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TAG-RECAPTURE VALIDATION OF MOLT AND EGG EXTRUSION PREDICTIONS BASED UPON PLEOPOD EXAMINATION IN THE AMERICAN LOBSTER, *HOMARUS AMERICANUS*

Techniques for molt prediction based upon epidermal and setal development in pleopods (Aiken 1973) and for egg extrusion prediction based upon pleopod cement gland development (Waddy and Aiken 1980; Aiken and Waddy 1982) provide opportunities for more comprehensive studies of growth and reproductive potential in natural American lobster, *Homarus americanus*, populations than have previously been possible. These laboratory-developed techniques have only recently been applied to field samples from a number of areas of Atlantic Canada (Robinson 1979; Campbell and Robinson 1983; Ennis 1984). Although the methodologies are fairly straightforward and may be applied in field studies quite readily, in practice the investigator will sometimes be faced with specimens for which predictions can only be made with some degree of uncertainty. A study of Newfoundland lobsters using these techniques has included the tagging of animals from which pleopods were obtained. This paper presents results from observations on recaptured lobsters which validate the predictions that were made at the time of tagging that molting or egg extrusion would or would not occur during the current molting/spawning period.

Materials and Methods

Pleopods were obtained from American lobsters (ranging from 33 mm to 130 mm CL (carapace length)) caught in traps and by scuba divers near Arnold's Cove, Placentia Bay, Newfoundland, between 24 June and 17 July 1981. These were examined for molt and cement gland stages according to the methodologies of Aiken (1973), Waddy and Aiken (1980), and Aiken and Waddy (1982).

It is clear from Aiken (1973) that one can predict with considerable confidence that lobsters with pleopod stages 3.0 and higher just prior to or early in the molting season will molt that year. It is also clear, however, that for animals with pleopod stages 1.0-2.5 one cannot predict with confidence that molting will or will not occur. Molt prediction for these stages is not reliable because of development plateaus that occur during D_0 (i.e., molt stages 1.0-2.5). However, most such plateaus occur at stages 1.5-2.0, and a lobster will rarely remain at stage 2.5 for more than 2 wk. Once an animal has passed beyond stage 2.5, there will be no further plateaus, and proecdysis will proceed at a rate that is regulated by temperature (Aiken 1973). Aiken (1980) also stated that at stage 2.5, the epidermis in the general integument begins to show signs of activity, indicating imminent transition from indecisive D_0 into the irreversible premolt development of D_1. Considering that animals with stage 2.5 pleopods should molt in 48-52 d at 10°C (Aiken 1973) plus the fact that at Arnold's Cove the July-August temperatures on the lobster grounds average in excess of 10°C (mean daily temperatures from 24 June to 31 August averaged 12.1°C in 1981), it appeared more likely that lobsters with stage 2.5 pleopods during the 24 June-17 July sampling at Arnold's Cove would molt. As a working hypothesis, it was decided to predict that lobsters with pleopod stages 2.5 and higher would molt during the 1981 molting season at Arnold's Cove and that those with pleopod stages 0-2.0 would not molt.

Cement glands were initially staged according to the classification scheme of Waddy and Aiken (1980). These stages were subsequently converted to their more recent scheme (Aiken and Waddy 1982). It is clear from these papers that for lobsters with stage 0 or stage 1 cement glands just prior to or early in the spawning season one can confidently predict that egg extrusion will not occur that year, whereas for those with stage 2 or higher cement glands one can confidently predict that egg extrusion will occur.

During the sampling at Arnold's Cove, 356 of the lobsters from which pleopods were removed for molt and cement gland staging were tagged with "sphyrion" tags, which are designed to remain attached through ecdysis (Scarratt and Elson 1965), and released within a few minutes of being taken from the water very close to where they were captured. Observations on 171 of these lobsters recaptured subsequent to the molting/spawning period (mainly during the 1982 fishing season, 20 April-30 June)

provide a basis for validating the molt or egg extrusion predictions.

Results

Molt Predictions

Four of the 11 males (36.4%) and 11 of the 27 females (40.7%) with pleopod stages 0-2.0 molted instead of not molting as was predicted (Table 1). Even some with pleopod stage 0 molted. Of the 16 females which did not molt, 14 extruded eggs, and the 2 females which did not extrude eggs had stage 1 cement glands, indicating that egg extrusion would not occur. Six out of 21 males (28.6%) with pleopod stages 2.5 and 3.0 did not molt, whereas all with pleopod stages ≥3.5 and all females with pleopod stages ≥2.5 did molt (Table 1). Overall, 78.4% of the predictions which could be validated were correct. There was greater success with predicting that molting would occur (89.8% correct predictions) than with predicting it would not (60.5% correct predictions). There was no pleopod stage at and below which none molted; however, at stage 3.5 and higher all molted.

Validations of molt prediction are available for males ranging in size from 73 to 104 mm CL. Except for one animal at 99 mm, it was only for animals smaller than 81 mm that any of the predictions were incorrect. The size range for which validations are available for females is limited (75-82 mm CL).

Egg Extrusion Predictions

All of 17 females with either stage 0 or stage 1 cement glands did not extrude eggs, and all of 7 with stage 3 cement glands did extrude eggs as predicted. However, 2 out of 9 with stage 2 cement glands, which were predicted would lay eggs, did not do so (Table 2). Overall, 93.9% of the predictions which could be validated were correct. The 2 females which failed to extrude eggs as predicted, molted, despite having molt stage 0 pleopods.

TABLE 1.—Summary of molt predictions and subsequent validations for American lobsters sampled and tagged at Arnold's Cove, Newfoundland, 24 June-17 July, 1981.

	Number of molt predictions/validations							
	Males				Females[1]			
Pleopod stage	Yes	Correct	No	Correct	Yes	Correct	No	Correct
0							14	9
1.0			1	1			2	2
1.5			8	5			8	4
2.0			2	1			3	1
2.5	7	4			2	2		
3.0	14	11						
3.5	13	13			1	1		
4.0	11	11			3	3		
4.5	1	1						
5.0	2	2						
5.5	5	5						

[1]This table does not include 69 females which were ovigerous with old eggs at the time of sampling/tagging, all of which subsequently molted.

TABLE 2.—Summary of egg extrusion predictions and subsequent validations for female American lobsters sampled and tagged at Arnold's Cove, Newfoundland, 24 June-17 July, 1981. Sixty-nine (69) females which were ovigerous with old eggs at the time of sampling/tagging, all of which subsequently molted, are not included in the table.

	Number of egg extrusion predictions/validations			
Cement gland stage	Yes	Correct	No	Correct
0			8	8
1			9	9
2	9	7		
3	7	7		

Discussion

There have long been problems associated with growth rate and functional maturity determinations in American lobsters. Reliable data on annual proportions molting (or molt frequency) and proportions laying eggs in relation to size are difficult to obtain. Both these parameters are essential in assessing the impact of size limit and/or exploitation rate changes in a lobster fishery on yield per recruit and reproductive potential. Such assessments are important to proper lobster fishery management.

The techniques used here to predict molting and egg extrusion provide new approaches to the study of lobster growth and maturity that have only recently been used in studies of lobster populations. Results of this validation study, however, clearly indicate that caution has to be used in their application.

In the case of molt prediction it appears that the time of sampling in relation to the molting period is critical. The ideal situation would be a very short annual molting period with sampling just prior to the start of molting when all animals going to molt would have well-developed (stage 3 or higher) pleopods. American lobsters reach the northern limit of their range in Newfoundland waters, and it is probably here that their annual molting period is the shortest. In the Arnold's Cove area, molting starts early in July and is virtually completed by early September. In the present study, 5 out of 14 lobsters (all females, Table 1), sampled and tagged between 24 June and 17 July 1981 and had stage 0 pleopods (for which it was pre-

dicted that molting would not occur that year), had molted when recaptured prior to the molting period the following year. For these animals premolt development must have occurred very rapidly during the 1981 molting period. This indicates that periodic sampling throughout the molting period along with a validation study are required in order to use these molt prediction techniques as a basis for estimating annual proportions molting in a lobster population.

The overall success rate with predicting egg extrusion was much greater than with molt prediction (94% cf. 78%). The small number of incorrect predictions may have resulted from loss of eggs rather than failure of the animals to extrude. One of 6 ovigerous females with newly laid eggs that were tagged during the 24 June-17 July sampling period had molted and was nonovigerous when recaptured. While egg extrusion prediction based upon the cement gland staging technique provides a reliable basis for estimating annual proportions laying eggs in a lobster population, it is clear that such estimates should be adjusted, using the kind of information that can be obtained from a validation study before being used in an assessment of reproductive potential in a population.

Acknowledgments

I am grateful to S. L. Waddy for her courtesy and cooperation in teaching P. W. Collins the pleopod and cement gland staging techniques. I am indebted to Collins who, in addition to examining all the pleopods in this study, participated in the field work involved in obtaining samples, tagging, and recovery of tagged animals and provided the data summaries. Assistance with field work was provided by G. Dawe and D. G. Badcock to whom I am also very grateful.

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COMPARISON OF PHYSIOLOGICAL AND FUNCTIONAL SIZE-MATURITY RELATIONSHIPS IN TWO NEWFOUNDLAND POPULATIONS OF LOBSTERS *HOMARUS AMERICANUS*

Lobster (genus *Homarus*) fisheries are characterized by excessive exploitation rates and small, minimum legal sizes in relation to sizes at maturity (Anonymous 1977, 1979). Under such conditions, widespread recruitment overfishing is a distinct possibility and in eastern Canada appears to be the cause of stock collapses in certain areas (Robinson 1979). Stock-recruitment relationships as such are poorly known for the genus *Homarus*; however, since current levels of landings are well below historical levels in most fisheries, it is reasonable to assume that, within the limits of habitat carrying capacity, increased egg production will result in increased recruitment. It is clear that increasing the minimum legal size and/or reducing exploitation rates will result in increased egg production within a lobster stock; however, detailed knowledge of size-fecundity and size-maturity relationships is required to properly assess the impact of changes in fishery regulatory measures on annual egg production within a given stock.