

VIRTUAL POPULATION ESTIMATES OF MONTHLY RECRUITMENT AND BIOMASS OF RABBITFISH, SIGANUS FUSCESCENS OFF BOLINAO, NORTHERN PHILIPPINES

A.G.C. del Norte (*1) and D. Pauly (*2)

(*1) Marine Science Institute, University of the Philippines, Diliman, Quezon City 1101 Philippines. (*2) International Center for Living Aquatic Resources Management (ICLARM), MC P.O. Box 1501, Makati, Metro Manila Philippines.

Abstract

The rabbitfish *Siganus fuscescens* (Pisces, Siganidae), is a dominant species of the seagrass beds near Bolinao, northern Philippines, with a fishery catch of 4 t/km² year. Length-frequency samples from various gears were assembled, and combined with growth parameters, a length-weight relationship and monthly catches in weight for analysis using a length-structured form of Virtual Population Analysis.

Results show annual recruitment to occur in two well-separated pulses with the peak months corresponding to observed runs of juveniles. Mean biomass was estimated to be about 2 t/km², a probable overestimate due to the fact that an unknown part of the population lives outside the 24 km² fishing and sampling area.

These results are related to the reproductive, feeding and migratory habits of *S. fuscescens*.

Introduction

Coral reef fisheries - generally multigear operations exploiting multi-species resources - are very important in Southeast Asia, as they contribute about 10-15% of the total Philippine marine catch (Carpenter 1977; Murdy and Ferraris 1980; Smith et al. 1980). However, these fisheries generally overexploit their resource bases and moreover tend to destroy the coral structures upon which they are based (White 1984; McManus 1988).

The Bolinao reef flat fishery reported upon here matches the general pattern alluded to above in that it is conducted with a wide number of gears; on the other hand, it differs from many other coral reef fisheries in that one species, the rabbitfish *Siganus fuscescens* (Pisces, Siganidae, see Fig. 1A) overwhelmingly dominates the catch (Aragones 1987; Campos et al. 1988). Due to this, an important commercial fishery exists both for the juvenile ("padas") and adult ("barangin") stages (Aragones and de la Paz, in press). Note that *S. fuscescens* was misidentified as *S. canaliculatus* in previous contributions based on samples from the Bolinao area (D.J. Woodland, pers. comm.).

Studying the population dynamics of and fishery for this rabbitfish, should lead to an understanding of the fishery as a whole and eventually help in the formulation of management option for this fishery.

Materials and Methods

Bolinao lies on the southwestern tip of Lingayen Gulf in northwestern Luzon, Philippines. The study area, Santiago Island reef flat, is located approximately 16°23' and 16°28' north latitude and between 119°23' and 120°00' east longitude. It covers approximately 24 km² and averages 2 m in depth. The bottom flora is dominated by seagrasses, especially *Thalassia* and *Enhalus*.

On the Bolinao reef flat, *S. fuscescens* is caught primarily by spearfishing, fish corrals, seine and by two types of gill nets (i.e. drive-in and bottom-set gill nets). To estimate total monthly catch, fishing effort and catch rates (CPUE) from these gears were monitored 2-3 times weekly from buyers' daily records from May 1987 to April 1988 (Campos et al. 1988). From these, monthly catches of *S. fuscescens* (in tonnes) were estimated. Aside from spearfishing record, wherein *S. fuscescens* is identified, catches for gill nets and fish corrals were estimated from monthly percentage occurrence of the species in the sampled multispecies catch. Sampling problems prevented data collection of catch estimation from the seine fishery.

The % length-frequency distributions grouped in 2-cm class intervals of each sampled gear were obtained bi-weekly from May 1987 to April 1988, as were the catches in weight.

The individual weights of 1,408 fish were only obtained and used to establish a length-weight relationship of the form:

$$W = aL^b \quad \dots(1)$$

The weight of the length-frequency samples were then estimated by multiplying each frequency by the mean weight of the fish in a given length class (\bar{W}) and totalling over all classes. \bar{W} was estimated for each length class (i) by

$$\bar{W}_i = 1/(L_{i2} - L_{i1}) \cdot a/(b+1) [L_{i2}^{b+1} - L_{i1}^{b+1}] \dots(2)$$

where L_{i1} and L_{i2} are the lower and upper limits of i , respectively, and a and b are as defined in equation (1) (Beyer 1987).

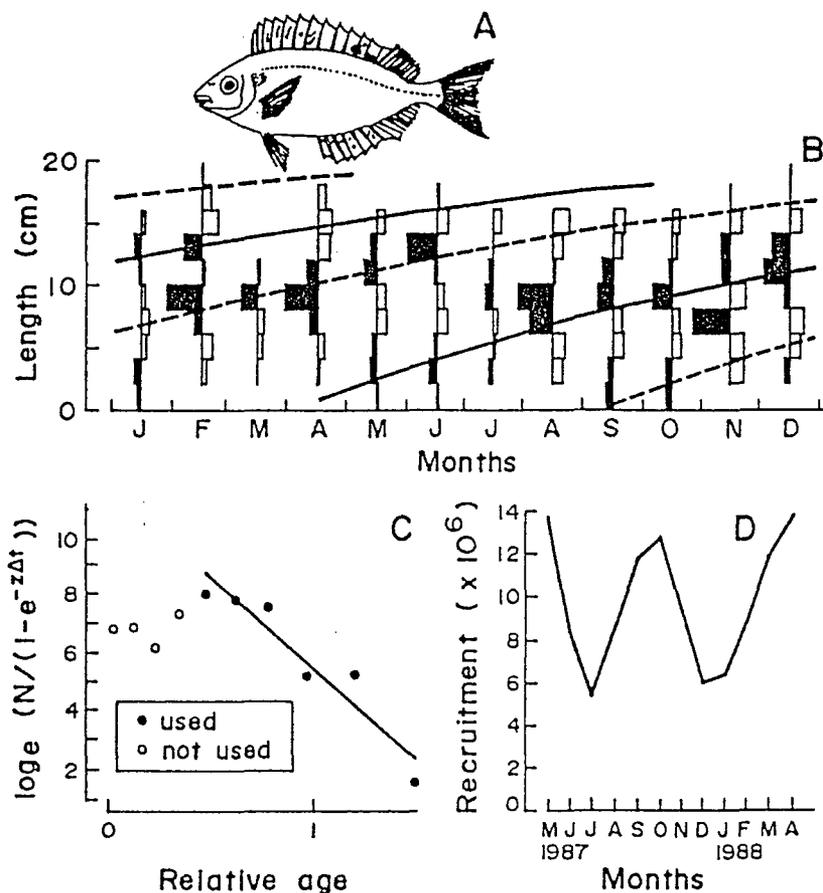


Fig. 1. Basic information on rabbitfish *Siganus fuscescens* (A) off Bolinao, Pangasinan, Philippines. (B) Growth curve ($L_{\infty} = 25$ cm, $K = 0.85$ year⁻¹) superimposed on length-frequency data restructured by the ELEFAN I program. Solid and broken lines refer to the two annual pulses of recruitment identified in D. (C) Catch curve, as used for estimation of Z . (D) Estimated recruitment of *S. canaliculatus* in Bolinao area, May 1987 to April 1988.

Combining the % length-frequency samples, their estimated weights and the absolute catches by each gear allowed computation of absolute number of fish caught by length class and gear. These were eventually combined to obtain, for each month, the total catch of *S. fuscescens* by length class, by all gears investigated here. These monthly catch-at-length data were first used to estimate the growth parameters L_{∞} and K of the von Bertalanffy growth equation using the ELEFAN I program (Pauly and David 1981; Pauly 1987; Gayanilo et al. 1988). Then, using the catch curve routine of the ELEFAN II program (Pauly 1987; Gayanilo et al. 1988), a preliminary estimate of total mortality Z was obtained. An estimate of natural mortality (M) obtained via the empirical equation of Pauly (1980) was then subtracted from Z to obtain a first estimate of fishing mortality (F), since $Z = F + M$.

The monthly catch-at-length data of the growth parameters were then used as inputs to a length-structured Virtual Population Analysis known as "VPA III"

(Pauly and Tsukayama 1983; Pauly 1987), implemented in the Compleat ELEFAN Software (Gayanilo et al. 1988). The VPA III routine of the Compleat ELEFAN package usually requires a long time series (i.e. 5 years or more) of monthly catch-at-length data to run. To overcome this, we repeated the one year series of monthly data at hand, i.e. we entered it as if it were a 5-year time series. Then, we discarded all outputs not pertaining to the period considered here.

Results and Discussion

The growth parameters estimated for *S. fuscescens* off Bolinao suggest the growth curve

$$L_t = 25 (1 - e^{-0.85(t - t_0)}) \dots (3)$$

where the lengths are in cm (total length) and the ages (t) are in years (Fig. 1B). The estimated value of $M = 1.66$ /year and apparent F are very high; of the order of 4 to 5/year (Fig. 1C). The VPA was run with terminal fishing mortalities of $F_t =$

2/year and $F_L = 5/\text{year}$. This yielded similar results and only the output for $F_L = 5/\text{year}$ are reported further below.

The length-weight relationship for S. fuscescens off Bolinao was

$$W = 0.0028 \cdot L^{2.922} \quad \dots (4)$$

where W is expressed in g live weight.

The catch-at-length data derived here are presented in Table 1, while Table 2 presents monthly estimates of rabbitfish recruitment to and biomass over the Bolinao fishing ground, along with the monthly total catch.

The estimates of Table 2 suggest that recruitment of young fish into the Bolinao fishing grounds occurs in two pulses, one in April-May, and the other in October. Siganus fuscescens has two spawning peaks in Bolinao: a major peak around August and September and a minor peak around March, April and May (Aragones 1987). Adults emigrate outside the reef flat to spawn offshore. The early juveniles then return to the reef flat, between March-May and August-September as they shift from a pelagic to an epibenthic phase. This transition does not take more than three

weeks (Hasse et al. 1977). This accounts for the bimodal recruitment pattern derived for the species. The pulses occurring in April-May and October (Fig. 1D) thus coincide with the observed juvenile runs (March-May and August-September) in Bolinao.

Because of the offshore migrations of S. fuscescens, and their recruitment from outside the exploited area, the biomass estimates presented here are overestimates of the stock actually over the fishing ground.

The total Annual catch of S. fuscescens (juveniles and adults) estimated from catches of spearfishing, gill nets and fish corrals on the reef flat was 96.9 t (Table 2). In terms of yield, this is equivalent to 4.04 t/km²/year, while the mean biomass is 1.82 t/km². From these, a turnover rate (P/B ratio) of 2.214 is estimated. This corresponds to a turnover time (reciprocal of turnover rate) of 0.45 years. S. fuscescens reaches size at sexual maturity at 50 mm for males and 56 mm for females (de la Paz and Aragones 1988). Based on the computed von Bertalanffy growth curve, these sizes correspond to an age of about

Table 1. Catch-at-length ($N \times 10^6$) data for Siganus fuscescens from Bolinao, May 1987-April 1988.

Midlength (cm)	1987						1988					
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1	9.3	4.1			59.3	148.4	4.0		9.4			
3	22.3	11.0	34.7	7.9	42.6	99.5	5.2	0.6	10.1	10.5	10.8	10.8
5	20.7	10.5	33.7	11.2	4.2	3.1	173.5	0.9	4.9	16.8	16.9	16.2
7	5.8	3.1	31.8	195.7	13.6	8.4	3.2	0.6	1.3	73.8	12.5	53.0
9	12.2	17.3	83.5	268.7	150.3	178.6	93.4	35.4	22.5	193.6	239.7	107.3
11	81.4	48.1	66.4	72.9	131.1	90.3	48.9	68.9	44.7	50.9	56.6	56.1
13	75.3	124.4	42.2	17.6	20.0	32.1	10.4	62.2	76.1	102.1		6.8
15	17.3	6.0	5.0	0.04	1.5	5.1	14.8	2.4	22.6	1.2		1.5
17		20.0							11.7	0.2		0.02
19								1.2		0.03		

Table 2. Monthly recruitment, biomass and catch estimates of Siganus fuscescens on the Bolinao reef flat, May 1987-April 1988.

Months	Recruitment (10^6)	Biomass (t)	Catch (t)
1987			
May	13.66	44.9	8.02
June	8.46	46.2	10.84
July	5.44	43.1	6.44
August	8.58	46.2	9.33
September	11.76	46.0	7.99
October	12.75	45.1	8.10
November	9.22	44.0	9.36
December	5.99	42.6	7.57
1988			
January	6.34	42.5	7.41
February	8.74	43.0	10.92
March	11.79	40.0	6.10
April	13.59	40.1	4.58

0.4-0.6 years (depending on the exact value of t_0 , an unknown). Thus fish recruited during a given pulse may become the parent of the fish in the next pulse.

This study did not include the catch of the seines, which have mesh sizes of 3 mm in their cod end and which catch newly-settled *S. fuscescens* (of about 2 cm) on the reef flat. Inclusion of these catches would have increased the precision with which we identified the recruitment seasons and allowed for a differential assessment of the impact of the various gears on the whole fishery. We intend to continue our analysis along these lines.

Acknowledgements

This work was financially supported by the Fisheries Stock Assessment-Collaborative Research Support Program (CRSP) under the University of the Philippines' Marine Science Institute. We thank W.L. Campos, C.L. Nanola, R. Reyes and J.B. Cabansag for their assistance in collecting the data. M.L. Palomares provided suggestions in the use of the software. This is UPMSI Contribution No.186 and ICLARM Contribution No. 513.

References

- Aragones, N.V. 1987. Taxonomy, distribution and relative abundance of juvenile siganids and aspects of the padas fishery in Bolinao, Pangasinan. University of the Philippines. 65 p. MS Thesis.
- Aragones, N.V. and R.M. de la Paz. Ecological notes on the juvenile siganid (padas) harvest in Bolinao, Pangasinan. *Micronesica* 22(2). (In press)
- Beyer, J. 1987. On length-weight relationships. Part 1: Computing the mean weight of the fish in a given length class. *Fishbyte*. 5(1):11-13.
- Campos, W.L., J.B.P. Cabansag, A.G.C. del Norte, C.A. Nañola and R.B. Reyes, Jr. 1988. Stock assessment of the Bolinao reef flat fishery: Yield estimates and the use of dominant species in assessing coastal multispecies resources. Unpublished manuscript.
- Carpenter, K.E. 1977. Philippine coral reef fisheries resources. *Philipp. J. Fish.* 17: 95-125.
- de la Paz, R.M. and N.V. Aragones. 1988. Length-weight relationship, growth and the reproductive biology of *Siganus fuscescens* (Mungo Park) and *S. spinus* (Linnaeus) caught off Bolinao, Pangasinan. Univ. of the Philippines, Mar. Sci. Inst. Tech. Rep. 8 p.
- Gayanilo, F.C., Jr., M. Soriano and D. Pauly. 1988. A draft guide to the Compleat ELEFAN. ICLARM Software 2, 65 p. International Center for Living Aquatic Resources Management, Manila, Philippines.
- Hasse, J.J., B.B. Madraisau and J.P. McVey. 1977. Some aspects of the life history of *Siganus fuscescens* (Park) (Pisces: Siganidae) in Palau. *Micronesica* 13(2): 297-312.
- McManus, J.W. 1988. Coral reefs of the ASEAN Region: status and management. *Ambio* 17(3): 189-193.
- Murdy, E.O. and C. J. Ferraris, Jr. 1980. The contribution of coral reef fisheries to Philippine fisheries production. *ICLARM Newsletter* 3(1): 21-22.
- Pauly, D. 1987. A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic invertebrates, p. 7-34. In D. Pauly and G.R. Morgan (eds.) Length-based methods in fisheries research. ICLARM Conference Proceedings 13, 468 p. International Center for Living Aquatic Resources Management, Manila, Philippines, and Kuwait Institute for Scientific Research, Safat, Kuwait.
- Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM* 39(3): 175-192.
- Pauly, D. and N. David. 1981. A BASIC program for the objective extraction of growth parameters from length-frequency data. *Meeresforsch.* 28: 205-211.
- Pauly, D. and I. Tsukayama. 1983. On the seasonal growth, monthly recruitment and monthly biomass of the Peruvian anchoveta from 1961 to 1979, p. 987-1004. In G.D. Sharp and J. Csirke (eds.) Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources, San José, Costa Rica, 18-29 April 1983. FAO Fish. Rep. No. 291. Vol. 3.
- Smith, J.R., M.Y. Puzon and C.N. Vidal-Libunao. 1980. Philippine municipal fisheries: a review of resources, technology and socioeconomics. *ICLARM Studies and Reviews* 4, 87 p. International Center for Living Aquatic Resources Management and Fishery Industry Development Council, Manila, Philippines.
- White, A.T. 1984. Marine parks and reserves: management for Philippine, Indonesian and Malaysian coastal reef environments. University of Hawaii. Ph.D. dissertation.