The distribution patterns of exploited girellid, kyphosid and sparid fishes on temperate rocky reefs in New South Wales, Australia

MICHAEL KINGSFORD

School of Marine Biology and Aquaculture, James Cook University, Townsville, Queensland 4811, Australia
(Michael.Kingsford@jcu.edu.au)

SUMMARY: Girellids and sparids rank highest as the groups of fishes taken by rock fishers in New South Wales, Australia. Rapid visual counts that were stratified by depth and transects that were stratified by habitat (e.g. kelp forest and urchin grazed barrens) showed that girellids were most abundant in shallow water (< 3m deep). A few aggregations (primarily *Girella tricuspidata*) were found in waters up to 15 m deep. No juvenile *G. tricuspidata* were observed on reefs, all of the fish in counts were greater than 200mm SL. In contrast, *G. elevata* of all size classes (30-300mm SL) were found in water less than 3 m deep. Almost all *Kyphosus* (98%) were in shallow water. Sparids (57%) were found in shallow water, although some (*Pagrus auratus*) were only found in deep or mid-depth strata. Girellids, kyphosids and some sparids used the intertidal at high tide. Girellids were observed to feed in the shallows. Juvenile *G. elevata* (30-70 mm SL) fed in the intertidal mostly on rocky surfaces, tubeworms and the backs of large limpets (*Cellana* spp.) where algae were abundant. Shallow waters and the intertidal of rocky reefs have probably been underestimated in terms of importance to fisheries.

KEY WORDS: Girellidae, Sparidae, Kyphosidae, temperate reef, depth, habitat

INTRODUCTION

Girellids are the most important recreational fish species taken by fishers on reefs in New South Wales, Australia.¹⁾ Although girellids are found on temperate reefs in Australia, the Pacific coast of North America,²⁾ South America³⁾ and Japan (pers. obs.), there are few data on their ecology. *Girella tricuspidata* are known to recruit to estuaries in large numbers and are thought to move to open coastal rocky reefs as subadults and juveniles,^{4,5)} as for other fishes such as *Achoerodus viridis* (Labridae;⁶⁾). In contrast, *Girella elevata* are rarely found in estuaries. These fish have been collected on rocky reefs⁷⁾ and 60% or more of the diet for fish of all sizes is algae.⁸⁾ Kyphosids (*Kyphosus sydneyanus*) and sparids (*Acanthopagrus australis*, *Rhabdosargus sarba* and *Pagrus auratus*) also rank highly in the catches of fishers and were also considered in this study. Girellids consume considerable quantities of algae, but are omnivorous, *Kyphosus* are obligate herbivores⁹⁾ and sparids are predators.

Studies in temperate waters of California and New Zealand have found that abundance patterns of fishes are often influenced by the presence of different habitat types (review:¹⁰⁾). Habitats are generally distinguished by the type and cover of algae. Sea urchins and limpets have important roles in maintaining areas devoid of algae [*sensu*: 'Barrens' habitat;¹¹⁾ in temperate waters of Australia and New Zealand (review:¹²⁾]. In addition to habitat type, the distribution of fishes often varies with depth on a reef (eg.¹⁰⁾).

The confounding influence of depth and habitat can only be resolved if habitats are found in a mosaic over the same depth range, as for New South Wales,¹¹⁾ and/or habitats are experimentally manipulated. It is also well known that different approaches may be required to look for secretive juveniles versus highly mobile adults. Multiple approaches were used in this study.

The objective of this study was to describe the distribution patterns of girellid, kyphosid and sparid fishes on rocky reefs in New South Wales, particularly the Sydney region. My specific aims were to: (1) describe the depth related patterns of highly mobile fishes using rapid visual counts, because girellids, kyphosids and sparids are generally diver negative; (2) describe patterns of abundance of fishes over a broad depth range where sampling was stratified according to habitat; (3) intensively sample the intertidal at high tide to describe the utilization of this area by fishes. Some girellids (eg. *Girella nigricans*;²⁾, *Girella laevis*;³⁾) use shallow areas including rock pools, but sampling was not done at high tide in these studies.

MATERIALS AND METHODS

Taxonomy was according to Hutchins and Swainston.¹³⁾

Rapid visual counts of girellids and sparids

Rapid visual counts are useful for estimating the abundance of large fishes that are typically diver negative or are found

in large groups that are well separated (eg.¹⁰). In New South Wales large herbivores (eg. *Girella tricuspidata*) and some carnivores (eg. *Acanthopagrus australis*) behave in one or both of these ways. Counts were stratified by depth [shallow (0-3m), mid (4-10m), deep (11-20m)] and 5x3min replicate counts were done at each depth. In a three-minute period I swam a distance of approximately 45m. Fishes were counted at four random times between May 1987 and May 1988 at three locations along the coast of NSW: Botany Bay (34°0'S, 151°10'E), Bass Point (34°30'S, 151°50'E) and Jervis Bay (35°10'S, 150°30'E). Two sites separated by 0.5-1km were sampled at each location. Data were analysed using a 4-factor partially-hierarchical ANOVA; factors: depth (fixed), time, location and site (nested within location). The latter factors were treated as random. Data were log (x+1) transformed.

Fish counts stratified by habitat

Most of the habitats were described in¹¹ and were classified as follows: 'Shallow broken rock' (0.5-2m), the 'Fringe' (2-3m), urchin grazed 'Barrens' (4-12m), *Ecklonia radiata* dominated kelp forest (4-12m) and 'Deep reef' (15-22m). Fishes, especially secretive juveniles, were counted using the transect method. Transects measured 25x5m (n=6). A 25x5m transect size was chosen because they fitted easily within habitats and gave usable average values for a variety of species of fishes. Transects were non-overlapping. A detailed search was made under all boulders and/or amongst kelp for more cryptic fishes (eg. juveniles).

Fishes were counted in 5 habitats and at two sites separated by 200m at Cape Banks (34°0'S, 151°10'E). Counts were done at two times: January 1988 and May 1988. Patterns of abundance for fishes in shallow broken rock habitat were extracted from maps of the intertidal and immediate subtidal as described below. The standard length (SL) of fishes was estimated by eye, this method was calibrated periodically when fishes were collected for other reasons. Fishes were considered to be juveniles if they were less than 100mm SL.

Fish counts in the intertidal

Two areas of the intertidal were mapped near Cape Banks and the position of fishes were plotted onto the maps: area A = 8000m² and area B = 6250m². Transect data (as for previous section) were extracted from maps using an acetate overlay of a 25x5m transect, the start point of the transect was determined using random numbers on the gridded maps. All transects were non-overlapping. The low tide mark determined the lowest side of each study area. The positions of fishes were plotted at area A on 7 occasions and 5 times at area B, due to bad weather (Table 1). Behavioural observations were made on snorkel for small

G. elevata; these fish were followed for 35 to 94 seconds. The bite rates of fish (per minute) were recorded and the substratum on which they were feeding. Observations were made within an area of 1ha.

Table 1 Abundance of reef fish in the intertidal at high tide (125m², n=6 transects); mean (SE). ND denotes no data collected due to rough seas.

Date (mo-yr)	11-90		12-90		02-91		04-91
Area	A	B	A	B	A	B	A
<i>Girella tricuspidata</i>	0.2 (0.2)	0.0	2.7 (1.9)	1.3 (1.3)	0.3 (0.3)	1.3 (1.0)	1.8 (1.6)
<i>Girella elevata</i>	0.8 (0.4)	4.3 (2.5)	0.3 (0.3)	5.0 (2.4)	0.0	8.0 (3.1)	0.0
<i>Kyphosus sydneyanus</i>	0.0	0.0	0.0	1.2 (1.2)	0.5 (0.5)	0.3 (0.3)	0.6 (0.4)
<i>Acanthopagrus australis</i>	0.3 (0.3)	0.0	1.3 (1.0)	0.0	0.5 (0.5)	0.3 (0.3)	0.6 (0.4)
Date (mo-yr)	04-91		06-91		12-91		04-92
Area	B	A	B	A	B	A	B
<i>Girella tricuspidata</i>	ND	5.0 (3.0)	ND	8.0 (6.0)	12.0 (11.0)	5.0 (4.0)	1.2 (0.5)
<i>Girella elevata</i>	ND	0.7 (0.7)	ND	2.0 (1.2)	3.3 (2.0)	1.3 (0.8)	4.3 (2.4)
<i>Kyphosus sydneyanus</i>	ND	0.0	ND	1.7 (1.3)	0.0	0.0	0.0
<i>Acanthopagrus australis</i>	ND	0.7 (0.4)	ND	0.3 (0.2)	0.2 (0.2)	1.3 (0.6)	0.0

RESULTS

Rapid Visual Counts of Sparidae, Girellidae and Kyphosus

Girellids (90%, n=1093) and *Kyphosus sydneyanus* (98%, n=43) were most abundant in very shallow water (Fig. 1). This pattern was consistent among times, locations and sites. On some occasions few fish of a given species were found in the shallows. This suggested that all of these species move over spatial scales greater than those addressed in this study (ie. >1km). Variation in abundance resulted in a depth x location x time interaction. *Girella tricuspidata* (n=602, 200-350mm SL), *G. elevata* (n=489, 30-300mm SL) and *G. zebra* (n=9, 100-340mm SL) were observed in counts.

Sparids were found at all depths on reefs, but the greatest percentage of fish was found in shallow water (57%, n=490, Fig. 1). ANOVA detected differences in the rank of sparid abundance at locations among times and significant differences were found among sites within times. The percentages of fish found at shallow, mid and deep strata were as follows: *Acanthopagrus australis* (67, 16, 17%, n=353), *Rhabdosargus sarba* (42, 25, 34%, n=101), *Pagrus auratus* (0, 29, 71%, n=35).

Most of the *A. australis* and *R. sarba* were juveniles (SL: 240-350mm, 200-300mm respectively), while the *P. auratus* were primarily juveniles (70-140mm SL).

A high proportion (30-70%) of the catch by recreational fishermen in the Sydney area were *G. tricuspidata* and *A. australis*.¹⁾ The fishes they caught were of a similar size

Fig. 1 Abundance of girellid and sparid fishes at different depths, locations, sites and times, mean $\pm$ SE. Results of ANOVAs: Girellidae: a depth $\times$ location $\times$ time interaction was significant (df 12, 18, $F=3$, $p<0.025$); Sparidae: a location $\times$ time (df 6, 9 $F=8.98$, $P<0.01$) and site (location) was significant (df 3, 9, $F=10.8$, $p<0.01$).

range [mean SL (range): *Girella* spp. 330mm (130-480mm, $n=181$), *A. australis* 240mm (100-400mm, $n=91$)] to those

observed in shallow water in this study (for sampling design see¹⁾).

Abundance patterns of fishes in subtidal habitats

Girellids were abundant in the study area. In general, patterns of abundance were consistent among habitats and times. *Girella elevata* were only found in shallow habitats (Fig. 2). Very high numbers of these fish were found and a high proportion of them were juveniles (75% < 70mm SL). *Girella tricuspidata* were observed outside of transects (see section: 'Rapid visual counts of girellids and sparids').

Abundance of fishes in the intertidal at high tide

Great numbers of girellids were observed grazing and swimming in the intertidal at high tide (Table 1). Large groups of *Girella tricuspidata* and *Girella elevata* were observed feeding on tufting algae, particularly where solitary ascidians ('cunjei' *Pyura stolonifera*) and/or *Ulva* covered a large percentage of the substratum (pers. obs.). All of the *G. tricuspidata* were over 250mm SL and large *G. elevata* were 150-300mm SL. Juvenile *G. elevata* (Fig. 3) were observed feeding at mean bite rates of 6.9 bites per min (SE=1.6; $n=29$ fish; 30-70mm SL). Fifty-eight percent of bites were on rock, 28% on tubeworms (*Galeolaria*), 9.7% on the backs of limpets (*Cellana* spp.) and 4% on solitary ascidians and algal turf. Recruitment of juvenile *G. elevata* varied greatly among times; a mean density of 9 recruits per 125m² was recorded in 1988 (Fig. 2) and was much higher than mean densities of recruits recorded in 1990, 1991 and 1992 (1.0, 2.2, 1.0 recruits per 125m² respectively).

Large and small predators were observed in the intertidal. *Acanthopagrus australis* (250-300mm SL) were seen in groups of up to six individuals in <0.5m of water, but only small numbers of these were seen.

Fig. 2 Abundance of two species of fishes in 5 habitats, two sites and at two times. S=shallow broken rock, F=fringe, B=barrers, E=*Ecklonia* laminarian forest, D=deep reef, mean $\pm$ SE.

DISCUSSION

There were great differences in the representation of girellids, kyphosids and sparids with depth. The herbivores (girellids and kyphosids) predominated in shallow water. Although herbivorous fishes are common at temperate latitudes,^{14,15,16} descriptions of their distribution patterns are limited despite their importance to recreational and commercial fisheries. Some taxa showed great variation in abundance among times (eg. *Girella tricuspidata*) indicating that they have poor site fidelity and appear to move around areas of reefs at spatial scales of over a kilometre, this concurs with casual observations by fishers.

There is a poor appreciation of how fishes utilise intertidal areas of rocky reefs in temperate regions. In my study, great numbers of girellids were found in the intertidal at high tide. Moreover, predatory *Acanthopagrus australis* were found in the intertidal. It cannot be assumed, therefore, that the effects of piscine herbivores and predators are negligible in the intertidal. For example, Parry¹⁷ argued that *Notolabrus fucicola* adults were a potentially important predator on limpets in the intertidal of Victoria. Treatments that include fish removals are required where problems concerning predation or grazing in intertidal areas are to be addressed.

Of relevance to managers, there are two categories of girellids and kyphosids. *G. tricuspidata* recruit to estuaries⁴) and move to and from the open coast as adults.¹⁸) In contrast, *G. elevata* and *Kyphosus* (pers. obs.) recruit to shallow water on rocky reefs and occupy the same habitat as adults. The sparids *A. australis* and *Rhabdosargus sarba* recruit in large numbers to estuaries and move to and from coastal reefs as adults. *Pagrus auratus* appears to recruit to both reefs and estuaries (pers. obs.). Although only juveniles were observed at mid and deep strata on reefs (and this has been my experience over 14 years), adults and juveniles are common on reefs in New Zealand.¹⁹)

In New South Wales, girellids and sparids (especially *A. australis*) rank as the greatest part of the catch taken by recreational rock-fishermen.¹⁾, these groups abound in shallow water (<3m deep). Hence, management policies that are concerned with the protection of coastal resources should consider the importance of shallow water habitats. Furthermore, this conclusion may be generally applicable to girellids and kyphosids for other temperate regions (eg.¹⁶).

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