Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 89/66

CSCPCA Document de recherche 89/66

Female size-maturity relationships for offshore lobsters (Homarus americanus)

by

D.S. Pezzack and D.R. Duggan
Benthic Fisheries and Aquaculture Division
Biological Sciences Branch
Department of Fisheries and Oceans
Scotia-Fundy Region
P.O. Box 550
Halifax, Nova Scotia
B3J 2S7

Abstract

The size at 50% maturity for offshore female lobsters is 94 mm carapace length, which is larger than reported for Newfoundland (81 mm), the Gulf of St. Lawrence (78.5 mm) or the eastern shore of Nova Scotia (92.5 mm), but smaller than that of the Bay of Fundy (108 mm). Maturity was determined by the staging of cement glands on the pleopods, before the period of egg extrusion. The number of berried females in the 90-100 mm size range in the commercial fishery is small. The proportion of berried females in trap-caught samples is likely a poor estimator of the actual percentage in any given size group because of the lower catchability of berried females, possible difference in the distribution and movements of berried and nonberried females, resorption of eggs, and egg loss.

Résumé

La longueur de carapace des homards femelles de haute mer parvenues au milieu de leur cycle de maturation est de 94 mm. Elle est donc supérieure à la longueur constatée à Terre-Neuve (81 mm), dans le golfe du Saint-Laurent (78,5 mm) ou sur la côte est de la Nouvelle-Ecosse (92,5 mm), mais inférieure à celle des homards de la baie de Fundy (108 mm). On a déterminé que la maturité était atteinte lorsqu'apparaissaient les glandes cémentaires sur les pléopodes, avant la période d'expulsion des oeufs. Dans la pêche commerciale, les femelles oeuvées dont la carapace se situe entre 90 et 100 mm sont rares. La proportion de femelles oeuvées présentes dans les échantillons capturés au casier est sans doute peu représentative du pourcentage réel de femelles dans tous les groupes d'âge, en raison du faible potentiel de capture des femelles oeuvées, des différences possibles dans la distribution et les migrations des femelles qui sont oeuvées et de celles qui ne le sont pas, ainsi que de la résorption et de la perte des oeufs.

Introduction

Knowledge of the size at 50% maturity is required in modeling growth and determining the reproductive potential and yield per recruit of a lobster stock. The majority of lobsters in the offshore catch are large lobsters (mean size 115-130 mm Carapace Length, CL) and believed to be above the size at 50% maturity, but the actual size of maturity has not been determined. It has been assumed that the offshore lobsters had a similar size of maturity to the Bay of Fundy lobsters, which had been determined by Campbell and Robinson (1983). The present study was undertaken as a first step in a study of offshore lobster growth rates and the population structure.

The size at 50% maturity has been determined for Newfoundland waters (Ennis 1984), the Bay of Fundy (Campbell and Robinson 1983), Northumberland Strait, and eastern shore of Nova Scotia (Campbell and Robinson 1983; Watson unpubl.) with size ranging from 79 mm in the Gulf of St Lawrence to 108 mm in the Bay of Fundy.

Methods

Maturity was determined by examining the pleopods of female lobsters for developed cement glands, using the method described in Aiken and Waddy (1982). Cement gland development was classified into one of 5 stages: Stages 0 and 1 which will not produce eggs during the year of measurement; Stages 2-4 which will produce eggs during the year of measurement. This differs from the method used by Campell and Robinson (1983) who assumed that only Stages 3-4 would extrude eggs. Their assumption that lobsters with stage 2 cement gland would not extrude eggs may have over estimated of size at 50% maturity.

Trap caught lobsters from the offshore fishing grounds (Figure 1) were sampled between June 18 and July 9 1988. A preliminary sampling during 1987 indicated that during May and early June the early maturity stages (Stage 2) were difficult to distinguish in larger animals. Sampling was not continued after mid-July for three reasons: (1) by mid-July the offshore landings decline because lobsters migrate out of the fishing grounds to shallower water and a biased sample could result; (2) egg extrusion has been observed in late July; and (3) lower catches make it difficult to obtain enough pleopods in the smaller size groups.

Up to 30 animals were sampled in each of the 5-mm groupings between 80 and 120 mm CL. Often it was impossible to obtain samples for lobsters less than 85 mm and often fewer than 20 animals were sampled in the 85-95 mm size range. Size groups with fewer than 10 pleopods were not included in the analysis.

The relationship between carapace length (CL) and the proportion of sexually mature females was approximated by the logistic curve (Chatterjee and Price, 1977; Mosteller and Tukey, 1977):

$$\mathbf{p} = e^{a+b\,\mathbf{CL}} \Big/ {}_{1+}\, e^{a+b\,\mathbf{CL}} \quad (1)$$

where **p**= proportion of mature females. Since the function is nonlinear the variables are transformed to make the function linear. The transformation used is that given in Chatterjee and Price (1977):

$$p' = \ln\,(\mathbf{p}\,/(1-\mathbf{p})) \quad (2)$$

which reduces the function to

$$p' = a + b\ CL \qquad (3)$$

Results

The number of lobsters sampled for pleopods is presented in Table 1. The regression results are presented in Table 2 and the untransformed data with the fitted curve in Figure 2. The regressions are significant for the pooled offshore data and the two geographic subareas examined Crowell Basin/ Browns Bank and the outer slope on S.E. Browns and Georges Bank (Figure 1).

The results show the size at 50% maturity in female offshore lobsters, is approximately 94 mm. The sampling design used 5 mm groupings of CL and does not allow small difference in the size of maturity to be detected. If more detailed determinations are needed lobsters sampling should be in 1 mm CL size groups

The data from the outer slope area has a wider range of maturity values at most sizes (Figure 2), and a higher residual mean square which suggest that the size of maturity may be more variable along the outer shelf on SE Browns and Georges Bank.

Table 1 Number of lobsters sampled for pleopods by CL groups in 1988 from three areas.

	SW Browns/Crowell			Georges Bank			SE Browns	
Date	June 21	June 30	July 6	June 17	June 20	June 24	June 17	July 8
CL(mm)								
81-85	16	28	23	1	0	0	0	0
86-90	15	30	25	2	0	0	0	0
91-95	20	32	25	9	10	12	16	0
96-100	19	31	24	18	20	12	19	16
101-105	20	21	25	21	21	20	20	15
106-110	21	0	0	26	18	26	23	13
111-115	10	0	0	4	0	0	29	0

Discussion

The size at 50% maturity for female lobsters is approximately 94 mm, which is larger than reported for Newfoundland (81 mm) (Ennis 1984), the Gulf of St. Lawrence (78.5 mm) or the eastern shore of Nova Scotia (92.5 mm) (Campbell and Robinson 1983) but smaller than that of the Bay of Fundy (108 mm) (Campbell and Robinson 1983). Comparison with data from Campbell and Robinson (1983) is difficult since a different method was used. By considering only stage 3 and 4 mature Campbell and Robinson (1983) may have overestimated the size at 50% maturity. This idea is supported by a recent study by Watson (unpubl. 1988) which found the size of maturity for eastern Nova Scotia to range between 77 and 84 mm (depending upon exact location) rather than the 92.5 mm reported by Campbell and Robinson (1983).

Samples from SW Browns and Crowell Basin showed less variability than those from the outer slope. This was due in part to the larger sample size and wider range of sizes sampled, but some of the higher variability may be explained by higher bottom temperatures disrupting the normal growth-reproduction pattern (Aiken and Waddy 1986).

Though the present study indicates that the majority of female lobsters between 95-105 mm are mature, the number of berried females in this size range in the commercial fishery is small (Figure 3). The proportion of berried females in trap-caught samples varies greatly with season and location (range 0-90% of females in catch) and is likely a poor estimator of the actual percentage in any given size group. Several reasons may account for this: (1) lower catchability of berried females; (2) possible difference in the distribution and movements of berried and nonberried females; (3) resorption of eggs and egg loss.

Resorption of eggs before extrusion occurs when a conflict occurs between the reproductive and molting cycles (Aiken and Waddy 1980, 1986). These cycles are believed to be synchronized by seasonal temperature changes and photoperiod. It is not obvious what signal lobsters would use in the offshore to synchronized the cycles, since in the offshore basins and along the slope, bottom water temperatures are relatively constant year-round (Mountain 1982), and much of the lobster depth range (up to 750 m) is at depths to which little or no light penetrates. The lack of strong synchronizing signals could result in a conflict in cycles, especially during the first season of maturity, such a conflict could lead to lower egg extrusion rates than the cement gland analysis predicts.

Acknowledgements

We thank F. Watson for her assistance in staging the cement glands, S. Waddy for instructing us in the cement gland staging technique, and the fishermen, workers and owners of Continental Seafoods in Shelburne N.S. for allowing us to sample their lobsters.

References

Aiken, D.E. and S.L. Waddy. 1980. Reproductive Biology. In J.S. Cobb and B.F. Phillips (ed), The biology and management of lobsters, Vol. 1, Physiology and behaviour, p. 215-276. Acad. Press, N.Y.

Aiken, D.E. and S.L. Waddy. 1982. Cement gland development, ovary maturation, and reproductive cycles in the American lobster *Homarus americanus*. J. of Crustacean Biology 2(3): 315-327.

Aiken, D.E. and S.L. Waddy. 1986. Environmental influences on recruitment of American lobster, *Homarus americanus*: A perspective. Can. J. Fish. Aquat. Sci. 43: 2258-2270.

Campbell, A. and D.G. Robinson. 1983. Reproductive potential of three American lobster (*Homarus americanus*) stocks in the Canadian Maritimes. Can. J. Fish. Aquat. Sci. 40: 1958-1967.

Chatterjee, S. and B. Price. 1977. Regression analysis by example. John Wiley & Sons N.Y.

Ennis, G.P. 1984. Comparison of physiological and functional size-maturity relationships in two Newfoundland populations of lobsters *Homarus americanus*. Fish. Bull. 82(1): 244-249.

Mosteller, F. and Tukey, J.W. 1977. Data analysis and regression, a second course in statistics. Addison-Wesley Pub. Co.

Mountain, D.G. 1982. Oceanographic conditions in NAFO Subareas 5 and 6 during 1970-79. NAFO Sci. Counc. Studies 5: 95-100

Watson, F.L. 1988. Size of functional maturity of female lobsters *Homarus americanus*, along the eastern coast of Nova Scotia, Canada. Unpublished Honours thesis, Dalhousie University. 35p.

Table 2: Regression statistics

OFFSHORE (all areas combined) 1988

$p' = -17.8583 + 0.1894\ CL$ (Size of 50% maturity= 94.3 mm)

N: 35 SQUARED MULTIPLE R: .804
STANDARD ERROR OF ESTIMATE: 0.7745

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	81.3764	1	81.3764	135.6460	0.0000
RESIDUAL	19.7973	33	0.5999		

SW BROWNS / CROWELL BASIN (1988)

$p' = -17.9346 + 0.1893\ CL$ (Size of 50% maturity= 94.7 mm)

N: 17 SQUARED MULTIPLE R: .881
STANDARD ERROR OF ESTIMATE: 0.6474

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	46.6698	1	46.6698	111.3453	0.0000
RESIDUAL	6.2872	15	0.4191		

SLOPE (SE BROWNS AND GEORGES) 1988

$p' = -16.0893 + 0.1728\ CL$ (Size of 50% maturity= 93.1 mm)

N: 18 SQUARED MULTIPLE R: .574
STANDARD ERROR OF ESTIMATE: 0.9043

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	17.6295	1	17.6295	21.5598	0.0003
RESIDUAL	13.0833	16	0.8177		

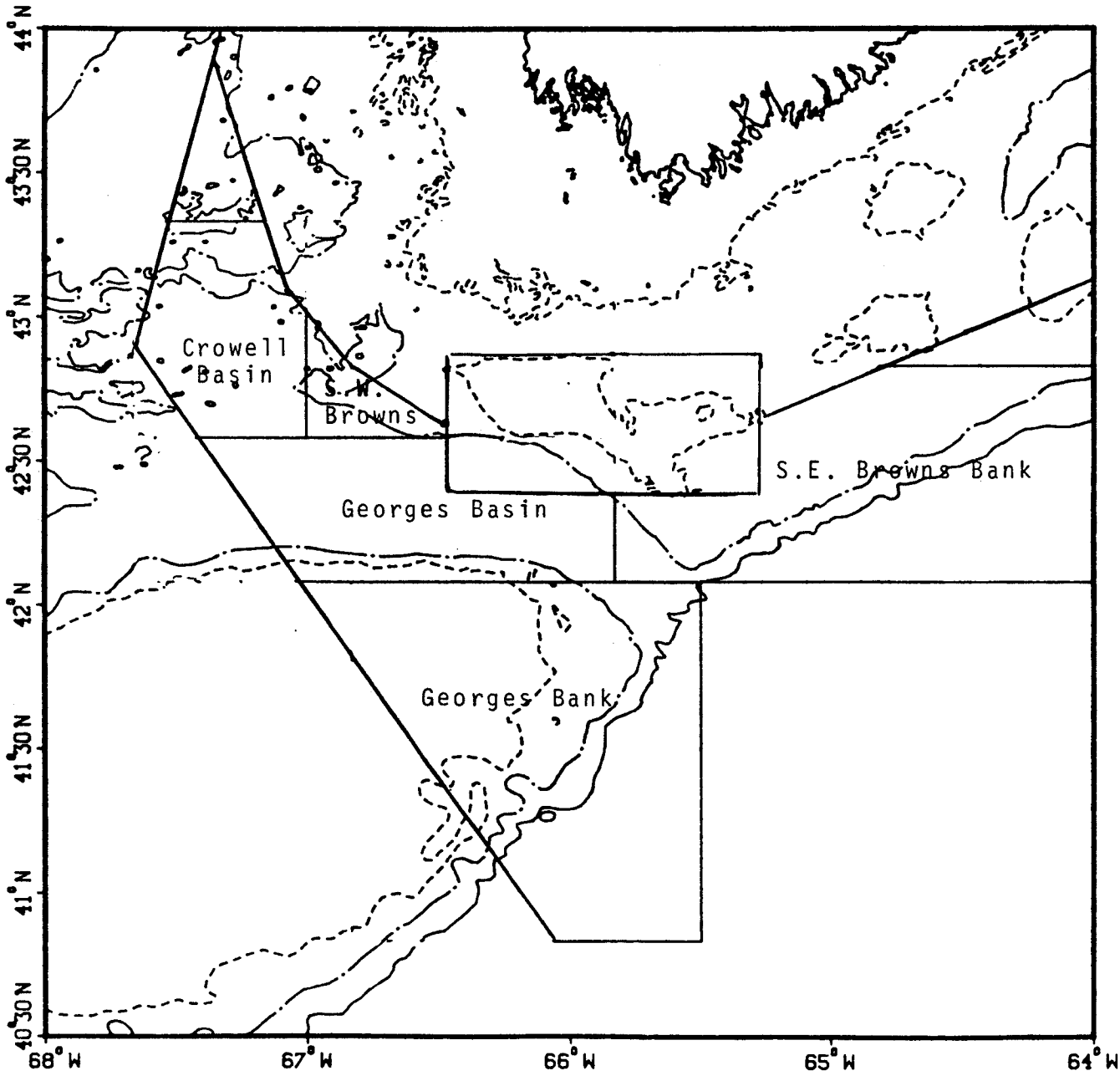

Fig. 1 Offshore Lobster fishing areas.

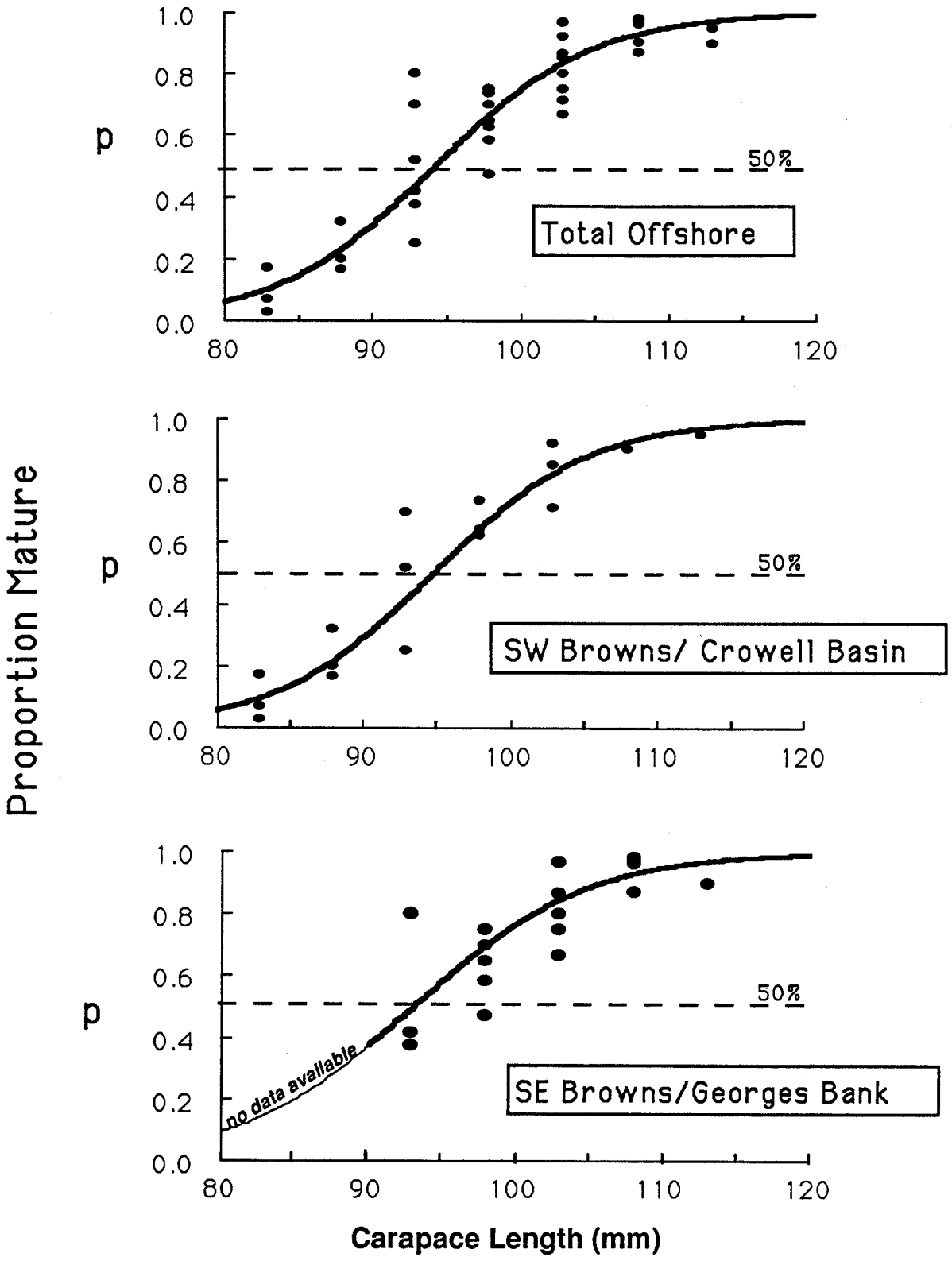

Figure 2 Proportion (p) of non-ovigerous females which are mature

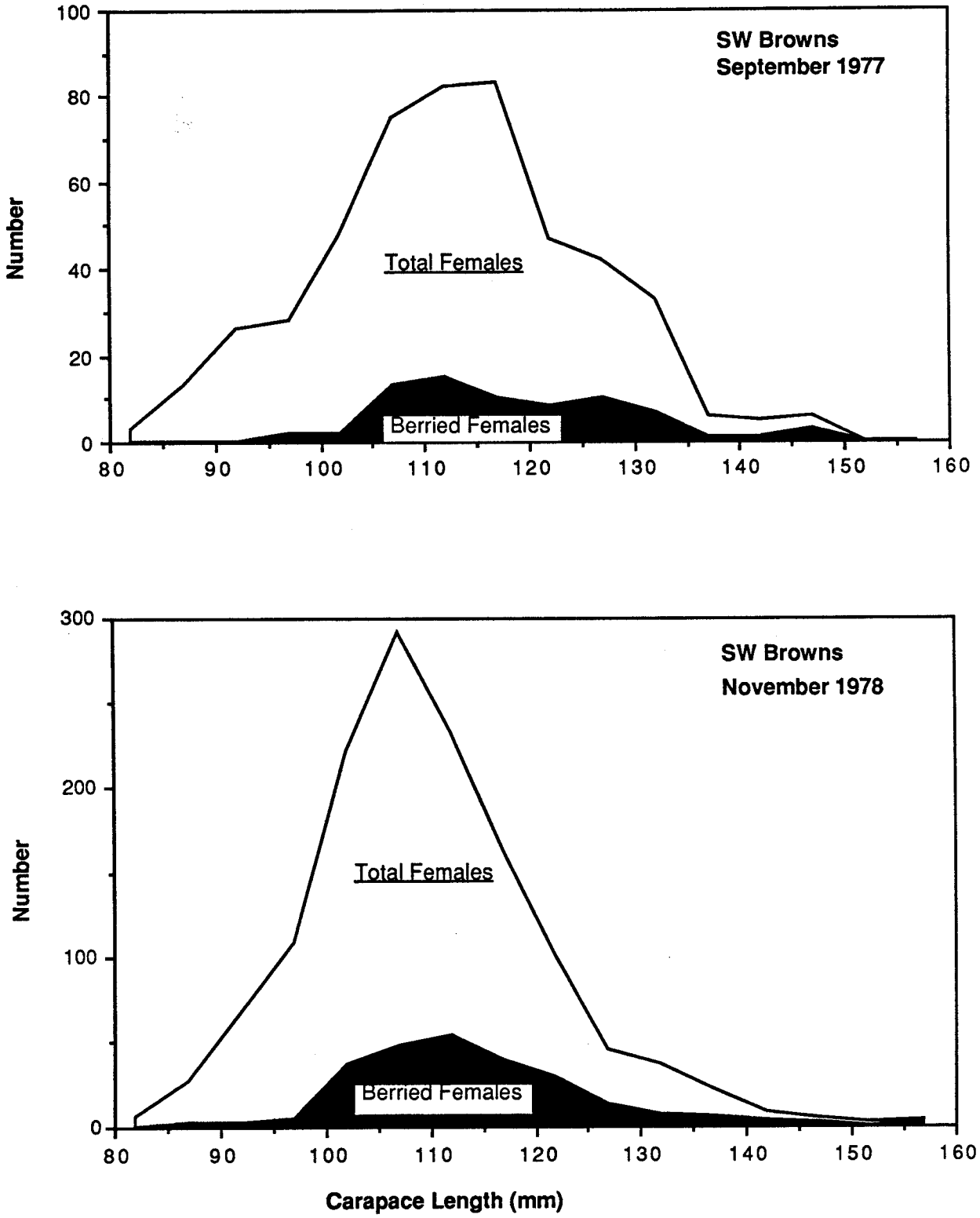

Figure 3 Number of berried female and total number of female lobsters in at-sea samples of the commercial offshore catch.