FISHERIES RESEARCH REPORT NO. 100, 1993

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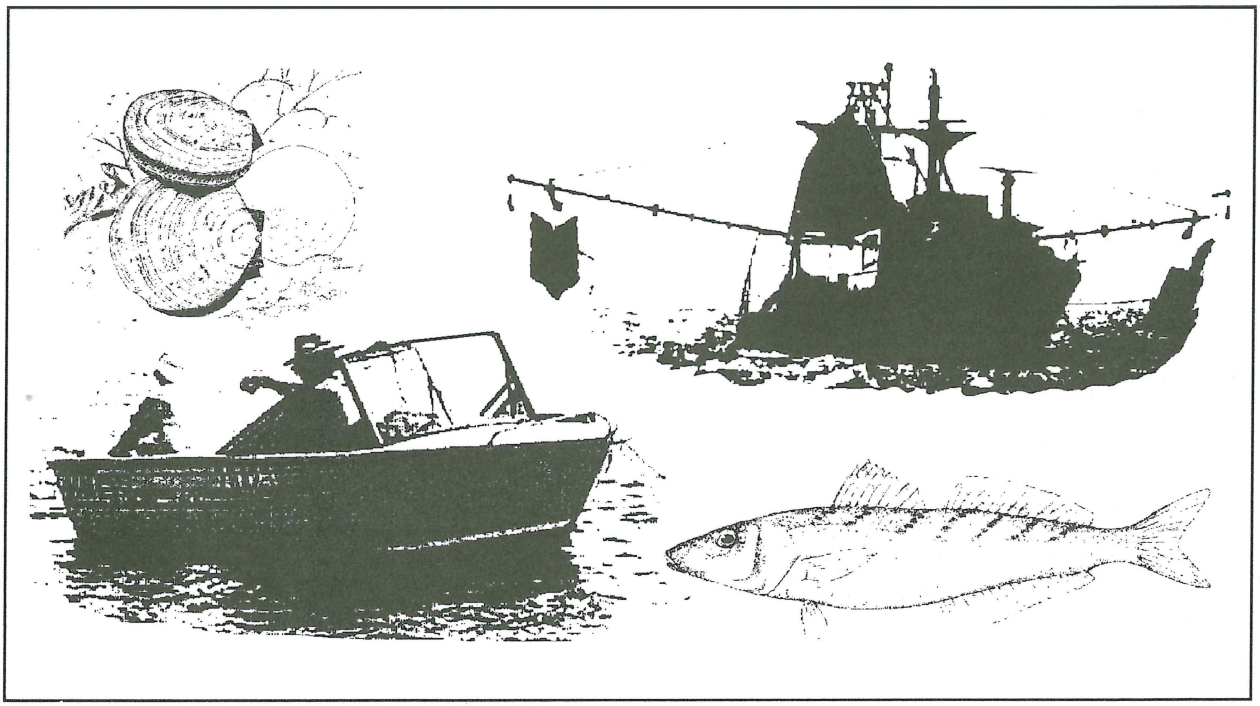

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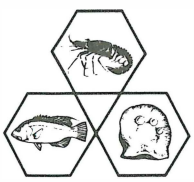

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Contents

The impact of trawling for saucer scallops and western king prawns on the benthic communities in coastal waters off south-western Australia

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Abstract

A two year study was undertaken to collect data for the assessment of the impact of the saucer scallop and western king prawn trawl fisheries on the benthic communities in coastal waters off south western Australia, between 31°20'S and 34°23'S latitude.

Monitoring of reported commercial landings, on-board sampling of commercial catches, research vessel trawl surveys, experimental and exploratory trawling, and underwater television observations, have enabled the development of an extensive data-base on the fishery and benthic communities of the region.

These data indicate that the existing fishery operates on a number of relatively small, discrete grounds where saucer scallops or prawns are abundant, and affects approximately 2 per cent of the waters shallower than 50 metres, within the fishery management zone. Recorded fishing effort and catches vary significantly from year to year, primarily in response to the abundance and price of saucer scallops and prawns which are the major target species in the southern sector of the fishery. During a year of intensive commercial catch sampling (1990/91), an estimated 354 tonnes of marine fauna were taken by the trawlers, comprising 109 tonnes of the target species, 21 tonnes of retained by-catch and 224 tonnes of discards of which approximately 67 per cent were unlikely to survive.

Research vessel surveys recorded 150 species of teleost (bony) fish, elasmobranchs (sharks and rays) and invertebrates from commercial trawl grounds. Of these species, 39 were recorded at some time in commercial landings, however only 5 species, in addition to the target species of saucer scallops and prawns, were taken in any quantity. Of the top 10 species taken as by-catch, only two species, the blue manna crab and southern school whiting were both abundant and of significant interest to recreational fishers. Other species in the trawl by-catch which were found to be reasonably abundant and also of recreational interest were sand trevally, red mullets, long spined and blue spotted flathead, squid and cuttlefish.

A detailed assessment of the stock of southern school whiting, the most recreationally important by-catch species, indicates that the adults are predominantly in offshore waters and more abundant in the northern half of the fishery. Surveys revealed that an extensive stock, in excess of 2000 tonnes, exists in the management area, and that trawl catches together with present recreational boat angling catches are not likely to exceed the estimated sustainable yield from the stock.

Underwater television observations indicated that productive scallop trawl grounds are predominantly sand substrates, and that such substrates dominate the fishery north of Geographe Bay. In contrast, the Geographe Bay sea-floor was found to be largely untrawlable with very limited areas of sand habitat suitable for saucer scallops. Comparisons of fish communities present in surveys of commercially trawled and untrawled grounds indicated that commercial trawling

had no significant impact on the benthic communities of existing commercial trawl grounds. Visual observations on these trawled sand substrates suggested that the physical impact of trawling was short lived.

The ground in the Zone D management sector (Comet Bay) was found to be atypical of the remainder of the fishery due to both the target species (western king prawns) and the size composition of the by-catch. The data show that Comet Bay, like other near-shore areas is a nursery area for a number of recreationally and commercially important species. However, only blue manna crabs, southern school whiting, goat fish and sand trevally were in significant numbers in the Zone D by-catch. The impact of trawling on the overall stocks of prawns, blue manna crabs and southern school whiting has been considered in detail.

1.0 Introduction

The development of a trawl fishery for saucer scallops (*Amusium balloti*) and western king prawns (*Penaeus latisulcatus*) in coastal waters off the south-west of Western Australia has raised public concern regarding the possible impact of trawling. These concerns generally fall into two categories,

(1) the physical impact of trawls on the ocean floor and its associated sessile flora and fauna and,

(2) the effects of exploitation on non-target species taken as by-catch, particularly for species which are also exploited by recreational or other commercial fishers.

Trawling in temperate waters of the Western Australian coast for saucer scallops occurs between Fremantle and Geographe Bay, in the lee of the Abrolhos Islands on the mid-west coast, and in the Esperance region of the western end of the Great Australian Bight. Trawling for western king prawns is, however, largely confined to the Comet Bay region to the north-west of Mandurah. In 1990, product valued at about $1 million was taken from the south-west inshore trawl fishery (Fig 1) which had a fleet strength of about 10 vessels. Since these vessels primarily target saucer scallops, which are mainly abundant in coastal embayments and in the lee of islands or substantial reef structures, this trawling activity is controversial, as it is concentrated in the inshore sections of the continental shelf, often near centers of human population.

Both the continued operation, and any further development of the south-west inshore trawl fishery is dependent on a number of factors. The key biological factors include,

(1) the ability of the stocks to withstand the fishing pressure generated by both the trawl fishery and any other fishing activities,

(2) the impact of trawling on non-target species which may impact on other fisheries, either recreational or commercial and,

(3) the ability of the habitat to withstand the impact of trawling over time.

These factors are not only important in Western Australia, but are common to most other inshore trawl fisheries in temperate Australian waters.

This study focused on a number of locations between Fremantle and Geographe Bay where the trawlers fish for saucer scallops, and in a single location, (Comet Bay) where western king prawns are the target species. A number of fin-fish species are also regularly taken as by-catch, the most commercially important of which are the whitings (*Sillago* spp.). Production and fishing activity varies substantially from year to year due to the natural recruitment driven variations in saucer scallop abundance, and the price of the marketed product. The catch taken by this fishery is usually sold fresh to the Perth markets and also caters to the tourism and restaurant industry of the south-west region.

Limited management of this developing fishery was undertaken in the early to mid 1980s, however, with the advent of the Offshore Constitutional Settlement in 1988, the Government of Western Australia was able to introduce a management plan which directly controlled trawl operations in all coastal waters from the Moore River to Cape Naturaliste. Initially, extensions to the closed areas were created to further protect inshore seagrass habitats, closed seasons were introduced to reduce the interaction between commercial and recreational fishing activities, and trawl mesh size controls were implemented in an attempt to reduce by-catch in some locations (Moore, 1989). These regulations, however, were based on the management and research experience from prawn trawl fisheries in the tropical north-west of the state, and have been criticized on the basis that temperate coastal water environments may require different management strategies.

A two year study funded by the Commonwealth Fishing Industry Research Committee and the Western Australian Fisheries and Development Fund was carried out to provide a scientific assessment of the impact of the south-west inshore trawl fishery on other species present in the trawl grounds and on the habitat itself. The specific purpose of the research programme was to provide information for the first full review of the present management plan for this trawl fishery. This report has been prepared to assist in the review process, and in addition, presents in a summarized form, an overview of the extensive database now available for future research on inshore fish communities.

1.1 History of commercial trawling in south-west coastal waters

1.1.1 The period between 1904 and 1978

The first trawl surveys of the south-west coastal waters were conducted in 1904 by the 91 tonne ketch *Rip* using otter trawls and steam driven winches (Gale, 1905). Nine trawls were attempted south of Mandurah and a further 17 directly off Fremantle.

Of the seven trawls attempted in the vicinity of the Naturaliste lighthouse, one was fouled. The numbers of animals caught in each trawl were low, with "large prawns" (probably western king prawns) and whiting (probably southern school whiting, *Sillago bassensis*) the only species caught in any quantities.

The trawls off Bunbury, in sight of the Bunbury light house, were unsuccessful with gear damage the main result. Gale wrote in 1905 that "...the ground proved to be very misleading, as the lead clearly showed sand bottom, evidently odd patches of coral exist all over the place, making it difficult to work with a sailing vessel".

While the damage to the nets was minimal in the Fremantle region, catches were not encouraging, with rays (probably *Urolophus* spp.) by far the most numerous species with 985 individuals caught, followed by whiting (probably southern school whiting) with 205 individuals.

Small scale commercial trawl fishing first began in the earlier part of the 1900s when small nets were towed by horses over shallow banks in Cockburn Sound (Penn, 1977). In the mid 1950s, a motorized trawl fishery targeting squid and fin-fish over seagrass

meadows also developed in the shallower areas of Owen Anchorage and Cockburn Sound. Concerns over the effects of these activities on the seagrass habitat, and a reduction in catches from Cockburn Sound, resulted in the Department of Fisheries closing the inshore areas to trawling in 1962. In August 1970, the remaining deeper areas of Cockburn Sound and Owen Anchorage were closed to commercial trawling to protect the stocks for recreational and non-trawling commercial fishing, and to avoid conflict with the increasing numbers of large ocean going vessels using the deeper areas of Cockburn Sound. Trawling for saucer scallops by Shark Bay prawn trawlers north-west of Fremantle, in the vicinity of Bell Buoy, began in the late 1960s and was the forerunner to the scallop trawl fishery operating today.

1.1.2 The period between 1979 and 1992

Consistent commercial exploitation of fisheries resources between Fremantle and Cape Naturaliste using trawlers began in the late 1970s and early 1980s. This development followed the conversion of a number of ex-rock lobster vessels to small trawlers to fish for western king prawns and saucer scallops, principally in the waters north-west of Fremantle. Although a number of commercial vessel skippers were aware of the existence of suitable western king prawn trawl grounds further to the south in Comet Bay off Mandurah, few attempts were made to exploit these before 1983. However, in the late summer/autumn period of 1982/1983, three small trawlers working out of Mandurah began to regularly fish this area. By the following spring, after reports of good catches of western king prawns, a further six vessels from the Geraldton based trawler fleet also commenced fishing these grounds.

This rapid increase in trawling in a relatively restricted, inshore region led to conflicts between the original and new trawler operators, and also with the Mandurah community who suggested that trawling in the area would deplete western king prawn and blue manna crab (*Portunis pelagicus*) numbers and damage the important inshore habitat. There were also complaints from residents regarding the noise from working trawlers. These concerns were allayed to some extent in 1983, by the introduction of a near-shore closure to trawling, and the establishment of a small, restricted entry fishery in State Territorial Waters. The latter closure covered an area of approximately 88km^2 located seaward of the shore-line closure but inside the Murray Reef system.

Sixteen applications seeking licence endorsements to fish in the restricted area were received. The Minister for Fisheries approved access for five small trawlers, comprising the initial three that first worked the area, together with a further two that commenced operations a little later.

Furthermore, to avoid potential conflicts, and to safeguard other likely inshore nursery areas, trawling was also prohibited within 800m of the high water mark between the mouth of the Moore River and Cape Naturaliste.

The closure of the Comet Bay fishery to all but five vessels led to a limited southern expansion of the south-west inshore trawl fishery, mostly by those vessels which did not gain access to the Comet Bay prawn fishery. The first reported commercial catches obtained in the Geographe Bay region occurred during October 1984, with two trawlers undertaking some "exploratory fishing" with the main target species being saucer

scallops and to a lesser extent southern school whiting. No further fishing occurred until October of the following year when a third vessel also undertook some "exploratory work" in the region (the vessels that worked the area in the previous year were no longer doing so).

The increasing exploitation in this region led the Minister for Fisheries to inform trawl operators (10 November 1985) that their continued access to this fishery could not be guaranteed, and that if access were restricted, then only those vessels with a history of full-time fishing in the area might be eligible for entry to the fishery. Low level exploratory fishing in Geographe Bay continued up until 1989, with a further four vessels entering and subsequently leaving the fishery. Much of the trawling activity in this area was seemingly influenced by the release of a joint statement (4 May 1987) by the Minister for Western Australian Fisheries and the Federal Minister for Primary Industry stating that trawling endorsements would be restricted to those fishers with a substantial history of trawling in the region. Four reasons for possible future trawling restrictions were given,

(1) that there were concerns over the possible damage to the wet line fishery,

(2) that the sea bed was considered to be fragile and potentially subject to severe damage by trawling,

(3) local wet line fishers were concerned about the increase in fishing pressure on the resource and,

(4) that trawling was incompatible with the rock lobster fishery.

In July 1989, a consistent pattern of trawling in Geographe Bay began to emerge, with three vessels more or less consistently fishing areas where saucer scallops occurred regularly. This level of exploitation reached a peak during 1990 with 1,066 boat days spent fishing in the area. The level of fishing effort has since declined.

1.2 Current management of trawling in south-west coastal waters

The Western Australian government obtained jurisdiction from the Commonwealth over inshore waters from three nautical miles out to the 200m isobath between longitude 125° E on the south coast and longitude 120° E on the west coast in April 1988. This allowed the establishment of the current management rules for the inshore trawl fishery. In January 1988, a draft management plan (Millington, 1988) was released for public comment. Thirty submissions were received and a number of changes were incorporated into the management plan. The south-west inshore trawl management plan (Moore, 1989) was released in February 1989 and the final plan gazetted in October of that year. The area managed under this plan stretches south from 31° 20'S, along the Western Australian coast to a line drawn south along 115° 8'E, inshore of the 200m isobath. Within this region, there are four management zones,

(1) the northern (Zone A) from 31° 20'S to 32° 16'S

(2) the southern (Zone B) from 32° 16'S to 115° 8'E,

(3) a seasonally closed region to the north-east of Cape Naturaliste (Zone C) and,

(4) the Mandurah inshore trawl fishery limited to Comet Bay (Zone D) (Fig. 1).

Currently (1993), there are 13 trawlers licensed to operate in the south-west inshore trawl fishery. There are three endorsements permitting fishing in Zone A, 11 in Zone B, four in Zone C and three in Zone D (Comet Bay) (most vessels hold endorsements for more than one fishing zone). These trawlers use 11 to 14.5m head rope length otter trawls with 45 or 100mm stretched mesh cod ends. The nets are hauled at between 2 and 3 knots and vessels can tow single, double or triple trawls. Zone D (Comet Bay) trawlers are only permitted to use a single 11.0m head rope net. Zone C (NE of Cape Naturaliste) trawlers are only permitted to use cod end mesh 100 mm or greater.

The size of vessels operating in this fishery is not permitted to exceed 375 boat units (see Moore 1989, for a detailed description of the methods used in calculating boat units). While there are 13 endorsements for the south-west inshore trawl fishery, only eight have been active in the last two years (1991-92). The largest vessel is 241 boat units which is well below the maximum of 375 boat units allowable for this fishery. Vessels range in length from 11 to 18m.

1.3 Current trawling activities

Although most of the area between Fremantle and Cape Naturaliste is open to commercial trawling, trawling usually only occurs on eight small fishing grounds in this region (Fig. 2). Only two of these trawl grounds (Comet Bay and a small area off the southern exit from Cockburn Sound) are fished for western king prawns. The remaining grounds are all fished primarily for saucer scallops.

The area of sea bed covered by the south-west inshore trawl fishery boundaries, inside the 200m isobath and between Moore River and Cape Naturaliste, is approximately 18,000km^2, however, the actively fished ground within this area covers approximately 250km^2, or about 1.4% of the total area.

Apart from management controls, the level of commercial trawling activity is largely determined by the weather and market factors. The most important aspect of the weather is the state of the sea. Generally, skippers will not trawl in seas or swells greater than 2 to 2.5m because the trawl nets cannot be operated efficiently or safely in such conditions. In the more exposed waters of zones A and B, most of the winter and some of the summer is lost due to unsuitable wind and sea conditions. Trawling activity in the protected waters of Comet Bay (Zone D) tends to be less dependent on sea conditions, but the seasonal presence of western king prawns, and to some extent, drift weed (detached seagrass and algae) on the trawl ground, restricts trawling to between October and May or June of the following year.

Trawling, whether for western king prawns or saucer scallops, is mostly undertaken at night. Vessels travelling further than 10nm to trawl grounds, generally spend two or three nights on the ground. The period a net is fishing on the bottom (termed a shot) varies from 30 minutes up to three hours, depending on the catch rates at that time.

The smaller trawlers carry only the skipper plus one crew while the larger trawlers carry up to three crew. A maximum of 25 people (including the license operators) were directly employed aboard trawlers with access to the south-west inshore trawl fishery during 1991. In 1992 there were approximately 14 people directly employed.

All vessels in the south-west inshore trawl fleet are fitted with radar and a number have Global Positioning System navigational equipment (GPS). Originally, radar and light marker buoys were deployed to aid in trawling, however, GPS has now largely taken over as the means of locating and fishing on individual trawl grounds.

Most of the catch, particularly saucer scallops, is processed at sea and stored on ice or in cool-rooms on board each vessel. Western king prawns are graded according to size and stored in a refrigerated brine or ice slurry until landed.

In addition to favourable weather conditions, the price that trawler skippers obtain for their target species also determines whether fishing occurs. During the latter half of 1992, for example, the market price for saucer scallop meat decreased from approximately $20 per kilogram to about $8 per kilogram due to an unusual over-supply of product from the Shark Bay fishery. The price reduction resulted in most Zone B and C trawlers either ceasing fishing, or diversifying into other commercial fishing activities. The operations of Zone A trawlers were less affected by the low market value for saucer scallops.

The catch from the south-west inshore trawl fishery is mostly marketed directly to the public via local retail outlets. Saucer scallops are marketed mainly as scallop meat, however, small quantities of scallops in the shell and half-shell are also sold. Western king prawns from Zone D (Comet Bay) and the by-catch from all four zones are sold in the Perth metropolitan area and regional towns such as Mandurah. The wholesale market prices in December 1992 for fresh western king prawns and saucer scallops were $10-14 and $12 per kilogram, respectively.

1.4 Objectives

One of the main purposes of the study was to examine the impact of the south-west inshore trawl fishery on other recreational and commercial species and their dependent habitat. To achieve this, three specific objectives were identified,

(1) document the occurrence of commercially and recreationally important fish species in the trawl by-catch,

(2) study aspects of the biology of whiting species which dominate the trawl by-catch and,

(3) examine experimentally and visually the impact of trawling on the benthic community of saucer scallop trawl grounds.

The above three objectives were further divided into a series of more specific questions which are likely to be raised in a review of the existing management plan for the fishery.

1.4.1 Commercial by-catch

(1) Which species and what quantities of each of these species are retained and discarded by commercial trawlers?

Trawling catches a wide variety of vertebrate and invertebrate species in addition to the intended target species. Some of these by-catch species have some commercial value while others do not and are usually discarded. Part of this study was to estimate the levels of discarded by-catch on the main trawl grounds in this fishery.

(2) Does the composition and quantity of the total commercial catch (including retained and discarded by-catch) vary substantially from one ground to the next?

The south-west inshore trawl fishery covers a large area, approximately 18,000km^2 inside the 200m isobath. Within this region there are a number of small discrete trawl grounds. While the substrate in each of these fishing grounds is predominantly sand, an understanding of the degree to which the composition and abundance of the fauna varies between each of these grounds was required.

(3) To what extent does mesh size influence the catch of recreational and commercially important species?

The catches from trawl nets can be altered substantially by varying their stretched mesh size. Generally, the smaller the mesh size, the smaller the animals which can be caught and the greater their number. The study endeavored to evaluate the variation in the effectiveness of the two different mesh sizes (45 and 100mm) which were specified in the original management plan (Moore, 1989).

(4) Are juvenile fish and crustaceans caught in substantial quantities by the fishery?

The purpose of this component of the study was to establish whether juvenile animals were caught in large quantities in any of the regularly commercially fished grounds of the south-west inshore trawl fishery.

1.4.2 Status and biology of the whiting species

The three main questions in the whiting study were:

(1) What is the general biology of whiting species in the south-west inshore trawl fishery region?

A number of whiting species occur in the south-west trawl region and are important to both the commercial and recreational fishing community. Future management of those species impacted by trawling requires an understanding of their general biology. This component of the study was undertaken in collaboration with Murdoch University. As this study is still in progress, only preliminary results are reported here.

(2) What is the proportion of the total whiting stock fished by the commercial fleet?

Whiting are known to occur in many areas on the continental shelf, however, the extent of their distribution outside the regular trawl grounds is not known. The purpose of this part of the study was to attempt to establish the extent of the habitat suitable for these

species; provide some estimate of the standing stocks available in these habitats, and from these data estimate the proportion of the standing stock currently exploited by the commercial trawl fishery.

(3) Does the size of whiting vary across the south-west inshore trawl region and what regions are important as nursery areas?

Whiting are widely distributed through the south-west inshore trawl region and some species are frequently taken as by-catch by trawlers. However, little is known about the size distribution of these species. The importance of this part of the study was to identify those areas in the inshore trawl region which are whiting nursery habitats.

1.4.3 Impact of scallop trawling on the trawl grounds

(1) What are the characteristics of the areas trawled for saucer scallops?

While saucer scallops are widely distributed along the coast of Western Australia, commercial quantities of this species are generally only found in a relatively few discrete areas. This aspect of the study sets out to describe the visual characteristics of the substrate in areas which are considered "good" commercial saucer scallop trawl grounds.

(2) What modification occurs to the substrate and its biota as a result of the passage of otter trawls?

The process of trawling can cause damage to sessile organisms such as sponges and seagrasses. This aspect of the study examines the extent to which the passage of otter trawls effects and removes the benthic biota associated with scallop habitats.

2.0 Materials and methods

2.1 Commercial fishing monitoring programme

2.1.1 Catch and effort statistics system database (CAESS)

Commercial fishers in Western Australia are required, as a condition of their commercial fishing licence, to provide monthly information on their fishing activities. Typically, these data include the total catch of each species and some measure of fishing effort. These catch and effort returns are routinely entered into a computer database known as the CAESS system (Catch and Effort Statistics System).

The CAESS system records data on a large grid (1^{o} x 1^{o}, approximately 110x110km blocks), and since none of the block boundaries coincide with the boundaries of the management zones in the south-west inshore trawl fishery, it is difficult to extract data separately for each zone. While this does not present great difficulties when dealing with Zone A (fishing is conducted well inside the zone boundaries), it does not readily allow separation of data from small management areas such as Zones C and D (Fig. 1).

The main distinguishing feature of the catches of Zones A, B, C and D are the target species catches. In the former three zones the target species is saucer scallops while in Zone D it is western king prawns. The target species catch of Zone D can be separated from the other three management zones since western king prawns are generally not caught in large numbers elsewhere in this fishery. This method of extracting the target species catch from Zone D cannot be applied to the saucer scallop catches from Zone C since this species is also caught in Zone B. It also cannot be applied to by-catch data in Zones C and D since the same by-catch species occur in Zone B. Consequently, the by-catch from Zones C and D have been included in the total by-catch from Zone B.

It was necessary, however, to obtain some measure of the target species catch from Zone C to estimate the retained and discarded by-catch from this zone (see section 2.1.2).

A rough estimate of the catch of saucer scallops from Zone C can be obtained by excluding all catches from Zone B which fall outside the open season for Zone C (*i.e.* July to September) and excluding the catches of all vessels without access to Zone C. However, the resulting value will tend to over-estimate the catch of saucer scallops from Zone C, since the vessels may fish in both Zones B and C during this period.

The best measure of targeted fishing effort available from the CAESS data set was the number of days all boats spent fishing in each calendar year. Catch per unit effort (CPUE) was calculated by obtaining the ratio of the total catch of the target species and the total number of boat days, summed over all vessels, during each calendar year.

Thus the following data were extracted from the CAESS database,

(1) the target species catch and effort from Zone A,

(2) the target species catch from Zones B and C combined,

(3) an estimate of the target species catch from Zone C,

(4) the effort from Zones B, C and D combined,

(5) the by-catch from Zone A, and

(6) the by-catch from Zones B, C and D combined.

The common names for fish species in the CAESS system refer to the groups of species given in Table 1.

2.1.2 Research sampling aboard commercial vessels

Between March 1991 and February 1992 research personnel collected data on board commercial vessels operating in the south-west inshore trawl fishery (Appendix 1). The time, location, depth and duration of each trawl were recorded along with the number of crew and configuration of the fishing gear. At the completion of each trawl, the following catch data were recorded,

(1) volume of catch (number of baskets - including weed), where one basket contains approximately $0.05m^3$,

(2) total catch of the target species; saucer scallops in Zones A, B and C (number of baskets), and western king prawns in Zone D (kg),

(3) volume of drift weed (baskets),

(4) weight (kg) and number of fish and total lengths (mm) of commercial and recreational by-catch species and,

(5) weight (kg) and number of non-commercial and non-recreational by-catch species (includes sponges, molluscs *etc.*).

The data collected while on board commercial vessels provided considerable information concerning the species composition of the total catch (including retained and discarded species) during a small part of the fishing season. To estimate the annual discarded and retained by-catch rates from each management zone, it was necessary to scale the data collected during some part of the year (between autumn 1991 and summer 1991/92) up to a full year.

Thus, to obtain an estimated total annual discarded and retained by-catch (tonnes) for the commercial fishery for each species and group of species in each management zone of the fishery (criterion used for categorizing groups of species is defined in Table 1), the catches measured by research personnel on board commercial vessels were multiplied by a scaling factor obtained using the following method.

The scaling factor for each management zone was obtained from the ratio of the catch of the target species recorded by research personnel aboard trawlers and the catch recorded for that species in the CAESS database. This method assumed that,

(1) the catch measured by research personnel on board commercial vessels in a zone during some part of a year was proportional to the total catch of the entire fleet fishing in that zone during that year,

(2) that catches of the commercial fleet were sampled randomly and,

(3) the data recorded in the CAESS database was a true reflection of the annual total catch of the target species in each management zone.

The above method of scaling was applied to data collected from Zones A, B and C using saucer scallops as the target species, and from Zone D using western king prawns as the target species.

2.2 Research vessel surveys

2.2.1 Seasonal surveys

Trawling was carried out using the *R.V. Flinders* a 20.4m, twin rigged otter trawler. The starboard gear was a standard 11m (head rope length) commercial prawn trawling net with stretched meshes of 50mm in the wings and 45mm in the cod end. A 10mm ground chain was positioned two links ahead of the ground rope. The port net was similar in all respects to the starboard, with the exception of 100mm stretched meshes in both the wings and cod end. The width swept by each net, including the otter boards, was approximately 8m. The above gear was used at nine sites during four consecutive seasons between Autumn 1991 and Summer 1991/92 (autumn - March to May, winter - June to August, spring - September to November, summer - December to February) (Fig. 2, Table 2, Appendix 1). The design of these nets was identical to those used by vessels in the commercial fleet.

Four by fifteen minute night trawls at approximately 2.5 knots were conducted at each site. The start (time the gear started fishing the bottom) and end (time the gear was lifted off the bottom) time, latitude and longitude (GPS) were recorded for each trawl. The distance of each trawl was calculated from the start and end GPS positions.

The entire contents of each cod end was emptied onto each half of a divided sorting table, identified (where possible), sorted into species, counted and weighed (nearest 10g). The lengths in millimeters (fish - total length, crustaceans - carapace length) of a minimum of 30 individuals (if available) of each species were recorded from each trawl site.

These data were used to compile comprehensive species lists of the fauna caught by this method of fishing on each fishing ground.

The catch rates were standardized to grams and numbers of individuals caught per hectare by dividing the catch for each trawl by the product of the sweeping width of the net and the distance trawled.

The abundance data collected with 45mm research trawl nets between autumn 1991 and summer 1991/92 were subjected to a cluster analysis using PATN (Pattern Analysis Package, using the Bray-Curtis equation) (Belbin, 1988). Cluster analysis is used to group similar and highly correlated variables into groups, thereby providing some indication of how closely the different variables are related to each another. The analysis is often presented as a tree-type dendogram.

An additional survey was conducted in autumn 1992 to examine the escapement of juvenile animals from the standard 45mm stretched mesh trawl net (Appendix 1). During this experiment, a 25mm mesh cod end cover net was placed over the normal 45mm mesh cod end to catch the smaller animals escaping through the larger mesh cod end.

2.2.2 Underwater video camera observations

On every available opportunity between December 1990 and May 1992 (Appendix 1), the benthic environment of a large region of Geographe Bay was examined using an ROV (Remotely Operated Vehicle) underwater video camera system.

The ROV consisted of a standard colour security camera mounted in a waterproof housing, and attached to the vessel by a cable tether. The camera was powered from the surface through a second cable which also provided a link to the surface for the video signal. While in operation, the video signal was fed directly into a video cassette recorder (VCR) located on the vessel. The VCR also received positional input from the vessels GPS via a portable computer linked to the GPS by modem. The computer provided the facility for the operator to record a description of the benthic environment, along with the current GPS position onto computer disk. The ROV was generally towed at less than three knots and generally < 1 m above the seabed. This allowed the observer to view a good quality image of a strip of seabed approximately 5 m wide. Every 15 seconds (approximately every 15 m) the observer entered a description of the seabed, while the date, time and current latitude and longitude were entered automatically from the GPS.

The ROV observations collected in Geographe Bay were separated into 500 x 500 m blocks and the data within each block summarized according to one of the following five categories.

(1) 100% sand

(2) >50% *Posidonia* seagrass

(3) >50% *Amphibolis* seagrass,

(4) >1% rock, and

(5) attached algae/sponge/weed etc.

Only category (1) above (ie 100% sand) is considered trawlable.

2.2.3 Depletion experiment

One of the most important and valuable pieces of information that can be provided to managers of biological resources is some knowledge of the total weight and numbers of individuals that can be found in a particular area. This information can be very difficult to obtain for marine species which cannot be directly observed and counted. However, in ideal circumstances, the total weight and numbers of a species living in a defined and small area of a marine environment, can be estimated by repeatedly fishing the area and documenting the rate of decline in the catch rates from that area. This experimental method is known as a depletion, Leslie or De Lury experiment (Ricker, 1958), and in addition provides an estimate of the efficiency of the gear in capturing animals in its path.

Experiments using this method make a number of assumptions concerning the performance of the gear, behaviour of species and catchability of species. These include,

(1) the vulnerability of the population to capture should not change during the course of the experiment,

(2) the whole population should be available to capture, *i.e.* migration into or out of the area is minimal and,

(3) there should be no significant excess of recruitment over natural mortality, or the reverse, during the course of the experiment.

A marine environment does not generally allow all of the above assumptions to be fully satisfied, and a number of them may be violated, particularly by larger more mobile free swimming species. However, this method has been successfully demonstrated by Joll & Penn (1990) on saucer scallops and western king prawns in Shark Bay, and it is considered to be useful for smaller fish species of limited mobility.

Two experiments of this type were conducted in Geographe Bay in waters ranging between 30 and 35m in depth. The first in an area where commercial trawling occurs at 33° 35.369'S and 115° 20.868'E (the Capel commercial trawl ground), and the second on what was considered to be previously untrawled ground at 33° 25.029'S and 115° 17.217'E (immediately adjacent to the Capel trawl ground) (Figs. 2, 13). The experiment conducted on the known commercial trawl ground occurred on the 20 February 1992 and that on the known commercially untrawled ground on the 21 February 1992 (Appendix 1). From initial ROV observations, the dominant substrate in both these areas was sand. The methodology for conducting this type of experiment in open waters has been described by Joll & Penn (1990). In summary, high precision navigation equipment was used (in this study, a Motorola Miniranger Position System) to guide the research vessel along pre-defined tracks during trawling. The high degree of navigational accuracy (within 2m) permitted the repeated trawling of the selected experimental area in these open sea locations.

The two experimental areas were approximately 500m long and 74m wide. Each was completely swept by the trawl gear on four successive occasions during a single night, with one sweep over each area consisting of four trawls, and taking about two hours.

While the main species of interest in these experiments were the saucer scallops and whiting, the total number and total weight of all other species which were caught in each sweep were also recorded. The lengths of a maximum of 30 individuals of each species of fish were recorded from each sweep of both areas.

Since equal units of effort were used in each of the four sweeps over the experimental areas, the data were analysed using the special case scenario described by Ricker (1958) in which cumulative catch can be plotted directly against catch.

The relationship developed between catch and cumulative catch should be linear with the slope equivalent to the catchability (or efficiency of the trawl gear), and the intercept on the cumulative catch axis corresponding to the original size of the population in the experimental area. The estimate of the density of animals in each experimental area was converted to numbers per hectare by obtaining the ratio of the original population size and the area of the experimental area in hectares (3.7 ha).

2.2.4 Statistical methods for mesh selection and seasonal catch rate comparisons

The lengths of different species of fish caught in the 45 and 100mm stretched mesh trawl nets during the seasonal research vessel surveys were compared using a Students t-test (Sokal & Rohlf, 1981).

Analysis of variance was used to compare the catch rates of whiting species among seasons. Homogeneity of variances was tested with Hartley's F_{max} test (Sokal & Rohlf, 1981).

2.2.5 Whiting and saucer scallop surveys

During May 1992 (Appendix 1), considerable time was spent searching for suitable trawl sites between Fremantle and Cape Naturaliste inside the 50m isobath. This search involved cruising along transects, previously identified from navigational charts and discussions with commercial vessel skippers, as locations potentially safe for trawling. During these transects, the echo sounder was carefully monitored and when ground was identified as potentially trawlable on the echo trace, the ROV was winched over the side to visually inspect the substrate. Although benthic descriptions were being recorded every 15 seconds, the inspection of the bottom was continuous during this period. The area was considered to be potentially trawlable if the substrate was found to be mostly sand for a distance of 1.5nm. Further ROV inspections of the 1.5nm transect were undertaken until a clear area sufficiently large to enable three separate trawls to be conducted was identified.

At each suitable trawl site located using this method, three shots of 15 minutes duration, using two standard 45mm mesh prawn trawl nets, were conducted (the data recorded for each shot was identical to that described earlier, section 2.2.1). All whiting species and scallops were identified, sorted and counted. For each shot, the total weight of the catch of each species was recorded and the total length of a minimum of 20 individuals of each species of whiting (if available) were measured.

Average catch rates for each site were standardized to kilograms and numbers per hectare using the methods described earlier in section 2.2.1 (Note that calculations in 2.2.1 were standardized to g/ha).

Estimates of the total biomass of southern school whiting were calculated by dividing the survey area into four regions,

(1) 31° 45'S to 32° 15'S,

(2) 32° 15'S to 32° 30'S.

(3) 32° 30'S to 33° 15'S and,

(4) 33° 15'S to 33° 40'S.

Within each of these four regions, and inside the 50m isobath, the following data were used to estimate the biomass of southern school whiting,

(1) the mean catch rate for southern school whiting (kg/ha) obtained from the survey described above,

(2) the estimated available habitat in which southern school whiting could be reasonably expected to occur. These data were obtained from the ROV observations (section 2.2.2) by calculating the percentage of the total number of observations that were exclusively sand (*i.e.* southern school whiting habitat) and assuming that an equivalent proportion of each region was reasonable southern school whiting habitat and,

(3) a correction factor for the efficiency of the trawl net in catching southern school whiting (obtained from the depletion experiment, section 2.2.3).

The biomass of southern school whiting in the area between Fremantle and Cape Naturaliste was estimated from the sum of the biomass values calculated for each of the above four regions.

2.3 Terminology and definitions

For the purposes of this report, and to ensure that there is no confusion in the terms, the following definitions have been used for *weed, total catch, landed catch, target species catch, retained by-catch* and *discarded by-catch.*

(1) *Weed* - detached drift seagrass or algae (not included in any of the categories defined below).

(2) *Total catch* - the sum of the catch of the target species and retained by-catch species. This is comprised of the following;

(i) *Landed catch* - the sum of the target species and by-catch species which are recorded in the commercial statistics as brought to shore and sold. This category does not include information on discarded material.

(a) Target species catch - The catch of those species which are the primary species sought by trawler operators, *i.e.* saucer scallops or western king prawns.

(b) *Retained by-catch* - by-catch species which have some commercial value and are retained by trawler operators.

(ii) *Discarded by-catch* - those animals which have no commercial value to trawler operators and are returned to the sea (N.B. This category includes undersized individuals of commercial species).

In many cases "rounding errors" have resulted in slight overestimates of sub-total and total values presented in the tables in this report.

3.0 Results and discussion

A particularly large and complex set of data has been collected during the two year study. As a consequence, it will take some time for most of the data to be published in peer reviewed scientific journals. However, there is an urgent need to provide the information necessary to address the important fisheries management and environmental issues presented in the introduction. This section provides an overview of the data and a basic analysis for these purposes.

3.1 Commercial catch

3.1.1 Landed catches (CAESS data)

The Fisheries Department of Western Australia's catch and effort statistics system (CAESS) provides some information on the reported landed commercial catch of the target species (saucer scallops) and reported retained by-catch dating back to the late 1970s.

The retained by-catch recorded in the CAESS system gives limited information concerning the total by-catch of the fishery, since the marketability of different species may vary over time and quantities of undersized animals of normally retained by-catch species are also discarded. This characteristic of the CAESS data applies to the data from all zones in the south-west inshore trawl fishery.

Data on the retained by-catch of commercial trawlers in the south-west inshore trawl fishing area before the implementation of the specific management plans in 1988 is difficult to validate, and has not been included in this report.

(1) CAESS data Zone A - north-west of Fremantle

While the annual catch of the target species (saucer scallops) in Zone A has ranged up to a maximum of 58 tonnes (1990) (Fig. 3), the annual retained by-catch has fluctuated between 5 and 8 tonnes between 1988 and 1991 (Table 3). In 1988 and 1989, when there were low catches of the target species, the retained by-catch constituted 35% and 70%, respectively of the annual total catch in this zone. The retained by-catch constituted 19% of the total catch for the four years between 1988 and 1991 in Zone A.

(2) CAESS data Zones B, C, and D - southern fishing grounds

It has been possible to extract reliable CAESS data for the commercial catch of the target species (saucer scallops) in Zone B (including Zone C), the catch of the retained by-catch species in Zone B (but including Zones C and D), and the catch of the target species alone in Zone D (see section 2.1.1).

While the annual catch of saucer scallops and western king prawns has ranged up to a maximum of 154 and 60 tonnes respectively (Fig. 4), the combined retained by-catch from Zones B, C and D ranged between 25 and 31 tonnes between 1988 and 1990 but has since decreased (1991) to 17 tonnes (Table 4). This amounts to 18% (13-23% annually) of the total catch for the four years between 1988 and 1991.

The retained by-catch constituted approximately one fifth by weight of the total catch from the commercial trawlers throughout the south-west inshore trawl fishery between 1988 and 1991. Fishers have indicated that in Zone A the by-catch contributed to the viability of their fishing operations. This would have applied particularly in those years when the target species were either scarce or low in value (Figs. 3, 4).

3.1.2 Estimates of the quantity and mortality of by-catch from commercial trawling

(1) Mortality of discarded by-catch

The independent research vessel surveys using commercial trawl nets on the fishing grounds between Fremantle and Cape Naturaliste have shown that a wide variety of species can be caught using 45mm trawl nets (see section 3.2, Table 5). However, data collected aboard commercial vessels found that only 39 species were generally retained for sale, only seven of which were taken in any quantity (Table 6). These 39 species represent 19% (by number) of the 202 species of fish, sharks, rays and invertebrates which were caught in this region during the independent research vessel sampling program.

This study did not attempt to determine the trawl induced mortality of various groups of animals. However, in establishing the proportion of discarded animals which can be expected to survive trawling, certain assumptions were made about the mortality of groups of animals. These assumptions were based on data obtained from the scientific literature and observations made during the last two years.

There is evidence in the literature (Jean, 1963; De Veen *et al.*, 1975; Wassenburg & Hill 1989, 1990) demonstrating that the majority of teleost fishes caught in commercial trawl nets and subsequently discarded will eventually die as a result of injuries sustained by the capture process and/or exposure. A high mortality of teleost fish has also been observed during this study. Thus it has been assumed that all teleost fishes caught in commercial trawl nets and subsequently discarded will probably die from their injuries (*i.e.* 100% mortality).

The mortality of crustaceans, which have been caught and discarded by commercial trawlers varies considerably. For example, in a recent study off the Queensland coast, 14% of blue manna crabs died within eight hours from the effects of trawling, despite having a high injury rate (51% of animals caught in the trawl had been injured) (Wassenburg & Hill, 1989). In contrast, during this study it was noted that the mortality of small prawns, including juvenile western king prawns was extremely high. It is worth noting, however, that larger animals of any species, caught and discarded by commercial trawlers, tend to have a lower mortality than smaller animals (Wassenburg & Hill, 1989). Thus it has been assumed that the mortality of smaller crustaceans, such as prawns in the discarded by-catch is 100%, for blue manna crabs it is 14% and all other crustaceans (*e.g.* balmain bugs) it is 50%.

No information on trawl induced mortality could be located in the literature for the cephalopods (squid and octopus) and the elasmobranchs (sharks, skates and rays). Observations made during this study on the mortality of cephalopods caught in trawl nets, indicated that there is likely to be a very high mortality in this group of animals.

Thus it has been assumed that 100% of cephalopods caught and subsequently discarded by trawlers will eventually die.

Elasmobranchs are reputed to be far better able to survive trawling. In this study, they were generally all alive when discarded. However, during attempts to keep some small gummy sharks (*Mustelus antarcticus*) in captivity during 1991 and 1992, about half the animals obtained from commercial prawn trawl died within 7 days of capture (unpublished data). Thus it has been assumed that there is an approximately 50% mortality of elasmobranchs as a result of the trauma associated with being caught and subsequently discarded by commercial trawlers.

Butcher *et al.* (1981) found that only 10% of scallops taken in dredges in Jervis Bay (New South Wales) suffered some form of trawl damage. However, dredges are generally regarded as fairly destructive. The fishing gear used in the south-west inshore trawl fishery (otter trawls) is less destructive than dredges, and it has therefore been assumed that only 5% (L.M. Joll pers. comm.) of the discarded saucer scallops caught in the south-west inshore trawl fishery die.

The above estimated mortality rates of various groups of animals have been used in obtaining annual estimates of the proportion (tonnes) of the discarded by-catch of the south-west inshore trawl fleet that did not survive during the period between autumn 1991 and summer 1991/92 in the four management zones of the fishery (Tables 7 - 10).

(2) ***Research sampling of commercial catches and mortality of discarded by-catch in Zone A***

The estimated total (annual) catch taken by the fleet in the Bell Buoy region of Zone A between autumn 1991 and summer 1991/92 was 105 tonnes, 40 tonnes of which was retained saucer scallops (38%), 5 tonnes was retained by-catch (5%) and 60 tonnes was discarded by-catch (57%) (Table 7). The southern school whiting was the most commercially important of the by-catch species with about 2.86 tonnes retained and 6.75 tonnes (70%) of presumably undersized animals discarded.

Approximately 46 tonnes of the discarded by-catch (78%) probably died while only 13 tonnes (22%) probably survived the effects of trawling. It is worthy of note that the majority of animals surviving the combined effects of trawling (elasmobranchs) were of little or no direct recreational and/or commercial importance.

(3) ***Research sampling of commercial catches and mortality of discarded by-catch in Zone B***

To a large extent, a similar situation to that occurring in Zone A also exists in the Zone B management region. The estimated (annual) total catch in Zone B between autumn 1991 and summer 1991/92 was 150 tonnes, 49 tonnes was retained saucer scallops (33%), 11 tonnes was retained by-catch (7%) and 90 tonnes was discarded by-catch (60%) (Table 8). The southern school whiting was the most frequently caught by-catch fish species with 3.52 tonnes retained and 4.07 tonnes (54%) of fish discarded presumably because they were undersized.

Approximately 27 tonnes (30%) of discarded by-catch is likely to survive the effects of trawling while 63 tonnes are unlikely to survive. As was the case in Zone A, the majority

of discarded by-catch species which survive the trauma of trawling (elasmobranchs) were of no commercial and/or recreational importance.

(4) Research sampling of commercial catches and mortality of discarded by-catch in Zone C

The commercial fishing regulations in operation in Zone C differ from all other management zones in the south-west inshore trawl fishery in that, (a) the area is only open to commercial fishing between July and September and, (b) only trawl nets with mesh sizes in excess of 100mm are permitted.

An estimated total catch of 34 tonnes was taken in 1991 in Zone C, 12 tonnes of which was retained saucer scallops (36%), 0.68 tonnes was retained by-catch (2%) and 21 tonnes was discarded by-catch (62%) (Table 9). The enforced use of the 100mm mesh in commercial trawl nets substantially reduced the retained by-catch, however, the discarded by-catch still represents a substantial component of the total catch.

Approximately 9 tonnes of the discarded by-catch species (44%) were likely to survive the effects of trawling. But as already noted in the results from the zone A and B management areas, the majority of these animals (elasmobranchs) have little or no commercial and/or recreational value.

(5) Research sampling of commercial catches and mortality of discarded by-catch in Zone D (Comet Bay)

An estimated total catch of 66 tonnes was obtained by commercial trawlers in Comet Bay between autumn 1991 and summer 1991/92 - 7 tonnes of which was retained western king prawns (11%), 4 tonnes was retained by-catch (6%) and 55 tonnes was discarded by-catch (83%) (Table 10).

Approximately 13 tonnes (77%) of blue manna crabs and all of the southern school whiting (5 tonnes) were discarded because the animals were undersize. Overall, about 26 tonnes of the discarded by-catch were probably returned to the water alive. An estimated 11 tonnes of this discarded by-catch was surviving blue manna crabs and the remainder mainly species of little recreational and/or commercial importance.

(6) Mortality of discarded by-catch - all zones combined

The groups of animals in the discarded by-catch of the south-west inshore trawl fishery with the highest overall mortality are the teleost fishes. In the entire south-west inshore trawl region, the total discarded by-catch between autumn 1991 and summer 1991/92 amounted to an estimated 224 tonnes (Zone A - 59 tonnes, Zone B - 90 tonnes, Zone C - 21 tonnes, Zone D - 54 tonnes), 149 tonnes (66%) of which probably did not survive (Zone A - 46 tonnes, Zone B - 63 tonnes, Zone C - 12 tonnes, Zone D - 28 tonnes). The total catch of this fishery (target species + discarded by-catch + retained by-catch) during this period was only 354 tonnes with the retained target species contributing 109 tonnes and the retained by-catch 21 tonnes of the total catch.

3.2 Research vessel surveys

Table 5 lists the species caught at each of the nine research vessel survey sites during the study and gives information on the total number of each species caught during the

period between autumn 1991 and summer 1991/92. This table of catches from the standardized survey gives an unbiased indication of the relative abundance (in numbers of individuals) on each trawl ground over a full year. A total of 202 species were recorded. They comprised of 146 teleosts, 19 elasmobranchs and 37 invertebrates recorded from nine locations (including five commercial trawl grounds).

The value of this table is in providing an overview of the fish communities on each ground and the significance of the individual species to those communities. Only species with four or five asterisks are considered to be significant catches.

The most numerous and widely distributed species, the southern silverbelly (*Paraquula melbournensis*), was caught at all research sites. The southern school whiting was also widely distributed and numerous. However, it was not caught at the Preston Shallow research site, presumably because the substrate was dominated by *Posidonia* seagrass (a habitat not favoured by this species).

A number of other species were also numerous and widely distributed (*e.g.* blue striped goatfish, sand trevally, toothbrush leatherjackets, saucer scallops). However, the majority of species caught with trawl nets in the south-west inshore trawl region were caught in low numbers (*e.g.* Australian anchovy, blue weed whiting, common pike eel) and often confined to only a few sites (*e.g.* wickerwork sole, turret fish, tailor) (Table 5). Given the area of the management zones relative to the areas trawled, the populations of species of low abundance are unlikely to be impacted significantly by trawling.

3.2.1 Variation in the species composition and quantity of commercial catch between fishing grounds

The results (in terms of the number of individuals of each species per hectare for all seasons combined) from the independent research vessel surveys of nine trawl grounds, five of which were commercially trawled, were subjected to a cluster analysis to determine how closely the fish communities of the various grounds were related. The resulting dendogram (Fig. 5) shows that, based on the abundance of each species, that these areas can be broken down into four groups,

(1) the fauna of the inshore Preston Shallow research site was quite distinct from all other sites,

(2) the fauna of the inshore sites of Cottesloe (research site) and Comet Bay (Zone D) were similar,

(3) the fauna of the off-shore, Zone A (Bell Buoy) and Zone B (Coventry Reef) commercial trawl grounds were similar, and different from

(4) the fauna of the Zone B (Capel) and Zone C (off Cape Naturaliste) commercial grounds, which were similar and closely related to the Zone B (Preston Deep) site.

In general, the grounds were of similar substrate (for descriptions see Tables 2, 17) except for the Preston shallow research trawl site which was different from all other locations, as it was dominated by large meadows of live *Posidonia* seagrass. The

remaining sites had predominantly sandy substrates, with the fauna of these sites seperating on the basis of depth. Latitude did not appear to contribute greatly to the differences between sites. Of particular interest was the close relationship between sites of similar depth which had different histories of trawling. For example, the fish communities on both the Comet Bay (trawled) and Cottesloe (untrawled) sites were similar, as were the communities on the Busselton (untrawled) and Capel (trawled) sites. The lack of a major difference between the communities at these sites suggests that the habitats of the trawled sites have not been significantly altered by trawling.

These data will also be used in a more in-depth analysis of the vertebrate benthic community structures of the south-west inshore trawl area in ongoing collaborative research with Murdoch University.

3.2.2 Variations in the catches of recreationally and commercially important species with different trawl net mesh sizes

The commercial trawl fishery uses trawl nets with 45mm or greater stretched meshes, depending on zonal gear restrictions (Moore, 1989). In Zones A and B, most vessels use 45mm mesh trawl nets although some use 100mm, while in Zone C the trawlers are required to use meshes of 100mm or greater in their nets. Trawl nets with 100mm mesh are used where saucer scallops are the sole target species and there is a desire on the part of the trawler skipper to minimize by-catch. In Comet Bay, the trawlers targeting western king prawns use 45mm mesh.

To estimate the level of escapement from each mesh size and the impact of mesh size on the catch rates, a survey was undertaken during autumn 1992 (Appendix 1) in which the catches from 25, 45 and 100mm stretched mesh nets were compared. The 25mm mesh net consisted of a cod end cover net placed over the cod end of the 45mm net. Because the 25mm mesh trawl net was a cover net over the cod end of the 45mm mesh net, only those animals escaping through the actual cod end section were caught. Animals passing directly through the 50mm wings of the net would not be caught, making the catch in the liner a minimum escapement value. Secondly, the 100mm mesh net was operated in parallel to the 45mm mesh net (with the 25mm cover), thus the catches, although generally comparable, did on occasions give very different results, presumably due to the patchy distribution of some species.

Despite these unavoidable variations, the results (Tables 11, 12) clearly demonstrate that, on average, the smaller the mesh size, the greater the numbers and biomass of animals caught by that net regardless of where fishing occurs. The escapement of animals from the 45mm mesh trawl net into the 25mm cover net also indicates that the recorded catch rates for juveniles are minimum values for estimates of the abundance of juveniles of most species. The data could also be used to assess escapement rates for individual species, however, for this initial report such data were not considered necessary.

As expected, the 100mm trawl net caught generally less by-catch than the 45mm mesh net with the catch of southern school whiting, the major commercially important by-catch species, being greatly reduced. This finding supports the management objective (Moore, 1989) in Zone C, of reducing the commercial catch of whiting by the imposition of a 100mm mesh requirement for trawling in this zone.

This mesh size effect can be confounded by the effect that drift weed (usually composed of detached seagrass and drift algae) has on the fishing characteristics of the gear. A trawl net with an accumulation of weed has a much smaller effective mesh size, and thus can retain smaller animals. A preliminary analysis has revealed that increasing quantities of weed in the trawl nets did not significantly reduce the mean size of finfish caught. However, increasing quantities of weed did reduce the mean size of the blue manna crabs in the catch. It should be noted, however, that negligible quantities of drift weed were caught in the research trawl nets during this part of the study, and thus clogging of the net with drift weed did not influence these results. Nevertheless, the quantity of drift weed caught in commercial nets needs to be considered in assessing commercial catch samples from locations such as Comet Bay.

3.2.3 Exploitation of juvenile fish and crustaceans by the commercial trawl fishery

The catch rate of juvenile fish and crustaceans is largely dependent on the size of the mesh used in the trawl net. However, as discussed above (Section 3.2.2), although drift weed can effect the fishing characteristics of the gear, the effect on the total size of finfish in the catch appeared to be minimal. Nevertheless, some juvenile fish species are selectively associated with drift weed habitats (Lenanton & Caputi, 1989). Thus the presence of weed in the trawl nets has the potential to influence the species composition and size of individuals in the catch.

No significant quantities of weed were caught in research trawl nets at four (Bell Buoy, Capel, Coventry Reef and Zone C) of the five sites which were located on known commercial trawl grounds between Fremantle and Cape Naturaliste (Table 13). The only exception to this situation was in the Zone D (Comet Bay) fishing area in which weed was caught during autumn, winter and spring of 1991. The prevalence of weed during these times of the year coincides with the period of least commercial trawling activity in the Bay. The relative quantities of drift weed caught in the research trawl nets indicate that at this site, the effective mesh size during autumn, winter and spring could be less then 45mm because the nets are occasionally filled with drift weed.

To compare the effect of the two commercial mesh sizes over a full year, the simultaneous catch rates obtained using 45 and 100mm research trawl nets at nine standard sites between Fremantle and Cape Naturaliste during the seasonal research surveys of the region between autumn 1991 and summer 1991/92 is presented in Table 14. Similar to the shorter time scale data presented in Tables 11 and 12, the total numbers and weights of fauna caught per hectare were almost invariably greater in the trawl net with 45mm rather than 100mm mesh size at all sites. A further characteristic of the catches in the 45mm stretched trawl net was that species caught in this mesh were often totally absent from the larger mesh net. While it has been shown that, for the target species, an increase in the mesh size to 100mm does not effect the catch of marketable size saucer scallops, it will substantially reduce the efficiency of the net for western king prawns. This result confirms the basis for the mesh size regulations used to separate prawn and scallop fishing activities in Shark Bay.

The tendency of the 45mm stretched mesh trawl net to catch smaller animals than the 100mm net was also clearly evident when the lengths of individuals of each species caught in these nets were compared (Table 15). In the majority of those cases where

catches were sufficient for a statistical comparison, the mean length of animals caught in the smaller mesh net was significantly smaller than the mean length of those caught in the larger mesh net. Notably, the 100mm mesh net did not catch sufficient individuals of many species to allow statistical comparisons of length. As noted earlier (Section 3.2.2), preliminary analysis has revealed that increases in the quantity of weed in the net appear to have little effect on the mean size of fish caught, but did reduce the mean size of the blue manna crabs. Thus at sites where drift weed was abundant, the effect of mesh size and weed are confounded.

The length frequency data of two of the more important by-catch species, red mullet (*Upeneichthys lineatus*) and southern school whiting (Figs. 6, 7), caught in 45mm stretched mesh research trawl nets also shows juveniles are a significant component of the catch. Juvenile red mullet were caught in all locations, however, juvenile southern school whiting were caught only in Cottesloe, Coventry Reef, Comet Bay and Capel. Comet Bay is unusual however, in having virtually no adults of either red mullet or southern school whiting. Adult red mullet were also rare at the Busselton site. The lack of adults of these two species could be interpreted as an effect of the trawl fishery. However, in contrast to red mullet and southern school whiting, the juveniles of sand trevally were widely distributed in most areas while the adults were abundant in Comet Bay, Capel and Zone C (Fig. 8). Given that, (a) southern school whiting, sand trevally and red mullet are of equivalent size, (b) the size distribution of southern school whiting in the commercial and research survey catches of Comet Bay during this study were similar to that measured in commercial catches during the commencement of the fishery in 1984-85 (Lenanton Unpub. data), and (c) assuming constant catchability at all sites, it appears that the different size composition at the nine sites surveyed is most likely the result of species specific natural distributional factors rather than the impact of trawling. That is, if trawling had caused the decline in adults of southern school whiting and red mullet, then sand trevally would have been similarly effected.

3.3 Biology and status of whiting species

A study of the biology of the two most numerous whiting species, southern school whiting and the non-commercial stout whiting (*Sillago robusta*), caught in the south-west inshore trawl fishery is currently being undertaken by Murdoch University as part of an on-going collaborative research arrangement. The following is a summary of the preliminary results obtained from the data on the biology of these two species.

(1) Preliminary results from biological studies

The maximum recorded length of southern school whiting and the stout whiting were 381mm and 211mm, respectively. The maximum age of southern school whiting was approximately 8 years with sexual maturity being attained at about 280mm at the age of approximately two years. This species is a multiple spawner, capable of spawning on more than one occasion during a protracted breeding season (from October to April). The stout whiting is also a multiple spawner but has a shorter breeding season than the southern school whiting, lasting only between December and April. This latter species reaches sexual maturity at approximately 100mm total length.

(2) Seasonal distribution of southern school and stout whiting

The southern school whiting was the more abundant (biomass and numbers) of the two main whiting species found using trawl nets between Fremantle and Cape Naturaliste. This species was particularly common in the Bell Buoy, Cottesloe, Coventry Reef, Comet Bay and Zone C areas. The stout whiting was mainly found in the northern off-shore areas at the Bell Buoy and Coventry Reef sites, small numbers were also present in Comet Bay. There was no significant seasonal variations in catch rate of southern school whiting or stout whiting between autumn 1991 and summer 1991/92 (Table 16).

(3) Whiting and scallop stock survey

The seasonal research surveys of the region between Fremantle and Cape Naturaliste focused on the five main commercial trawl grounds and four additional research sites. To obtain a better overview of the distribution, biomass and abundance of whiting species in this general region, a more extensive one-off survey of the region was undertaken. Since there were no significant seasonal variations in abundance of the two more abundant whiting species (Table 16), the survey was carried out during May 1992, when weather conditions in the region were most favourable.

A total of 19 trawlable sites (including the nine regular research trawling locations) were located during the survey (Table 17). As indicated earlier, a trawl site required a 1.5nm obstacle free transect, over an area of bottom which ROV observations revealed as mostly sand. The difficulty in locating more than a few grounds that were suitable for trawling is indicative of the lack of clear bottom in this region. Furthermore, it is worth noting that at most of these sites, a sophisticated colour echo sounder, ROV and GPS equipment were needed to both find suitable areas and to guide the vessel over a very restricted trawlable bottom. Nevertheless, two nets were destroyed when attempting to trawl over ground surveyed as trawlable.

The survey data (Fig. 9) showed that southern school whiting were widely distributed over the inner continental shelf area. The species was found to be particularly abundant on the commercial grounds of Comet Bay (mostly juveniles), immediately to the south of Rottnest Island (adults) and on the commercial Bell Buoy grounds directly to the north-west of Fremantle (adults). Stout whiting were not found in Geographe Bay but were fairly abundant to the north of this region, and particularly on the station immediately to the south of Rottnest Island (Fig. 10). Saucer scallops were found at most off-shore sites but were most common in the Zone C, Naturaliste Reef, Bell Buoy and Busselton trawl areas (Fig. 11), all of which, with the exception of the Busselton trawl area, are existing commercial trawl grounds.

To put the exploitation of southern school whiting into perspective, a broad estimate of the biomass of this species was calculated. This procedure (Appendix 2) suggests that the estimated total biomass of the southern school whiting stock in the region between Fremantle and Geographe Bay during May 1992 was approximately 2,806 tonnes. Between autumn 1991 and summer 1991/92, the south-west inshore trawl fishery removed an estimated 22 tonnes of the total stock, *i.e.* 9.61 tonnes from Zone A (Table 7), 7.59 tonnes from Zone B (Table 8), 0.01 tonnes from Zone C (Table 9) and 4.77 tonnes from Zone D (Table 10). This 22 tonnes represents 0.8% of the estimated southern school whiting stock presented in May 1992.

3.4 The impact of trawling on the substrate and biota of thetrawl grounds

The purpose of this section of the study was to examine the type of ground targeted by saucer scallop trawlers and to examine the impact of trawling on the sea floor and its associated biota using both visual and experimental procedures.

(1) What are the characteristics of areas trawled for saucer scallops?
From experience in other parts of the Western Australian coastline, grounds where saucer scallops are sufficiently abundant to be commercially trawled, have substrates comprising mostly clean sand (Joll, 1987). In this study, the observations made by Joll (1987) were confirmed by the extensive ROV data collected during the whiting survey (Section 3.3). While saucer scallops were associated with sandy substrates, not all sandy areas contained scallops (c.f. Table 17, Fig. 11). This indicates that the abundance of this species is determined by a variety of factors including substrate.

(2) What modification occurs to the substrate and its biota as a result of the passage of otter trawls?
This objective was addressed experimentally using depletion experiments as detailed in Section 2.2.3. The technique provided a means of assessing the abundance of the biota before and after set periods of trawling, as well as measuring the efficiency of the trawl gear at capturing individual species or groups of species.

Two similar areas in the Capel region of Geographe Bay, one with a history of commercial trawling and an adjacent untrawled area, were subjected to depletion experiments.

A comparison between the fauna caught during the depletion experiments on commercially trawled and untrawled grounds revealed some differences (Table 18). Although the dominant fauna of each area showed marked similarities, the two areas were also each represented by a different group of less abundant species. Subsequent ROV observations of both experimental areas showed that, although the untrawled experimental area was primarily sand, it was an extremely small area encroached on all sides by *Amphibolis* seagrass meadows. By contrast, the trawled area was located in a much larger area of sandy substrate. This would explain the fewer numbers of saucer scallops and southern school whiting caught in the untrawled area, since both species tend to be associated with sandy habitats. It would also explain the greater presence of sponge caught in the trawls conducted in the untrawled experimental area, since sponge is usually associated with a harder substrate. Thus the faunal differences between the untrawled and the trawled experimental areas are likely to be the result of the proximity of the untrawled area to substantial seagrass cover.

Despite the differences in catch between the trawled and untrawled areas, as indicated above, the more detailed ROV observations of the substrate of both areas clearly determined that the actual experimental habitats of each were very similar. Furthermore, ROV examinations of both experimental areas before and after the completion of the depletion experiment failed to detect any visual impact on the substrate or habitat.

The results of the two depletion experiments conducted in trawled and untrawled ground are given in Figure 12. These data show that for saucer scallops, southern school

whiting and all species combined, considerably lower numbers were present on the untrawled compared with the trawled experimental area. This factor, together with the limited number of trawl passes over each experimental area (only four passes were possible on a single night) make it difficult to obtain statistically significant results. However, a sizeable reduction in abundance was usually generated by four passes over the ground.

However, despite these difficulties, the experiments indicate that the trawl gear was relatively efficient in removing the two most important commercial species (*i.e.* saucer scallops and southern school whiting) from the commercially trawled experimental area. Forty-four percent of the southern school whiting stock were removed from the trawled area by each pass of the trawl gear; that is, the gear has a 44% efficiency in the take of whiting in the path of the net. Saucer scallops on the commercially trawled ground were removed at approximately 14% with each pass; while for all species combined, the gear had an efficiency of about 44%. The lower efficiency for scallops was not unexpected because of the burying nature of this species which causes varying efficiencies in trawl capture (Joll & Penn, 1990).

The results for the commercially untrawled ground, while not significant for both saucer scallops and southern school whiting, clearly demonstrate that the abundance of these species is lower in this area.

In addition to providing a broad indication of the trawl efficiency which can be used as an estimate of catchability in the whiting survey, this technique also allows estimation of the total stock present in the area, and the actual density of animals on each ground. For example, the number of saucer scallops on the trawled experimental area was estimated to be 790 with a density of 214/ha. The southern school whiting stock in this area was estimated at 152 individuals and 41/ha, and for all species combined the respective values were 7,992 individuals and 2,160/ha.

On the untrawled experimental area, the one significant result, *i.e.* for all species, indicated that approximately 5,174 individuals were present and the density was 1,398/ha. These data showed that, despite its history of previous commercial trawl exploitation, the known commercial trawl ground has a greater overall abundance of fish and saucer scallops than the adjacent untrawled area.

3.5 Underwater video observations of Geographe Bay

Many locations between Fremantle and Geographe Bay were visually inspected with the use of an ROV. The area which received the greatest amount of attention was the Capel and Zone C commercial trawl grounds of Geographe Bay. In this region, transects covering a total of 240km of ocean floor were examined with the ROV (Fig. 13).

These observations indicate that, for the most part, the sea floor in Geographe Bay is untrawlable. Shallow near-shore areas were confirmed as containing extensive seagrass beds dominated by *Amphibolis*. In deeper waters (20m) where seagrasses were less

common, the ground was characterized by small intermittent outcrops of rock and hard bottom, to which sponges and algae were commonly attached.

Transects crossing the region of the commercially trawled Capel area indicated that the trawl ground was restricted to a few areas of bare sand surrounded by sponge and algae habitats (Fig. 13). The Zone C management area was found to contain some clear sand areas, however, most of the zone appeared untrawlable as there were many rocky outcrops.

While these data have provided considerable information in selected areas within Geographe Bay, the very limited field of view of the towed ROV, the vessel effort required to undertake ROV transects, and the volume of information generated per kilometer of transect operation, meant that there were insufficient resources to undertake a detailed grid survey of the region. Consequently, alternative sources of broader scale habitat survey data were investigated towards the end of the study.

High resolution satellite images of the Geographe Bay area with unusually good water penetration were located by CSIRO (courtesy of P. Hick) and are to be ground-truthed using the intensive ROV data from this study. The combination of both sets of data should allow the extent of trawlable areas of the region to be more accurately delineated.

Trawlable ground occurs widely in the northern parts of Zones A and B while smaller trawlable areas were also found in southern Zone B and in Zone C. However, most of the region between Fremantle and Cape Naturaliste was found to be untrawlable.

3.6 Fishery interactions

3.6.1 Major stocks exploited by the trawl fishery

Major stocks exploited by the south-west inshore trawl fishery include the two key target species, saucer scallops and western king prawns, and the retained by-catch species southern schooi whiting and blue manna crabs.

3.6.1.1 Target species

Vessels with access to the south-west inshore trawl fishery primarily target, (1) saucer scallops in Zones A, B and C and (2) western king prawns in Zone D (Comet Bay).

(1) Saucer scallops

No commercial fishers, other than the licensed trawlers working in the south-west inshore trawl fishery, are permitted to take saucer scallops in the south-west of Western Australia.

The species is fast growing and short lived, spawns at about one year of age and is characterized by highly variable annual recruitment (Joll, 1987). Variable recruitment is considered to result from environmental effects on larval survival and spatfall, and leads to considerable variation in catch from year to year (Table 3). Because the species is short lived, usually surviving for no more than three years, and the breeding stock is widely dispersed at low densities (Fig. 11), commercial trawl fishing of aggregations of saucer

scallops appears unlikely to have a significant impact on future recruitment levels in the south-west region.

(2) Western king prawns

Western king prawns are prized both by the commercial and recreational fishing community in the south-west of Western Australia. While commercial exploitation of the species in this region occurs in the entrance channels to estuaries and in inshore marine waters, recreational exploitation is confined to the estuaries.

Western king prawns grow to maturity and spawn in a single year, but generally only live for one to two years in unfished environments. Spawning occurs in coastal waters during spring and summer in the south-west of Western Australia (Penn, 1980, Potter *et al.*, 1991). The released eggs hatch and pass through a series of larval stages over approximately 14 days before settling in marine embayments and estuaries, where they grow to catchable sized juveniles over summer (Potter *et al.*, 1991). The juveniles migrate out of the estuaries on the ebb tide during autumn to join the adult population in the ocean. Adult breeding sized animals of this species are common in most near-shore waters off the south-west with concentrations present in Geographe Bay, off the Leschenault Estuary, in Comet Bay, Cockburn Sound and off Fremantle. Extensive transport and mixing of larvae along the coast is likely during a 14 day larval phase in summer. Thus breeding stock levels in any one area are therefore unlikely to directly effect recruitment into individual estuaries. Intensive fishing of breeding stocks of this species elsewhere in the State has not been found to affect future recruitment primarily due to variable (to low) catchability of adults (Penn & Caputi, 1986). Western king prawns, like saucer scallops are prone to variable recruitment due to variations in hydrological conditions. This can result in variable catches, particularly in estuaries (Potter *et al.*, 1991), and ultimately in the trawl fisheries further off-shore (Table 4).

3.6.1.2 By-catch species

(1) Southern school whiting

The southern school whiting is one of the most commonly caught recreational species of the south-west region (ABS Survey data). The data from this survey support previous observations in near-shore waters (Lenanton & Caputi, 1989), that the animals are generally associated with sandy substrates. Adults concentrated in off-shore waters and juveniles more common closer to shore. Notably, juveniles were absent from the only research site where live seagrass dominated the substrate (*i.e.* Preston Shallow).

The extended survey for this species in the south-west inshore trawl region found that the stock susceptible to capture by trawl nets was widespread. The biomass (B) in May 1992 was estimated to be approximately 2,800 tonnes (Appendix 2). Lenanton (1970) estimated the total mortality (Z) of *Sillago schombergii*, a similar species, to be about 0.5 in a heavily exploited stock. Since southern school whiting are less heavily exploited in the south-west trawl fishery, natural and fishing mortality have each been assumed to be 0.15, giving a total annual mortality of approximately 0.3. Using the relationship

$$Ymax = 0.3\ Z\ B \qquad \text{(Gulland, 1983)},$$

where Ymax is the maximum yield or catch, suggests that a stock with the above characteristics should be able to support a sustainable yield of approximately 253 tonnes annually.

Exploitation of this species occurs by both licensed south-west trawl vessels and recreational anglers, particularly in coastal waters off Fremantle. Since the biomass exploited by the commercial trawl fishery over the survey year was estimated to be of the order of 22 tonnes, and the potential annual yield is in excess of 250 tonnes, it appears unlikely that the combined commercial and recreational catches will have a significant impact on the overall stock at the present levels of exploitation. Heavy fishing could cause localized depletions, however, the size composition of this species on grounds to the north-west of Fremantle (Fig. 7), does not indicate that this has occurred, at current levels of fishing (Tables 3, 4). The lower reported landed catches of southern school whiting in 1990 and 1991 therefore appears to be more likely a function of increases in the levels of discarding rather than a reduction in the population of this species.

(2) Blue manna crabs

Blue manna crabs are widely distributed along the Western Australian coast, and similar to western king prawns, also utilize marine embayments and estuaries as nursery areas. Adults generally spawn in oceanic waters during spring (Penn, 1977). The released larvae then spend approximately six weeks in coastal waters being mixed and distributed by the prevailing currents before settling inshore and migrating into estuaries in the spring and summer. Rapid growth occurs in the estuaries and protected bays over summer. Juveniles and adults migrate out into the ocean during winter to avoid the freshwater flow (Potter *et al.*, 1983) and many then migrate back into the estuaries before the summer. Females only spawn and hatch their eggs in oceanic waters, either in the entrance channels of estuaries or adjacent coastal waters.

The major exploitation of blue manna crabs occurs by both recreational and commercial fishers in estuaries. Where trawling occurs for western king prawns near the mouth of an estuary, such as in Comet Bay, some crabs will also be taken, particularly if trawling occurs during the winter and early spring, when the bulk of the crab stocks are over-wintering in the ocean.

Because blue manna crabs occur throughout the south-west inshore trawl region and beyond, and as the larval dispersal occurs over an extended period, it appears unlikely that local adult stocks will directly contribute recruits to specific nearby nursery areas. As appears to be the case with western king prawns, environmental conditions occurring at the time of migration into nursery areas and in the estuaries and marine embayments over summer are believed to have a major influence on the year to year variations in abundance of blue manna crabs. (Potter *et al.*, 1983)

3.6.2 Major recreational species of the south-west inshore trawl fishery region

In 1987 a major Australian Bureau of Statistics survey of recreational fishing in Western Australia established that the major species targeted by recreational fishers were in order of importance, Australian herring, whiting, tailor, blue manna crabs, snapper, westralian

jewfish, prawns, Australian salmon and "gamefish". Whiting, in this context, included southern school whiting, King George whiting and western sand whiting.

Other important near-shore species included garfish, mulloway, flathead (blue spotted, long spined and bar-tail), trevally (sand and blue), small toothed flounder, squid and cuttlefish. Offshore angling species might include breaksea cod, samson fish, baldchin groper and sharks.

Of this array of species, few of the shore-line angling species are taken in any significant numbers in the trawl by-catch. The two exceptions to this are the southern school whiting and the small sand trevally, which is often mistaken for juvenile blue trevally (Table 5).

Recreational boat angling species tend to overlap to a greater extent with those caught in the trawl by-catch. The most important, is the southern school whiting which has been considered in detail above (Section 3.6.1.2). Small toothed flounder, squid and cuttlefish are also taken by trawlers. The remainder of the recreational boat angling species were either not represented in the trawl by-catch or were in such low numbers that trawling could not be reasonably expected to have a significant impact on the stocks.

3.6.3 The impact of trawling on commercial trawl grounds

(1) Zone A

The commercial trawl grounds located to the north-west of Fremantle have been trawled for saucer scallops since the late 1970s. Currently, up to three trawlers fish these grounds. The commercial activity in this region seems to be less affected by the variability in the value of saucer scallops than it does in other zones, with fishing occurring continuously, unless prevented by prevailing weather conditions and/or the closed season during November to January to protect migrating rock lobsters.

The major impact of trawling on this area is on the targeted saucer scallop stocks, which provide highly variable catches (Table 3) for reasons other than fishing pressure (see Section 3.6.1.1). The major by-catch species is the southern school whiting which has provided a landed catch of 3 to 6 tonnes annually (Table 3) and is also a significant recreational angling species in this region. As noted in section 3.6.1.2, the potential yield from this stock appears adequate to support the existing trawl catch levels. Two unusual features of the survey data from the Bell Buoy trawl grounds were, (a) that the area contained mostly large individuals and, (b) the density of animals was relatively high, both of which suggest that southern school whiting in this area was not being adversely affected by fishing.

A second feature of the survey information (Fig. 7) was the presence of both juvenile and adult fish in the area closed to commercial trawling off Cottesloe. The distribution of large fish outside of the normally trawled areas (Fig. 7 and data not presented), also suggests that the stock available to anglers is widespread and, therefore, not able to be greatly impacted by the present level of trawling activity.

The present impact of trawling on the substrate in this area, which was found to be predominantly clean sand (ROV data not presented, Table 17), appears to be low.

(2) Zone B

Trawling in Zone B is focused in two general areas, west of Coventry Reef (to the north-west of Mandurah, Stations 6, 8, 9, Table 17) and an area 15nm west of Capel (central Geographe Bay, Station 15, Table 17).

The area off Coventry Reef is fished intermittently for saucer scallops. Since the fauna on this ground is similar to that of the Bell Buoy commercial fishing area (Fig. 5), the overlap in catches of different species between the trawl and recreational fisheries could also be similar. Thus, the most important of the species caught by both groups of fishers off Coventry Reef is the southern school whiting. The large size of this species in this area again suggests that the level of commercial and recreational fishing is not having a great impact on the stock. The recreationally important sand trevally, is also abundant on this ground (Table 5) and is a major component of the discarded by-catch of the trawl fishery (Fig. 8, Table 8)

The Zone B commercial trawl grounds, which include the Capel trawl area of Geographe Bay, have been subjected to sporadic periods of trawling since 1983. The method used to collect and record prevents CAESS data any proportion of this trawling activity being directly attributed to the Capel ground. However, anecdotal evidence suggests that much of the early trawling in the area was exploratory, and that there was little trawling due to difficulties in locating and fishing the saucer scallop grounds. In more recent years, and particularly during 1990 with the advent of GPS, the fishing activity has increased markedly with a number of vessels specifically targeting saucer scallops on the Capel ground. Commercial fishing on these grounds is governed by the availability of good fishing weather and on the price of saucer scallops. During the last two years (1991 and 1992), the price of saucer scallops has been very low; so that trawling has largely ceased in this area of the Western Australian coast. As the value of this species again rises, it is likely that there will be a commensurate rise in the fishing activity in this sector.

The Capel ground, although similar in species composition to the other offshore sites (Fig. 5), is more restricted in area and surrounded by variety of different habitats in which trawling is both impractical and undesirable (Fig. 13). The southern school whiting is again the major recreational angling species overlapping with the trawl fishery in this sector. On the basis of interviews with recreational fishers, Walker (1978) determined that there was some recreational boat angling in the central Geographe Bay region, which might include the Capel trawl ground (if whiting were the target species). The only other abundant species of potential angling importance which is abundant in this area is the long spined flathead (Table 5).

Since the Coventry Reef and Capel areas have predominantly sand habitats and have histories of commercial trawling, it is unlikely that trawling will further alter the habitat or its sessile biota appreciably. However, the actively trawled areas (particularly Capel) appear to be relatively restricted, and exploratory trawling away from the known trawlable areas is likely to encounter more fragile benthic biota as illustrated by the ROV survey (Fig. 13).

(3) Zone C

As noted previously, the trawl area to the north of Dunsborough cannot be distinguished in the historical (CAESS) catch data from other areas south of 33° S (grid boundaries). The seasonal closure enforced in the area, permits trawling only during a 12 week period from July to September. The result is that trawling in Zone C is now of short duration annually, and targets saucer scallops alone.

The data collected aboard commercial vessels fishing this area indicates that gear restriction of a minimum mesh size of 100 mm has substantially reduced the by-catch. This is shown by the observation that virtually no southern school whiting and no red mullet (*Upeneichthys* spp.) were caught commercially in the area during winter 1991 (*i.e.* the open season), even though research sampling with 45mm mesh showed both species were abundant in the area.

While this trawl ground is relatively close to the coast, due to the deep water extending close inshore, the fauna in this zone has a greater affinity with those of the Capel and Busselton research sites (Fig. 5)

The Zone C management area is characterized largely by untrawlable substrates (Fig. 13). While there are some extensive sandy areas in Zone C (to the north-west of the trawled area), these apparently do not contain economical quantities of saucer scallops, and hence do not have any history of trawling. Trawling only occurs successfully in this zone largely because vessels are able to use marker buoys or GPS equipment to fish in the limited sandy areas available. The extent of productive trawlable ground is therefore extremely limited, confirming earlier assessments (Heald, 1977). Any further exploratory trawling is likely to encounter more fragile benthic biota, and result in trawl damage due to the prevalence of rock in many parts of the zone (Fig. 13).

(4) Zone D

The activities of the commercial trawl fishery for western king prawns in Comet Bay has become increasingly controversial since the beginning of the 1980s. In the initial stages of the development of the fishery, there was a rapid increase in vessels fishing the area. By the mid 1980s the number was curtailed through management controls to just five endorsed vessels. A further two vessels withdrew from the fishery before 1989 and the remaining three endorsements have been responsible for the continued fishing in Comet Bay ever since.

The commercial trawling operations in this location have largely been influenced by a combination of the seasonality of the fishery for western king prawns and the seasonality of the drift weed which frequently overlays the sandy substrate characteristic of this region (Tables 13, 17).

In considering the impact of fishing on the target species (western king prawns) in this location, it is necessary to consider the full extent of the distribution of the stock throughout both the Peel-Harvey Estuary as well as Comet Bay.

Assuming that the Peel-Harvey estuary constitutes the main nursery area for western king prawns in the Comet Bay region, juveniles in the estuary are first taken by

recreational hand trawling nets between December and February. Between March and July, western king prawns leave the estuary and migrate off-shore (Potter *et al.*, 1991). During this migration they are taken by recreational dip netting, hand trawling and by commercial estuarine beam tide trawlers. It is not until this species has left the estuary that the Comet Bay commercial trawlers are able to take a share of the annual crop. Given the life history and dispersed nature of the breeding stock and experience elsewhere (Penn & Caputi, 1986), it is considered unlikely that any of these fishing activities will directly impact on future recruitment levels to the estuary. The major determinant of the annual level of abundance is more likely to be the prevailing environmental conditions (wind *etc.*) when the larvae are entering the estuarine nursery area and then upon conditions within the estuary itself (see section 3.6.1.1).

Thus the most likely overall impact of fishing on the general western king prawn stock in the Mandurah region is to reduce the numbers of western king prawns which are available to the Comet Bay trawlers rather than to reduce the numbers subsequently available to the estuarine recreational fishing community.

The by-catch species in Comet Bay is largely dissimilar to the other commercially trawled areas, but shares the same species characteristic of the other near-shore research trawling site, *i.e.* off Cottesloe. Comet Bay is clearly a nursery area for a number of commercially and recreationally important species, and an over-wintering area for blue manna crabs (Potter *et al.*, 1983). For example, southern school whiting and red mullet were relatively abundant as juveniles, while sand trevally were present both as juveniles and adults.

In assessing the significance of the abundant juveniles of the angling species, such as southern school whiting, the overall distribution of the stock needs to be considered. As noted in section 3.2.3, this species has a wide distribution as both juveniles and adults. The current exploitation level of southern school whiting does not indicate that it is heavily exploited. Indeed, the continued high abundance of juveniles in the Comet Bay trawls, despite the trawl mortality, suggests that recruitment of this stock is being sustained under the present regime of exploitation of the adult stock by both trawlers and recreational anglers.

The other major by-catch species of concern in the Comet Bay fishery is the blue manna crab. The retained catch of market size crabs in 1991 was approximately 4 tonnes, however, an estimated 13 tonnes of crabs were discarded during the same year (Table 10). According to Wassenburg & Hill (1989) in a study conducted in Moreton Bay, 86% of blue manna crabs caught in trawl nets survived for eight hours after capture, however, 51% of these animals had received some form of injury. It is worth noting that since the area in which commercial trawlers operate in Comet Bay is quite restricted, a certain proportion of the blue manna crabs which have been returned to the water may be repeatedly caught. This could be expected to increase the mortality of individuals, but also inflate the estimates of abundance of crabs in the by-catch.

A second feature of the data collected in this survey was that blue manna crabs were caught mainly during summer, even though the bulk of the crabs are likely to be in Comet Bay over winter (Potter *et al.*, 1983). This situation arises because trawlers find it

difficult to fish when there is an abundance of drift weed, *i.e.* in winter (Table 13), and tend to avoid fishing at these times. The drift weed problem in winter effectively protects a significant proportion of the over-wintering legal size crabs from exploitation by commercial trawlers. Secondly, the crabs caught over summer have not migrated back into the estuary and therefore were unlikely to contribute to the estuarine catch. To judge the overall impact of the trawl fishery on this species, it is necessary to consider the total exploitation of the stock, including both the recreational and commercial fishing community inside the Peel-Harvey Estuary. This is beyond the scope of the present study. However, because of the anticipated dispersal of larvae (Section 3.6.1.2), the trawl fishery by itself, is considered unlikely to effect local recruitment to the estuarine system.

All other recreationally important species taken in the trawl fishery were taken in relatively small quantities. Relative to recreational fishing activities and the high levels of natural mortality usually suffered by marine species, the current trawling activity is unlikely to significantly impact on alternative user groups or breeding stock levels for these animals.

As is the case in all the other commercially trawled areas of the south-west inshore trawl fishery, the area fished in Comet Bay has a substrate consisting of mostly sand and has a history of commercial trawling. Any further modification to the substrate is therefore unlikely to occur if trawling is confined to the existing area impacted by trawling.

4.0 Conclusions

From the initial analysis of the extensive data collected during this study a number of general conclusions can be drawn about the impact of the south west trawl fishery.

(1) The south-west trawl fishery presently operates on seven small, reasonably well defined grounds, which collectively cover an estimated area of 250 km^2, which is approximately 1% of the total area covered by the management plan and approximately 2% of the waters less than 50 metres in depth.

(2) Research vessel surveys have demonstrated that commercial trawlers can take a wide variety of species. They comprise 150 species from the recognised commercial trawl grounds, including 106 finfish, 14 sharks, skates and rays, and 30 invertebrates. An additional 52 species were recorded from research catches from non-commercial trawl sites. Of the 150 species from the commercial grounds, 39 were occasionally retained for sale and only 7, including the two target species, were taken in any quantity.

(3) Over the 12 month survey period an estimated total of 354 tonnes of fauna were caught by the trawlers operating in the entire fishery. This was made up of 109 tonnes of the target species (31%), 21 tonnes of retained by-catch (6%), and 224 tonnes of discarded by-catch (63%) of which approximately 149 tonnes (67%) was unlikely to survive.

(4) In Zones A, B and C the abundance and price of the target species, saucer scallops, has determined the recent levels of trawling activity and the take of by-catch species. Across the three zones, the dominant fish by-catch categories by weight were: stingarees, whiting, rays, angel sharks and silverbellies. Of these only southern school whiting are of significant interest to recreational fishers. The only other by-catch species that were reasonably abundant and of recreational interest were sand trevally, red mullets, long spined and blue spotted flathead, small-toothed flounder, squid and cuttlefish.

(5) There was no evidence that the stocks of any of these recreationally important species in Zones A, B, C are being overfished to the extent that future recruitment could be jeopardised.

(6) Variations in trawl mesh size were found to significantly alter the efficiency of the gear for the capture of many by-catch species. The standard prawn trawls (45 mm mesh cod end) were found to be approximately 44% efficient in the capture of biota on sand substrates. The 100 mm mesh in contrast was very inefficient and reduced the take of the most valuable by-catch species, southern school whiting, to negligible quantities.

(7) A detailed examination of the stock of southern school whiting, the most important recreational finfish species, suggests that the nursery areas for this species are located inshore in Zone A and include the Cottesloe, Coventry Reef

and Comet Bay sites. Adults were found over much of the continental shelf and were particularly abundant in the northern part of the fishery.

(8) The overall standing stock of southern school whiting in the fishery has been estimated at approximately 2,500 tonnes corresponding to a sustainable annual yield of more than 250 tonnes. The present commercial catch of this species is less than 25 tonnes.

(9) The commercial trawl grounds where scallops were abundant had substrates comprising mainly of sand. Such substrates dominate Zone A and the northern half of Zone B. In contrast southern Zone B, and particularly Geographe Bay, is dominated by seagrass, rock and rubble habitats and is largely untrawlable. The limited availability of suitable ground for trawling, or scallop habitats in this sector indicates that further expansion of the area trawled is unlikely.

(10) Depletion experiments on the Capel ground in Geographe Bay showed that trawling is an effective method of removing small fish species, scallops and attached benthic fauna such as sponges. However, the physical impact of trawling over the sandy substrates inhabited by scallops could not be detected 24 hours after trawling had been completed.

(11) Comparisons of the fish communities on commercially trawled and untrawled locations, at similar depths and with similar substrate types, did not show any appreciable differences which would indicate habitat alteration.

(12) Comet Bay is the only zone in which trawl by-catch interacts with a significant number of recreationally important species. The majority of these species were caught as juveniles, however, only blue manna crabs, southern school whiting, goat fish and sand trevally were abundant in the catches. Of these only blue manna crabs are also important in the adjacent estuary where they are exploited prior to becoming available for capture by the trawlers in Comet Bay. There is no evidence that the current level of trawling is having any adverse impact on the subsequent levels of recruitment to the overall crab stock, or to the western king prawn stock which is the target of the trawling activity in Comet Bay (Zone D).

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Tables

Table 1: The species categories used in the CAESS database and the common and scientific names of species which are included in each category by trawlers in the south-west inshore trawl fishery.

	Category	Common Name	Scientific Name
1	Whiting	western school whiting	*Sillago vittata*
		southern school whiting	*Sillago bassensis*
		trumpeter whiting	*Sillago maculata*
		stout whiting	*Sillago robusta*
2	Red mullet	goatfish	*Upeneichthys stotti*
		blue striped goatfish	*Upeneichthys lineatus*
3	Flatfish	flounders	Bothidae
		flounders	Pleuronectidae
		soles	Soleidae
		soles	Cynoglossidae
		flatheads	Platycephalidae
4	Sharks	sharks, skates and rays	Elasmobranchii

Table 2: Sites in the region between Fremantle and Cape Naturaliste which were sampled seasonally by *R.V. Flinders* between autumn 1991 and summer 1991/92. T - trawled commercially, U - not trawled commercially, S - sand substrate, DW - drift weed substrate, SG - seagrass substrate, R - rocky substrate;

Site	Trawl History	Location	Depth (m)	sub-strate
Bell Buoy	T	31° 56'S 115° 38'E	32	S
Cottesloe	U	32° 0'S 115° 42'E	10	S/SG
Coventry Reef	U	32° 22'S 115° 37'E	20	S
Comet Bay	T	32° 26'S 115° 42'E	10	S/DW
Preston (shallow)	U	33° 10'S 115° 40'E	10	SG
Preston (deep)	U	33° 10'S 115° 22'E	30	S/R
Capel	T	33° 25'S 115° 22'E	30	S
Busselton	U	33° 34'S 115° 19'S	12	SG/R
Zone C	T	33° 33'S 115° 11'S	25	S/R

Table 3: Reported annual catch (tonnes) and effort from trawlers in Zone A of the south-west inshore trawl fishery from the Fisheries Department of Western Australia's catch and effort database system (CAESS). Catches reflect the reported catch and do not include discarded animals.

	Year				
	1988	1989	1990	1991	Total
Effort					
Effort (Boat days)	155	116	245	199	715
Target Species Catch					
Target Species					
Saucer Scallops	11.56	3.43	58.48	39.91	113.36
% of total landed catch	65%	30%	92%	86%	81%
Retained By-catch					
Whiting spp.	4.16	5.68	3.47	3.49	16.78
Red mullet	0.73	0.26	0.37	0.16	1.52
Flat Fish	0.20	0.03	0.02	0.29	0.54
Sharks	0.01	0.00	0.10	0.36	0.47
Other Fish	0.90	1.28	0.69	0.74	3.60
Other Molluscs	0.26	0.33	0.57	1.12	2.28
Other Crustaceans	0.00	0.55	0.01	0.08	0.64
Sub-Totals					
Total Retained by-catch	6.25	8.12	5.21	6.24	25.82
% of total landed catch	35%	70%	8%	14%	19%
Discarded by-catch	No data				
Total Landed Catch	17.81	11.54	63.69	46.14	139.18

Table 4: Reported annual total catch (tonnes) of species from trawlers in zones B,C and D of the south-west inshore trawl fishery from the Fisheries Department of Western Australia's catch and effort database system (CAESS). Catches reflect the reported catch and do not include discarded animals.

	Year				
	1988	1989	1990	1991	Total
Effort					
Effort (Boat days)	462	992	1066	654	3174
Target Species Catch					
Target Species Zone D Western King Prawns	23.96	60.22	36.64	11.56	132.38
Target Species zones B & C Saucer Scallops	80.68	33.62	153.95	53.42	321.67
Percentage Target Species Catch of Total Landed Catch	77%	79%	87%	79%	82%
Retained By-catch					
Whiting spp.	7.86	3.37	5.44	2.49	19.17
Red mullet	0.98	0.53	0.82	0.33	2.66
Flat Fish	2.18	2.86	4.28	2.24	11.55
Sharks	3.01	2.68	2.69	1.45	9.82
Other Fish	7.31	4.27	5.69	3.22	20.50
Other Molluscs	2.59	2.30	2.38	1.41	8.68
Other Crustaceans	6.77	9.20	6.95	5.73	28.65
Sub-Totals					
Total Retained by-catch	30.70	25.20	28.26	16.87	101.03
Percentage Retained By-catch of Total Landed Catch	23%	21%	13%	21%	18%
Total Discarded By-catch	No data				
Total Landed Catch	135.34	119.05	218.85	81.84	555.09

Table 5: A list of all species which were caught using 45 and 100mm stretched mesh cod ended research trawl nets in the south-west inshore trawl fishery between autumn 1991 and summer 1991/92. + = Known commercial trawl grounds, * n = 1-10, **n = 11-50, *** n = 51-100, **** n = 101-1000, ***** n = ≥1001

Species	Common Name	Site								
		Bell Buoy +	Cottesloe	Coventry Reef +	Comet Bay +	Preston Deep	Preston Shallow	Capel +	Busselton	Zone C +
Elasmobranchei										
Squatina australis	Angel shark	*	*	*	**	*		*	*	**
Aulohalaelurus labiosus	Black-spotted catshark					*	*			
Urolophus circularis	Circular stingaree					*				
Orectolobus tentaculatus	Cobbler carpetshark								*	
Pristiophorus cirratus	Common sawshark					*			*	*
Myliobatis australis	Eagle ray	*	**	*	*	*	*	*	*	*
Trygonorhina fasciata	Fiddler ray	*	*	*	*	*	*	*	*	*
Mustelus antarcticus	Gummy shark			*	*					
Urolophus lobatus	Lobed stingaree	***	***	****	*	***		**		
Trygonoptera personata	Masked stingaree	**	**	**	*	**	*	**	*	*
Hypnos monopterygium	Numbfish				*	*	*			
Heterodontus portusjacksoni	Port Jackson shark	*	****	*	**	*	*	*	*	**
Sphyrna zygaena	Smooth hammerhead				*					
Dasyatis brevicaudata	Smooth stingray		*	*						
Aptychotrema vincentiana	Southern shovelnose ray	*	*	*	*	*		*		*
Urolophus paucimaculatus	Sparsely-spotted stingaree	**	*	***	*	*		****	***	***
Parascyllium variolatum	Varied catshark						*			
Urolophus mucosus	Western stingaree	**	**	*	**	**	*	**	*	***
Orectolobus sp.	Western wobbegong						*			
Teleostei										
Engraulis australis	Australian anchovy	*								
Arripis georgianus	Australian herring		*							
Strabozebrias unicolor	Banded sole	*	*	*						*
Torquigener pleurogramma	Banded toadfish		*	*						
Upeneichthys tragula	Bat-tailed goatfish				*					
Gonorynchus greyi	Beaked salmon	*	*	*	*	*		**	*	*
Pseudophycis barbata	Bearded cod				*	*	*		*	*
Hypoplectrodes nigrorubrum	Black banded seaperch					*				
Chromis klunzinger	Black-headed Puller					*			*	*
Austrolabrus maculatus	Black-spotted wrasse					*			*	
Spratelloides robustus	Blue sprat			*	*					
Haletta semifasciata	Blue weed whiting		*							
Meuschenia galii	Blue-lined leatherjacket						*			
Omegophora cyanopunctata	Blue-spotted toadfish	***				*			**	*
Upeneichthys lineatus	Blue-striped goatfish	**	****	*	***	****	****	****	****	****
Eubalichthys cyanaura	Blue-tailed leatherjacket		*	*			*			
Pseudolabrus parilus	Brown-spotted wrasse				*		*		*	
Lepidotrigla spinosa	Butterfly gurnard	*	*	*	*	**		**	***	****
Dotolabrus aurantiacus	Castlenau's wrasse						*			
Nelusetta ayraudi	Chinaman leatherjacket	*	*	*		*		**	*	**
Neosebastes scorpaenoides	Common gurnard perch								*	*
Muraenesox bagio	Common pike-eel			*						

Table 5 continued

Species	Common Name	Site								
		Bell Buoy +	Cottesloe	Coventry Reef +	Comet Bay +	Preston Deep	Preston Shallow	Capel +	Busselton	Zone C +
Phylloperyx taeniolatus	Common seadragon					*	**	*	*	
Foetorepus calauropomus	Common stinkfish	*		*						
Ammotretis elongatus	Elongate flounder		*		*	*			*	*
Cnidoglanis macrocephalus	Estuary catfish	*	*	*	**	*	*	*		
Monocanthus chinensis	Fan-bellied leatherjacket				*					
Neatypus obliquus	Footballer sweep	*				**		*	**	*
Ichthscorpus barbartus	Fringed stargazer			*						*
Caesioscorpis theagene	Fusilier sweep		*	*						
Diodon nicthemerus	Globe fish		**	*		*	****	**	**	**
Upeneichthys stotti	Goatfish	**			*	**		*	*	
Apogon rueppelli	Gobbleguts		*		**		**		*	
Glyptauchen panduratus	Goblin fish						*			
Callionymus goodladi	Goodlad's stinkfish	*			*	*		**	*	***
Lepidotrigla modesta	Grooved gurnard	***		***		**		**	*	*
Neosebastes bougainvilli	Gulf gurnard perch					*	**		*	*
Neosebastes pandus	Gurnard perch	*	*	**	*	*	*	*	**	**
Pataecid sp.	Indianfish						*			
Zeus faber	John dory								*	*
Heteroclinus johnstoni	Johnston's weedfish						*			
Sillaginodes punctata	King George whiting		*		*		*			
Oxyconger leptognathus	Large-eyed pike eel	*				*	*			
Saurida undosquamis	Large-scaled grinner	*								
Phycodurus eques	Leafy seadragon						*			*
Paraplagusia unicolor	Lemon tongue sole	*	*		**					*
Gnathophis habenata	Little conger eel		*			*				
Dotalabrus sp.	Little rainbow wrasse						*			
Maxillacosta scabriceps	Little scorpionfish	**	**	**	*	*	**	***	****	****
Leviprora inops	Long-headed flathead		*			*	**	*	*	*
Siphonognathus radiatus	Long-rayed weed whiting		*				**		*	*
Pentaceropsis recurvirostris	Long-snouted boarfish					*				
Platycephalus longispinus	Long-spined flathead	***	**	**	**	***	*	****	**	****
Arnoglossus meuleri	Meuler's flounder	**	*	*	*	**		*	*	*
Eubalichthys mosaicus	Mosaic leatherjacket	*			*					
Argyrosomus hololepidotus	Mulloway				*			*		
Enoplosus armatus	Old wife		*			*				*
Vicentia punctata	Orange cardinalfish					*	**		*	*
Polyspina piosae	Orange-barred pufferfish		****	**	**					
Pempheris sp.	Orange-lined bullseye					*		**		
Torquigener vicinus	Orange-spotted pufferfish	*								
Trachinocephalus myops	Painted grinner		*							
Eocallionymus papilio	Painted stinkfish						*			
Contusus brevicaudus	Prickly toadfish	*	*		**	*		*		**
Brachaluteres jacksonianus	Pygmy leatherjacket	*			*	*	*		*	
Odax acroptilus	Rainbow cale				*	*	****	*	*	
Chelidonichthys kumu	Red gurnard	*		*	**	*				
Pataecus fronto	Red indianfish		*				*			

Table 5 continued

Species	Common Name	Site								
		Bell Buoy +	Cottesloe	Coventry Reef +	Comet Bay +	Preston Deep	Preston Shallow	Capel +	Busselton	Zone C +
Gnathanacanthus goetzeei	Red velvetfish						*			
Caesioperca sp.	Red-lined Seaperch								*	*
Cleilodactylus rubrolabiatus	Red-lipped morwong						*			
Apogon victoriae	Red-striped cardinalfish						*			
Caprichthys gymnura	Rigid boxfish									
Omegophora armilla	Ringed toadfish		*		*	**	*	*	*	*
Gerres subfasciatus	Roach				**					
Leviprora laevigatus	Rock flathead						*			
Heteroclinus roseus	Rosy weedfish						*			
Pempheris klunzingeri	Rough bullseye	*	*	*		****	****	**	*****	****
Scobinichthys granulatus	Rough leatherjacket		*	*	**	*	****	***	****	****
Trachichthys australis	Roughy						*		*	*
Seriola hippos	Samsonfish	*	*							*
Pseudocaranx wrighti	Sand trevally	****	**	****	****	***	*	**	*	****
Leseurina sp.	Sandfish					*				
Hyperlophus vittatus	Sandy sprat		*	*	**	*	*			
Maroubra perserrata	Sawtooth pipefish			*						
Pelsartia humeralis	Sea trumpeter		*				*		*	
Pictilabrus laticlavius	Senator wrasse						*			
Aulopus purpurissatus	Sergeant baker					*				
Pterygotrigla polyommata	Sharp-beaked gurnard			*				*		
Aracana aurita	Shaw's cowfish	*	**	*	**	**	****	*	**	**
Parazanclistius hutchinsi	Short boarfish	*						*	*	*
Threpterius maculosus	Silver spot						*			
Pelates sexlineatus	Six-lined trumpeter	*	*		***		*			
Meuschenia freycineti	Six-spined leatherjacket		*				*		*	*
Pseudocaranx dentex	Skipjack trevally									*
Parapriacanthus elongatus	Slender bullseye	**	*	***	*	****	*	***	***	**
Strongylura leiura	Slender longtom	*								
Optivus elongatus	Slender roughy					*				
Parapegasus natans	Slender seamoth			*	*					
Siphonognathus attenuatus	Slender weed whiting						*		*	
Allomycterus pilatus	Small-spined porcupinefish	*	*	*		*		*	*	*
Pseudorhombus jenynsii	Small-toothed flounder	*		*	**	*	*	*	*	*
Eupetrichthys angustipes	Snakeskin wrasse								*	
Sphyraena novaehollandiae	Snook		*	*		*	*			
Gymnapistes marmoratus	Soldierfish				**					
Arnoglossus sp.	Sole	*		*		*		*		*
Parequula melbournensis	Southern silverbelly	****	****	*****	****	*****	****	*****	*****	*****
Platycephalus speculator	Southern blue-spotted flathead		*		*	*		*	*	*
Cristiceps australis	Southern crested weedfish				**	*	*			
Sillago bassensis	Southern school whiting	****	****	****	****	****		****	**	****
Hyporamphus melanochir	Southern sea garfish	*	*	*	*				*	
Cynoglossus broadhursti	Southern tongue sole	*	*	*	**	*	*	*	*	**
Lepidotrigla papilio	Spiny gurnard	*		*		**		***	**	****
Parapercis ramsayi	Spotted grubfish					*		*		*

Table 5 continued

Species	Common Name	Site								
		Bell Buoy +	Cottesloe	Coventry Reef +	Comet Bay +	Preston Deep	Preston Shallow	Capel +	Busselton	Zone C +
Stigmatopora argus	Spotted pipefish						*	*	*	*
Uranoscopid sp.	Stargazer	*	*							
Sillago robusta	Stout whiting	****		****	*					
Pempheris schwenkii	Striped bullseye								*	
Pomatomus saltator	Tailor			*	**					
Rhabdosargus sarba	Tarwhine				****					
Thysanophrys cirronasus	Tassel-snouted flathead						*		*	
Filicampus tigris	Tiger pipefish		*							
Penicepelta vittiger	Toothbrush leatherjacket	**	***	*	**	**	****	****	****	****
Sillago maculata	Trumpeter whiting			*	**					
Siphonognathus argyrophanes	Tubemouth								*	
Trioris reipublicae	Turret fish		*	*	*					
Aluteres monoceros	Unicorn leatherjacket					*				
Velifer multiradius	Veilfin	***	*	****	*	*		**	*	**
Aploactisoma milesii	Velvetfish						*			
Glaucosoma hebraicum	West Australian jewfish					*				
Pentapodus vitta	Western Australian butterfish		*		**					*
Centropogon latifrons	Western fortescue									*
Chironemus georgianus	Western kelpfish						**			
Scorpaena sumptuosa	Western red scorpioncod					*			*	
Sillago vittata	Western school whiting		*		**					*
Anoplocapros robustus	Western smooth boxfish	**	****	*	*	*		**	**	**
Neopataecus waterhousi	Whiskered prowfish					*	*			
Anoplocapros lenticularis	White-barred boxfish	**					*	*	*	
Perryena leucometopan	White-nose pigfish						*			
Maxillicosta whitleyi	Whitley's scorpionfish						*	*	*	*
Zebrias craticula	Wickerwork sole	*		*					*	*
Siphamia cephalotes	Wood's siphonfish				*					
Cristiceps aurantiacus	Yellow-crested weedfih		*		*	*	*			
Trachurus novaezealandicus	Yellowtail	*	*	*	*	*		**	*	*
Platycephalus aurimaculatus				*		*		*		*
Neoplatycephalus sp.										*
Crustacea										
Ibacus peronii	Balmain bug	**	*	**	**	**	*	**	**	**
Portunus pelagicus	Blue manna crab	**	**	*	****		*		*	**
Euryallid spp.	Burrowing crabs	**								*
Carid spp.	Carid shrimps						*			
Xanthid spp.	Dark-fingered crabs	*					**		**	*
Dromid spp.	Decorator crabs						*	**		
Penaeid spp.	Hardback prawn			*		*				*
Squilla spp.	Manta shrimps				*	*	*	*		*
Ovalipes australiensis	Sand crab	*	**	**	*	*	*	*	*	*
Alpheidae spp.	Snapper shrimps					*	*			
Majid spp.	Spider crabs		*	*		*	**	*	*	*
Portunid spp.	Swimming crabs	*	*					*		*
Penaeus latisulcatus	Western king prawn	*	*	*	****	**			*	**
Panulirus cygnus	Western rock lobster	*			*	*	*			
Crab spp.		**	*	**	**	**		*	**	**

Table 5 continued

Species	Common Name	Site								
		Bell Buoy +	Cottesloe	Coventry Reef +	Comet Bay +	Preston Deep	Preston Shallow	Capel +	Busselton	Zone C +
Mollusca										
Nototodarus gouldii	Arrow squid			*		*		*		
Melo spp.	Baler shells									*
Bivalves	Bivalve shells	*		**	*			*	**	****
Sepioteuthis australis	Calamari	***	***	****	**	***	***	***	***	***
Cypraea spp.	Cowries					*				
Sepioid spp.	Cuttlefish	**	*	**	*	**	**	**	***	***
Rossia sp.	Dumpling squid		*	*	*	*	*		*	*
Octopoda spp.	Octopus	*		*		*	**	*	*	*
Pecten sp.	Pecten scallops	*						*	*	***
Amusium balloti	Saucer scallop	*****	*	****		***		****	****	*****
Nudibranch	Sea slugs	*	*							
Opisthobranch	Sea slugs				*					
Gastropod	sea snails		*							*
Trochid spp.	Top shells		**							
Cymattid spp.	Trumpet shell						*			
Turbinid spp.	Turban shells		*							
Philine sp.		*	*		*				*	*
Echinodermata										
Crinoid spp.	Basket stars					*	*			
Ophiuroid spp.	Brittle stars	*				*				
Holothuroid spp.	Sea cucumbers					*	*		*	*
Asteroid spp.	Sea stars	*	*		*	*	*	*	**	*
Echinoid spp.	Sea urchins		**	*	*		*		*	*

Table 6: A list of species which have been retained as marketable product by trawler skippers in the south-west inshore trawl fishery at some time between July 1990 and January 1992. The data represent the total catch of each species obtained from 365 commercial trawls sampled during this period. * - 0 to 50kg, ** - 51 to 100kg, *** - > 101kg, # - target species Zone A, B and C, ## - target species Zone D, R - Recreationally important species.

Number		Species	Catch
1		balmain bug	*
2	R	blue manna crab	***
3	R	blue spotted flathead	*
4		blue striped goatfish (red mullet)	*
5	R	cobbler	*
6	R	cuttlefish	**
7		eagle ray	*
8		fringed stargazer	*
9		red mullet (*Upeneichthys stotti*)	*
10	R	gurnard perch	***
11	R	harrowed sole	*
12	R	john dory	*
13		knife jaw	*
14	R	lemon tongue sole	*
15	R	long headed flathead	*
16	R	long spined flathead	*
17	R	mulloway	*
18	R	octopus	*
19		prickly leatherjacket	*
20		red gurnard	*
21	R	sand trevally	*
22		saucer scallop #	***
23		sharp beaked gurnard	*
24		short boarfish	*
25	R	silver bream	*
26	R	six spined leatherjacket	*
27	R	skipjack trevally	*
28	R	small toothed flounder	***
29	R	snook	*
30	R	sole spp.	*
31	R	southern school whiting	***
32	R	southern tongue sole	**
33	R	squid	***
34	R	tailor	*
35	R	trumpeter whiting	*
36	R	western king prawn ##	***
37	R	western school whiting	*
38	R	western wobbegong	*
39	R	yellowtail	*

Table 7: The predicted commercial retained and discarded catch (tonnes) from trawlers of Zone A between autumn 1991 and summer of 1991/92.

	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Target Species					
Saucer scallops	5%	39.99	0.54	40.53	1%
Commercial & Recreational Species					
Balmain Bug	50%	0.20	0.00	0.20	0%
Blue-striped Goatfish	100%	0.06	0.02	0.08	25%
Cuttlefish	100%	0.00	0.04	0.04	100%
Eagle Ray	50%	0.00	3.61	3.61	100%
Fringed Stargazer	100%	0.00	0.36	0.36	100%
blue lined goatfish	100%	0.00	0.22	0.22	100%
Gurnard Perch	100%	0.52	0.14	0.66	21%
harrowed Sole	100%	0.14	0.02	0.16	13%
John Dory	100%	0.10	0.04	0.14	29%
Long-spined Flathead	100%	0.00	2.38	2.38	100%
Prickly Leatherjacket	100%	0.00	0.14	0.14	100%
Red Gurnard	100%	0.00	0.12	0.12	100%
Sand Trevally	100%	0.00	1.61	1.61	100%
Small Toothed Flounder	100%	0.00	0.20	0.20	100%
Southern school Whiting	100%	2.86	6.75	9.61	70%
Southern Tongue Sole	100%	0.24	0.00	0.24	0%
Short boarfish	100%	0.00	0.02	0.02	100%
Squid	100%	0.91	0.08	0.99	8%
Western King Prawn	100%	0.08	0.00	0.08	0%
Yellowtail	100%	0.00	2.00	2.00	100%
Sub-total		5.11	17.75	22.86	78%

Table 7 Continued	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Discarded Catch					
Aplysiidae	50%	0.00	0.50	0.50	100%
Bothidae	100%	0.00	0.08	0.08	100%
Dasyatididae	50%	0.00	1.59	1.59	100%
Diodontidae	100%	0.00	0.30	0.30	100%
Gerreidae	100%	0.00	2.82	2.82	100%
Harpadontidae	100%	0.00	0.10	0.10	100%
Heterodontidae	50%	0.00	0.38	0.38	100%
Monacanthidae	100%	0.00	0.26	0.26	100%
Mullidae	100%	0.00	0.24	0.24	100%
Myliobatidae	100%	0.00	3.61	3.61	100%
Ostraciidae	100%	0.00	2.18	2.18	100%
Pempheridae	100%	0.00	0.02	0.02	100%
Porifera	100%	0.00	0.72	0.72	100%
Portunidae	14%	0.00	0.02	0.02	100%
Rhinobatidae	50%	0.00	3.10	3.10	100%
Scorpaenidae	100%	0.00	0.15	0.15	100%
Sillaginidae	100%	0.00	6.81	6.81	100%
Soleidae	100%	0.00	0.40	0.40	100%
Squatinidae	50%	0.00	2.42	2.42	100%
Triglidae	100%	0.00	0.72	0.72	100%
Uranoscopidae	100%	0.00	0.36	0.36	100%
Urolophidae	50%	0.00	13.78	13.78	100%
Veliferidae	100%	0.00	0.76	0.76	100%
Sub-Total		0.00	41.32	41.32	100%
Total		45.10	59.61	104.71	57%

Predicted weights of discarded animals which survive and die from trawling.

1. Survive Trawling	13.22	tonnes
2. Do not survive Trawling	46.39	tonnes
Percentage Survive Trawling	22%	

Table 8: The predicted commercial retained and discarded catch (tonnes) from trawlers of Zone B between autumn 1991 and summer of 1991/92.

	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Target Species Catch					
Saucer scallops	5%	49.59	0.00	49.59	0%
Commercial Recreational Species					
Arrow Squid	100%	0.14	0.02	0.16	13%
Balmain Bug	50%	0.10	0.04	0.14	29%
blue manna	14%	0.16	0.00	0.16	0%
Blue spotted Flathead	100%	0.41	0.00	0.41	0%
Blue-striped Goatfish	100%	0.31	0.60	0.91	66%
Cuttlefish	100%	0.16	0.00	0.16	0%
Eagle Ray	50%	0.00	1.57	1.57	100%
Flathead Sp	100%	0.53	0.14	0.67	21%
Fringed Stargazer	100%	0.00	0.10	0.10	100%
blue lined goatfish	100%	0.02	0.31	0.33	94%
cobbler	100%	0.00	0.02	0.02	100%
Gurnard Perch	100%	0.16	0.24	0.40	60%
harrowed Sole	100%	0.00	0.02	0.02	100%
John Dory	100%	0.33	0.00	0.33	0%
lemon tongue sole	100%	0.00	0.02	0.02	100%
Long-spined Flathead	100%	0.20	2.89	3.09	94%
Octopus	50%	0.24	0.00	0.24	0%
Red Gurnard	100%	0.00	0.10	0.10	100%
Sand Trevally	100%	1.38	2.52	3.90	65%
Sharp-beaked Gurnard	100%	0.00	0.04	0.04	100%
Small Toothed Flounder	100%	0.18	0.47	0.65	72%
Southern school Whiting	100%	3.52	4.07	7.59	54%
Southern Tongue Sole	100%	0.92	0.14	1.06	13%
Squid	100%	1.18	0.00	1.18	0%
Western King Prawn	100%	0.96	0.00	0.96	0%
Yellowtail	100%	0.10	0.06	0.16	38%
Sub-Total		11.00	13.37	24.37	55%

Table 8 Continued	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Discarded Catch					
Aplysiidae	50%	0.00	2.54	2.54	100%
Ascidian	50%	0.00	0.61	0.61	100%
Bivalve	50%	0.00	0.06	0.06	100%
Bothidae	100%	0.00	0.47	0.47	100%
Caesioscorpididae	100%	0.00	0.04	0.04	100%
Carangidae	100%	0.00	2.62	2.62	100%
Cnidarian	50%	0.00	0.04	0.04	100%
Cynoglossidae	100%	0.00	0.16	0.16	100%
Dasyatididae	50%	0.00	1.46	1.46	100%
Diodontidae	100%	0.00	1.10	1.10	100%
Enoplosidae	100%	0.00	0.02	0.02	100%
Gerreidae	100%	0.00	3.64	3.64	100%
Gonorynchidae	100%	0.00	0.10	0.10	100%
Harpadontidae	100%	0.00	0.28	0.28	100%
Heterodontidae	50%	0.00	0.55	0.55	100%
Monacanthidae	100%	0.00	0.69	0.69	100%
Mullidae	100%	0.00	0.92	0.92	100%
Muraenesocidae	100%	0.00	0.02	0.02	100%
Myliobatidae	50%	0.00	1.57	1.57	100%
Ommastrephidae	100%	0.00	0.02	0.02	100%
Ostraciidae	100%	0.00	3.38	3.38	100%
Palinuridae	50%	0.00	0.51	0.51	100%
Pectinidae	5%	0.00	0.02	0.02	100%
Pempheridídae	100%	0.00	0.24	0.24	100%
Platycephalidae	100%	0.00	3.03	3.03	100%
Pleuronectidae	100%	0.00	0.02	0.02	100%
Porifera	50%	0.00	24.54	24.54	100%
Portunidae	14%	0.00	2.38	2.38	100%
Rhinobatidae	50%	0.00	3.62	3.62	100%
Scorpaenidae	100%	0.00	0.24	0.24	100%
Scorpididae	100%	0.00	0.04	0.04	100%
Scylaridae	100%	0.00	0.04	0.04	100%
Serranidae	100%	0.00	0.02	0.02	100%
Sillaginidae	100%	0.00	4.31	4.31	100%
Soleidae	100%	0.00	0.40	0.40	100%
Squatinidae	50%	0.00	4.11	4.11	100%
Tetraodontidae	100%	0.00	0.69	0.69	100%
Triglidae	100%	0.00	1.81	1.81	100%
Uranoscopidae	100%	0.00	0.10	0.10	100%
Urolophidae	50%	0.00	8.68	8.68	100%
Veliferidae	100%	0.00	1.18	1.18	100%
Sub-Total		0.00	76.27	76.27	100%
Total		60.59	89.64	150.23	60%

Predicted weights of discarded animals which survive and die from trawling.

1. Survive Trawling	27.02	tonnes
2. Do not survive Trawling	62.62	tonnes
Percentage Survive Trawling	30%	

Table 9: The predicted commercial retained and discarded catch (tonnes) from trawlers of Zone C between autumn 1991 and summer of 1991/92.

	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Target Species					
Saucer scallops	5%	12.34	2.68	15.02	82%
Commercial & Recreational Species					
Balmain Bug	50%	0.00	0.04	0.04	100%
Blue Manna	14%	0.14	0.26	0.40	65%
Blue-striped Goatfish	100%	0.00	0.02	0.02	100%
Cuttlefish	100%	0.02	0.01	0.03	33%
Gurnard Perch	100%	0.45	0.04	0.49	8%
Sand Trevally	100%	0.01	0.01	0.02	50%
Southern school Whiting	100%	0.00	0.01	0.01	100%
Small Toothed Flounder	100%	0.02	0.00	0.02	0%
Squid	100%	0.04	0.00	0.04	100%
Sub-Total		0.68	0.39	1.07	64%
Discarded Catch					
Anthozoa	50%	0.00	0.62	0.62	100%
Ascidian	50%	0.00	0.21	0.21	100%
Carangidae	100%	0.00	0.01	0.01	100%
Cnidarian	50%	0.00	0.14	0.14	100%
Diodontidae	100%	0.00	1.51	1.51	100%
Gerreidae	100%	0.00	0.04	0.04	100%
Heterodontidae	50%	0.00	0.25	0.25	100%
Holothuroidea	50%	0.00	0.08	0.08	100%
Monacanthidae	100%	0.00	0.01	0.01	100%
Mullidae	100%	0.00	0.01	0.01	100%
Myliobatidae	50%	0.00	0.06	0.06	100%
Ostraciidae	100%	0.00	2.18	2.18	100%
Pectinidae	50%	0.00	0.01	0.01	100%
Pempheridídae	100%	0.00	0.01	0.01	100%
Porifera	100%	0.00	1.50	1.50	100%
Portunidae	14%	0.00	0.28	0.28	100%
Rhinobatidae	50%	0.00	0.18	0.18	100%
Scorpaenidae	100%	0.00	0.04	0.04	100%
Squatinidae	50%	0.00	5.15	5.15	100%
Tetraodontidae	100%	0.00	0.03	0.03	100%
Urolophidae	50%	0.00	5.29	5.29	100%
Sub-Total		0.00	17.61	17.61	100%
Total		13.02	20.68	33.70	61%

Predicted weights of discarded animals which survive and die from trawling

1. Survive Trawling	9.03	tonnes
2. Do no survive Trawling	11.65	tonnes
Percentage survive trawling	44%	

Table 10: The predicted commercial retained and discarded catch (tonnes) from trawlers of the Comet Bay (Zone D) fishery between autumn 1991 and summer 1991/92.

	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Target Species					
Western King Prawn	100%	6.90	0.00	6.90	0%
Commercial & Recreational Species					
Blue Manna	14%	4.06	13.25	17.31	77%
Blue spotted Flathead	100%	0.08	0.19	0.27	70%
Blue-striped Goatfish	100%	0.02	0.19	0.21	92%
Cobbler	100%	0.00	0.41	0.41	100%
Eagle Ray	50%	0.00	2.87	2.87	100%
harrowed Sole	100%	0.00	0.02	0.02	100%
Lemon Tongue Sole	100%	0.02	0.35	0.36	96%
Long-spined Flathead	100%	0.00	0.32	0.32	100%
Mulloway	100%	0.00	0.14	0.14	100%
Octopus	50%	0.00	0.02	0.02	100%
Red Gurnard	100%	0.00	0.58	0.58	100%
Sand Trevally	100%	0.00	0.36	0.36	100%
Small Toothed Flounder	100%	0.00	0.55	0.55	100%
Southern school Whiting	100%	0.00	4.77	4.77	100%
Southern Tongue Sole	100%	0.04	0.16	0.20	79%
Squid	100%	0.00	0.04	0.04	100%
Tailor	100%	0.03	0.11	0.15	78%
Tarwhine	100%	0.00	0.00	0.00	0%
Trumpeter Whiting	100%	0.00	0.33	0.33	100%
Western School Whiting	100%	0.00	1.03	1.03	100%
Sub-Total		4.25	25.68	29.93	86%

Table 10 Continued	Percent Mortality of Discards	Retained Catch	Discarded Catch	Total Catch	Percent Discards
Discarded Catch					
Apogonidae	100%	0.00	0.02	0.02	100%
Clupeidae	100%	0.00	0.15	0.15	100%
Cnidarian	50%	0.00	0.02	0.02	100%
Gerreidae	100%	0.00	0.52	0.52	100%
Gonorynchidae	100%	0.00	0.06	0.06	100%
Heterodontidae	50%	0.00	2.14	2.14	100%
Hypnidae	50%	0.00	0.24	0.24	100%
Monacanthidae	100%	0.00	0.05	0.05	100%
Mullidae	100%	0.00	0.04	0.04	100%
Nemipteridae	100%	0.00	0.02	0.02	100%
Ostraciidae	100%	0.00	1.00	1.00	100%
Palinuridae	50%	0.00	0.47	0.47	100%
Penaeidae	100%	0.00	0.19	0.19	100%
Pennatulacea	50%	0.00	0.39	0.39	100%
Pleuronectidae	100%	0.00	0.32	0.32	100%
Porifera	50%	0.00	0.14	0.14	100%
Portunidae	14%	0.00	1.78	1.78	100%
Rhinobatidae	50%	0.00	12.56	12.56	100%
Sillaginidae	100%	0.00	0.37	0.37	100%
Squatinidae	50%	0.00	2.58	2.58	100%
Squillidae	100%	0.00	0.05	0.05	100%
Teraponidae	100%	0.00	0.03	0.03	100%
Tetraodontidae	100%	0.00	0.17	0.17	100%
Triakidae	100%	0.00	0.11	0.11	100%
Triglidae	100%	0.00	0.03	0.03	100%
Urolophidae	50%	0.00	5.38	5.38	100%
Sub-Total		0.00	28.83	28.83	100%
Total		11.15	54.51	65.66	83%

Predicted weights of discarded animals which survive and die from trawling.

1. Survive Trawling	26.33	tonnes
2. Do not survive Trawling	28.18	tonnes
Percentage Survive Trawling	48%	

Table 11: Comparison of the catch rates (numbers/ha) of research trawl nets with mesh sizes of 25, 45 and 102mm from the south-west inshore trawl fishery. The catches obtained for the 25mm cod end net are the sum of the 25 and 45mm cod end nets, since the former cod end was placed over the latter. * - Areas currently commercially trawled.

Commercial & Recreational Species	Bell Buoy * Number/ha Mesh Size			Cottesloe Number/ha Mesh Size			Coventry Reef * Number/ha Mesh Size			Comet Bay * Number/ha Mesh Size			Preston (shallow) Number/ha Mesh Size			Preston (deep) Number/ha Mesh Size			Capel * Number/ha Mesh Size			Busselton Number/ha Mesh Size			Zone C * Number/ha Mesh Size		
	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100
Blue Manna				1	1	4	0	0		166	165	43				0	0										
Blue spotted Flathead				0	0	0				0	0								1	1		1	1				
Blue sprat							1	1		1	1																
Blue striped Goatfish	2	1		80	46	3	0			9	8		36	23	4	7	2		234	161		241	94	0	208	185	
Cobbler				1	1		1	1		3	3		0	0	0	0											
Elongated Flounder				1	1					1	1											3	2		1		
Gurnard Perch	0	0		0	0		1	1	2			0							3	3	1	1	1	1	1	1	1
Long spined Flathead	9	6		1	0		2	2		1	1		0	0		2	2		20	19		2	2		9	9	
Rock Lobster												0				0	0	0									
Sand Trevally	1	1		2	1		7	7		3	3								6	1					54	22	0
Saucer scallops	19	19	19			1	0	0											17	17	9	24	24	13	68	68	80
Small Toothed Flounder	1	1								14	13	0				0	0							0			
Southern School Whiting	45	45	1	16	12	1	16	16		427	371					5	5		19	18	1	1	1		14	14	
Southern Tongue Sole										2	1					0	0		1	1		0			0	0	
Squid	0	0	0	9	8	1	7	6	0	1	1		1	1		5	4	1	11	10	1	27	19	0	14	14	2
Trumpeter Whiting										48	48	0															
Western King Prawn	4	4		1	1		2	2		241	237														0	0	
Sub-totals	81	76	20	112	72	9	38	37	2	918	853	45	38	25	4	20	13	1	310	230	12	302	144	15	369	314	83

Table 11 continued

Other Families	Bell Buoy * Number/ha Mesh Size			Cottesloe Number/ha Mesh Size			Coventry Reef * Number/ha Mesh Size			Comet Bay * Number/ha Mesh Size			Preston (shallow) Number/ha Mesh Size			Preston (deep) Number/ha Mesh Size			Capel * Number/ha Mesh Size			Busselton Number/ha Mesh Size			Zone C * Number/ha Mesh Size		
	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100
Aploactinindae													0														
Apogonidae				1						91	53	0	0									3	0				
Arripidae				2	1	0																					
Caesioscorpidae	0	0		5	3																						
Callionymidae				0	0					11	9	0				0	0		1	0		4	2				
Carangidae							0	0											0	0					4	3	
Chironemidae													0	0	0				2	2		0	0		0	0	
Clinidae				0			0						2	1		1	0					3					
Clupeidae										10	10																
Congridae										1	1											0	0				
Cynoglossidae				0	0					2	2																
Dasyatididae				0	0				0										0	0	0	0	0				
Diodontidae				10	9	3			0	1	1		6	6	3	0	0	1	4	4	3	5	5	6			
Gerreidae	42	20		340	161	1	130	42		230	118		25	22	3	293	90	0	949	524	2	501	216	1	2	2	2
Gonorynchidae	0	0		0			2	1		10	4					0	0		3	2		5	4		642	541	0
Harpadontidae							0	0																	1	1	
Hemirhamphidae				0	0																						
Heterodontidae			0	5	5	3	1	1		8	8	2	1	1							0	0	0				
Labridae													1	0					0			1	0		0	0	1
Monacanthidae	7	2		49	29	2	9	2		46	32	0	28	16	5	6	2		68	38	0	61	24				
Moridae										3	1		1	0					2	1		6	0		41	36	0
Mugiloididae																			1	1		0					
Mullidae	4	2		0			4	3		21	5					3	1		8	7					0	0	
Muraenesocidae	7	1		0			0			1																	
Myliobatidae			1	4	4	5	1	1	0	0	0		0	0					1	1	2	0	0				
Nemipteridae				1	1					2	1														2	2	3
Odacidae				1	0								8	7	1	3	0		0			3	0		1	1	
Orectolobidae																						0	0				
Ostraciidae	1	1	1	10	10	11	1	1	0	2	1	3	8	8	6	1	1	0	2	2	1	3	3	3			
Pempheridae	1	0		6	3		8	5		0			5	4	2	48	5		10	5		74	29	0	6	6	10
Platycephalidae													1	1											3	2	0
Pomacentridae													5	1	0							1	1				
Pomatomidae										4	4																
Rhinobatidae	1	1	1	2	2	1			0	7	7	5						0	1	1	0	0	0				
Scorpaenidae	4	2		3	2					7	1	0	3	1		0			15	10		75	21		0	0	1
Scorpididae	0	0																	2	2		0	0		19	15	0
Sillaginidae	56	25		12	12	0	42	15		16	16																
Soleidae	5	0		0			0			1	0					1	1		2	1		3	2				
Sparidae										1	1														1	1	
Sphyraenidae																						0	0				
Squatinidae	1	1	0	1	1	1			0	0	0	0				1	1	0	1	1	0	0	0	0			
Syngnathidae	1	1		1	0								1	1	0									0	2	2	2
Teraponidae				2	2	0				0	0														0		
Tetraodontidae	9	5		15	11	0	9	3	0	5	3	0	0	0	1	0	0	0				4	0				
Trachichthyidae													0	0											2	2	2
Triglidae	6	6		1	1		6	6		2	2					0	0		20	20	1	25	15				
Uranoscopidae																0			1						33	32	0
Urolophidae	5	5	3	9	9	8	32	32	18	2	2	1				3	3	3	25	25	15	5	5	2	0	0	0
Veliferidae	3	2		0	0		3	2		1	0					0	0		7	6	0			0	3	3	14
Zeidae									0												1				2	2	
Sub-totals	152	75	5	480	267	36	249	116	21	489	285	14	98	71	22	362	106	5	1125	653	25	785	332	13	765	652	36

Table 11 continued

Other Invertebrates	Bell Buoy * Number/ha Mesh Size			Cottesloe Number/ha Mesh Size			Coventry Reef * Number/ha Mesh Size			Comet Bay * Number/ha Mesh Size			Preston (shallow) Number/ha Mesh Size			Preston (deep) Number/ha Mesh Size			Capel * Number/ha Mesh Size			Busselton Number/ha Mesh Size			Zone C * Number/ha Mesh Size		
	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100
Bivalve							2	2											2	2		1	0				
Cnidarian												0													1	1	2
Crinoidea															0												
Crustacea				1	0		0						0	0		0						0					
Echinoidea				3			2		0													0					
Gastropoda	1			0			1												1								
Octopodidae										1	0	0	0	0					0			0	0	0			
Ommastrephidae	1			6	2		1			14	7		1	1	0				3			1					
Ophuiroidea						0				0	0				0			0	1	1	0	1	1	1			
Pectinidae	0	0	0	0	0														5	5					0	0	0
Penaeidae	31	4		5	0		4	1		14	3				0				6			9					1
Porifera							0	0	0													0	0	0			
Portunidae	0	0		1	1	0	1															0	0				
Scyl ridae	0	0					0	0				0			0				1	1		2	2	1			
Sepiidae				0	0	0	0						1	1	1	0	0	1	12	7	2	25	22	8	1	1	0
Squillidae	0									1	0		1	0											9	9	4
Trochidae	0			6															1								
Xanthidae				0	0								0	0		0	0										
Sub-totals	70	5	0	22	4	1	11	3	1	30	12	1	3	3	2	2	0	1	31	15	2	39	26	10	11	11	8
Totals	303	156	25	637	343	46	310	157	23	1469	1149	60	143	98	29	383	119	7	1496	897	38	1167	503	38	1145	978	128

Table 12: Comparison of the catch rates (g/ha) of 25, 45 and 100mm stretched mesh research trawl nets from the south-west inshore trawl fishery. The catches obtained for the 25mm cod end net are the sum of the 25 and 45mm cod end nets, since the former cod end was placed over the latter. * - Area currently commercially trawled.

Commercial & Recreational Species	Bell Buoy * Weight/ha (g) Mesh Size			Cottesloe Weight/ha (g) Mesh Size			Coventry Reef * Weight/ha (g) Mesh Size			Comet Bay * Weight/ha (g) Mesh Size			Preston (shallow) Weight/ha (g) Mesh Size			Preston (deep) Weight/ha (g) Mesh Size			Capel * Weight/ha (g) Mesh Size			Busselton Weight/ha (g) Mesh Size			Zone C * Weight/ha (g) Mesh Size		
	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100
Blue Manna				457	457	1738	28	28		4910	4907	3910				1	1										
Blue spotted Flathead				361	361	125				240	240								27	27		49	49				
Blue sprat							32	32		26	26																
Blue striped Goatfish	49	41		2708	2438	603	3			221	199		1684	1553	425	114	51		5644	4785		4539	3153	33	4114	3833	
Cobbler				157	157		86	86		268	268		49	49	98	5											
Elongated Flounder				73	73					48	48											89	64		8		
Gurnard Perch	223	223		230	230		434	434	670			175							1637	1637	520	554	554	708	529	529	668
Long spined Flathead	389	338		25	21		76	72		59	59		120	120		246	234		1389	1369		243	227		803	797	
Rock Lobster												153				764	764	368									
Sand Trevally	12	11		50	47		200	197		235	235								22	6					712	492	32
Saucer scallops	1995	1995	2044			111	41	41											1322	1322	1067	1616	1616	1312	6766	6766	8637
Small Toothed Flounder	228	228								552	543	144				90	90							397			
Southern School Whiting	3303	3280	96	1003	938	116	1394	1394		11387	10528					396	396		1808	1792	72	250	250		1487	1487	
Southern Tongue Sole										48	38					49	49		80	80		9			21	21	
Squid	53	53	78	765	760	656	815	811	20	42	42		332	329		207	199	17	605	591	236	1071	1011	108	1207	1207	480
Trumpeter Whiting										2065	2065	14															
Western King Prawn	69	68		8	8		48	48		4756	4717														7	7	
Sub-totals	6322	6236	2217	5836	5489	3349	3157	3142	690	24856	23914	4397	2185	2051	523	1872	1785	384	12535	11609	1894	8419	6923	2557	15654	15140	9818

Table 12 continued

Other Families	Bell Buoy * Weight/ha (g) Mesh Size			Cottesloe Weight/ha (g) Mesh Size			Coventry Reef * Weight/ha (g) Mesh Size			Comet Bay * Weight/ha (g) Mesh Size			Preston (shallow) Weight/ha (g) Mesh Size			Preston (deep) Weight/ha (g) Mesh Size			Capel * Weight/ha (g) Mesh Size			Busselton Weight/ha (g) Mesh Size			Zone C * Weight/ha (g) Mesh Size		
	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100
Aploactinindae													0														
Apogonidae				2						555	380	2	0									8	1				
Arripidae				301	250	33																					
Caesioscorpididae	2	2		30	22																						
Callionymidae				3	3					163	141	9				3	1		19	15		64	40				
Carangidae							21	21											22	22					130	114	
Chironemidae													4	4	5				206	206		4	4		5	5	
Clinidae				2			0						19	10		7	3					16					
Clupeidae										14	14																
Congridae										12	12											0	0				
Cynoglossidae				63	63					111	111																
Dasyatididae				4265	4265				1034										2826	2826	3281	3365	3365				
Diodontidae				1229	1226	375			88	14	14		827	825	826	217	217	495	1168	1168	1356	2079	2079	2755			
Gerreidae	469	297		3512	2392	20	756	365		2723	1824		446	415	69	1683	774	2	14392	8309	28	6611	4716	32	929	929	1739
Gonorynchidae	4	4		33			124	116		360	137					20	20		141	108		253	113		13083	9410	13
Harpadontidae							19	19																	127	112	
Hemirhamphidae				3	3																						
Heterodontidae			28	642	642	592	164	164		1747	1747	425	112	112							87	2644	2644				
Labridae													65	59					6			15	4		79	79	116
Monacanthidae	51	30		1322	1224	243	76	40		620	530	23	1406	1376	395	56	37		1382	1109	3	1156	945				
Moridae										30	13		9	5					12	6		37	5		1279	1215	22
Mugiloididae																			16	9		2					
Mullidae	66	52		2			61	55		128	58					43	16		213	195					7	7	
Muraenesocidae	217	22		12			3			45																	
Myliobatidae			2789	5133	5133	4654	1833	1833	2020	477	477		2080	2080					2115	2115	1184	2572	2572				
Nemipteridae				118	118					91	66														1014	1014	7379
Odacidae				13	7								327	313	56	33	12		1			18	4		70	70	
Orectolobidae																						625	625				
Ostraciidae	281	281	190	2273	2273	3296	420	420	207	221	219	845	1591	1591	1657	281	281	92	964	964	260	1703	1703	1724			
Pempheridae	14	13		36	29		58	43		2			74	57	45	231	27		149	107		1054	849	5	1982	1982	3351
Platycephalidae													198	198											25	18	12
Pomacentridae													21	3	1							6	6				
Pomatomidae										396	376																
Rhinobatidae	525	525	513	3019	3019	226			154	2429	2429	2391						391	203	203	197	745	745				
Scorpaenidae	13	8		45	44					39	12	105	87	77		1			196	162		711	368		304	304	1576
Scorpididae	2	2																	28	28		7	7		228	204	1
Sillaginidae	1022	598		1312	1312	31	597	262		1092	1055																
Soleidae	109	15		3			7			6	2					16	16		18	11		92	84				
Sparidae										44	44														8	7	
Sphyraenidae																						24	24				
Squatinidae	903	903	935	251	251	517			858	143	143	1748				1925	1925	69	2821	2821	1172	2072	2072	961			
Syngnathidae	7	7		4	3								14	14	3									2	8809	8809	9484
Teraponidae				262	262	47				26	26														2		
Tetraodontidae	170	152		576	566	33	414	394	170	28	17	38	17	17	118	74	74	10				51	43				
Trachichthyidae													2	2											528	528	393
Triglidae	192	192		20	10		151	149		126	126					12	12		585	582	121	391	294				
Uranoscopidae																0			3						608	600	187
Urolophidae	1560	1560	651	1792	1792	2208	4603	4603	4602	1349	1349	167				1316	1316	1524	8768	8768	5150	3309	3309	913	52	52	45
Veliferidae	57	54		17	17		77	74		19	17					9	9		229	226	10			4	1409	1409	6871
Zeidae									337												713				71	70	
Sub-totals	5664	4717	5105	26298	24927	12274	9384	8558	9470	13010	11339	5754	7299	7156	3173	5928	4740	2583	36481	29959	13562	29638	26623	6397	30749	26937	31190

Table 12 continued

Other Invertebrates	Bell Buoy * Weight/ha (g) Mesh Size			Cottesloe Weight/ha (g) Mesh Size			Coventry Reef * Weight/ha (g) Mesh Size			Comet Bay * Weight/ha (g) Mesh Size			Preston (shallow) Weight/ha (g) Mesh Size			Preston (deep) Weight/ha (g) Mesh Size			Capel * Weight/ha (g) Mesh Size			Busselton Weight/ha (g) Mesh Size			Zone C * Weight/ha (g) Mesh Size		
	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100	25	45	100
Bivalve							7	7											16	15		4	3				
Cnidarian												95													20	20	52
Crinoidea															0												
Crustacea				4	3		1						3	3		0						0					
Echinoidea				4			2		11													0					
Gastropoda	1			0			1												1								
Octopodidae										118	24	14	271	271					9			5	2	14			
Ommastrephidae	1			56	47		2			91	63		4	3	1				7			2					
Ophuiroidea						13				32	32				21			1	54	54	49	24	24	51			
Pectinidae	18	18	14	33	33														32	32					16	16	5
Penaeidae	60	15		10	2		9	2		32	12				1				12			19					41
Porifera							40	40	59													1343	1343	11911			
Portunidae	1	1		56	56	7	1															5	5				401
Scylaridae	44	44					139	139				32			5				15	15		48	48	19			
Sepiidae				82	82	33	0						1119	1119	2318	49	49	330	548	520	453	2023	2002	1237	17	17	45
Squillidae	1									11	10		9	5											1164	1164	938
Trochidae	0			7															1								
Xanthidae				15	15								5	2		5	5										
Sub-totals	251	78	14	533	238	52	400	188	70	569	141	142	2822	1404	2346	108	53	331	1388	636	503	6948	3429	13233	2434	1217	1481
Totals	12237	11031	7336	32667	30653	15676	12941	11888	10230	38434	35394	10292	12305	10611	6042	7909	6579	3299	50404	42204	15960	45004	36975	22187	48837	43294	42489

Table 13: The prevalence of drift weed caught in research trawls at nine sites between Fremantle and Cape Naturaliste. + = Known commercial trawl ground.

Site	Estimated Volume of Drift Weed			
	Autumn 1991	Winter 1991	Spring 1991	Summer1991/92
Bell Buoy +	0	0	0	0
Cottesloe	0	0	0	0
Coventry Reef +	0	0	0	0
Comet Bay +	**	****	**	0
Preston Shallow	***	0	*	0
Preston Deep	*	0	0	*
Capel +	0	0	0	0
Busselton	*	0	0	**
Zone C +	0	0	0	0

**** Very Abundant *** Abundant ** Moderate * Little 0 None

Table 14: Catch rates obtained by trawl nets with 45 and 100mm stretched meshes research trawl nets between autumn 1991 and summer 1991/92 in the region between Fremantle and Cape Naturaliste. * = Known commercial trawl ground

Commercial & Recreational Species	Bell Buoy *				Cottesloe				Coventry Reef *				Comet Bay *				Preston shallow			
	No/ha Mesh (mm)		g/ha Mesh (mm)		No/ha Mesh (mm)		g/ha Mesh (mm)		No/ha Mesh (mm)		g/ha Mesh (mm)		No/ha Mesh (mm)		g/ha Mesh (mm)		No/ha Mesh (mm)		g/ha Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
blue manna	0.1	0.1	12.1	16.4	1.6	1.9	425.6	719.9	0.2	0.1	43.0	2.7	17.5	16.9	2931.4	3425.6	0.1		31.7	
blue spotted flathead					0.5		188.9						0.3		75.1					
blue sprat									0.2		2.6		0.1		0.4					
blue striped goatfish	1.9	0.1	99.7	6.0	23.1	0.5	1202.4	76.7	0.8	0.1	33.1	5.4	7.2	0.1	204.7	0.6	31.8	1.5	1906.3	143.3
cobbler	0.1		30.3		0.5		208.3		0.1		26.8		1.4		102.7		0.4	0.3	104.6	99.5
elongated flounder					0.6	0.1	77.4	12.1					0.1	0.1	5.9	11.7				
gurnard perch	0.3		239.2		0.1	0.1	42.5	25.0	1.1	0.7	388.1	337.7	0.1	0.1	46.7	26.3	0.1	0.1	3.5	30.2
long spined flathead	6.2		251.3		1.7		101.7		3.3		202.0		2.1		148.7		0.1		37.0	
rock lobster	0.1		113.5										0.5	0.1	81.8	38.0	0.3	0.4	34.9	96.8
sand trevally	17.2		645.7		1.1		23.3		34.0		846.2		8.8	0.5	567.8	53.4	0.1		0.3	
saucer scallops	84.6	47.4	5122.9	3925.1	0.4	0.5	13.9	76.5	15.8	7.8	1967.2	1006.2		0.2		26.3		0.1		5.8
school whiting	49.8	0.1	3787.5	24.8	17.9	0.2	1695.7	43.7	36.2	0.1	1778.5	7.5	72.5	0.2	1433.8	6.5				
small toothed flounder	0.7		111.1			0.1		59.0	0.4	0.1	89.5	53.9	1.9	0.1	162.5	23.4	0.1		2.9	
southern tongue sole	0.3		39.1		0.3		50.5		0.4		34.1		1.5	0.1	111.8	5.9	0.1		25.4	
squid	4.2	0.1	310.9	6.9	3.9	0.7	294.9	218.8	8.7		383.1		1.5	0.2	78.0	45.1	4.3	0.9	333.9	273.1
trumpeter whiting									0.1		3.8		3.9		191.8					
western king prawn	1.3		52.8		0.6		20.1		0.4		18.9		23.4	1.5	586.2	254.0				
Sub-totals	166.7	47.9	10816.2	3979.2	52.2	4.0	4345.3	1231.7	101.7	8.9	5817.0	1413.4	142.7	19.9	6729.2	3916.6	37.3	3.3	2480.4	648.8
Other Families																				
Antennariidae																		0.1		2.4
Aploactinindae																	0.1	0.1	1.5	2.1
Apogonidae					0.7		48.5						3.9		28.5		1.1		11.3	
Arripidae					0.4		43.6													
Aulopodidae																				
Belonidae	0.1		5.3																	
Bothidae	1.2		12.8		0.1		2.4		0.6		9.0		0.2		76.8					
Caesioscorpididae					0.1		1.0		0.1		2.7									
Callionymidae	0.1		3.0						0.1		6.5		0.4		8.2		0.1		0.5	
Carangidae	0.4		8.7		0.2		10.8		0.2		11.3		0.2		3.4					
Chaetodontidae																				
Cheilodactylidae																	0.1		3.2	
Chironemidae																	2.6	0.3	241.4	74.4
Clinidae					0.2		4.2						1.2	0.1	25.8	2.4	1.6		32.8	
Clupeidae					0.1		0.4		0.1		0.6		3.8	0.2	7.7	0.9	0.1		0.2	
Congridae					0.1		6.1		0.1		0.3		0.3		3.5					

Table 14 continued

Other Families	Bell Buoy * No/ha Mesh (mm) 45	100	g/ha Mesh (mm) 45	100	Cottesloe No/ha Mesh (mm) 45	100	g/ha Mesh (mm) 45	100	Coventry Reef * No/ha Mesh (mm) 45	100	g/ha Mesh (mm) 45	100	Comet Bay * No/ha Mesh (mm) 45	100	g/ha Mesh (mm) 45	100	Preston shallow No/ha Mesh (mm) 45	100	g/ha Mesh (mm) 45	100
Cynoglossidae	0.2		26.7		0.6		73.2						2.1	0.1	402.9	4.0				
Dasyatididae					0.1		485.4		0.1		804.7									
Diodontidae	0.5	0.3	216.6	229.1	2.1	1.1	361.3	450.3	0.2	0.5	162.9	512.1		0.4		23.6	8.7	4.8	806.4	1150.3
Engraulididae	0.1		4.2																	
Enoplosidae					0.1		0.6													
Gerreidae	53.8	0.2	802.5	3.3	77.0	0.7	1209.9	8.8	141.6	0.1	1381.6	1.8	46.5	0.5	611.0	5.6	21.8	1.0	360.6	32.2
Glaucosomidae																				
Gnathanacanthidae																	0.4	0.1	18.0	16.2
Gongiopodidae																	0.1		1.3	
Gonorynchidae	0.1		9.5		0.2		28.1		0.1		1.3		0.2		27.2					
Harpadontidae	0.2		9.2																	
Hemirhamphidae	0.1		1.1		0.1		0.3		0.3		5.4		0.1		1.2					
Heterodontidae	0.7	0.3	236.6	36.9	11.6	4.2	1250.7	468.1	0.2	0.2	26.2	29.0	2.9	1.6	430.0	285.7	0.2	0.2	619.0	554.8
Hypnidae													0.1	0.1	82.7	255.5	0.1	0.1	18.5	113.1
Labridae													0.1		11.7		1.4	0.1	184.9	34.9
Leptoscopidae																				
Monacanthidae	2.5		61.4		8.4	1.3	471.0	205.9	1.1		32.6		5.6	0.2	98.7	31.3	23.2	3.3	1635.3	509.7
Moridae													0.1		4.7		0.4	0.1	5.0	0.5
Mugiloididae																				
Mullidae	3.5		127.2										0.8		23.6					
Muraenesocidae	0.1		5.5						0.1		4.7						0.2		48.3	
Myliobatidae	0.5	0.6	447.4	838.2	3.6	3.1	3132.3	2387.3	0.3	0.4	760.7	1128.8	0.5	1.0	2006.8	1442.2	0.1	0.2	133.1	649.8
Nemipteridae					0.1	0.1	15.8	12.5					0.9		47.5					
Odacidae					0.3		16.7						0.1		1.8		10.3	0.5	394.9	18.4
Orectolobidae																	0.2	0.1	71.5	187.0
Ostraciidae	3.5	1.9	1057.0	663.6	9.4	7.8	1945.3	1794.5	0.9	0.4	155.6	170.1	2.3	1.9	362.2	360.8	12.4	13.0	2711.3	3031.8
Parascylliidae																	0.3	0.1	67.5	36.2
Pataecidae					0.1		0.3										0.4	0.1	3.7	0.9
Pempheridae	4.0		39.9		0.8		9.0		5.8		49.8		0.1		0.9		12.9	0.6	201.5	27.0
Pentacerotidae	0.1		2.1						0.1		7.5									
Platycephalidae					0.2	0.1	55.3	93.6	0.1		5.4						2.0	0.6	465.8	214.2
Pomacentridae																	1.2		7.9	
Pomatomidae									0.1		5.4		0.9		126.2					
Priacanthidae																				
Pristiophoridae																				
Rhinobatidae	0.8	0.5	678.6	309.6	0.4	0.4	59.4	146.8	0.8	0.7	296.3	483.7	1.2	1.7	750.6	694.3	0.2	0.2	357.5	217.4
Sciaenidae													0.1		1.7					

Table 14 continued	Bell Buoy *				Cottesloe				Coventry Reef *				Comet Bay *				Preston shallow			
	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
Other Families	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
Scorpaenidae	1.5		9.9		1.2		22.3		1.2		6.9		3.0		33.9		3.8	0.2	120.1	9.7
Scorpididae																				
Scyliorhinidae																	0.1		15.9	
Serranidae																				
Sillaginidae	14.5	0.1	345.2	3.3	0.6		112.6		14.7		241.6		3.8		210.1		0.1		26.7	
Soleidae	0.6		14.8		0.1		24.0		0.5	0.1	69.8	6.5					0.2		26.7	
Sparidae													9.2		878.5					
Sphyraenidae					0.1		75.6		0.1		1.2						0.2	0.1	231.2	20.3
Sphyrnidae													0.1		70.1					
Squatinidae	0.3	0.3	376.2	123.6	0.3	0.3	709.8	410.3	0.1	0.1	147.1	422.9	1.1	1.7	1646.9	1404.8		0.1		635.3
Syngnathidae					0.1		0.7		0.1		1.2						1.2	0.8	17.6	11.3
Synodontidae					0.1		4.4													
Teraponidae	0.1		27.6		0.9		126.5						5.7		278.8		1.2	0.4	198.8	65.2
Tetraodontidae	8.8	0.2	128.1	170.1	11.9	0.3	304.5	10.0	1.9	0.1	15.5	84.0	4.1	0.1	62.1	1.2	0.2	0.3	77.7	76.2
Trachichthyidae																	0.4	0.1	13.3	2.5
Triakidae									0.1		8.6		0.1		8.5					
Triglidae	8.2		239.9		0.2		4.0		6.4	0.1	242.1	67.1	1.2	0.4	55.6	43.9				
Uranoscopidae	0.1	0.1	1.1	92.7	0.1		0.3		0.1		158.9									
Urolophidae	10.9	7.5	2716.0	2295.3	10.2	8.4	2437.7	2213.0	23.8	20.6	4082.4	4527.3	2.3	1.8	952.7	642.3	0.9	1.1	1041.8	1569.0
Veliferidae	4.0		127.4		0.6	0.1	13.3	1.2	23.2		198.7		0.1	0.1	1.8	5.8				
Zeidae										0.1		18.9								
Sub-totals	211.4	211.9	7831.4	4965.8	233.0	227.8	13157.2	8402.2	314.6	223.5	8994.6	7652.2	195.0	211.8	9433.9	5404.2	200.5	228.6	10262.7	9462.7
Other Invertebrates																				
Aplysiidae																		0.1		114.6
Ascidian	0.1				0.3	0.2	0.3	1.2	0.1		1.2						0.2		53.4	
Asteroidea		0.3		93.7	0.1	0.1	10.9	14.5		0.2		6.0	0.2	0.5	11.8	16.9	0.2	0.7	26.1	61.7
Bivalve	0.5		10.7						2.0		25.9		0.1		1.8					
Bryozoa																				
Caridae																	0.2		0.3	
Cnidarian		0.1		27.6	0.2	0.1	78.9	68.6					0.1	0.1	9.6	16.9	0.2	0.1	96.8	19.3
Coral	3.5		9.3		0.7		1.0		0.5	0.1	1.6	0.3	0.8		2.7		0.2	0.0	0.4	20.3
Crinoidea	0.1		0.1														0.1	0.2	0.2	1.2
Crustacea									0.1	0.1	0.1	13.5					0.7	0.2	0.8	1.5
Cypraeidae																				

Table 14 continued	Bell Buoy *				Cottesloe				Coventry Reef *				Comet Bay *				Preston shallow			
	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
Other Invertebrates	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
Echinoidea					2.2	1.1	18.4	12.1	0.1		0.2		0.3		1.2		0.3	16.2	6105.1	1913.6
Gastropoda					0.2		2.2										0.1	0.1	191.1	6.3
Holothuroidea																	0.2	0.2	20.0	17.8
Majidae					0.3	0.2	3.7	12.1	0.1		0.6			0.1		2.4	1.0	0.1	10.7	6.3
Octopodidae	0.2	0.1	22.4	6.0					0.3		24.2		0.1		6.3		1.1	0.2	390.0	70.5
Ommastrephidae					0.1		1.9		0.5		9.2		0.5		1.9		0.7		5.2	
Ophuiroidea	0.9	0.1	0.3	0.0	0.1	0.1	0.1	3.0	0.4	0.1	48.1	6.7	0.9	0.1	17.0	6.5	0.3	0.1	4.6	9.9
Opistobranch	0.2		3.8		0.1		1.2										0.0	0.1	1.5	0.9
Pectinidae	0.5		6.6																	
Penaeidae	1.6	0.1	8.1	17.2	0.3	0.1	0.6	0.2	1.0	0.1	6.2	31.1	1.2		4.8					
Pennatulacea									0.1		0.3		0.1	0.2	2.8	6.2				
Philinidae	0.1		0.1		0.2		1.6						0.1		1.2					
Porifera			108.6	115.4				9.4			1.8	3.5		0.2		18.1			7035.3	8650.7
Portunidae	0.9	0.1	18.0	3.3	1.5	0.6	109.7	64.4	0.8	0.1	27.3	13.5	0.6	0.7	29.7	47.9	0.1	0.1	0.0	3.7
Scylaridae	0.9	0.4	171.2	143.3	0.1	0.1	3.0	6.1	0.9	0.9	163.3	224.4	0.1	0.1	12.9	5.8	0.5	0.3	51.5	67.7
Sepiidae	1.0		10.4		0.1	0.1	12.5	6.1	1.3		15.2		0.1		11.7		1.3	0.7	702.8	596.7
Squillidae													0.1		0.6		0.1	0.1	0.7	2.4
Trochidae					0.9		0.3													
Turbinidae					0.1		0.1													
Volutidae																				
Xanthidae		0.1		0.5	0.4	0.3	7.9	15.6		0.1		2.9		0.1		0.6	2.4	1.9	76.3	55.3
Subtotal	55.3	101.2	414.8	507.0	52.8	102.9	299.1	313.3	52.9	101.5	370.3	401.9	50.2	102.1	160.8	221.3	55.0	121.3	14817.7	11720.5
Total	433.5	361.0	19062.4	9451.9	338.0	334.7	17801.6	9947.2	469.2	333.8	15181.8	9467.5	387.9	333.7	16323.9	9542.1	292.7	353.2	27560.9	21831.9

Table 14 continued	Preston Deep				Capel *				Busselton				Zone C *			
Commercial &	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
Recreational Species	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
blue manna		0.1		14.3		0.1		8.3	0.2	0.2	45.0	55.3	0.8	1.1	220.3	252.4
blue spotted flathead	0.1		60.8		0.1		17.8		0.1		1.2		0.1	0.1	112.5	67.5
blue sprat																
blue striped goatfish	11.5	0.1	486.5	2.1	51.9	0.2	1734.5	27.1	62.7	0.2	1626.8	46.4	49.4	0.2	1725.5	15.6
cobbler	0.1		81.9											0.1		49.4

Table 14 continued Commercial & Recreational Species	Preston Deep				Capel *				Busselton				Zone C *			
	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
elongated flounder	0.1		14.6						0.6	0.1	15.1	1.2	0.7		18.1	
gurnard perch	0.6	0.3	257.3	171.6	0.7	0.7	308.6	347.9	1.2	1.0	688.9	716.6	1.5	1.0	837.7	597.2
long spined flathead	6.8	0.1	816.3	23.9	9.0		801.5		2.9	0.1	333.5	9.1	9.3		759.3	
rock lobster	0.2	0.1	471.7	23.8												
sand trevally	7.9		184.3		1.2		57.6		0.2		4.5		21.0	1.2	1020.1	96.0
saucer scallops	5.5	0.2	17.7	20.5	31.2	17.4	3104.4	2063.8	26.7	25.0	2661.5	3113.3	90.4	72.8	8343.0	7077.5
school whiting	15.0	0.1	1325.2	3.4	9.2	0.2	1035.3	31.6	2.2		307.3		13.7	0.1	1232.0	8.6
small toothed flounder	0.5	0.3	111.4	144.3	0.3	0.1	24.7	44.9	0.3	0.1	41.7	115.5	0.8	0.3	102.7	105.7
southern tongue sole	0.3		25.0		0.1		18.9		0.1		3.2		1.0		138.2	
squid	5.3	0.2	201.9	17.3	6.3	0.5	380.7	122.0	6.5	0.7	629.7	116.4	4.8	0.7	326.2	75.1
trumpeter whiting																
western king prawn	0.9		23.4		0.8		19.6		0.1		1.9		1.1		18.1	
Sub-totals	99.8	101.4	4123.0	521.2	155.7	119.1	7548.6	2745.5	148.8	127.4	6405.4	4273.8	239.6	177.5	14898.6	8445.0
Other Families																
Antennariidae																
Aploactinindae																
Apogonidae		0.1		0.2					0.1		0.4					
Arripidae																
Aulopodidae	0.1		47.5													
Belonidae																
Bothidae	1.2		30.7		0.4		18.7		0.1		5.8		0.6		12.8	
Caesioscorpididae																
Callionymidae	0.1		2.0		1.1		37.0		0.6		21.6		4.2		114.3	
Carangidae	0.3		29.9		0.8		39.4		0.1		8.8		0.4		33.2	
Chaetodontidae										0.1		12.8				
Cheilodactylidae																
Chironemidae																
Clinidae	0.1		1.5													
Clupeidae	0.1		0.6													
Congridae	0.1		2.9													
Cynoglossidae													0.3		6.5	
Dasyatididae		0.1		139.6												
Diodontidae	0.7	0.6	434.6	438.4	2.4	1.6	777.3	820.2	4.0	4.5	1189.7	2347.3	2.5	2.8	1503.3	1460.7
Engraulididae																

Table 14 continued	Preston Deep				Capel *				Busselton				Zone C *			
	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
Other Families	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
Enoplosidae	0.3		105.8							0.1		32.1	0.1	0.1	23.6	21.9
Gerreidae	96.1	0.9	1337.8	15.4	252.1	0.3	3498.6	20.1	130.1	1.3	3031.8	50.0	318.1	2.2	6489.3	67.2
Glaucosomidae	0.1		6.9							0.1		205.3				
Gnathanacanthidae																
Gongiopodidae																
Gonorynchidae	0.2		18.8		0.9		83.7		0.2		17.4		0.4		50.6	
Harpadontidae																
Hemirhamphidae					0.1		9.3		0.1		3.6					
Heterodontidae	0.2	0.1	21.0	14.3	0.1	0.2	42.8	108.4	0.1	0.1	32.1	43.8	2.5	2.2	371.2	456.3
Hypnidae	0.1		71.3							0.1		243.2				
Labridae	0.1		2.1						0.3		18.4					
Leptoscopidae	0.1		1.2													
Monacanthidae	2.3	0.8	111.5	44.7	26.1	0.5	1031.3	30.7	51.1	2.6	2103.7	276.8	56.3	2.0	2475.1	212.7
Moridae	0.3		5.1						0.6		11.3		0.6		8.7	
Mugiloididae	0.1		2.3		0.1		1.7						0.2		12.0	
Mullidae	1.5		61.2		0.7		29.4		0.1		1.2					
Muraenesocidae	0.1		4.2													
Myliobatidae	0.1	0.3	1168.0	387.1	0.6	0.5	283.5	685.9	0.1		89.8		0.5	0.2	1779.6	124.3
Nemipteridae													0.1		6.3	
Odacidae	0.1		6.9		0.1		5.8		0.6		5.6		0.1		0.6	
Orectolobidae		0.1		755.5					0.1		304.0					
Ostraciidae	1.0	1.0	401.0	329.1	1.2	0.9	520.4	418.1	5.3	4.0	2199.4	1749.3	4.3	4.4	1654.5	1930.2
Parascylliidae																
Pataecidae	0.1		1.4													
Pempheridae	47.8	1.6	559.7	39.4	7.6		93.1		85.0	2.7	2117.1	137.7	23.8	0.2	684.9	9.4
Pentacerotidae	0.1	0.2	65.4	180.1	0.3	0.1	54.2	46.6	0.2	0.4	139.2	271.1	0.5	0.1	125.8	125.3
Platycephalidae	0.4	0.1	87.6	25.7	0.2		37.7		0.4	0.1	119.8	48.6	0.7	0.1	173.8	46.5
Pomacentridae	0.3		3.6						0.4	0.1	5.3	0.6	0.1		0.9	
Pomatomidae																
Priacanthidae		0.1		2.7												
Pristiophoridae	0.1		97.1			0.1		180.7	0.1		186.9		0.1		206.8	
Rhinobatidae	0.9	0.8	878.7	917.4	0.5	0.1	218.9	144.3	0.1	0.2	559.3	654.9	0.7	1.1	1150.3	1284.1
Sciaenidae					0.1		555.1									
Scorpaenidae	0.9	0.3	97.2	90.0	6.2		100.2		20.4	0.3	307.5	35.7	25.6	0.2	357.5	50.7
Scorpididae	1.4	0.2	68.7	27.5	0.1		7.2		2.1	0.3	106.9	199.4	0.5	0.1	36.9	50.2
Scyliorhinidae	0.2		46.9													
Serranidae									0.1		13.9		0.1		6.3	

Table 14 continued	Preston Deep				Capel *				Busselton				Zone C *			
	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
Other Families	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
Sillaginidae													0.1		9.4	
Soleidae	0.4	0.1	6.3	25.7	0.3		6.3		0.5	0.2	31.9	10.4	0.5		17.7	
Sparidae																
Sphyraenidae	0.1		17.6													
Sphyrnidae																
Squatinidae	0.5	0.5	1008.1	488.2	0.4	0.6	1126.0	1543.5	0.7	0.6	1219.2	1836.4	1.6	2.6	3393.9	3671.5
Syngnathidae	0.3	0.1	4.9	2.7	0.2		1.4		0.6	0.6	1.6	5.5	0.3		2.7	
Synodontidae																
Teraponidae									0.2		33.4					
Tetraodontidae	1.7	0.5	307.1	170.7	0.2	0.1	40.1	8.4	2.2	0.3	147.8	82.9	2.9	0.4	190.6	33.8
Trachichthyidae	0.4		5.2						0.1	0.1	3.6	4.3	0.1		6.1	
Triakidae																
Triglidae	4.1		110.5		13.1	0.1	436.6	10.0	10.1		204.1		28.9	0.2	605.7	85.6
Uranoscopidae		0.1		20.0						0.1		83.4	0.1		31.8	
Urolophidae	11.4	10.8	5480.7	5237.6	15.3	8.3	3758.4	2366.9	6.7	5.5	3249.4	3124.4	12.6	16.0	4469.7	6213.6
Veliferidae	0.2		3.9		1.6	0.1	57.1	3.4	0.1		0.6		0.9		40.9	
Zeidae									0.1		93.5		0.1	0.2	0.6	226.2
Sub-totals	266.7	219.0	12815.1	9551.9	422.7	213.2	12960.8	6587.4	413.5	224.2	17676.0	11655.9	581.0	235.2	26143.9	16270.4
Other Invertebrates																
Aplysiidae		0.2		285.9												
Ascidian	0.1	0.1	5.4	68.7					0.1		11.7		0.1		10.5	
Asteroidea	0.1	0.1	12.6	2.9	0.1	0.9	2.2	61.1	1.2	0.6	43.2	89.5	0.9	1.0	13.1	58.3
Bivalve					0.5		21.9		1.6		4.2		17.0	1.8	311.4	48.3
Bryozoa									0.1		42.6					
Caridae																
Cnidarian	0.1		20.0													
Coral	0.0	0.0	58.5	814.3	0.6		104.2		1.0	0.2	3.5	3783.1	0.1	0.0	0.9	21.5
Crinoidea	0.6	0.2	27.0	2.2						0.1		0.6		0.1		0.3
Crustacea	0.1	0.1	0.7	0.3	0.1		0.2		0.1		0.6		0.2		0.3	
Cypraeidae	0.1		1.4													
Echinoidea									0.8	0.4	52.9	28.2	0.7	0.9	46.4	72.8
Gastropoda										0.1		1.9	0.2		0.6	
Holothuroidea	0.6		28.8						0.4	0.2	28.1	102.4	0.1	0.3	17.7	87.7
Majidae	0.3	0.1	3.9	2.7					0.3	0.1	2.6	5.1	0.1		1.3	

Table 14 continued

Other Invertebrates	Preston Deep				Capel *				Busselton				Zone C *			
	No/ha		g/ha		No/ha		g/ha		No/ha		g/ha		No/ha		g/ha	
	Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)		Mesh (mm)	
	45	100	45	100	45	100	45	100	45	100	45	100	45	100	45	100
Octopodidae	0.1	0.1	12.3	12.2	0.4		101.6		0.2	0.1	36.5	121.9	0.2		50.4	
Ommastrephidae	0.3		35.3		0.3		28.6		0.4		3.8		0.1	0.1	0.4	3.1
Ophuiroidea	0.5	0.1	33.0	24.1	0.5		14.3		3.4	1.8	168.8	292.5	2.1	1.6	127.3	66.2
Opistobranch																
Pectinidae					0.4		8.1		0.2	0.1	3.7	0.3	4.6	3.6	210.8	128.9
Penaeidae	1.1		7.8		1.6		7.7		1.5		6.3		2.4		6.6	
Pennatulacea	0.1		1.8													
Philinidae									0.6		1.7		0.1		0.7	
Porifera			12277.4	21031.2	0.1	0.2	196.4	677.4			12229.2				794.3	4826.8
Portunidae	0.4		3.2		0.2		3.8		0.6		18.8		0.5	0.2	13.4	5.2
Scylaridae	0.5	0.4	33.1	94.4	1.0	0.3	28.3	18.9	1.8	0.9	77.8	60.6	0.9	0.2	58.2	7.6
Sepiidae	0.8	0.5	215.2	379.9	1.4	0.3	160.9	142.5	7.4	2.1	1116.7	1474.8	4.4	1.2	339.0	270.5
Squillidae	0.1		0.7		0.1		1.7						0.1		0.6	
Trochidae																
Turbinidae										0.1		23.4				
Volutidae													0.1	0.1	89.0	40.7
Xanthidae					0.8		12.5		2.1	0.1	22.4	2.4	0.7	0.1	6.2	0.6
Sub-total	50.8	101.8	12823.2	22818.7	52.9	101.7	737.3	999.8	68.7	106.8	13920.0	6086.7	80.6	111.0	2144.0	5738.4
Total	417.3	422.3	29761.2	32891.8	631.4	434.0	21246.7	10332.7	630.9	458.5	38001.3	22016.3	901.2	523.7	43186.6	30453.8

Table 15: Significant differences between the mean lengths (mm, t-test) of commercially and recreationally important species caught in trawl nets of 45 and 100mm stretched meshes at nine sites between Fremantle and Cape Naturaliste. * - P < 0.05, ** P < 0.01, *** - P < 0.001, ns - not significant, + - site located in a known commercial trawl ground.

Species	Bell Buoy +		Busselton		Capel		Comet Bay +		Cottesloe		Coventry Reef +		Preston Deep	Preston Shallow	Zone C +
	45mm	100mm	45mm	100mm	45mm	100mm	45mm	100mm	45mm	100mm	45mm	100mm			
blue manna crab			133 ns	136		114	126 ns	130	141 ns	153	132 ns	92			137 ns 127
blue spotted flathead			332		310		268		337		228		417		421
blue sprat							65				139				
blue striped goatfish	165		115 ns	157	135 **	205	114		142 ***	240	168		134 ***	204	148 ns 157	134 ns 190
cobbler	285		520		433		222		370		475				398 ns 395	
elongated flounder	200		124 ns	121			167		213 ns	280						124
gurnard perch	331 ns	293	288 ns	318	292 ns	304				305	252 ns	285	275 ns	263	317	302 ns 320
long spined flathead	201		243		225		191		195		206		243			208
rock lobster	97						54						143		52 ns 74	
sand trevally	148 ***	170	108		151		150 ***	194	109		122		127		81	128 *** 197
saucer scallop	96 ns	98									102 ns	102				
small toothed flounder	195 **	335	144		120 **	347	198			322	258 ns	362	347 ns	353		
southern tongue sole	296		123		304		226		290		294		234			263
southern school whiting	220		249		203		148		216 *	293	196		232			222
squid	92		105		90 *	153	70 *	176	83 ***	175	88		78 ns	108	93 * 153	87 *** 140
trumpeter whiting							179				194					
western king prawn	93		54		46		53		57		56		41			37

Table 16: Analysis of varience of seasonal catch rates (kg/ha) for southern school whiting and stout whiting between autumn 1991 and summer 1991/92 at nine sites between Fremantle and Geographe Bay. O - offshore, I - inshore, ns - not significant.

Species	Season Mean Square	Residual Mean Square	F
Southern School Whiting	199397 (ns)	232318	0.86
Stout Whiting	22099 (ns)	29499	0.75

Site	Autumn 1991	Winter 1991	Spring 1991	Summer 1991/92
Southern School Whiting				
Bell Buoy	4.4	4.0	3.9	2.9
Cottesloe	1.6	1.6	1.4	2.1
Coventry Reef	2.3	1.2	1.4	2.3
Comet Bay	1.7	1.0	1.4	1.6
Preston (I)	0.0	0.0	0.0	0.0
Preston (O)	0.6	2.9	1.1	0.7
Capel	1.0	0.6	1.0	1.5
Busselton	0.2	0.3	0.6	0.1
Zone C	1.4	1.7	1.4	0.5
Stout Whiting				
Bell Buoy	0.5	0.5	0.2	0.1
Cottesloe	0.0	0.0	0.0	0.2
Coventry Reef	0.4	0.1	0.1	0.4
Comet Bay	0.3	0.1	0.4	0.0
Preston (I)	0.0	0.0	0.0	0.0
Preston (O)	0.0	0.0	0.0	0.0
Capel	0.0	0.0	0.0	0.0
Busselton	0.0	0.0	0.0	0.0
Zone C	0.0	0.0	0.0	0.0

Table 17: ROV observations of the substrate at the 19 sites surveyed for whiting spp. and sauce scallops in May 1992. * - Areas of known commercial trawling activity, **bold** - research sampling sites (see table 2).

Site	Description
1	**Cottesloe** - Mixture of loose sand and seagrasses with a few rocks (31^{O} 58' S 115^{O} 43'E).
2 *	**Bell Buoy** - Mostly a sandy bottom with the occasional small rock and patches of seagrass (31^{O} 52'S 115^{O} 37'E).
3	Mixture of sand, small rocks and kelp - bottom appeared fairly hard (31^{O} 56' S 115^{O} 28' E).
4	Similar to 3 (31^{O} 55' S 115^{O} 31' E).
5	Clean sand (32^{O} 3' S 115^{O} 30' E).
6 *	**Coventry Reef** - Clean sand (32^{O} 18' S 115^{O} 36' E).
7 *	**Comet Bay** - Generally clean sand (32^{O} 27' S 115^{O} 43' E).
8 *	Flat, fairly hard sandy bottom covered with a low sparse algae (32^{O} 3' S 115^{O} 30' E).
9 *	Similar to 8 (32^{O} 19' S 115^{O} 36' E).
10*	Soft sand (33^{O} 4' S 115^{O} 4' E).
11	Soft sand between sand stone outcrops. Difficult to find suitable trawl grounds in this region - bottom highly unpredictable (33^{O} 2' S 115^{O} 17' E).
12	As for 11 (33^{O} 1' S 115^{O} 27' E).
13	**Preston Deep** - As for 11 and 12 (33^{O} 12' S 115^{O} 23' E).
14	**Preston Shallow** - Large and extensive posidonia seagrass beds (33^{O} 11' S 115^{O} 39' E).
15*	**Capel** - Extensive areas of soft sand interspersed with occasional patches of seagrass (33^{O} 25' S 115^{O} 19' E).
16	**Busselton** - Rough ground consisting of patches of sand, seagrass, rocks, corals and sponges (33^{O} 31' S 115^{O} 16' E).
17*	**Zone C** - Patches of sand but ground interspersed with large outcrops of limestone, coral, sponge and seagrasses (33^{O} 33' S 115^{O} 9' E).
18	Soft sand with occasional limestone outcrops covered with kelp (32^{O} 45' S 115^{O} 10' E).
19	As for 18 (32^{O} 39' S 115^{O} 21' E).

Table 18: The numbers of each species caught during the two depletion experiments conducted in commercially trawled and untrawled grounds in Geographe Bay during 1992.

Trawled Ground	Number	Untrawled Ground	Number
southern silverbelly	4239	southern silverbelly	2385
blue striped goatfish	1176	rough bullseyes	414
saucer scallop	359	blue striped goatfish	336
bridled leatherjacket	194	*Upeneichthys stotti*	227
Urolophus paucimaculatus	165	squid	112
spiny gurnard	148	spiny gurnard	61
southern school whiting	136	bridled leatherjacket	44
rough leatherjacket	98	cuttlefish	41
little scorpionfish	93	rough leatherjacket	40
long spined flathead	78	*Urolophus paucimaculatus*	37
cockle	62	little scorpionfish	35
toothbrush leatherjacket	59	southern school whiting	34
Urolophus lobatus	48	gurnard perch	28
starfish	45	gulf gurnard perch	25
squid	34	long spined flathead	23
chinaman leatherjacket	31	saucer scallop	23
veilfin	22	sponge	23
masked stingaree	18	globefish	22
grooved gurnard	16	*Aplysia sp.*	21
coral prawn	15	shaw's cowfish	20
pectin scallop	15	slender roughy	18
portjackson shark	14	starfish	18
cuttlefish	13	western smooth boxfish	17
sand trevally	13	cockle	16
Arnoglossus meuleri	12	footballer sweep	16
slender bullseye	11	slender bullseye	14
samsonfish	10	coral prawn	12
southern fiddler	10	toothbrush leatherjacket	11
western smooth boxfish	10	ringed toadfish	10
blue manna crab	9	*Arnoglossus meuleri*	9
globefish	9	balmain bug	8
prickly toadfish	9	bivalves	8
Upeneichthys stotti	9	coral	8
balmain bug	8	grooved gurnard	7
Euryalidae	7	black headed puller	6
bivalves	6	black spotted wrasse	6
gurnard perch	6	chinaman leatherjacket	6
smooth stingray	6	masked stingaree	6
southern tongue sole	6	redline seaperch	6
eagle ray	5	beaked salmon	5
beaked salmon	4	bearded cod	5
angel shark	3	octopus	5

Table 18 continued

Trawled Ground	Number	Untrawled Ground	Number
dumpling squid	3	basket star	4
blue spotted flathead	2	sand crab	4
brown spotted wrasse	2	*Urolophus lobatus*	4
common stinkfish	2	angel shark	3
long rayed weed whiting	2	portjackson shark	3
pebble crab	2	sand trevally	3
ringed toadfish	2	veilfin	3
sea mouse	2	wickerworks sole	3
sharp beaked gurnard	2	ascidian	2
small toothed flounder	2	boarfish sp	2
yellowtail	2	flathead sp	2
arrow squid	1	giant boarfish	2
bearded cod	1	long headed flathead	2
fringed stargazer	1	pectin scallop	2
Goodlads stinkfish	1	western red scorpion cod	2
long headed flathead	1	blue spotted puffer	1
mantis shrimp	1	dumpling squid	1
rough bullseyes	1	eagle ray	1
sandfish	1	feather star	1
sea cucumber	1	fringed stargazer	1
sea squirt	1	gastropods	1
shaw's cowfish	1	Goodlads stinkfish	1
six spined leatherjacket	1	jewfish	1
slender seamoth	1	orange barred puffer	1
small spined porcupinefish	1	rigid boxfish	1
southern shovelnose ray	1	roughy	1
sponge	1	samsonfish	1
spotted pipefish	1	sea urchin	1
Urolophus mucosus	1	sharp beaked gurnard	1
white barred boxfish	1	short boarfish	1
whitley's scorpionfish	1	smooth stingray	1
yellow crested weedfish	1	southern fiddler	1
		southern shovelnose ray	1
Total	7275		4227

Figures

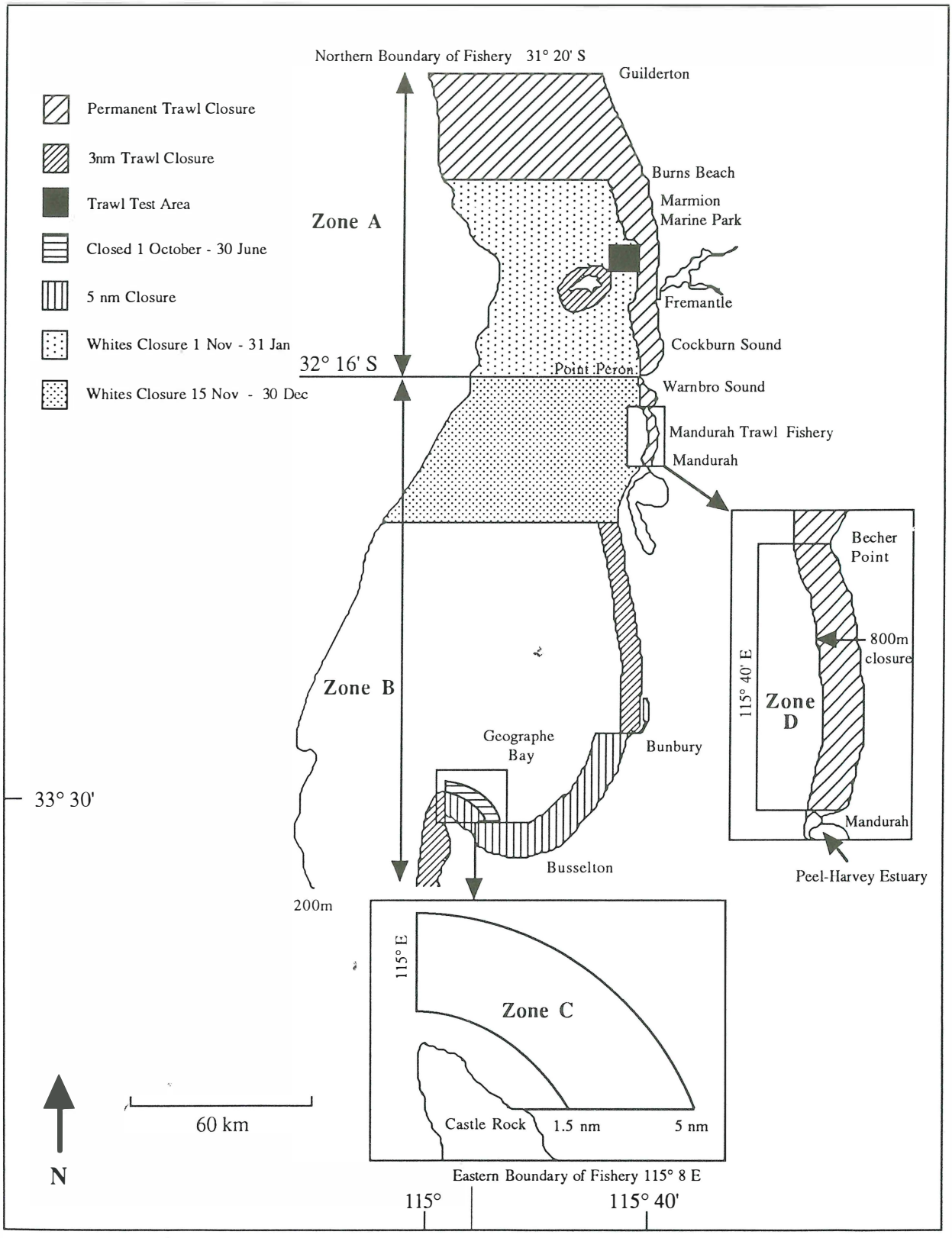


Figure 1: Zonal boundaries of the current management plan for the south-west inshore trawl fishery between Moore River and Cape Naturaliste

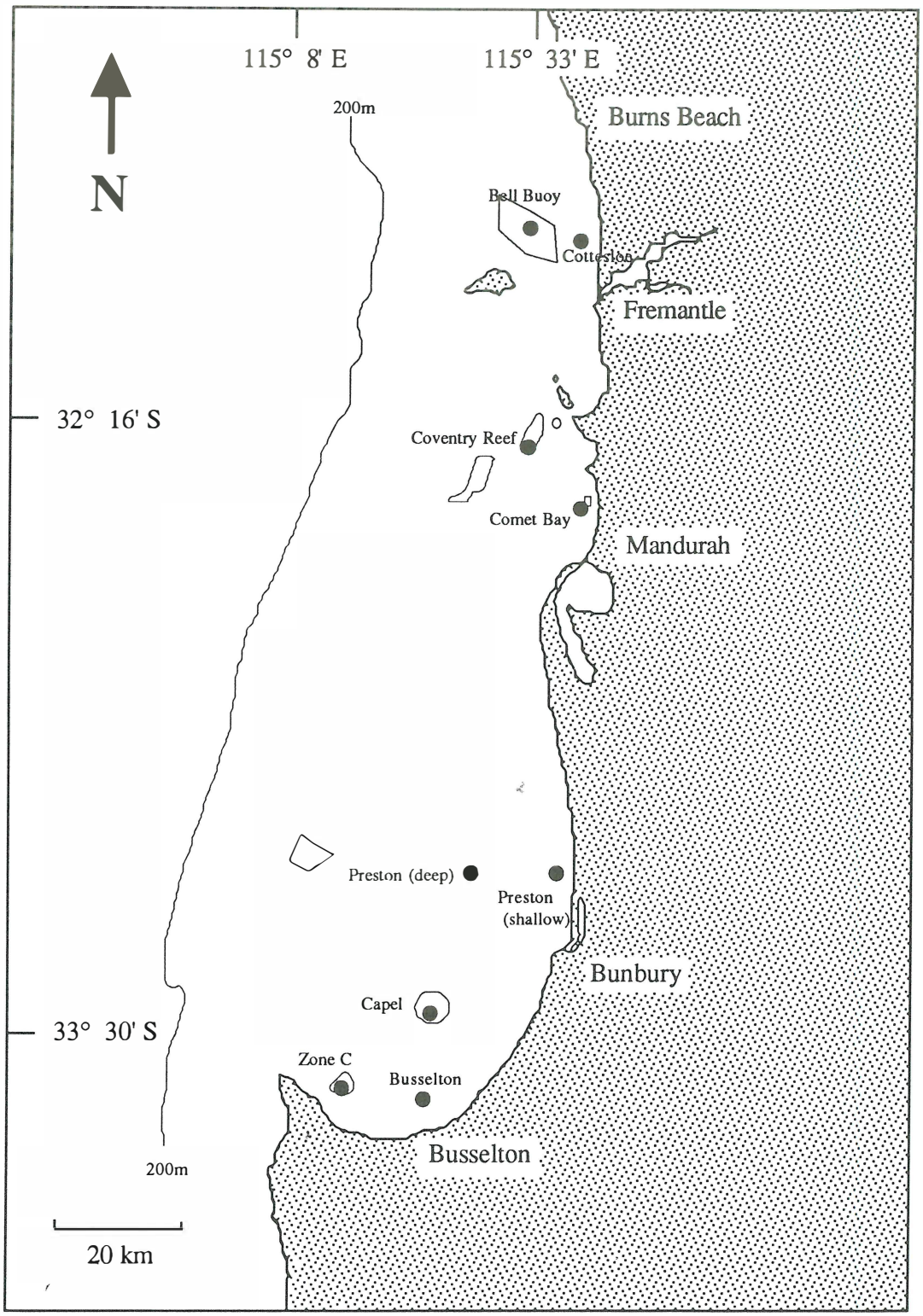


Figure 2: Sites in the south-west inshore trawl fishery which were sampled seasonally between autumn 1991 and summer 1991/92 with a research vessel and 45 and 102mm mesh cod end research trawl nets.

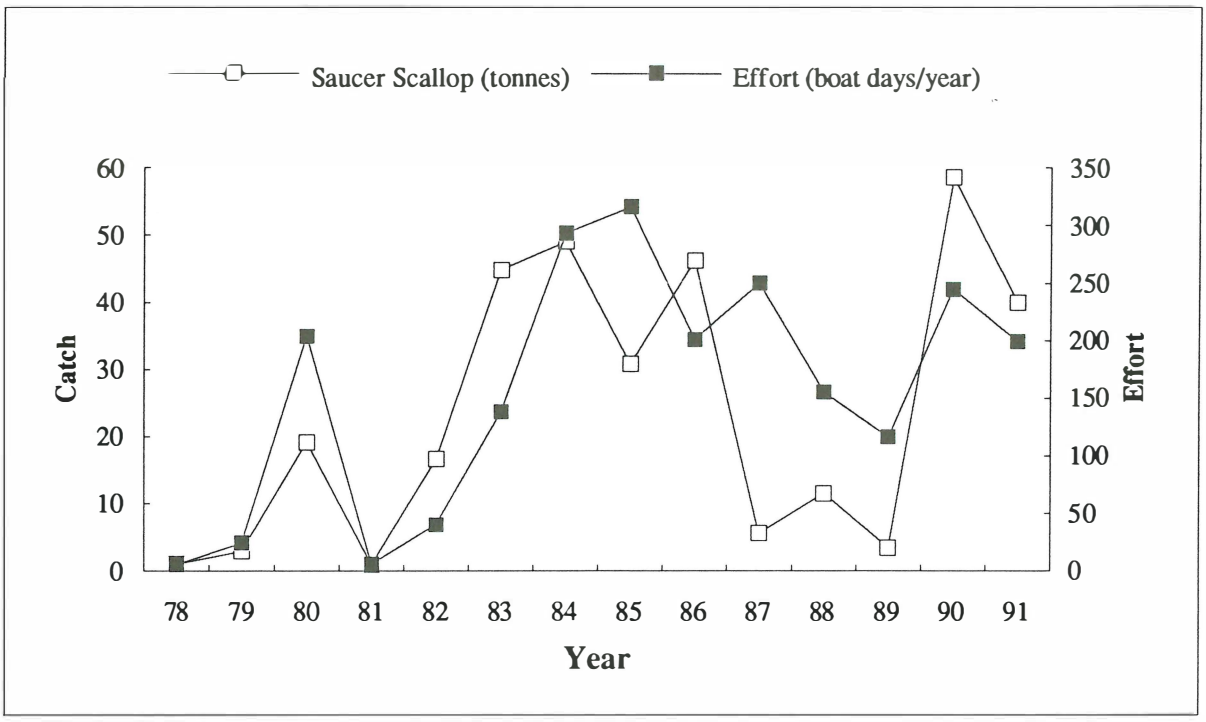


Figure 3: Reported landings of the commercial target species catch (saucer scallops) for Zone A trawlers of the south-west inshore trawl fishery. Data obtained from the Fisheries Department of Western Australia's CAESS database.

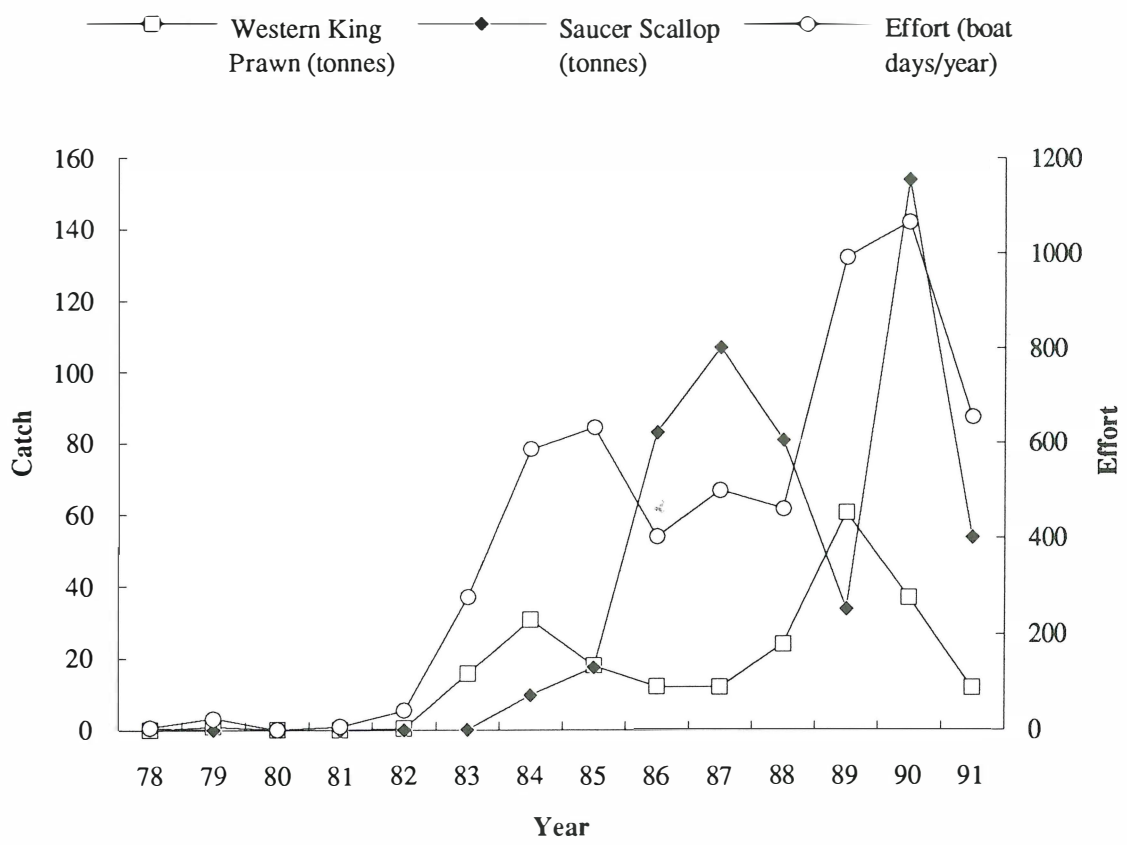


Figure 4: Reported landings of the commercial target species caught (saucer scallops) from Zones B and C, and (western king prawns) Zone D from the south-west inshore trawl fishery. Data obtained from the Fisheries Department of Western Australia's CAESS database.

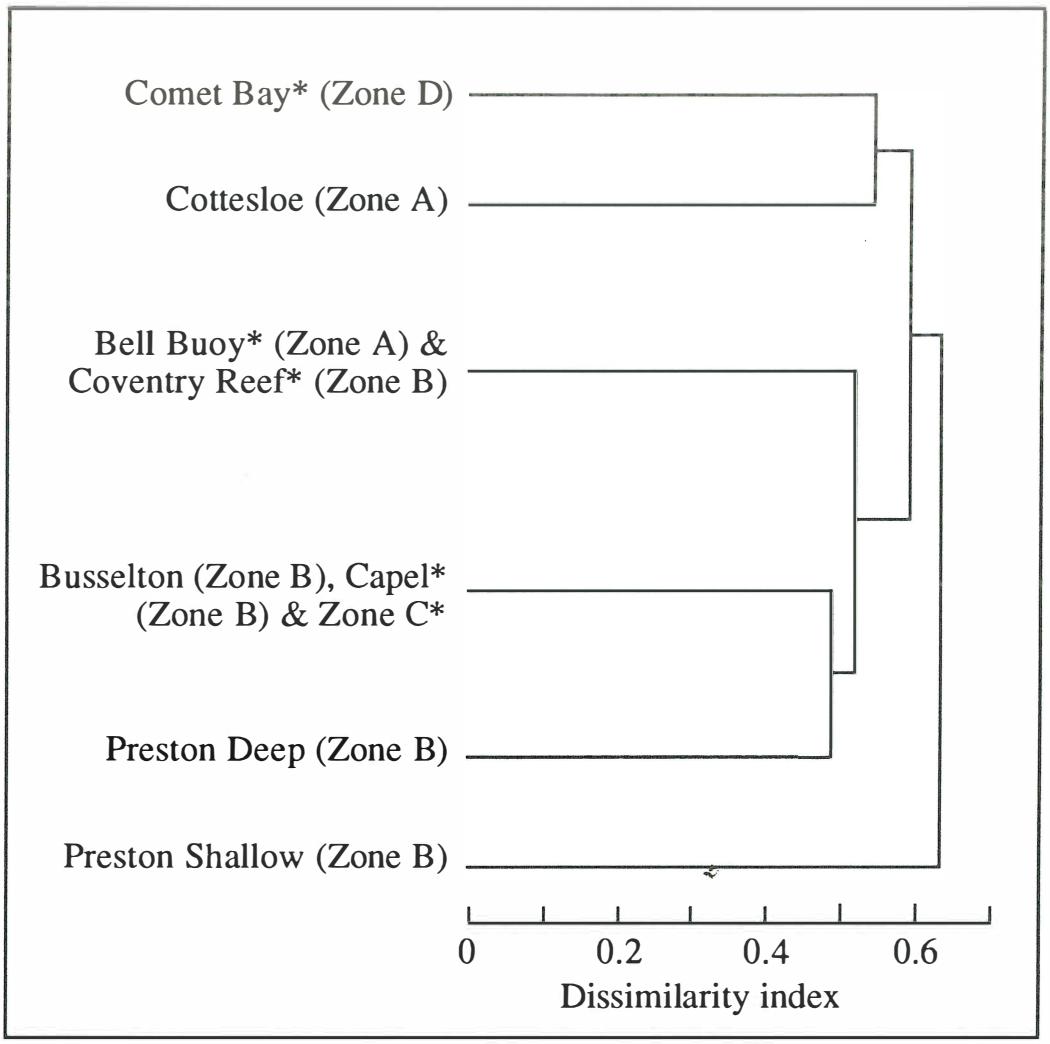


Figure 5: A dendogram relating the community of fish species from nine sites surveyed with 45mm stretched mesh research trawl nets in the region between Fremantle and Geographe Bay. * = Known commercial trawl ground.

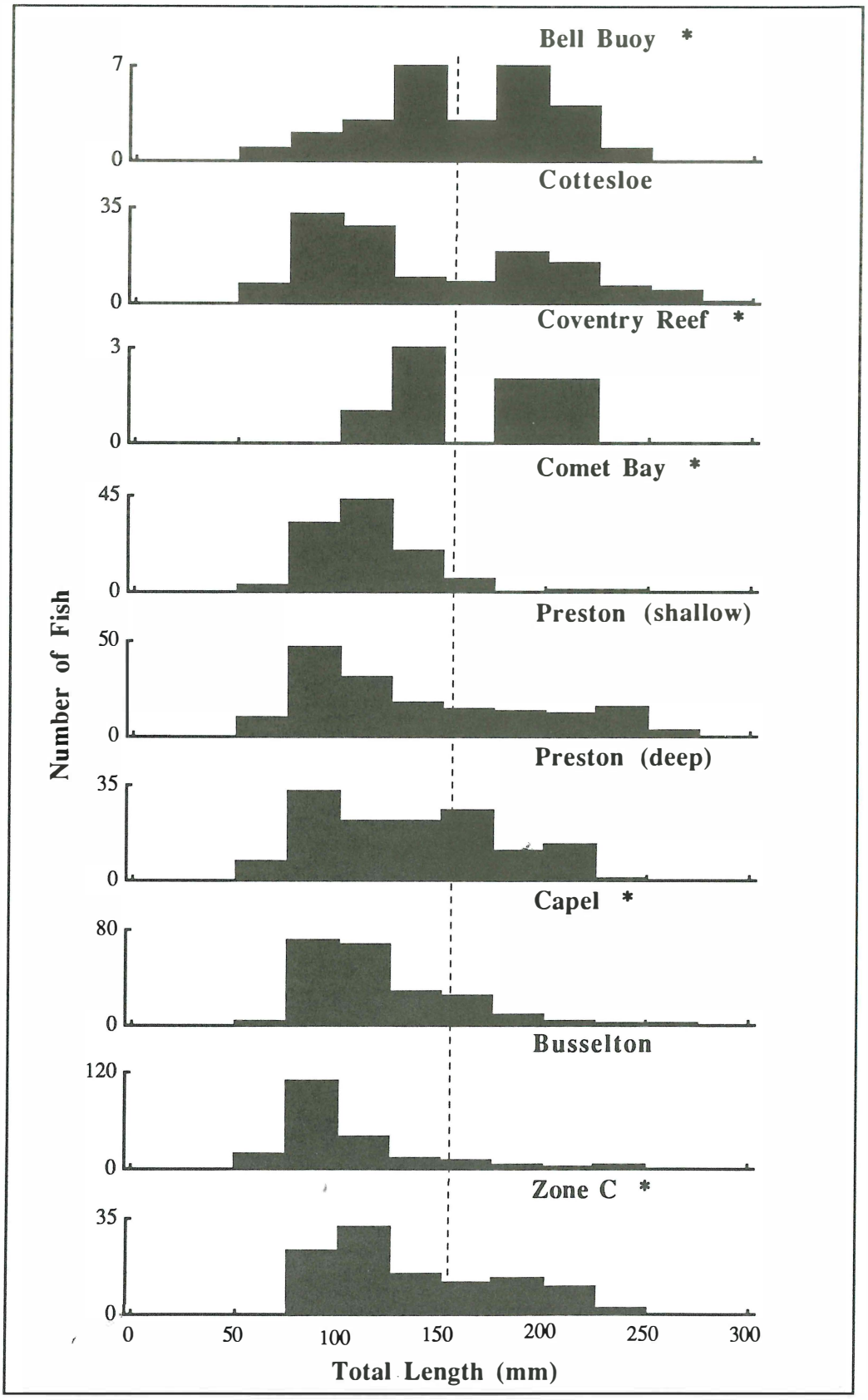


Figure 6: The length-frequencies of catches of the most frequently caught red mullet species (*Upeneichthys lineatus*) using research trawls nets with 45mm stretched meshes. Dashed line - estimated minimum size at sexual maturity (M. Platell, pers. comm.). * - Commercial trawl grounds.

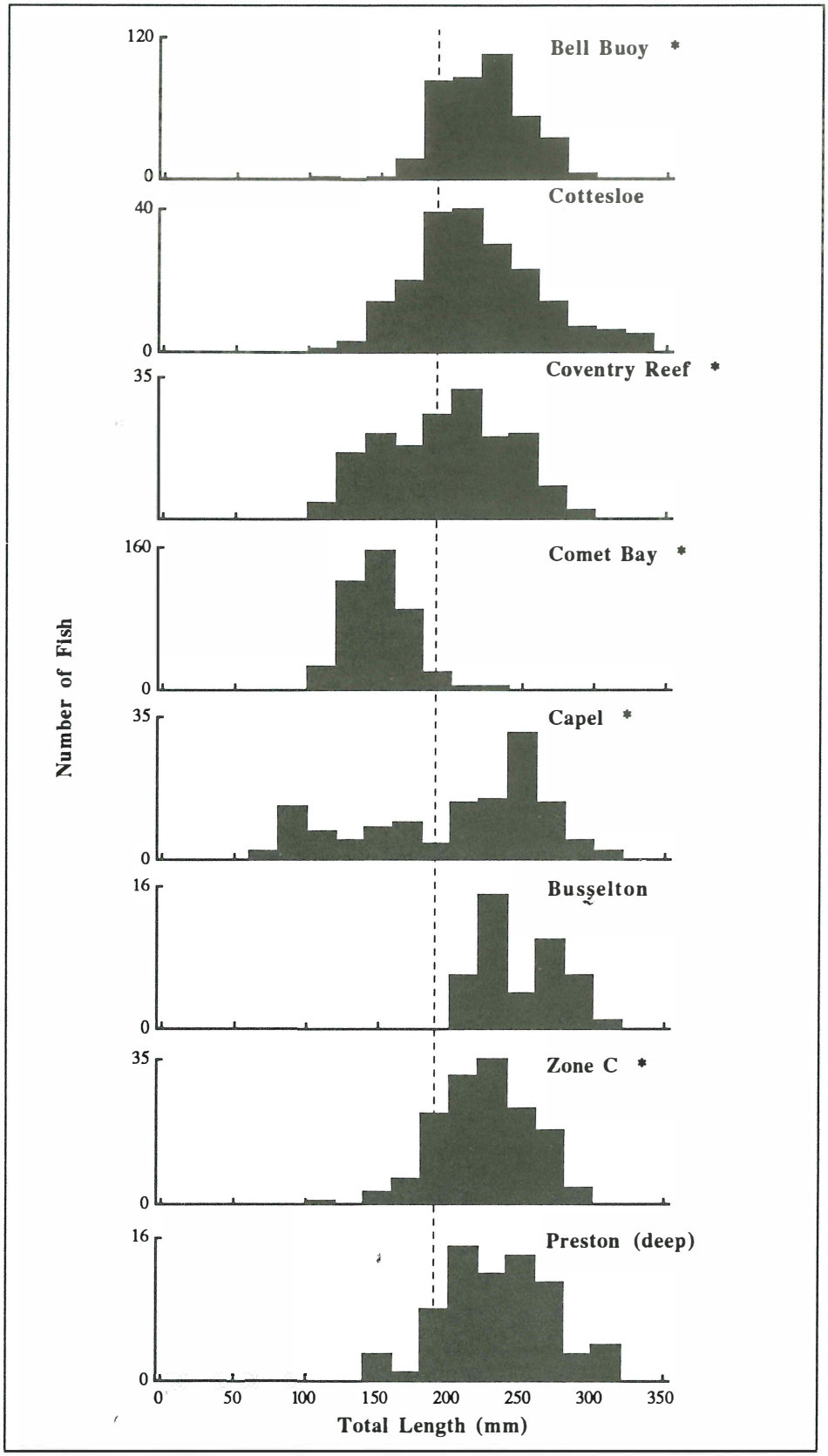


Figure 7: The length frequencies of southern school whiting (*Sillago bassensis*) caught using 45mm stretched mesh research trawls nets. Dashed line - Estimated minimum size at sexual maturity (G. Hyndes, pers. comm.). * - Commercial trawl grounds.

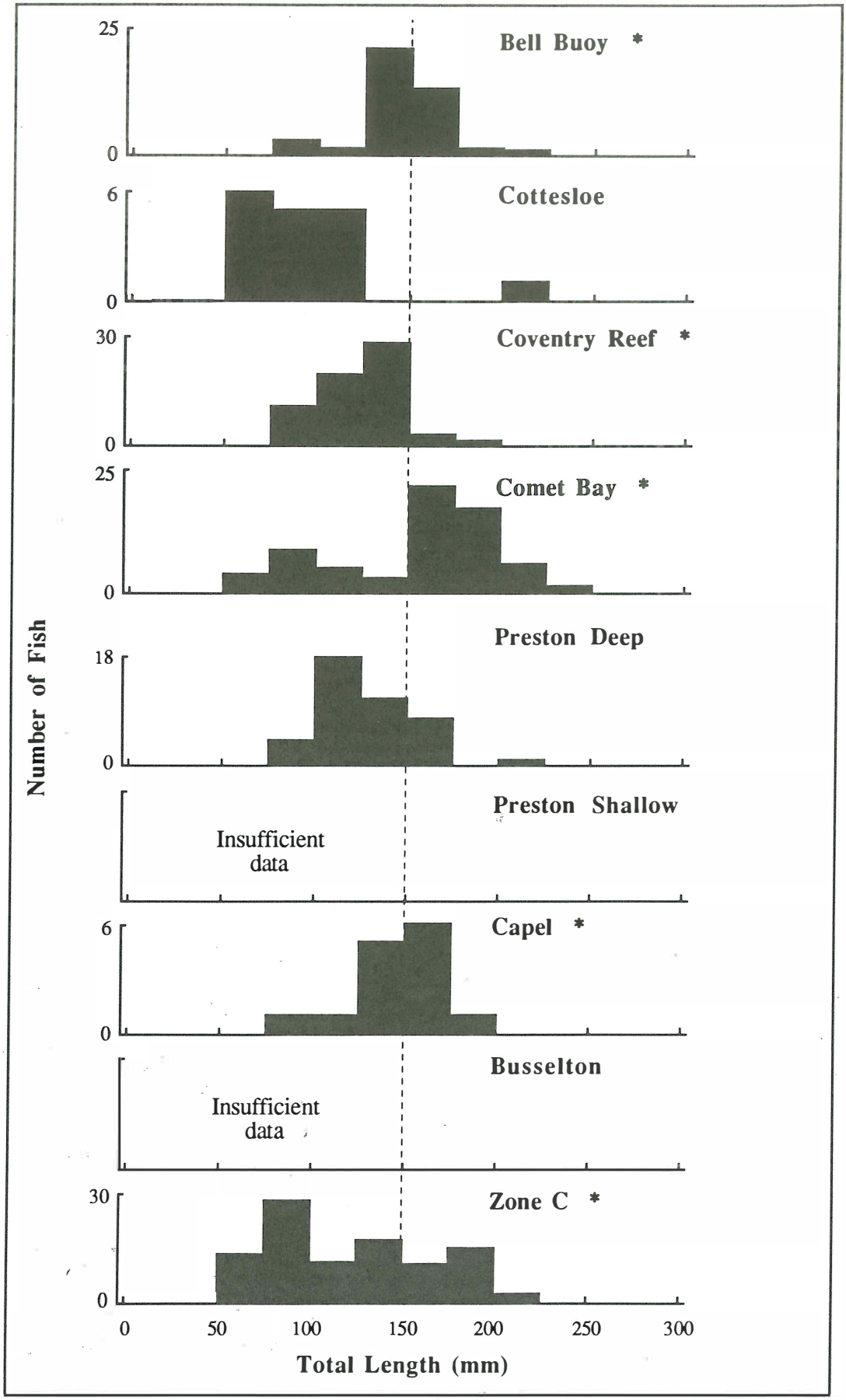


Figure 8: The length-frequencies of sand trevally (*Pseudocaranx wrighti*) caught using 45mm stretched mesh research trawl nets. Dashed line - Estimated minimum size at sexual maturity (M. Platell, pers. comm.). * - Commercial trawl grounds.

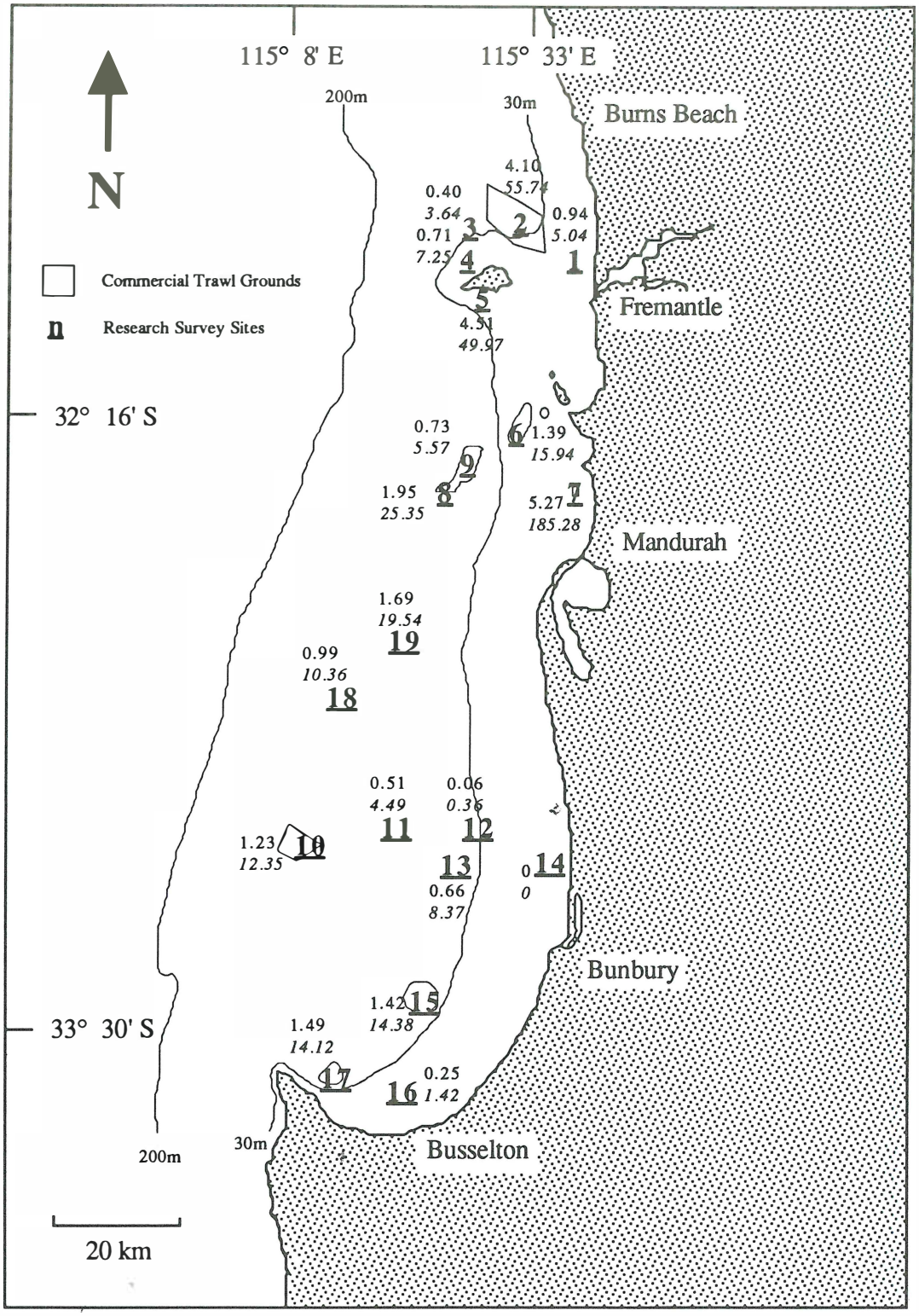


Figure 9: Catches (kg/ha - normal text, number/ha - italics) of southern school whiting *(Sillago Bassensis)* taken in May 1992 using 45mm stretched mesh research trawl nets. Areas of known commercial trawl ground are outlined.

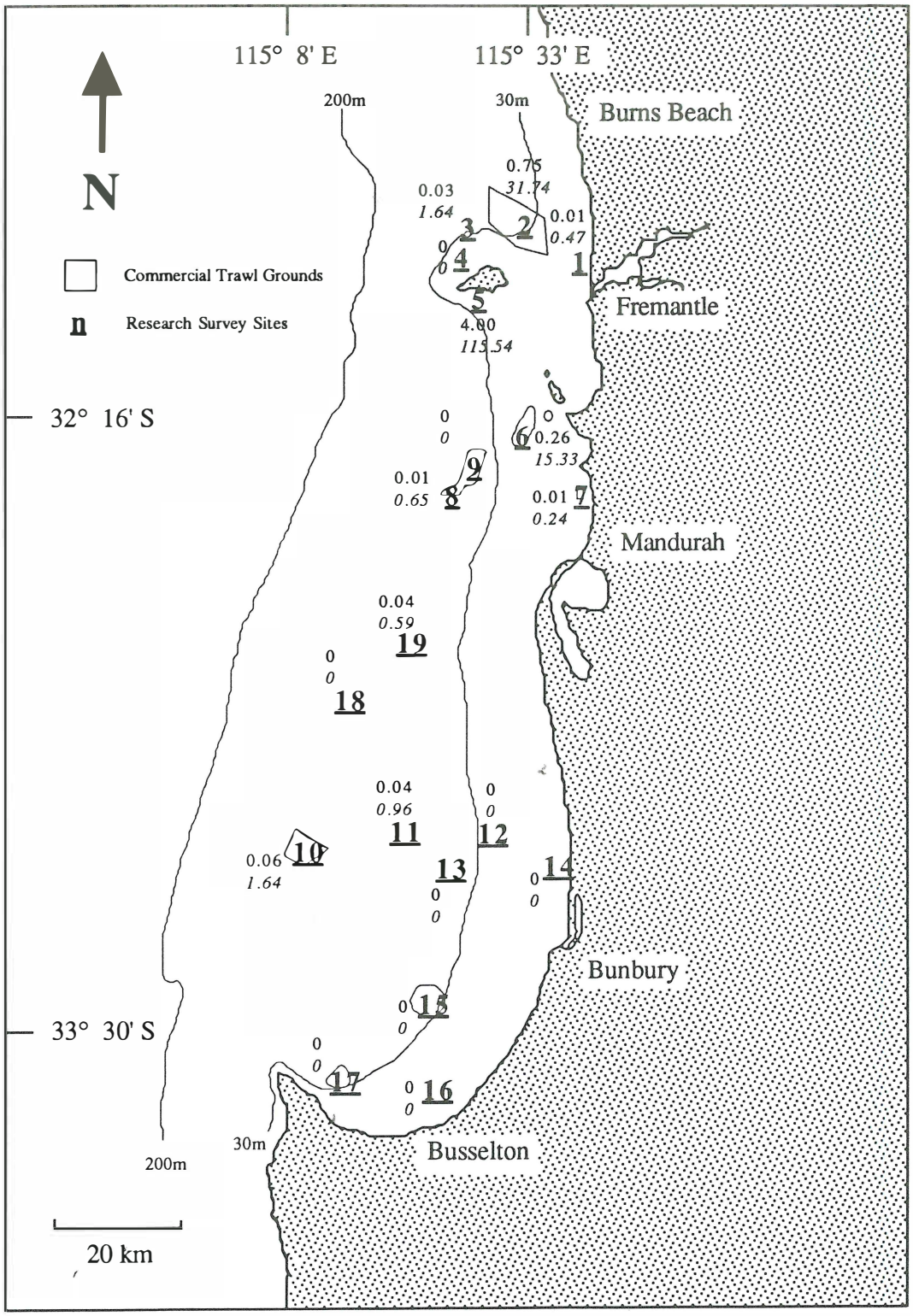


Figure 10: Catches (kg/ha - normal text, number/ha - italics) of stout whiting *(Sillago robusta)* taken in May 1992 using 45mm stretched mesh research trawl nets. Areas of known commercial trawl ground are outlined.

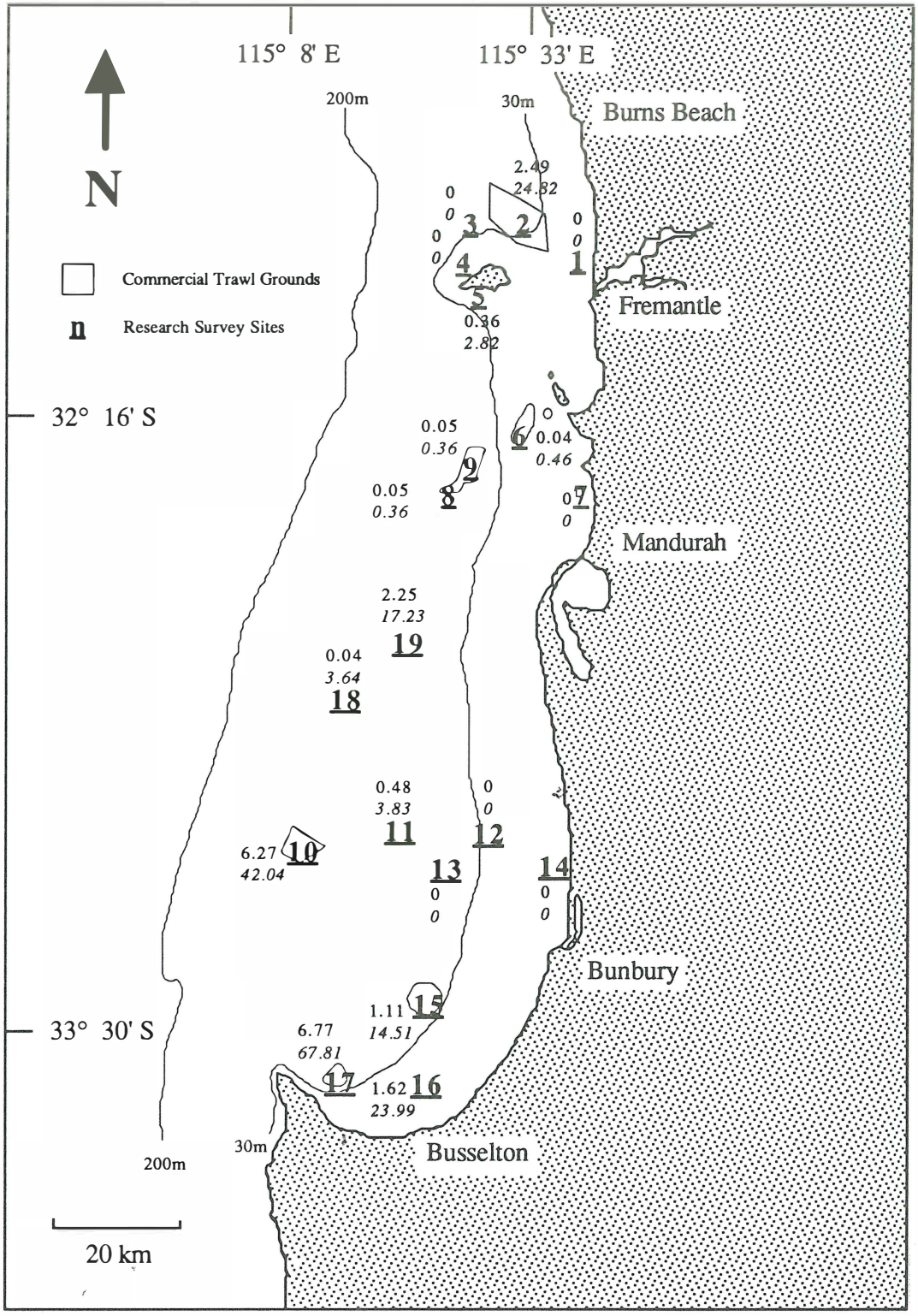


Figure 11: Catches (kg/ha - normal text, number/ha - italics) of saucer scallops *(Amusium balloti)* taken in May 1992 using 45mm stretched mesh research trawl nets. Areas of known commercial trawl ground are outlined.

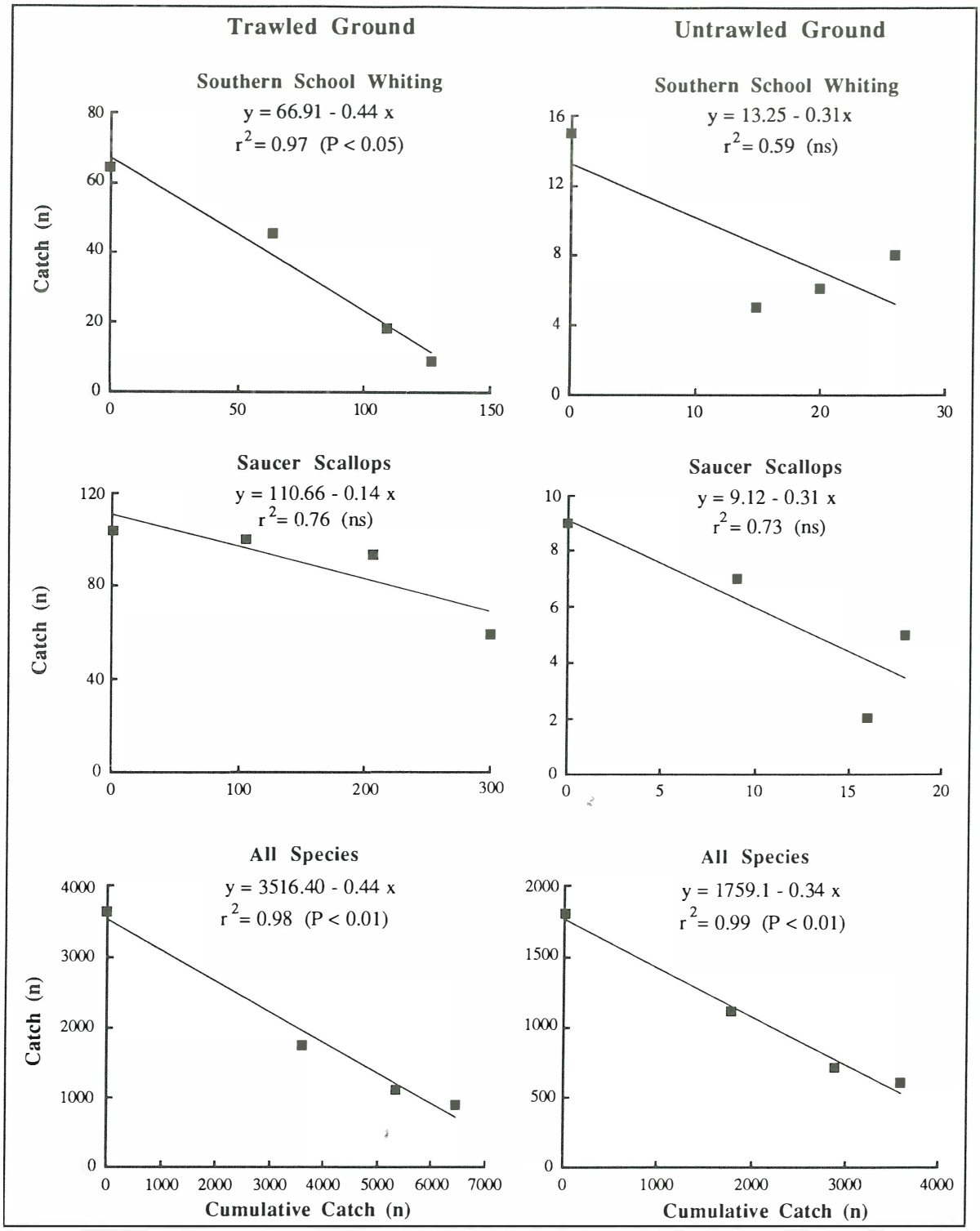


Figure 12: The catch plotted against cumulative catch of southern school whiting (*Sillago bassensis*), saucer scallops (*Amusium balloti*) and all species pooled from two depletion experiments conducted in commercially trawled and untrawled grounds in Geographe Bay. ns - not significant

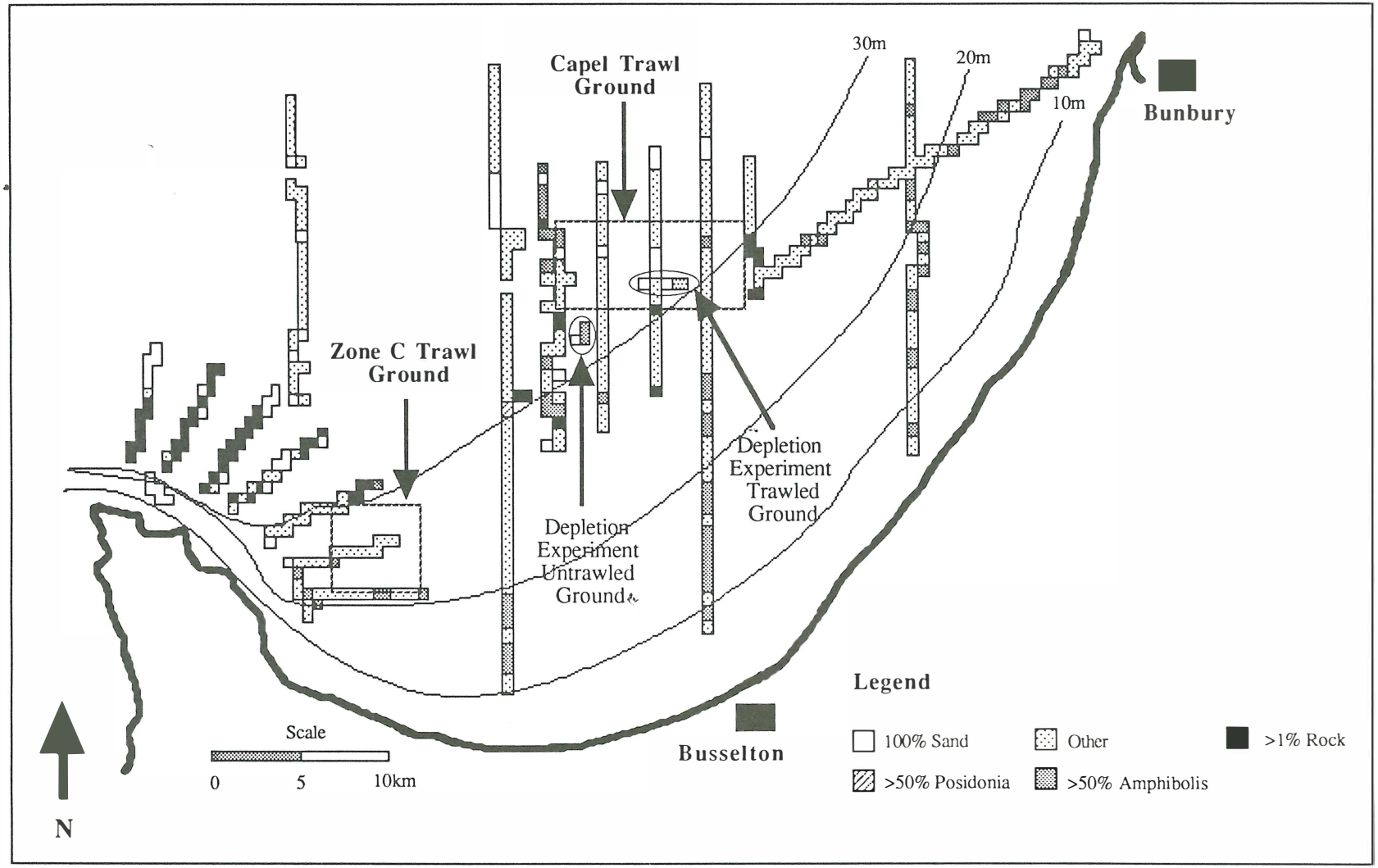
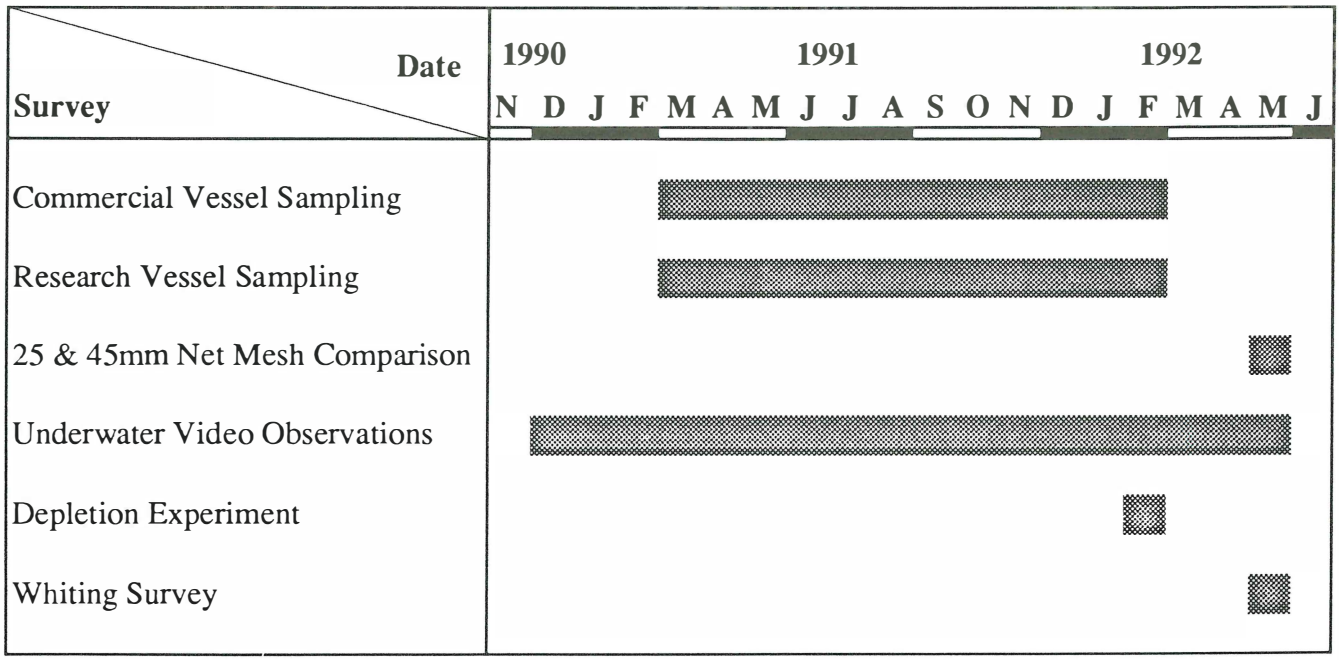


Figure 13: Transects carried out using a remotely operated underwater video camera system in Geographe Bay between 1991 and 1992. Dashed boxes around the commercial trawl ground represent stylised limits of the grounds and do not indicate borders. Data were collected in transects with a field of view approximately 5m wide. The category 'Other' consists of areas of attached algae, sponge and weed and are largely considered as untrawlable. Note with the aggregation of ROV observations, some small trawlable areas may be masked by this presentation.

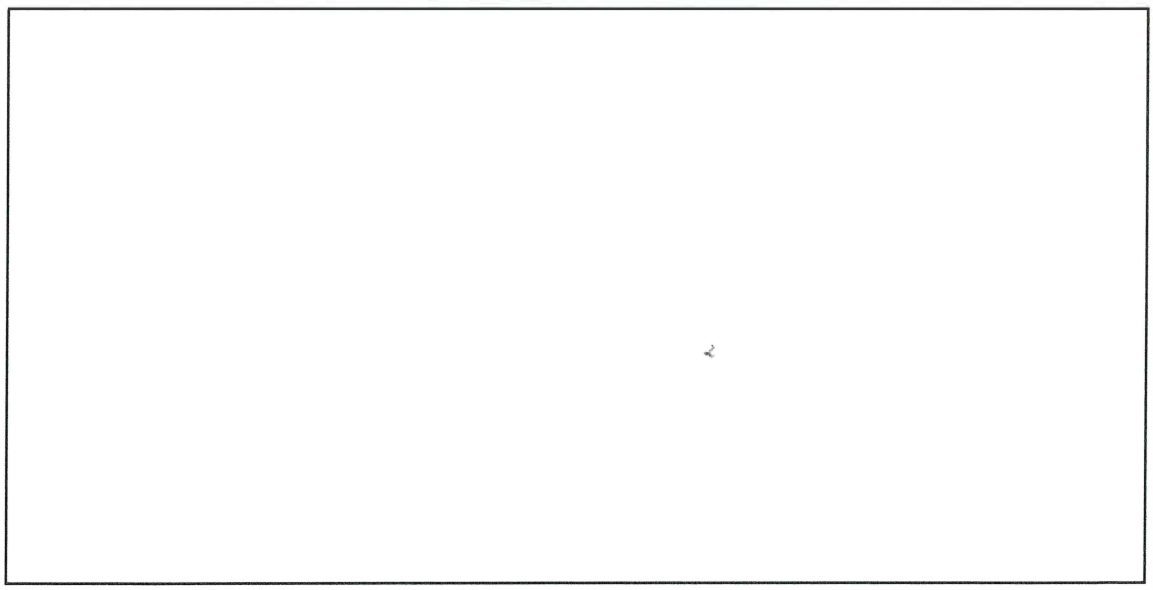
Appendices

Appendix 1: Sampling periods for research and commercial data from the south-west inshore trawl fishery. Shaded blocks immediately beneath the month represent summer and winter while unshaded blocks represent autumn and spring.



Appendix 2: Calculation of the biomass and sustainable yield of southern school whiting in the region between Perth and Fremantle inside the 50m isobath. Area was estimated from navigational charts. The percentage of the region which was whiting habitat was obtained from ROV observations of the substrate. Trawl net efficiency was obtained from a depletion experiment conducted in Geographe Bay. Sustainable yield was calculated using the relationship defined by Gulland (1983) where mortality (Z) was assumed to be 0.3 and the biomass (B) calculated below. Sustainable Yield = 0.3 Z B.

	Catch Rate (kg/ha)	**Estimated Area of Region (ha) in 50m Isobath**	**% of Region Whiting habitat**	**% Efficiency of Trawl Net**	**Estimated Biomass (tonnes)**
South of Burns Beach and North of Cockburn Sound (31 45' to 32 15')	2.73	264788	72%	44%	1181
South of Cockburn Sound and North of Mandurah (32 15' to 32 30')	3.61	173315	72%	44%	1024
South of Mandurah and North of Bunbury (32 30' to 33 15')	0.73	502469	55%	44%	461
Geographe Bay 33 15' to 33 40'	1.05	171940	34%	44%	140
	Total Biomass (tonnes)				2806
	Sustainable Yield (tonnes)				253



The W.A. Marine Research Laboratories at Waterman (incorporating the Bernard Bowen Fisheries Research Institute), Perth, are the centre for fisheries research in Western Australia.