Population parameters of deep-water shrimp (*Pandalus borealis*) and fish community in Isfjord and Jan Mayen area

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Abstract

This investigation was carried out in Isfjord (Spitsbergen) and at Jan Mayen with the aim to study the population dynamics of *Pandalus borealis* and to compare and contrast the fish and shrimp fauna of the two areas. For P. borealis, differences were found with respect to depth, time of day and between the two areas. *P. borealis* was more frequent close to the bottom during day than during night, and males dominated the shallow waters while females were more frequent in deeper waters. The two populations differed in population parameters as length-frequency, growth, length/age at female maturity and possibly also maximum age. The fish fauna of the two areas showed differences, and variations were also detected inside the Jan Mayen area. CTD data could not explain these variations and it is speculated that they could be caused by other abiotic data, e.g. bottom structure, or by biotic factors as zoogeographical distribution and habitat preferences.

Keywords: Isfjord, Jan Mayen, *Pandalus borealis*, benthic fish communities

Introduction

The aim of this work was to study the Isfjord and Jan Mayen populations of *Pandalus borealis*. Biomass, size and maturity distribution in connection to depth, and also the cohorts and growth were investigated. Further, a comparison of fish and shrimp fauna in the two areas was made.

Isfjord is located on the western side of Spitsbergen and relatively warm waters of the West Spitsbergen Current influence the water masses (Nilssen *et al.* 1989). Both Arctic water from the East Greenland Current and warmer Atlantic waters dominate the Jan Mayen area (Gabrielsen *et al*. 1997).

Until 1970 the Norwegian shrimp fishery was confined to coastal areas and fjords. In 1970 large shrimp fields were discovered in the open part of the Barents Sea and Spitsbergen area, which opened for extensive fisheries (Aschan *et al.* 1996). Relatively few investigations have been conducted on the deep-water shrimp, *Pandalus borealis*, in the polar waters of Spitsbergen and Jan Mayen.

The distribution of *P. borealis* is probably regulated by abiotic factors such as temperature, currents, salinity, depth and sediment type and by biotic factors as e.g. predation (Rasmussen 1953). Commonly, *P. borealis* is found in waters with temperatures between 0°C and 5°C, although extremes occur at both sides (Ofstad 1998).

Both the Svalbard and Jan Mayen populations are at the lower limit of the temperature scale. The distribution in the Arctic is shown to be regulated by large-scale water currents, i.e. the transport of warmer and saltier water from the south with the Gulf Stream and the North Atlantic Drift (Ofstad 1998). *P. borealis* is ecologically described as a stenohaline species and they prefer relatively high salinities (34.1-35.7 PSU) (Ofstad 1998). These animals most often occur at depths between 80-650 m. Depths with the highest biomass will vary according to other abiotic factors such as latitude, temperature, time of day and also according to biotic factors of the species itself, like sex and age (Ofstad 1998). Concerning sediment type there is a preference for soft muddy bottoms (Ofstad 1998).

P. borealis is a protandric hermaphrodite, which means that the individuals are born as males but transform to females at a certain stage in life (Ofstad 1998).

There are also reasons to believe that the fish faunas of Isfjord and Jan Mayen are different with respect to species, since species composition depends on numerous factors as e.g. temperature, salinity and mobility.

Materials and methods

The work was conducted between September the 9th and the 21st aboard the ship 'F/F Jan Mayen'.

Two stations were sampled in Isfjord (ST778 and ST779). At Jan Mayen 20 stations were sampled (ST785, ST786, ST787, ST788, ST789, ST797, ST798, ST799, ST810, ST811, ST812, ST829, ST830, ST831, ST844, ST845, ST846, ST847 ST865, ST866). The different stations were chosen after criteria as depth, latitude and longitude (Figure 2).

The sampling trawl used was a standard sampling trawl, Campelen 1800 super, a modified shrimp trawl with "rockhopper" ground gear. The mesh size of the inner net was 20 mm and the sweep width 11.7 m. For biomass calculations there is a common standard, kg/20 minutes trawl.

Trawling was mainly conducted during night but two stations were sampled during day, ST865 and ST866. These stations were chosen where night sampling already had been conducted, so that ST785 corresponds to ST865 and ST786 corresponds to ST866.

For temperature and salinity data, CTD (Conductivity, Temperature and Density) was run while other weather data were received from the ship's bridge (Table 1). The trawl itself carried a depth recorder and measured depth every five minutes during trawling. The trawl depths used are the mean depths measured on the trawl itself and will, for that reason, be somewhat different from the depths given by the CTD.

Statistical analyses were done using SYSTAT 8.0.

Population dynamics of *Pandalus borealis*

Total weight of *P. borealis* was noted but in some cases only a subsample was used for further investigations. The subsamples were treated as follows. Total weight of the subsample was noted and all individuals were counted. Individuals were sorted into groups of different life stages and coded after Grimsmo's standard (Ofstad 1998) (Table 13).

The sorting is a simplified version of this standard. Males included all individuals with spines under their, females in general were those individuals without spines under carapace and they were further divided with respect to the location of roe. Females without roe were interpreted as resting females. Carapace length (CaLe) was measured with 0.1 mm accuracy using an electronic calliper (Mitutoyo CD-150 mm, Mitutoyo, Japan). Length was measured from the eye to the back of the carapace. Some individuals were recorded as present in the subsample but not measured due to disruptions of the carapace (i.e. these were included in the total weight). Calibration was done regularly, data were manually checked and some values of the original file were excluded due to failure of the equipment.

Table 13. Life stages used in this study and their respective code.

Life stage	Code
Males	2
Females with head roe	4
Females with roe	5
Resting females	8

Data of carapace length were grouped into 0.5 mm intervals prior to cohort analyses. The programme used was MIX version 3.0, which analyses histograms and is specially made with the aim to find cohorts in a set of data where only length/frequency data from a given time are available (Ofstad 1998). The main problem using MIX is that the number of cohorts has to be defined prior to analysis. The Isfjord MIX analysis included both males alone and males/females, and the stations were combined to an 'Isfjord total'. The Jan Mayen MIX analyses included only the males and the stations combined gave a 'Jan Mayen total'. Some individuals were excluded due to atypical size (Table 15, appendix).

Fish and shrimp community analyses

The landings were sorted, counted and weighed. In species with high individual abundance (e.g. *Boreogadus saida*) the numbers were calculated based on total weight. Some trawls contained large biomasses and hence subsamples were taken for species determinations and other data.

Cluster analyses were used for analysing and comparing the different stations and species combinations, detecting similarities and differences. These were based on the present/absent data, the ranked abundance data and the ranked biomass data.

All species of fish and the four most common shrimps (*P. borealis, Sabinea septemcarinatus, Sclerocrangon ferox* and *S. boreas*) were included. Species of shrimps that occurred in small numbers and weights and animals other than fish and shrimps were excluded. These data were ranked before clustering (Appendix). Station ST846 was excluded from all the cluster analyses due to sampling errors. In consideration of identification problems, some individuals were only determined to the genus or family level.

A permuted data matrix of the present/absent data was made in order to visualise the connection between groups of species and groups of stations.

Results

Population dynamics of *Pandalus borealis*

The total biomass of *P. borealis* was recorded at all stations (Table 19, appendix). Biomass varied greatly from 0.008 kg (only 2 individuals) to 53.17 kg. Catch at station ST865 (day) was approximately six times higher than at station ST785 (night). Catch at station ST866 (day) was also higher than at station ST786 (night), and the catches at the two stations sampled during the day were both higher than any of the other stations (appendix, Figure 25). Comparing Isfjord and Jan Mayen, Isfjord catches were higher.

The length frequency distribution of the shrimps is shown in Figure 20. Numbers of individuals measured were mainly dependent upon catch and varied between 91-1225 individuals. The weight of the samples measured is shown in Appendix (Table 19). This weight also includes some individuals that were not measured due to disruptions of their carapace. In some of the samples this number was very high, because some individuals had just finished moulting (Nilssen, E.M., pers. comm.). The arrangement of the stations in Figure 20 were selected after area, time of day and depth. Even though some stations contained quite few individuals there was a trend in the data both according to area and time of day. Males dominated in the shallow waters while the abundance of females increased with depth. Comparing Isfjord and Jan Mayen there were also differences in carapace lengths both according to males and females (Figure 20). Carapace length of the smallest females in Isfjord was 18.05 mm, while it was 19.90 mm for Jan Mayen. All individuals were females at a carapace length > 26.3 mm in Isfjord and at a carapace length > 27.3 mm at Jan Mayen (Table 18, appendix).

Nilssen, E.M. conducted MIX analyses (Table 16, appendix). 3-4 cohorts were chosen. Means from the MIX analyses were used to define the cohorts (Table 14). Age had to be assumed for all the means. For the Isfjord population May the 1st was chosen to be the birth date (Nilssen, E.M., pers. comm.) while May the 15th was assumed for the Jan Mayen population (Ofstad 1998). The results indicate that the youngest age groups were absent in all stations. Based on these results a growth curve was drawn (Figure 21).

In order to find maturing age of females the proportion of females in the different length groups were plotted against total number of individuals in their respective groups (Figure 22). Carapace lengths where 50% of the individuals were mature females were estimated to be 21.5 mm in Isfjord and 25.0 mm at Jan Mayen.

Individuals carrying the parasitic isopod *Hemiarthrus abdominalis* were observed at all stations. This parasite attaches to the abdomen of small males and inhibits development, moult and consequently the transition into females (Ofstad 1998).

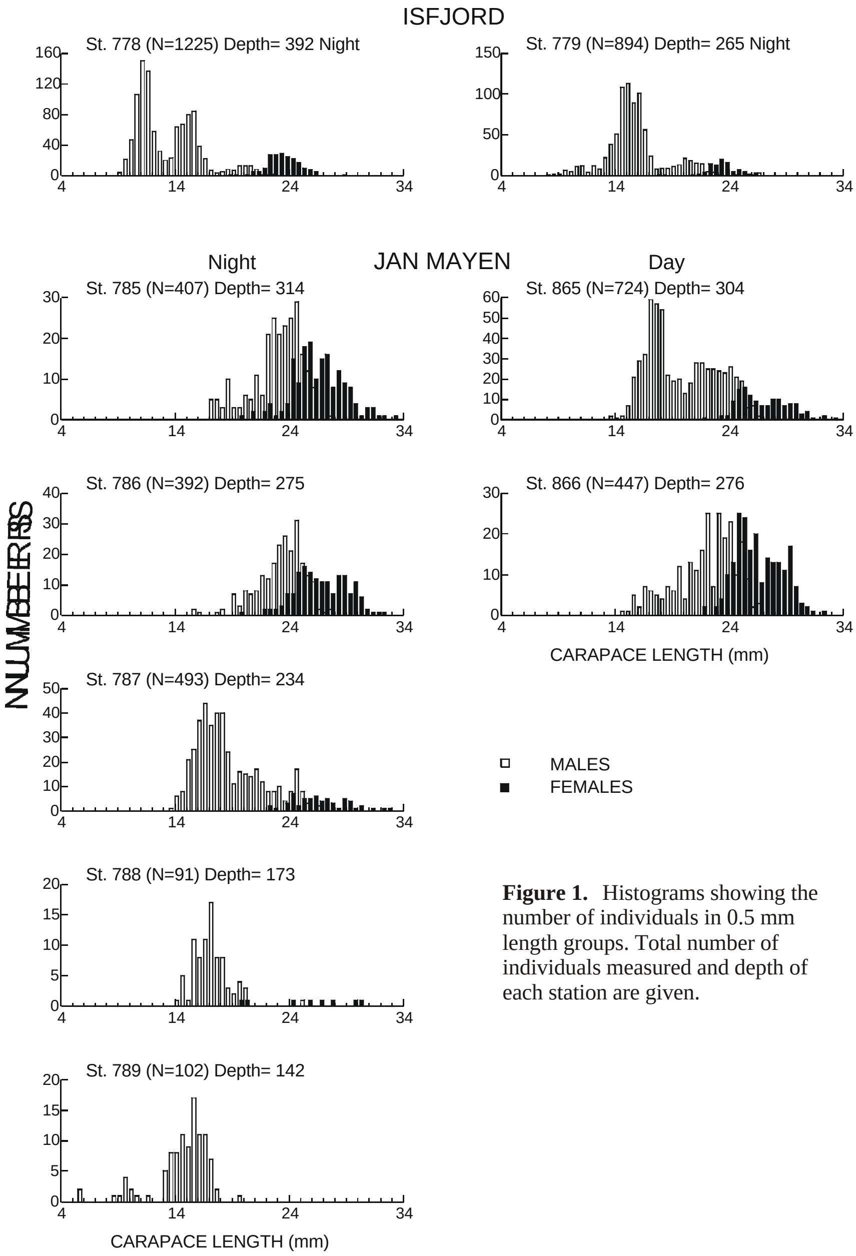

Figure 20. Histogram showing the number of individuals in the 0.5 mm length groups. Total number of individuals measured and depth of each station are given.

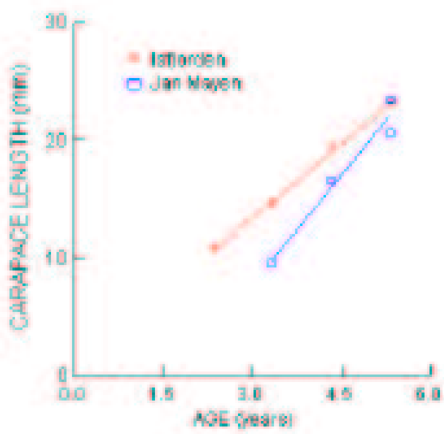

Figure 21. Size and maturity distribution of *P. borealis*. The trendlines were drawn linear. In the Isfjord plot the total cohort ages of males and females were used, whereas the Jan Mayen plot only included the total cohort ages of males.

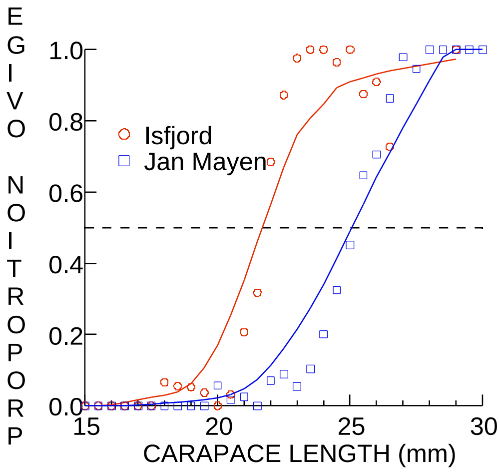

Figure 22. Average proportion of ovigerous females dependent on carapace length. The trendlines were drawn in SYSTAT, using LOWESS – smooth with tension 0.6, which uses weighted averages of the data points.

Fish and shrimp community analyses

The total biomass of each station is shown in Figure 23. Biomasses in the Isfjord stations were higher than in all Jan Mayen stations, and the highest biomasses from Jan Mayen were those which were caught during day. Considering the by-catch in the trawl, i.e. not including *P. borealis* the trend shown in total biomass in Figure 23 is not so clear (Figure 27, Table 19, appendix). The by-catches from Isfjord were larger than all the by-catches from Jan Mayen, but the day trawling in Jan Mayen did not exceed catches from all the stations at Jan Mayen even though they exceeded the catches from the same locality during night. In other words *P. borealis* is an important factor in the trend shown in Figure 23.

The various cluster analyses gave almost the same results, and the groups presented (Table 15 and 17, appendix) are a summary of all the analyses. Only the cluster trees for the present/absent data are included in this paper.

The species analysis (Figure 24) divided the species into two groups of about the same size. Group A contains species like *Sclerocrangon ferox*, *Pandalus borealis*, *Leptagonus decagonus* and *Boreogadus saida*, while group B consists of species as *Sclerocrangon boreas*, *Hippoglossoides platessoides* and species of Myctophidae.

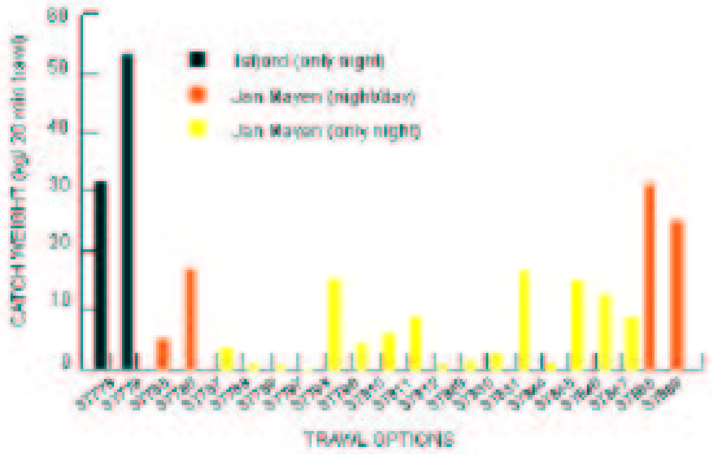

Figure 23. Bar plot of wet weight biomass at each landing. The dark and light colours indicate the stations with only night trawling. The medium colour indicates the two sites at Jan Mayen with night respective day trawling.

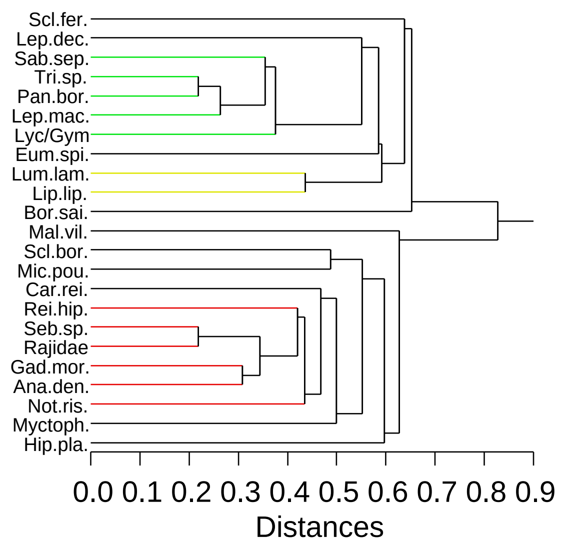

Figure 24. Cluster tree for present/absent data for the most common fish and shrimp species. There is a clear division in two groups, group A on top and group B on bottom. (Shortenings are explained in Table 15, appendix).

The station analysis (Figure 25) shows a major division between the two Isfjord stations and those at Jan Mayen. Still, the two Isfjord stations are quite different from each other. As for Jan Mayen, five subgroups are formed.

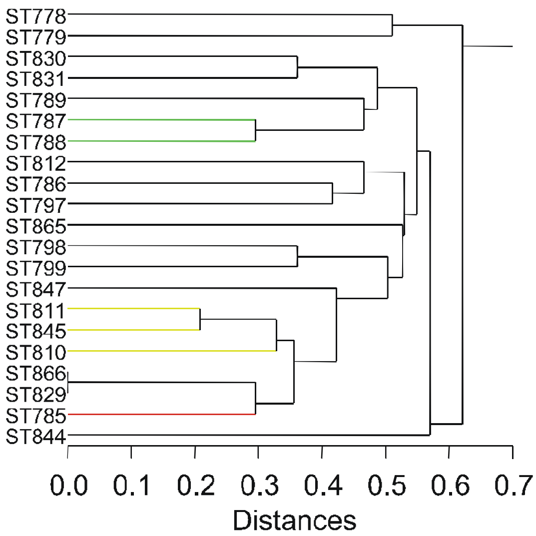

Figure 25. Cluster tree for present/absent data for all stations. The Isfjord stations (ST778 and ST779) are separated from all the Jan Mayen stations.

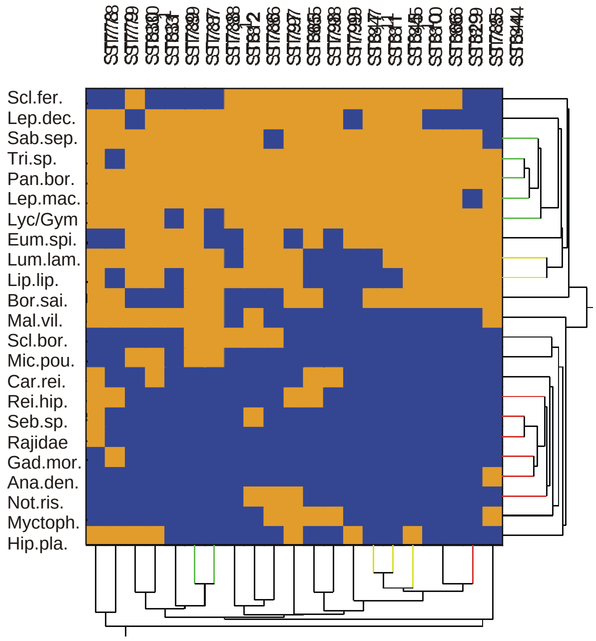

Figure 26. Permuted data matrix for the present/absent data. The cluster tree for the species is shown on the right, and the cluster tree for the stations is at the bottom. The light colour represents presence and the dark colour represents absence.

The permuted data matrix (Figure 26) shows that the Isfjord stations had a mixture of the two species groups A and B. Moving to the right in Figure 26, the stations seem to have increasing amount of group A species and decreasing amount of group B species. Station group 6 (Table 17, appendix) is the most homogenous, having almost only group A species.

Discussion

Population dynamics of *Pandalus borealis*

Comparing the two areas it is obvious that the catches of *P. borealis* were higher in Isfjord than in Jan Mayen. This may be due to either biotic factors (food, predation, natural cycles) or abiotic factors (temperature, salinity, sediment structure, currents, wind) or both. Anthropogen impact from fishing may also be an explanation, but none of these parameters may be explained with data from this investigation alone. Only two stations were sampled in Isfjord and it is difficult to compare these, but since there was little variation in physical parameters (Fig. 3) other factors could explain why biomass was higher in station ST779 than in station ST778 (Table 19, appendix). The increase of females, and thereby biomass, with increasing depth was mentioned in results. However, for the Jan Mayen population Aschan *et al.* (1996) found biomass maximum in the 200-299 m depth interval. If the same theory applies to Isfjord this may explain the differences in biomass between the two Isfjord stations (no samples were taken at depths less than 200 m so this is purely speculation). Concerning the Jan Mayen population the highest biomass was found at depths between 164-317 m, but the only two stations with biomass exceeding 15 kg were in the 200-299 m depth interval (day trawling not included) (Table 19, appendix). *P. borealis* is known to have a vertical diurnal migration. Trawling during the night would theoretically result in smaller catches. To test this theory two stations were sampled during day resulting in higher catches. However they still did not exceed the landings of Isfjord, and sampling in Isfjord during day would possibly have given even higher catches.

Although the numbers of individuals measured were sparse in some of the stations the results show that the males dominated in shallow waters while the proportion of females increased with depth (Figure 20). Earlier investigations (Ofstad 1998, Aschan *et al.* 1996) show the same trend. Carapace length of the smallest female was smaller for Isfjord than for Jan Mayen (Table 18, appendix) and all individuals had transformed into females earlier in Isfjord than in Jan Mayen. This indicates that the population in Isfjord may have a shorter life span than the one of Jan Mayen. Ofstad (1998) found for the Jan Mayen population that the smallest female was 22 mm which is somewhat higher than the results of this investigation. Concerning carapace length where all individuals were females the results of this investigation give almost the same result as Ofstad (1998) (> 28 mm).

Age classes may easily cluster and thereby be masked, a factor which is more prevalent when the numbers of individuals measured at each station is low (Figure 20). For that reason, detecting age classes is a difficult task (Table 14). Crustaceans in general moult and length will be constant between every moulting. A main problem concerning large individuals (i.e. females) is that growth normally decreases as age increases, which means that finding the right age classes would be particularly difficult with respect to females. Another factor concerning females is that energy may be invested in reproduction at the cost of growth, hence there is no growth of females if they carry roe (Ofstad 1998). Since the cost of reproduction is so high, some females are resting females (Nilssen & Hopkins 1991), a factor which was also observed in this investigation (Table 18, appendix). Carapace length may even decrease after a moult due to bad environmental conditions the previous year (Nilssen, E.M., pers. comm.). Sampling the smallest individuals was almost impossible since these easily escape from the trawl (dependent upon the total biomass in the trawl) and for that reason no individuals born this spring were caught. Also the individuals born last year were difficult to catch. Some individuals of this group were probably caught at station ST789, and this indicates that the mean length of this group is close to 5.5 mm (Table 18, appendix). Based on this observation the first mean included in the MIX analyses from Jan Mayen was thought to be the 2 years old.

Table 14. Age classes of the Isfjord population (males and females) and the Jan Mayen population (males) with their respective mean lengths. Age of the Isfjord population is x.37 years, age of the Jan Mayen population is x.33 years (see Table 19, appendix). Also results from Ofstad and Nilssen (Ofstad 1998.) (x.25 years) concerning the Jan Mayen population are included.

Age (years)	Isfjord CaLe (mm)	Jan Mayen CaLe (mm)	Ofstad CaLe (mm)	Nilssen CaLe (mm)
2	10.82	9.53	8.74	9.97
3	14.80	16.62	14.01	13.78
4	19.52	20.66	17.62	17.20
5	23.24 (F)	23.52	21.38	19.73
6			23.97	22.80
7				24.83

Comparing with the results of Ofstad and Nilssen (Ofstad 1998), the means of the 2 years old are quite similar. The means of the other cohorts differ more. Hence, this investigation seems to have missed a cohort in the Jan Mayen population, compared with the other investigations. This is a weakness using MIX with sparse data (see statistical parameters in appendix, Table 16). Comparing with Figure 20 it seems likely that what were interpreted as four cohorts in this investigation may have been five, or more. Knowing that the parasite *H. abdominalis* was present in the samples from all stations measured adds another variable to the data. Since the growth of males will be inhibited this means that some males of a given carapace length could be older than suggested by the MIX analyses.

According to Figure 21 there is a trend that the Isfjord population grows faster than the Jan Mayen population the first years. Normally growth curves would be logarithmic but both growth curves seem more linear (no data available for the first two cohorts), a trend which has been observed earlier for northern populations (Nilssen, E.M., pers. comm.). However, the material in this study is too sparse to conclude this type of growth pattern.

Length of female maturity was higher for Jan Mayen than for Isfjord (Figure 22). Converted to age, the results indicate that the females in Isfjord mature at an age of 4 years, while the females at Jan Mayen would mature somewhat later. Nilssen & Hopkins (1991) determined the age to be 5 for the Isfjord population, while Ofstad (1998) reported 25.4 mm/ 5 years for the Jan Mayen population as well.

Maximum age of the two populations can not be determined by the available data. Concerning both populations, earlier investigations have shown that an age of 8-10 years may be reached (Ofstad 1998, Nilssen, E.M., pers. comm.).

All results concerning the populations of *P. borealis* in Isfjord and Jan Mayen indicate that some external factor (biotic or abiotic) control their life spans. Earlier comparisons between populations with respect to latitude (boreal or Arctic areas) have shown that carapace length growth is positively correlated to water temperature, i.e. the fastest growth rates and the shortest life spans are seen in southern and warmer areas (Nilssen & Hopkins 1991). Another factor is the seasonal supply of food. Cushings 'match-mismatch' theory stresses the importance of matching the reproduction to the production time of the food needed (Cushing 1969), and temperature is an indirect factor contributing to either match or mismatch. Even though all physical data collected on this cruise indicated presence of Atlantic water masses (appendix A), the Jan Mayen area will be strongly influenced by Arctic water masses during some part of the year (Gammelsrød, T. pers. comm.). Aschan *et al.* stresses the importance of predation and fishing mortality. These factors may be of great importance for the population in Isfjord while at Jan Mayen predation is probably minimal (cod is absent and ray species are sparse) and so is also fishing mortality. These factors together with low temperatures could probably explain the longer life span of *P. borealis* at Jan Mayen.

Fish and shrimp community analyses

In order to explain why there was a division in two groups concerning species (Figure 24) factors as zoogeographical distributions and habitat preferences have been studied (Table 15, appendix). The results indicate that group A contained more Arctic species while group B contained more Atlantic species, and that almost all species of group A were pure benthic, while group B had a mixture of benthic and pelagic species. Analysing the matrix (Figure 26) it seems as if the Isfjord community had a mixture of species from group A and B, while Jan Mayen was dominated by species from group A. *Gadus morhua* may exemplify an Atlantic species found only in Isfjord, while Arctic species only found at Jan Mayen may be exemplified by *Eumicrotremus spinosus* and *Sclerocrangon ferox*. The distance to neighbour populations and the possibility of migration are also important factors. Isfjord is closely connected to the Barents Sea through the West Spitsbergen Current. Transport of larvae this route may give Isfjord a fish fauna with similarities to the Barents Sea. Also, when the fish grows up, active migration is possible since the Barents Sea is a shallow sea (Cochrane *et al.* 1998) and depth is thereby no restriction. Concerning Jan Mayen, currents could easily bring larvae of different species to the island both from the south and from the north. Migration as adults, on the other hand, may be restricted since deep waters surround the island (Gabrielsen *et al.* 1997).

The division of the Jan Mayen stations into smaller groups can not be explained by the abiotic data alone (Table 17, appendix), because these data differed too little from each other at the time of investigation. CTD stations from this investigation indicate presence of Atlantic waters at all stations. However, this situation may change quite rapidly within weeks (Gammelsrød, T., pers. comm.) and the waters might be influenced by Arctic waters most of the year. There might also be differences between the stations explained by their location relative to the island (Figure 2) since the waters around the island will be unequally influenced by the different water masses (Gabrielsen *et al.* 1997). Biotic factors may be equally important in explaining the differences found. It is speculated upon the importance of patchy vs. uniform distribution. In connection to habitat, fish and shrimps have different preferences concerning bottom structure (both directly and indirectly) and this factor could create patches. Trawling may hit upon these patches and influence the landings, making the different catches difficult to compare.

A weakness in this study was that some individuals were only determined to genus or family level (e.g. *Lycodes* sp./*Gymnerus* sp., Rajidae and *Triglops* sp.) (Table 15, appendix). Some of these may have been strictly Arctic, boreal or Atlantic, benthic or pelagic, and some trends might have been lost. E.g. *Lycodes* sp./*Gymnerus* sp. could have been good indicator species concerning Arctic or Atlantic influenced communities. Other factors of importance that were not investigated here are the importance of interspecific competition concerning feeding and predation. Also, the material is small and therefore influenced by chance (particularly concerning Isfjord), which means that the trends found may be different from the actual conditions.

Acknowledgements

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Appendix

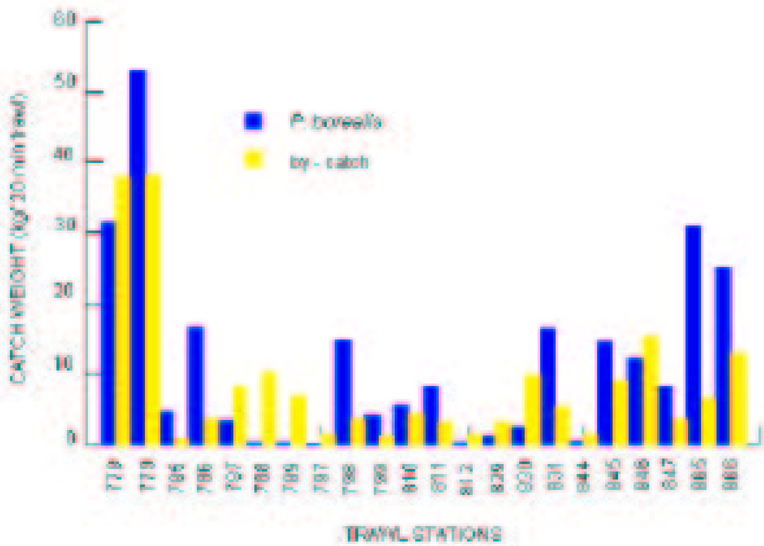

Figure 27. Total catch divided into *P. borealis* and by–catch to visualise the importance of *P. borealis* concerning the variation in biomass.

Table 15. Survey over abbreviation, habitat and distribution of the fish and shrimp species caught in Isfjord and at Jan Mayen (Christiansen, M.E. 1972, Pethon, P. 1994). Group A and B correspond to the groups from the species cluster analysis.

	Taxon	Abbreviation	Habitat	Distribution
Group A	Pandalus borealis	Pan.bor.	Benthopelagial	Arctic/Atlantic
	Sabinea septemcarinatus	Sab.sep.	Benthos	Arctic/Atlantic
	Sclerocrangon ferox	Scl.fer.	Benthos	Arctic
	Boreogadus saida	Bor.sai.	Benthopelagial	Arctic
	Lycodes/Gymnelus sp.	Lyc/Gym	Benthos	most species Arctic
	Triglops sp.	Tri.sp.	Benthos	Arctic/Atlantic
	Leptagonus decagonus	Lep.dec	Benthos	Arctic
	Liparis liparis	Lip.lip.	Benthos	Atlantic
	Eumicrotremus spinosus	Eum.spi.	Benthos	Arctic
	Lumpenus lampraetaeformis	Lum.lam.	Benthos	Atlantic
	Leptoclinus maculatus	Lep.mac.	Benthos	Arctic/Atlantic
Group B	Sclerocrangon boreas	Scl.bor.	Benthos	Arctic
	Mallotus villosus	Mal.vil.	Pelagial	Arctic
	Notolepis rissoi kroyeri	Not.ris.	Pelagial	Atlantic
	Gadus morhua	Gad.mor.	Benthos	Atlantic
	Micromesistius poutassou	Mic.pou.	Pelagial	Atlantic
	Sebastes sp.	Seb.sp.	Pelagial	Arctic/Atlantic
	Careproctus reinhardti	Car.rei.	Benthopelagial	Arctic
	Anarhichas denticulatus	Ana.den.	Benthopelagial	Arctic/Atlantic
	Hippoglossoides platessoides	Hip.pla.	Benthos	Atlantic
	Reinhardtius hippoglossoides	Rei.hip.	Benthopelagial	Arctic/Atlantic
	Rajidae indet.	Rajidae	Benthopelagial	?
	Myctophidae indet.	Myctoph.	Pelagial	Atlantic

Table 16. Test statistics for MIX analyses of *P. borealis.* Males (M), Females (F)

Station	M/F	Age	Year class	X2	df	P-value	Mean	Sd	Prop.	N	N tot
778[1]	M	2.37	1997	21.6	19	0.303	10.83	0.749	0.5405	558.836	
		3.37	1996				14.66	0.930	0.3893	402.516	
		4.37	1995				19.51	1.112	0.0703	72.649	1034
778[2]	M&F	2.37	1997	26.5	24	0.330	10.83	0.748	0.4564	558.683	
		3.37	1996				14.66	0.934	0.3293	403.100	
		4.37	1995				19.46	1.030	0.0583	71.371	
		5.37	1994				23.39	1.326	0.1559	190.858	1224
779	M	2.37	1997	27.7	24	0.270	10.53	1.090	0.0707	56.089	
		3.37	1996				14.90	1.090	0.7864	623.599	
		4.37	1995				20.02	1.090	0.1429	113.312	793
779	M&F	2.37	1997	34.2	26	0.130	10.79	1.321	0.0713	63.733	
		3.37	1996				14.91	1.060	0.6857	612.980	
		4.37	1995				19.54	1.089	0.0902	80.630	
		5.37	1994				22.81	1.785	0.1529	136.648	894
Isfjord	M	2.37	1997	17.9	22	0.710	10.82	0.806	0.3390	619.426	
(778+779)	M	3.37	1996				14.80	1.017	0.5570	1017.566	
	M	4.37	1995				19.78	1.182	0.1040	190.008	1827
Isfjord	M&F	2.37	1997	26.9	26	0.420	10.82	0.806	0.2925	619.702	
(778+779)	M&F	3.37	1996	26.9	26	0.420	14.80	1.017	0.4805	1018.264	
	M&F	4.37	1995	26.9	26	0.420	19.52	1.081	0.0768	162.633	
	M&F	5.37	1994	26.9	26	0.420	23.24	1.469	0.1503	318.401	2119
785	M	3.33	1996	22.1	14	0.076	18.08	1.003	0.1354	32.228	
785	M	4.33	1995	22.1	14	0.076	21.82	1.003	0.3340	79.487	
785	M	5.33	1994	22.1	14	0.076	23.96	1.003	0.5306	126.285	238
866	M	3.33	1996	34.0	18	0.013	16.87		0.1587	38.256	
866	M	4.33	1995	34.0	18	0.013	20.60		0.2964	71.430	
866	M	5.33	1994	34.0	18	0.013	23.42		0.5449	131.314	241
786	M	3.33	1996	18.7	18	0.410	14.91	1.338	0.0140	3.190	
786	M	4.33	1995	18.7	18	0.410	20.27	1.338	0.2050	46.729	
786	M	5.33	1994	18.7	18	0.410	23.68	1.338	0.7811	178.082	228
865	M	3.33	1996	21.5	20	0.370	17.00	1.146	0.5346	315.420	
865	M	4.33	1995	21.5	20	0.370	21.09	1.146	0.2433	143.559	
865	M	5.33	1994	21.5	20	0.370	23.74	1.146	0.2221	131.027	590
787	M	3.33	1996	28.4	20	0.100	16.53	1.244	0.6593	286.149	
787	M	4.33	1995	28.4	20	0.100	20.24	1.244	0.2084	90.433	
787	M	5.33	1994	28.4	20	0.100	23.76	1.244	0.1323	57.418	434
788[3]	M	3.33	1996	13.5	8	0.096	16.33	1.113	0.8732	71.602	
788	M	4.33	1995	13.5	8	0.096	18.99	1.113	0.1268	10.398	82
789[4]	M	2.33	1997	15.0	13	0.310	9.31	0.575	0.0914	18.195	
789	M	3.33	1996	15.0	13	0.310	14.94	1.246	0.9086	180.805	199
Jan Mayen	M	2.33	1997				9.53		0.0053	10.221	
Jan Mayen	M	3.33	1996				16.62		0.4392	840.705	
Jan Mayen	M	4.33	1995				20.66		0.1927	368.770	
Jan Mayen	M	5.33	1994				23.52		0.3628	694.304	1914

[1] 7 individuals were neglected
[2] 1 individual was neglected
[3] 1 individual was neglected
[4] 2 individuals were neglected

Table 17. Station groups from the cluster analysis, showing CTD data for the respective stations. Group 1 is the Isfjord group, the rest are at Man Mayen.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Station	778	833	787	812	798	811
	779	831	788	786	799	845
			789	797		810
						866
						829
						785
Temperature (°C)	2.56	0.16	-0.04	-0.11	0.1	0.39
	2.66		0.13	-0.02	-0.25	0.26
			0.4	-0.29		0.26
						?
						0.16
						-0.07
Salinity (PSU)	34.9	34.87	34.87	34.88	34.87	34.87
	34.87		34.86	34.87	34.89	34.88
			34.86	34.89		34.87
						?
						34.87
						34.87
Depth (m)	392	243	234	452	327	183
	265	246	173	275	429	225
			142	459		230
						276
						246
						314

Table 18. Extreme values for the carapace measurement and number of measured individuals per life stage at the 9 stations included in carapace length measurements.

Station	CaLe of smallest individual (mm)	CaLe of smallest female (mm)	CaLe of largest male (mm)	N males (2)	N females (4)	N females (5)	N females (8)
779	8.59	18.92	22.26	1034	21	159	11
779	7.77	20.73	26.32	800	2	92	0
785	16.61	19.75	27.28	238	17	105	47
786	15.28	19.75	27.29	228	5	119	40
787	13.4	22.27	26.52	434	5	24	30
788	5.25	19.9	24.62	185	2	2	4
789	5.25	-	19.06	102	-	-	-
865	13.15	23.22	26.54	590	30	64	40
866	14.5	21.66	26.32	241	22	154	27

Table 19. Geographical position and landing parameters for each trawl station. When CTD data were not available, data from the nearest CTD station were used (station number shown in parentheses). The last column shows biomass of length measured *P. borealis.*

Station number	Latitude	Longitude	Area	Depth (m)	Temperature (°C)	Salinity (PSU)	Total Biomass (kg)	Biomass P.bor. (kg)	Biomass Rest (kg)	Biomass P.bor. CaLe (kg)
778	78°10.62 N	13°45.73 E	Isfjord	392	2.56 (783)	34.90 (783)	69.2	31.5	37.7	3.45
779	78°14.94 N	12°29.19 E	Isfjord	265	2.66 (784)	34.87 (784)	91.15	53.17	37.98	3.26
785	70°58.81 N	07°49.73 W	Jan Mayen	314	-0.07	34.87	5.56	4.8	0.76	3.6
786	70°52.83 N	07°44.90 W	Jan Mayen	275	-0.02	34.87	20.54	16.7	3.84	5.064
787	70°56.42 N	07°55.56 W	Jan Mayen	234	-0.04	34.87	11.84	3.46	8.38	3.986
788	70°55.07 N	08°12.04 W	Jan Mayen	173	0.13	34.86	10.5	0.34	10.16	0.346
789	70°52.85 N	08°35.00 W	Jan Mayen	142	0.40	34.86	7.26	0.24	7.02	0.222
797	71°02.51 N	09°07.16 W	Jan Mayen	459	-0.29	34.89	1.35	0.008	1.342	-
798	71°00.10 N	08°46.25 W	Jan Mayen	317	0.10	34.87	18.5	14.8	3.7	-
799	71°03.38 N	08°45.02 W	Jan Mayen	429	-0.25	34.89	5.4	4.2	1.2	-
810	71°03.01 N	09°24.07 W	Jan Mayen	230	0.26 (815)	34.87 (815)	9.98	5.6	4.38	-
811	71°06.27 N	09°23.87 W	Jan Mayen	183	0.39 (815)	34.87 (815)	11.8	8.5	3.3	-
812	71°08.75 N	09°35.10 W	Jan Mayen	452	-0.11 (815)	34.88 (815)	1.74	0.41	1.33	-
829	70°47.48 N	08°07.37 W	Jan Mayen	246	0.16 (833)	34.87 (833)	4.34	1.14	3.2	-
830	70°38.11 N	08°17.07 W	Jan Mayen	243	0.16 (833)	34.87 (833)	12.6	2.67	9.93	-
831	70°29.88 N	08°27.92 W	Jan Mayen	246	0.16 (833)	34.87 (833)	21.7	16.3	5.4	-
844	70°56.07 N	09°27.16 W	Jan Mayen	433	-0.11	34.88	2.2	0.64	1.56	-
845	70°47.20 N	09°10.36 W	Jan Mayen	225	0.26	34.88	23.8	14.7	9.1	-
846	70°39.61 N	09°09.08 W	Jan Mayen	164	0.36	34.88	27.8	12.3	15.5	-
847	70°36.23 N	09°19.49 W	Jan Mayen	350	0.02	34.88	12.1	8.5	3.6	-
865	70°59.63 N	07°51.73 W	Jan Mayen	304	0.5 (862)	34.85(862)	37.6	31	6.6	4.32
866	70°52.56 N	07°43.03 W	Jan Mayen	276	0.5 (862)	34.85 (862)	37.8	25	12.8	4.02