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Relationship between abundance of age-2 shrimps, pre-recruits and fishable biomass two to four years later

by

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Abstract

The relationship between West Greenland abundance of age-2 shrimps, pre-recruits and the fishable biomass, as well as the relationship between the age-2 shrimps and pre-recruits two to four years later, using simple linear regression. Autocorrelation was only observed in the relationship between age-2 index and the biomass index two years, and not in any of the other cases. The relationship between the age-2 index and two years ahead was still significant after correction for autocorrelation. The strongest relationship was found between number of age-2 shrimps and the fishable biomass four years ahead ($r^2 = 0.63$), and between the pre-recruits and the fishable biomass one year ahead ($r^2 = 0.68$). Nevertheless, the large confidence and prediction intervals of the linear regression indicate that these estimates are subjected to some degree of uncertainty. Furthermore, the predictions for coming years might only be true, if the overall effect from the underlying processes do not shown considerably changes. Variation in the number of pre-recruits was explained by 52% of the variation in numbers of age-2 shrimps 2 years earlier.

Introduction

Since 1988, the Greenland Institute of Natural Resources has carried out annual trawl surveys on the West Greenland shelf between June and July to assess the biomass and recruitment of the stock of *Pandalus borealis*.

Recruitment of the northern shrimp has been assessed based on indices of age-2 shrimps (10.5 to 13.5 mm Carapace length) and indices of pre-recruits (14 to 16.5 mm Carapace length). Cohorts with modal lengths

between 12 to 16 mm carapace lengths have dominated this size rage over the past 20 years (Burmeister and Rigét, 2020a).
Since the late 80'ties the commercial fishery for northern shrimp have expanded, and has become the most economically important for Greenland. The catches and biomass of northern shrimp has varied but peaked from 2002 to 2006, followed by a decline to low values in 2014 (Burmeister and Rigét, 2020a, Burmeister and Rigét 2020c). Nevertheless, fishable biomass has in the following years slightly increased and is in 2020 above the serial mean. The fishery is mainly target individuals above 17 mm carapace length, which assumed to be both males and females aged minimum 4-5 year and up to +8 year. It is unknown to which extend the variation in recruitment can explain the variation in future fishable biomass, while it also might be affected by other factors than recruitment.

This document presents the results of the relationship between recruits (e.g. number of age-2 shrimps and pre-recruits) and the fishable biomass with a lag of one, two, three and four year, based on data from surveys in the period from 1993 to 2020.

Methods

Modal analysis is carried out using Partiel Mix (Kingsley, 2014, MCSKMIX 2014 © Greenland Institute of Natural Resources), implemented in an Excel spread sheet. Partiel MIX fits numbers of shrimps at age 2 years and is estimated by decomposing the length distributions, fitting Normally distributed components. To prevent a skewness to the plus age 3 group, analysis was only done on shrimps below or equal to 19 mm CPL While using this new method in 2014, all age-2 results from 1993 to 2014 was re-calculated. A more comprehensive description of the method is found in Kingsley (2014).

The composition of the stock by size and sex is based on a two-stage analysis of lengths and weights. From catch samples, 1000–2000 individual shrimps are both weighed and measured, and these measurement pairs are used to estimate a weight-length relationship. From each catch a sample of about 0.5 to 3 kg was taken and sorted to species. All specimens of Northern shrimp were classified: juveniles and males composed one class, (Allen 1959, McCrary 1971). The oblique carapace length (CL) of each shrimp in the sample was measured to the nearest 0.1 mm. These length measurements are then supplemented with weight estimates based on the fitted weight-length curve. Aggregated, and then averaged over the stations in a stratum, these observations of sex and measurements of length and their associated estimates of weight are used to estimate the distribution of the stratum biomass between sex and length classes as well as the numbers of shrimps in the stratum in the various sex and length classes. Numbers of pre-recruits was estimated as the number of juvenile males from 14 to 16.5 mm carapace length (CL). A more comprehensive description of the methods used for analysis of the survey data is found in Burmeister and Rigét (2020a).

Least squares linear regression was used to test for relationships between the age-2 shrimps and fishable biomass with lags of two to four years as well as to test the relationship between the pre-recruits and fishable biomass with lags of one and two years. All analysis was done in SAS 9.4 TS level 1M3, X64-8pro platform, using the PROC REG and PROC AUTO REG procedures.

Results and discussion

Age-2 shrimps and fishable biomass

The number at age-2 (10.5 to 13.5 mm) reached a peak in 2000 and 2001 and has since declined to a much lower level, with two high values only in 2015, 2019 and 2020 (Burmeister and Rigét, 2020a). Abundance indices for age-2 shrimps (CL 10.5 to 13.5 mm) showed significant correlations with the fishable biomass (all individuals ≥ 17 mm CL) two, three and four years later (Fig. 1). Autocorrelation of the residuals was only significant in case of the residuals deriving from the regression of age-2 shrimp index and the fishable biomass two years ahead. In no other cases, any pronounced autocorrelation was detected. The Durban-Watson (D) shown a positive 1. order autocorrelation at 0.652, pr < DW <.0001. An autoregressive model was applied and reviled a significant linear relationship between number of age-2 shrimps and the fishable biomass 2 years ahead (Autoregressive regression; y =183.32 – 17.90x, r^2 = 0.40, p = 0.005).

For the age-2 shrimp and fishable biomass 3 years ahead the slope was steeper (Fig. 1), and 50% of the variation in the fishable biomass could be explained by the variation in abundance three years earlier (simple linear regression; y =176.55– 19.64 x, r^2 = 0.50 p < 0.001). The strongest relationship were found between number of age-2 shrimps and the fishable biomass four years ahead (Fig. 1) while as much as 64% of the variation in the fishable biomass could be explained by the variation in age-2 recruits (simple linear regression; y =164.47– 21.90 x, r^2 = 0.64 p < 0.001).

Time lags of three and four years in the correlation between recruitment at age 2 and fishable biomass are reasonable considering that the main contribution in the fishable biomass comes from individuals in the size range of age 4 to 6 years (Wieland 2004). The relative low recruitment observed in the past 2 years might suggests a decrease of the fishable biomass in the coming years. The predictions for coming years might only be true, if the overall effect from the underlying processes (e.g. growth, natural mortality predation by cod and other fish species and exploitation rate) do not shown considerably changes.

Pre-recruits, age-2 and fishable biomass

The pre-recruit index (14–16.5 mm, expected to recruit to next year's fishable biomass) had a high values in 2002 -2005, except in 2004) and has since fluctuated at a lower level, with relatively high values in 1999-2000 and again 2015 and 2017. Numbers of pre-recruits in 2020 are above the 1993 to 2020 average (Burmeister and Rigét 2020b).

Linear regression has shown a significant relationship between the number of pre-recruits and the fishable biomass with a lag of 1 and 2 years later. The correlation were strongest (Simple linear regression; y =137.56 – 14.81 x r^2 = 0.68, p < 0.0001) between number of pre-recruits shrimp and the fishable biomass 1 years ahead, suggesting that most pre-recruits will be available to the fishery the next year. However, some of the smaller pre-recruits seems also to recruit into the fishable biomass 2 years later while the correlation was less but still strong (Simple linear regression; y =160.14 – 12.8 x r^2 = 0.52, p < 0.0001).

Furthermore, there was also a significant relationship between number of age-2 shrimp and the number of re-recruits 2-years later (Simple linear regression; y = 3.24 – 1.34 x r^2 = 0.52, p < 0.0001). It seems reasonably that age-2 shrimps shows up as pre-recruits 2 years later, and at this time might be approx. 4 years old.

References

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Figures

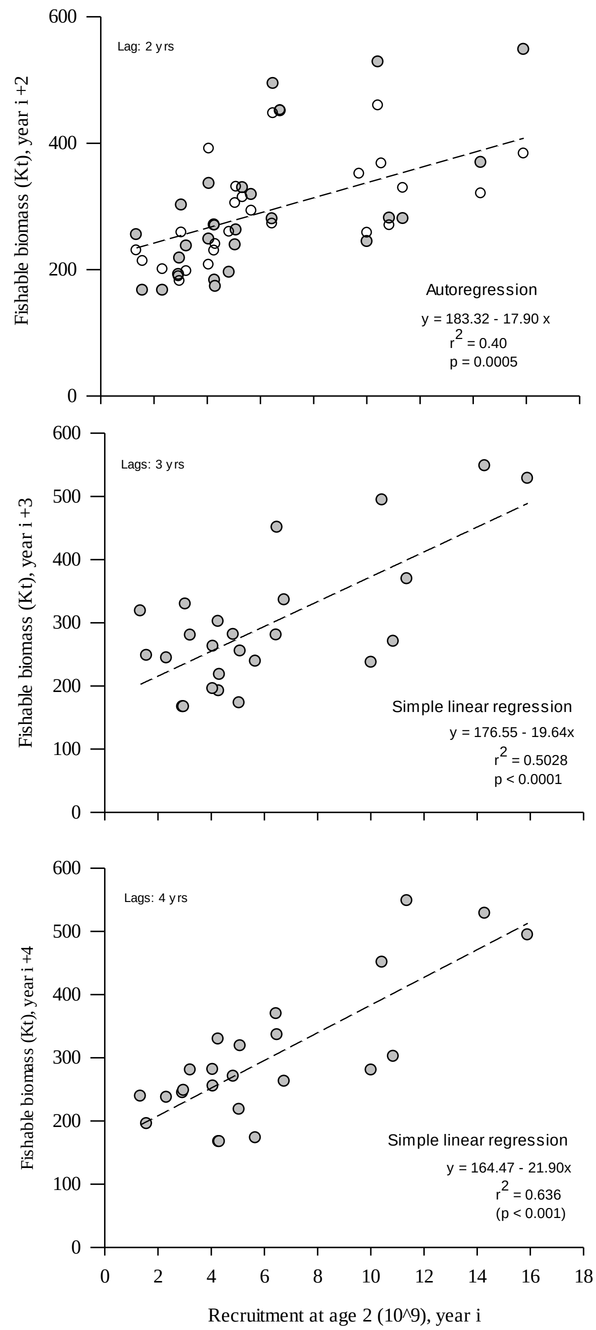

Figure 1. *Pandalus borealis* in West Greenland: lagged fishable biomass vs survey estimates of numbers at age-2 (10.5 til 13.5 mm Cl) from 1993 to 2020 (autocorrelated regressions lags: 2 yrs; open circles predicted from autoregression).

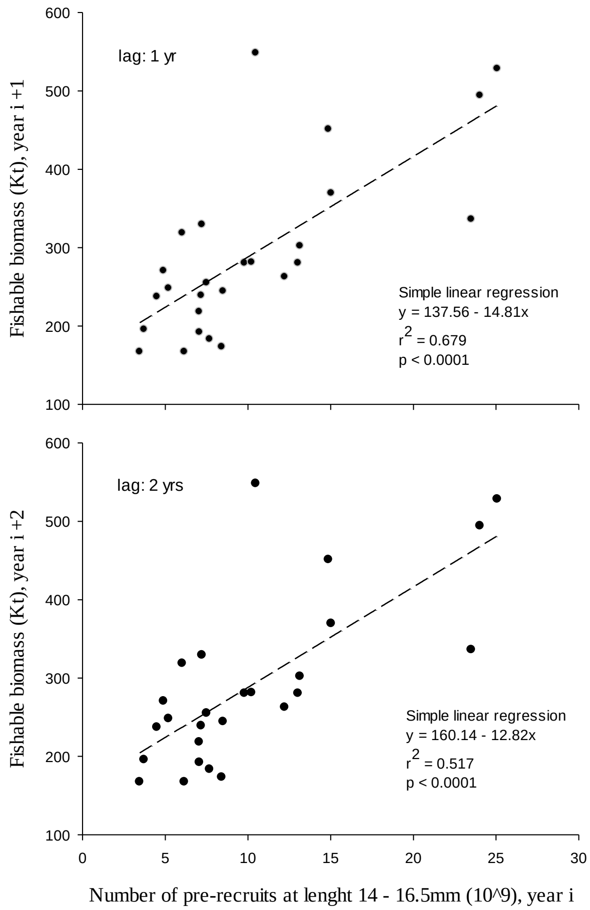

Figure 2. *Pandalus borealis* in West Greenland: lagged fishable biomass vs survey estimates of numbers of pre-recruits (14 – 16.5 mm Cl) from 1993 to 2020.

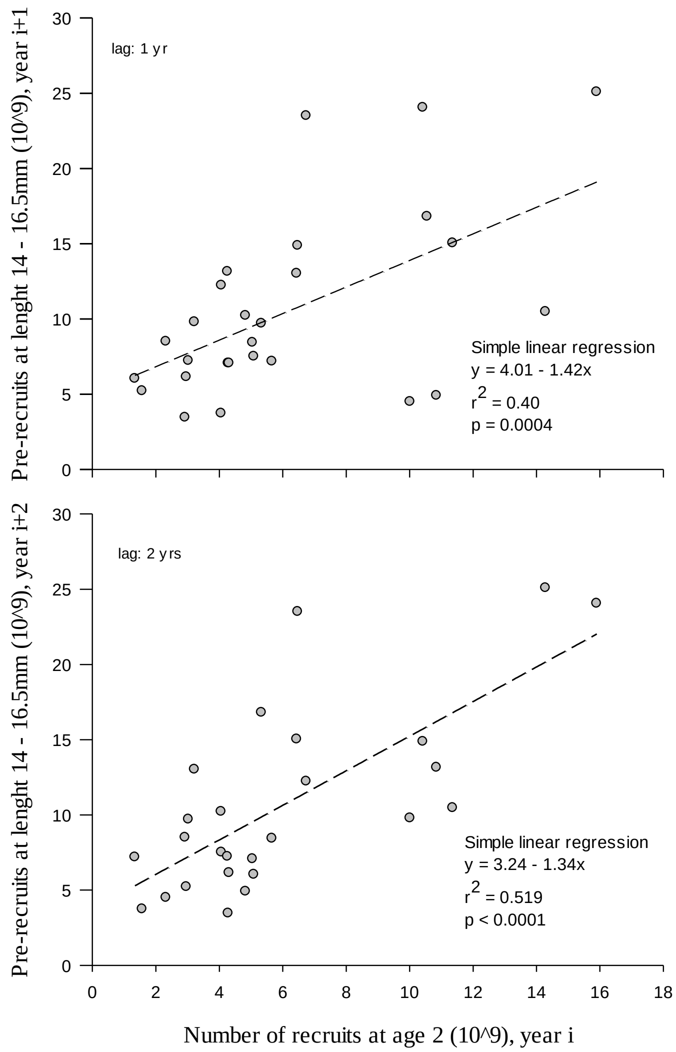

Figure 3. *Pandalus borealis* in West Greenland: lagged number of age-2 shrimps (10.5 – 13.5 mm CL) vs survey estimates of numbers of pre-recruits (14 – 16.5 mm Cl) from 1993 to 2020.