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TWENTY-FIFTH REGIONAL TECHNICAL MEETING ON FISHERIES

(Noumea, New Caledonia, 14-18 March 1994)

SPINY LOBSTERS

Panulirus penicillatus* and *Panulirus longipes

ON THE ISLE OF PINES (New Caledonia)

GROWTH, MORTALITY AND YIELD PER RECRUIT

(Claude Chauvet and Richard Farman)

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(Claude Chauvet, LERVEM [Laboratory for Research on Living Resources and the Ocean Environment], Université Française du Pacifique, Noumea, New Caledonia and Richard Farman: Economic Development Service, Marine Division, Southern Province, Noumea, New Caledonia)

This paper aims to derive a size at first capture which could be applied to all the species of spiny lobsters harvested in New Caledonia. Such a study requires knowledge of individual growth rates and estimated mortality rates.

On the Isle of Pines, a team of 8 fishermen brings in almost 2/3 of the island's total harvest. This group mainly works on "Nekanmue" atoll.

During the first half of 1991, the team of 8 fishermen filled out logsheets, then, between 10 July and 18 September, a researcher accompanied the team on all its trips. All the spiny lobsters caught were sorted according to species and sex, weighed and then the length of the cephalothorax (Lc) was measured to the nearest 0.5 cm.

Given the objectives, this sample is considered to be unbiased and brief enough that individual growth of the lobsters during the time elapsed would not have affected the demographic picture of the population. Bhattacharya's (1967) logarithmic differences method was used to analyse growth and the results were fitted to a von Bertalanffy (1938) model by the Chauvet (1989) iterative method.

Total mortality rates were obtained by Baranov's logarithmic method (1918) applied to the relative population estimated by the Bhattacharya (1967) method. Natural mortality rates were gleaned from reference sources and supported by the values obtained with the Pauly (1978), Tanaka (1960) and Beverton and Holt (1956) models.

The Ricker (1945) model is used to calculate yield per recruit.

Results

Over a period of 160 days, the group of 8 fishermen working out of Vao harvested 1,590 kg of spiny lobsters, mainly marketed in Noumea. The levels of activity for the 8 fishermen are very uneven. Each excursion involves 4 to 5 people out of 8. The group went out 25 times. On average, each fisherman goes out once every 10 days, but one of them goes out on average once every 6 days, while, at the other end of the scale, another goes out on average once every 7 weeks. (Table I).

During the period from 10/9/91 to 18/9/91, a total of 70 days, a group of fishermen caught 18,346 spiny lobsters whose distribution by species and sex is given in Table II.

Table I: Activity level of the group of 8 fishermen from Vao (Isle of Pines)

	SAMPLE OF 8 FISHERMEN			
Duration from 17/1/1991 to 26/6/1991	**TOTAL (group)**	**Average per fishermen**	**Standard deviation**	**Variation co-efficient**
Fishing time (days x fishermen)	123.0	15.4	8.6	1.79
Total harvest (kg)	1589.0	198.6	156.1	1.27
Yield per excursion (kg per day)	63.6	12.1	3.6	3.37

Table II: Breakdown of harvest by species and sex

	NUMBERS OF EACH SPECIES HARVESTED			
Duration from 10/7/1991 to 18/9/1991	***P. penicillatus***	***P. longipes***	***P. versicolor***	***P. ornatus***
Male	646	355	5	2
Female	468	357	3	0
Sex-ratio (% males)	58.0% ± 2.9	49.9% ± 3.7	-	-

The two large spiny lobster species are poorly represented in the harvest on the Isle of Pines: *P. versicolor* 0.4% and *P. ornatus* 0.1%. By contrast, the other two species together represent 95.5% of the harvest: *P. penicillatus* 60.0%, *P. longipes* 35.5%.

Napierian (natural) logarithms for measurements of length and weight of the lobsters required linear adjustment (Table III, Figs. no. 2 and 3)

$$W_i = a.L_i^{\,b} \Longrightarrow \mathrm{Ln}(W_i) = b.\,\mathrm{Ln}(L_i) + \mathrm{Ln}(a)$$

These relationships are all allometric except for males of *P. longipes* whose coefficient b does not vary significantly from 3.

Table III: Parameters of length/weight relationships

Length/Weight Relationships		
Species	**b**	**a**
Panulirus penicillatus fem.	2.74 ± 0.16	0.167
Panulirus penicillatus male	2.75 ± 0.15	0.121
Panulirus longipes female	2.79 ± 0.16	0.194
Panulirus longipes male	3.01 ± 0.15	-0.020

Growth and Mortality

For growth, analysis of histograms produced using the Bhattacharya (1967) method, give the results shown in Table IV.

Table IV: Growth parameters for *P. penicillatus* and *P. longipes*

Species sex	*P. penicillatus* male		*P. penicillatus* female		*P. longipes* male		*P. longipes* female	
Parameters of the V. Bertalanf. curve	$L_{c\infty} = 17.18$ K = 0.22 $t_0 = -0.87$		$L_{c\infty} = 12.03$ K = 0.32 $t_0 = 1.3$		$L_{c\infty} = 10.90$ K = 0.47 $t_0 = -0.22$		$L_{c\infty} = 10.90$ K = 0.39 $t_0 = -0.49$	
Length/age	Lc_{obs}	Lc_{th}	Lc_{obs}	Lc_{th}	Lc_{obs}	Lc_{th}	Lc_{obs}	Lc_{th}
L1 (cm)		5.8		6.2		4.8		4.8
L2 (cm)	7.4	8.0	7.3	7.8	6.6	7.1	6.9	6.8
L3 (cm)	9.1	9.8	8.5	8.9	8.2	8.5	8.2	8.1
L4 (cm)	10.4	11.3	9.7	9.8	9.2	9.4	8.9	9.0
L5 (cm)	11.7	12.4	10.3	10.4	10.8	10.0	9.6	9.6
L6 (cm)	12.8	13.4	11.5	10.8				
L7 (cm)	13.8	14.1						
L8 (cm)	14.8	14.7						

t_0 in years K: in cm per year^{-1} Lc in cm;
Lc_{obs}: observed lengths Lc_{th}: calculated lengths

Natural mortality "M" was estimated by the Pauly (1978), Tanaka (1960) and Beverton and Holt (1956) empirical methods. All the values thus obtained are slightly different from the one cited by Prescott (1988), so we decided to use M = 0.35.

Analysis of Bhattacharya method histograms also allows estimation of relative numbers by age group and thus the calculation of total mortality "Z". The fishing mortality "F" is then calculated by subtracting M from total mortality Z.

P. penicillatus..... male .... Z = 0.40 ...... F = 0.05
P. penicillatus .....female .... Z = 0.54 ..... F = 0.19
P. longipes .... male ...... Z = 0.49 .... F = 0.14
P. longipes .... female ... Z = 0.53 ..... F = 0.18

i.e. a mean Z of 0.49 and a mean F of 0.14.

Yield per recruit model

The Ricker (1945) yield-per-recruit model totals separate catch weights catches over an arbitrarily chosen period of time: here 2 months.

As they showed the fastest growth rate, only *P. penicillatus* males were studied. The results obtained will apply *a fortiori* to the other spiny lobsters.

Discussion

The growth curves for *P. penicillatus* show some interesting differences from those obtained in the Solomon Islands (Prescott, 1980) and on Enewetak Atoll (Ebert and Ford, 1986). In fact, on the Isle of Pines, this spiny lobster show a more gradual growth curve, demonstrating that, even at a more advanced age, it maintains a more regular growth rate. For this reason, the maximum sizes for both sexes are greater in New Caledonia. Life expectancy, however, seems to be less, and these differences can not be explained by biases due to different fishing pressures. The imprecision of the methods of analysis used at the three sites could explain these differences more simply.

Significant sexual dimorphism was also shown. Males have a higher growth rate than females, which are therefore, on average, older at similar sizes. This difference is also found in the length/weight relationship with females being on average lighter than males of a similar size.

The results obtained for *P. longipes* are the first of their kind. No other work on this species appears to exist. Unlike this species, the red spiny lobster does not show any marked sexual dimorphism with growth. At equal sizes, males are on the average slightly younger than females but their weights are identical.

The two species show a large difference in growth, with *P. longipes* having, at similar ages, a considerably smaller size than *P. penicillatus*.

The mortality figures actually reflect the flow of arrivals and departures at the fishing site (death, migration, etc.). Our approach assumes a stable situation, and our results are presented from the angle of fishermen's income on the Isle of Pines in a situation where neighbouring areas not harvested by these fishermen are not in competition with the exploited area under study. In other words, we propose optimising returns per recruit without exploring the number of recruits available or accessible at the fishery.

The fishing mortality coefficient is low in comparison to natural mortality, with a harvest rate certainly under 0.33. Because of this, biomass losses through natural means are so great that fishing yield per recruit models lead to advocation of harvest conditions which in practice are irrational. Indeed, the eumetric F curve of the yield-per-recruit analysis leans to an asymptotic size value (Lc) at first capture of close to 3.5 cm. It is clear that this size will not stand up under an analysis made on an economic basis, since at this size, spiny lobsters have no market value. This size is therefore irrational and must be rejected. Since we also cannot change the fishing effort value (i.e. the number of fishermen and the frequency of their excursions), we sought the optimum size at capture for the level of effort expended on Isle of Pines, and then tried to determine what would happen to yield per recruit if fishing effort grew because, for example, of population expansion on the Isle of Pines.

Simulations made using the Ricker model indicate that for a fishing effort corresponding to a mortality rate of 0.15, the maximum yield is attained for cephalothorax size values of between 7.5 and 8.2 cm when the spiny lobster weighs from 350 to 400 g and is at optimal market size. This size approximately corresponds to an age of 2 years for both sexes of the two species, an age at which growth differentials are not yet large.

Now, if this size of 7.5 cm is adopted and respected, eumetric simulations at constant size show that yields per recruit will increase with effort until such time as effort is twice its present value and will not drop until its exceeds three times this value. In concrete terms, this size will be suitable for spiny lobster harvesting on Isle of Pines for many years to come, as long as the efficiency of harvesting techniques does not change.

We wish to re-emphasise that the calculated size at first capture refers to a model which makes no assumptions about the number of recruits. It is therefore valid however great the recruitment and compliance with it allows maximum benefit to be drawn from the stock in the context of the current fishing effort. However, as regards future fishery development, attention should be focused on the fishing effort in order to control its level rather than on readjustment of the minimum size at first capture.

Conclusion

The minimum size at first capture was set at 7.5 cm given both the current level of fishing effort on the Isle of Pines and market requirements. Theoretical results of the analysis, at constant natural mortality, actually led to a value which was much lower but which was economically irrational. The value chosen, Lc = 7.5 cm, will be suitable as long as fishing techniques do not become more efficient and/or the number of fishermen from the Isle of Pines does not exceed three times its current value.

Determination of size at first capture is based on individual biological parameters and considers the population as a whole, without reference to the reality of the stock's actual geographical limits and without regard to spatial restrictions on exploitation. It is a static approach which includes neither the exploitation differentials, and thus competition between fishing grounds, nor, more importantly, population dynamic aspects linked to adult migration or feeding movements. Respect of a minimum size which guarantees the best returns per recruit does not, therefore, protect the population from localised overexploitation.

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