NAFO Sci. Coun. Studies, 32: 37–43

Evaluation of the Shrimp (*Pandalus borealis*) Stock at Flemish Cap (NAFO Div. 3M) Based on an Area Comparison

Michaela Aschan[1]
Norwegian Institute for Fisheries and Aquaculture
N-9005 Tromsø, Norway

Olav Rune Godø[1]
Institute of Marine Research
P. O. Box 1870, N-5024 Bergen, Norway

Abstract

In 1993 an important shrimp (*Pandalus borealis*) fishery developed on Flemish Cap, (NAFO Div. 3M) and has continued with many nations still involved. There are important difficulties connected with the regulation placed on the fishery of limiting fishing effort, because of insufficiency of reliable long-term time series data and the lack of basic knowledge on stock dynamics.

In 1996 Canada conducted a shrimp survey at Flemish Cap using the same sampling gear as used in the Norwegian surveys for shrimp in the Barents Sea and Svalbard area. Further, Norwegian shrimp trawlers exploit the resources with the same type of commercial gear both in the eastern and western Atlantic. This paper explores the possibility of applying these data links between Div. 3M and the Barents Sea and Svalbard area, to improve the understanding of the state of the Div. 3M shrimp stock with respect to stock biomass.

Though there are many uncertainties, when comparing annual CPUE-abundance data and monthly CPUE data, the conclusion that may be drawn is that the shrimp stock in Div. 3M is showing signs of decline. This first comparison suggests that valuable information might emerge when comparable CPUE and survey results are available, and a more detailed analysis could potentially improve the results. One comparable survey in Div. 3M was not enough to draw reliable conclusions. Further considerations are proposed for when additional survey data are available.

Key words: Barents Sea, CPUE, effort, Flemish Cap, shrimp, surveys

Introduction

In 1993 an important fishery for shrimp (*Pandalus borealis*) developed on Flemish Cap (NAFO Div. 3M), where many nations were involved. NAFO considered fishing effort as a criterion for management of the fishery. There are, however, difficulties connected with the regulation of fishing effort in Div. 3M. The important drawbacks are caused by insufficiency of reliable long-term time series data on shrimp stock abundance and composition from surveys, and the lack of basic knowledge on stock dynamics.

In 1996 Canada conducted a survey on Flemish Cap which applied a Campelen 1800 meshes shrimp sampling trawl (Parsons *et al.*, MS 1997). This is similar to the sampling gear used in the Norwegian surveys for shrimp in the Barents Sea and Svalbard area. Consequently, there is presently a one-point link in surveys (sampling trawl) between the two areas. Additionally, the Norwegian shrimp trawlers exploit the resources with the same type of commercial gear both in the eastern and western Atlantic. Consequently, there is a continuous link in commercial trawl catch per unit effort (CPUE) during the period of this new fishery on Flemish Cap.

[1] Equal authorship

Assessment methodologies for shrimp in Div. 3M were discussed during a NAFO Scientific Council *ad hoc* Working Group meeting in November 1996 (Parsons, MS 1996). Due to the fact that the same sampling trawl is used in the Barents Sea and in Div. 3M, it was proposed to investigate the potential of using the Norwegian survey and commercial CPUE data from the Northeast Atlantic to review the biomass situation of shrimp in Div. 3M. It is the aim of the present analysis to explore the possibility of applying the links between Div. 3M and the Barents Sea and Svalbard area to improve the understanding of the state of the Div. 3M shrimp stock with respect to biomass. It is hoped that this will give better fundamental information for scientific advice for the management of shrimp in Div. 3M.

Material and Methods

Commercial catch and effort data

The data were obtained from the Norwegian commercial fishery catch and effort reports from the Barents Sea and Svalbard area for the period 1982 to 1996, and from Div. 3M for the period 1993 to 1997. They consisted of basic fishery logbook data produced by the Norwegian Fisheries Directorate. Data for 1995, 1996 and 1997 were preliminary data. In the analyses, annual commercial CPUEs were compared with the results from the surveys in the Barents Sea and Svalbard area. When comparing CPUEs in Div. 3M with CPUEs in the Barents Sea and Svalbard area, monthly statistics were applied.

Survey data

The survey areas are shown in Fig. 1. Surveys for shrimp have been conducted annually in the Barents Sea and the Svalbard area since 1980 by Norwegian Research Institutes. The surveys have been conducted each year in the period April to September for 25 to 97 days. Until 1992 the Institute of Marine Research in Bergen (IMR) carried out the investigations, and thereafter the Norwegian Institute of Fisheries and Aquaculture Ltd. (Fiskeriforskning) in Tromsø has been doing the work. All together four different vessels have been involved (Aschan and Sunnanå, MS 1997).

The survey trawl, a Campelen 1800 meshes shrimp trawl, has been the same throughout the period, although with some modifications of both the ground gear and the rigging. The modifications have had an influence on the trawls sampling pattern and effectiveness over time. Since 1992 sampling has been performed day and night and tow distance has been 1 naut. mile.

The Svalbard area has been stratified according to depth and latitude (area F–H in Fig. 1) while the study area in the Barents Sea was stratified according to fishing grounds and homogenous geographical areas (area A–E in Fig. 1). Aschan and Sunnanå (MS 1997) have documented and evaluated these surveys.

Three different approaches to survey design have been used: i) random stratified trawl stations, ii) fixed trawl stations in a modified regular grid within a stratification of the area, and iii) fixed trawl stations in a depth stratified system. A study has been undertaken to calculate an optimum sampling density with respect to a desired level of precision (Harbitz *et al.*, 1998). In this analysis the biomass indices as given in the assessment report (Aschan *et al.*, MS 1996) were used.

The Northeast Atlantic Fisheries Centre, St. John's, Newfoundland, Canada conducted a survey in Div. 3M during the period 24 September to 12 October 1996. The sampling trawl used was the same Campelen 1800 trawl as used in the shrimp survey in the Barents Sea and Svalbard area, however, small modifications have been done (Brodie, 1996). Sampling was conducted day and night and tow distance was 0.75 naut. miles (Parsons *et al.*, MS 1997).

In this study the "sweep width" was set at 11.7 m for all shrimp surveys in both areas resulting in a swept area of 0.006317 naut. mile^2 for a 1 naut. mile haul.

Comparisons between Div. 3M and the Barents Sea and Svalbard area

The annual commercial CPUE and the annual survey index of shrimp in the Barents Sea and Svalbard area for the period 1982–96 were compared by means of a simple linear regression. Simple linear regressions were also run separately for years with an increasing abundance or high abundance, and years with a decreasing abundance. The shrimp abundance received from the Canadian survey and the Norwegian CPUE in 1996 in Div. 3M were compared with the Norwegian CPUE and

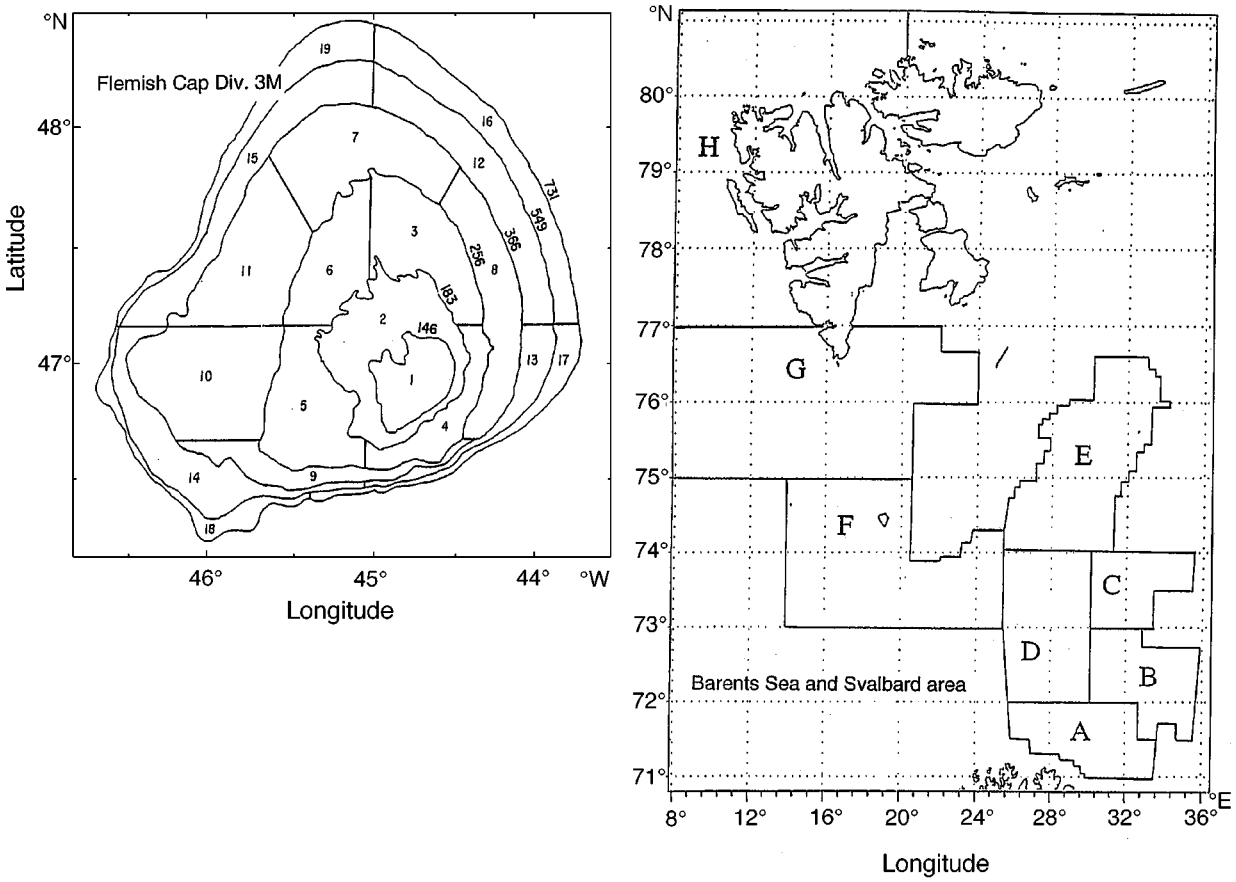

Fig. 1. Maps of survey areas. Stratification scheme used at Canadian trawl survey on Flemish Cap (Parsons *et al.*, MS 1997). The Barents Sea and Svalbard area presented with main survey areas (A–H).

biomass index relationship from the Barents Sea and Svalbard area.

The level and variability of the monthly CPUE in 1993–97 in Div. 3M and the Barents Sea and Svalbard areas were compared. Only data from the vessel size groups represented in both areas were used. Data were analysed on a monthly basis, and seasonal effects and trends were estimated with the Proc. x11 in the SAS system (SAS 1993). To fill in empty cells in the monthly CPUE statistics, the SAS Proc. expand program was used.

Results and Discussion

Barents Sea stock and catch

The shrimp fisheries in the Barents Sea and Svalbard area started in the early-1970s. The landings increased continuously and reached a maximum of 130 000 tons in 1984 (Fig. 2). Due to reductions in the shrimp abundance, the annual landings were reduced to 45 000 tons in 1987. A peak above 80 000 tons occurred in 1990 but it has been followed by reductions. Although there was a concurrent variation in landings, biomass indices and commercial CPUE in the Barents Sea and Svalbard area, there seemed to be a time lag between biomass index and commercial CPUE. The 'path' of the data from 1982 to 1996 indicated different relationships between commercial CPUE and abundance, where the stock abundance increased compared to when CPUE was going down (Fig. 3). It is noted that this shrimp fleet maintains a high CPUE on the shrimp ground for a year or two after the shrimp abundance appeared to be reduced in the large distribution area.

A linear regression for the commercial CPUE (dependent variable) calculated against the abundance (independent variable) were as follows:

CPUE = 35.7×abundance (r^2 = 0.94) [equation 1]

CPUE = 31.6×abundance (r^2 = 0.98) [equation 2]

CPUE = 50.7×abundance (r^2 = 0.99) [equation 3]

When the data were separated into years with increasing or high abundance and years with decreasing abundance, the slope parameters for the linear regression was lower for the years when the abundance was increasing (equation 2) and higher for the years when the abundance was decreasing (equation 3) (Fig. 4). Thus, survey data were assumed to reflect density correctly, while the commercial CPUE overestimated the density when the stock decrease.

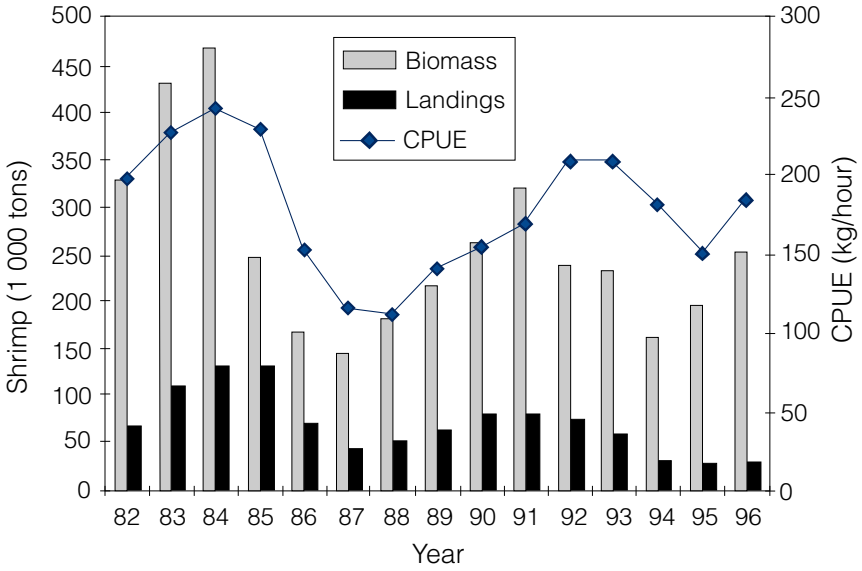

Fig. 2. Biomass indices from the Norwegian surveys, total landings and Norwegian CPUE for ICES areas I , IIa and IIb.

Comparison between the Barents Sea and Svalbard area and Div. 3M

The CPUE for Norwegian vessels in area Div. 3M in 1996 was 211 kg/hour. The survey in area Div. 3M in 1996 gave a mean abundance of 2.7 tons per naut. mile^2, when all strata were included. When strata with no shrimp (strata 501, 502 and 504) were excluded, the mean abundance was 3.2 tons per naut. mile^2. This was comparable to the lower end of the density distribution observed in the Barents Sea and Svalbard area, but nevertheless supported a high CPUE in the commercial fishery (Fig. 3). The position of Div. 3M in the commercial CPUE and abundance comparison, suggests that the Norwegian vessels were more effective in Div. 3M than in the Barents Sea and Svalbard area, where an abundance of more than 4 tons per naut. mile^2 is needed before reaching a CPUE larger than 200 kg/hr. However, this may have been caused by factors related both to the fisheries data and the survey results. The vessels operating in Div. 3M were generally larger and more efficient. Also, the efficiency of the Campelen 1800 during the Canadian survey in Div. 3M might have been lower due

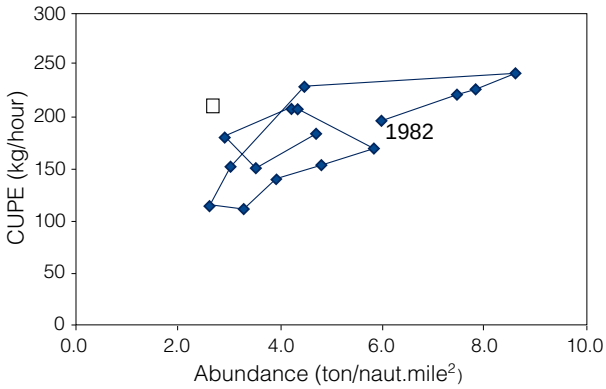

Fig. 3. Annual commercial CPUE (kg/hr) of the Norwegian fleet and shrimp abundance (ton per naut. mile^2) in the Svalbard and Barents Sea area for the years 1982–96 and for Div. 3M in 1996 (square).

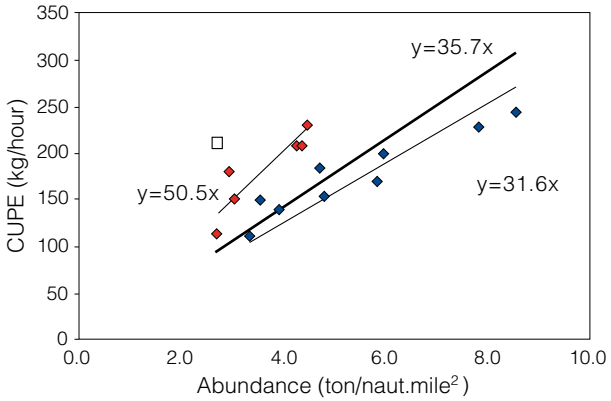

Fig. 4. Regression curves for the annual commercial CPUE and shrimp abundance. The solid line represents all years, the line underneath represents years when the abundance was increasing (grey rhombi) and the line above represents the years when the stock decreasing (black rhombi) in the Svalbard and Barents Sea area. The square marks the relation between CPUE and abundance in Div. 3M in 1996.

to differences in equipment and operation (e.g. the use of a cross wire ("strapping") and other type of otter-boards). Further, the day and night sampling done in the Barents Sea and Svalbard area in the period May to August did not include sampling in darkness as was the case on the Flemish Cap in October. It is noted here that if light measurements are available for the surveys, it could be possible to adjust survey data to the diurnal variation in catch rates. Such an adjustment would probably increase the abundance estimate in Div. 3M more than in the Barents Sea and Svalbard area.

For shrimp in Div. 3M in 1996 the slope parameter of a theoretical linear regression would be 78, according to the observed abundance of 2.7 tons per naut. mile^2 and the commercial CPUE of 211 kg/hour (Fig. 4). The abundance of 3.2 tons per naut mile^2 would give a slope parameter of 66 for the theoretical linear regression. The comparison of the commercial CPUE and abundance relationships in the two areas shows that the shrimp stock in Div. 3M probably is in a situation where the stock size is declining.

A comparison of CPUE of Norwegian vessels in Div. 3M and those in the Barents Sea and Svalbard area can be done in many ways. Due to the strong seasonal effect on the catch rates in both areas, a seasonal difference in effort distribution between areas or by year may seriously bias the results. However, the commercial CPUEs for the two study areas show the same type of seasonal variation (Fig. 5). When analysing them with a time series model (Proc. x11) this becomes even more evident (Fig. 6). The CPUEs both from original (Fig. 5) and modelled (Fig. 6) time series show that

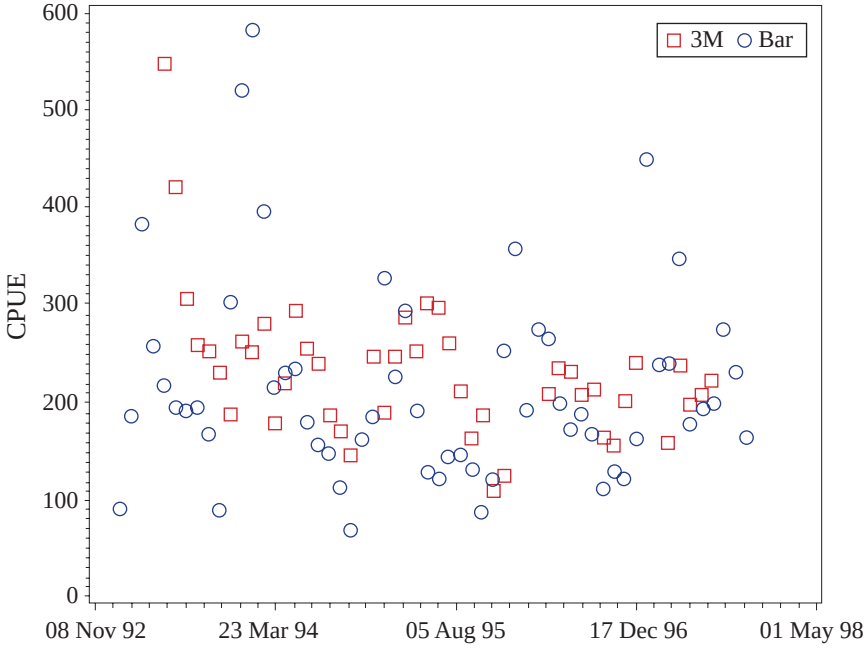

Fig. 5. Comparison of commercial CPUE each month in Div. 3M and in the Barents Sea and Svalbard area.

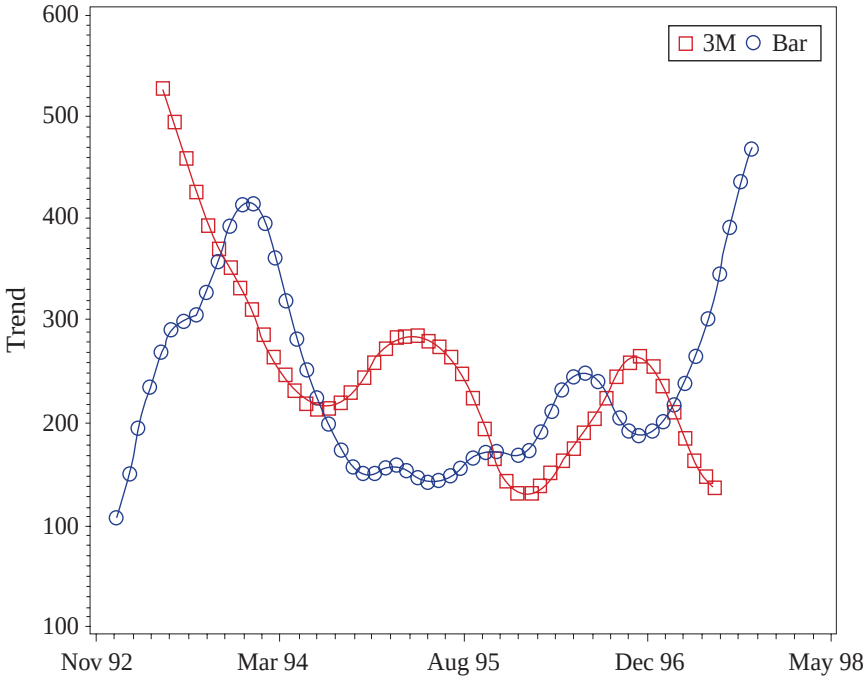

Fig. 6. Comparison between Svalbard and Div. 3M trends as estimated by proc. x11.

commercial catch rates in the two areas are similar, and that the CPUE observed in Div. 3M do show a downwards trend compared to an area with a longer catch history. It is recognised that the reduction in the recent year might be an effect of the few logbooks in 1997. However, though there are many uncertainties, when comparing Div. 3M with the Barents Sea and Svalbard area according to annual CPUE and abundance data and monthly CPUE data, one may draw the conclusion that the shrimp stock in Div. 3M is showing signs of decline.

While the comparison undertaken in this study were not conclusive, this first comparison suggests that valuable information might emerge when comparable commercial CPUE and survey results are available. It was apparent that a more thorough and detailed analysis could potentially improve the results. However, one comparable survey in Div. 3M is not enough to draw definite conclusions. When additional survey data are available further work encompassing the following may be considered:

- Careful comparison of Canadian and Norwegian sampling performance and rigging of trawl.
- Study variation in catches related to diurnal migration on Flemish Cap (introduction of sigmoid curves, light measurements).
- Limit the CPUE data to the periods when surveys are performed.
- Comparison as above, but limited to the most important fishing grounds or areas with similar topography as in Div. 3M, e.g. the Svalbard area.
- Include new areas.
- Include biological comparison.

Acknowledgements

We express our thanks to Don Parsons who kindly sent us the data from the Canadian survey on Flemish Cap in 1996.

References

ASCHAN, M., B. BERENBOIM, and S. MUKHIN. MS 1996. Results of Norwegian and Russian investigations of shrimp (*Pandalus borealis)* in the Barents Sea and in the Svalbard area 1995. *ICES C.M. Doc*., No. K:6, 18 p.

ASCHAN, M., and K. SUNNANÅ. MS 1997. Evaluation of the Norwegian Shrimp Surveys conducted in the Barents Sea and the Svalbard area 1980–1997. *ICES C.M. Doc*., Y:07, 24 p.

BRODIE, W. B. MS 1996. A description of the 1995 fall groundfish survey in Divisions 2J3KLNO. *NAFO SCR. Doc*., No. 27, Serial No. N2700, 7 p.

HARBITZ, A., M. ASCHAN, M., and K. SUNNANÅ. 1998. Optimum stratified sampling design for biomass estimates in large area trawl surveys – exemplified by shrimp surveys in the Barents Sea. *Fish. Res.*, Vol 37. In print.

PARSONS, D. G. MS 1996. Report of *ad hoc* Working Group on shrimp (*Pandalus borealis*) in Div. 3M. 19–20 November, 1996. *NAFO SCS Doc.*, No. 102, Serial No. N2785, 9 p.

PARSONS, D. G., D. W. KULKA, and P. J. VEITCH. MS 1997. Distribution, biomass, abundance and demography of shrimp (*Pandalus borealis*) in Flemish Cap (NAFO Div. 3M) based on data obtained during a Canadian research trawl survey, September–October, 1996. *NAFO SCR Doc.*, No. 81, Serial No. N2927, 14 p.

SAS. 1993. SAS/ETS User's Guide. Version 6, Second Edition, Cary, NC: SAS Institute Inc., 1993. 1022 p.