum legal size-limits show that (except for tarwhine) they appear to be heavily exploited with the bulk of fish landed around the minimum legal size. There is a clear need for species assessments to be done on all of the major species in the New South Wales demersal trap fishery. The size distributions reported here should be used as the basis of future ongoing monitoring. Where possible this monitoring should be done onboard commercial vessels (using either fisheries observers or as part of an organized log-book) so that discarded and retained catches can be documented. This is particularly necessary to understand the effects of future changes in size-limits for some of these species, and potential changes in trap mesh selectivity.

4. Selectivity of standard mesh sizes used in the NSW demersal trap fishery

4.1. Introduction

The mesh size selectivity of a wire-covered fish trap can be defined by the ability of a fish to pass through, or be retained by, the trap meshes once it has entered the trap. While escape through meshes may occur in any part of a net or trap, selectivity is estimated from the part of the gear where most fish escape, e. g. the cod-end in towed gears (Pope et al., 1975; Wileman et al., 1996; Millar & Fryer, 1999), the net wings in seines (Gray et al., 2000) or the escape gaps in pots (Xu and Millar, 1993; Treble et al., 1998; Jeong et al., 2000). In the fish traps used in NSW, fish can escape through meshes at either: (i) when the trap is fishing undisturbed on the sea floor or; (ii) when the trap is lifted and is being hauled to the surface. Fish may escape through any part of the trap when the trap is on the sea floor, although observations that fish in fish traps tend to swim into the current (Whitelaw et al., 1991) suggests that when set properly (i. e. with the trap entrance facing down current) that fish would be more likley to encounter and escape through the back panel of the trap. Fish are most likely to escape through the back panel of the trap as the trap is being hauled to the surface. This is because traps are rigged with a bridle at the front of the trap and when hauled, the back of the trap becomes the lowest part of the trap. Observations show that fish being hauled to the surface in a fish trap tend to orientate downwards and try to escape through the back of the trap. Consequently, we believe that the most important part of a fish trap in terms of mesh selectivity is the back panel, and for this study we use the mesh sizes in their back panels to describe selectivity.

The only fully satisfactory method for describing a fishing gears absolute selectivity is to compare selection curves for 2 different mesh types (Wileman et al., 1996). Many studies which have claimed to describe the selectivity of wire-covered fish traps have done so by comparing catch rates between traps with different mesh sizes (Munro, 1983; Olsen et al., 1978; Sutherland & Harper, 1983; Taylor & McMichael, 1983; Moran & Jenke, 1990; Harper et al., 1994; Newman & Williams 1995; Sary et al., 1997; Robichaud et al., 1999). Such studies do not describe the size selectivity of the traps, but rather their fishing efficiencies at a given time and place. Without calculating size selectivity curves for each mesh type and species, these types of studies are of little use when using traps at different times or locations and on different populations of fish.

There have been relatively few studies estimating the selectivity of traps compared to studies on towed gears, gillnets and hooks. A few studies have estimated the selectivity of escape gaps in lobster and crab fisheries (Xu and Millar, 1993; Treble et al., 1998; Jeong et al., 2000), while the selectivity of fish traps has really only been studied in the Antilles region (e.g. Ward, 1988; Gobert, 1994, 1998). These studies have modelled selectivity by comparing the sizes of fish retained in traps with different mesh sizes. Such studies are analogous to alternate hauls using towed gears (Wileman et al., 1996) and selectivity curves can be estimated using the same techniques (Millar & Fryer, 1999). The factors affecting trap mesh selectivity are poorly understood and previous studies have focused on the assumption that the sizes of fish retained in a trap are a function of their body size and the trap mesh size (Munro, 1983, Ward, 1988). While trap mesh selectivity must be affected by the physical ability of fish to pass through meshes, it has been shown that simple selection models based on mesh size and fish size do not fully account for the length structures in catches (Ward, 1988; Gobert, 1998; Robichaud, 1999), and that fish behaviour can be an important factor in determining trap mesh selectivity (Gobert, 1998).

Current regulations in NSW state that fish traps must be covered with mesh having a measurement from one plain wire to the opposite plain wire of not less than 50 mm. Our results in chapter 2 showed that almost all commercial fish trappers used a 50 mm hexagonal wire mesh to cover their traps and that some fishers (32% in our survey) also used panels of 50 x 75 mm welded mesh somewhere in their traps. The results in chapter 3 suggested that the selectivities of these standard meshes used in the fishery were inappropriate for all important species which had minimum legal lengths, with many undersized fish being captured and subsequently discarded with unknown mortality rates. There is a clear need for the baseline selectivity operating within the fishery to be described.

In this chapter we estimate the selectivity of the standard meshes currently used in the NSW demersal trap fishery, 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh, for the important species in the fishery. These estimates of selectivity are compared with those predicted based on fish height and maximum mesh diameter. We use estimates of selectivity to calculate the potential gains (reduction in by-catch) and losses (loss of legal product) from using a 50 x 75 mm welded mesh back panel in place of the 50 mm hexagonal wire mesh back.

4.2. Materials and methods

Study area

This study was done by chartering commercial fishers to fish experimental fish traps on commercial fishing grounds at 3 locations along the NSW coast. The charters were done offshore from Greenwell Point (34° 54'S, 150° 46'E) during March 1999, Terrigal (33° 28'S, 151° 27'E) during May/June 1999 and Crowdy Head (31° 51'S, 152° 46'E) during October, 1999.

Trap design

Twenty fish traps of similar dimensions to those used in the fishery were built by a commercial fisher. The traps consisted of a rectangular timber frame and measured approximately 165 cm x 135 cm x 90 cm. Luckhurst & Ward (1987) noted that mesh selectivity could be biased by fish attraction to different trap silhouettes, so to keep the visual profile of each trap the same all traps were covered with 37 mm (1½") galvanized hexagonal wire mesh, except for their back panels. The back panels of 6 traps were of 37 mm mesh, (which we assumed would retain fish well below the sizes we were interested in), the rest of the traps had back panels made of the 2 types of wire used in the fishery, i. e. 7 traps had back panels of 50 mm (2") galvanized wire mesh and 7 traps had back panels of 50 x 75 mm welded mesh fixed with the long axis vertical. Traps with back panels of 37 mm mesh, 50 mm mesh and 50 x 75 mm welded mesh respectively are referred to as 37 mm, 50 mm and 50 x 75 mm traps throughout this chapter.

Sampling procedure

Traps were baited (using either chicken offal, cuttlefish heads or fish flesh), and set in random order at depths between 15 m and 70 m. Traps were left to soak for at least 24 hours before being lifted, however soak times varied between 24 hours and 72 hours when bad weather prevented fishing. In total we sampled catches from 104 sets of 37 mm traps, 129 sets of 50 mm traps and 122 sets of 50 x 75 mm traps, and data were pooled for each mesh type. For each trap lift we recorded the mesh type and measured the fork length (FL) of each fish to the nearest whole centimetre (cm) rounding down.

Fishery sampling

Many species important to the trap fishery are either captured in relatively low numbers or are targetted only at certain times and places. Consequently it was not possible to capture sufficient numbers of all important species during the charter work to estimate their selectivities in the 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh. To overcome this we recruited commercial fishers to participate in a voluntary log-book, as well as placing an observer onboard commercial vessels, to document the sizes of the less common species captured in traps with 50 mm hexagonal wire backs and 50 x 75 mm welded mesh backs – details are given in chapter 3. In these cases we assumed that 50 mm traps retained fish of all sizes and the selectivity of 50 x 75 mm traps was calculated by comparing the sizes of fish retained in 50 x 75 mm traps with the sizes retained in normal 50 mm traps.

Statistical analyses

The present selectivity experiment was a comparative (indirect) one in which estimates of selectivity were made by comparing the sizes of fish captured in 50 mm traps and 50 x 75 mm traps with those in 37 mm traps. In this experiment the 37 mm traps were considered the control gear and the size distribution of the catch in these traps was assumed to be representative of the fish entering the trap.

Methods for determining the selectivity of fishing gears have been extensively reviewed by Pope et al. (1975), Wileman et al. (1996) and Millar & Fryer (1999). The SELECT (Share Each LEngth's Catch Total) method (Millar, 1992; Millar & Walsh, 1992; Wileman et al., 1996) is the most popular method for analysing data from selectivity experiments using comparative catches from 2 or more gears. The method has been used to estimate the selectivity of traps and pots for crustaceans (Xu & Millar, 1993; Treble et al., 1998; Jeong et al., 2000) and for fish (Jeong et al., 1999).

We used the SELECT model to fit data to the most commonly used logistic function

$$r(l) = \frac{\exp(a+bl)}{1+\exp(a+bl)}$$

where $r(l)$ is the probability that a fish of size l will be retained, and parameters a and b are estimated, with $a<0$ and $b>0$. The length at 50% retention, l_{50}, is given by:

$$l_{50} = \frac{-a}{b}$$

The SELECT model includes a "split" parameter, p, which can be defined as the relative fishing power and can be split into: (i) relative fishing effort, and; (ii) relative fishing efficiency of the trap types, given that all fish captured were measured. In this study the number of hauls per trap type were not equal and the relative fishing effort will be the number of successful trap hauls of experimental traps compared to the number of successful trap hauls of the control traps. We constructed each of our trap types to have the same visual profiles and used identical baits in each trap type in an attempt to create equal fishing efficiencies between trap types, however there are many unknown factors concerning the way traps work and it may be possible that one trap type fished more efficiently than another. The model can be fitted with p set at a pre-defined relative fishing effort, (i. e. equal fishing efficiencies), and also with p estimated. To test whether estimating the parameter p gave a better fit to the data we tested the hypothesis Ho: $p = 0.5$ using the likelihood ratio statistic. The likelihood ratio statistic has a chi square distribution with 1 degree of freedom and is the difference between the model deviances of models with p estimated and p set at equal fishing efficiencies.

The logistic curve is symmetrical about the l_{50}, however asymmetrical curves often fit selectivity data better (Millar, 1991). The Richards curve can be written:

$$\mathrm{r(l)} = \left(\frac{\exp(a+bl)}{1+\exp(a+bl)} \right)^{1/\delta}$$

The parameter, δ, quantifies the amount of asymmetry. When $\delta > 1$ the curve has a longer tail to the left of l_{50}, when $0 < \delta < 1$ the curve has a longer tail to the right and when $\delta = 1$ the curve is the symmetrical logistic curve.

To test whether the Richards curve gave a better fit to the data we tested the hypotheses Ho: $\delta = 1$ using the likelihood ratio statistic of the difference between the model deviances of models estimating a, b and a, b and δ.

Four models were fitted to the data using the SELECT methodology, maximum likelihood and SAS as described in Millar (1993). The 4 models were: model 1 - p fixed and logistic curve – parameters a, b; model 2 - p estimated and logistic curve – parameters a, b, p; model 3 - p fixed and Richards curve – parameters a, b, δ, and; model 4 - p estimated and Richards curve – parameters a, b, p, δ. Each model was fitted using parameters a, b, p and δ, and then reparameterized in terms of $l50$ (the length at 50% retention), l_{25} (the length at 25% retention), l_{75} (the length at 75% retention) and selection range ($\mathrm{SR} = l_{75} - l_{25}$). The outputs gave estimates of these parameters with standard errors and the model deviances.

We used the ratio of the model deviance over its degrees of freedom as an estimate of overdispersion (or failure of the assumption that fish behave independently). This is equivalent to Pearson's statistic and has an approximate chi-square distribution when the data are binomial. The p-value for the hypothesis test was obtained by the SAS code:

```
Data; pvalue=1-probchi(model deviance, d.f.); proc print;
```

as given in Millar (1993). Overdispersion has little effect on parameter estimation, but does affect standard errors (Millar and Fryer, 1999). To correct inferences for overdispersion standard errors were multiplied by the square root of the dispersion parameter.

To test whether catch rates of legal sized snapper differed between trap type, a 1 factor analysis of variance was done on the mean numbers of legal sized snapper (> 24 cm FL) captured per trap lift.

Estimating the impact of using 50 x 75 mm welded mesh panels

We used the best fitting selectivity models for each species to estimate the changes that may occur if 50 x 75 mm welded mesh panels are used in the backs of fish traps rather than standard 50 mm hexagonal mesh. Where 50 mm traps retained fish of all sizes encountered we did this by using the probabilities of retention in each 1 cm size-class in 50 x 75 mm traps, with the data on current landings taken in 50 mm traps in chapter 3, to estimate the potential gains (reduction in by-catch of undersized fish) and potential losses (reduction in numbers of marketable fish). Where fish were already being selected by size in 50 mm traps we took the reciprocal of the proportion retained in each size class and multiplied it by the proportion retained in 50 x 75 mm traps to estimate the total proportion retained in that size class.

4.3. Results

Snapper

We captured 407 snapper in 104 trap lifts using 37 mm traps, 661 snapper in 129 trap lifts using 50 mm traps and 406 snapper in 122 trap lifts using 50 x 75 mm traps (Fig. 4.1). Fig 4.1 shows that 50 mm traps retained smaller snapper than the control 37 mm traps. This suggests that 50 mm hexagonal wire mesh retained snapper of all available sizes, and that there was no size selectivity occuring. Consequently we estimated the selectivity of snapper in 50 x 75 mm traps by comparing the sizes retained in these traps with those retained in 37 mm and 50 mm traps combined.

Analyses of the model fits in Table 4.1 show that the logistic curve with equal fishing efficiencies provided the best fit to the data. The size at 50% retention l_{50}, was 20.98 cm FL (SE = 0.105) (Fig. 4.2). The estimated selection size for snapper in 50 x 75 mm traps based on the maximum mesh aperture and maximum body height was approximately 21 cm FL (see chapter 5 for length/height relationships).

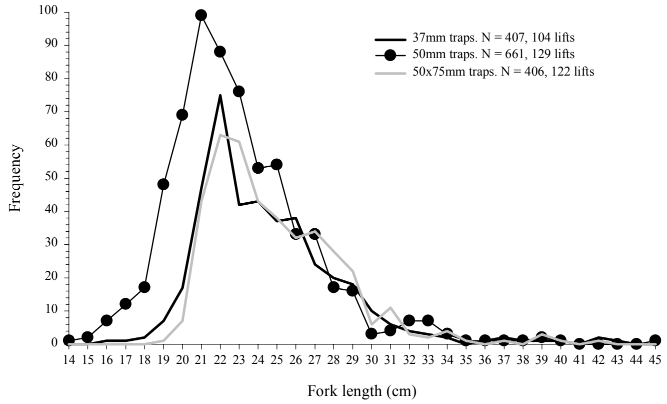


Figure 4.1. Length frequency distributions of snapper captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

To estimate potential gains and losses by using 50 x 75 mm welded mesh back panels rather than 50 mm hexagonal mesh when capturing snapper, we applied the logistic selectivity curve to the length distribution of snapper captured in standard 50 mm meshed traps in chapter 3 (Figs 3.2 & 3.3). Fig. 4.3 shows that using 50 x 75 mm mesh back panels would reduce the catch of undersized snapper by 33% without affecting the catch of legal sized fish.

There was no significant difference between the numbers of legal sized snapper (> 24 cm FL) captured per trap lift in the 3 trap types (1 factor ANOVA F = 0.017).

Table 4.1. Selection curve parameter estimates for snapper in 50 x 75 mm traps. Standard errors are given in parentheses for the model of best fit.

	Logistic selection curve		Asymmetric selection curve	
	model 1	model 2	model 3	model 4
	p=122/355	estimated p	p=122/355	estimated p
a	-33.82 (4.03)	-35.8	-20.36	-22.29
b	1.612 (0.196)	1.71	1.05	1.13
p	0.34366	0.334	0.34366	0.34
δ	1	1	0.248	0.322
l_{25}	20.30 (0.102)	20.26	18.32	18.73
l_{50}	20.98 (0.105)	20.90	19.36	19.71
l_{75}	21.67 (0.159)	21.54	20.41	20.67
model deviance	18.86897	18.8086	18.26749	18.3212
d.f.	32	31	31	30
	H_0: $p = 0.5$ (models 1 & 2)		H_0: $\delta = 1$ (models 1 & 3)	
	deviance = 0.06037		deviance = 0.60148	
	$p > 0.05$	Accept H_0: $p = 0.5$	$p > 0.05$	Accept H_0: $\delta = 1$
conclude that best model is logistic curve with p fixed.				

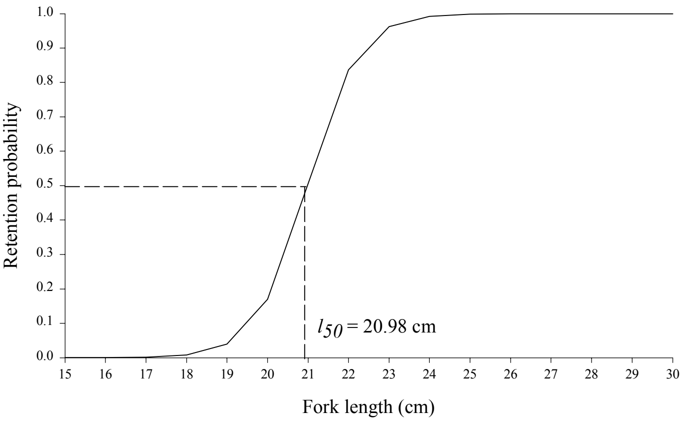


Figure 4.2. Fitted logistic curve for snapper retained in 50 x 75 mm welded mesh traps.

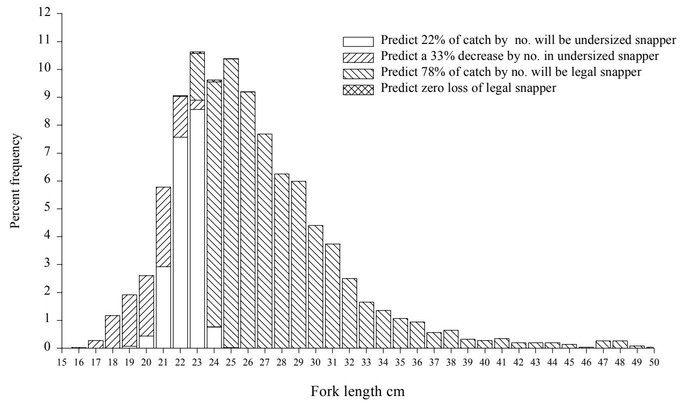


Figure 4.3. Predicted changes in the catch of undersized and legal snapper in traps when using 50 x 75 mm welded mesh back panels rather than 50 mm hexagonal mesh.

Bream

Our estimates of the selectivity of standard meshes for bream came from observer work onboard commercial vessels in Sydney Harbour. We measured 2149 bream from 68 trap lifts using 50 mm traps and 170 bream from 24 trap lifts using 50 x 75 mm traps during March-April 2000. Selectivity was estimated by comparing the sizes of bream retained in each mesh type, assuming that 50 mm traps retained bream of all sizes encountered (Fig. 4.4).

Selectivity of bream in 50 x 75 mm traps was best modelled by the logistic curve with estimated p (Table 4.2). The asymmetric model with equal fishing efficiency failed to converge to sensible parameters. The size at 50% retention l_{50}, was 22.5 cm FL (SE = 0.38). The estimated selection size for bream in 50 x 75 mm traps based on the maximum mesh aperture and maximum body height was approximately 22 cm FL.

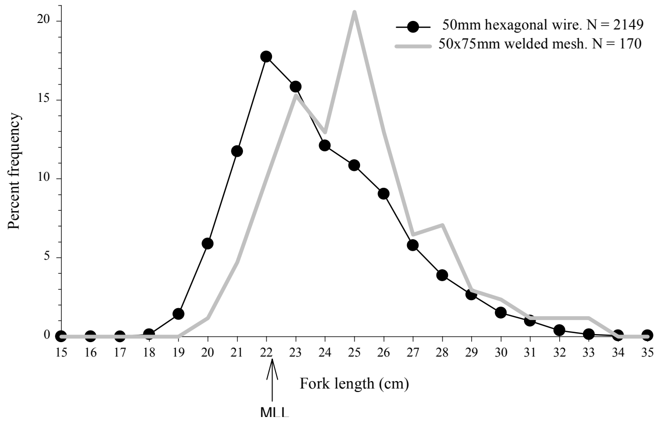


Figure 4.4. Length frequency distributions of bream captured in 50 mm hexagonal wire mesh and 50 x 75 mm welded mesh back traps. MLL is the minimum legal size limit of 25 cm total length (approximately 22 cm fork length).

Table 4.2. Selection curve parameter estimates for bream in 50 x 75 mm traps. Standard errors are given in parentheses for the model of best fit.

	Logistic selection curve		Asymmetric selection curve	
	model 1	model 2	model 3	model 4
	p=24/92	estimated p	p=24/92	estimated p
a	-7.11	-18.67 (3.74)		-48.98
b	0.24	0.83 (0.18)		2.03
p	0.2609	0.113 (0.01)		0.1095
δ	1	1		4.27
l_{25}	24.7	21.23 (0.28)		23.6
l_{50}	29.2	22.5 (0.38)		24.1
l_{75}	33.7	23.9 (0.61)		24.6
model deviance	18.8246	11.0055		10.6538
d.f.	17	16		15
	H_0: $p = 0.5$ (models 1 & 2)		H_0: $\delta = 1$ (models 2 & 4)	
	deviance = 7.8191		deviance = 0.3517	
	$p < 0.005$	Reject H_0: $p = 0.5$	p > 0.005	Accept H_0: $\delta = 1$
conclude that best model is logistic with p estimated				

To estimate potential gains and losses by using 50 x 75 mm mesh back panels rather than 50 mm hexagonal mesh when capturing bream, we applied the fitted logistic selectivity curve to the length distributions of bream captured in standard 50 mm meshed traps in ocean and estuarine waters chapter 3 (Fig 3.4). Fig. 4.5 shows that using 50 x 75 mm mesh back panels would reduce the catch of undersized bream by 80% and the catch of legal bream by 24% (18.6% by weight). The catch of undersized bream would be reduced by 79.5% in estuarine waters and 82% in ocean waters. The catch of legal bream would be reduced by 26% (21% by weight) in estuarine waters and 19.6% (14% by weight) in ocean waters.

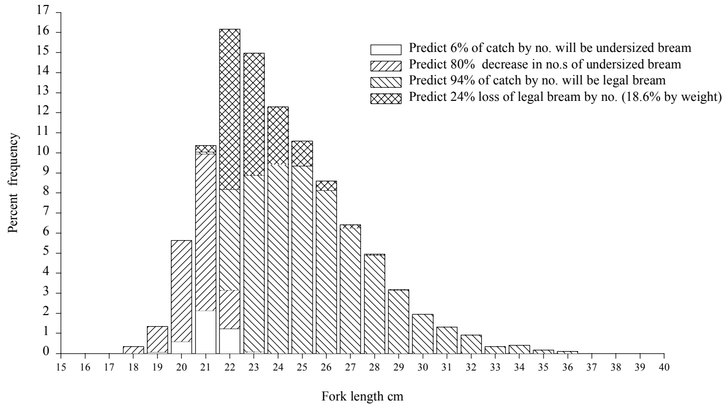


Figure 4.5. Predicted changes in the catch of undersized and legal bream when using 50 x 75 mm welded mesh back panels rather than 50 mm hexagonal mesh.

The model predicts a theoretical reduction of 24% (18.6% by weight) of legal bream if using 50 x 75 mm welded mesh. While the estimated selection size of l_{50} = 22.5 cm FL was close to the predicted size based on fish height and maximum mesh aperture, the selection range predicted by the model may be unrealistic. The small sample size in 50 x 75 mm welded mesh has resulted in a distribution which is not smooth and may have contributed to this. For example, the estimated size at 75% retention was 23.9 cm FL and as such the model predicts that 25% of bream in the 23-24 cm size class would be lost if using 50 x 75 mm welded mesh. This is not likely given that a 23.9 cm FL bream averages 96.2 mm maximum height (see table in chapter 5), 8.7 mm larger than the maximum mesh aperture of 87.5 mm. A legal bream of 25 cm TL is approximately 22 cm FL If the size at 50% retention was 22.5 cm FL it is probable that 50% of bream in the 22-23 cm size class would be retained and that 100% retention would be achieved in the 23-24 cm size class. This would result in a loss of only 9% by number and 6% by weight. More data on the sizes of bream retained in 50 x 75 mm traps is needed to provide confidence in the models results.

Rubberlip morwong

We captured 77 rubberlip morwong in 104 trap lifts using 37 mm traps, 87 rubberlip morwong in 129 trap lifts using 50 mm traps and 42 rubberlip morwong in 122 trap lifts using 50 x 75 mm traps during the charter work. This was supplemented by the 945 rubberlip morwong measured onboard commercial vessels using 50 mm traps and 488 rubberlip morwong measured onboard commercial vessels using 50 x75 traps which are presented in Fig. 3.7. Fig. 4.6 shows the numbers of rubberlip morwong captured in each mesh type during the charter work and, as with snapper, the 50 mm traps retained fish smaller than the 37 mm control traps. Selectivity of 50 mm traps was therefore assumed to be 100% for all sizes encountered. The selectivity of 50 x 75 mm traps was estimated by comparing fish retained in 50 x 75 mm traps with those retained in 37 mm and 50 mm traps pooled during the charter work, combined with the scaled-up measurements from 50 mm and 50 x 75 mm traps onboard commercial vessels presented in Fig. 3.7.

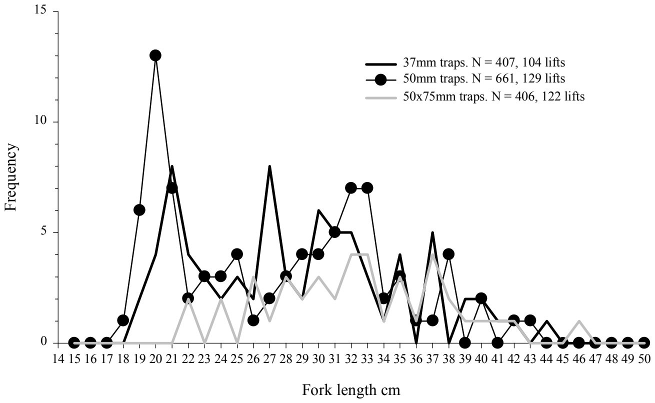


Figure 4.6. Length frequency distributions of rubberlip morwong captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

Analyses of the model fits in Table 4.3, along with the model residuals, showed that the logistic curve with estimated fishing efficiency provided the best fit to the data. The size at 50% retention l_{50}, was 22.02 cm FL (S.E. = 0.35). The estimated selection size for rubberlip morwong in 50 x 75 mm traps based on the maximum mesh aperture and maximum body height was approximately 22.8 cm FL. The narrow selection range of 1.46 cm (l_{75}-l_{25}) suggests that selection was relatively knife-edged.

To estimate potential gains and losses by using 50 x 75 mm mesh back panels rather than 50 mm hexagonal mesh when capturing rubberlip morwong, we applied the logistic selectivity curve to the length distribution of rubberlip morwong captured in standard 50 mm meshed traps in chapter 3 (Fig 3.6). Fig. 4.7 predicts that using 50 x 75 mm mesh back panels would reduce the catch of undersized rubberlip morwong by 57% with only 1.8% of legal sized fish being lost.

Table 4.3. Selection curve parameter estimates for rubberlip morwong in 50 x 75 mm traps. Standard errors are given in parentheses for the model of best fit.

	Logistic selection curve		Asymmetric selection curve	
	model 1	model 2	model 3	model 4
	p=122/355	estimated p	p=122/355	estimated p
a	-42.06	-33.15 (0.35)	-72.7	-492.87
b	2.17	1.505 (0.45)	3.313	21.57
p	0.347578	0.4988 (0.03)	0.347578	0.493
δ	1	1	2.412	22.13
l_{25}	20.69	21.297 (0.27)	22.42	22.81
l_{50}	21.2	22.02 (0.35)	21.753	22.84
l_{75}	21.71	22.758 (0.53)	22.08	22.88
model deviance	195.03	45.4101	193.864	43.176
d.f.	26	25	25	24
	H_0: p= 0.5 (models 1 & 2)		H_0: δ= 1 (models 2 & 4)	
	deviance = 149.62		deviance = 2.2341	
	$p < 0.005$	Reject H_0: $p = 0.5$	$p > 0.05$	Accept H_0: $\delta = 1$
conclude that best model is logistic with p estimated				

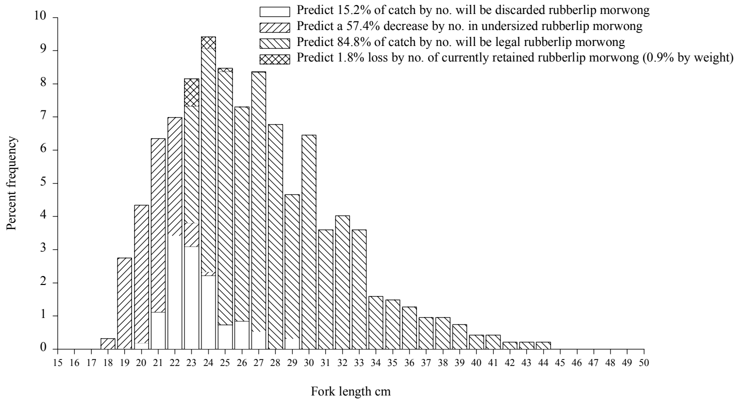


Figure 4.7. Predicted changes in the catch of undersized and legal rubberlip morwong when using 50 x 75 mm welded mesh back panels rather than 50 mm hexagonal mesh.

Ocean leatherjacket

We captured 540 ocean jackets in 77 trap lifts using 37 mm traps, 338 ocean jackets in 87 trap lifts using 50 mm traps and 156 ocean jackets in 87 trap lifts using 50 x 75 mm traps during the charter work (Fig. 4.8). Estimates of selectivity were made by comparing the sizes of ocean jackets captured in 50 mm and 50 x 75 mm traps with those captured in 37 mm traps. The best model describing mesh selectivity for ocean jackets in 50 mm traps was the logistic curve with equal fishing efficiencies (Table 4.4), while the best model describing mesh selectivity for ocean jackets in 50 x 75 mm traps was the asymmetric curve with equal fishing efficiencies (Table 4.5). The asymmetric curve with estimated p failed to converge to stable parameter estimates.

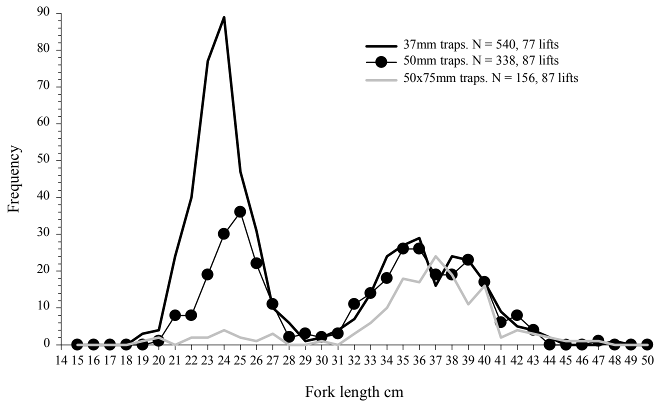


Figure 4.8. Length frequency distributions of ocean leatherjackets captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

Table 4.4. Selection curve parameter estimates for Ocean leatherjackets in 50 mm traps. Standard errors are given in parentheses for the model of best fit.

	Logistic selection curve		Asymmetric selection curve	
	model 1	model 2	model 3	model 4
	p=87/164	estimated p	p=87/164	estimated p
a	-10.19 (2.38)	-11.22	-40.89	-359.67
b	0.403 (0.1)	0.457	1.494	13.416
p	0.53049	0.495	0.53049	0.4872
δ	1	1	5.017	22.916
l_{25}	22.54 (0.46)	22.14	22.63	26.64
l_{50}	25.27 (0.58)	24.54	27.363	26.78
l_{75}	27.99 (1.18)	26.95	28.098	26.93
model deviance	23.57384	21.77659	22.6397	19.45
d.f.	27	26	26	25
	H_0: $p = 0.5$ (models 1 & 2)		H_0: $\delta = 1$ (models 1 & 3)	
	deviance = 1.797		deviance = 0.934	
	$p > 0.05$	Accept H_0: $p = 0.5$	$p > 0.05$	Accept H_0: $\delta = 1$
conclude that best model is logistic with p fixed				

Table 4.5. Selection curve parameter estimates for Ocean leatherjackets in 50 x 75 mm traps. Standard errors are given in parentheses for the model of best fit.

	Logistic selection curve		Asymmetric selection curve	
	model 1 p=87/164	model 2 estimated p	model 3 p=87/164	model 4 estimated p
a	-9.33	-9.5	-12.76 (29.6)	
b	0.265	0.275	0.34 (0.7)	
p	0.53049	0.51	0.53049	
δ	1	1	1.484 (4.2)	
l_{25}	30.99	30.47	33.64 (16.9)	
l_{50}	35.13	34.45	36.81 (10.7)	
l_{75}	39.27	38.44	39.97 (5.1)	
model deviance	70.6782	72.8565	65.79667	
d.f.	28	27	27	
	H_0: p=0.5 (models 1 & 2)		H_0: $\delta = 1$ (models 1 & 3)	
	deviance = 2.1783		deviance = 5.67907	
	$p > 0.05$	Accept H_0: $p = 0.5$	$p < 0.05$	Reject H_0: $\delta = 1$
conclude that best model is asymmetric with p fixed				

To estimate potential impacts on ocean jacket catches by changing mesh sizes, we fitted the selectivity curves for 50 mm traps and 50 x 75 mm traps to the weighted length distribution of ocean jackets in the fishery (Fig. 3.9). We have estimated the potential change in catches by using 37 mm mesh and the losses by using 50 x 75 mm mesh. The results indicate that using 37 mm meshed traps would increase the catch of ocean jackets by nearly 5% by numbers, and that using 50 x 75 mm traps may reduce the catch of ocean jackets by nearly 40% by numbers and 30% by weight (Fig. 4.9).

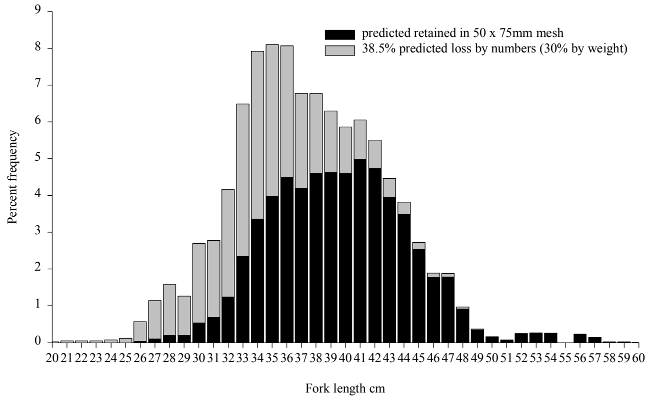


Figure 4.9. Predicted change in catch of ocean jackets if using 50 x 75 mm traps rather than 50 mm traps.

Sweep

We captured 24 sweep in 104 trap lifts using 37 mm traps, 27 sweep in 129 trap lifts using 50 mm traps and 38 sweep in 122 trap lifts using 50 x 75 mm traps during the charter work. 37mm and 50 mm traps captured sweep of similar sizes, so we concluded that 50 mm traps retained all sweep encountered and pooled the data for these 2 trap types. To supplement the relatively small numbers of sweep observed during the charter work we used measurements of sweep from observer days onboard commercial vessels. We measured 318 sweep from 50 mm traps and 75 sweep from 50 x 75 mm traps during observer trips and scaled these to have equal numbers at 25 cm FL (well above the estimated maximum physical size which could fit through 50 x 75 mm mesh). We set p as the number of successful trap lifts during the charter, i.e. 122/233.

The estimated selection size for sweep in 50 x 75 mm traps based on their maximum height and maximum mesh aperture was approximately 18 cm FL. We observed very few sweep smaller than 18 cm FL during the study, and consequently the selectivity of 50 x 75 mm traps was close to 100% for the sizes of sweep observed. The data did not fit well to the selectivity models, however the logistic curve with equal fishing efficiency provided parameter estimates of l_{50} = 17.05, l_{25} = 17.0 and l_{75} = 17.1 cm FL, model deviance = 95.9 with 17 d.f.

When fitted to the length frequency data for sweep catches in chapter 3 (Fig. 3.13), the selection model predicted a loss of 0.2% of sweep if using 50 x 75 mm welded mesh. The selectivity of sweep in 50 x 75 mm traps can be assumed to be close to 100% retention for all sizes encountered.

Pigfish

We only captured 7 pigfish during our charter work, however measurements of 124 pigfish from 50 x 75 mm traps and 415 pigfish from 50 mm traps (Fig. 3.16) allowed us to calculate the selectivity of pigfish in 50 x 75 mm traps. The best model describing the selectivity of pigfish in 50 x 75 mm traps was the logistic model with equal fishing efficiency which produced parameters l_{50} = 33.07 cm FL, l_{25} = 30.65 cm FL, l_{75} = 35.49 cm FL, model deviance = 15.2959 with 17 d.f. Based on maximum mesh aperture and maximum body height we predicted pigfish would be selected at approximately 32 cm FL.

When fitted to the length frequency data for pigfish retained in 50 mm traps in chapter 3 (Fig. 3.16), the selection model predicted a loss of 71% by numbers and 65% by weight of pigfish if using 50 x 75 mm welded mesh. It should be noted, however, that these calculations were made from pigfish measured from 50 mm traps which were mostly made from Coffs Harbour southwards.

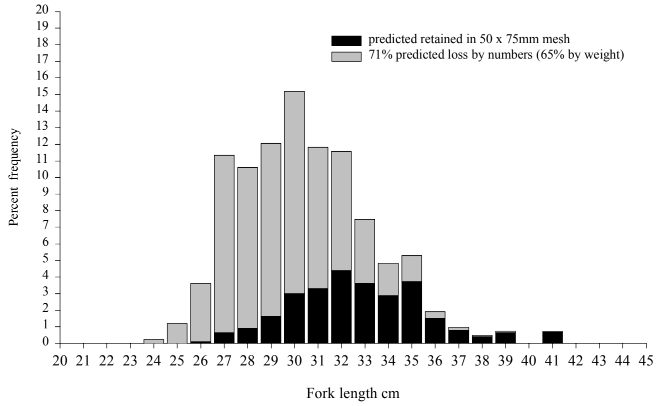


Figure 4.10. Predicted change in catches of pigfish if using 50 x 75 mm welded mesh traps.

Tarwhine

We captured 37 tarwhine in 104 trap lifts using 37 mm traps, 43 tarwhine in 129 trap lifts using 50 mm traps and 15 tarwhine in 122 trap lifts using 50 x 75 mm traps. There was no apparent difference between the sizes of tarwhine retained in either 37 mm or 50 mm traps and the data for these mesh sizes were therefore pooled. To supplement the limited data from the charter work we added measurements of 4 tarwhine from 37 trap lifts using 50 mm traps and 6 tarwhine from 77 traps using 50 x 75 mm traps while onboard commercial vessels fishing out of Tuncurry.

The logistic model with equal fishing efficiency produced parameter estimates of l_{50} = 23.9 cm FL, l_{25} = 21.8 cm FL, l_{75} = 25.9 cm FL, model deviance = 22.7869 with 14 d.f. Based on the maximum mesh aperture and the maximum body height we predicted tarwhine would be selected at approximately 20.5 cm FL. It is clear that the limited numbers of tarwhine measured were inadequate to produce realistic selectivity curves. To overcome this problem when estimating potential gains/losses if using 50 x 75 mm welded mesh, we fitted a selection curve with l_{50} = 20.5 cm FL and with a selection range of 1.4 cm (the same as for snapper). This curve was fitted to the length frequency distribution of discarded and retained tarwhine from 50 mm traps presented in chapter 3 (Fig. 3.20). This model predicted an almost 100% reduction in the catch of undersized tarwhine (98.6%) and a reduction of 33% of legal sized fish by numbers and 25% by weight (Fig 4.11).

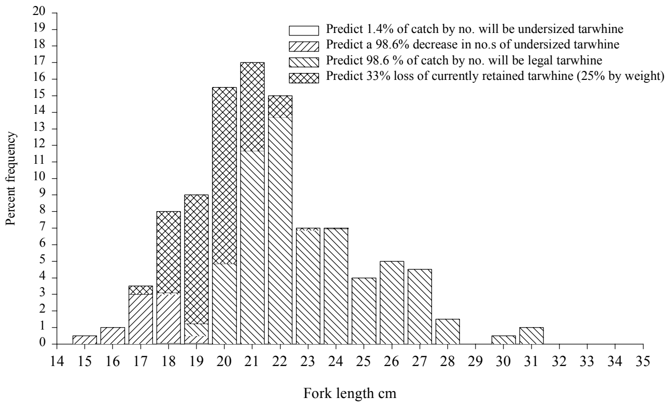


Figure 4.11. Predicted change in catches of tarwhine if using 50 x 75 mm welded mesh traps.

6-spine jacket

We captured 125 6-spine jackets in 104 trap lifts using 37 mm traps, 103 6-spine jackets in 129 trap lifts using 50 mm traps and 91 6-spine jackets in 122 trap lifts using 50 x 75 mm traps during our charter work (Fig. 4.12).

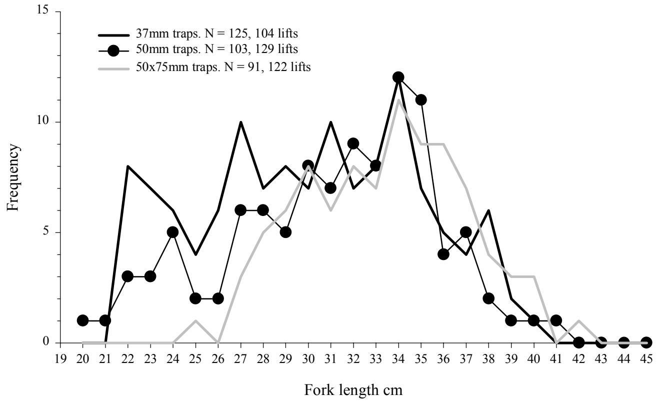


Figure 4.12. Length frequency distributions of 6-spine jackets captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

Estimates of mesh selectivity were made by comparing the sizes of 6-spine jackets retained in 50mm and 50 x 75 mm traps with those retained in 37 mm traps. Logistic curves with equal fishing efficiencies gave best fits to both data sets. Parameters describing the selectivity of 6-spine jackets in 50 mm traps were l_{50} = 24.2 cm, l_{25} = 15.48 cm, l_{75} = 33.1 cm, model deviance = 11.98, 20 d.f. Parameters describing the selectivity of 6-spine jackets in 50 x 75 mm traps were l_{50} = 28.1 cm, l_{25} = 27.0 cm, l_{75} = 29.4 cm, model deviance = 8.74, 18 d.f.

The predicted selection sizes for 6-spine jackets based on fish height and maximum mesh apertures were 21.0 cm FL in 50 mm traps and 28.0 cm FL in 50 x 75 mm traps.

Fitting these selectivity models to the sizes of 6-spine jackets retained in the fishery (chapter 3, Fig, 3.25) predicts that the catch would increase by 55% by numbers if using 37 mm traps and would be reduced by 35% if using 50 x 75 mm traps (Fig. 4.13).

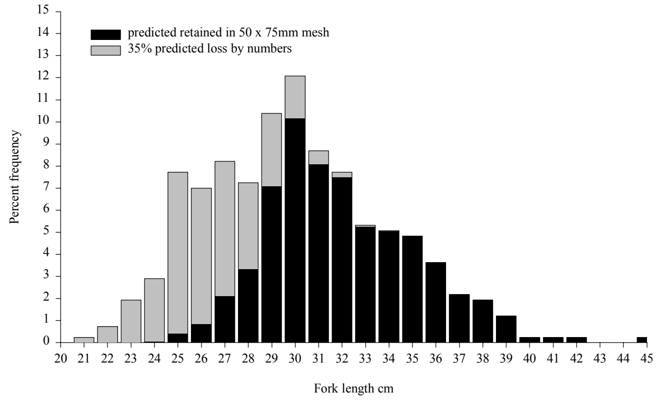


Figure 4.13. Predicted change in catches of 6-spine jackets if using 50 x 75 mm welded mesh traps.

Velvet jacket

We captured 82 velvet jackets in 104 trap lifts using 37 mm traps, 74 velvet jackets in 129 trap lifts using 50 mm traps and 5 velvet jackets in 122 trap lifts using 50 x 75 mm traps (Fig. 4.14).

It was apparent that retention of velvet jackets in 50 x 75 mm traps was close to zero. We estimated the selectivity of velvet jackets in 50 mm mesh by comparing the lengths of those retained in 50 mm traps with those retained in 37 mm traps. Selectivity was best modelled by the logistic curve with equal fishing efficiency, producing estimates of l_{50} = 19.94 cm, l_{25} = 19.91cm, l_{75} = 20.0 cm and the model deviance = 4.02 with 9 d.f. Our best estimate of numbers lost by using 50 x 75 mm traps was the ratio of numbers retained in 50 mm and 50 x 75 mm traps during the charter work, i. e. 5/74 and a predicted reduction of approximately 93%.

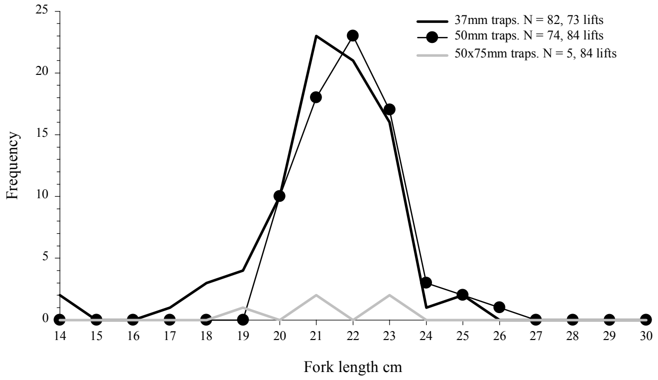


Figure 4.14. Length frequency distributions of velvet jackets captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

Maori wrasse

While Maori wrasse are not a major species in the fishery, they are a welcome bycatch and are a highly priced fish. We captured 97 Maori wrasse in 104 trap lifts using 37 mm traps, 17 Maori wrasse in 129 trap lifts using 50 mm traps and 6 Maori wrasse in 122 trap lifts using 50 x 75 mm traps (Fig 4.15).

Selectivity was best modelled by the logistic curve with equal fishing efficiency for both 50 mm and 50 x 75 mm traps. While the model estimated l_{50} = 35.2 cm FL for maori wrasse in 50 x 75 mm traps, it is likely that retention in this mesh is close to zero for the sizes encountered. Similarly, an estimated l_{50} of 33.7 cm FL for maori wrasse in 50 mm traps may be misleading because of the length distribution sampled (i. e. the almost knife-edged distribution to zero beyond 33 cm FL). Our best estimates of the changes in maori wrasse catches if using either 37 mm or 50 x 75 mm traps was therefore made directly from the raw data scaled to equal trap lifts, i. e. the catch of maori wrasse would increase by 691% if using 37 mm traps and would decrease by 63% if using 50 x 75 mm traps.

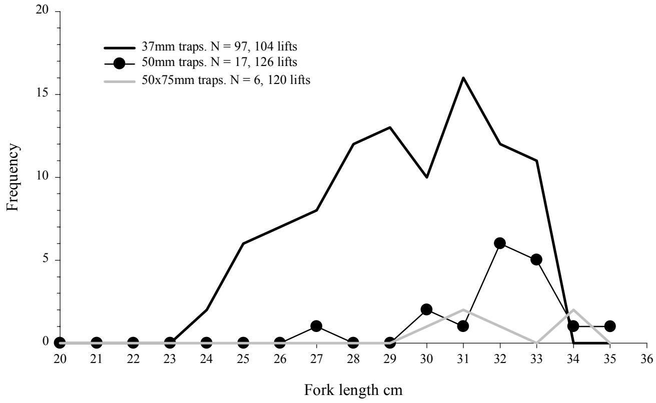


Figure 4.15. Length frequency distributions of maori wrasse captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

Other commercial species

We were not able to collect enough information to estimate formal selection curves for the other species in the fishery. We were, however, able to make predictions on potential losses due to increases in trap mesh selectivity based on the fishes sizes in current catches. The maximum diagonal aperture of 50 x 75 mm welded mesh is between 87 and 88 mm. Mesh selectivity of fish with body heights much larger than 87-88 mm can therefore be assumed to be 100%.

It is likely that any losses in silver trevally catches due to increases in trap mesh selectivity by using 50 x 75 mm welded mesh back panels would be very small. All trevally larger than 24 cm FL would be retained based on body height. Even if all trevally smaller than 24 cm FL escaped through the larger mesh, (this would more likely be 50% escaping based on a predicted l_{50} = 24 cm FL) this would result in only a 2% loss by weight based on the size distribution of landings in Fig. 3.11. These very small trevally receive low prices and any potential losses of trevally can be considered inconsequential. The sizes of tuskfish landed (Fig. 3.18) were generally larger than 25 cm FL and the self imposed limit of around 27 cm FL for pearl perch (Fig. 3.21) suggests that landings of these species would be unaffected by using 50 x 75 mm welded mesh traps. Likewise, carpet shark and conger eel observed during the study were always large animals and catches would be unaffected by using even much larger mesh. The 2 other morwong species in the trap fishery, red morwong and jackass morwong are of similar morphology to the rubberlip morwong, and we predict that they would be selected at similar sizes to rubberlip morwong using 50 x 75 mm welded mesh traps. Consequently using 50 x 75 mm welded mesh should reduce the catch of undersized red and jackass morwong while not losing any legal sized fish. We estimate l_{50} for goatfish (red mullet and black-spot goatfish combined) to be 29 cm FL in 50 x 75 mm welded mesh based on fish height and the maximum mesh aperture. Applying this l_{50} size with a selection range of 3 cm (the estimated S. R. for maori wrasse which have a similar body shape) and applying it to the sizes of goatfish observed in the fishery (N = 206), there was a predicted loss of 52% by numbers if using 50 x 75 mm welded mesh.

Other discarded species

There are a range of species captured in fish traps which have no commercial value and are always discarded. Most of these species are captured in very low numbers, however mado (*Atypichthys strigatus*) are extremely common and the bigger ones are captured in large numbers in 50 mm hexagonal wire traps. One of the arguments used by commercial fishers who advocate the use of larger mesh such as the 50 x 75 mm welded mesh is to reduce the catch of these discarded species and so reduce their sorting times. We documented the catches of mado in experimental traps during the charter work out of Greenwell Point and Terrigal to estimate the effectiveness of 50 x 75 mm traps in reducing the bycatch of these discarded fish. We measured 1144 mado in 73 trap lifts using 37 mm traps, 714 mado in 84 trap lifts using 50 mm traps and 265 mado in 84 trap lifts using 50 x 75 mm traps (Fig 4.16). This represented a reduction of 63% in the catch of mado if using 50 x 75 mm traps.

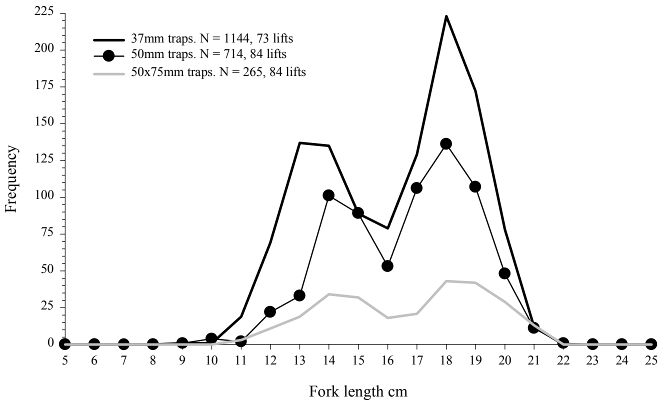


Figure 4.16. Length frequency distributions of mado captured in 37 mm traps, 50 mm traps and 50 x 75 mm traps during the charter work.

Summary

To assist in a discussion of the effects of changing from 50 mm hexagonal wire back panels to 50 x 75 mm welded mesh back panels, we have summarized the selectivity data for the major species in Table 4.6.

To determine whether mesh selectivity could be determined directly from the physical ability of a fish to pass through meshes, we have tabled estimates of selection sizes based on maximum fish body height (see chapter 5) and maximum mesh aperture for 50 x 75 mm welded mesh (87.5 mm), with estimates of l_{50} resulting from fishing comparative trap types (Table 4.7).

Table 4.6. Summary table of predicted changes in catches of the major trap species by changing to 50 x 75 mm welded mesh backs from standard 50 mm hexagonal mesh. MLL is the minimum legal limit in centimeters fork length. Fish with no MLL's are considered as being marketable at all sizes.

Species	MLL cm FL	Selection size in 50 mm mesh	Selection size in 50x75 mm welded mesh	Predicted change in catches if using 50x75 mm welded mesh backs
Snapper	23.5	all retained	l_{50} = 21 cm FL	33% reduction in no.s of undersized fish no loss of legal fish
Bream	22.1	l_{50} = 17 cm FL	l_{50} = 22.5 cm FL	80% reduction in no.s of undersized fish 9% loss of legal fish by no. (6% by weight)
Rubberlip morwong	23.0	all retained	l_{50} = 22 cm FL	57% reduction in no.s of discarded fish 1.8% loss of marketable fish by no. (0.9% by weight)
Tarwhine	17.5	l_{50} = 15 cm FL	l_{50} = 20.5 cm FL	98.6% reduction in no.s of discarded fish 33% loss of marketable fish by no. (25% by weight)
Ocean jackets	none	l_{50} = 25 cm	l_{50} = 35 cm	38.5% loss of marketable fish by no. (30% by weight)
Silver Trevally	none	all retained	l_{50} = 24 cm FL	2% loss of marketable fish by weight
Sweep	none	all retained	l_{50} = 17 cm FL	no loss of marketable fish
Pigfish	none	l_{50} = 25 cm FL	l_{50} = 33 cm FL	71% loss of marketable fish by no. (65% by weight)
6-spine jacket	none	l_{50} = 24 cm FL	l_{50} = 28 cm FL	35% loss of marketable fish by no.
Velvet jacket	none	l_{50} = 20 cm FL	above observed sizes	93% loss of marketable fish by no.
Maori wrasse	none	l_{50} = 34 cm FL	above observed sizes	63% loss of marketable fish by no.
Tuskfish	none	all retained	all retained	no loss of marketable fish
Pearl perch	none	all retained	all retained	no loss of marketable fish
Carpet shark	none	all retained	all retained	no loss of marketable fish
Conger eel	none	all retained	all retained	no loss of marketable fish
Goatfish	none	l_{50} = 22 cm FL	l_{50} = 29 cm FL	52% loss of marketable fish by no. (42% by weight)
Octopus	none	unknown	unknown	unknown

Table 4.7. Comparison of estimated selection points in 50 x 75 mm welded mesh determined using selectivity models with those based on fish height and maximum mesh aperture dimensions.

Species	Predicted physical selection point (cm FL)	Predicted l_{50} from models (cm FL)
Snapper	21.0	21.0
Bream	22.5	22.0
Rubberlip morwong	22.0	22.8
Ocean jacket	36.5	36.8
Sweep	17.0	17.5
Pigfish	33.1	32.0
6-spine jacket	28.1	28.0

4.4. Discussion

A major finding in this chapter is that the selectivity of fish traps using standard legal 50 mm hexagonal wire mesh is inappropriate for all important species in the fishery which have minimum legal lengths (MLL's), i. e. snapper, bream, rubberlip morwong and tarwhine. Large proportions (up to 30%) of the total catches of these species are undersized (chapter 3) and these undersized fish are discarded with unknown mortality. These undersized fish are likely to suffer from injury and mortality from: (i) gas embolisms as traps are lifted to the surface; (ii) physical damage as the trap is lifted from the water and stress from handling at the surface prior to release; and (iii) predators such as sea-birds, seals, dolphins and sharks after release. Snapper, bream and rubberlip morwong are the 3 most valuable species in the fishery (chapter 3) and as such there is a strong argument to increase the trap mesh selectivity for these species to reduce the potential mortality of undersized fish. Unfortunately, the NSW demersal trap fishery is a complex multispecies fishery and any changes in trap mesh selectivity to reduce the catch of undersized fish will impact negatively on catches of some species with no MLL's. The selectivity of 50 mm hexagonal wire is already too large for species such as ocean jackets, pigfish, goatfish, maori wrasse, 6-spine and velvet jackets, and any increase in mesh size will further reduce the proportions of these species retained once they have entered a trap.

Table 4.6 predicts the gains and losses from changing to 50 x 75 mm welded mesh back panels in fish traps. Predicted losses of Maori wrasse, velvet jacket, 6-spine jacket and tarwhine may seem large, however they are unlikely to be of great significance to individual trapping businesses. The model predicted a 71% loss of pigfish by numbers if using 50 x 75 mm welded mesh, however this is likely to be misleading. The length distribution of pigfish captured in 50 mm traps, on which this estimation was made, was taken from catches made from Coffs Harbour southwards. We have little information on the size-distribution of pigfish with latitude, however it is likely that pigfish may be more abundant and larger in the north of the state where fish trappers generally use 50 x 75 mm weldmesh. The largest catchers of pigfish in the state are from the far north coast and use 50 x 75 mm weldmesh in their traps. We have at least provided an estimate of 33 cm FL as the selection size of pigfish in 50 x 75 mm weldmesh and individual trappers can assess the impact this may have on their businesses. While pigfish bring the most $/kg in the fishery, they are never captured in large numbers (averaging 4.9 tonnes per year during 1997/98-1999/00) and are not the basis of any businesses.

Ocean jackets were the major species which we predicted may lead to substantial losses to individual businesses if using 50 x 75 mm weldmesh panels. Our estimated size at 50% retention in 50 x 75 mm weldemsh was 35 cm, which was the most abundant size-class observed in the fishery (see chapter 3, Fig. 3.9). However, we have also shown that the sizes of ocean jackets in catches varied significantly with location and season and that in many places selecting ocean jackets at 35 cm would have a minimal effect on catches (Fig. 3.8). Ocean jackets tend to be specifically targetted on known ‘jacket’ grounds and little of any other species are captured when they are abundant. It may be possible for fishers using 50 x 75 mm welded mesh panels to cover them with standard 50 mm hexagonal mesh during these times to prevent losses.

These examples illustrate that our best estimates of the sizes of fish captured in the fishery will not be representative of individual fishing businesses. Consequently the predicted impacts on catches presented in Table 4.6 will be unlikely to reflect those for separate fishing businesses. It will be up to individual fishers to use our predicted selection sizes and assess the impacts that may occur in their catches if changing to 50 x 75 mm welded mesh panels.

We are confident that building each trap type with the same visual profile (i. e. using 37 mm mesh for all parts of the trap except the back panel) resulted in equal fishing efficiencies between trap types. Analysis of variance showed no differences between the numbers of legal sized snapper (> 24 cm FL) captured per trap lift for each mesh type. All selectivity models based on the charter data (apart from rubberlip morwong) with *p* set at equal fishing efficiency provided the best fits to the data. The data for rubberlip morwong when re-analysed using only charter data was best described by the logistic function with equal fishing efficiencies.

Table 4.7 shows estimates of selection points for species for which we had good selectivity data and fish length/height relationships. For these species the selection sizes in 50 x 75 mm welded mesh were accurately predicted by the maximum height of the fish and the maximum mesh aperture (the diagonal 87.5 mm aperture). These results support the hypotheses of Munro (1983) and Ward (1988) that the sizes of fish retained in rigid meshed traps is a function of body depth (or height) and mesh size. This is in contrast to the findings of other studies on trap mesh selectivity, where for many species such predictions have under-estimated the sizes of fish retained (Ward, 1988; Gobert, 1998; Robichaud et al., 1999). Hypotheses explaining this under-estimation have concentrated on the “squeezability” of some fish, or the ability of fish with body-depths slightly larger than the maximum mesh aperture to squeeze through the meshes (Ward, 1988; Gobert, 1998; Robichaud et al., 1999). Gobert (1998) has shown that the ability to squeeze through trap meshes is effected by fish behaviour and is density dependent. Sutherland et al., (1991) have shown that reef fish from South Florida waters can force their way through meshes by bending the wire. We believe that the 50 x 75 mm welded mesh, with a wire diameter of 2.5 mm, is too rigid to be bent by fish attempting to escape and hence the “squeezability” hypothesis of Ward (1988) does not apply with this mesh type. The narrow selection ranges observed in many of the above models also suggests that selection is relatively knife-edged and that if a fish can physically escape through a mesh then it will most likely escape this way. We note here that this may not be the case for all species in the fishery and that our results on the selectivity of silver trevally in novel meshes in chapter 5 suggest that fish behaviour is also a major contributor to trap mesh selectivity.

5. Development of novel mesh sizes for fish traps in the NSW demersal trap fishery

5.1. Introduction

The results in chapter 4 on the selectivity of standard meshes used in the fishery show 2 important points: (i) that the selectivity of 50 mm hexagonal mesh is inappropriate for all species which have minimum legal size limits, and; (ii) that the selection sizes for the species studied could be accurately predicted based on the maximum mesh aperture of the back panel of the trap and the maximum body height of the fish. This suggests it should be possible to develop a mesh size to select fish at a pre-determined size. We have demonstrated in chapter 3 that rubberlip morwong and tarwhine may have inappropriate minimum legal size limits in the NSW demersal trap fishery, with many legal sized fish being discarded. We believe that increases in mesh size selectivity may result in reductions in the catch of small, discarded fish of many species and that gains in yield may be achieved by harvesting these species at larger sizes. Snapper are by far the most valuable species in the fishery and the next stage in improving the selectivity of fish traps was to design a mesh size to reduce the catch of undersized snapper. This is particularly important in light of the proposed change to the minimum legal length of snapper (to 30 cm total length, approximately 25.5 cm FL) to take effect as of 1st July, 2001.

While the processes effecting the selectivity of wire meshed fish traps are still poorly understood, previous studies on the selectivity of trap meshes have shown that fish body shape is important in determining retention sizes, with slender fishes such as eels being more likely to escape through meshes than compressed fishes such as triggerfishes or depressed fishes such as flatfishes (Sutherland et al., 1991). Many of the important species in the NSW demersal trap fishery have similar, but slightly different, body shapes and a knowledge of their length/body-height relationships will allow us to predict selection sizes in various novel trap meshes.

There have been no previous studies which attempted to design trap meshes to select fish at pre-determined sizes. Several studies have assessed the effectiveness of escape gaps in reducing ghost fishing of lost fish traps (Scarsbrook et al., 1988; Kumpf, 1994), while others have attempted to select particular species by modifying trap entrances (Carlile et al., 1997). Most studies on fish trap selectivity have documented the sizes of fish retained in traps with different mesh sizes (Ward, 1988; Moran & Jenke, 1990; Harper et al., 1994; Newman & Williams 1995; Sary et al., 1997; Robichaud et al., 1999), concluding that mesh size does influence catch rates and the sizes of fish captured. None of these studies recommended an optimal mesh size for their fisheries. There has been an effort by fisheries managers in the Caribbean trap fishery to increase fish populations by increasing the trap mesh size being used, and Sary et al. (1997) documented an increase in yields just 3 years after many fishers adopted a larger mesh size.

We have shown in chapters 2 and 3 that the NSW demersal trap fishery is a diverse, multi-species fishery, with different fishing businesses relying heavily on different species. Any changes in trap mesh selectivity designed to reduce the catch of undersized snapper will change the retention sizes of these other important species, and it is important to have some estimate of the impact any such changes may have. The diverse nature of the fishery means that it is impossible to observe the impacts of changes in mesh selectivity on catches of all species in a study of this size. However we can use the fish-length/body-height relationships to predict their selection sizes based on the maximum mesh apertures being tested.

The aims of this chapter were to: (i) test the hypothesis that we could design a novel mesh to select snapper at a pre-determined size; (ii) to assess the feasibility of manufacturing novel mesh to select fish at pre-determined sizes and; (iii) to assess the impacts of using several larger mesh types than currently used in the fishery.

5.2. Materials and methods

Fish morphometrics

We measured length/height/width relationships for the important species in the fishery, either at the Sydney fish markets or at sea onboard commercial vessels. Height was measured as the maximum height of the fish when lying on a flat surface. Width was measured as the maximum body width when lying on a board and using a set-square to measure width. Fork length (FL) and total length (TL) were measured using a measuring board. All measurements were made to the nearest mm. Linear regressions were fitted to the length/height/width relationships.

Development of the parlour trap

In association with several commercial fishers we developed a trap designed to gain better estimates of trap selectivity. We describe this novel trap as a "parlour type" trap because it has 2 sections, the main body of the trap and a back section separated only by an experimental mesh panel approximately 50 cm from the back of the trap. The trap is wholly wrapped with standard 50 mm hexagonal wire mesh and has a second door into the parlour section through which fish can be removed (Fig. 5.1). The theory being that once a fish has entered the trap normally through the trap opening, it will pass through, or be retained by, the experimental mesh panel when the trap is being lifted to the surface. This is analogous to the covered codend selectivity experiments designed for trawls and is preferable to comparing catches from different gear types. The parlour trap was beneficial as it allowed commercial fishers to experiment using larger than normal mesh types and yet not lose any marketable product. It also allowed us to obtain better estimates of selectivity by using fewer traps.

Novel mesh type 1: 40 x 100 mm welded mesh

The results in chapter 4 showed that the selectivity of the commonly used meshes (50 mm hexagonal wire and 50 x 75 mm welded mesh) were too small for species with minimum legal lengths (MLL's). Snapper is the most important species in the fishery and there was a need to test novel meshes that would select snapper at pre-determined sizes and yet minimise the loss of other commercially important fish. The first attempt at designing such a novel mesh was aimed at selecting snapper at 30 cm TL (2 cm above the current MLL). We contracted Neumann Steel Pty Ltd in the Gold Coast, Queensland to make custom weldmesh panels. After consultation with Neumann Steel we ordered panels of welded mesh with mesh heights of 100 mm and widths of 40 mm. Using 4 mm wire this produced gap heights of 96 mm, gap widths of 36 mm and maximum diagonal widths of 102.5 cm. Each panel was 1400 mm x 900 mm which we considered to be an average size of the back end of a fish trap. Each panel cost approximately $20. Given that the selectivity of the 50 x 75 mm welded mesh determined for snapper in chapter 4 was very close to the predicted size based on the height of the fish and the maximum diagonal aperture, we predicted that this first novel mesh would select fish at approximately 30 cm TL (25.5 cm FL). The minimum legal size limit for snapper is 28 cm TL, however at the time we developed this mesh there was a proposal to increase it to 30 cm TL.

Nineteen commercial fishers took panels of this 40 x 100 mm novel weldmesh to fish in the backs of their traps. These fishers kept log-books of fish sizes either in a normal trap and a modified trap with a 40 x 100 mm welded mesh back fished nearby, or in the front and back sections of parlour traps.

Our main aim was to determine the selectivity of snapper using the 40 x 100 mm welded mesh panels, but observers onboard commercial vessels also collected data on the selectivity of other important species.

Novel mesh type 2: 50 x 87 mm BHP welded mesh

The 40 x 100 mm welded mesh panels were only ever intended to be experimental in helping us to determine whether we could predict the selection size of snapper using fish height and maximum mesh aperture. Consultation with fishers told us that any future wire mesh products would have to be commercially available and should come in rolls. Also, the $20 cost of each 40 x 100 mm welded mesh panel was considered prohibitive. We recognized the need to produce wire mesh which was commercially available, came in rolls, had thinner gauge wire and which had a smaller height to width ratio than the 40 x 100 mm welded mesh. We approached BHP Wire products with our needs and they were extremely helpful in developing a special run of welded mesh to suit our needs. BHP wire products manufacture galvanized welded mesh in a variety of sizes (i. e. 50 x 50 mm, 50 x 75 mm and 50 x 100 mm). Changing the machine to manufacture different sized meshes is both difficult and expensive. BHP were unable to alter the 50 mm width dimension, but were willing to alter the height dimension to do a special run for NSW Fisheries. We chose a mesh height of 87 mm which, together with a width of 50 mm and using 2.5 mm wire has a maximum diagonal aperture of 97 mm, the average height of a 28 cm TL (24 cm FL) just legal sized snapper. BHP manufactured 2 x 30 m rolls of this novel 50 x 87 mm welded mesh @$111.50 per roll for us.

Novel mesh types 3 & 4: 60 mm x 80 mm and 80 mm x 100 mm gabion wire

We tested the selectivity of 2 commercially available wire products which we considered suitable as trap mesh. These were the gabion wire used in rock retaining walls which are made of a heavily galvanised woven wire. The woven wire is superior to the twisted wire mesh currently used as it cannot unwind. We trialed 60 x 80 mm hexagonal gabion mesh made of heavily galvanised 2 mm wire, and 80 x 100 mm hexagonal gabion mesh made of heavily galvanised 2.7 mm wire. The wire was supplied by Maccaferri Pty Ltd, the 60 x 80 mm wire coming in 50 m x 2 m rolls (@ $273/roll) and the 80 x 100 mm wire coming as 16 m^2 boxes @ $82 each.

Measuring 10 meshes in the gabion wires showed that the maximum mesh aperture (i. e. the long axis of the hexagonal mesh) differed considerably from the manufacturers specifications. The smaller gabion wire had a maximum mesh aperture of mean 93.7 mm (SE = 0.65 mm) and the larger gabion wire had a maximum mesh aperture of mean 121.5 mm (SE = 0.48 mm).

We trialed these novel mesh types 2, 3 & 4 by chartering a commercial fish trapper for 15 days between August and October 2000 and fishing offshore from Sydney. We built parlour traps to estimate selectivity and fished 2 traps with 50 x 87 mm welded mesh panels (long axis vertical), 2 traps with 60 x 80 mm gabion wire panels (1 with the long axis vertical and one with the long axis horizontal) and 2 traps with 80 x 100 mm gabion wire panels (one with the long axis vertical and one with the long axis horizontal).

Estimates of selectivity

We analysed the data in this chapter using the SELECT methodology outlined in chapter 4. The parlour trap design is analogous to the covered codend design used to estimate selectivity in trawls (Wileman et al., 1996). The relative fishing efficiency (*p*) was set at 0.5 for analysing the parlour trap data as once a fish had entered the trap then the probability of it encountering the expermental mesh was 100%.

5.3. Results

Fish morphometrics

Conversion keys for length/height/width relationships for the major species in the fishery are presented in Table 5.1. We predicted that the sizes at 50% retention, l_{50}'s, from the selectivity models could be estimated from these relationships based on fishes physical dimensions and maximum trap mesh apertures.

Novel mesh type 1: 40 x 100 mm welded mesh

Snapper

The selectivity of snapper in 40 x 100 mm welded mesh was estimated by commercial fishers who measured fish as part of a voluntary log-book. Three fishers built parlour traps with 40 x 100 mm welded mesh panels in them and they measured 228 snapper (91 in the parlour section and 137 in the main trap) from 14 trap lifts (Fig. 5.2). Seven fishers also measured 540 snapper retained in 55 trap lifts using traps with standard 50 mm mesh backs and 605 snapper retained in 45 trap lifts using traps with 40 x 100 mm welded mesh backs. We used the data from the parlour traps to estimate selectivity curves as we considered the data to provide better estimates and to be more reliable.

A logistic curve provided the best fit to the data and produced parameters of l_{50} = 24.6 cm FL, l_{25} = 21.4 cm FL, l_{75} = 27.8 cm FL, model deviance = 3.27 with 18 d.f. The predicted selection size, l_{50}, based on fish height and maximum mesh aperture was 25.5 cm FL.

Table 5.1. Total length (TL)/fork length (FL), fork length/height (HT) and fork length/width (W) conversion keys for the major species in the trap fishery.

Species TL/FL	**Scientific Name**	**Sample size**	**Size range F.L. (mm)**	**Total length/Fork length key** FL(mm) = a*TL(mm)+b	**R^2**	**Current size limit total length (mm)**	**Current size limit fork length (mm)**
Snapper	*Pagrus auratus*	112	167-329	FL=0.839416*TL+2.8841	0.989	280	238
Yellowfin Bream	*Acanthopagrus australis*	109	67-292	FL=0.868016*TL+4.06094	0.996	250	221
Rubberlip morwong	*Nemadactylus douglasi*	74	185-425	FL=0.849812*TL-5.373524	0.995	280	233
Tarwhine	*Rhabdosargus sarba*	60	174-291	FL=0.878863*TL-0.043478	0.994	200	176
Silver Trevally	*Pseudocaranx dentex*	87	189-329	FL=0.832129*TL+2.224963	0.997	none	none
Species FL/HT	**Scientific Name**	**Sample size**	**Size range F.L. (mm)**	**Fork length/Max. Height key HT(mm)=a*FL(mm)+b**	**R^2**	**Current size limit total length (mm)**	**Current size limit height (mm)**
Snapper	*Pagrus auratus*	175	167-349	Ht=0.364486*FL+9.407943	0.939	280	96.1
Yellowfin Bream	*Acanthopagrus australis*	71	47-351	Ht=0.409317*FL-3.218724	0.979	250	87.3
Rubberlip morwong	*Nemadactylus douglasi*	153	154-425	Ht=0.364822*FL+3.3393	0.981	280	88.2
Tarwhine	*Rhabdosargus sarba*	60	174-291	Ht=0.0.408538*FL+2.60112	0.959	200	74.4
Silver Trevally	*Pseudocaranx dentex*	115	189-356	Ht=0.265524*FL+23.30746	0.911	none	none
Sweep	*Scorpis lineolatus*	82	196-299	Ht=0.258262*FL+41.06012	0.679	none	none
Ocean Jackets	*Nelusetta ayraudi*	282	195-474	Ht=0.24429*FL-1.515649	0.949	none	none
Pigfish	*Bodianus vulpinus*	129	255-430	Ht=0.305763*FL-9.380875	0.918	none	none
Red Mullet	*Upeneichthys lineatus*	43	141-336	Ht=0.290752*FL+2.481581	0.962	none	none
Red Morwong	*Cheilodactylus fuscus*	17	266-386	Ht=0.390384*FL-15.21601	0.906	250	approx. 67
6-spine jacket	*Meushenia freycineti*	28	240-420	Ht=0.271776*FL+10.55253	0.957	none	none
Species FL/W	**Scientific Name**	**Sample size**	**Size range F.L. (mm)**	**Fork length/Width key W(mm)=a*FL(mm)+b**	**R^2**	**Current size limit total length (mm)**	**Current size limit width (mm)**
Snapper	*Pagrus auratus*	59	228-349	W=0.162428*FL - 3.775929	0.847	280	34.9
Yellowfin Bream	*Acanthopagrus australis*	18	221-340	W=0.176845*FL - 9.668728	0.944	250	29.4
Rubberlip morwong	*Nemadactylus douglasi*	58	158-415	W=0.141625*FL - 6.732185	0.985	280	26.2
Silver Trevally	*Pseudocaranx dentex*	25	207-356	W=0.136624*FL -1.141229	0.896	none	none
Sweep	*Scorpis lineolatus*	14	196-289	W=0.158234*FL - 4.985738	0.838	none	none
Pigfish	*Bodianus vulpinus*	93	255-430	W=0.145959*FL -5.174183	0.907	none	none

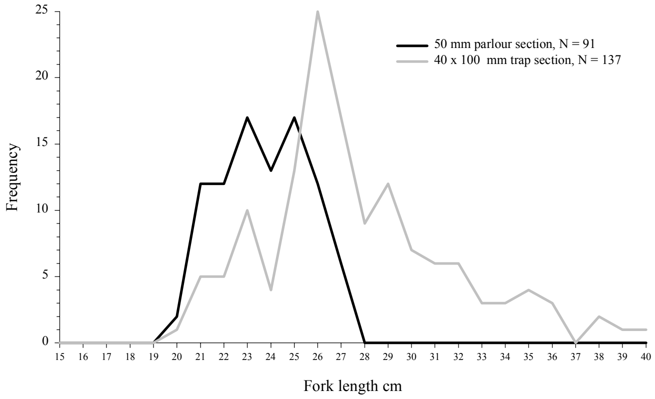


Figure 5.2. Length frequency distributions of snapper captured in 40 x 100 mm welded mesh parlour traps.

Close consultation with fishers quickly showed some problems with the novel 40 x 100 mm welded mesh panels. Some fishers reported poor catches in traps with the panels fitted and suggested that the galvanized 4 mm wire used in the panels was too thick and visible and was frightening fish. Other fishers did not think that the thickness of the wire was a problem. The major problem with the novel welded mesh was that a lot of legal sized snapper were being meshed in it (Fig. 5.3). Meshing was obviously occurring both before the trap was lifted and as it was being winched to the surface. Meshed fish were often damaged to a degree making them unsuitable for sale and time spent getting meshed fish out of the back panel of a trap was a large disruption to normal trapping operations. One fisher kept excellent records of snapper getting meshed in these panels and recorded 32% (21 of 65) of snapper which were 26 cm FL getting meshed and 22% (15 of 68) of snapper which were 27 cm FL getting meshed. We considered that meshing such a large proportion of marketable fish to be unacceptable and ended the trial of this mesh. Fish getting meshed were caught just behind their gills and were wedged in tightly both top and bottom and on either side. We believe that the narrow meshes (only 36 mm) were too close to the width of the fish and that once they were stuck in the mesh that they had no room to struggle and twist out again. Despite ending the trials of the 40 x 100 mm welded mesh we collected sufficient information to estimate selectivity curves for bream, rubberlip morwong, ocean leatherjackets and silver trevally.

Figure 5.1. The newly developed parlour trap. The back chamber (parlour) and side door are on the left.

Figure 5.3. Snapper meshed in 40 x 100 mm welded mesh panel.

Bream

Our estimates of the selectivity of 40 x 100 mm welded mesh for bream came from observer work onboard commercial vessels in Sydney Harbour. We measured 2149 bream from 68 trap lifts using 50 mm traps and 143 bream from 8 trap lifts using traps with 40 x 100 mm welded mesh during January-March 2000 (Fig. 5.4).

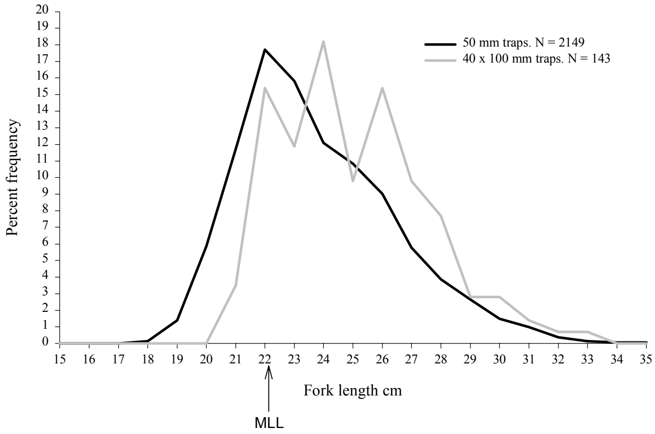


Figure 5.4. Length frequency distributions of bream captured in 50 mm traps and 40 x 100 mm traps. MLL is the minimum legal length of 25 cm total length (approximately 22.1 cm fork length).

A logistic curve with equal fishing efficiency provided the best fit to the data, generating parameter estimates of l_{50} = 22.8 cm FL, l_{25} = 21.4 cm FL, l_{75} = 24.1 cm FL, model deviance = 11.93 with 17 d.f. The predicted selection size based on fish height and maximum mesh aperture was 25.8 cm FL.

Rubberlip morwong

We measured 36 rubberlip morwong from 10 trap lifts using 40 x 100 mm traps and 74 rubberlip morwong from 18 trap lifts using 50 mm traps during observer days onboard commercial vessels (Fig. 5.5A). One fisher measured 25 rubberlip morwong captured in a 40 x 100 mm welded mesh parlour trap, 6 in the parlour section and 19 in the main trap section (Fig. 5.5B). We analysed the data from each source separately and logistic curves provided the best fits. The comparative trap data generated parameter estimates of l_{50} = 23.0 cm FL, l_{25} = 20.7 cm FL, l_{75} = 25.3 cm FL, model deviance = 28.19 with 21 d.f. The parlour trap data generated parameter estimates of l_{50} = 27.0 cm FL, l_{25} = 26.9 cm FL and l_{75} = 27.1 cm FL, with model deviance = 0.001 with 13 d.f. The predicted selection size based on fish height and maximum mesh aperture was 27.2 cm FL. It was apparent that despite having only 25 observations that the parlour trap data produced better estimates of selectivity than the comparative trap data.

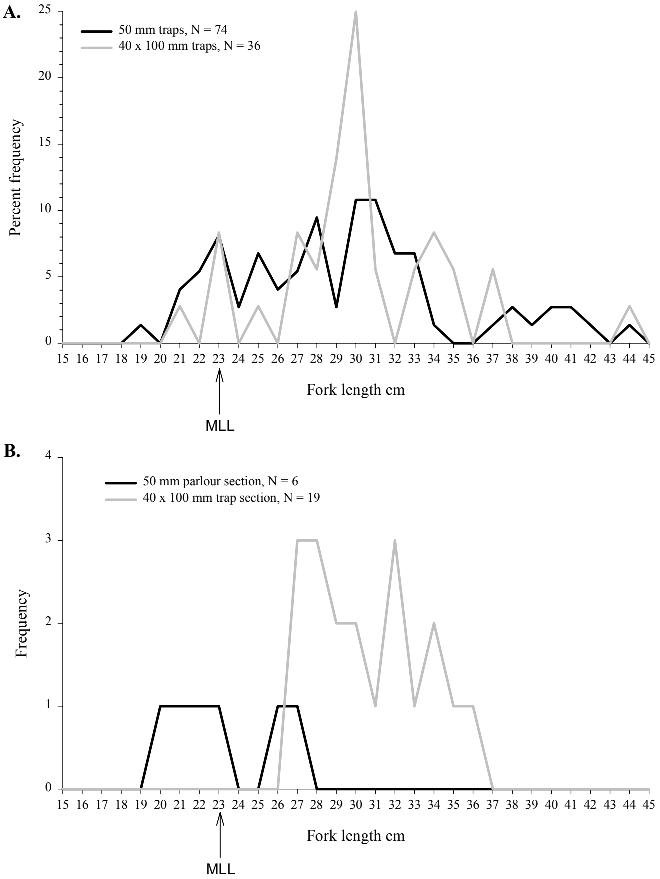


Figure 5.5. Length frequency distributions of rubberlip morwong captured in **A.** 50 mm and 40 x 100 mm traps, and **B.** in parlour traps with 40 x 100 mm welded mesh panels. MLL is the minimum legal length of 28 cm total length (approximately 23 cm fork length).

Ocean leatherjacket

We measured 70 ocean leatherjackets from 3 trap lifts using 40 x 100 mm welded mesh traps and 456 ocean leatherjackets from 13 traps using 50 mm hexagonal mesh during observer days onboard commercial vessels (Fig. 5.6A). One fisher measured 45 ocean leatherjackets captured in a 40 x 100 mm welded mesh parlour trap, 6 in the parlour and 39 in the main trap (Fig. 5.6B).

The selectivity models did not fit the data well from either data source, having high model deviances, skewed residuals and not converging to realistic parameter estimates. However it was clear from Fig. 5.6 that ocean leatherjackets were being selected at sizes much smaller than the estimated selection size based on fish height and maximum mesh aperture of 42.5 cm FL.

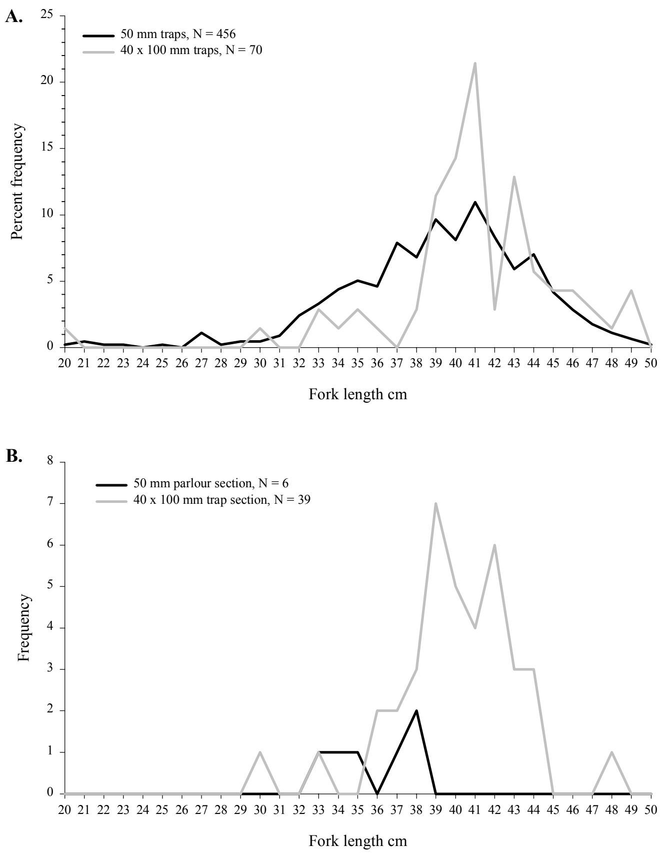


Figure 5.6. Length frequency distributions of ocean leatherjackets captured in **A.** 50 mm and 40 x 100 mm traps, and **B.** in parlour traps with 40 x 100 mm welded mesh panels.

Silver trevally

We measured 181 silver trevally from 10 trap lifts using 40 x 100 mm welded mesh traps and 89 silver trevally from 13 trap lifts using 50 mm hexagonal mesh traps, while onboard commercial vessels out of Tuncurry between March and May 2000 (Fig. 5.7).

The selectivity models did not fit the data well, possibly due to the much higher catch rate in 40 x 100 mm traps, and our best estimate was from the logistic curve with l_{50} = 27.8 cm FL, smaller than the estimated selection size of 30 cm FL based on fish height and maximum mesh aperture.

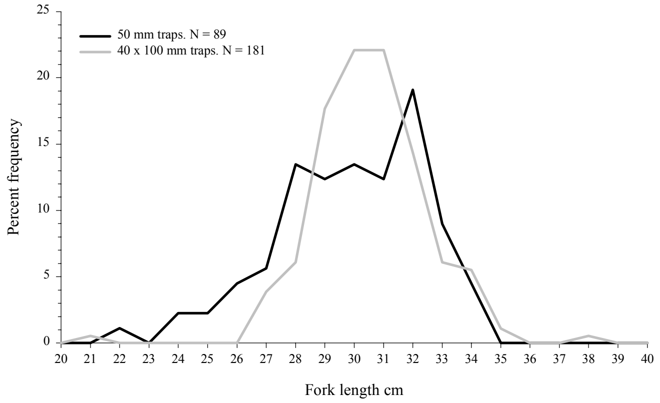


Figure 5.7. Length frequency distributions of silver trevally captured in 50 mm and 40 x 100 mm traps.

Novel mesh type 2: 50 x 87 mm BHP welded mesh

We collected sufficient data to estimate the selectivity of snapper, rubberlip morwong and silver trevally in 50 x 87 mm welded mesh traps.

Snapper

During the charter work offshore from Sydney we measured 155 snapper from 24 trap lifts using parlour traps with 50 x 87 mm welded mesh panels. One fisher kept a log of snapper captured in a parlour trap using 50 x 87 mm welded mesh, measuring 120 snapper from 10 trap lifts. Another fisher measured 45 snapper captured in a trap with a 50 x 87 mm welded mesh back. We considered the measurements obtained from the charter work to be the most reliable and estimates of selectivity were based on these data (Fig. 5.8).

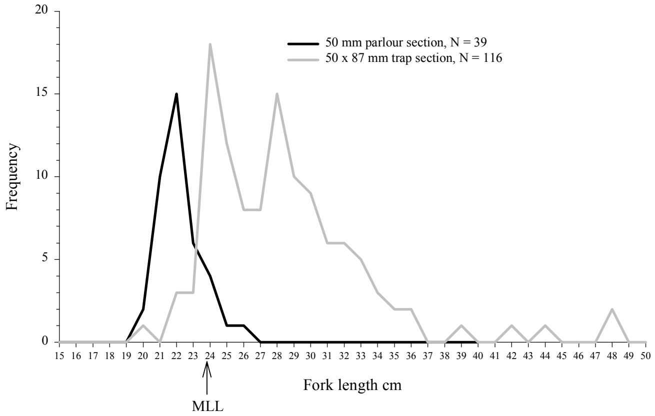


Figure 5.8. Length frequency distributions of snapper captured in 50 x 87 mm welded mesh parlour traps. MLL is the mimimum legal length of 28 cm total length (approximately 23.8 cm fork length).

A logistic curve provided the best fit to the data and generated parameter estimates of l_{50} = 23.2 cm FL, l_{25} = 22.2 cm FL, l_{75} = 24.3 cm FL, model deviance = 8.15 with 19 d.f. The estimated selection size based on fish height and maximum mesh aperture was 24.0 cm FL. Fig 5.8 shows that selectivity was relatively knife-edged, with few undersized snapper (< 24 cm FL) being retained in the 50 x 87 mm mesh and few legal snapper passing through into the parlour section.

Of the 281 snapper observed retained in 50 x 87 mm mesh we observed 2 fish to be meshed in it. They measured 24 and 26 cm FL respectively and were not damaged to any extent, therefore making them marketable.

Estimates of potential changes in catches of snapper if using 50 x 87 mm welded mesh rather than 50 mm hexagonal wire were made by applying the fitted logistic selectivity curve to the sizes of snapper retained in standard 50 mm traps in chapter 3 (Figs. 3.2 & 3.3). The model predicted a reduction of 77% in the catch of undersized snapper with a loss of 9% of legal sized fish (6% by weight) (Fig. 5.9).

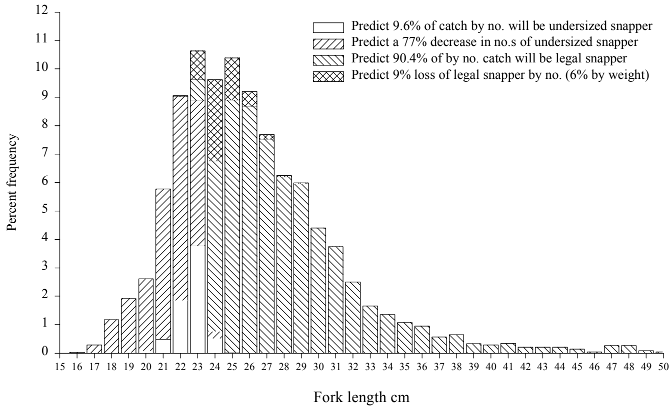


Figure 5.9. Predicted changes in the catch of undersized and legal snapper in traps when using 50 x 87 mm welded mesh back panels rather than standard 50 mm hexagonal wire.

Rubberlip morwong

We captured 32 rubberlip morwong in parlour traps with 50 x 87 mm welded mesh panels during the charter work, 21 in the parlour section and 11 in the main trap (Fig. 5.10). A logistic curve fitted the data best and produced parameter estimates of l_{50} = 26.3 cm FL, l_{25} = 26.0 cm FL, l_{75} = 26.7 cm FL, model deviance = 0.07 with 10 d.f. The predicted selection size based on fish height and maximum mesh aperture was 25.7 cm FL. These results suggest that selection is occurring over a narrow size range.

Of the 18 rubberlip morwong observed retained in 50 x 87 mm mesh (11 in the parlour trap and 7 measured from commercial fishers using this mesh), we observed no fish to be meshed in it.

Estimates of potential changes in catches of rubberlip morwong if using 50 x 87 mm welded mesh rather than 50 mm hexagonal wire were made by applying the fitted logistic selectivity curve to the sizes of rubberlip morwong captured in standard 50 mm traps in chapter 3 (Fig. 3.7). The model suggests a reduction of 97% in the catch of undersized rubberlip morwong with a loss of 36% of legal sized fish (25% by weight).

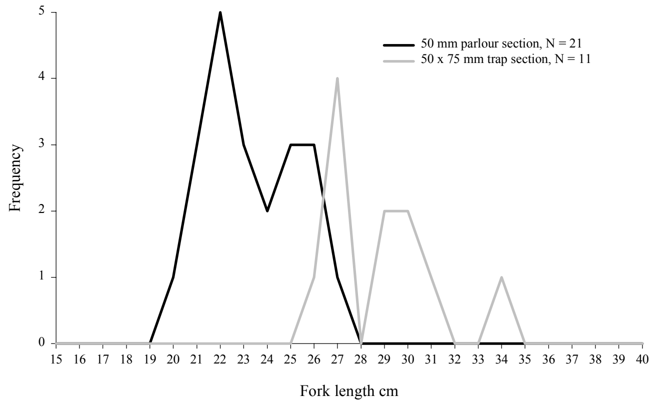


Figure 5.10. Length frequency distributions of rubberlip morwong captured in 50 x 87 mm welded mesh parlour traps.

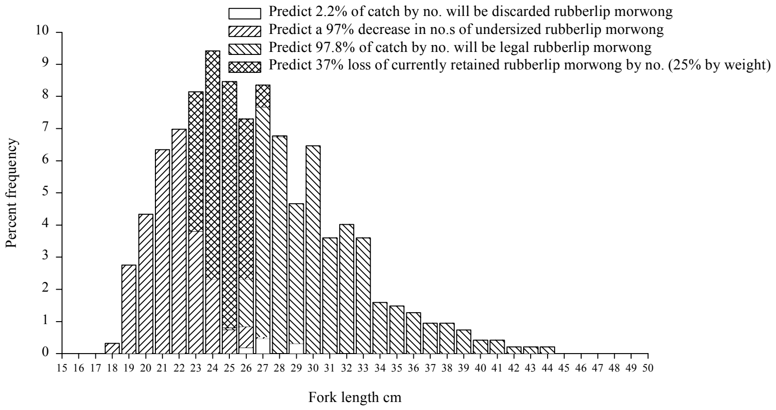


Figure 5.11. Predicted changes in the catch of undersized and legal rubberlip morwong in traps when using 50 x 87 mm welded mesh back panels rather than standard 50 mm hexagonal wire.

Silver trevally

We captured 267 silver trevally in parlour traps with 50 x 87 mm welded mesh panels during the charter work, 23 in the parlour section and 444 in the main trap (Fig. 5.12). This figure shows that relatively very few silver trevally were retained in the parlour section of the traps, even though they could physically have fitted through the 50 x 87 mm mesh. The predicted selection size for silver trevally based on fish height and maximum mesh aperture was 27.7 cm FL

A logistic curve was the best fit to the data and produced parameter estimates of l_{50} = 24.4 cm FL, l_{25} = 22.7 cm FL, l_{75} = 26.0 cm FL, model deviance = 1.189 with 19 d.f.

Of the 444 silver trevally retained in the 50 x 87 mm section of the trap, we observed 24 to be meshed in the panel. Meshed fish ranged in size from 29 cm to 33 cm FL, and as many as 10% of trapped fish in the 29 cm FL size class were meshed.

Estimates of potential changes in catches of silver trevally if using 50 x 87 mm welded mesh rather than 50 mm hexagonal wire were made by applying the fitted logistic selectivity curve to the sizes of silver trevally retained in standard 50 mm traps in chapter 3 (Fig. 3.11). The model predicted a loss of 13% of silver trevally by number (6.6% by weight).

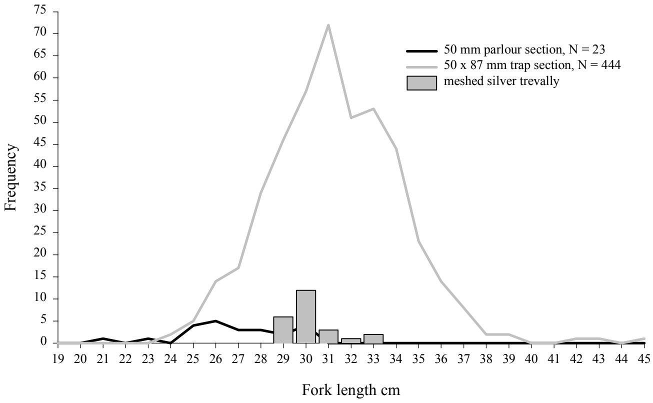


Figure 5.12. Length frequency distributions of silver trevally captured in 50 x 87 mm welded mesh parlour traps. Meshed fish are represented by shaded bars and are also included in the totals retained in the trap section.

Other species

To estimate changes in catches of bream, ocean leatherjackets, sweep and pigfish by using 50 x 87 mm welded mesh rather than standard 50 mm hexagonal wire, we fitting logistic selectivity curves to the sizes currently retained in chapter 3, with the l_{50}'s equal to the predicted selection sizes based on fish height and maximum mesh aperture (97 mm), and with selection ranges equal to those predicted in chapter 4. Predicted changes are presented in Table 5.2.

Novel mesh type 3: 60 mm x 80 mm gabion wire

We measured sufficient fish in suitable size ranges to estimate selectivity curves for snapper and silver trevally in 60 x 80 mm gabion wire. We also compared the selection characteristics of this mesh when orientated with the longest axis horizontally and vertically.

Snapper

We captured 55 snapper in parlour traps with 60 x 80 mm gabion wire placed with the longest axis vertical (5 in the parlour section and 50 in the main trap). We captured 146 snapper in parlour traps with 60 x 80 mm gabion wire placed with the longest axis horizontal (22 in the parlour section and 124 in the main trap).

Fitted logistic selectivity curves showed no difference in the selectivity of meshes orientated either vertically or horizontally, with the selection sizes with standard errors being l_{50} = 22.0 (14.0) for vertical mesh and l_{50} = 22.5 (0.11) for horizontal mesh. We combined the data for vertical and horizontal meshes to estimate the selectivity of 60 x 80 mm gabion wire (Fig. 5.13).

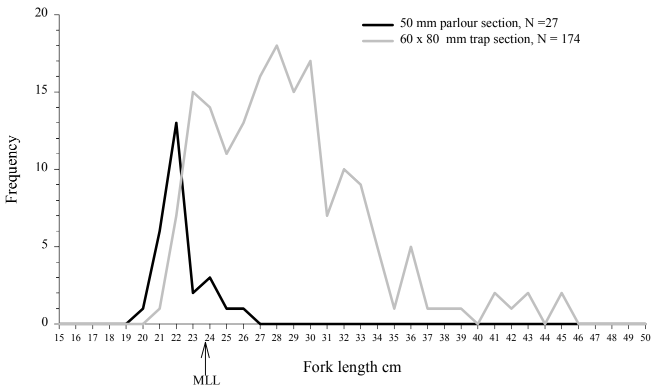


Figure 5.13. Length frequency distributions of snapper captured in 60 x 80 mm gabion wire parlour traps (vertical and horizontal meshes combined). MLL is the minimum legal size limit of approximately 23.8 cm fork length.

A logistic curve fitted to the data produced parameter estimates of l_{50} = 22.3 cm FL, l_{25} = 21.6 cm FL, l_{75} = 23.0 cm FL, model deviance = 0.51 with 22 d.f. The predicted selection size based on fish height and maximum mesh aperture was 23 cm FL. These results show that selection is happening over a narrow range of sizes, it is happening close to the size predicted from physical dimensions, and it is less than the minimum legal length of approximately 24 cm FL.

To estimate the impact of using 60 x 80 mm gabion wire instead of 50 mm hexagonal wire on snapper catches, we applied the fitted logistic curve to the length distribution of snapper captured in standard 50 mm meshed traps in chapter 3 (Figs 3.2 & 3.3). The model predicted a reduction of 61% in the catch of undersized snapper with a loss of 1.5% of legal sized fish by number (0.9% by weight) (Fig. 5.14).

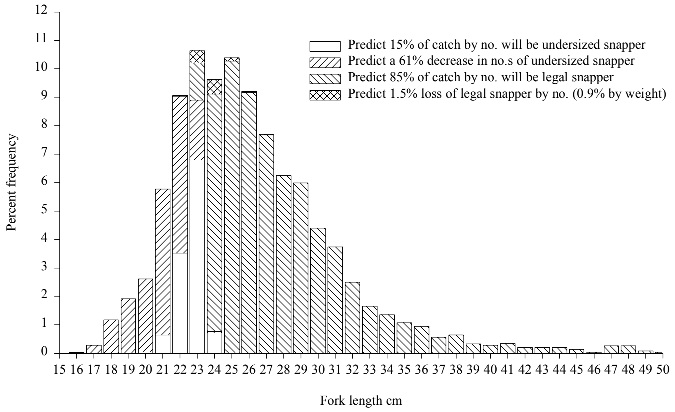


Figure 5.14. Predicted changes in the catch of undersized and legal snapper in traps when using 60 x 80 mm gabion wire back panels rather than standard 50 mm hexagonal wire.

We observed 2 snapper meshed in the 60 x 80 mm gabion wire orientated vertically (of 50 fish retained) and 3 snapper meshed with the wire orientated horizontally (of 124 fish retained). These meshed snapper ranged in size from 22 cm to 24 cm FL, were not damaged and appeared to have been lightly meshed as the trap was being lifted to the surface.

Silver trevally

We captured 539 silver trevally in parlour traps with 60 x 80 mm gabion wire placed with the longest axis vertical (54 in the parlour section and 485 in the main trap). We captured 245 silver trevally in parlour traps with 60 x 80 mm gabion wire placed with the longest axis horizontal (18 in the parlour section and 227 in the main trap). There was little difference in selection sizes between mesh orientation, with the selection ranges ($l_{75} - l_{25}$) being 23.0 to 27.8 cm for vertical mesh and 25.5 to 26.8 cm for horizontal mesh. The data were therefore combined (Fig. 5.15) and selectivity curves fitted. Fig. 5.15 shows that lots of trevally which were physically able to pass through the mesh (approximately 26 cm FL) were still retained in the main trap and that some fish which we predicted could not pass through the panel did. This suggests that the fish length/height relationship may be more variable for silver trevally as indicated by the fitted regression in Table 5.1. The logistic curve provided the best fit to the data and generated parameter estimates of l_{50} = 25.6 cm FL, l_{25} = 23.6 cm FL, l_{75} = 27.5 cm FL, model deviance = 1.116 with 20 d. f. The predicted selection size for silver trevally based on fish height and maximum mesh aperture was 26.2 cm FL.

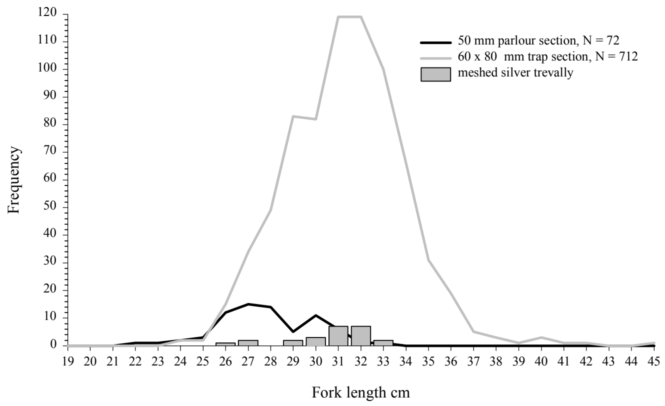


Figure 5.15. Length frequency distributions of silver trevally captured in 60 x 80 mm gabion wire parlour traps (vertical and horizontal meshes combined). Meshed fish are represented by shaded bars and are also included in the totals retained in the trap section.

We observed 24 silver trevally of the 485 retained in the vertically orientated 60 x 80 mm gabion wire to be meshed in it (Fig. 5.16). This represented nearly 5% of fish retained, and the meshed fish were damaged to an extent making them unmarketable. Meshed fish ranged in size between 26 and 33 cm FL. We did not observe any silver trevally (of 227 retained in the trap section) to be meshed in the horizontally orientated 60 x 80 mm gabion wire.

Estimates of potential changes in catches of silver trevally if using 60 x 80 mm gabion wire rather than 50 mm hexagonal wire were made by applying the fitted logistic selectivity curve to the sizes of silver trevally retained in standard 50 mm traps in chapter 3 (Fig. 3.11). The model predicted a loss of 20.8% of silver trevally (11.9% by weight) (Fig. 5.17).

Figure 5.16. Silver trevally meshed in vertically orientated 60 x 80 mm gabion wire. Note fish in both parlour and trap sections of the trap.

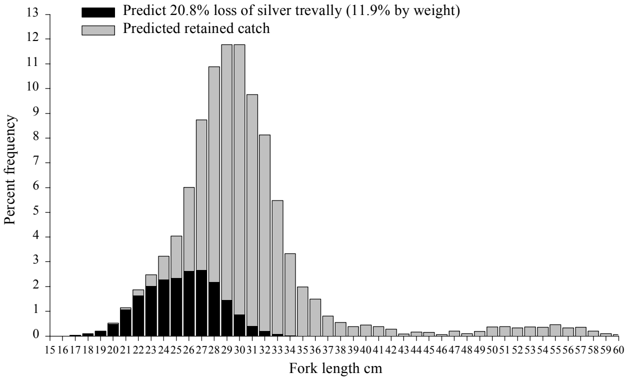


Figure 5.17. Predicted changes in the catch of silver trevally in traps when using 60 x 80 mm gabion wire back panels rather than standard 50 mm hexagonal wire.

Other species

Estimates of the changes in catches of rubberlip morwong, bream, ocean leatherjackets, sweep and pigfish were made by fitting logistic selectivity curves to the sizes currently retained in chapter 3, with the l_{50}'s equal to the predicted selection sizes based on fish height and maximum mesh aperture (93.7 mm) and with selection ranges equal to those predicted in chapter 4. Predicted changes are presented in Table 5.2.

Novel mesh type 4: 80 mm x 100 mm gabion wire

We measured sufficient fish in suitable size ranges to estimate selectivity curves for snapper and silver trevally in 80 x 100 mm gabion wire. We also compared the selection characteristics of this mesh with the longest axis orientated both horizontally and vertically.

Snapper

We captured 251 snapper in parlour traps with 80 x 100 mm gabion wire placed with the longest axis vertically (169 in the parlour section and 82 in the main trap). We captured 139 snapper in parlour traps with 80 x 100 mm gabion wire placed with the longest axis horizontally (84 in the parlour section and 55 in the main trap).

Fitted logistic selectivity curves showed no difference in the selectivity of meshes orientated either vertically or horizontally, l_{50}'s with standard errors of 27.64 (0.53) cm and 27.32 (0.38) cm FL respectively. The data was subsequently combined (Fig. 5.18) and an asymmetric Richards curve provided the best fit to the data. The parameters for the Richards curve were l_{50} = 29.8 cm FL, l_{25} = 29.2 cm FL, l_{75} = 30.4 cm FL, δ = 6.2, model deviance = 12.71 with 23 d.f. The predicted selection size based on fish height and maximum mesh aperture was 30.6 cm FL.

To estimate the impact of using 80 x 100 mm gabion wire instead of 50 mm hexagonal wire on snapper catches, we applied the fitted Richards curve to the length distribution of snapper captured in standard 50 mm meshed traps in chapter 3 (Figs 3.2 & 3.3). The model predicted a decrease of 91% in the catch of undersized snapper with a loss of 46% of legal sized fish by number (33% by weight). We did not observe any meshed snapper in 80 x 100 mm gabion wire.

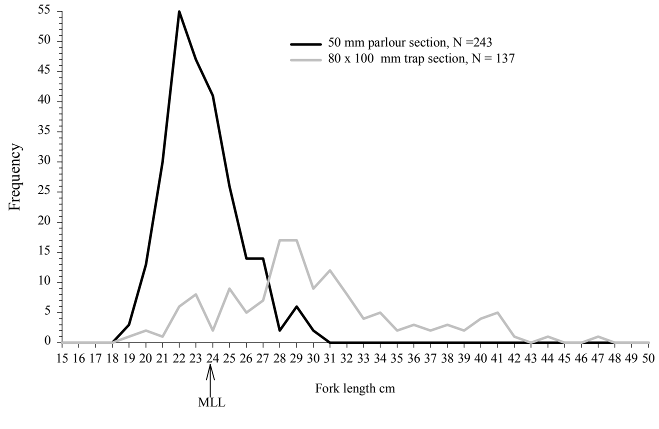


Figure 5.18. Length frequency distributions of snapper captured in 80 x 100 mm gabion wire parlour traps (vertical and horizontal meshes combined). MLL is the minimum legal size limit of approximately 23.8 cm fork length.

Silver trevally

We captured 67 silver trevally in parlour traps with 80 x 100 mm gabion wire placed with the longest axis vertically (38 in the parlour section and 29 in the main trap) (Fig. 5.19A), and 97 snapper in parlour traps with 80 x 100 mm gabion wire placed with the longest axis horizontally (30 in the parlour section and 67 in the main trap) (Fig. 5.19B). There were differences in the selectivities of vertical and horizontal meshes, with Fig. 5.19 and the fitted logistic selectivity curves showing that a higher proportion of larger silver trevally passed through the 80 x 100 mm gabion wire when it was orientated vertically. The selection sizes being l_{50} = 29.8 cm FL (SE = 1.1 cm) for vertical wire and l_{50} = 24.2 cm FL (SE = 0.9 cm) for horizontal wire. The predicted selection size based on fish height and maximum mesh aperture was 36.8 cm FL, above most of the sizes observed. While most silver trevally observed were of sizes which were physically able to pass through the 80 x 100 mm gabion wire, many were retained in the main section of the trap.

We did not observe any silver trevally to be meshed in the 80 x 100 mm gabion wire.

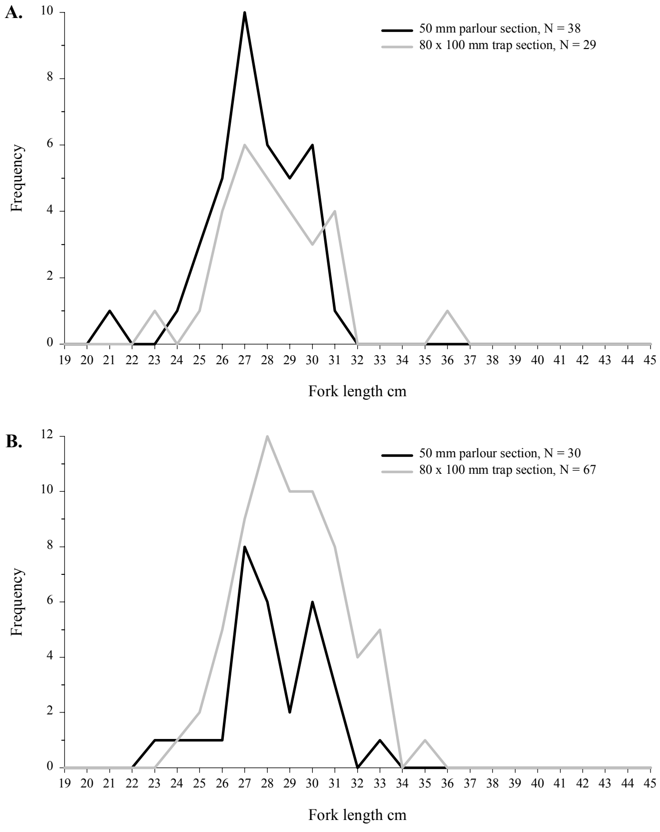


Figure 5.19. Length frequency distributions of silver trevally captured in 80 x 100 mm gabion wire parlour traps **A.** meshes orientated vertically and **B.** meshes orientated horizontally.

Other species

Estimates of the changes in catches of rubberlip morwong, bream, ocean leatherjackets, sweep and pigfish were made by fitting logistic selectivity curves to the sizes currently retained in chapter 3, with the l_{50}'s equal to the predicted selection sizes based on fish height and maximum mesh aperture (121.5 mm) and with selection ranges equal to those predicted in chapter 4. Predicted changes are presented in Table 5.2.

Table 5.2. Summary table of predicted changes in catches of the major trap species by changing to 50 x 87 mm welded mesh, 60 x 80 mm gabion wire and 80 x 100 mm gabion wire trap backs. MLL is mimimum legal length. Fish with no MLL's are considered as being marketable at all sizes.

Species	**MLL cm FL**	**50 x 87 mm weldmesh l_{50}**		**Predicted change in catches if using 50x87 mm weldmesh rather than 50 mm hexagonal wire**
		observed	**predicted**	
Snapper	23.5	23.2	24.0	77% reduction in number of undersized fish 9% loss of legal fish by number (6% by weight)
Rubberlip morwong	23.0	26.3	25.7	97% reduction in number of undersized fish 36% loss of marketable fish by number (25% by weight)
Bream	22.1	N/A	24.5	99% reduction in number of undersized fish 50% loss of legal fish by number (39% by weight)
Silver trevally	none	24.4	27.7	13% loss of marketable fish by number (6.6% by weight)
Ocean leatherjackets	none	N/A	40.3	66% loss of marketable fish by number (55% by weight)
Sweep	none	N/A	21.7	19% loss of marketable fish by number (12% by weight)
Pigfish	none	N/A	34.8	82% loss of marketable fish by number (% by weight)
Species	**MLL cm FL**	**60 x80 mm gabion l_{50}**		**Predicted change in catches if using 60x80 mm gabion wire rather than 50 mm hexagonal wire**
		observed	**predicted**	
Snapper	23.5	22.3	23.0	61% reduction in number of undersized fish 1.5% loss of legal fish by number (0.9% by weight)
Rubberlip morwong	23.0	N/A	24.5	88% reduction in number of undersized fish 1.7% loss of marketable fish by number (9.6% by weight)
Bream	22.1	N/A	23.6	90% reduction in number of undersized fish 36% loss of legal fish by number (29% by weight)
Silver trevally	none	25.6	26.2	21% loss of marketable fish by number (12% by weight)
Ocean leatherjackets	none	N/A	39.0	59% loss of marketable fish by number (49% by weight)
Sweep	none	N/A	20.4	8% loss of marketable fish by number (4% by weight)
Pigfish	none	N/A	33.7	75% loss of marketable fish by number (69% by weight)
Species	**MLL cm FL**	**80 x 100 mm gabion l_{50}**		**Predicted change in catches if using 80x100 mm gabion wire rather than 50 mm hexagonal wire**
		observed	**predicted**	
Snapper	23.5	29.8	30.6	91% reduction in number of undersized fish 46% loss of legal fish by number (33% by weight)
Rubberlip morwong	23.0	N/A	32.4	100% reduction in number of undersized fish 82% loss of legal fish by number (67% by weight)
Bream	22.1	N/A	30.5	100% reduction in number of undersized fish 93% loss of legal fish by number (89% by weight)
Silver trevally	none	29.8	36.8	51% loss of marketable fish by number (46% by weight)
Ocean leatherjackets	none	N/A	50.3	96% loss of marketable fish by number (93% by weight)
Sweep	none	N/A	31.1	100% loss of marketable fish by number (100% by weight)
Pigfish	none	N/A	42.8	99% loss of marketable fish by number (98% by weight)

5.4. Discussion

The development of the parlour trap has been an important innovation in gear design to determine the selectivity of trap meshes. Analogous to the covered codend type experiments used in trawl studies (Wileman et al., 1996), the parlour trap allows better estimates of selectivity to be made from fewer numbers of fish and therefore fewer trap sets. We think that the parlour trap will be an excellent method for commercial fishers to test what may be lost by using non-standard meshes for themselves. The traps are easy to build, require minimal extra time to clear during normal trapping operations, and the experimental panel can simply be cut out when no longer needed.

The results of the selectivity of the 40 x 100 mm welded mesh support the hypothesis that we can predict the selection size of snapper based on fish height and maximum mesh aperture. The large proportion of snapper being meshed (up to 32% in one size class) revealed an important problem not previously considered to be an issue in the fishery. While smaller discarded species such as mado have been observed meshed in standard 50 mm hexagonal wire, the level of meshing has not been quantified. It may be that commercially important fish are rarely encountered in the ocean at the sizes which may be susceptible to meshing in 50 mm hexagonal wire traps (i. e. with body heights approximately 67 - 68 mm). The results of Ferrell & Sumpton (1997) support this as they only rarely observed snapper smaller than 16 cm FL in their offshore surveys using 37 mm mesh. The levels of meshing of snapper, bream and tarwhine in estuarine fish traps, where juveniles of these species are known to occur (Ferrell & Sumpton, 1997; Gray et al., 2000), needs to be quantified. We deliberately designed the 40 x 100 mm welded mesh to have a narrow width (36 mm) to minimise the loss of important species such as pigfish which have a more rounded profile than snapper. The problem of meshing snapper in narrow meshes leads to the conclusion that the mesh height to width ratio needs to be smaller than 96 mm:36 mm.

It was apparent that the estimated selection sizes of bream, ocean leatherjackets and silver trevally in the 40 x 100 mm welded mesh were all somewhat smaller than the sizes predicted based on fish height and maximum mesh aperture of 102.5 mm. It is possible that these species were being selected by their body widths in the narrow (36 mm) meshes. Bream and ocean leatherjackets gorge themselves on bait once in a trap and become bloated with food, whereas silver trevally are more rounded in profile. There may be scope to design meshes to select fish based on their body widths rather than heights, but body width is a more difficult dimension to model (see R^2s in Table 5.1) because of the condition of the fish i. e. full of food or enlarged gonads at breeding times.

The 40 x 100 mm welded mesh was only ever intended to be used to test the hypothesis that we could build a mesh to select snapper at a pre-determined size. The willingness of BHP Wire Products to change their machine to alter the mesh heights allowed us to design the 50 x 87 mm welded mesh for commercial use. The wire can be made to exactly the same specifications as the currently used 50 x 75 mm welded mesh, at a similar price, but with longer meshes. The recent development of BHP Wire Products “waratah duramesh” with permaseal coating may result in a longer life before the mesh corrodes in saltwater. The “waratah duramesh” is also made in different colours and the effect of mesh colour on selectivity needs to be examined. The reaction of fishers who used the 50 x 87 mm welded mesh was extremely positive, with all of them saying it was more effective at reducing the catch of small snapper than the 50 x 75 mm welded mesh currently in common use.

The selectivity of 50 x 87 mm welded mesh was appropriate for snapper, selecting fish at around 23.2 cm FL. Predicted reductions in catches of undersized snapper by 77% and rubberlip morwong by 97%, with losses of marketable fish being 0.9% and 25.5% by weight respectively, indicates that this mesh may be a suitable product for many fish trappers. However, the selectivity of this mesh is inappropriate for the sizes of bream, ocean leatherjackets and pigfish currently harvested in the fishery.

Of the three novel mesh types tested after the 40 x 100 mm welded mesh, the 80 x 100 mm gabion wire was obviously inappropriate for the current NSW trap fishery. The 80 x 100 mm gabion wire selected snapper at approximately 30 cm FL, and may be a suitable mesh in the future for fishers specifically targetting snapper. There is currently a proposal to increase the minimum legal size of snapper in NSW to 32 cm total length (approximately 27 cm FL) and if this happens there would be a need to use a mesh size of these proportions to minimize the catch of undersized fish. The selectivity of the 80 x 100 mm gabion wire is likely to be inappropriate for all other important species in the fishery. The estimates of *l50* for silver trevally of 29.8 cm FL for vertical mesh and of 24.2 cm FL for horizontal mesh were well below the predicted size of 36.8 cm FL. This is likely to be an artefact of: (i) some fish spilling back through the experimental mesh from the parlour section to the trap section when the trap was lifted onboard, and; (ii) the schooling behaviour of the fish (see discussion below).

The 60 x 80 mm gabion wire proved to be an acceptable, commercially available product suitable for use in fish traps. Snapper were selected at 22.3 cm FL and using this wire would reduce the catch of undersized snapper by 61% with almost zero loss of legal fish. However using 60 x 80 mm gabion wire would see large reductions in the numbers of marketable bream, ocean leatherjackets and pigfish captured. The heavily galvanized, woven wire is likely to last much longer in saltwater than the currently used 50 mm hexagonal twisted wire. One commercial fisher is trialing a fish trap wrapped entirely with the 60 x 80 mm gabion wire and we will be following its durability closely.

Silver trevally provided an example of fish behaviour being important in trap mesh selectivity. We have demonstrated that the selection sizes of most other species in the fishery (i. e. snapper, bream, rubberlip morwong, ocean leatherjackets etc.) can be predicted from their heights and the maximum mesh aperture. Observations of these species in traps when being lifted are that they orientate themselves to swim downwards, away from the direction the trap is moving, and so encounter the back panel of the trap. However, observations of silver trevally in traps as they are being lifted are that they form a tight school and orientate themselves to swim in the same direction as the trap is moving, only encountering the back of the trap as it is being lifted onto the vessel. There were no differences in selectivity of snapper in gabion meshes orientated either vertically or horizontally, and we think that snapper (and most other species in the fishery) can turn on their sides to escape through the longest mesh aperture whereas silver trevally do not. In fact it was common to see snapper meshed upsidedown in the back panel which would never happen when the trap was upright on the sea floor. This hypothesis may explain several observations: (i) the smaller selection size for silver trevally in horizontally orientated 80 x 100 mm gabion wire than in vertically orientated wire; (ii) the large proportion of silver trevally physically able to pass through into the parlour sections which were retained in the 80 x 100 gabion trap sections, and ; (iii) the meshing of large numbers of silver trevally in the 50 x 87 mm welded mesh and the vertically orientated 60 x 80 mm gabion wire (as well providing a simple solution to the problem). Silver trevally were becoming meshed while the trap was still on the sea floor (evidenced by the severe damage to the fish) with fish being stuck between their anterior dorsal spine and their protruding anal spine in the longest axis of the mesh. We did not observe any silver trevally to be meshed in wire orientated horizontally. We hypothesize that silver trevally do not turn on their sides to escape through meshes and that the problem of meshing fish can be solved by simply orientating the wire with the longest axis horizontally. The behaviour and escape responses of other important species suggests that this should not effect their selection sizes.

These results demonstrate the difficulty of designing a trap mesh with appropriate selectivities for all species in a multi-species trap fishery, particularly when the major species in the fishery either have no minimum legal size limits or differing size limits. While the most important species in the

NSW demersal trap is undoubtedly snapper, designing a trap mesh to minimize the capture of undersized snapper would result in large losses of other important species, to the extent that trap fishing may become uneconomical in many areas. This is particularly the case now that an increase in the MLL for snapper to 30 cm TL has been announced. Alternatively, increasing mesh sizes to capture fewer undersized snapper may ultimately result in increased yields for species such as rubberlip morwong, ocean leatherjackets and silver trevally. Fish escaping through trap meshes are not lost to the fishery and are likely to be recaptured at more valuable sizes. In fact, the recently completed FRDC funded study on silver trevally (Rowling & Raines, 2000) recommended an optimal size at first capture of over 30 cm FL. More work is needed on these “other” trap species to determine suitable harvest sizes.

6. Recommendations and implications

6.1. Benefits

This study has identified the processes influencing fish selectivity in a wire mesh trap fishery. Estimates of trap mesh selectivity will be primarily of use to the New South Wales trap fishery but will also be of interest to the ocean jacket trap fishery in South Australia and to other trap fisheries in Australia and overseas. The selectivities estimated for the important species will be utilized in future management of the trap fishery in NSW. Information on selectivity operating in the fishery will be used in NSW fisheries stock assessment models on the major species in the fishery.

Knowledge of trap mesh selectivity will be of interest to all researchers using traps as sampling tools. The development of the new parlour trap design for estimating selectivity should benefit all trap selectivity research around the world.

6.2. Further Development

Further extension of these results to industry will be done shortly. It is expected that educating fishers about the potential benefits and losses of using mesh larger than standard 50 mm hexagonal wire will result in voluntary uptake of larger mesh sizes. The experience gained by industry participating in this project will be of great benefit when the opportunity arises to test other trap meshes.

6.1. Conclusion

This study has successfully documented the selectivities of wire meshed fish traps currently used for the major species in the N.S.W. demersal trap fishery. We identified that the selectivity of standard 50 mm hexagonal wire mesh was inappropriate for all species with minimum legal lengths, (snapper, rubberlip morwong, bream and tarwhine) as well as pearl perch, with large numbers of undersized fish being captured and subsequently discarded with unknown mortality rates. The selectivity of 50 mm hexagonal mesh appeared to be suitable for all other important species without minimum legal lengths in the fishery.

There was a trend in the fishery for some fishers to use panels of 50 x 75 mm welded mesh in their traps to reduce the catch of undersized fish. Of fishers who responded to a questionnaire at the start of the study, 32% already used 50 x 75 mm welded mesh somewhere in their traps. Most of these fishers operated off northern N. S. W. The selectivity of 50 x 75 mm welded mesh was better than standard 50 mm hexagonal mesh, retaining fewer undersized fish per trap lift, but still retained large numbers of undersized snapper and rubberlip morwong. Catches of marketable snapper, rubberlip morwong, bream, silver trevally, sweep, tuskfish, pearl perch, carpet shark and conger eels were virtually unaffected when using 50 x 75 mm welded mesh. Estimates of catches of some other important species in the fishery suggest substantial losses of marketable fish may occur when using this mesh i.e. ocean jackets (30% by weight), tarwhine (25% by weight), pigfish (65% by weight) and goatfish (42% by weight). These estimates are based on statewide averages and may therefore vary significantly for individual fishing businesses. The fact that many fishers use 50 x 75 mm welded mesh in their traps suggests that any losses are insignificant to their incomes.

Trials of 4 novel mesh types showed the difficulty of designing trap meshes with appropriate selectivities for all important species in such a multi-species fishery. We conclude that some of the novel meshes trialed may be appropriate for snapper, but potential losses of species either with minimum legal lengths smaller than snapper or with no minimum legal lengths may be large, and that uptake of these meshes should therefore be on a voluntary basis.

Trap mesh selectivity was shown to occur at the back panel of a fish trap. We demonstrated that fish behaviour is important in determining selectivity, but that selection sizes of most species in the fishery could be approximated from the maximum mesh aperture used and the fishes body depth.

7. References

Carlile, D. W., Dinnocenzo, T. A. and Watson, L. J. (1997) Evaluation of modified crab pots to increase catch of Pacific cod and decrease bycatch of Pacific Halibut. *North American Journal of Fisheries Management* 17: 910-928.

Ferrell, D. and Sumpton, W. (1997) Assessment of the fishery for snapper (*Pagrus auratus*) in Queensland and New South Wales. Final report to the Fisheries Research & Development Corporation, project no. 93/074.

Gobert, B. (1994) Size structures of demersal catches in a multispecies multigear tropical fishery. *Fisheries Research* 19: 87-104.

Gobert, B. (1998) Density-dependent size selectivity in Antillean fish traps. *Fisheries Research*. 38: 159-167.

Gobert, B. (2000) Comparative assessment of multispecies reef fish resources in the Lesser Antilles. *Fisheries Research*. 44: 247-260.

Gray, C. A., Larsen, R. B. and Kennelly, S. J. (2000) Use of transparent netting to improve size selectivity and reduce bycatch in fish seine nets. *Fisheries Research* 45: 155-166.

Gray, C. A., Pease, B. C., Stringfellow, S. L., Raines, L. P., Rankin, B. K. and Walford, T. R. (2000) Sampling estuarine fish species for stock assessment. Final report to the Fisheries Research & Development Corporation, project no. 94/042. NSW Fisheries Final Report Series No. 18.

Harper, D. E., Bohnsack, J. A. and Mcclellan D. B. (1994) Investigation of bycatch from the wire fish-trap fishery in federal waters off southern Florida. *Proceedings of the 43rd Annual Gulf and Caribbean Fisheries Institute*. 3-25.

Jeong, E. C.,Kim, S. K., Park, C. D., Shin, J. K. and Tokai, T. (1999) Size-selectivity of hole on tubular-pot for white spotted conger eel *Conger myriaster* in the adjacent sea of Korea. *Nippon Suisan Gakkaishi*. 64: 260-267.

Jeong, E. C., Park, C. D., Park, S. W., Lee, J. H. and Tokai, T. (2000) Size selectivity of trap for red queen crab *Chionoecetes japonicus* with the extended SELECT model. *Fisheries Science*. 66: 494-501.

Kumpf, H. E. (1994) Practical considerations and testing of escape panel material in fish traps.

Luckhurst, B. and Ward, J. (1987) Behavioral dynamics of coral reef fishes in Antillean fish traps at Bermuda. *Proc. Gulf Caribb. Fish. Inst*. 38: 528-546.

Moran, M. and Jenke, J. (1990) Effects of fish trap mesh size on species and size selectivity in the Australian north west shelf trap fishery. *Fishbyte* 8(2): 8-13.

Millar, R. B. (1991) Estimation of asymmetric selection curves for trawls. ICES Doc. C. M.1991/B:56, 21pp.

Millar, R. B. (1992) Estimating the size-selectivity of fishing gear by conditioning on the total catch. *J. Am. Stat. Assoc*. 87: 962-968.

Millar, R. B. (1993) Analysis of trawl selectivity studies (addendum): implementation in SAS. *Fisheries Research* 17:373-377.

Millar, R. B. and Walsh, S. J. (1992) Analysis of trawl selectivity studies with an application to trouser trawls. *Fisheries Research* 13: 205-220.

Millar, R. B. and Fryer, R. J. (1999) Estimating the size-selection curves of towed gears, traps, nets and hooks. *Reviews in Fish Biology and Fisheries* 9: 89-116.

Moran, M. and Jenke, J. (1990) Effects of fish trap mesh size on species and size selectivity in the Australian north west shelf trap fishery. *Fishbyte*. 8(2): 8-13.

Munro, J. L. (1983) Caribbean coral reef fishery resources. *ICLARM Studies and Reviews* 7: 276 pp.

Newman, S. J. and Williams, D. M. (1995) Mesh size selection and diel variability in catch of fish traps on the central Great Barrier Reef, Australia: a preliminary investigation. *Fisheries Research* 23:237-253.

Olsen, D. A., Dammann, A. E. and LaPlace, J. A. (1978) Mesh selectivity of West Indian fish traps. *Marine Fisheries Review* 40 (7): 15-16.

Pope, J. A., Margetts, A. R. and Hamley, J. M. (1975) Manual of methods for fish stock assessment part III. Selectivity of fishing gear. *FAO Fisheries Technical Paper* 41: 65 pp.

Robichaud, D., Hunte, W. and Oxenford, H. A. (1999) Effects of increased mesh size on catch and fishing power of coral reef fish traps. *Fisheries Research* 39: 275-294.

Rowling, K. R. and Raines, L. P. (2000) Description of the biology and an assessment of the fishery for Silver Trevally *Pseudocaranx dentex* off New South Wales. Final report to the Fisheries Research & Development Corporation, project no. 97/125. NSW Fisheries Final Report Series No. 24 ISSN 1440-3544.

Sary, Z., Oxenford, H. A. and Woodley, J. D. (1997) Effects of an increase in trap mesh size on an overexploited coral reef fishery at Discovery Bay, Jamaica. *Marine Ecology Progress Series*. 154: 107-120.

Scarsbrook, J. R., McFarlane, G. A. and Shaw, W. (1988) Effectiveness of experimental mechanisms in sablefish traps. *North American Journal of Fisheries Management* 8: 158-161.

Stevenson, D. K. and Stuart-Sharkey, P. (1980) Performance of wire fish traps on the western coast of Puerto Rico. *Proc. Gulf Caribb. Fish. Inst*. 32:172-193.

Sutherland, D. L. and Harper, D. E. (1983) The wire fish-trap fishery of Dade and Broward counties, Florida December 1979 – September 1980. Florida Marine Research Publications 40.

Sutherland, D. L., Bohnsack, J. A., Harper, D. E., Holt, C. M., Hulsbeck, M. W. and Mcclellan, D. B. (1991) Preliminary report. Reef fish size and species selectivity by wire fish traps in south Florida waters. *Proceedings of the Gulf of Caribbean Fisheries Institute*. 40: 108-125.

Taylor, R. G. and McMichael Jr. R. H. (1983) The wire fish-trap fisheries in Monroe and Collier counties, Florida. Florida Marine Research Publications 39.

Treble, R. J., Millar, R. B. and Walker, T. I. (1998) Size-selectivity of lobster pots with escape-gaps: application of the SELECT method to the southern rock lobster (*Jasus edwardsii*) fishery in Victoria, Australia. *Fisheries Research*. 34: 289-305.

Ward, J. (1988) Mesh size selection in Antillean arrowhead fish traps. FAO Fisheries Report 389. Rome.

Whitelaw, A. W., Sainsbury, K. J., Dews, G. J. and Campbell, R. A. (1991) Catching characteristics of four fish-trap types on the north west shelf of Australia. *Australian Journal of Marine and Freshwater Research* 42: 369-382.

Wileman D. A., Ferro, R. S. T., Fonteyne, R. and Millar, R. B. (1996) Manual of methods of measuring the selectivity of towed fishing gears. *ICES Cooperative Research Report* (Copenhagen) No. 215: 126pp.

Xu, X. and Millar, R. B. (1993) Estimation of trap selectivity for male snow crab (*Chionoecetes opilio*) using the SELECT modeling approach with unequal sampling effort. *Can. J. Fish. Aquat. Sci*. 50: 2485-2490.

SEANET
smarter fishing for industry

8. Appendix I. Extension program for the fish trap mesh selectivity project

Background
As previously reported, NSW Fisheries undertook a 2-year study into the effectiveness of using escape panels in fish traps. This study was funded through the Fisheries Research and Development Corporation, project number 97/126. As with all research programs an extension component is necessary to ensure that the aims, objectives and outcomes of the research are effectively communicated to the key stakeholders. In addition, if the research includes the development of new technologies such as escape panels - an extension program can improve the level of voluntary uptake of this new technology. SeaNet was contracted to assist NSW Fisheries to deliver the extension component of the Fish Trapping Research Program.

SeaNet has been providing extension services to the Australian Commercial Fishing Industry for over 2 years in QLD, NSW, VIC, SA and some Commonwealth Fisheries (East Coast Tuna and South East Trawl). SeaNet's primary objective is to provide easy access to information and advice about bycatch reduction and environmental best practice. SeaNet is funded by Environment Australia through the Natural Heritage Trust and is administered by Ocean Watch Australia Ltd.

SeaNet is particularly well received by the fishing industry because the Extension Officers are hosted by the Fishing Industry Association of that State. The National SeaNet program is overseen by a Steering Committee consisting of the Australian Seafood Industry Council, the Australian Marine Conservation Society, Ocean Watch Australia Ltd, Environment Australia, Agriculture, Fisheries and Forestry Australia and the Fisheries Research and Development Corporation.

Aims of the Extension Program

The aims of the extension program were:

1. To advise industry on the outcomes of recent research and trials on various sized and shaped mesh panels in fish traps which aim to reduce the bycatch of undersized fish.
2. To provide industry with information on the selectivity of the mesh panels and potential gains and losses of using the panels.
3. To link each port/region with a fish trapper that has already trialed different panels.
4. To provide industry with novel meshes to try.
5. To increase trappers knowledge of discards issues and what is expected from industry regarding improved practices and reduction of discards.
6. To encourage trappers to participate in the development of bycatch reduction devices and techniques.
7. Improve Fish Trappers understanding and awareness of SeaNet's services.

Methods

In order to effectively deliver the above aims NSW Fisheries in conjunction with SeaNet arranged for:

1. Pre-arranged port meetings through the Regional Industry Convenors (RIC) (Barb Radley and Shirley Massey).
2. An invitation was sent to all endorsement holders inviting them to attend an informal meeting with NSW Fisheries (John Stewart) and SeaNet (Katie Gill) to discuss the findings of the research.
3. A brochure with a brief description of the bycatch and the use of escape panels was sent with the invitation.
4. Video footage of escape panels in the back of a fish trap and general footage of fish trapping best practices (sorting bycatch first, fish measuring etc).
5. Port visits were conducted with a focus on visiting the major fish trapping ports.
6. At the port meetings results were presented using a photocopied handout which summarised the results in plain English.
7. Discussions regarding the effectiveness of the panels were initiated and contact details of fishers who use escape panels were provided.
8. Free samples of various mesh panels was provided.
9. Fishers were encouraged to try using an escape panel to reduce bycatch of undersized or unwanted species, where appropriate.
10. Feedback was collected from fishers regarding the research and extension programs.
11. Phone contact made to extra fishers who were unable to attend the port meetings.

Outcomes

In June 2001 an invitation to the port meetings and the “Reducing Bycatch in Fish Traps” brochure was sent to every Fish Trap endorsement holder in NSW.

In July 2001 port visits were held at 15 ports along the coast of NSW and three house visits were arranged (see table 1). The home and port visits enabled NSW Fisheries and SeaNet to meet with 68 fish trappers in person. The port visits consisted of informal meetings in the tearoom of the fisherman’s coop or on the wharf at the port. A 6 page non-technical summary paper was given to all fishers who attended the meetings and video footage and photos of the escape panels in action was shown. The video footage was a very popular and effective way to show how the escape panel works and was probably the most effective tool used in the port visits.

At each port there was at least one fish trapper who had used an escape panel before. The port meetings provided an excellent opportunity for other fishers to ask each other questions about their experience with the panels. Bob Radley and Noel Gogerly (commercial fish trappers) also offered their contact details should any one want to discuss the use of escape panels with a fellow fisher. Both Bob and Noel use panels in all of their traps and readily encourage others to do the same.

Free samples of 3 types of mesh were provided at the port visits. The samples were so readily received that all meshes were given out by the end of the port visits. Contact details of mesh suppliers were also provided.

19 fishers took samples of mesh to try in their panels. These fishers have been encouraged to provide John or Katie with ongoing feedback regarding bycatch and the escape panels. All fishers that attended the port visits were given John Stewart and Katie Gill's contact details to ensure that trap fishers have a point of contact in the future should they wish to participate in the further development of BRD's in the trap fishery.

During port meetings, discussions were held regarding bycatch reduction, sustainable fishing practices and environmental best practice. This was particularly significant to the trap fishers, as they had recently received a bill for an Environmental Impact Assessment to be undertaken in their fishery. This initiated many discussions about the need to reduce bycatch and to pursue sustainable fishing practices.

During the port visits it was apparent that those present had a good understanding of the need to pursue sustainable fishing practices, and as such the use of escape panels to reduce bycatch was generally well received. One concern raised however, was the possibility of the escape panels becoming mandatory. In particular fishers were concerned that NSW Fisheries may make even bigger mesh sizes compulsory in the future - as size limits for individual species increase. This would be a great set back to many fishers who target a variety of species and would stand to lose a large proportion of their catch.

The port visits resulted in 19 trap fishers taking sample escape panels to trial for the first time. It was pleasing to see that 32 fishers who attended the port visits had already tried various escape panels and of those 25 fishers continue to use escape panels in their fish traps. There were 13 fishers at the port visits who were not interested in trialing any escape panels as they did not think the larger mesh sizes were suitable for their target catch. Information was left with these individuals should they wish to look into it at a later date. See table 1 for more detail on ports visited and attendance numbers.

Phone contact was also made to 8 trap fishers who were unable to attend the port meetings. In addition extra handouts were provided and contact details passed on for those that were unable to attend.

SEANET

smarter fishing for industry

Table 1. Ports Visited and Outcomes.

Location of Port Visit	**No. people at meetings**	**Outcomes** **Eg. sample taken or not, have already tried using escape panels, not suitable etc..**
Newcastle	2	Both took sample panels to try
Wallis Lakes	1	Uses escape panels in every trap
Crowdy Head	9	3 fishers took samples of 60x80 hex, 50x87 mesh, 50x75 mesh 1 already uses 3x2 in the door 4 fishers did not think the mesh size was suitable for their target species
Laurieton	5	1 fisher has tried using escape panels but is not currently using any 1 fisher uses 3x2 in the door of trap 1 fisher is interested in using a bigger mesh in his lobster pots None took samples
Port Macquarie Home Visit	1	Already uses 3x2 panel in the door
Port Macquarie	2	Both fishers already use 3x2 in back of trap.
Terrigal	7	1 fisher has tried using escape panels, but doesn't use them anymore 4 fishers took sample panels of the 3x2 2 fishers did not think the mesh size was suitable for their target species
Coffs Harbour	13 present (2 were not fishers Co-op Manager and Coop Rep)	1 fisher trialed a large 100x40 mesh which was unsuccessful and does not currently use any other escape panels 8 fishers have tried using various mesh sizes and some continue to use the panels in their traps 1 fisher does not think the larger mesh sizes are suitable for his traps
Wooli	5	2 fishers took samples of escape panels 2 fishers have tried various mesh sizes and are supportive of using escape panels
Brunswick Heads Home Visit	1	Fisher uses 3x2 escape panels in every trap
Ballina	4	1 fisher used 3 ½ x2 but lost 28cm snapper, will try hexagonal 2 have already tried using panels 1 fisher does not think the larger mesh sizes are suitable for his traps
Tweed Heads	2	1 fisher will try panels (new entrant to fishery) 1 fisher was not interested in trying any panels
Sydney Fish Markets	1	Already tried escape panels, is very cynical about their effectiveness
Wollongong	7	3 fishers took sample panels to try 2 fishers already use escape panels 1 fisher uses set lines to catch snapper, so escape panels not relevant
Nowra	2 (one RIC)	New entrant to fishery, will try using escape panels
Greenwell Point	3	2 fishers already use 3x2 in door of traps, but showed an interest in trying the mesh in the back of trap 1 fisher did not think the mesh size was suitable for their target species
Ulludulla	2	1 fisher already uses a panel in his trap 1 fisher did not think the mesh size was suitable for their target species
Other methods of contact prior to Port Visits		
Home Visit	1	Trialed various meshes but not currently using any
Phone calls	8	2 not interested. 5 already tried panels (2 not using anymore)
Total Number of people contacted through extension	**76**	**SUMMARY OF OUTCOMES** **19** fishers took sample meshes to try **24** fishers already use escape panels **7** fishers have trialed escape panels and found them unsuitable **13** fishers are not interested in trialing an escape panel as they do not think the larger mesh size is unsuitable for their target catch **12** were either not fishers, used different methods or did not voice an opinion

9. INTELLECTUAL PROPERTY

No patentable inventions or processes have been developed as part of this project. The work reported in this report will be published in scientific journals and industry magazines.

10. STAFF

Staff directly employed on this project with FRDC funds were:

Doug Ferell
Dr John Stewart

Other titles in this series:

ISSN 1440-3544

No. 1 Andrew, N.L., Graham, K.J., Hodgson, K.E. and Gordon, G.N.G., 1998. Changes after 20 years in relative abundance and size composition of commercial fishes caught during fishery independent surveys on SEF trawl grounds. Final Report to Fisheries Research and Development Corporation. Project No. 96/139.

No. 2 Virgona, J.L., Deguara, K.L., Sullings, D.J., Halliday, I. and Kelly, K., 1998. Assessment of the stocks of sea mullet in New South Wales and Queensland waters. Final Report to Fisheries Research and Development Corporation. Project No. 94/024.

No. 3 Stewart, J., Ferrell, D.J. and Andrew, N.L., 1998. Ageing Yellowtail (*Trachurus novaezelandiae*) and Blue Mackerel (*Scomber australasicus*) in New South Wales. Final Report to Fisheries Research and Development Corporation. Project No. 95/151.

No. 4 Pethebridge, R., Lugg, A. and Harris, J., 1998. Obstructions to fish passage in New South Wales South Coast streams. Final report to Cooperative Research Centre for Freshwater Ecology.

No. 5 Kennelly, S.J. and Broadhurst, M.K., 1998. Development of by-catch reducing prawn-trawls and fishing practices in NSW's prawn-trawl fisheries (and incorporating an assessment of the effect of increasing mesh size in fish trawl gear). Final Report to Fisheries Research and Development Corporation. Project No. 93/180.

No. 6 Allan, G.L., and Rowland, S.J., 1998. Fish meal replacement in aquaculture feeds for silver perch. Final Report to Fisheries Research and Development Corporation. Project No. 93/120-03.

No. 7 Allan, G.L., 1998. Fish meal replacement in aquaculture feeds: subprogram administration. Final Report to Fisheries Research and Development Corporation. Project No. 93/120.

No. 8 Heasman, M.P., O'Connor, W.A., O'Connor, S.J., 1998. Enhancement and farming of scallops in NSW using hatchery produced seedstock. Final Report to Fisheries Research and Development Corporation. Project No. 94/083.

No. 9 Nell, J.A., McMahon, G.A., and Hand, R.E., 1998. Tetraploidy induction in Sydney rock oysters. Final Report to Cooperative Research Centre for Aquaculture. Project No. D.4.2.

No. 10 Nell, J.A. and Maguire, G.B., 1998. Commercialisation of triploid Sydney rock and Pacific oysters. Part 1: Sydney rock oysters. Final Report to Fisheries Research and Development Corporation. Project No. 93/151.

No. 11 Watford, F.A. and Williams, R.J., 1998. Inventory of estuarine vegetation in Botany Bay, with special reference to changes in the distribution of seagrass. Final Report to Fishcare Australia. Project No. 97/003741.

No. 12 Andrew, N.L., Worthington D.G., Brett, P.A. and Bentley N., 1998. Interactions between the abalone fishery and sea urchins in New South Wales. Final Report to Fisheries Research and Development Corporation. Project No. 93/102.

No. 13 Jackson, K.L. and Ogburn, D.M., 1999. Review of depuration and its role in shellfish quality assurance. Final Report to Fisheries Research and Development Corporation. Project No. 96/355.

No. 14 Fielder, D.S., Bardsley, W.J. and Allan, G.L., 1999. Enhancement of Mulloway (*Argyrosomus japonicus*) in intermittently opening lagoons. Final Report to Fisheries Research and Development Corporation. Project No. 95/148.

No. 15 Otway, N.M. and Macbeth, W.G., 1999. The physical effects of hauling on seagrass beds. Final Report to Fisheries Research and Development Corporation. Project No. 95/149 and 96/286.

No. 16 Gibbs, P., McVea, T. and Louden, B., 1999. Utilisation of restored wetlands by fish and invertebrates. Final Report to Fisheries Research and Development Corporation. Project No. 95/150.

No. 17 Ogburn, D. and Ruello, N., 1999. Waterproof labelling and identification systems suitable for shellfish and other seafood and aquaculture products. Whose oyster is that? Final Report to Fisheries Research and Development Corporation. Project No. 95/360.

No. 18 Gray, C.A., Pease, B.C., Stringfellow, S.L., Raines, L.P. and Walford, T.R., 2000. Sampling estuarine fish species for stock assessment. Includes appendices by D.J. Ferrell, B.C. Pease, T.R. Walford, G.N.G. Gordon, C.A. Gray and G.W. Liggins. Final Report to Fisheries Research and Development Corporation. Project No. 94/042.

No. 19 Otway, N.M. and Parker, P.C., 2000. The biology, ecology, distribution, abundance and identification of marine protected areas for the conservation of threatened Grey Nurse Sharks in south east Australian waters. Final Report to Environment Australia.

No. 20 Allan, G.L. and Rowland, S.J., 2000. Consumer sensory evaluation of silver perch cultured in ponds on meat meal based diets. Final Report to Meat & Livestock Australia. Project No. PRCOP.009.

No. 21 Kennelly, S.J. and Scandol, J. P., 2000. Relative abundances of spanner crabs and the development of a population model for managing the NSW spanner crab fishery. Final Report to Fisheries Research and Development Corporation. Project No. 96/135.

No. 22 Williams, R.J., Watford, F.A. and Balashov, V., 2000. Kooragang Wetland Rehabilitation Project: History of changes to estuarine wetlands of the lower Hunter River. Final Report to Kooragang Wetland Rehabilitation Project Steering Committee.

No. 23 Survey Development Working Group, 2000. Development of the National Recreational and Indigenous Fishing Survey. Final Report to Fisheries Research and Development Corporation. Project No. 98/169. (Volume 1 – main report, Volume 2 – attachments).

No.24 Rowling, K.R and Raines, L.P., 2000. Description of the biology and an assessment of the fishery of Silver Trevally *Pseudocaranx dentex* off New South Wales. Final Report to Fisheries Research and Development Corporation. Project No. 97/125.

No. 25 Allan, G.L., Jantrarotai, W., Rowland, S., Kosuturak, P. and Booth, M., 2000. Replacing fishmeal in aquaculture diets. Final report to the Australian Centre for International Agricultural Research. Project No. 9207.

No. 26 Gehrke, P.C., Gilligan, D.M., Barwick, M., 2001. Fish communities and migration in the Shoalhaven River – Before construction of a fishway. Final report to Sydney Catchment Authority.

No. 27 Rowling, K.R., and Makin, D.L., 2001. Monitoring of the fishery for Gemfish *Rexea solandri*, 1996 to 2000. Final report to the Australian Fisheries Management Authority.

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).

No. 29 Heasman, M.P., Goard, L., Diemar, J. and Callinan, R. 2000. Improved Early Survival of Molluscs: Sydney Rock Oyster (*Saccostrea glomerata*). Final report to the Aquaculture Cooperative Research Centre (Project No. A.2.1.).

No. 30 Allan, G.L., Dignam, A and Fielder, S. 2001. Developing Commercial Inland Saline Aquaculture in Australia: Part 1. R&D Plan. Final Report to Fisheries Research and Development Corporation. Project No. 1998/335.

No. 31 Allan, G.L., Banens, B. and Fielder, S. 2001. Developing Commercial Inland Saline Aquaculture in Australia: Part 2. Resource Inventory and Assessment. Final report to Fisheries Research and Development Corporation. Project No. 1998/335.

No. 32 Bruce, A., Growns, I. and Gehrke P. 2001. Woronora River Macquarie Perch Survey. Final report to Sydney Catchment Authority, April 2001.

No. 33 Morris, S.A., Pollard, D.A., Gehrke, P.C. and Pogonoski, J.J. 2001. Threatened and Potentially Threatened Freshwater Fishes of Coastal New South Wales and the Murray-Darling Basin. Report to Fisheries Action Program and World Wide Fund for Nature. Project No. AA 0959.98.

No. 34 Heasman, M.P., Sushames, T.M., Diemar, J.A., O'Connor, W.A. and Foulkes, L.A. 2001. Production of Micro-algal Concentrates for Aquaculture Part 2: Development and Evaluation of Harvesting, Preservation, Storage and Feeding Technology. Final report to Fisheries Research and Development Corporation. Project No. 1993/123 and 1996/342.

No. 35 Stewart, J. and Ferrell, D.J. 2001. Mesh selectivity in the NSW demersal trap fishery. Final report to Fisheries Research and Development Corporation. Project No. 1998/138.