The effects of haul seining in Victorian bays and inlets

Ian A. Knuckey, Alexander K. Morison and David K. Ryan

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OBJECTIVES:

1. To describe the seine nets, fishing methods and fishing boats used in bays and inlets of Victoria.
2. To assess the effect of haul seine fishing methods on the fish stocks in bays and inlets.
3. To determine the survival of fish captured and released from haul seine nets used in the major Victorian bays and inlets.

NON TECHNICAL SUMMARY:

OUTCOMES ACHIEVED

The project has provided the first description of the fishing gear and practices used in the Victorian haul seine fishery. It has also provided the first estimates of the rate of discarding in this sector, together with estimates of the survival of released fish, which are generally high. Modifications to haul seines that greatly reduce the meshing of undersized fish, particularly King George whiting, were tested during the project and were quickly adopted by commercial fishers. Commercial fishers have responded very positively to the project findings, and they are keen to see the results disseminated more widely. Results have been disseminated to a range of audiences using video productions, newsletters, oral presentations and articles.

In Victoria's bays and inlets, generations of fishermen have used haul seines to target several species such as King George whiting, snapper, Australian salmon, southern sea garfish, flathead, calamari, yellow-eye mullet and flounder. Over the past 20 years, haul seines have taken 62% of the total reported catch from bay and inlet fisheries (excluding the purse seine fishery). In recent years, there has been a growing public perception that haul seines cause excessive mortality of juvenile fish and degrade habitats. This project sought to investigate the factors underlying this perception and to provide an objective assessment of the effects of haul seines.

The project objectives evolved somewhat during the course of the study, reflecting the preliminary results of the present research and those of a concurrent haul seine project in New South Wales. The final objectives of the present study and the associated research results are presented below.

Objective 1 Describe the seine nets, fishing methods and fishing boats used in bays and inlets of Victoria.

The design and use of haul seines varies considerably depending on the species targeted and areas fished. Detailed descriptions of fishing practices and the design of haul seines were obtained from interviews with 104 commercial haul-seine fishers. This represented most of the active fishers (out of 187 licensed operators) in Victoria's major bays and inlets: Port Phillip Bay, Corner Inlet, Lakes Entrance and Mallacoota. Detailed information on net size, design and dimensions, methods of deployment, and vessel characteristics were obtained. A cluster analysis of these data was undertaken to determine the natural groupings of nets, the characteristics of groups, their geographical distribution, and their target species. Generally, the results indicated that the four categories of haul seines that fishers described (beach seines, estuary seines, garfish seines and ringing seines) did represent discrete types of nets. The main groupings, to some extent, also reflected differences in the locations fished suggesting that the nets have developed along different lines in the different bays and inlets. These differences probably reflect a combination of historical differences in the types of gears traditionally employed, in the conditions experienced, and in the designs that are most suitable for the suite of species targeted in the different areas.

Observations of fishing practices indicated that haul seines are a distinct type of mobile trawl gear characterised by slow tow speeds, short tow duration, operation in shallow depths, and sorting of the catch in the water. These characteristics mean that fish are slowly herded into the bag or codend, are not exhausted or overtaken by the net and are not exposed to the same stresses as those caught by other active fishing methods. Thus, if conducted properly, there is potential for high survival of un-meshed fish that are released from a haul seine.

Objective 2: Assess the effect of haul seine fishing methods on the fish stocks in bays and inlets.

This objective was addressed by a combination of research approaches including on-board observations of commercial haul seine operations to record the composition of the retained and discarded catch, surround net experiments to determine escapement and selectivity of the mesh for different fish species, and assessment of the effectiveness of polyethylene mesh to reduce meshing of under-sized King George whiting and other species.

The size and species composition of samples of the unsorted catch were recorded for 37 shots by 4 different fishers in Corner Inlet and 43 shots by 6 different fishers in Port Phillip Bay between 17 July 1997 and 16 October 1998. Fifty three taxa were recorded, of which 28 (53%) were of some commercial value and the remainder (47%) were discarded. Only six taxa (King George whiting, globefish, smooth toadfish, prickly toadfish, leatherjackets, and greenback flounder) were recorded in more than 50% of shots.

From the 43 haul seine shots monitored in Port Phillip Bay, the retained catch averaged 38% of the numbers of fish caught and 32% of the total weight. Of the discarded portion of the catch, approximately 23% by number, and 18% by weight were species of commercial value that were undersized. The lower proportion by weight predominantly reflects the discarding of a few very large rays. In Port Phillip Bay, average catch rates (by number) for King George Whiting were highest of all species and most were retained. Discarding was highest for smooth toadfish, globefish, snapper and King George whiting. Discards of the latter two species were of fish under the legal minimum length (LML).

From the 37 shots monitored in Corner Inlet, the retained catch accounted for 26% by number and 31% by weight of the total catch. Of the discarded portion of the catch, approximately 36% by number, and 11% by weight were commercial species. The difference between the two measures mainly reflected the catch of large numbers of small leatherjackets that contribute greatly to the numbers but very little to the average weight. In Corner Inlet, average catch rates (by number) for leatherjackets were the highest of all species but most were discarded. Discarding was also high for two toadfish species and globefish. Of the commercially important species, average catch rates were highest for garfish, King George whiting and silver trevally but a large proportion of the latter two species were undersized and discarded.

The species and size composition of fish caught in the surround net provided data on the fish that passed through a commercial net. The surround net was deployed around normal commercial shots on two occasions in October 1998 in Corner Inlet and on three occasions between October 1998 and January 1999 Port Phillip Bay. In Corner Inlet, there were six species caught in the surround net which were not caught in the commercial net, 15 species caught only in the commercial net, and nine species caught in both net types. In Port Phillip Bay there were seven species caught only in the surround net, 17 species caught only in the commercial net, and 23 species caught in both nets. About 70% by number of the total catch was caught in the commercial net in Corner Inlet, and this proportion rose to over 90% by weight. In contrast, less than 40% of the total catch by number was caught in the commercial net in Port Phillip Bay, reflecting the larger number of hardyheads and blue sprat in the surround net. Because these fish are small, however, 80% of the total catch by weight was caught in the commercial net.

The other important aspect to the selectivity of the haul seines is the size of fish that are retained by the commercial net through being meshed. King George whiting was the particular focus of this part of the work because this species was one of the most commonly meshed. King George whiting that have been meshed are usually dead by the time they are removed from the net, so the meshing rate of undersized fish could contribute significantly to the mortality of discarded fish. Data on the sizes and numbers of King George whiting meshed during normal operation of haul seines was recorded from 6 shots by 2 different operators in Corner Inlet, and from 7 shots by one operator in Port Phillip Bay, between 19 August 1998 and 12 January 1999. For those shots monitored in Corner Inlet, the King George whiting caught in the wings of haul seines (5.08 cm mesh) was predominantly of the larger fish in the catch with a mode at 30 cm. In Port Phillip Bay, however, the King George whiting meshed in the wings (4.45 cm mesh) had a mode at 25 cm and were generally less than 30 cm. King George whiting meshed in the shoulders of nets in Port Phillip Bay (2.86 cm mesh) were all in a narrow size range of 17-20 cm. Attempts were made to collect more information on the relative numbers of fish meshed and bagged for shots in Port Phillip Bay, but significant numbers of fish were only meshed when the small King George whiting were prevalent in the areas fished. This did not occur during the later phases of the project when this aspect of the study was being investigated.

To measure the selectivity of nets constructed with different materials, experiments were conducted with a commercial net that had one wing constructed of polyethylene mesh and one of normal nylon mesh. The number of fish meshed in each wing type was recorded in 61 shots of the net. In these shots, a total of 477 King George whiting were meshed in the nylon wing, compared to 18 in the polyethylene wing. This represented >25-fold reduction in number. There are clear benefits from this simple change to gear and a growing number of fishers are replacing the mesh in the wings of their seine nets as a result.

Objective 3: Determine the survival of fish captured and released from haul seine nets used in the major Victorian bays and inlets.

The survival of released fish was assessed by transferring fish caught in normal shots of a commercial seine net to holding cages anchored nearby. Trials to monitor the survival of fish released from haul seines show that survival rates were generally in excess of 80% and were 100% for many species. In Port Phillip Bay, the experiments assessed 18 different species (596 fish) and the average survival was 89% per species. No mortalities were recorded for 12 species. However, mortality of garfish was 100% as this species is prone to high scale loss. In Corner Inlet, 5 species were assessed (170 fish) and the average survival was 97% per species. No mortalities were recorded among the 4 bycatch species (ornate cowfish, globefish, barred toadfish and smooth toadfish). Survival of King George whiting averaged 81% across 14 separate trials conducted in both areas involving 540 fish.

Combined discussion

Estimates of the numbers of fish which pass through haul seines and the numbers discarded were combined with the estimates of the survival rates of discards to give an overall mortality rate of fish that encounter a seine net. Using numbers of fish and values averaged across all species and both Corner Inlet and Port Phillip Bay, the fate of fish encountering a haul seine was estimated. For every 100 fish encountering the net, 44 pass through, 18 are retained and marketed, 34 are released and survive and 4 are released but die. The ratio of retained fish to dead discards is in excess of 4.5:1. Values for individual species will obviously vary from these averages. An estimate for King George whiting, again combining data from Corner Inlet and Port Phillip Bay, was obtained. For every 100 King George whiting encountering the net, 66 pass through, 21 are retained and marketed, 11 are released and survive and 1.7 are released but die. The ratio of retained fish to dead discards is in excess of 12:1.

The effects of haul seining in Victorian bays and inlets result mostly from the impact of removing targeted commercial species, and any subsequent, indirect effects this has on fish communities. The impact on non-target species or under-sized fish is likely to be relatively minor, because of the generally high survival rates of released fish. Slow tow speeds, short tow duration, shallow depths of operation, and sorting of the catch in the water all contribute to the ability of fish released from haul seines to survive. Meshing and mortality of under-sized fish, particularly King George whiting, may still be an issue in some seasons when there is high recruitment. This could be substantially reduced, however, by using nets constructed of polyethylene, rather than nylon, mesh.

KEYWORDS: Haul seines, bycatch reduction, effects of fishing, bycatch mortality

2 Acknowledgments

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3 Background

In Victoria's bays and inlets, generations of commercial fishermen have used haul seines to target several species such as King George whiting, snapper, Australian salmon, southern sea garfish, flathead, calamari, yellow-eye mullet and flounder. Generally, haul seines are set in a large semi-circle from a gentle sloping beach and the two ends of the net are hauled towards the shore by hand or a small winch mounted on the boat. Fish that are herded into the codend or "bag" during hauling are sorted and the bycatch of undersized or unwanted fish are released back into the sea. Apart from the purse seining of pilchards and anchovies, haul seines have been the most important fishing method in Victoria's bays and inlets over the past 20 years, and have accounted for 62% of the total commercial catch (MAFRI unpublished).

Expansion of the recreational fishing sector and the gradual improvement of commercial fishing methods in recent years has increased concerns about the level of fishing pressure on fish stocks in Victoria's bays and inlets. It has also exacerbated a range of resource allocation issues. Recreational fishers were concerned that commercial fishing reduced their catches, and that methods of deploying some nets killed large quantities of undersized fish and non-target species and had adverse impacts on important fish habitats (VIFTA 1997; VRFish 1997). Consequently, the Victorian Fishing Tackle Association (VIFTA) and the Victorian Recreational Fishing Peak Body (VRFish) released two submissions calling on the Government to ban netting in bays and inlets. A media release in November 1996 by VRFish contended "that if commercial netting practice is allowed to continue in the inshore areas, major damage will result to the long-term sustainability of the Victorian fishery". They further emphasised that "it is now time to take action on the problem of netting in the inshore areas of Port Phillip Bay and Westernport". Commercial fishers, on the other hand, were concerned about the illegal supply of recreational catch to traditional commercial markets. They were also concerned about reduced access to traditional fishing grounds either by direct presence of recreational fishers, or by regulations introduced to resolve access conflicts (DKO 1997).

Ultimately, the recreational fishers urgently called for a detailed study on the effects of netting and long lining in the bays. This call was supported by the Fisheries Co-management Council and resulted in the Premier's announcement for a review of commercial scalefish fishing methods in Victoria bays and inlets to be undertaken in 1997. The review concluded that there was little evidence that commercial fishing had substantially adverse impacts on habitats and that haul seining had negligible impacts on seagrass. Furthermore, based on studies in other haul seine fisheries, the review found that haul seines had little impact on the mortality of juvenile and non-target fish if good netting practice was followed. Nevertheless, it was recognised that sound management of bays and inlet fisheries resources was hampered by a lack of scientific information on a range of issues.

It was under this scenario that the current project was developed to provide stakeholders with statistically robust and quantitative information on the effects of haul seine fishing in Victoria's bay and inlet fisheries.

4 Need

In recent years, state and commonwealth policies on fisheries management have been developed to ensure fishing activities are being carried out in an ecologically sustainable manner. Strategic assessments of fisheries are underway to determine whether they meet Ecological Sustainable Development (ESD) requirements and this often involves some level of independent onboard monitoring of vessels to record fishing activities and the composition of the retained and discarded catch. Scientists at the recent World Fisheries Congress on developing and sustaining fisheries resources identified reductions of bycatch and discards as one of the top priority methods for increasing global catches. In fisheries around the world, innovative techniques and modifications to fishing gear are being deployed to significantly reduce levels of bycatch. Kennelly (1997) identified important steps in this process that were adopted during the present study including: identification and quantification of retained and discarded catches through a comprehensive observer program; cooperation and collaboration between Industry and scientists to determine and trial various ideas that may solve/alleviate the problem; and finally, publication of the results amongst all stakeholder groups so the improvement of the situation is recognised.

In Victoria, draft fishery management plans for Port Phillip Bay, Corner Inlet and Gippsland Lakes are currently being developed. Common to all these plans are objectives of minimising the bycatch of unwanted fish and damage to fish habitats. In order to meet these ESD objectives, more information was needed on the current fishing gear and practices used by haul seine fishers and their effects on bycatch (juvenile and non-target) and seagrass habitats. Although haul seine fishers have introduced a code of practice to limit fishing pressure and reduce gear impacts on fish and fish habitats, they have not reduced the perceived problems with commercial netting. To address this, the current project was initiated to accurately describe haul seine fishing activities, to quantify bycatch, discarding and mortality levels and to investigate ways of reducing the impact of haul seining on fish and fish habitats. This research supported the initiatives taken by commercial fishers in the implementation of a Code of Practice and provided the sound scientific information required to improve management of the commercial haul seine fishery in bays and inlets.

The design and use of haul seines varies considerably depending on the species targeted and areas fished. In Victoria, they have been loosely categorised into methods described as “beach”, “estuary”, “ringing” and “garfish” seines, but prior to this study, there was no comprehensive and objective description of these net types (netting materials, mesh sizes, warp lengths, float to weight ratios etc) nor of the fishing practices that were associated with them. This was the first aspect of the project that needed to be undertaken before the effects of fishing with these different gears could be analysed.

Having established the characteristics of the different haul seine gears, there was a need to quantify the effect of haul seines on the fish they encountered. Using on-board observers, the species and size composition of commercial haul seine catches were recorded together with information on whether the fish were retained or discarded. Small-mesh surround-nets were deployed around a sub-sample of these shots to determine the net selectivity. Further, sea-cage experiments were undertaken to assess the mortality rate of the discarded fish. Ultimately, these different experiments would provide a good understanding of the fate of all fish that encounter haul seine gear.

Once the impact of the gear on the different fish species was quantified, there was the need to evaluate the potential of new fishing technologies to reduce bycatch and/or improve survival rates of discarded species. The adoption of such "environmentally friendly" technologies has proved very effective in a number of different fisheries. By working closely with the commercial haul seiners and discussing the results of the current study, trials of the most appropriate technologies were undertaken.

Finally, the project needed to publicise the results of the research amongst scientists, commercial fishermen, fishery managers and other stakeholder groups so that the real (rather than perceived) impacts of hauls seines were better understood. In this manner, all stakeholders can work together to ensure that haul seining in Victoria's bays and inlets is an ecologically sustainable method of harvesting fish.

5 Objectives

The final project objectives were:

1. To describe the seine nets, fishing methods and fishing boats used in bays and inlets of Victoria.

2. To assess the effect of haul seine fishing methods on the fish stocks in bays and inlets.

3. To determine the survival of fish captured and released from haul seine nets used in the major Victorian bays and inlets.

These project objectives vary from those in the project proposal that was originally approved. The changes were approved by FRDC and were made after the results of the first phases of the project were reviewed at a workshop. This workshop had the initial aim of identifying ways to modify the gear to reduce bycatch and impact on the habitat.

Several significant points were raised at the workshop. The first was that the selectivity of the nets was generally well suited to the capture of legal sized whiting, the main target species. Second, the nature of the fishing gear and the variety of species present as bycatch meant that modification of the gear to reduce bycatch would not be easy and would require a number of different approaches. Finally, and most significantly, it was contended that most of the fish that are discarded have not been meshed in the net and are alive when released. It was concluded that more benefit could be derived from the project if it investigated the survival of the discarded fish rather than attempting to reduce their capture. The original third objective of the project – "To develop and evaluate appropriate fishing technologies which maximise the fish harvest value and minimise bycatch and habitat impacts" was therefore amended to reflect this change in emphasis.

In addition, the component of the original objective that concerned minimising the habitat impacts, was later dropped. This decision was made following liaison with researchers on similar interstate projects in South Australia and New South Wales. In particular the early results of the New South Wales project examining the impacts of haul seines on seagrass habitats, showed that the impacts were limited. This now completed study (Otway and Macbeth 1999) also demonstrated that the detection of impacts required a more detailed and sophisticated experimental design than was possible within the scope of the current project.

6 Methods

6.1 Objective 1. Describe fishing gear and methods

6.1.1 Regulation of haul seining in Victoria

Haul seining is one of the fish capture methods permitted to holders of Fishery Access Licences in Victoria's bay and inlets. Seine nets are defined in the Victorian Fisheries regulations (1998) as any net that is drawn through the water but does not include a recreational bait net, trawl net, purse seine net or dip net. For reporting of catch and effort data, commercial fishers are asked to use one of five categories for their haul seines (Table 1). These were modified in 1998 from earlier categories that used the terms beach seine, estuary seine, garfish seine and ringing seine. In taking fish using a haul seine, there is a prohibition on dragging or drawing the net on to dry land, or into water less than 60 cm deep.

Table 1. Categories of seine nets used in recording catch and effort data by commercial fishers in Victorian bays and inlets.

Code	Gear	Floating or bottom set	Smallest bunt or bag size (mm)
H2	Bait seine (small mesh)	Floating or bottom set	Less than 30 mm
H3	Haul seine (medium mesh)	Bottom set	30-59 mm
H4	Haul seine (large mesh)	Bottom set	60-100 mm
H5	Garfish seine	Floating	25-29 mm
H6	Ringing seine	Bottom set	25-45 mm

Regulations prohibit the towing of nets in all bays and inlets except Corner Inlet, so a ringing seine of the type used in Corner Inlet cannot legally be used in the same manner in Port Phillip Bay. There is a restriction on the length of rope that can be attached to a haul seine of 300 m for Westernport Bay and of 660 m for a large section of the east side of Port Phillip Bay. In this section of Port Phillip Bay, there is also a requirement that seine nets only be hauled or winched from the beach only. The latter restrictions were implemented because of concern that the haul seine catches of large snapper made in spring in the1950s and 1960s were excessive (S. McCormack personal communication). These catches were achieved by hauling seine nets from a long distance offshore. There are also restrictions on the lengths of nets that can be used in each bay or inlet, restricted fishing seasons in Tamboon Inlet and Lake Tyers, and year-round weekend closures in most waters (Table 2). There is also a range of permanent area closures in Mallacoota Inlet, Lake Tyers, the Gippsland Lakes and Port Phillip Bay, and a seasonal closure (1 October – 31 December) for part of Westernport Bay.

There is a general requirement in the Fisheries Act (1998) that applies to all fishing operations (commercial and recreational), for unwanted fish to be returned to the water with the least possible injury or damage (Section 5.31). Minimum legal sizes are also specified for many species caught in haul seines.

Table 2. Restrictions applied to haul seining in each Victorian bay and inlet.

Waterbody	Maximum no. licences	Maximum length of haul seine (m)	Duration of fishing season	Weekend closure?
Mallacoota Inlet	4	550	All year	No
Tamboon Inlet[1]	1	No limit	2 May-13 Oct	Yes
Lake Tyers	3	366	Wed after Easter - 6 Sept	Yes
Gippsland Lakes	18	732	All year	Yes
Corner Inlet	20	650	All year	Yes
Westernport Bay[2]	53	366	All year	No
Port Phillip Bay[2]	53	460	All year	No

[1] The last Access Licence for the Tamboon Inlet fishery was removed in 2001.
[2] There is no separate Fishery Access Licence for these waterbodies.

In addition to the restrictions imposed by regulation, Industry has developed voluntary Codes of Practice specific to each bay and inlet. For example, in the Gippsland Lakes fishermen have adopted a minimum mesh size ($3^5/_8$ inches) for the bag of haul seines, and all commercial fishing is prohibited in a range of areas near population centres, either permanently or during holiday periods, to reduce conflict with recreational fishers.

6.1.2 Description of fishing gear and methods.

Interviews were conducted with 104 haul seiners who held commercial fishing licences at the early stages of the study. This represented most of the active fishers (out of 187 licensed operators) in Victoria's major bays and inlets: Port Phillip Bay, Corner Inlet, Lakes Entrance and Mallacoota. Since this phase of the project was completed, a voluntary buy-out of commercial fishing licences reduced the number of operators across Victoria to 100 — 96 of which operate in the major bays and inlets.

Early discussions with fishers revealed that a very wide range of nets was being deployed across the various bays and inlets and that the terminology used by fishers to describe their nets was not consistent. It was decided that to properly describe the gear, it would be necessary to classify the various nets based on their mesh characteristics, construction and deployment using a more formal and objective analysis of the data collected.

To this end, detailed information was collected on the vessel (length; type: planing or displacement; horsepower), net (floating or sinking; haul rope length; length, drop, mesh size and mesh type for the wings, shoulders and bunt; sling ratios of the headline and footline) and fishing method (target species; anchor type and position; haul method; haul rate). A copy of the data-sheet used to collect this information is provided in Appendix 13.3.

It should be noted that while this project was targeted at the haul seine fishery, licence holders are able to use other fishing gears to catch fish. At some times of year and in some areas (for example in winter in the Gippsland Lakes) mesh nets are the favoured capture method. The same vessels are generally deployed for all fishing operations and the characteristics of the vessels may reflect this diversity.

6.1.3 Classification of Haul Seine Nets

Using results obtained from the interviews this component of the project aimed to:

- Develop an objective classification of the observed haul seine nets into categories according to their various characteristics and identify the variables most significant in determining category membership.
- Assess strength of associations between these categories and names/locations of the nets.
- Assess strength of associations between categories and target species.

Preliminary analyses and inspection of the interview results indicated the presence of a few extreme observations (evident in the results). They also indicated that some variables did not describe characteristics of nets objectively, or were entirely derived from the combination of other variables. These latter types of variables were excluded from the cluster analysis as using them would give undue weighting to some variables. A preliminary analysis was also undertaken to exclude variables that were highly correlated ($r > 0.8$) with other variables. Rather than excluding correlated variables, it is possible to use principal component analysis but this was not used in the present study because of the mixture of quantitative and qualitative variables involved. After excluding non-independent and correlated variables, the cluster analysis was performed using the 25 variables shown in Table 3. Although some of the variables shown in the table as discrete are actually continuous measurements (e.g. mesh sizes), the fact that the measurements can only take a small number of specific values suggested that they be treated as discrete.

Three cluster methods commonly used to produce classifications were compared: Ward's method, farthest neighbour method, and unweighted pairs method. The data was standardised to give each quantitative variable a mean of zero and standard deviation of one. For all methods there was a mixed dissimilarity coefficient, obtained by taking a weighted average of a normalised Euclidean distance over the quantitative variables and a simple matching coefficient over the categorical variables.

The association between the clusters identified by the classification analysis and the names and locations of the nets were determined by inspection of the dendrograms. Association between the clusters identified in the classification analysis and the target species was examined initially by inspection of contingency tables. This showed such strong associations that further statistical analysis was not warranted.

Table 3. Variables used in cluster analyses and their type.

Variable Name	Variable Type	Description
Float/sink	Discrete	Floating or sinking net
Anchor	Discrete	Boat anchored or not
Haul rope	Continuous	Length of hauling rope used with net
Wingmesh	Discrete	Mesh size of wing of net
Winglength1	Continuous	Length of one wing of net
Winglength2	Continuous	Length of second wing of net
Wingply	Discrete	Ply rating of mesh used in wing of net
Wingmaterial	Discrete	Type of material used in wing of net
Wingstud/float	Continuous	No. of studs between floats on the wings
Wingstud/lead	Continuous	No. of studs between leads on the wings
Shoulmesh	Discrete	Mesh size in shoulder of net
Shoullength1	Continuous	Length of shoulder of net
Shoulply	Discrete	Ply rating of mesh used in shoulder of net
Shoulmaterial	Discrete	Type of material used in shoulder of net
Shoulstud/float	Continuous	No. of studs between floats on the shoulders
Shoulstud/lead	Continuous	No. of studs between leads on the shoulders
Bagmesh	Discrete	Mesh size of bag of net
Baglength	Continuous	Length of bag of net
Bagply	Discrete	Ply rating of mesh used in bag of net
Bagmaterial	Discrete	Type of material used in bag of net
Bagstud/float	Continuous	No. of studs between floats on the bag
Bagstud/lead	Continuous	No. of studs between leads on the bag
Wdropin	Continuous	Height of drop in inches in the wings
Bagdrop	Continuous	Height of drop in the bag
Leadsling	Continuous	Ratio of meshes per stud on the leadline

6.2 Objective 2: Assess the effects of haul seining on fish stocks

6.2.1 Retained and discarded components of the catch

On-board monitoring of commercial haul seine catches was conducted by a scientific observer. The first aspect of bycatch quantification was to design a sampling strategy that adequately represented what was actually being caught by the haul seines. Different methods of estimating the catch weight and length frequency of retained and discarded species were trialed before a final sampling protocol was established.

Initially, extensive sampling of individual catches was conducted in Port Phillip Bay, Corner Inlet and Gippsland Lakes between July and December 1997. Data from these initial samples were used in a power analysis to determine the minimum number and size of “scoops” required to provide a statistically valid sample of the catch. The catch was sampled once the fish had been concentrated or “bagged up” in the codend and before any sorting had occurred.

A dip net was deployed to scoop sub-samples of the fish out of the codend for counting, weighing and measuring. Depending on the size of the catch, a number of scoops of 5 to 10 kg of fish were sampled from the codend. The total weight and number of each fish species and other species groups was recorded for each scoop. Lengths of at least a sub-sample of all fish species in the samples were also recorded.

The statistics used to describe the catch were Shannon Weiner diversity index using numbers and weights of each species, weight and number of each species, proportion of each species by weight and number, number of species, and length frequency of each species. The total length frequency distribution of the catch of each species was simulated from weighted samples. Random sampling from this distribution was simulated.

For each combination of scoop size and number, the mean weighted coefficient of variation (MWCV) was calculated for each statistic to provide a matrix of the number of samples required and the corresponding size of each sample. An example of such a matrix is shown in Table 4. The equations used to determine the MWCV for each statistic are provided below.

$$MWCV\_L = \sum_{C} CV(L_s) * \frac{L_s}{\sum_{S} L}$$

$L =$ Length frequency of species

$$MWCV\_W = \sum_{C} CV(W_s) * \frac{W}{\sum_{S} W_S}$$

$W =$ Weight of species

$$MWCV\_N = \sum_{C} CV(N_s) * \frac{N_s}{\sum_{S} N_S}$$

$N =$ Number of species

$$MWCS\_W = \sum_{C} CV(\omega_s) * \frac{\omega}{\sum_{S} \psi\omega}$$

$\omega =$ Shannon Weiner Index

where: $s =$ Frequency of each species; and
$c =$ Number of simulations.

The MWCV was calculated following 200 simulations of individual catches being sampled using from 1 to 20 scoops of between 5 to 10 kg each. Optimal sample sizes for each simulation were taken at the point at which the change in MWCV was less than 1% for an increase in 1kg of sample size. At this point, larger sample sizes will give only a small increase in precision in the statistic of interest. The outcome of these simulations was that 3 to 5 scoops of at least 8 - 10 kg from each shot were required to achieve a precision level in which all combinations of the MWCV were less than 10% (Table 4). This minimum sampling regime was applied to each shot monitored since January 1998.

Table 4 Mean weighted coefficient of variance (MWCV) of length-frequency for each combination of scoop number and weight. MWCV of less than 10% are highlighted.

Number of Scoops	Weight of scoops (kg)					
	5	6	7	8	9	10
1	39.22	35.60	35.50	28.40	27.66	25.31
2	35.83	29.05	28.30	20.10	19.56	14.70
3	16.39	28.23	14.60	9.90	9.80	9.20
4	10.11	10.10	9.70	9.61	9.50	9.51
5	9.60	9.18	9.80	8.90	8.56	8.50
6	9.61	9.67	8.13	9.60	7.80	7.23
7	9.40	9.06	8.72	8.89	6.90	6.75
8	9.39	9.74	8.10	9.65	9.23	6.36
9	9.44	8.71	8.03	7.55	6.98	6.40
10	8.76	7.15	9.95	5.56	6.29	6.14
11	8.12	12.07	9.11	7.46	6.39	6.34
12	8.13	8.61	6.01	5.46	6.12	6.00
13	8.34	5.25	7.47	7.03	5.88	4.60
14	6.83	7.20	4.26	7.53	5.79	4.79
15	7.55	6.23	6.54	7.27	4.95	4.78
16	7.15	5.16	6.90	6.76	5.88	5.51
17	8.34	7.35	4.44	6.26	3.71	3.40
18	8.60	4.97	4.39	5.38	4.21	3.60
19	7.40	6.64	4.51	4.75	4.05	4.00
20	6.14	5.70	6.40	4.60	4.94	3.56

Data on size frequency and catch rates from the sub-sampled catches were multiplied by a weighting factor before length-frequency data from different shots were combined. The weighting factor was calculated as the ratio of the weight of the retained catch of a species to the weight of that species in the sub-sample. Where weight data were collected on more than one retained species, a combined weighting factor was calculated. The weighting factors for each individual species in the shot were combined as a weighted average, using the total retained catch as the weighting value. Once the weighting factor was calculated for a shot, it was used to scale-up the numbers and weights of all species in that shot. This approach was necessary because no count or measure of all discards was possible without severely disrupting the normal seine operations and increasing the mortality of fish that would otherwise have been quickly discarded.

Although there was some initial sampling in the Gippsland Lakes, the main sampling and survey work was undertaken only in Corner Inlet and Port Phillip Bay. This was to allow more intensive sampling in the latter two locations rather than spread the available field time across a larger number of areas. Early observations suggested substantial similarity between the seining operations in the Gippsland Lakes and Port Phillip Bay although the target species are different. The number of sampling cruises undertaken each month in the different sampling areas is given in Table 5.

Table 5. Number of sampling cruises in Port Phillip Bay, Corner Inlet and Gippsland Lakes by month for 1997 and 1998.

Study Phase	Year & Month	Area		
		Port Phillip Bay	Corner Inlet	Gippsland Lakes
Power analysis samples	1997 July	2		
	Aug			1
	Sept	3		
	Oct	2	1	
	Nov	2	2	1
	Dec	2	2	1
	Sub-total	11	5	3
Main samples	1998 Jan	2	3	
	Feb	4	4	6
	Mar	4	5	
	Apr	5	4	
	May	5	5	
	June	5	5	
	Sub-total	25	26	6

6.2.2 Selectivity of haul seines

In order to appreciate how the selectivity of haul seines was determined, it is necessary to understand the way in which fish are herded and caught by this method. A standard haul seine is a symmetrical net consisting of a loose section of small-mesh netting forming the codend or "bag", with larger mesh wings at either side. Each of the wings is connected to long hauling ropes. One of the haul ropes is anchored in shallow water and taken out perpendicular to the beach. The net is then set parallel to the shore and the other haul rope is taken back into the beach. The ropes are then slowly hauled in evenly (by hand or winch) until the net is in shallow water. Up until this stage, any fish that have been surrounded have simply been herded by the rope and wings into the shallow water, generally without contacting each other or endeavouring to escape through the net. Usually, it is only at the last stage, when the wings are hauled in and the fish become confined to the shoulders and bag, that they attempt to escape through the net; often as a sudden rush of a whole school. Once the fish have been "bagged up" in the shallow water, they are sorted and the unwanted fish are scooped out or allowed to swim over the headline. Any fish that have been meshed in the net are manually removed and either retained or discarded. Ringing seines differ in design and operation (Section 7.1.5) but the catch is handled in the same manner.

To measure the selectivity of the haul seine, a small (12 mm) mesh "surround" net was used to encircle the commercial haul seine before it was tightened up around the enclosed fish. After the commercial net was surrounded, the haul was completed and the captured fish were identified, counted and measured. Similarly, the surround net was then hauled and all fish that had escaped through the meshes of the haul seine were identified, counted and measured.

Some fish are "meshed" as they attempt to escape through the commercial seine. Fish that are entangled in the net in this manner often suffer damage on removal that severely reduces their chances of survival if they are released. The species and size of fish meshed were recorded separately, together with the position (bag or wing) and size of the mesh in which they were entangled.

6.2.3 Bycatch reduction trials using polyethylene mesh

Early in the study, it became clear that one of the important issues for the haul seine fishery was the meshing of undersized King George whiting in the wings of haul seines. Mortality of these fish was apparently quite high. Commercial fishers had recognised this problem and initiated a trial of polyethylene netting as a potential method of reducing the incidence of meshing. Polyethylene netting is stiffer than the nylon netting normally used in haul seines.

To test the effect of the different mesh material, two commercial fishers working fishing grounds in western side of Port Phillip Bay agreed to keep the conventional nylon netting in one wing of their net and to replace the other with polyethylene netting of the same mesh size. Fish meshed in the two wings were then removed and counted separately for each shot by the fishers themselves. When research staff were present, fish from the different wings were measured as well as counted. Apart from the different mesh in one wing, normal fishing practices were adopted.

6.3 Objective 3: Determine the survival of discarded fish

Experiments were conducted to determine the survival of fish that are normally released in commercial seining operations. During these experiments, normal commercial fishing practices were adopted until the fish were "bagged" up next to the boat. During sorting, however, fish that would have been normally discarded were transferred into covered holding cages positioned next to the net or anchored close by.

The cages were 2.4 m long by 0.9 m wide by 1.0 m deep and were made of 30 mm knotless mesh (Figure 1). The net was attached to a rectangular galvanised metal frame with a lid. Weights attached to each bottom corner kept the net in shape and the metal frame was made buoyant by a sealed collar of 90 mm PVC pipe. After the fish had been added, the cages were slowly towed to protected water where they were anchored in water over 2 m deep for up to seven days. This method was adopted because it minimised potential mortalities resulting from handling and transport to land-based storage that would confound estimation of survival rates.

Overall, 15 different survival experiments were conducted in Port Phillip Bay and Corner Inlet. Some used a range of bycatch species, while others examined the survival of discarded

King George whiting. The species and number of fish was recorded as they were transferred into each cage. The number of mortalities was then recorded each day for up to seven days. The length of dead and surviving fish was recorded at the conclusion of the experiment. For some of the later experiments, scale loss on fish that had died was also recorded as an indication of the level of injury sustained.

Experiments conducted in Port Phillip Bay involved 13 species in the first experiment and 14 species in the second experiment (a total of 18 different species). Numbers of individuals per species ranged from 1 to 111. Fish were not fed during these experiments. Two additional experiments were conducted to examine the survival of King George whiting.

Three survival experiments were conducted in Corner Inlet. The first two aimed to examine the survival of King George whiting. The third experiment included King George whiting and four species that are frequently caught and always discarded (ornate cowfish, globefish, barred toadfish and smooth toadfish). Fish were not fed during the first two experiments but in the third experiment, fish were provided with dead pilchards threaded onto wire and suspended inside the cage. The first experiment was terminated prematurely because the large tidal range in Corner Inlet and strong winds at the time of the experiment created highly turbid and shallow water at the anchoring site. The second experiment was run for 7 days with mortalities recorded each day. The third experiment was terminated after 6 days for logistical reasons.

Figure 1. Example of cage used for survival experiments. Lid not shown.

7 Results

7.1 Objective 1: Describe fishing gear and methods

7.1.1 Description of fishing gear

Four main nets described by fishers as ringing, garfish, beach and estuary seines were used in the different bays and inlets (Figure 2). These names are well entrenched in the vernacular of fishermen in the various ports and provided a useful initial classification of the gear. Ringing seines are a modified haul seine used predominantly in Corner Inlet (Figure 3) where large tidal ranges dictate that the nets are usually hauled from within the boat. They are asymmetric with one long and one short wing, and there are rings on the footrope through which a line is passed to bag up the catch.. The lengths of both wings of each seine are reported, but only for ringing seines is there a difference between the two. Garfish seines are a floating net that has small mesh in the wings and codends to target these small, slender, surface-swimming fish. Differences between beach and estuary seines were far less apparent. Our analyses revealed that general names did not necessarily provide useful or accurate categorisation of either net construction or utilisation and this was especially the case for “beach” and “estuary” seine terminology. Discussion with the fishers revealed that it was likely that these names had acquired local meanings that were not necessarily the same as in other areas of the State. This was apparent in the comparisons of the net components of similarly termed gear between the various areas (Figure 4, Figure 5).

Some of the differences between nets may relate to the different regulations in each waterbody. For example, the maximum length of seine nets is 732 m in Gippsland Lakes, 650m in Corner Inlet, 550m in Mallacoota Inlet, 460m in Port Phillip Bay, and 366m in Westernport Bay and Lake Tyers. Maximum net length would explain why beach seines used in the Gippsland Lakes have much longer wings than those used in Port Phillip Bay and Westernport Bay, but not why those used in Corner Inlet are shorter.

Another factor that may be important is the species targeted in each area. For example, the mesh sizes used in the bag, shoulder and wings of beach seines in the Gippsland Lakes are larger than those used elsewhere, but this reflects differences in the species targeted rather than regulation net length. In the Gippsland Lakes, nets termed beach seines are primarily used for targeting larger species (e.g. Australian salmon) for which a larger mesh size is preferable. Among estuary seines, wing length is greatest in Corner Inlet, but the mesh used in the bags is smaller in Corner Inlet than elsewhere. This smaller mesh size is used primarily to target King George whiting, one of the key species in the Corner Inlet fishery. Among garfish seines, those used in the Gippsland Lakes are two to three times as long as those used in Port Phillip Bay and Westernport Bay, which in turn are one and a half to two times as long as those used in Mallacoota Inlet (Figure 10). However, the mesh used is of similar size in each area, as the narrow shape of garfish imposes strict limits on the effective shape of these nets.

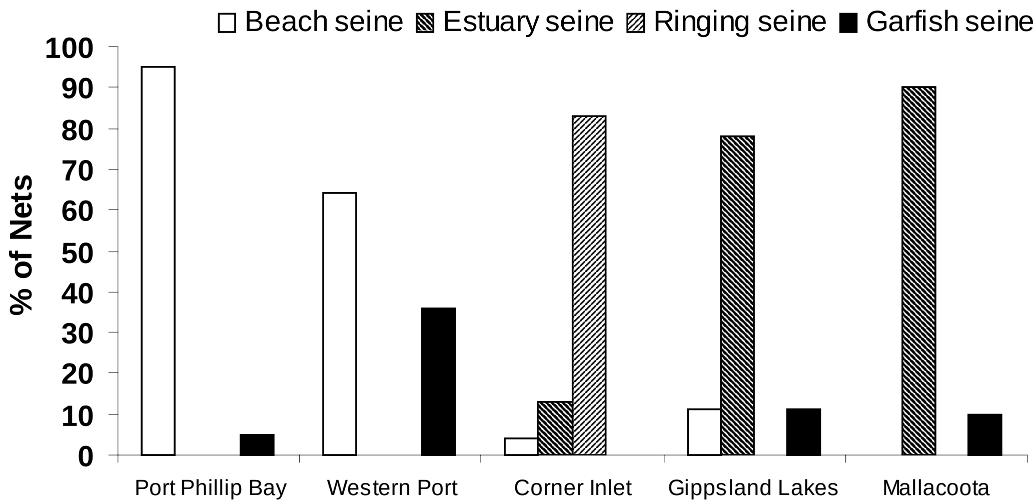

Figure 2. Percentages of different seine nets used in Victorian bays and inlets

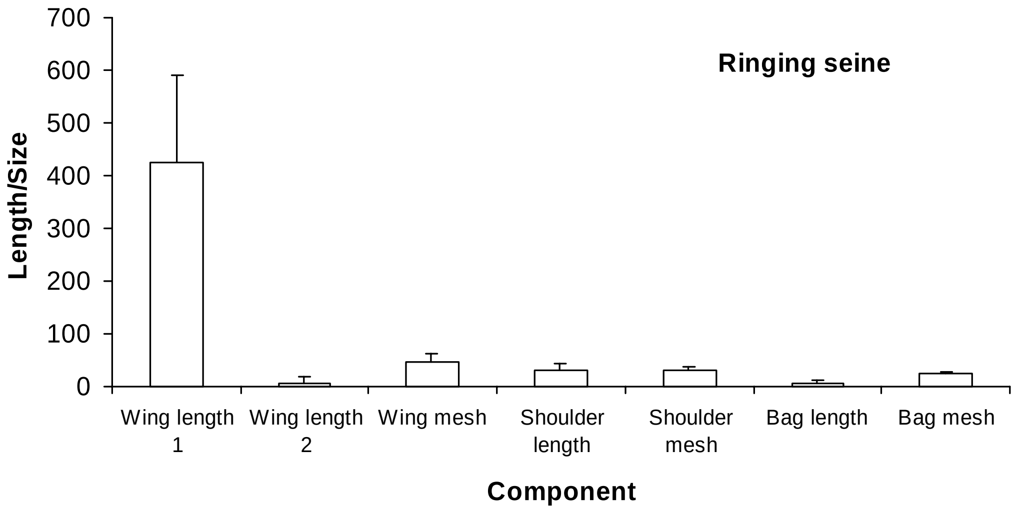

Figure 3. Net component lengths (m) and mesh sizes (mm) for ringing seine nets used predominantly in Corner Inlet. Ringing seines are asymmetric with one wing much longer than the other.

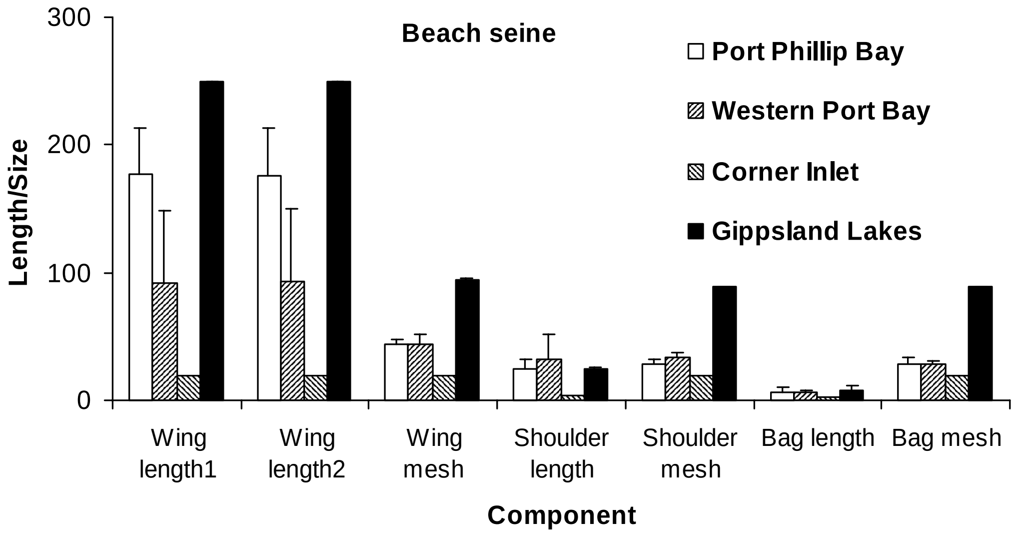

Figure 4. Net component lengths (m) and mesh sizes (mm) for beach seine nets used in different bays and inlets.

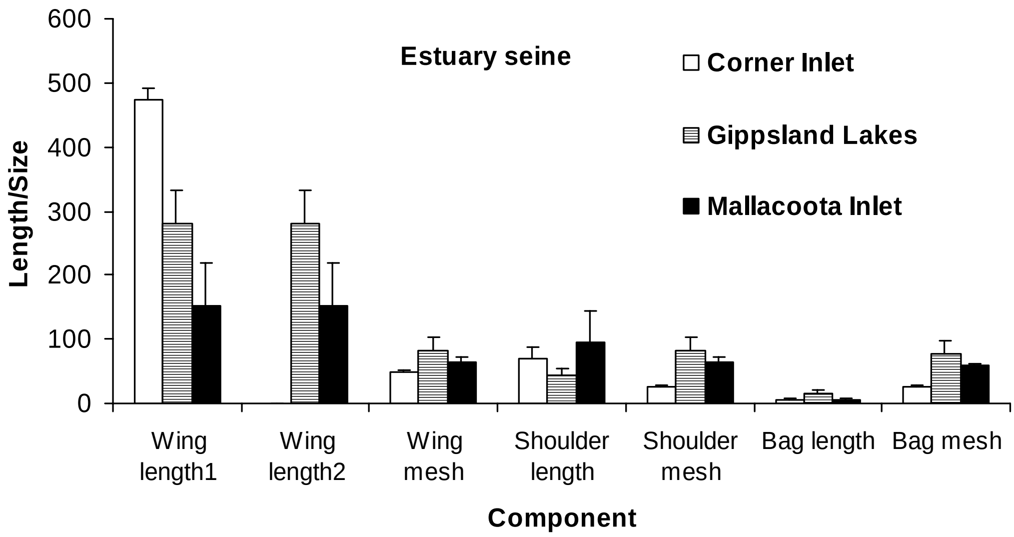

Figure 5. Net component lengths (m) and mesh sizes (mm) for estuary seine nets used in different bays and inlets.

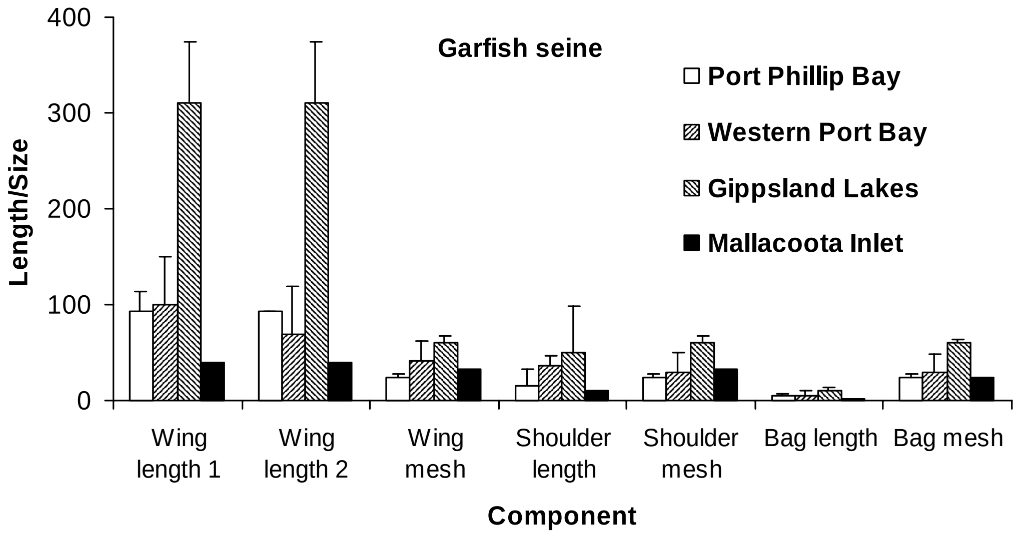

Figure 6. Net component lengths (m) and mesh sizes (mm) for garfish seine nets used in different bays and inlets.

7.1.2 Classification of Haul Seine Nets

Preliminary cluster analyses of data obtained from interviews and the observers identified the presence of a few outlying observations that appeared in separate clusters. In order to identify these points, a search was conducted for very large variations (≥ 4 standard deviations from mean) in any of the continuous variables. These were found for the nets shown in Table 6. They include all observations that appear as outliers in subsequent cluster analysis.

Table 6. Nets and variables identified as having extreme values.

Net	Variable(s)	Values	Standard Deviations from Mean
5	Wingstud/lead	15	4.08
	Shoulstud/lead	15	4.86
23	Wingstud/lead	15	4.08
	Shoulstud/lead	15	4.86
44	Bagstud/lead	12	5.4
91	Length1	0	4.44
94	Wingstud/float	30	5.49

Results of the comparison of the three cluster methods commonly used to produce classifications are given below.

7.1.2.1 Results for Ward's Method.

For this clustering method, a cut value at 4.85 separates the data into three clusters that are described as follows:

Cluster W1: East Gippsland nets called estuary seines

Cluster W2: Central Victorian nets called beach or less commonly garfish seines

Cluster W3: Corner Inlet nets called ringing seines

This classification is quite robust in the sense that moving the cut value by ±0.4 does not affect the clusters. More detailed descriptions of the clusters are shown in Table 7. The full dendrogram for Ward's method is given in Figure 7.

Table 7. Clusters for Ward's method with cut value 4.85

Cluster	Nets	Cluster Value	Name	Location
W1	43, 30, 88, 24, 47, 45, 46, 33, 29, 42, 41, 36, 35, 37, 32, 28, 39, 40, 34	2.428	Estuary seine (17) Beach seine (1) Garfish seine (1)	LE (14) Mallacoota (3) Flinders (1) Sale (1)
W2	93, 87, 86, 25, 15, 14, 52, 51, 63, 50, 102, 27, 26, 67, 57, 53, 85, 31, 101, 73, 69, 66, 68, 65, 82, 70, 83, 58, 75, 74, 77, 72, 71, 76, 64, 84, 81, 80, 56, 60, 49, 1, 94, 90, 89, 48, 38, 103, 100, 92, 96, 104, 97, 91, 44, 79, 78, 62, 61, 55, 54, 59, 99, 98, 95	4.440	Beach seine (48) Garfish seine (12) Estuary seine (3) Ringing seine (2)	PPB (37) WPB (11) LE (5) CI (3) Mallacoota (2) Tamboon Inlet (2) Torquay (2) Jan Juc (1) Pt. Fairy (1) Warrnambool (1)
W3	21, 20, 19, 18, 17, 8, 7, 9, 2, 22, 10, 13, 11, 6, 16, 12, 4, 3, 5, 23	4.144	Ringing seine (17) Estuary seine (3)	CI (20)

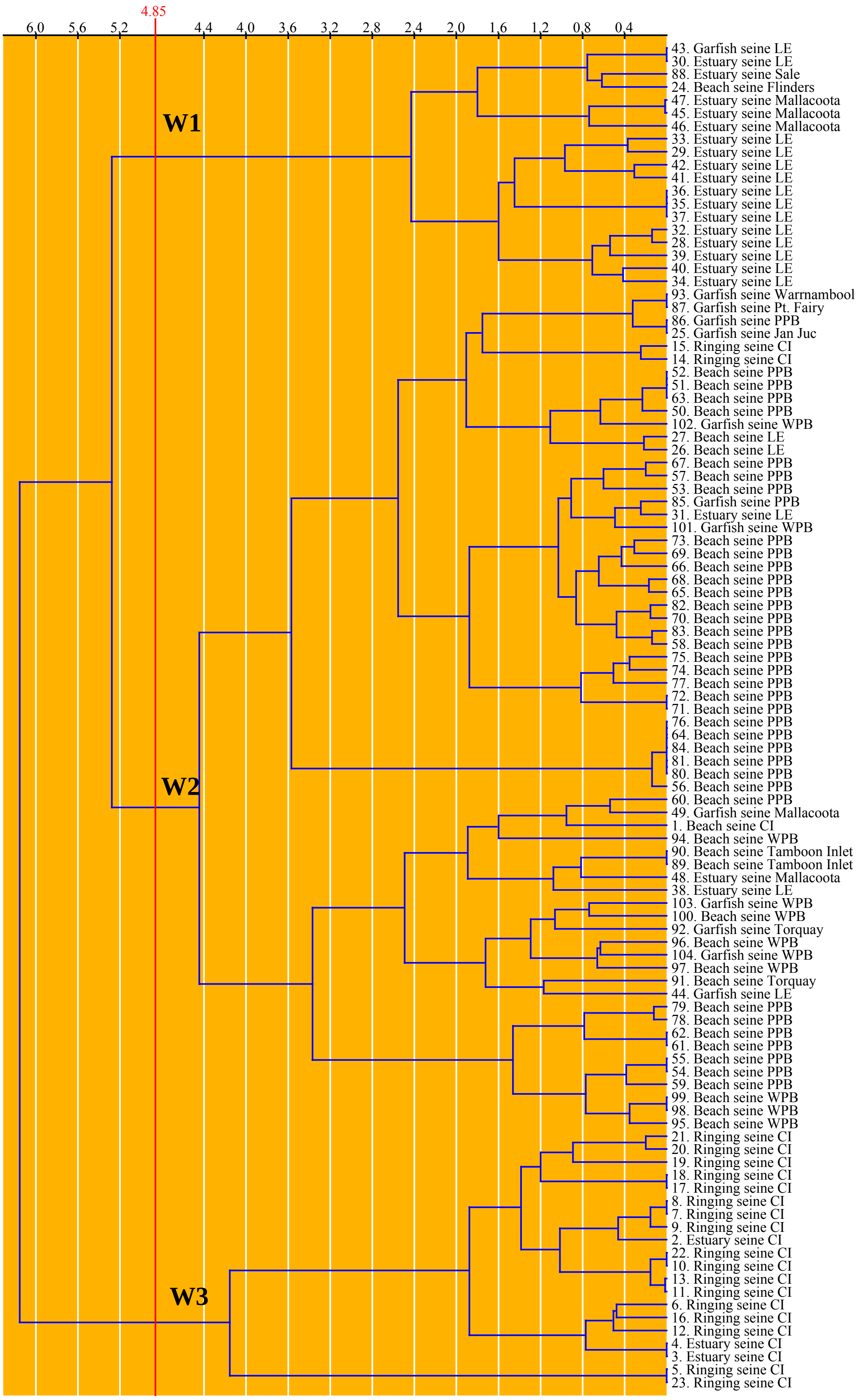

Figure 7. Dendrogram for Ward's method (cut line at 4.85).

7.1.2.2 Results for farthest neighbour method.

For a cut value of 1.4, the farthest neighbour method gives a refinement of the classification given by Ward's method. The East Gippsland estuary seine cluster (W2) is the same. The Corner Inlet ringing seine cluster (W3) is the same, except that a small cluster of outliers has split off. These outliers were identified in earlier analysis. The Central Victorian beach/garfish seine cluster (W2) has split three smaller clusters plus a small cluster of outliers. Again, these outliers were identified in earlier analysis. Table 8 gives more details of this classification and the full dendrogram is shown in Figure 8.

The clusters in this classification may be described as follows:

Cluster F1: Outliers.

Cluster F2: East Gippsland nets called estuary seines.

Cluster F3: Gippsland nets mostly called beach seines.

Cluster F4: Central Victorian nets called beach or less commonly garfish seines.

Cluster F5: Corner Inlet nets called ringing seines.

Cluster F6: Port Phillip and Western Port nets called beach seines.

Cluster F7: Corner Inlet outliers called ringing seines.

The farthest neighbour classification is quite robust in that it persists under movements of ±0.09 in the cut value. Note that the cluster F3 does not have a particularly well defined identity here and the presence of the two outlying clusters makes the classification somewhat less clear than the one given by Ward's method. The preservation of the clusters W1 and W3 shows that these clusters are robust. Cluster F6 appears as a high level sub-cluster of W2, which suggests that W2 is also a robust cluster. Overall, the farthest neighbour clusters compare well with Ward's method.

7.1.2.3 Results for unweighted pairs method.

This method gives unsatisfactory results for these data as any cut value sufficiently low (<1.07) to distinguish the W1 and W3 clusters discussed above, gives rise to four clusters each containing a single outlier and one containing two outliers. Not all of these outliers were identified as such in the previous analyses. For this clustering method, a cut value of 1.03 separates the data into 11 clusters. The details of the classification are given in Table 9 and the full dendrogram is shown in Figure 9.

In spite of the drawback just mentioned, this classification is fairly robust, and distinguishes the clusters W1 ≈ F2 ≈ U3, W3 ≈ F5 ≈ U5 and F3 ≈ U2. The clusters F4 and F6 appear to be combined as U4. Thus, although not convenient to use as a classification, the unweighted pairs analysis gives further supports the clusters distinguished by the previous analyses.

7.1.2.4 Preferred classification.

In view of the foregoing discussion, the unweighted pairs analysis will not be discussed further. The Ward's method analysis was preferred because it was simple, robust and provided logical results, although the sub-clusters of W2 distinguished by the farthest neighbour analysis also seemed reasonably logical. Both classifications were compared in subsequent analyses.

Table 8. Clusters for farthest neighbour method with cut value 1.4.

Cluster	Nets	Cluster Value	Name	Location
F1	91, 44	1.172	Beach seine (1)	LE (1)
			Garfish seine (1)	Torquay (1)
F2	42, 41, 27, 26, 32, 28, 39, 40, 34, 33, 29, 36, 35, 37, 43, 30, 88, 24, 47, 45, 46	1.252	Estuary seine (17)	LE (16)
			Beach seine (3)	Mallacoota (3)
			Garfish seine (1)	Flinders (1)
				Sale (1)
F3	90, 89, 48, 38, 60, 49, 1	1.213	Beach seine (4)	Mallacoota (2)
			Estuary seine (2)	Tamboon Inlet (2)
			Garfish seine (1)	CI (1)
				LE (1)
				PPB (1)
F4	103, 100, 52, 51, 63, 50, 102, 93, 87, 86, 25, 85, 31, 101, 76, 64, 84, 81, 80, 56, 73, 69, 66, 82, 70, 83, 58, 67, 57, 68, 65, 53, 75, 74, 72, 71, 77, 96, 104, 97, 92	1.316	Beach seine (30)	PPB (29)
			Garfish seine (10)	WPB (7)
			Estuary seine (1)	Jan Juc (1)
				LE (1)
				Pt. Fairy (1)
				Torquay (1)
				Warrnambool (1)
F5	6, 16, 4, 3, 12, 15, 14, 8, 7, 9, 2, 22, 10, 13, 11, 18, 17, 21, 20, 19	1.268	Ringing seine (17)	CI (20)
			Estuary seine (3)	
F6	55, 54, 59, 99, 98, 95, 79, 78, 62, 61, 94	1.268	Beach seine (11)	PPB (7)
				WPB (4)
F7	5, 23	0.0	Ringing seine (2)	CI (2)

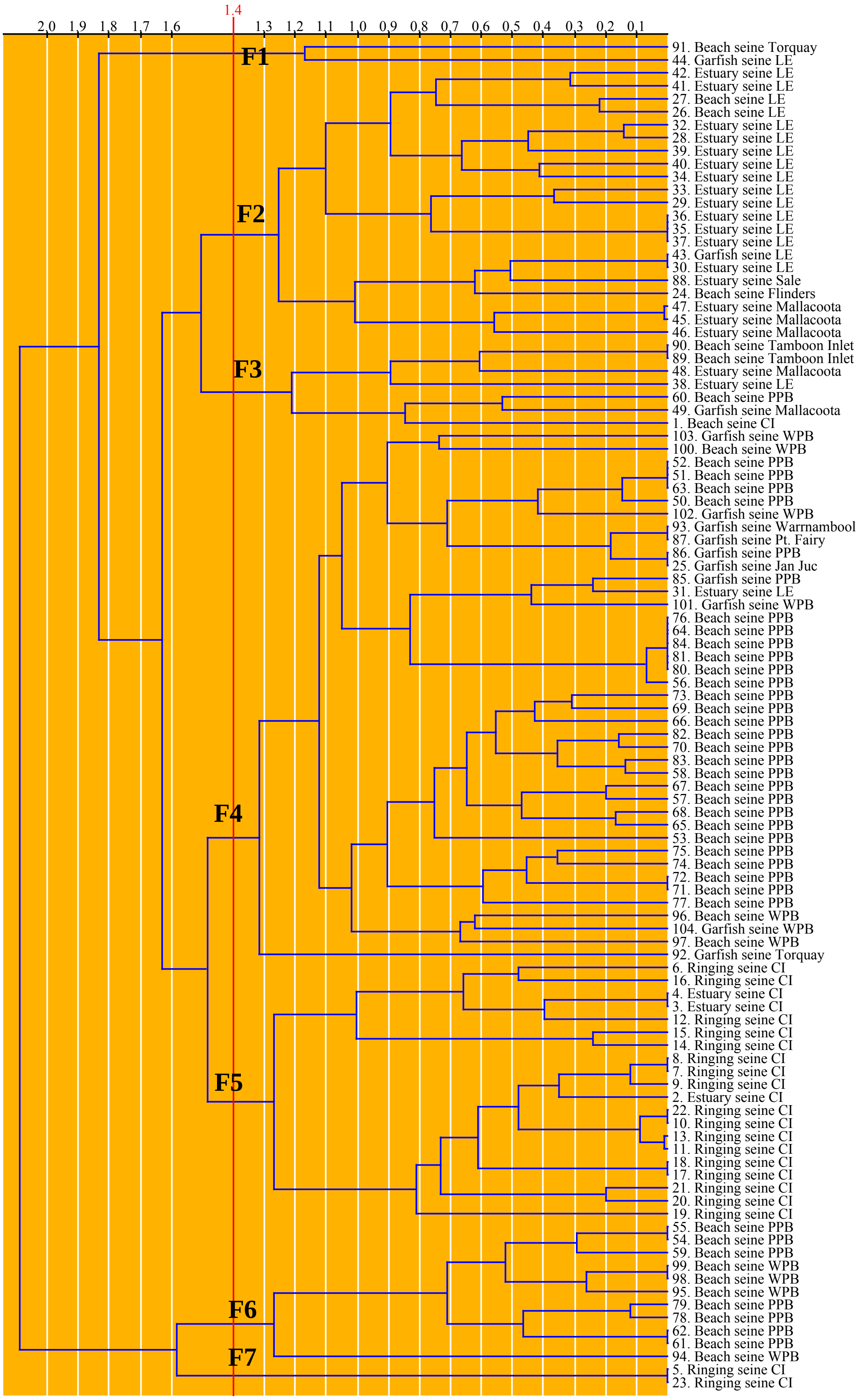

Figure 8. Dendrogram farthest neighbour method (cut line at 1.4).

Table 9. Unweighted pairs method with cut value of 1.03.

Cluster	Data Points	Cluster Value	Names	Locations
U1	5, 23	0.0	Ringing seine (2)	CI (2)
U2	90, 89, 48, 38	0.863	Beach seine (2)	Tamboon Inlet (2)
			Estuary seine (2)	LE (1)
				Mallacoota (1)
U3	33, 29, 36, 35, 37, 42, 41, 32, 28, 39, 40, 34, 27, 26, 43, 30, 88, 24, 47, 45, 46	0.942	Estuary seine (17)	LE (16)
			Beach seine (3)	Mallacoota (3)
			Garfish seine (1)	Flinders (1)
				Sale (1)
U4	96, 104, 97, 101, 52, 51, 63, 50, 102, 93, 87, 86, 25, 60, 49, 82, 70, 83, 58, 73, 69, 66, 85, 31, 68, 65, 67, 57, 53, 75, 74, 72, 71, 77, 76, 64, 84, 81, 80, 56, 79, 78, 62, 61, 55, 54, 59, 99, 98, 95	0.954	Beach seine (40)	PPB (37)
			Garfish seine (9)	WPB (8)
			Estuary seine (1)	Jan Juc (1)
				LE (1)
				Mallacoota (1)
				Pt. Fairy (1)
				Warrnambool (1)
U5	8, 7, 9, 2, 22, 10, 13, 11, 18, 17, 21, 20, 6, 16, 4, 3, 12, 19	0.869	Ringing seine (15)	CI (18)
			Estuary seine (3)	
U6	15, 14	0.2419	Ringing seine (2)	CI (2)
U7	103, 100, 92	0.9779	Garfish seine (2)	WPB (2)
			Beach seine (1)	Torquay (1)
U8	91	na	Beach seine (1)	Torquay (1)
U9	44	na	Garfish seine (1)	LE (1)
U10	1	na	Beach seine (1)	CI (1)
U11	94	na	Beach seine (1)	WPB (1)

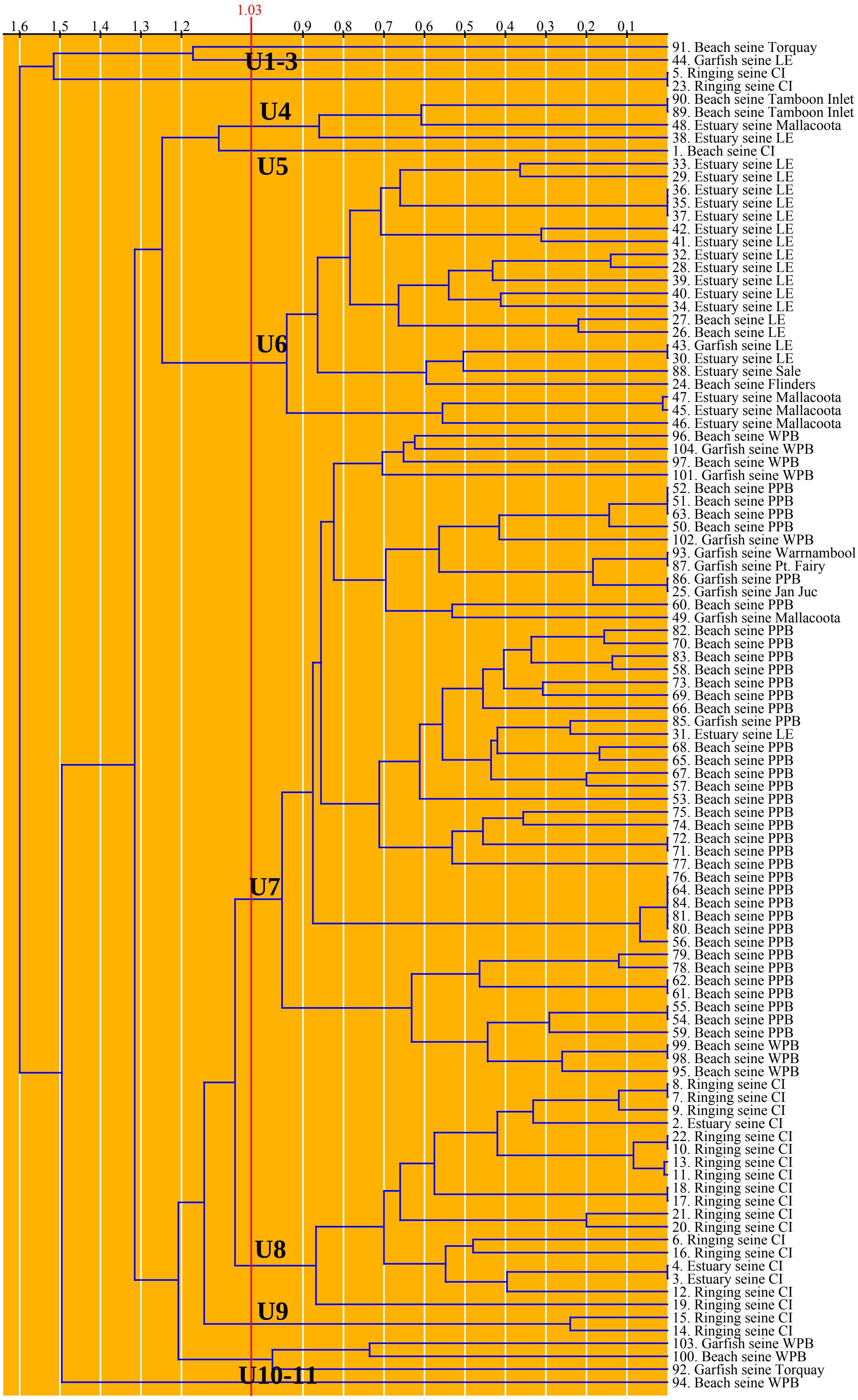

Figure 9. Dendrogram for unweighted pairs method (cut value of 1.03).

7.1.3 Association between classification and target species.

The following contingency tables demonstrate very strong association between the clusters defined by Ward's method (Tables 10 to 14) and the farthest neighbour method (Tables 15 to 19) and the target species. The associations were so clear that further statistical measures were unwarranted.

Table 10. Contingency table of target species by net type for Ward's method classification for the primary target species.

	Bream	Garfish	Mullet	Whiting	Other	Totals
W1	16	0	0	0	3	19
W2	4	14	4	38	5	65
W3	0	1	0	16	3	20
Totals	20	15	4	54	11	104

Table 11. Contingency table of target species by net type for Ward's method classification for the secondary target species.

	Flounder	Garfish	Mullet	Snapper	Squid	Whiting	Other	Totals
W1	0	0	7	0	0	0	6	13
W2	9	3	6	5	16	4	8	51
W3	1	12	0	0	2	3	1	19
Totals	10	15	13	5	18	7	15	83

Table 12. Contingency table of target species by net type for Ward's method classification for other target species.

	Flounder	Squid	Trevally	Other	Totals
W1	0	0	9	1	10
W2	1	10	5	6	22
W3	7	0	0	2	9
Totals	8	10	14	9	41

Table 13. Aggregated contingency table for of target species by net type for Ward's method classification variables SP1, SP2 and SP3

Cluster	Bream	Flounder	Garfish	Mullet	Snapper	Squid	Trevally	Whiting	Other	Total
W1	17	0	0	7	0	0	11	0	7	42
W2	4	10	18	11	5	26	7	42	15	138
W3	0	10	14	0	0	2	0	19	3	48
Total	21	20	32	18	5	28	18	61	25	228

Table 14. Summary of target species for net types classified by the Ward's method.

Cluster	Primary Target	Other Major Targets
W1	Bream	Trevally, Mullet
W2	Whiting	Squid, Garfish, Mullet, Flounder, Trevally
W3	Whiting	Garfish, Flounder

Table 15. Contingency table of target species by net type for farthest neighbour method classification for variable SP1.

Cluster	Bream	Garfish	Mullet	Whiting	Other	Totals
F1	0	1	0	0	1	2
F2	18	0	0	0	3	21
F3	2	1	4	0	0	7
F4	0	12	0	28	1	41
F5	0	1	0	16	3	20
F6	0	0	0	8	3	11
F7	0	0	0	2	0	2
Totals	20	15	4	54	11	104

Table 16. Contingency table of target species by net type for farthest neighbour method classification for variable SP2.

Cluster	Flounder	Garfish	Luderick	Mullet	Snapper	Squid	Whiting	Other	Totals
F1	0	0	0	1	0	0	0	0	1
F2	0	0	4	9	0	0	0	2	15
F3	0	0	0	1	0	0	0	5	6
F4	7	0	0	0	3	13	3	3	29
F5	1	12	0	2	0	0	3	1	19
F6	2	3	0	0	2	3	1	0	11
F7	0	0	0	0	0	2	0	0	2
Totals	10	15	4	13	5	18	7	11	83

Table 17. Contingency table of target species by net type for farthest neighbour method classification for variable SP3.

Cluster	Flounder	Squid	Trevally	Other	Totals
F1	0	0	0	1	1
F2	0	0	11	1	12
F3	0	0	3	1	4
F4	0	8	0	4	12
F5	6	0	0	2	8
F6	0	2	0	0	2
F7	2	0	0	0	2
Totals	8	10	14	9	41

Table 18. Aggregated contingency table of target species by net type for farthest neighbour method classification for variables SP1, SP2 and SP3.

Cluster	Bream	Flounder	Garfish	Mullet	Snapper	Squid	Trevally	Whiting	Other	Total
F1	0	0	2	1	0	0	0	0	1	4
F2	19	0	0	9	0	0	13	0	7	48
F3	2	0	1	6	0	0	4	0	4	17
F4	0	7	12	0	3	21	1	31	7	82
F5	0	9	14	2	0	0	0	19	3	47
F6	0	2	3	0	2	5	0	9	3	24
F7	0	2	0	0	0	2	0	2	0	6
Total	21	20	32	18	5	28	18	61	25	228

Table 19. Summary of target species for net types classified by the farthest neighbour method.

Cluster	Primary Target	Other Major Targets
F1	Garfish	Mullet
F2	Bream	Trevally, Mullet
F3	Mullet	Trevally
F4	Whiting	Squid, Garfish , Flounder
F5	Whiting	Garfish, Flounder
F6	Whiting	Squid
F7	Whiting	Flounder, Squid

7.1.4 Characteristics of categories

Inspection of the summary statistics shown in Appendix 13.5 suggests particularly noticeable features of the nets in the various categories which have been summarised in the following tables for Ward's (Table 20) and farthest neighbour methods (Table 21). Very pronounced modal values for discrete variables taking numeric values are shown. Variables for which differences are not striking have been omitted.

Table 20. Results of Ward's method classification of haul seine nets.

Variable	W1	W2	W3
Float/sink	Sinking	Varies	Sinking
Anchor	Beach	Most Beach	One end
Wingmesh	Mode = 89	Mode = 45	Mode = 51
Wingply	Most ≥18	Most ≤ 18	All ≤ 12
Materials*	Most Poly	Most Nylon	Varies
Shoulmesh	Most ≥ 70	Mostly ≤ 38	Mode = 29
Shoulply	Most ≥ 18	Mode = 12	Mode = 9
Bagmesh	Most ≥ 64	Most ≤ 32	All ≤ 32
Bagply	Mode = 24	Mode = 18	Mode = 9
Haul rope	Range = (80, 600)	Range = (0, 1000)	All 0
Winglength1	Range = (110, 320)	Range = (10, 320)	Range = (250, 580)
Winglength2	Range = (110, 320)	Range = (0, 320)	All 0
Wingstud/float	Mean = 4.95	Mean = 7.44	Mean = 10
Shoullength1	Mean = 63.16	Mean = 23.66	Mean = 39.4
Baglength	Mean = 14.21	Mean = 6.78	Mean = 5.63

* Includes variables Wingmaterial, Shoulmaterial, Bagmaterial.

Table 21. Results of farthest neighbour method classification of haul seine nets. The outlying clusters F1 and F7 have been omitted. Numbers in square brackets indicate ranges for continuous variables.

Variable	F2	F3	F4	F5	F6
Float/sink	Sinking	Most Sinking	Varies	Sinking	Sinking
Anchor	Beach	Most Beach	Beach	One end	Beach
Wingmesh	Mode = 89	-	Mode = 45	Mode = 51	Mode = 45
Wingply	Most 9 or 12	Most 18 or 24	Most 9 or 12	Mode = 9	Mode = 9
Materials*	Most Poly	Most Nylon	Most Nylon	Varies	Most Nylon
Shoulmesh	Most ≥ 57	Varies	All ≤ 32	Most ≤ 32	Most ≤ 32
Shoulply	Varies	All ≤ 25	Most 12 0r 18	All ≤ 12	Mode = 12
Bagmesh	Most ≥ 57	Varies	All ≤ 45	All ≤ 32	All ≤ 32
Bagply	Most ≥ 24	Varies	Most ≤ 18	Mode = 12	Most ≤ 18
Haul rope	(80, 600)	(0,700)	(0, 800)	All 0	(300, 1000)
Winglength1	(110, 320)	(20, 250)	(20, 200)	(40, 580)	(12, 220)
Winglength2	(110, 320)	(20, 250)	(20, 200)	(0, 50)	(12, 220)
Wingstud/float	Mean = 5.05	Mean = 7.0	Mean = 6.12	Mean = 2.55	Mean = 6.0
Shoullength1	Mean = 59.38	Mean = 18.14	Mean = 24.12	Mean = 37.2	Mean =27.91
Baglength	Mean = 13.62	Mean = 6.14	Mean = 6.87	Mean = 5.02	Mean = 2.45

* Includes variables Wingmaterial, Shoulmaterial, Bagmaterial.

7.1.5 Characteristics of vessels

Planing vessels are the favoured type of hull in all areas except the Gippsland Lakes (Figure 10). They outnumber displacement hulls by a factor of six in Port Phillip Bay, and are at least twice as common in other waterbodies. Most vessels were 6-7.9 m in length in all the larger bays and inlets (Figure 11). In other waterbodies, vessels of less than 6 m were the most common, and were almost as common as the larger vessels in Port Phillip Bay. The narrowest size range of vessels was found in the Gippsland Lakes. Motors of less than 50 hp are more common than other categories in Corner Inlet and the Gippsland Lakes (Figure 12). In Port Phillip Bay, motors of this size and of 50-99 hp are equally common. In Westernport Bay, motors of 100-149 hp predominated. There was no relationship between the size of vessel and the horsepower of the motor use to power it (Figure 13). These figures exclude eight vessels for which data on motors were not obtained, and five vessels which were rowed when setting nets.

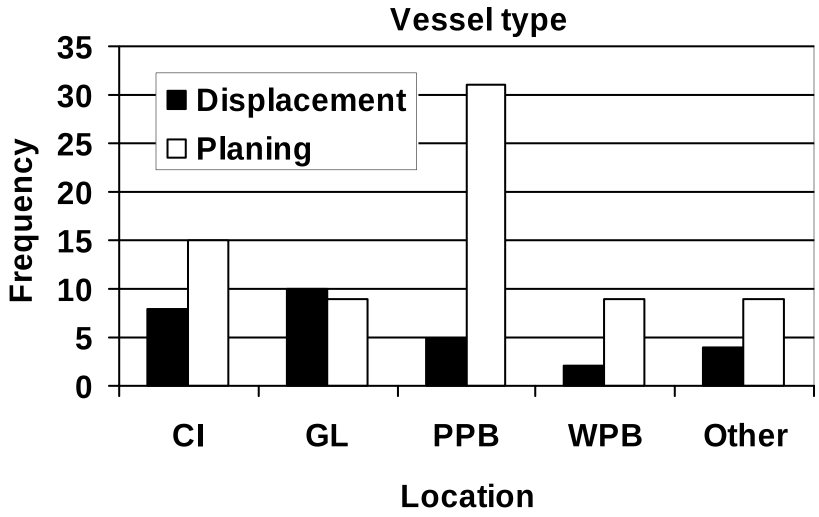

Figure 10. Number of planing and displacement types of hull used by haul seine fishers, by location. CI Corner Inlet, GL Gippsland Lakes, PPB Port Phillip Bay, WPB Westernport Bay.

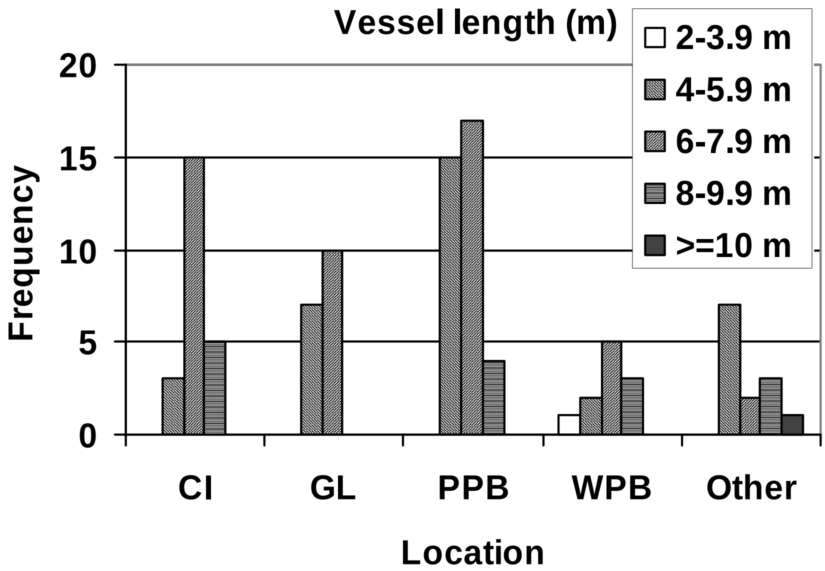

Figure 11. Length of vessels used by haul seine fishers, by location. CI Corner Inlet, GL Gippsland Lakes, PPB Port Phillip Bay, WPB Westernport Bay.

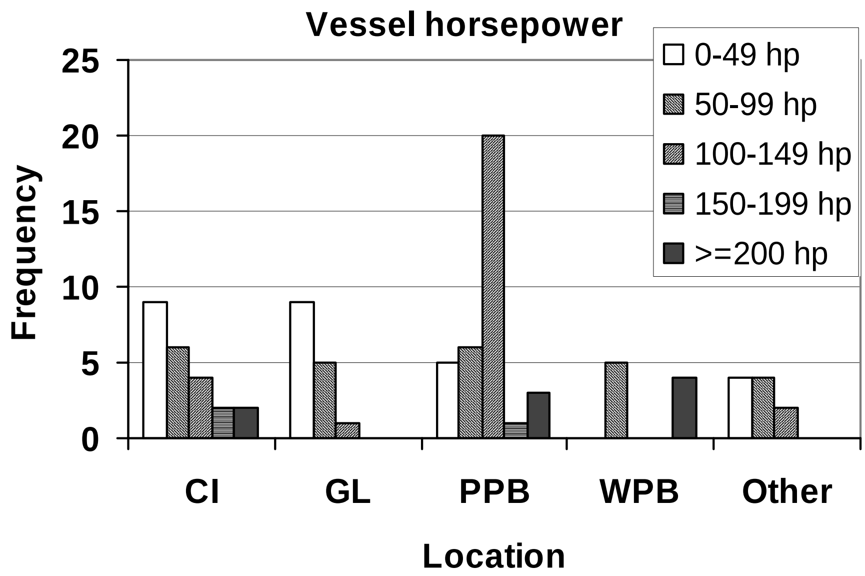

Figure 12. Horsepower of motors used to power vessels used by haul seine fishers, by location. CI Corner Inlet, GL Gippsland Lakes, PPB Port Phillip Bay, WPB Westernport Bay.

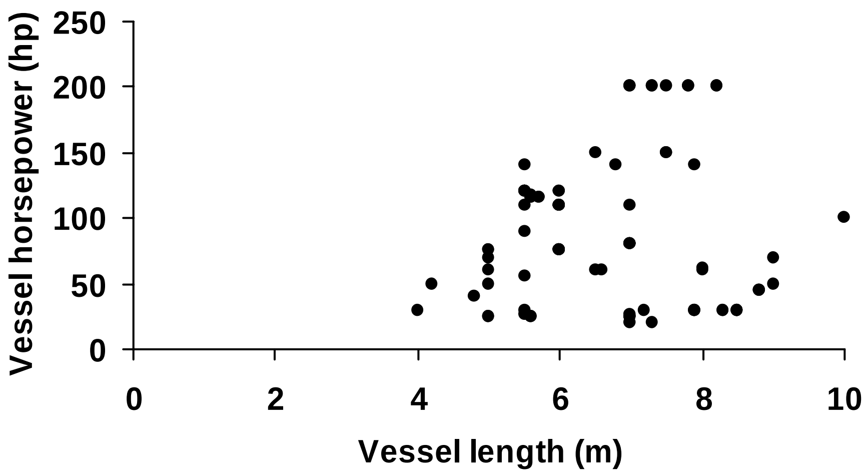

Figure 13. Scatter plot of power of motor on a vessel and its length for vessels used in haul seine fishery.

7.1.6 Methods of operation of haul seines

The haul seines used in Victoria's bays and inlets can be characterised as an active fishing gear. The nets (except for garfish seines) are usually negatively buoyant and they can only be successfully operated in areas that are free of obstructions. They operate by encircling fish and slowly crowding them together, finally trapping them in the bag or cod-end. Total time from the setting of the net to final closure of the net is usually less than 2 hours. The reported duration of shots is 1-4 h (Figure 14); longer haul times usually indicated the occasional need to change the direction of haul to avoid underwater obstacles. The distances over which the seines were towed depended on the length of rope attached, the type of net, the physical features of each waterbody, and the expected location of the targeted fish. The distance towed was normally less than 1 kilometre. The slow haul speeds meant that fish were not forced to swim at speed before capture and the nets did not rely on fish becoming exhausted or overtaken by the net, as is the case for other active methods such as otter trawls. The shallow depths from which fish were caught (less than 15m) meant that captured fish are also not subject to the large temperature and pressure changes that occur with offshore trawl fishing.

As well as being constructed differently, the ringing nets used by fishers in Corner Inlet were generally operated in a very different manner than the haul seines used in Port Phillip Bay. The following descriptions do not apply to all nets used in each area, but are generally typical of the fishing operations employed.

Corner Inlet ringing seines are asymmetrical, with one long wing (average 425 m) and one much shorter wing (average 5 m). They are operated from a single vessel, with two crew. To deploy a ringing seine, the fisher drops the end of the large wing at the point at which he intends to complete hauling. The net is then shot in a large arc, partially enclosing the area to be fished. The net is closed by towing the short wing, attached to the vessel, back to where the shot was started. Towing speed is slow; generally less than 2 knots. The longer wing is then picked up by the boat, which then drops anchors from the side of the vessel, away from the net. The long wing of the net is hauled in by hand until the two wings are of approximately equal length, at which point the lead-lines of both nets are brought together, closing up the base of the net like a purse seine. Both wings are manually hauled into the boat until the bag is brought alongside the vessel. At this stage the float line is raised above the water and held off the vessel by two wing poles, effectively providing a relatively large net cage in which the fish are still able to swim freely. Fish are then dip-netted by hand from this enclosure, the unwanted species being released quickly to the water outside the net and the marketable species being placed in bins on board. The first fish to be released are usually the globefish, which inflate their bodies and float on the surface. The cod end is pulled in progressively as the density of fish within it is reduced. All sorting is done from within the boat, which must remain in sufficient depth of water to allow it to operate its outboard motors. This also has the effect of ensuring that the fish are sorted in a depth of water that prevents excessive crowding of the catch.

Haul seines used in Port Phillip Bay are deployed in a more conventional manner. Two vessels are used with one crew in each. A shot commences 200-300m offshore from the point at which the haul is to be completed. One end of the net is held in one vessel, which is anchored, while the net is shot by the other in a semi-circle. Both vessels then deploy up to 300-600m of hauling rope attached to the net as they move closer to shore and closer together. The vessels then anchor and together begin to haul the net using small motors with an attached pulley that the hauling rope is wound around. These motors haul the net at approximately 0.5 m/sec. If the vessels are still too far offshore when all of the rope is retrieved, (the net was initially set more than about 300m offshore), the vessels will redeploy the rope and move further inshore before again anchoring and recommencing hauling. The vessels may move and anchor two or three times during the hauling operation to bring them closer to shore and closer together. Once all the hauling rope has been retrieved and the vessels are in shallow enough water for the fishers to stand, the wings are hauled by hand. When the cod-end is reached, the lead-line is brought up and attached to the sides of the vessel. The float-line is held up by hand and the catch is sorted. This is undertaken by one or more of the fishers standing in the water (wearing waders), and fish are passed to another crew member who remains onboard and sorts the retained catch into fish bins.

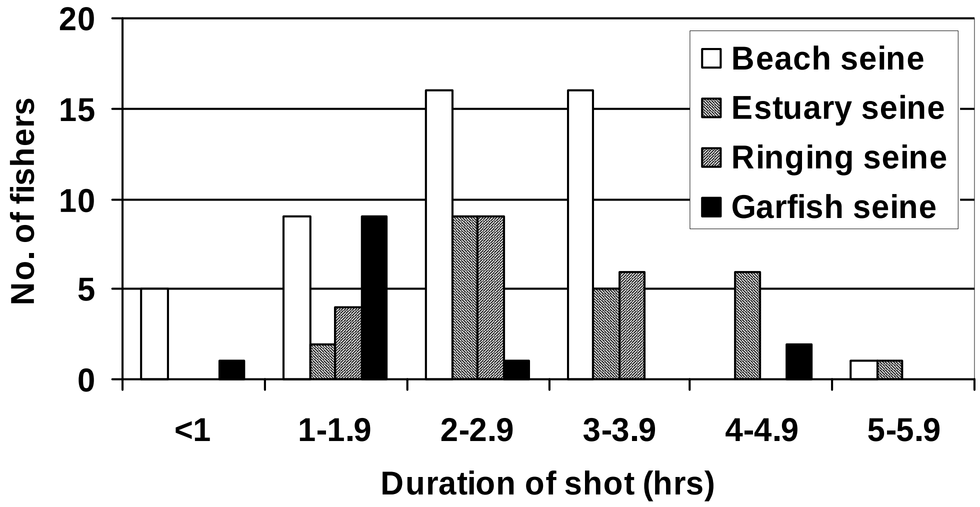

Figure 14. Reported average duration of shots (from beginning of the set of a net to the completion of the sorting of the catch) by net type.

An important feature of both types of operations is that the nets are hauled at low speeds relative to other active gear such as otter trawls. The slow speed at which the seines are hauled means that fish can generally swim to the front of the net and remain relatively unstressed and in good condition until they enter the codend. The net does not rely on pursuing fish until they are exhausted and fall back into the cod-end. Escape responses are not generally observed from many fish until most of the net has been retrieved. Even small fish such as sprats and anchovy, which could easily pass through the mesh, remain within the wings until the net is almost fully retrieved. The differences between net types are at least partly the result of differences in the regulations that apply to fishing in the different waters as described earlier (Section 6.1.1).

7.2 Objective 2: Assess the effect of haul seining on fish stocks

The size and species composition of samples of the unsorted catch were recorded for 37 shots by 4 different fishers in Corner Inlet and 43 shots by 6 different fishers in Port Phillip Bay between 17 July 1997 and 16 October 1998. Fifty three taxa were recorded, of which 28 (53%) were of some commercial value and the remainder (47%) were discarded. Only six taxa (King George whiting, globefish, smooth toadfish, prickly toadfish, leatherjackets, and greenback flounder) were recorded in more than 50% of shots, and 31 taxa were recorded in less than 10% of shots (Figure 15).

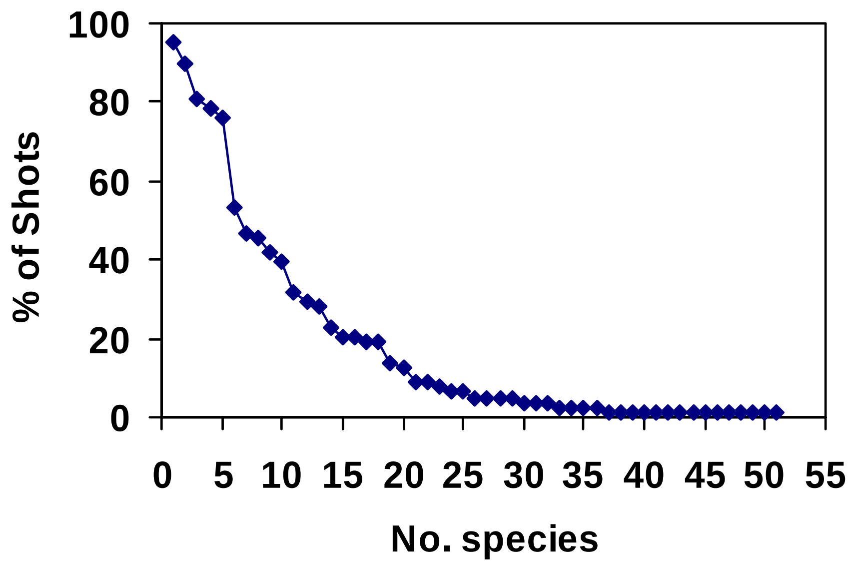

Figure 15. Percentage of shots in which a total number of species were recorded, for Port Phillip Bay and Corner Inlet combined.

7.2.1 Retained and discarded components of the catch

From the 43 haul seine shots monitored in Port Phillip Bay, the retained catch averaged 38% of the numbers of fish caught and 32% of the total weight (Figure 16, Table 22). Of the discarded portion of the catch, approximately 23% by number, and 18% by weight were species of commercial value that were undersized. The lower retained proportion by weight predominantly reflects the discarding of a few very large rays, which elevated the weight of the discarded component.

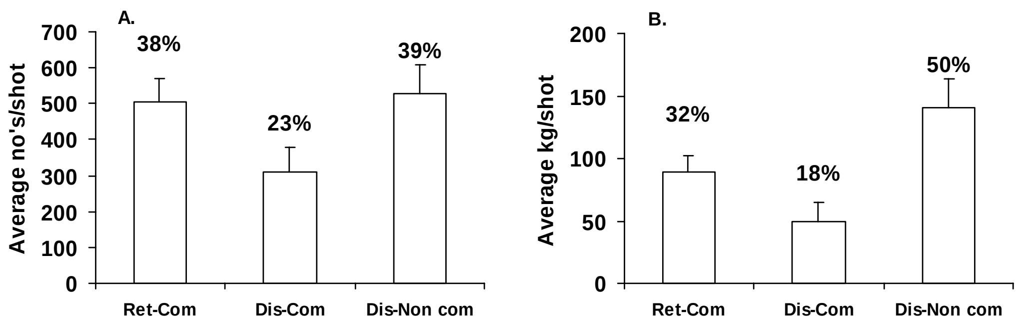

Figure 16. Average numbers (A.) and weights (B.) per shot (and standard error) of commercial species that are retained (Ret-Com), commercial species that are discarded (Disc-Com), and non-commercial species that are discarded (Disc-Non Com), from measured shots in Port Phillip Bay.

In Port Phillip Bay, average catch rates (by number) for King George Whiting were highest of all species and most were retained (Figure 17). Discarding was highest for smooth toadfish, but large numbers (averaging over 100/shot) of globefish, snapper and King George whiting were discarded. Discards of the latter two species were of fish under the legal minimum length (LML). The spider crab was a common non-commercial crustacean observed in the catches. This species often became entangled in the wings of the nets, and can be injured or killed during attempts to remove them. Catch rates (by weight) were highest for common stingarees, which were caught less frequently than other species but because of their large size, produced a large average weight per shot (Figure 18). King George whiting, snapper and globefish recorded average catch rates of over 40 kg/shot.

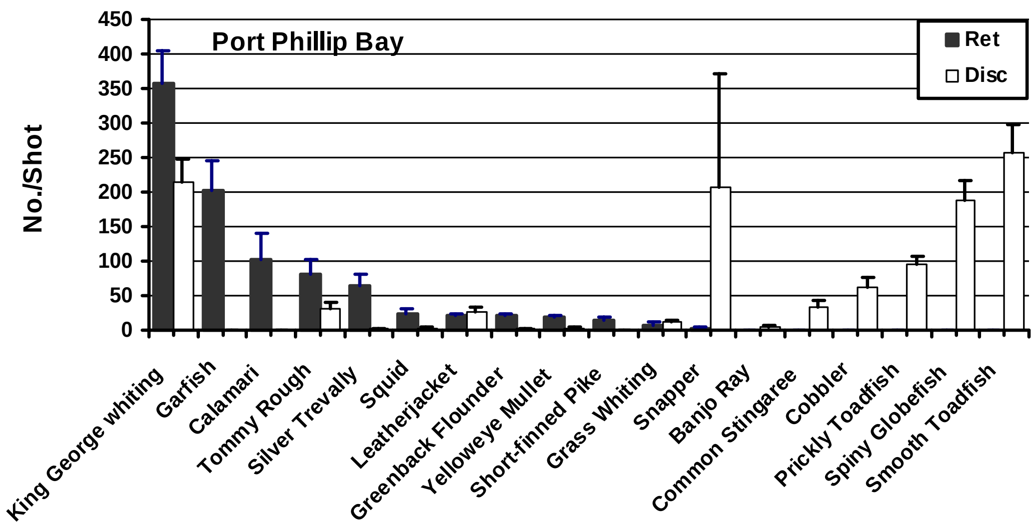

Figure 17. Average (and standard error) number of fish retained and discarded per shot from haul seines in Port Phillip Bay, in order of decreasing numbers retained. Data are presented for species recorded in at least five shots.

Table 22. Total numbers and weights of each taxon that were retained and discarded for all shots monitored in Corner Inlet (n=37) and Port Phillip Bay (n=43).

Taxon name	Corner Inlet				Port Phillip Bay			
	Retained		Discarded		Retained		Discarded	
	Number	Wt (kg)	Number	Wt (kg)	Number	Wt (kg)	Number	Wt (kg)
Algae				135				1492
Ascidians						2		1
Barracouta					51	14		
Bream, black							4	
Calamari, southern	6	1	14	1	926	125		
Cobbler			918	30			1615	298
Cowfish			369	21			1	
Crab, blue swimmer							15	1
Crab, other/unspec.			14	2			32	6
Cuttlefish							30	2
Flathead, rock	252	48	47	5	11	2		
Flathead, sand					18	7	284	1
Flathead, yank	145	35			24	12		
Flounder, greenback	833	232	75	11	271	50	24	2
Garfish, southern sea	3628	285			1614	153		
Globefish, spiny			6235	1946			7164	1838
Gurnard, unspec.							11	1
Jellyfish, unspec.			56	33			17	48
Leatherjacket, unspec.	636	131	11862	219	723	265	889	66
Luderick			1					
Mackerel, unspec.	97	26	23	9				
Morwong, dusky					8	3	71	12
Mullet, red					11	2		
Mullet, yelloweye	351	67	49	10	189	37	33	2
Old wife			40	3				
Pike, short-finned	88	21	113	20	105	39	2	1
Ray, banjo			23	45			29	68
Rough, tommy	325	27			2170	192	817	63
Shark, angel							1	2
Snapper					34	86	2082	502
Squid, red arrow	153	133	58	4	441	114	52	11
Stingaree, common			105	104			233	621
Stingaree, sparsely-spotted			40	58			77	32
Stingray, black			1	4			46	632
Tailor			106	4				
Teleost, unspec.							41	8
Toadfish, smooth			4997	282			8718	637
Toadfish, unspec.			5191	988			3568	718
Trevally, silver	248	40	1946	141	316	83	13	1
Weedfish, unspec.							72	4
Whiting, grass	711	137	250	12	49	9	71	7
Whiting, King George	4770	895	3232	293	14686	2649	8800	799
Totals	12243	2078	35768	4379	21647	3844	34812	7876

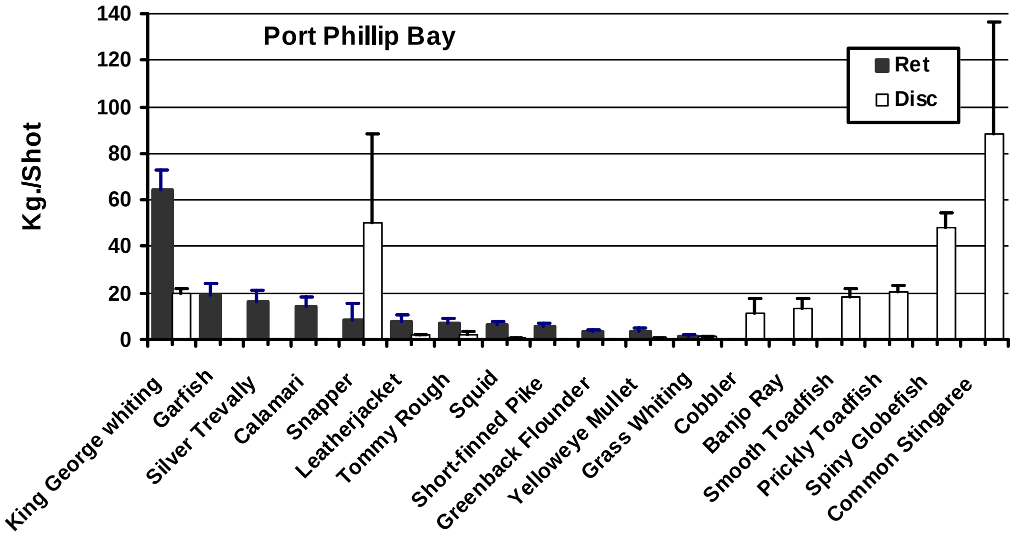

Figure 18. Average (and standard error) weight of fish retained and discarded per shot from haul seines in Port Phillip Bay, in order of decreasing weights retained. Data are presented for species recorded in at least five shots.

Length-frequency distributions were plotted for species for which at least 50 fish were measured (Figure 19). The difference between the length distributions of retained and discarded fish, demonstrated that only the larger leatherjackets, snapper and King George whiting were retained. For King George whiting and snapper, the LML (27 cm) marks the size below which most fish were discarded, whereas some of the largest leatherjackets were sometimes discarded. For tommy rough, however, there was little difference in the length-frequency distribution of retained and discarded fish, indicating that factors other than size determined whether this species was retained or discarded.

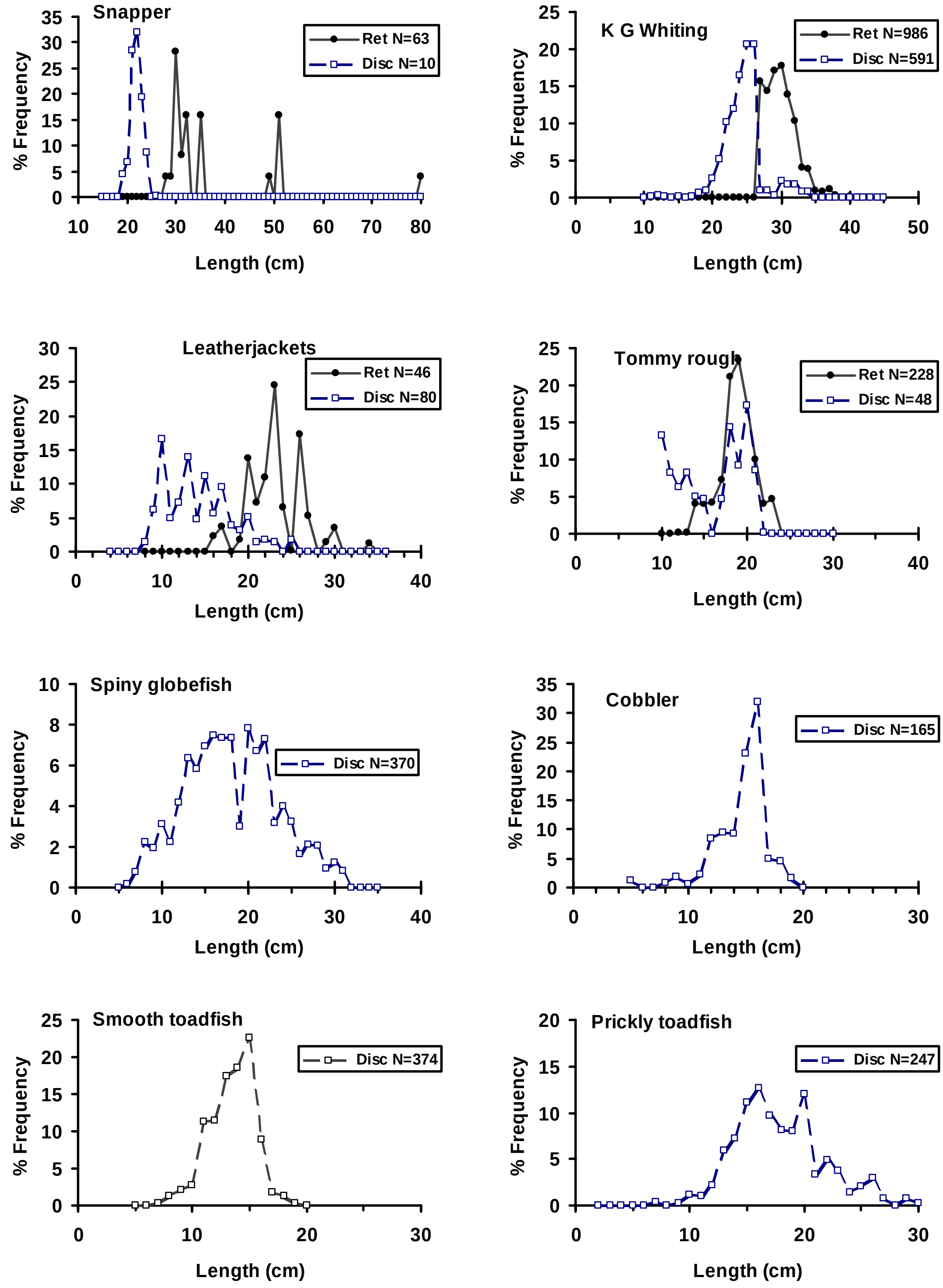

Figure 19. Length-frequency distributions for retained (Ret) and discarded (Disc) components of the catch of shots monitored in Port Phillip Bay.

From the 37 shots monitored in Corner Inlet, the retained catch accounted for 26% by number and 31% by weight of the total catch (Figure 20). Of the discarded portion of the catch, approximately 36% by number, and 11% by weight were commercial species. The difference between the two measures mainly reflected the catch of large numbers of small leatherjackets that contribute greatly to the numbers discarded but very little to the average weight.

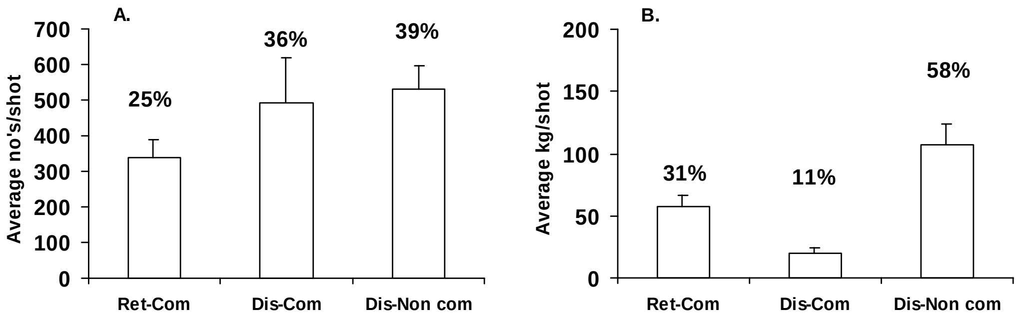

Figure 20. Average numbers (A.) and weights (B.) per shot (± standard error) of commercial species that are retained (Ret-Com), commercial species that are discarded (Disc-Com), and non-commercial species that are discarded (Disc-Non Com), from monitored shots in Corner Inlet.

In Corner Inlet, average catch rates (by number) for leatherjackets were the highest of all species but most were discarded (Figure 21). Discarding was also high for two toadfish species and globefish. Of the commercially important species, average catch rates were highest for garfish, King George whiting and silver trevally but a large proportion of the latter two species were undersized and discarded. Average catch rates, by weight, were highest for globefish and prickly toadfish, two species which are entirely discarded, but were also high for King George whiting (mostly retained) and squid (rarely discarded) (Figure 22).

Length-frequency distributions were plotted for species for which at least 50 fish were measured (Figure 23). Generally, the LML (grass whiting 20 cm, greenback flounder 23 cm, King George whiting 27 cm and silver trevally 20cm) marked a clear boundary between retained and discarded fish. For garfish, for which there is no legal minimum length, discarded fish were generally 25 cm or less, but fish down to 18 cm may be retained. All leatherjackets less than 15 cm were discarded and few above this size were retained.

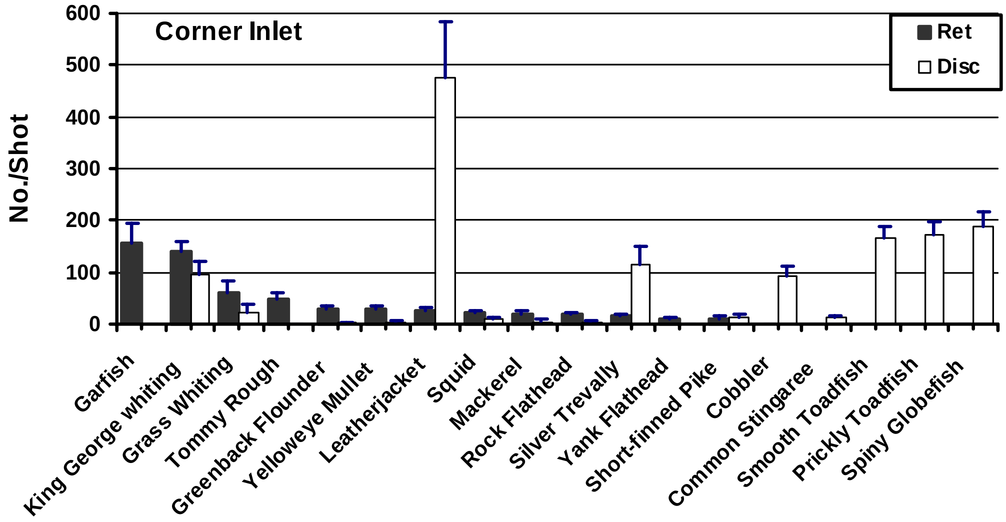

Figure 21. Average (and standard error) number of fish retained and discarded per shot from haul seines in Corner Inlet, in order of decreasing numbers retained. Data are presented for species recorded in at least five shots.

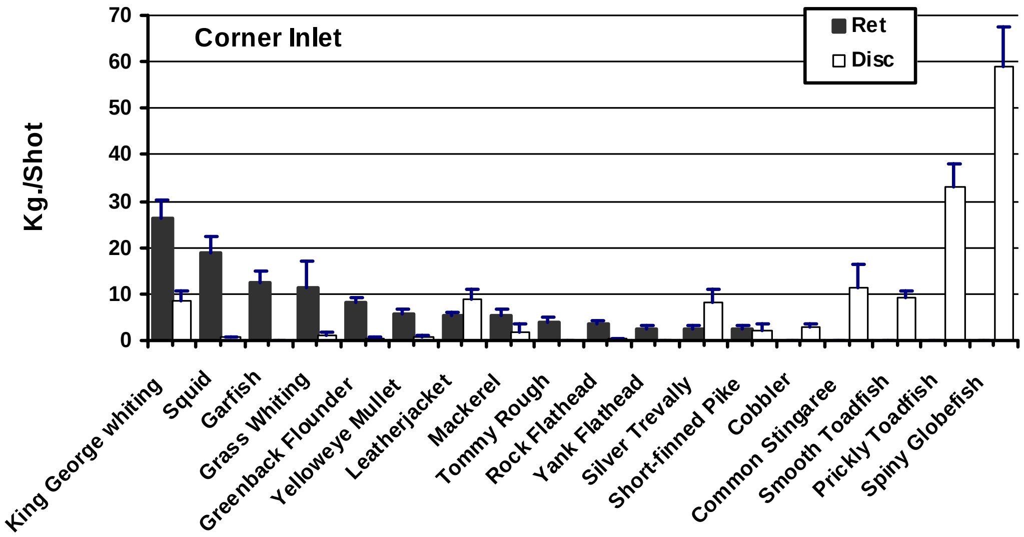

Figure 22. Average (and standard error) weight of fish retained and discarded per shot from haul seines in Corner Inlet, in order of decreasing weights retained. Data are presented for species recorded in at least five shots.

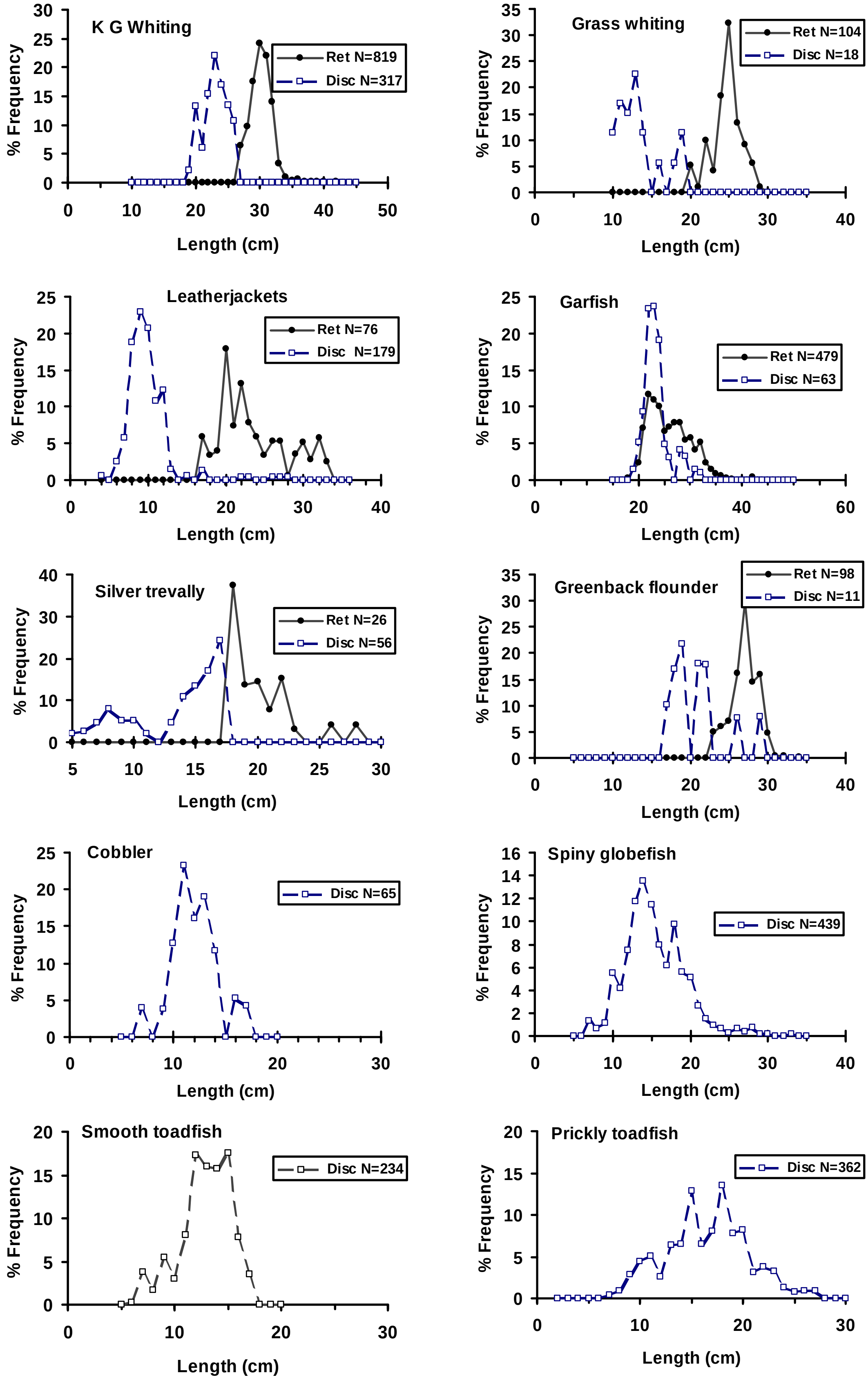

Figure 23. Length-frequency distributions for retained (Ret) and discarded (Disc) components of the catch of shots monitored in Corner Inlet.

7.2.2 Selectivity of haul seines

The species and size composition of fish caught in the surround net provided data on the fish that passed through a commercial net. The surround net was deployed around normal commercial shots on two occasions in October 1998 in Corner Inlet and on three occasions between October 1998 and January 1999 Port Phillip Bay. In Corner Inlet, there were six species caught in the surround net which were not caught in the commercial net, 15 species caught only in the commercial net, and nine species caught in both net types (Table 23). In Port Phillip Bay there were seven species caught only in the surround net, 17 species caught only in the commercial net, and 23 species caught in both nets. The most numerous species were generally unevenly distributed between the two nets in both Corner Inlet (Figure 24) and Port Phillip Bay (Figure 25), being either found mostly in the surround net or mostly in the commercial net. When proportions were calculated by weight, the commercial net was shown to catch a greater proportion of the species which occur in both nets for both Corner Inlet (Figure 26) and Port Phillip Bay (Figure 27). Similarly, whereas about 70% by number of all species caught were caught in the commercial net in Corner Inlet, this proportion rose to over 90% by weight. In contrast, less than 40% of the total catch by number was caught in the commercial net in Port Phillip Bay, reflecting the larger number of hardyheads and blue sprat in the surround net. Because these fish are small, however, 80% of the total catch by weight was caught in the commercial net.

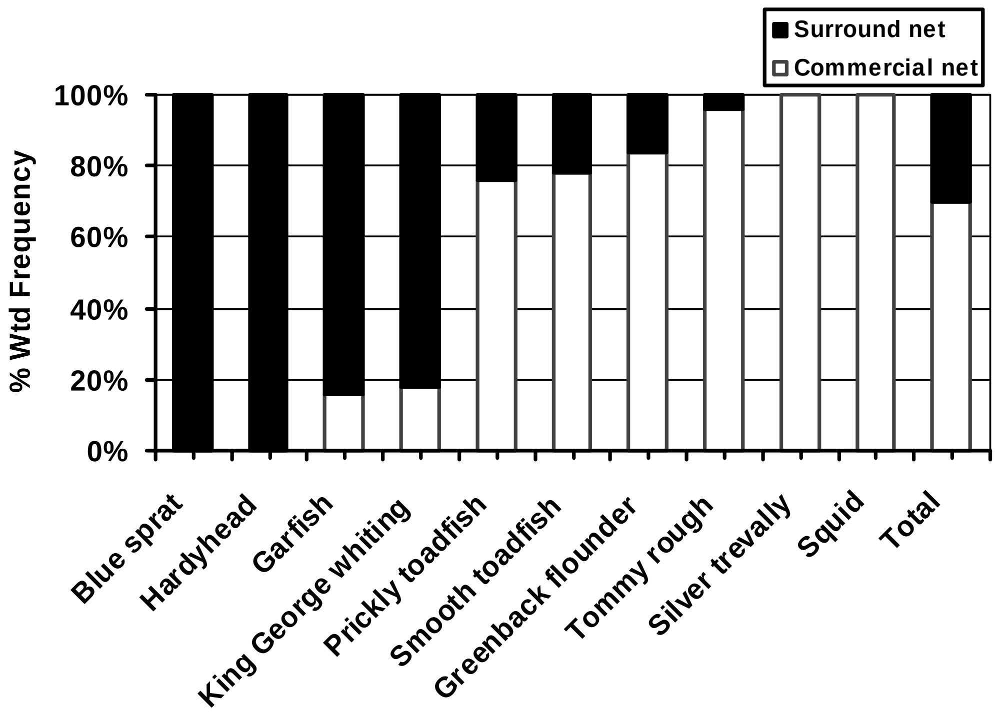

Figure 24. Percentage frequency of the weighted catch for the ten species most commonly caught species in the commercial and surround nets for shots in Corner Inlet.

Table 23. Summary of total numbers of fish recorded in the commercial net and the surround net for shots monitored in Corner Inlet and Port Phillip Bay.

Species	Corner Inlet		Port Phillip Bay		Grand Total
	Commercial Net	Surround Net	Commercial Net	Surround Net	
Anchovy		8		155	163
Angel shark			1		1
Australian salmon	8		9	1	18
Banjo ray	12		42	2	56
Barracouta			1		1
Big-headed gudgeon,			4		4
Blue sprat		168		1314	1482
Butterfly gurnard			1		1
Calamari			64		64
Cobbler	1		39	2	42
Common stingaree	1		50	1	52
Cowfish			1		1
Crab			2	1	3
Crested weedfish			6	16	22
Dusky morwong			2		2
Eagle ray			3		3
Garfish	19	100	175	41	335
Goby		3		8	11
Grass whiting	2		3	16	21
Greenback flounder	51	10	54	12	127
Gummy shark			1		1
Hardyhead		80		2240	2320
King George whiting	28	127	750	1159	2064
Old wife			6	1	7
Pipefish				10	10
Prickly toadfish	561	178	218	26	982
Red mullet			7		7
Rock flathead	3		3	2	8
Rough leatherjacket	9		129	1	139
Round-snouted gurnard	1				1
Sand flathead	6		16	7	29
Sandy sprat				65	65
Short-finned pike	3		5		8
Silver trevally	385		1	1	387
Six-spined leatherjacket	2	2	144	4	152
Smooth toadfish	1156	329	680	73	2239
Snake blenny				1	1
Snapper			27		27
Sole	1				1
Sparsely-spotted stingaree	1		48		49
Spiny globefish		1	242	24	267
Spotted stingaree			2		2
Squid	13		95	24	132
Thornback skate			4		4
Tommy rough	71	3	8	6	88
Velvet leatherjacket		2			2
Yank flathead	10	1	6	2	19
Yelloweye mullet	5	1	9	3	18
Grand Total	2349	1013	2858	5218	11439

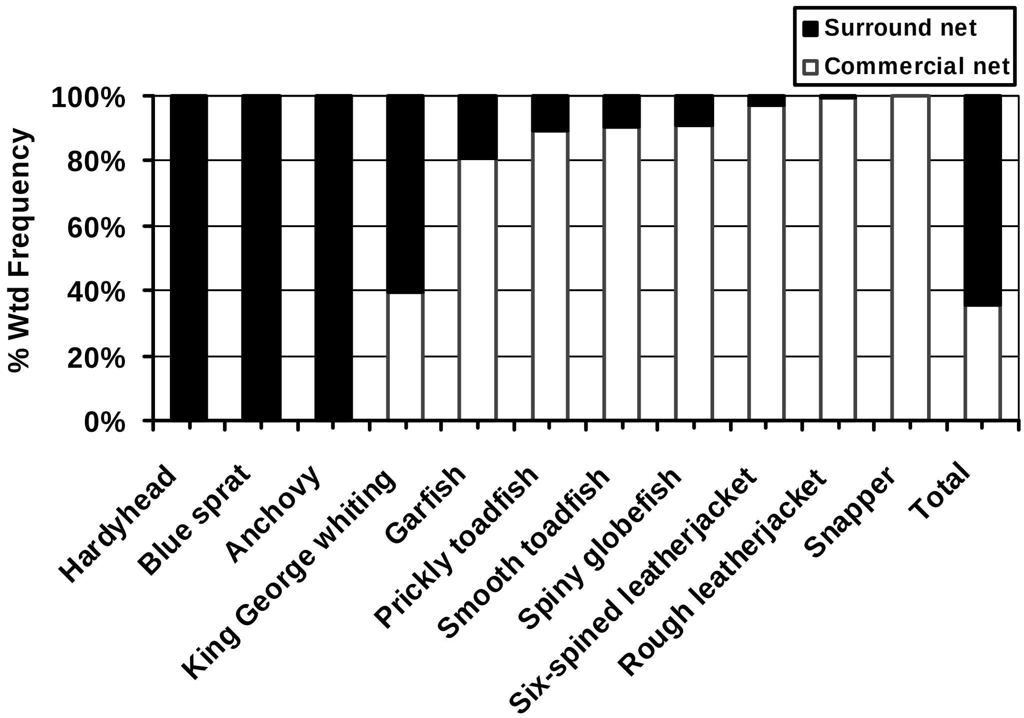

Figure 25. Percentage frequency of the weighted catch for the ten species most commonly caught species in the commercial and surround nets for shots in Port Phillip Bay.

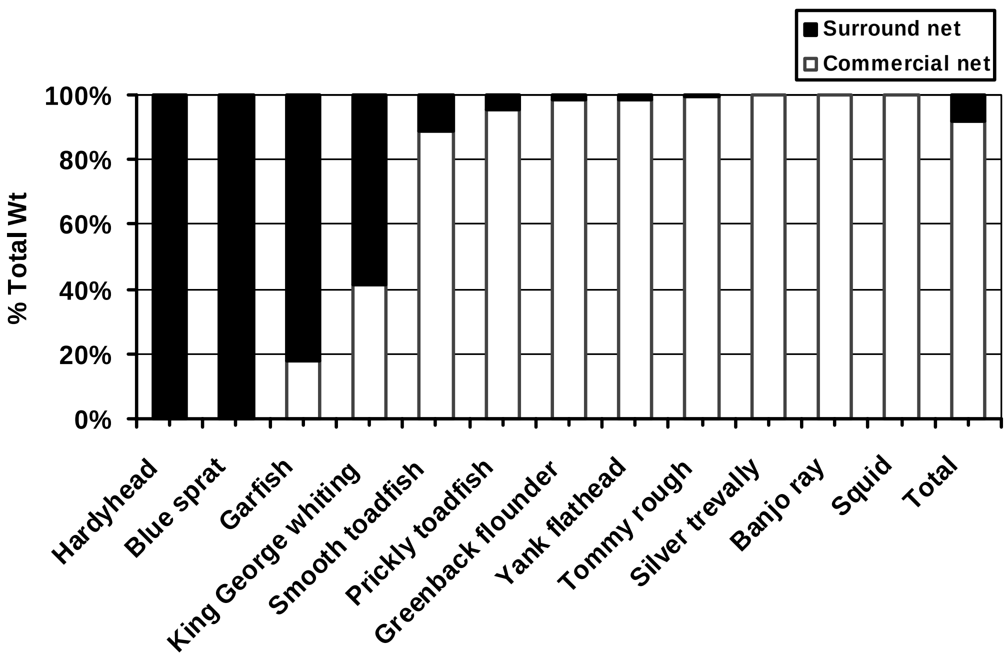

Figure 26. Proportion of the catch by weight from commercial and surround nets for the most commonly caught species in shots in Corner Inlet.

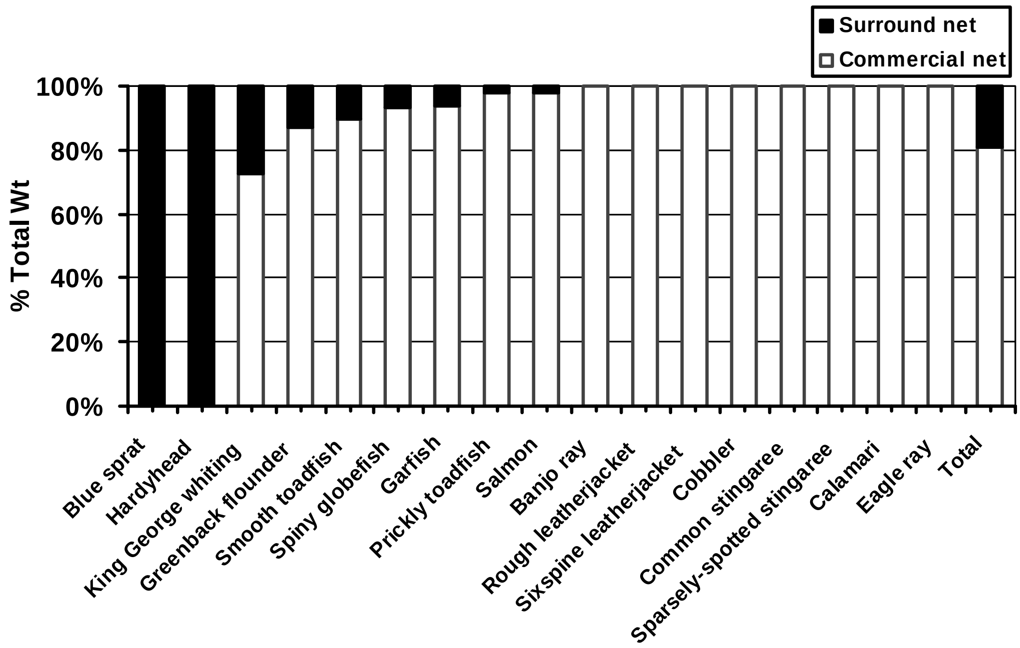

Figure 27. Proportion of the catch by weight from commercial and surround nets for the most commonly caught species in shots in Port Phillip Bay.

Length-frequency distributions for the species which occurred in both the surround and commercial nets in Corner Inlet (Figure 28) show that there was little overlap in the size of garfish and King George whiting caught in the two net types. For the two toadfish species, the size range was very similar for the two nets but there was a greater proportion of smaller fish caught in the surround net.

Similar length-frequency distributions of prickly toadfish and King George whiting occurred in both net types in Port Phillip Bay (Figure 29) also showed a similar overlap for prickly toadfish and similar degree of separation for King George whiting, as in Corner Inlet. However, both nets caught more larger garfish than in Coner Inlet suggesting a greater proportion of large garfish were present in Port Phillip Bay during sampling. For smooth toadfish, there was little difference in the distributions in the two nets, but this is probably due to there being few fish less than 10 cm caught in Port Phillip Bay.

The other important aspect to the selectivity of the haul seines is the size of fish that are retained by the commercial net through being meshed. King George whiting was the particular focus of this part of the work because this species was one of the most commonly meshed. King George whiting that have been meshed are usually dead by the time they are removed from the net, so the meshing rate of undersized fish could contribute significantly to the mortality of discarded fish. Data on the sizes and numbers of King George whiting meshed during normal operation of haul seines was recorded from 6 shots by 2 different operators in Corner Inlet, and from 7 shots by one operator in Port Phillip Bay, between 19 August 1998 and 12 January 1999.

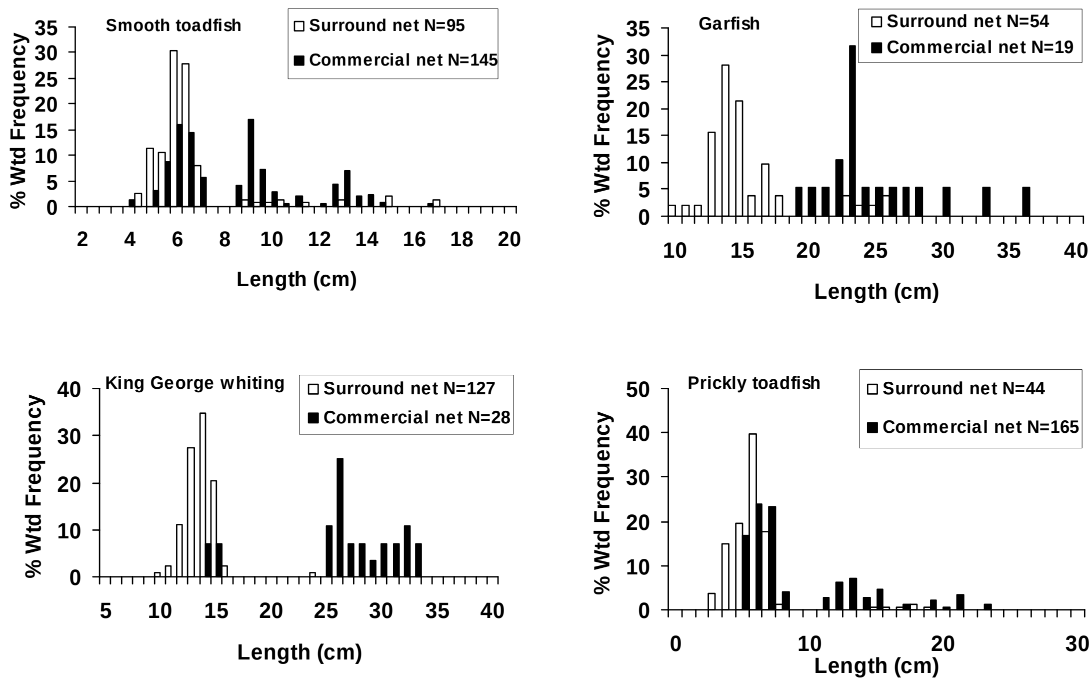

Figure 28. Weighted length-frequency distributions for species found in both commercial and surround nets in shots in Corner Inlet.

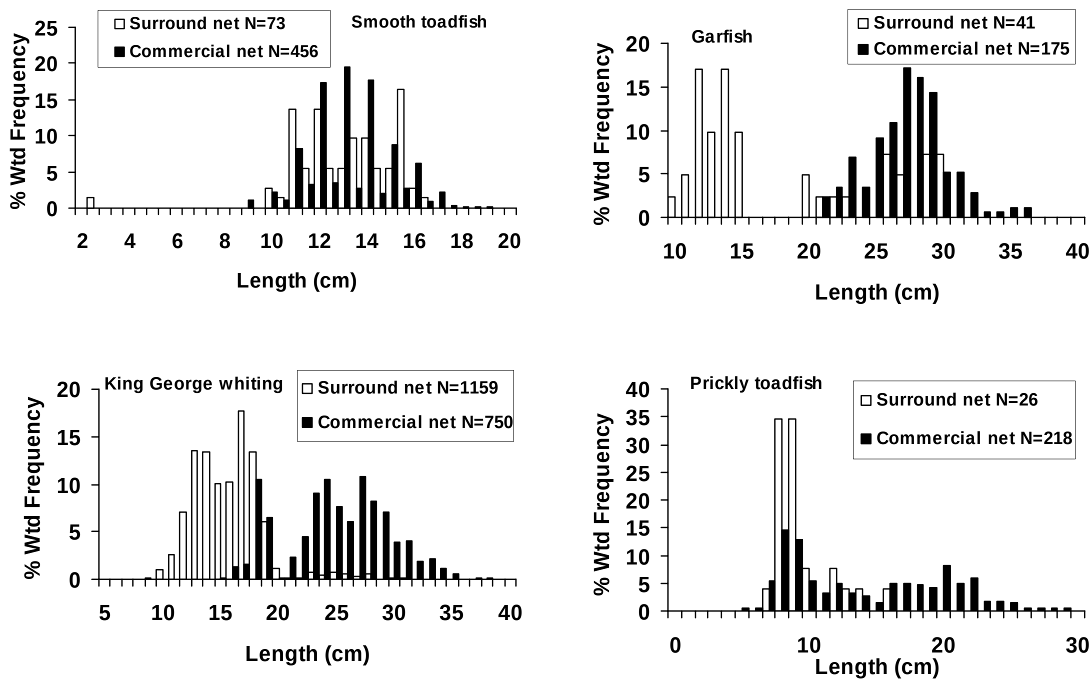

Figure 29. Weighted length-frequency distributions for species found in both commercial and surround nets in shots in Port Phillip Bay.

For those shots monitored in Corner Inlet, the King George whiting caught in the wings of haul seines (5.08 cm mesh) was predominantly of the larger fish in the catch with a mode at 30 cm (Figure 30). In Port Phillip Bay, however, the King George whiting meshed in the wings (4.45 cm mesh) had a mode at 25 cm and were generally less than 30 cm (Figure 31). King George whiting meshed in the shoulders of nets in Port Phillip Bay (2.86 cm mesh) were all in a narrow size range of 17-20 cm. Attempts were made to collect more information on the relative numbers of fish meshed and bagged for shots in Port Phillip Bay, but significant numbers of fish were only meshed when the small King George whiting were prevalent in the areas fished. This did not occur during the later phases of the project when this aspect of the study was being investigated. The data collected therefore, while showing the size ranges of fish caught, do not provide good estimates of the relative numbers caught by meshing and in the cod end. The difficulty in collecting this information, however, is itself an indication that the meshing of large numbers of fish was not a common event during the study period. This may not be the case in years when larger numbers of young King George whiting are recruiting to the fishery.

7.2.3 Bycatch reduction trials using polyethylene mesh

The nets with different mesh wings were used for 47 shots between 18 November 1999 and 9 February 2000. Total catch of King George whiting from these shots was 562kg. From these shots, 473 King George whiting were meshed in the nylon wings, and 22 were meshed in the polyethylene wings, which represents a greater than 20 fold reduction in numbers meshed.

A smaller size range of King George whiting was caught in the polyethylene mesh than in the nylon mesh (Figure 32), but because of the small sample size obtained from the polyethylene mesh, the significance of this difference is difficult to determine. Australian salmon (2 fish) and Tommy rough (4 fish) were also meshed in wings during the trials, but their numbers were equally split between the two mesh types.

7.3 Objective 3: Determine the survival of discarded fish

Trials to monitor the survival of fish released from haul seines show that survival rates were generally in excess of 80% and were 100% for many species (Figure 33). In Port Phillip Bay, the experiments assessed 18 different species (596 fish) and the average survival was 89% per species (Figure 34). No mortalities were recorded for 12 species. However, mortality of garfish was 100% as this species is prone to high scale loss. In Corner Inlet, 5 species were assessed (170 fish) and the average survival was 97% per species. No mortalities were recorded among the 4 bycatch species (ornate cowfish, globefish, barred toadfish and smooth toadfish); the only mortalities recorded were of King George whiting.

Survival of King George whiting averaged 81% across all 14 trials (range 67-100%, standard error 2.7%) (Figure 35). The size range of fish that died was similar to those that lived but there was a bias towards larger fish among survivors, indicating that there was a length-related component to the mortality (Figure 36).

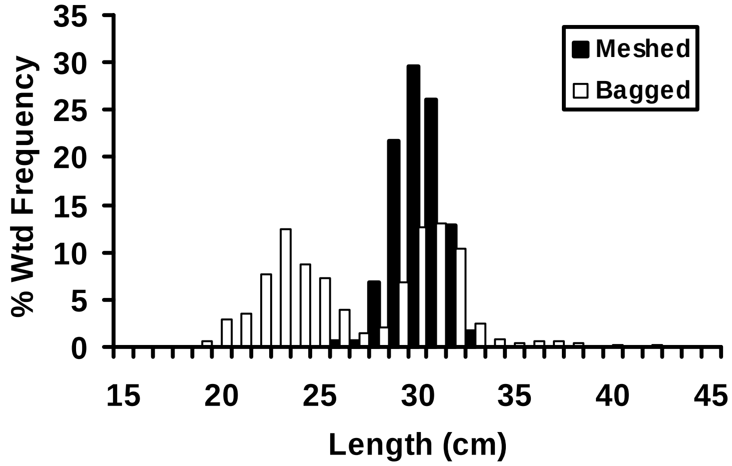

Figure 30. Length-frequency distributions for King George whiting meshed in the wings of haul sines (5.08 cm mesh) and caught in the cod end (bagged) from specifically monitored shots in Corner Inlet.

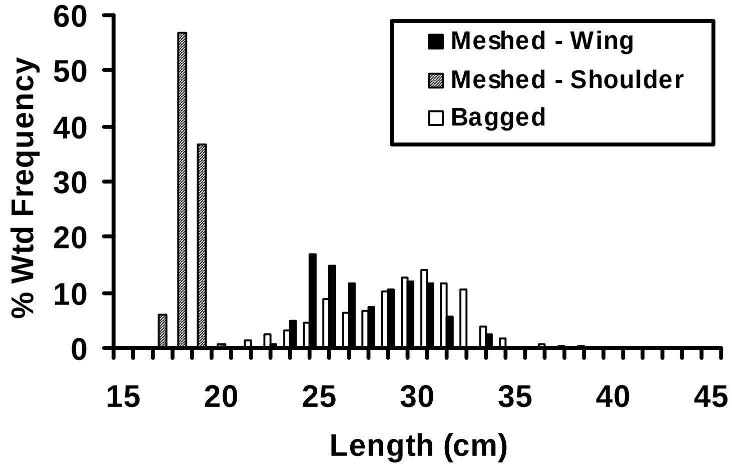

Figure 31. Length-frequency distributions for King George whiting meshed in wings (4.45 cm mesh) and shoulders (2.86 cm mesh) of haul seines and caught in the cod end (bagged) from specifically monitored shots in Port Phillip.

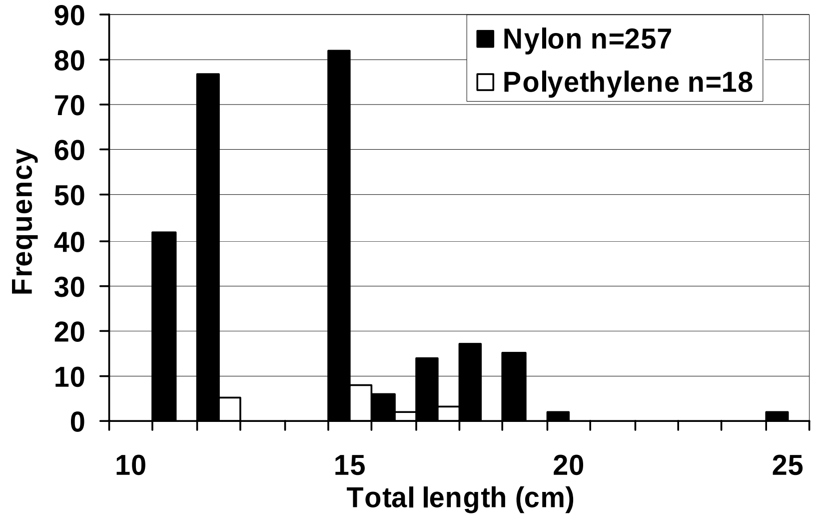

Figure 32. Length-frequency distributions of a sub-sample of King George whiting meshed in nylon and polyethylene mesh wings of haul seines.

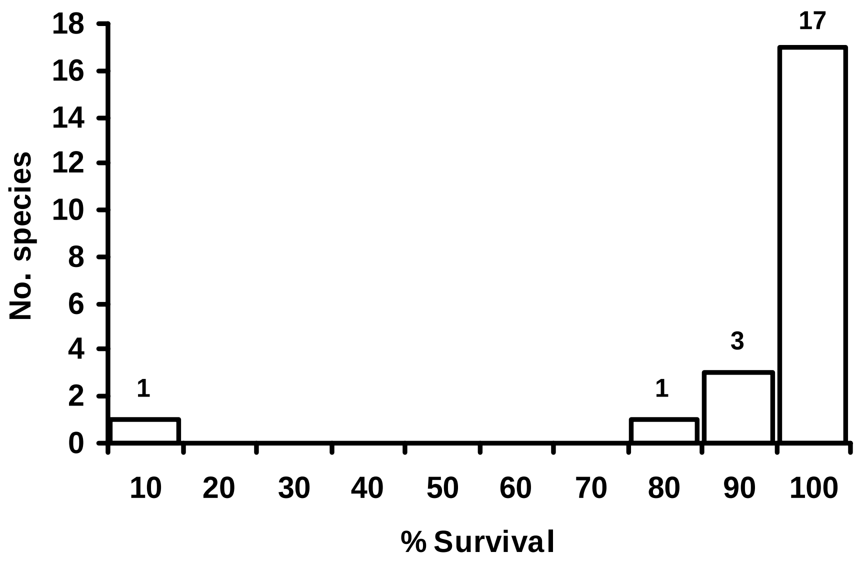

Figure 33. Frequency distribution of the average percent survival of species used in the survival experiments.
Data from Port Phillip Bay and Corner Inlet combined. Labels indicate the number of species in each group.

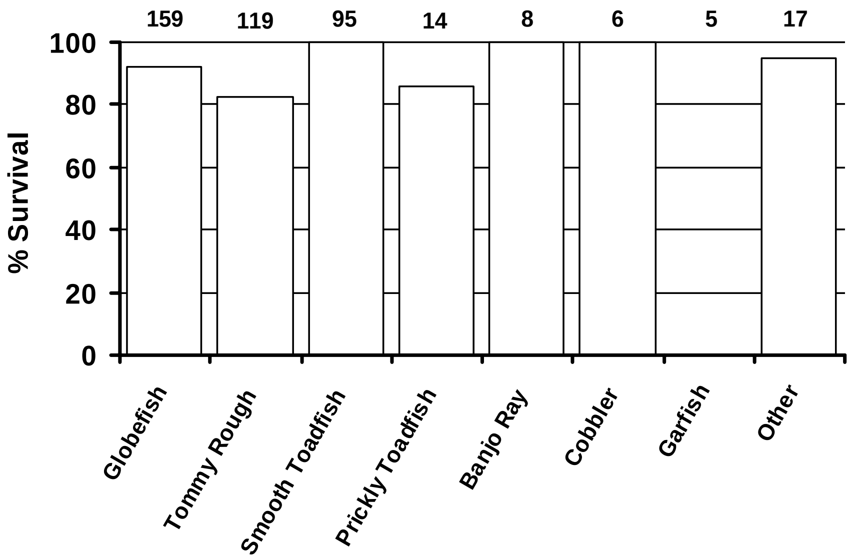

Figure 34. Average percent survival of fish caught in haul seines in Port Phillip Bay. Survival measured after 7 days in sea cages. Species for which less than five individuals were caught are grouped in Other. Numbers above bars are total numbers of fish assessed.

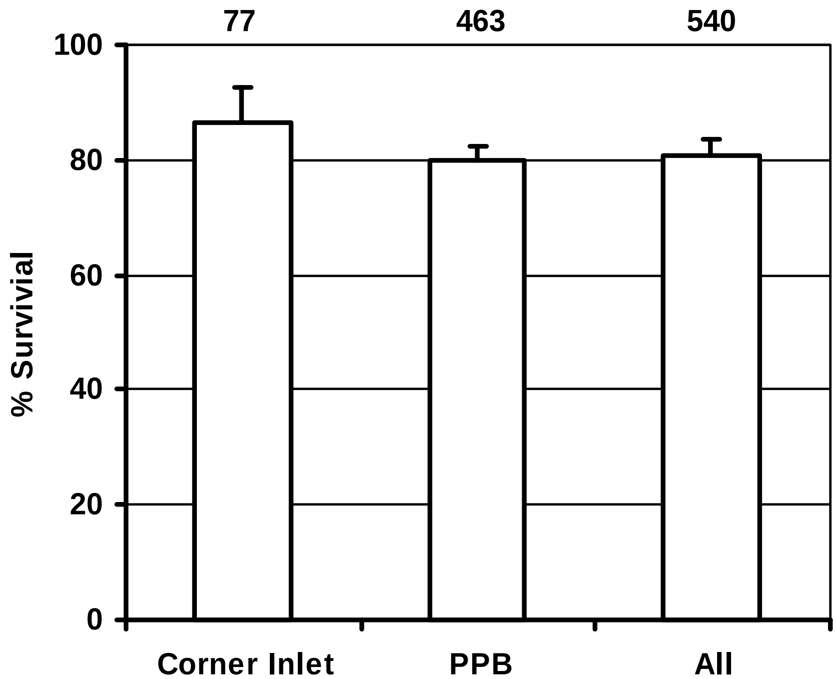

Figure 35. Average percent survival (and SE) of King George whiting caught in haul seines and held in sea cages in Corner Inlet (5 trials), Port Phillip Bay (PPB-9 trials), and both sites combined.
Numbers above bars are total numbers of fish assessed.

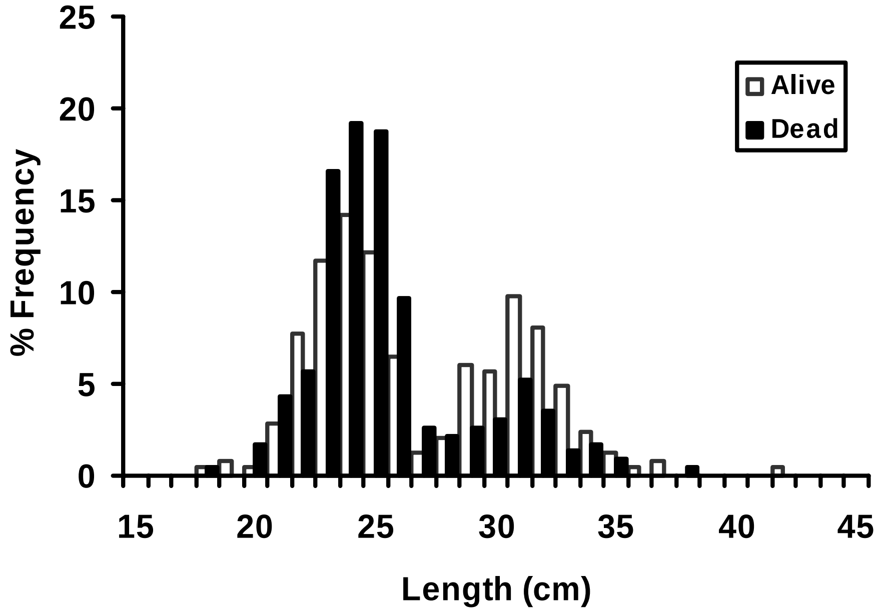

Figure 36. Percentage length- frequency distribution of King George whiting used in mortality trials showing size of fish which survived and those which died.

7.4 The fate of fish surrounded by haul seines

Estimates of the number of fish which pass through haul seines and the number discarded were combined with the estimates of survival rates of discards to give an overall mortality rate of fish that encounter a seine net. These estimates will vary depending on whether numbers or weights of fish are used for the calculations. Estimates based on numbers will show lower proportions in the retained catch than for estimates based of weights, because mostly small fish pass through seines, and also because undersized fish of a number of species are discarded. Nevertheless, calculations based on numbers are also valid, as larger numbers of smaller fish may be more significant to the future population than a smaller number of larger fish of equivalent weight.

Using numbers of fish and values averaged across all species and both Corner Inlet and Port Phillip Bay (there were too few data on survival of many species from Corner Inlet alone), the fate of fish encountering a haul seine can be summarised as follows:

56% remain within the commercial net

44% pass through the commercial net.

Of the those remaining within the net:

32% are retained as being of commercial value

68 % are released (30% being commercial species and 38% non-commercial).

Of those released:

90% survive

10% die .

Thus for every 100 fish encountering the net:

0.44 X 100 = 44 pass through

0.56 X 0.32 X 100 = 18 are retained and marketed

0.56 X 0.68 X 0.9 X 100 = 34 are released and survive

0.56 X 0.68 X 0.1 X 100 = 4 are released but die.

The ratio of retained fish to dead discards is in excess of 4.5:1.

Values for individual species will obviously vary from these averages. We had sufficient data to make similar estimates for King George whiting, again combining data from Corner Inlet and Port Phillip Bay.

34% remain within the commercial net

66% pass through the commercial net

Of the those remaining within the net:

62% are retained above the LML

38 % are released.

Of those released:

87% survive

13% die .

Thus for every 100 King George whiting encountering the net:

0.66 X 100 = 66 pass through

0.34 X 0.62 X 100 = 21 are retained and marketed

0.34 X 0.38 X 0.87 X 100 = 11 are released and survive

0.34 X 0.38 X 0.13 X 100 = 1.7 are released but die.

The ratio of retained fish to dead discards is in excess of 12:1.

These estimate have not taken into account estimates for the numbers of fish meshed in the wings of nets. Only 5% of those meshed, however, were less than the LML. Thus, if 25% of whiting caught were meshed (a high estimate, the percentage of dead fish less than the LML would increase by 0.26% (0.21 X 0.25 X 0.05) to about 2%, and the ratio of retained fish to dead discards would reduce to about 10:1.

8 Discussion

8.1 Objective 1: Describe fishing gear and methods

This study has provided an objective classification of types of hauls seines used in the main Victorian bays and inlets. At the broadest level (Ward's method) these nets can be described as East Gippsland estuary seines, central Victorian beach seines (including garfish seines) and Corner Inlet ringing seines. The analyses have shown that some of the common descriptors used for haul seines reflect real characteristics of the beach seines, estuary seines, garfish seines and ringing seines used. The main groupings, to some extent, also reflected differences in the locations fished suggesting that the nets have developed along different lines in the different bays and inlets. These differences probably reflect a combination of historical differences in the types of gears traditionally employed, in the conditions experienced, and in the designs that are most suitable for the suite of species targeted in the different areas. For example, Corner Inlet fishers have to contend with large tidal ranges and strong currents in an area dissected with channels. Port Phillip Bay fishers work a large open waterbody with a small tidal range, and over gently sloping bottom. Gippsland Lakes fishers work in relatively sheltered and calm waters but with a diversity of habitat types and a range of depths.

Obviously, many of the characteristics of the nets were clearly associated with the target species in the different areas. Bag mesh size is an obvious example. The East Gippsland estuary seines had bream as the primary target species, with trevally and mullet as other target species. This reflects the major black bream fishery that operates primarily in the Gippsland Lakes. The mesh size in the bags of these nets was usually greater than 64 mm (2½ inch). In contrast, the central Victorian beach seines and Corner Inlet ringing seines both used a bag mesh of ≤ 32 mm (1¼inch) to primarily target whiting, with garfish and flounder as important other target species. Squid, mullet and trevally were other common target species in the central Victorian beach seines.

Fishers are constantly modifying their gear and trying innovative ways to improve the efficiency of their operations, and are quick to adopt new features they see working for other fishers. Thus, the differences in gear designs that are deployed are likely to reflect those features that have been found over time to be effective for the conditions encountered and species targeted.

Although the classification presented has provided an accurate snapshot of the situation during the study, it may become progressively less accurate as the gear continues to evolve. For example, the use of polyethylene mesh as a means of reducing bycatch, which was first trialed in Port Phillip Bay during this study, has apparently already been adopted by a significant number of Port Phillip Bay fishers. In addition, the voluntary buy-out of commercial licences that took place after the descriptive part of the project was completed may produce change in the fishery and alter the range of haul seines employed. Although an initial examination of the proportions of types of gear and vessels used by fishers has changed little since the buy-out, no information was available on the possible selling of gear or vessels among fishers.

There was no clear relationship between vessel/engine characteristics and other characteristics of the fishery such as net type and target species. There are likely to be a number of reasons for this. The type of vessel and engine that a fisher may use can be influenced by whether a fisher has a regular berth for the vessel or must trailer the vessel on roads to reach appropriate fishing locations. If a fisher needs to travel considerable distances by road (or sea) to access fishing grounds, he is more likely to opt for a lighter, faster planing hull vessel with an outboard rather than a wooden displacement hull vessel. This may explain the predominance of planing hull vessels used on Port Phillip Bay. Environmental factors such as the prevailing currents, swell and waves in a fishing area may also influence a fishers choice of vessel and engine power. It should also be remembered that many fishers involved in haul seining also use their vessels for other fishing activities such as mesh netting.

Costs may also be an important factor. The purchase of a vessel and engine involves considerable capital outlay and fishers may choose to keep older vessels (which tend to be displacement hulls) if they adequately serve their purpose. A secondary “net boat” might only be required to carry and set the net and is towed at all other times. In such cases, this vessel may have no other characteristic of importance to the fishing method other than the fact that it floats. The greater running cost of planing hull vessels with outboards, mainly associated with fuel consumption, may also influence the choice of vessel.

There was no effort in the present study to correlate any of the above factors with vessel characteristics.The differences in fishing methods between major inlets are also important. Some of these differences relate to the fishing regulations applying to the different waters. For example, it is not permitted for a haul seine to be towed by a vessel in Port Phillip Bay but this is the standard way in which a ringing net is retrieved in Corner Inlet.

Because ringing seines are retrieved from a boat, the nets are cleared in deeper water than in seines used in the other bays and inlets. There is likely to be increased water flow through these nets during sorting, which reduces stress resulting from elevated temperatures and/or lowered dissolved oxygen concentrations. These factors are known to contribute to a generally better condition of released fish from ringing seines (Fritz and Johnson 1987).

8.2 Objective 2: Assess the effect of haul seining on the fish stocks

There are over 700 species of marine and estuarine fish recorded along Australia’s south coast (Gomon *et al.* 1994). However, less than 10% of these are exploited commercially in the Victoria’s bay and inlet fisheries. The results of this study showed that relatively few species were found in the majority of monitored shots and sometimes a large catch of a single species dominated the species composition of a shot: for example, when a large school of Australian salmon, black bream or King George whiting are successfully targeted.

For most of the species of commercial or recreational interest (such as King George whiting), more fish were retained than discarded (whether considering weights or numbers). Exceptions to this were observed during the study for leatherjacket in Corner Inlet, and snapper in Port Phillip Bay. With regard to the latter, most of the catch of undersized snapper occurred in one haul seine shot. There has been strong recruitment of snapper in recent years in Port Phillip Bay (MAFRI, unpublished data) which is likely to have influenced the high catch of small snapper recorded during the present study. This study recorded the catch rates within a relatively short period of time, and the species composition of the catch will be expected to vary annually. Changes in the abundance of species, as strong and weak year classes pass through their populations, will have a marked effect on catch rates, and for some species, also on the ratio of retained to discarded catch.

The observed ratios of retained to released fish are likely to vary substantially within and between waters, among seasons, and over years in response to changes in fishing practices, the behaviour of fish, recruitment patterns and environmental conditions. The observed proportions of discarded fish (62% by number and 68% by weight in Port Phillip Bay, 75% by number and 69% by weight in Corner Inlet) are substantially higher than those reported from beach seining in Botany Bay (44% by number, and 38% by weight) for a similar type of fishery (Gray *et al.* 2001). The reasons for this higher discard rate are unknown, but may relate to a larger minimum cod-end mesh size of 30 mm in NSW, which would allow a greater proportion of smaller fish to escape before sorting begins.

Many of the small species, such as gobies and sprats, and small fish of larger species, pass through a haul seine, as evidenced by the size and species composition of the catch in the surround net. Nevertheless, the surround net itself, which is made of 12mm mesh, would allow many of the smallest fish to escape. Consequently, our figures on total escapement from haul seines are probably underestimated. High levels of escapement have been recorded from similar studies for beach seines in South African estuaries where 95% of the combined catch (for nets of 44 mm mesh) was caught in the surround net (Lamberth *et al.* 1995a).

One of the main impacts of haul seines that was thought to occur, apart from the direct effect of removing target species, was that significant quantities of juveniles of important commercial or recreational species were caught and killed. The results of this study indicate that, although there may be significant quantities of small fish caught in haul seines, those that are discarded usually have a high chance of survival. This high survival rate substantially reduces the potential impact of haul seine fishing on fish stocks.

Originally, the present study also intended to address the issue of potential damage to seagrass beds by haul seines. As explained earlier, however, this aspect of the work was dropped following the undertaking of a far more comprehensive study in NSW on this subject. The results of that study (Otway and Macbeth 1999) are in accordance with observations made during the present study that haul seines cause minimal disturbance to seagrass beds. Underwater footage taken of haul seines being hauled over seagrass beds in Victoria clearly indicated that seagrass bends parallel to the substrate as the net passes and then subsequently resumes its normal vertical orientation. Observations of the contents of haul seines also indicated that very small quantities of vegetation were displaced during hauling. The amounts of seagrass observed in nets were considered more likely to have been free floating material simply collected by the nets as they moved through the water, rather than newly displaced plants.

Overall, the level of disturbance to the benthic plants and animals caused by haul seines was considered to be relatively minor. The same conclusion was reached for a beach seining study in South Africa (Lamberth *et al.* 1995b). Although haul seines may be regarded as an active fishing gear, they share few of the features of otter trawls or prawn trawls with regard to habitat disturbance that have attracted much attention both locally and internationally (e.g. Kennelly 1995; Watling and Norse 1998; Knuckey and Liggins 1998; Blaber *et al.* 2000).

The results of the trials of meshing rates with polyethylene netting indicate that relatively inexpensive alterations to gear can significantly improve the selectivity characteristics of a haul seine. The design of the experiments (with one wing of polyethylene and the other of nylon) did not allow the retained catch rates of the two mesh types to be assessed, but the mesh size was unchanged and the commercial fishers using the gear expressed no concern that the effectiveness of their nets had been compromised. Indeed, as the first experimental hauls showed clear benefits, fishers were impatient to convert both wings to polyethylene. If these results are transferred to all operators in the fleet, the reduction in the meshing and mortality of undersized whiting should be substantial. In NSW, an increase in mesh size was suggested to reduce the capture of small sand whiting, *Sillago ciliata* (Kennelly and Gray 2000). The introduction of polyethylene mesh into haul seines may be an alternative to increasing the mesh size to reduce mortality of undersized fish, but only if accompanied by responsible handling of the released fish.

8.3 Objective 3: Determine the survival of discarded fish

Estimation of the survival rate of discarded fish is important for understanding the impact of discarding on fish stocks. The impact of discarding on fish stocks also depends on the proportion of the stocks represented by discards, and the natural mortality that individuals would have experienced had they not been captured (Gray *et al.* 2001).

The survival rate of fish held in sea cages was generally very high, suggesting that the level of trauma suffered by most species during capture was not sufficient to cause significant mortality among released fish. The levels of mortality observed for King George whiting in this study (average 19%) are similar to the 24% combined pre-release (average 13 %, range 3.5-23.8%) and post-release (average 11.1%, range 10.3-12.3%) mortality levels recorded for the same species in South Australia (Kumar *et al.* 1995). That study, however, used only undersized fish in their post-release experiments, and fish were held in laboratory aquaria rather than sea cages.

The main exception to the high survival rates was for garfish, which are very susceptible to scale loss and die after a minimum of handling. This problem has been recognised previously by fisheries managers, and for this reason garfish are one of the few species for which there is no LML in Victorian waters.

The survival of fish that passed through the haul seines was not determined. In a review of studies that examined the condition of fish escaping from fishing gears (Chopin and Arimoto 1995), mortality of fish escaping from seine nets was found to be low even though it included studies of captured and released fish within its definition of escapement. Mortality of cod (*Gadus morhua*) was negligible and that of haddock (*Melanogrammus aeglefinus*) was reported to be less than 10% for fish escaping from a demersal trawl (Soldal *et al.* 1993). Results from experiments in which simulated net injuries were inflicted and fish were physically exhausted were consistent with observations from field experiments (Soldal *et al.* 1993). Fish escaping from haul seines in bays and inlets are not subject to the stress of sustained swimming experienced by fish trying to escape from trawls. Consequently, they are expected to have similar or higher levels of survival.

The level of physiological stress experienced by fish enclosed by haul seines prior to their escape or release, and the effect of this on their subsequent survival rate, is uncertain. Factors that can potentially increase post-release mortality include increased duration of the haul operation, increased water temperature, reduced dissolved oxygen levels, increased sorting time and increased catches (through increased sorting time and possibly reduced oxygen levels within the cod-end). King George whiting caught in garfish seines in South Australia showed elevated cortisol levels up to 3 days post-capture (Kumar *et al.* 1995). Snapper captured by trawls and longline have been found to have increased blood cortisol levels for at least 12 hours after capture (Pankhurst and Sharples 1992). Cortisol levels returned to normal levels after 48 hours for fish kept in the laboratory, but are likely to have fallen sooner if returned to their natural habitats.

When a large catch is obtained in a haul seine shot, sorting of the catch may take up to 2 hours. During this time the catch is not usually tightly confined in the cod-end but is progressively restrained as the sorting process takes place. Nevertheless, in summer when water temperatures and metabolic rates of the fish are higher, and dissolved oxygen levels likely to be lower, significant respiratory stress is likely to occur on captured fish on some occasions. This may lead to higher levels of mortality than those observed during this study. Survival of freshwater drum, *Aplodinotus grunniens,* released after capture by seines was inversely related to the time they spent exposed to deoxygenated water and in general, survival was greater in smaller catches (Fritz and Johnson 1987).

The survival of captured fish is also likely to be influenced by the species composition of the catch. Catches that include large number of fish with spines, such as globefish, are more likely to lead to injuries to other fish. Fishers also reported that the presence of high numbers of squid can adversely affect other species if the squid discharge their ink during sorting.

One source of increased mortality attributable to haul seining but not quantified during the study is that due to predation by birds and other fish. Great cormorants and Australian pelicans in particular, but also silver gulls and terns are attracted to fishing operations and were observed to feed on escaping or discarded fish as well as those meshed in the net. Similar (also unquantified) observations have been made for the South Australian seine fishery (Kumar *et al.* 1995). In the Gulf of Maine shrimp fishery, the proportion of live fish eaten by sea birds once the fish had been released varied between 6 and 63 percent for four species of fish discarded from nets (Ross and Hokenson 1997). In that study, however, fish were sorted on deck and were out of the water for up to 60 minutes prior to their release; predation levels increased with increasing time spent on deck. In contrast, fish caught in the Victorian haul seine fishery are kept in the water during sorting, and released fish are normally able to swim away immediately. The fact that avian predators congregate around commercial fishing vessels indicates that they have learnt that those operations provide feeding opportunities. But whether they feed primarily on the dead discards or are a cause of significant additional fish mortality is not known.

Predation by fish may occur within the haul seine during its retrieval. For example, squid and Australian salmon have been reported to continue feeding while a haul seine was being cleared (Kumar *et al.* 1995). No similar observations were made during the present study although the same species are caught in the Victorian fishery.

The present study did not attempt to investigate the seasonal variation in catch composition, discard rates or survival of released fish. These may show significant variation over time, in response to changes in fish behaviour, recruitment of juvenile fish, fishing practices and environmental conditions. For example, although there was no significant seasonal variation in post-release mortality, the level of pre-release mortality suffered by King George whiting caught in seines in South Australia was significantly higher in January to March compared with later periods of the year, and coincided with the period of time when the greatest numbers of small fish were caught (Kumar *et al.* 1995). Gray *et al.* (2001), however, found no significant temporal differences in the total numbers and weights of the retained and discarded catches of Botany Bay haul seiners. Investigation of temporal variability was beyond the scope of the present study.

The relatively high survival rate of discarded fish is an important feature of the haul seine fishery in Corner Inlet and Port Phillip Bay, and presumably also in the fisheries that use similar nets in other Victorian bays and inlets. It indicates that the design and operation of these nets is distinctly different from other demersal mobile fishing gears. The component of the catch not retained is usually termed discards, but this term has negative connotations from its application to other demersal fish trawls in which discarded fish are "almost always dead before being returned to the water" (Saila 1983). Estimates of the levels of bycatch (e.g. Saila 1983; Alverson *et al.* 1994; Kennelly 1995) and the low survival rates observed (Wassenberg and Hill 1989) in demersal trawl fisheries are not applicable to inshore haul seine fisheries. For haul seine fisheries in bays and inlets, the terms 'retained' and 'released' more accurately convey the results of the sorting and selection processes used in these fisheries.

The combination of slow tow speeds, short haul duration, shallow water operations, and sorting of catch in the water all contribute to the potentially high survival rate in the bay and inlet haul seine fisheries. These findings may not be representative of the survival rates for fish released by all fishers, but they do indicate that when fishers follow best-practice in the sorting and handling of their catch, the level of mortality of non-commercial species or undersized commercial species can be relatively minor.

8.4 The fate of fish surrounded by haul seines

The estimates of the percentage of fish that escape, are retained, are released and survive and are released but die, are indicative only as there will be considerable variation depending on the circumstances of individual shots. However, these values do suggest that the haul seine fishery is very efficient in terms of the proportion of the catch that is retained and marketed, compared to that which is discarded. The apparently low level of wastage is a positive feature of the fishery that is probably an important contributor to the overall sustainability of the fishery.

9 Benefits

This project has provided the first comprehensive description of the Victorian haul seine fishery, including the gear and vessels used and the fishing practices adopted. This description has provided a knowledge base against which future changes to the fishery can be assessed. This will be particularly important following the voluntary buy-out of 52% of licensed fishers from Victorian bay and inlet fisheries. For Corner Inlet and Port Phillip Bay, the project has also provided a description of the selectivity of the fishery by documenting the size and species composition of fish retained and released by haul seiners, and of fish that escape haul seines in these waters. Experiments on the survival of fish released from haul seine catches show that, for most species, survival is high. The impacts of this fishery on fish stocks are therefore substantially less than would be predicted based on the quantities of non-target or under-sized fish caught. The project has also documented a simple change to the material used in nets, from nylon to polyethylene, that has the potential to substantially reduce the quantity of undersized King George whiting that are meshed and die in haul seines. This material has already been adopted by some industry members in Port Phillip Bay.

Results have been disseminated to a range of audiences using video productions, newsletters, oral presentations and articles. Response to the project has been very positive from all audiences. Project results have also been used in compiling responses from the Director of Fisheries Victoria and from the Minister for Energy and Resources to recreational fishing journalists and to members of the public regarding the impact of haul seines. A summary of the extension activities undertaken during the project is provided in Appendix 6, together with copies of the Project Newsletters and articles.

10 Further Development

Several lines of development are warranted. Extension of the on-board monitoring of catches to other bays and inlets, particularly to the Gippsland Lakes, would be useful. The Gippsland Lakes fishery is substantial, and targets a different suite of species, including black bream. Also, haul seines used there are different from those used in Corner Inlet and Port Phillip Bay.

More systematic estimates of survival (more species, over months and years) from commercial shots in all bays and inlets would allow better estimates of the impact of the industry as a whole. The experiments conducted did not cover the spatial and temporal range of conditions in the fishery, and assessed the catches from a few of the more cooperative fishers. The extent to which these fishers are representative of all industry members is not known.

Extension of the findings regarding the benefits of polyethylene net to more industry members, could provide rapid reductions in the quantity of under-sized fish meshed in haul seines. The benefits would be significant in terms of reduced handling time, reduced wastage, and contribution to demonstrating the sustainability of the fishery. A video is already being developed in conjunction with Seanet and Fisheries Victoria to promote the message to industry.

This project has also highlighted the need to examine the same issues for the mesh net fishery in bays and inlets. Mesh netting is the other method that accounts for a significant quantity of the fish that is harvested from bays and inlets.

11 Conclusion

The effects of haul seining in Victorian bays and inlets result mostly from the impact of removing targeted commercial species, and any subsequent, indirect effects this has on fish communities. The impact on non-target species or under-sized fish is likely to be relatively minor, because of the generally high survival rates of released fish. Slow tow speeds, short tow duration, shallow depths of operation, and sorting of the catch in the water all contribute to the ability of fish released from haul seines to survive. Meshing and mortality of under-sized fish, particularly King George whiting, may still be an issue in some seasons when there is high recruitment. This could be substantially reduced, however, by using nets constructed of polyethylene, rather than nylon, mesh. Effects of haul seines on seagrasses or other benthic biota, while not assessed explicitly in this study, are also believed to be minor (e.g. Otway and Macbeth 1999).

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13 Appendices

13.1 Intellectual Property and Valuable Information

The intellectual property from this project will be shared between the Fisheries Research and Development Corporation and the Marine and Freshwater Resources Institute as outlined in the project contract. The Fisheries Research and Development Corporation will be acknowledged in all publications arising from the project.

13.2 Staff

Ms Shellie Cashmore

Mr Ian Duckworth

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Mr David McKeown

Mr Alexander Morison

Mr David Ryan

13.3 Sample survey sheet

Sample survey sheet to record details of haul seine construction and operation in Victorian bays and inlets.

SEINE NET SURVEY
FISHERMAN: __________________________ **DATE:** __________________________ **LOCATION:** __________________________ **NET NAME:** __________________________ **BOAT TYPE:** __________________________ **H.P.:** __________________________

NET No.		
TYPE OF NET	*sinking/floating*	
MAJOR USE/TARGET SPECIES	*fish*	
TIME USED	*day/night*	
HOW HAULED	*lazyline/fleet haul*	
AVERAGE DURATION OF HAUL	*mins*	
RATE OF HAUL	*metre/min*	
METHOD ANCHOR	*boat/beach*	
DISTANCE B/N ANCHOR POINT	*metre*	
HOW MARKED? wing/bag	*dan, floats, lights*	
LENGTH OF HAULING ROPE	*min/max metre*	
TYPE OF ROPE		
FLOATS? (SAME ALL NET?)	*No. where*	

WEIGHTS? (SAME ALL NET?)	*No. where*	
MESH SIZE-WINGS & LENGTH	*cm*	
PLY		
MESH SIZE-SHOULD & LENGTH	*Cm*	
PLY		
MESH SIZE-BUNT & LENGTH	*Cm*	
PLY		
MATERIAL (SAME ALL NET?)	*mono/poly*	
TOTAL LENGTH	*Metre*	
DROP (SAME ALL NET?) **No. MESH'S**	*metre(s)*	
SLING RATIO - headline **(SAME ALL NET?)**	*stud length* *meshes per stud*	
SLING RATIO - footline **(SAME ALL NET?)**	*stud length* *meshes per stud*	

COMMENTS:

13.4 List of scientific names of taxa referred to in the report

Species group	Taxon name	Scientific name
Scyphozoa	Jellyfish, white	*Catostylus mosaicus*
	Jellyfish, red-brown	*Pseudorhiza haeckelli*
Molluscs	Calamari, southern	*Sepioteuthis australis*
	Cuttlefish	*Sepia spp.*
	Squid, red arrow	*Nototodarus gouldi*
Crustaceans	Crab, blue swimmer	*Portunus pelagicus*
	Crab, spider	*Leptomithrax gaimardii*
	Crab, other/unspec.	*Order Decapoda*
Elasmobranchs	Ray, banjo	*Trygonorrhina fasciata*
	Ray, eagle	*Myliobatis australis*
	Shark, angel	*Squatina australis*
	Shark, gummy	*Mustelus antarcticus*
	Stingaree, common	*Trygonoptera sp.*
	Stingaree, sparsely-spotted	*Urolophus paucimaculatus*
	Stingaree, spotted	*Urolophus gigas*
	Skate, thornback	*Raja lemprieri*
	Stingray, black	*Dasyatis thetidis*
Teleosts	Anchovy, southern	*Engraulis australis*
	Australian salmon	*Arripis truttacea/A. trutta*
	Barracouta	*Thyrsites atun*
	Bream, black	*Acanthopagrus butcheri*
	Cobbler	*Gymnapistes marmoratus*
	Cowfish, ornate	*Aracana ornata*
	Cowfish	*Aracana spp.*
	Flathead, rock	*Platycephalus laevigatus*
	Flathead, sand	*Platycephalus bassensis*
	Flathead, yank	*Platycephalus speculator*
	Flounder, greenback	*Rhombosolea tapirina*
	Garfish, southern sea	*Hyporhamphus melanochir*
	Globefish, spiny	*Diodon nicthemerus*
	Goby	*Family – Gobiidae*
	Gudgeon, big-headed	*Philypnodon grandiceps*
	Gurnard, butterfly	*Lepidotrigla vanessa*
	Gurnard, round snouted	*Lepidotrigla mulhalli*
	Gurnard, unspec.	*Family –Triglidae*
	Hardyhead	*Family – Atherinidae*

List of scientific names of taxa referred to in the report (Cont'd).

Species group	Taxon name	Scientific name
Teleosts	Leatherjacket, six-spined	*Meuschenia freycineti*
	Leatherjacket, rough	*Scobinichthys granulatus*
	Leatherjacket, velvet	*Meuschenia scaber*
	Leatherjacket, unspec.	*Family - Monacanthidae*
	Luderick	*Girella tricuspidata*
	Mackerel, unspec.	*Family - Scombridae*
	Morwong, dusky	*Dactylophora nigricans*
	Mullet, red	*Upeneichthys vlamingii*
	Mullet, yelloweye	*Aldrichetta forsteri*
	Old wife	*Enoplosus armatus*
	Pike, short-finned	*Sphyraena novaehollandiae*
	Pipefish	*Family – Syngnathidae*
	Rough, tommy	*Arripis georgiana*
	Snake blenny	*Ophiclinus sp.*
	Snapper	*Pagrus auratus*
	Sole, unspec.	*Family – Soleidae*
	Sprat, blue	*Spratelloides robustus*
	Sprat, sandy	*Hyperlophus vittatus*
	Tailor	*Pomatomus saltatrix*
	Toadfish, smooth	*Tetractenos glaber*
	Toadfish, prickly	*Contusus richei*
	Toadfish, unspec.	*Family – Tetradontidae*
	Trevally, silver	*Pseudocaranx dentex*
	Weedfish, southern crested	*Cristiceps australis*
	Weedfish, unspec.	*Cristiceps sp.*
	Whiting, grass	*Haletta semifasciata*
	Whiting, King George	*Sillaginodes punctata*
Other	Mixed Algae	*Unspec. Algae*
	Ascidians	*Class Ascidiacae*

13.5 Summary of variables for classification categories.

Frequency tables are given for discrete variables and summary statistics are given for continuous variables.

13.5.1 Ward's method classification.

Cluster W1

Discrete Variables

FLOAT/SINK	Sinking:19
ANCHOR	Beach:19
WINGMESH	102:1 51:1 57:2 70:2 89:7 90:2 95:4
WINGPLY	18:7 21:1 24:3 30:2 32:1 36:1 8:1 9:3
WINGMATERIAL	Nylon:6 Poly:13
SHOULMESH	102:1 25:1 57:2 64:1 70:2 89:5 90:2 95:5
SHOULPLY	10:1 12:3 18:4 24:2 30:5 32:2 33:1 36:1
SHOULMATERIAL	Nylon:6 Poly:13
BAGMESH	13:1 57:3 64:3 76:2 89:3 90:2 95:5
BAGPLY	12:1 15:1 24:7 26:1 30:5 32:2 33:1 36:1
BAGMATERIAL	Nylon:5 Poly:14

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(80.0, 600.0)	350.0	152.86159317
WINGLENGTH1	(110.0, 320.0)	262.36842105	71.82866228
WINGLENGTH2	(110.0, 320.0)	262.36842105	71.82866228
WINGSTUD/FLOAT	(4.0, 6.0)	4.94736842	0.84811452
WINGSTUD/LEAD	(1.0, 3.0)	2.02631579	0.53938453
SHOULLENGTH1	(40.0, 125.0)	63.15789474	29.06938664
SHOULSTUD/FLOAT	(4.0, 6.0)	4.94736842	0.84811452
SHOULSTUD/LEAD	(1.0, 3.0)	2.02631579	0.53938453
BAGLENGTH	(5.0, 20.0)	14.21052632	5.83646532
BAGSTUD/FLOAT	(3.0, 6.0)	3.89473684	0.87526103
BAGSTUD/LEAD	(1.0, 3.0)	1.86842105	0.52286883
WDROPIN	(2.0, 6.0)	3.42105263	1.30493889
BAGDROP	(2.5, 9.0)	4.16842105	1.70849272
LEADSLING	(0.5, 0.7)	0.54210526	0.07685332

Cluster W2

Discrete Variables

FLOAT/SINK	Floating:14 Sinking:51
ANCHOR	0:1 One end:3 Beach:61
WINGMESH	19:2 20:1 25:5 29:1 32:5 38:5 45:32 48:2 51:3 55:2 57:1 64:3 70:1 ≥92:2
WINGPLY	11:1 12:19 15:3 16:2 18:11 24:2 8:2 9:24
WINGMATERIAL	Nylon:45 Poly:20
SHOULMESH	0:1 19:2 20:1 25:13 29:20 32:17 38:3 45:2 55:2 64:2 89:2
SHOULPLY	0:1 12:25 14:1 15:4 18:13 24:4 25:1 32:5 8:2 9:8
SHOULMATERIAL	0:1 Nylon:54 Poly:10
BAGMESH	0:2 19:2 20:1 25:20 29:20 32:12 45:2 55:2 64:2 89:2
BAGPLY	0:2 12:6 14:1 15:7 18:27 19:1 24:5 32:5 36:2 8:1 9:7
BAGMATERIAL	0:2 Nylon:44 Poly:19

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(0.0, 1000.0)	373.89230769	248.81406983
WINGLENGTH1	(10.0, 320.0)	148.87692308	74.66979554
WINGLENGTH2	(0.0, 320.0)	146.56923077	77.17208231
WINGSTUD/FLOAT	(2.0, 30.0)	7.44444444	4.63081466
WINGSTUD/LEAD	(1.0, 12.0)	4.24603175	2.52227658
SHOULLENGTH1	(0.0, 70.0)	23.66153846	12.60614548
SHOULSTUD/FLOAT	(0.0, 10.0)	5.80952381	2.30607293
SHOULSTUD/LEAD	(0.0, 12.0)	3.70634921	1.91689206
BAGLENGTH	(0.0, 20.0)	6.77692308	3.69123833
BAGSTUD/FLOAT	(0.0, 10.0)	5.11111111	2.39024301
BAGSTUD/LEAD	(0.0, 12.0)	3.57142857	1.84009367
WDROPIN	(1.0, 8.0)	2.346875	1.48462691
BAGDROP	(1.5, 8.0)	2.8	1.5751984
LEADSLING	(0.3, 0.7)	0.50634921	0.07802608

Cluster W3

Discrete Variables

FLOAT/SINK	Sinking:20
ANCHOR	Anchor one end of net.:20
WINGMESH	25:3 45:1 48:5 51:9 73:2
WINGPLY	12:5 9:15
WINGMATERIAL	Nylon:11 Poly:9
SHOULMESH	25:4 29:11 32:4 51:1
SHOULPLY	12:2 6:2 9:16
SHOULMATERIAL	Nylon:5 Poly:15
BAGMESH	25:6 29:10 32:4
BAGPLY	10:2 12:2 6:2 9:14
BAGMATERIAL	Nylon:4 Poly:16

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(0.0, 0.0)	0.0	0.0
WINGLENGTH1	(250.0, 580.0)	471.4	95.07692177
WINGLENGTH2	(0.0, 0.0)	0.0	0.0
WINGSTUD/FLOAT	(6.0, 15.0)	10.0	2.38415824
WINGSTUD/LEAD	(1.5, 15.0)	3.75	3.96199046
SHOULLENGTH1	(15.0, 80.0)	39.4	17.86322303
SHOULSTUD/FLOAT	(5.0, 15.0)	8.8	2.87640126
SHOULSTUD/LEAD	(1.5, 15.0)	3.55	3.99637994
BAGLENGTH	(4.0, 10.0)	5.615	1.73395653
BAGSTUD/FLOAT	(2.0, 12.0)	5.35	2.51887611
BAGSTUD/LEAD	(1.5, 4.0)	2.275	0.75175234
WDROPIN	(1.0, 2.5)	1.85	0.49364381
BAGDROP	(2.0, 3.6)	2.77	0.37430638
LEADSLING	(0.5, 0.6)	0.545	0.05104178

13.5.2 *Farthest neighbour method classification.*

Cluster F1

Discrete Variables

FLOAT/SINK	Floating:1 Sinking:1
ANCHOR	0:1 Beach:1
WINGMESH	32:1 70:1
WINGPLY	12:1 9:1
WINGMATERIAL	Nylon:2
SHOULMESH	29:1 32:1
SHOULPLY	12:1 9:1
SHOULMATERIAL	Nylon:2
BAGMESH	29:2
BAGPLY	12:2
BAGMATERIAL	Nylon:2

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(2.0, 450.0)	226.0	316.78383797
WINGLENGTH1	(10.0, 320.0)	165.0	219.20310217
WINGLENGTH2	(10.0, 320.0)	165.0	219.20310217
WINGSTUD/FLOAT	(4.0, 10.0)	7.0	4.24264069
WINGSTUD/LEAD	(10.0, 12.0)	11.0	1.41421356
SHOULLENGTH1	(8.0, 40.0)	24.0	22.627417
SHOULSTUD/FLOAT	(4.0, 10.0)	7.0	4.24264069
SHOULSTUD/LEAD	(10.0, 12.0)	11.0	1.41421356
BAGLENGTH	(10.0, 15.0)	12.5	3.53553391
BAGSTUD/FLOAT	(4.0, 8.0)	6.0	2.82842712
BAGSTUD/LEAD	(8.0, 12.0)	10.0	2.82842712
WDROPIN	(1.2, 3.2)	2.2	1.41421356
BAGDROP	(3.0, 3.2)	3.1	0.14142136
LEADSLING	(0.5, 0.5)	0.5	0.0

Cluster F2

Discrete Variables

FLOAT/SINK	Sinking:21
ANCHOR	Beach:21
WINGMESH	102:1 51:1 57:2 70:2 89:7 90:2 92:1 95:5
WINGPLY	15:2 18:7 21:1 24:3 30:2 32:1 36:1 8:1 9:3
WINGMATERIAL	Nylon:6 Poly:15
SHOULMESH	102:1 25:1 57:2 64:1 70:2 89:7 90:2 95:5
SHOULPLY	10:1 12:3 18:4 24:2 30:5 32:4 33:1 36:1
SHOULMATERIAL	Nylon:6 Poly:15
BAGMESH	13:1 57:3 64:3 76:2 89:5 90:2 95:5
BAGPLY	12:1 15:1 24:7 26:1 30:5 32:4 33:1 36:1
BAGMATERIAL	Nylon:5 Poly:16

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(80.0, 600.0)	334.76190476	152.82732241
WINGLENGTH1	(110.0, 320.0)	261.19047619	68.24413458
WINGLENGTH2	(110.0, 320.0)	261.19047619	68.24413458
WINGSTUD/FLOAT	(4.0, 6.0)	5.04761905	0.86464967
WINGSTUD/LEAD	(1.0, 3.0)	2.02380952	0.51176632
SHOULLENGTH1	(22.0, 125.0)	59.38095238	30.05075072
SHOULSTUD/FLOAT	(4.0, 6.0)	5.04761905	0.86464967
SHOULSTUD/LEAD	(1.0, 3.0)	2.02380952	0.51176632
BAGLENGTH	(5.0, 20.0)	13.61904762	5.87772227
BAGSTUD/FLOAT	(3.0, 6.0)	4.0	0.9486833
BAGSTUD/LEAD	(1.0, 3.0)	1.88095238	0.49761335
WDROPIN	(2.0, 6.0)	3.28571429	1.30968917
BAGDROP	(2.4, 9.0)	4.0047619	1.70131602
LEADSLING	(0.5, 0.7)	0.53809524	0.07400129

Cluster F3

Discrete Variables

FLOAT/SINK	Floating:1 Sinking:6
ANCHOR	Anchor one end of net.:1 Beach:6
WINGMESH	20:1 32:1 51:1 55:2 64:2
WINGPLY	12:1 18:3 24:2 9:1
WINGMATERIAL	Nylon:6 Poly:1
SHOULMESH	20:1 32:2 55:2 64:2
SHOULPLY	12:2 18:2 24:2 25:1
SHOULMATERIAL	Nylon:6 Poly:1
BAGMESH	20:1 25:2 55:2 64:2
BAGPLY	12:1 18:2 24:2 36:2
BAGMATERIAL	Nylon:6 Poly:1

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(0.0, 700.0)	315.0	308.07196129
WINGLENGTH1	(20.0, 250.0)	165.71428571	107.8358541
WINGLENGTH2	(20.0, 250.0)	162.14285714	110.74961034
WINGSTUD/FLOAT	(5.0, 9.0)	7.0	1.87082869
WINGSTUD/LEAD	(1.0, 5.0)	3.5	1.58113883
SHOULLENGTH1	(4.0, 25.0)	18.14285714	8.07111251
SHOULSTUD/FLOAT	(5.0, 8.0)	6.6	1.51657509
SHOULSTUD/LEAD	(1.0, 5.0)	3.3	1.4832397
BAGLENGTH	(2.0, 10.0)	6.14285714	3.76069902
BAGSTUD/FLOAT	(4.0, 8.0)	5.8	1.4832397
BAGSTUD/LEAD	(1.0, 5.0)	3.2	1.4832397
WDROPIN	(3.2, 8.0)	5.9	2.1330729
BAGDROP	(4.8, 8.0)	6.84285714	1.46043046
LEADSLING	(0.3, 0.5)	0.46	0.08944272

Cluster F4

Discrete Variables

FLOAT/SINK	Floating:12 Sinking:29
ANCHOR	Beach:41
WINGMESH	19:2 25:5 29:1 32:3 38:4 45:22 51:2 57:1 64:1
WINGPLY	12:16 15:1 18:7 8:2 9:14
WINGMATERIAL	Nylon:25 Poly:16
SHOULMESH	0:1 19:2 25:12 29:15 32:11
SHOULPLY	0:1 12:15 15:3 18:10 24:2 32:1 8:2 9:6
SHOULMATERIAL	0:1 Nylon:34 Poly:6
BAGMESH	19:2 25:17 29:11 32:9 45:2
BAGPLY	12:3 15:3 18:22 24:3 32:1 8:1 9:7
BAGMATERIAL	Nylon:30 Poly:11

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(0.0, 800.0)	351.6097561	199.28683826
WINGLENGTH1	(20.0, 200.0)	140.85365854	62.33881655
WINGLENGTH2	(0.0, 200.0)	137.80487805	66.07806728
WINGSTUD/FLOAT	(2.0, 18.0)	6.12195122	3.4655095
WINGSTUD/LEAD	(1.5, 12.0)	3.70731707	2.32372441
SHOULLENGTH1	(0.0, 70.0)	24.12195122	12.86700261
SHOULSTUD/FLOAT	(0.0, 8.0)	4.58536585	1.26442892
SHOULSTUD/LEAD	(0.0, 6.0)	3.07317073	1.22250243
BAGLENGTH	(2.0, 20.0)	6.87804878	3.61382845
BAGSTUD/FLOAT	(2.0, 6.0)	4.14634146	1.15240999
BAGSTUD/LEAD	(1.5, 6.0)	3.19512195	1.08902507
WDROPIN	(1.3, 3.5)	1.895	0.4094712
BAGDROP	(1.5, 3.5)	2.22195122	0.42983264
LEADSLING	(0.3, 0.7)	0.51219512	0.08998645

Cluster F5

Discrete Variables

FLOAT/SINK	Sinking:20
ANCHOR	Anchor one end of net.:20
WINGMESH	25:3 45:1 48:7 51:7 73:2
WINGPLY	12:3 9:17
WINGMATERIAL	Nylon:13 Poly:7
SHOULMESH	25:4 29:9 32:4 45:2 51:1
SHOULPLY	12:3 6:2 9:15
SHOULMATERIAL	Nylon:7 Poly:13
BAGMESH	0:2 25:4 29:10 32:4
BAGPLY	0:2 10:2 12:2 6:2 9:12
BAGMATERIAL	0:2 Nylon:4 Poly:14

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(0.0, 0.0)	0.0	0.0
WINGLENGTH1	(40.0, 580.0)	417.9	154.68198276
WINGLENGTH2	(0.0, 50.0)	4.5	13.94538218
WINGSTUD/FLOAT	(6.0, 12.0)	9.1	1.97084006
WINGSTUD/LEAD	(1.5, 4.0)	2.55	0.95834287
SHOULLENGTH1	(10.0, 80.0)	37.2	19.98051683
SHOULSTUD/FLOAT	(5.0, 12.0)	7.9	2.04939015
SHOULSTUD/LEAD	(1.5, 4.0)	2.45	0.95834287
BAGLENGTH	(0.0, 10.0)	5.015	2.43532663
BAGSTUD/FLOAT	(0.0, 12.0)	5.05	2.94645193
BAGSTUD/LEAD	(0.0, 4.0)	1.975	0.97972875
WDROPIN	(1.0, 2.5)	1.945	0.50935976
BAGDROP	(2.0, 3.6)	2.765	0.37874446
LEADSLING	(0.5, 0.6)	0.55	0.05129892

Cluster F6

Discrete Variables

FLOAT/SINK	Sinking:11
ANCHOR	Beach:11
WINGMESH	38:1 45:10
WINGPLY	11:1 12:1 16:2 18:1 9:6
WINGMATERIAL	Nylon:10 Poly:1
SHOULMESH	25:1 29:4 32:3 38:3
SHOULPLY	12:6 14:1 15:1 18:1 32:2
SHOULMATERIAL	Nylon:10 Poly:1
BAGMESH	25:1 29:7 32:3
BAGPLY	14:1 15:4 18:3 19:1 32:2
BAGMATERIAL	Nylon:6 Poly:5

Numeric Variables

Name	Range	Mean	Std Deviation
HAUL ROPE	(300.0, 1000.0)	622.72727273	242.24330369
WINGLENGTH1	(12.0, 220.0)	165.63636364	57.66675425
WINGLENGTH2	(12.0, 220.0)	165.63636364	57.66675425
WINGSTUD/FLOAT	(9.0, 30.0)	13.18181818	6.11258017
WINGSTUD/LEAD	(5.0, 7.5)	6.0	1.161895
SHOULLENGTH1	(4.0, 45.0)	27.90909091	13.59010335
SHOULSTUD/FLOAT	(9.0, 10.0)	9.72727273	0.46709937
SHOULSTUD/LEAD	(5.0, 7.0)	5.18181818	0.60302269
BAGLENGTH	(2.0, 10.0)	6.77272727	2.84045451
BAGSTUD/FLOAT	(8.0, 10.0)	9.18181818	0.75075719
BAGSTUD/LEAD	(4.0, 7.0)	4.90909091	0.80056798
WDROPIN	(1.0, 2.7)	1.8	0.53665631
BAGDROP	(1.7, 4.5)	2.45454545	0.92126395
LEADSLING	(0.5, 0.5)	0.5	0.0

Cluster F7

Discrete Variables

FLOAT/SINK	Sinking:2
ANCHOR	Anchor one end of net.:2
WINGMESH	51:2
WINGPLY	12:2
WINGMATERIAL	Poly:2
SHOULMESH	29:2
SHOULPLY	9:2
SHOULMATERIAL	Poly:2
BAGMESH	25:2
BAGPLY	9:2
BAGMATERIAL	Poly:2

Numeric Variables

Name	Range	Mean	StdDev
HAUL ROPE	(0.0, 0.0)	0.0	0.0
WINGLENGTH1	(580.0, 580.0)	580.0	0.0
WINGLENGTH2	(0.0, 0.0)	0.0	0.0
WINGSTUD/FLOAT	(15.0, 15.0)	15.0	0.0
WINGSTUD/LEAD	(15.0, 15.0)	15.0	0.0
SHOULLENGTH1	(32.0, 32.0)	32.0	0.0
SHOULSTUD/FLOAT	(15.0, 15.0)	15.0	0.0
SHOULSTUD/LEAD	(15.0, 15.0)	15.0	0.0
BAGLENGTH	(6.0, 6.0)	6.0	0.0
BAGSTUD/FLOAT	(3.0, 3.0)	3.0	0.0
BAGSTUD/LEAD	(3.0, 3.0)	3.0	0.0
WDROPIN	(1.5, 1.5)	1.5	0.0
BAGDROP	(2.5, 2.5)	2.5	0.0
LEADSLING	(0.5, 0.5)	0.5	0.0

13.6 Extension activities during the project

Extension activities conducted during the project are summarised in the following table.

Date	Activity
1 August 1997	Workshop with industry members, fishing gear technologists, and project staff to review project directions and potential for gear modifications.
December 1999	Segment titled 'Sustainable Seining in Corner Inlet' in 'Bycatch' No. 10: video series produced by the Information and Eduction unit of Fisheries Victoria
30 March 2000	Project results presented at the Corner Inlet Fishery Assessment Workshop
6 June 2000	Project results presented at the Gippsland Lakes Fishery Assessment Workshop for species other than black bream
July 2000	First Project Newsletter produced and disseminated (copy attached)
September 2000	Article in Marine and Coastal Community Network newsletter '*Waves'* Vol 7 No 3 Spring 2000 (copy attached).
January 2001	Second Project Newsletter produced and disseminated (copy attached)
27 April 2001	Presentation and discussion of results at annual meeting of the East Gippsland Estuary Fishermen's Association, at Lakes Entrance.
7 May 2001	Summary of project results included in presentation of research activities to staff of Port Phillip Bay Region of DNRE.
9 May 2001	Project results presented at the Black bream Stock Assessment Workshop
10 May 2001	Project results presented at the Lake Tyers Fishery Assessment Workshop
13 June 2001	Presentation and discussion of results at a specially convened meeting of the Corner Inlet Fishermen's Association, Welshpool.
11 July 2001	Project results presented at the Mallacoota Inlet Fishery Assessment Workshop
September 2001	Talk to Australian Society for Fish Biology annual conference in Bunbury Western Australia
October 2001	Third Project Newsletter produced and disseminated (copy attached)