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Will More Egg Production Increase Lobster Fishery Yields in LFAs 31-32-33?

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[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

The following arguments are discussed in support of the hypothesis that more lobster egg production will increase fishery yields in LFAs 31, 32, and 33. There are no density dependent controls on survival of larval stages. Benthic habitats supported higher populations in the past and benthic carrying capacity has not changed. The stock has been recruit overfished since near the turn of the century. The number of eggs required to yield one fishery recruit differs among locations. The status quo in lobster management is expected to result in landings at or below those of the 1920-80 period.

RÉSUMÉ

On examine les facteurs suivants, pour étayer l'hypothèse selon laquelle une augmentation de la production d'oeufs de homard aboutira à une hausse des rendements de la pêche dans les ZPH 31, 32 et 33. Il n'y a pas de mécanismes de régulation de la survie aux stades larvaires qui soient reliés à la densité. Les habitats benthiques ont fait vivre de plus grandes populations par le passé et leur capacité d'accueil n'a pas changé. Les stocks font l'objet d'une surpêche des recrues depuis le début du siècle. Le nombre d'oeufs nécessaires pour produire une recrue à la pêche varie d'un endroit à un autre. On s'attend à ce que le statu quo dans la gestion du homard se traduise par des débarquemets égaux ou inférieurs à ceux de la période 1920-1980.

Introduction

This report argues that more egg production will result in higher fishery yields, potentially much higher. The report is a compilation of arguments in support of fishery management change recently presented at meetings with fishers in LFAs 31, 32, and 33 (Fig. 1). The main points of the argument are: the fishing grounds have supported larger lobster stocks in both the distant and recent past; the lobster carrying capacity of the bottom habitat has not decreased; there are no density dependent controls on survival of lobster larvae; and in the absence of density dependent mortality, over time, a higher average egg production will result in a higher average number of fishery recruits. Without change to lobster fishery management we can expect a return to, or below, the long term average landings seen in the 1920-1980 period.

Carrying Capacity of Bottom Habitats

We hypothesize that the benthic habitat for lobster has not degraded over the history of the lobster fishery, although support for this view is mostly anecdotal. There has been no extensive dredging or filling on this coast, i.e. the shape of the coastal zone has been little changed by man. There is little heavy industry or agriculture to pollute coastal waters. The human population has increased in the Dartmouth to Lunenburg area, but that represents a small part of the coast under consideration, and, from our observations, there is little apparent coastal impact away from the immediate area of towns. Any long term change in predator or prey limits to lobster populations is probably untestable, although the principal prey of lobster, crabs and mussels (Elner and Campbell 1987), are only lightly fished. Climate may have changed, but Nova Scotia is near the middle of the lobster's range and thus not likely threatened by drifts in climatic variables. In thorough tests of temporal correlations between temperature and fishery yields using examples representing much of the range of the species, Drinkwater et al. (1996) found no evidence of temperature control. If the habitat has not been degraded then it should be able to sustain levels near previous highs.

Guysborough and Halifax Counties had 25 years of high landings early in their history (Fig. 2), too long for a fishing-up period (Robinson 1979). This period was followed by successively lower peaks. Now the landings are about 15% of the 25 best years and below the long term 1920-1979 mean (Table 1). This habitat would seem to be underused.

Lunenburg and Queens counties have shown similar trends since 1920, including a late-1980s peak (Fig. 2). Landings have now declined to about one-half that peak and one-half their best 25 years, but have not yet decreased to the 1920-79 average (Table 1).

About 70% of the landings for Shelburne Co. are in LFA 34, and the 33 and 34 portions can be separated only since 1947. Since 1947 landing trends have been similar to those of Lunenburg and Queens (Table 1). Given recent and early history, it seems probable that these three counties could sustain more than their present landings.

Table 1. Summary of long term lobster landings (t) for counties in LFAs 31-32-33.

County	Mean of 25 best successive years	Mean 1920-1979	Latest peak	1995 or 1994-95
Guysborough	2680	580	482	351
Halifax	2600	450	508	435
Lunenburg	650	190	838	351
Queens	470	190	565	288
Shelburne	N/A	~500	1900	886

The recent high landings in Lunenburg, Queens, and Shelburne counties beg the question of why they only occurred after 60 years of low landings if the habitat carrying capacity was underused. Because this recent peak occurred at nearly the same time throughout the range of the species (Miller 1995), it must have been caused by a (as yet unidentified) widespread environmental effect favouring lobster survival. Because it is the first high landings for several decades, it could be considered a fortuitous gift of nature, and a rare event we cannot depend on to reoccur.

In summary, the lobster fishery developed very rapidly, reaching peak landings within a few years after its inception. Given that the average sized lobster in the catch was reduced from 3-5 pounds in the early 1870s to <1 pound by 1898 (Robinson 1979), and that the catch hasn't recovered yet in one-half the area and only recovered after a long period of low landings in the other half, it seems reasonable to conclude that the stock has been recruit overfished since the turn of the century.

Larval Production

If the bottom habitat is not limiting lobster production, then the supply of larvae must be. Possible mechanisms are density-dependent controls, density-independent controls, and lobster eggs.

We reject density-dependent mortality because larvae are too dilute to compete for resources or attract predators. In a 2-year larval study conducted nearshore along 190 km of LFA 33, 800 plankton collections filtered 640 m^3 each (Miller, in press). The highest larval density in any collection was $0.11/m^3$, and the highest mean for one day's collection was <20% of this value. Such low density of such small animals would not compete for food or space. It is also unlikely that any planktivorous predator would alter its behaviour to target such a dilute prey.

Density independent factors must affect larval survival; survival varies temporally and spatially (Scarratt 1964; Harding et al. 1982; Miller in press). Ocean circulation and temperature have been most commonly investigated (Dow 1969; Sutcliffe 1973; Harding et al 1983; Campbell et al. 1991; Hudon 1991; Drinkwater et al. 1996, and several others), but food, predators, and disease should not be overlooked. However, density independent controls are by definition no bottleneck to production; averaged over time, the more first stage larvae that enter the plankton the more postlarvae that leave the plankton to live on the bottom.

Before proceeding, we should digress to a semantic problem. Density dependent mortality is considered here to be a survival bottleneck at some life history stage, and mortality increases with the density of that stage. Density independent mortality can also regularly occur at a particular life history stage, but is not related to the lobster stage density. Density dependence or independence need not be absolute. The best documented correlation between larval abundance and fishery yields is for the Western Australian rock lobster. There, larval densities are raised to the power of 0.25 to predict catches (Caputi et al. 1995), with results in each doubling of larvae increasing fishery yield by 19%.

Egg Production

If density dependent bottlenecks to the survival of larval or benthic phase lobsters are absent or weak, then eggs are the remaining life history stage that can limit recruits to the fishery. Egg production could be less now than when the lobster stock was larger because either fecundity per mature female is lower or there are fewer mature females. Clearly, increasing the number of mature females is the easier of these two possibilities to target through stock management.

There are no doubt many factors which affect survival of different lobster life history stages. However, if all these factors are density independent or nearly so at present stock densities, it follows that more mature females will produce more eggs and more eggs will produce more fishery recruits. Correlations between eggs or early stage larvae and time-lagged fishery yields have been notoriously difficult to demonstrate for decapods (Fogarty and Idoine 1986; Phillips 1986; Botsford 1991; Pollock 1993; Lipcius and Cobb 1994) and fish (Gulland 1977; Leggett and DeBlois 1994). This is because year to year changes in the survival of intermediate stages mask the egg-to-recruit correlation. Furthermore, larval drift adds to the difficulty because we are unsure of the local origin of the eggs that grew into a cohort of recruits. For the foreseeable future we will probably have to make decisions on the value of eggs to fishery yields without a method of testing the benefits.

All Lobster Grounds Are Not Created Equal

Some areas of coast may require more eggs than others to produce a fishery recruit. In the early 1990s in LFA 33, data were obtained on abundance of ovigerous females (no./100 trap hauls in May) and number of recruit lobsters entering the fishery per square km of fishing ground (Miller in press). Averages for each of seven statistical districts are plotted in Fig. 3. In Shelburne County, represented by data points on the left side of Fig. 3, the ratio was 1.7 ovigerous females to 3000 recruits. On the right side, representing Halifax County, the ratio was 3 ovigerous females to 800 recruits. This result suggests that larval survival is lower in Halifax County and that more eggs must be hatched there to yield each fishery recruit.

Drift of larvae from where they hatch to another area where they settle to the bottom and became fishery recruits cannot be ruled out.

Larvae hatched on Browns Bank could conceivably have drifted 160 km to the westernmost area in wind-induced surface currents. However, most probable directions of drift were north towards the Bay of Fundy and east offshore on the Scotian Shelf (Harding and Trites 1988; Watson and Miller 1991). Longshore drift between the seven sampled areas is also possible, but these areas were not small, they are 20-45 km wide and include numerous bays.

Recent Trends in Stock Abundance

The long term history of catches was discussed above. We now turn to look at time series of fishery monitoring from the last decade. Most series show little change in effort, but decreases in catch per unit effort.

In LFA 31, Canso, Port Bickerton, and western Guysborough Co. have experienced large decreases in annual mean catch per trap haul but little change in effort as measured by annual trap hauls per boat (Fig. 4). The same holds true for the two areas monitored in LFA 32 (Fig. 4); Eastern Halifax Co. and Clam Bay have shown constant effort and a 40% drop in catch per unit effort.

In LFA 33 catch per trap haul has decreased by one-half or more in Halifax and Lunenburg Counties (Fig. 4). Queens and Shelburne counties likewise experienced decreases, but smaller. Effort per year (trap hauls per boat) has been erratic over the 10-year history with no particular trend. Data for Fig. 4 are tabled in Appendix 1.

From Figures 2 and 4, and Table 1 it appears that the recent peak in landings is finished. Because fisheries management has not changed for many years we might expect a return to pre-peak levels or lower. Improved electronics on fishing vessels, such as colour sounders and GPS, has increased the power of fishing effort by making it easier for fishers to locate good lobster habitat and return to it once found. Fishers tell us that fishing effort is higher than a few years ago because of less opportunity in the groundfish sector, although our logbook records do not show this. Thus, effective fishing effort may be higher and egg production lower than in the 1980s. The solutions to more egg production are the same as biologists have advocated for many years, and as repeated by the recent FRCC report (FRCC 1995): refuge areas, a larger minimum size, a maximum size, and reduced fishing mortality.

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Appendix 1. Data plotted in Fig. 4, plus number (n) of logbooks for each year and port.

Counties of LFA 33

	Halifax Co.			Lunenburg Co.			Queens Co.			Shelburne Co.		
Season	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat
85-86	2	-	10410	3	0.41	12607	2	0.55	15120	3	0.49	14412
86-87	3	0.49	8414	3	0.34	14547	3	0.54	17229	3	0.56	11978
87-88	3	0.34	7163	3	0.30	16006	3	0.57	14185	3	0.50	9449
88-89	5	0.27	8521	3	0.23	16071	3	0.37	12569	2	0.32	10849
89-90	3	0.33	7861	3	0.35	15701	4	0.49	11239	3	0.47	7324
90-91	2	0.54	9282	3	0.19	18505	4	0.44	17471	3	0.47	9123
91-92	7	0.45	4616	2	0.20	15118	4	0.40	12492	3	0.50	6609
92-93	4	0.31	5087	4	0.20	9278	3	0.43	11357	1	0.46	7069
93-94	6	0.24	4526	3	0.26	12439	5	0.49	15363	6	0.35	11192
94-95	6	0.25	5337	4	0.18	15717	3	0.31	16169	6	0.34	12367
95-96	4	0.25	5812	4	0.23	15311	4	0.37	13396	8	0.31	14662

Sampling areas of LFAs 31-32

	Canso			P. Bickerton			W. Guys. Co.			E. Halifax Co.			Clam Bay		
Year	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat	n logs	CPTH	TH/ boat
1986	1	0.33	6221	-	0.3	9194	1	0.28	10665	1	0.28	8495	2	0.27	8988
1987	3	0.42	7878	2	0.28	11114	1	0.13	11224	1	0.39	8774	4	0.23	9946
1988	3	0.41	8082	3	0.32	10502	3	0.12	10695	2	0.32	8939	3	0.18	9187
1989	4	0.48	9814	3	0.43	11877	1	0.18	11462	2	0.35	10810	1	0.21	10410
1990	4	0.41	9492	4	0.37	12524	2	0.12	8195	3	0.29	9853	2	0.23	9219
1991	4	0.39	9388	4	0.44	12051	2	0.17	11341	3	0.27	9558	3	0.22	8313
1992	4	0.34	9059	4	0.31	12786	1	0.14	11912	4	0.24	10177	2	0.17	9013
1993	4	0.24	9059	6	0.25	11425	1	0.09	10875	7	0.31	9353	4	0.16	9782
1994	4	0.22	7855	6	0.19	11607	1	0.1	9865	8	0.25	9151	7	0.17	10036
1995	4	0.25	8470	6	0.15	10974	1	0.13	10766	8	0.21	10104	9	0.15	10311
1996	2	0.13	8826	8	0.1	11218	0	-	-	8	0.31	10503	7	0.12	10779

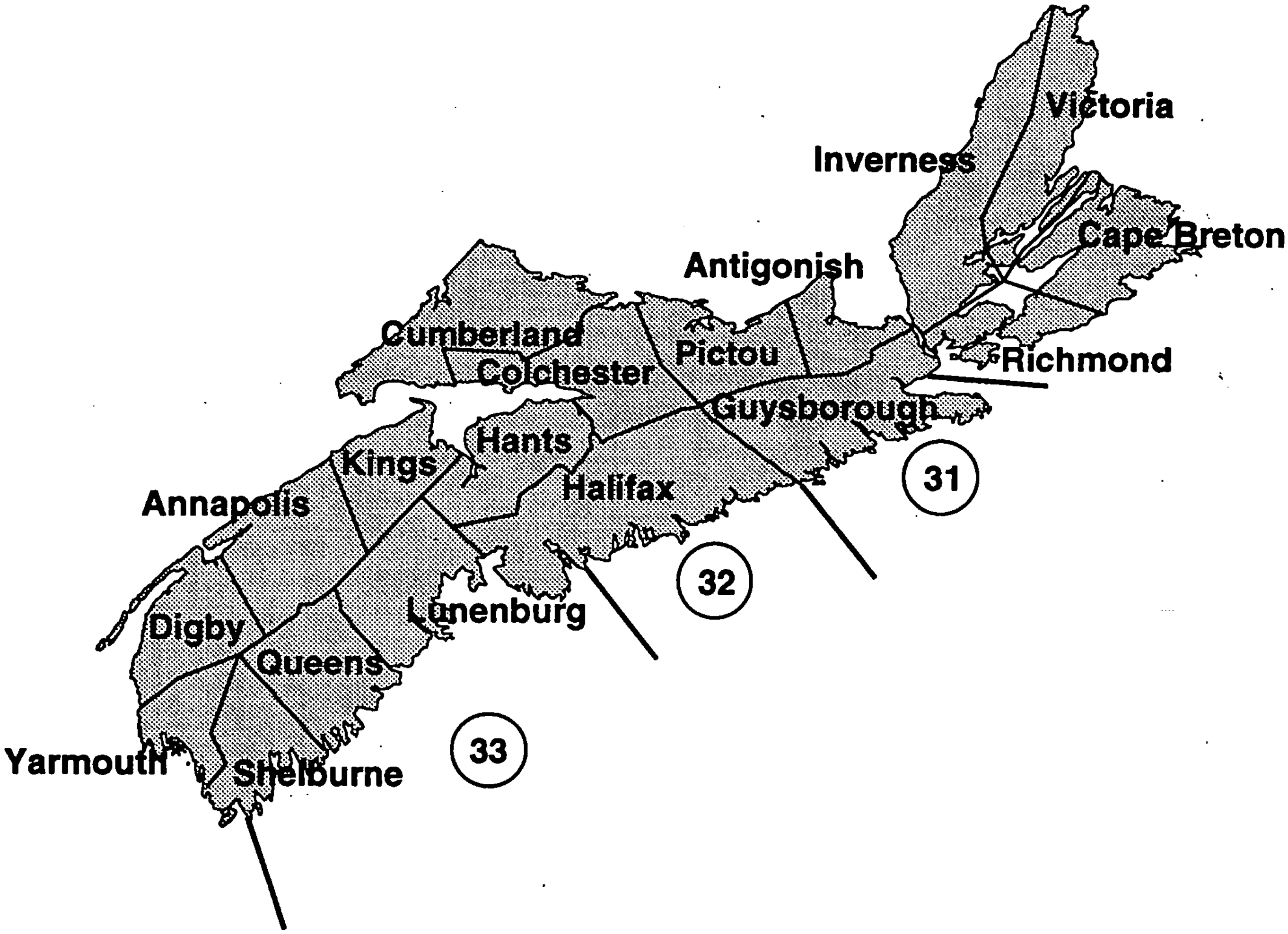

Fig. 1. Counties of Nova Scotia and LFAs 31, 32 and 33.

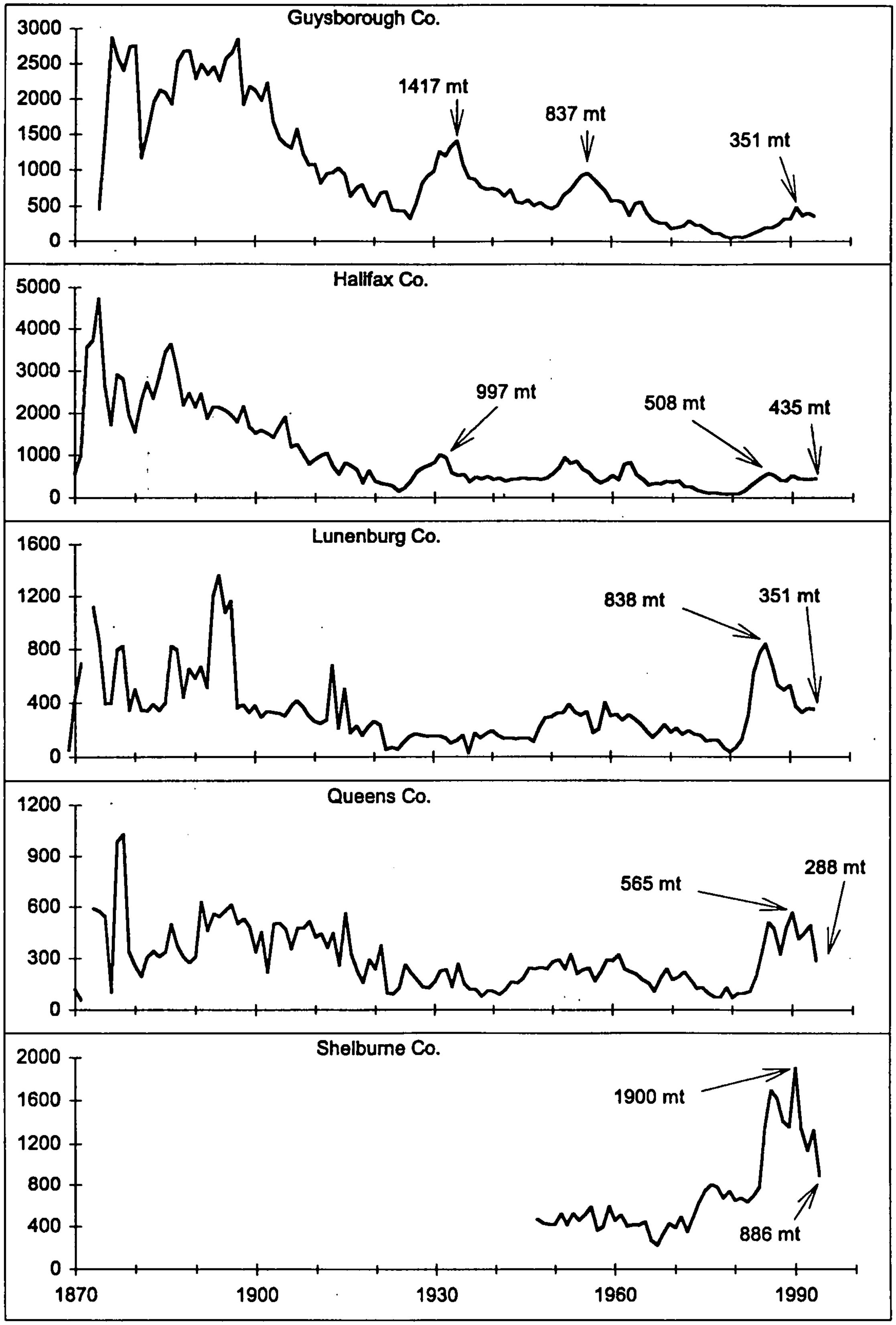

Fig. 2. History of lobster landings by county.

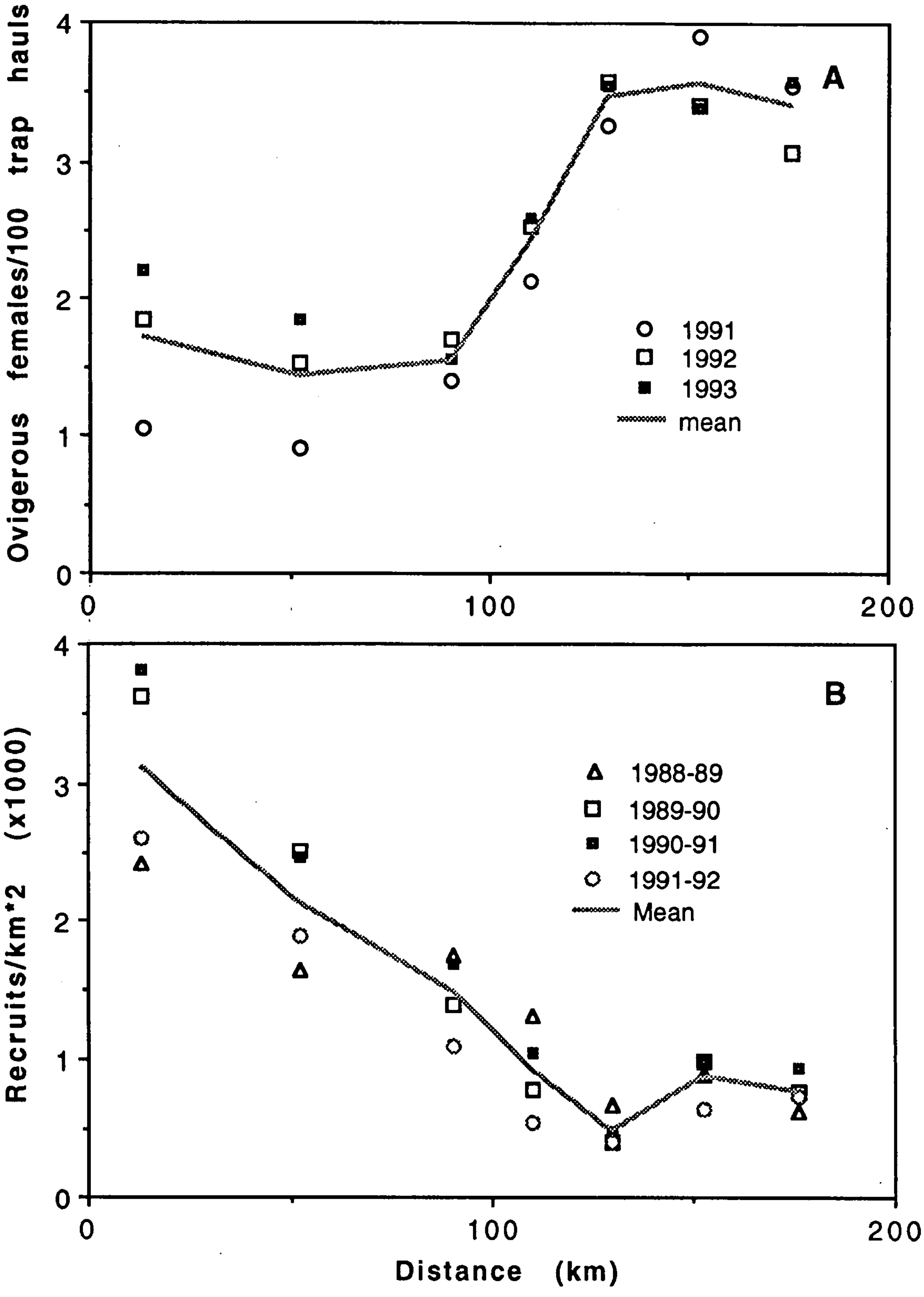

Figure 3. Abundance of ovigerous females (A) and fishery recruits (B) in seven statistical districts in LFA 33. Distance is measured from eastern Shelburne County (0 km) to western Halifax County (180 km).

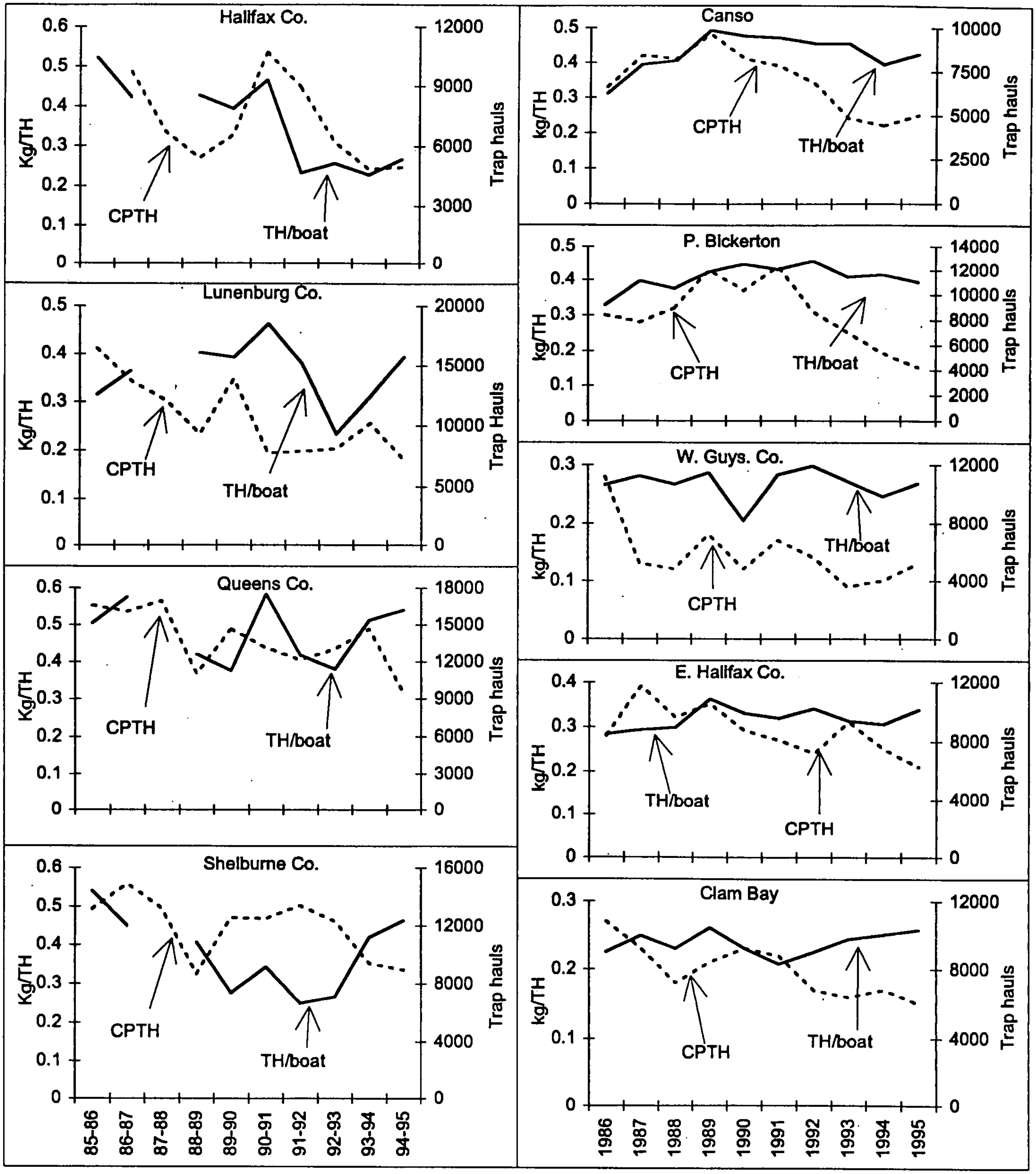

Fig. 4. Mean Annual catch per trap haul (CPTH) and total annual trap hauls (TH) per boat for sampling ports in LFAs 31 and 32, and counties in LFA 33.