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Indices of distribution and location of shrimp biomass for the West Greenland research trawl survey.

by

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Introduction

In recent years, the shrimp fishery in West Greenland has shown signs of contracting its range: the proportion of the catch that is taken in the southernmost areas has decreased. Analyses of fishery data have in the past presented the mean latitude of the catch taken by the offshore fleet (SCR Docs 02/151, 03/75), and a simple index that summarises in one number how widely spread the fishery is has been presented in recent analyses of fishery logbook data (SCR Docs 07/69, 08/57). This index has declined rapidly over the last 6 years, showing that the fishery has become more concentrated.

A research trawl survey on the West Greenland shrimp fishing grounds is a key data source for the assessment of the stock, and it is useful to compare the findings from the survey with those from the fishery not only as indices of total biomass, but also as indices of distribution. Doing so is somewhat hampered by different stratification schemes applied to the two kinds of data. However, subjectively based comments that the results of the West Greenland research trawl survey have shown this or that change in the distribution of the stock, have over the years, been a feature of the presentation. It has been suggested that it would be helpful to develop quantitative and reproducible indices that would summarise the distribution of the survey biomass. This document presents two simple indices, of the distribution and north-south location of shrimp biomass as estimated by the West Greenland research trawl survey.

Methods

Data from surveys executed in 1994–2008 was used: there was no survey before 1994 in the southernmost areas and before 1991 in Disko Bay or Vaigat, but since 1994 the series has been consistent. Biomass estimates from the annual survey are customarily presented (e.g Ziemer and Siegstad 2008) for 7 divisions of the survey area:

- a northern division, formerly stratified as N1–N9, and re-stratified according to depth information (Wieland and Kanneworff 2004) as U1–U3 with depth strata;
- Disko Bay and Vaigat, formerly stratified as D1–D9, restratified as I1 and I2 with depth strata;
- Canadian Exclusive Economic Zone, once 2 divisions, now 1;
- 3 subdivisions of the west coast, from the mouth of Disko Bay and adjacent shelf waters to Paamiut;
- an extreme southerly division, comprising Julianehåb Bay and adjacent waters.

These divisions were given southerly ranks: Julianehåb Bay and the adjacent shelf waters were 1; the subdivisions up the coast were given ranks 2,3 and 4. The small Canadian sub-division was included with the subdivision west of the mouth of Disko Bay lying at about the same latitude. Disko Bay and Vaigat were given rank 5, and the northernmost subdivision of the survey area was ranked 6.

Then a 'lat. index' was calculated as a mean rank for the survey, weighting by estimated total survey biomass. This index summarises how far north a (weighted) centre of gravity of the stock biomass lies, as estimated by the research trawl survey and measured in survey subdivisions. Small values of the index indicate that the centre of gravity of the stock distribution is further south, and larger values indicate a more northerly distribution.

A 'spread index' was calculated as a Simpson diversity index (Simpson 1949) of the distribution of the biomass:

$$SpreadIndex = \left(\sum_{Subdivisions} Biomass_{Subdiv.} \right)^2 \Big/ \sum_{Subdivisions} \left(Biomass_{Subdiv.} \right)^2$$

This index summarises how evenly the survey stock biomass is distributed between survey subdivisions. High values (6 is the limit) would show that one-sixth of the biomass was found in each division; low values, near 1, would show that the biomass was concentrated in only one or two subdivisions. The units of both indices are 'subdivisions'.

Results and Discussion

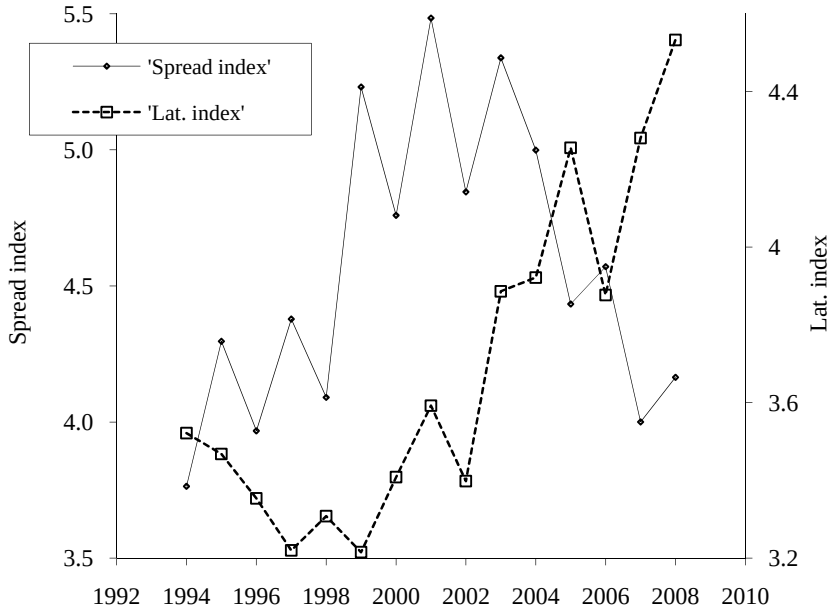

Figure 1. Indices of location and distribution of the total stock biomass in the West Greenland research trawl survey for northern shrimp, 1994–2008.

Both indices have varied over the period covered by the data series (Figure 1). With a bit of imagination, one can distinguish 3 periods: from 1994 to about 1999, the 'spread index' was increasing while the 'lat. index' decreased slowly as the stock spread southwards and survey biomasses in the southernmost subdivisions increased. However, even at the start of this period the 'lat. index' was already fairly low, because the survey had not been extended into the southernmost subdivisions until some years after the fishery had started making important catches there and densities had reached moderately high levels. During a second period, from 1999 to about 2004, the 'lat. index' was

starting to increase as biomass in the southern subdivisions decreased, but the 'spread index' stayed high, probably because biomasses in the northerly subdivisions were increasing at the same time. I.e. at this time, the stock was shifting northwards. After 2004 the 'lat. index' continued to increase, but the 'spread index' declined. This could be interpreted as showing that during this period, biomass in the southern subdivisions continued to decrease, but biomasses in the northern subdivisions did not continue to increase and the biomass became more concentrated in central subdivisions.

Even for a set of data as simple as biomass estimates from 6 subdivisions of a survey area, many different summary indices could be proposed. These are only two of them. They are characterised by extreme simplicity: they do not depend on knowing the area of each subdivision, its mean latitude, or much else, and they are easy both to calculate and to explain. These are quantitative indices in the sense that they can be reproducibly calculated by anyone year after year. However, their units are 'subdivisions', which have neither equal areas or importance to the shrimp stock (significant for the 'spread index') nor regular north-south spacing (significant to the 'lat. index'), and they therefore do not have proportional relationships with more elaborate indices using exact calculations of latitude or subdivision area. One limitation that may be pointed out is that if the biomass were evenly distributed between just two subdivisions in the centre of the survey area (3 and 4), each index would have the same value as it would if the biomass were evenly distributed between the two extreme subdivisions (1 and 6)

The spread index has a serial correlation of 43% and the Lat. index of 82% so they are tracking progressive changes in the distribution of the stock and not just bouncing around at random. Both are consistent with the subjective interpretations of the survey data that have been presented over the years.

Conclusion

These two candidate indices show orderly behaviour and are consistent with qualitative interpretations of the survey results that have been offered over time. They are simple to calculate and based on recognised indices.

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