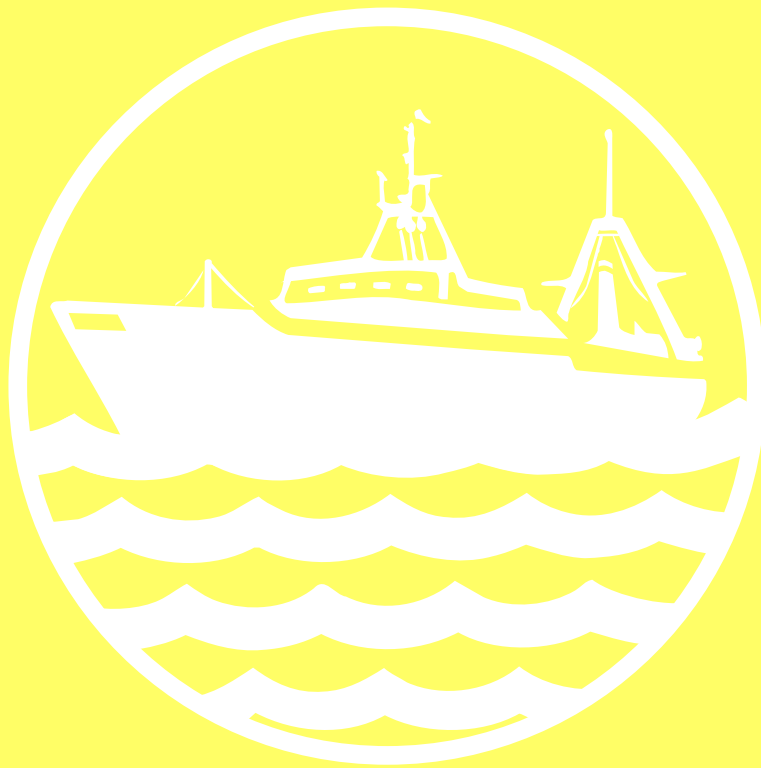


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Journal of Northwest Atlantic Fishery Science



Volume 27

Pandalid Shrimp Fisheries – Science and Management
at the Millennium

Edited by P. A. Koeller, J. Boutillier and S. Tveite

NAFO/ICES/PICES Symposium
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Foreword

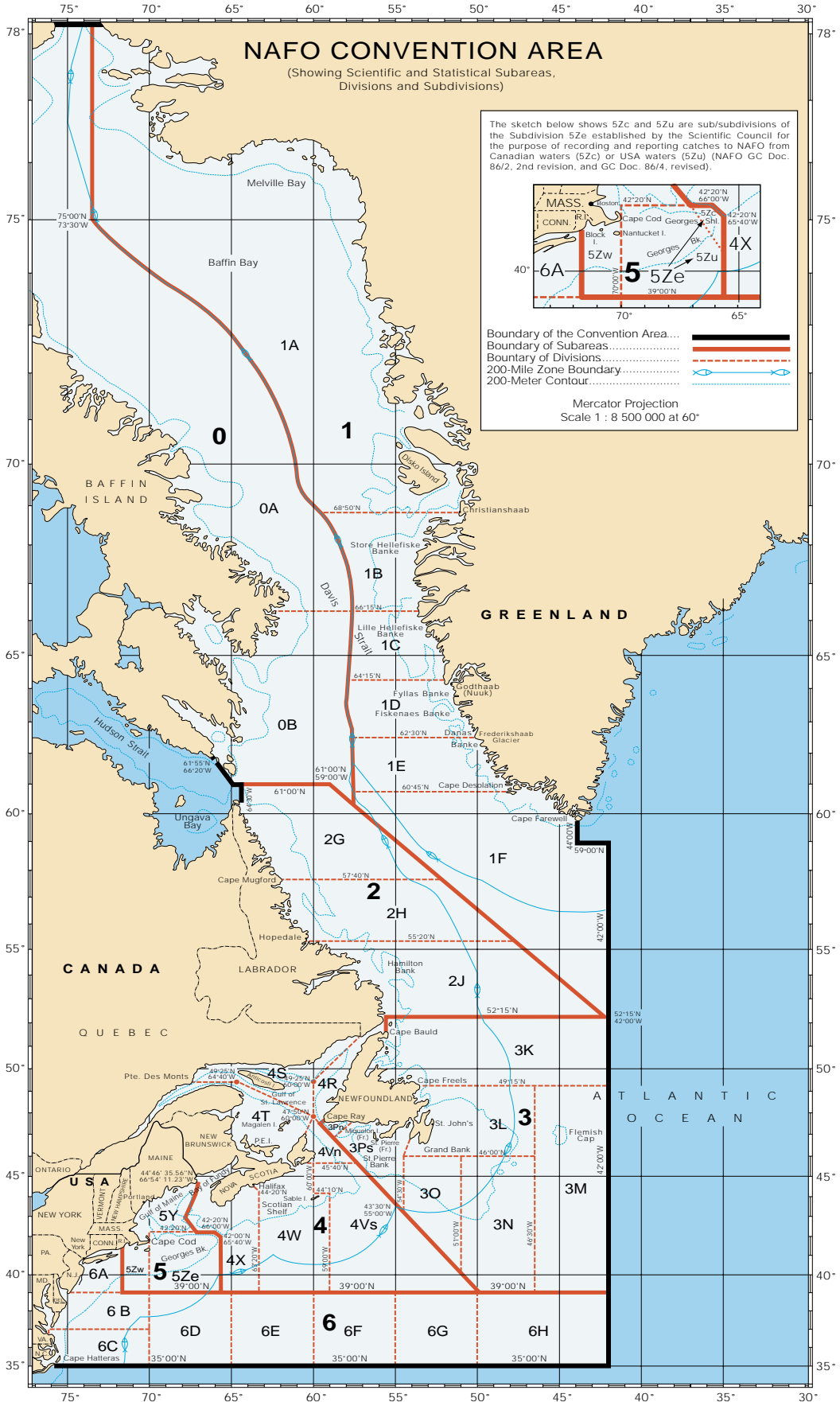
In accordance with its mandate to disseminate information on fisheries research to the scientific community, the Scientific Council of NAFO publishes the *Journal of Northwest Atlantic Fishery Science*, which contains peer-reviewed primary papers and notes on original research, and *NAFO Scientific Council Studies*, which contains review papers of topical interest and importance. Each year since 1981, the Scientific Council has held at least one Special Session on a topic of particular interest, and many of the contributions to those sessions have been published in either of these Publications. For 1999, the Scientific Council initiated this Special Session titled "*Pandalid Shrimp Fisheries – Science and Management at the Millennium*", as a Symposium of topical interest to NAFO. Further to the NAFO Scientific Council decision of June 1997, the Council invited the International Council for the Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES) to co-sponsor the Symposium (*NAFO Sci. Coun. Rep.*, 1997, p. 15). The Joint NAFO/ICES/PICES Symposium was hosted by the NAFO Scientific Council in conjunction with the NAFO 21st Annual Meeting held at the Holiday Inn, Dartmouth, Nova Scotia, Canada. In accordance with the decision of the Scientific Council of June 1999 (*NAFO Sci. Coun. Rep.*, 1999, p. 33), this volume of the *Journal of Northwest Atlantic Fishery Science* contains many of the papers presented at the Symposium.

The Symposium was jointly convened by P. A. Koeller (Canada–NAFO) from the Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada, S. Tveite (Norway–ICES) from the Institute of Marine Research, and J. Boutillier (Canada–PICES) from the Pacific Biological Station, British Columbia, Canada. A total of 47 papers and posters were presented of which 23 papers were accepted for publication in this issue.

In accordance with the decision of the Scientific Council, P. A. Koeller, S. Tveite and J. Boutillier were invited to undertake the normal Journal editorial process. At the NAFO Secretariat final editorial work was done as needed and this issue was printed. The publication was completed in the one year time-frame proposed by the co-sponsoring organizations and this issue captures the quality of the presentations, the stimulating discussions at the Symposium, and the comprehensive coverage achieved at the Symposium.

December 2000

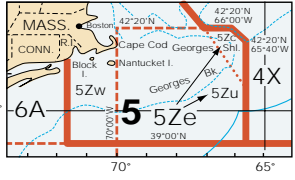
Tissa Amaratunga
Assistant Executive Secretary
Journal of Northwest Atlantic Fishery Science



NAFO CONVENTION AREA

(Showing Scientific and Statistical Subareas, Divisions and Subdivisions)

The sketch below shows 5Zc and 5Zu are sub/subdivisions of the Subdivision 5Ze established by the Scientific Council for the purpose of recording and reporting catches to NAFO from Canadian waters (5Zc) or USA waters (5Zu) (NAFO GC Doc. 86/2, 2nd revision, and GC Doc. 86/4, revised).



Boundary of the Convention Area...

Boundary of Subareas...

Boundary of Divisions...

200-Mile Zone Boundary...

200-Meter Contour...

Mercator Projection
Scale 1 : 8 500 000 at 60°

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Introduction

The papers in this special volume are a result of the international Symposium entitled "*Pandalid Shrimp Fisheries – Science and Management at the Millennium*" jointly sponsored by the Northwest Atlantic Fisheries Organization (NAFO), the International Council for the Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES). The symposium was hosted by the NAFO Scientific Council, and convened by Jim Boutillier (PICES), Peter Koeller (NAFO), and Stein Tveite (ICES), with Peter Koeller (NAFO) taking the lead role, at the Holiday Inn in Dartmouth, Nova Scotia, Canada from 8–10 September 1999 in conjunction with the 21st Annual Meeting of NAFO. In total, 32 oral presentations were delivered at four sessions, and 15 posters were displayed. The convenors invited both oral and poster presenters to submit papers for publication in this volume. Following the usual peer review and editing procedures of the *Journal of Northwest Atlantic Fisheries Science* a total of 23 papers were accepted and appear in this volume. Most have been revised extensively from the original presented at the Symposium. A summary report of the Symposium follows with details on the sessions and contributions. The latter are listed at the end of the Report of the Symposium, are available as NAFO Scientific Council Research Documents and are posted on the NAFO website (www.nafo.ca).

This volume provides ample evidence as to the success of the Symposium, which the Chairman of the NAFO Scientific Council cited in his closing remarks as one of the most successful of the series. The symposium and this volume could not have been possible without the cooperation, dedication and hard work of many people, first and foremost the participants and presenters themselves who are listed at the end of this edition. The convenors also thank the Canadian Association of Prawn Producers and the governments of Canada, Greenland, Iceland, Norway and the United States of America for their logistic support and/or generous financial contributions. The social events sponsored by some organizations were especially appreciated by participants in that they allowed everyone to get better acquainted and discuss shrimp issues informally. Special thanks to Chris Hopkins (ICES), Doug McKone (PICES) and Tissa Amaratunga (NAFO) for facilitating the acceptance of the initial proposals within their organizations, and the NAFO Secretariat staff for handling the logistics and accommodations of the meeting. Michele Covey ably assisted with the audio-visuals. We thank Tissa Amaratunga for his work beyond his official capacity as technical editor. It is noted that the editorial process included reviews by T. Amaratunga and P. Koeller as a secondary step. Finally, we thank the reviewers of the papers in this volume who often suffered through seemingly innumerable revisions. They include: P. Anderson, M. Aschan, B. Bergström, C. Bishop, P. Bjarneson, A. Bundy, A. Buyanovski, N. Cadigan, S. Cadrin, D. Carlsen, J. Clark, S. Clark, R. Claytor, L. Convey, K. Frank, C. Fu, S. C. Gallager, S. Gavaris, R. Hannah, H. Hansen, A. Harbitz, B. Ivanov, P. Kannevorff, E. Kenchington, M. Kingsley, R. Lauzier, G. Lilly, T. Minami, R. Mohn, J. Moores, S. Munch-Pederson, A. Nicolajsen, E. Nilsen, N. Olsen, D. Orr, D. Parsons, I. Perry, S. Petersen, M. Prager, R. Ramseier, D. Roddick, L. Savard, D. Schick, J. M. Sévigny, A. Sinclair, B. Sjøstrand, S. Smith, G. Stefánsson, M. Stein, and N.C. Stenseth. If anyone has been inadvertently missed we apologize and extend our thanks.

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Report of the Symposium

Further to the NAFO Scientific Council initial discussion in June 1997 (*NAFO Sci. Coun. Rep.*, 1997, p. 15) the Joint NAFO/ICES/PICES Symposium on "*Pandalid Shrimp Fisheries – Science and Management at the Millennium*" was held in conjunction with the NAFO 21st Annual Meeting.

The Meeting was opened by H. P. Cornus (EU–Germany), Chairman of the Scientific Council, who on behalf of the Scientific Council welcomed participants to Dartmouth, and presented a brief overview of NAFO and its activities.

Introduction

"*Pandalid Shrimp Fisheries – Science and Management at the Millennium*", was held at the Holiday Inn Harbourview, Dartmouth, Nova Scotia, Canada during 8 to 10 September 1999. When the Symposium convened it had been 20 years since world authorities on Pandalid shrimp had met in a similar forum. The last international symposium was held in Alaska during 1979, at a time when the situation regarding the fisheries for Pandalid shrimp was very different from now. That meeting had been motivated by a drastic downturn in the Alaskan shrimp fishery. The Gulf of Maine fishery had just collapsed. Catches on both sides of the Atlantic were only a fraction of what they are today. The present meeting was at least partly prompted by the contrast between then and now. By the end of the century the Alaska stocks had not recovered, and total Pacific catches, which had accounted for most of the world catch, were only a fraction of what they had once been. On the other hand the Atlantic fisheries, almost exclusively for *Pandalus borealis*, had experienced an unprecedented expansion and now accounted for most of the world catch. Such large changes in important natural resources inevitably invite questions as to their cause. For many shrimp stocks, time series of environmental data were now available which spanned periods of increasing and decreasing abundances. As fisheries expanded in the Atlantic many laboratories began shrimp-targeted surveys and collected commercial fisheries data for assessment purposes which would benefit from review and evaluation. The shrimp industry, faced with bycatch problems, had made major technological advances to address this issue. Accordingly, the purpose of the Symposium was to review, discuss and synthesize all aspects of Pandalid shrimp biology, ecology, and fisheries science relevant to the rational management of these resources, including:

- **Environmental and Ecological influences** – Can useful predictive relationships between environmental factors and stock abundance be developed? What is the evidence for predator forcing of shrimp stock dynamics? How can this information be quantified and applied in multispecies management models?
- **Stock Assessments and Associated Biological Research** – How do shrimp stocks respond to exploitation? What are the constraints to analytical stock assessments and how can they be overcome? What biological indicators are useful in detecting changes in stock status?
- **Management Strategies** – What biological reference points and conservation limits should be used in stock management? How can the precautionary approach be applied to shrimp fisheries?
- **Harvesting** – How have technological advances influenced the development of shrimp fisheries? What are the latest developments in harvesting and processing and their impacts?

The response from shrimp biologists, fisheries managers, and industry personnel, including fishers, processors and technologists, was enthusiastic. There were 96 participants from Canada, Denmark, Faroe Islands, Germany, Greenland, Iceland, Japan, Luxembourg, Norway, Portugal, Russia, Spain, Sweden, Ukraine, and the United States of America.

Session Summaries

Keynote Paper: B. Bergström (Sweden) provided a comprehensive review of the biology of the genus *Pandalus*, comparing distributions, reproductive strategies, behaviour, growth, and population dynamics of the

sixteen known species. Key gaps in our knowledge of *Pandalus* biology were identified, including the long period of relative inactivity in laboratory studies since the 1970s despite the need for basic physiological information. A communications gap exists not only between stock assessment biologists and those working on fundamental biological and ecological problems, but also between shrimp assessment biologists themselves, who tend to be isolated within their own management regimes.

B. Bergström emphasized the need to use the large amount of good quality data originally collected for stock assessment purposes to address the many fundamental biological questions which remain unanswered, and to publish results in the primary literature. This is the best way to attract the young and eager minds needed to revitalize research in this field.

Session 1: Environmental and Trophic Considerations

The invited speaker for the session, G. Stefánsson (Iceland), described how environmental variables can be applied in multispecies models and stock assessments for *P. borealis*, a species where traditional methods tend to fail. In particular, the use of cod abundance in a production model used to assess Icelandic shrimp stocks were described. Another presentation described how a boreal ecosystem in the Northeast Pacific rapidly reorganized from a shrimp to a groundfish dominated system due to decadal environment changes, and how Pandalid shrimp can be used as indicators of a regime shift. Commercial and survey data were used in a paper to identify spatial scales and patterns of Pacific shrimp aggregations and how they are influenced by environmental conditions and interannual variations in abundance. One paper used time series analysis to construct predictive models of shrimp abundance on the Newfoundland-Labrador Shelf and supported the hypothesis that colder conditions favour larval survival. The relative importance of temperature, habitat and predation on the Scotian Shelf shrimp stock in contrast to more northern and southern stocks were described in another presentation. One researcher extended previously identified correlations between recruitment, spawning stock biomass and spring surface temperatures in the Gulf of Maine to include freshwater runoff, wind velocity and direction, and predation. Research vessel survey biomass indices of cod and shrimp were used to show that release of predation pressure by cod may have contributed significantly to the unprecedented increase of shrimp stocks off Newfoundland and Labrador in recent years. The importance of temperature to the biology and population dynamics of shrimp was evident throughout this session but was highlighted by a paper describing growth in the Svalbad Area in relation to environmental parameters. Two papers described the importance of large scale hydrographic features on the distribution of shrimp in the Northwest Atlantic, including a first description of the strong relationship between the distribution of shrimp and Particulate Organic Carbon as determined from sediment trap data and a sedimentation model; and the role of warm water influxes in the recent displacement of shrimp from the traditional fishing grounds off east Greenland. The session clearly demonstrated that environmental and trophic considerations along with multispecies modelling must play an increasingly important role in the assessment and management of Pandalid populations in the future.

Session 2: Stock Assessments

The two invited speakers, B. Ivanov (Russia) and R. Mohn (Canada) gave a historical perspective of shrimp research in Russia, and described the application of data poor assessment methods to shrimp stocks, respectively. The importance of surveys in shrimp assessments were highlighted in several papers describing innovative survey designs, including the use of subjective prediction to optimize sample stratification in the Barents Sea, and a method for estimating biomass from trawl surveys on the Newfoundland-Labrador Shelf using information on depth and distance to adjacent stations. The trawl survey for *P. borealis* off West Greenland was described in detail, including changes in design and methodology over time to improve biomass estimates and information on biological parameters. A paper described a pre- and post-season pot survey for *P. platyceros* to estimate harvest rates in southeast Alaska. Two papers were presented on stock assessment methods and their performance in the Gulf of Maine: one described the sensitivity of results from production models to survey catchability estimates and the usefulness of these models in describing abundance trends despite the difficulties in obtaining absolute stock size when catchability is unknown or poorly estimated; the second provided a historical review of the fishery and concluded that fishing mortality has been the overriding factor in affecting survival and abundance of the shrimp stock since the 1970s, although environmental influences have also played a role at times; stock assessments in the Gulf of Maine have consistently shown that poor recruitment is more likely at low levels of spawning stock

biomass. A paper describing the variations in growth of *P. borealis* in the Gulf of St. Lawrence demonstrated persistent spatial size gradients and synchronism in the events leading to them which impact on the interpretation of assessment data. The genetic variability of *P. borealis* in the Northwest Atlantic described in another paper suggested a high level of gene flow in this species and that differences observed between some areas may not be stable through time. A final paper described recruitment and abundance indices from surveys in the Norwegian Deeps and Skagerrak in relation to the abundance of finfish species and environmental parameters including fluxes of Atlantic water into the area.

Session 3: Management

The invited paper by L. Savard, D. Parsons, P. Koeller (Canada) and C. Fu (USA) described the "traffic light" approach to shrimp assessment adopted by Canadian east coast shrimp assessment scientists and by NAFO for data poor stocks. Simulation results suggest that "traffic light" scores could be linked to simple harvest control rules in a way that is consistent with shrimp stock dynamics and precautionary management requirements, creating an integrated management framework. Session papers highlighted the wide variety of approaches adopted for *Pandalus* stocks, ranging from the relatively simple TAC and limited entry controls in the large stock areas of the northwest Atlantic, to the complex suite of management programs in the Pacific northwest, including time and area closures, catch ceilings, limited entry, fixed escapement, and quotas assigned to many small management units. One paper evaluated different harvest strategies for Pandalid shrimp populations including fishing during different times in the growth/life cycle, the use of several mesh size scenarios, and the use of area closures, with the effectiveness of the different policies being contingent on seasonal and annual variations in growth and natural mortality.

Session 4: Harvesting and Processing

Invited presentations were made by leading industry participants from four countries. In his presentation on modern trawling and by-catch reducing devices R. Larsen (Norway) expressed concern about the continuing trend toward the development of super-efficient gear and the use of twin and even triple trawl configurations. In addition the problem of small fish by-catch continues to challenge technologists. Two submitted papers on gear trials with different grate bar spacings, secondary grates, cod end strengtheners, square mesh codends, and footrope configurations showed the potential for improvement in reduction of by-catch and catches of small shrimp. The continued development of conservation oriented, selective fishing gear was seen to be essential to the future of the shrimp fishing industry. The history and development of shrimp fishing in eastern Canada, Iceland and the United States was explored in invited presentations by J. Angel (Canada), P. Bjarneson (Iceland) and R. Hurtubise (USA), respectively. The eastern Canadian experience of quota management coupled with rights-based fishing was offered as a sensible and conservative management system, which has produced positive results. The importance of focused marketing in Iceland was demonstrated through an outline of a marketing initiative targeting German consumers – part of a "Mutual Nordic Marketing" program developed to promote prawn products from Nordic countries. Trends in the processing and marketing of Gulf of Maine shrimp was explored including the development of a niche for frozen, breaded shrimp.

Posters

Of the 15 posters submitted to the meeting, 9 were relevant to the theme of Session 1. Two dealt with trophic interactions, including one highlighting the importance of cod on the population dynamics of *P. borealis* in the Barents Sea and another describing the role of the same species in the food webs of the Sea of Japan. Several papers described distribution and migration patterns for various *Pandalus* species and showed that: spatial and temporal distributions in the Gulf of Maine are strongly dependent on temperature, depth and substrate, and are size/year class specific; length frequencies of *P. borealis* in the Barents Sea varies both spatially and temporally, with much of the variation explained by temperature; *P. hypsinotus* in the Sea of Japan forms local populations with relatively little migrations between them. One poster presented preliminary results from ongoing recruitment studies of *P. borealis* in Greenland waters, including information on distribution and lipid composition in relation to hydrography and potential food resources. Another poster described an association between an anemone and various shrimp species, including *Pandalus* spp., which has not been observed before in northern waters. A final poster concluded that the positive relationship between size at transition and average size of breeders previously

presented as evidence for environmentally controlled sex change could simply be explained as density dependent growth. The four posters relevant to Session 2 dealt with different aspects of assessment methodology including: description of a new survey gear (beam trawl) used for a pre-recruit survey and recruitment studies in the Gulf of St. Lawrence; the incorporation of economic considerations into yield-per-recruit analysis for *P. jordani* off California and its usefulness in defining management strategies; jack-knifing a production model for the *P. borealis* stock off west Greenland using independently modeled catch-per-unit effort and survey series; and age determination of *P. borealis* in Icelandic waters using the deviation method. Three posters were associated with Sessions 3 and 4, including one which described temporal changes in cod and shrimp distributions as inferred from commercial data which corroborated the link between the decrease in cod and the increase in shrimp on the Newfoundland-Labrador Shelf; one poster described the relatively insignificant impact of by-catch and excluder devices on the quality of *P. jordani* catches; and a final poster described a monitoring program for the shrimp trawl fishery in British Columbia.

Summary of Discussions

A comment after the keynote address reiterated the major gaps in knowledge of Pandalid biology outlined by B. Bergström, including the gap between the flurry of laboratory studies in the 1970s and the present, and the communication gap between stock assessment biologists and those working on fundamental biological and ecological problems. While the lack of research funding has contributed to the first gap, this may improve in areas such as the Northwest Atlantic as shrimp overshadow groundfish in economic importance. The second gap may be addressed with available tools, including future international meetings of this nature, and e-mail facilities such as the SHRIMP-NORTH discussion list.

Much discussion reiterated the sensitivity, apparent in many of the presentations, of *Pandalus* spp. stock distributions and abundances to hydrographic changes. Process studies on the planktonic stages were considered essential to establish the links between environmental changes and recruitment which have been inferred from historical time series analysis. The use of modern tools such as the satellite imagery of Sea Surface Temperatures showing the instability of the water masses off east Greenland is essential if hydrographic data is to figure in shrimp stock predictions. Although workers in ocean climate may never be in a position to "forecast" beyond the short term, they are working towards predicting likely longer term trends in some areas. Discussions of a warming trend in the Northwest Atlantic associated with the North Atlantic Oscillation, and an anticipated cooling trend in the North Pacific perhaps delayed by recent unusual El Niño-Southern Oscillation (ENSO) events and their probable effect on shrimp stocks suggest a growing confidence in our ability to, if not understand all the linkages between ocean climate and shrimp populations, at least formulate testable hypotheses involving such large scale events.

Presented papers clearly showed that two main components of any stock assessment model, fishing mortality (F) and natural mortality (M), vary substantially. It was noted that it is essential that the varying predation component of M be incorporated into the advisory process in a quantitative way. The discussion clearly identified the need for further work on the influence of predation on shrimp stock dynamics and eventually, to develop the ability to recognize and separate effects due to predation from those due to environmental factors and fishing. A fundamental question in this area is the extent to which predation changes the size composition of a shrimp stock, which influences our interpretation of important parameters such as growth and distribution, and ultimately stock health.

It was pointed out that more comparative biological and ecological studies of different stocks are needed to identify differences in population dynamics and vulnerabilities to overfishing. It is unlikely that the sustainable exploitation rate of a small stock isolated within a pocket of favourable environmental conditions at the edge of the species range would be the same as a large stock well within the species range. It was felt the biological basis for exercising a more precautionary approach in some stocks *versus* others should be established and documented.

Discussion on management focused on the application of the Precautionary Approach to shrimp stocks, specifically the "traffic light" adopted by shrimp assessments biologists and managers on the east coast of Canada, and adopted as an interim method for data poor stocks within NAFO. This discussion quickly polarized into 2 camps, namely those who felt that the approach was not quantitative and should be interim, and those who felt it

was quantitative and could be a long-term alternative to traditional methods. On the defensive, proponents pointed out that traditional quantitative models often give the perception of providing more information or certainty than is actually there in reality, especially to those unfamiliar with the underlying assumptions. In addition, important ancillary observations are often ignored or devalued because there is no place for them in the model. Traffic light scores incorporate a suite of observations and their respective interpretations ranging from quantitative assessment results from surveys, commercial sampling, and VPAs if available, to semi-quantitative biological observations on demographic stability, natural mortality, environmental conditions, distribution, etc., to qualitative anecdotal information provided by industry, into a single score that represents current stock status more comprehensively and cautiously than traditional models. Simulations show that this score, when translated directly into a management response through harvest control rules, performs better than a constant exploitation approach in terms of yield-per-unit risk. Results are consistent with shrimp stock dynamics and precautionary management requirements and indicate that the method has considerable potential in the creation of an integrated management framework. It was pointed out that the management response as presently implemented in the model is limited to exploitation rates *via* TACs and should also incorporate additional response controls on fishing mortality *via* e.g. effort controls.

There was considerable discussion on the wide variety of sampling strategies, survey methods and data analysis techniques adopted by the various organizations, many of which have undergone considerable change recently. While many of these differences in methods are dictated by different stock characteristics it is clear that large differences also occur among organizations which assess shrimp stocks with relatively similar characteristics, e.g. the large stocks on both sides of the North Atlantic. Continued dialogue between these organizations should be encouraged to allow for improvements of assessment methodologies. The need for recruitment indices was emphasized and it was pointed out that these could be obtained through relatively simple and inexpensive means, for example the "juvenile bag" used in Iceland, and the "underbelly" bags used in the Barents Sea.

During the discussions after the session on harvesting and processing, it was pointed out that the phenomenal success of the Nordmore grate and similar By-catch Reduction Devices (BRDs) is not without problems. These devices have been accepted and used for a relatively short time (10 yr) and their long-term effects are still to be determined. In particular, their impact on commercially important juvenile fish may be considerable in some areas and times. In Norway, fishermen feel that the release of "trash" fish by the grate may impact shrimp stocks negatively by increasing predation pressure. These problems can only be addressed by continuing to improve the selectivity of the gears. The trend in cooperative government-industry research and management in Canada was lauded by the industry representative as exemplary, but it was pointed out that successful industry participation is contingent on a guarantee of access to the resource and its early participation in the development of any management framework.

Synopsis

The two international Pandalid shrimp Symposia, separated by 20 years, serve as benchmarks to progress in fishery science, management and harvesting of these important renewable resources. They also identify the gaps still remaining in our knowledge of their biology and ecology. Relatively little laboratory work was conducted between the two meetings, and discrepancies between earlier laboratory studies and field observations remain. We have recognized the importance of environmental and ecological influences in the dynamics of Pandalid populations to the point where environmental indicators and established predator-prey relationships are beginning to find their way into shrimp stock assessment models and are influencing management decisions. The need for a predictive capability in short lived species such as Pandalid shrimp has always been understood, but the resources for process-oriented studies into recruitment mechanisms remain elusive. The use of special samplers to capture small shrimp during standard assessment surveys is promising in this regard. Modern statistical techniques have found their way into shrimp assessment methodologies, their sophistication often challenged by the quality of the data at their disposal. While tremendous progress has been made in fishing technology, the future promises to hold significant challenges for fishers, scientists and managers alike, first and foremost in preventing, or at least minimizing the rapid changes often seen in these fisheries in the past. The (hopefully) return of groundfish stocks to previous levels in many parts of the Northwest Atlantic may result in juvenile fish by-catch problems that will require directed research and management action. A climatic and ecological regime shift in the Gulf of Alaska may

result in a resurgence of Pandalid populations that can draw on a greater set of tools and pool of knowledge than was previously available. And finally, the long time span between these meetings is itself instructive in that it suggests that scientists working on northern shrimp are relatively isolated within their own management regimes and disciplines. New methods of communication developed since the first meeting, especially e-mail, were invaluable in organizing the second symposium and should help narrow this gap in the future.

P. Koeller
Co-convener

Papers and Posters Presented at the Symposium

Keynote: BERGSTRÖM, B. The biology of *Pandalus*.

Theme Session 1: Environmental and Trophic Considerations (Chair: Paul Anderson)

Oral Presentations

- 1.1 **Stefánsson, G.** Assessment Methods and Utilization of Shrimp Stocks – from Simple-minded Approaches through Resignation to Multispecies and Simulation Methods (INVITED PAPER).
- *1.2 **Anderson, P. J.** Pandalid Shrimp as Indicators of Marine Ecological Regime Shift.
- 1.3 **Perry, R. I., and J. A. Boutillier.** Spatial Scales of Shrimp (*Pandalus jordani*) Aggregations, Environmental Influences, and Consequences for Management.
- *1.4 **Parsons, D. G.** Forecasting Fishery Performance for Northern Shrimp (*Pandalus borealis*) in NAFO Divisions 2HJ.
- *1.5 **Koeller, P. A.** Relative Importance of Environmental and Ecological Factors to the Management of the Northern Shrimp (*Pandalus borealis*) Fishery on the Scotian Shelf.
- 1.6 **Richards, A.** Physical and Biological Factors Influencing Recruitment of Northern Shrimp *Pandalus borealis* in the Gulf of Maine.
- *1.7 **Ramseier, R. O., and C. Garrity.** How Does the Particulate Organic Carbon Sedimentation Within the Seasonal Sea-ice Regime Influence the Distribution of Northern Shrimp (*Pandalus borealis*)?
- *1.8 **Lilly, G. R., and D. G. Parsons.** Was the Increase in Shrimp Biomass on the Northeast Newfoundland Shelf a Consequence of a Release in Predation Pressure?
- *1.9 **Hansen, H. Ø., and M. Aschan.** Growth Performance, Size and Age at Maturity of Shrimp *Pandalus borealis* in the Svalbard Area Related to Environmental Parameters.
- *1.10 **Stein, M.** Do Hydrographic Conditions Affect the Distribution of Shrimp (*Pandalus borealis*) off East Greenland?

Poster Presentations

- *P.1. **Aschan, M.** Spatial Variability in Length Frequency Distribution and Growth of Shrimp (*Pandalus borealis* Krøyer 1984) in the Barents Sea.
- *P.2. **Berenboim, B. I., A. V. Dolgov, V. A. Korzhev, and N. A. Yaragina.** Cod Impact on the Stock Dynamics of Shrimp (*Pandalus borealis*) in the Barents Sea and Applying this Factor in Multispecies Models.

* original paper/poster revised for this publication

Poster Presentations (Continued)

- P.3. **Buyanovsky, A.** Biology and Distribution of *Pandalus hypsinotus* (Brandt) in the Northern Part of the Sea of Japan.
- P.4. **Clark, S. H., S. Vaughn, E. Holmes, and J. B. O'Gorman.** Observations on the Biology and Distribution of Northern Shrimp, *Pandalus borealis*, in the Gulf of Maine, from Research Vessel Surveys.
- *P.5. **Koeller, P., R. Mohn, and M. Etter.** Density Dependent Sex-reversal in Pink Shrimp, *Pandalus borealis*, on the Scotian Shelf.
- *P.6. **Stevens, B. G., and P. J. Anderson.** An Association Between the Anemone, *Cribrinopsis fernaldi*, and Shrimps of the Families Pandalidae and Hippolytidae.
- P.7. **Minami, T.** Predator-prey Relationship and Trophic Levels of the Pink Shrimp, *Pandalus eous*, in the Yamato Bank, the Sea of Japan.
- P.8. **Pedersen, S. A.** Hydrographical and Biological Processes of Importance in Determining Recruitment Variability of Northern Shrimp in West Greenland Waters.

**Theme Session 2: Stock Assessments and Associated Research
(Chair: Michaela Aschan)****Oral Presentations**

- 2.1 **Ivanov, B. G.** Pandalid Shrimps of the Boreal Area: History of Fisheries and Research with Special Reference to Russia (INVITED PAPER).
- 2.2 **Mohn, R.** Data-poor Stock Assessment Methods and Their Application to Shrimp Stocks (INVITED PAPER).
- *2.3 **Cadrin, S.** Assessment of *Pandalus borealis* Stocks in the Northwest Atlantic: Challenges with Catch and Catchability.
- *2.4 **Evans, G. T., D. C. Orr, D. G. Parsons, and P. J. Veitch.** A Non-parametric Method for Estimating Biomass from Trawl Surveys, with Monte Carlo Confidence Intervals.
- *2.5 **Harbitz, A.** A Bayesian-adaptive Approach to Sampling Design with Application to Shrimp Abundance Surveys in the Barents Sea.
- *2.6 **Carlsson, D., O. Folmer, P. Kannevorff, M. Kingsley, and M. Pennington.** A Trawl Survey for *Pandalus borealis* in West Greenland.
- *2.7 **Clark, S. H., S. Cadrin, D. Schick, P. Diodati, M. Armstrong, and D. McCarron.** The Gulf of Maine Northern Shrimp Fishery – A Review of the Record.
- 2.8 **Clark, J., G. Bishop, and T. Koeneman.** Estimation of Harvest Rates in the Spot Shrimp Pot Fishery in Southeast Alaska using Pre- and Post-fishery Stock Assessment Surveys.
- *2.9 **Hannah, R. W.** By-catch Reduction in an Ocean Shrimp (*Pandalus jordani*) Trawl from a Simple Modification to the Trawl Footrope.

* original paper/poster revised for this publication

Oral Presentations (Continued)

- 2.10 **Savard, L.** Variations in the Growth Pattern of Northern Shrimp (*Pandalus borealis*) in the Gulf of St. Lawrence.
- *2.11 **Séigny, J.-M., L. Savard, and D. G. Parsons.** Genetic Characterization of the Northern Shrimp, *Pandalus borealis*, in the Northwest Atlantic.
- *2.12 **Tveite, S.** Fixed Stations Survey for Shrimp Abundance Indices, 15 Years of Investigations in the Norwegian Deeps and Skagerrak.

Poster Presentations

- P.9. **Bouchard, H., J. Lambert, and L. Savard.** Catching Juvenile Northern Shrimp (*Pandalus borealis*) in the St. Lawrence Estuary with a Rigid Frame Trawl.
- P.10. **Gallagher, C. M., R. Hannah, and G. Sylvia.** Biological and Economic Yield-per-recruit: Alternative Strategies for Managing Pacific Ocean shrimp (*Pandalus jordani*).
- *P.11. **Kingsley, M.C. S., and C. Hvingel.** Jack-knifing an Assessment Model for the West Greenland Stock of *Pandalus borealis*.
- P.12. **Skúladóttir, U.** Age Determination of Northern Shrimp, *P. borealis*, in Icelandic Waters Using the Deviation Method in Conjunction with the Method of MacDonald and Pitcher.

Theme Session 3: Management (Chair: Don G. Parsons)**Oral Presentations**

- *3.1 **Parsons, D., L. Savard, C. Fu, and P. Koeller.** The Traffic Light: A Colourful but Ugly Approach to Precautionary Shrimp Stock Management (INVITED PAPER).
- 3.2 **Harbo, R., L. Convey, J. Boutillier, and D. Hay.** Pacific Coast Shrimp Trawl Fisheries: New Management and Assessment Co-management Programs.
- *3.3 **Fu, C., T. J. Quinn, and G. H. Kruse.** Analyses of Harvest Strategies for Pandalid Shrimp Populations.
- 3.4 **Bishop, G. H., T. M. Koeneman, and C. A. Botelho.** Development of a Management and Stock Assessment Program for the Pot Shrimp Fishery for *Pandalus platyceros* in Southeastern Alaska.
- 3.5 **Bond, J. A., and J. A. Boutillier.** A Progress Report on the Control of Growth and Recruitment Overfishing in the Shrimp Trap Fishery in British Columbia.

Theme Session 4: Harvesting and Processing (Chair: John Angel)**Oral Presentations**

- 4.1 **Larsen, R.** Modern Trawling and By-catch Reducing Devices in the North Atlantic Shrimp Fisheries (INVITED PAPER).

* original paper/poster revised for this publication

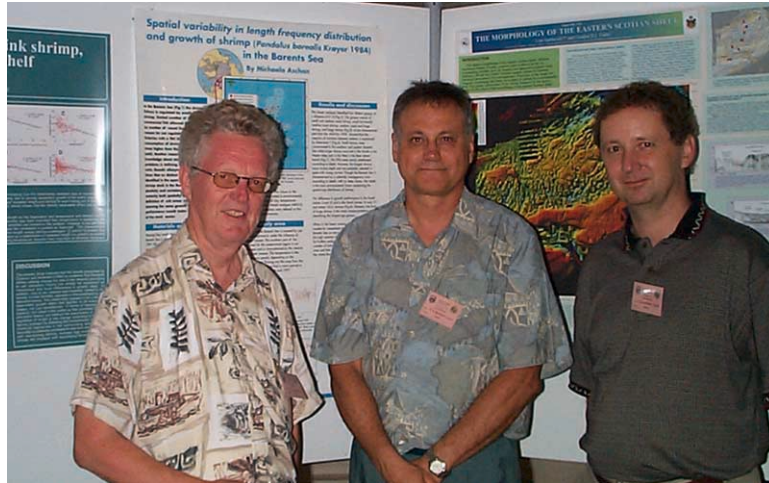
Oral Presentations (Continued)

- 4.2 **Angel, J.** Managing the Canadian Shrimp Fishery (INVITED PAPER).
- 4.3 **Schick, D. F., and M. Brown.** Gear Testing in the Northern Shrimp Fishery in the Gulf of Maine to Improve Size Selectivity, Reduce By-catch and Decrease Production Loss.
- 4.4 **Hurtubise, R.** Trends in Processing and Marketing in the Gulf of Maine Shrimp Fishery (INVITED PAPER).
- 4.5 **Bjarneson, P.** The Icelandic Shrimp Industry (INVITED PAPER).

Theme Sessions 3 and 4: Posters

- P.13. **Kutzikowski, V. H., R. Hannah, G. Sylvia, and M. T. Morrissey.** Finfish By-catch Effects on the Quality of Ocean Shrimp, *Pandalus jordani*.
- P.14 **Clarke, J., and W. E. L. Clayton.** Monitoring the Shrimp Trawl Fishery in British Columbia.
- P.15 **Kulka, D., D. G. Parsons, and G. Lilly.** Livin' on the Edge – Distribution of Cod and Shrimp on the Newfoundland-Labrador Shelf from Commercial Fisheries Data.

* original paper/poster revised for this publication



Co-conveners: S. Tveite, P. A. Koeller, J. Boutillier



Keynote Speaker: B. Bergström



Lobster Race Participants: S. Clark, L. Savard, B. Bergström, D. G. Parsons plus four numbered lobsters

