Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 87/85

CSCPCA Document de recherche 87/85

Overview of the Inshore Lobster Resources in the Scotia-Fundy Region

By

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INTRODUCTION

Lobster landed weight and value in the Scotia-Fundy Region increased 2.8 and 4.1 times respectively from 1980-86. Landed weight in 1986 was the highest since 1905 (Fig. 1). These increases have encouraged requests for additional access to the lobster fishery.

This report reviews exploitation of the inshore stocks by lobster fishing area (Fig. 2), and predicts the impacts of increased effort and increased minimum legal size. We recommend for most areas that legal size be increased to improve both yield per recruit and reproductive capacity. Following these changes to increase physical yields, economic objectives could be used to decide how many fishermen should share the landings. Common economic objectives for Atlantic Canada fisheries are that employment is created and that fishermen make a reasonable income from their labour and investment (Kirby1982).

Recent papers by Campbell (1985, 1986a), Campbell and Robinson (1983), Ennis (1978a, 1985), and Fogarty (1980) have presented detailed analyses of how certain management options and natural mortality rates can affect yield per recruit (y/r) and eggs per recruit (e/r) in *Homarus americanus* stocks. Management options considered were exploitation rates, minimum legal size, maximum legal size, a closed size window, and protection of berried females. Although a near endless list of 'what if' management options could be tested by simulation, only the most likely choices, changes in exploitation rate and recruit size, were considered here. Effects of these changes may be generalized as follows:

1. Mean size of capture would increase from raising recruit size or lowering exploitation rate.
2. At current recruit sizes y/r would typically peak at exploitation rates of 20-40%/yr, lower than in the fishery now, decrease rapidly to rates of about 60%/yr, then continue to decrease slowly.
3. E/r decreases rapidly over the full range of exploitation rates now present or likely to be present.
4. The higher the exploitation rate the greater the benefit of increased recruit size to y/r and e/r.

METHODS

Lobster landings from 1892 were summarized by county from Statistics Canada Records (Ann Williamson, Biological Sciences Branch, St. Andrews). Miscellaneous government reports were used to extend the series to the 1870's. Boundaries of Lobster Fishing Districts similar to those now in place (Fig. 2) were established in 1947. Beginning in 1986 these were called Lobster Fishing Areas. Landing records by area are kept current by Williamson, using data from the Scotia-Fundy Regional Statistics Division.

Catch per trap haul (cpth) for Areas 34-38 were obtained by biologists going to sea with fishermen and recording their catch from each trap. In the remaining areas cpth was determined from interviews or logbooks in 1980 and 1984, and logbooks only in 1986. Trap hauls per area per year were calculated by dividing area landings by cpth.

Landed value per license was based on the number of lobster licenses issued per fishing area (Scotia-Fundy Regional Licensing Unit) and landed value per area (Scotia-Fundy Regional Statistics Division). No adjustment was made for inactive licenses. Thus, this statistic is a measure of mean earnings/license amortized over all licenses. One would expect the higher potential earnings per license, the more likely it is to be used. Pringle and Duggan (1984) estimated from random interviews of 15% of license holders that 5% of licenses in Areas 27-33 were inactive in 1982. J. Nelson (unpublished rep., Economics Branch) compared C.F.V. numbers of license holders with C.F.V. numbers on lobster sales slips, and estimated that 15% of fishermen in Areas 34-38 did not use their licenses in 1985. We started with the same data sources as Nelson for areas 27-30 and found that 6% of licenses were unused and 9% obviously underused in Area 27, none were unused or underused in Area 30, and 16% were unused and 23% obviously underused in Areas 28 and 29. We obtained explanations of why C.F.V. numbers on licenses and sales slips did not match by interviewing fishermen and fishery officer.

Total annual mortalities (Z) and exploitation rates (A) were calculated as:

$$Z = \log_e (M_2/M_1)$$
$$A = 1 - (M_2/M_1)$$

where $M_1 = M_1'/t_{m1}$ and $M_2 = M_2'/t_{m2}$. M_1' and M_2' are the number of lobsters in the catch in the first and second molt classes of market size (approx. 81-93 mm and 93-107mm c.l.), and t_{m1} and t_{m2} are the average times in yr spent in the molt classes. In Area 27, lobsters recruit to the fishery as canners (70 mm c.l.), however the first two market molt classes were used because vulnerability to trapping is thought to be significantly lower for cannner than for market sizes (Smith 1944; Ennis 1978b; Conan and Maynard, unpublished ms). Frequencies of lobsters in M_1' and M_2' molt classes were obtained from at sea samples or port samples of landings. In most areas more than one port and more than one year contribute to estimates.

Natural mortality was assumed to be 0.1/yr. Estimates vary but this is a commonly assumed value (Thomas 1973; Campbell 1985). Instantaneous fishing mortality was calculated as Z - 0.1.

Yield per recruit in grams, and number of eggs per female recruit were calculated using Caddy's (1979) Fortran program as modified by Campbell (1985) and adapted to a microcomputer by D. Swetnam (Biological Sciences Branch, Halifax). The required inputs were time between molts (the reciprocal of proportion molting per year) vs. size, carapace length increase per molt vs. size, fecundity vs size, relative vulnerability to capture vs. size, proportion of females mature vs. size, length-weight regressions, natural mortality, and recruit size. For areas 34-36, y/r and e/r were taken from figures and tables in Campbell (1985). Y/r was calculated separately for males and females, then averaged.

Calculation of y/r and e/r required estimates of 24 parameters, 14 for females and 10 for males, providing ample opportunities for inaccuracies. Sources of bias discussed in the I and MP Subcommittee meeting on April 22, 1987 were as follows

1. A and Z were determined from size frequencies of fishermen's catches. If areas populated by large lobsters were fished at lower intensity than areas with small lobsters, A and Z would be overestimated. Emigration of large lobsters from an area of high exploitation (e.g. inshore) to an area of low exploitation (e.g. offshore) could lead to size segregation.
2. In the above example of emigration, increasing recruit size would benefit y/r and e/r less than predicted.
3. An apparent increase in recruitment could be caused by a decrease in natural mortality of recruits, and the reverse. M has not been measured in any area considered in this report (nor but for a few stocks of any of our commercial species).
4. If all recruited sizes are assumed to be equally vulnerable to trapping, but vulnerability increases with size, A and Z will be underestimated.

RESULTS

This section is organized by Lobster Fishing Areas. Landing trends post war and for the 100 year record are considered; cpth and th/yr. are compared for the last 4-6 years; estimates of recent y/r, e/r (inputs are given in Table 1), exploitation rates, and fishing mortality rates are given; effects of higher F's and larger recruit sizes on y/r and e/r are considered; and advice is offered on changes in both number of licenses and recruit size.

A 30% increase in F would cause a small decrease in y/r in every area and a large decrease in e/r in most areas (Table 2). Thus, increasing effort would cause no increase in landings except for a short fishing up period. In areas of high exploitation more effort may actually decrease landings because more short lobsters would be killed by handling and lower egg production may decrease recruitment. Neither of these factors have been quantified. As is the case for all our commercial species except seals and salmon, we have no predictive relationship between egg production and subsequent recruitment.

We presume that all potential fishing grounds are exploited in most areas and that they are fished at greater than F_{max} (the fishing mortality of greatest yield) (Table 2). The addition of active licenses in these areas would decrease earnings of existing active licenses (Table 3) in equal or greater proportion to the added effort.

AREAS 35, 36, 38.

A dip in landings in the late 1970's and a rise in the 1980's are the biggest changes for the Bay of Fundy since the early 1940's (Fig. 3a). Current landings were last equaled in the 1950's and at the turn of the century. Since the 1980-81 season cpth has increased moderately, from 0.84 to 0.95 kg, as has fishing effort, from 624,000 to 937,000 th/yr (Table 4). Exploitation rates are 71%/yr (Table 5) for the

Bay as a whole, but landings on the northern end of Grand Manan and at the head of the Bay are sustained by large migratory lobsters for which exploitation rates are unknown (Campbell and Duggan, 1980).

Increasing the recruit size by one and two molt classes would increase y/r by 33% and 67% respectively (Table 2). Exploitation rate would have to be reduced from the current 71% to 33% to achieve the increase in y/r given by one molt class size increase. The increase in y/r achieved by a two molt size increase would be unattainable at any exploitation rate at the present recruit size. An increase in recruit size to >94 mm c.l. is recommended.

AREA 34

From 1947 through 1980 landings varied between 2700 and 5000 t (Fig. 3b). By 1986 they had increased to 7500 t, the highest since 1900. From the 1981-82 to 1985-86 seasons effort increased 81% in spite of no change in the number of licenses (Table 3), and cpth increased 37% (Table 4). The effort increase has kept the exploitation rate high, now estimated at 83% (Table 5).

Increasing recruit size by one and two molt classes would increase y/r by 35% and 73% respectively (Table 2). Exploitation rate would have to be reduced from the current 83% to 36% to achieve the same y/r as a one molt size increase. The increase in y/r from a two molt size increase is unattainable by adjusting the exploitation rate.

Effort has increased on the middle ground in the last few years, but by an unknown amount. This area extends from approximately the 25 fathom contour out to the 50 mile offshore line, and from Lurcher Shoals in the north to Brown's Bank in the south. Because the inshore grounds are now so crowded with traps, an increase in licenses would probably accelerate the effort increase on the middle ground. Because the middle ground is more expensive to fish than inshore, boats require larger landings just to cover costs.

Regretably, the location of brood stock for the inshore grounds is still unknown, but the possibilities are narrowing. Recent information on currents around Georges Bank suggest that this area rarely contributes larvae inshore (Perry and Hurley 1986). The closed area on Brown's Bank and the fished area on German Bank have concentrations of mature females during the spawning season (Pezzack 1983; D. Robichaud, pers. comm.). Lobsters inshore during the fishing season are rarely berried (Stasko 1978) so probably contribute few larvae, however berried females appear inshore from an unknown location during the summer spawning season (Campbell and Pezzack 1986). The juveniles making up the inshore fishery are probably recruited to the inshore from larvae rather than by juvenile migration. Tagging studies elsewhere show little movement of juveniles (Stasko 1980; Krouse 1980). Tagging studies in parts of southwest Nova Scotia are unrewarding because many fisherman do not return lobster tags.

If licenses are added to Area 34 the recruit size should first be increased to >94 mm c.l.to increase y/r and provide some protection against the inevitable increase in effort on mature females on the middle ground. The following is a possible scenario. By spacing the size increase over 3 years the fishery would experience a net loss of landings the first year, return to about original levels in the second, and profit from the change in the third and subsequent years. Starting in the third year additional temporary-nonrenewable licenses could be added. They should be temporary (e.g. 3 years) so that the number of licenses can revert to the present number if landings return to more usual levels. They should be nonrenewable so that new license holders have NO expectation of permanent licenses and if landings remain high more fishermen could share the windfall.

AREA 33

Landings increased 11-fold (248 to 2675 t) from 1980 to 1986 (Fig. 3c). These values are both the lowest and highest since the turn of the century. Fishing effort increased five-fold and cpth nearly doubled from the 1980-81 to 1985-86 seasons (Table 4) from a near constant number of licenses (Table 3). The exploitation rate of 73% (Table 5) is similar to the rate in the Bay of Fundy.

Increasing recruit size one molt class would increase y/r by 34% (Table 2). To gain this increase by reducing effort, exploitation rate would need to be decreased from the current 73% to 34%.

An increase in recruit size to about 94 mm c.l. is recommended to increase y/r.

AREAS 31,32

Landings for 1986 are up five-fold over 1980, but are still depressed by historical standards (Fig. 3d). They remain below the mean for the postwar period and are only about 10% of the peak landings of the 1880's. Fishing effort increased three-fold from 1980-86, and cpth doubled from a depressed level in 1980 to 0.32 kg in 1986 (Table 4). Recent exploitation rates average a relatively modest 52% (Table 5). Fishermen in these areas have profited from a 50% reduction in licenses during the 1978-81 buyback program.

An increase in recruit size to 94 mm c.l. would increase y/r by 21%. This increase is unattainable at any exploitation rate at the present recruit size. According to Harding et al. (1983) Areas 29 and 31 (at least) received lobster larvae from the Gulf of St. Lawrence before construction of the Canso Causeway. These areas may now need higher local reproductive effort to return catches to former levels. No immediate addition of licenses is recommended because landings are low historically and cpth is modest. However, if the stock continues to recover and recruit size is raised to increase y/r and protect the current high reproductive effort, licenses might be added (by transfer or new issue) in a few years.

AREAS 28, 29, 30

Landings were six times higher in 1986 than in 1980 but are still low historically (Fig. 3e). They are about one-half the three previous peaks this century and one-quarter the mean for the 1880-1900 period. Cpth in Areas 28-29 was still less than 0.2 kg in 1986, whereas in Area 30 it had reached 0.52 kg (Table 4). These areas also benefitted from a 48% buyback of licenses during 1978-81.

Increasing recruit size by one molt would increase y/r by 15% (Table 2). This is low because exploitation rate is 43% (Table 5), the lowest in Scotia-Fundy. Overcoming local resistance to a size increase may not be possible at this time. In spite of low exploitation in Areas 28 and 29 ,no increase in licenses is recommended, cpth is low and landings are low historically. However, higher catch rates, low exploitation rates, and recovering landings suggest that a few licenses could be added to Area 30.

We suggest that the southeast portion of the contiguous Area 27 (to about Scatarie Island) would more logically be managed as a unit with Area 30. This portion is more similar to Area 30 in both physical environment (temperature and physiography, Moore et al. 1986) and fisheries characteristics (exploitation rate, Table 5; history of landings, Scotia-Fundy Statistics Branch; mean size of female sexual maturity, unpub. data) than to the remainder of Area 27.

AREA 27

Landings have nearly tripled since the late 1970's (Fig. 3f), and in 1986 became the highest in the 110 years of record. Both cpth and th/yr have increased since 1980 (Table 4) despite a nearly constant number of licenses (Table 3). Exploitation rate has averaged 82% in recent years (Table 5).

Area 27 is Scotia-Fundy's only canner fishery. If the recruit size were raised to market size, y/r would increase by 15% (Table 2); a smaller gain than for most areas because in the y/r model the vulnerability of canners to capture was set at one-half the vulnerability of market sizes, and growth rates were less because females matured at a smaller size. However, since market lobsters have higher value per unit weight than canners, the y/r in dollars would increase by 35%. Benefits of increasing the recruit size can also be calculated as the increase in value of a kg of canner lobsters caught as markets. One kg of canners would on average weigh 1.22 kg if not fished until market size. The values of canners and markets in 1986 were $4.73 and $7.06/kg respectively. Thus, for every kg of lobster landed as canners the value was $4.73, but landed as markets the value would have been 1.22 X $7.06, or $8.61, and increase of 82%.

An increase to market size is recommended.

DISCUSSION

Lobster landed weight increased from 10% to 11-fold in Scotia-Fundy's 11 Lobster Fishing Areas during 1980-86. Because the increases in landings were synchronous throughout the Region during the 1980's, we presume the cause was a wide spread environmental effect. However, a likely environmental cause has not been identified.

The number of licenses in the region has changed little from 1982-86. Nevertheless, fishing effort has increased considerably by the activation of inactive licenses, by increases in days fished per year, and by increases in the number of traps hauled per day. The lobster license buyback program of 1978-81 reduced Scotia-Fundy licenses by 30%, and in the areas with most depressed landings (28, 29, 30, 31, 32) licenses were reduced by 50% . Without this program fishing effort in these depressed areas would now be much greater and earnings per license much lower.

The maximum potential lobster yield is a moving, ill-defined, and unrealistic target, however the potential in Scotia-Fundy lobster stocks is undoubtedly underused. Yield per recruit and eggs per recruit can be increased by increasing minimum legal size or reducing fishing effort. Reducing fishing effort is impractical at present because license or season reductions would be unpopular with industry, and trap hauls by a single license can always be increased in ways which are impractical to regulate. Increases in yield per recruit equals yield to the fishery, but the benefit of increased egg production is unknown because of our ignorance of stock-recruitment relationships.

The recommendation for increasing the recruit size of Canadian lobsters has been made many times in the last 10 years. We add our recommendation to the following list: Anon (1977) - all *Homarus* fisheries, Ennis (1978a) - Newfoundland, Robinson (unpub. ms.) - eastern Maritime provinces, Robinson (1979) - eastern Nova Scotia, Anthony and Caddy (1980) - Atlantic Canada, Ennis (1980) - Newfoundland, Pringle et. al (1983) - Atlantic Canada, Campbell and Robinson (1983) - Maritime provinces, Campbell (1985) - Bay of Fundy, Campbell (1986a) - Bay of Fundy and southwest Nova Scotia, and Campbell (1986b) - Bay of Fundy.

In several meetings with representatives of government and the lobster fishery the only criterion seriously considered for choosing the number of licenses has been the status quo. Although earnings per license is an emotional topic for industry and an uncomfortable one for government, we believe that more reasoned criteria than status quo should be developed for present and future petitioners.

THANKS

R. E. Duggan, D. Graham, D.S. Pezzack, D. Robichaud, and A. Williamson are acknowledged for contributing data and background to this report. A. Campbell was on sabbatical at the time of preparation but contributed, in absentia, through his published papers and unpublished data.

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Table 1 Inputs for the yield per recruit and egg per recruit calculations.

Fishing Area		Probability of molting	Growth per molt	Fecundity	Probability of maturity
34-38	males	[a] $P=1.76e^{-.0084L}$	[a] $L_{m+1}=10.1+1.04L_m$		
	females	[a] $P=1.95e^{-.0097L}$	[a] $L_{m+1}=9.60+1.04L_m$ [a] $L_{m+1}=18.0+0.95L_m$	[b] $E=.003135L^{3.354}$	[b] $P=1.0/(1+e^{23.23-.214L})$
33		same as above	same as above	same as above	[bb] $P=1.0/(1+e^{14.23-0.144L})$
31-32	males	[c] $P=2.59e^{-.014L}$	[e] $L_{m+1}=1.90+1.135L_m$		
	females	[d] $P=2.59e^{-.014L}$	[f] $L_{m+1}=5.20+1.085L_m$	[b] $E=.000057L^{4.28}$	[b] $P=1.0/(1+e^{10.4-.112L})$
28-30	males	[c] $P=2.59e^{-.014L}$	[g] $L_{m+1}=5.05+1.095L_m$		
	females	[d] $P=2.59e^{-.014L}$	[h] $L_{m+1}=8.92+1.027L_m$	[b] $E=.000057L^{4.28}$	[b] $P=1.0/(1+e^{10.4-.112L})$
27	males	[i] $P=3.77e^{-.019L}$	[j] $L_{m+1}=-0.27+1.15L_m$		
	females	[i] $P=3.77e^{-.019L}$	[j] $L_{m+1}=9.67+1.00L_m$	[b] $E=.000057L^{4.28}$	[j] $P=1.0/(1+e^{21.8-.258L})$

[a] Campbell (1985)
[b] Campbell and Robinson (1983)
[bb] Combined data for Bay of Fundy and eastern N.S. (Campbell and Robinson (1983)
[c] Combined data from Gabarus (Wilder, unpublished, n=90) and Magdalens (Dube, 1986)
[d] Combined data from Gabarus (Wilder, unpublished, n=91) and Magdalens (Dube, 1986)
[e] Combined data from New Harbour and Little Harbour (Hfx. Co.), n=102 (Robinson, unpublished)
[f] Same as [e], n=128
[g] Combined data from Gabarus, Fourchu, and Isle Madame, n=106 (Robinson, unpublished)
[h] Same as [g], n=89
[i] Combined data from Gabarus (Wilder, unpublished, n=91) and Magdalens (Dube, 1986) and Northumberland Strait (Campbell and Robinson, 1983)
[j] Dube (1986)

$M=0.1/\text{year}$

Males	$W(g)=.000566L(mm)^{3.078}$	Campbell(1985)
Females	$W(g)=.00153L(mm)^{2.861}$	Campbell(1985)

Table 2 Effects of changes in effort and recruit size on yield per recruit and eggs per recruit. The first line for each area gives the present recruit size and recent F.

Area	Recruit size (mm.C.L.)	F	Y/R(g)	E/R(no.)	Y/R($)
35, 36, 38	81	1.1	510	820	
	81	1.5	490	210	
	81	0.2(F_{max})	730		
	94	1.1	680	3,000	
	107	1.1	850	11,000	
34	81	1.7	480	110	
	81	2.2	470	40	
	81	0.2(F_{max})	730		
	94	1.7	650	1,000	
	107	1.7	830	6,000	
33	81	1.2	500	2,300	
	81	1.6	480	1,200	
	81	0.2(F_{max})	730		
	94	1.2	670	6,900	
	107	1.2	840		
31, 32	81	0.6	570	12,000	
	81	0.8	540	7,400	
	81	0.3(F_{max})	630		
	93	0.6	690	21,000	
28, 29, 30	81	0.5	553	15,000	
	81	0.6	545	11,000	
	81	0.4(F_{max})	570		
	93	0.5	637	24,000	
27	70	1.6	355	1,200	2.44
	70	2.1	351	580	
	70	0.9(F_{max})	380		
	80	1.6	407	2,600	3.29

Table 3 Number of licences and landed value per licence in each fishing area.

Fishing area	No. licences[a] 1982	No. licences[a] 1986	Landings/licence ('000s$) 1982	Landings/licence ('000s$) 1986
38	127	127	22.2	22.2
36	191	184	8.1	13.8
35	99	97	9.9	26.4
34	963	963	14.1	71.7
33	685	685	3.0	36.2
32	150	149	1.5	13.7
31	137	137	4.4	11.4
30	19	19	7.4	35.8
28-29	78	78	3.4	14.4
27	494	456	11.4	31.2

[a] Numbers given as A licence equivalents where 3B licences = 1A licence and 1 partnership = 2A licences.

Table 4 Mean catch per trap haul and total trap hauls per season.

		1980		1984		1986	
Fishing area	Sampling port	CPTH (kg)	TH (000s)	CPTH (kg)	TH (000s)	CPTH (kg)	TH (000s)
38		1.12	214	0.90	414	1.12	290
36		0.75	213	0.75	284	0.79	373
35		0.70	197	1.5	116	0.96	274
	Total Fundy	0.84	624	0.91	814	0.95	937
34	Port Maitland	0.56		0.78		0.77	
	Lobster Bay	0.46		0.66		0.62	
	Total	0.51[a]	5925[a]	0.72	7110	0.70	10720
33	Port LaTour	0.27				0.39	
	Port Mouton	0.23				0.46	
	Stonehurst	0.10		0.28		0.30	
	Total	0.20	1490	0.28	3720	0.38	7040
32	Little Hbr.	0.17	240	0.26	650	0.31	710
31	Port Bickerton			0.22		0.36	
	Canso	0.13		0.36		0.28	
	Total	0.13	310	0.29	480	0.32	890
30	Fourchu	0.19	68	0.33	210	0.52	160
28+29	Petit de Grat			0.10	690	0.18	870
27	Glace Bay	0.40		0.38		.058	
	Ingonish	0.34		0.37		0.57	
	Total	0.37	2640	0.38	3980	0.58	4020

[a]Nov. 1981 to May 1982 season.

Table 5 Total instantaneous annual mortality rates (Z) and annual exploitation rates (A)

Area		Seasons	Z	A
Bay of Fundy				
	Area 35	83-84	0.43	0.35
	Area 36	83-84, 84-85	1.31	0.73
	Area 38	83-84, 84-85	1.61	0.80
	Combined	83-84, 84-85	1.24	0.71
Area 34				
	Port Maitland	83-84, 84-85	1.76	0.82
	Lobster Bay	83-84, 84-85	1.77	0.83
	Combined		1.77	0.83
Area 33				
	Port LaTour	84, 85, 86	1.02	0.64
	Port Mouton	84, 85, 86	1.56	0.79
	Stonehurst	84, 85, 86	1.34	0.74
	Eastern Passage	84, 85, 86	1.33	0.74
	Combined		1.31	0.73
Areas 31+32				
	Little Harbour	84, 85, 86	0.86	0.59
	Port Bickerton	84, 85, 86	0.62	0.47
	Canso	84, 85, 86	0.58	0.44
	Combined		0.73	0.52
Areas 28, 29, 30				
	Petit de Grat	84, 85, 86	0.54	0.42
	Fourchu	85	0.59	0.45
	Combined		0.56	0.43
Area 27				
	Glace Bay	84, 85, 86	1.69	0.82
	Ingonish	84, 85, 86	1.72	0.82
	Combined		1.71	0.82

Figure 1.

Scotia-Fundy Lobster Landings

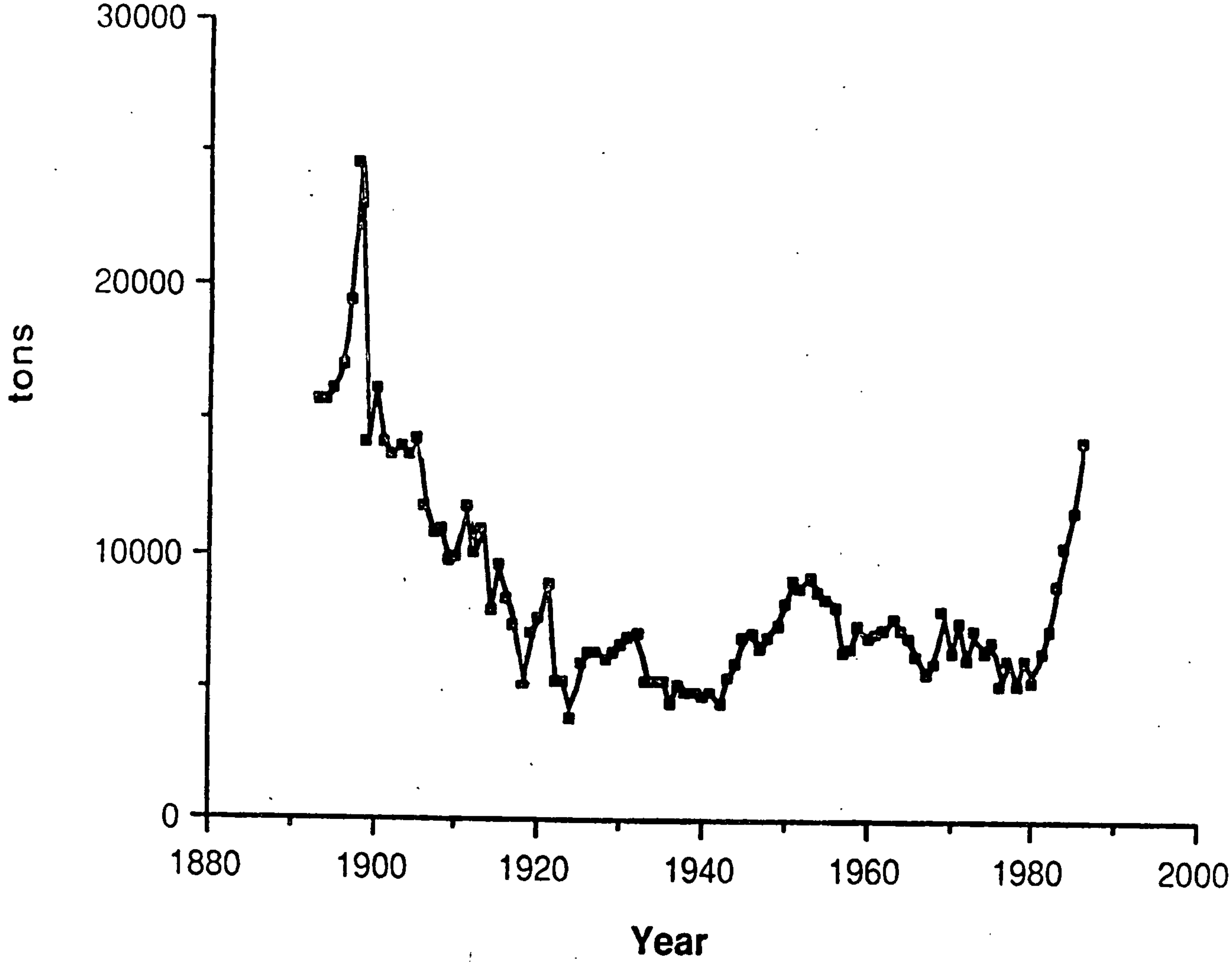
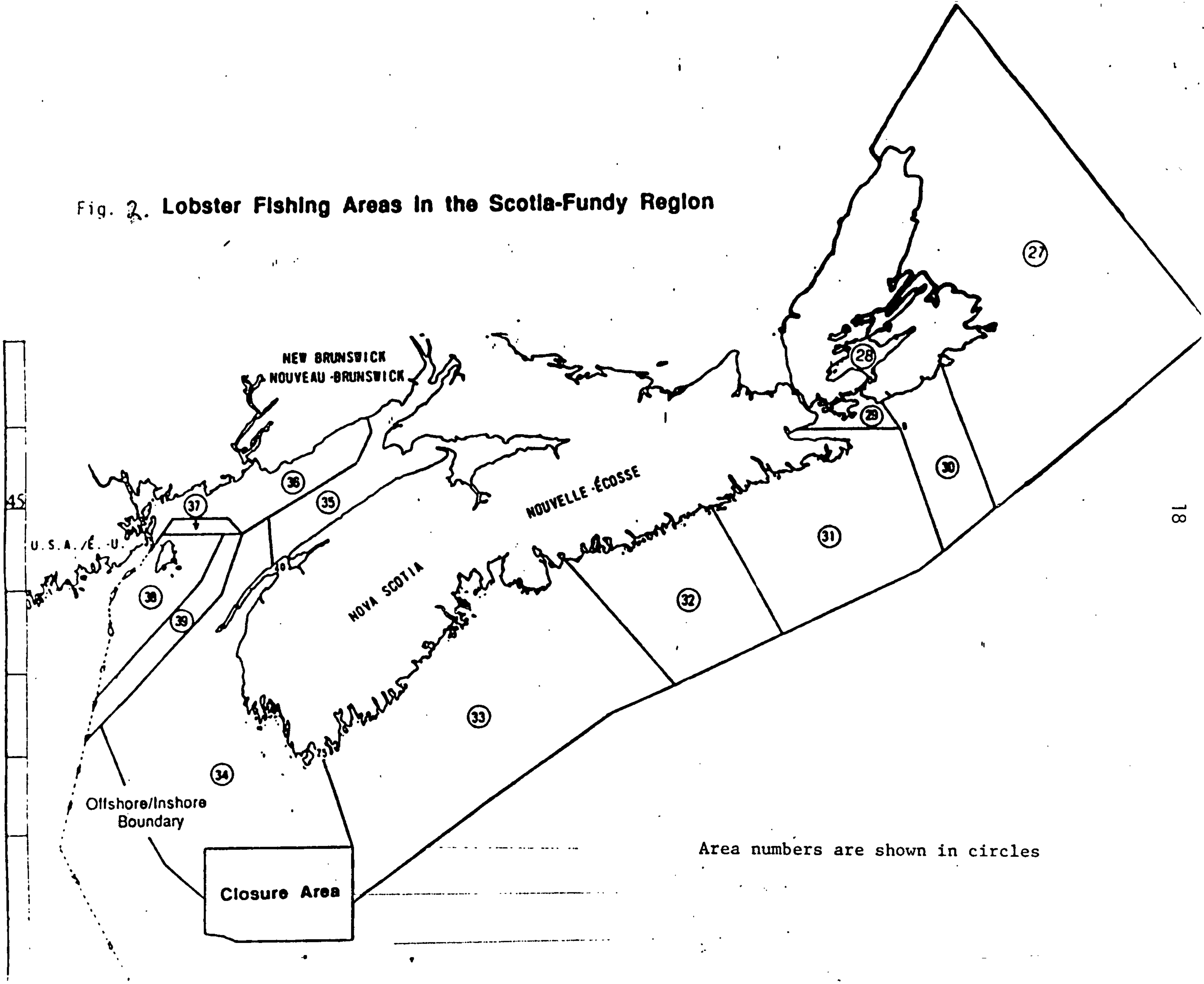


Fig. 2. **Lobster Fishing Areas in the Scotia-Fundy Region**



Area numbers are shown in circles

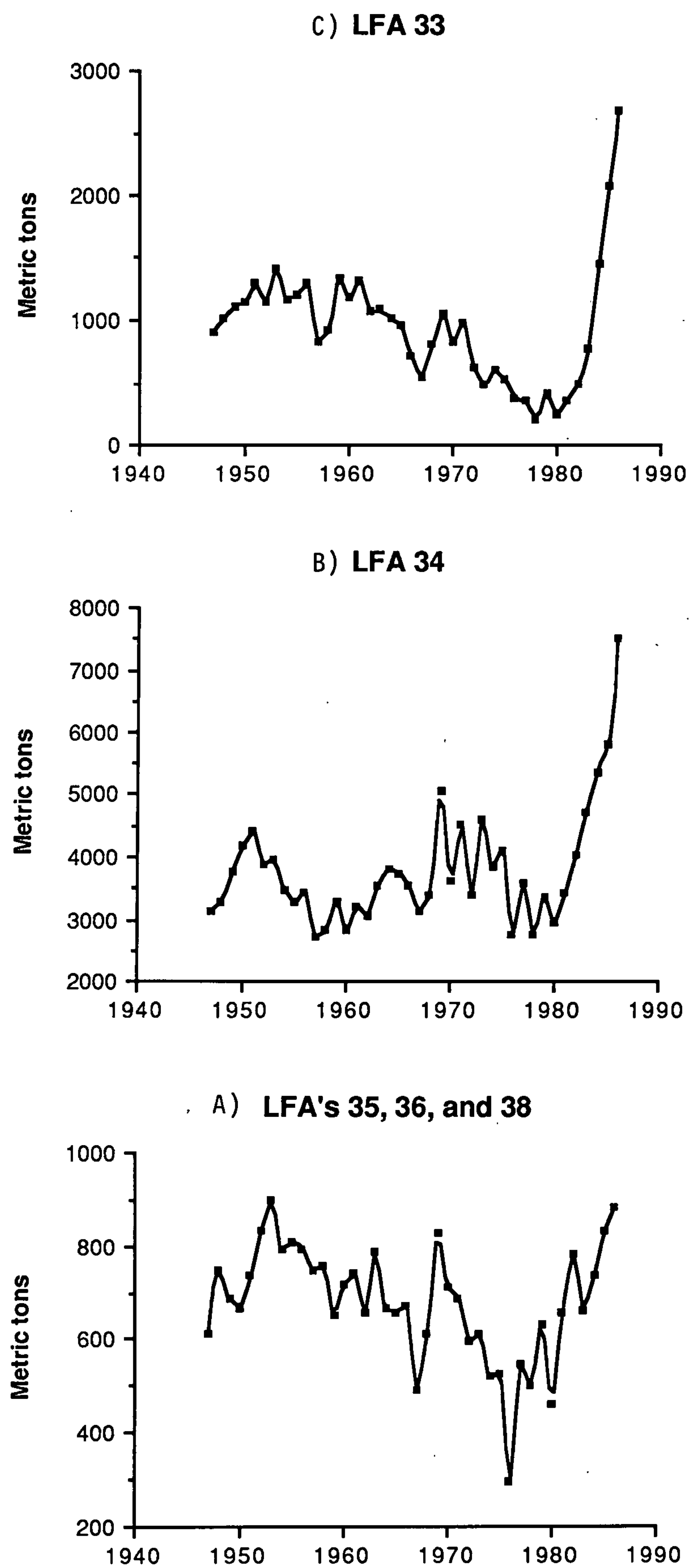
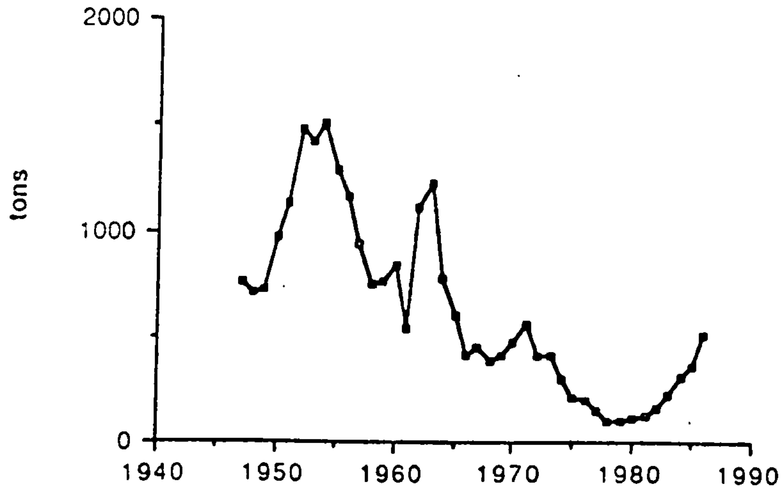
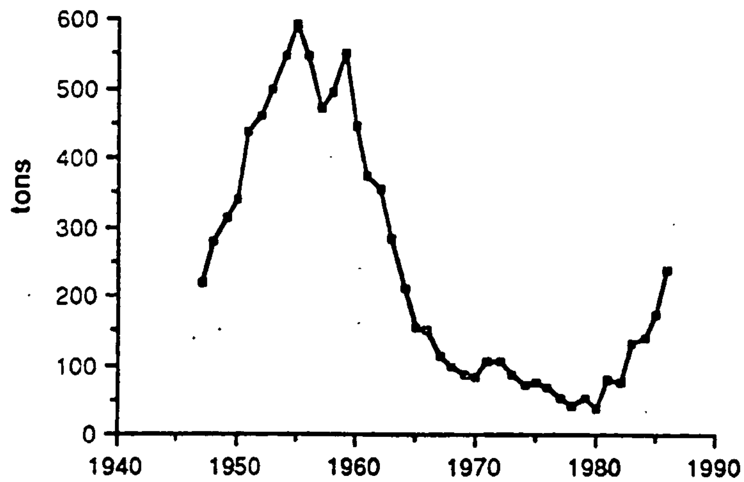


Fig. 3. Lobster landings in Scotia-Fundy Region fishing areas.

d) **LFA 31 and 32**



e) **LFA 28 29 and 30**



f) **LFA 27**

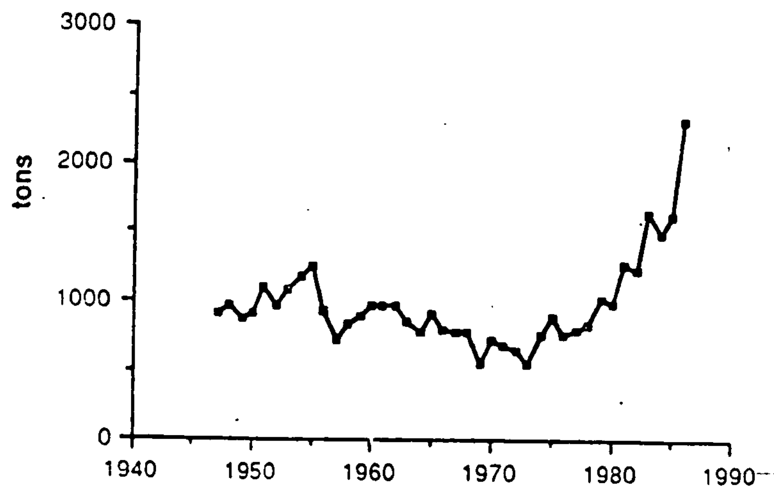


Figure 3 (continued)