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Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 90/78

CSCPCA Document de recherche 90/78

**Growth rate and preliminary Y/R values for lobsters in the offshore regions of the Gulf of Maine and Southern Scotian Shelf**

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

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## Abstract

Lobsters were tagged on the offshore Scotian Shelf between 1982-1988 and data from recaptures were used to calculate growth per molt and annual proportion molting for male and female (62-155 mm carapace length) lobsters. Growth per molt inreased with size for males (linear regression slope=1.09) and decreased for females (linear regression slope=0.97). The proportion molting, determined by the anniversary method, declined with increasing size, with the intermolt period females being greater than that of males at the same size. The relationship between proportion molting and size was similar to results reported for S. Georges Bank and offshore New England waters.

Yield/Recruit values for offshore lobsters on the Scotian Shelf are presented. Y/R was calculated using two different models; the Caddy model, and the Fogarty-Idoine model (developed for the American offshore fishery). The two models yielded similar yield curves, and F-Max.

## Résumé

On a utilisé les données provenant des recaptures de homards étiquetés au large de la Nouvelle-Ecosse entre 1982 et 1988 pour calculer la croissance par mue et la proportion annuelle de mues chez les mâles et les femelles de 62 à 155 mm de longueur de carapace. Il s'est avéré que la croissance par mue augmentait avec la taille chez les mâles (courbe de régression linéaire = 1,09) et diminuait chez les femelles (courbe de régression linéaire = 0,97). La proportion de mues, déterminée par la méthode de l'anniversaire, diminuait au fur et à mesure que la taille augmentait, la période d'intermues étant plus élevée chez les femelles que chez les mâles de même grosseur. Cette relation entre la proportion de mues et la grosseur était comparable à celle obtenue au sud du banc Georges et au large de la Nouvelle Angleterre.

On présente ici les valeurs de rendement/recrue pour les homards de haute mer de la plate-forme néo-écossaise. Ces valeurs ont été calculées à l'aide de deux modèles différents, soit le modèle Caddy et le modèle Forgarty-Idoine (conçu pour les pêcheries de haute-mer des Etats-Unis). Les courbes de rendement et les valeurs F-Max obtenues dans les deux cas étaient similaires.

## Introduction

A knowledge of growth is important in determining exploitation rates and calculating yield/recruit (Y/R), and understanding size population structure. Growth patterns are a function of temperature and vary over the lobsters range (Aiken and Waddy 1986). Lobsters inhabit the coastal waters of North America from Newfoundland to Cape Hatteras, and along the edge of the continental shelf from Sable Island to off North Carolina. The deep-water of the offshore environment have more constant temperatures with less seasonal variation than in the shallow coastal areas. Under these constant temperatures growth patterns would be different (Aiken and Waddy 1986) then coastal areas (Aiken 1980; Krouse 1980; Wilder 1953). The only previous growth data for lobsters in offshore areas is for southern Georges Bank and New England waters (Fogarty *et al.* 1982).

The Canadian offshore lobster fishery on the Scotian Shelf and northeastern Georges (Fig. 1) only began in 1972 (Pezzack and Duggan 1985). The offshore areas offer a unique opportunity to study growth in a stock dominated by mature sizes.

The following paper examines the growth of lobsters from a 5 year tagging study on the Scotian Shelf and Northeastern Georges Bank, and presents the first Y/R values for the Canadian offshore lobster fishery.

## Methods

Tagging was done from commercial lobster fishing vessels during commercial fishing and while under charter to fish in areas closed to commercial fishing. Trap caught lobsters were measured, sexed, tagged with Sphyrion tags (Campbell 1983; Scarratt and Elson 1965), and returned to the water within 5 minutes. The Sphyrion tag remains with the animal through the molt.

Lobsters were recaptured by fishermen during commercial fishing. If a biologist was on board they would measure the tagged lobsters and return it to the sea. For the majority of the returns biologists were not present at sea, and the fishermen either landed the lobster with the tag in place, to be measured onshore by the biologist, or measured and recorded the size at sea. Since egg bearing females cannot be landed they were measured by the fishermen and released at sea. Many of these were recaptured 2-5 times over a 1-5 year period.

The proportion of individuals molting in a given year, in each size group was determined using the modified anniversary method (Hancock and Edwards 1967).

The anniversary method calculates the proportion of tagged lobsters recaptured before the next molting season, which had molted. The peak molting period is between July and September, and lobsters tagged or recaptured during these months were not used in the calculations. Lobsters were grouped into 10 mm size groups (e.g., 90-99 mm CL), except between 100 -130 were 5 mm groupings were used (e.g., 105-109; 110-114 mm CL)

Bias in estimates of the annual proportion of individuals molting can occur due to tag loss during molt, molt dependent mortality, differing catchability among sizes, due to gear selectivity, changes in behavior or habitat. The proportion of lobsters molting were corrected for tag loss during molt and molt dependent mortality (Fogarty and Idoine 1988) using the following:

$$Pmolt = \frac{N_{im}}{(1-T)\,(1-M_m)} \Big/ \left( N_{in} + \frac{N_{im}}{(1-T)\,(1-M_m)} \right)$$

Where $M_m$ is molt-dependent mortality, T is tag loss of individuals that survive molt (i.e. molt dependent tag loss), $N_{im}$ is the number of recaptured animals in size $i$ that molted and $N_{in}$ is the number of recaptured animals in size class $i$ that did not molt. T was assumed to be 0.1.

The relationship between size (by 5 and 10 mm groups) and proportion molting was modeled with a logistic function (Cox 1970; Wilkinson 1989):

$$\mathbf{Pmolt = e^{(a+b*CL)} / (1+(e^{(a+b*CL)})}$$

Where Pmolt= proportion molting in year, and CL= carapace length. Molt increment and proportion molting was determined separately for males, and females.

**Yield/Recruit**

Two different Y/R models were used; the Caddy model (Caddy 1977; Caddy 1979), which has been used in the Scotia Fundy Region (Campbell 1985; Miller *et al.* 1987), and the Fogarty-Idoine model (Fogarty and Idoine 1988), developed for the American offshore fishery. The empirical model developed by Caddy is a modified Thompson-Bell approach, in which size classes or molt groups are treated as age groups. The model developed by (Fogarty and Idoine 1988) is based on size dependent statistics and yield and egg production are integrated over both time and size, and accounts for the variability in molt increments and intermolt periods.

The original Caddy model, and later modifications of it (Campbell 1985), used an exponential function to describe the proportion molting at size. In the present analysis this was replaced with a logistic molt probability function.

Unlike the Caddy model, the Fogarty-Idoine model does not make direct use of the premolt/postmolt carapace length relationship, but instead uses molt increments assigned from a normal distribution with the mean and SD of the observed growth data. The molt increments were calculated separately for 3 size groups <85 mm, 85-105 mm, and >105 mm. Lobsters which molt from a 1 mm size group are distributed over a specified range of new size groups, with a normal distribution and a mean increment and S.D. equal to that of the observed growth increments.

More details on the two models are found in (Caddy 1977; Caddy 1979; Campbell 1985; Fogarty and Idoine 1988).

## Results and Discussion

### Molt increment

Growth was indicated by an increase of >5 mm CL between release and recovery. Increments less then 5 mm were assumed to be measuring errors. The results of the regression analysis of the relationship between premolt and postmolt carapace length is used in the Y/R models and are shown in Fig. 2. The slope of line indicates that growth is progressive (b= 1.09) (increasing with size) for the males and regressive in the females (b=0.97)

Table 1 Summary of results

Premolt-Postmolt CL

| Linear Regression Parameter | Male | Female |
|---|---|---|
| a (SE) | 5.371 (2.360) | 14.285 (1.396) |
| b (SE) | 1.097 (0.021) | 0.722 (0.013) |
| n ($R^2$) | 131 (.95) | 155 (.97) |

Molt Probability (not corrected for catchability)

| Logistic Regression Parameters | | |
|---|---|---|
| a | 7.787 | 6.923 |
| b | -0.0641 | -0.0635 |

The premolt/postmolt relationships correspond closely to those of studies in other areas (Fig. 3) (Campbell 1983; Ennis *et al.* 1982; Fogarty *et al.* 1982; Fogarty and Idoine 1988; Krouse 1980). This agrees with published findings that there is no significant geographic trend in the molt increments (Conan 1978).

**Molt Probability**

The proportion of lobsters molting decreases with increasing size and the decline occurs at a smaller size in females then in males. (Fig. 4). The relationship between proportion molting and size observed on the offshore Scotian Shelf is similar to the combined data from S. Georges Bank and offshore New England waters (Fogarty and Idoine 1988) (Fig.5), but different from Newfoundland (Ennis *et al.* 1982) and the Bay of Fundy (Campbell 1983). In the Bay of Fundy the proportion molting does not decline as sharply or as low as in the two offshore regions (Campbell 1983).

The anniversary method has serious draw backs for calculating proportion molting in the smaller and larger sizes. The anniversary method assumes equal catchability at size, so that there is equal probability of recapture for animals which molt and those which do not. Very large sizes (160-210 mm) were less common, and very few were recovered which had shown growth. The lack of detectable growth in the larger sizes may be due to the long intermolt period which decreases the likelihood of detecting growth, as well as molting to a larger size which is less catchable because of trap selectivity or behavioral.

The longer intermolt periods and slower growth at large sizes may result in a piling up of lobsters at these larger sizes (Fig. 6). Hartnoll (1982) has suggested that such a population structure should be expected in long lived crustaceans.

**Yield/Recruit Calculations**

These are the first Y/R calculations for the Canadian offshore and should be treated as preliminary results.

The two models produced similar yield curves, and F-Max, though absolute values were higher using the Fogarty-Idoine model (Fig. 7). Males had a higher Y/R at low F, then females, because of their faster growth rates and larger potential sizes. The female Y/R curve is relatively flat. Both models were run for a minimum size of 81 mm.

Egg/ recruit calculations are preformed in both models and indicate relative egg production under different F (Fig. 8). The significance of E/R calculations is not known since no stock recruitment relationship has been shown to exist. Both models show the sharp decline between F=0.0 and 0.4.

Both models assume constant F at all sizes, which assumes all sizes are equally catchable. Traps selectivity (Krouse 1989; Miller 1990) could result in high F in some sizes and very low F in others. Trap selectivity and its effect on fishing mortality should be considered in the future.

It is too soon to draw any conclusions from the Y/R results. The mean size of the catch, which has been relatively stable since the fishery began, would suggest a very low F. However if the size in the catch is determined by size related catchability, then F could be higher.

## Acknowledgments

We thank all the offshore fishermen and plant workers for their exceptional cooperation in measuring lobsters and returning tags, and Wade Scott for editing the data. We thank Mike Fogarty and Joe Idoine for kindly supplying a copy of their Y/R program and for assistance in getting it up and running, and Chris Hunter for her assistance in modifying the program to operate on our system. We also thank Dr. R. Miller for comments on an earlier draft of this paper.

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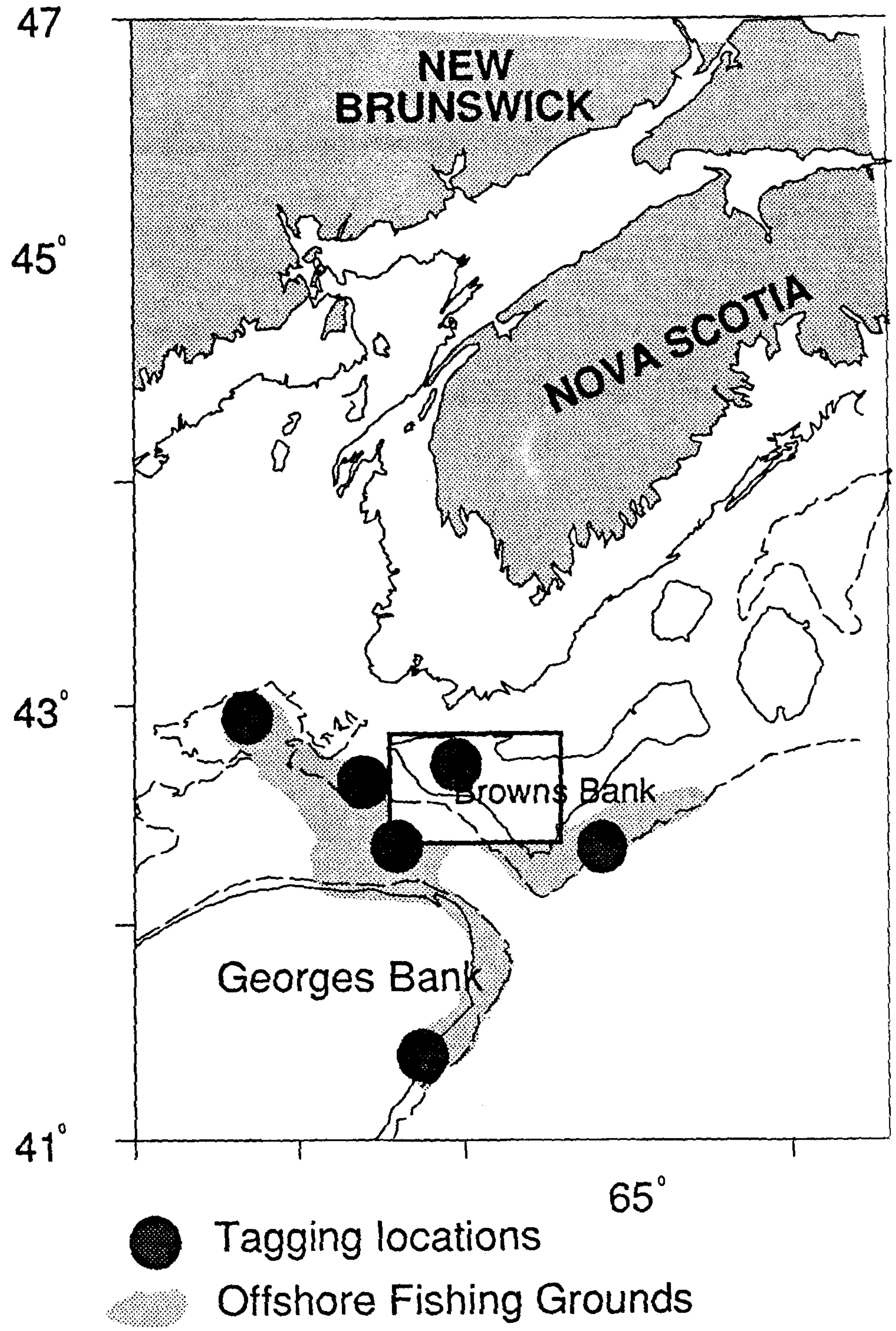


Figure 1: Southwestern Scotian Shelf and Eastern Gulf of Maine, showing offshore lobster fishing areas and lobster tagging sites

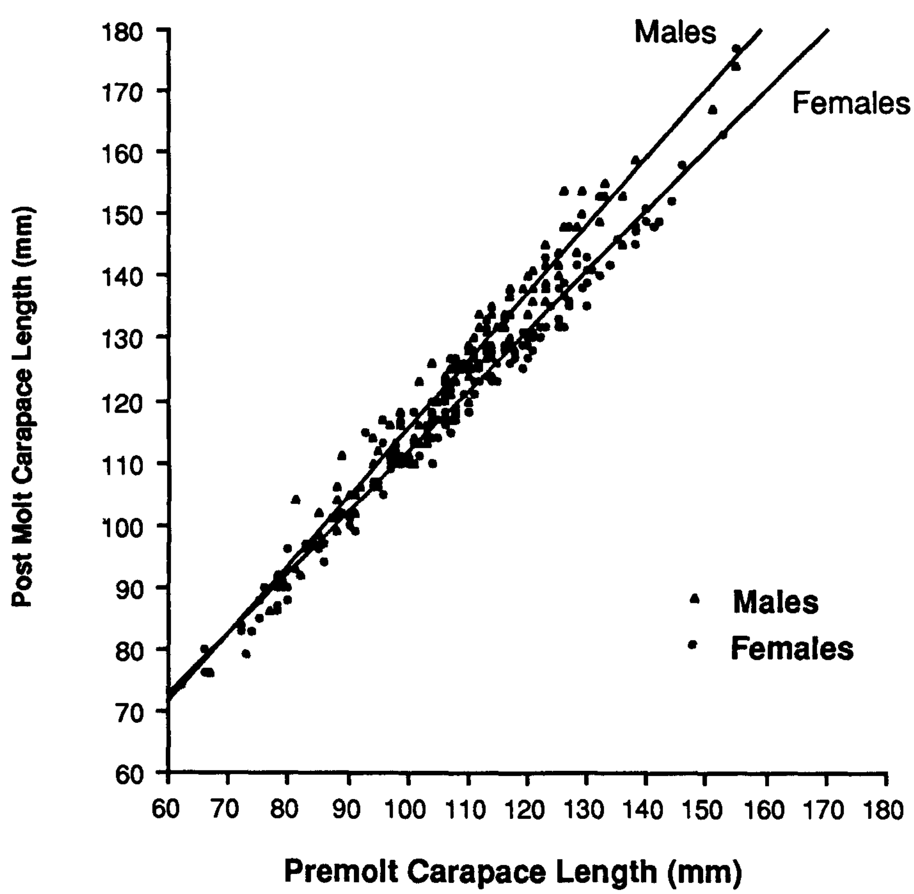


**Figure 2:** Relationship between Premolt and Post molt CL for males and females. Line fit by least squares linear regression (see Table 1)

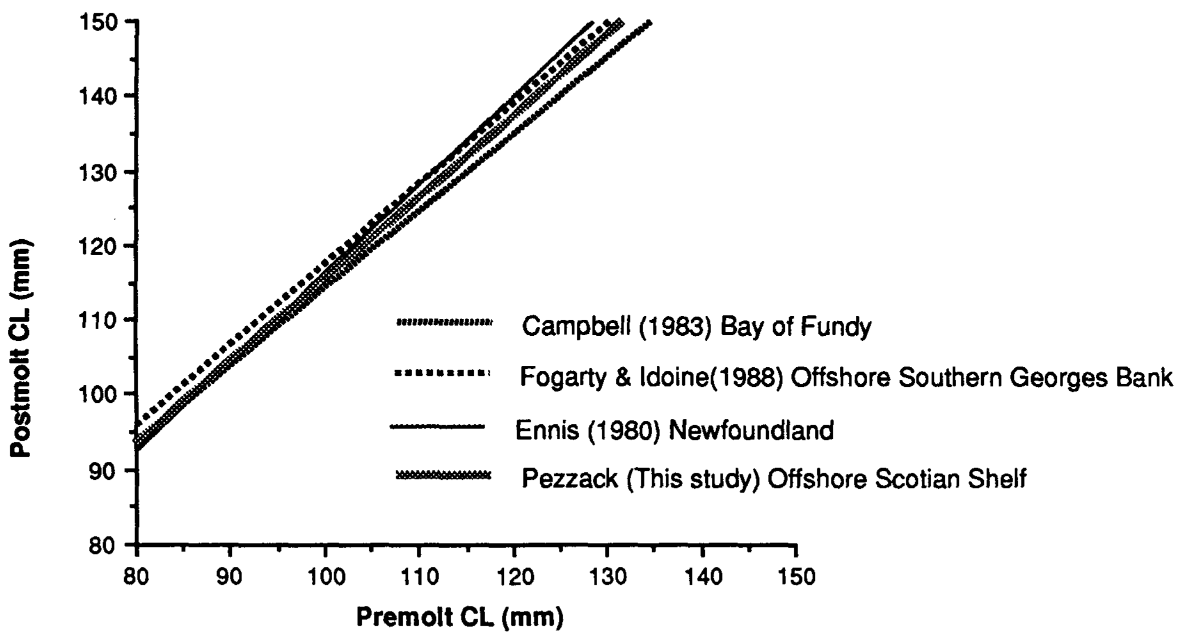


**Figure 3:** Comparison of premolt/post molt CL relationships for males from geographically different areas.

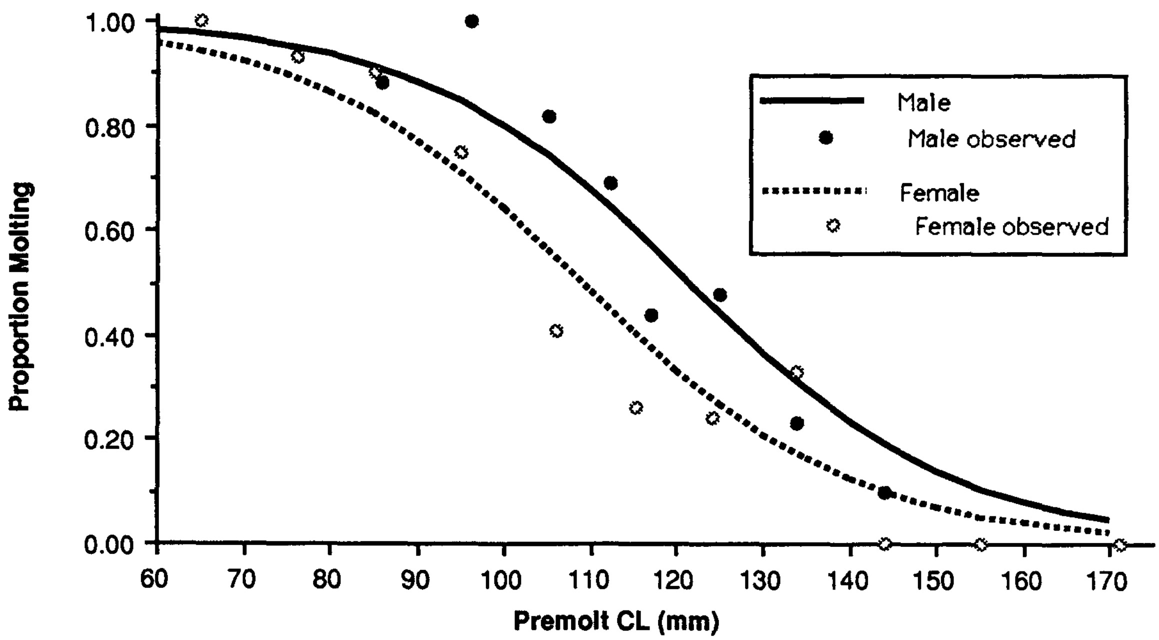


**Figure 4:** Proportion (corrected) of tagged lobsters molting at size, line fit to logistic curve (see table 1).

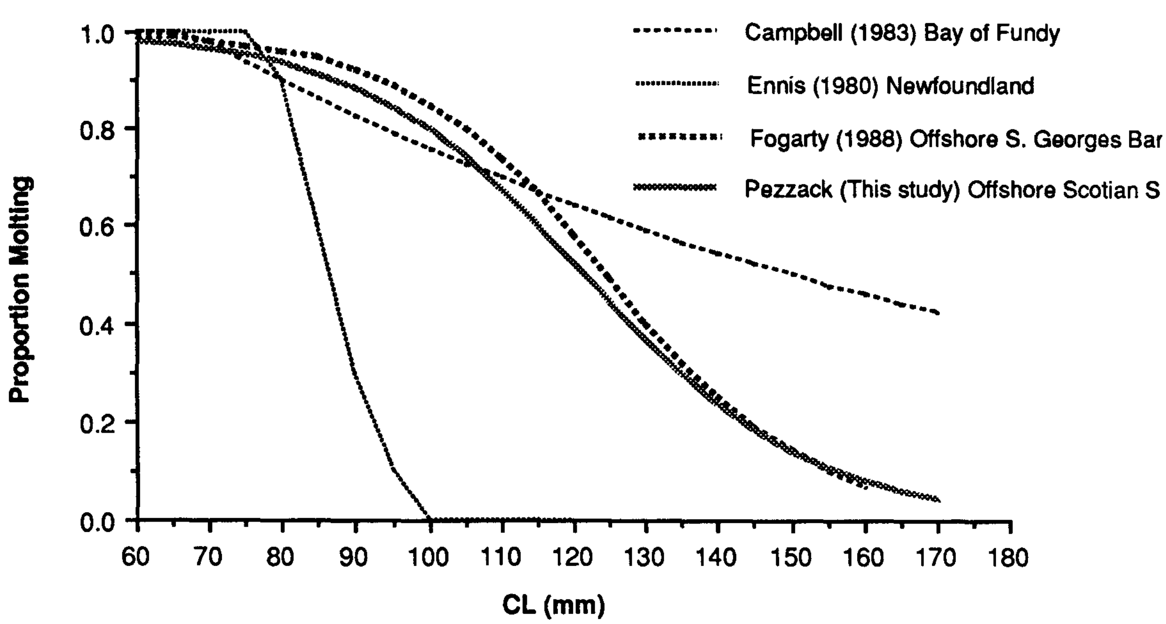


**Figure 5:** Comparison of proportion molting at size for males, from previous studies.

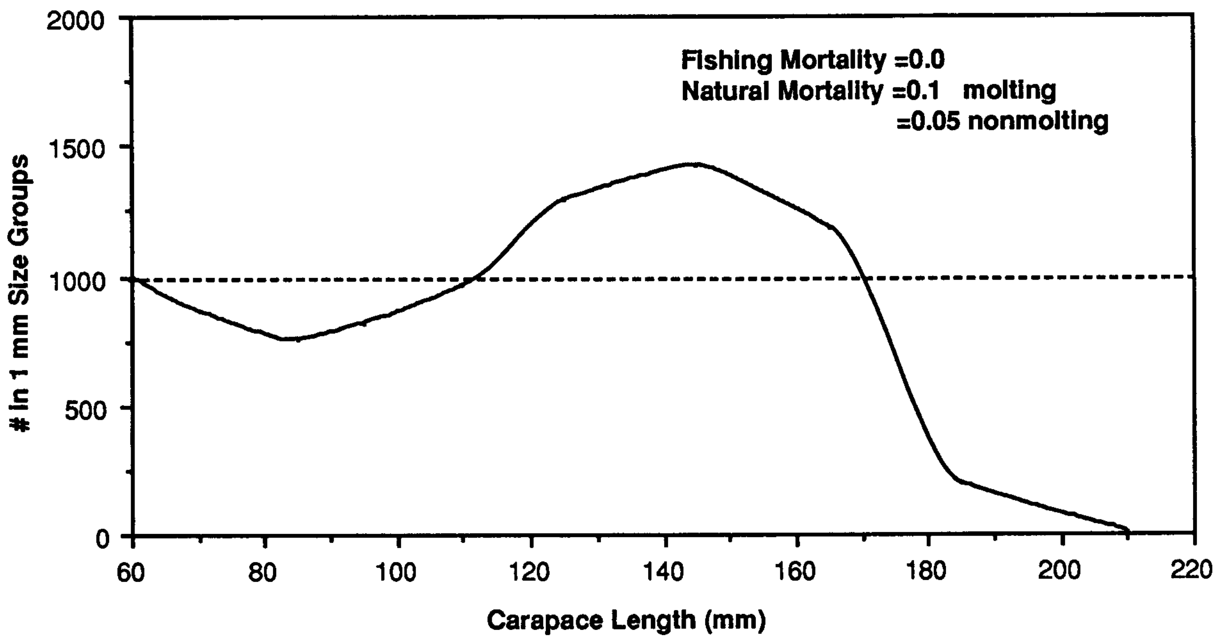


**Figure 6:** Simulated population size structure assuming no fishing mortality, and natural mortality of 5% for non molting animals and 10% for those molting. Simulation was run for 75 years and used molt increment and proportion molting data. The bulge observed between 120-170mm CL is the result of a piling up due to increased intermolt periods.

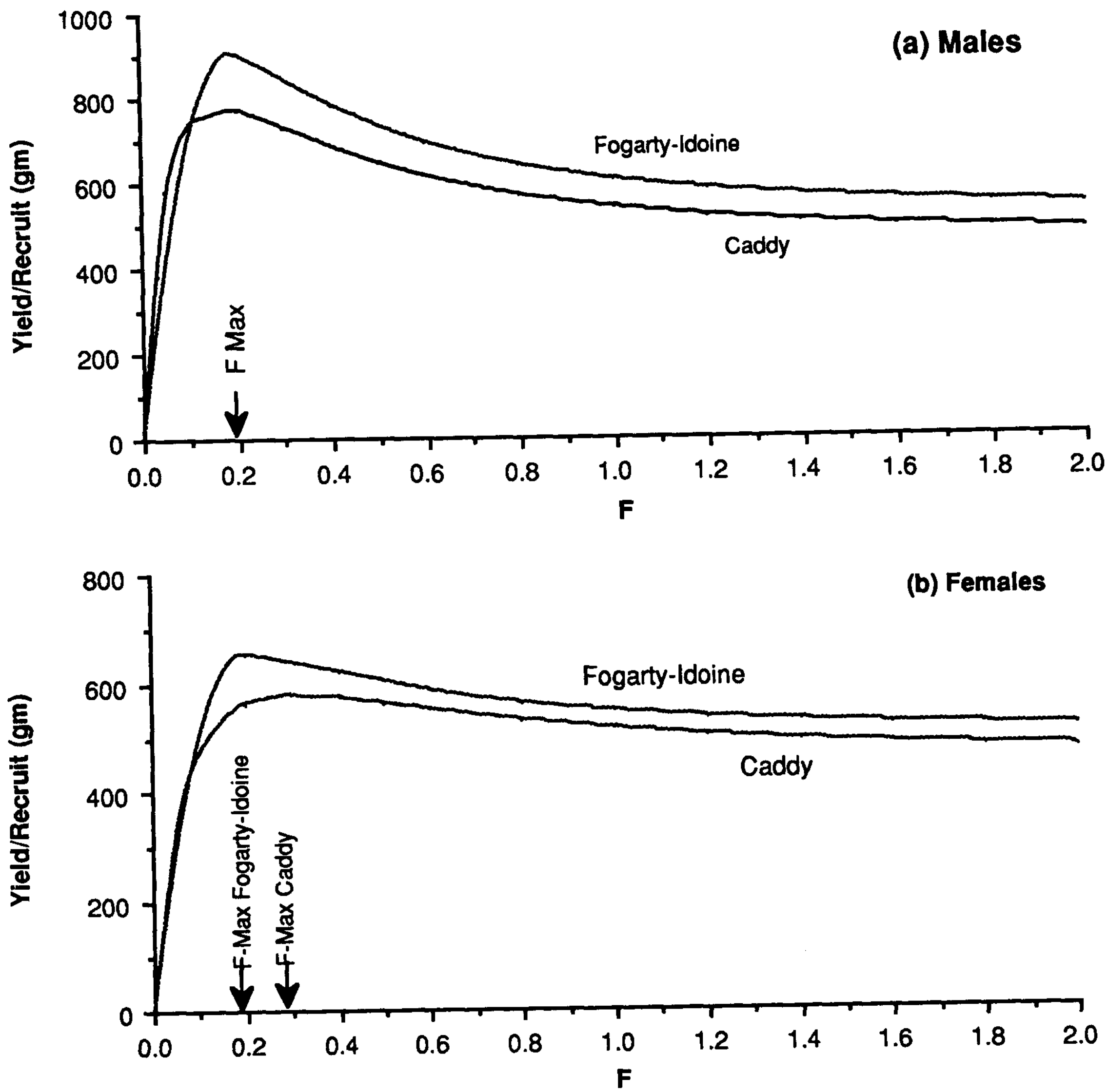


**Figure 7:** Yield per recruit at various F as calculated by the Fogarty-Idoine and Caddy models. (a) Males (b) Females.

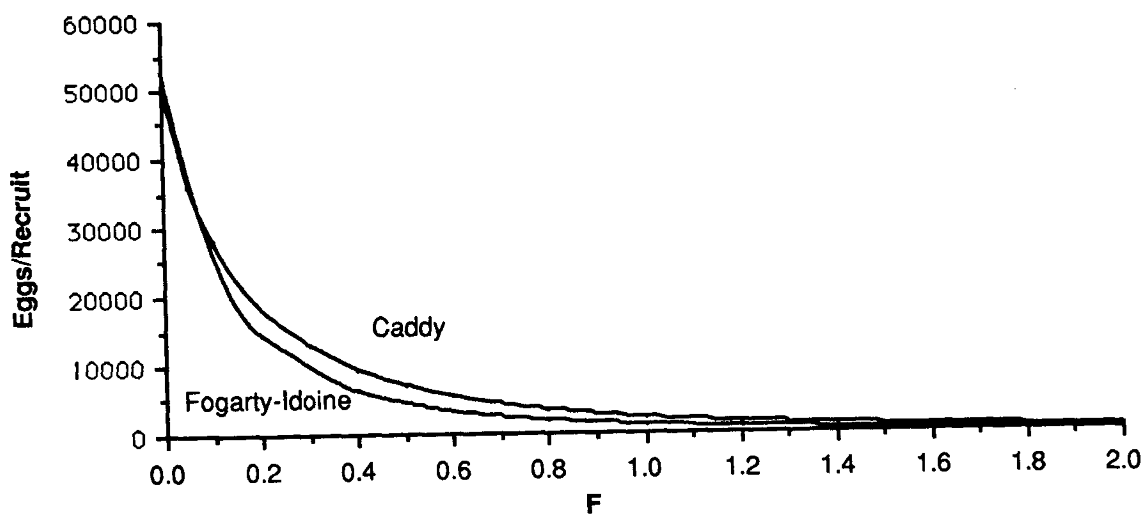


**Figure 8:** Eggs per Recruit at various F as determined by the two models.