# Fisheries and Population Biology of Lobsters (Homarus americanus) at Boswarlos, Port au Port Bay, Newfoundland 

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## September 1995

# FISHERIES AND POPULATION BIOLOGY OF LOBSTERS (HOMARUS AMERICANUS) AT BOSWARLOS, PORT AU PORT BAY, NEWFOUNDLAND 

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Abstract<br>Ennis, G. P., P. W. Collins, G. Dawe, and W. R. Squires. 1995. Fisheries and population biology of lobsters (Homarus americanus) at Boswarlos, Port au Port Bay, Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci.<br>Characteristics of the lobster fishery in the area on the coast of Newfoundland are described. A review of historical catch and effort data along with results from annual monitoring of the fishery for catch rates and composition of landings from 1976 to 1982 are presented. Details of some aspects of lobster population biology and ecology of the area including estimates of growth, standing stock, recruitment and exploitation rates are provided along with a general discussion of recruitment considerations.

Résumé
Ennis, G. P., P. W. Collins, G. Dawe, and W. R. Squires. 1995. Fisheries and population biology of lobsters (Homarus americanus) at Boswarlos, Port au Port Bay, Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci.

Le rapport décrit les caractéristiques de la pêche du homard dans le secteur côtier de Terre-Neuve. Il présente un rappel historique des données sur les prises et l'effort de pêche, ainsi que les résultats de l'évaluation annuelle des taux de capture et de la composition des débarquements entre 1976 et 1982. Il contient aussi des détails sur certains aspects de la biologie et de l'écologie des populations de homards de la région, y compris des estimations du taux de croissance, des stocks actuels, du taux de recrutement et du taux d'exploitation, et esquisse un examen général de considérations associées au recrutement.

## Introduction

Squires (1970) reported on various aspects of the fishery and population biology of lobsters in Port au Port Bay based on field sampling conducted from 1960 to 1965. Another study was initiated in 1974 by DFO Newfoundland Region in the Boswarlos area (Fig. 1) which was similar to studies being conducted on lobsters in other Newfoundland localities (Ennis et al. 1982, 1986, 1989, 1994). Included in this study was annual monitoring of the lobster fishery for catch and effort, catch rates, and composition of landings. Data to estimate or describe various aspects of population biology and dynamics were also obtained. Included was sphyrion tagging for information on growth per molt and movement, carapace strap tagging of commercial lobsters to estimate standing stock, recruitment and exploitation rate during the spring fishing season, and shell condition sampling to estimate annual growth.

The study at Boswarlos was terminated prematurely in 1982 when the mandate for shellfish research along the west coast of Newfoundland was transferred to DFO Gulf Region. Summaries and analyses of the data that were collected during the 8 -year study are presented. The purpose is to describe some basic characteristics of the fisheries and population biology of lobsters in the area and to make the information readily available to all potential users.

Materials and Methods
The study area extended east and west along the coast from the community of Boswarlos for a total distance of approximately 4.5 km and offshore to $\sim 15 \mathrm{~m}$ depth (Fig. 1). Several fishermen in the area voluntarily maintained records of their daily catches (by number) of commercially legal lobsters and effort expended (traps hauled) throughout each fishing season from 1975 to 1982. Periodically throughout each season, landings from individual fishermen were sampled opportunistically for carapace length (CL) and sex composition. Carapace length was measured to the nearest 1 mm from the base of the eye socket parallel to the middorsal line to the posterior edge of the carapace
(excluding the setal fringe).
Each autumn, following the molting period, research fishing was carried out. Commercially legal lobsters were caught, tagged with carapace strap tags (Wilder 1954), and released immediately after being removed from the traps. Highly visible secondary marks (coloured lobster claw bands positioned on the carpopodite of each claw) were applied as well to obtain estimates of tag loss over the 6-month period between tagging and the start of the following spring fishing season. Field staff maintained frequent contact with fishermen during the following spring fishing season to maximize returns of recaptured tags. Overall returns during the fishing season, along with returns by
individual fishermen who provided logbook data, were used to estimate exploitation rate and standing stock by the Petersen method. Details of the analyses and consideration of the assumptions of the model are provided by Ennis et al. $(1982,1986,1989)$ in relation to similar estimates for other Newfoundland lobster populations.

Each year, all lobsters caught during the autumn tagging period were examined for shell condition to determine which had molted during the preceding summer molting period (Ennis 1977). This provided a basis for estimating percent molting at size as described by Ennis (1978a).

During early July 1974, 1975, 1977 and 1978, 636 lobsters ranging from 60 to 144 mm CL were sphyrion tagged immediately after removal from traps and released where they were caught (see Ennis 1972). Returns were obtained mostly from fishermen during subsequent spring fishing seasons. CL's before and after molting for individual lobsters at large through one molting season were used to determine premolt-postmolt CL relationships using Somerton's (1980) HIATT program. The dates and locations of tagging and recapture provided data on distance moved and time at large.

Results and Discussion
The Fishery

## General Description

Boswarlos is located at the bottom of East Bay in Port au Port Bay on the west coast of Newfoundland
(Fig. 1). The physical features of the lobster grounds throughout Port au Port Bay are described in Squires (1970). The coast in the area is relatively straight but towards the west extends into a broad crescent that continues to Shoal Point, which separates the bottom of Port au Port Bay into East Bay and West Bay. The lobster grounds in the west of the Boswarlos area are a wide band of cobbles, boulders, bedrock slabs, and outcrops
interspersed with large gravel and sandy areas that slopes from a sandy-gravel beach to a depth of about 15 m at $\sim 2.5 \mathrm{~km}$ from shore. To the east the shoreline becomes rocky ledges and low cliffs and the grounds are a narrower band of predominantly boulders and cobble close to shore with bottom similar to elsewhere in the area sloping to 15 m at around 1 km from shore. Conventional wooden-lathed traps with $13 / 4$ inch spacing between the lower laths are set individually at depths between 5 m to 15 m and hauled manually. Fishing is carried out from 7 to 8 m outboard powered open boats. The annual fishing season opens April 20 and closes July 5. Egg-bearing females and all lobsters smaller than 81 mm (3 3/16 in) CL must be
returned to the water, protecting them from exploitation. During the study period, 12 lobster license holders fished in the area and the number of traps each was licensed to fish (as per the licensing policy implemented in 1976) ranged from 50 to 200.

## Catch and Effort

Lobster fishing statistics (landings and number of traps) are available for Statistical Area L (Lobster Fishing Area 13B - Cape St. George to Cape St. Gregory) since 1953 and for the three Statistical Sections (42, 43 (Port au Port Bay), and 44) which comprise Area L since 1976 (Fig. 1). Statistical sections are the smallest units for which these data are available from the DFO reporting system.

The highest landings recorded for Area $L$ were 1,208,522 lbs (548 t) in 1956 following which they dropped steadily each year to 442,205 lbs (201 t) in 1961 (Fig. 2). There were a number of sharp fluctuations after 1961 but the long-term trend was downward to a low of only 308,973 lbs ( 140 t ) in 1978. Landings increased rapidly though the 1980's to a high of 887,574 lbs (403 t) in 1989 and remained high up to 1992. However, landings declined significantly to 723,673 lbs (328 t) in 1993 and to 495,621 lbs (225 t) in 1994. The patterns of landings for Sections 42 to 44 since 1976 have varied somewhat but overall have been consistent with the increasing trend and
recent decline for Area $L$.
Fishing effort, as indicated by the number of traps fishermen indicated (on their license applications) that they intended to fish each year, increased from 41,382 in 1962 to 86,375 in 1974. A licensing policy implemented in 1976 eliminated some license holders from participation in the fishery and restricted those remaining to the number of traps they had indicated on their 1975 license applications they intended to fish that year. As licenses were gradually eliminated, the number of traps registered (as per the licensing policy) dropped to 63,897 in 1984. With the implementation of uniform trap limits of 300 for fulltime and 100 for parttime fishermen in 1987, the number of registered traps increased to 84,000 and, with the subsequent addition of new licenses and upgrading of others, the number had increased to 93,300 by 1992.

No measure of real or effective fishing effort, such as the total number of trap hauls for the season, is available for the fishery. However, the downward trend in landings during the 1960's and 1970's in Area L coincided with sharply increasing numbers of traps in use and it appears that effort was increasing as landings increased during the 1980's as part of a widespread recruitment phenomenon that resulted in increased landings throughout the lobster's range (Pezzack 1992). Around Newfoundland generally it
appears that considerably more traps than the number registered are actually being used. Effort in recent years has probably been considerably in excess of that prior to the 1976 licensing policy.

## Catch Rates

The pattern of variation in weekly catch rates over the course of the fishing season varied considerably from year to year (Fig. 3). In some years there were pronounced peaks, usually during the early weeks of the season, followed by declines at varying rates as the season progressed. In other years catch rates were generally low and either remained fairly uniform throughout or declined very gradually. Several factors contribute to catch rate variation over the fishing season. These include the fishing-up process and temperature changes along with variability in the number of traps on the grounds, number of traps hauled, soak time and weather conditions. Mean CPUE for 1 -week intervals ranged from 0.025 kg to 0.528 kg per trap haul during the twelfth week of fishing in 1976 and the third in 1982, respectively.

Mean CPUE for the full fishing season ranged from 0.11 kg to 0.31 kg (equivalent to 0.17 and 0.48 commercial lobsters) per trap haul in 1975 and 1981, respectively. High values tend to be associated with a high peak/rapid decline seasonal pattern and low values with a gradual decline pattern. Year
to year variation in total trap hauls, exploitation rates and standing stock contribute to the variability in mean CPUE. Estimated total trap hauls for the season ranged from $\sim 12,250$ to $\sim 31,500$ and averaged ~18,600.

## Size and Sex Composition of Landings

In the Boswarlos area lobsters just below the minimum legal size of 81 mm ( $3 \mathrm{3} / 16 \mathrm{in}$ ) CL grow an average of 13 mm on molting in the case of males and 11 mm in the case of females (see section on growth). Therefore the majority of lobsters growing to commercial sizes in any year will be included in the $81-93 \mathrm{~mm}$ and $81-91 \mathrm{~mm}$ CL ranges for males and females, respectively. The percentage of lobsters landed from 1975 to 1982 within these recruit size groups ranged from 45.3 to $65.6 \%$ for males and from 40.6 to $60.6 \%$ for females (Fig. 4). Percentage of recruits fluctuates due to annual variation in exploitation rate and recruitment to the standing stock. The lower percentages for females are likely due to the degree of protection from exploitation that is afforded egg-bearing females which would tend to increase their numbers at larger sizes relative to males. The higher percentages at the Bank suggest a more intensive fishery with higher
exploitation rates in that area. Although usually close to $1: 1$, sex ratios in landings vary somewhat from year to year (Table 1) but overall
tend to favour males
(M:F = 1:0.93).

## Water Temperature

Continuous recording thermographs were maintained on the bottom at a depth of 9 m near Boswarlos year round from February 1984 to May 1991. An average annual temperature regime was compiled (Fig. 5) which indicates sub-zero conditions prevailing from December to April. Temperature begins to increase rapidly in late April - early May and reaches about $8^{\circ} \mathrm{C}$ by the end of June, peaks at around $15^{\circ} \mathrm{C}$ near the end of August and begins to drop off rapidly in September. Changing catchability of lobsters during the fishing season in response to rapidly increasing temperature affects the seasonal pattern of catch rate variation in the fishery. Also, year to year shifts in the timing and rate of temperature increase will contribute to annual variability in catch rate patterns and mean values.

## Biology

Detailed biological sampling of lobsters was carried out in Port au Port Bay during 1960 to 1965. Various morphometric, length-weight, size-maturity, and size-fecundity relationships were generated (Squires 1970).

## Growth

Growth per Molt. Premolt and postmolt CL's for sphyrion
tagged lobsters that molted only once between tagging and recapture were analyzed using a program (HIATT) developed by Somerton (1980) for fitting a pair of straight lines to crustacean growth increment data. plots of premolt-postmolt CL data sometimes show an abrupt change in slope associated with attainment of sexual maturity. However, for each of the sexes from the Boswarlos area a single straight line (the so-called Hiatt growth diagram) fitted the data better than a pair of straight lines (Fig. 6).

The equations derived from least squares regression of postmolt CL on premolt CL are:
males: $\mathrm{y}=1.0553 \mathrm{x}+8.5662(\mathrm{n}=30, \mathrm{r}=.98)$
females: $y=0.9502 x+14.5758(n=57, r=.98)$
Analysis of covariance demonstrated that these relationships had similar residual variances ( $p=.06$ ) but different slopes ( $\mathrm{p}=.02$ ). The slope for males is not significantly greater than $1(\mathrm{p}=.20)$ but meets Kurata's (1962)
requirement (b > 1.05) for progressive growth, i.e. molt increment increases with premolt size. The slope for females is significantly less than $1(p=.047)$ but barely meets Kurata's requirement ( $1.05>b>.95$ ) for arithmetic growth, i.e. molt increment is constant in relation to premolt size. Molt increments calculated from the equations above for premolt carapace lengths of 70 and 100 mm are 12.4 mm and
14.1 mm , respectively for males, which represent relative molt increments of $17.7 \%$ and 14.1\%, and for females is 11.1 mm and 9.6 mm which represent relative increments of $15.8 \%$ and $9.6 \%$, respectively.

Percent Molting. Estimates of percent molting were derived from the autumn shell condition sampling as described by Ennis (1978a). Curves of percent molting in relation to size from probit analysis (Fig. 7) show substantial annual variation, particularly for females. Much of this is probably related to year to year variation in temperature conditions (Ennis 1983); possibly also to variation in density of lobsters (Ennis 1991); and, in the case of females especially, too few sampled at larger sizes. A detailed consideration of possible biases associated with the method of estimating percents molting and of other factors related to the greater variability among females is provided in Ennis et al. (1982, 1986).

The data for all years were combined and "average" percent molting-size relationships were derived (Fig. 7). The probit equations for these relationships are:
males: $\mathrm{y}=7.8747-0.0722 \mathrm{x}(\mathrm{n}=1660$;
from $\chi^{2}$ test $p=.82$ )
females: $y=3.9574-0.0272 \times(\mathrm{n}=1359$;
from $\chi^{2}$ test $p=.66$ )
The data indicate that for both sexes most animals in the $60-70 \mathrm{~mm}$ CL range molt in a
given year. There is no evidence that in this area lobsters of this size range molt more than once annually. Percentage molting each year drops below 100\% over the 7080 mm CL range. Estimates from the probit equation indicate that it drops to 50\% at 109 mm and to near 0\% at 141 mm for males. The relationship for females does not conform to the typical negative sigmoid over the range of the data. This is due to the high prevalence of 100\% values in the data at sizes $\geq 110 \mathrm{~mm}$ CL. As a result of their egg-bearing status during the preceding fishing season providing protection from exploitation, it appears that relatively more females than males reach large sizes (Ennis et al. 1986). Overall, however, very few animals reach large sizes which may make the question of their growth academic but interesting nevertheless. At sizes $\geq 110 \mathrm{~mm}$, 14 of 47 males and 35 of 39 females were molters. The much greater prevalence of molters among large females is related to their physiological requirement for synchrony between the molting and reproductive cycles. The recently-molted females taken in fall sampling were egg bearing during the spring fishing season and molted during summer soon after hatching their eggs.

Estimates of Standing Stock
Standing stock at Boswarlos was estimated by the Petersen method for each year from 1975 to 1982. This was a period of
major fluctuations in annual landings (25,900 to 157,000 lbs) in the general area (Section 43).

Data on which the estimates are based are provided in Table 2 and the estimates in Table 3. The mean was 9,305 lobsters (range: 4,141 to 16,831). Confidence intervals ranged from $\pm 5.8 \%$ to $\pm 20.0 \%$ except for the 1976 estimate (16,831 lobsters) for which it was Bellburns and from $\pm 15.9$ to $\pm 21.2 \%$ at $\pm 43.7 \%$.
Estimated landings (based on standing stock and exploitation rate estimates) for this area represent about 10-15\% of the Section 43 total.

Recruitment between fishing seasons is the main factor determining the size of the standing stock in a given year. This is especially so at very high exploitation rates. At Boswarlos, tag-recapture estimates of exploitation rate ranged from 47.6\% to 86.1\% and averaged 62.1\% (Table 2). The upper limits of the recruit size ranges ( $81-93 \mathrm{~mm}$ for males; $81-91 \mathrm{~mm}$ for females) were determined from the premolt-postmolt relationships. The number of recruits (i.e. the number of lobsters that molted to commercial size ( $\geq 81 \mathrm{~mm}$ CL) since the preceding fishing season) was estimated as described by Ennis (1979) using data from the preceding fall shell condition sampling and from commercial catch sampling during the fishing season. The percentage of recruits in the standing stock
averaged 23.4\% at Boswarlos (Table 3).

## General Discussion

Lobster landings in Statistical Area L (Lobster Fishing Area 13B) since the mid 1950's are characterized by sharp annual fluctuations with a pronounced downward trend from 1956 to 1978 followed by an upward trend to 1992 and a sharp downward fluctuation in the past two years. There is no basis to indicate if this recent decline represents the beginning of a long-term downward trend or just a short-term fluctuation.

The increased landings in Area L up to 1992 has been part of a widespread recruitment phenomenon that resulted in record-high landings throughout the lobster's range. The cause of the increased recruitment is unknown but appears to be related to some environmental/ecological changes. The factors involved and where in the lobster's life cycle they are acting is unknown.

Common features of lobster fisheries are a small minimum legal size in relation to size at maturity and very high exploitation rates. This situation not only restricts yield per recruit to substantially below maximum values (Ennis 1978b, 1980) but also constrains egg production in lobster populations towards the low end of the potential range (Ennis 1985). This and the long-term downward trend
in landings that prevailed in most lobster fishing areas by the early 1970's lead to widespread concern over recruitment overfishing and the possibility of recruitment failure (Anon. 1977, 1979). The lengthy period of increased recruitment that followed was unexpected. At the time there was no basis for predicting its occurrence.

Very limited work on the shape of the stock-recruitment relationship in the American lobster suggests it is asymtotic with a very steep ascending limb (Fogarty and Idoine 1986, Ennis 1995). Although recruitment is bound to vary greatly at any given level of egg production, an asymtotic relationship would tend to generate a relatively uniform level of recruitment over a wide range of egg production beyond a certain level. Habitat carrying capacity could be a factor tending to constrain recruitment at high levels of egg production.

Patterns of landings for many areas throughout the lobster's range since the early 1970's indicate that very high levels of recruitment can originate at very low levels of egg production. And, similarly high recruitment can also originate at high levels of egg production. Although recruitment overfishing may have generally prevailed at the time, it appears that very favourable
environmental/ecological conditions resulted in a high level of recruitment from the
low level of egg production at the low level of abundance during the early 1970's. The extent to which the generally high level of recruitment of the past $15-20$ years was maintained by continued favourable conditions or by an increased level of egg production at the high level of abundance or by a combination of the two is unknown. Understanding of the lobster recruitment phenomenon of the past 20 years is still quite limited and provides no basis for predicting trends in landings. It is unrealistic, however, to expect strong recruitment to continue indefinitely and the recent decline in landings in many areas could represent the early stages of a widespread downward trend. The concern with recruitment overfishing that prevailed during the 1970's was largely ignored as recruitment increased and continued relatively strong. This concern, however, has reemerged. Recent analyses indicate that egg production in most lobster populations around Atlantic Canada is only about $1 \%$ or less of what it could be potentially if females were not exploited. Maintaining egg production at such an extremely low level has to be considered a very high-risk management regime. It could be too low to maintain high recruitment under average environmental/ecological conditions and could lead to recruitment failure under unfavorable conditions.

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Table 1. Sex ratios in commercial landings at Boswarlos, 1975-82.

| Year | Male | Female | M:F |
| :--- | :---: | :---: | :---: |
| 1976 | 198 | 198 | $1: 1$ |
| 1977 | 278 | 224 | $1: 0.81$ |
| 1978 | 165 | 149 | $1: 0.90$ |
| 1970 |  |  | $1: 0.67$ |
| 1980 | 221 | 283 | $1: 1.27$ |
| 1981 | 221 | 1134 | $1: 0.88$ |
| 1982 | 1283 |  |  |
| Totals |  |  |  |

Table 2. Data from which Petersen estimates of population size at Boswarlos were obtained.

| Year | No. <br> pre <br> M | of lo tagge ding F | sters <br> fall <br> Total | No. of tagged lobsters in population at beginning of fishing season |  |  | No. of <br> tagged lobsters returned during fishing season |  |  | Exploitation rate (\%) $M$ and $F$ combined | No. of tagged lobsters returned by fishermen providing catch data M |  | No. of lobsters caught by fishermen providing catch data M F |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1975 | 206 | 124 | 330 | 174 | 105 | 279 | 84 | 59 | 143 | 51.3 | 40 | 30 | 512 | 892 |
| 1976 | 160 | 109 | 269 | 135 | 92 | 227 | 72 | 36 | 108 | 47.6 | 15 | 6 | 785 | 763 |
| 1977 | 210 | 142 | 352 | 177 | 120 | 297 | 107 | 87 | 194 | 65.3 | 46 | 44 | 675 | 587 |
| 1978 | 175 | 292 | 467 | 148 | 246 | 394 | 111 | 165 | 276 | 70.1 | 67 | 94 | 1782 | 1375 |
| 1979 | 176 | 162 | 338 | 149 | 137 | 286 | 75 | 61 | 136 | 47.6 | 69 | 51 | 1847 | 1787 |
| 1980 | 169 | 97 | 266 | 143 | 82 | 225 | 94 | 55 | 149 | 66.2 | 36 | 27 | 1619 | 1564 |
| 1981 | 128 | 102 | 230 | 108 | 86 | 194 | 77 | 56 | 133 | 68.6 | 49 | 26 | 3197 | 2537 |
| 1982 | 104 | 101 | 205 | 88 | 85 | 173 | 75 | 74 | 149 | 86.1 | 75 | 74 | 2575 | 2549 |

Table 3. Estimates of the percentage of recruits in the standing stock at Boswarlos, 1975-82.

| Year | Standing stock estimate |  | Percent in recruit size range' |  | Percent molters in recruit size range ${ }^{2}$ |  | Number <br> recruits in standing stock |  | ```rcent recruits in standing stock``` |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | M | F | M | F | $\bar{M}$ | F | M | F | combined |
| 1975 | 2190 | 3053 | 57.8 | 59.4 | 52.8 | 51.3 | 1266 | 1813 | 28.8 |
| 1976 | 6681 | 10150 | 65.6 | 58.1 | 39.2 | 48.4 | 4383 | 5897 | 28.5 |
| 1977 | 2560 | 1581 | 55.1 | 60.6 | 41.2 | 40.5 | 1411 | 958 | 23.4 |
| 1978 | 3907 | 3578 | 49.4 | 50.7 | 40.9 | 33.2 | 1930 | 1814 | 18.1 |
| 1979 | 3960 | 4745 | 45.3 | 40.6 | 48.8 | 40.5 | 1794 | 1926 | 19.2 |
| 1980 | 6305 | 4639 | 61.0 | 52.1 | 38.0 | 26.6 | 3846 | 2417 | 18.7 |
| 1981 | 6972 | 8178 | 54.2 | 54.0 | 42.0 | 36.5 | 3778 | 4416 | 21.7 |
| 1982 | 3017 | 2924 | 59.5 | 59.9 | 59.1 | 44.6 | 1795 | 1751 | 31.0 |
| 1 based on commercial catch sampling |  |  |  |  |  |  |  |  |  |
| 2 | d on | 11 con | tion | pling | ecedi | 11 |  |  |  |



Fig. 1. Map of southern part of the west coast of Newfoundland showing Statistical Area L (Lobster Fishing Area 13B), boundaries of Statistical Sections 42-44, and places mentioned in the text.




Fig. 2. Historical lobster landings and effort for Statistical
Area L and Statistical Sections 42-44.

## BOSWARLOS

> 0.711975
> 0.6
> 0.5
> $0.4-$
> $\begin{aligned} & 0.3-1 \\ & 0.2-1\end{aligned}$
> 0.1
> 0.0

Fig. 3. Average weekly CPUE (number of commercial lobsters per trap haul) throughout the 1975 to 1982 fishing seasons at Boswarlos with season averages indicated.


Fig. 4. Size frequency distributions of lobsters landed at Boswarlos during the 1975 to 1982 fishing seasons. Clear areas and numbers directly above represent the percentage within the recruit size ranges.


Fig. 5. Annual temperature at 9 m depth near Boswarlos, Port au Port Bay. Polnts represent the average of the mean daily temperatures for the first and second half of each month for the years 1984-91. Vertical lines indicate the range in daily mean temperatures, $x^{\prime}$ s indicate the range in 2 -week mean temperatures.


Fig. 6. Premolt-postmolt carapace length relationships for Boswarlos area lobsters.


Fig. 7. Carapace length-percentage molting relationships for Boswarlos area lobsters. Top - . relationship for each year 1975-82; Bottom - relationship for all years combined.

