An Alternate Methodology for Estimating Snow Crab (Chionoecetes opilio) Populations in Commercially-fished Areas

by

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Abstract

Biomass estimates based on the simple relationship between catch per unit of effort, effective area fished per trap and the area of commercial crab grounds available are presented for eight Newfoundland snow crab (Chionoecetes opilio) management areas. These estimates are compared to those previously derived by Leslie analyses.

In most instances biomass estimates derived by this methodology are significantly higher than those obtained by Leslie analyses.

However, in several areas, areas in which the grounds available are fully fished but not overexploited, biomass estimates calculated by both methodologies are quite similar.

Résumé

L'article qui suit contient des estimations de biomasse fondées sur de simples relations entre prises par unité d'effort, aire effectivement pêchée par casier et superficie des bancs de pêche commerciale du crabe des neiges (Chionoecetes opilio) dans huit zones de gestion de cette espèce à Terre-Neuve. Ces estimations sont comparées avec celles qui avaient été obtenues antérieurement à la suite d'analyses de Leslie.

Dans la plupart des cas, les estimations de biomasse obtenues par la présente méthode sont nettement supérieures à celles découlant d'analyses de Leslie.

Cependant, dans plusieurs zones, là où les bancs de pêche existants sont pleinement pêchés mais non surexploités, les estimations de biomasse, calculées par les deux méthodes, sont assez semblables.

Introduction

At present the best estimates of snow crab (Chionoecetes opilio) biomass can only be generated retrospectively. This is due to the fact that biological data essential to perform life history based production models of a predictive nature are not available for this species.

The most commonly used estimators of snow crab biomass are Leslie and Petersen's analyses. Several authors, Bailey (1978a and 1978b), Elner and Robichand (1980), and Taylor and O'Keefe (1981 and 1983) have generated biomass estimates for commercial snow crab populations in Atlantic Canada. While these estimates are thought to be reasonably reliable, an independent means of assessment is necessary due to the biasis inherent in Leslie's and Petersen's methods. These biases are discussed by Taylor and O'Keefe (1981).

Miller (1977) estimated snow crab biomass for areas in Newfoundland that had commercial potential (demonstrated by exploratory fishing) but at that time were not fished. Stone and Bailey (1980) performed a similar exercise for red crab (Geryon quinquedens) on Georges Bank and the Scotian Shelf. Commercial biomass available was estimated by Miller (1977) using the following:

$$\text{Biomass (kg)} = \frac{C \times A}{a}$$

where:

C = mean catch of commercial-sized crabs in kilograms/trap;

a = 0.0041 km^2/trap, the effective area fished per trap;

A = area of fishing grounds in km^2.

Materials and Methods

The effective fished area/trap had been calculated previously (Miller 1975). As this figure was derived from four separate areas it was decided that the value of 0.0041 km^2/trap obtained from that work could be applied to this study.

Commercial fishing areas in Newfoundland are divided into management areas (Fig. 1). Fishermen's logbooks were examined in order to determine the total trap hauls and landings for each management area. From these data $\bar{X}$ CPUE (catch per unit effort - C) was calculated for each area. Commercial fishing grounds were determined for each area by examination of logbooks, conversations with fishermen, and the authors' own knowledge of the fishery. From these data, A, area of fishing grounds, was estimated by using a Keuffel and Esser compensating polar planimeter.

Results and Discussion

Biomass estimates for commercial-sized (>95 mm carapace length) snow crab populations in the various management areas examined are presented in Table 1. For comparison purposes biomass estimates based on Leslie analysis (Taylor and O'Keefe 1981 and 1983) are also given.

Examination of Table 1 demonstrates that there is for some management areas, fairly close agreement between biomass estimates derived by both methodologies. This is despite the fact that both techniques are virtually independent of each other. Although CPUE is essential to the calculation of

biomass in each method the values of CPUE in either technique would be quite different. While this method uses a constant value of $\bar{X}$ CPUE Leslie analysis is dependent on decreasing values of CPUE experienced by fishermen as the fishing season progresses.

In many management areas in Newfoundland, particularly those in which exploitation rates are high (area 24), initial CPUE is quite high but catch rates in subsequent weeks drop off drastically. This decline in CPUE causes a rapid reduction in effort and landings. This results in a $\bar{X}$ CPUE which is artifically high and does not reflect the high exploitation rates and subsequent rapid decline of the fishery. An additional complication in an area that exhibits this type of seasonal pattern is that generally, near the end of the fishing season there is a large pulse of recruitment consisting of newly moulted animals. This influx of individuals causes the $\bar{X}$ CPUE to assume an even higher value. The fact that the initial biomass of snow crab in an area is being over-exploited is masked. Thus in effect, one is comparing total biomass as determined by this formula and initial biomass as calculated by Leslie analysis.

Other characteristics of the Newfoundland fishery can also bias biomass estimates derived by this formula. For example, examination of the data in Table 1 shows a biomass estimate for management area 36 (White Bay) that is consistantly much larger than estimates derived by Leslie analyses.
Such a discrepency in the two biomass estimates is inexplicable unless one is familiar with the seasonality of the various types of fisheries in the area. The crab fishery and groundfish gillnet fishery occur at the same time and on the same grounds in White Bay. Naturally, there is competition between gillnet

and crab fishermen for the same grounds. This competition results in a large portion of the fishing grounds being unavailable to crab fishermen if gear conflicts are to be avoided. Somewhat similar to area 36 is area 14 where the area of potential crab grounds is much greater than those which are currently supporting a fishery. Use of Miller's methodology provides a biomass estimate for the whole area of potential fishing grounds at a $\bar{X}$ CPUE, while Leslie analysis provides an estimate for just the portion of the management area which is being exploited.

A drawback to both methodologies is that they are dependent on CPUE figures that currently must be obtained from fishermen's logbooks. These records while generally useful probably vary greatly in accuracy in reporting of traps hauled per day. Whether these inaccuracies are deliberate or accidental is immaterial for the purposes of this discussion. Another flaw in logbook reporting is that the amount of crab landed is often greater than the amount recorded in the fishermen's logbooks. This is due to the fact that "weighback", crab that is unacceptable to the processor, is often unreported in fishermen's logbooks and on sales slips. This results in an unrealistically low CPUE for many management areas during a large portion of the fishing season and causes exploitation rates to be underestimated.

Another problem in using Miller's formula is the unavoidable subjectivity involved in determining the area of fishing grounds in each management area. It is unlikely that all the area delineated as commercial crab grounds has commercially acceptable densities of snow crab uniformly spread throughout the management area therefore the $\bar{X}$ CPUE value is often artificially high. Also, in delineating crab grounds it is possible that areas which supported large

populations of snow crab could be overlooked simply because hydrographic charts indicate that these areas do not have depth strata which are currently conceived as being essential for snow crab habitation. For example, in Newfoundland depending on the area, fishing is conducted at depths ranging from 146 to 412 meters. An area off the east coast of the Avalon Peninsula had not been fished until 1981 simply because it was considered by fishermen and scientists alike as being too shallow (146 m) to support a fishery.

The authors while fully cognisant of the short-comings in using Miller's formula nevertheless recommend that in conjunction with current methods of snow crab assessment, this methodology can prove to be a valuable tool. However, in using any of the currently available means of assessment it is essential that workers have a thorough knowledge of the fishery dynamics of a given area. In view of the short-comings of each methodology, it is perhaps wise to regard all biomass estimates derived by these methodologies as indicators of relative abundance rather than hard and fast population estimators.

References

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Table 1. Comparison of snow crab biomass estimates for Newfoundland managment areas. $\frac{C \times A}{a}$ vs. Leslie Analysis B_0, initial commercial biomass (Taylor and O'Keefe 1989, 1982, and 1983).

Management Area	Area sq. Km	1979 $\bar{x}$ CPUE kg/trap haul	1979 Est. biomass (M.T.) $\frac{C \times A}{a}$	1979 Est. biomass (M.T.) Leslie B_0	1980 $\bar{x}$ CPUE kg/trap haul	1980 Est. biomass (M.T.) $\frac{C \times A}{a}$	1980 Est. biomass (M.T.) Leslie B_0	1981 $\bar{x}$ CPUE kg/trap haul	1981 Est. biomass (M.T.) $\frac{C \times A}{a}$	1981 Est. biomass (M.T.) Leslie B_0
14	1794.8	20.1	8799.0	1095	20.6	9017.8	Insufficient Data	16.0	7004.1	614.3
16	392.1	16.1	1539.7	1351	15.0	1434.5	1571.0	11.5	1099.8	689.3
18	3572.1	17.2	14985.4	14359	20.9	18209.0	14,166.0	16.4	14288.4	1165.9
22	871.3	9.9	2103.9	1467	8.5	1806.4	912.3	7.2	1530.1	323.9
24	1118.9	8.4	2292.4	1208	9.3	2538.0	1929.0	8.0	2183.2	941.0
26	540.3	11.0	1449.6	1003	11.5	1515.5	634.0	8.0	1054.2	647.0
32	421.0	10.6	1088.4	882	9.6	985.8	811.3	11.9	1221.9	1845.5
36	955.9	7.3	1702.9	383	8.8	2051.7	276.4	11.6	2704.5	503.7

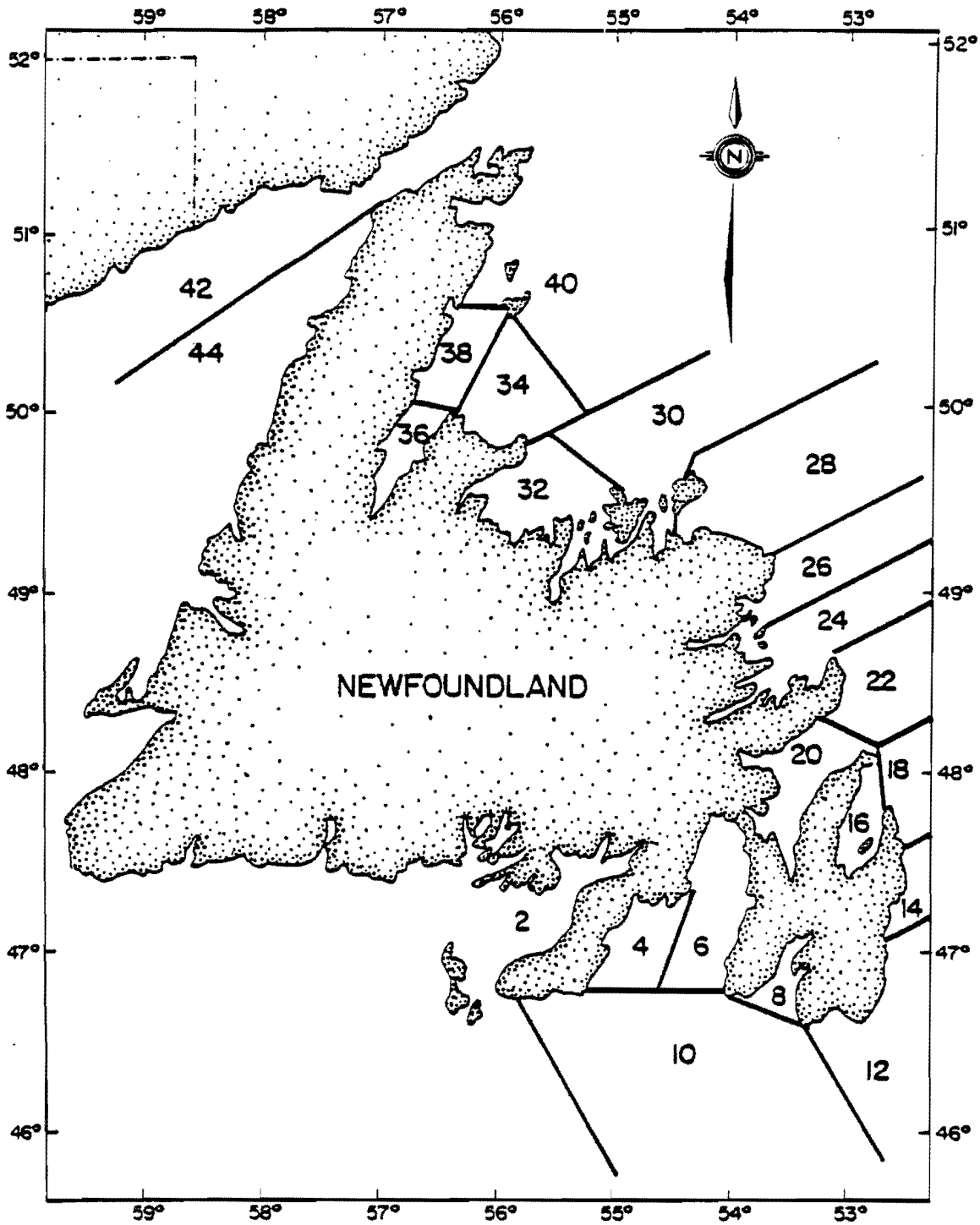

Figure 1. Newfoundland snow crab management areas (after Miller, unpublished)