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Calculating a TAC for Northern Shrimp (*Pandalus borealis*) in West Greenland Waters (NAFO Subareas 0+1)

by

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Abstract

A method for the calculation of a TAC for northern shrimp off West Greenland one and two years ahead is presented. The method combines survey data on biomass and recruitment and fishery information on the level of exploitation suggesting TACs of 130 kt for 2004 and approximately 100 kt for 2005.

Introduction

Management advice for the stock of northern shrimp (*Pandalus borealis*) off West Greenland in NAFO Subarea 1 and Division 0A is formulated based on expert consensus at NAFO Scientific Council meetings. Until 2002, the recommended TAC was based solely on trends in survey estimates of biomass and commercial CPUE, and stock composition including recruitment was assessed qualitatively by visual inspection of length frequencies. In 2003, a quantitative model developed in a Bayesian framework (Hvingel and Kingsley, 2002) was adopted. This model allows risk assessment focussing on long-term (10 years) sustainability of different levels of annual removals from the stock (Hvingel, 2003a), but it does not explicitly consider recruitment and is thus not capable to account for short-term (1 to 2 years) changes in the strength of incoming year classes.

The survey data, however, offer estimates of the fishable biomass as well as indices of the abundance of recruiting year-classes. By analysis of the various young year-classes that can be followed from one year to the next the growth of these year-classes can be determined, and their recruitment to the fishery in the coming year can be predicted (Wieland, 2003).

This paper presents a simple method for the calculation of a TAC for the next year and two years ahead that is based on survey estimates of biomass and recruitment and the level of exploitation observed in the past years.

Material and Methods

The long (1988-2003) time series of stratified-random surveys in Davis Strait (NAFO Subarea 1 and a part of Div. 0A) with satisfactory confidence limits (Kanneworff and Wieland, 2003) opens a possibility for the calculation of a TAC combining information from the surveys and the fishery.

The basic calculation for a TAC is made by simply multiplying the fishable biomass (all shrimp $\geq$17 mm CL $\approx L_{50}$ of a commercial trawl) estimated by the survey with the exploitation rate averaged over some time, e.g. a period over which no negative effect by the fishery on stock biomass has been observed. Without modifications this would give a rather crude value taking neither uncertainty of the biomass estimates nor recruitment into consideration.

A more cautious approach is to use the lower 95% confidence limit rather than the point estimate of the fishable biomass. Due to uncertainties about the level of magnitude of the 'end-effect' Kanneworff and Wieland (2003) did not include corrections for this in the final estimates of biomass. However, to be more cautious when assessing a TAC the correction for 'end-effect' should be included, because the towing time has been changed from a standard of 60 minutes to a mixture of 15 and 30 minutes in recent years (Kanneworff and Wieland, 2003). The estimated 'end-effect' in terms of a constant addition to the towing time (2.78 minutes; Kingsley, 2001) has a varying effect on the biomass estimates from the trawling operations through the years, ranging from less than 5 % in the early years to 9-11 % in the most recent years.

The procedure for calculation of the TAC includes the following steps:

- The point value and the lower 95 % confidence limit for the fishable biomass (FB) as estimated from the survey are determined and reduced by the 'end-error' correction (EE, in %), i.e.

$$B_{corr} = FB * (100 - EE).$$

- A term representing the part of the recruits at age 2 that will become available to the fishery in the next year (ΔRecr) is calculated using the deviation of the recruitment index for age group 2 from a long-term (10 year) average (Diff), the mean length (L) of age group 3 converted to weight, the natural mortality (M), and the proportion harvested by the commercial gear of this group (Prop) as

$$Recr = Diff * a * L^{b} * e^{-M} * Prop$$

  here a and b are the coefficients of the length-weight relationship (Kanneworff and Wieland, 2003), and M is set arbitrarily to 1.3 per year. Changing this value, however, by ± 50 % has only a small effect on the estimated TAC (± 5 %).

- Finally, the corrected fishable biomass with the recruitment correction term added is multiplied by the exploitation rate (E = Catch / FB) averaged over the past five years to give a TAC for the next year:

$$AC = (FB_{corr} + \Delta Recr) * E.$$

To propose a TAC two years ahead (for 2005) forecast values for fishable biomass and for abundance of age group 2 are needed. By regressing historical abundances of age group 2 to estimates of fishable biomass two years later Wieland (2003) estimated the fishable biomass in 2004 to be approximately 360 kt. This prediction is, however, only valid if growth, predation and in particular removal by the fishery relative to stock size (exploitation rate) remain unchanged. Thus, the catch for 2004 was set to 130 kt corresponding to the average exploitation rate for the years 1993-2003. The 2004 abundance of age group 2 is estimated by using the average of the five preceding years. Levels of error coefficient of variation and 'end-effect' percentage are proposed unchanged from 2003 to 2004.

Results and Discussion

Table 1 shows the input values for the TAC calculation from the survey period 1988-2003. Due to averaging of some of the parameters, such as abundance and exploitation rate, calculated TACs are given for 1999 and onwards only. The recruitment value used for 2004 may be too optimistic considering the relative poor recruitment observed in 2003, despite the actual high level of female biomass and the favourable temperature conditions at present (Kanneworff and Wieland, 2003). This has no substantial effect on the calculated TAC for 2005, as the proportion of the 2-group that will contribute to the fishery in the coming year is small in general.

The TACs calculated for the lower 95 % confidence limit of the corrected fishable biomass are considerably below the realised catches (Fig. 1). Survey biomass (Kanneworff and Wieland, 2003) and commercial CPUE (Hvingel, 2003b) have increased in past years at catch levels close to TACs corresponding to the point estimates of corrected fishable biomass (Fig. 2). This as well as the declining exploitation rate in the most recent years may indicate that the stock could have tolerated catches above the recommended TACs. Consequently, the calculated TACs for 2004 are the highest in the time series. However, neither a TAC of 160 kt (point estimate) nor a TAC of 130 kt (lower 95 % confidence limit estimate) calculated for 2004 can be maintained in 2005 (Fig. 1 and 2) taking the lower fishable biomass estimated for 2004 into account, which is a result of the declining recruitment at age 2 after 2001. The expected TAC for 2005 would be about 100 kt if the long-term average of exploitation rate (0.35) were maintained suggesting a TAC of 130 kt for 2004.

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TABLE 1. TAC-calculation for total shrimp distribution area in SA 0+1. (Catches 1988-2003 from Hvingel, 2003b; Catch for 2004 corresponds to the proposed TAC; CV: coefficient of variation, L_{50}: length at which 50% of the shrimp are retained in a commercial trawl, Age 2 abundance 1988-1992 set to 4.0 due to missing observations).

Year	Catch	Biomass				Recruitment					Exploitation rate			Calc. TAC for next year			
	'000 tons	Total	CV %	Fishable	End-error corr. %	Age 2 abundance index	Diff. from 10-yr mean	Mean length age 3	Prop. of age 3 > L_{50}	ΔRecr.	Yearly	5-year average	1993-2004	Lower CL $E_{5\,yr}$	Lower CL $E_{'93-'04}$	Point estimate $E_{5\,yr}$	Point estimate $E_{'93-'04}$
1988	73.6	229.8	13.5	216.9	-	4.00					0.339						
1989	80.7	228.0	17.8	199.6	-	4.00					0.404						
1990	84.0	228.3	17.9	213.9	4.0	4.00					0.393						
1991	91.5	172.6	13.2	146.3	6.5	4.00					0.625						
1992	105.5	225.1	13.0	202.0	5.9	4.00					0.522	0.457					
1993	91.0	256.8	11.7	232.7	5.7	4.86		16.9			0.391	0.467					
1994	92.8	270.6	19.6	249.5	5.8	3.62		17.4			0.372	0.461					
1995	87.4	217.1	13.4	201.2	6.2	2.63		17.7			0.434	0.469					
1996	84.1	248.9	16.0	212.0	6.1	13.50		17.3			0.397	0.423					
1997	78.1	206.2	15.0	185.4	5.8	3.94		17.7			0.421	0.403					
1998	80.5	293.3	18.9	263.0	6.8	7.23	+2.37	17.4	0.55	1.1	0.306	0.386		59		95	
1999	92.2	287.4	14.1	251.6	9.0	12.60	+7.42	18.4	0.65	4.8	0.366	0.385		65		90	
2000	97.2	349.5	10.8	301.0	10.2	15.99	+9.95	18.5	0.65	6.6	0.323	0.363		79		100	
2001	102.8	349.2	12.3	304.3	11.4	19.88	+12.65	18.2	0.60	7.4	0.338	0.351		73		97	
2002	129.2	492.7	13.4	393.3	9.2	12.71	+3.88	17.0	0.50	1.5	0.328	0.332		87		119	
2003	132.0	653.3	11.4	582.0	11.5	7.29	-2.41	16.4	0.45	-0.8	0.227	0.316		126		163	
2004	130.0		11.4	358.3	11.5	13.69	+3.76	16.4	0.45	1.2	0.363	0.316	0.356		87		113

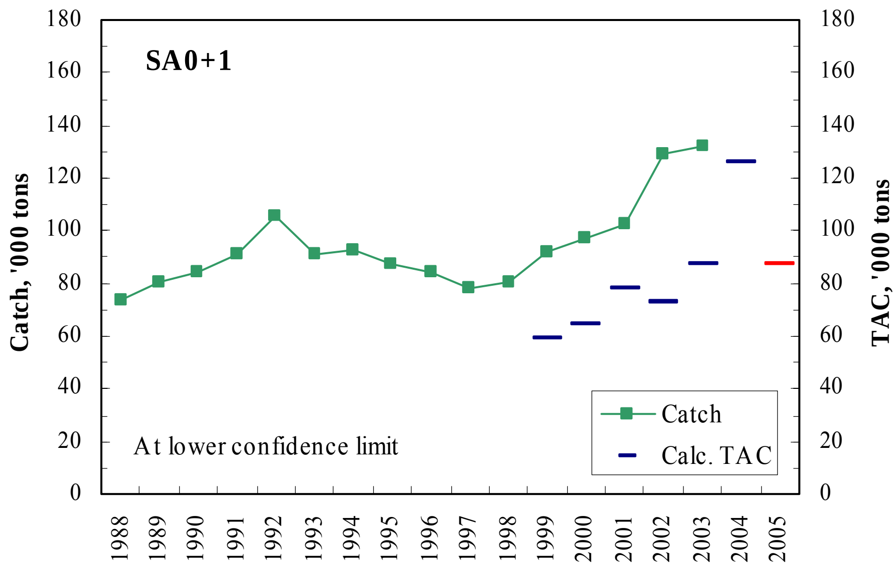

Fig.1. Calculated TAC for 1999-2005 and total catch 1988-2003 of northern shrimp in NAFO SA 0+1. TACs are calculated based on the lower 95 % confidence limit of the fishable biomass.

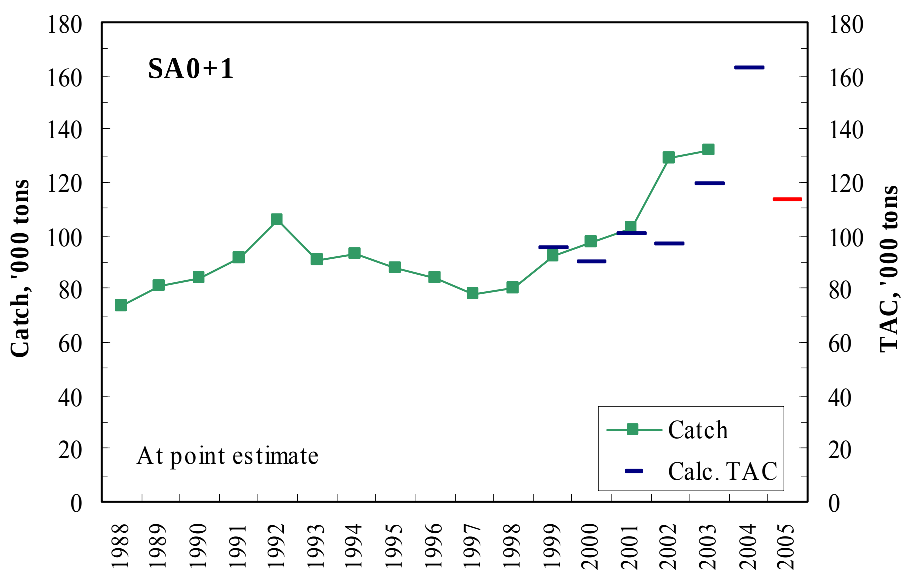

Fig.2. Calculated TAC for 1999-2005 and total catch 1988-2003 of northern shrimp in NAFO SA 0+1. TACs are calculated based on the point estimates of the fishable biomass.