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A Comparison of Exploited and Unexploited Seabass *Lates calcarifer* Populations in Two Rivers in the Northern Territory, Australia

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Abstract

Populations of seabass *Lates calcarifer* in the Daly River, which is heavily exploited by commercial and recreational fishermen, and the remote Liverpool River, which has had only very minor exploitation, were sampled concurrently in June/July, 1986, using standard sets of gillnets ranging from 127 mm to 203 mm stretched mesh.

A total of 200 seabass was caught in the Daly River and 172 in the Liverpool River. Damage to nets by sharks and crocodiles at the Daly River resulted in comparatively less actual fishing effort. Adjusted catch per unit effort for the Daly Rive r was 1.8 times that for the Liverpool River.

The size distributions of seabass in the two rivers were not markedly different but differences in age structure consistent with the respective fishing histories were indicated. In the Daly River the precommercial ages 2+ and 3+ were predominant while the Liverpool River catch included higher proportions of the 4 and 5 year olds which form the bulk of the commercial catch in exploited areas. Size-at-age data, although limited, suggested that growth is faster in the Daly River.

Introduction

The large centropomid perch, *Lates calcarifer*, known in much of Asia as seabass and in Australia as barramundi, is widely distributed throughout the Indo-West Pacific. The seabass is catadromous and occupies a great diversity of habitats in both freshwater and saltwater (Dunstan 1959; Moore and Reynolds 1982). In northern

Australia it forms the basis of commercial, recreational and subsistence fisheries. In the Northern Territory, seabass populations are considered to be excessively exploited and management measures have been implemented (Grey and Griffin 1979; Rohan et al. 1981; Grey 1986; Lea et al. 1987).

Because biological research on the species in the Northern Territory was not commenced until 1979 when catch rates had already begun to decline, data on the age (or size) structure of unexploited stocks were not available. However, not all rivers in the Northern Territory have been intensively exploited, and most fishing effort has been concentrated on the major rivers, in particular those close to Darwin (Fig 1).

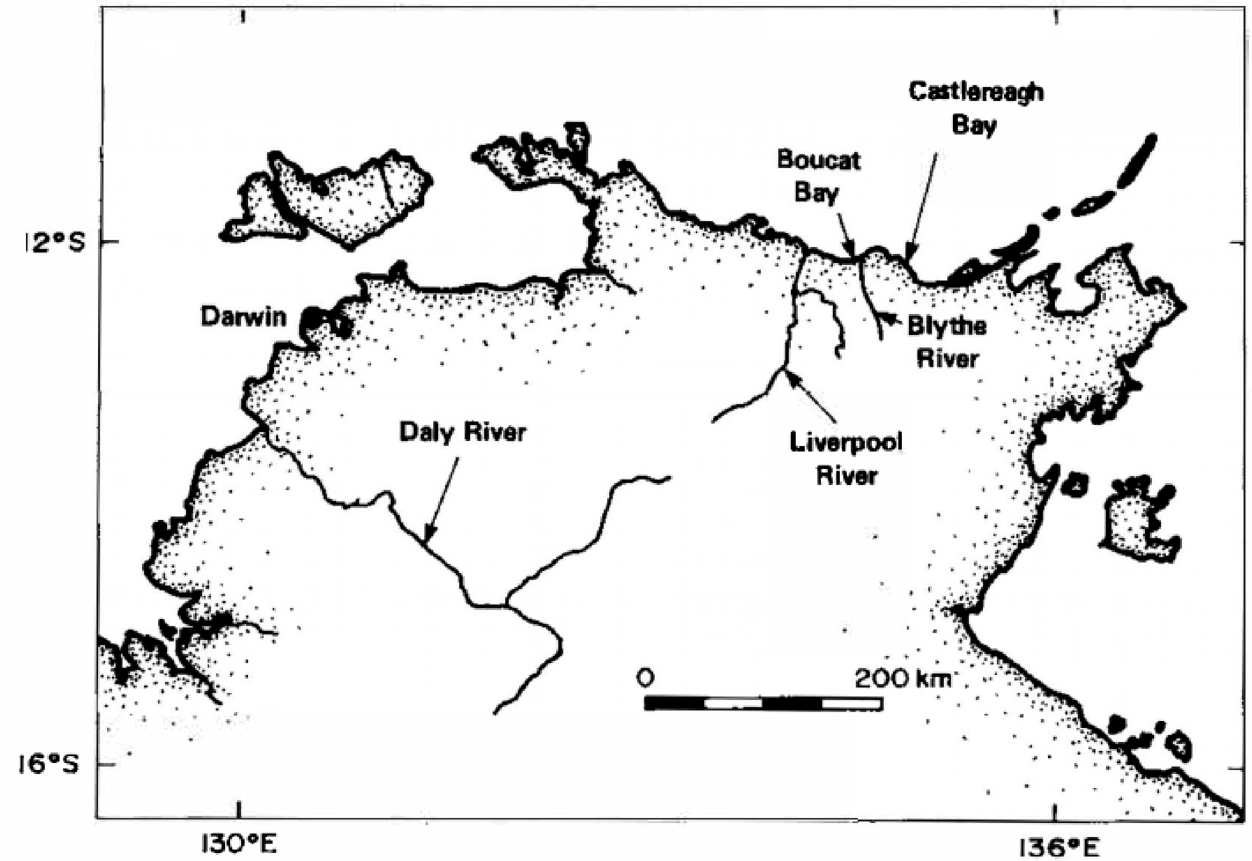

Fig. 1. The study area in Northern Territory, Australia.

The Liverpool River, 500 km east of Darwin (Fig. 1), in the Arnhem Land Aboriginal Reserve, is one of the most remote of the Northern Territory's major rivers. As a consequence it has a history of minimal exploitation of its seabass population by recreational, commercial or subsistence fishermen. The Liverpool River was closed to commercial fishing upstream of its mouth in 1980 and no commercial fishing has been reported in the adjacent area since that time. Since 1977 the catch from the statistical grid in which the river lies has averaged only 0.7% of the total Northern Territory catch (4.6 t) and 0.5% of the total Northern Territory effort (Northern Territory Fisheries Division statistics).

Most of the commercial effort in that grid has been reported from the Boucat Bay/Blythe River area and from Castlereagh Bay to the east (Fig. 1). This situation presented an opportunity to examine the age structure and relative abundance of an unexploited seabass population.

The Daly River, southwest of Darwin (Fig 1), has historically been one of the major seabass producing rivers, yielding an annual average of 93.9 t since 1972 (13% of the Northern Territory catch). Surplus production models suggest that the Daly River has been subject to fishing effort in excess of the optimum since 1978 (Grey 1986).

In most situations, gillnetting (the normal commercial fishing method) has been found to be the most efficient method of sampling. This method has not yet been able to provide for reliable definition of population age structure because of gillnet selectivity. However, it was considered that controlled sampling using standard sets of gillnets with overlapping selection ranges in different rivers would enable comparisions of relative abundance of size and age classes.

Assuming that seasonally influenced recruitment variations (Griffin 1985, 1987) have been comparable, it was hypothesized that these two rivers would have different population structures, with the Liverpool River having a much greater proportion of larger, older individuals.

Study Areas

Sampling was conducted in the brackish tidal sections of the Daly River (44-46 km upstream) and the Liverpool River (34-44 km upstream). The Daly River system has a catchment of 51,800 km^2 and a tidal length of 100 km making it the third largest river in the Northern Territory. Its annual discharge is 4,180 x 10^6 m^3. The Liverpool River has a smaller catchment area of 8,280 km^2 but its annual discharge, by proportion, is quite large at 2,850 x 10^6 m^3 (Anon. 1975).

Although it was planned to undertake sampling in the two rivers at approximately equal salinities, this was not achieved due to radio communication problems. The salinity range at the Daly River was from less than 1 ppt to 5.4 ppt and at the Liverpool River from 6.4 to 17 ppt.

Methods

Sampling was undertaken between 28 June and 5 July 1986. At each location four nets, each of 28 m (headrope) of 127 mm, 152 mm, 178 mm and 203 mm, stretched mesh monofilament, respectively, were set in selected locations and checked at every high and low tide or more often when possible. Nominal fishing effort (in hundred-meter net-days, hmd) was adjusted to allow for losses of fishing time and efficiency due to damage by sharks and crocodiles, debris entanglement and dragged anchors. In the Liverpool River loss of efficiency was minor in comparison with the Daly River where losses were substantial, particularly for the 127 mm mesh net.

Those fish which were in sufficiently undamaged condition were measured (total length, cm), tagged with numbered Hallprint dart tags (Floy FT-2 equivalent) and released. Prior to release, tagged fish were injected with Terramycin (1 ml per 10 kg body weight) to prevent infection of net injuries. Fish which were dead or badly damaged were examined to determine length, sex, maturity, gut contents and general condition. Scales were taken from all fish for age analysis (after Davis and Kirkwood 1984).

Results

At the Daly River, 200 fish were caught and 149 were tagged and released while at the Liverpool River, 172 were caught and 128 tagged and released.

Comparison of catch (numbers), effort and catch per unit of effort (fish/hmd) for each mesh size used (after compensation of effort for reductions of efficiency) at the two locations (Table 1) shows that numerical catch rates were higher in the Daly River than in the Liverpool River.

Examination of the size of fish taken in the four mesh sizes (Table 2) revealed no significant difference between rivers. Comparison of length-frequency distributions for total catches for the two rivers weighted to compensate for differences in actual fishing

Table 1. Catch, fishing effort and catch per unit effort of *L. calcarifer* by river.

Mesh size (mm)	Daly No. fish	Daly Effort (hmd)*	Daly CPUE (No./hmd)	Liverpool No. fish	Liverpool Effort (hmd)	Liverpool CPUE (No./hmd)
127	117	1.01	115.8	109	1.81	60.2
152	57	1.68	33.9	32	1.83	17.5
178	19	1.43	13.3	19	1.84	10.3
203	7	1.37	5.1	12	1.86	6.5
Total	200	5.49	36.4	172	7.34	23.4

*hundred-meter net-days

Table 2. Comparison of mean length of *L. calcarifer* by mesh size.

Mesh size (mm)	Daly No.	Daly Length (cm)	Liverpool No.	Liverpool Length (cm)
127	116	56.7	109	58.4
152	56	64.5	32	68.2
178	18	70.7	18	73.3
203	7	91.3	12	76.0
Total	197		171	

effort (Fig. 2) showed that the mean size of fish from the Liverpool River was significantly greater than from the Daly River (Student's t-test, $p < 0.05$).

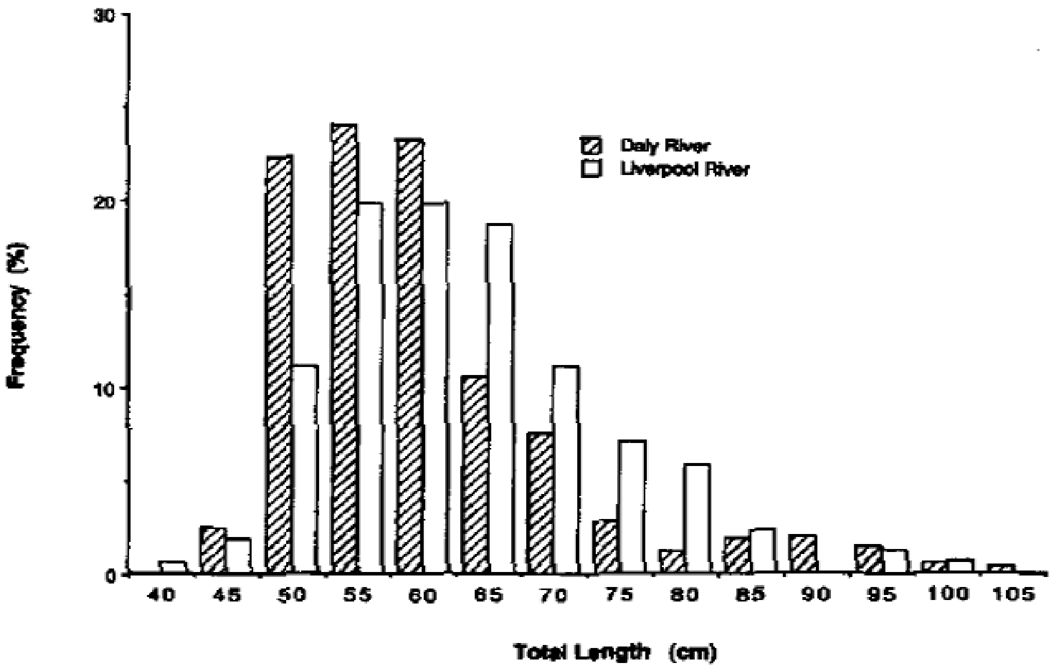

Fig. 2. Grouped length-frequency distribution of *L. calcarifer*, Daly River and Liverpool River, adjusted for fishing effort differences.

The ages of fish were estimated from scales using criteria described by Davis and Kirkwood (1984). Not all scales could be accurately aged, particularly larger fish with ages exceeding 6 years. Nineteen fish from the Daly River and 24 from the Liverpool River could not be reliably aged. There was no significant difference in the size of unaged fish between rivers. When the effort-weighted age-frequency distributions for the two rivers were compared (Table 3) there was a clear and significant difference (Kolmogorov-Smirnov 2 sample test, $p > 0.05$). In the Daly River age 2+ and 3+ fish comprised 78.8% of the weighted sample while in the Liverpool River those ages comprised 47.5%.

For ages 2+ to 5+ which were considered to be adequately sampled by the gillnets used (Table 4), comparison of size at age

Table 3. Age distribution of *L. calcarifer* by river (weighted to equalize fishing effort).

	Daly		Liverpool	
Age	No.	%	No.	%
0+	9	3.3	3	2.0
1+	12	4.4	2	1.4
2+	119	43.6	28	19.1
3+	96	35.2	42	28.6
4+	22	8.1	44	29.9
5+	13	4.8	22	15.0
6+	1	0.4	6	4.1
7+	1	0.4	0	0
Total	273		147	
Unknown	27		24	

Table 4. Size at age of *L. calcarifer* by river.

	Daly		Liverpool	
Age	Total length (cm)	No.	Total length (cm)	No.
0+	49.4	5	56.0	2*
1+	51.3	7	43.5	2*
2+	56.9	74	52.7	27*
3+	59.9	64	59.3	42
4+	70.1	15	64.1	44*
5+	77.4	9	68.5	22*
6+	90.0	1	80.7	6
7+	97.0	1	-	0
Unknown	72.8	19	70.8	24

*Indicated significant differences (Student's t-test, $p > 0.05$)

shows that with the exception of age 3+, fish from the Daly River were larger than fish of the same age from the Liverpool River, (Student's t-test, $p > 0.05$).

Discussion

The most significant result of this study is the difference between the age structures of the two populations. In the Northern Territory seabass fishery, where meshes less than 152 mm (6") are prohibited, the majority of the catch has typically been comprised of 3 to 5-year-old fish with fish becoming vulnerable in their third year. Thus, it is considered significant that the prerecruit or partially recruited age groups are dominant in the Daly River while the Liverpool River has a greater spread of age classes and in particular has a much higher proportion of age 4 and 5 fish which would normally form the bulk of the commercial catch.

The observed differences in size at age suggest that growth of seabass is faster in the Daly River than in the Liverpool River. The fact that there is no difference in size at age for 3-year-old fish could be explained by a proportion of the larger, faster growing 3 year olds becoming vulnerable to 152 mm mesh nets in the commercial fishery. The mean selection length for seabass in 152 mm nets was estimated to be 69.3 cm by Reynolds (1978). Thus, fish greater than the observed mean size for 3 year olds (59 cm approximately) could be expected to have a greater than 30% probability of being caught in 152 mm nets encountered in the commercial fishery.

This study also clearly demonstrates that relative abundance of seabass, as measured by catch per unit effort, is substantially greater in the Daly River than in the Liverpool River. While the situation in the Daly River prior to exploitation can only be speculated upon, it is reasonable to assume an age distribution somewhat similar to that observed by this study in the Liverpool River. If this was the case then it is likely that the effect of fishing has not been to reduce dramatically the numerical abundance of seabass but to convert their biomass to a greater number of younger, smaller fish. Such a population will more efficiently utilize the available resources according to the general principles of additions and removals as summarized by Ricker (1975). It does seem unlikely, however, that these effects would result in an increase in numbers as high as the observed 77% difference between the Daly and Liverpool Rivers. It is possible that differences in biological productivity brought about by geographical differences, such as floodplain area, allow the Daly River to support a higher abundance or density of seabass than does the Liverpool River.

The seabass is a voracious predator sometimes taking prey greater than 50% of its body length and a relatively high incidence of cannibalism has been reported (Davis 1985; Griffin 1985). The observed higher relative abundance of younger age groups (1+, 2+) in the exploited population may be partly due to reduced mortality of juveniles because of the reduced abundance of larger fish which might prey upon them.

The differences in age distribution, size at age and numerical abundance observed in this study are generally consistent with the different fishing histories of the two rivers. Those differences provide support for the assumption that seabass populations respond to fishing in a manner consistent with the underlying principles of the surplus production modelling techniques which have been applied in management of the fishery.

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