Demersal finfish resource assessment survey of the north-west slope of Western Australia

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Department of Fisheries

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Fish for the future

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Objectives:

1. To determine the species distributions and composition of demersal scalefish resources on the NW slope and to examine industry collected catch and effort data to determine an index of relative abundance.
2. To assess the viability of exploiting the demersal scalefish resource of the North-West slope using (a) fish trawls, traps and lines in the western zone (west of 120°E longitude) and; (b) traps and lines in the eastern zone (east of 120°E longitude)..
3. To gather biological information on the major species (e.g. to investigate longevity, natural mortality and aspects of their reproductive biology).

Non-Technical Summary:

Outcomes Achieved

This project was not completed due a limited number of commercial size landings. Given the high cost of undertaking survey work in the deep water regions of north-western Australia, it is advisable that any further development be co-operative joint ventures among fishing companies in order to share both the cost of survey work and the knowledge generated. More importantly funding will be required to cover fuel costs and other overheads when commercial landings are limited.

However, one of the outcomes from this project is a proposed developmental zone to be created for deep slope waters to facilitate further development.

The nature and extent of demersal finfish resources in deep slope waters (>200m) off the northwest coast of Western Australia are poorly understood. Existing fish trawl, trap and line fishing effort is concentrated in shallower waters (<200m), while trawling in deep slope waters (>200m) exclusively targets crustaceans.

Despite significant initial levels of interest in this project, poor commercial catches contributed to fishers returning to grounds in shallower waters on the shelf. As a consequence of the lack of significant commercial catches in the deep slope region there was a very low level of industry participation in the project. To date there is little evidence to indicate the existence or otherwise of significant demersal fish resources in the deep slope region.

A number of high value species were landed from the survey and include; lenko snapper (*Dentex tumifrons*), ruby snapper (*Etelis carbunculus*), flame snapper (*Etelis coruscans*), eight bar cod/grouper (*Epinephelus octofasciatus*) and Tang snapper (*Lipocheilus carnolabrum*).

Deepwater tropical fish are in general slow growing, long-lived fish with large-sizes and ages at maturity. These life history attributes indicate that these fish have a low production potential and are vulnerable to over-harvesting. Harvest strategies of low frequency and/or low intensity may provide fishery managers with sustainable catch strategies for these deep slope waters.

Jurisdiction of waters deeper than 200 metres resides with the Commonwealth (AFMA) for fish trawling, while the State (Department of Fisheries, WA) has jurisdiction over trap and line methods in these waters. Current management arrangements for the State-based trap and line fisheries permit development research activities to be undertaken in waters deeper than 200m given appropriate exemptions. The undertaking of fish trawl research activities in waters deeper than 200 metres involves approval of an appropriate research application from AFMA.

The State-based trap and line fisheries in the Pilbara and Kimberley region have the potential to be developed through an adaptive management process. The demersal fisheries of north-western Australia are managed through the use of input controls where fishing capacity is regulated by utilising a total allowable effort control system explicitly allocated through individually transferable effort units. This control system would effectively limit the total allowable effort in each sector but will serve as an adaptive tool to encourage exploitation of these deepwater areas and stocks. Requirements for this process are that these waters be zoned separate to the existing fisheries; determination of a notional target catch for each sector and a notional CPUE (e.g. a lower CPUE is proposed at a level of 50% of the current catch rates in the shelf region).

Survey results from this project indicate that trap and line fishing methods have a much-reduced impact on the both by-catch levels and the benthic environment than fish trawl fishing. The level of by-catch species in total trap and line catch was low at 2.1%. In contrast, the level of by-catch species in fish trawl catch was relatively high comprising 63.8% of the total landed catch, of which one-third was comprised of benthic organisms such as sponges and corals. In addition, the fish trap and line fishing appeared to be highly selective for commercially desirable species by both type and size.

The deep slope demersal fish resources of north-western Australia are potentially highly valuable, and could provide an alternative fishery to a small number of vessels from other fisheries, thereby increasing their viability, however, these resources are likely to have a limited production potential as a corollary of the life history characteristics of the key species. Hence, the sustainable level of exploitation is likely to be low. There are serious difficulties in managing demersal fisheries resources if the species aggregate and hence become very vulnerable to fishing at certain times of the year. Effective management of these demersal fish resources will therefore require effective collaboration among State and Commonwealth management agencies and may be developed through an adaptive management approach including appropriately targeted spatial and/or temporal closures to protect a portion of the spawning stock biomass of these demersal fish resources.

KEYWORDS: Deep slope, Tropical, Limited production potential, Fisheries, management, Adaptive management.

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Background

Trawl fisheries for demersal scalefish on the North-West (NW) Shelf have been highly successful, initially for foreign vessels and more recently for domestic vessels. However, successful fishing on the North-West Slope (that is, waters deeper than 200 metres) has been, to date, limited to trawling for crustaceans (the North West Slope Trawl Fishery - NWSTF). Demersal line fishing in slope waters is commercially viable in other areas of the tropical Indo-Pacific, but has resulted in overfishing in some areas (e.g. Hawaii; Moffitt pers. comm.).

It is likely that the demersal scalefish resources of the North-West Slope are not as uniformly spread as those on the shelf, and that there are greater similarities with temperate deep water fishing for species such as orange roughy, with large schools forming, perhaps seasonally, which can provide profitable catches if the aggregations can be found. Not all the species are known, but those expected include a variety of eteline snappers (jobfishes), lenko snapper and Darwin's roughy. It is very likely that most of the deep-water fish will be long-lived species capable of sustaining only low levels of fishing mortality (that is, low levels of fishing effort).

For many years since the development of the deep-water crustacean fishery there has been little interest in fishing for demersal scalefish. However, the maturing of adjacent fisheries has now led to a number of sectors believing that they have the capability to fish the slope waters for demersal scalefish. Moreover, advances in gear technology have also made deepwater stocks more accessible to trawl gears. The interest of these sectors has been heightened by recent good catches of species such as ruby snapper (*Etelis* spp.) in the northern waters of the Western Deep-Water Trawl Fishery (WDWTF). Fishing effort in the WDWTF is sporadic and seasonal. Members of this fishery feel that they are the deep-water fish trawl fishers in the region and that they should have the rights to the North-West Slope region. North-West Slope crustacean fishers feel that the demersal scalefish resource should be part of their fishery. Fishers in the state-managed Pilbara Fish Trawl Fishery on the North-West Shelf believe that they are the fish trawlers in that region and that the north-west slope area is the natural extension of their fishery. The slope waters east of 120ºE are already part of a state-managed trap and line fishery, which is steadily extending into deeper waters.

The maturing of domestic markets with the widespread market acceptance of a great variety of deep-water species and the increased availability of export markets indicate that the exploitation of deep slope species in the North-West slope region may be highly profitable.

The problem of numerous interest groups is compounded by an overlap in jurisdiction. Under the Offshore Constitutional Settlement (OCS) arrangement, the Commonwealth (Australian Fisheries Management Authority (AFMA)) controls trawling activities in waters of the Australian Fishing Zone off Western Australia deeper than 200 metres, while Western Australia controls trap and line fishing in these waters.

To date, there has been little or no fishing for demersal scalefish in the north-west slope waters and the opportunity exists to allocate and manage the demersal scalefish resource in a rational and sustainable manner. This requires knowledge of the approximate size of the resource, the sustainable exploitation rate, the viability of different fishing methods in exploiting different components of the resource and characteristics such as the timing and location of aggregations (if any) of the various species.

At its 1996 meeting, WESTMAC (the management advisory committee providing advice to AFMA for the NWSTF and the WDWTF) decided that demersal scalefish on the North-West Slope should not be exploited prior to the development and implementation of a research program. At its June 1997 meeting, WESTMAC decided that the research should take the form of a controlled commercial operation, with full observer coverage and safeguards to prevent a gold rush wiping out fish aggregations. The research would also evaluate trawling and trap and line fishing as methods for utilising the demersal scalefish resource. It was acknowledged that one of the most important parameters in fish stock assessment, and usually one of the most difficult to obtain, is the natural mortality rate. It was agreed that the opportunity to estimate natural mortality rates from the previously unexploited stocks of the North-West Slope should be undertaken as part of the research program.

The demersal scalefish resource of the North-West Slope is potentially highly valuable, and could provide an alternative fishery to a small number of vessels from other fisheries, thereby increasing their viability. The long-lived nature of many deep-water species, however, means that the sustainable level of exploitation is likely to be low. There are serious difficulties in managing these fisheries if the species aggregate and hence become very vulnerable to fishing at certain times of the year. Industry's perception of such situations is that there is huge stock of fish and that a large part of the aggregation can be taken. It is important to have an understanding of the size of the resource and its characteristics, which determine the sustainable exploitation rate, before long term access is granted.

Need

Trawling in waters west of the 200m isobath is managed by AFMA as part of the NWSTF. AFMA's draft Management Plan for the NWSTF does not encompass fishing for finfish, and this omission has been the main impediment to implementing the Management Plan to date. In order for the Management Plan to fully cover all fishery resources within the

NWSTF area, knowledge of the distribution of demersal scalefish and their relative abundance is urgently needed.

In the waters east of 120ºE, a fishery already exists which covers the slope for line and trap fishing, though no formal discussions have been held with the Commonwealth regarding trawling for the same fish resource in that area. Clearly the jurisdictional arrangements need to be reviewed. The capability of the State-managed and the Commonwealth-managed fishing methods to utilise the resources at different depths form part of the basis for this review.

There is a need for information on the type of resource available to fishers, the relative abundance of those species which have either commercial potential or current market acceptance in the Indo-Pacific region and the relative catchability of each of the fishing methods (fish trawl vs. fish trap vs. line). Furthermore, there is a need for biological information (including information on longevity, natural mortality and reproductive biology) about the key species available to fishers in order to begin to understand the population dynamics of these species and hence to assess their vulnerability to fishing pressure.

The information that will be provided by this project will form the basis for reviewing the current OCS arrangements between the State and the Commonwealth and will assist in developing management plans for the sustainable exploitation of the demersal fish resources of the North West slope.

Objectives

1. To determine the species distributions and composition of demersal scalefish resources on the NW slope and to examine industry collected catch and effort data to determine an index of relative abundance.

2. To assess the viability of exploiting the demersal scalefish resource of the NW Slope using fish trawls, fish traps and lines.
3. To gather biological information on the major species (eg. to investigate longevity, natural mortality and aspects of their reproductive biology).

Methods

Survey area and restrictions

Central to the project was an initial two-year survey beginning on 1 July 1998 and conducted by commercial trawl, trap and line vessels. The survey area comprised the area within the NWSTF, that is, the body of water bounded to the east by the 200m isobath and to the west by the AFZ boundary, and by the 114ºE longitude to the south and 124ºE longitude to the north (Fig. 1). The charted area was divided into a grid system of 30-minute square blocks numbered alpha-numerically (Fig. 1). Western and eastern zones were divided east and west of 120ºE longitude. This boundary is a natural boundary between the Pilbara and Kimberley regions. The number of vessels involved and the amount and distribution of survey effort within each of the allotted zones was left to the discretion of participating fishers due to logistic constraints related to trip profitability.

Trawling was permitted only in the western zone, except in designated “scampi exclusion zones” whose coordinates were determined by agreement between AFMA and NWSTF crustacean fishers to protect existing scampi trawl grounds. A 20-day per block trawling limit was set to control potential local depletions and comprised total net-on-bottom time accrued by all trawlers in a given block within a single permit period. Pilbara and Kimberley trap and line fishers were regionally restricted to the western and eastern zones respectively, under normal licensing arrangements. Trap and line fishers were not formally excluded from scampi grounds as it was deemed highly unlikely they would fish on the types of substrate found there.

Survey Permits – Trawlers

Initial six-month exemption permits to fish trawlers in the NWSTF were issued by AFMA to approved applicants and re-application was required for subsequent six-month periods. Initially applicants were required to nominate which survey grid blocks they intended to fish, however, as there was no limit set as to how many blocks could be fished the requirement was deemed unnecessary and was subsequently dropped. Additional permit conditions to those mentioned above included the requirement to:

- accommodate an on-board Department of Fisheries (WA) observer at all times when in the fishery
- supply the observer with all relevant information (e.g. catch and positional data) and make available specimens for biological sampling
- have installed an approved Automatic Location Communicator (ALC) linked to the AFMA Vessel Monitoring System (VMS)
- complete an AFMA daily logbook and submit landing figures for each trip
- report fishing activity daily to AFMA via fax or VMS

Survey Permits – Trap and Line vessels

The Northern Demersal Scalefish Fishery (NDSF) currently extends out to the AFZ boundary and fishers are allotted an annual quota of fishing effort. All time in the fishery (without an exemption), irrespective of depth fished, is subtracted from the effort quota. In the Pilbara, the trap fishery extends only to the 200m isobath with only line fishing (under an Open West Coast Licence) permitted beyond that depth. To encourage survey participation in both regions Department of Fisheries (WA) issued six-month scientific exemption permits to facilitate deep slope access for eligible applicants. Exemptions included the right to use both traps and lines regardless of whether fishers were normally licensed for one method only and, in the Kimberley, discounted time spent in deep water from that otherwise normally accrued. Permits imposed conditions similar to those for trawlers with major differences being that fishers were required:

- to carry an observer only if so requested;
- complete a specific deep slope Department of Fisheries (WA) logbook for all fishing activities;
- report intentions to Department of Fisheries (WA) Operations whenever leaving or entering the survey area;
- allow inspection of deep slope catch by a Department of Fisheries (WA) Fisheries Officer before unloading.

Vessels and Gear

Trawlers

Eleven trawlers were endorsed under permit at some time during the survey period. However, only three actually participated in the survey. Two of these, each approximately 22 m L.O.A., were involved in the Pilbara Fish Trawl Fishery (PFTF) located inshore of the NWSTF and had previously fished in the WDWTF. The third was a 39 m converted offshore tug with deepwater fishing history in the South East Fishery (SEF), Great Australian Bight and, briefly, in the WDWTF while en route north from Fremantle. Both vessel types were of steel construction and had crew complements of 4 and 7 respectively.

The demersal fish trawl nets employed varied slightly among vessels but were all fairly typical of those used in the PFTF, namely a “cutaway” (not a full-wing) design with 228mm

(9”) wing mesh and 100mm (4”) codend mesh. Footropes were of standard steel wire-cored combination rope threaded with small (approx. 50mm diameter) rubber washers interspaced at regular intervals with 200mm (8”) bobbins. Headrope length was typically 33-39 m (18-20 fathoms). Trawls were towed with 14-16mm steel warp wires and spread achieved with steel “V” or “super V” trawl doors. The 35m trawler also employed a midwater trawl known as a French String Trawl with wing meshes up to 16 m long and 125mm codend meshes.

Correct net setting depth was achieved on the PFTF trawlers by applying a trawl wire to bottom depth ratio of approximately 2.5:1 and visually determining the warp length deployed using fixed measuring marks. The large trawler employed a net monitoring system that provided constant readings of headrope depth and net opening width and height via an echo-sounder signal relayed to a bridge-mounted monitor. The retained catch was stored in refrigerated holds of 14-18 tonnes capacity for the smaller trawlers and 70 tonnes for the larger 35m vessel.

Trap and Line vessels

Seven permits were issued to NDSF fishers and four to Pilbara fishers. Three vessels participated in the survey with two of the three trips monitored by observers. A Pilbara vessel fished with traps only and comprised a 14m custom-built ex-lobster boat from Tasmania with a steel displacement hull and counter stern. The Kimberley boats were approximately 17m L.O.A. and each set a few trial traps but mainly line-fished.

Fish traps used in each zone were rectangular and of similar size and design. They typically measured 1.5m long by 1.3m wide by 0.3m high and were constructed of hot-dipped galvanised weld-mesh measuring either 50mm square or 50x75mm and welded to a light steel frame. A bait basket with a sliding hatch and filled with pilchards and occasionally lobster heads (Kimberley only) was attached to the inside of the top of the trap. Traps were retrieved by a horizontal friction winch and were side-hauled via a gunwale-mounted roller attached to a tipping platform used to lever traps inboard.

Handlines were predominantly used with some droplines with 30 hooks attached, known as “throwaways”, were occasionally tried. Hooks were generally size 13/0 tuna circle hooks. Line reels were spooled with 1.7mm non-stretch flat-weave Dynex braided line of 250 kg breaking strain and lines were directed outboard through a pulley attached to a short steel bar. Hooks were on short nylon line snoods and clipped to the main line at about 2m intervals. Generally six hooks were attached to each line. Bait was usually frozen pilchards but occasionally fresh bycatch species such as trevally were tried.

Retained catch was processed similarly to trawler catch and refrigerated in holds of about 6 tonnes and 3 tonnes for the Kimberley and Pilbara vessels respectively. Several insulated deck storage bins of approximately 500 kg capacity were usually also carried to increase capacity.

Fishing Practices

All fishing was conducted at the discretion of individual skippers within permit conditions and the duration of trips varied but did not exceed one week. Skippers tended to use the gear available from their customary fisheries although there was some scope to experiment and improvise and to use additional gear to which they might not be normally be entitled. One trawler employed a mid-water trawl net as a trial and several trap and line skippers who were normally licensed to use only one method experimented with both. All followed a loosely predetermined survey plan to explore known or suspected potentially productive areas. Prior to the commencement of fishing, areas were surveyed using sounders for any indication of suitable substrate, bottom features or fish schools. Where no signs of fish life were found, gear was occasionally deployed for a brief speculative trial but skippers generally moved on to the next area without fishing.

Trawl duration was determined to suit conditions and varied from eight minutes to 2.75 hours. Trap soak time was dependent upon the preference of individual skippers and varied from 1.5 hours in the Pilbara to 2.5 hours in the Kimberley. Line soak times varied according to catch success and vessel drift rate but were typically 20-30 minutes. Retrieval times for fish trawls, traps and lines varied with depth (approx. 10 minutes to pull trap at 200m and approx. 20 min. to haul fish trawls at 200m).

Commercial catches by all methods were treated in a similar manner. Fish were immersed in chilled brine tanks above deck as soon as possible to rapidly reduce core body temperature. After approximately two hours the fish were removed and repacked whole in plastic bag liners within lidded plastic fish bins and stored dry at 0° to -1° C until being unloaded at port.

Catch Recording

The composition and magnitude of all catches including by-catch or discard species were recorded. Length frequency measurements, biological sampling from major commercial species, and by-catch specimen collection for identification were undertaken opportunistically. The commercial catch component was always processed first to minimise product exposure to the tropical heat. By-catch was left on deck until the crew finished sorting and cleared the area. Length frequency measurements (fork length) were undertaken only on abundant commercial species. All by-catch species were routinely collected to verify their identification. Specimens that could not be readily identified were sent to either the Western Australian Museum or CSIRO (Hobart) to be identified.

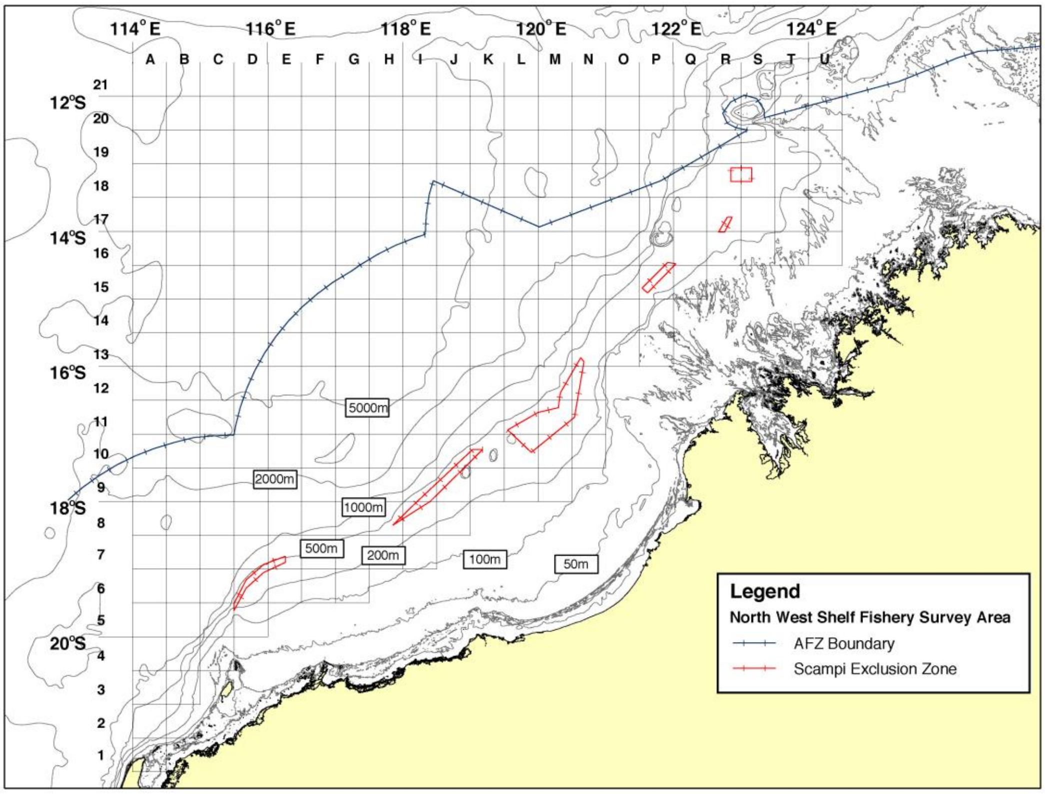

Figure 1. Location of the study area depicting the grid zones for each block across north-western Australia.

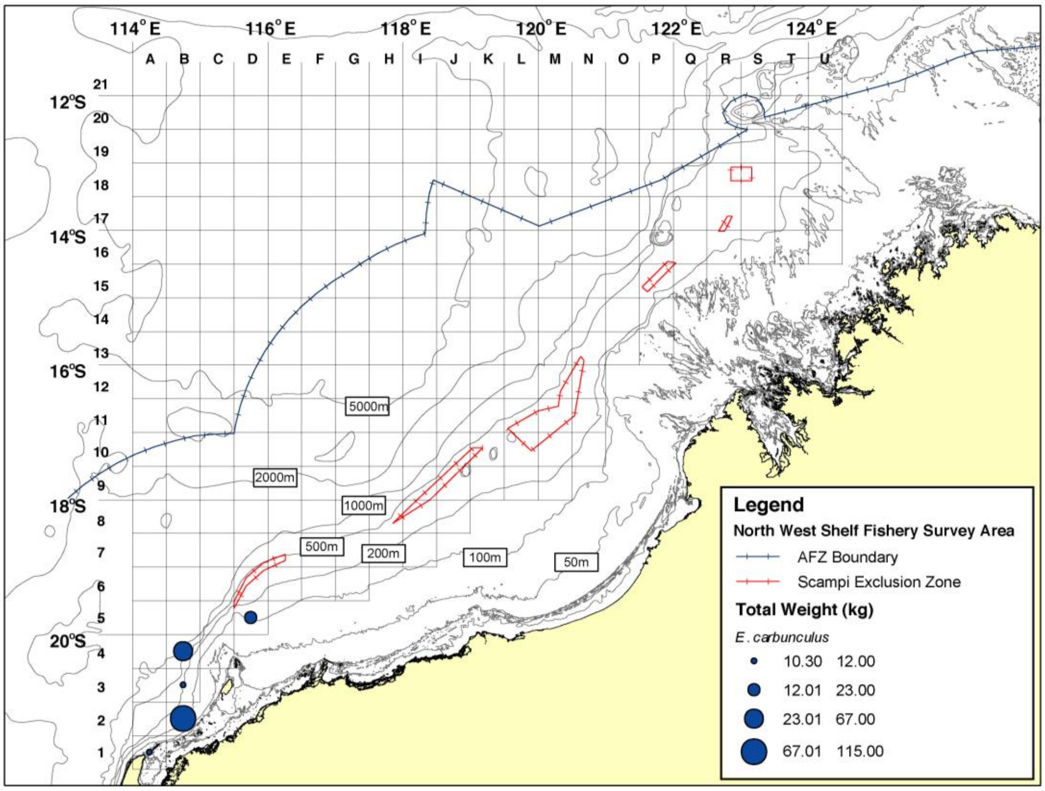

Figure 2. Spatial distribution of the catch of *Etelis carbunculus* landed during the survey (note: effort and catch was sparse and distribution is indicative only).

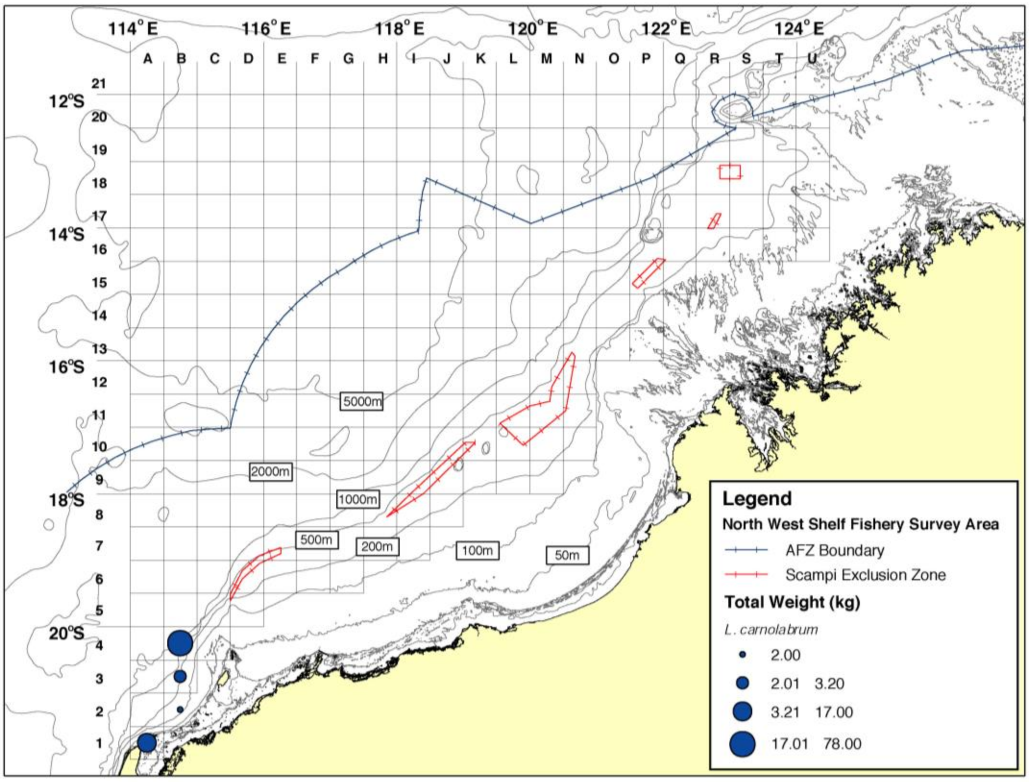

Figure 3. Spatial distribution of the catch of *Lipocheilus carnolabrum* landed during the survey (note: effort and catch was sparse and distribution is indicative only).

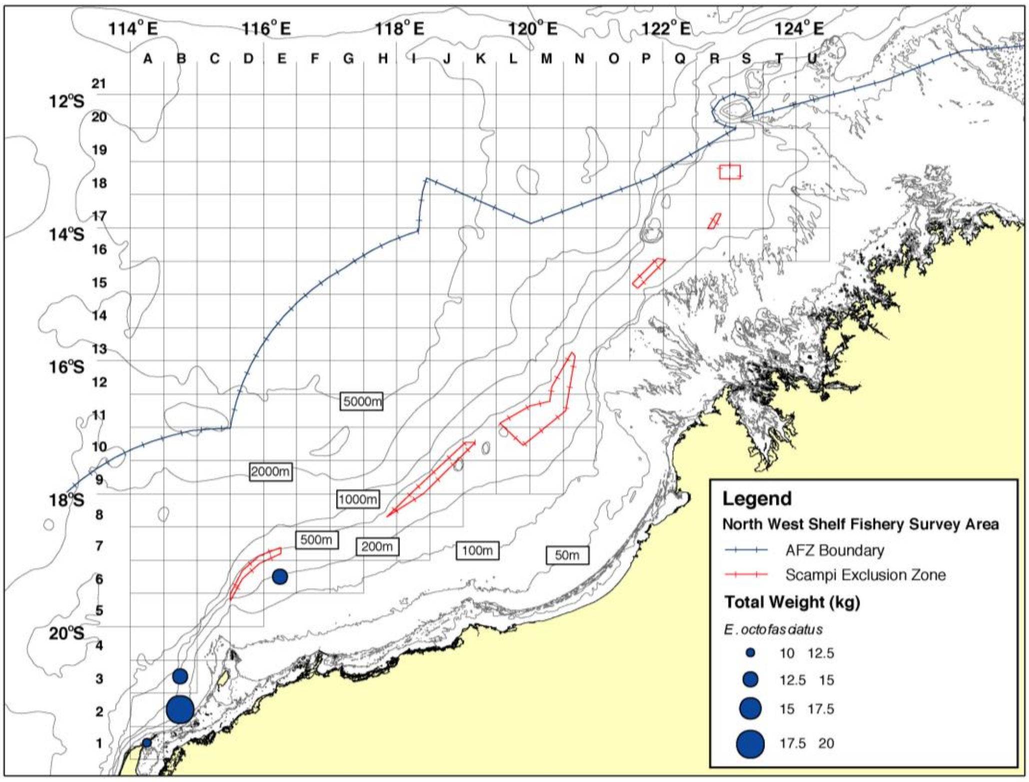

Figure 4. Spatial distribution of the catch of *Epinephelus octofasciatus* landed during the survey (note: effort and catch was sparse and distribution is indicative only).

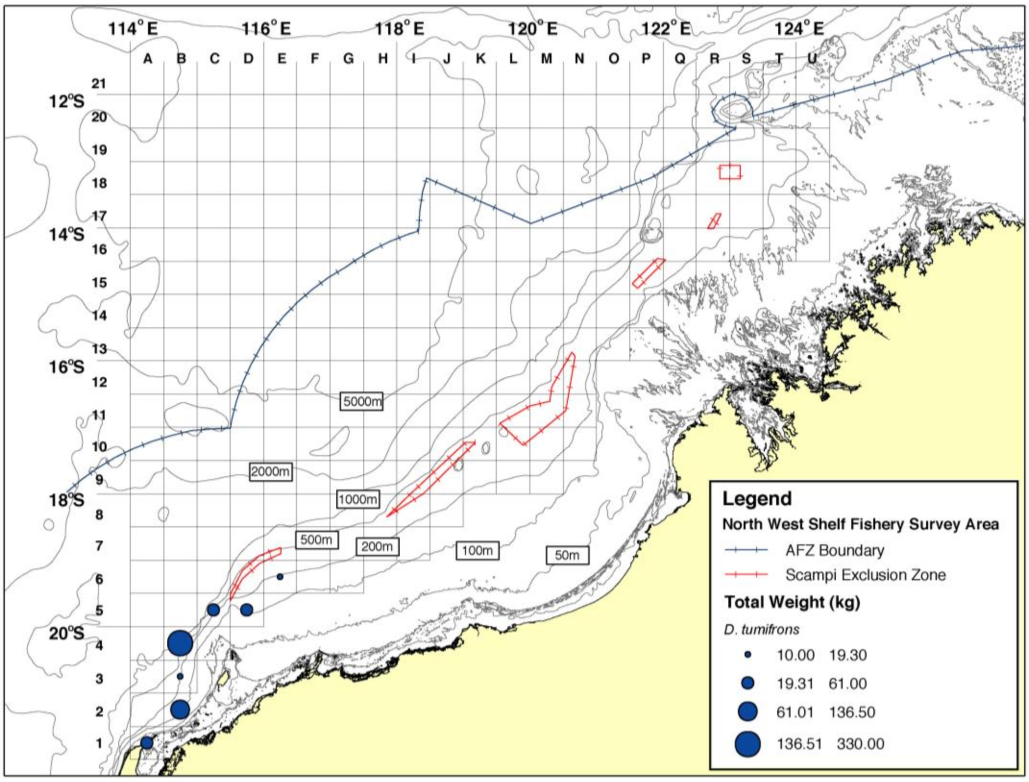

Figure 5. Spatial distribution of the catch of *Dentex tumifrons* landed during the survey (note: effort and catch was sparse and distribution is indicative only).

Results

Survey Effort and Distribution

The survey commenced in July 1998 and access to the deep slope permit holders remained open until the end of June 2000. Although most fish trawl permit applicants consistently reapplied for permits every six months, and trap and line exemption permits were regularly reissued, survey participation was very poor. Several letters encouraging greater effort were sent to permit holders throughout the survey period, but had little effect. Overall survey coverage of the study area was consequently too low to provide useful effort and distribution analyses. However, the spatial distributions of the catch of the 4 most dominant species landed are depicted in Figures 2-5 as an example.

Trawl Effort

Three trawlers provided survey catch and effort data. One completed a single trip, one completed 2 trips, and another completed three short trips. Total time spent at sea by all trawlers, including steaming time, was 32 days during which 31 trawls were completed within 16 separate survey blocks. A large proportion of vessel time accrued during the survey was dedicated to searching for targets (i.e. bottom features and fish schools). Total trawl time was 37.95 hours giving an average trawl duration of 1.2 hours.

Trawl Distribution

Most trawl effort was concentrated in the south of the survey in area although the highest single block effort (12.5%) was in block I8 in the north. Most vessels were not equipped for deeper slope trawling and consequently 23 of the trawls (74%) were deployed in 200-300 m with the shallowest being in 205m. Seven trawls were done in 300-400 m and a single trawl in 685m.

Trap and Line Effort

Three vessels participated to some extent in the survey. A single Pilbara trap boat completed two trips, one logbook-monitored, and one with an observer on board. Two Kimberley trips were conducted, one with an observer on-board and one in which logbook records were not submitted. Total vessel time spent on the survey, including steaming time, was an estimated fifteen days, with about half that time spent in each zone. Trap effort in the Pilbara zone was 353 trap-hours (i.e. the total number of traps set [235] multiplied by the average soak time of 1.5 hours). Effort in the Kimberley zone was 40 trap-hours from four operational sets of four traps each with an average soak time of 2.5 hours per trap. No line fishing was undertaken in the Pilbara zone.

It was difficult to accurately quantify Kimberley trap and line fishing effort given the ad hoc nature of setting and hauling operations and the variation in gear usage among vessels. The total Kimberley line fishing effort was approximately 30 handline hours (using 24 hooks and 4 lines) and 5 dropline hours (using 30 hooks per dropline).

Trap and Line Distribution

Grouped operational data indicated that the total trap and line survey effort in the study was approximately 52 hours, with 74% being from the Kimberley region. In the Kimberley region effort data was dominated by the use of handlines (80%). The effort in the Pilbara region was confined to 2 blocks (B2 and B3) situated off Onslow. Kimberley effort was more widely distributed with 8 survey blocks fished. The nine trap sets in the Pilbara ranged between 211 and 293 m, while the four Kimberley trap sets were between 192 and 275 m. The 20 line fishing events in the Kimberley ranged from 156 to 549 m though the majority were less than 300 m depth.

Given the low amount of survey data, only summary data on catches and catch rates are presented below. A detailed provisional species list of the fish fauna from deep slope waters off the north-west coast of Western Australia is listed in Appendix 3.

Trawl Catch

The total biomass caught from the 31 trawls was 2241.9 kg. The commercial (retained) component was 811.9kg or 36.2% and comprised 21 species. The main commercial species and their relative contribution to the total fish trawl catch by weight are listed in Table 1. By-catch consisted of 168 species or categories totalling 1430.0 kg (63.8%). Average commercial CPUE was of 21.4 kg hr^{-1}. Three species accounted for 85.5% of the retained catch by weight and include lenko snapper, *Dentex tumifrons* (60%), ruby snapper, *Etelis* *carbunculus* (13.8%) and Tang snapper, *Lipocheilus carnolabrum* (11.7%, see Table 1). The total weight of catch for all the other commercial species comprised less than 5% of the total catch. In terms of abundance, lenko snapper were clearly dominant species landed with 930 fish being caught compared with the next two most abundant species, ruby snapper (51) and Tang snapper (50).

The dominant by-catch species group by weight (67.3% of total) was the benthos (23.1%) category that comprised seven groups (Table 2). Stingrays (23.0%) were also dominant in the by-catch represented by 13 species groups. In declining order of abundance the by-catch consisted of sharks (15.2% - 12 species groups), big-eyes or Priacanthidae (6.1% - at least 3 species). The combined benthos component consisted largely (54%) of an unidentified species of stalked crinoid (feather star) and an assortment of sponges (30%). The large black stingray, *Dasyatis thetidis* (50.2%), and other Dasyatididae species (38.1%) dominated the biomass of stingrays. Of the finfish by-catch, only four species had a total catch weight comprising more than 2% of the total by-catch biomass and included the whitefin trevally, *Carangoides equula* (5.1%), red big-eye, *Priacanthus macracanthus* (3.9%), large-headed hairtail, *Trichiurus lepterus* (3.0%), lenko snapper, *Dentex tumifrons* (2.5%) and white-striped big-eye, *Pristogenys niphonia* (2.0%). The relatively significant by-catch of the normally retained lenko snapper indicated the occurrence of a considerable number of small unmarketable sized individuals.

Table 1. Summary list of retained commercial species and their relative contribution to the total fish trawl catch by weight.

COMMERCIAL SPECIES		Weight (kg)
Lenko snapper	*Dentex tumifrons*	**487**
Ruby snapper	*Etelis carbunculus*	**112**
Tang snapper	*Lipocheilus carnolabrum*	**95**
Eight Bar cod	*Epinephelus octofasciatus*	**34**
Deepwater Big-eye	*Cookeolus japonicus*	**27**
Flame snapper	*Etelis coruscans*	**12**
Goldband snapper	*Pristipomoides multidens*	**11**
Radiant cod	*Epinephelus radiatus*	**9**
Others		**26**
	Totals	**812**

Table 2. Summary list of by-catch species and species groups and their relative contribution to the total fish trawl catch by weight.

TRAWL BY-CATCH SPECIES		kg	% of total
Benthos (sponges, corals etc)	combined species	330.8	23.1%
Rays	combined species	328.6	23.0%
Sharks	combined species	216.7	15.2%
Bigeyes	combined species	87.0	6.1%
Carangoides equula	whitefin trevally	78.8	5.5%
Salps	combined species	51.0	3.6%
Trichiurus lepturus	Hairtail, Large-headed	43.1	3.0%
Dentex tumifrons	Lenko snapper	35.6	2.5%
COMBINED lizardfishes	combined species	27.2	1.9%
Satyrichthys spp.	armoured gurnards	20.3	1.4%
Doederleinia berycoides	Bass, rosy	19.8	1.4%
Thamnaconus tessellatus	Leatherjacket, Many-spotted	16.0	1.1%
Ibacus pubescens	Bug, Velvet	15.9	1.1%
	Total by-catch (165 species groups)	**1430.1**	**88.9%**

Trap and Line Catch

The total biomass caught from the trap and line component of the survey was approximately 1100.5 kg. The commercial (retained) component was 1077.9 kg or 97.9%, comprising 15 species. The commercial species landed by trap and line and their relative contribution to the total catch by weight are listed in Table 3. Most of the commercial species landed by trap and line from deep slope waters are deepwater snappers and groupers of the families Lutjanidae and Serranidae, respectively. The two dominant species in the retained catch were the ruby snapper, *Etelis carbunculus* (535 kg, 49.7%) and the lenko snapper, *Dentex tumifrons* (380 kg, 35.3%). The dominant species in the trap and line catch were the same as the dominant species in the fish trawl catch.

Table 3. Summary list of retained commercial species and their relative contribution to the total trap and line catch by weight.

Total Trap and Line Catch		
Species	**Wt**	**% all**
Etelis carbunculus	**535.40**	**49.7%**
Dentex tumifrons	**380.15**	**35.3%**
Epinephelus octofasciatus	**36.00**	**3.3%**
Pristipomoides multidens	**29.00**	**2.7%**
Epinephelus radiatus	**24.70**	**2.3%**
Seriola dumerili	**20.00**	**1.9%**
Lipocheilus carnolabrum	**15.20**	**1.4%**
Pristipomoides filamentosus	**9.00**	**0.8%**
Etelis coruscans	**8.00**	**0.7%**
Lutjanus argentimaculatus	**6.00**	**0.6%**
Pristipomoides zonatus	**5.60**	**0.5%**
Epinephelus amblycephalus	**4.00**	**0.4%**
Wattsia mozambica	**3.20**	**0.3%**
Hapalogenys kishinouyei	**1.00**	**0.1%**
Pristipomoides argyrogrammicus	**0.60**	**0.1%**
Total	**1077.85**	

Table 4. Summary list of by-catch species and species groups and their relative contribution to the total trap and line catch by weight.

Trap and Line by-catch species	Weight (kg)
Eels, UID, undifferentiated	**1.50**
Nautilus pompilius	**0.50**
Scorpaenidae spp.	**2.00**
Sharks, UID, undifferentiated	**12.00**
Squalus spp.	**3.00**
Ostichthys japonicus	**1.50**
Squalidae spp.	**2.10**
Total	**22.60**

By-catch from the trap and line-fishing operations was relatively small comprising only 22.6 kg or 2.1% of the total landed catch (Table 4). A number of deepwater shark species dominated this by-catch. The by-catch also comprised *Nautilus* and is potentially valuable to the shell trade.

Length Frequency Data

Length frequency data were collected from the three most abundant fish trawl species (Figs. 6-8). A progression of increasing length classes with increasing depths was evident for the lenko snapper (Fig. 6). There was no evidence of any relationship between length and increasing depth with either the ruby snapper or the Tang snapper. However, this may have been a reflection of the small sample sizes of these species in comparison to the lenko snapper samples.

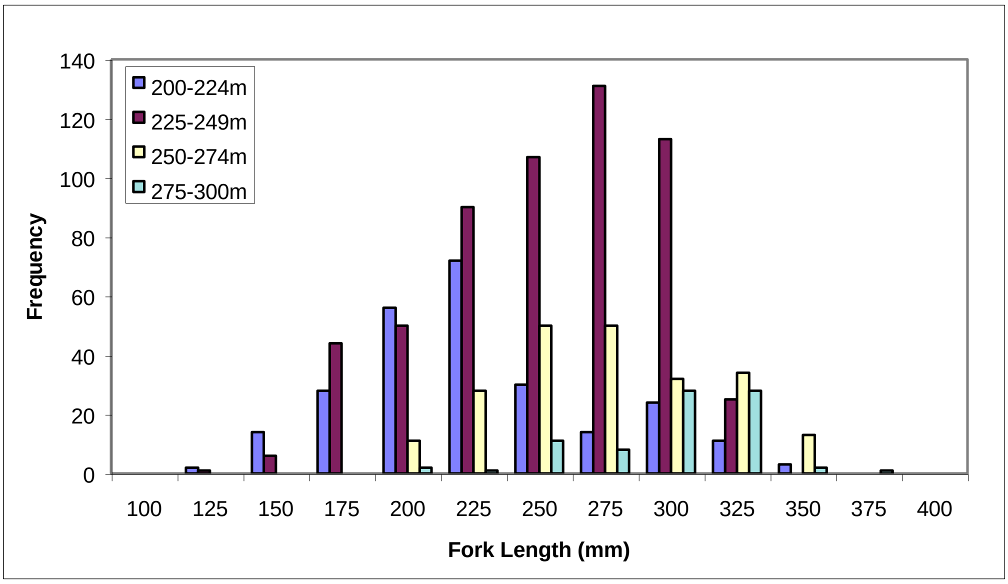

Figure 6. Length frequency distribution (25 mm length classes) of *Dentex tumifrons* sampled from depths of 209-288 metres along the north-west slope of Western Australia (n = 1120).

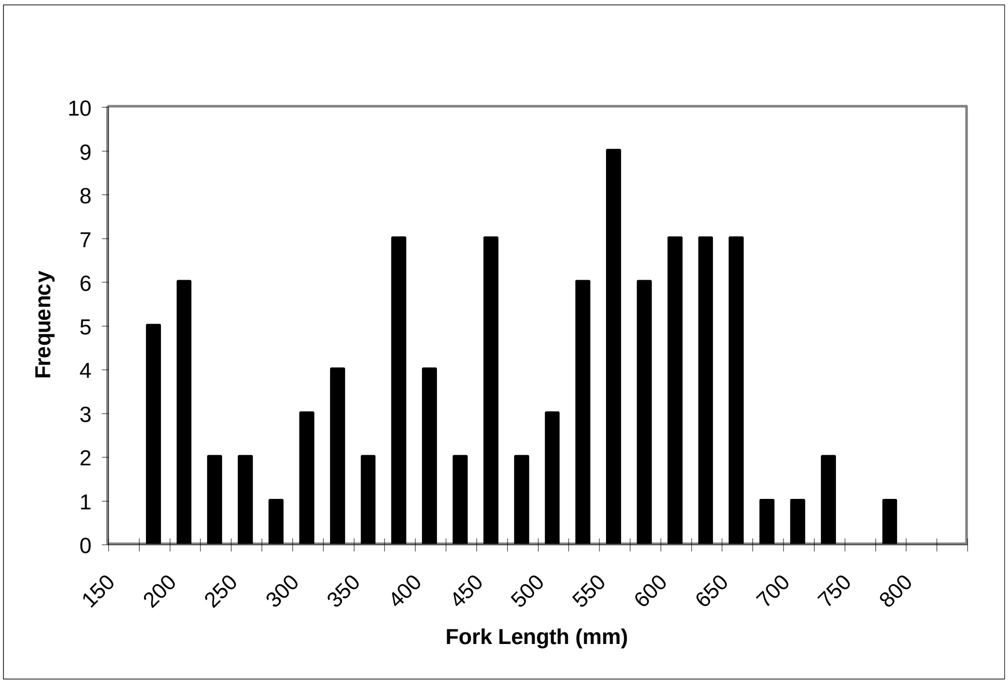

Figure 7. Length frequency distribution (25 mm length classes) of *Etelis carbunculus* sampled from depths of 209-288 metres along the north-west slope of Western Australia (n = 97).

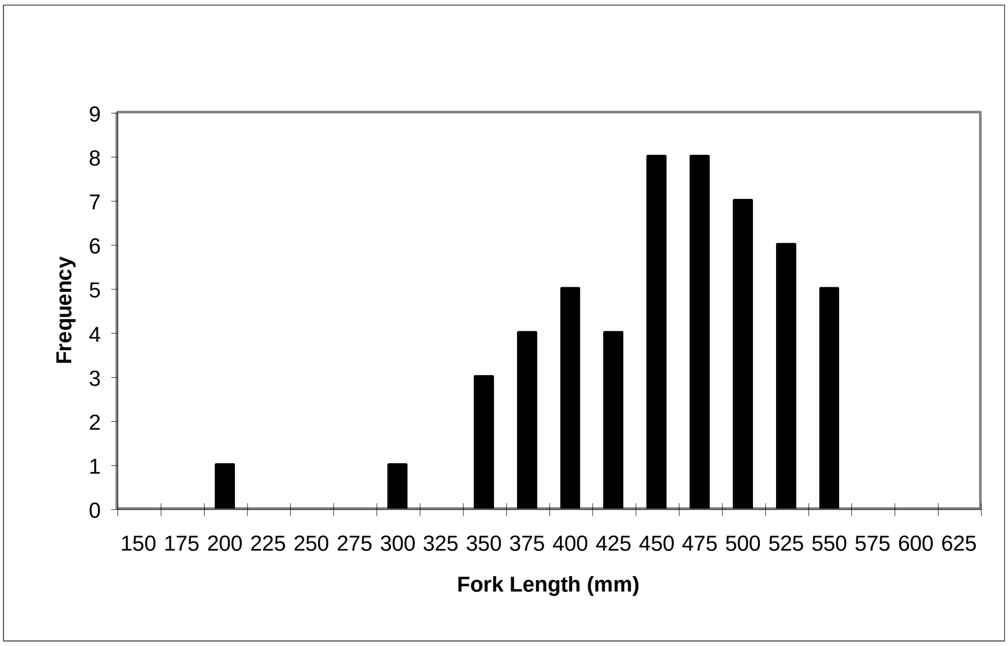

Figure 8. Length frequency distribution (25 mm length classes) of *Lipocheilus carnolabrum* sampled from depths of 205-242 metres along the north-west slope of Western Australia (n = 52).

Discussion

The original goal of this project was to provide information on the type of demersal finfish resources available to fishers, the relative abundance of those species which have either commercial potential or current market acceptance in the Indo-Pacific region and the relative catchability of each of the fishing methods, e.g. fish trawl vs. fish trap vs. line. In addition, it was anticipated that detailed biological information would be collected (including information on longevity, natural mortality and reproductive biology) in relation to the key species available to fishers in order to begin to understand the population dynamics of these species and hence to assess their vulnerability to fishing pressure. Unfortunately industry participation in the survey was poor due a limited number of commercial size landings hence the project was discontinued. The early completion of this project therefore precluded achievement of the original objectives.

Each of the objectives for this project and the extent to which these objectives could be achieved given the project was not completed are summarised below;

Objective 1: To determine the species distributions and composition of demersal scalefish resources on the NW slope and to examine industry collected catch and effort data to determine an index of relative abundance.

Due to the limited number of survey trips completed it was not possible to complete this objective. However, part of this objective was achieved. The data collected during this project provides an indication of the likely species composition and their general distribution. Moreover, detailed descriptions of the by-catch and benthos data is important for future assessments of the deep slope region based on ecologically sustainable development criteria. In addition, the collation of species identification data allows for the capacity to generate field guides for the use of fishers in future years to accurately report catch data should the offshore waters be further developed.

Objective 2: To assess the viability of exploiting the demersal scalefish resource of the North-West slope using (a) fish trawls, traps and lines in the western zone (west of 120°E longitude) and; (b) traps and lines in the eastern zone (east of 120°E longitude).

Due to the limited number of survey trips completed it was not possible to assess each of the zones and complete this objective. However, part of this objective was achieved.

Survey results from this project indicate that trap and line fishing methods have a much-reduced impact on the both by-catch levels and the benthic environment than fish trawl fishing. The level of by-catch species in total trap and line catch was low at 2.1%. In contrast, the level of by-catch species in fish trawl catch was relatively high comprising 63.8% of the total landed catch, of which one-third was comprised of benthic organisms such as sponges and corals. In addition, the fish trap and line fishing appeared to be highly selective for commercially desirable species by both type and size.

Objective 3: To gather biological information on the major species (e.g. to investigate longevity, natural mortality and aspects of their reproductive biology).

Due to the limited number of survey trips completed and the lack of commercial size landings, this objective was not achieved. The production potential of this area is discussed below in relation to what is known about deep slope fish stocks in other areas of the Indo-Pacific region.

The demersal fish resources in the survey area appear to be limited and are not as uniformly distributed as those on the inner continental shelf. The species landed indicate that the demersal fish resource in deep slope waters are valuable, consisting primarily of highly prized lutjanid, serranid and sparid fish species. Deepwater tropical snappers (Lutjanidae) and groupers (Serranidae) are important demersal fishery resources in many regions of the Indo-Pacific (Polovina and Ralston 1987, Dalzell and Preston 1992). Many of these species often form large schools particularly during the spawning season. Management of these fish resources can be problematic as large catches can be taken over a short period of time. Hence, those species that form aggregations or aggregate at certain times of the year are highly vulnerable to fishing activities. For example, Grandcourt (2003) demonstrated that intensive line fishing (12 dories supported by a mothership) over a 13-day period could remove over 80% of the initial biomass of *Pristipomoides filamentosus* (rosy jobfish) in the southwest Indian Ocean at Saya de Malha Bank. In addition, this initial catch represented more than 3 times the estimated sustainable yield, and further indicated that that fishing operations can rapidly deplete demersal fisheries resources (Grandcourt 2003).

Deepwater tropical demersal fish resources are very sensitive to exploitation pressure due to a reduced productive capacity resulting from slow growth, extended longevity, late maturity and large size (Polovina and Ralston 1987). For example, in Hawaii, populations of *Etelis carbunculus* (local name ehu) and *E. coruscans* (local name onaga) were heavily fished for decades resulting in reductions of their spawning stocks to less than 10% of original levels and greatly reduced annual catches (Moffitt pers. comm.). The State of Hawaii established spatial area closures (harvest refugia) for deep slope demersal fish in July 1998 in response to critical declines in *Etelis carbunculus* and *E. coruscans* resources in the main Hawaiian Islands. These spatial area closures are intended to allow rebuilding of *Etelis carbunculus* and *E. coruscans* stocks to healthy levels with spawning stocks approaching 40-50% of original levels (Moffitt pers. comm.).

Considerable time and effort is required to travel across the broad continental shelf of north-western Australia to deep water areas and at present most vessels are only marginally large enough to operate comfortably and safely at this distance offshore. Setting and retrieving of lines and traps takes considerably longer in the deeper depths and can require expensive gear modification (e.g. hydraulic line reels) to increase efficiency. Most fishers have little knowledge of requirements for effective deepwater fishing and are wary of sustaining considerable financial loss while gaining the necessary experience. In addition, as fishing access in some fisheries is limited (NDSF management is based on an effort quota allocation), deep slope exploratory fishing is perceived as being a less productive use of available time allocation than operating on the shallower inner shelf region.

Development of the deep slope region may be facilitated through the implementation of an adaptive management process for the State-based trap and line fisheries in the Pilbara and Kimberley regions. This process would require that the deep slope waters are zoned separate to the existing fisheries with a notional target catch developed for each sector to be used in conjunction with a lower CPUE, at a level of approximately 50% of the current catch rates on the shelf, which would effectively limit the total allowable effort in each sector but will serve as an adaptive tool to encourage exploitation of these deepwater areas and stocks.

The deep slope demersal fish resources of north-western Australia may provide an alternative source of fish to a small number of vessels from other fisheries, thereby increasing their viability. However, as the production potential of these fish resources is likely to be low, the sustainable level of exploitation for these resources is also likely to be low. In addition, species that aggregate and hence become very vulnerable to fishing at certain times of the year are often difficult to mange effectively. Therefore, development of the demersal fish resources in deep slope waters through an adaptive management approach should give consideration to incorporating appropriately targeted spatial and/or temporal closures to protect a portion of the spawning stock biomass of these demersal fish resources.

The deepslope region has overlapping jurisdictions. Under the current Offshore Constitutional Settlement (OCS) arrangements the State manages trap and line fisheries from the 200-metre depth contour to the edge of the Australian Fishing Zone (AFZ) while the Commonwealth (AFMA) managed the trawl based activities in this region. Effective management of the demersal fish resources in this region of jurisdictional overlap will therefore require effective collaboration among State and Commonwealth management agencies. Careful management arrangements will be required to allocate effort access equitably across competing fishing sectors.

Benefits

Collation of species identification data and the capacity to generate field guides for the use of fishers in future years should the offshore waters be further developed.

Further Development

Trawl industry members initiated the concept of a commercial industry funded survey design such that the cost of surveys could be subsidised by landing any fish caught. Survey plans were subsequently developed following a WESTMAC meeting in June 1997. At this meeting, a survey of demersal scalefish resources in the NWSTF was rated as the highest research priority for the NWSTF. In response to this, industry members and observers at the meeting helped develop a preliminary survey plan and offered their fullest support for seeking FRDC funding to assist with the survey. Following the WESTMAC meeting all permit holders in the WDWTF and NWSTF were informed of the planned proposal and WESTMAC members unanimously supported a pre-proposal circulated in September, 1997.

Despite this level of industry support the project was discontinued due to a lack of industry participation. Given the high cost of undertaking survey work in the deep water regions of north-western Australia, it is advisable that any further development be co-operative joint ventures among fishing companies in order to share both the cost of survey work and the knowledge generated. However, more importantly funding will be required to cover fuel costs when commercial landings are limited.

Planned Outcomes

This project was not completed due a limited number of commercial size landings. Given the high cost of undertaking survey work in the deep water regions of north-western Australia, it is advisable that any further development be co-operative joint ventures among fishing companies in order to share both the cost of survey work and the knowledge generated. More importantly funding will be required to cover fuel costs and other overheads when commercial landings are limited.

However, one of the outcomes from this project is a proposed developmental zone to be created for deep slope waters to facilitate further development.

Conclusion

The low yields to date in the deep slope region indicate that the potential fish resources of the region are probably low. However, the fish landed to date are highly valuable with high export market potential. Therefore, harvest strategies of low intensity and low volume that yield a high value product may enhance the current fisheries along north-western Australia.

The development of the demersal fish resources in deep slope waters of north-western Australia should be encouraged through an adaptive management approach that incorporates appropriately targeted spatial and/or temporal closures to protect a portion of the spawning stock biomass of these demersal fish resources.

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Appendices

Appendix 1: Intellectual Property

Nil

Appendix 2: Staff

Dr. S. Newman
Mr. D. Evans
Mr. R. Ashworth

Appendix 3: Provisional species list of the fish fauna from deep slope waters off the north-west coast of Western Australia (includes common names, Australian Aquatic Biota Codes [CAAB] - Yearsley et al., 1997; Rees et al., 1999 and preferred common names if different).

Scientific Name (* denotes retained species)	**Authority**	**Common Name (local)**	**CAAB Code**	**CAAB Common Name (if different)**
Chondrichthyes				
Sharks: Undifferentiated				
Shark spp.	Undifferentiated	Shark spp.	37 990003	
Hexanchidae: Sixgill and Sevengill Sharks				
Hexanchidae spp.	Undifferentiated	Sixgill and Sevengill Sharks	37 000500	
Heterodontidae: Horn Sharks				
Heterodontidae spp.	Undifferentiated	Horn Sharks	37 007000	
Heterodontus zebra	(Gray, 1831)	Zebra Horn Shark	37 007002	
Scyliohinidae: Swell Sharks				
Cephaloscyllium fasciatum	Chan, 1966	Swell Shark, Reticulate	37 015007	
Triakidae: Hound Sharks				
*Triakidae spp.	Undifferentiated	Hound Sharks	37 017000	
Mustelus sp. B	[in Last & Stevens, 1994]	White-spotted Gummy Shark	37 017004	
Carcharhinidae: Whaler Sharks				
*Carcharhinidae spp.	Undifferentiated	Whaler Sharks	37 018000	
Squalidae: Dogfishes				
Squalidae spp.	Undifferentiated	Dogfishes	37 020000	
Squalus spp.	Undifferentiated	Greeneye Dogfishes	37 020901	
Squatinidae: Angel Sharks				
Squatina sp. B	[in Last & Stevens, 1994]	Western Angel Shark	37 024005	
Rhinobatidae: Shovelnose Rays				
Rhinobatidae spp.	Undifferentiated	Shovelnose Rays	37 027000	

Appendix 3: cont.

Scientific Name (* denotes retained species)	**Authority**	**Common Name (local)**	**CAAB Code**	**CAAB Common Name (if different)**
Narcinidae: Numbfishes				
Narcine spp.	Undifferentiated	Numbfishes	37 028002	
Narcine sp. B	[in Last & Stevens, 1994]	Numbfish, western	37 028004	
Torpedinidae: Torpedo Rays				
Torpedo spp.	Undifferentiated	Torpedo Rays	37 028900	
Rajidae: Skates				
Rajidae spp.	Undifferentiated	Skates	37 031000	
Irolita sp. A	[in Last & Stevens, 1994]	Skate, Western Round	37 031017	
Raja sp. D	[in Last & Stevens, 1994]	False Argus Skate	37 031030	Blotched Skate
Raja sp. N	[in Last & Stevens, 1994]	Skate, Thintail	37 031013	
Dasyatididae: Stingrays				
Dasyatididae spp.	Undifferentiated	Stingrays	37 035000	
Dasyatis annotata	Last, 1987	Plain Maskray	37 035012	
Dasyatis thetidis	Ogilby, 1899	Black Stingray	37 035002	
Urolophidae: Stingarees				
Urolophus flavomosaicus	Last & Gomon, 1987	Patchwork Stingaree	37 038010	
Urolophus westraliensis	Last & Gomon, 1987	Brown Stingaree	37 038009	
Myliobatididae: Eagle Rays				
Myliobatididae spp.	Undifferentiated	Eagle Rays	37 039000	
Chimaeridae: Shortnose Chimaeras				
*Chimaeridae spp.	Undifferentiated	Ghostsharks, Shortnose Chimaeras	37 042000	
Hydrolagus lemures	(Whitley, 1939)	Blackfin Ghost Shark	37 042003	

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Actinopterygii				
Nettastomatidae: Wire or Witch Eels				
Nettastomatidae spp.	Undifferentiated	Wire or Witch Eels	37 065000	
Sternoptychidae: Marine Hatchetfishes			37 107000	
Polyipnus sp. C1		Marine Hatchetfish sp. (id. code NWS36)	unassigned	
Polyipnus sp. C2		Marine Hatchetfish sp. (id. code NWS49)	unassigned	
Astronesthidae: Stareaters			37 108000	
Astronesthes? sp. C1		Stareater sp. (id. code NWS34)	unassigned	Dragonfish sp.
Aulopodidae: Threadsails			37 117000	
Aulopus sp. C1		Threadsail sp. (id. code NWS32)	unassigned	
Bathysauridae: Lizardfishes				
Saurida filamentosa	Ogilby, 1910	White-spot Lizardfish	37 118006	
Saurida spp.	Undifferentiated	Deepsea Lizardfishes	37 118901	
Saurida undosquamis	(Richardson, 1848)	Checkered Lizardfish	37 118001	Brushtooth Lizardfish
Saurida longimanus	Norman, 1939	Longfin Lizardfish	37 118014	
Chlorophthalmidae: Greeneyes				
Chlorophthalmus agassizi		Northern Cucumber Fish	37 120002	
Chlorophthalmus sp. P2		Greeneye sp. P2 (id. code NWS55)	unassigned	
Chlorophthalmus sp. W3a		Greeneye sp. W3a (id,. code NWS56)	unassigned	
Myctophidae: Lanternfishes				
Myctophidae spp.	Undifferentiated	Lanternfishes	37 122000	
Myctophum sp C1		Lanternfish sp. (id. code NWS33)	unassigned	
Paralepididae: Barracudinas			37 126000	
Paralepididae (?) sp.C1		Barracudina (?) sp. (id. code NWS35)		

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Ateleopodidae: Jellynosefishes			37 136000	
Atelopus cf. *japonicus*		Jellynosefish (id. code NWS03)	unassigned	
Chaunacidae: Coffinfishes				
Chaunax endeavouri		Coffinfish sp.	37 211003	
Chaunax sp. W3a (CSIRO)		Coffinfish sp. W3a (id. code NWS11)	unassigned	
Chaunax sp. W3b (CSIRO)		Coffinfish sp. W3b (id. code NWS19)	unassigned	
Lophiidae: Goosefishes				
Lophiomus setigerus	(Vahl, 1797)	Goosefish sp.	37 208001	
Lophiomus sp.		Goosefish sp. (id. code NWS20)	unassigned	
Ogcocephalidae: Deepwater Batfishes				
Halieutaea stellata	(Vahl, 1797)	Starry Handfish	37 212002	
Ophidiidae: Cusk Eels			37 022800	
Monomitopus sp. W3a		Cusk Eel sp. (id. code NWS51)	unassigned	
Macrouridae: Rattails, Whiptails and Grenadiers				
Caelorinchus sp. C1		Whiptail sp. (id. code NWS44)	unassigned	
Caelorinchus sp. W4		Whiptail sp. (id. code NWS27)	unassigned	
Macrouridae spp.	Undifferentiated	Whiptails	37 232000	
Macrouridae sp C1		Whiptail sp. (id. code NWS45)	unassigned	
Ventrifossa sp. W8		Whiptail sp. (id. code NWS52)	unassigned	
Polymixiidae: Beardfishes				
Polymixia berndti	Gilbert, 1905	Pacific Beardfish	37 253001	
Berycidae: Redfishes, Nannygais and Alfonsinos				
**Centroberyx* cf. *australis*	Shimizu & Hutchins, 1987	Nannygai	37 258006	Yellow-eye Redfish
Monocentrididae: Pineapplefishes				
Monocentris japonica	(Houttuyn, 1782)	Japanese Pineapplefish	37 259002	

Appendix 3: cont.

Scientific Name (* denotes retained species)	**Authority**	**Common Name (local)**	**CAAB Code**	**CAAB Common Name (if different)**
Holocentridae; Squirrelfishes and Soldierfishes				
Ostichthys japonicus	(Cuvier, 1829)	Japanese Squirrelfish	37 261003	Northwest Red Fish
Zeniontidae: Dories; macrurocyttids			37 263000	
Zenion sp. C1		Dory sp. (id. code NWS43)	unassigned	
Zeidae: Dories				
**Zenopsis nebulosus*	(Temminck & Schlegel, 1845)	Mirror Dory	37 264003	
Cyttopsis cypho	(Fowler, 1934)	Dory sp.	37 264009	
Caproidae: Boarfishes				
Antigonia rhomboidea	McCulloch, 1915	Pink Boarfish	37 267001	Rhomboidal Boarfish
Fistulariidae: Flutemouths				
Fistularia petimba	Lacepede, 1803	Rough Flutemouth	37 278002	
Scorpaenidae: Scorpionfishes				
Neosebastes entaxis	Jordan & Starks, 1904	Orange-banded Scorpionfish	37 287009	Orange Scorpionfish
Scorpaena neglecta	Temminck & Schlegel, 1844	Scorpionfish	37 287041	Coral Perch
Scorpaenidae sp. P2		Scorpionfish sp. (id. code NWS18)	unassigned	
Scorpaenidae spp.	Undifferentiated	Scorpionfishes	37 287000	
Setarches guentheri	Johnson, 1862	Scorpionfish sp.	37 287047	Coral Perch
Setarches longimanus	(Alcock, 1894)	Red Scorpionfish	37 287013	none
Setarches sp. 1		Scorpionfish sp. (id. code NWS57)	unassigned	
Setarches sp. C1		Scorpionfish sp. (id. code NWS41)		
Setarches sp. C2		Scorpionfish sp. (id. code NWS48)		
Triglidae: Gurnards				
Lepidotrigla sp. P1		Butterfly Gurnard sp. (id. code NWS24)	unassigned	
Lepidotrigla sp. P2		Butterfly Gurnard sp. (id. code NWS10)	unassigned	

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Lepidotrigla sp. P3		Butterfly Gurnard sp. (id. code NWS04)	unassigned	
Lepidotrigla spp.	Undifferentiated	Butterfly Gurnards	37 288901	
Peristedion liorhynchus	(Günther, 1872)	Slender Armoured Gurnard	37 288022	none
Pterygotrigla leptacanthus	(Günther, 1880)	Dark Fin Gurnard	37 288014	
Pterygotrigla sp. E		Gurnard sp. (id. code NWS25)		
Satyrichthys rieffeli	(Kaup, 1859)	Spotted Armoured Gurnard	37 288023	none
Satyrichthys sp. C1		Armoured Gurnard sp. (id. code NWS40)	unassigned	
Satyrichthys sp. P2		Armoured Gurnard sp. (id. code NWS22)	unassigned	
Satyrichthys spp.	Undifferentiated	Armoured Gurnards (id. code PDW18)	unassigned	
Satyrichthys welchi	(Herre, 1925)	Robust Armoured Gurnard	37 288019	none
Platycephalidae: Flatheads				
Bembras longipinnis	Imamura & Knapp, 199	Green-spotted Flathead	37 296026	
Elates ransonnetii	(Steindachner, 1877)	Dwarf Flathead	37 296013	
Ratabulus diversidens	(McCulloch, 1914)	Orange-freckled Flathead	37 296011	
Hoplichthyidae: Ghost Flatheads				
Hoplichthys citrinus	Gilbert, 1905	Ghost Flathead sp.	37 297002	
Dactylopteridae: Flying Gurnards				
Dactyloptena peterseni	(Nystrom, 1887)	One-spined Flying Gurnard	37 308002	
Serranidae: Rock Cods (Groupers)				
**Epinephelus amblycephalus*	(Bleeker, 1857)	Yellow-lipped or Blunt-headed Cod	37 311015	Bighead Grouper
**Epinephelus epistictus*	(Temminck & Schlegel, 1843)	Black-dotted Rock Cod	37 311046	Spottedback Grouper
**Epinephelus radiatus*	(Day, 1868)	Radiant Cod	37 311042	Oblique-banded Grouper
**Epinephelus octofasciatus*	Griffin, 1926	Eight Bar Cod		Eight Bar Grouper
Anthias (?) sp. W3		Butterfly Perch (?) sp. (id. code NWS14)	unassigned	

Appendix 3: cont.

Scientific Name (* denotes retained species)	**Authority**	**Common Name (local)**	**CAAB Code**	**CAAB Common Name (if different)**
Percichthyidae: Temperate Ocean-basses				
Acropoma japonica	Gunther, 1859	Japanese Bass	37 311167	
Doederleinia berycoides	(Hilgendorf, 1879)	Rosy Sea Bass	37 311025	Rosy Bass
Malakichthys cf. *elegans*	Matsubara & Yamaguchi, 1943	Temperate Ocean Bass sp.	37 311048	
Malakichthys sp.1	[in Sainsbury et al, 1985]	Sharp-chinned Bass	37 311031	
Banjosidae: Banjosids:				
**Banjos banjos*	(Richardson, 1846)	Banjofish	37 322001	
Priacanthidae: Bigeyes				
**Cookeolus japonicus*	(Cuvier, 1829)	Long-finned Bigeye	37 326002	Long-finned Bullseye
Priacanthus fitchi	Starnes, 1988	Deepsea Bigeye	37 326011	
**Priacanthus hamrur*	(Forsskål, 1775)	Lunar-tailed Bigeye	37 326005	Black Spot Bigeye
**Priacanthus macracanthus*	Cuvier, 1829	Red Bigeye	37 326001	
Pristigenys niphonia	(Cuvier, 1829)	White-striped Bigeye	37 326006	
Echeneidae: Suckerfishes				
Echeneis naucrates	Linnaeus, 1758	Slender Suckerfish	37 336001	
Carangidae: Trevallies and Jacks				
Carangoides equula	(Schlegel, 1844)	Whitefin Trevally	37 337013	
Decapterus kurroides	Bleeker, 1855	Redtail Scad	37 337056	none
**Seriola lalandi*	Valenciennes, 1833	Yellowtail Kingfish	37 337006	
Bramidae: pomfrets			37 342000	
Brama (?) sp. C1		Pomfret (?) sp. (id. code NWS39)	unassigned	
Emmelichthyidae: Bonnetmouths			37 345000	
Emmelichthys sp C1		Bonnetmouth (?) sp. (id.code NWS37)	unassigned	

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Lutjanidae: Tropical Snappers				
**Etelis carbunculus*	Cuvier, 1828	Ruby Snapper	37 346014	Northwest Ruby Fish
**Etelis coruscans*	Valenciennes, 1862	Flame Snapper	37 346038	Ruby Snapper
**Lipocheilus carnolabrum*	(Chan, 1970)	Tang's Snapper or Golden Sea Perch	37 346031	none
**Lutjanus argentimaculatus*	(Forsskål, 1775)	Mangrove Jack	37 346015	
**Pristipomoides argyrogrammicus*	(Valenciennes, 1831)	Ornate Jobfish	37 346054	
**Pristipomoides filamentosus*	(Valenciennes, 1830)	Rosy Jobfish	37 346032	King Snapper
**Pristipomoides multidens*	(Day, 1870)	Gold Band Snapper	37 346002	
**Pristipomoides sieboldii*	(Bleeker, 1854-57)	Lavender Jobfish	37 346064	none
**Pristipomoides zonatus*	(Valenciennes, 1830)	Oblique-banded Snapper	37 346056	
Nemipteridae: Threadfin Breams and Monocle Breams				
**Nemipterus bathybius*	Snyder, 1911	Yellowbelly Threadfin Bream	37 347001	
Parascolopsis rufomaculatus	Russell, 1986	Northwest Yellow Perchlet	37 347011	
Parascolopsis tanyactis	Russell, 1986	Yellow-bellied Dwarf Monocle Bream	37 347010	Yellow-bellied Sea Bream
Haemulidae: Sweetlips				
**Hapalogenys kishinouyei*	Smith & Pope, 1906	Lined Javelinfish	37 350001	Striped Javelinfish
Lethrinidae: Emperors and Sea Breams				
**Wattsia mozambica*	(Smith, 1957)	Paddle Tail Emperor	37 351027	none
Sparidae: Breams				
**Dentex tumifrons*	(Temminck & Schlegel, 1843)	Lenko Snapper	37 353002	Sea Bream
Pentacerotidae: Boarfishes				
**Histiopterus typus*	(Temminck & Schlegel, 1843)	Three-barred Boarfish	37 367008	Deep Sea Boarfish
Percophidae: Duckbills			37 393000	
Chrionema sp. W2		Duckbill sp. (id. code NWS06)	unassigned	

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Uranoscopidae: Stargazers				
Uranoscopsus kaianus		Stargazer sp.	37 400024	
Uranoscopus sp. 1	[in Sainsbury et al, 1985]	White-spotted Stargazer	37 400009	
Champsodontidae: Gapers				
Champsodon longipinnis	Matsubara *et al*, 1964	False Lizard Fish	37 401002	
Gempylidae: Snake Mackerels and Gemfishes				
Gempylidae spp.	Undifferentiated	Snake Mackerels, Gemfishes	37 439000	
Rexea prometheoides	(Bleeker, 1856)	Royal Escolar	37 439006	none
Thyrsitoides marleyi	Fowler, 1929	Black Snoek	37 439016	none
Trichiuridae: Hairtails				
Trichiurus lepturus	Linnaeus, 1758	Large-headed Hairtail	37 440004	
Scombridae: Mackerels and Tunas				
**Sarda orientalis*	(Temminck & Schlegel, 1844)	Oriental Bonito	37 441006	
Nomeidae: Driftfishes				
Cubiceps whiteleggii	(Waite, 1894)	Whitelegge's Cubehead	37 446013	Coastal Cubehead
Ariommatidae: Eyebrow Fishes				
Ariomma cf. *lurida*		Eyebrow Fish sp. (id. code NWS01)	unassigned	
Ariomma indica	(Day, 1870)	Indian Eyebrow Fish	37 447007	
Ariomma sp.	[in Sainsbury et al, 1985]	Elongate Eyebrow Fish	37 447003	
Bothidae: Lefteye Flounders				
Pseudorhombus megalops		Flounder sp.	37 460035	
Pseudorhombus sp. C1		Flounder sp. (id. code NWS30)	unassigned	
Triacanthodidae: Deepwater Tripodfishes				
Triacanthodes ethiops		Deepwater Tripodfish sp.	37 464003	

Appendix 3: cont.

Scientific Name (* denotes retained species)	**Authority**	**Common Name (local)**	**CAAB Code**	**CAAB Common Name (if different)**
Monacanthidae: Leatherjackets				
Thamnaconus tessellatus	(Günther, 1880)	Many-spotted Leatherjacket	37 465026	
Ostraciidae: Boxfishes				
Kentrocapros cf. *flavofasciatus*	(Kamohara, 1938)	Boxfish sp.	37 466023	
Tetraodontidae: Toadfishes				
Tetraodontidae spp.	Undifferentiated	Toadfishes	37 467000	
Torquigener hicksi	Hardy, 1983	Hicks' Toadfish	37 467026	none
Tylerius spinosissimus	(Regan, 1908)	Fine-spined Pufferfish	37 467022	Chinese PuffefFish
Eels: Undifferentiated				
Eel spp.	Undifferentiated	Eel spp.	37 990005	
Cephalopoda				
Nautilidae: Chambered Nautiluses				
Nautilus pompilius	(Linnaeus, 1758)	Emperor Nautilus	23 600001	
Sepiidae: Cuttlefish				
Sepia spp.	Undifferentiated	Cuttlefish spp.	23 607901	
Teuthoidea (ORDER): Squid				
Squid spp.	Undifferentiated	Squid spp.	23 615901	
Histioteuthis celetaria pacifica	(G. Voss, 1962)	Strawberry or Jewel Squid	23 630003	
Ommastrephidae: Arrow Squid				
Nototodarus gouldi	(McCoy, 1888)	Gould's Arrow Squid	23 636004	Gould's Squid
Ommastrephidae spp.	Undifferentiated	Flying Squid spp.	23 636000	

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Crustacea				
Penaeidea, Caridea (INFRAORDERS): Prawns and Carid Shrimps				
Penaeidea, Caridea	Undifferentiated	Prawn, and Shrimp spp.	28 710901	
Pandalidae: Pandalid shrimps				
Pandalidae spp.	Undifferentiated	Pandalid Shrimps	28 770000	
Nephropidae: Scampis				
Metanephrops boschmai	(Holthuis, 1964)	Boschmai Scampi	28 786002	Boschma's Scampi
Metanephrops velutinus	Chan & Yu, 1991	Velvet Scampi	28 786005	
Palinuridae: Spiny Lobsters				
Linuparus trigonus	(Von Siebold, 1824)	Red Spear Lobster	28 820004	Red Champagne Lobster
Linuparus sordidus	Bruce, 1965	Whire Spear Lobster	28 820003	White Champagne Lobster
Panulirus ornatus	(Fabricius, 1798)	Painted Rock Lobster	28 820006	Ornate Rock Lobster
Scyllaridae: Balmain Bugs, Shovel-nosed Lobsters, Slipper Lobsters				
Ibacus pubescens	Holthuis, 1960	Velvet Bug	28 821002	none
Ibacus alticrenatus	Bate, 1888	White-tailed Bug	28 821001	Deepwater Bug
Brachyura (INFRAORDER): Crabs				
Majidae spp	Undifferentiated	Spider Crabs	28 880000	
Anomura (INFRAORDER): Hermit Crabs				
Anomura spp.	Undifferentiated	Hermit Crabs (id. code PDW56)		
Portunidae: Swimming Crabs				
Portunidae spp.	Undifferentiated	Swimming Crabs	28 911000	
Galatheidae: Squat Lobsters				
Galatheidae spp.	Undifferentiated	Squat Lobsters	28 840000	

Appendix 3: cont.

Scientific Name (* denotes retained species)	Authority	Common Name (local)	CAAB Code	CAAB Common Name (if different)
Other Marine Organisms				
Porifera (PHYLUM): Sponges				
Porifera spp.	Undifferentiated	Sponges (id. code PDW08)	unassigned	
Alcyonacea (ORDER): Gorgonians, Soft Corals, Sea Whips etc.				
Alcyonaceans	Undifferentiated	Gorgonians, etc. (id. code PDW16)	unassigned	
Antipatharia (ORDER): Black Corals				
Antipatharians	Undifferentiated	Black Corals (id. code PDW33)	unassigned	
Thaliacea (CLASS): Salps				
Thaliaceans	Undifferentiated	Salps (id. code PDW10)	unassigned	
Echinodermata (PHYLUM): Sea Urchins, Feather Stars, Starfish etc.				
Echinoderms	Undifferentiated	Sea Urchins, etc. (id. code PDW14)	unassigned	
Crinoidea (CLASS) sp.	Undifferentiated	Blue and White Crinoid (id. code NW05)	unassigned	
Unidentidied Hard Corals				
Hard Coral spp.	Undifferentiated	Hard Corals (id. code NWS16)	unassigned	
Unidentidied Benthic spp.				
Benthos spp.	Undifferentiated	Uid. Benthos spp. (id. code NWS53)	unassigned	
Actinaria (ORDER): Anemones				
Actinarians	Undifferentiated	Uid. Anemone spp. (id. code NWS54)	unassigned	
Unidentified Bycatch spp.				
Unidentified Bycatch spp.	Undifferentiated	Uid. Bycatch spp. (id. code UID99)	unassigned	
Unidentified sp.		Unidentified sp. (id. code NWS42)	unassigned	