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An Estimate of Yields for Oceanic Nova Scotia Lobster Grounds

By

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ABSTRACT

Logbook data are not available from lobster fishermen in Lobster Fishing Districts (LFD's) 4B-7A; thus common fisheries data such as fishing intensity, fishing effort, yields (fishing grounds biomass per square kilometer), and CPUE are not available. Fifteen percent of the fishermen in this area were randomly chosen and interviewed. The data collected permitted the following estimations of the above characteristics per LFD: fishing intensity (trap density per square kilometer) ranged between 30.6 and 114.9; yield (kilogram of lobster per square kilometer) ranged between 82.3 and 1,249.5; effort (trap hauls per square kilometer) ranged between 1,256.2 and 4,584.8; and CPUE [average catch (kilogram) per trap haul] ranged between 0.05 and 0.22. Fishing intensity (r=0.93) and fishing effort (r=0.92) were directly related to yield throughout the study area; but CPUE was not, nor was CPUE directly related to fishing effort in all LFD's.

We suggest that yield is a direct measure of recruit abundance and that the latter controlled annual landings and not fishing effort. We discuss the results in terms of historical annual landings in LFD's 6A, 6B, and 7A.

RESUME

On ne dispose d'aucune donnée de journal de bord des pêcheurs de homard des districts de pêche au homard (DPH) 4B-7A; notamment des données habituelles sur la pêche, comme l'intensité de la pêche, l'effort de pêche, les rendements (biomasse des lieux de pêche par km^2) et le nombre de prises par unité d'effort (PUE). Quinze pour cent des pêcheurs de cette région ont été choisis au hasard et interviewés. Les données recueillies ont permis d'établir les estimations suivantes des caractéristiques susmentionnées par DPH : l'intensité de la pêche (densité des cages par km^2) variait entre 30,6 et 114,9; le rendement (kg de homard par km^2) variait entre 82,3 et 1249,5; l'effort (levées de cages par km^2) variait entre 1256,2 et 4584,8; et les prises par unité d'effort/prises moyennes (kilogrammes) par levée de cage/variaient entre 0,05 et 0,22. L'intensité de la pêche (r = 0,93) et l'effort de pêche (r = 0,92) étaient directement reliés au rendement dans toute la région étudiée; mais le PUE ne l'était pas et n'était pas non plus relié à l'effort de pêche dans tous les DPH.

Nous suggérons d'utiliser le rendement comme mesure directe de l'abondance des recrues et de le considérer, plutôt que l'effort de pêche comme contrôlant les débarquements annuels. Nous analysons les résultats en termes de débarquements annuels historiques dans les DPH 6A, 6B et 7A.

INTRODUCTION

Eastern Canadian annual lobster landings per lobster fishing district (LFD) are available back to the late 1800's. Landings alone are of little use, however, when one wants to assess the health of a stock or compare lobster production between districts. CPUE is a "...proper index of stock..." (Cushing 1981) and can be employed to estimate "...the mean stock present..." (Ricker 1975); but CPUE data were unavailable for LFD's 4B through 7A ("oceanic" Nova Scotia) and, due to the numbers of fishermen, impractical to attain via logbooks (Anthony and Caddy 1980). An indirect method using fishermen interviews was designed and a study carried out (see Pringle and Duggan 1984 for details of the interview technique). We report here on the following characteristics for LFD's 4B through 7A for 1982: 1) fishing ground size; 2) fishing effort; 3) yield per unit area; and 4) CPUE. We conclude that calculated yield values represent recruit abundance, that the latter drives each fishery, and that we have little understanding of the mechanisms underlying recruit abundance and thus have difficulty in explaining differences in lobster density between lobster grounds.

CONCEPTS AND METHODS

Fishing effort (f) is the total fishing gear used in an area over a specific time period (Ricker 1975). Here we define it for each LFD as the total number of trap hauls per area of fishing grounds (square kilometer) per season. Effort was calculated using the following formula:

$$f = \frac{NF \cdot Tr \cdot DF}{A} \quad \text{where}$$

NF = number of licensed fishermen per LFD;

Tr = the sum of the mean number of traps hauled daily by both "A" and "B" licensed fishermen per LFD;

DF = mean number of days fished per licensed fisherman; and

A = area (square kilometer) of fishing grounds for the LFD.

Fishing effort information was acquired via interviews of fishermen (see Pringle and Duggan 1984 for details and Appendix 1 for a list of questions). Licensed fishermen number per LFD was acquired from the Conservation and Protection Division, Fisheries Operations Branch, Scotia-Fundy Region. We did not correct for an estimated 5% "back-pocket" licenses. Mean number of both days and traps fished per license, per district, per season (Table 1) were estimated by Pringle and Duggan (1984). CPUE was determined by:

$$CPUE = c/f \quad \text{where}$$

c = the LFD annual landings

Fishing ground area per (A) LFD was determined as follows: the seaward boundary was estimated from responses of interviewees to questions of maximum depth and distance fished offshore. District mean maximum depth was then determined and contoured on a navigational chart. The shoreward fishing limit was always the upper-subtidal fringe. Unsuitable lobster bottom, i.e. large areas of sand and mud, heads of bays and estuaries, etc. were eliminated using data from Moore and Miller, (1983). The perimeter of the lobster grounds was traced on a digitizer (Hewlett Packard 9874) linked to a desk-top computer (HP9825) equipped with a program which converted enclosed area to square millimeters. Actual area was determined by conversion using chart scale.

Yield (Y), or catch per square kilometer per LFD was calculated as follows:

$$Y = \frac{c}{A}$$

RESULTS

Area of fishing grounds per LFD varied markedly (Table 1 and Fig. 1), ranging from 130 km² (LFD 6A) to 982 km² (LFD 6B). The number of fishermen per district peaked in LFD 6B (517) and troughed in LFD 6A (21) (Table 1). The area of fishing grounds per fisherman was greatest in the latter district (6.20 km²) and least in LFD 4B (1.76 km²) (Table 2). The ratio between number of "B" licensed to "A" licensed fishermen varied from 0.23 (LFD 4B) down to 0.09 (LFD 5B) (Table 2). The percentage of "B" licensed fishermen in a district did not appear to reduce district fishing effort ($r=0.39$).

The seasonal number of traps employed per LFD for "A" and "B" licensed fishermen varied markedly between districts (Table 1), ranging from 147.0 (LFD 4B) to 239.5 (LFD 6B) and from 46.8 (LFD 6B) to 83.0 (LFD 7A) respectively. Mean trap density per square kilometer (Table 1) per LFD ranged from 30.6 (LFD 6A) to 114.9 (LFD 6B). Mean number of trap hauls per fisherman per LFD (Table 1) ranged from 5,260.9 (LFD 4B) to 8,708.4 (LFD 6B) and appears to be linearly related to CPUE ($r=0.79$) (Fig. 2). Fishing effort (trap hauls per square kilometer) per LFD varied markedly from 1,245.0 (LFD 5B) to 4,584.8 (LFD 6B).

Landings per district (Table 1) varied from 27 t (LFD 6A) to 1,227 t (LFD 6B). Yield (kilogram of lobster per square kilometer) ranged widely, from 82.3 (LFD 5A) to 1,249.5 (LFD 6B). There appears to be a linear relationship between yield and trap density per district (Fig. 3; $r=0.93$).

CPUE (kilogram of lobsters per trap haul) varied substantially between districts, ranging from 0.05 (LFD 5A) to 0.22 (LFD 6B). Although CPUE appeared to have a direct influence on the mean number of trap hauls per fishermen per LFD (Fig. 2), it appeared not to influence fishing effort in all LFD's. For example, CPUE in LFD's 5B and 6A was considerably greater per unit effort than in the remaining districts (Fig. 4).

DISCUSSION

CPUE is an important characteristic of a fishery; it can be used to assess recruit abundance (Ricker 1975), and resource managers can use it as a guide to the welfare of the fishery. We have shown (Table 1) in this study that between-district differences, by up to a factor of 4.4, exist in CPUE values. CPUE is a function of recruit abundance, fishing effort, and fishing power.

Direct measures of recruit abundance are unavailable; however, district yields have been estimated (Table 1). Yields, if exploitation rates are high, should be a relative measure of preseason recruit abundance. Although exploitation rates where measured are high in eastern Canadian lobster fisheries (G.P. Ennis, pers. comm.[1]), recent estimates are not available for the study area. There is no reason to believe these rates would be significantly less than those measured elsewhere. Consequently, yields are likely a reasonable measure of recruit abundance. If this is correct, there were then major inter-district differences in recruit abundance in 1982. Reasons for this are unknown but may be due to past fishing history and inter-district differences in both ecosystem productivity and lobster support systems. The reason for this was apparent; catches reached all-time lows in the late 1970's and early 1980's (see Fig. 6-10). Fishing efforts in most districts likely attained that level where further increases resulted in reduced CPUE. The exceptions were in LFD's 5B and 6A (Fig. 4).

Differences in fishing power (vulnerability of stock to different boats and gear - Ricker 1975) were noted throughout the study (Duggan in press); fishing power appeared greatest where CPUE was highest.

Figures 3 and 5 demonstrate a linear relationship between yield and both fishing intensity (r=0.93) and fishing effort (r=0.92). Given this and the above, we conclude that the LFD yield differentials were mainly due to respective recruit abundance levels and not due to the differentials in fishing effort and fishing power. We suggest that the bulk of the inter-district difference in CPUE was not due to fishing power differentials, however, but to lobster abundance. The increased fishing power was likely due to increased monetary returns from improved CPUE.

We conclude that the observed inter-district differences in CPUE are due to differences in lobster abundance and not to fishing effort and levels of fishing power.

A number of hypotheses have been developed to explain the marked decline in annual landings in LFDs 4B-6A and 7A (Figures 6, 7, 8, 10): these are as follows - 1) a reduction in larval biomass and hence recruits through the 1955 closure of Canso Strait (Dadswell 1979); 2) recruitment overharvesting (Robinson 1979); 3) generally poor larval survival due to physical oceanographic conditions (Harding et al 1983); and 4) nearshore habitat disruption due to massive increases in sea urchin densities (Wharton and Mann 1981). Unfortunately, too little is yet known about lobster ecology to give support to any of the above. We suggest that ultimately, none of the above hypotheses will give a satisfactory explanation for the demise of lobster abundances throughout the study area. A synthesis incorporating some of them will likely emerge.

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[1]G.P. Ennis, Fisheries Research Branch, Dept. of Fisheries and Oceans, Newfoundland Region, St. John's, Nfld., A1C 5X1.

The lobster fishery of eastern Canada is the backbone of the inshore fishery as the bulk of these fishermen tend to attain the major portion of their annual income from lobster. It should be noted that to both attain and retain a lobster fishing license one must be a full-time fisherman. Consequently, in the study area in 1982/83, 95% of these licenses were active (Pringle and Duggan 1984). Given the above, one would expect fishing effort to be at maximum levels. This was not the case; Pringle and Duggan (op. cit.) showed that 25% of potential effort was latent. We suggest this was not due to affluence or indolence but to lobster abundance levels.

Support for the first two hypotheses was presented at a single workshop; and of the two, recent developments tend to support the recruitment overharvesting hypothesis although anomalies exist. The Canso Strait hypothesis predicts no recovery of the fishery until Canso Causeway removal. Supporters of the recruitment overharvesting hypothesis appealed for an increase in minimum legal carapace length (CL) to permit an increase in egg production (D.G. Robinson, pers. comm.;[2] Campbell and Robinson 1983). Despite the existence of the Causeway and a status quo on CL, annual landings have increased markedly throughout the study area (not shown in Fig. 6-10). Furthermore, LFD 6B bears the shortest minimum legal CL (70 mm/2.75") and the highest fishing intensity and fishing effort (Table 1) in the study area. Annual catches, however (Fig. 9), have been high and steady and fishermen enjoy the highest CPUE. The lower size at sexual maturity (Campbell and Robinson 1983) is likely not sufficient explanation. An exterior source of larval recruits and/or a good larval retention system are suggested as two of the factors important in sustaining this fishery.

Of interest is the fishery in adjacent LFD 6A (see Fig. 1 and 8). Here, fishermen apparently lobbied (D.G. Robinson, pers. comm.) for and received in 1934 a minimum legal CL (79 mm/3.1"). Fishermen of neighbouring districts (5, 6B, and 7A) only incorporated a minimum CL in 1940 (54 mm/2.1"), a year prior to LFD 6A fishermen moved to 81 mm, the present measure. Fishermen of LFD 6B began employing the present 70 mm CL (2.75") in 1952 only. LFD 7A fishermen attained the present 81 mm CL in 1961. Fishing effort patterns over the years in both LFD's 6A and 7A appears similar (D.S. Moore, pers. comm.[3]). Given the above, egg production over the years should have been greater in LFD 6A than LFD 7A. If increased egg production translates into increased district yields then LFD 6A should have had superior yields; we do not see this, and in fact the annual catch has been similar for many years (Fig. 8 and 10). Furthermore, our calculated 1982 yields for LFD's 6A and 7A were nearly identical at ~207 kg lobster km^{-2} (Table 1). Fishing intensity and effort were greater in LFD 7A by factors of 1.8 and 1.7 respectively. These differences in intensity and effort appear to have prevailed for at

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least the past 35 yr (D.S. Moore, pers. comm.). In spite of this and the long period of a much larger CL in LFD 6A, these grounds appear to be similar in recruit abundance.

The above suggests that insufficient information are available to permit the development of long-term resource management plans in this area. Information on all aspects of lobster ecology from larval distribution through to habitat requirements appears necessary, along with good physical oceanographic data. Until these data are available, resource management plans should be conservative.

The objective of the biological science side of resource management is long-term optimal yield; the objective of the economic side is long-term maximization of earnings. Despite having the same resource management system over many years and occupying contiguous LFD's, fishermen in LFD's 6A and 7A have markedly different CPUE's (0.10 vs 0.17 - Table 1) and mean annual catches (0.62 t vs 1.23 t) although yields are identical. This suggests that mean annual earnings for LFD 6A fishermen are about double LFD 7A fishermen. Through the history of these two fisheries one group has fared better financially than the other; reasons for this are unclear at present. The resource manager should strive to improve CPUE and annual catches in all LFD's but in particular in LFD 7A.

CONCLUSIONS

1) That there was a large between-LFD difference in yields in the study area and that yields are a measure of LFD recruit abundance.

2) That recruit abundance drives each district fishery; they are not driven by fishing effort, fishing intensity, fishing power, or any combination thereof.

3) That, over the study site generally, CPUE is not directly related to yield.

4) That we do not comprehend the underlying biological mechanisms of lobster recruit abundance.

RECOMMENDATIONS

1) To permit an understanding of the mechanisms underlying recruit abundance the existing program on the ecology of lobsters, with emphasis on larvae, juveniles, and habitat requirements be continued and extended to include an increased emphasis on physical oceanography and a better coverage of LFD's 4B to 7A.

2) That lobster management plans for LFD's 4B to 7A take into consideration our lack of understanding of mechanisms underlying recruit abundance and thus proceed cautiously. It is particularly important in the near future to ensure that lobster fishing pressure does not increase beyond that legally allotted at present.

3) That lobster management plans strive to improve CPUE, particularly in LFD's 4B, 5A, and 7A.

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Table 1. Characteristics of the lobster fishery for each of lobster fishing districts 4B, 5A, 5B, 6A, 6B, and 7A. Base data were collected via personal interviews with 15% of the fishermen (see Pringle and Duggan 1984) in the study area. Lobster landings were provided by the Statistics Division, Scotia-Fundy Region.

Lobster district	No. "A" lic[a]	No. "B" lic[a]	$\bar{X}$ no. traps "A"	$\bar{X}$ no. traps "B"	Total no. traps fished[e]	Estimated fishing area (km^2)	$\bar{X}$ Trap density[f] km^{-2}	Recorded landings t/000 lbs	Yield ($\bar{X}$ kg lob. captured km^{-2}[g])	Estimated $\bar{X}$ no. days fished $fishermen^{-1}$	Total no. trap hauls[h]	Effort (trap hauls km^{-2}[i])	$\bar{X}$ no. trap hauls $fishermen^{-1}$[j]	CPUE[k] (avg. catch trap $haul^{-1}$ (kg/lb)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4B[b]	412	98	147.0	58.0	66,248	900	73.6	297/654.8	330.0	40.5	2,683,044	2981.2	5260.9	.11/.24
5A	152	17	189.2	52.5	29,651	741	40.0	61/134.5	82.3	37.8	1,120,809	1512.6	6632.0	.05/.12
5B	129	12	189.3	75.0	25,320	661	38.3	103/227.1	155.8	32.5	822,900	1245.0	5836.0	.13/.28
7A	71[c]	10[c]	177.7	83.0[d]	13,447	241	55.9	50/110.2[c]	207.5	38.6	520,212	2158.6	6422.0	.10/.21
6A	19	2	203.0	63.0	3,983	130	30.6	27/59.5	207.7	41.0	163,303	1256.2	7776.0	.17/.36
6B	460	57	239.5	46.8	112,838	982	114.9	1227/2705.0	1249.5	39.9	4,502,236	4584.8	8708.4	.22/.60

(a) Includes estimated 5% of issued but unused "back pocket" licenses.
(b) Does not include Shelburne Co. portion of district 4B.
(c) Excludes licenses fished in Bras D'or Lakes.
(d) No "B" fishermen interviewed in this district – value is mean for all "B" fishermen interviewed.
(e) (Column 2 · Column 4) + (Column 3 · Column 5)
(f) (Column (6) ÷ Column (7).
(G) (Column (9) ÷ Column (7).
(H) (Column (6) x Column (11). (Assume a 24 h soak time).
(i) (Column (12) ÷ Column (7).
(j) (Column (12) ÷ [Column (2) + Column (3)].
(k) (Column (9) ÷ Column (12).

Table 2. Number of lobster fishermen per LFD (4B through 7A - oceanic Nova Scotia) and the area of fishing grounds (square kilometer) per fisherman.

District	No. fishermen "A" License	No. fishermen "B" License	Ratio of "B"/"A"	Total No. of fishermen	Fishing ground area (km^2)	Fishing ground area per fisherman
4B	412	98	0.23	510	900	1.76
5A	152	17	0.11	169	741	4.38
5B	129	12	0.09	141	661	4.69
7A	71	10	0.14	81	241	2.98
6A	19	2	0.10	21	130	6.20
6B	460	57	0.12	517	982	1.90
e or $\bar{x}$	1,243	196	0.16	1,439	3,655	2.54

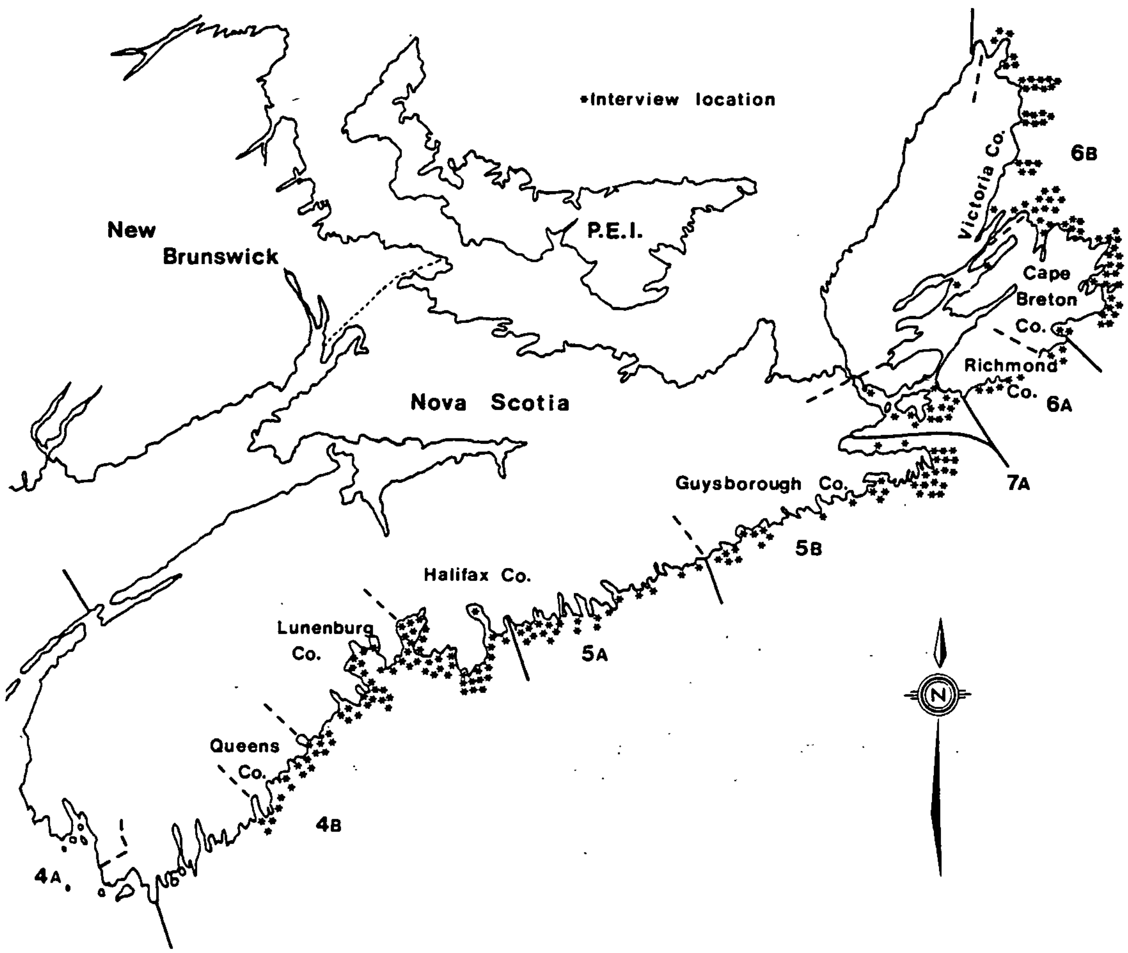


Figure 1. Oceanic Nova Scotia lobster fishing districts (LFD's 4B through 7A) and the distribution of interviewees (represented by the stars) per district.

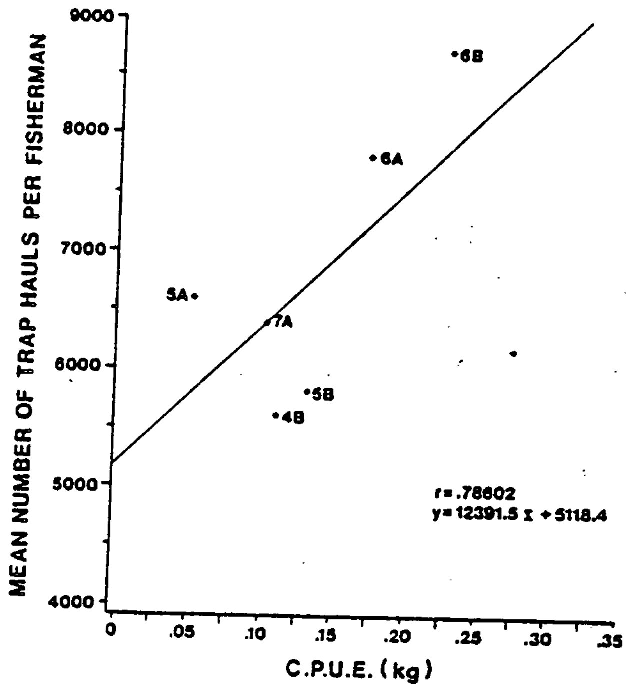


Figure 2. The relationship between trap haul number per fishermen per lobster fishing district (LFD's 4B through 7A) and CPUE [mean catch (kilogram) per trap haul] during 1982.

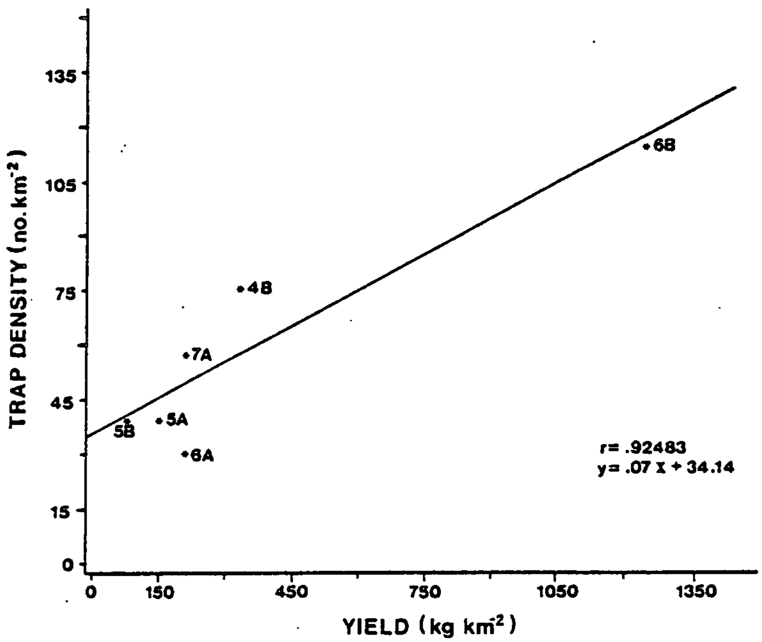


Figure 3. The relationship between trap density (number per square kilometer) per lobster fishing district and yield (kilogram of lobster per square kilometer) for 1982.

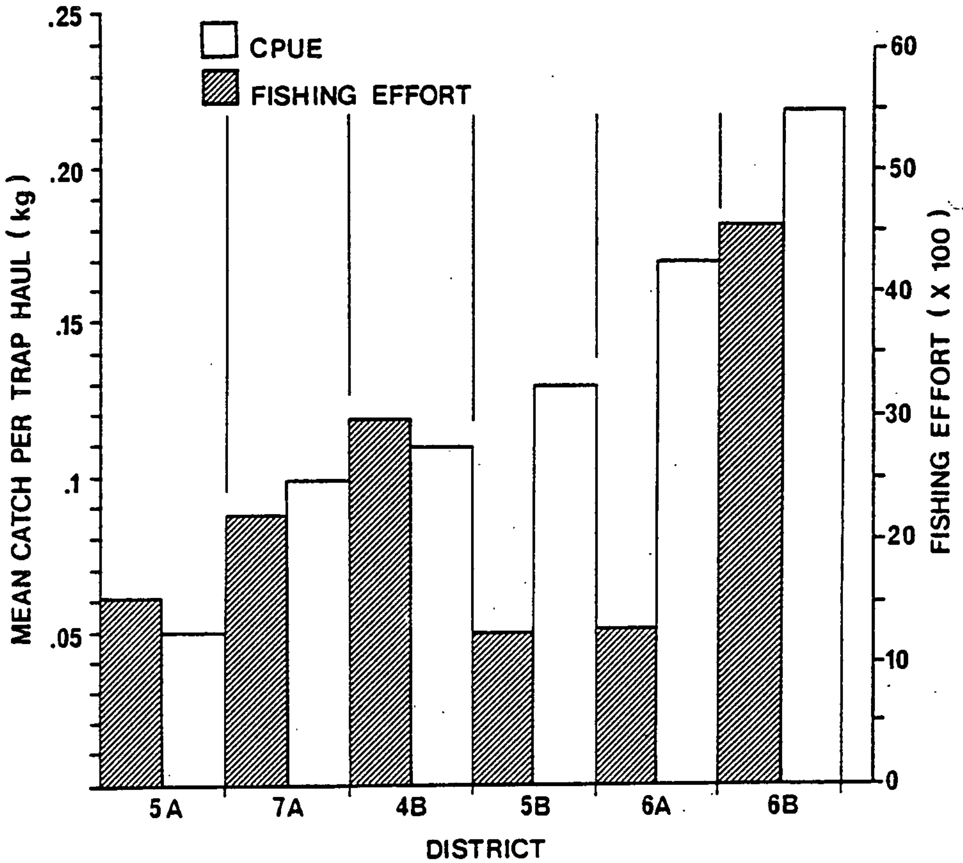


Figure 4. CPUE and fishing effort per lobster fishing district (LFD's 4B through 7A) for 1982.

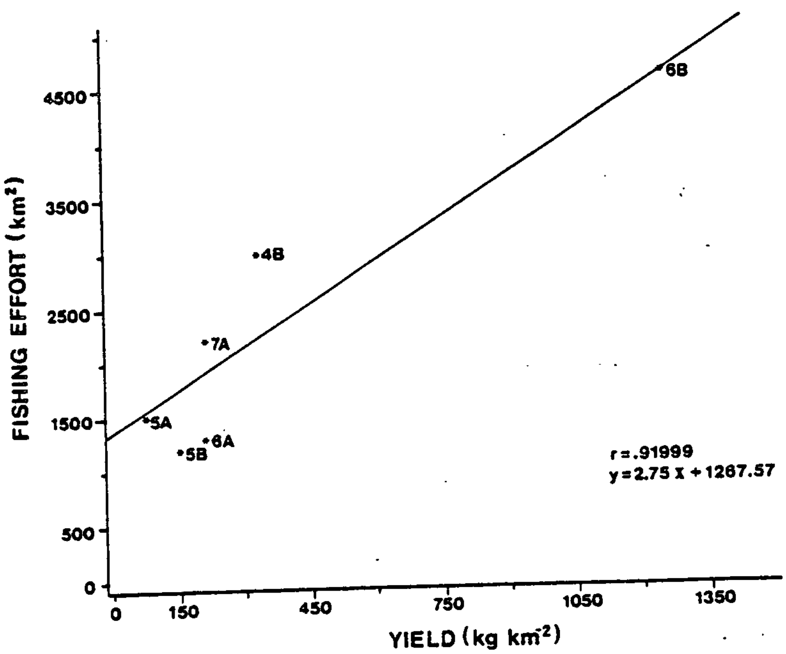
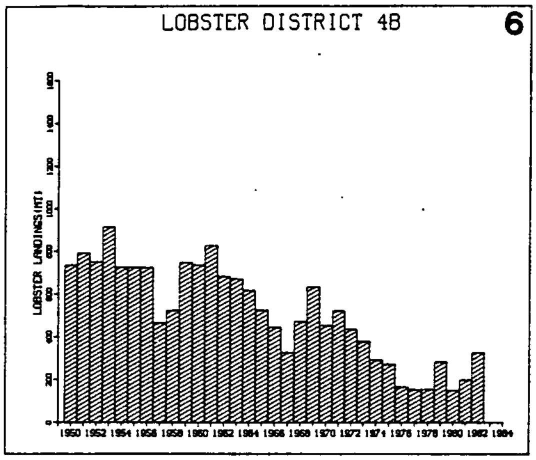
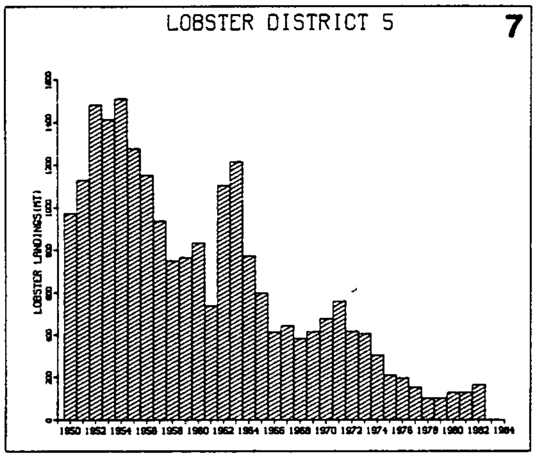
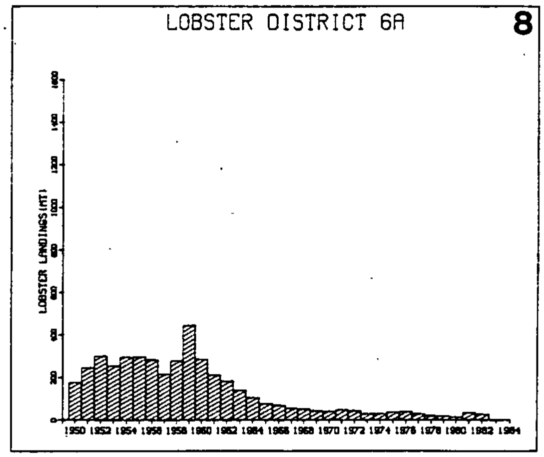
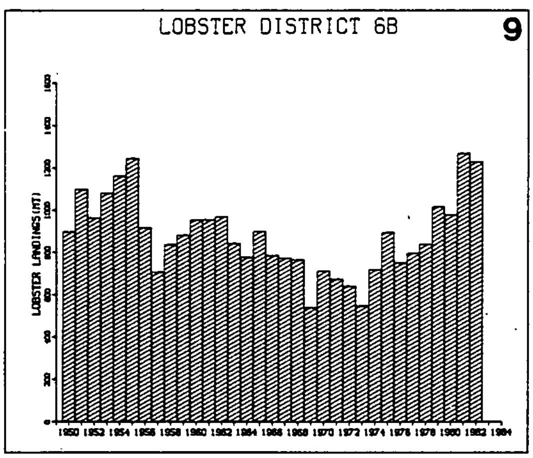


Figure 5. The relationship between fishing effort (number of trap hauls per square kilometer) and yield (kilograms of lobster per square kilometer) in Lobster Fishing Districts 4B-7A during 1982.









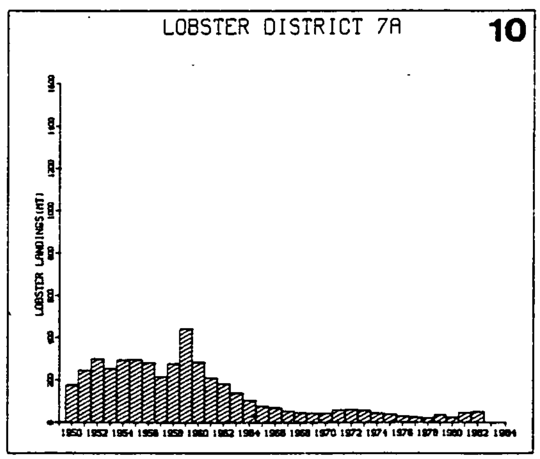


Figure 6. Annual lobster landings in Lobster Fishing District 4B (does not include the Shelburne Co. portion of this district) between 1950 and 1982.

Figures 7 to 10. Annual lobster landings in Lobster Fishing Districts 5, 6A, 6B, and 7A between 1950 and 1982.