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By-catches of Fish in the West Greenland Shrimp Survey: an Initial Analysis.

by

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Abstract

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A stratified random sample survey based on one-hour trawl stations has been carried out since 1988 as a component of the assessment of the stock of northern shrimp *Pandalus borealis* in offshore West Greenland waters. Fish by-catch in the survey is counted and weighed, and for some species measured. A multivariate analysis of the most abundant by-catch species was carried out using factor analysis and canonical correlation. Strongly associated groups of fish species were not detected, although there were some weak associations among species that apparently prefer deeper water. Although there has been a strong change in average bottom temperature over the data period, there was little sign of any general response in the fish by-catch, and no abundances among fish by-catch appeared to be related to temperature change.

Introduction

The northern shrimp (*Pandalus borealis*) occurs off West Greenland in NAFO Divisions 0A and 1A-1F**,** mostly in water between 150 and 600 m deep. An offshore fishery began in about 1970 and has thriven. A trawl survey is a component of the assessment process for this stock, and has been carried out annually since 1988 (Carlsson and Kanneworff 1998a; b).

The catch is sampled and sorted. Fish by-catch is removed, and is identified to species or species group, weighed and counted.

An initial report on by-catch species listed 126 species or species groups of fishes by-caught in the shrimp survey, but most with very low occurrence (Carlsson and Kanneworff 1998c). The number of species is very large, and the occurrence of many of them quite low. To carry out individual analyses of so many species would be tedious, and would provide voluminous outputs, which would be difficult to synthesise. Therefore, an appropriate first step may be to look for related communities of species, the occurrence or density of which might be simultaneously affected by common factors. This document presents an initial exploratory analysis of some of the by-catch data in this way. It is limited to data for 1992–1999, when procedures for recording data on by-catch have been relatively uniform.

Methods

The survey was a stratified random bottom trawl survey carried out on the West Greenland shrimp fishing grounds. 56% of the area had good enough depth information to allow stratification by depth. For most years of the survey, tows lasted one hour. The equipment was a Skervøy trawl with Greenland Perfect doors. The cod-end liner was 44 mm stretched mesh in 1992, 20 mm thereafter. We only fished in daytime, between 0900 and 1900 UTC. The area swept by each tow was calculated from the door-spread (measured by Scanmar sensors and recorded 5 times per tow) and the towed track length (calculated from GPS positions at the start and end). Mean depth was recorded for all stations and bottom temperature for most.

The processing of the catch included removing all the fish by-catch. From about 1992 on the by-catch was then sorted, identified, counted, and weighed. Identification was variable. Most species were identified at least to genus, but identification to species level depended on the characteristics of the species group and on the level of interest and expertise available on each cruise.

For most groups for which both unspeciated and speciated observations had been made, all observations were pooled into unspeciated. After a preliminary calculation of mean catches, a selection of species and species groups was made. The species retained were about the top 15 by catch weight. The least abundant species in this group had average catches about 0.5% of the most abundant.

Biomass estimates were made by calculating, for each tow, a station density by dividing catch by swept area, and converting that to a stratum biomass estimate by multiplying by stratum area. The mean and variance of the stratum estimates were progressively combined to give area, region and overall annual survey biomass estimates. These estimates apply only to the shrimp survey area deeper than 150m, shallow-water stations fished only to investigate bottom-fish abundance being omitted.

Associations between species were explored using multivariate analyses. Station data on catch for 16 species was converted to density by dividing by swept area. To find associations between species we used variable clustering and factor analysis. To look for associations between fish species and water conditions, we used factor analysis and canonical correlation. For these association analyses, the shallow-water 'fish stations' were retained. We have omitted the occasionally caught shrimp species that are found either in shallow or in deep water.

Results and Discussion

The most abundant species by weight are the major commercial species, redfishes (*Sebastes* spp.) and Greenland halibut (*Rheinhardtius hippoglossoides*). Also common, especially in the northern areas, is Arctic cod (polar cod) (*Boreogadus saida*). Among the more abundant minor groups, the most prominent are sculpins (Cottidae) and eelpouts (*Lycodes* spp.). *Lycodes* are seldom identified further. Sculpins tend to be identified as far as genus, less often to species. Common genera include the mailed sculpins *Triglops* spp. and hookear sculpins *Artediellus* spp. *Species* that are fairly readily identified and seldom accompanied by congeners are the thorny skate *Raja radiata* and the American plaice *Hippoglossoides platessoides*. Snailfishes (*Liparis* and related genera) are seldom identified, and lanternfishes (Myctophidae) seldom come out of the net in a condition to be identified. Snake blennies (Lumpenidae) are numerous, often small. Among cephalopods, decapods are distinguished from octopods, but usually no further. The Atlantic poacher (*Agonus decagonus*) is easily distinguished from alligatorfishes *Aspidophoroides* spp. Wolffishes *Anarhichas* spp. occur and are usually identified to species, one of the commoner being the spotted wolffish *A. minor*.

There is a rapid decline in the biomass of by-catch species as one goes down the list (Table 1). Redfishes, combined, average about 9% of the catch weight of *Pandalus borealis*. The fifth on this list, all species of *Lycodes* combined, is less than one-tenth of this. Many species have increased slightly between 1992 and 1999, but correlations are not significant except for Greenland halibut (at 1%), which appears to have increased by 1 900 mt/yr (about 11%/yr). An apparent trend in *Triglops* spp., significant at 5%, is mostly due to a tripling of the by-catch in 1999.

Variable clustering produced 5 clusters from 16 most abundant species by weight (Table 2). Clusters 1 and 2 were correlated. Cluster 1 contained a number of species with little clear affiliation; cluster 2 contained apparently associated deep-water species. Factor analysis with varimax rotation (SAS Institute) produced 6 factors (Table 3). There was little clear association between clusters and factors. The first factor looked like the sum of the first 2 clusters, and the second factor looked like their difference. Factors 3, 4 and 5 mostly contained components of clusters 3 and 4. Factor 6 was mostly cluster 5—capelin, which tends to segregate. Most analyses showed a negative association between lanternfishes and spiny lumpsucker *Eumicrotremus spinosus*, which may be consistent with lanternfishes' being a pelagic group.

When the environmental variables Year, Bottom temperature and Depth were added into the factor analysis, 7 factors were retained compared with 6 before (Table 5). Water conditions heavily loaded only 2 factors, one of which was depth only, and was also heavily loaded for most of the members of the first two clusters. I.e. these groups appear to be identified as deep-water species. The other was heavily loaded for Year and Temperature, (which are highly correlated), and lightly loaded for Depth. Species noticeably loaded on this factor were spiny lumpsucker, snailfishes, and Atlantic poacher with negative loadings, and redfishes and lanternfishes with positive loading. A third environmental factor, less heavily loaded, was positive for temperature and negative for depth, i.e. associated with shallower warmer water, and was positively loaded for species in cluster 1 and negatively with cluster 2.

The results of canonical correlation were similar. The three environmental variables depth, year, and temperature produced canonical variables corresponding to depth alone, year and temperature together, and a year-temperature difference (Table 5). The first one, depth alone, was positively correlated with most of the fish species, but neutral for capelin, snake blennies and mailed sculpins, and strongly negative for spiny lumpsucker; the first canonical correlation was 0.601. The second canonical correlation was 0.383, and the canonical variable corresponding to temperature and year together was positively correlated with redfish, but negatively or little for other species. The third canonical correlation was 0.222 and the variable was not much correlated with any individual species.

The lack of success in separating the by-catch into distinct communities of fish species may be because the species looked at are occupying a common habitat, i.e. the shrimp fishing grounds off West Greenland. The depth band is fairly narrow, the range of water temperatures is not large, whereas the variability in density of both shrimp and fish species is considerable. Therefore, there may be so much variability in the data that more sophisticated techniques would be necessary to get useful results.

The survey is carried out on the shrimp fishing grounds, which are intensively fished by commercial trawlers with fairly small-mesh gear. It is not known what effect this activity has on the fish community structure. However, the fishery started in 1972 and was intense for at least a decade before the start of the data series analysed here, and therefore the effects may have stabilised.

Conclusions

This preliminary attempt at a multivariate analysis of by-catch has not been very successful in separating the common by-catch species into distinct communities. Some species grouped together as showing a general tendency to prefer deeper water, and separated themselves from some others that did not. However, in general, the correlations are not strong, and different analyses tend to give different results. Pelagic species tended to separate themselves from demersal species. There was no clear response to the change in temperature that has taken place over the period spanned by the data.

References

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Table 1. Estimated survey biomass in the West Greenland shrimp survey area for the main by-catch fish species in 1992–1999

	Estimated survey biomass in:								
	1992	1993	1994	1995	1996	1997	1998	1999	Mean ECV (%)
	'000 tonnes								
Sebastes (all spp.)	26.19	19.20	30.89	17.18	26.35	20.63	21.77	16.98	19.4
Greenland halibut	12.69	13.22	14.22	13.00	19.63	18.45	25.62	23.47	15.8
Boreogadus saida	8.85	18.18	14.55	16.69	26.88	10.99	18.40	16.74	17.2
Capelin	0.06	4.87	3.19	21.43	4.48	1.19	8.66	106.97	56.1
Triglops spp. (all)	3.02	1.03	3.82	1.67	3.04	4.46	4.85	9.27	28.3
Lycodes (all)	0.75	1.07	1.78	1.42	1.77	1.75	2.12	1.38	13.2
Thorny skate	1.10	0.89	1.66	2.32	2.12	2.09	2.00	1.41	16.1
American plaice	0.62	0.50	1.32	0.82	1.19	1.38	1.42	1.00	12.5
Snailfishes (all)	0.37	1.36	0.68	1.53	1.85	0.87	0.58	0.32	23.8
Snake blennies	0.02	0.39	0.46	0.70	1.24	0.32	1.00	0.69	29.2
Lanternfishes	0.08	0.12	0.03	0.30	1.53	1.04	0.39	0.90	44.5
	Tons								
Spiny lumpsucker	439	162	935	643	635	321	278	271	26.2
Squids	379	390	538	708	389	697	466	448	15.5
Hookear sculpins	143	230	1141	348	222	591	356	291	21.9
Spotted wolffish	334	282	438	664	552	393	430	358	39.2
Atlantic poacher	276	337	397	397	550	450	531	281	20.8

Over this period the estimated survey biomass of *Pandalus borealis* has ranged from 217 000 to 297 000 mt with mean 251 000 mt.

Table 2. Variable clustering of the most abundant by-catch species in the West Greenland shrimp survey.

	R-squared with		
	Own cluster	Next closest	$1-R^2$ ratio
	Cluster 1		
Eelpouts	0.5268	0.26	0.6395
Thorny skate	0.4972	0.0865	0.5505
Am. plaice	0.5553	0.063	0.4746
Snailfishes	0.4665	0.1091	0.5988
Snake blennies	0.2555	0.0004	0.7448
Atlantic poacher	0.392	0.0405	0.6336
	Cluster 2		
Greenland halibut	0.6369	0.177	0.4412
Arctic cod	0.2859	0.0804	0.7766
Squid	0.6162	0.0391	0.3994
	Cluster 3		
Redfishes	0.3686	0.0044	0.6342
Mailed sculpins	0.1721	0.0002	0.8281
Hookear sculpins	0.5699	0.0166	0.4374
Spotted wolffish	0.0972	0.0057	0.908
	Cluster 4		
Lanternfishes	0.5194	0.0078	0.4844
Spiny lumpsucker	0.5194	0.0089	0.4849
	Cluster 5		
Capelin	1	0.0003	0

Table 3. Varimax-rotated factor patterns for fish by-catch density.

	Factor					
	1	2	3	4	5	6
Redfishes			0.693		0.308	
Greenland halibut		0.796				
Arctic cod	0.252	0.282		0.561		
Capelin						0.895
Mailed sculpins				0.713		
Eelpouts	0.465	0.625				
Thorny skate	0.513	0.413	0.270			
American plaice	0.778					
Snailfishes	0.558	0.386				
Snake blennies	0.723					
Lanternfishes					0.581	
Spiny lumpsucker				-0.405	-0.605	
Squid		0.736				
Hookear sculpins			0.709			
Atlantic poacher	0.615					
Spotted wolffish						0.412
Variance explained by factor						
	2.41	2.09	1.25	1.17	1.13	1.02

Note: factor loadings under 0.25 are not shown.

Table 4. Varimax-rotated factor pattern for fish density, with environmental variables included.

	Factor						
	1	2	3	4	5	6	7
Redfishes				0.463	-0.262	0.501	
Greenland halibut	0.793						
Arctic cod	0.320				0.565		
Capelin							0.797
Mailed sculpins					0.699		
Eelpouts	0.593	0.482		0.275			
Thorny skate	0.354	0.489		0.405			
American plaice		0.795					
Snailfishes	0.397	0.533	-0.254				
Snake blennies		0.761					
Lanternfishes						0.640	
Spiny lumpsucker			-0.379		-0.378		
Squid	0.715						
Hookear sculpins				0.782			
Atlantic poacher		0.596					
Spotted wolffish						0.403	0.565
Year			0.808				
Depth	0.610		0.281	0.261		0.337	
Bottom temperature			0.836				
Variance explained by factor							
	2.44	2.43	1.83	1.39	1.21	1.20	1.02

Note: factor loadings under 0.25 are not shown.

Table 5. Correlation with canonical variables in the canonical correlation of fish density with Year, Density, and Bottom temperature.

	Correlation with environmental canonical variable:		
	W1	W2	W3
Year		0.54	-0.84
Depth	0.99		
Bottom temperature	0.19	0.98	
Redfishes	0.23	0.15	
Greenland halibut	0.45		
Arctic cod	0.17	-0.16	
Capelin			
Mailed sculpins			
Eelpouts	0.38		
Thorny skate	0.26		
American plaice	0.20		
Snailfishes	0.24	-0.26	
Snake blennies			
Lanternfishes			
Spiny lumpsucker	-0.26	-0.15	
Squid	0.31		
Hookear sculpins	0.16		
Atlantic poacher		-0.18	
Spotted wolffish			
Correlation with Fish canonical variable	0.601	0.383	0.222

Note: correlations below 0.125 are not shown.