Northwest Atlantic Fisheries Organization

Serial No. N2818

NAFO SCS Doc. 96/20

SCIENTIFIC COUNCIL - DECEMBER 1996

# Northern Shrimp Working Group Report

23-29 May 1996
Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, Canada

by

Carsten Hvingel, Rapporteur

Greenland Institute of Natural Resources, P. O. Box 570
3900 Nuuk, Greenland

## Introduction

This meeting of the Northern Shrimp Working Group was sponsored by the Greenland Institute of Natural Resources, Nuuk, Greenland and the Science Branch, DFO, Canada, and held during 23-29 May 1996 at the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland. Participants attended from Canada, Denmark and Greenland.

## Agenda

1. **West Greenland**

   1.1 Analysis of CPUE data from the shrimp fishing fleets -revision of existing models.

   1.2 Implementation of the revised models in the assessment.

   1.3 Construction of a long time-series index of shrimp abundance.

   1.4 Retrospective analysis of existing indices.

2. **Flemish Cap**

   2.1 Timing of meeting (September vs November).

   2.2 Approach/strategy for the 1996 September meeting.

3. **Shrimp research strategy**

   3.1 International survey, objectives, methods.

   3.2 International coordination of research.

## 1. West Greenland

The primary objective of this workshop was to construct a catch-per-unit-effort (CPUE) index to trace the abundance of shrimp at West Greenland. This required an analysis of the underlying biological assumptions of the multiplicative models used so far in the assessment and an evaluation of which variables and in what form they should enter the models.

The possibilities of integrating Greenlandic data (beginning in 1975) and Canadian data (beginning in 1981) in a long time-series index was also one of the main objectives of the meeting.

### 1.1 Analysis of CPUE data from the shrimp fishing fleets - revision of existing models

The objective of this analysis was to develop an index based on catch and effort data as reported in commercial vessel logs which can be assumed to represent shrimp abundance. The index was derived using a multiplicative model including variables describing: a. Individual vessel fishing power, b. Temporal availability of shrimp, c. Spatial availability, d. Annual abundance of shrimp, and taking the form:

CPUE = Vessel fishing power * Temporal and area Availability * Overall annual abundance

To determine the behaviour of the model, the parameters where investigated for potential problems with respect to the assumption that CPUE can be used as index for shrimp abundance.

*Vessel*

The use of this variable in its present form assumes that no improvement of individual vessel fishing power is taking place. The vessel component will, however, over time include some element of technological improvements. Quantification of the magnitude of the increase in fishing power, which e.g. for the US Pacific coast groundfish trawl fishery (1982-1989) has been estimated to almost 3% per year (Squires, 1994), is needed.

Giving that this subject is a study in itself, only preliminary elements were discussed. It was agreed that ancillary data would be required for individual vessels, focusing on events such as the acquisition of SCANMAR and GPS to pin point the periods when changes had taken place. Hans Lassen will continue looking further into the subject after this meeting. He will investigate some of the theoretical implications and, if needed, make a proposal including guidelines for further investigation into the subject.

*Area*

The areal structure in the models used so far is based on the distribution of geographical well- defined fishing grounds (Fig. 1). This seemed an appropriate geographical scale for determining areal abundance dynamics. The areas in the models are assumed to have a well-defined structure in distribution of shrimp abundance. The area term, however, might include some element of migration between areas or in and out of areas.

*Month*

It was agreed that no finer time scale than month is needed to capture seasonal variation, partly based on the advantage of averaging out the large haul to haul variations in CPUE. On the contrary, a coarser time scale may be appropriate if between month similarity is found.

There was some discussion that day/night differences might need to be addressed but it was agreed that such differences would likely be obscured in the haul to haul variation.

*Year*

This element should be the factor tracing the annual abundance of the shrimp population in the model. In Principle, no interactions between year and the other factors are allowed, as it is assumed that CPUE in any one year is a given proportion of CPUE in another year.

*Interactions*

Several interactions with potentially significant influence on the model exists:

| | | |
|---|---|---|
| Vessel | *Area | (Vessel fishing power varies between areas). |
| | *Month | (Vessel fishing power varies between month). |
| | *Year | (Vessel efficiency depends on year ie. vessels change their efficiency out of phase). |
| Area | *Month | (Seasonal migrations). |
| | *Year | (Abundance distributions change between years). |
| Month | *Year | (The seasonal distributional pattern varies between years). |

*Unbalanced design*

The implications of unbalanced design regarding the parameters of the model were discussed. Some parameters may be 1. correlated, 2. estimated with high variance and 3. driven by few high leverage observations.

It was also noted that there were various ways to treat zero catches and that, at least, the proportion of zero catches over time should be closely examined.

*Analysis of large shrimp index, NAFO Div. 1B*

Due to ice, access to all or some of the fishing grounds in Div. 1B may be hampered in the first three months of the year. As data from the first quarter, therefore, likely provide more information about ice conditions than of actual shrimp abundance and given that, on average, less than 6% of the annual catches of large shrimp (>8.5 g) are taken in this time period, month 1-3 were not included in the model.

The first run, including the second-order effects noted above, showed that all interactions except vessel*area were significant. The R-square for the full model was 71 %.

Removing the vessel*area interaction did not change the result appreciably. The main "area" effect was now no longer significant (1% level) and the R-squared only decreased slightly. Also, although the vessel*month interaction was significant in the first run, it was concluded that this effect was relatively inconsequential to the interpretation of the result of the analysis.

The interactions including year indicate that there is no clear systematic pattern from one year to the next. A run without these year interactions, i.e. the model:

$$\log(CPUE) = VESSEL + AREA + YEAR + MONTH + MONTH*AREA \qquad \text{Model 1}$$

reduced the R-square to 41%. This model also showed that the main area effect was not significant (i.e. that there is an area structure which, however, varies with season, possibly resulting from a repeated annual migrational pattern).

To further investigate this annual pattern, the model was expanded with a year term:

$$\log(\text{CPUE}) = \text{VESSEL} + \text{YEAR*MONTH*AREA} \qquad \text{Model 2}$$

In this model, the mean seasonal effect (differences in availability) is included in the third order effect.

The resulting pattern was graphically depicted on screen at the meeting. Unfortunately a satisfying print-out is not available at present. However, the conclusion was that no decisive pattern in the by year month*area interaction was seen i.e. the seasonal migratory pattern (or seasonal availability pattern in areas) is not repeated in any definite pattern from one year to the next.

A more detailed investigation of the results of this model *showed that there are some* years and some areas (although fairly unsystematic) where the average CPUE is much above/below what is predicted by model 1. There is a tendency in the analysis that the model will underestimate in May and overestimate in the autumn (Aug-Nov).

As the index is used as a predictor of the annual abundance estimate in the current year based on partial data for the year, the year effect is not possible to apply to the month*area interaction in the final model. There is also concern about the stability of the model if a year interaction model would be applied.

The remaining consideration focused on a version of Model 1 where the area and month main effects are included in the 2nd order interaction effect:

$$\log(\text{CPUE}) = \text{VESSEL} + \text{YEAR} + \text{AREA*MONTH}$$

The estimated parameters from this model are given in Table 1. Inspection of the residuals Fig. 2 did not reveal any structure in the pattern.

The interpretation of this model is that there is a migration/concentration followed by a dispersion of the shrimp. The concentration takes place in the early months (April-May) the precise time period varying between years.

### 1.2 Implementation of revised models in the assessment

Revision of all models using the approach outlined above will take place before the November 1996 meeting. It is suggested that the annual abundance indices for 1996 and the following two years should be calculated using the fishing power and spatial/temporal pattern as estimated by these revised multiplicative models. At the end of three years, a revision of the models should be performed and modifications made, if required.

### 1.3 Construction of a long time-series index of shrimp abundance

Six CPUE-based indices of shrimp abundance have/are been/being used in the Davis Strait: The Greenlandic "large-" and "Total Shrimp index" *for both Div 1B and* 1CD dating back to 1987, the Greenlandic KGH index based on seven trawlers in the period 1975-1989; and the Canadian shrimp index for Div. 0A since 1981.

The possibility of combining all these data into one model was discussed. However, besides the problem with a lot of empty cells in such a model, the group felt it unwise to try to "average" distributional patterns as displayed by different fleets in different areas over different time periods. Instead, it was agreed to use the existing Greenlandic large shrimp- and KGH indices and the Canadian index, adjusted to the same level and weighted by area (i.e. calculating a sort of swept area index).

This index will also be presented at the November meeting 1996.

### 1.4 **Retrospective analysis of existing indices**

Correlation analysis were made between the various indices of abundance as estimated from both the commercial fishery and from survey results (Fig. 3).

There was found to be a reasonable correlation within the different commercial CPUE based indices but no correlation between those and the biomass estimates from the Greenlandic survey. This indicates that there is much more noise in the survey estimates than in the commercial CPUE or the CPUE does not reflect biomass.

Further investigation into this subject is needed.

## 2. **Flemish Cap**

Discussions about the shrimp fishery at Flemish Cap had reduced priority at the meeting as it became evident that more shrimp biologists than expected will attend the NAFO meeting in September. Therefore the September meeting will be the right forum for these discussions in 1996.

Don Parsons will continue to investigate the possibility of moving the Flemish Cap session to the November meeting but, given the international importance of this fishery and the need for Scientific Council advice in advance of the Annual Meeting, this will not likely happen in the short term.

## 3. **Shrimp research strategy**

At the November meeting 1995 the possibility of a joint Canadian/Greenlandic shrimp survey at Flemish Cap was proposed by Louise Savard (Mont Joli). Further discussion of this proposal was intended for this meeting but, unfortunately, Louise was not able to attend. She did, however, provide a conceptual model of some of the major challenges in shrimp research and possible ways to approach them (Appendix 1).

The group supports and highly recommends the idea of joining forces internationally in shrimp research and it was agreed that the "Savard Plan" forms a good background for making future research schemes. There was only little time to discuss different ideas of how to implement the Plan in practice but it was tentatively agreed that a site at West Greenland (e.g. Godthaab Fjord) would be the most appropriate location for long-term, *in situ* studies and that controlled experiments would best be handled in Mont-Joli. The group also agreed to do some home work and readdress the subject, in detail, at a meeting in near future.

The group also agreed that a "one-time" survey of Flemish Cap shrimp would still be appropriate and that this topic could be discussed in detail at the NAFO Annual Meeting in September, 1996.

Some time was also used to discuss alternative assessment methods. Hans Lassen noted that the so-called "dynamic pool models" (as described in chapter 8 of Walters and Hilbourne, 1992) appeared to be promising but there was insufficient time to explore these methods in more detail at this meeting. Length-based methods for SPA were viewed as an alternative to age-based standards but lack of time series data seemed to be the limiting factor for their application. Also, since M is assumed high relative to F, the resulting population estimates would be highly uncertain and projection, based on some average recruitment, would be inappropriate. Traditional yield-per-recruit analysis also were viewed as inappropriate given the objective to maintain the female biomass and under the assumption that the stock is self-sustaining.

A Delury-type approach, designed to strike a balance between catch and recruitment, was described by Hans Lassen. Estimates of recruitment and survival might be calculated by looking at the eggs per kg of female biomass and the survival rate of eggs.

These data would be used to construct a relationship between the catch and the reproductive capacity of the stock.

The utility of annual research surveys to provide a good abundance index was also discussed. The current survey results do not correlate with CPUE indices, which indicates that something is amiss with one index or the other. Although it was acknowledged that more "weight" tends to be given to the interpretation of the CPUE index when deciding if the stock is increasing, decreasing or stable, it was recognized that the surveys provide valuable information on distribution, stock structure and recruitment potential.

## References

Hilborne, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment, choice, dynamics and uncertainty. 570 p.

Squires, D. 1994. Sources of growth in marine fishing industries. *Marine Policy*, **18**(1): 5-18.

## Participants

Hans Lassen, Danish Fisheries Research.
Don G. Parsons, Northwest Atlantic Fisheries Centre.
Pat Veitch, Northwest Atlantic Fisheries Centre.
Dan M. Carlsson, Greenland Institute of Natural Resources.
Ole Folmer, Greenland Institute of Natural Resources.
Carsten Hvingel (rapporteur), Greenland Institute of Natural Resources.

## Resources

*Ole Folmer, Greenland Institute of Natural Resources*
Carsten Hvingel (rapporteur), Greenland Institute of Natural Resources.

Table 1. SAS Output from run of the model Ln(CPUE)=YEAR+VESSEL+MONTH*AREA.

| Class | Levels | Values |
|---|---|---|
| VESSEL | 33 | OUIN OUIQ OUKV OUOQ OUPJ OUTM OUWH OUYM OVUG OWDV OWGG OWLQ OWPQ OWQU OWSH OWUD OWUJ OWVM OWWP OXSY OYAQ OYBZ OYCK OYFF OYKK OYNR OYNS OYRK OYRT OYXT OZKQ OZSI ZZZZ |
| YEAR | 9 | 87 88 89 90 91 92 93 94 95 |
| MONTH | 9 | 4 5 6 7 8 9 10 11 12 |
| AREA | 4 | 3 4 5 6 |

Number of observations in data set = 2075

General Linear Models Procedure

Dependent Variable: LNCPUE

| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| Model | 74 | 398.3079689 | 5.3825401 | 18.91 | 0.0001 |
| Error | 2000 | 569.1857640 | 0.2845929 | | |
| Corrected Total | 2074 | 967.4937329 | | | |

| R-Square | C.V. | Root MSE | LNCPUE Mean |
|---|---|---|---|
| 0.411690 | 10.33750 | 0.533472 | 5.160558 |

| Source | DF | Type I SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| VESSEL | 32 | 197.5905914 | 6.1747060 | 21.70 | 0.0001 |
| YEAR | 8 | 103.5520980 | 12.9440123 | 45.48 | 0.0001 |
| MONTH*AREA | 34 | 97.1652795 | 2.8578023 | 10.04 | 0.0001 |

| Source | DF | Type III SS | Mean Square | F Value | Pr > F |
|---|---|---|---|---|---|
| VESSEL | 32 | 190.0819193 | 5.9400600 | 20.87 | 0.0001 |
| YEAR | 8 | 100.0823636 | 12.5102955 | 43.96 | 0.0001 |
| MONTH*AREA | 34 | 97.1652795 | 2.8578023 | 10.04 | 0.0001 |

| Parameter | | Estimate | T for H0: Parameter=0 | Pr > \|T\| | Std Error of Estimate |
|---|---|---|---|---|---|
| INTERCEPT | | 4.789529602 B | 47.05 | 0.0001 | 0.10180419 |
| VESSEL | OUIN | 0.305767388 B | 3.20 | 0.0014 | 0.09565424 |
| | OUIQ | 0.293041267 B | 2.88 | 0.0040 | 0.10161895 |
| | OUKV | 0.937184287 B | 7.93 | 0.0001 | 0.11811429 |
| | OUOQ | 0.170093467 B | 1.75 | 0.0811 | 0.09745229 |
| | OUPJ | 0.468018288 B | 4.80 | 0.0001 | 0.09754994 |
| | OUTM | 0.381961868 B | 4.20 | 0.0001 | 0.09086166 |
| | OUWH | 0.334385303 B | 3.44 | 0.0006 | 0.09724177 |
| | OUYM | 0.127349514 B | 1.43 | 0.1527 | 0.08901061 |
| | OVUG | -0.697307025 B | -5.10 | 0.0001 | 0.13669077 |
| | OWDV | 0.137858636 B | 1.61 | 0.1075 | 0.08561195 |
| | OWGG | 0.747568413 B | 6.80 | 0.0001 | 0.10997211 |
| | OWLQ | 0.072128931 B | 0.63 | 0.5304 | 0.11495917 |
| | OWPQ | -0.117414133 B | -1.12 | 0.2612 | 0.10447013 |
| | OWQU | 0.877097289 B | 9.19 | 0.0001 | 0.09543439 |
| | OWSH | 0.207573657 B | 1.49 | 0.1352 | 0.13889967 |
| | OWUD | 0.160456964 B | 1.80 | 0.0714 | 0.08895031 |
| | OWUJ | 0.011240584 B | 0.12 | 0.9024 | 0.09169054 |
| | OWVM | 0.065939672 B | 0.58 | 0.5598 | 0.11304834 |
| | OWWP | 0.560197840 B | 6.15 | 0.0001 | 0.09105572 |
| | OXSY | -0.606900460 B | -5.76 | 0.0001 | 0.10534937 |
| | OYAQ | -0.106854885 B | -1.06 | 0.2897 | 0.10089276 |
| | OYBZ | 0.524475246 B | 5.02 | 0.0001 | 0.10449615 |
| | OYCK | 0.141733840 B | 1.49 | 0.1353 | 0.09487162 |
| | OYFF | 0.592508343 B | 5.32 | 0.0001 | 0.11146627 |
| | OYKK | 0.392574150 B | 4.17 | 0.0001 | 0.09404304 |
| | OYNR | 0.236605103 B | 2.74 | 0.0063 | 0.08645433 |
| | OYNS | 0.326829549 B | 3.35 | 0.0008 | 0.09756636 |
| | OYRK | 0.339711625 B | 4.09 | 0.0001 | 0.08311273 |
| | OYRT | 0.595090226 B | 6.01 | 0.0001 | 0.09897836 |

Table 1. continued..
Dependent Variable: LNCPUE

| Parameter | | Estimate | | T for H0: Parameter=0 | Pr > \|T\| | Std Error of Estimate |
|---|---|---|---|---|---|---|
| VESSEL | OYXT | 0.658130885 | B | 6.70 | 0.0001 | 0.09818645 |
| | OZKQ | 0.726458578 | B | 7.20 | 0.0001 | 0.10096608 |
| | OZSI | -0.521332847 | B | -4.93 | 0.0001 | 0.10564729 |
| | ZZZZ | 0.000000000 | B | . | . | . |
| YEAR | 87 | 0.749749224 | B | 11.04 | 0.0001 | 0.06791367 |
| | 88 | 0.469436234 | B | 8.35 | 0.0001 | 0.05621825 |
| | 89 | 0.012913842 | B | 0.22 | 0.8263 | 0.05883932 |
| | 90 | 0.031915336 | B | 0.56 | 0.5731 | 0.05662699 |
| | 91 | -0.058237772 | B | -1.05 | 0.2924 | 0.05529385 |
| | 92 | -0.104799697 | B | -1.76 | 0.0785 | 0.05952809 |
| | 93 | 0.093251756 | B | 1.66 | 0.0970 | 0.05615930 |
| | 94 | -0.084769609 | B | -1.54 | 0.1237 | 0.05504607 |
| | 95 | 0.000000000 | B | . | . | . |
| MONTH*AREA | 4 3 | 0.380226089 | B | 2.07 | 0.0381 | 0.18325603 |
| | 4 4 | 0.788927419 | B | 4.14 | 0.0001 | 0.19077774 |
| | 4 5 | 0.732100488 | B | 7.91 | 0.0001 | 0.09256461 |
| | 4 6 | 0.129829428 | B | 1.62 | 0.1056 | 0.08018716 |
| | 5 3 | 0.015627829 | B | 0.10 | 0.9189 | 0.15351128 |
| | 5 4 | -0.310383717 | B | -3.26 | 0.0011 | 0.09521283 |
| | 5 5 | 0.207639391 | B | 2.62 | 0.0090 | 0.07937941 |
| | 5 6 | -0.291041728 | B | -3.51 | 0.0005 | 0.08288751 |
| | 6 3 | -0.285053472 | B | -1.81 | 0.0702 | 0.15735887 |
| | 6 4 | -0.256322768 | B | -3.03 | 0.0025 | 0.08465602 |
| | 6 5 | -0.164227124 | B | -2.03 | 0.0426 | 0.08093907 |
| | 6 6 | 0.002067405 | B | 0.02 | 0.9813 | 0.08818093 |
| | 7 3 | 0.142499051 | B | 0.85 | 0.3952 | 0.16756508 |
| | 7 4 | -0.171004358 | B | -2.04 | 0.0414 | 0.08379676 |
| | 7 5 | 0.093637158 | B | 1.11 | 0.2660 | 0.08416239 |
| | 7 6 | -0.092619027 | B | -0.97 | 0.3342 | 0.09589070 |
| | 8 3 | -0.024762993 | B | -0.12 | 0.9074 | 0.21288241 |
| | 8 4 | -0.229017261 | B | -2.82 | 0.0049 | 0.08127897 |
| | 8 5 | 0.086257090 | B | 1.06 | 0.2914 | 0.08174095 |
| | 8 6 | -0.170700407 | B | -1.66 | 0.0970 | 0.10280752 |
| | 9 3 | 0.082843165 | B | 0.77 | 0.4419 | 0.10771458 |
| | 9 4 | -0.107689454 | B | -1.37 | 0.1710 | 0.07863285 |
| | 9 5 | -0.278459687 | B | -3.15 | 0.0017 | 0.08851903 |
| | 9 6 | -0.194872310 | B | -1.75 | 0.0803 | 0.11135420 |
| | 10 3 | 0.332143954 | B | 3.14 | 0.0017 | 0.10588893 |
| | 10 4 | 0.068722221 | B | 0.88 | 0.3768 | 0.07773913 |
| | 10 5 | -0.042071255 | B | -0.42 | 0.6739 | 0.09996254 |
| | 10 6 | 0.008543192 | B | 0.07 | 0.9409 | 0.11517089 |
| | 11 3 | 0.295691662 | B | 2.42 | 0.0157 | 0.12227700 |
| | 11 4 | 0.116766722 | B | 1.49 | 0.1377 | 0.07862783 |
| | 11 5 | -0.005471443 | B | -0.06 | 0.9517 | 0.09028332 |
| | 11 6 | 0.170264320 | B | 1.96 | 0.0504 | 0.08698443 |
| | 12 4 | 0.210086478 | B | 2.29 | 0.0221 | 0.09170335 |
| | 12 5 | -0.372756822 | B | -2.65 | 0.0081 | 0.14060917 |
| | 12 6 | 0.000000000 | B | . | . | . |

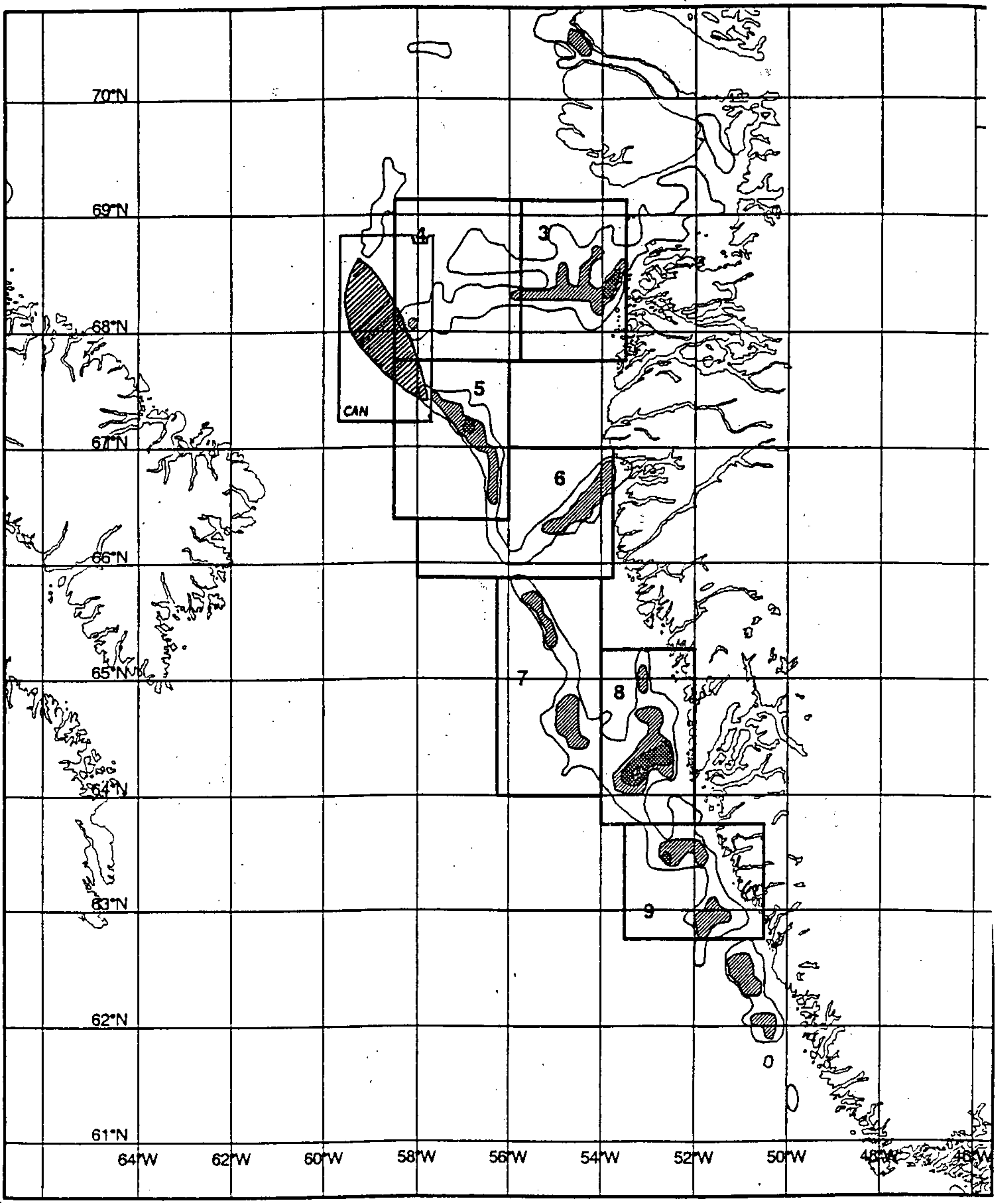
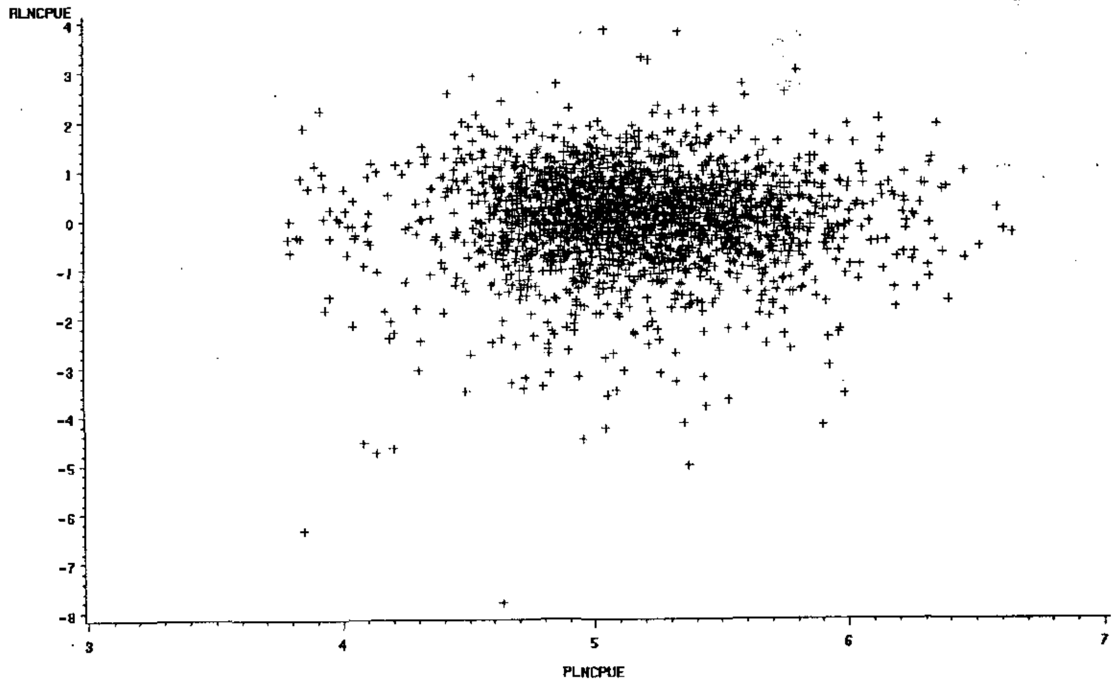
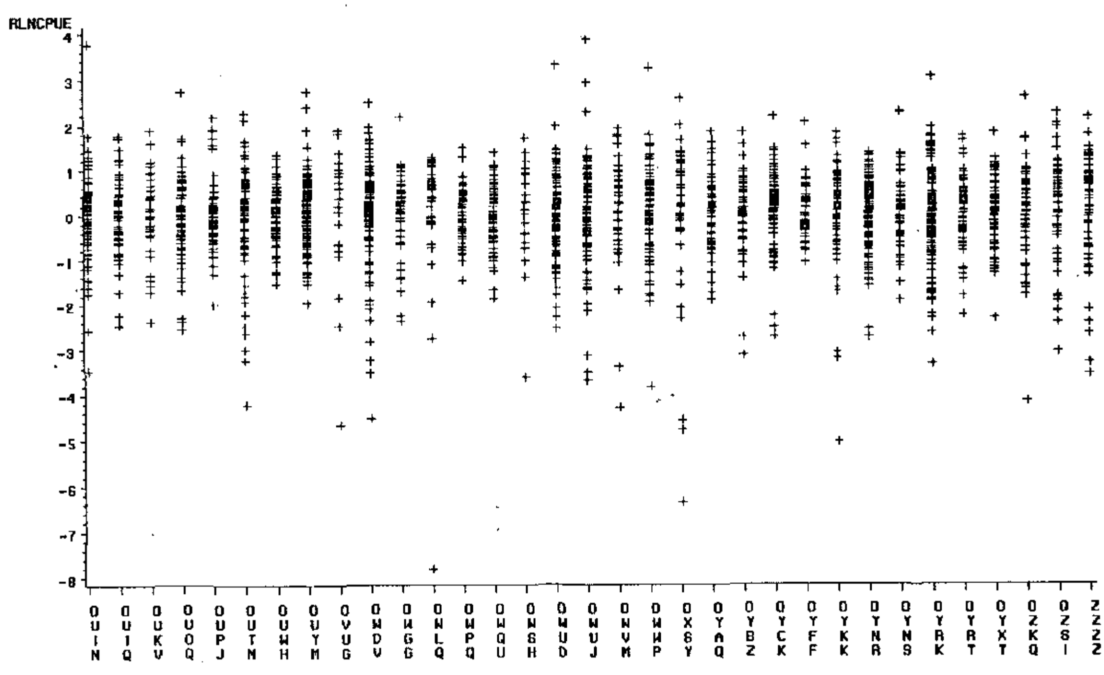


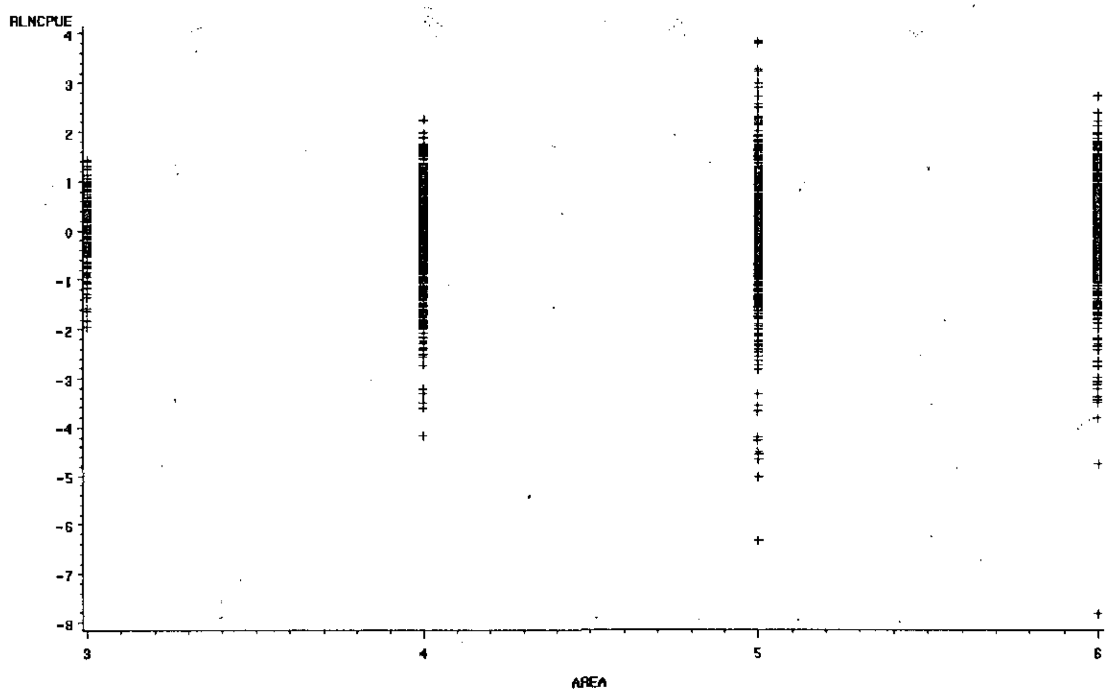

Fig. 1. Map showing areas used in the multiplicative models. Areas 3-6 is incorporated in the indices for Div. 1B, areas 7-9 in the 1CD indices and CAN constitutes the area used in the canadian index for S.A. 0A.




<u>Fig. 2.</u> Residual plots from run of the model Ln(CPUE)=YEAR+VESSEL+MONTH*AREA. (Continues...)

Fig. 2. continued...



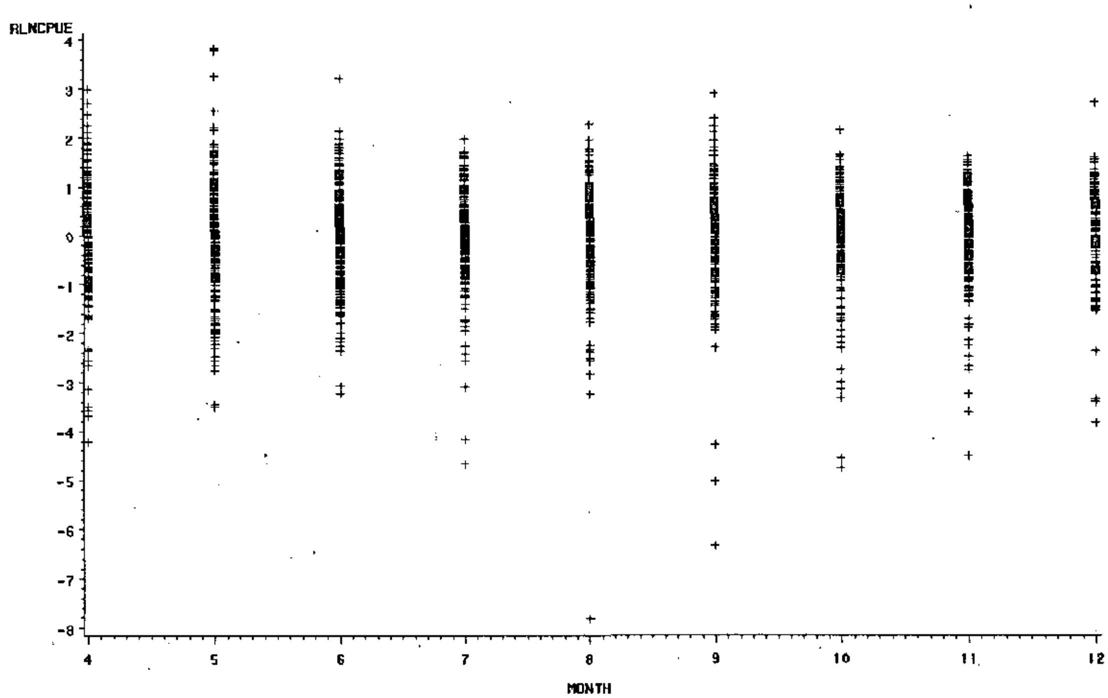
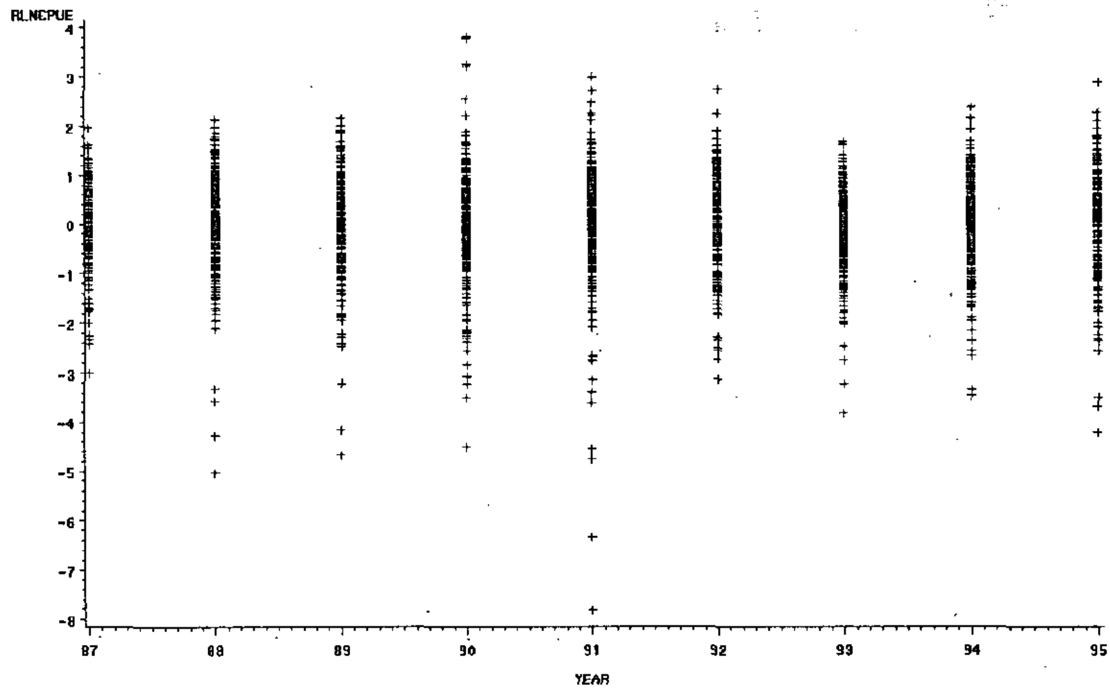
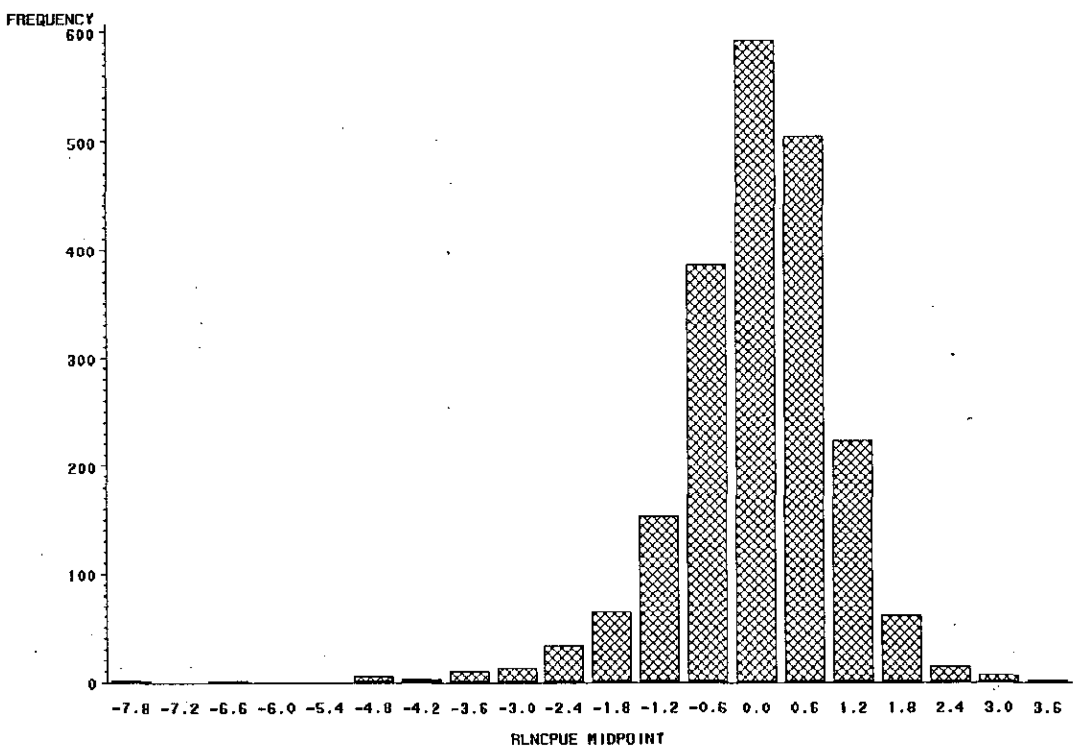
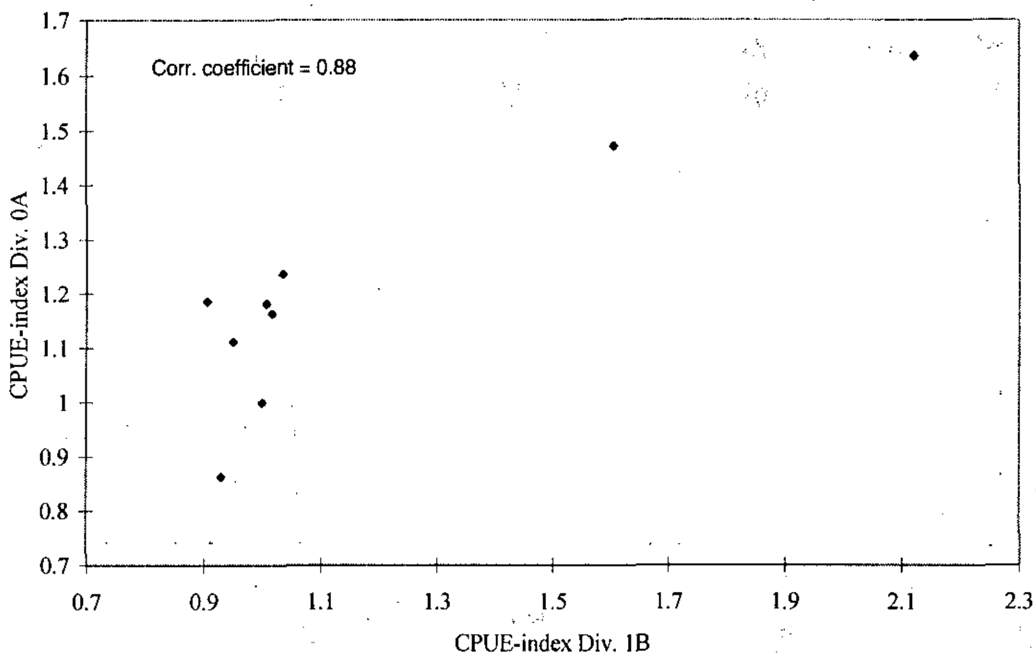



Fig. 2. Continued...





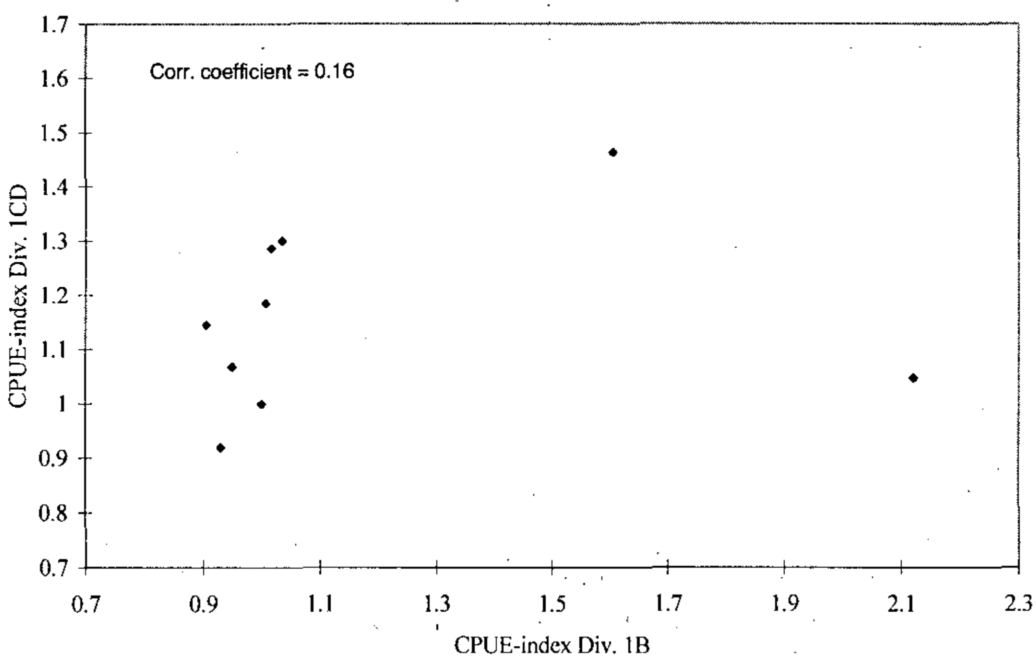
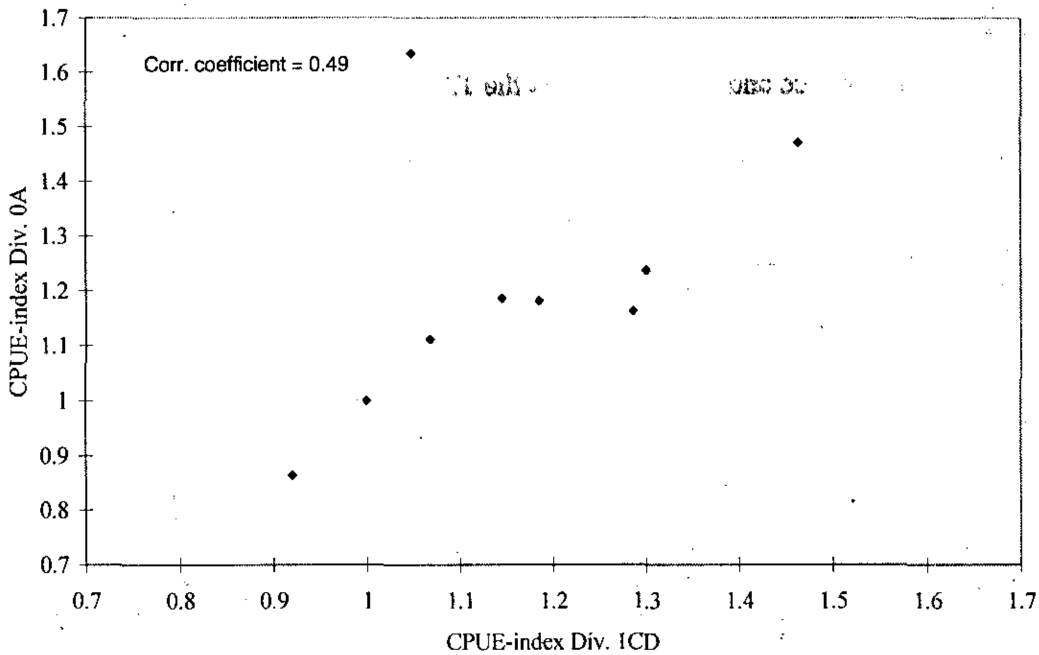




Fig. 3. X/Y-plots of the various indices examined at the workshop with correlation coefficients given. Continues....



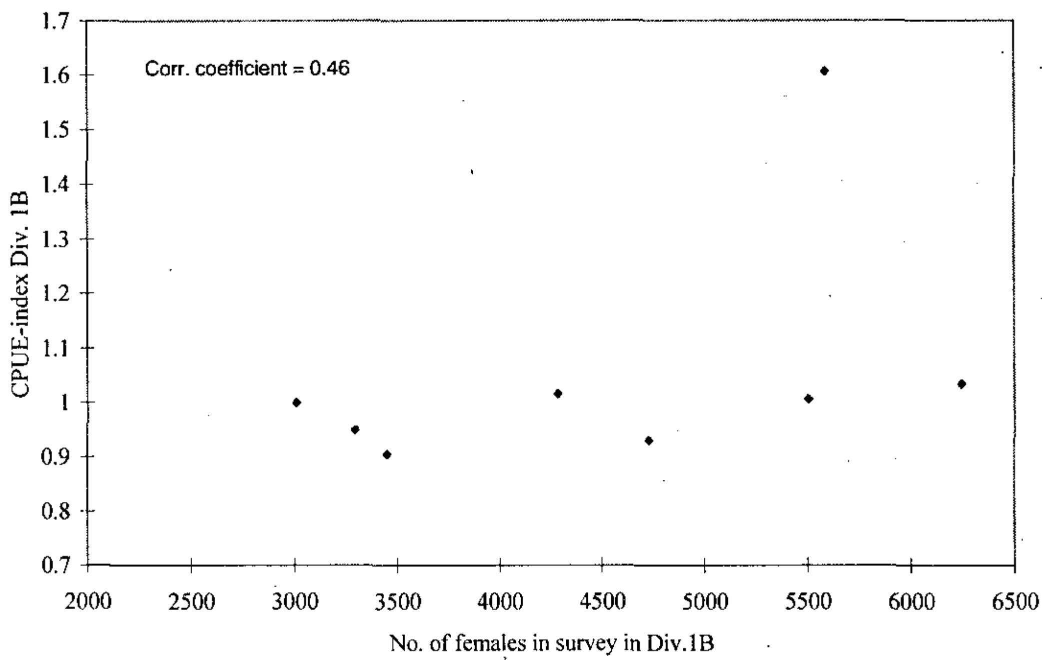




Fig. 3. Continued.

Appendix 1. "The Sarvard Plan"

SHRIMP

The challenge for shrimp fishery management:
- to predict the abundance and to timely adjust the TAC to avoid over and under exploitation

To meet this challenge, we need:
- to follow closely the fluctuations of abundance of a shrimp population
- to identify cohorts
- to understand the behavior of a cohort
- to understand the behavior of the population
- to recognize the signs of an overexploitation
- to determine the optimal level of exploitation

In order to obtain these informations, we should go beyong the usual population monitoring and undertake a comprehensive research program aimed at:
- following a population on many years so that some cohorts are monitored during their whole life and their response to different population densities or different environmental conditions are assessed; to do so we need to determine an area, find the limits of the shrimp distribution and visit regularly all sites where a cohort could spend its life (from post-larvae to multiparous females)
- measuring the environment conditions (water mass parameters, competition and/or predation from other species)
- determining tolerance of shrimp to different water conditions by undertaking tank experiments (controled environment)
- determining the response of shrimp (growth, sex change, fertility, condition, survival) to different population densities by undertaking tank experiments

A comprehensive study should give answers to:
- why do shrimp appears in areas or sites where there were none (or so little) before
- why do the appear to spread their distribution
- why do they seem to change their age or size at sex change
- why do they experience changes in their vertical migration pattern so that the availibilty to fishing gear seems to have changed
- why do they produce huge cohorts from time to time
- what seems to be the minimum spawning stock biomass
- what would be the optimal exploitation rate

The difficulties in undertaking a research program of this scale come from the fact that nobody has all the expertise, the time or the money. The solution resides in a joint effort where each participant offers different but complementary expertise.

Such a study would need regular sampling at sea with different gears (to be able to catch different development stages). Also, tank experiment should give answers to what is observed on the field where no variable could be controled. This approach, sampling at sea - tank experiments, has

Appendix 1. Continued..

proven to be very useful for the cod physiology research program and certainly deserves to be considered. Also, the results of such research programs based on this approach could be directly applied to other shrimp populations in other areas. The theoritical answers are measured in a controled environment; then the behavior of a shrimp poluation could be determined in relation to the local conditions.

The planification of a multiyear study
... take time

- to define the hypothesis that sustains the research program
- to orientate the projects towards the solution of the hypothesis
- to find the right expertise to define and do the projects
- to plan the work over many years with clear objectives and schedule
- to find money and to obtain the support for the duration of the research program

As a group, we could
- choose aspect or expertise each of us want to represent
- identify and obtain support from scientist for the expertise
- arrange meetings to allow indepth discussions between scientists and the identification of hypothesis
- summarize the discussions, put the ideas together, make the link between the hypothesis and the vital information needed for a better management of shrimp fisheries
- write the workplan of the program, present it to the authorities, obtain their support
- present the program to the fishing industry and obtain their support