Fisheries Research Report No. 238, 2012

Identification of critical habitats for juvenile dhufish *(Glaucosoma hebraicum)*

NRM Project 09038 – Protecting Inshore and Demersal Finfish

P. Lewis, G. Mitsopoulos & B. Molony

Government of **Western Australia**
Department of **Fisheries**

This project is supported by funding from the Western Australian Government's State NRM Program

Fisheries Research Division
Western Australian Fisheries and Marine Research Laboratories
PO Box 20 NORTH BEACH, Western Australia 6920

Fish for the future

Fisheries Research Reports

Titles in the Fisheries Research Report series present technical and scientific information for use in management processes. Research Reports are subject to full internal refereeing by senior scientists of the Fisheries Research Division, and in many cases, elements of the work are published in international scientific literature.

Correct Citation:

P. Lewis, G. Mitsopoulos & B. Molony, (2012) *Identification of critical habitats for juvenile dhufish* (Glaucosoma hebraicum). NRM Project 09038 – Protecting Inshore and Demersal Finfish. Fisheries Research Report No 238. Department of Fisheries, Western Australia. 64p.

Enquiries:

WA Fisheries and Marine Research Laboratories, PO Box 20, North Beach, WA 6920
Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

A complete list of Fisheries Research Reports is available online at **www.fish.wa.gov.au**

ISSN: 1035 - 4549 ISBN: 978-1-921845-49-9

Contents

Executive Summary

The Western Australian dhufish *(Glaucosoma hebraicum)* is an iconic demersal species that is endemic to the lower west and south coasts of Western Australia (WA). Information on the critical habitat and distribution of juvenile dhufish, less than two years of age and *ca* 150 mm total length (TL), was limited to a single study in one area where they have been previously collected. Increasing the knowledge on the habitat types occupied by juvenile dhufish, the distribution of these habitats in the West Coast Bioregion and methods to potentially monitor the annual recruitment of the species are important in their management.

The objectives of the study were to apply the information gathered in an initial multi-agency workshop on the biology and ecology of juvenile dhufish to design and execute a field component that aimed to:

1) identify the critical habitat for juvenile dhufish of TL < 150 mm,

2) determine the likely extent of this habitat in the Perth metropolitan area and

3) trial a wide range of potential methods for monitoring dhufish recruitment.

The evidence collected suggests that the critical habitat for juvenile dhufish appears to be predominantly sandy areas of marginal sand-inundated low profile reef (with mixed macroalgae, sponge and seagrass), small isolated patches of low or medium profile reef (bombies or ledges) in predominantly sandy areas or seagrass beds among sandy areas in inshore coastal waters. This differs to the low to high profile reef habitats where adults generally occur. A shift in habitat types is not uncommon in demersal fish species and may be due to a combination of predator avoidance and prey availability. Evidence collected suggests juvenile dhufish occur along the WA coast from the Houtman-Abrolhos Islands to at least Augusta in a depth range of 2 – 48 m.

The project has utilised a range of field sampling techniques including baited remote underwater video (BRUV), various fish traps, towed underwater video, habitat mapping and limited trawling to collect a number of juvenile dhufish and survey the benthic habitat types on which they are occurring. Sites have been identified that may be suitable for monitoring their annual recruitment. To further develop the ongoing monitoring of annual juvenile dhufish recruitment, three alternative approaches are suggested, each relying on a range of methods. The methods suggested are:

- the identification of specific locations with critical habitat along the WA coast as monitoring sites with regular trapping, diver and BRUV surveys of these,
- the assessment and establishment of specifically designed artificial habitats in other specific areas along the WA coast and the regular survey of these,
- the cooperation with other ongoing research surveys as well as enhancement of recreational fisher and diver logbooks to obtain specific data on juvenile dhufish.

The further trialling and refinement of the methods for effectiveness and the use of a combination of these at a number of sites along the WA coast is recommended. The development of a long-term dataset would provide a reliable index of annual recruitment for dhufish, which can be utilized in the weight of evidence assessment to provide management advice on recruitment strength to the fishery in following years.

1.0 Background & project outline

Western Australian dhufish *(Glaucosoma hebraicum)* is a large, long-lived demersal species that is endemic to the west and south coasts of Western Australia (WA) from Shark Bay to Esperance (Hutchins & Swainston 1999). It is a highly sought after recreational fish, growing up to 25 kg and is widely regarded as the "jewel in the crown" of demersal scalefish. The species is also one of the primary target species for the West Coast Demersal Scalefish Fishery in the West Coast Bioregion (WCB), which is currently valued at approximately $3 million annually (Fairclough *et al.* 2010).

Dhufish is one of three indicator species used by the Department of Fisheries, Western Australia (DoFWA) to monitor the status of the suite of inshore demersal scalefish species in the WCB (Anon. 2011). A recent assessment, in 2007, identified a risk to the sustainability of dhufish stocks under catch levels recorded in the WCB during 2005/06 (Wise *et al.* 2007; Fairclough *et al.* 2010). As a result, significant changes to the management of both the commercial and recreational sectors were introduced from 2008 to reduce effort and thus catches of dhufish and other demersal species to at most 50% of 2005/06 levels.

Monitoring and management currently focuses on the exploited portion of the demersal species stock, particularly for the indicator species, i.e. dhufish, pink snapper *(Pagrus auratus)* and baldchin groper *(Choerodon rubescens)*. However, very little is known about the early life history of dhufish prior to recruitment to the fishery at about 300 mm in total length (TL) and *ca* 3 – 5 years of age. At this size they become vulnerable to capture by non-selective fishing methods (hook and line or demersal gillnet) although they cannot be retained until they reach 500 mm in length, the current minimum legal length. Juveniles of less than 300 mm TL are rarely observed by divers or captured by fishers and thus are not included in the data obtained by the DoFWA's fishery-dependent monitoring. Knowledge is particularly limited with regard to the type of habitat occupied by newly recruited 0+ and 1+ juveniles of TL < 150 mm, as is the extent of their distribution. Although, the stock structure information indicates that juvenile habitat exists throughout their distribution, as there is little evidence of movement by adults once they recruit to an area as juveniles (Fairclough *et al. in prep*).

The identification of the locations of this nursery habitat for juvenile dhufish will also allow the habitat requirements of this species to be considered in any marine planning discussion with the WA Department of Environment and Conservation (DEC) and Commonwealth Department of Sustainablity, Environment, Water, People and Communities (SEWPaC) environmental management bodies.

The age structure of adult fish collected during fishery-dependent monitoring has in the past suggested that the annual recruitment of dhufish in the WCB is relatively consistent, except in more southern latitudes (Lenanton *et al.* 2009a). Nonetheless, recent monitoring has demonstrated that recruitment strength can be more variable across the bioregion, as the age structure now comprises relatively strong and weak cohorts (Wise *et al*. 2007, D. Fairclough *pers. comm.*). A strong positive correlation exists between sea surface salinity and a recruitment index for dhufish, determined from the back-calculation of the frequencies of each age in age structure data (Lenanton *et al.* 2009b). The variations in salinity are suggested to be a function of localised upwellings of nutrient rich bottom water from beyond the shelf and the Capes current. At present, the extent of recruitment variability can only be confirmed from analysis of age structure data from fishery-dependent monitoring. However, as this species is only fully recruited to the fishery by ten years of age (i.e. 100% of year class >500 mm TL), there is no ability to provide predictions of future entry of strong cohorts to the fishery. Furthermore, the sudden recruitment of a strong cohort to the fishery, reflected in increased catches or catch rates, is often mis-interpreted by fishers to mean that there are no issues with stock status. The ability to monitor annual juvenile recruitment variability in areas of critical juvenile habitat would allow the future strength of cohorts to be predicted up to eight years before they enter the fishery. Although, a considerable time series of recruitment and adult ageing data would be required before the relationship can be validated. Such monitoring of juveniles and prediction of future recruitment strength to the fishery has been conducted successfully for the western rock lobster *(Panulirus cygnus)* fishery in WA (see Caputi and Brown 1986).

The biology and ecology of dhufish and the current knowledge of juvenile dhufish habitat is summarised in the first report for this project (Mitsopoulos & Molony 2010). Previous research by Hesp *et al.* (2002) collected important growth information for juvenile dhufish and indicated that the habitat requirements of dhufish change as they increase in size and age. The study collected 0+ and 1+ dhufish in one particular area on hard, flat substrate adjacent to reefs, where sponges were abundant. However, dhufish of two to three years of age (*ca* 150 – 300 mm TL) were caught over low relief reefs with small ledges, while larger and older individuals (> 300 mm TL) occurred on distinct low profile ledges or prominent medium and high profile reef structures.

Platell *et al.* (2010) provided further evidence to support this habitat shift by demonstrating that a size-related change in diet occurs in dhufish. The diet of dhufish less than 200 mm TL comprised predominantly small crustaceans, such as isopods and amphipods, while teleosts constituted a substantial proportion of the diets of dhufish > 299 mm TL. These small crustaceans are typically associated with sand habitats (Lek *et al.* 2011) which indicates juvenile dhufish are likely to be associated with sand areas until they reach 200 – 300 mm in length, at which point their diet preference changes to predominantly fish and they become more reef associated. Retinal development in dhufish (Shand *et al.* 2001) suggests juveniles are well adapted for functioning in coastal waters of intermediate depth (10 – 50 m) and relatively low light levels. Thus, juvenile dhufish are likely to be distributed in coastal water in depths of less than 50 m.

Trawling has been used previously along the WA coast to sample and describe demersal fish communities. A research trawl survey of scallop grounds consisting of predominantly sandy habitats along the south-west coast of WA to depths of 35 m (Laurenson *et al.* 1993, Hyndes *et al.* 1999) recorded only a single dhufish at a site off Bunbury. The study by Hesp *et al.* (2002) utilised trawling to collect moderate numbers of juvenile dhufish (TL < 200 mm) between 1996 and 1999 in the Perth metropolitan area. This study area provided an important starting point for this project. In addition, a recent research trawl survey undertaken as part of the NRM-funded study of marine habitats and biodiversity in southern WA by the Centre for Marine Futures (CMF) did not record any juvenile dhufish in the areas sampled off Jurien Bay, the Capes region and the Perth metropolitan area (L. Bellchambers *pers comm.*).

The overall objectives of this project were to;

1) identify the critical habitat of juvenile dhufish (< 150 mm TL),

2) determine the extent of this habitat in the Perth metropolitan area, and

3) trial various methods that could potentially be utilised in ongoing monitoring strategies for dhufish recruitment.

The first component of the project pooled all available information on the ecology and early life history of dhufish in order to determine likely habitats for young, small dhufish and potential methods for monitoring juvenile dhufish. This was achieved through a workshop in March 2010 resulting in the publication of a Fisheries Research Report detailing the proceedings and recommendations (Mitsopoulos & Molony 2010). The recommendations of this report for the approaches to the field component of the project, aimed at defining the critical habitat, trialling potential monitoring methods and collecting additional information on juvenile dhufish were:

1. Contacting trawl operators and Dr Alex Hesp to confirm the areas where juvenile dhufish were previously collected (as reported in Hesp *et al.* 2002)

2. Undertake additional trawl surveys, given that this is the only method so far that has captured juvenile dhufish less than 150 mm TL, as well as the use of video transects over trawl grounds where small, juvenile dhufish were captured by Hesp *et al.* (2002). Using these techniques together would allow the collection of information on the habitat where juvenile dhufish are captured, providing information on critical juvenile habitats.

3. Contacting south-west trawl operators to report on juvenile dhufish taken as bycatch

4. Contacting marine aquarium fish and specimen shell collector licence holders to determine if they have observed small dhufish, and if so, collect details (e.g. locations, areas, depths, habitats, fish size and numbers)

5. Re-analyse the University of Western Australia (UWA) stereo baited remote underwater video (BRUV) fish community composition data of over 1200 sets along the coast of WA from the Houtman Abrolhos Islands to Cape Leeuwin to identify additional records of small, juvenile dhufish and report habitat, depth and species associations. This was undertaken and reported separately in a report by the CMF (Meeuwig 2011).

6. Trial a range of pot and trap designs to determine if juvenile dhufish will reliably trap, as crab traps have been used to capture the congener pearl perch *(Glaucosoma scapulare)* in Qld, both within areas where juvenile dhufish have been previously collected (i.e. trawl grounds) and to explore other areas and habitat types (e.g. deeper areas).

This report details the methods and results for the second component of the project, which was undertaken following the above recommendations between September 2010 and March 2011. This component attempted to apply the techniques in a limited field program to meet the objectives of the project. Additionally, further information on the distribution, habitats and possible monitoring techniques for juvenile dhufish (< 150 mm TL) was gained through the collation of anecdotal reports of juvenile dhufish from both commercial and recreational fishers and divers generated by the media exposure of the project as well as examination of the DoFWA research angler program (RAP) voluntary recreational angler logbook data. The ability to effectively monitor annual juvenile dhufish recruitment strength would allow researchers to provide advice to management on the potential future strength of recruitment of adults to the fishery contributing significantly to the weight of evidence assessment of the stocks.

2.0 Methods

A planning meeting for the field component of the project was held at the Western Australian Fisheries and Marine Research Laboratories (WAFMRL) on the 24th August 2010. The objective was to meet with the stakeholders involved in the initial workshop and provide them with an opportunity to comment on and be involved with the planning for the field component of the project. The outcomes of this meeting are provided in Appendix 1.

Field surveys were conducted predominantly within the Perth metropolitan area (Latitude 31-33 ^{o}S) of the WCB (Figure 2.1). The principal study site was the trawl ground (Figure 2.1a) suggested by Ian Riggs (commercial trawl operator in Southwest trawl fishery) at the initial juvenile dhufish workshop (Mitsopoulos & Molony, 2010) and incorporated the area where moderate numbers were collected by trawling by Hesp *et al.* (2002). An additional six sites were also surveyed at different depths and habitat types in the Perth metropolitan area, details provided in Table 2.1 and locations indicated in Figure 2.1a.

The two primary surveys in the Perth metropolitan area were conducted on board the *RV Naturaliste* (surveyed length 22 m) during 13 days in September 2010 and 10 days in February 2011, with an additional 10 days on the *RV Snipe II* (surveyed length 7.4 m) conducted in the trawl ground between these two trips. An additional opportunistic survey was conducted over five days during February 2011 aboard the *RV Naturaliste* at three sites in south-western WA (see Figure 2.1b; Table 2.1). The study was divided into a) Perth metropolitan and b) South-west areas of the WCB.

In both the Perth metropolitan and South-west areas, a range of techniques were employed to:

1. determine the presence of juvenile dhufish (i.e. different trap types, trawling and remote underwater videos) and the effectiveness of each method for collecting juvenile dhufish and,
2. map the habitat types at each site (using seabed classification software and towed video).

The effort for each technique at each site in the two study areas is given in Table 2.2, the details of each technique are as follows.

Table 2.1 Characteristics of depths, habitat types and other comments for each study site investigated in each area.

Area	Site	Depths (m)	Habitat/s	Comments
Perth metropolitan	Trawl ground	22 – 32	Sand/ seagrass/ reef	Large area/mixed habitats
	Metro deep	46 & 66	Reef	Old submerged coastline
	Alkimos	30 – 32	Sand/ seagrass/ reef	Reef edge
	Hillarys	24 & 34	Sand/ seagrass/ reef	Over two depths
	South Rottnest	38 – 42	Reef	Around two reefs
	North Rottnest	28 – 34	Sand/ reef	Along reef edge
	Northwest Rottnest	37 – 40	Sand/ seagrass/ reef	Small ridge
South-west	Cape Naturaliste	36 & 46	Sand/ seagrass/ reef	Over two depths
	Geographe Bay	20, 30 & 40	Sand/ seagrass/ reef	Over three depths
	Preston deep	34 – 38	Sand/ seagrass/ reef	Previous scallop trawl study area

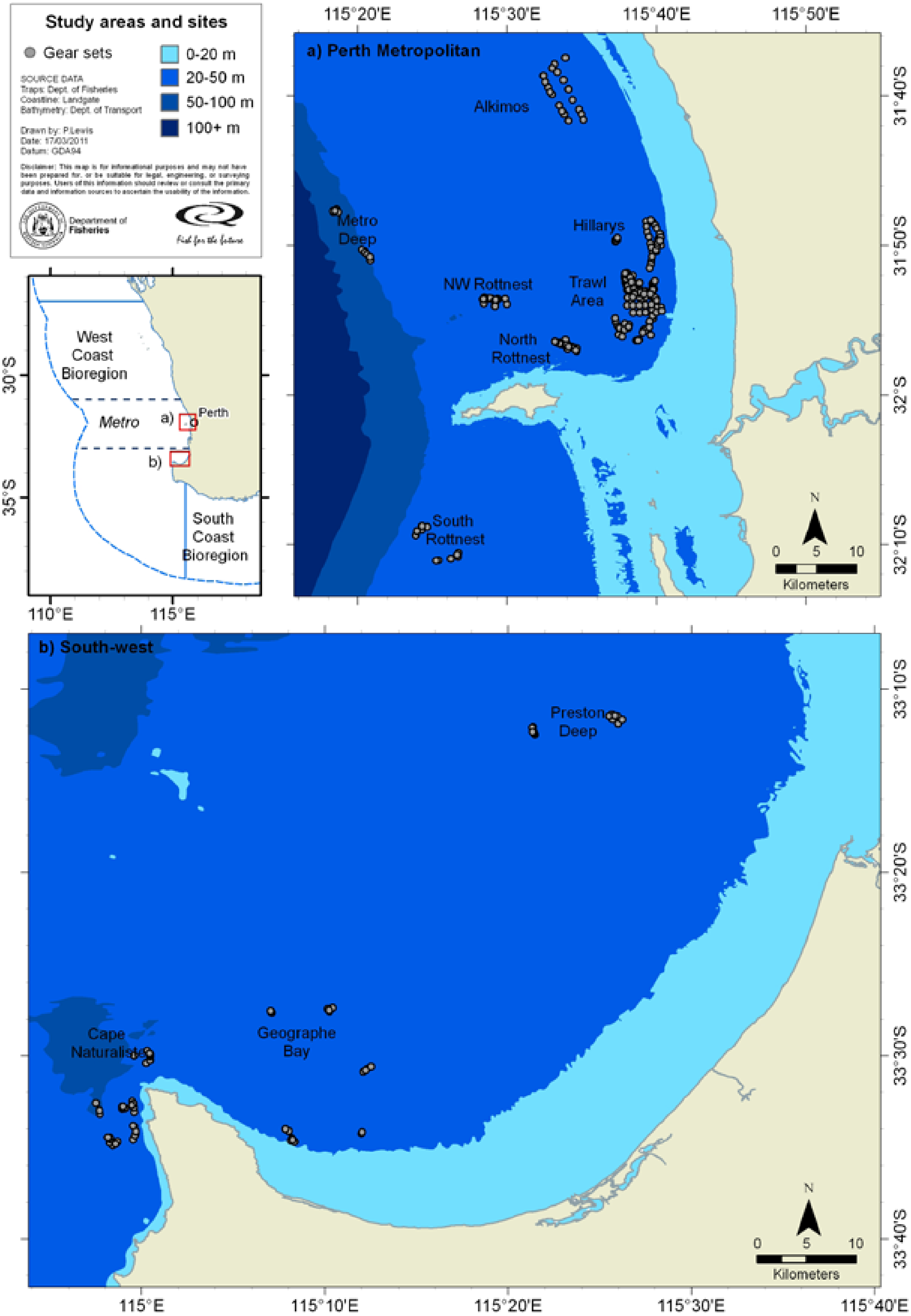


Figure 2.1 Maps of south-western WA showing location of study areas a) Perth metropolitan and b) South-west with sites, sampling locations (grey dots) and bathymetry.

Table 2.2 Summary of sampling effort (in number of sets, trawls or hours) at each site in each study area during the current project, where <u>underline</u> indicates overnight or night time sets.

Area	Site	BRUV	Opera trap	Small fish trap	Large fish trap	Crab trap	Lobster pot	Trawl	Tow video (hrs)
Perth metropolitan	Trawl ground	20 + <u>13</u>	60 + <u>32</u>	18 + <u>12</u>	16 + <u>16</u>	4 + <u>4</u>	8 + <u>12</u>	24 + <u>6</u>	13
	Metro deep	2	<u>2</u>		<u>4</u>	<u>4</u>		-	0.5
	Alkimos	2	<u>5</u>	<u>2</u>	<u>4</u>	<u>2</u>	<u>5</u>	-	0.5
	Hillarys	5	<u>7</u>	<u>3</u>	<u>8</u>	<u>2</u>	8	-	0.5
	South Rottnest	2	<u>2</u>		<u>4</u>		<u>4</u>	-	0.5
	North Rottnest	4	3 + <u>4</u>	1 + <u>1</u>	2 + <u>4</u>	1 + <u>1</u>	2 + <u>4</u>	-	1
	NW Rottnest	4	3 + <u>4</u>	2 + <u>2</u>	3 + <u>4</u>	1 + <u>1</u>	2 + <u>4</u>	-	1
	Total effort	**52**	**122***	**41**	**65**	**16**	**53**	**30**	**17**
South-west	C. Naturaliste	6	<u>6</u>		<u>13</u>		<u>11</u>		0.5
	Geographe Bay	4	<u>4</u>		4 + <u>4</u>		3 + <u>3</u>		1.0
	Preston deep	2	<u>4</u>		4		<u>3</u>		0.5
	Total effort	**12**	**14***		**25**		**20**		**2**

2.1 Fish sampling methods

Remote underwater video

Stereo remote underwater video (RUV) systems (Figure 2.2) were deployed both during the day in all study areas and at night in the trawl ground. Each RUV frame measured 1300 (length) x 1000 (width) x 700 (height, mm). A cross bar is mounted at a height of 450 mm within the frame and consisted of brackets for two waterproof housings mounted 725 mm apart. Each housing was angled inwards at approximately 4-degrees convergence each so as to provide overlapping camera fields of view at a distance of 1500 mm (location of bait on pole) encompassing the synchronising diode (HandsTek™). Each housing contained a high definition video camera (Canon, Model HV20) fitted with high definition super wide-angle conversion lenses (Raynox, 0.62 magnification). The duration of all recordings was the full 1-hour capacity of the mini-DV tape in high definition video (HDV), progressive scan mode (PF25, 1080P). A stereo baited remote underwater video (BRUV) setup was used during the day with the bait bag filled with approximately 400 g of crushed pilchards *(Sardinops sagax)* positioned 1.5 m from the cameras, however both baited and unbaited setups were trialled at night.

In general, each set consisted of 2 or 3 stereo RUV units deployed within a study site interspersed with the various types of fish traps. As each unit was deployed, data including camera numbers, date, time, latitude, longitude, depth and other comments (ie baited/unbaited, bait type, weather, filter colour, etc) were recorded. The units were generally retrieved after 90 minutes.

Night sets employing artificial light sources (Underwater Kinetics, Light Cannon 100) were restricted to the trawl ground site. On the baited sets (n = 12) the light source was fitted with either red, blue or white diffuser filters to investigate whether dhufish may be sensitive to different wavelengths of light. Studies of dhufish retina indicate they are sensitive to light wavelengths of 460 – 522 nanometres (green – blue) (Shand *et al* 2001). Unbaited RUV sets using the white diffuser filter (n = 4) were also trialled at night in the trawl ground to reduce the attraction by the bait of large predatory fish, such as pink snapper, wobbegong sharks *(Orectolobus spp.)*

and adult dhufish, as well as promote the opportunity of observing planktivorous and timid fish species, which juvenile dhufish were considered to be.

Prior to use in the field, each stereo unit was calibrated using the calibration cube and Cal software (SeaGIS™). In the laboratory, the footage was processed using the BRUVs tape reading interface (Ericson and Cappo 2006, Australian Institute of Marine Science) to record;

- Time of first appearance of each species,
- MaxN – maximum number of individuals of each species in the field of view during the 60 minutes of footage,
- Time at which MaxN occurred for all species,
- Activity of each species (feeding, passing, scavenging),
- Time of first feed by each species,
- Habitat characteristics (i.e. on reef, sand near reef, sand, seagrass etc).

Once the videos were processed the database was queried for;

- Species abundance (MaxN data for each species),
- The time of MaxN for dhufish to determine the sections of footage to be captured for length analysis (see below).

Sections of footage in which dhufish occurred on both cameras were digitally captured using video editing software (Windows Movie Maker) as phase alternating line (PAL) standard definition (576i) audio video interleave (avi) files which allowed most dhufish observed to be measured using the Photomeasure software (SeaGIS™). The reduction of the HDV recording to PAL 576i output slightly reduced the potential accuracy of measurements through less pixels, however retained the progressive scan (PF25) edge definition making measurement points easier to detect and dramatically reduced the file sizes of the captured sections of footage.

Figure 2.2 Stereo BRUV setup for night drop with light source (dive torch) attached to crossbar.

The species association of juvenile dhufish in the trawl ground was investigated by Primer 6.1.11 with PERMANOVA (Clarke and Warwick 2001). Each BRUV drop was allocated to a broad seabed category of sand, sand with sponge and macroalgae or reef as well as presence or absence of juvenile dhufish. The MaxN data was square root transformed and the Bray Curtis similarity coefficient matrix calculated to generate the non-metric Multi Dimensional Scaling (MDS) ordination plot of the BRUV data. The species association vectors were calculated from the Pearson correlation values of the MaxN data.

Fish traps

Five different types of fish trap were trialled during both day and night (see below). Set times ranged from two to seven hours during the day and a minimum of 12 hours at night. For each trap set the date, location (latitude and longitude), depth and time were recorded. Upon retrieval, the date and time were recorded and all captured fish were identified and sorted to species level where possible, counted and measured to TL and/or fork length (FL; to nearest 1 mm). The majority of fish were then released however some were retained for specific research projects. All trap types were used on the surveys aboard the *RV Naturaliste*. Additional opera-house trap sets were conducted in the trawl ground from the *RV Snipe II*.

a. Small opera-house

Three different opera-house fish traps of varying dimensions, opening type, ballast, mesh size and colour were trialled (Table 2.3). Each set comprised five or six baited opera-house traps clipped on a line between an anchor and ballast plate (Figure 2.3). To test for the effect of different baits on the capture of juvenile dhufish, a small number of trials were conducted in the trawl ground using pilchard, prawn, squid, pollard and fish attractant spray as alternative types of bait. In all other sets, 3- 4 chopped pilchards (approximately 100 g) or Northsea herring *(Clupea herengus)* were used as bait.

Table 2.3 Specifications of the three different types of opera-house traps

Trap type	**Mesh colour**	**Ballast type**	**Weight** (kg)	**Mesh size** (mm)	**Opening type, diameter** (mm)	**Dimensions** (LxWxH, mm)
1	Light green	2 x Steel bars	2.6	12	Ring, 90	900 x 600 x 300
2	Black	2 x Steel bars	2.6	12	Ring, 90	900 x 600 x 350
3	Dark green	Dive weight	1.4	18	Soft, up to 80	650 x 480 x 250

Figure 2.3 Opera-house traps (type 1) being deployed.

b. Small fish traps (various types)

A number of different sized and designed small fish traps were used during the project, based on those employed to capture the congener *G. scapulare* during studies conducted in Queensland (Mitsopoulos & Molony, 2010). Each trap was between 600 and 800 mm in diameter, had one or two slot openings of 30 or 80 mm width, 20 mm mesh and ballast. Some traps had solid wire mesh bases and others had 12.5 mm chicken wire added (Figure 2.4) to reduce the chance of damaging the mesh on reef and to retain smaller fish. Each trap was baited with approximately 500 g of pilchards. The small fish traps were not used in the South-west area due to strong currents at the time.

Figure 2.4 Example of a small fish trap used in the current study.

c. Large commercial fish traps (2 sizes of mesh)

Large industry standard commercial fish traps, constructed with heavy-duty galvanized steel, were trialled using two sizes of mesh. The traps measured 1600 (L) x 1600 (W) x 800 mm (H) and comprised 50 mm square steel mesh. Two of the traps trialled were standard, while the other two were covered with 12.5 mm square wire mesh (Figure 2.5) in an attempt to capture and retain small fish (less than 100 mm in length). The funnel entrances to these traps were also narrowed with the mesh to approximately 50 mm instead of the standard 150 mm to prevent the entry of larger predatory fish, which may consume smaller fish in the traps or discourage them from entering. Each trap was baited with approximately 1 kg of pilchards.

Figure 2.5 Large commercial fish trap meshed with 12.5 mm chicken wire.

d. Meshed lobster pots

Standard commercial lobster pots 950 (L) x 800 (W) x 450 mm (H) were trialled, consisting of a steel base, jarrah frame and pine batten slats meshed with 25 mm wire to retain small fish and lobsters (Figure 2.6). Each bait basket was filled with 1kg of pilchards and/or blue mackerel *(Scomber austrasicus)*. In general, 2 – 4 lobster pots were set overnight on the reef areas at each site.

Figure 2.6 Commercial lobster pot meshed with wire.

e. Crab traps

Collapsible commercial float ring hourglass crab traps were tested (Figure 2.7), similar to those used in Queensland to successfully capture juvenile pearl perch (Mitsopoulos & Molony, 2010). Traps measured 1000 mm in diameter, approximately 500 mm in height, had 4 slot openings around the convergence and covered with 40 mm rope mesh. These traps had a PVC canister with holes and end caps filled with 300g of pilchards as bait. The traps were set as 4 or 5 clipped to a line, as per opera-house traps. In general, two lines were set overnight in each study site, except those sites in the South-west area due to strong currents at the time.

Figure 2.7 Commercial float ring hourglass crab trap.

Trawling

Trawling was conducted by the *RV Naturaliste* in September 2010 and February 2011, using a pair trawl of six or eight fathom prawn nets with 50 mm mesh. Small mesh cod ends (20 mm mesh) were attached around the existing cod ends in order to retain smaller fish. Day and night trawls were conducted in the trawl ground with each shot conducted at a speed of approximately four knots for 20 minutes covering a distance of approximately one nautical mile. At the commencement of each shot, the date, time, start location (latitude and longitude) and depth were recorded. At the conclusion of each shot, time, end location (latitude and longitude) and depth were again recorded. All fish caught were sorted, identified to species level (where possible) and counted. Length (TL, and FL in mm) measurements were also recorded for all key, high risk demersal species in the WCB (DoFWA) for comparison and future reference.

The species abundance data from the research trawl surveys (September 2010 and February 2011) were analysed in Primer 6.1.11 with PERMANOVA (Clarke and Warwick 2001). The overall dataset was square root transformed and the Bray Curtis similarity coefficient matrix calculated. The data was tested for significant differences between nets (port and starboard) and between surveys (September 2010 and February 2011) by a single factor ANOSIM. To further examine the data a non-metric multi-dimensional scaling (MDS) ordination plot was generated that differentiated between surveys and showed species association vectors using the Pearson correlation values from the MaxN data.

2.2 Habitat survey methods

MaxSea seabed classification

The *RV Naturaliste* is equipped with a SeaScan ground discrimination unit (Model No. 101) that analyses echo sounder data from a Furuno (Model FCV 1500) depth sounder to give values for the hardness and roughness measured on a scale of 0 to 10 of each sounder reading. These data are fed into MaxSea software along with geographical positioning system (GPS) location (latitude and longitude) and recorded into a bathymetry database. These data also generate a seabed-type classification. Initial ground-truthing of seabed classification was validated with visual information from towed video and eight general seabed types were determined (Table 2.4).

Table 2.4 Seabed types set in MaxSea with ranges of hardness and roughness defining each and the display colour plotted on map.

	MaxSea parameters		
Seabed type	**Roughness**	**Hardness**	**Colour allocated on map**
Sand	0 – 4	0 – 5	Yellow
Silt	0 – 4	5.1 – 10	Light yellow
Weed/sponge on sand	4 – 5	0 – 6	Light turquoise
Sand on reef	4 – 5	6.1 – 10	Orange
Sponge/seagrass	5 – 7.5	0 – 5	Light green
Gravel/reef	5 – 7.5	5.1 – 10	Grey 25%
Reef - med/high profile	7.6 – 10	0 – 5	Sea Green
Reef - low profile	7.6 – 10	5.1 – 10	Grey 40%

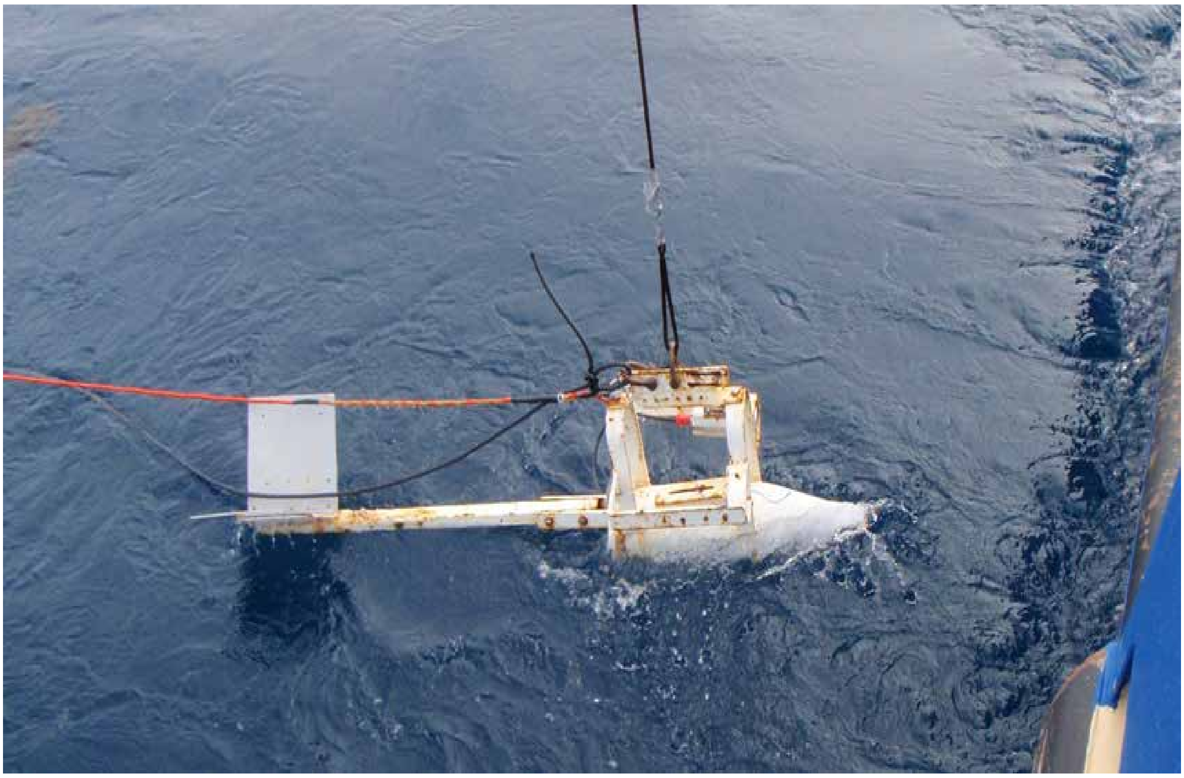
The transfer of data from the MaxSea into ArcGIS 10.0 mapping software could not be done directly as the export data is encrypted and can only be read by MaxSea software. To overcome this problem, a number of known reference waypoints at each 30 seconds of latitude and longitude were entered onto each required seabed classification map. The map was captured and georeferenced in ArcGis 10.0, based on the reference waypoints.

Towed video benthic habitat mapping

A towed live-feed underwater video system with GPS overlay unit was used in two slightly different configurations on the different vessels, *RV Naturaliste* and *Snipe II* (Figure 2.8), to map the benthic habitat types, search for juvenile dhufish and ground truth the MaxSea seabed classification settings. The video system consisted of a colour progressive scan security camera (Dallmeier Model DF3000AXS) in a stainless steel underwater housing (Mariner 75) attached to a 300 m underwater cable (SubSea) for power and video signal. The cable is on a hand-operated reel (Absolute Monitoring Technologies - FSP500). The system also included a GPS overlay (SeaViewer - Sea-Trak GP800) imprinting the GPS coordinates on the recording. As tows were conducted the footage was viewed on a LCD television and recorded on a video camera. The *RV Naturaliste* used 240 volt power supply to run the system and allowed the use of a large downweight (Figure 2.8a, weight 120 kg) with winch controls to raise and lower as it was towed at between 1.5-3 knots. The smaller *RV Snipe II* relied on AC inverters to run the video system from 12 volt power supply and utilised a small paravane (Figure 2.8b, weight 10 kg) which was raised and lowered by small electric winch or by hand as the vessel drifted at speeds of 0.5 – 1.5 knots. The drift surveys were performed due to the reduced manoeuvrability of the small boat as the paravane was deployed from the davit on the starboard side of the vessel.

Position corrections were not applied to the data to allow for the video observations being slightly different to that of the vessels GPS position however were calculated as follows. For the *RV Naturaliste*, the time difference between significant benthic features appearing on the vessels sounder and on the towed video was between 10 – 15 seconds at a speed of 2 knots or 1 m/sec. Thus, the position difference was approximately 10 – 15 m. For the *RV Snipe*, the length of rope on the paravane to reach the bottom in 31 m water depth was 36 m so by Pythagoras' theorem the separation was 18.3 m. The correction was not deemed to be required for confirmation of the MaxSea seabed classification and habitat type determination, however it could be applied in the future for finer scale mapping.

As each tow was conducted the locations of significant habitat types and fish species were noted and marked on the vessels GPS system for later trap or BRUV sets. When processing of the towed video footage, the habitat type and GPS coordinates were recorded at minute intervals, as well as at any change in habitat type. The data was then mapped in ArcGIS 10.0 and overlaid on the Maxsea seabed classification map.

a) 

b) 

Figure 2.8 Towed underwater video systems for a) *RV Naturaliste* and b) *RV SnipeII*.

2.3 Additional methods

Dietary analysis

Stomach contents of juvenile dhufish collected (all < 200 mm TL) (n = 6) were examined under reflected light using a stereo dissecting microscope (Olympus SMZ745T) fitted with a digital video camera (Jenoptik ProgRes® C7). The imagery was processed using the software (ProgRes® CapturePro 2.7.6) and images captured for future reference. Each stomach was removed, opened and contents scraped into a petri dish. Contents were weighed to 0.01g and irrigated with 1 ml of seawater and the items gently teased apart to allow identification. Where possible, items were identified to family or genus using appropriate references for crustaceans (Jones & Morgan 2002) and fish otoliths (Furlani *et al.* 2007). Items were subsequently preserved in 70% ethanol solution for later examination and further identification.

Plankton tows

During the February 2011 survey on the *RV Naturaliste* to the South-west and Perth metropolitan areas (Figure 2.1), a series of plankton tows were conducted in an attempt to collect dhufish eggs and larvae. The peak spawning period of the species occurs during the summer (Hesp *et al.* 2002) and biological sampling confirmed there was dhufish spawning activity in the area at the time. During the south-west component of the trip, six ocean drifters were released as part of another project. At each drifter release site (Figure 2.9), a five-minute surface bongo net tow (dual 600 mm diameter, 1500 mm length nets of 500 µm mesh) was conducted to sample the planktonic fish eggs and larvae in the surface water. At a number of the study sites (n = 15) in both study areas, additional 10-minute benthic plankton tows were conducted with the bongo net attached to the towed underwater video downweight in place of the tailfin and live feed underwater video (Figure 2.10). Benthic plankton tows were conducted as larval dhufish are known to develop light sensitivity as early as 5 days of age (Shand *et al.* 2001) and may only be found close to the seabed. Thus this benthic plankton tow sought to sample the fish eggs and larvae near the sea floor during the day and assess habitat types.

Each tow was conducted at a speed of approximately 2 – 3 knots, the downweight was deployed to the seafloor at a rate of approximately 1 m/s and the net towed approximately 0.5 m off the seabed for 10 minutes with the habitat types and GPS coordinates recorded on the towed video footage before being retrieved. At the surface, the net was washed down with seawater and the sample from each cod-end preserved separately in 5% formalin with seawater solution. A flowmeter reading was recorded at the start and finish of each tow to estimate the volume of water sampled by the nets.

The samples were sorted under a dissecting microscope and all fish eggs and larvae retained and preserved in 90% ethanol for later examination by larval fish taxonomists. Any eggs in the appropriate size range for dhufish of 960 – 1200 µm with a large anterior pigmented oil globule (210 – 273 µm) were noted as well as fish larvae that were similar in morphology to aquaculture dhufish larvae illustrations (Pironet and Neira 1998).

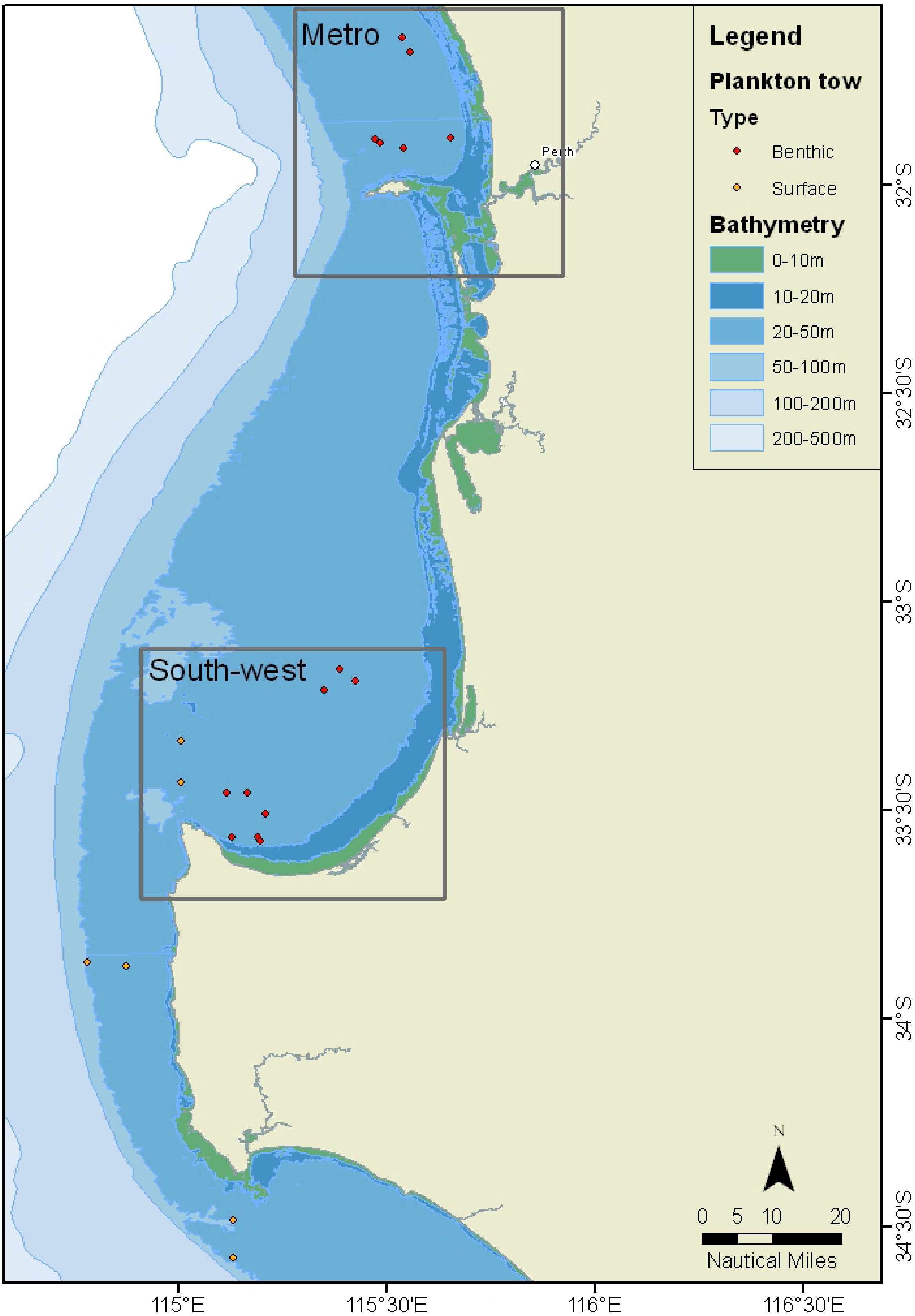


Figure 2.9 Map of south-western WA indicating the Perth metropolitan (Metro) and South-west study areas, ● locations of ocean drifter release sites where surface plankton tows were conducted and ● benthic plankton tow sites.

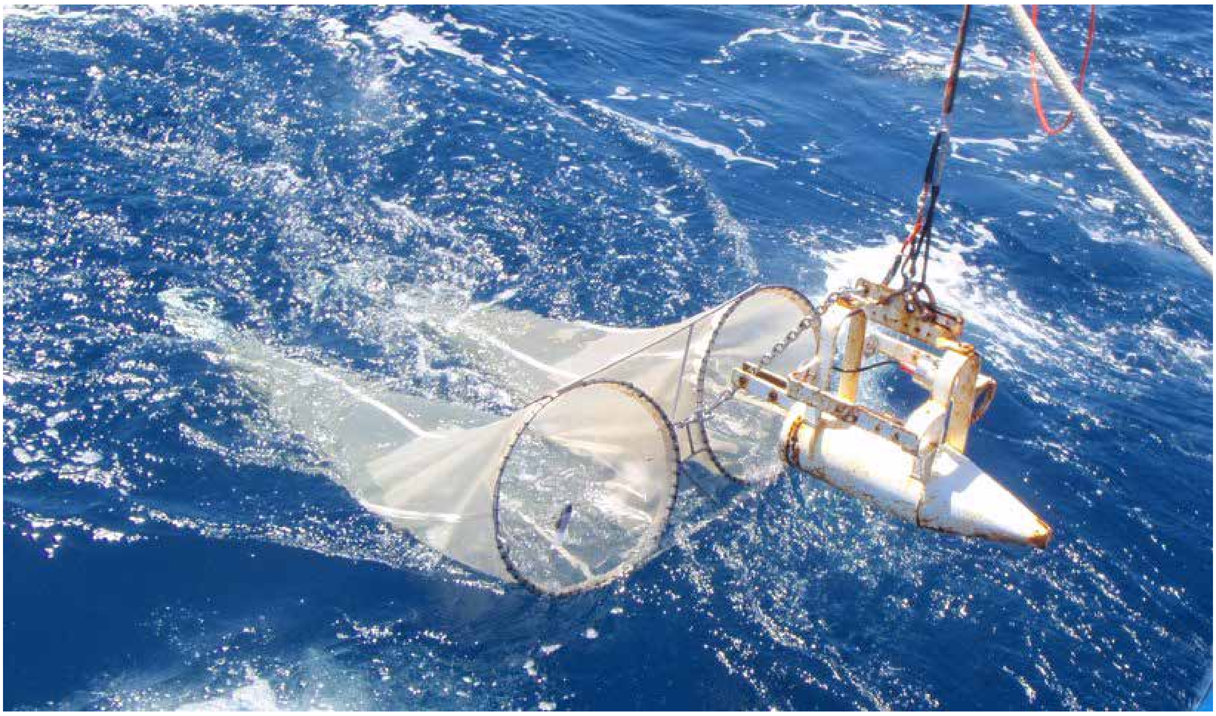


Figure 2.10 Towed underwater video downweight fitted with a 500 mm mesh plankton bongo net for benthic plankton sampling.

Anecdotal reports

Throughout the project, a number of fishers and divers (both commercial and recreational) were contacted for information on juvenile dhufish (< 300 mm TL). In addition, the project produced a number of media releases and popular articles (Appendix 2) which generated reports from divers and fishers of sightings or captures of juvenile dhufish. Each report was assessed for time of year, location, method, depth, habitat type, size and number of dhufish plus any other relevant comments and these reports collated.

Recreational fisher logbook data

The Research Angler Program (RAP) volunteer angling logbook database from 2005 to 2010 was queried for captures of juvenile dhufish (TL < 300 mm). Relevant information on date, location (GPS or five nautical mile (nm) block number), depth, method and length (TL) for each capture was retrieved and analysed. The location of capture for each dhufish < 300 mm TL was mapped by five nautical mile block in ArcGIS 10.0 software. The annual catch rates for the 300 – 350 mm TL length class were calculated by dividing the annual catch in numbers by the total boat based seagoing RAP fisher days for each year. The annual catch rate was shifted to reflect the year when they were likely to have been spawned i.e. 300 – 350 mm TL and approximately 3 years of age, based on the growth curve (Hesp *et al.* 2002).

3.0 Results

3.1 Monitoring methods

Dhufish

Juvenile dhufish (< 150 mm TL) were successfully sampled by BRUVs (n = 1), type 1 opera-house traps (n = 2) and trawling (n = 3), albeit in low numbers despite moderate levels of effort for each method (Table 3.1). Other methods utilised during the project were successful in observing or obtaining larger dhufish (> 250 mm TL, Table 3.1). Juvenile dhufish were only encountered at the trawl ground site in the Perth metropolitan area where the majority of sampling was focussed. Sampling in the South-west area did not capture any juveniles but was limited to only five days and encompassed a variety of depths and habitat types that are likely to be suitable for juvenile dhufish.

In the Perth metropolitan area, the effort for each method, other than trawl, was spread between the six sites (Table 3.1). At each site, sampling was conducted on the range of different habitat types found at the site. However, this does not reflect the actual success rate of the methods on the sand inundated reef or seagrass habitats where juvenile dhufish were found to occur (Figure 2.1). Of the total effort in the Perth metropolitan area, 32 overnight opera-house trap sets and 26 BRUV sets were within the trawl ground, where juvenile dhufish are known to occur from the study by Hesp *et al.* (2002). By habitat type in the trawl ground, 20 of the overnight opera-house traps were set on marginal sand-inundated reef or seagrass/sponge habitat while only 12 BRUV drops were conducted on this same habitat. Of these, four were night sets that had a limited field of view due to poor visibility and light reflection off suspended particles.

On one particular BRUV drop during the day, a single juvenile dhufish was observed on three separate occasions during the hour of footage, indicating that juvenile dhufish are active during the day. The regular appearance of the fish in a similar location on each occasion, near a frond of macroalgae, suggests they may not venture far from refuge. It was also evident from observing the fish behaviour that the juvenile was not attracted to the bait, but to the activity of the other fish at the bait. An interesting observation was noted that markings between horizontal stripes on the side of the fish differed between the three occasions (Figure 3.2). It was also apparent that these markings differed to those on the juvenile dhufish caught in a subsequent overnight opera-house trap set at the same location. This possibly suggests that there was more than a single juvenile dhufish at this location and there may have been up to four juveniles.

Table 3.1 Overall numbers and length ranges of dhufish recorded in each area for each monitoring method trialled during the project, with effort for each, where* indicates each drop included five or six individual traps, juveniles are TL < 150 mm and NM indicates not able to measure.

		BRUV	Opera*	Small fish trap	Large fish trap	Lobster pot	Crab pot	Trawl	Towed video
Perth metropolitan area	Effort (drops /trawls/hours)	52	122*	41	65	53	16	30	17
	Total no. of dhufish	19	2	0	9	1	0	7	6
	Length range (mm)	126 – 827	114 – 119		376 – 788	423		98 – 304	NM
	Average length (mm)	457	117		561			194	NM
	No. of juveniles	1	2		0			3	0
South-west area	Effort	12	14*		25	20			2
	Total No. of dhufish	2	0		2				1
	Length range (mm)	255	-		285 – 739				-
	Average length (mm)	255	-		512				-
	No. of juveniles	0	0		0	0			0

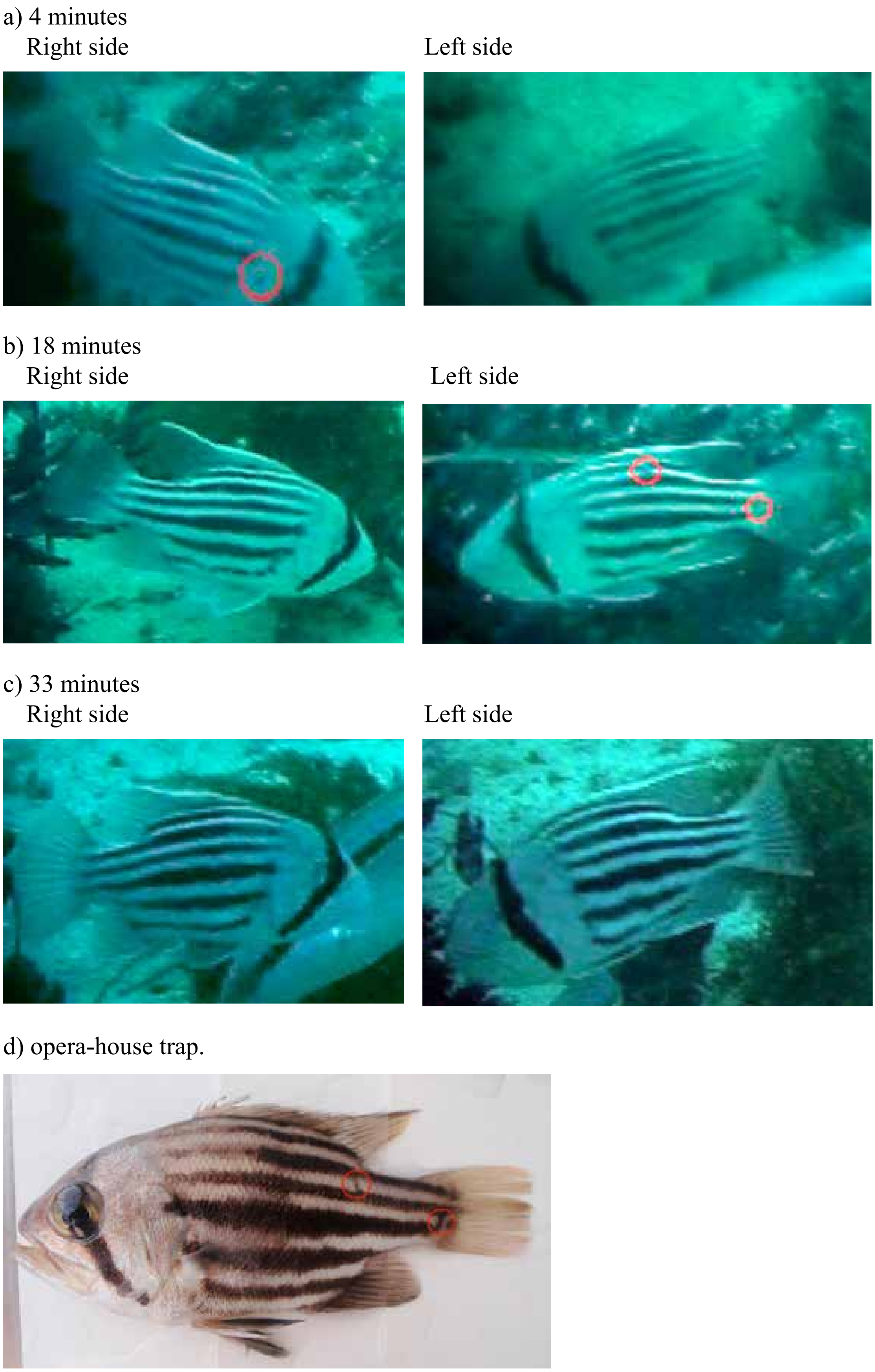


Figure 3.2 Images of left and right side stripe patterns for juvenile dhufish at each time of appearance a), b) and c) seen in BRUV footage and d) left side of juvenile dhufish caught in opera-house trap on next day at the same location, red circles highlighting the distinct marks between bands.

Although no juvenile dhufish < 200 mm TL were observed on the BRUVs set at night, a number of larger dhufish (n = 5) were recorded. However, due to a limited field of view at night, only one of these could be measured at 289 mm TL. The others observed were evidently larger than 300 mm in TL and mature, as indicated by the long dorsal filament on the males. Dhufish were observed with both white and blue light filters; however no dhufish were detected while using red light. Additionally, individual adult dhufish were observed on two of the four unbaited night-time RUV sets.

Other key species

During the project, data were also opportunistically collected for 18,342 individual fish representing 160 species (Appendix 3), including a number of key, high risk recreational species in the WCB such as pink snapper, breaksea cod *(Epinephelides armatus)*, baldchin groper and King George whiting *(Sillaginodes punctata)* (Table 3.2). The numbers and length range recorded for each of these key species by each of the sampling methods may provide insight to the relative abundance of each species at the time in the area surveyed. It also indicates the effectiveness of each method used for sampling key species with all species recorded by two or more methods. In general, BRUVs recorded the highest numbers of these species and were deemed the most effective method for overall monitoring. This method is commonly used in collecting fish species relative abundance and composition data (e.g. Watson *et al.* 2007). The towed video also proved effective in recording all of the above key species, with much less effort, and importantly provided data on habitat association and location, which could be used in refining a targeted BRUV sampling program. It was of note that species such as baldchin groper and King George whiting were not sampled by the various types of traps utilised in the project.

Over the course of the project, a large number of different fish species were retained relevant to other current research projects. The species, number retained and project they were retained for are summarised in Table 3.3. Thus, the current project was able to contribute to other DoFWA and university student research projects.

Table 3.2 Overall numbers and lengths of key species recorded in the Perth metropolitan area by each monitoring method trialled during the project, with effort for each, where *indicates each drop included five or six individual traps, NM- not measured.

	BRUV	Opera*	Small fish trap	Large fish trap	Lobster pot	Crab pot	Trawls	Towed video
Effort (drops /trawls/hours)	52	121*	41	65	53	16	30	17
All species								
Total count	4405	729	114	1035	136	72	11717	
No. of species	112	53	19	42	26	15	103	
Pink snapper								
Total No.	149	36	5	131	4	0	7	18
Size range (mm)	NM	200 – 335	254 – 271	243 – 601	249 – 300		NM	-
Breaksea cod								
Total No.	13	0	1	5	1	0	1	2
Size range (mm)	NM		228	265 – 461	333		402	-
Baldchin groper								
Total No.	15	0	0	0	0	0	0	8
Size range (mm)	NM							-
King George whiting								
Total No.	13	2	0	0	0	0	1	2
Size range (mm)	NM	410 – 420					NM	-

Table 3.3 Summary of species retained and number provided to other research projects.

Species	Number	Agency	Project
Silver trevally	95	Murdoch	PhD project
Mixed whiting sp	120	DoFWA	NRM Nearshore project
Pink snapper	85	Murdoch	PhD project
Dhufish	8	DoFWA	WCD age structure monitoring
Tailor/A. herring	32	DoFWA	NRM Nearshore project
King George whiting	4	Murdoch	PhD project

Pink snapper

Pink snapper were recorded in higher numbers than any of the other key recreational species and by almost all sampling methods (Table 3.2), indicating they were relatively abundant at the time of sampling and that the methods employed were effective for this species. BRUVs and the large commercial fish traps each recorded more than 100 pink snapper, while opera-house traps and towed video were less effective. A comparison of the lengths sampled by the different types of traps demonstrates that the smaller opera-house traps selected for smaller fish than the larger commercial traps (Figure 3.3). Note however that the selectivity of the different setups of commercial fish traps (meshed vs unmeshed and narrow vs wide entrances) has not been investigated. Future processing of the stereo BRUV footage to provide an additional pink snapper length frequency estimate would illustrate the size selectivity of this method and allow for comparison with the trapping results but was not a component of the current juvenile dhufish project.

The trapping results from the larger commercial fish traps indicate a predominant size for pink snapper of 280 – 360 mm TL. This corresponds to approximately three years of age, suggesting they would have been spawned in the 2007/2008 spring to summer Perth metropolitan spawning season (Fairclough *et al.* 2010).

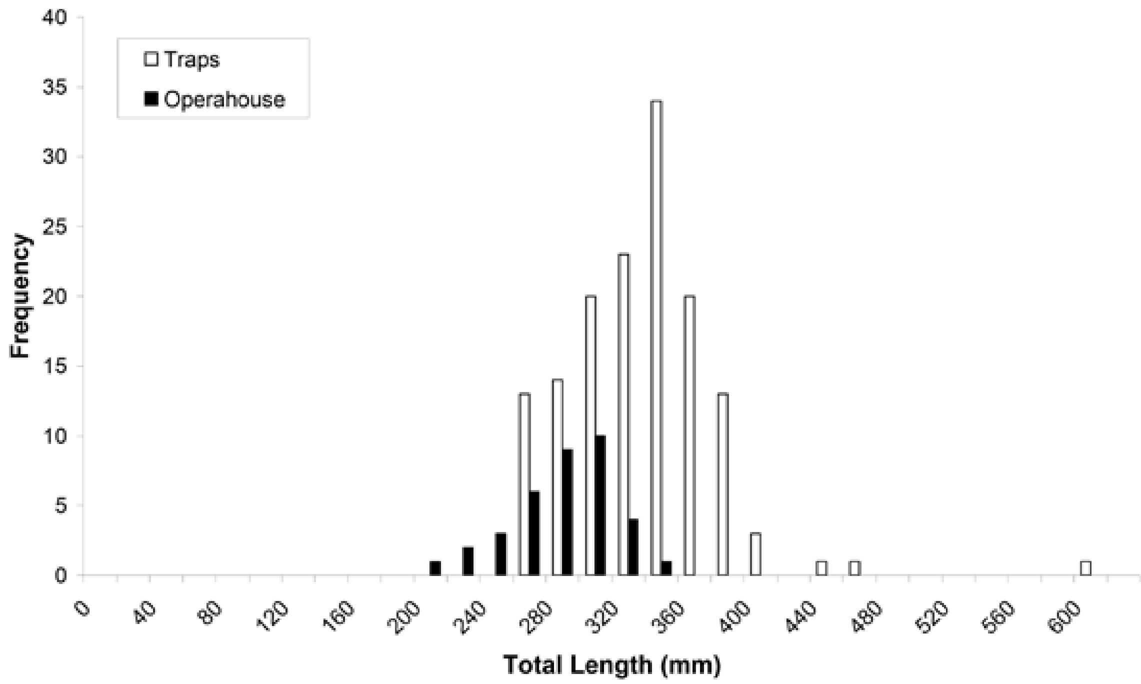


Figure 3.3 Length frequency distributions of pink snapper sampled by opera-house traps and by large commercial fish traps.

3.2 Critical habitat for juvenile dhufish

Juvenile dhufish < 150 mm TL (n=6), which would represent fish that are approximately 11 to 15 months of age were all recorded or collected in the trawl ground of the Perth metropolitan area on habitats consisting of either a mixture of sand with dense to light seagrass coverage *(Posidonia angustifolia)* or sand inundated-marginal reef with sponges, macroalgae, sessile invertebrates and seagrasses (*Posidonia sp.* and *Amphibolis sp.*). Juveniles were not recorded or collected on the main area of low profile and flat reef consisting of dense sponge, macroalgae and mixed seagrass (*Posidonia sp., Halophila sp.* and *Amphibolis sp.*) areas where the slightly larger juveniles (TL 150-300 mm) and adults were recorded (Figure 3.4). A MaxSea seabed classification map of the trawl ground also showed the extent of each habitat type in the vicinity (Figure 3.4).

Of the juveniles collected, only two could be allocated to distinct habitat types where the exact location was known. These included one recorded by BRUV in 30 m on sand-inundated marginal reef consisting of mixed macroalgae, sponges and some seagrass and one caught by opera-house traps on a small ridge of *Posidonia angustifolia* seagrass, also in 30 m of water (Figure 3.5).

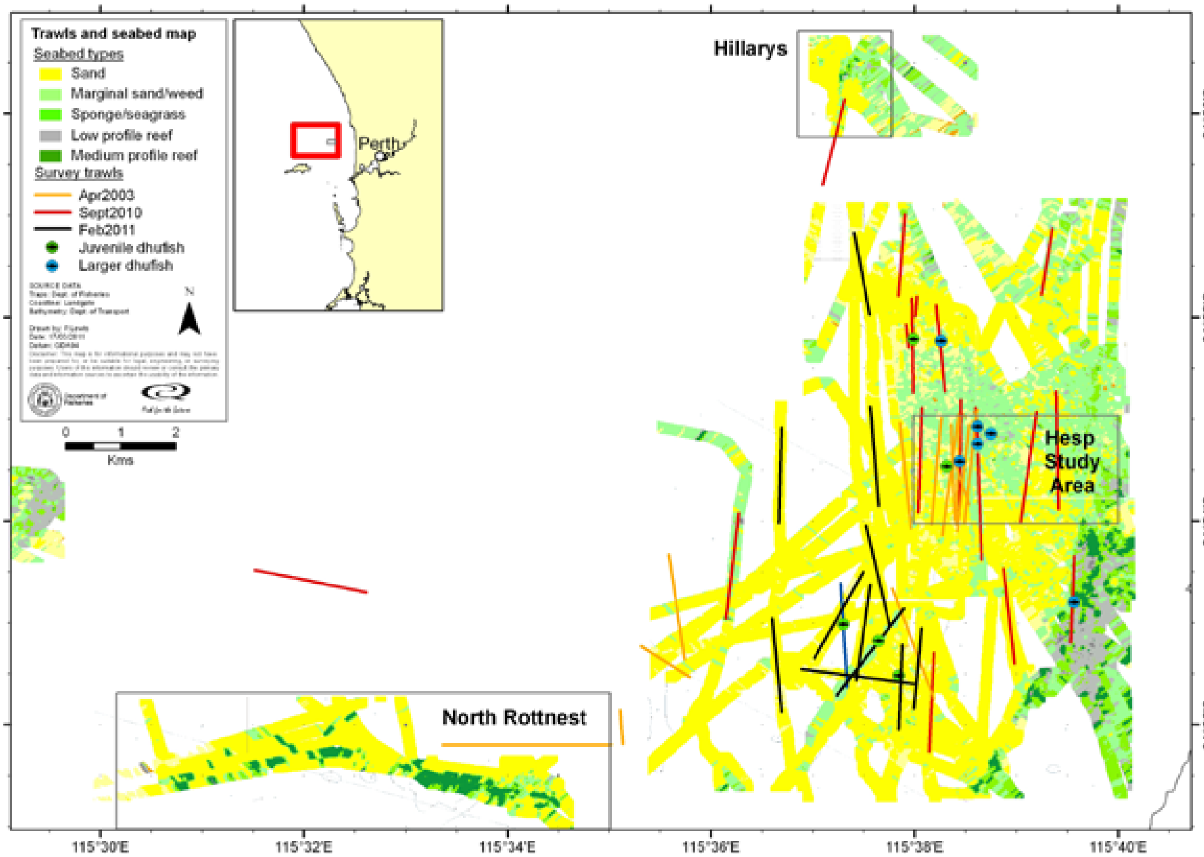
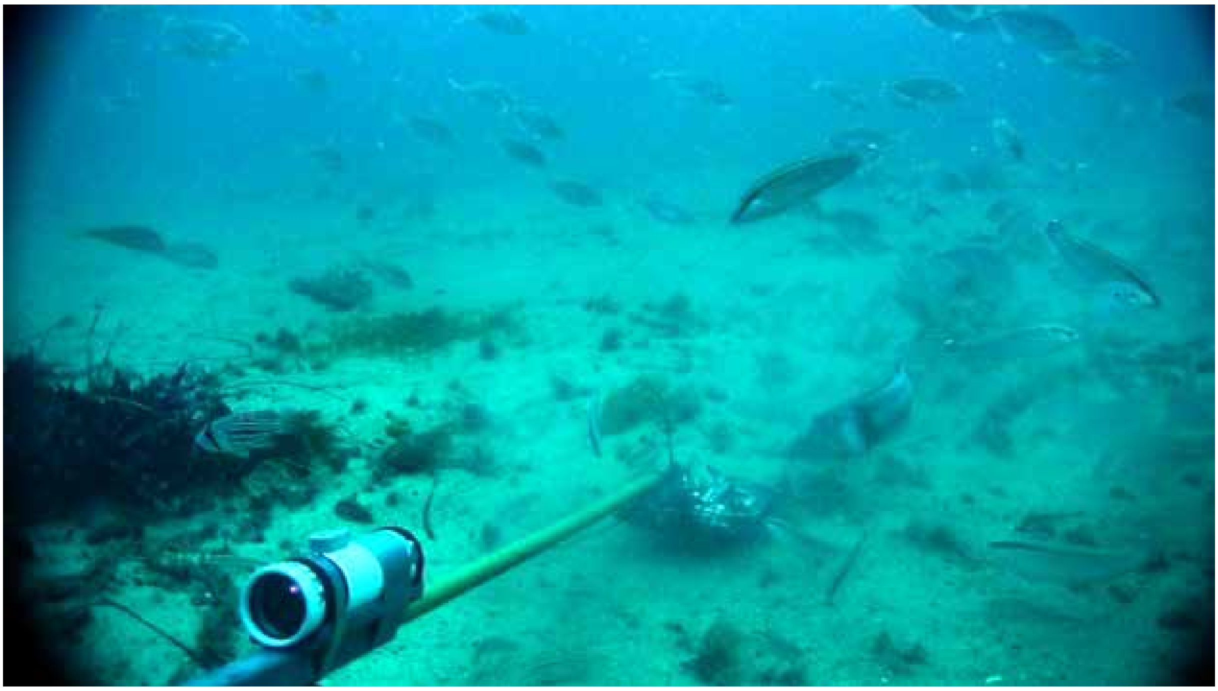


Figure 3.4 Map of trawl ground showing study area of Hesp *et al.* (2004), Hillarys and North Rottnest sites, location of DoFWA research trawl sampling (lines), relative size of dhufish caught (juveniles < 150 mm and larger dhufish > 300 mm) and habitat types predicted by MaxSea.

a) BRUV footage



b) Towed video footage

Figure 3.5 Still images taken from a) BRUV footage showing habitat of marginal sand-inundated reef and b) towed video of a small ridge of Posidonia angustifolia seagrass, both in 30 m of water and at locations at which juvenile dhufish were recorded.

The MDS analysis of the BRUV fish community composition data collected during the current study indicate a separation of sites by habitat type (Figure 3.6). Although only a single juvenile < 150 mm TL was recorded, the fish community composition recorded on this BRUV set appeared different to that of those set on reef or with undersize and adult dhufish. The fish community at the site occupied by the juvenile was more closely aligned with sand-associated species such as yellowtail scad *(Trachurus novaezelandiae)*, chinaman leatherjacket *(Nelusetta ayraudi),* silverbelly *(Parequula melbournensis)* and flathead *(Platycephalida sp.)*, rather than reef associated species such as footballer sweep *(Neatypus obliquus)* and wrasses (such as brownspotted wrasse, *Notolabrus parilus* and western foxfish, *Bodianus frenchii*).

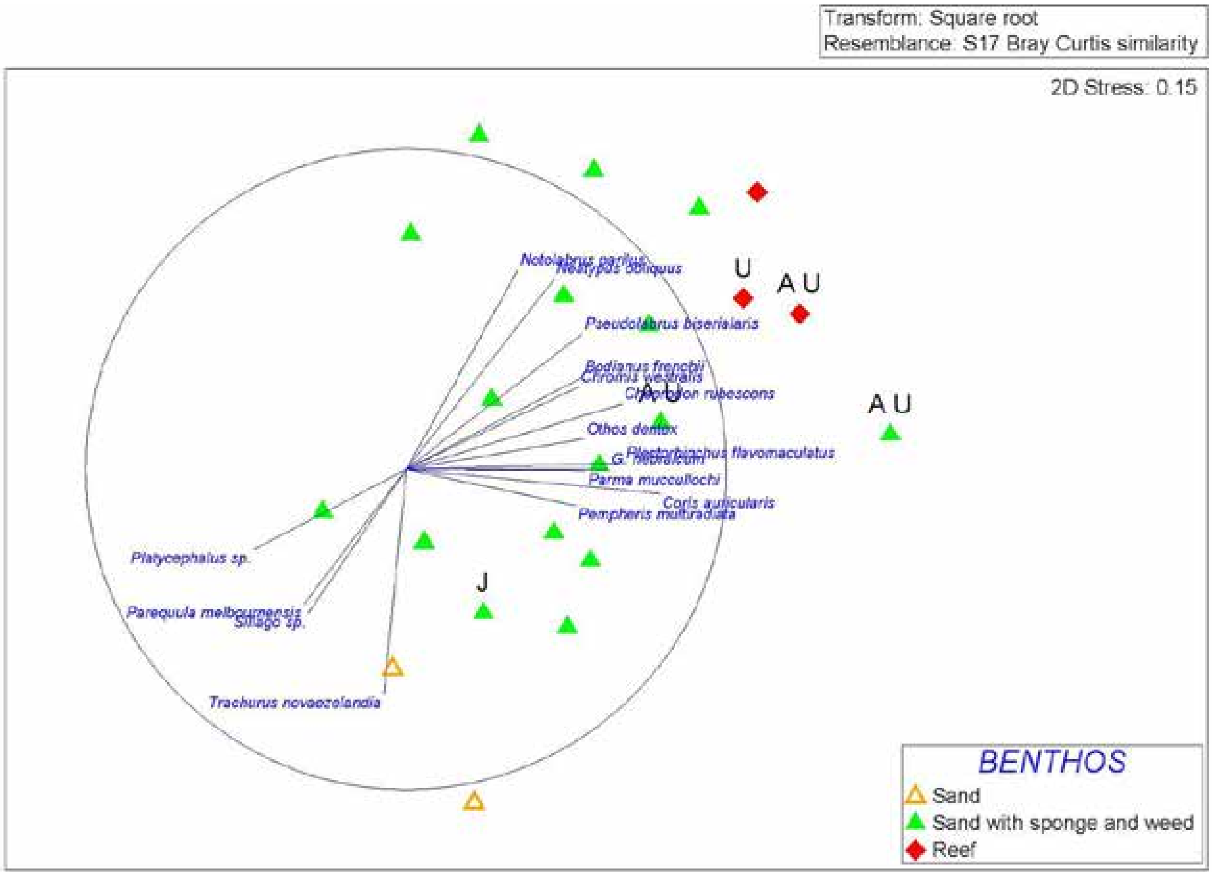


Figure 3.6 Non-metric MDS ordination plot of species abundance data for each individual BRUV set to investigate habitat and species correlations (Pearson correlation coefficient >0.51) to species associations for juvenile (J), undersize (U) and adult (A) dhufish, where blue circle indicates full correlation.

No significant difference existed between the catch composition of each side (port vs starboard) for individual trawls (R statistic = -0.007, P = 0.572) indicating both nets were sampling similarly, however there was a significant difference between the September 2010 and February 2011 trawls (R statistic = 0.579, P < 0.001), (Figure 3.7). The species correlations in this plot indicate that the September survey sampled weed associated species, such as old wife (*Enoplosus armatus*) and blue spotted goatfish (*Upeneichthys vlamingii*), while the survey conducted in February collected species more closely aligned with sandhabitat, including sand or silver trevally *(Pseudocaranx sp.)* and stout whiting *(Sillago robusta)*. This was confirmed by examining the locations of each surveys trawls on the MaxSea seabed type map (Figure 3.4), which showed that different areas and habitat types were sampled on each survey. In

September 2010 trawls were conducted over sponge, weed and marginal reef habitats compared to February 2011, which sampled predominantly sand and sand with some seagrass or sparse cover of macroalgae and sponge.

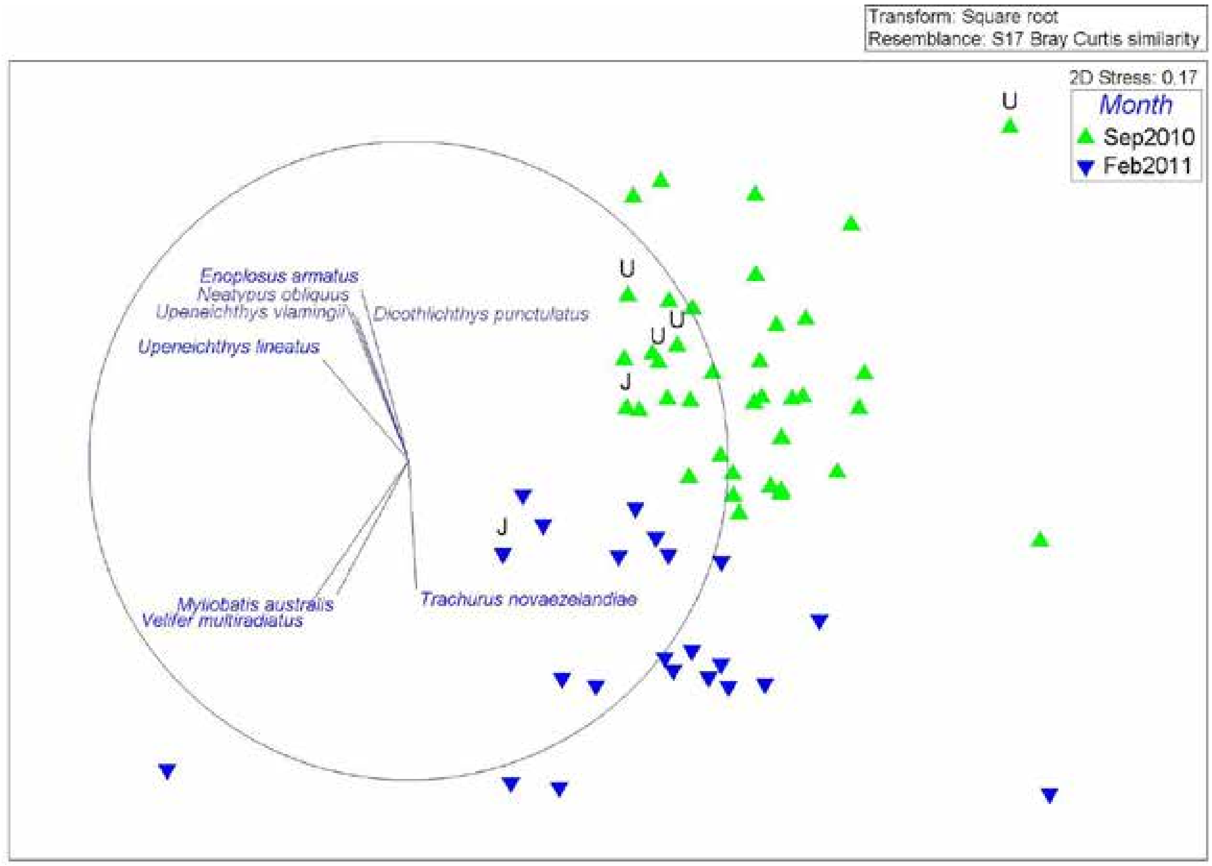


Figure 3.7 Non-metric MDS ordination plot of species abundance data from trawls by sampling month to illustrate differences between trips and species correlations (Pearson correlation >0.4) to show species associations of juvenile (J) and undersize dhufish (U), where blue circle indicates full correlation.

Extent of critical habitat

Habitat maps derived from MaxSea classification and validated by towed-video surveys revealed a mixture of seabed types at each site. The extent of critical marginal reef and sand/seagrass habitats at each site was also investigated. Even though juvenile dhufish were not collected or recorded at all sites, the marginal sand inundated reef habitat types appear to be widespread and thus future targeted monitoring may reveal the presence of juveniles at some of those sites, particularly in years of high recruitment.

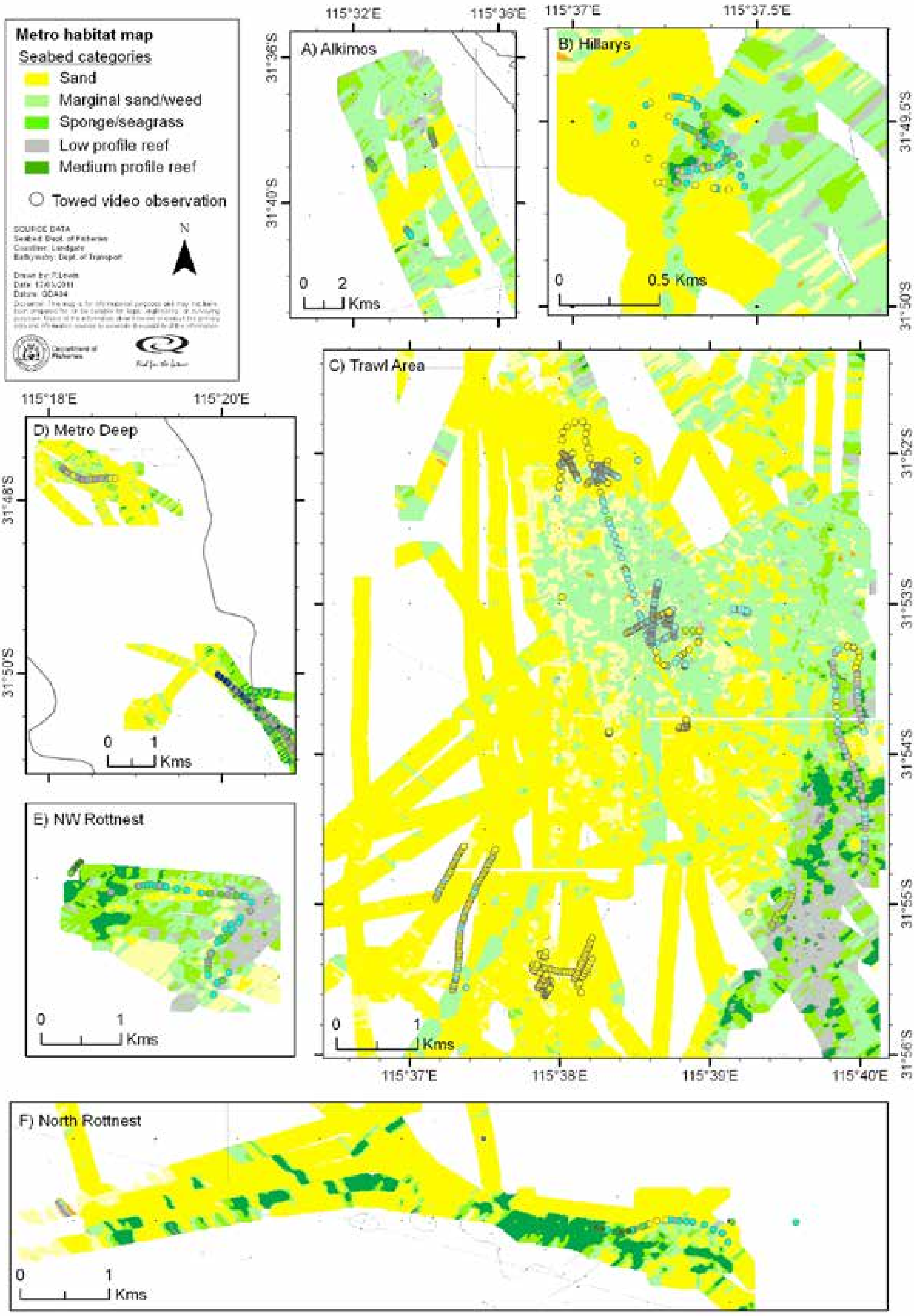


Figure 3.8 Habitat classifications derived by MaxSea seabed mapping and validated with towed video habitat type observations (indicated by appropriately coloured dots) for sites a) Alkimos, b) Hillarys, c) trawl area, d) metro deep, e) NW Rottnest and f) north Rottnest in the Perth metropolitan area. See legend for seabed categories and Figure 2.1 for location of each site.

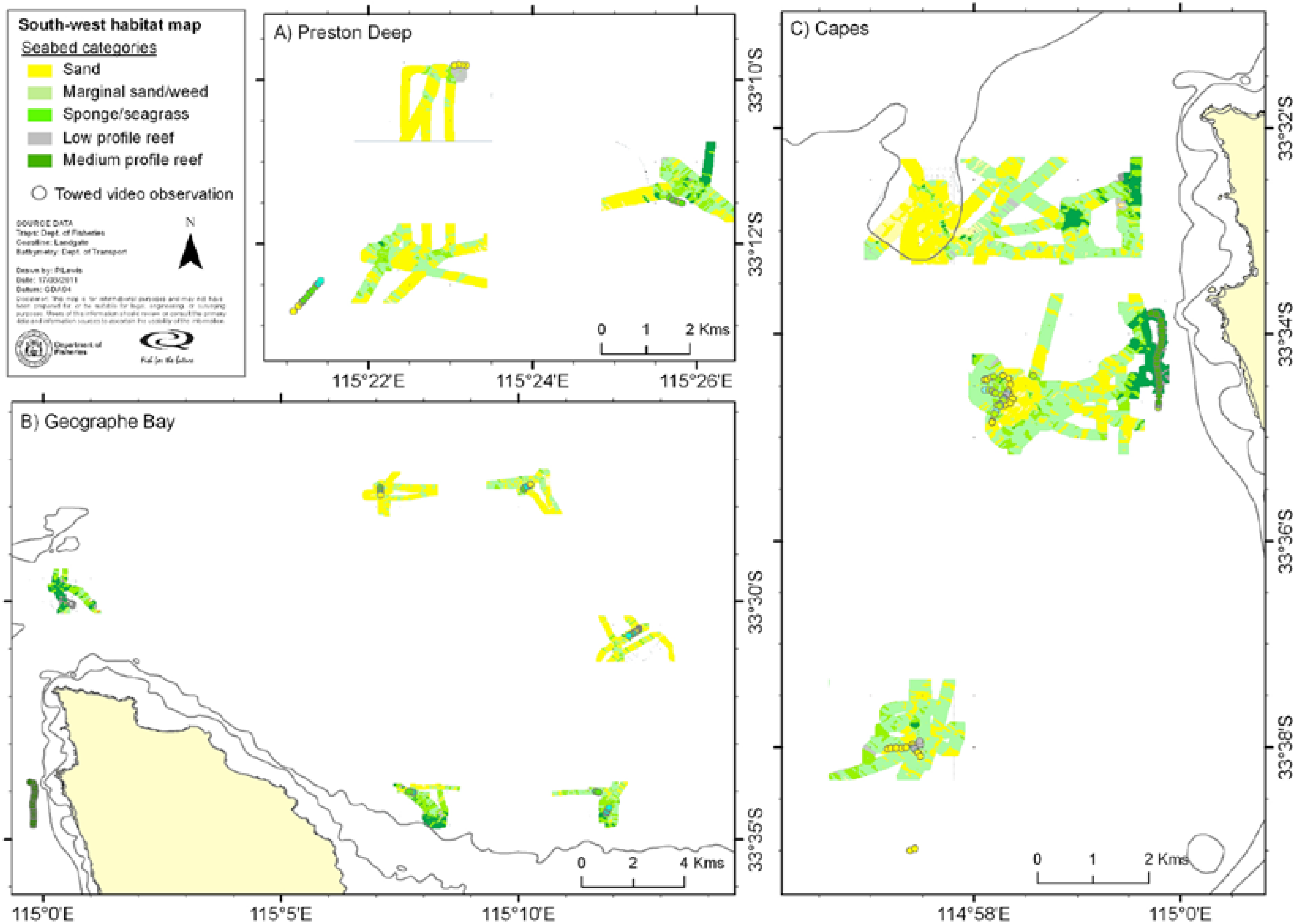


Figure 3.9 Habitat classifications derived by MaxSea seabed mapping and towed video habitat type observations (indicated by appropriately coloured dots), for sites a) Preston deep, b) Geographe Bay and c) Capes region in the South-west study area, see Figure 2.1 for location of each.

3.3 Additional methods

Dietary analysis

The diet of juvenile dhufish (n = 4, less than 150 mm TL) was predominantly composed of mysids of the genus *Siriella* (Figure 3.10 a). The stomach contents of one individual also contained three pairs of otoliths from a gadiform cod in the Moridae family, possibly of the *Notophycis* genus. This indicates that juvenile dhufish are also piscivorous at sizes less than 150 mm. Further identification of such prey items in the future may help to better determine the type of habitat juvenile dhufish are occupying and feeding in (Figure 3.10 b).

a) b)

Figure 3.10 Stomach content of juvenile dhufish showing a) *Siriella sp.* mysid and b) otoliths from a *Notophycis* sp. fish.

Benthic plankton tows

A total of fifteen benthic plankton tows were conducted and resulted in the collection of eggs and larvae of a number of different species of fish, some of which were similar to those of dhufish but could not be definitively classified as such. These samples were retained and will be further examined by larval fish taxonomists at a later date. Information from this study has been provided to CSIRO scientists responsible for an upcoming Fisheries Research and Development Corporation (FRDC) funded project to develop methods for the collection of dhufish eggs and larvae in south-western WA. The juvenile dhufish project has therefore contributed to some of the background research for this multi-agency research project (involving DoFWA and CSIRO) to investigate the location and abundance of dhufish eggs and larvae (FRDC project 2011/016).

Recreational fisher logbook data

Investigation of the DoFWA research angler program (RAP) voluntary angler logbook database (in operation since 2005) produced 43 reports of small dhufish (less than 300 mm in TL). Of these only four juveniles (TL less than 150 mm) were reported by recreational anglers, highlighting the selectivity of recreational fishing gear to target larger fish (above 150 mm in TL) and also the difficulty in sampling juveniles. The smallest dhufish reported, at 105 mm TL, was caught in a recreational lobster pot set in 30 m of water off Hillarys (Perth metropolitan area) in December 2009 and was released. The spatial distribution of these captures, which are reported by 5 nm fishing blocks, indicates juvenile dhufish are widespread along the WA coast and across the coastal shelf waters (Figure 3.11).

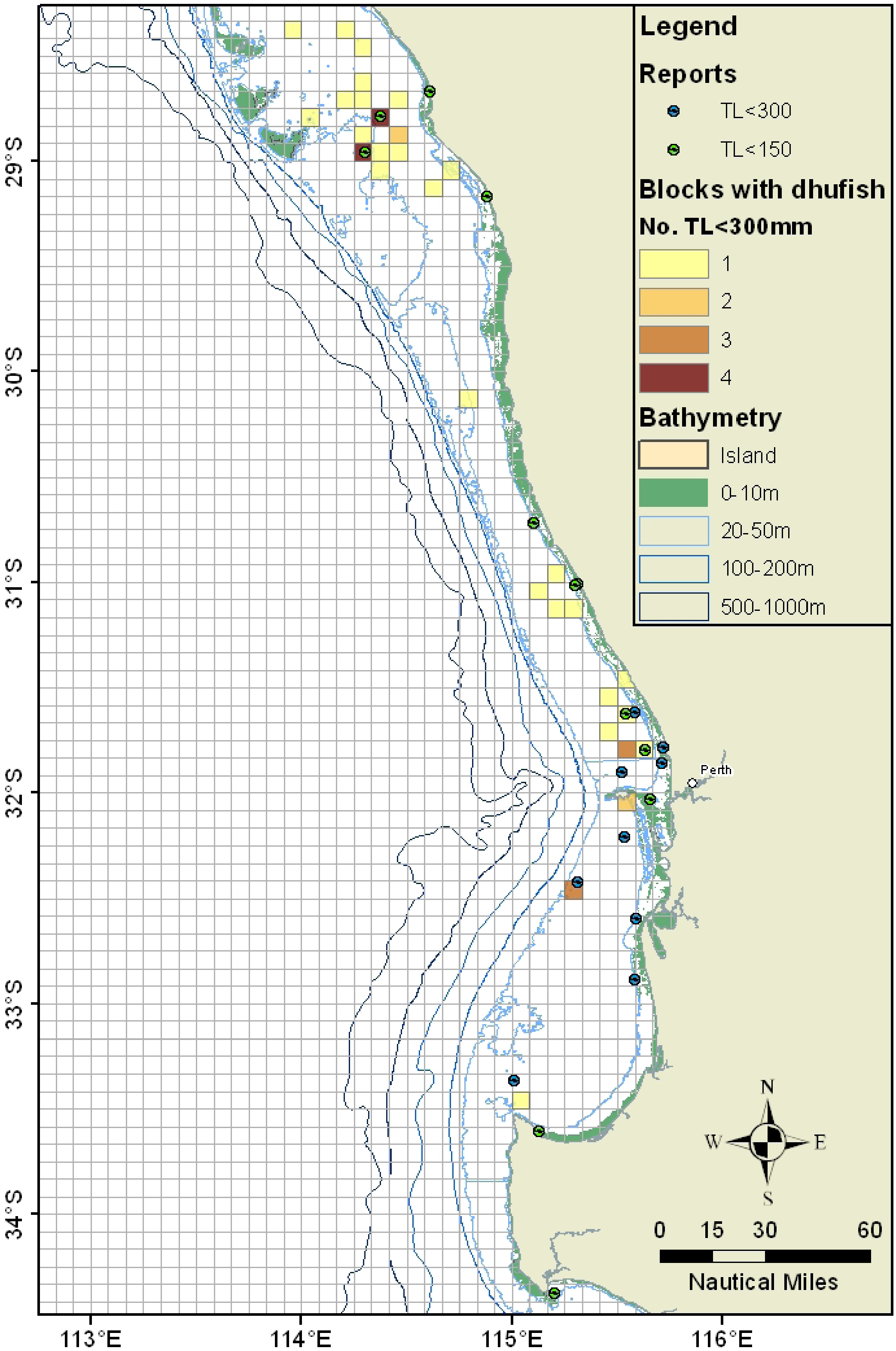


Figure 3.11 Map of locations along the lower west WA coast at which dhufish less than 300 and 150 mm TL have been anecdotally observed or caught, and blocks in which RAP logbook fishers have indicated catching and releasing dhufish less than 300 mm TL, from 2005 – 2010.

The RAP database was also queried for annual patterns in the catch rate of undersize dhufish reported in the WCB by boat based fishers (Figure 3.12). The pattern for the smallest size class, 300 – 349 mm, indicates a distinct peak in the catch rate of fish that were most likely spawned in 2004. Thus the annual catch rate calculated from the RAP logbook data may be useful at a coarse scale for back-calculating annual dhufish recruitment strength.

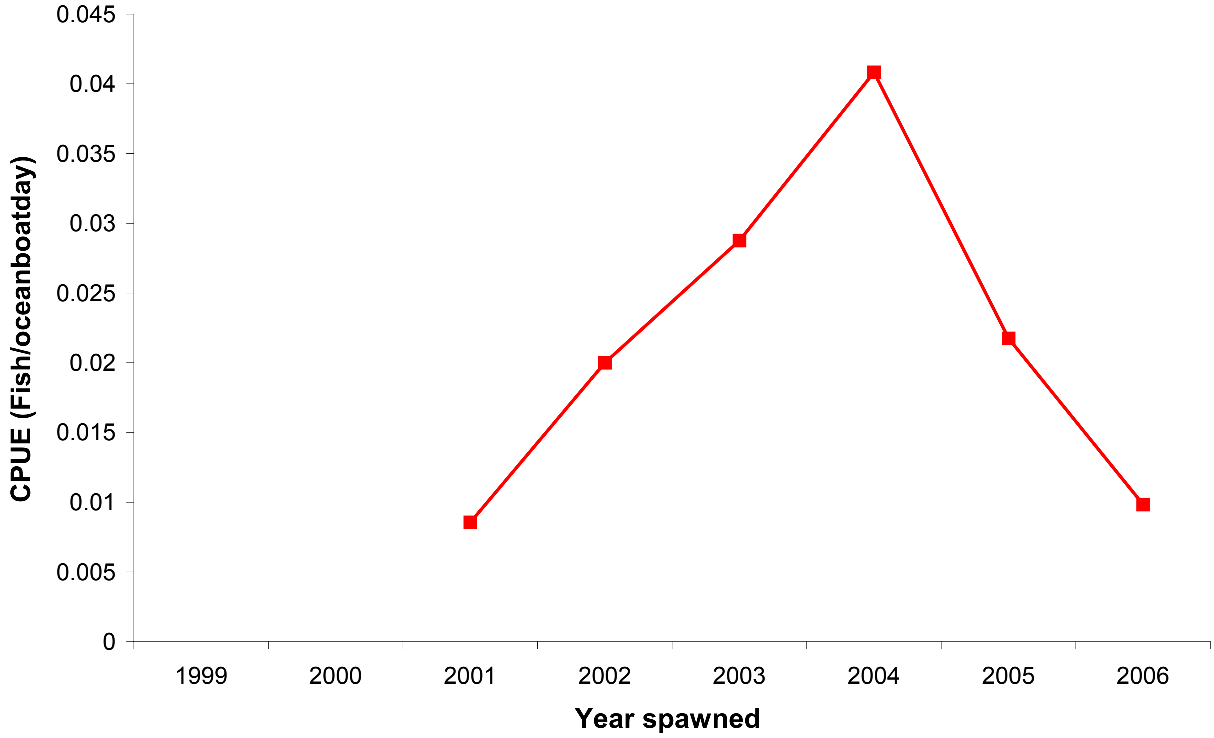


Figure 3.12 Annual catch rate of 300 – 349 mm TL size dhufish from RAP logbook data by back calculated year spawned .

Anecdotal evidence

A number of commercial fishers and divers (such as commercial trawlers and specimen shell and marine aquarium fish divers) were contacted and where possible, provided an account of their observations of any encounters with juvenile dhufish. Additionally, a number of media articles regarding the project (see Appendix 2) resulted in recreational fishers and divers also reporting captures and observations of juvenile dhufish. Most recreational divers focus on reef habitats and as a result are unlikely to encounter very small dhufish < 300 mm TL. However, the information received from the few diver reports described a common habitat-type consisting of a small ledge or rock in predominantly sand and/or weed area in depths of 3 – 30 m. Some diver reports also indicated that very small dhufish were consistently found in similar locations among years.

Recreational fishers reported capturing very small dhufish (less than 150 mm TL) while targeting whiting on sandy areas (Table 3.4). Overall, the reports indicated that juvenile dhufish occurred at depths of 2 – 45 m.

The wide spatial distribution of anecdotal reports of juvenile dhufish along the west coast (Figure 3.11) indicated that juveniles were not concentrated in any particular location or distance from shore, supporting information from the RAP database. One particular report from an experienced diver in Geographe Bay describes regular observations of very small dhufish “down to the size of a goldfish” in a particular area associated with small ledges in an area of sand and seagrass of 8 – 10 m depth. This area requires further investigation and may be a potential monitoring site for dhufish recruitment.

A number of experienced divers reported seeing more undersize dhufish than they have previously observed over the past year in the 200 – 300 mm TL size range during early 2011. Fishers have also reported catching undersize dhufish of a similar size range that they have never or rarely encountered in the past, as well as regularly encountering just undersize dhufish (TL 450 – 499 mm). These observations indicate that good recruitment pulses of 200 – 300 mm (2 – 3 years of age) and 450 – 500 mm (7 – 8 years of age) dhufish are entering the fishery in 2011. These fish would have likely been spawned in approximately 2008 – 09 and 2003 – 04, respectively.

Table 3.4 Summary of anecdotal sightings and captures of juvenile dhufish (TL less than 300 mm) reported by fishers and divers during juvenile dhufish project.

Date	Area	Depth (m)	Habitat	TL (mm)	Method	Comments
Feb 1990	Out of Grey	25	Back of reef	50 – 75	Lobster pot	50 – 60 very small dhufish
		96	Coral	< 500		
	Jurien Bay	30		Small	Diving	Off lighthouse
1993 – 95	Off Leighton	20	Back of seagrass	100	Trawl	
	Abrolhos	To 30	Reef edge	170	Diving	No more than 3 dhufish in one place
2004 – 2011	Albany	40 – 65	Reef	100 – 900	Diving - shell collector	200 dives/yr, dhufish becoming more common, 5 years ago to 100 mm in TL
Nov 2008	Lancelin Is	10		75 – 100	Diving	
Mar 2009	Off Mindarie	28	Small ledge in seagrass	200	Diving	Confirmed by a photograph
Oct 2010	Off Garden Is	32	Small ledge in seagrass	200	Line	Dived on spot
Jan 2011	Eagle Bay	15	Reef	150 – 200	Line	2 juvenile dhufish caught
Mar 2011	Marmion	20	Small ledge in sand	200 – 300	Diving	2 – 4 small dhufish, others at 500 mm
10 Mar 2011	Drummond Cove	Shore	Beach	80	Line	
20 Mar 2011	Off Scarborough	30	Sand/weed	200	Line-whiting	Confirmed by a photograph
	Off Garden Is.	37	Reef/sand	200 – 400	Line-whiting	12 dhufish in 2 drifts
26 Mar 2011	Off Hillarys	35	Sand/weed	180	Line- whiting	Confirmed by a photograph
April 2011	Mullaloo	10	Small ledge in seagrass	200	Diving	Regular dive spot, not seen dhufish before
	Off City Beach	15 – 20	Reef	100 – 120	Line - skippy	Prawns and fresh octopus as bait & burley
	Dongara	3 – 4	Small ledge in sand	50 – 70	Diving	Lots of small dhufish in area

Table 3.4 (cont.)

Date	Area	Depth (m)	Habitat	TL (mm)	Method	Comments
April 2011	Off Garden Is	32 – 36	Small ledges in seagrass	150 – 200	Diving	Schools 2 – 5 dhufish, no big dhufish
	Bunbury	12 – 15	Small lumps in sand	100 – 300	Diving	More this year, 3 or 4 dhufish some spots
	Mandurah	8 – 12	Small ledges in seagrass	200 – 300	Diving	Seen 12 this year, 1or 2 dhufish on each
	Quindalup	8 – 10	Limestone rocks in weed	80 – 200	Diving	Regularly see very small dhufish on 1 spot
9 Apr 2011	Lancelin Is	2 – 3	Sand/weed	100	Line-whiting	
18 Apr 2011	Cape Naturaliste	45	Broken ground	200 – 300	Line	Lots of small dhufish in area, had to move
May 2011	Drummond Cove - Pt Gregory	11 – 13	Reefs	250 – 500	Diving	Regular trip, more undersize dhufish than ever before, 10 – 15 on some locations
17 May 2011	Rottnest Island	15	Mooring set in sand	80 – 100	Diving	Juvenile dhufish on and around mooring
Summer	Abrolhos	28 – 42	Plate coral near edge	>100	Diving	
Regularly dived spot.	Off Mandurah	30	Reef with hole/cave	150 – 900	Diving	Small area, 12 – 15 dhufish, lots of fish, blue groper
Annual trip	Ledge Pt/Dongara	10 – 20	Reef & coral	200 – 300	Line	Numerous small dhufish each year

Recent reports and underwater video footage, collected in March 2011 by Brad Adams (Ocean Grown Abalone Pty Ltd), of a number (n = 3) of small juvenile dhufish (40 – 80 mm TL) recruiting to artificial habitats in an abalone aquaculture site off Augusta, may provide a potential location and method for monitoring juvenile dhufish recruitment (Figures 3.13). The artificial habitats are designed for abalone and consist of a mixture of cement blocks, pipes and bricks set at a depth of 20 m in areas of sand with mixed macroalgae wrack (*Ecklonia* sp, *Platythalia* sp. and others) and seagrasses (*Amphibolis* sp. and *Heterozostera* sp.), with small patches of low profile reef habitat in the vicinity.

The artificial habitat was deployed in January 2011 and juvenile dhufish of approximately 50 mm TL were reported to have first appeared in late March 2011. At this size the juveniles are less than 6 months of age (Hesp *et. al* 2002) and were likely spawned in November or December 2010. The lease owner observed that the juveniles appeared intermittently, and that they seem to be residing separately in each artificial habitat unit. In May 2011, there were five individual juvenile dhufish counted and the video footage provided of the juveniles was used to estimate their size in relation to the concrete blocks (width = 190 mm). These juvenile dhufish were less than 1/3 the width of a block, and as such, less than 70 mm TL confirming that these were 0+ age class fish which had likely been spawned in the previous summer (December 2010 – February 2011). This size concurs with the size range of 57 – 81 mm recorded by Hesp *et al* (2002) for 0+ dhufish in the April-May period.

A subsequent research dive survey of the Ocean Grown Abalone Pty Ltd lease in June 2011 counted 10 juvenile dhufish ranging in size from 60 – 90 mm TL. The range in size of dhufish present indicates that both early and late spawned juveniles may be recruiting to the site. As dhufish spawn over a protracted period from November until April in the WCB (Hesp *et al.* 2002, Mistopoulos & Molony 2010), there could be up to 6 months difference in ages, which is reflected in the sizes. The addition of a further 50 tonnes of artificial structure to the lease in July 2011, trialling 5 different designs for abalone aquaculture, was followed by at least 60 juvenile dhufish being observed in the area the following month. The video footage provided confirmed at least 23 individual juvenile dhufish and initial analysis indicates that more juveniles occurred on structures with large hollows. A further observation by DoFWA research divers of a juvenile dhufish (TL 80 – 100 mm) on the mooring block for a shark monitoring network buoy at Rottnest Island in May 2011 also confirms the possible application of artificial structures set in sand and seagrass areas within in the Perth metropolitan area as possible recruitment monitoring methods for dhufish.

a)

b)

Figure 3.13 Still frames taken from video footage of juvenile dhufish a) associating with and b) residing inside artificial habitat at an abalone aquaculture site in May 2011.
Footage courtesy of Brad Adams.

4.0 Discussion

This project observed and collected a small number of juvenile dhufish (n = 6) through a range of different methods together with information on their associated habitat type. This is the most thorough assessment undertaken to date in the WCB, trialling different techniques to capture and monitor juvenile dhufish and also identify their critical habitats. The successful observation and collection of juveniles using a range of methods, analysis of recreational logbook data and compilation of anecdotal reports on the occurrence of juvenile dhufish, has provided initial evidence for their critical habitat and the widespread distribution of this habitat on the lower west coast of WA has been established. The effectiveness of sampling techniques and the habitats types are discussed. Finally, the project presents an assessment of three alternative techniques with the potential for ongoing monitoring of annual juvenile dhufish recruitment for consideration by fishery managers.

4.1 Monitoring techniques

The project trialled four different techniques (trawl, BRUVs, various fish traps and towed video) for the sampling and monitoring of juvenile dhufish (TL less than 150 mm). Trawling, type 1 opera-house traps and BRUVs were successful, although only low numbers of juvenile dhufish were collected or observed (three, two and one individual, respectively). The low numbers of juvenile dhufish captured suggests that 2010 was a year of relatively low recruitment of dhufish to the study area, as previous similar trawl surveys by Hesp *et al.* (2004) collected considerably higher numbers of juveniles with similar methods and levels of effort.

Importantly, methods other than trawling were identified for collecting juvenile dhufish. Previously, trawling was the only known successful method by which they were collected. While the success rate of BRUVs and small operahouse traps may be considered low, the sampling during the study covered a wide range of habitat types and depths in the search for juvenile dhufish and may not reflect the true effectiveness of the techniques. The actual targeted effort on suitable habitat by opera-house traps and BRUVs in recording juvenile dhufish was relatively low and would benefit from greater attention in any future study as potential monitoring techniques. Further surveys using overnight sets with small opera-house traps and BRUVs targeted on marginal sand inundated reef and seagrass/ habitats may be a robust and cost effective method for monitoring juvenile dhufish. In addition, trapping and BRUVs are considered to be less destructive monitoring methods (compared to trawling) and collect data on a range of other important species. It must be noted that it was identified in the workshop that traps have been used successfully for the capture of recruits for the congeneric *G. scapulare* in Queensland.

All techniques, except small opera-house traps, were successful in monitoring slightly larger dhufish (300 – 500 mm TL, 3 – 5 year old). BRUVs could be considered as a non-destructive method to monitor this size range of dhufish as they recruit to reef areas (Meeuwig 2011, Attachment 1). Such monitoring could be enhanced with the addition of fisher/diver logbooks to give an indication of future recruitment to the fishery to managers, although monitoring this larger size class gives less lead in time for recruitment issues than monitoring the smaller 0+ and 1+ age classes.

Numerous studies have utilised BRUVs along the WA coast and very few juvenile dhufish have ever been observed (Watson *et al.* 2007, Fairclough *et al.* 2011). In reviewing the UWA data from 2,335 BRUV sets along the coast of WA, Meeuwig (2011) found very few small dhufish (n = 8, TL< 300 mm) and only three of TL< 200 mm of which two were seen in first five minutes of a BRUV drop. This suggests that the juvenile dhufish were in the vicinity of BRUV and not necessarily attracted to the bait. It was concluded that BRUVs are not a successful method for detecting dhufish smaller than 300 mm in length, but may be suitable for monitoring larger size classes of dhufish even though dhufish rarely feed at the bait.

In the current study a single juvenile dhufish less than 150 mm was observed and measured on a stereo BRUV. At 126 mm TL, it is the smallest known dhufish recorded by this method. Analysis of the footage indicated a slight variation in colour pattern, which may indicate there was more than one individual present at this site. However, as each appearance lasted only 4 – 6 seconds, was in the same vicinity close to refuge and there was no sign of attraction to the bait, it appears to be a chance event of the BRUV landing near the small refuge and pointing in the right direction.

The BRUVs with artificial lights at night were successful for larger dhufish using blue and white lights and may be useful for monitoring the relative abundance of larger dhufish. The lack of observations with red light may suggest that dhufish are repelled or non-responsive to red light. Their retinal analysis indicates they are unable to detect light at this wavelength however this does not explain the lack of response/attraction to the bait. It must also be considered that as red light is absorbed in water at a quicker rate than the other wavelengths there was a restricted range of view compared to the others colours. This requires dhufish to be at the bait to be observed and given the lack of feeding observed by dhufish at the BRUV bait in general this is not often the case. The observations of dhufish on two of the four unbaited night RUV sets is of interest and may indicate that light alone and the planktonic activity it creates is sufficient to attract dhufish to the RUVs without the biases that bait creates. Even though these RUV sets were in areas where dhufish were known to occur, the results are encouraging for monitoring dhufish abundance by an unbaited method and warrant further investigation.

Important behavioural observations were recorded from the BRUV and diver video footage taken at the Augusta abalone aquaculture lease. It demonstrates that juvenile dhufish are active during the day, associated with a refuge and not as cryptic as originally thought. Thus, 0+ and 1+ dhufish recruits would be suited to monitoring by diver surveys in areas of critical habitat or suitable artificial structure in relatively shallow, diveable depths as a way of monitoring annual recruitment of dhufish.

The range of techniques used during the project recorded additional information of habitat association and abundance data for 160 species of fish (Appendix 3), nine of which are listed by the DoFWA as high risk demersal species for the WCB: pink snapper, breaksea cod, baldchin groper, queen snapper *(Nemadactylus valenciennesi)*, western blue groper *(Achoerodus gouldii)*, harlequin fish *(Othos dentex)*, bight redfish *(Centroberyx gerrardi)*, swallowtail *(Centroberyx lineatus)*, and western foxfish. The amount of data collected for each of these species varied from 1 to 337 individuals. For the majority of these species, BRUVs proved to be the most effective sampling technique and for species such as pink snapper the project was able to collect sufficient data to demonstrate that a combination of trapping and BRUVs could be used to monitor this species.

The project recorded a useful relative abundance and length-frequency estimate for pink snapper in the Perth metropolitan area. These data could potentially be compared to those from future surveys utilising similar methods in this area to track annual changes in the abundance and size distribution of the species and monitor the presence of the strong 2007 year group in the Perth metropolitan area. Although the processing of the stereo BRUV data to generate length frequencies was not completed as part of the current project, this would be important in a full assessment of the monitoring techniques for pink snapper.

The data for pink snapper indicates an abundance of 280 – 360 mm TL fish in the Perth metropolitan area at the time of sampling. These fish are approximately 3 – 4 years of age (Wakefield *et. al* 2008) and likely spawned in 2007/08. Annual surveys of the abundance of snapper eggs and 0+ juveniles in Cockburn Sound, where this species aggregates to spawn and subsequently recruits as juveniles, has indicated that 2007 was a relatively strong recruitment year (Fairclough *et al.*2010). This is reflected in the relative abundance of this cohort and in the length data recorded of those captured by the large commercial fish traps during the recent current survey. Thus, the larger trap types caught a wider range of sizes, are detecting the higher abundance of this age group in the Perth metropolitan area indicating that commercial sized fish trapping may be an effective method for monitoring recruitment strength in the species. BRUVs however, are likely to have recorded similar results and may also prove to be effective. The processing of the length frequency information from the BRUV footage collected during the project is essential for a full comparison of methods for monitoring the species.

Trawling proved the most successful method for collecting juvenile dhufish (< 150 mm TL, n = 3) however it was by far the most labour intensive and costly method. Trawling could only be conducted aboard the *RV Naturaliste* with a crew of five and two or three research staff whereas most of the other methods (opera-house traps and BRUVs) could be carried out from the smaller *RV Snipe 2* by three research staff. The nature of the marginal low relief reef habitat being sampled resulted in the destruction of six trawl nets and one set of trawl boards, albeit a set of old boards that may have succumbed to fatigue. In addition, trawling does not provide the exact location and habitat type on which a juvenile was collected due to sampling over a one nautical mile distance and often a range of different habitat types. It was however, the only method that could be compared to historical trawl surveys in the area that captured a moderate number of juveniles (Hesp *et al.* 2002).

The low numbers of juvenile dhufish caught by trawling during the current project are in line with those of a similar trawl survey conducted in April 2003 by the *RV Naturaliste*, when only a single juvenile was collected by this method through 16 trawls in the same area (D. Fairclough *pers comm.*). However, previous work in the same area by Dr A. Hesp (Murdoch University) between 1996 and 1999 collected reasonable numbers of 10 – 40 individuals each month (Hesp *et al.* 2002). Unfortunately, no exact effort data was kept from this study to allow a thorough comparison with the current study. However, as 'an average of one juvenile dhufish per trawl' (A. Hesp *pers. comm.*) was collected in the previous study, which is an order of magnitude more than the current study. This could reflect differences in stock levels, sampling methods, annual recruitment strength to the area or a combination of these factors. It is possible that there is variable recruitment of dhufish contributing to these annual differences and further cooperation with an annual scallop research trawl survey as well as commercial scallop trawlers in the area may provide an indication of annual fluctuations in juvenile dhufish recruitment.

The reasonably high numbers of juvenile dhufish observed on the artificial habitats at the Augusta abalone lease provides good evidence that establishing artificial structures in areas of critical habitat can be utilised as a method for monitoring annual juvenile dhufish recruitment. Artificial structures are used elsewhere in the world in areas of open sand habitat such as in the Gulf of Mexico for red snapper *(Lutjanus campechanus)*, that undergo an ontogenetic shift in habitats, to monitor recruitment (Szedlmayer and Lee 2006). As the lease is trialling various types of structure for abalone it is also effectively testing their suitability for juvenile dhufish.

These initial observations and surveys have effectively provided the first annual index of dhufish recruitment for WA and ongoing cooperation with the leaseholder will allow monthly stereo DOV surveys of the lease into the future as a dhufish recruitment monitoring site.

As the underwater footage and BRUV observations demonstrate that juvenile dhufish are not cryptic and do not appear to avoid divers, suitable artificial habitats could be established in shallow water (less than 30 m) that could be routinely surveyed by divers in the future. The assessment of different artificial reef designs for suitability to juvenile dhufish, and the establishment of such artificial reefs in shallow depths in the WCB with regular stereo diver operated video (DOV) surveys to count the abundance and measure juveniles, could potentially be explored to provide an annual recruitment index for dhufish. The establishment of artificial sites at a range of depths in a number of areas along the WA coast along with a number of natural sites of critical habitat where juveniles occur would possibly allow for any spatial variability in dhufish recruitment to also be detected. These sites could potentially be utilised to monitor the recruitment of other species including introduced pests and climate change induced range extensions.

The analysis of RAP logbook catch rate data for 300 – 350 mm TL dhufish indicated a distinct peak for those that were likely spawned in 2004. Fish from the 2003 – 04 recruitment will likely appear in the annual dhufish ageing composition data over the next few years. Current anecdotal reports from recreational and charter fishers in 2011 indicate they are releasing more slightly undersize fish, TL 450 – 500 mm which would approximate to this recruitment event. Thus, the catch rates of undersize dhufish in the RAP logbook may prove to be an additional method for monitoring dhufish recruitment strength of fish at 3 – 4 years of age, providing managers a 5-6 year warning of potential future fishery strength or weakness. However, the data are limited, the effort is not spread evenly and areas fished have not been investigated for consistency between years. The results should therefore be used in combination with a number of other methods to monitor recruitment. Possible additional data could be gained from diver observations to make use of anecdotal reports from divers of undersize dhufish numbers and hence recruitment.

Current recreational fisher and diver reports of high numbers of juvenile dhufish in the 200 – 300 mm and 450 – 500 mm size range indicate that there was good recruitment in approximately 2007 – 08 and 2003 – 04, respectively. Data indicates 2008 was a year with a reasonably strong Leeuwin current (Caputi *et al.* 2010), saw a high recruitment of pink snapper in Cockburn Sound (D. Fairclough *pers comm*) and also recorded good tailor recruitment at the Point Walter RAP angler tailor monitoring (Smith and Brown 2010), and seems could have potentially been a good year for dhufish recruitment as well.

4.2 Critical habitat

The project surveyed a range of different habitats and depths within the Perth metropolitan and Geographe Bay regions, and was successful in assessing and mapping the benthic habitat on which the juvenile dhufish less than 150 mm TL were collected. The successful trawls covered a wide area of habitats along their one nautical mile length including a mixture of sand, dense and light seagrass *(Posidonia angustifolia)* and marginal reef with sponges, algae, sessile invertebrates and seagrasses (*Posidonia sp* and *Amphibolis sp*.). In contrast, the successful traps and BRUV were set on two distinct habitats of a small ridge of *Posidonia angustifolia* seagrass and marginal sand inundated reef habitat with sparse cover of mixed macroalgae and sponges, both in 30 m of water. The review of over 2,300 BRUV deployments (Meeuwig 2011) reported very few small dhufish (TL<300 mm) and they appeared to be associated with low profile reef (Meeuwig 2011).

The project has also received a number of anecdotal reports from fishers and divers of juvenile dhufish being caught or observed in similar habitats, particularly near small ledges or bombies in areas of sand and seagrass. The horizontal striped colour pattern of juvenile dhufish is distinctive, with the stripes becoming less prominent at 300 mm in TL as they move onto reef area. These stripes virtually disappear when fish reach 500 mm TL. This juvenile pattern is known as disruptive colouration and is thought to break up the outline of the juveniles and assist with camouflage in weed and seagrass habitats (MacFarland 1991). This pattern is common to other seagrass associated species such as striped trumpeter *(Pelates sexlineatus)*, juvenile chinaman leatherjacket *(Nelusetta ayraudi)* and red-striped cardinalfish *(Apogon victoriae)* and is suited to their association with some form of refuge in particularly weed or seagrass habitats. The disappearance of the pattern with size is further evidence for a shift in habitat type of dhufish.

Further evidence for the association of juvenile dhufish with marginal sand inundated reef and deepwater seagrass habitat is provided by the analysis of BRUV community composition data and the diet of juveniles. While only a single juvenile dhufish (TL < 150 mm) was observed via BRUVs, the analysis of the fish community composition data indicated that the fish community at the site was dominated by sand associated species, such as whiting *(Sillago sp)* and silverbelly, rather than reef-associated species such as western foxfish and footballer sweep *(Neatypus obliquus)* or larger dhufish. The review of BRUV data (Meeuwig 2011) indicated that small dhufish (TL < 300 mm) co-occurred with a range of reef associated species but particularly with western king wrasse *(Coris auricularis)* and western butterfish *(Pentapodus vitta)* (Meeuwig 2011). The former species is widespread, occupying a range of habitats from high profile reef to sand; the latter species is predominantly found in coastal embayments.

The diet of juvenile dhufish TL < 200 mm was demonstrated by Platell *et al.* (2010) to consist predominantly of small crustaceans, particularly isopods and amphipods. The findings of the current study that the diet composition of the few small dhufish collected were dominated by mysids is similar to previous work but indicates they can switch between small crustaceans depending upon their availability. Mysids generally undergo a pronounced diel vertical migration during the day, generally occur in swarms in open areas, are disassociated with complex habitat and can be found in benthic sediments (Taylor 2008). This further supports the evidence of critical habitat for juvenile dhufish consisting of marginal reef or seagrass refuge adjacent to sand areas.

In addition, data from the RAP logbook and that reported by divers indicates that critical habitat of juvenile dhufish is widespread along the WA coast and occurs at a range of depths (2 – 45 metres). Reports include a number of sites where juvenile dhufish are observed regularly and these could be assessed and used as future monitoring sites. The MaxSea seabed mapping and towed underwater video at different sites and depths through the Perth metropolitan and South-west areas showed the existence of extensive marginal reef/sponge or patchy seagrass on sand habitats in all of these areas.

During the project, much of the only previously known area of juvenile dhufish habitat sampled by Hesp *et al.* (2002) was mapped by MaxSea and towed underwater video. This area ranges in depth from 28 – 31 m and consists of a mixture of habitats including low ridges of low profile reef with sponges, algae, sessile invertebrates and mixed seagrasses *(Posidonia sp, Halophila sp. and Amphibolis sp.)* with large areas of sand and sand inundated reef with light sponge/weed or sparse seagrass *(Posidonia angustifolia)* between and to the south and west. Thus trawl sampling within this area sampled a range of different habitats including marginal sand inundated reef and deepwater seagrass beds which are thought to be critical to juvenile dhufish.

A number of studies have investigated the fish communities of shallow water sand and seagrass habitats in coastal waters and embayments to depths less than 20 m along the WA coast, using beach seine nets, various sized beam or otter trawls, BRUVs and small fish traps (Scott 1981, Hyndes *et al.* 2003, Vanderklift and Jacoby 2003, Wakefield *et al.* 2009, Fairclough *et al.* 2011,). None of these studies has reported finding juvenile dhufish by these methods in those habitats and the few that have recorded dhufish have observed a few larger individuals by BRUVs or diver visual census surveys on nearby reef habitats. Thus, from the findings of the project of juvenile dhufish associated with seagrass habitat in 30 m of water it would seem they might only occur in deeper water seagrass habitats of exposed coastal shelf waters. Particular species of seagrasses such as *P. angustifolia* can be found to depths of at least 35 m along the coast of WA (Robertson 1984) from Shark Bay to Esperance, which gives a further indication to the possible extent of this particular critical habitat.

Existing benthic habitat mapping data on the extent of the deepwater seagrass beds and marginal sand inundated weed and sponge beds in the Perth metropolitan area is limited. Previous studies mapping benthic habitats have focused on the shallower areas of Cockburn Sound, Owen Anchorage and Marmion Marine Park (Bancroft 2003). The CMF benthic habitat mapping around and to the west of Rottnest Island, found little seagrass and marginal reef habitat in water greater than 20 m in depth (Radford *et al.* 2008). Further habitat mapping by the CMF of the Capes area in south-western WA and a study mapping the seagrass distribution in Geographe Bay (Barnes *et al.* 2008) have mapped large areas including seagrass beds in water deeper than 20 m that may be suitable habitat for juvenile dhufish. BRUVs were used in both of these studies, but no juvenile dhufish (TL < 150 mm) were detected. However, this is not unexpected as this technique has so far proven to be relatively ineffective in the detection of juvenile dhufish (Meeuwig 2011) . However, the habitat maps produced of the area could be used as a basis to design an opera-house trapping and diver-operated stereo video survey or choose locations to trial artificial monitoring structures in the area.

4.3 Potential methods for monitoring juvenile dhufish recruitment

Three potential methods for the ongoing monitoring of juvenile dhufish recruitment were identified in this project for management consideration. For each method, costs, risks, benefits and possible enhancements are also identified.

1. **Monitor relative abundance of 0+ and 1+ (TL < 150 mm) juvenile dhufish at identified sites of critical habitat through trapping and trawl surveys;**

- Overnight sets of 100 opera-house traps in areas of marginal reef and seagrass habitats of the trawl ground site in the Perth metropolitan area.
- Cooperation with the trawl fishery during the annual scallop trawl surveys of the Perth metropolitan area.

Benefits

- Monitors relative abundance of 0+ and 1+ juvenile dhufish, thus giving lead in time of ca 9 – 10 years before fully recruited to fishery for management advice.
- Collect information on the relative abundance of other demersal species.
- Relatively low cost, conducted over 4 – 5 days with little post-trip processing.

Costs/Risks

- Both methods are focussed on a single, small area that may not be representative of the WCB.
- Numbers of juvenile dhufish may be relatively small, even in good years
- May only detect juveniles in good recruitment years to Perth metropolitan area.
- Possibly poor survival of released juveniles due to barotrauma.
- Possible limitations to trawling due to Commonwealth marine bioregional planning.
- Negative perception that trawling is an ethically unacceptable and destructive method.

Enhancement

- Assess the reported sites with juvenile dhufish at Quindalup, south of Rottnest Island, Lancelin Island, Dongara and at the Abrolhos Islands using opera-house traps.
- Extend the spatial coverage of the recruitment monitoring to assess and allow for spatial variations in dhufish recruitment.
- Use in unison with Method 2 (below).

2. Monitor relative abundance of 0+ and 1+ (TL < 150 mm) juvenile dhufish at established artificial habitats;

- Trial a range of artificial habitat designs to identify the most favourable for juvenile dhufish
- Set up specifically designed artificial reefs at a number of sites in a range of shallow depths in suitable seagrass or marginal reef habitat along the WA coast (e.g. South-west, Perth metropolitan, Mid-west areas).
- Monitor (monthly) through recruitment period (Feb-June) for juvenile dhufish size and numbers through diver surveys (stereo DOV).
- Cooperation with the abalone aquaculture lease holders to monitor dhufish recruitment in the Augusta and Albany regions.

Benefits

- Monitors 0+ and 1+ fish giving maximum lead in time for management advice (9 – 10 years).
- Spatial distribution of artificial habitats could provide better certainty on spatial variability in annual recruitment.
- Standardised structures in a range of sites can be used to detect recruitment variability.
- The Augusta abalone lease is effectively conducting the first trial of suitable artificial structure design for monitoring juvenile dhufish recruitment strength.
- Monitoring sites set up specifically to meet DoFWA diving policy guidelines.
- Diving and stereo video allows cohorts to be distinguished and potentially collect information for other important species encountered.
- Non-destructive sampling method.

Costs/Risks

- A labour intensive method requiring the setting up artificial habitats and use of divers.
- May not be representative of overall recruitment.
- Suitable areas may not be identified.

Enhancement

- Should be used in unison with method 1 utilising natural habitats where possible, as well as artificial habitats for areas with access or depth issues.
- Use of stereo DOVs would increase costs through processing time for video footage but would add extra value by measuring sizes of fish to establish recruitment ages and provide a permanent record to use for other species.

3. Monitor 3 – 5 year old (TL 200 – 400 mm) dhufish abundance by multiple methods.

- Annual stereo BRUV and diver surveys in particular areas.
- Monitor annual RAP logbook reports of undersize dhufish and catch rates.

Benefits

- This approach would collect additional data on other species (such as pink snapper).
- A recreational angling logbook program already established, although modification and extension may be required to identify effort targeting dhufish.

Costs/Risks

- Less lead in time for management advice as dhufish are already recruiting to the fishery and only 5 – 8 years from being fully recruited to fishery.
- Higher costs of processing video footage.
- Less accuracy in annual recruitment strength due to difficulty assigning fish to specific cohorts, by back-calculation methods.
- Modification and extension of RAP logbook programme.

Enhancement

- The incorporation of a recreational diver logbook to record diver observations of undersize dhufish and catches in the RAP program would provide important additional information on annual rates and locations.
- The extension of reporting by charter boat operators of release sizes of undersize dhufish (TL < 500 mm) as an additional method to monitor annual catch rates of small dhufish.

4.4 Recommendations

The extension of research surveys to identify other areas of critical habitat where juvenile dhufish have been reported, such as the Abrolhos Islands, Lancelin Island, Quindalup and Augusta is of critical importance. Also of importance is the further trialling of artificial monitoring sites as these may prove to be an effective method to monitor annual recruitment. The continued investigation of both aspects would reveal further details on the spatial variation in recruitment and potentially provide a robust annual index of dhufish recruitment. Such an index would be an invaluable addition to the weight of evidence assessment of the species. The juvenile recruitment recorded during this project and observations at the Augusta abalone lease have effectively provided the first data point in the annual monitoring of dhufish recruitment strength in WA. It must be noted however, that this may not be representative and a considerable time series is required before the correlation to adult age structure can be established. Alternatively, it may be feasible to monitor the recruitment of larger dhufish (TL 250 – 400 mm) to the reef habitat through the use of BRUVs and traps as well as diver and fisher logbooks. However, even though monitoring this larger size class may be easier it will give less accuracy on annual recruitment strength and less lead in time on recruitment issues for managers.

5.0 Acknowledgements

The authors acknowledge that this project is supported by funding from the Western Australian Government's State Natural Resource Management Program and the Department of Fisheries, Western Australia.

We also acknowledge the wide range of stakeholders including recreational and commercial fishers and divers for their contributions, which were very much appreciated and valued. A special thank you to Brad Adams for providing the footage and reports of juvenile dhufish on his abalone aquaculture site. We would like to thank the managers and researchers from a number of government organisations including the WA Department of Fisheries, University of Western Australia, Murdoch University, and RecFishWest for participating in and contributing to the planning of this project. Finally, a big thank you to the crew of the *RV Naturaliste* for their efforts during some trying times.

6.0 References

Anon, 2011. *Resource assessment framework (RAF) for finfish resources in Western Australia,* Fisheries Occasional Publication, No. **85**, Department of Fisheries, WA. 24 p.

Bancroft, K.P. 2003. A standardised classification scheme for the mapping of shallow-water marine habitats of Western Australia. Report MCB-05/2003. June 2003. Marine Conservation Branch, Department of Conservation and Land Management. Unpublished report.

Barnes, P., Westera, M., Kendrick, G., and Cambridge, M. 2008. *Establishing benchmarks of seagrass communities and water quality in Geographe Bay, Western Australia.* Final Report for Southwest Catchment Council Project CM.01B, University of Western Australia, Perth 126 p.

Caputi, N., Pearce, A., and Lenanton, R. 2010. *Fisheries-dependent indicators of climate change in Western Australia, WAMSI subproject 4.2.3.* Fisheries Research Report No. **213**. Department of Fisheries, WA. 32 p.

Caputi, N. and Brown, R. 1986. Relationship between indices of juvenile abundance and recruitment in the western rock lobster *(Panulirus cygnus)* fishery. Canadian Journal of Fisheries and Aquatic Science **43**: 2131-2139.

Fairclough, D., Lai, E., and Bruce, C. 2010. West coast demersal scalefish fishery status report. *In:* Fletcher, W.J., and Santoro, K. (eds) 2010. *State of the fisheries and aquatic resources report 2009/10.* Department of Fisheries, Western Australia, pp. 80 – 90.

Fairclough, D.V., Potter, I.C., Lek, E., Bivoltsis, A.K. and Babcock, R.C. 2011. *The fish communities and main fish populations of the Jurien Bay Marine Park.* Strategic Research Fund for the Marine Environment Collaborative Research Project Final Report, Murdoch University, Perth. 363 p.

Ericson, G. and Cappo, M. 2006. BRUVS tape reading interface. Draft 2.1, Australian Institute of Marine Science, Townsville, QLD, 38 p.

Furlani, D., Gales, R., and Pemberton, D. 2007. *Otoliths of common Australian temperate fish; A photographic guide.* CSIRO Publishing, Victoria, Australia, 208 p.

Hesp, S. A., Potter, I. C and Hall, N. G. 2002. Age and size composition, growth rate, reproductive biology, and habitats of the West Australian dhufish *(Glaucosoma hebraicum)* and their relevance to the management of this species. *Fishery Bulletin* **100**, 214 – 227.

Hutchins, B. and Swainston, R. 1999. *Sea Fishes of Southern Australia.* Gary Allen Pty Ltd, Australia, 180 p.

Hyndes, G.A., Kendrick, A.J., MacArthur, L.D. and Stewart, E. 2003. Differences in the species- and size-composition of fish assemblages in three distinct seagrass habitats with differing plant and meadow structure. *Marine Biology* **142**: 1195-1206.

Hyndes, G.A., Platell, M.E., Potter, I.C., and Lenanton, R.C.J. 1999. Does the composition of the demersal fish assemblages in temperate coastal waters change with depth and undergo consistent seasonal changes? *Marine Biology* **134**: 1195 – 1206.

Jones, D. and Morgan, G. 2002. *Field guide to crustaceans of Australian waters.* New Holland Publishing, 224 p.

Laurenson, L.J.B., Unsworth, P., Penn, J.W. and Lenanton, R.C.J. 1993. *The impact of trawling for saucer scallops and western king prawns on the benthic communities in coastal waters of south-western Australia.* Fisheries Research Report No. **100**, Department of Fisheries, WA. 55 p.

Lenanton, R., StJohn, J., Keay, I., Wakefield, C., Jackson, G., Wise, B. and Gaughan, D. 2009a. *Spatial scales of exploitation among populations of demersal scalefish: implications for management. Part 2: Stock structure and biology of two indicator species, West Australian dhufish (Glaucosoma hebraicum) and pink snapper (Pagrus auratus), in the West Coast Bioregion. Final Report to Fisheries Research and Development Corporation on Project No. 2003/052.* Fisheries Research Report No. **174**. Department of Fisheries, WA. 187 p.

Lenanton, R.C., Caputi, N., Kanges, M., and Craine, M. 2009b. The ongoing influence of the Leeuwin Current on economically important fish and invertebrates off temperate Western Australia – has it changed? *Journal of the Royal Society of Western Australia,* **92**: 111-127.

McFarland, W.N. 1991 The visual world of coral reef fishes, *In:* Sale, P.J. (Ed) *The ecology of fishes on coral reefs,* Academic Press, USA. pp 16-36.

Meeuwig, J. 2011. *Whither small dhufish? An analysis of existing dhufish survey data to detect patterns in the distribution of small animals.* Centre for Marine Futures Report 2011/02, University of Western Australia, Perth, 24 p.

Mitsopoulos, G. and Molony, B. 2010. *Protecting inshore and demersal finfish; Identification of critical habitats for juvenile dhufish.* Fisheries Research Report No. **210**, Department of Fisheries, WA. 31 p.

Pironet, F.N. and Neira, F.J. 1998. Hormone induced spawning and development of artificially reared larvae of the West Australian dhufish, *Glaucosoma hebraicum* (Glaucosomatidae). *Marine and Freshwater Research,* **49**: 133 – 142.

Platell, M.E., Hesp, S.A, Cossington, S.M., Lek, E., Moore, S.E and Potter, I.C. 2010. Influence of selected factors on the dietary compositions of three targeted and co-occurring temperate species of reef fishes: implications for food partitioning. *Journal of Fish Biology* **76**: 1255-1276.

Radford, B., Van Niel, K.P., and Holmes, K. 2008. *WA Marine Futures: Benthic modelling and mapping final report,* University of Western Australia, Perth. 51 pp.

Robertson, E. 1984. Seagrasses. *In:* Womersley, H.B.S. Ed, "*The marine benthic flora of Southern Australia"* South Australian government printer, Adelaide, pp 57 – 122.

Scott, J.K. 1981. The seagrass fauna of Geographe Bay, Western Australia. *Journal of the Royal Society of Western Australia* **63**: 97-102.

Shand, J., Archer, M.A., Thomas, N. and Cleary, J. 2001. Retinal development of West Australian dhufish *Glaucosoma hebraicum, Visual Neuroscience,* **18**, 711-724.

Smith, K.A., and Brown, J. 2010. West coast nearshore and estuaruine finfish resources status report. In: Fletcher, W.J., and Santoro, K. (eds) 2010. *State of the fisheries and aquatic resources report 2009/10.* Department of Fisheries, Western Australia, pp. 65 – 77.

Szedlmayer, S.T. and Lee, J.D. 2006. Diet shifts of juvenile red snapper (Lutjanus camechanus) with changes in habitat and fish size. *Fishery Bulletin* **102**: 366-375.

Taylor, M.D. 2008. Spatial and temporal patterns of habitat use by three estuarine species of mysid shrimp. *Marine and Freshwater Research,* **59**: 792-798.

Vanderklift, M.A. and Jacoby, C.A. 2003. Patterns in fish assemblages 25 years after major seagrass loss, *Marine Ecology Progress Series* **247**: 225-235.

Wakefield, C.B., Johnston, D.J., Harris, D.C., and Lewis, P. 2009. *A preliminary investigation of the proposed Kwinana Quay development on the commercially and recreationally important fish and crab species in Cockburn Sound.* Fisheries Research Report No. **186**. Department of Fisheries, WA. 94 p.

Watson, D.L., Harvey, E.S., Kendrick, G.A., Nardi, K., and Anderson, M.J. 2007. Protection from fishing alters the species composition of fish assemblages in a temperate-tropical transition zone. *Marine Biology* **152**: 1197-1206.

Wise, B. S., St. John, J. and Lenanton, R.C. 2007. *Spatial scales of exploitation among populations of demersal scalefish: implications for management. Part 1: Stock status of the key indicator species for the demersal scalefish fishery in the West Coast Bioregion.* Fisheries Research Report No. **163**. Department of Fisheries, WA. 130p.

7.0 Appendices

Appendix 1 Outcomes of planning meeting

Key actions arising from field component planning meeting, where DoF- Department of Fisheries, UWA- University of Western Australia, MU-Murdoch University, AH- A. Hesp (MU), CW-C. Wakefield (DoF), GM-G. Mitsopoulos (DoF), JM- J. Meeuwig (UWA), and PL-P.Lewis (DoF).

What	Who	When
Collect information from divers around Busselton and other dive clubs to determine if they have seen juvenile dhufish.	GM	October 2010
Dive club contact details to be forwarded to GM, PL	JM	September 2010
Confirm access and availability of BRUVs, towed video gear and underwater light set-ups (3) from UWA for upcoming field trips (1 – 22/9/2010)	JM	ASAP
Confirm schedule for RV *Naturaliste* trip including days in /out of port; Distribute to all. Consider cod end covers on trawl net	PL	ASAP
Confirm crewing for Naturaliste trip, including DoF, UWA and MU staff and students. Availability of UWA experts to assist/crew	PL All JM	ASAP
Consider targeting previous trawled areas (from AH) as a starting point	PL 1st Trip	September 2010
Stratified sampling of other areas (e.g. transects across shelf at 10 metre depth intervals) as suggested by AH; systematic sampling	PL All	
Compile habitat-dhufish (x size) from previous BRUV footage; location data (overlay with below)	JM	November 2010
Identify location of hotspots from fishery CPUE data (overlay with above)	CW	ASAP
Consider how RV *Naturaliste* and other trips may be used to ground truth habitat predictions (from UWA)	JM	September 2010
Drogue mapping (?) data from CSIRO (contact Matt Harvey)	?	
Consider lights traps (contact Lynneth Beckley, MU)	PL, GM	October 2010
Contact Errol Sporer (DoF) in order to query SW Trawl data for fish catch (species list); look for dhufish; identify locations Contact Lynda Bellchambers (DoF) in order to query Abrolhos Islands Trawl data for fish catch (species list); look for dhufish; identify locations	PL, GM	November 2010
Note: while searching for dhufish, note the opportunity to collect other information (e.g. other species of fish, inverts etc)	All	
Note: negative results still important	All	

Appendix 2 Media articles

a. Western Fisheries magazine July 2010 edition

The great juvenile dhuie hunt

By Ben Carlish

The Department of Fisheries has brought together a group of experts and interested parties to crack one of the great mysteries of Western Australia fisheries that has to date eluded scientists – what are the critical habitat requirements for juvenile dhufish and where are they located?

A wide range of stakeholders, including local and interstate marine and fisheries scientists, commercial and recreational fishers, and fisheries managers attended a think-tank workshop at the Department of Fisheries Hillary's research laboratories to brainstorm theories and evidence on the subject.

Prized for its eating qualities and as a recreational fishing trophy fish, the iconic West Australian dhufish – or *Glaucosoma hebraicum* to give it its scientific name – is endemic to (only found in) Western Australia and is widely regarded as the 'jewel in the crown' of demersal (living on or near the seafloor) scalefish.

Due to heavily increased fishing pressure in recent years, the Department's researchers have identified the species is at high risk from overfishing and that the annual dhufish catch needs to be reduced by at least 50 per cent.

But more research is required into the biology and behaviour of the slow-growing dhufish to refine fisheries management measures and ensure fishing for them is genuinely sustainable.

Part of the challenge is that because dhufish are endemic to south-western Australia, there is no information about the species from other parts of Australia or the rest of the world.

While other species within the same family exist, it is not known how applicable information about them is to WA dhufish.

In December, the Department of Fisheries announced a new $225,000, 12-month research program into dhufish, funded from the WA Government's Natural Resource Management (NRM) strategy.

An essential component of the program, led by Fisheries Technical Officer Gabby Mitsopoulos, is to identify where juvenile dhufish spend the early part of their life cycle, before they become vulnerable to fishing gear (after their third to fourth year of life).

"At present, stock status monitoring is largely focused on adult fish, but little is known about juveniles between spawning and becoming vulnerable to fishing," Department of Fisheries Supervising Finfish Scientist Dr Brett Molony explained.

"This is one of the at-risk demersal species, which has prompted tighter management of both the recreational and commercial fishing sectors, so the more we can learn about juvenile dhufish habitats, the better we can manage its sustainability."

He said the workshop had provided a good starting point for the research, allowing individuals and groups with experience and interests in dhufish to pool key information.

"The wide range of stakeholders who attended all helped us build up a wider picture, narrowing down where we should be looking for the juvenile dhufish and in what habitats – small juvenile dhufish have only been reported from trawls in the metropolitan area in depths between 20 and 40 metres. However, information we got from the workshop suggests the juvenile dhufish may well be deeper, up to between 90 and 120 metres around limestone ledges and drop-offs.

"The dhufish show up in the fishery between three to seven years old, but by locating them up to one year of age, we may be able to monitor the juveniles to provide information to managers several years before they start turning up in commercial and recreational fisheries.

"With this kind of information we will be in a much better position to fine-tune our management of the fishery, ensuring its sustainability. But before we get there, there's a lot of work we need to do in the background."

Ms Mitsopoulos said the conference's findings have provided a solid launch pad for further investigation into the juvenile dhufish mystery.

"The next stage of the research will be to apply a range of sampling techniques, such as underwater cameras, traps and modified trawls, in the identified likely areas, in an attempt to locate small dhufish and determine the preferred types of habitat," she said.

"If successful, the habitat will be mapped, in order to estimate its size and range throughout the Metro Zone. Ultimately, the aim is to develop an ongoing monitoring tool to estimate the relative abundance of juvenile dhufish prior to their recruitment into the fishery and capture in the recreational and commercial fisheries." ■

Star in stripes – a rare picture of a juvenile dhufish. Photo: Department of Fisheries

WESTERN FISHERIES JULY 2010 17

b. Reel News Article by RecFishWest announcing the release of the workshop findings and search for juveniles.

recfishwest

REEL NEWS

Issue 12 September 2010

Search for baby Dhufish begins

One of the biggest mysteries facing fisheries scientist in WA is the locations and habitats of juvenile dhufish. The general ecological traits of this iconic species have been studied for many years and are well known. Over these years, however, very few juvenile dhufish (less than 150 mm in length) have ever been observed or collected.

The first step towards solving this mystery took place in March this year when the Department of Fisheries hosted a Juvenile Dhufish Workshop.

This workshop brought together a wide range of stakeholders including managers and scientists as well as commercial and recreational fishing representatives. It also included a scientist from Queensland who has had great success in finding juveniles of the closely related Pearl Perch.

The objective of the workshop was to compile all biological, ecological and anecdotal information on the early life history of dhufish and provide a plan as to where and how to start searching. The report from this workshop is available on the Department's website: http://www.fish.wa.gov.au/docs/frr/frr210/frr210.pdf

Equipped with this information, fisheries researchers will start the search this week aboard the *RV* Naturaliste. This fieldwork will focus on places where small juvenile dhufish have been found in the past. Researchers will be employing multiple methods in this expedition including towed and baited underwater video, fish traps of various sizes and small trawl nets.

It is hoped that this project will identify critical habitats and locations of juvenile dhufish which will greatly increase our understanding of this species. It may also potentially lead to the development of an index of dhufish recruitment to aid in future management.

If you have any information that may help solve the mystery of the juvenile dhufish please contact Recfishwest. It is worth noting that a small species of fish known as gobbleguts, which are common in the Swan River, look similar and are often mistaken for juvenile dhufish.

Fish today for tomorrow

www.recfishwest.org.au

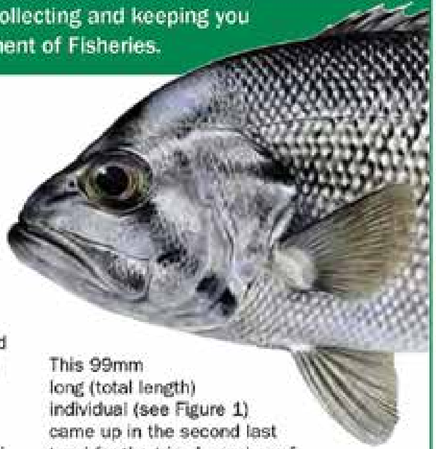
Western Australian Recreational and Sportfishing Council Inc Trading as Recfishwest ABN 77 922 817 608
Phone (08) 9246 3366 Fax (08) 9246 3955 Email recfish@recfishwest.org.au Address PO Box 34 North Beach WA 6920

c) RAP newsletter No 19 Dec 2010.

RESEARCH ANGLER PROGRAM

RAP Newsletter No.19 – December 2010

Welcome to the RAP Newsletter, giving you feedback on the data you are collecting and keeping you informed about what is happening at the Research Division of the Department of Fisheries.



Where do baby dhufish live?

A Western Australian National Resource Management funded project to identify the critical habitats for juvenile Western Australian dhufish (*Glaucosoma hebraicum*) is underway and due to be completed in June 2011. Juvenile dhufish less than 300mm in length are rarely seen by fishers, divers and researchers; the few collected in the past have come from trawling in a particular commercial trawl area. This raises an interesting and important question – where do juvenile dhufish live? The project was launched to fill this knowledge gap. Specifically, what are the critical habitat requirements for juvenile (zero – three-year-old) dhufish, and if this can be established, can juvenile dhufish be monitored to give an indication of how well dhufish replenish their stocks each year, much like the rock lobster puerulus?

The project kicked off in March this year with a workshop for stakeholders to gather all known biological and ecological information on juvenile dhufish and the related pearl perch (*Glaucosoma scapulare*). Juvenile pearl perch have been successfully caught through a range of sampling methods on the east coast of Australia. Participants at this workshop included recreational fishers and divers, commercial fishers, RecfishWest representatives, scientists from the Department of Fisheries, University of WA, Murdoch University, CSIRO, and Queensland DPI, plus fisheries managers. A research report was recently published which summarises the discussions and includes the presentations given at this workshop. This report is available at **http://www.fish.wa.gov.au/docs/frr/frr210/frr210.pdf.**

The project is using a range of techniques including trapping, research trawling within selected commercial fishing grounds, baited remote underwater video cameras (BRUVs) during both day and night and towed video with 'MaxSea' seabed classification software to map habitat types. BRUVs use stereo video to give researchers a '3D view' that allows length estimates of individual fish. The project has also been reviewing historical BRUV footage from the University of WA to look for any juvenile dhufish and their preferred habitats.

As Queensland research demonstrated that small mesh traps are effective at capturing juvenile pearl perch, the project will trial a range of fish traps of different types and sizes (as well as different baits) for juvenile dhufish.

Our initial surveys concentrated on the trawl grounds where juvenile dhufish have been collected previously. In addition, habitats over a range of depths within the metropolitan area are being surveyed with underwater video, traps and BRUVs to identify habitat types and fish species present in each.

The result from the first field trip aboard the WA Department of Fisheries Research vessel the RV *Naturaliste* in September was…we got one!

This 99mm long (total length) individual (see Figure 1) came up in the second last trawl for the trip. A number of other small dhufish (180-300mm total length) were captured in the trawls and detected in the towed video as well as being filmed in both day and night BRUV footage, but they are not as small as we hoped to find. During our field work we also surveyed the habitat types of the trawl areas by towed underwater video and acoustic seabed classification.

Further field work is planned over the coming months and more time on the RV *Naturaliste* in February 2011 will allow us to trial other techniques including night towed videos and unbaited stereo BRUVs with blue lights which attract zooplankton (food for juvenile dhufish). Meanwhile, if you happen to come across a very small dhufish or have previously seen one, then please let us know about it! (For contact details – see the back page of this newsletter).

Paul Lewis and Gabby Mitsopoulos

Figure 1. Juvenile dhufish (99mm total length).

A three-month-old juvenile dhufish measuring just over three centimetres. Photo: Julia Shand, University of WA

d) December 2010 Newsletter of the Australian Society for Fish Biology.

collected for identification to ascertain exactly which species are being caught by each of these sectors in the WCB and SCB. In WA, 9 different species of whiting are potentially caught but many of these are branded as 'sand' or 'school' whiting. Josh Brown is producing a whiting identification guide over the next few months to assist both commercial and recreational fishers as well as Fisheries Research staff to successfully identify whiting to species level. For more details contact Kim.Smith@fish.wa.gov.au

A second WA NRM funded project that is being carried out by Paul Lewis with the help of Gabby Mistopoulos is attempting to identify the critical habitats for juvenile WA dhufish (*Glaucosoma hebraicum*) and has now been extended until June 2011. A research report has now been published and is available at http://www.fish.wa.gov.au/docs/frr/frr210/frr210.pdf) that summarises outcomes from a workshop that was held in March to pull together information on what is known about juvenile dhufish and its congener pearl perch (*Glaucosoma scapulare*). More recently, field work has used a range of techniques such as stereo BRUVs, during both day and night, different types and sizes of fish traps, towed video and MaxSea seabed classification software, for mapping habitat type, as well as some trawling to locate 0+ (100-150 mm TL) dhufish and describe the associated benthic habitat. The initial surveys were stratified by depth but also concentrated on an area of trawl ground where juvenile dhufish had been collected in the past by trawling. The result from the first field trip aboard the DoF *RV Naturaliste* in September was….we got one!

The juvenile dhufish (TL-99mm). Photo: Paul Lewis

This individual (see above) came up in the second last trawl for the trip and the 1 nautical mile length of that particular trawl has been surveyed by towed video for habitat types and had all other methods deployed along its length. A number of other small dhufish (180-300 mm TL) were also captured in the trawls and initial analysis of the video footage showed a number of similar size fish on the towed video, and both day and night time stereo BRUVs. Interestingly, no small dhufish were captured in the various types of fish traps deployed at the same locations. Further field work is planned over the coming summer. For more details contact Paul.Lewis@fish.wa.gov.au

Research into West Coast Demersal species continues headed by Dave Fairclough ably assisted by Ian Keay and Brett Crisafulli. Following the introduction of new management measures to reduce catch in each sector of the West Coast Demersal Scalefish Fishery to 50 % of its levels in 2005/06, the commercial sector has met this (effort and) catch target and the preliminary results from the recreational sector are very encouraging. A stock assessment based on fishing mortality rates will be conducted in 2012 involving the three indicator species, West Australian dhufish, pink snapper and baldchin groper. Collection of otolith samples between Kalbarri and Augusta is progressing well, having now entered its final year in a 3-year cycle. WAMSI-funded otolith microchemistry work on baldchin groper indicates that juveniles recruit to locations where they remain throughout their adult life and thus mixing occurs during the egg/larval stage. Genetic studies being undertaken at Murdoch University by Michelle Gardner/Jennie Chaplin will complement this work. If baldchin groper stock structure is similar to that with the other WA endemic in this study (Dhufish), then it should also comprise a single genetic population. Analysis of otolith microchemistry for snapper and dhufish is continuing.

Each year, pink snapper aggregate in Cockburn Sound to spawn between September and December. Traditional mark-recapture tagging indicates some fish are resident all year round while others leave following the spawning period. Around the time they enter and leave the Sound, which coincides with a closure of the area to fishing, fishers target them avidly. A gate system of acoustic receivers was set up in 2009 and 30 adults were tagged. The majority of those fish left and early in the 2010 spawning season, several have returned to the same place where they were tagged. This included one recaptured fish that was tagged in 2009 that had fully recovered from the surgery. We need to examine the vulnerability to capture of these fish when entering and leaving the sound and whether individuals return

e) Western Fisheries (Jan/Feb 2011) describing a survey for juvenile dhufish and the NRM project.

SCIENCE FOR SUSTAINABILITY

Piecing together the dhufish jigsaw

By Ben Carlish, Gabby Mitsopoulos and Paul Lewis

Department of Fisheries research scientists have taken a step closer to unlocking one of the enduring mysteries of Western Australia fish research: where do juvenile Western Australia dhufish (*Glaucosoma hebraicum*) live?

Juvenile dhufish less than 300 millimetres in length are rarely seen by fishers, divers and researchers. The few collected in the past have been caught in trawl nets.

But a WA Natural Resource Management-funded project launched in March last year to identify their critical habitats has already picked up three juvenile dhufish less than 100 mm and several more under 300 mm through a variety of research techniques since fieldwork commenced three months ago.

The project kicked off with a workshop for stakeholders to gather all known biological and ecological information on juvenile dhufish and the related pearl perch (*Glaucosoma scapulare*). Juvenile pearl perch have been successfully caught through a range of sampling methods on the east coast of Australia.

"Our initial surveys concentrated on the trawl grounds where juvenile dhufish had been collected previously by Dr Alex Hesp of Murdoch University," reported Department of Fisheries Technical Officer Gabby Mitsopoulos. "In addition, habitats over a range of depths within the metropolitan area are being surveyed with towed underwater video, various fish traps and baited remote underwater video cameras (BRUVs) to identify habitat types and fish species present in each."

BRUVs use stereo video to give researchers a "3D view" that allows length estimates of individual fish, and are being used both day and night. The project has also been reviewing historical BRUV footage from the University of WA to look for any juvenile dhufish and their preferred habitats.

"The juveniles collected to date have all been within the trawl area they had been reported previously," said Gabby. "Importantly, one of these individuals was collected in a small opera house fish trap, a method not known to have previously worked for dhufish, and further trials will establish whether this method can be used in future monitoring for the species.

"A number of other small dhufish (180-500 mm) were captured and detected in the towed video, as well as being filmed in both day and night BRUV footage, but they are not as small as we hoped to find. During our field work we also surveyed the habitat types of the areas by towed underwater video and *MaxSea* acoustic seabed classification."

If the critical habitat requirement for juvenile dhufish can be established, fisheries scientists will explore the extent and distribution of this habitat in the metropolitan area, and determine if monitoring juvenile dhufish can give an indication of how well dhufish replenish their stocks each year – in a similar way juvenile lobster (puerulus) can be monitored to determine the future abundance of western rock lobster stocks.

Department of Fisheries Research Scientist Paul Lewis outlined the planned future activity for the program.

"Further field work is planned over the coming months to further trial the small opera house fish traps as a monitoring technique. Also, more time on the Department of Fisheries' Research Vessel *Naturaliste* will allow us to survey different areas and habitat types as well as trial other techniques, including night-towed videos and unbaited remote underwater video cameras at night with blue lights that attract zooplankton (food for juvenile dhufish).

Meanwhile, if anyone happens to come across a very small dhufish or have previously seen one, then please let us know about it!" ■

To pass on any information relating to possible juvenile dhufish habitats, please ring 9203 0111 or email Paul.Lewis@fish.wa.gov.au

Sweet petite – a 99 mm juvenile dhufish captured as part of the project. Photo: Paul Lewis

Out the traps – the research team prepares to drop baited opera house traps overboard in the search for juvenile dhufish. Photo: Paul Lewis

Lights, camera, action – a young dhufish shows up on Baited Remote Underwater Video (BRUV). Photo: Paul Lewis

46 WESTERN FISHERIES JANUARY/FEBRUARY 2011

WESTERN FISHERIES JANUARY/FEBRUARY 2011 47

f) Fisheries Media Release on Satellite drifters and dhufish research in southwest.

Satellite drifters to research WA's Capes Current

Date: Tuesday, 8 February 2011

Six satellite-linked drifters will be deployed between Cape Leeuwin and Cape Naturaliste this week, to help Department of Fisheries WA researchers learn more about the Capes Current.

Supervising Scientist, Dr Dan Gaughan said little was known about the day-to-day behaviour of the important Capes Current, but it was vital in carrying and dispersing eggs and larvae of summer spawning fish, such as the popular Western Australian dhufish.

"There is a need to understand where the eggs and larvae of shelf species may be transported to, if anywhere, after spawning," Dr Gaughan said.

"The Capes Current is a northbound ocean current that flows up the continental shelf of south west Australia every year around summer. It is named after Capes Leeuwin and Naturaliste, where it is thought to originate.

"We know it is driven by the persistent and seasonal southerly winds, but the drifters we will be dropping into the current will give us a better idea of its speed, the direction of flow and sea surface temperatures, on an hourly basis.

"This data will help improve our oceanographic modelling for the region and provide a better understanding of both along-shelf and cross-shelf water movements and their potential impacts on dispersal of eggs and larvae."

Dr Gaughan said the new satellite drifters were being deployed under a project funded by the *Western Australian Marine Science Institution* and the drifters could be tracked online by researchers and also interested members of the public at http://sharkmonitor.com/.

"These drifters are designed to follow surface currents by having a six-metre long drogue (think of it as a sock with holes), suspended below the surface. It is tethered to a surface unit that, every hour, will transmit sea temperatures and position via satellite."

Additional research projects will also be carried out from the RV (Research Vessel) Naturaliste, as it journeys through South West waters this month.

"It will be a multi-faceted trip, as far as dhufish research is concerned," said Dr Gaughan.

"A researcher from the Curtin University will be aboard with his acoustic logger, listening for dhufish noises as part of a Fisheries Research Development Corporation-funded project.

"Department of Fisheries researchers will also be continuing work on the identification of critical habitats for juvenile dhufish, which is part of a Natural Resource Management study."

g) JAKO'S FISH TIPS *The West Australian* - 27 February 2010 - Page 46 (Motoring section)

GLEN JAKOVICH

Helping juveniles to join the dhufish army

A nice present appeared in the run-up to Christmas for those fishos who like to chase one of WA's most sought-after fish — the dhufish.

The present was a 12-month research project by the Department of Fisheries, funded through the WA Government's Natural Resource Management strategy, which will help build-up vital knowledge about critical habitats for juvenile dhufish.

As most fishos will know, dhufish — or Glaucosoma hebraicum to use their scientific name — are unique to WA. The bad news for the species — and fishos in general — has been that we are in danger of loving the slow-growing fish to death.

In recent years departmental scientists have identified that the popular species is seriously at risk from over-fishing.

Little is known about juvenile dhufish between the time they are spawned and when they become vulnerable to fishing — three to four years. The more the scientists can learn about the habitats of juveniles — where they live — the better they can manage the species' overall sustainability.

One of the aims of this research is to gather enough information to potentially develop what the department's scientists call a "recruitment index".

A recruitment index will provide a measure of how well the adult stock is doing in producing young dhufish and give scientists another tool to assess the species' sustainability in the West Coast Bioregion, which lies roughly between Kalbarri and Augusta.

For many fish species, environmental conditions can affect the level of biological and fishery recruitment and dhufish are no different in this regard.

By knowing more about the critical habitats for the juvenile dhufish and the factors that affect their abundance, more can be done to better manage the West Coast Demersal Scalefish Fishery and improve the rates of stock recovery.

The first part of the research will involve holding a workshop involving scientists, commercial and recreational fishers and representatives from their peak representative bodies — the Western Australian Fishing Industry Council and Recfishwest.

The idea is to gather all the information possible from experts — both fisheries scientists and fishers — so as to compile the most comprehensive details possible on the distribution and habitat needs of juvenile dhufish.

One important thing to realise about the dhufish is that in addition to being one of the hottest of bites for a recreational fisho, it is an important species in the commercial fishery which provides fresh, high-quality fish for local fish markets and restaurants.

On the subject of demersal scalefish in general, fishos may be interested to know that the vast majority of recreational fishers did the right thing during the two-month seasonal closure of the fishery for high-risk species, which included dhufish, breaksea cod, pink snapper and baldchin groper, that came to an end on December 15.

During the closure, which started on October 15, Fisheries officers made contact with more than 2200 fishers in the West Coast Bioregion.

This is great going — and the even better news is that the department only had to hand out 10 infringement notices and six warnings for demersal fishing-related matters.

Appendix 3 Relative number of each species caught in each area by method.

where – not recorded, * rare (less than 3), ** low (3-100), *** common (100-500) and **** abundant (500+). Note: *Pseudocaranx* not always possible to identify to sp.

			Perth metropolitan				South-west		
FAMILY	GENUS	SPECIES	BRUV	Opera	Trap	Trawl	BRUV	Opera	Trap
Apogonidae	*Apogon*	*rueppellii*	-	-	-	-	**	**	*
Apogonidae	*Apogon*	*victoriae*	-	-	-	*	-	-	-
Apogonidae	*Siphamia*	*cephalotes*	-	-	-	-	*	-	-
Aulopodidae	*Aulopus*	*purpurissatus*	**	-	*	*	-	-	-
Berycidae	*Centroberyx*	*gerrardi*	-	**	-	-	*	-	-
Berycidae	*Centroberyx*	*lineatus*	-	-	-	-	**	-	-
Berycidae	*Centroberyx*	*australis*	-	-	*	-	-	-	-
Bothidae	*Pseudorhombus*	*arsius*	-	-	-	*	-	-	-
Bothidae	*Pseudorhombus*	*jenynsii*	-	-	-	*	-	-	-
Caesioscorpidae	*Caesioscorpis*	*theagenes*	-	-	-	**	-	-	-
Carangidae	*Pseudocaranx*	*dentex*	-	**	**	**	**	-	-
Carangidae	*Pseudocaranx*	*sp*	***	-	-	****	-	-	-
Carangidae	*Pseudocaranx*	*wrighti*	-	**	-	****	-	-	-
Carangidae	*Seriola*	*hippos*	**	-	-	**	**	-	-
Carangidae	*Seriola*	*sp*	*	-	-	-	-	-	-
Carangidae	*Trachurus*	*novaezelandiae*	***	*	**	***	-	-	-
Carcharhinidae	*Carcharhinus*	*brevipinna*	*	-	-	-	-	-	-
Carcharhinidae	*Carcharhinus*	*sp.*	*	-	-	-	-	-	-
Chaetodontidae	*Chaetodon*	*assarius*	*	-	-	-	-	-	-
Chaetodontidae	*Chelmonops*	*curiosus*	**	-	-	**	**	-	-
Chaetodontidae	*Heniochus*	*acuminatus*	-	-	-	*	-	-	-
Cheilodactylidae	*Cheilodactylus*	*gibbosus*	-	-	-	*	-	-	-
Cheilodactylidae	*Dactylophora*	*nigricans*	*	-	-	-	*	-	-
Cheilodactylidae	*Nemadactylus*	*valenciennesi*	**	-	-	-	**	-	-
Clupidae	*Etrumeus*	*teres*	-	-	-	*	-	-	-
Clupidae	*Sardinops*	*neopilchardus*	-	-	-	**	-	-	-
Congridae	*Conger*	*wilsoni*	-	*	-	-	-	-	-
Congridae	*Congridae*	*sp.*	-	-	-	-	-	*	-
Congridae	*Gnathophis*	*habenatus*	-	-	-	*	-	-	-
Cynoglossidae	*Cynoglossus*	*broadhursti*	-	-	-	**	-	-	-
Dasyatidae	*Dasyatis*	*brevicaudata*	**	-	-	**	*	-	-

FAMILY	GENUS	SPECIES	Perth metropolitan BRUV	Opera	Trap	Trawl	South-west BRUV	Opera	Trap
Dasyatidae	*Dasyatis*	*sp.*	*	-	**	*	-	-	-
Dinolestidae	*Dinolestes*	*lewini*	*	-	-	-	**	-	-
Diodontidae	*Dicothlichthys*	*punctulatus*	-	-	-	**	-	-	-
Engraulidae	*Engraulis*	*australis*	-	-	-	*	-	-	-
Enoplosidae	*Enoplosus*	*armatus*	**	-	**	**	-	-	*
Gerreidae	*Parequula*	*melbournensis*	**	**	**	****	**	**	**
Girellidae	*Girella*	*tephraeops*	-	-	-	-	*	-	-
Glaucosomatidae	***Glaucosoma***	***hebraicum***	**	*	**	**	*	-	*
Haemulidae	*Diagramma*	*labiosum*	*	-	-	-	-	-	-
Haemulidae	*Plectorhinchus*	*flavomaculatus*	**	-	*	-	-	-	-
Haemulidae	*Plectorhinchus*	*gibbosus*	*	-	-	-	-	-	-
Harpadontidae	*Saurida*	*undosquamis*	-	-	-	**	-	-	-
Heterodontidae	*Heterodontus*	*portusjacksoni*	**	**	**	**	*	-	*
Labridae	*Anampses*	*geographicus*	*	-	-	-	-	-	-
Labridae	*Austrolabrus*	*maculatus*	**	**	-	**	**	-	-
Labridae	*Bodianus*	*frenchii*	**	*	*	*	**	-	-
Labridae	*Choerodon*	*rubescens*	**	-	-	-	**	-	-
Labridae	*Coris*	*auricularis*	***	***	***	**	**	-	**
Labridae	*Eupetrichthys*	*angustipes*	**	-	-	**	**	-	-
Labridae	*Notolabrus*	*parilus*	**	**	**	**	**	-	*
Labridae	*Ophthalmolepis*	*lineolatus*	**	*	**	*	**	*	**
Labridae	*Pseudojuloides*	*elongatus*	-	-	-	*	-	-	-
Labridae	*Pseudolabrus*	*biserialis*	**	**	**	-	**	*	*
Labridae	*Suezichthys*	*cyanolaemus*	-	-	-	*	-	-	-
Monacanthidae	*Acanthaluteres*	*spilomelanurus*	**	**	**	***	-	-	-
Monacanthidae	*Acanthaluteres*	*vittiger*	**	**	**	**	-	-	-
Monacanthidae	*Brachaluteres*	*jacksonianus*	-	-	-	**	-	-	-
Monacanthidae	*Chaetodermis*	*pencilligera*	-	-	-	*	-	-	-
Monacanthidae	*Eubalichthys*	*mosaicus*	*	-	*	**	-	-	-
Monacanthidae	*Meuschenia*	*flavolineata*	**	-	-	*	**	-	*
Monacanthidae	*Meuschenia*	*freycineti*	*	-	-	*	-	-	-
Monacanthidae	*Meuschenia*	*galii*	**	-	**	**	**	-	**
Monacanthidae	*Meuschenia*	*hippocrepis*	-	*	**	-	**	-	**
Monacanthidae	*Meuschenia*	*sp.*	-	-	-	*	-	-	-
Monacanthidae	*Nelusetta*	*ayraudi*	**	***	**	**	-	*	**

			Perth metropolitan				South-west		
FAMILY	GENUS	SPECIES	BRUV	Opera	Trap	Trawl	BRUV	Opera	Trap
Monacanthidae	*Scobinichthys*	*granulatus*	**	**	*	**	*	-	*
Moridae	*Lotella*	*rhacinus*	*	*	-	-	-	-	-
Moridae	*Pseudophycis*	*barbata*	-	*	-	-	-	-	-
Mugiloidae	*Parapercis*	*haackei*	*	-	-	*	-	-	-
Mugiloidae	*Parapercis*	*ramsayi*	*	-	*	-	-	-	-
Mullidae	*Parupeneus*	*chrysopleuron*	**	-	-	-	*	-	-
Mullidae	*Upeneichthys*	*lineatus*	**	**	**	***	-	-	**
Mullidae	*Upeneichthys*	*vlamingii*	**	**	**	***	**	-	-
Mullidae	*Upeneus*	*asymmetricus*	-	-	-	**	-	-	-
Muraenidae	*Gymnothorax*	*prasinus*	-	*	-	-	*	-	-
Muraenidae	*Gymnothorax*	*sp.*	*	-	*	-	*	-	*
Muraenidae	*Gymnothorax*	*woodwardi*	**	*	**	-	*	-	-
Myliobatidae	*Myliobatus*	*australis*	**	-	-	***	**	-	-
Nemipteridae	*Pentapodus*	*vitta*	**	*	**	-	-	-	-
Odacidae	*Odax*	*acroptilus*	-	-	-	*	-	-	-
Odacidae	*Odax*	*cyanomelas*	*	-	-	*	-	-	-
Odacidae	*Siphonognathus*	*caninus*	-	-	-	*	-	-	-
Orectolobidae	*Orectolobus*	*sp*	*	*	**	-	-	-	-
Ostraciidae	*Anoplocapros*	*lenticularis*	**	-	-	**	*	-	-
Ostraciidae	*Anoplocapros*	*robustus*	**	-	-	**	-	-	-
Ostraciidae	*Aracana*	*aurita*	*	-	-	**	-	-	-
Ostraciidae	*Caprichthys*	*gymnura*	-	-	-	*	-	-	-
Ostraciidae	*Lactoria*	*concatenatus*	-	**	-	**	-	-	-
Palinuridae	*Panulirus*	*cygnus*	*	*	**	**	-	-	*
Pempheridae	*Parapriacanthus*	*elongatus*	***	-	-	***	-	-	-
Pempheridae	*Pempheris*	*klunzingeri*	***	*	**	****	*	-	**
Pempheridae	*Pempheris*	*multiradiata*	***	-	-	-	-	-	-
Pempheridae	*Pempheris*	*ornata*	*	-	-	-	-	-	-
Pempheridae	*Pempheris*	*sp.*	**	-	-	-	-	-	-
Pentacerotidae	*Pentaceropsis*	*recurvirostris*	-	-	-	*	-	-	-
Pentacerotidae	*Zanclistius*	*elevatus*	-	-	-	*	-	-	-
Platycephalidae	*Leviprora*	*inops*	-	-	-	*	-	-	-
Platycephalidae	*Platycephalus*	*longispinis*	**	**	**	**	-	*	-
Platycephalidae	*Platycephalus*	*speculator*	**	*	*	**	-	-	-
Platycephalidae	*Platycephalus*	*sp.*	**	-	-	-	-	-	-

FAMILY	GENUS	SPECIES	Perth metropolitan BRUV	Opera	Trap	Trawl	South-west BRUV	Opera	Trap
Platycephalidae	*Platycephalus*	*endrachtensis*	-	*	-	-	-	-	-
Platycephalidae	*Thysanophrys*	*cirronasus*	-	-	-	**	-	-	-
Plesiopidae	*Paraplesiops*	*meleagris*	*	-	-	-	*	-	-
Plesiopidae	*Trachinops*	*noarlungae*	**	-	-	-	**	-	-
Pleuronectidae	*Ammotretis*	*elongatus*	-	-	-	*	-	-	-
Plotosidae	*Cnidoglanis*	*macrocephalus*	*	-	-	**	-	-	-
Pomacentridae	*Chromis*	*klunzingeri*	**	-	-	-	**	-	-
Pomacentridae	*Chromis*	*westaustralis*	**	*	*	**	*	-	-
Pomacentridae	*Parma*	*bicolor*	*	-	-	-	-	-	-
Pomacentridae	*Parma*	*mccullochi*	**	-	-	-	-	-	*
Pomacentridae	*Parma*	*occidentalis*	**	-	-	-	-	-	-
Pomacentridae	*Parma*	*sp.*	*	-	-	-	-	-	-
Pomatomidae	*Pomatomus*	*saltatrix*	-	-	-	*	-	-	-
Rhinobatidae	*Aptychotrema*	*vincentiana*	*	-	-	*	-	-	-
Rhinobatidae	*Trygonorhina*	*fasciata*	**	*	-	**	**	-	-
Rhynchobatidae	*Rhynchobatus*	*djiddensis*	-	-	-	**	-	-	-
Scorpaenidae	*Helicolenus*	*barathri*	*	-	-	-	-	-	-
Scorpaenidae	*Maxillicosta*	*scabriceps*	-	-	-	**	-	-	-
Scorpaenidae	*Neosebastes*	*bougainvillii*	**	-	*	**	-	**	-
Scorpaenidae	*Neosebastes*	*pandus*	**	*	-	**	*	-	-
Scorpaenidae	*Neosebastes*	*sp.*	**	-	-	-	*	-	-
Scorpaenidae	*Scorpaena*	*sumptuosa*	-	**	-	**	-	-	-
Scorpididae	*Neatypus*	*obliquus*	***	**	***	**	**	**	**
Scorpididae	*Scorpis*	*aequipinnis*	**	-	-	-	*	-	-
Scorpididae	*Scorpis*	*georgianus*	**	-	-	-	**	-	*
Scorpididae	*Tilodon*	*sexfasciatum*	**	-	-	-	*	-	-
Scyliorhinidae	*Aulohalaelurus*	*labiosus*	*	*	*	-	-	**	**
Serranidae	*Acanthistius*	*serratus*	-	*	*	-	*	-	**
Serranidae	*Caesioperca*	*rasor*	-	-	-	-	**	-	-
Serranidae	*Caesioperca*	*sp*	**	-	-	-	**	-	-
Serranidae	*Callanthias*	*australis*	**	-	-	*	-	-	-
Serranidae	*Epinephelides*	*armatus*	**	-	**	*	**	-	**
Serranidae	*Hypoplectrodes*	*nigroruber*	*	*	-	*	**	*	*
Serranidae	*Othos*	*dentex*	**	*	*	-	*	-	*
Sillaginidae	*Sillaginodes*	*punctata*	**	*	-	*	-	-	-

FAMILY	GENUS	SPECIES	Perth metropolitan BRUV	Opera	Trap	Trawl	South-west BRUV	Opera	Trap
Sillaginidae	*Sillago*	*sp.*	**	-	-	-	-	-	-
Sillaginidae	*Sillago*	*bassensis*	-	**	**	****	-	-	-
Sillaginidae	*Sillago*	*robusta*	-	-	-	****	-	-	-
Sillaginidae	*Sillago*	*vittata*	-	-	-	***	-	-	-
Soleidae	*Strabozebrias*	*cancellatus*	-	-	-	*	-	-	-
Sparidae	*Pagrus*	*auratus*	***	**	***	**	*	-	**
Sparidae	*Rhabdosargus*	*sarba*	**	**	**	**	-	-	-
Sphyraenidae	*Sphyraena*	*obtusata*	-	*	-	-	-	-	-
Squatinidae	*Squatina*	*australis*	-	-	-	**	-	-	-
Sygnanthidae	*Filicampus*	*tigris*	-	-	-	*	-	-	-
Sygnanthidae	*Phyllopteryx*	*taeniolatus*	-	-	-	*	-	-	-
Teraponidae	*Pelsartia*	*humeralis*	**	*	**	-	-	-	-
Tetraodontidae	*Contusus*	*brevicaudas*	-	-	-	*	-	-	-
Tetraodontidae	*Lagocephalus*	*sceleratus*	*	-	-	-	-	-	-
Tetraodontidae	*Omegophora*	*armilla*	-	-	-	**	-	-	-
Tetraodontidae	*Polyspina*	*piosae*	-	-	-	**	-	-	-
Tetraodontidae	*Torquigener*	*vicinus*	-	-	-	*	-	-	-
Trachichthyidae	*Trachichthys*	*australis*	-	*	-	-	*	-	*
Triakidae	*Mustelus*	*antarcticus*	-	**	-	-	-	*	-
Triglidae	*Chelidonichthys*	*kumu*	-	-	-	**	-	-	-
Triglidae	*Pterygotrigla*	*polyommata*	-	-	-	*	-	-	-
Urolophidae	*Trygonoptera*	*ovalis*	**	-	-	-	-	-	-
Urolophidae	*Trygonoptera*	*personata*	*	-	*	**	-	-	-
Urolophidae	*Urolophus*	*mucosus*	*	*	*	***	-	-	-
Urolophidae	*Urolophus*	*sp*	-	-	-	-	*	-	-
Urolophidae	*Urolophus*	*testaceus*	*	-	-	-	-	-	-
Veliferidae	*Velifer*	*multiradiatus*	*	-	-	***	-	-	-
Zeidae	*Zeus*	*faber*	-	-	-	*	-	-	-