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Standardized CPUE indices for Shrimp (*Pandalus borealis*) in Division 3M (Flemish Cap) 1993-2003

by

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Abstract

With the purpose of tracking the status of the Flemish cap shrimp stock a standardized catch per unit effort (CPUE) indices is carried out based on a standard six nation data set. The results are that the index declined from 1993 to 1994 and was at low levels until 1997. From 1998 it gradually increased to 2003 and is now above the index in 1993.

Introduction

A standardized catch per unit effort (CPUE) model is fitted for the shrimp stock on Flemish Cap. It can possibly be used as an indicator of stock change over time. The model takes into account changes in catch rate due to seasonality, individual vessels and gear type (single, double or triple).

Material and Methods

A standardized dataset, consisting of data from Canada, the Faroe Islands, Greenland, Iceland, Norway and Russia from 1993 to 2002, exists. Data from Iceland and Greenland for the year 2003 was added to it. All data from Norway were extracted from the standardized dataset as a new datafile was provided from Norway, which was then added to the datafile. Data were selected from the standardized datafile where catch > 0 kg and/or effort > 10 hours.

As it was not possible to split the Norwegian estimated catches on single, double or triple trawl before 1999, Norwegian data before 1999 are not used in this analysis. A summary table was made from this data (Table 1). A table showing the number of data records used in the model by year and country was also made (Table 2). Next it was tested whether the data had constant variance. This is done by plotting standard errors versus mean CPUE (Smith and Showell, 1996) and fitting a line through the points (Fig. 1). Since the coefficient of variance was constant (Table 3) a gamma distribution can be used. It should be mentioned that the log-normal distribution requires it also. As area is not defined in the Norwegian data and it has been noticed that area is not important to the regression (Gudmundsdottir, 2003) area it not used in the regression. CPUE is modelled against year, vessel, month and gear, by using the Generalized Linear Model function *glm* in S-plus (version 6). The family parameter is set as Gamma and the modelled cpue is log-linked. Effort is used as the weighting factor. The model is standardized to data from 1993, June, single trawl and Icelandic data.

Results

Some results from the model fit are shown in Table 4. Standard S-plus diagnostic plots for the fit are shown in Fig. 2. From the deviance residuals plots it can been seen that the right link function as well as the assumed variance function has been chosen. But there are outliers in the model. Therefore data with the deviance residuals >= 10 were excluded and the model fit again. The results from the new model are shown in Table 5 and the diagnostic plots in Fig. 3. The residual deviance has reduced and the left tail of the Normal quantile plot of the Pearsons residuals also fits better. The right tail is still broad but inspite of it this model is considered better then the model with all data included. The resulting index is shown in Table 6 and Fig. 4. The index declined from 1993 to 1994 and were at low levels until 1997. From 1998 it gradually increased and in 2003 it is above the index in 1993. All year index values except 2003 were significantly different (P<0.05) from zero.

References

Gudmundsdottir, A. 2003. A short note on modelling in S-plus the standardized CPUE for Northern Shrimp (*Pandalus borealis*) in Division 3M.

Smith, S.J. and M.A. Showell. 1996. Analysis of catch-per-unif effort data for ScotianShelf silver hake, 1977-95. *NAFO SCR Doc.*, 96/17, Serial No.2690, 8p.

Statistical models in S. Chambers, J.M., and Hastie, T.J. 1992. Wadsworth & Brooks/Cole Advanced Books & Software. Pacific Grove, California.

*S-PLUS 4 Guide to Statistics,*Data Analysis Products Division, MathSoft, Seattle.

Table 1. Analyses about the CPUE data.

Year	Number of obs.	Mean cpue	Std. dev.	Minimum	Maximum
1993	170	386.2746	147.7421	92.81818	894.5000
1994	130	246.4198	126.2234	10.37500	720.8765
1995	362	276.7768	141.3902	38.14345	1181.9231
1996	863	229.4332	116.9914	45.23596	847.5866
1997	365	284.8268	99.6234	44.30877	602.2971
1998	316	377.0577	147.2426	34.38776	1315.7314
1999	348	382.8243	148.6931	35.25763	851.3818
2000	316	447.8508	162.1424	47.95910	1185.8592
2001	274	413.7121	141.1518	59.23077	976.8994
2002	172	503.3756	165.2182	123.88060	944.8406
2003	77	768.7821	233.8626	334.13953	1448.8382

Table 2. Number of datarecords which are used in the modelfit by year and country.

Year	ICE	CAN	FRO	GRL	NOR	RUS
1993	41	54	0	75	0	0
1994	48	38	0	44	0	0
1995	171	54	87	37	0	13
1996	469	27	236	30	0	101
1997	152	19	176	7	0	11
1998	131	17	154	14	0	0
1999	164	11	119	8	20	26
2000	108	8	121	25	19	35
2001	126	8	0	0	75	65
2002	69	0	0	15	63	25
2003	23	0	0	13	41	0

Table 3. Result of fitting standard error versus mean cpue.

```
Call: lm(formula = cpue.std ~ cpue.mean, data = tab)
Residuals:
    Min     1Q Median    3Q  Max
 -25.68 -2.862  2.317 4.538 17.8

Coefficients:
             Value Std. Error t value Pr(>|t|)
(Intercept) 64.7136 10.4554     6.1895  0.0002
  cpue.mean  0.2127  0.0250     8.5120  0.0000

Residual standard error: 12 on 9 degrees of freedom
Multiple R-Squared: 0.8895
F-statistic: 72.45 on 1 and 9 degrees of freedom, the p-value is 0.00001344

Correlation of Coefficients:
          (Intercept)
cpue.mean -0.9382
```

Table 4. Results from the multiplicative model. The ship factors are not shown.

```
Call: glm(formula = cpue ~ factor(year) + factor(ship.nr) + factor(month.nr) +
factor(gear), family = Gamma(link = log), data = reg.data, weights = effort)

Deviance Residuals:
       Min       1Q     Median       3Q      Max
 -32.08557 -1.77068 -0.3275766 1.230795 14.36222

Coefficients:
```

	Value	Std.Error	t.value
(Intercept)	6.41552146	0.04592784	139.686996
factor(year)1994	-0.53678637	0.03777521	-14.210018
factor(year)1995	-0.36591260	0.03822907	-9.571580
factor(year)1996	-0.47981446	0.03845309	-12.477917
factor(year)1997	-0.49196320	0.03956348	-12.434780
factor(year)1998	-0.23048656	0.04054565	-5.684618
factor(year)1999	-0.20193769	0.04032721	-5.007480
factor(year)2000	-0.07285528	0.04079848	-1.785735
factor(year)2001	-0.09640602	0.04402039	-2.190031
factor(year)2002	-0.08202613	0.04650947	-1.763644
factor(year)2003	0.09662968	0.05248256	1.841177
factor(month.nr)2	-0.100561297	0.04495169	-2.23709709
factor(month.nr)3	0.017002017	0.03638368	0.46729784
factor(month.nr)4	-0.007954603	0.02125625	-0.37422421
factor(month.nr)5	-0.056802981	0.01787436	-3.17790365
factor(month.nr)6	-0.04397154	0.01595103	-2.756659
factor(month.nr)7	-0.06724543	0.01497182	-4.491468
factor(month.nr)8	-0.17278630	0.01739458	-9.933340
factor(month.nr)9	-0.23242151	0.01828392	-12.711799
factor(month.nr)10	-0.25194793	0.01987592	-12.676039
factor(month.nr)11	-0.25980087	0.02251117	-11.540975
factor(month.nr)12	-0.17779423	0.03327598	-5.343020
factor(gear)2	0.15878587	0.01976543	8.033516
factor(gear)3	0.11836665	0.08144272	1.453373

```
(Dispersion Parameter for Gamma family taken to be 9.11433 )

    Null Deviance: 136584.4 on 3392 degrees of freedom

Residual Deviance: 31787.5 on 3223 degrees of freedom

Number of Fisher Scoring Iterations: 4
```

Table 5. Results from the multiplicative model, when outliers had been removed. The ship factors are not shown.

```
Call: glm(formula = cpue ~ factor(year) + factor(ship.nr) + factor(month.nr) +
factor(gear), family = Gamma(link = log), data = new.reg.data, weights = effort)

Deviance Residuals:
       Min         1Q     Median       3Q      Max
 -11.46354 -1.761924 -0.3419124 1.131025 10.52905

Coefficients:
```

	Value	Std.Error	t.value
(Intercept)	6.41064349	0.03962334	161.7895803
factor(year)1994	-0.54621076	0.03259611	-16.7569286
factor(year)1995	-0.36096513	0.03297050	-10.9481240
factor(year)1996	-0.47846985	0.03314217	-14.4368882
factor(year)1997	-0.43477862	0.03429180	-12.6787926
factor(year)1998	-0.22501138	0.03500327	-6.4282958
factor(year)1999	-0.18691701	0.03489525	-5.3565166
factor(year)2000	-0.08952019	0.03533514	-2.5334609
factor(year)2001	-0.09795464	0.03799331	-2.5782075
factor(year)2002	-0.08511081	0.04013320	-2.1207084
factor(year)2003	0.08837600	0.04527728	1.9518842
factor(month.nr)2	-0.103286049	0.03868285	-2.67007351
factor(month.nr)3	-0.011756324	0.03177361	-0.37000279
factor(month.nr)4	-0.007174768	0.01852824	-0.38723417
factor(month.nr)5	-0.052889916	0.01564243	-3.38118233
factor(month.nr)6	-0.04300495	0.01395247	-3.082247
factor(month.nr)7	-0.07319174	0.01300798	-5.626682
factor(month.nr)8	-0.16855763	0.01523641	-11.062822
factor(month.nr)9	-0.23503130	0.01591887	-14.764319
factor(month.nr)10	-0.27092838	0.01723310	-15.721398
factor(month.nr)11	-0.26818433	0.01943117	-13.801758
factor(month.nr)12	-0.18560135	0.02865940	-6.476107
factor(gear)2	0.17087146	0.01713362	9.972878
factor(gear)3	0.12376155	0.07004939	1.766776

```
(Dispersion Parameter for Gamma family taken to be 6.737619 )

    Null Deviance: 123713.1 on 3357 degrees of freedom

Residual Deviance: 21712.02 on 3188 degrees of freedom

Number of Fisher Scoring Iterations: 3
```

Table 6. CPUE index by year and the approximate 95 percent confidence limits.

year	index	upper 95% conf. limits	lower 95% conf. limits
1993	1.0000000	1.0000000	1.0000000
1994	0.5791402	0.6173480	0.5432970
1995	0.6970033	0.7435324	0.6533859
1996	0.6197309	0.6613241	0.5807537
1997	0.6474080	0.6924171	0.6053245
1998	0.7985071	0.8552128	0.7455614
1999	0.8295126	0.8882320	0.7746750
2000	0.9143698	0.9799406	0.8531865
2001	0.9066900	0.9767859	0.8416243
2002	0.9184105	0.9935710	0.8489357
2003	1.0923988	1.1937737	0.9996326

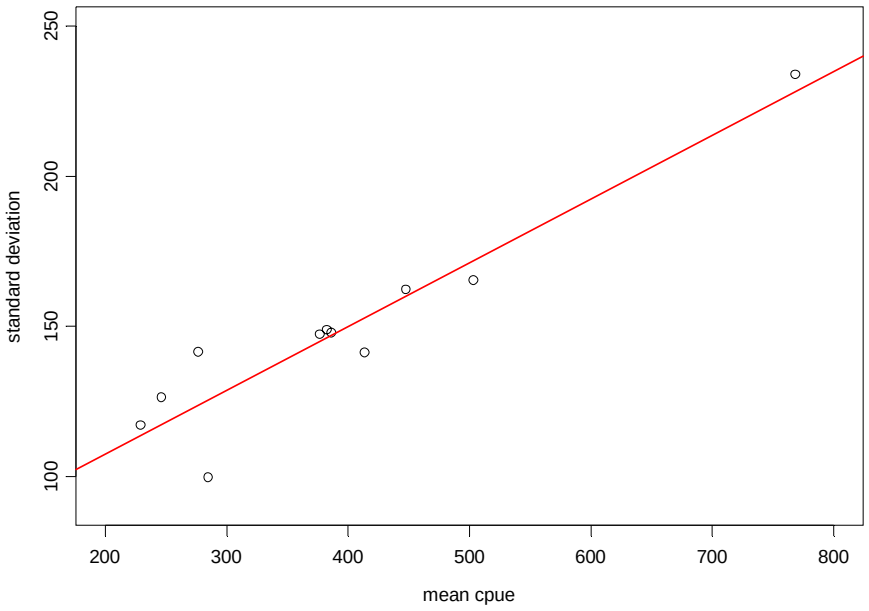

Fig. 1. Coefficient of variation around the annual mean CPUE. The point with the highest mean cpue value is the 2003 datapoint.

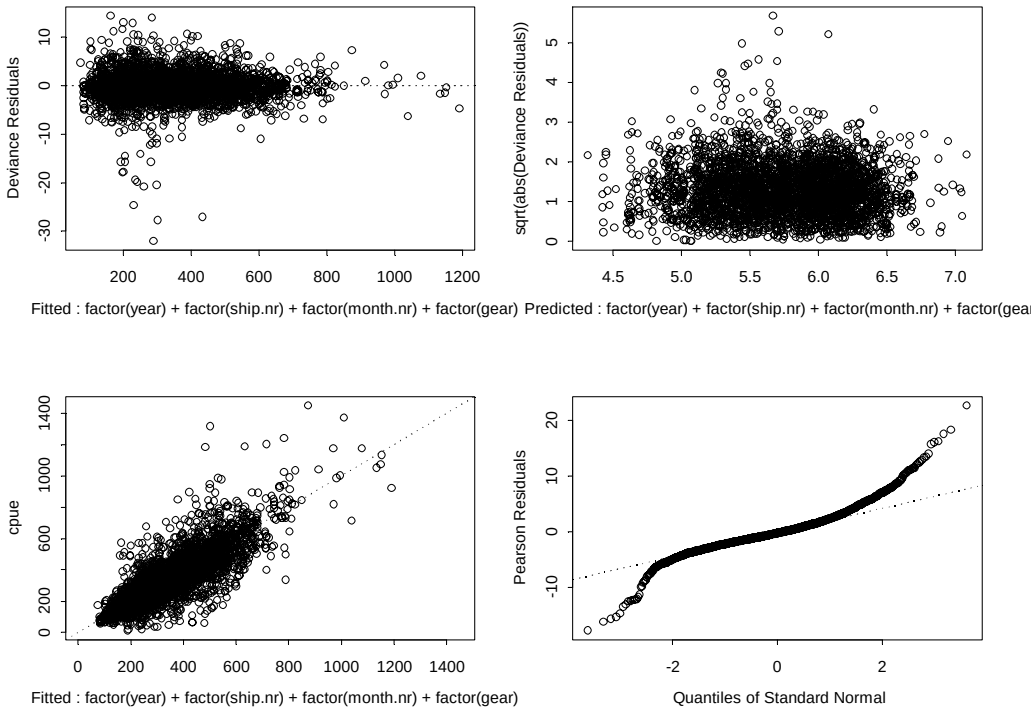

Fig. 2. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear.

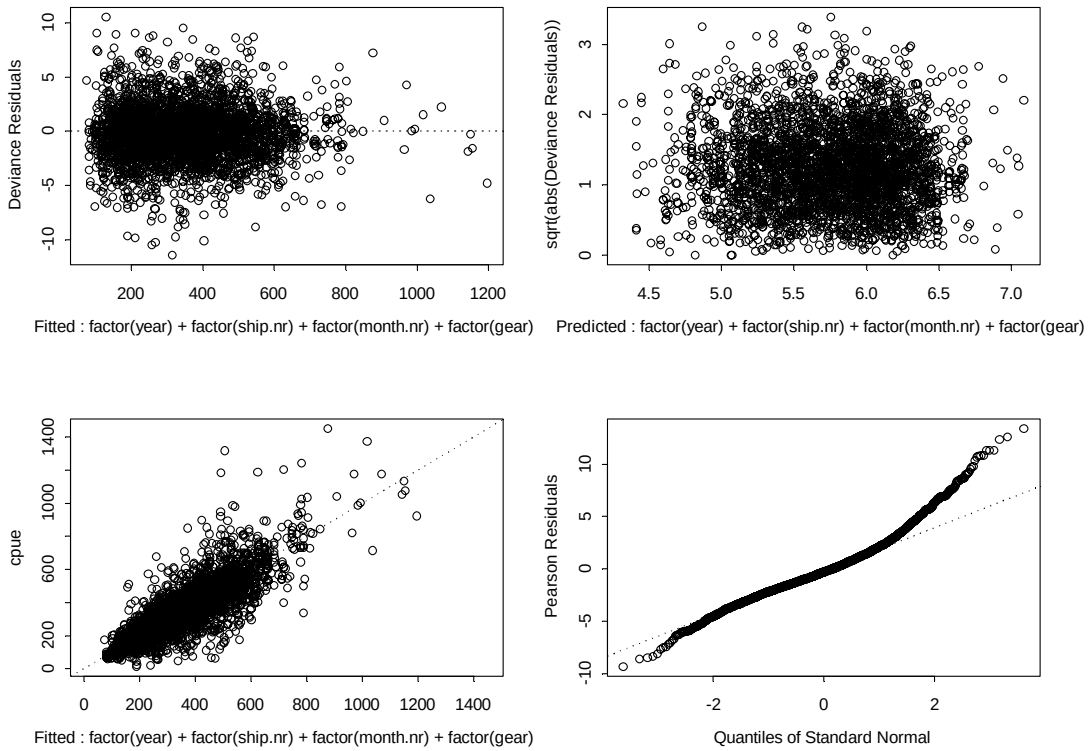

Fig. 3. Plots of the generalized linear model of CPUE predicted by year, vessel, month and gear, when outliers had been removed from the data.

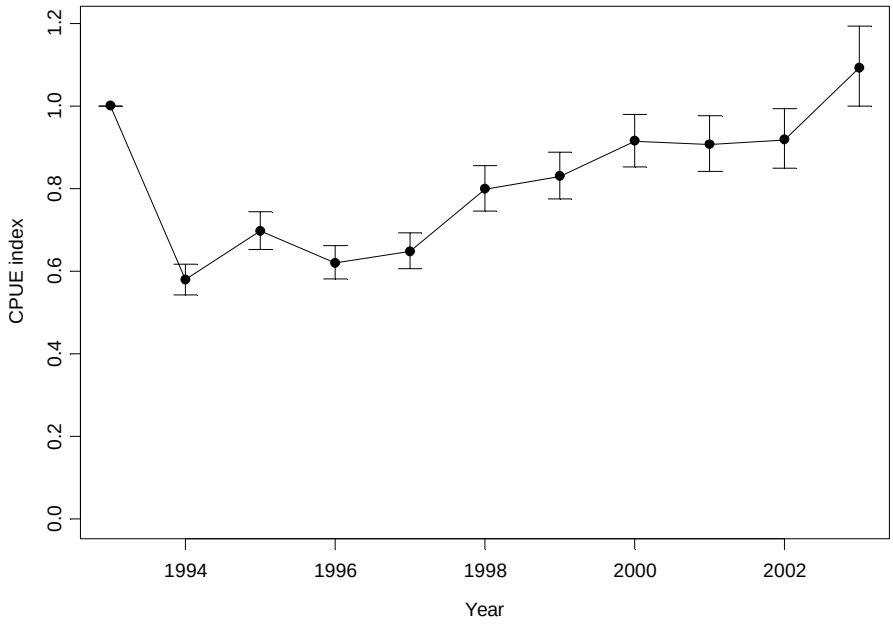

Fig. 4. The modelled CPUE index with approximate 95% confidence limits.