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Photo: Adrian Brown

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SUMMARY

The abundance of the western blue groper (WBG), *Achoerodus gouldii*, was examined in the nearshore rocky reef areas on the western and northern coasts of Kangaroo Island, which is near the eastern limit of the species' geographic range. Adult males occupied a home range which at several sites was estimated to vary from 4 000 to 16 000 m^2. Females and sub-adults are site-attached and swim in loose aggregations. The use of transect lines of 100 m with which a diver sampled an area of 500 m^2 of the substratum with 5-8 replicates was found to be an appropriate sampling strategy to estimate abundance of sub-adult blue groper 20-60 cm size with adequate precision, but not enough for the less abundant juveniles and adults. Densities of juveniles (<20 cm size) ranged from 0.1 to 0.4 per 500 m^2 at most sites but were a hundred times higher in a shallow sheltered site at Penneshaw. Sub-adult densities ranged from zero to 5.7 per 500 m^2 and tended to decrease with increasing distance from the western end of the island. Adult densities (>60 cm size) ranged from zero to 1 per 500 m^2 and also declined in density with increasing distance from the Western end of the island.

INTRODUCTION

The western blue groper (WBG), *Achoerodus gouldii*, is found on the exposed coasts of southern Australia from Cape Leeuwin, W.A. to Victoria but is rare east of the River Murray mouth. Little is known of the biology of the species, but much of it can be inferred from that of the eastern blue groper (*Achoerodus viridis*), reviewed by Gillanders (1999). The little that is known is as follows. From a few samples Glover (1967) estimated that WBG is 40 cm long at 8 years, 60 cm at 15 years and 80 cm at 25 years. This may represent optimum growth rates because a 72 cm fish from Pearson I. was aged at 63 years (unpublished data). These age-length data were obtained from scales and otoliths and must be considered tentative until validated. The WBG is believed to be a protogynous hermaphrodite attaining sexual maturity at about 15 years when it changes from greenish colour to blue (Glover 1967). Dietary studies in progress by the first author show that crabs, smaller crustaceans, sea-urchins and molluscs mainly comprise the diet. Feeding preference experiments showed that crabs are highly preferred followed by other crustaceans, sea-urchins and abalone. A male WBG is site-attached and wanders over a home-range of up to 8000 m^2 in the Investigator Group. The WBG, like other wrasses (Shepherd and Clarkson 2001), may play a key role in coastal ecosystems by controlling the abundance of crabs (which predate on small abalone), and sea-urchins (which consume epibenthic macroalgae).

The reported annual catch of WBG in 1999/2000 was 1 t taken in the eastern great Australian Bight, but there are no records of discards, or of the quantity recorded as 'mixed species'. These figures do not include amounts reported by Commonwealth-

only licence holders working outside State waters. Recreational fishers have a daily bag limit of 2 WBG per person per day in West Coast waters (K. Jones pers.comm.)

The current status of WBG in South Australian is unknown. The species is listed in the 'Lower risk – conservation-dependent' IUCN red list category by the Australian Society for Fish Biology (Crook 2001), and was reported by Johnson (1982) to have markedly declined from spear-fishing in the previous decade. Recent studies by the first author in the eastern GAB show that the species is abundant on off-shore islands, but its abundance on mainland coasts is not known. A recent survey by one of us (SAS, unpublished data) at 6 sites on southern Yorke Peninsula recorded few juveniles and no adults.

This survey was undertaken to estimate abundance and size distributions of adults and juveniles of WBG on Kangaroo Island. In addition we obtained data on habitat and the abundance of other reef species at the same sites; these latter data will be presented elsewhere. The survey was largely restricted to the north coast of the Island, where the rocky coast below water falls steeply to a sandy seabed at a depth of 6-12 m according to site some 10-40 m from shore. Water clarity was high (usually 15-20 m) permitting both snorkelling and diving techniques to record data.

METHODS

Our surveys were carried out from 28th April 2002-5 May 2002. We used the visual census technique along transect lines to estimate abundance of fish and estimated sizes of individuals visually. Six divers received training beforehand in estimation of sizes underwater. The diver swam , by snorkelling or with SCUBA, along a 100 m transect line or two 50 m calibrated surveyor tapes set end to end (the sampling unit) and parallel to the coast and recorded on a slate the size in 5 cm categories of all species seen within a swathe 5 m wide. On occasions the observer on the return searched for juveniles that may have been missed but we did not attempt to record cryptic species. Replicate transects were set sequentially and systematically along the coast over the maximum distance possible (600- 1200 m) in order to estimate, where possible, the size of the home range of adults. Two divers used ocean kayaks to enable divers to paddle up to 800 m from the point of entry in order to maximise coverage of the coast. We estimated the average width of rocky bottom between low tide mark and the rock-sand boundary for sites surveyed and so in several cases calculated the area of the home range for individual males by recording the approximate length of coast which they occupied and the observed junctions with neighbouring territorial males. Surveys were conducted at 9 sites along the north and west coasts of KI. and at its eastern extremity (Fig. 1).

Habitat substratum characteristics were noted, an index of exposure to swell subjectively estimated, and the dominant canopy algae recorded along the transect line on sloping or horizontal rock in terms of average percentage cover.

RESULTS

Kangaroo I. habitats
At West Bay and Cape Willoughby gneissic rocks form the subtidal and exposed coastal substratum, and along the north coast metasediments of the Kanmantoo

Group, with distinctive layering of black biotite and grey quartz-rich bands are exposed on the shore and subtidally, and form numerous fissures and crevices (Daily et al. 1979, Short and Fotheringham 1986).

The western and southern coasts are exposed to strong prevailing SW swell, whereas along the north coast there is a gradient of exposure declining from strong at the western extremity to weak at Hog Point, Penneshaw, and increasing slightly again at the eastern extremity, Cape Willoughby. At the western extremity the coastal cliff falls precipitously to a depth of 10-12 m some 5-20 m offshore whereas at the eastern end the rocky shore may terminate abruptly in sand at shallow depths some 5 –50 m from shore according to location.

Algal dominants reflected the gradient in water movement from west to east. At the western end of the island species adapted to strong water movement, *Cystophora siliquosa, C. moniliformis and Caulerpa* spp., have relatively high cover, whereas in more sheltered areas calmer water species, *Cystophora subfarcinata, C. monilifera* and *Sargassum fallax,* become dominant. (*Ecklonia* is a somewhat ambiguous indicator of strong water movement). Total algal cover was generally 80-100% on horizontal and sloping substrata.A summary of topographic and habitat features of the study sites and algal dominants are given in Table 1.

Abundance of blue groper

Abalone divers and fishers provided some anecdotal information on the distribution of WBG to guide our surveying. They reported that adults were mainly found west of Stokes Bay on the north coast of the Island and west of Seal Bay on the south coast. East of those bays there were mainly juveniles and sub-adults. Fishers suggested that light fishing of WBG occurred at popular rock fishing sites on the Island, and they also reported an abundance of juveniles in shallow rocky habitat in American River.

Data for all sites (Table 2, Fig. 2) are presented in three length classes: juveniles (< 20 cm) the size class adopted by Gillanders (1997) to represent mainly 0+ aged individuals of the eastern groper; sub-adults or imature (20-60 cm) ; and adults (>60 cm). Adult WBG were most abundant at the western end of the Island and were associated with deeper reefs exceeding 10 m depth. Sub-adults were abundant at some sites on the north coast at depths of 5-10 m but were uncommon at most sites. At those sites where they were common, we noted that sub-adults and adults frequently swam in small schools of 3-5 individuals. Juveniles were rare at all sites, except inside the breakwater at Penneshaw where we recorded very high densities (~75 per 500 m^2) in a shallow (1 m depth) very sheltered area of algal-dominated rocky reef.

A size frequency distribution by sex for all sites combined (Fig. 3) shows that juveniles were rare at all sites except within the Penneshaw Breakwater. Sexual maturity is apparently attained in the size range 50-70 cm.

Estimates of the size of the home range for adult male WBG were made at West Bay, Harvey's Return and Snug Cove. At West Bay we encountered only one territorial male in the inner part of the bay with a range size of ~16 000 m^2. At the other sites males exclusively occupied about an 80-120 m section of the coast and the mean range size was 4500 m^2 (s.e. 700 m^2; N=6). These estimates are likely to be conservative, given that our observations were made only over a brief period of time.

Table 1. Topographic and habitat features of study sites on Kangaroo Island, ordered from west to east. Exposure index in relation to swell is: 4 - strong; 3 - moderate; 2 - sheltered; 1 - very sheltered. Average percent cover of algal dominants (canopy species) is given.

Site	Exposure To swell	Substratum	Location of transects	Algal dominants
West Bay	3.5-4	Gneissic sheets, blocks 5-10m diam. Few crevices.	On SE side of bay starting 50 m from beach to point 750 m toward SW	*C. siliquosa 35%, C. subfarcinata 10%, C. moniliformis 25%, Caulerpa* spp. 20%
Harvey's Return	3	Layers and sheets of folded metasediments	Starting on rocky bottom on each side of inlet and going for 450 m east and west	*Ecklonia 30% C.siliquosa 30% C.moniliformis 10%,* remainder turf spp.
Snug Cove	3	with abundant fissures and crevices	Starting on rocky bottom near entrance to inlet and going for 600 m east and west	E*cklonia 30% C.siliquosa 25% C.moniliformis 10% Acrocarpia 30% Caulerpa* spp 5%.
King George Beach	2.5	As above	Starting on rocky bottom at the entrance to inlet and going 250 m east and west.	*Ecklonia 10%, C.moniliformis 10% , C. monilifera 35%, C. subfarcinata 40%. Amphibolis* on sand
Stokes Bay	2	As above	Starting on rocky bottom west of shacks and going 1.2 km west	*Ecklonia 5%, C. moniliformis 5%, C. monilifera 40 %, C. subfarcinata 35%, Caulerpa* 5%.
Cape Cassini	2	As above	Starting on rocky bottom at rocky point where road ends and going 400 m east and west	*Ecklonia 5%, C.siliquosa 5% , C.moniliformis 10%, C. monilifera 50%, C. subfarcinata 20%, Acrocarpia 10%*
Hog Point, Penneshaw	2 (-2.5?)	Blocks (1-2 m) and boulders going to sand at 5 m depth	Rocky bottom in front of penguin rookery surveyed over 400 m	*Ecklonia 30%, C.siliquosa 20%, C.moniliformis 20%, C. monilifera 20% , Sargassum fallax 10%*
Penneshaw Breakwater	1-2.5	Blocks to 1m diam. Abundant crevices. Sandline at 7m	100m surveyed along inside and outside of breakwater.	As above
Moncrieff Bay	2.5	Blocks (1-2 m) and boulders going to sand at 5 m depth	Rocky bottom at southern end of bay 250 m each side of beach	*Ecklonia 5%, C.siliquosa 40% C.moniliformis 15% Acrocarpia 20%, ,C. intermedia 10%, Sargassum fallax 10% ,*
Windmill Bay	3.5	Gneissic sheets and blocks (1-5 m). Few crevices	From Devil's Kitchen to north and NW side of Bay for 800 m	*Ecklonia 5% , C.moniliformis 45% , C. intermedia 10%, Acrocarpia 40%*

DISCUSSION

This study of WBG is important because it provides the first information on the abundance of a species protected in Gulf waters. Moreover, the study was carried out near the eastern end of the species' geographic range, so might be expected to provide

clues about factors limiting population sizes in South Australia. So far the data generally accord with the anecdotal information supplied by the Kangaroo I. abalone divers about WBG distribution.

Table 2. Density (numbers.500 m^{-2}) of juvenile (<20 cm), subadult (20-60 cm), and adult groper (> 60 cm) at 9 sites on Kangaroo I. N = number of replicate 500 m^2 samples. Standard errors are in brackets.

Site	N	Juveniles (s.e.)	Sub-adults (s.e.)	Adults (s.e.)	Total
West Bay	7	1.0 (0.4)	0.21 (0.14)	0.79 (0.20)	2.0 (0.6)
Harvey's return	9	0.44 (0.38)	5.72 (0.91)	0.73 (0.33)	6.9 (1.0)
Snug Cove	12	0.17 (0.17)	3.96 (0.69)	0.96 (0.17)	5.1 (0.7)
King G. Beach	6	0	0	0	0
Stokes Bay	12	0.13 (0.05)	1.00 (0.34)	0.08 (0.08)	1.2 (0.5)
Cape Cassini	8	0.16 (0.16)	2.44 (1.07)	0	2.6 (1.2)
Hog Point	4	0	2.5 (0.83)	0	2.5 (0.8)
Penneshaw breakwater	1	~75	0	3	~78
Moncrieff Bay	6	0.17 (0.17)	1.33 (0.45)	0	1.5 (0.5)
Windmill Bay	8	0	0	0.13 (0.12)	0.13 (0.12)

Perusal of the density data set (Table 2) shows that this species is sparse, and that, at the densities of sub-adults encountered, 5-8 replicate 100 m transects are necessary for precise estimates of density i.e. to reduce standard errors to < 30% of mean values per site. Equally precise estimates of juvenile and adult densities would require at least twice as many replicate transects per site. Examination of variance:mean ratios for sub-adult density data per site give values ranging from 0.9 to 1.5 indicating that at the scale of the sampling unit (100×5 m) individuals are randomly distributed or weakly aggregated. Hence 100 m transect lines are an appropriate unit for sampling sub-adult WBG.

Our data on sex ratios are subject to two sources of error. Sex determination was subjectively based on colour (green coloured individuals are sexually immature, blue greenish individuals are female, and dark blue individuals are male). First, the assumption that colour is a good criterion for sex determination needs verifying by gonad dissection of a sample, and second, even if colour recognition of sex proves valid, there is the possibility of diver error.

A comparison of our density data with that available for the eastern blue groper is of especial interest. Gillanders and Kingsford (1993) and Gillanders (1997) recorded high densities of juveniles in seagrass beds and in shallow sheltered reef habitats. The highest densities found or reviewed by them (60-127 per 500 m^2) are in the same range as our single estimate inside Penneshaw breakwater. Anecdotal evidence from fishers of Kangaroo I. was that juvenile WBG are also common in sheltered algal forest habitats in American River and Nepean Bay. If this proves to be true then WBG, like its eastern counterpart, may recruit largely in sheltered rocky habitat. This raises the possibility that WBG populations on Kangaroo I. are limited by lack of habitat for the recruitment of juveniles, especially at the western end of the island where we recorded very few of them.

Our data show that total densities of 2-7 per 500 m^2 are common on parts of the north coast, but these densities are substantially lower than total densities of 7-27 per 500 m^2 recorded by Gillanders (1997) on exposed coastal reefs of NSW. We received much anecdotal evidence that recreational fishers fishing from shore or on boats occasionally take groper incidentally to targetted reef species. A low incidental fishing mortality may be enough to keep a slow-growing recruitment-limited species such as WBG in very low densities, even though our evidence on the abundance and size of other reef species at our census sites did not suggest intense fishing pressure on rocky shores.

Our data are also curious in that they show a mismatch between densities of sub-adults and adults. The number of adults at a site appears to be independent of the number of sub-adults or juveniles there.

The study suggests a number of hypotheses which merit further investigation around Kangaroo I. These are:

1. WBG larvae settle and survive best in sheltered rocky areas. This can be further examined by surveying sheltered rocky sites in American River, Bay of Shoals, parts of Nepean Bay and sheltered parts of Hanson Bay and Vivonne Bay. It is worth noting in this connection that the eastern blue groper migrates as a juvenile from inshore sheltered habitat to adult habitat on more exposed reef.

2. With increasing size juvenile WBG migrate to deeper and more exposed waters, where adults appear to be largely restricted. Of especial interest is the possibility that sub-adult WBG migrate from the eastern to the western end of the sland. Such movement could be tested by mark-recapture experiments.

3. The west-east gradient in density of sub-adults and adults along the north coast of Kangaroo I. from Harvey's Return eastward may be associated with declining quality of the near-shore habitat in terms of depth range, water movement or available food. This could be examined by studies of food and feeding behaviour.

At present nothing is known of the distribution or abundance of WBG on the south coast of the Island. This also needs to be examined to complete the picture on the species' distribution around Kangaroo Island.

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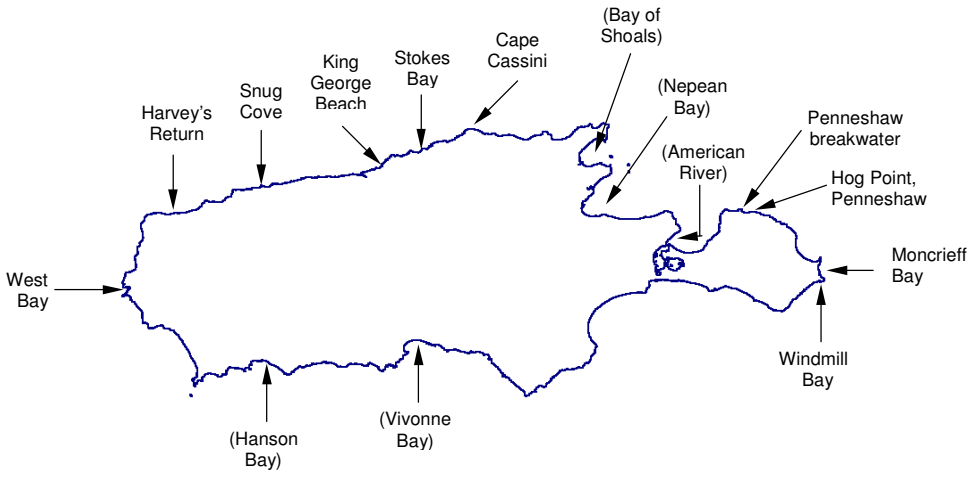

Figure 1. Map of kangaroo Island with sites referred to in the text.

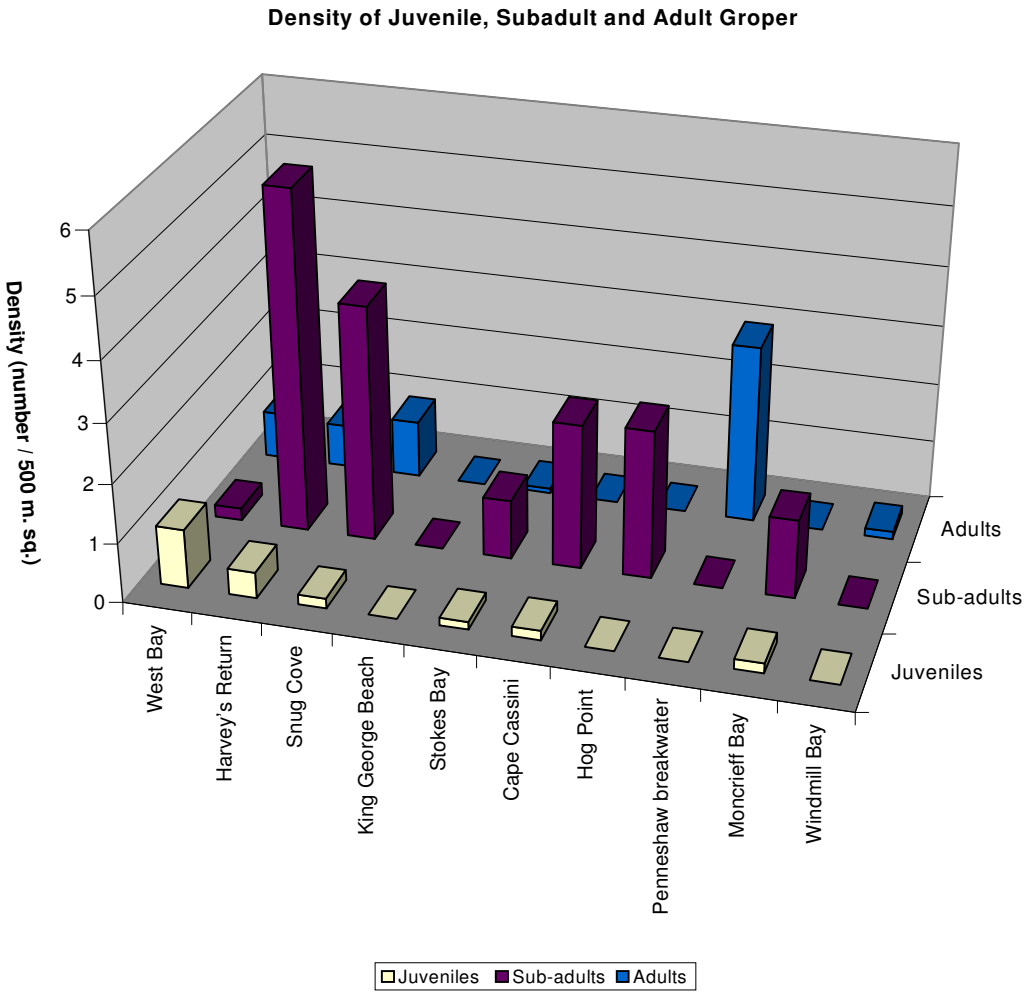

Figure 2. Density (in numbers. 500 m^{-2}) of juveniles (<20 cm), sub-adults (20-60 cm), and adult (> 60 cm) blue groper on the north coast of Kangaroo Island ordered from west to east. Data for juveniles inside Penneshaw Breakwater are omitted (see Fig. 3).

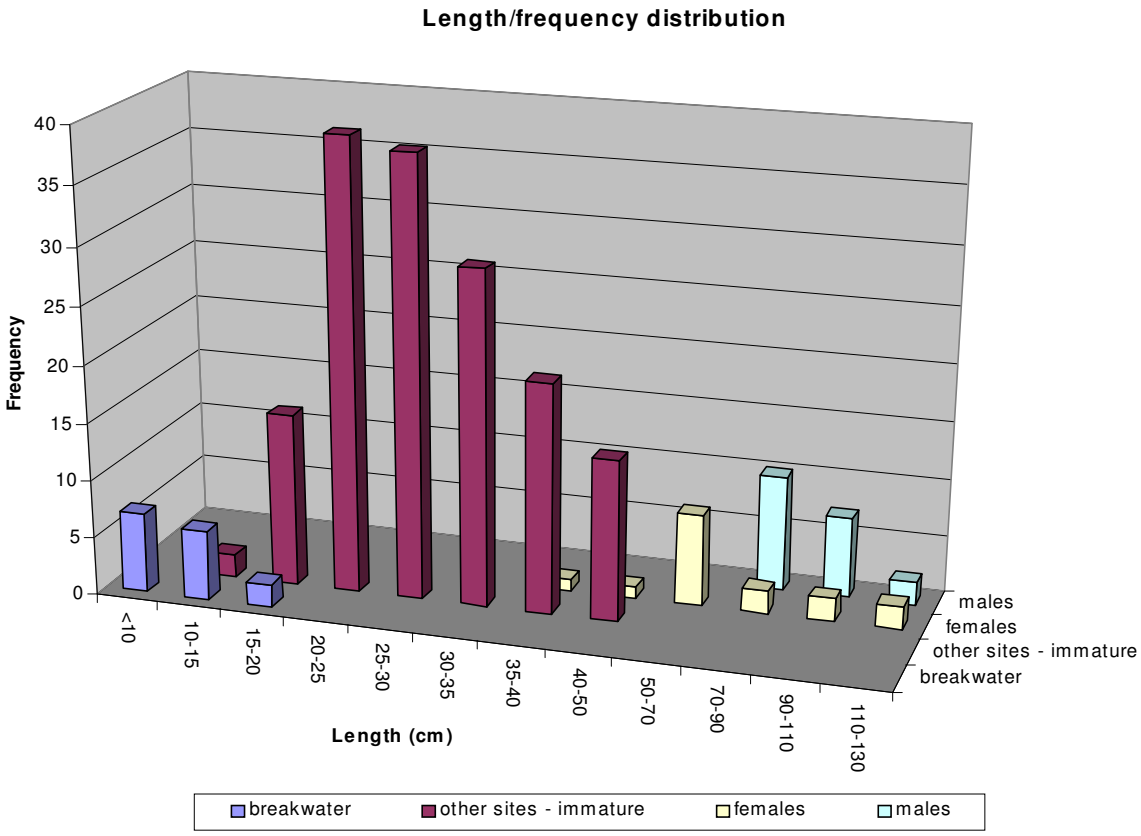

Figure 3. Distribution of sizes of juvenile, sub-adult (i.e. immature), and adult male and female blue groper for (a) Penneshaw Breakwater and (b) all other sites combined.