Northwest Atlantic Fisheries Organization

Serial No. N5534 **NAFO SCR Doc. 08/33**

SCIENTIFIC COUNCIL MEETING – JUNE 2008

A Revised ASPIC Based Assessment of Redfish in NAFO Divisions 3LN

by

A. M. Ávila de Melo [1], R. Duarte [1], D. Power [2], and R. Alpoim [1]

[1] Instituto Nacional de Recursos Biológicos (INRB/IPIMAR)
Av. Brasília 1449-006, Lisboa, Portugal

[2] Science, Oceans and Environment Branch, Department of Fisheries and Oceans
P. O. Box 5667, St. John's, NL, Canada A1C 5X1

Abstract

There are two species of redfish in Divisions 3L and 3N, the deep-sea redfish (*Sebastes mentella)* and the Acadian redfish (*Sebastes fasciatus*) that have been commercially fished and reported collectively as redfish in fishery statistics. Redfish in Div. 3LN is regarded as a management unit composed of two Grand Bank populations from those two very similar redfish species. The present assessment is based on the results of a non-equilibrium surplus production model (ASPIC Prager, 1994, 2004 and 2007), adjusted to a standardized catch rate series (Power, 1997) and to most of the stratified-random bottom trawl surveys conducted by Canada and Russia in various years and seasons in Div. 3L and Div. 3N, from 1978 onwards. All input series consist of annual observed values and were given equal weight in the analysis. As regards Canadian surveys, only Campelen data and Engel data converted into Campelen equivalents are used in this assessment.

The assessment was preceded by an exploratory analysis with different data formulations derived from the available data series, and a sensitive and retrospective analysis with the chosen input formulation. The assessment was then carried out with ASPIC on bootstrap mode (1000 trials based on the random re-sampling of *cpue* and survey log residuals) giving bias corrected estimates of model parameters, relative biomass (B/B_{msy}) and relative fishing mortality (F/F_{msy}) trajectories, with associated 50% and 80% confidence intervals. Biomass and fishing mortality rates were finally projected (2008-2012/2013) under a low constant catch regime (5000 ton). The stock trajectory related to the surplus production analysis shows a biomass rapidly declining to bellow B_{msy} when fishing mortality rate rises from just above to well above F_{msy} (1986-1987), and a biomass rapidly returning to above B_{msy} after fishing mortality drops to well bellow F_{msy} (1993-1994). A constant catch level of 5000 ton will keep the redfish in Div. 3LN in its present safe zone, with the lower 80% CL of relative biomass well above the B_{msy} level and the upper 80% CL of relative fishing mortality rate well bellow the F_{msy} level. Finally, in order to test if these projection results are robust or if they might be affected by differences on results from previous assessment, the same projection exercise was performed starting one year earlier (2007). Regardless the retrospective bias between the two assessments both runs shown the stock at the same high level relative to B_{msy} , five-six years after the reopening of a directed fishery at a small scale of 5000 ton.

Introduction

There are two species of the genus *Sebastes* that have been commercially fished in Div. 3LN, the deep sea redfish (*Sebastes mentella)*, with a maximum abundance at depths greater than 300m, and Acadian redfish (*Sebastes fasciatus*), preferring shallower waters of less than 400m. Due to their external resemblance *S. mentella* and *S. fasciatus* are commonly designated as beaked redfish.

Beaked redfish are viviparous with the larvae eclosion occurring right before or after birth, long living and slow growing, with females attaining size of 50% maturity at 30-34cm (Power, 2001). Both species have pelagic and demersal concentrations as well as a long recruitment process to the bottom. Their external characteristics are very similar, making them difficult to distinguish, and as a consequence they are reported collectively as “redfish” in the commercial fishery statistics. For the same reason *S. mentella* and *S. fasciatus* are treated as a single species in the Grand Bank surveys carried out by Canada, Russia and more recently by EU-Spain.

This redfish assessment regards the beaked redfish in Div. 3LN as a management unit composed of two Grand Bank fish populations of two very similar species. Nevertheless, it is accepted that in this management unit *S. mentella* is the dominant population, representing almost 100% of the commercial catch and the major proportion of the exploitable redfish biomass in Divisions 3L and 3N.

The 2007 assessment (Ávila de Melo *et al.*, 2007) was based on a non-equilibrium surplus production model (ASPIC Prager, 1994, 2004 and 2007), adjusted to a standardized catch rate series (Power, 1997) and two series of stratified bottom trawl surveys on Div. 3L and Div. 3N, covering from 1991 onwards almost the entire area of redfish distribution in north and south east Grand Bank. The assessment was preceded by an exploratory analysis of different data formulations derived from the available data series, using a traffic light framework to evaluate the diagnostics of the ASPIC runs. In order to reduce non explained variability and improve the fit of the ASPIC model to the available biomass indices two different categories of the data set formulations were considered: one based on the original annual values of each biomass index and the other where the annual values were smoothed by 3-year moving averages. The results of the exploratory analysis lead to the conclusion that the use of moving average formulations allowed a better ASPIC FIT than the one with the observed annual data series. So the moving average formulation incorporating both CPUE and spring and autumn survey series in their full extension was the one chosen to pursue with last year assessment.

STACFIS recognized ASPIC as a useful tool to carry out an analytic assessment of the 3LN redfish stock (NAFO 2007), but didn’t accept the 2007 assessment based on two major concerns regarding the chosen input formulation:

“*Regardless of the wide inter-annual variability of the observed CPUE and survey data and poorer fit of the model, the original values of each biomass index provide very similar results namely as regards relative biomass and fishing mortality trajectories and should be used instead of moving averages;*

From the early 1980s to the beginning of the 1990s, when catches were quickly raised from a previous average level of 21 000 tons (1965-1985) to a much higher average level of 41 500 tons (1986-1992), including a peak of 79 000 tons in 1987, available survey data from Canadian summer survey on Div. 3L (1978-1979, 1981, 1984-1985, 1990-1991 and 1993) and Russian trawl survey on Div. 3LN (1983-1993) suggests that stock size suffered a substantial reduction. However throughout this period stock dynamics from ASPIC basically rely on the CPUE series. In order to capture the full extent of this former stock decline ASPIC input should include the observed biomass indices from the two above mentioned survey series.

Therefore, STACFIS recommends that a revised ASPIC model utilizing (1) the original values of cpue and survey indices and (2) incorporating additional Canadian 3L summer and Russian 3LN survey series be evaluated during the interim assessment of redfish in Div. 3LN at the June 2008 Scientific Council meeting”.

The present assessment goes beyond the 2007 STACFIS guidelines, incorporating most of the survey biomass indices available for this redfish stock, not only from the Canadian summer survey on Div. 3L and Russian bottom trawl survey on Div. 3LN, but also from the Canadian winter and autumn surveys on Div. 3L, with all input series presented as annual observed data.

Nominal catches and TAC's

Reported catches from Div. 3LN declined from 45 000 to 10 000 ton on the first years of catch records (1959-1964) and oscillated over 21 years afterwards (1965-1985) around 21 000 tons average level. Catches increased sharply to a 79,000 tons high in 1987 and fall steadily afterwards to 450 tons in 1996. From 1986 till 1993 reported catches exceeded TAC's, but in the rest of the years prior to the close of the fishery catches fell well bellow annual TAC's. The NAFO Fisheries Commission implemented a moratorium on directed fishing for this stock since in 1998.

Catch increased to 900 tons in 1998, the first year under a moratorium on directed fishing, with a further increase to 3 100 tons in 2000. Catches declined in 2001-2003 and were stable in 2004-2005 at 650 tons level. Catch almost reached the historic low level in 2006 with 496 tons, but recorded over a tree times fold increase in the final year, with a STACFIS catch estimate of 1664 tons (Table 1, Fig. 1).

Description of the fishery

In the early 1980's the former USSR, Cuba and Canada were the primary fleets directing for redfish in Div. 3LN. The rapid expansion of the fishery was due to the entry of EU-Portugal in 1986 and South Korea in 1987, along with various re-flagged fleets. In the early 1990's Russia and the Baltic mid-water trawlers, together with South Korea and Portuguese bottom trawlers, were still responsible for the bulk of fishing effort, concentrated by that time on the "Beothuk Knoll" (Div. 3LMN border, southwest of the Flemish Cap).

South Korea left the area by the end of 1993 and from 1994 onwards the other fleets reduced effort substantially on Div. 3LN. The quick decline of redfish catch rates was the main reason for this reduction of redfish fishing effort, and justified its partial shift southeast to Div. 3O. Since 1994 most of the redfish catches in NAFO Divisions 3L and 3N were taken as by-catch of the Greenland halibut fishery pursued from the northern slopes of the Sackville Spur in Div. 3L through Flemish Pass till the canyons of northern Grand Bank in Div. 3N. The EU-Spain and EU-Portugal bottom- trawl fleets became the main fleets responsible for the 3LN redfish by-catch over moratorium years, with EU Portugal recently taking most of the by-catch (2006 and 2007).

Commercial Fishery Data

Catch and Effort

On the 1997 assessment (Power, 1997) catch/effort data for Div. 3L and Div. 3N from 1959 to 1995 were analyzed with a multiplicative model (Gavaris, 1980) in order to derive a catch rate series for each division standardized for country-gear-tonnage class, NAFO division, month, and amount of by-catch associated with each observation. Both CPUE series shows much within year variability over time, with no statistically difference between the catch rates for most of the years. The assessment considered that catch rate indices for Div. 3L and Div. 3N were not reflective of year to year changes in population abundance but they may be indicative of trends/patterns over longer periods of time.

This assessment recovers the predicted effort series in fishing hours for Div. 3L and Div. 3N from the 1997 multivariate analysis, in order to derive a single annual catch rate for Div. 3LN: for each year of the 1959-1994 interval this standardized catch rate is given by the ratio between the sum of Div. 3L and Div. 3N STATLANT catch (thousand tons) and the sum of Div. 3L and Div. 3N predicted effort (fishing hours) (Table 2). Annual catch rate for Div. 3LN was finally scaled (difference between each observation and the mean, scaled to the standard deviation of the series) in order to be presented on Fig. 2. Catch rates for Div. 3LN were above average from 1959 till 1965, increasing on the first years of the time series, oscillate around the average on the intermediate years and start declining from 1987 onwards. On the final years, 1990-1994, catch rates were stable at a minimum level well bellow average.

Commercial fishery sampling

Most of the commercial length sampling data available for the 3LN beaked redfish stocks came, since 1990, from the Portuguese fisheries and has been annually included in the Portuguese research reports on the NAFO SCS Document series (Vargas *et al.*, 2008). Taking into account that the majority of the length sampling was from depths greater than 400m, these data should represent *S. mentella* catches. Length sampling data from Spain and Russia were used to estimate the length composition of the commercial catches for those fleets in 2003-2005 and 2003-2007 respectively (González *et al*., 2006; Vaskov *et al*., 2008). The 1990-2007 per mille length composition of the Portuguese trawl catch was applied to the rest of the commercial catches (Table 3a). In all cases the 3LN beaked redfish length weight relationships, used to compute each absolute length frequency vector of the 3LN redfish commercial catch (Table 3b), were derived from individual length /weight observations collected annually through the sampling on board of the Portuguese by-catches from both Divisions 3L and 3N (Alpoim and Vargas, 2004; Vargas *et al.*, 2008). The 1998 length weight relationship was applied to the previous years, back to 1990.

The annual mean length of the catch was calculated as a weighted mean of catch numbers at length for each year (Table 3a). The overall mean length of the 1990-2007 catch (arithmetic mean of the annual mean lengths of the commercial catch) was used to derive the anomalies in the mean length on the 3LN beaked redfish commercial catch over this period (Table 3a, Fig. 3). The proportion of small redfish (less than 20cm) in the catch is presented as well, in Table 3a. The purpose of the first exercise (length anomalies) was to detect eventual shifts in the length structure of the commercial catch or by-catch that could reflect changes in the exploitable stock structure. As for the second exercise (proportion of small redfish), a sudden and important increase on the proportion of small redfish in the catch could be regarded as signal of the income of a good recruitment.

Stability in the length structure of the catch/by-catch is observed through the 1990-2007 interval, with no clear pattern on length anomalies detected over time (Fig. 3). Higher negative anomalies are coupled with higher proportions of small redfish in 1991, 1998, 2003 and 2006 suggesting the income in those years of above average recruitments to the exploitable stock, from year classes 4-5 years back in time.

Research Surveys

From 1978 till 1990 several stratified-random bottom trawl surveys have been conducted by Canada in various years and seasons in Div. 3L. However only since 1991 Canadian stratified-random surveys covered both Div. 3L and Div. 3N on a regular annual basis: a spring survey (May-Jun.) and an autumn survey (Sep.-Oct. 3N/Nov.-Dec. 3L for most years). The design of the Canadian surveys was based on a stratification scheme down to 732 m for Div. 3LN (Doubleday, 1981). From 1996 onwards the stratification scheme has been updated to include depths down to 1 464 m (800 fathoms) (Bishop, 1994), but only the autumn surveys have swept strata bellow 732 m depth, most on Div. 3L.

Up until the autumn of 1995 the Canadians surveys were conducted with an Engels 145 high lift otter trawl with a small mesh liner (29 mm) in the codend and tows planned for 30 minute duration. Starting with the autumn 1995 survey in Div. 3LN, a Campelen 1800 survey gear was adopted with a 12 mm liner in the codend and 15 minute tows utilizing SCANMAR. A comparison of the generated data with the original Engel data suggested overall trends in abundance were the same except that the relative measure of abundance estimated for the Campelen trawl conversions were higher (Power and Parsons, 1998).

According to the headers on the original spreadsheets with Canadian survey abundance and biomass data, all surveys on Div. 3L have Engel data converted into Campelen equivalents from 1985 onwards with the exception of the spring survey (conversion since 1980). However for the summer survey the first year of conversion of Engel data remains unclear, since the same figures for the years prior to 1985 on the original spreadsheet with the Canadian summer survey data had been published as Campelen trawl equivalent units as well (Power and Parsons, 1999). So, two alternate series of biomass indices are considered in the assessment for the Canadian summer survey in Div. 3L, one starting in 1978 and the other in 1985.

Abundance and biomass indices have been converted into Campelen equivalents since the start of Canadian surveys on Div. 3N, in 1991. Campelen equivalent data series extended till 1994 (autumn surveys in Div. 3L and Div. 3N) or 1995 (spring surveys in Div. 3L and Div. 3N) and are coupled with the following original Campelen series starting since then. No spring survey was carried out in 2006 on Div. 3N. As regards Canadian surveys, only Campelen data and Engel data converted into Campelen equivalents are used in this assessment.

Since 1983 Russian bottom trawl surveys in NAFO Div. 3LMNO turn to stratified-random, following the above mentioned Canadian stratification for Sub area 3. On 1984 standard tows were set to half hour at 3.5 knots, with a standard gear. From 1984 till 1990, vessels conducting this survey were of the same tonnage class (the BRMT series) with the exception of 1985, when a vessel of smaller tonnage class (PST series) was employed. This smaller category was later employed on the 1991 and 1993 surveys. On 1992 and 1994 no survey was carried out in Div. 3N. On 1995 the Russian bottom trawl series in NAFO Sub area 3 was discontinued (Bulatova *et al.*, 1997).

On 1992 redfish results of the 1984-1991 stratified-random surveys in Div. 3LN by Russia were revised according to standard methodology (Power and Vaskov, 1992).Mean number and mean weight per standard tow were estimated from successful sets only, each tow being adjusted to 1.8 n mi. distance before analysis. Overall mean estimates by year and division were derived from the respective means by strata (weighted by the stratum area) and presented with associated 95% CI's. Survey abundance and survey biomass are finally tabulated by year and division. However in 1994, a Russian research document presents new figures for redfish bottom survey abundance and biomass from the same Russian survey series in Div. 3LN (1984-1991, plus the results of the 1993 survey) (Vaskov, 1994). No details are given regarding the method and the strata used to derive these new figures. The two series (Power, 1984-1991; Vaskov, 1984-1991 and 1993) are considered as alternate biomass indices for Div. 3LN combined from Russian stratified-random surveys.

All the available survey biomass results from the Canadian and Russian stratified-random bottom trawl surveys are presented in Table 4. About 96% of the available biomass data are included in the exploratory analysis preceding the assessment and 88% incorporated in the final framework of the ASPIC assessment.

In 1995 EU-Spain started a new stratified-random bottom trawl spring (May-June) survey on NAFO Regulatory Area of Div. 3NO. Despite changes on the depth contour of the survey, all strata in the NRA till 732m were covered every year, following the standard stratification. From 1998 onwards the Spanish survey was extended to 1464 m (with the exception of 2001, with 1116m depth limit) and in 2004 expanded to the Regulatory Area of Div. 3L. From 1995 till 2000 the survey was carried out by the Spanish stern trawler *C/V Playa de Menduiña* using a *Pedreira* bottom trawl net. In 2001 the *R/V Vizconde de Eza*, trawling with a *Campelen* net, replaced the commercial stern trawler. In order to maintain the data series obtained since 1995, comparative fishing trials were conducted in spring 2001 to develop conversion factors between the two fishing vessel and gear combinations. Former American plaice and Greenland halibut survey indices from C/V *Playa de Menduíña* were transformed to R/V *Vizconde de Eza* units (*González et al.*, 2004), but so far this exercise has not been carried out for beaked redfish. That is the main reason why the Spanish survey data are not yet included in the assessment suite.

Survey biomass and female spawning biomass

All available survey biomass results from the Canadian and Russian stratified-random bottom trawl surveys are presented in Table 4. About 96% of these biomass data are included in the exploratory analysis preceding the assessment and 88% incorporated in the final framework of the ASPIC assessment.

The 1991-2007 spring and autumn survey indices for Div. 3LN combined (biomass and female SSB) are also presented on Table 4. Biomass indices for redfish, derived either from commercial or survey catch rates, typically show large inter-annual variability, too drastic to be only explained by changes in stock abundance from one year to the next. These fluctuations are caused not only by the schooling behaviour of redfish, but also by a wide and "non-uniform" distribution within their geographical and depth limits (all redfish species present both demersal and pelagic concentrations). That is why it is generally accepted that a redfish biomass index represents better a stock trajectory on the long term than the stock size on a short term basis. In order to smooth the wide inter annual variability of the indices, turn the survey series comparable and facilitate the detection of trends within stock dynamics, the survey biomass series used in the assessment and the female SSB survey series were standardized (difference between each observation and the mean scaled to the standard deviations of the series) and so presented on Figure 4a and 4b. From the mid 1980s to the beginning of the 1990s, when catches quickly raised from a previous average level of 21 000 tons (1965-1985) to a much higher level of 41 500 tons (1986-1992), Canadian survey data in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggests that stock size suffered a substantial reduction. Redfish survey bottom biomass in Div. 3LN remained bellow the average level until 1998 and increase to above average level afterwards. A punctual decline is observed in 2002-2004, followed by a consistent increase of the remaining biomass indices over the most recent years.

In order to estimate spring and autumn female spawning survey biomass by division, Div. 3L and Div. 3N female proportion and maturity at length vectors (Power 2001; Ávila de Melo et al., 2005) were applied to the respective 1991-2007 spring and autumn survey abundances at length. Female spawners and stock abundance at length by division were used to calculate female spawning and stock biomass for Div. 3L and Div. 3N as sum of products (SOP), using the 3M *Sebastes sp.* annual length weight relationships (Ávila de Melo et al., 2007). The SOP ratios (SSB/stock biomass) by division were then applied to the respective swept area survey biomasses to give estimates of the 1991-2007 spring and autumn female SSB in Div. 3L and Div. 3N. Finally the sum of these two indices for each survey series gave the spring and autumn female spawning biomass for Div. 3LN combined.

The 1991-2007 standardized female SSB series showed patterns similar to correspondent total survey biomass series over the years, with all observations bellow average before 1998 and most above average afterwards (Fig.4b).

Abundance at length

Spring and autumn survey abundance at length, for Div. 3LN combined, are presented in Table 5a and 5b. Survey abundance at length for each division, year and survey is derived from the correspondent mean number per tow at length, expanded to the survey abundance estimated by the swept area method. The overall 1991-2007 mean length for each survey series (arithmetic mean of the annual mean lengths of the survey abundances at length) was used to derive the spring and autumn survey length anomalies for the stock over this period (Table 5a and 5b, Fig. 5a and 5b). On both survey series all/most of the anomalies during the first half of the 1990's were negative while all were positive between 1996 and 2000. This shift on the survey catch length structure to larger individuals could reflect a relatively high survival of the year classes through the second half of the 1990's. From 2001 onwards length anomalies are either positive or negative with no clear pattern on the spring survey, whereas on the autumn survey most became closer to the overall mean. The lack of a clear pattern on length residuals from both surveys suggests stability on population structure over recent years. With the exception of 1991 and 1992 on the autumn survey, when a couple of large negative residuals are observed probably as a consequence of a pulse on recruitment from the late 1980's, no further signs of other pulses on recruitment are detected.

ASPIC assessment suite

A non-equilibrium surplus production model (ASPIC; Prager, 1994, 2004 and 2007) was used to assess the status of the stock. The model was adjusted to the STACFIS catches (1959-2007, with catches conditioned on *cpue* series) and to the following

Input series:

I1 (Statlant CPUE)	Standardized cpue for Div. 3LN,$_{1959\text{-}1994}$
I2 (3LN spring survey)	Canadian spring survey biomass for Div. 3LN, $_{1991\text{-}2005,\ 2007}$
I3 (3LN autumn survey)	Canadian autumn survey biomass for Div. 3LN, $_{1991,\ 1993\text{-}1994,\ 1996\text{-}2007}$
$I4_{Power}$ (3LN Power russian survey)	Russian srping survey biomass for Div. 3LN , $_{1984\text{-}1991}$ (Power and Vaskov,1992) *versus*
$I4_{Vaskov}$ (3LN Vaskov russian survey)	Russian srping survey biomass for Div. 3LN , $_{1984\text{-}1991}$ and 1993 (Vaskov,1994)
I5 (3L winter survey)	Canadian winter survey biomass for Div. 3L, $_{1985\text{-}1986}$ and 1990
I6 (3L summer survey)	Canadian summer survey biomass for Div. 3L, $_{1985,\ 1990\text{-}1991}$and 1993 *versus*
I6 (3L full summer survey)	Canadian summer survey biomass for Div. 3L, $_{1978\text{-}1979,\ 1981,1984\text{-}1985,\ 1990\text{-}1991}$and 1993
I7 (3L autumn survey)	Canadian autumn survey biomass for Div. 3L, $_{1985\text{-}1986,\ 1990\text{-}1994,\ 1996\text{-}2006}$

All input series consist of annual observed values and were given equal weight in the analysis. On the rest of the analysis each Canadian series is referred by its season and division(s), while the Russian series is referred by its country name. The model assumes that all catchability coefficients are constant over time. Because of the imprecision associated with the estimate of catchability for the various indices, absolute estimates of stock size and fishing mortality are normalized to the stock size and fishing mortality at MSY (B_{msy} and F_{msy} respectively). That is why normalized estimates are included in ASPIC output and used in the printer plots trajectories of biomass and fishing mortality. In a production model fishing mortality refers to catch/biomass ratio.

Basic assumptions

In this assessment the ASPIC version 5.16 fit the logistic form of the production model (Schaefer, 1954). Being K the carrying capacity stock biomass, r the intrinsic rate of stock biomass increase, C the catch biomass, MSY and $Bmsy$ the long term yield and biomass associated with $Fmsy$, the model basic assumptions are:

1) A logistic population growth over time of the unexploited stock (Schaefer, 1954)

$$dB_t / dt = rB_t - (r / K)B_t^2 \qquad (1)$$

2) For an exploited stock catch is also incorporated in the population growth

$$dB_t / dt = rB_t - (r / K)B_t^2 - C_t \qquad (2)$$

3) The biological reference points are

a. $$MSY = rK / 4 \qquad (3)$$

b. $$Bmsy = K / 2 \qquad (4)$$

c. $$Fmsy = r / 2 \qquad (5)$$

Starting with user guesses for the key parameters, Initial Biomass (as a ratio to *Bmsy*), *K*, *MSY* and catchability coefficients for each biomass index, ASPIC generate iteratively estimates of expected biomass indices for each series of observed indices. The key parameters of the model are found by a minimization routine for log squared residuals of *cpue* and biomass from each input survey series.

A summary of the ASPIC model (Prager, 1994) can be found on the 2003 assessment of redfish in Div. 3M (Ávila de Melo *et al.*, 2003).

Input file settings

The ASPIC Ver. 5.16 (Prager, 2005) requires from the user a set of initial definitions/starting guess /constraints that have been specified in the input file as follows:

Line 1: Both `FIT` and `BOT` program modes were used. Starting guesses and minimum and maximum bounds were kept constant from FIT to BOT mode.
Line 2: Fit the `LOGISTIC` (Schaefer) model with condition fitting on `YLD` (yield) and SSE (sum of squared errors) as objective function.
Line 4: `1000` Number of bootstrap trials when running on BOT mode.
Line 11: `0d0` No penalty term in objective function for B1>K (biomass on the 1st year of the assessment greater than carrying capacity biomass).
Line 12: 7 data series are to be analyzed as biomass index of the stock (Statlant CPUE, five Canadian and one Russian surveys).
Line 13: `1d0 1d0 1d0 1d0 1d0 1d0 1d0` When computing the objective function the squared residuals of each one of the 7 data series have equal weight.

Line 14: `0.5d0` Starting guess for $B1/K$ = 0.5, the biomass on the 1st year of the assessment is at B_{msy} level.
Line 15: `2.0d4` Starting guess for *MSY* = 20000 ton. Between 1965 and 1985 catches oscillated with no trend around 21000, catch rates declined when catches were raised above that level.
Line 16: `2.000E+05` Starting guess for carrying capacity *K* = 200000 ton, twice the highest observed level of survey biomass (autumn survey average 1998, 2000-2001).
Line 17: `9.007E-06 0.658d0 1.0d0 0.658d0 0.322d0 0.275d0 0 .275d0` Starting guess of catchability for: STATLANT cpue (derived from *q* of Statlant CPUE for Div. 3M redfish ASPIC assessment, Ávila de Melo *et al.* 2003); spring survey in Div. 3LN combined (average size of spring survey biomass relative to autumn survey biomass, 1991-2005); autumn survey in Div. 3LN combined (a conservative guess, assuming that autumn survey biomass is a proxy of absolute stock biomass); Russian survey in Div. 3LN combined (all Russian surveys in Div. 3LMNO were made between March and July, so the same starting guess for catchability as the Canadian spring survey); winter survey in Div. 3L (average spring survey in Div. 3L/Div. 3LN ratio times average spring in Div. 3LN/autumn Div. 3LN ratio); summer and autumn survey in Div. 3L (average autumn survey Div. 3L/Div. 3LN ratio).
Line 18: `1 1 1 1 1 1 1 1 1 1` All key parameters of the model ($B1/K$, *MSY*, *K*, q_{cpue}, $q_{spring3LN}$, $q_{autumn3LN}$, $q_{Russiann3LN}$, $q_{winter3L}$, $q_{summer3L}$ and $q_{autumn3L}$) are estimated by the ASPIC program and not kept constant at the starting guess.
Line 19 and Line 20: minimum and maximum bounds on the estimate of *MSY* (5000-50000 ton) and *K* (100000-500000 ton) respectively. All ASPIC runs on FIT mode gave final estimates of these parameters far from either constraint. The number of bootstrap trials discarded due to parameter estimates falling outside their bounds is minimal.
Line 22: `49` Total number of years in the data sets included in the input file, from 1959 to 2007.

The rest of the settings of the input file were kept with the default options of the ASPIC Ver.5.16. The input file with the formulation used in the assessment, retrospective analysis and projections is presented on Appendix 1.

Exploratory analysis

The 1992 autumn biomass index for Div. 3N and the 1995 autumn index for Div. 3L have anomalously high magnitudes, while staying between relatively low indices from the neighbouring years. The original mean weights per tow have also associated anomalously high errors (highest of each survey series). So survey biomass from these years and divisions were considered outliers of the respective survey series and excluded from the analysis.

Due to the short time overlap between *cpue* and surveys in Div. 3LN combined (1991-2007, 4 years on 49 years of data) the assessment assumes that *cpue* time series, Russian survey and 3L summer and winter surveys basically represent the abundance of the stock during the former period prior to 1990, while 3L autumn survey and surveys in Div. 3LN combined basically represent the abundance of the stock during the more recent period of the 1990's and 2000's. With such a short time overlap, the two pair-wise negative correlations found among STATLANT cpue and the survey series for Div. 3LN combined, each series based on just four pairs of observations, have been disqualified to halt the ASPIC assessment. Therefore only negative correlations between the model and any of the input series of biomass indices, or between surveys overlapping most of the years, were considered a violation of the fundamental assumption of ASPIC that all indices reflect the abundance dynamics of the stock.

Three $ASPIC_{2008}$ formulations, corresponding to three possible arrangements of the alternate Russian and summer in Div. 3L survey series (see table above), were run on FIT mode in order to explore the goodness of fit of the model under three different input survey data:

$ASPIC_{Power,2008}$	I1 (Statlant CPUE)+I2 (3LN spring survey)+I3 (3LN autumn survey)+I4Power (3LN Power russian survey)+I5 (3L winter survey)+I6 (3L summer survey)+I7(3L autumn survey)
$ASPIC_{Power,fullsummer,2008}$	I1 (Statlant CPUE)+I2 (3LN spring survey)+I3 (3LN autumn survey)+I4Power (3LN Power russian survey)+I5 (3L winter survey)+I6 (3L summer survey full series)+I7(3L autumn survey)
$ASPIC_{Vaskov,2008}$	I1 (Statlant CPUE)+I2 (3LN spring survey)+I3 (3LN autumn survey)+I4Vaskov (3LN Vaskov russian survey)+I5 (3L winter survey)+I6 (3L summer survey)+I7(3L autumn survey)

Besides the correlation between alternate Russian and summer series with those which overlap with them, and between ASPIC estimated and observed annual values from each data series (`R squared in CPUE`) other parameters were used as diagnostics of the FIT outputs from the three formulations considered:

- `Number of restarts required for convergence`: The routine used in ASPIC to minimize the objective function can stop at a local minima. In order to find a true minimum of the objective function, which is kept constant regardless the initial values of the key parameters, ASPIC program has a restarting algorithm that requires the same solution to be found several times in a row before it is accepted (Prager, 2005). The shorter the number of restarts the quicker is the convergence the better is the fit of the model to the data series.
- `Estimated contrast index (ideal = 1.0): C* = (Bmax-Bmin)/K.` A wider contrast on the biomass trajectory reflects wider coverage by the stock exploitation history of the Yield/Biomass curve defined by the ASPIC underlying surplus production model.
- `Estimated nearness index (ideal = 1.0): N* = 1 - |min(B-Bmsy)|/K.` Being a production model centred on *MSY*, the biomass trajectory given by ASPIC should pass at least once through B_{msy}.
- `TOTAL OBJECTIVE FUNCTION.` Measuring the overall size of the of *cpue* and survey residuals the least squares objective function points out how close model estimates are to observed data.

An overview of the exploratory analysis (Table 6a) lead to the main conclusion that no significant improvement on ASPIC FIT diagnostics is obtained either by using the non documented figures for the Russian survey series (with an extra point on 1993) from Vaskov (1994) or the full series of the summer survey in Div. 3L, which the first four points (1978, 1979, 1981 and 1984) remained unclear if expressed in original Engel or converted Campelen units.

All runs of the three $ASPIC_{2008}$ formulations gave very similar results, both for model parameters (Table 6b) and B/B_{msy} and F/F_{msy} trajectories (Fig. 6a and 6b), framing a very similar picture of the stock:

- Carrying capacity (*K*) at 263000-285000 ton
- Level of biomass on the 1st year of the assessment higher than B_{msy} (70-73% of *K*)
- Relatively low rate of stock biomass increase (*r*), 0.34-0.39
- *MSY* at 24000-25000 ton
- Relatively low F_{msy} , 0.17-0.19
- Fishing mortality on the last year of the assessment (2007) near zero and biomass at the beginning of next year near *K*
- Very close B/B_{msy} and F/F_{msy} trajectories

The consistency on the outputs between the three formulations left both the lack of references regarding the Russian survey series by Vaskov (1994) and the doubts regarding the units on the first years of summer survey in Div. 3L as the justification for choosing the $ASPIC_{Power2008}$ formulation to pursue with the 2008 assessment. A secondary reason is that this formulation gives a slightly more conservative result in terms of stock dynamics, namely as regards relative biomass trajectory (Fig. 6a). The input file for the selected $ASPIC_{2008}$ formulation is presented as Appendix 1.

Sensitivity analysis

Different starting guesses for key parameters or different random number seeds were used to run the $ASPIC_{Power2008}$ formulation. The purpose was to check if the model was sensitive to changes in the starting "region" of key parameters (or number seed) used to initialize the search of a solution that minimizes the *cpue* and survey log squared residuals. Four starting options were tested against the standard starting option specified on $ASPIC_{Power2008}$ input file (Table 7a):

- 25% above and bellow the default random number seed (Input file, line 21)
- an "optimistic start" given by -25% *cpue* and survey catchabilities together with +25% *MSY*, *K* and *B1/K*,
- and a pessimistic start given by +25% cpue and survey catchabilities together with -25% *MSY*, *K* and *B1/K*.

The FIT parameter solutions from each of these four options are compared with the standard FIT solution on Table 7b. The four different starting options arrived to the same or very similar solutions, showing that the ASPIC results given by the selected formulation are robust and independent of the values chosen for the input parameters used to initialize the model.

<u>Retrospective Analysis</u>

A 2008-2004 retrospective analysis with the $ASPIC_{Power2008}$ formulation was carried out in order to check for patterns on bias of relative biomass and fishing mortality estimates. Going back in time the results present an over bias on biomass and an under bias on fishing mortality, but without the typical pattern of increasing bias as each assessment stop one year sooner (Table 8a, 8b and 8c; Fig. 7a and 7b). In fact the upper and lower limit of the analysis (2008-2004) showed similar B/B_{msy} and F/F_{msy} trajectories while the assessments from the last couple of years (2008-2007) fell more apart. The closest results are from the runs of intermediate years (2006 and 2007).

Moreover the largest biases are not found at recent years but through the second half of the 1990's-beginning of 2000's (Fig. 7c). How fast and how far stock biomass recovers after taking off from the depressed level of the mid 1990's is what marks the difference between the assessments included in this retrospective analysis. Not the stock dynamics on the final years, when the difference between biomass and fishing mortality results from sequential assessments tend to smooth as a consequence of a very low level of catches. The consistency of terminal biomass retrospective results will later on be reflected on consistency of medium term projections from consecutive years.

<u>Assessment results</u>

The $ASPIC_{2008}$ formulation runs on both deterministic (FIT) and bootstrap (BOT) mode using 1000 trials. Deterministic results are presented on Appendix 2, with a summary of diagnostics and parameters included on Table 6a and 6b under $ASPIC_{Power,2008}$. Bootstrap results are presented on Appendix 3, with a summary on Table 9. Despite the negative correlations among STATLANT *cpue* and both spring and autumn survey biomass for Div. 3LN combined (conditioned by the very small number of pair-wise observations and not regarded as an assessment constraint), correlation among these surveys is relatively high (r^2 > 0.5). Correlation is high (r^2 > 0.7) among Canadian surveys in Div. 3L and between those and the Russian survey in Div. 3LN The model has a poor fit to either to CPUE or most of the survey data due to the usual wide inter annual variability of redfish abundance indices (Appendix 2). Apart the Canadian spring survey for Div. 3LN combined, where residuals seem to be randomly distributed, negative/positive patterns on residuals between observed and model generated values are present for the rest of the input series. Nevertheless these poor diagnostics seem to have little impact on the consistency of the assessment, taking into account the bootstrap results (Appendix 3 and Table 9): generally small bias of the point estimates (< = 5%) for most parameters. The high level of bias on the absolute and relative (to MSY) equilibrium yield for 2008 is due to a status quo fishing mortality close to zero, leading to a very small equilibrium catch for last year+1. The impact of survey/CPUE residuals on biomass and fishing mortality is minimal as well, with B/B_{msy} and F/F_{msy} bias corrected trajectories practically undistinguishable from their deterministic ones (Fig. 8a and 8b).

The model results suggest a maximum sustainable yield (*MSY*) of 25000 ton (80% CL = 21800, 26600 ton) that can be produced with a fishing mortality of 0.18 (80% CL = 0.12, 0.23) when stock biomass is at B_{msy} level. This magnitude of F_{msy} is consistent with the results of the yield per recruit analysis for redfish in Div. 3LN presented on the 1999 assessment of this resource ($F_{0.1}$ = 0.12, F_{max} = 0.22) (Power and Parsons, 1999). Relative biomass oscillated 13-30% above B_{msy} for most of the former years up to 1987, supporting an average level of catches just bellow MSY (1960-1985 average level of catch at 21000 ton). Apart the 1971-1973 interval, when fishing mortality was at (or slightly above) F_{msy}, fishing mortality oscillated within bounds bellow F_{msy} (35-80%) until 1985. Between 1986 and 1990 catches were higher than *MSY* (29000-79000 ton), pushing fishing mortality to well above F_{msy} from 1986 till 1993. Those eight years of heavy over-fishing determine the fall of biomass from 26% above B_{msy} in 1987 to 35% bellow in 1994, when a minimum stock size is recorded. Long living/slow growing species such as redfish can not sustain over-fishing but for short periods of time: the quick decline of stock biomass through the second half of the 1980's – first half of the 1990's was followed by a drop on catch and fishing mortality. Since 1996 both were kept at low to very low levels. Over the moratorium years biomass was allowed to increase and is now (2007) well above B_{msy} (80% CL = 1.55, 1.96 B_{msy}) (Table 9, Fig. 8a and 8b).

Catch versus surplus production (Appendix 2, ESTIMATED POPULATION TRAJECTORY NON BOOTSTRAPPED, 8th column from the left) trajectories are presented on Fig. 9. From 1960 till 1985 catches form a scattered cloud of points up and down surplus production curve but always within its vicinity. On 1986-1987 catches rise well above the surplus production and though declining continuously since then were still above equilibrium yield in 1993. Estimated catch has been well bellow surplus production levels since 1994.

ASPIC projections

Regardless the input formulations, the starting guess scenario or the mode of the model runs, the main conclusion of this assessment is that at present the biomass of redfish in Div. 3LN is well above B_{msy} , while fishing mortality is well bellow F_{msy} . From ASPIC results the status of the stock allows its exploitation, but this is a first attempt to pursue an analytical assessment of this stock. Therefore these results should be treated with caution.

Underlying assumptions for the low catch option

Redfish in Div. 3LN has been under moratorium over the past ten years. A stepwise approach to direct fishery should start by a low exploitation regime associated with a high probability of keeping the stock biomass within its present safe zone. From the ASPIC bootstrap results (Table 9 and Appendix 3, ESTIMATES FROM BOOTSTRAPPED ANALYSIS, Line 22) this safe zone can be defined as B/B_{msy} = > 1.55, the bias-corrected 80% lower confidence limit of relative biomass at the beginning of 2008.

An ASPIC medium term projection was carried out under constant catch instead of constant fishing mortality. The reason for this option relates to the proposed approach to reopen the fishery keeping the biomass well above B_{msy},, until future assessments confirms a positive answer of the stock to exploitation as suggested by the present assessment. This strategy turns the analysis of medium term projections under a range of F_{msy} percentages useless, since the purpose is to keep a fishing mortality within a low level able to maintain the present stock size.

The catch options for medium term projections should include in principle MSY (25000 ton) and a catch of 21000 ton, a "real world" proxy of MSY corresponding to the average level of catches sustained by the stock over 25 years (1960 -1985). However the purpose of this exercise is not to compare the impact of different full exploitation regimes on the stock but to predict how biomass and fishing mortality react to the beginning of exploitation, just at the actual surplus production level. Therefore ASPIC projection was carried out with a constant catch of 5000 tons. This level of catch is a conservative proxy of the actual equilibrium yield (75% of the bias corrected equilibrium yield for 2008) (Table 9).

The ASPICP program

ASPIC has an auxiliary program, ASPICP, to provide not only bias corrected estimates of biomass and fishing mortality on an annual basis for the assessment time interval (with associated 50% and 80% confidence limits) but also provides projections of these trajectories to the future. ASPICP reads information from the 1000 trials of the BOOTSRAP results kept in a .BIO file and project each of these trials a number of years ahead, under an annual $F_{status\ quo}$ multiplier or yield. These constraints are specified by the user in a .CTL file (Appendix 4) that controls the projection.

The ASPICP run with a 2008 *status quo* catch (2007 level of 1700 ton) and an annual catch of 5000 ton for the rest of the years (2009-2012). Results are stored in a .PRJ file presented in Appendix 5.

Projection results

The bias corrected 1959–2012/ 2013 trajectories of biomass and fishing mortality rate (relative to B_{msy} and F_{msy}.), with associated 80% lower and upper CL's are presented in Table 10a and 10b, Appendix 5 and Fig. 10a and 10b. From the ASPICP results a low exploitation regime of 5000 ton will keep biomass at the same high level, between 1.84 B_{msy} at the beginning of 2008 and 1.87 B_{msy} at the beginning of 2013 (80% CL's, 1.74 -1.91B_{msy}). , Meanwhile fishing mortality will increase from 0.04F_{msy} in 2008 to 0.11 F_{msy} in 2012 (80% CL's, 0.10-0.13 F_{msy}). In other words, a constant catch level of 5000 ton will keep the stock size of redfish in Div. 3LN in its present safe zone, with the lower 80% CL of relative biomass well above the B_{msy} level. At the same time fishing mortality rate will remain at a (very) low level, with an upper 80% CL well bellow F_{msy}.

In order to test if these projection results are robust or if they might be affected by differences on results from previous assessment, the same projection exercise was performed till the same year of 2013, but starting one year earlier (2007). The ASPICP run with the bootstrap results of the 2007 assessment using the same $ASPIC_{Power}$ formulation, but for the 1959-2006 interval. A *status quo* catch was adopted for 2007 (= 2006 level of 500 ton) followed by an annual catch of 5000 ton for the rest of the years (2008-2012). The bias corrected 2007-2013 B/B_{msy} trajectories from the two consecutive $ASPICP_{2008}$ and $ASPICP_{2007}$ runs are very similar (Table 11, Fig. 11). Regardless the retrospective bias between the two last assessments both runs shown the stock at the same high level relative to B_{msy} , five-six years after the reopening of a directed fishery at a small scale of 5000 ton.

Reference Points under Precautionary Approach

The ASPIC bias corrected results were input under the precautionary framework (Fig. 12). The stock trajectory presented under this precautionary approach framework shows a stock rapidly declining to bellow B_{msy} when fishing mortality rate rises from just above to well above F_{msy} (1986-1987), and a stock rapidly returning to above B_{msy} after fishing mortality drops to well bellow F_{msy} (1993-1994).

The NAFO SC Study Group recommendations from the meeting in Lorient in 2004 (SCS Doc. 04/12), as regards Limit Reference Points (LRP's) for stocks evaluated with surplus production models, considered F_{lim} at F_{msy} and F_{target} at 2/3 F_{msy}. The Study Group also considered that the biomass giving production of 50% *MSY* was a suitable B_{lim}. Under the Schaeffer model used in the present ASPIC assessment this is 30% B_{msy}. However the stock biomass decline of the late 1980's – early 1990's didn't reach such level, having a minimum at 35% B_{msy}. Taking into account that bellow this level the dynamics of the stock is unknown, a B_{lim}= 35% B_{msy} can be regarded as first attempt to have a biomass LRP for redfish in Div. 3LN.

REFERENCES

Alpoim, R., and J. Vargas, 2004. Length-weight relationships of the Portuguese commercial catches in NAFO, 1998-2003. *NAFO SCR Doc.* 04/40 Ser. No N4991, 10pp.

Ávila de Melo, A.M., R. Alpoim and F. Saborido-Rey, 2003. An assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Div. 3M. *NAFO SCR Doc.* 03/45 Ser. No N4863, 72p.

Ávila de Melo, A. M., Power, D. And R. Alpoim, 2005. An assessment of the status of the redfish resource in NAFO Divisions 3LN. NAFO SCR Doc. 05/52, Serial No. N5138, 19 pp.

Ávila de Melo, A. M., Duarte, R., Power, D. and R. Alpoim, 2007. An ASPIC Based Assessment of Redfish in NAFO Divisions 3LN. NAFO SCR Doc. 07/38, Serial No. N5390, 51 pp.

Ávila de Melo, A., Saborido-Rey, F. and R. Alpoim, 2007. An XSA based assessment of beaked redfish (*S. mentella and S. fasciatus*) in NAFO Division 3M. NAFO SCR Doc. 07/47, Serial No. N5399, 43 pp.

Bishop, C. A., 1994. Revisions and additions to stratification schemes used during research vessel surveys in NAFO Subareas 2 and 3. *NAFO SCR. Doc.* 94/43 (rev.). Ser. No N2413.

Bulatova A. Yu., Vaskov A. A., Kiseleva and P. I. Savvatimsky 1997: Review of Russian Bottom Trawl Surveys in the NAFO Subareas 0, 2 and 3 for 1954-95. NAFO Sci. Coun. Studies, 30: 51-55.

Doubleday, 1981. Manual of groundfish surveys in the Northwest Atlantic. . *NAFO Sci. Coun. Studies* 2, 55p.

Gavaris, S., 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. *Canadian Journal of Fisheries and Aquatic Science* 37, 2272-2275.

González, F., del Río, J. L., Murua, H., Román E., Casas, M. and G. Ramilo, 2006. Spanish research report for 2005. NAFO SCS Doc. 06/09, Serial Number N5232. 25 pp.

González Troncoso, D., C. González and X. Paz, 2004. American plaice biomass and abundance from the surveys conducted by Spain in the NAFO Regulatory Area of Divisions 3NO, 1995-2003. NAFO SCR 04/9, Serial Number N4954, 22 pp.

González Troncoso, D., E. Román and X. Paz, 2004. Results for Greenland halibut from the surveys conducted by Spain in the NAFO Regulatory Area of Divisions 3NO, 1996-2003. NAFO SCR 04/11, Serial No N4956, 16 pp.

NAFO, 2007. Northwest Atlantic Fisheries Organization Scientific Council Reports 2007. Dartmouth, Nova Scotia, Canada, 279 pp.

Power, D. and A. A Vaskov, 1992. Abundance and biomass estimates of redfish (*S. mentella*) in Div. 3LN from Russian groundfish surveys from 1984-91. NAFO SCR Doc. 92/59. Serial No. N2113. 9 pp.

Power, D.,1997. Redfish in NAFO Divisions 3LN. NAFO SCR Doc. 97/64, Serial No. N2898.

Power, D. and D. Maddock Parsons, 1998. Canadian research survey data conversions for redfish in Div. 3LN based on comparative fishing trials between an Engel 145 Otter Trawl and a Campelen 1800 shrimp trawl. NAFO SCR Doc. 98/71. Serial No. N3063. 21 pp.

Power, D. and D. Maddock Parsons, 1999. The status of the redfish resource in NAFO Div. 3LN. SCR Doc. 99/65. Serial No. N4124. 27 pp.

Power, D., 2001. An assessment of the status of the redfish resource in NAFO Divisions 3LN. NAFO SCR Doc. 01/62, Serial No. N4440, 22 pp.

Power, D., 2003. An assessment of the status of the redfish resource in NAFO Divisions 3LN. NAFO SCR Doc. 03/55, Serial No. N4873, 21 pp.

Praguer, M. H., 1994. A suite of extensions to no-equilibrium surplus-production model. *Fish. Bull. U.S.*, 90(4): 374-389.

Praguer, M. H., 2004. User's manual for ASPIC: a stock production model incorporating covariates (ver. 5) and auxiliary programs. *NMFS Beaufort Laboratory Document* BL-2004-01, 25pp.

Praguer, M. H., 2007. Quick reference to ASPIC Suite 5.x. http://www.sefsc.noaa.gov/mprager/index.html as consulted in 25/01/07.

Vargas, J., Alpoim, R., E. Santos, and A.M. Ávila de Melo, 2008. Portuguese research report for 2007. *NAFO SCS Doc.* 08/5 Ser. No N5495, 47 pp.

Vaskov, A.A., 1994. Assessment of redfish stocks in Divisions 3LN from trawl acoustic survey data, 1993. NAFO SCR Doc. 94/13, Serial No. N2376, 9 pp.

Vaskov, A.A., Pochtar, M.V., Skryabin, I.A., Sigaev, I.K. and V.A. Rikhter, 2008. Russian research report for 2007. NAFO SCS Doc. 08/06, Serial No. N5496, 28 pp.

Table 1: Summary of catch and TAC's of redfish
in Div. 3LN estimated from various sources

YEAR	3L	3N	TOTAL	TAC
1959	34107	10478	44585	
1960	10015	16547	26562	
1961	8349	14826	23175	
1962[a]	3425	18009	21439	
1963[a]	8191	12906	27362	
1964[a]	3898	4206	10261	
1965	18772	4694	23466	
1966	6927	10047	16974	
1967	7684	19504	27188	
1968[a]	2378	15265	17660	
1969[a]	2344	22356	24750	
1970[a]	1029	13359	14419	
1971[a]	10043	24310	34370	
1972	3095	25838	28933	
1973	4709	28588	33297	
1974	11419	10867	22286	28000
1975	3838	14033	17871	20000
1976	15971	4541	20513	20000
1977	13452	3064	16516	16000
1978	6318	5725	12043	16000
1979	5584	8483	14067	18000
1980	4367	11663	16030	25000
1981	9407	14873	24280	25000
1982	7870	13677	21547	25000
1983	8657	11090	19747	25000
1984	2696	12065	14761	25000
1985	3677	16880	20557	25000
1986	27833	14972	42805	25000
1987[b]	30342	40949	79031	25000
1988[b]	22317	23049	53266	25000
1989[b]	18947	12902	33649	25000
1990[b]	15538	9217	29105	25000
1991[b]	8892	12723	25815	14000
1992[b]	4630	10153	27283	14000
1993[b,c]	5897	9077	21308	14000
1994[b,c]	379	2274	5741	14000
1995	292	1697	1989	14000
1996	112	339	451	11000
1997	151	479	630	11000
1998	494	405	899	0
1999[b]	518	1318	2318	0
2000[b,c]	657	819	3141	0
2001[b]	653	245	1442	0
2002[b]	651	327	1216	0
2003	584	751	1334	0
2004	401	236	637	0
2005	581	78	659	0
2006	53	444	496	0
2007[b]	118	1546	1664	0

a Includes catch that could not be identified by division
b includes estimates of unreported catches
c Catch could not be precisely estimate due to discrepancies in figures from
available sources: average of the range of the different catch estimates.

Table 2: Redfish STATLANT catch and predicted effort for Div. 3L and Div. 3N, 1959-1994 (Power,1997).
Annual catch rate for Div. 3LN, 1959-1994.

Year	3L		3N		3LN		3LN
	STATLANT Catch	Predicted EFFORT	STATLANT Catch	Predicted EFFORT	STATLANT Catch	Predicted EFFORT	CPUE annual
1959	34107	22604	10478	8659	44585	31263	1.426
1960	10015	5690	16547	10892	26562	16582	1.602
1961	8349	3610	14826	10049	23175	13659	1.697
1962	3425	2049	18009	11090	21434	13139	1.631
1963	8191	3973	12906	8958	21097	12931	1.632
1964	3898	1491	4206	2981	8104	4472	1.812
1965	18772	8190	4694	2551	23466	10741	2.185
1966	6927	4615	10047	4915	16974	9530	1.781
1967	7684	3793	19504	10569	27188	14362	1.893
1968	2378	1446	15265	17684	17643	19130	0.922
1969	2344	1354	22356	17109	24700	18463	1.338
1970	1029	499	13359	10026	14388	10525	1.367
1971	10043	5207	24310	20320	34353	25527	1.346
1972	3095	1877	25838	18982	28933	20859	1.387
1973	4709	2078	28588	18186	33297	20264	1.643
1974	11419	11907	10867	5374	22286	17281	1.290
1975	3838	2443	14033	8265	17871	10708	1.669
1976	15971	11335	4541	4537	20512	15872	1.292
1977	13452	10461	3064	2738	16516	13199	1.251
1978	6318	5961	5725	4925	12043	10886	1.106
1979	5584	3517	8483	6176	14067	9693	1.451
1980	4367	2873	11663	6229	16030	9102	1.761
1981	9407	6020	14873	9216	24280	15236	1.594
1982	7870	4812	13677	8160	21547	12972	1.661
1983	8657	4960	11090	7734	19747	12694	1.556
1984	2696	1804	12065	12263	14761	14067	1.049
1985	3677	2104	16880	16858	20557	18962	1.084
1986	27833	15247	14972	15057	42805	30304	1.413
1987	34212	22369	44819	29517	79031	51886	1.523
1988	26267	19629	26999	24453	53266	44082	1.208
1989	19847	10567	13802	14884	33649	25451	1.322
1990	17713	16774	11392	18513	29105	35287	0.825
1991	8892	12329	12723	20052	21615	32381	0.668
1992	4630	2452	10153	13755	14783	16207	0.912
1993	5897	1576	9077	17116	14974	18692	0.801
1994	379	410	2274	2900	2653	3310	0.802

Table 3a: Length composition (absolute frequencies in '000s) of the 3LN redfish commercial catch, 1990-2007.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998
10									
11									
12	12								
13	6								
14	21								
15	28	28							
16	73	103	9						
17	199	394	28			2			
18	286	1034	412		5	2		0	1
19	445	2157	1291	5	6	3	1	0	2
20	720	3313	2375		16	14	4	2	13
21	1309	3780	2943	235	287	9		11	57
22	2081	**4922**	3600	714	683	65	6	17	**151**
23	3212	**7340**	**4358**	1141	594	64	17	34	**277**
24	**4164**	**7575**	**5552**	2565	708	99	9	64	**296**
25	**5216**	**6944**	**4981**	**5237**	**944**	100	9	**98**	**248**
26	**5560**	**5981**	**5145**	**5115**	**1297**	277	12	**118**	**221**
27	**5410**	**6197**	**4579**	**5433**	**1404**	**330**	35	**144**	**218**
28	**5217**	**5322**	**4063**	**5004**	**1182**	**300**	**75**	**114**	**173**
29	**4712**	**3354**	**4637**	**4437**	**1188**	**263**	**76**	**114**	**154**
30	**4751**	**4043**	**3911**	**3283**	**1011**	**310**	**182**	**114**	**120**
31	**4551**	2695	3711	**2964**	**912**	**313**	**197**	**154**	**129**
32	**3943**	2478	2187	2313	**944**	**309**	**98**	**146**	**119**
33	3082	1582	1355	2291	596	226	**67**	**131**	**110**
34	2737	1179	1569	1527	526	189	30	71	66
35	2100	928	1604	1059	363	182	35	24	19
36	1681	831	1895	923	202	106	23	19	18
37	1416	580	1571	766	196	160	7	14	11
38	1128	482	1303	807	158	171	5	10	8
39	729	363	1114	489	124	100	11	3	3
40	458	292	790	505	69	144	2	4	3
41	321	188	558	320	49	63	3	1	2
42	255	117	420	306	23	1	1	1	0.09
43	227	68	203	137	15	3	2	2	0.10
44	157	83	85	175	7	3	2	1	1
45	84	33	76	107	1	3	2	0.07	
46	58	8	32	9	3			0.10	0.02
47	24		9	47	0.22				
48	11	2	8	5		3		0.15	
49	6		1		0.07				
50									
51	1	25			2				
52	2								
53	1								
54	2								
no ('000)	66410	74421	66375	47918	13517	3815	910	1411	2422
weight (tons)	29105	25815	27283	21308	5741	1989	451	630	899
mean weight (g)	438	347	411	445	425	521	496	446	371
mean length	29.3	26.6	28.4	29.6	29.1	31.6	31.2	29.8	27.4
length anomalies	0.23	-2.5	-0.7	0.5	0.0	2.5	2.1	0.7	-1.7
%lengths <20cm	1.6%	**5.0%**	**2.6%**	0.0%	0.1%	0.2%	0.1%	0.0%	0.1%

Table 3a: cont.

Length	1999	2000	2001	2002	2003	2004	2005	2006	2007
10									
11					0.03				
12					0.03				
13					1				
14					1			0.00	
15					5			10	
16			1	0	8			24	
17	0	1	2	1	21	1	2	34	
18		1	1	1	44	2	4	65	
19	16	4	4	3	90	6	9	99	47
20	47	6	18	14	151	15	11	**182**	157
21	80	10	52	41	**218**	28	13	**300**	84
22	150	26	102	81	**269**	35	11	**347**	163
23	128	46	118	101	**277**	41	16	**340**	232
24	120	85	114	132	**258**	54	35	**210**	182
25	178	**195**	114	154	**261**	85	61	**147**	**232**
26	**318**	**364**	126	**204**	**309**	**157**	**138**	**111**	**216**
27	**555**	**546**	**170**	**248**	**324**	**190**	**181**	99	**129**
28	**712**	**943**	**188**	**289**	**286**	**184**	**201**	88	**557**
29	**673**	**1003**	**179**	**289**	**245**	**184**	**223**	62	**450**
30	**520**	**1027**	**236**	**294**	**225**	**178**	**176**	60	**387**
31	**413**	**564**	**289**	**295**	**204**	**107**	**109**	35	**348**
32	**434**	**315**	**303**	**276**	189	**108**	**91**	28	**637**
33	**383**	**237**	**298**	**216**	196	95	83	19	**335**
34	**268**	**217**	**218**	132	149	73	71	17	**268**
35	141	129	**212**	83	112	51	63	10	133
36	89	60	121	37	62	36	56	5	120
37	82	78	82	18	41	17	31	2	4
38	51	50	55	11	22	10	15	1	3
39	37	47	30	3	14	9	8	0.01	25
40	23	23	18	2	7	5	8	0.32	25
41	19	12	10	1	2	2	4	0.00	1
42	13	15	7	2	3	1	2	0.00	
43	3	9	4	2	2	2	6		0.1
44	3	1	3	1	2	1	3		0.1
45		2	1		0.1	1	1		0.1
46	0.24	1	1		2	0.2	0		
47		0.48	0.20		0.04	0.80	2		
48							0.04		
49									
50									
51					0.26				
52									
53									
54					0.31				
no ('000)	5457	6020	3075	2929	3999	1681	1632	2295	4734
weight (tons)	2318	2617	1442	1216	1334	637	659	497	1729
mean weight (g)	425	435	469	415	334	379	404	217	365
mean length	29.9	30.1	30.8	29.5	27.5	29.5	30.1	23.9	29.4
length anomalies	0.8	1.0	1.7	0.4	-1.6	0.4	1.0	-5.2	0.3
%lengths <20cm	0.3%	0.1%	0.2%	0.2%	**4.2%**	0.5%	0.9%	**10.1%**	1.0%

Table 3b: Length weight relationships from 3LN Sebastes sp. commercial sampling data used in the computation of 3LN catch parameters. (Alpoim and Vargas, 2004; Vargas et al., 2005-2008)

Year	*a*	*b*
1990-1998	0.1115	2.4353
1999	0.0689	2.5588
2000	0.0979	2.4602
2001	0.0769	2.5298
2002	0.0447	2.6885
2003	0.0095	3.1279
2004	0.0208	2.8851
2005	0.0208	2.8851
2006	0.0611	2.5597
2007	0.0207	2.8946

Table 4: Survey biomass from all stratified bottom trawl surveys on Div. 3L and Div.3N, 1978-2007(shaded observations included in the ASPIC assessment suite, observations in brackets excluded). Survey female SSB from spring and autumn Canadian surveys on Div. 3LN, 1991-2007 (two last columns on the right)

	Canadian		Russian		Canadian							Canadian	
	Div. 3LN	Div. 3LN	Div. 3LN	Div. 3LN	Div. 3L	Div. 3L	Div. 3L	Div. 3L	Div. 3N	Div. 3N	Div. 3N	Div. 3LN	Div. 3LN
	$I2_{spring}$	$I3_{autumn}$	$I4_{Power}$	$I4_{Vaskov}$	$I5_{winter}$	$I6_{summer}$	$I7_{autumn}$	$I8_{spring}$	$I9_{spring}$	$I10_{autumn}$	$I11_{summer}$	$I2_{springSSB}$	$I3_{autumnSSB}$
1978						311.2							
1979						227.8							
1980								40.3					
1981						261.4							
1982													
1983													
1984			215.9	199.4		277.7							
1985			94.0	85.9	90.2	161.0	98.2	105.3					
1986			63.0	46.8	36.6		17.1						
1987			70.3	60.8									
1988			44.9	40									
1989			12.3	10.9									
1990			8.4	7.1	18.2	92.8	20.7						
1991	10.6	37.9	18.7	14.5		37.6	13.7	6.3	4.4	24.2	47.6	1.5	5.2
1992	10.1	(136.4)					13.4	7.4	2.7	(123.0)		2.3	
1993	22.6	19.2		30.3		20.8	6.0	6.5	16.1	13.2	129.8	5.8	4.3
1994	4.2	31.8					7.2	2.3	1.9	24.6		0.7	5.4
1995	5.9	(90.7)					(50.1)	3.3	2.6	40.7		1.0	
1996	22.8	16.0					4.7	16.8	6.0	11.3		2.9	3.1
1997	14.9	70.7					19.5	9.3	5.7	51.1		2.1	8.6
1998	59.4	112.2					18.5	27.6	31.8	93.7		10.9	15.6
1999	61.5	72.0					38.9	21.3	40.2	33.1		10.2	14.1
2000	87.8	100.5					24.9	36.2	51.7	75.5		17.6	15.7
2001	41.6	132.6					28.6	26.2	15.4	104.0		9.2	16.2
2002	31.0	50.1					11.9	9.1	21.8	38.2		4.9	9.0
2003	27.7	71.9					15.0	10.5	17.2	56.9		3.8	9.4
2004	79.6	49.9					9.3	14.4	65.3	40.6		18.2	12.1
2005	66.5	58.6					16.7	36.5	29.9	41.9		9.0	11.9
2006		91.9					27.2	35.3		64.7			13.2
2007	218.8	124.8					57.5	174.1	44.7	67.2		40.9	14.2

Table 5a: 3LN spring survey abundance at length, 1991-2007 (thousands).

Length	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
4								
5								
6						466		20
7						228		39
8						149	685	8
9	849					298	360	39
10	1149			500		296	251	113
11	798	381	122	316		478	730	533
12	558	2988	1304	501		806	722	455
13	2523	7925	2397	462	108	919	540	172
14	321	5192	5646	494	272	408	1871	561
15	698	2862	11061	1228	278	712	1859	895
16	2249	382	13648	1611	967	846	1129	1505
17	3864	419	8798	2831	2852	1592	1201	2045
18	6225	1111	2720	2801	4295	4354	1860	2124
19	7747	2480	2475	1266	5026	9475	3280	2848
20	4521	2574	3841	763	2708	10903	4711	9468
21	3481	3559	5756	853	1818	12106	6367	24836
22	5146	1690	5304	717	1337	13832	7008	34249
23	7250	1732	5713	1132	1259	16619	8191	31104
24	6185	2721	4761	1439	1361	12491	10669	28361
25	3365	2865	3400	1700	1005	8315	9469	21270
26	1963	3250	3703	1522	1601	5648	7757	19508
27	1426	2411	4481	1014	1694	5102	4047	16076
28	952	1834	3286	775	1437	4897	2760	12714
29	1037	1506	2877	699	1154	4260	1871	9626
30	607	1048	2607	461	722	3320	1801	6118
31	534	1014	2970	304	474	2229	1354	6512
32	417	810	3088	234	548	1563	995	6155
33	369	825	2621	132	265	757	637	5685
34	399	540	2161	146	144	337	438	3286
35	251	544	1503	102	105	167	160	970
36	190	366	880	132	113	105	77	659
37	222	216	696	121	151	117	42	402
38	159	219	669	78	101	32	88	82
39	130	300	726	28	70	59	4	82
40	118	220	483	46	62	28		216
41	45	77	371	0	15	15		15
42	88	85	216	8	46	4		20
43	69	85	83	47	27	35	15	201
44	45	77	189	27	31		31	12
45	57	62				15	15	15
46		46	51			15	46	
47		4	20		15		15	
48	11	31	31					
49		31						
50								
abundance (millions)	66.0	54.5	110.7	24.5	32.1	124.0	83.1	249.0
biomass ('000 tons)	10.6	10.1	22.6	4.2	5.9	22.8	14.9	59.4
mean length (cm)	21.6	21.6	22.6	21.6	22.7	23.4	23.5	25.1
length anomalies (cm)	-1.7	-1.7	-0.7	-1.7	-0.6	0.1	0.2	1.8

Table 5a: cont.

Length	1999	2000	2001	2002	2003	2004	2005	2006[(1)]	2007
4							40		
5				62		31			
6	16	185	109	170	293	804	108		154
7	656	795	1512	472	2059	2399	540	309	3452
8	3280	378	1302	1072	1684	1236	950	602	9327
9	5878	89	484	1525	1525	2208	2891	494	2625
10	1343	166	240	2517	1202	4106	4893	633	886
11	309	402	116	1085	418	2910	7296	1235	1683
12	430	191	451	1645	1449	1653	8756	1343	2296
13	517	412	346	853	1102	1330	9684	1575	1908
14	369	353	1073	533	1279	639	7710	2903	1928
15	179	1207	1741	766	2631	1235	7437	5775	3631
16	774	2063	1666	1371	3567	1335	7357	8060	5993
17	703	2651	3337	2595	6196	2764	8647	10731	14187
18	3440	2954	5241	6444	8659	3668	16473	12769	24588
19	2989	6491	8252	8160	15503	8994	31508	14607	26944
20	5395	11472	9589	11325	21130	11904	33704	19192	26004
21	16819	22819	14394	13957	23795	16955	33184	26681	43667
22	31066	42444	15553	14930	19308	16583	30969	30001	68146
23	38231	52730	15592	15596	15146	20421	30647	23763	87379
24	45397	54039	14842	16048	10830	17002	28563	19146	96979
25	21478	34955	10153	12608	8066	14655	24308	10685	78850
26	30238	27243	10044	11223	6898	24394	18439	5466	90999
27	21651	21635	11334	8886	5109	38931	20028	6300	81120
28	15676	14299	10225	7495	3557	43212	15249	2764	36970
29	14330	15399	10373	6418	2782	24423	11907	3258	38024
30	6697	13924	9530	3736	2705	18143	8832	2640	30267
31	5727	13111	10453	3588	2199	13712	5769	2038	30138
32	4310	13224	8903	2238	2360	9705	3036	1868	21975
33	3259	6491	5180	1378	1979	3487	2012	1328	9163
34	2039	5984	3032	980	1015	5390	1618	371	8158
35	877	3590	975	455	642	2248	832	262	7223
36	537	1019	300	212	228	476	592	139	9422
37	269	663	382	93	82	877	222	31	1894
38	102	504	101	43	35	75	112	46	1945
39	67	186	140	59	32	43	86	0	193
40	79	199	23		94	23	12	0	115
41	51	16	0	15		4	15	46	59
42	66	31	63	15		15	8	31	24
43	0	31	28		15	15		46	8
44	27	31	28				15		23
45		31	15			8			
46	31	15							
47									
48									
49									
50									
abundance (millions)	285.3	374.4	187.1	160.6	175.6	318.0	384.4	217.1	868.3
biomass ('000 tons)	61.5	87.8	41.6	31.0	27.7	79.6	66.5	35.3	228.6
mean length (cm)	24.7	25.5	25.2	23.5	22.0	25.7	22.2	21.9	25.1
length anomalies (cm)	1.4	2.2	1.9	0.2	-1.3	2.4	-1.1	-1.4	1.7

(1) Survey data only from Division 3L

Table 5b: 3LN autumn survey abundance at length, 1991-2007 (thousands).

Length	1991	1992[(2)]	1993	1994	1995	1996	1997	1998
4								
5				15	243	66	75	17
6					259	419	626	
7	203				139	103	16	39
8	1299				111	76	227	47
9	1237				241	168	918	251
10	7273		92	31	293	291	1613	214
11	22263	371	64	31	214	406	1070	203
12	62498	62	371	0	242	118	373	275
13	109476	3189	456	335	305	293	768	595
14	33919	27936	1768	551	515	1434	1017	894
15	14047	104299	1332	2362	969	739	926	1736
16	7819	113967	3258	3697	1617	969	1037	1377
17	7870	106449	5285	12985	9655	863	1386	7058
18	16212	95897	8711	28686	37959	2335	1767	12588
19	32254	71578	6427	29297	72230	5280	8721	10094
20	27223	113848	3908	15293	78338	6758	23419	40553
21	15830	148631	5308	7702	43446	6878	49398	75450
22	7924	153399	6377	5120	27694	6418	52015	103747
23	6144	89709	6578	6494	20177	6963	46245	103927
24	8384	28664	5161	5456	10338	5086	37485	71785
25	8951	14231	3944	6807	12971	4598	35505	42836
26	6607	13420	4115	8670	8576	4519	33288	23682
27	4025	14708	4357	7830	17498	2987	26053	23132
28	3779	8777	4235	8402	17645	2829	13431	21289
29	2528	4861	3500	7625	16465	2807	5507	15372
30	2112	3344	2760	6195	12821	2379	4260	9646
31	1961	3232	1945	4553	16433	3516	2886	6359
32	1315	2391	1897	2710	10724	2300	2434	5377
33	1213	3301	1668	1603	7330	1280	1310	4524
34	1117	1433	1283	916	3477	583	636	4940
35	1288	717	1042	610	1985	230	346	2537
36	1185	596	799	297	1180	135	382	1097
37	1005	386	459	211	338	74	320	606
38	1167	401	427	257	401	16	120	199
39	787	228	308	274	576	24	142	112
40	663	93	237	119	75	24	97	35
41	221	124	154	0	20	24	163	40
42	135	77	132	15	20			
43	102	31	37	32	32			35
44	129	46	99			49	67	17
45	46	15	69	15	36	33	34	17
46	24	46			12	16	17	
47	15	15	15	8		12		
48								
49		15						
50	15							
abundance (millions)	422	1130	89	175	434	74	356	593
biomass ('000 tons)	37.9	136.4	19.2	31.8	90.7	16.0	70.7	112.2
mean length (cm)	16.4	19.7	23.4	22.2	22.7	23.5	23.5	23.5
length anomalies (cm)	-6.1	-2.8	0.9	-0.3	0.2	1.0	1.0	1.0

(2) Including original Div. 3N survey data

Table 5b: cont.

Length	1999	2000	2001	2002	2003	2004	2005	2006	2007
4									
5		118	440	233	1090	34		84	234
6	251	482	937	932	2428	85	133	1418	512
7	50	675	755	868	2185	61	162	1831	2222
8	37	603	2114	1624	2715	620	908	466	2914
9	438	622	3147	1292	2096	1281	2236	829	8312
10	171	389	4324	1131	2863	1720	1574	1457	8497
11	402	232	2846	2846	1838	1047	3957	1709	7526
12	786	202	1283	2257	1124	1132	9943	3083	6351
13	868	321	1056	2086	1497	1437	11091	3970	5871
14	2472	589	445	2560	1457	1015	10310	8256	9045
15	1548	3653	407	1896	1950	538	8462	13285	21881
16	717	4668	11014	2146	8394	880	6084	20910	40242
17	1143	5483	31422	4703	15466	1985	5713	27174	51163
18	3183	7038	57684	9077	26300	5471	7249	23007	43357
19	6551	11929	74240	13656	39434	8226	10930	24341	35091
20	9087	31700	80546	12557	46149	9796	15984	26792	45869
21	15328	50192	65583	16499	43651	13141	25649	36447	55969
22	23115	66827	130049	20161	40404	13640	23902	49628	61547
23	28995	60122	118401	23556	40085	16741	29789	71776	84208
24	26962	53001	85166	25378	32339	15467	20365	67363	81982
25	29823	50556	64492	21327	21740	13073	15826	34947	57414
26	27500	40214	39712	19867	18303	10438	12714	32335	39978
27	25590	21893	33741	16414	17872	9402	10858	19109	26126
28	24786	17449	20399	10516	14177	12141	12472	11650	19085
29	16315	16404	14954	7233	7874	13958	12661	10147	13205
30	11341	12158	11078	5064	4974	12274	9866	7475	7643
31	7621	10211	9148	5083	3803	9071	7348	9530	6404
32	6313	7170	5257	4618	3559	6791	5215	7469	4179
33	5641	5032	4337	3830	3377	4639	4906	4870	3623
34	4544	3391	2777	2678	2199	2961	3943	2096	2183
35	3255	1306	1662	1440	1183	1761	2721	1118	1067
36	1538	1111	675	581	508	1260	1456	537	416
37	339	516	631	334	200	765	1298	444	847
38	184	330	282	82	113	392	385	136	275
39	272	228	215	62	116	666	228	55	40
40	67	151	180	129		308	60	116	17
41	82	67	85			76	85	61	103
42		67	0	16		232	60		0
43	50		4	19		99			0
44	50	4		16					0
45	50	76		16					63
46		18	17					16	
47	17								
48	17								
49									
50									
abundance (millions)	288	487	882	245	413	195	297	526	755
biomass ('000 tons)	72.0	100.5	132.6	50.1	71.9	49.9	58.6	91.9	124.8
mean length (cm)	25.3	23.9	22.3	23.3	21.8	24.9	22.5	22.3	21.4
length anomalies (cm)	2.8	1.4	-0.2	0.8	-0.7	2.4	0.0	-0.2	-1.1

Table: 6a: Diagnostics for three $ASPIC_{2008}$ formulations.

	correlation among input series				
	I4/I1	I4/I5	I4/I6	I4/I7	I6/I1
$ASPIC_{Power,2008}$	0.108	0.908	0.840	0.794	0.885
$ASPIC_{Power,fullsummer,2008}$			0.964		0.733
$ASPIC_{Vaskov,2008}$	0.133	0.961	0.726	0.845	

	R squared in CPUE						
	I1	I2	I3	I4	I5	I6	I7
$ASPIC_{Power,2008}$	0.097	0.274	0.239	0.231	0.402	0.787	0.124
$ASPIC_{Power,fullsummer,2008}$	0.039	0.278	0.254	0.250	0.416	0.640	0.119
$ASPIC_{Vaskov,2008}$	0.133	0.261	0.262	0.252	0.398	0.768	0.119

	N restarts	contrast index	nearness index	Total obj. function
$ASPIC_{Power,2008}$	47	0.766	1.000	25.24
$ASPIC_{Power,fullsummer,2008}$	33	0.793	1.000	26.28
$ASPIC_{Vaskov,2008}$	16	0.758	1.000	25.99

Table 6b: Deterministic estimates of ASPIC parameters for three $ASPIC_{2008}$ formulations

	K	B1/K	*r*	MSY	Fmsy	$F_{lastyear/}$Fmsy	$B_{lastyear+1/}$Bmsy
$ASPIC_{Power,2008}$	283800	0.70	0.344	24440	0.172	0.0379	1.880
$ASPIC_{Power,fullsummer,2008}$	262600	0.73	0.385	25290	0.193	0.0358	1.917
$ASPIC_{Vaskov,2008}$	285200	0.72	0.343	24480	0.172	0.0377	1.886

Table7a: Parameter seeds of sensitivity analysis for $ASPIC_{2008}$

	Standard	-25%seed	+25%seed	Pessimistic	Optimistic
B1/K	0.5d0	0.5d0	0.5d0	0.375	0.625
MSY	2.0d4	2.0d4	2.0d4	15000	25000
K	2.00E+05	2.00E+05	2.00E+05	1.50E+05	2.50E+05
q_{cpue}	9.01E-06	9.01E-06	9.01E-06	1.13E-05	6.76E-06
$q_{3LNspring}$	0.658	0.658	0.658	0.823	0.494
$q_{3LNautumn}$	1	1	1	1.250	0.750
$q_{3LNRussia}$	0.658	0.658	0.658	0.823	0.494
$q_{3Lwinter}$	0.322	0.322	0.322	0.403	0.242
$q_{3Lsummer}$	0.275	0.275	0.275	0.344	0.206
$q_{3Lautumn}$	0.275	0.275	0.275	0.344	0.206
Random seed	3941285	2955964	4926606	3941285	3941285

Table 7b: Key parameter results from sensitivity analysis of $ASPIC_{2008}$

	Standard	-25%seed	+25%seed	Pessimistic	Optimistic
K	283800	283800	284300	284100	284100
B1/K	0.70	0.70	0.70	0.7024	0.70
r	0.344	0.344	0.344	0.3438	0.344
MSY	24440	24440	24420	24430	24430
Fmsy	0.172	0.1722	0.172	0.1719	0.1719
$F_{lastyear/}Fmsy$	0.0379	0.0379	0.0380	0.03795	0.0379
$B_{lastyear+1/}Bmsy$	1.880	1.880	1.879	1.879	1.879

Table 8a: $ASPIC_{2007-2004}$ over bias of B/B_{msy} referred to $Aspic_{2008}$ results

	$ASPIC_{2007}$	$ASPIC_{2006}$	$ASPIC_{2005}$	$ASPIC_{2004}$
1959	10%	10%	7%	2%
1960	9%	9%	7%	2%
1961	9%	9%	7%	2%
1962	9%	9%	7%	2%
1963	9%	9%	7%	2%
1964	9%	9%	7%	2%
1965	9%	9%	7%	2%
1966	9%	8%	7%	2%
1967	8%	8%	6%	3%
1968	8%	8%	6%	2%
1969	8%	8%	6%	3%
1970	8%	7%	6%	3%
1971	7%	7%	6%	3%
1972	7%	7%	5%	2%
1973	7%	7%	5%	2%
1974	7%	7%	5%	2%
1975	8%	7%	6%	3%
1976	8%	8%	6%	3%
1977	8%	8%	6%	3%
1978	8%	8%	6%	3%
1979	8%	8%	6%	3%
1980	8%	8%	6%	3%
1981	7%	7%	5%	3%
1982	7%	6%	5%	3%
1983	6%	6%	5%	3%
1984	6%	6%	5%	2%
1985	6%	6%	4%	2%
1986	5%	5%	4%	2%
1987	5%	5%	4%	2%
1988	3%	3%	2%	1%
1989	2%	2%	2%	0%
1990	3%	3%	2%	0%
1991	5%	5%	4%	0%
1992	8%	8%	5%	0%
1993	12%	12%	8%	0%
1994	18%	18%	12%	0%
1995	24%	23%	16%	2%
1996	27%	26%	18%	4%
1997	29%	28%	20%	5%
1998	29%	28%	20%	6%
1999	27%	26%	19%	7%
2000	24%	23%	17%	7%
2001	21%	20%	15%	6%
2002	17%	17%	13%	5%
2003	14%	13%	10%	5%
2004	11%	10%	8%	4%
2005	8%	8%	7%	
2006	6%	6%		
2007	5%			

Table 8b: $ASPIC_{2007-2004}$ under bias of F/F_{msy} referred to $Aspic_{2008}$ results

	$ASPIC_{2007}$	$ASPIC_{2006}$	$ASPIC_{2005}$	$ASPIC_{2004}$
1959	-15%	-14%	-11%	-4%
1960	-14%	-14%	-11%	-4%
1961	-14%	-14%	-11%	-4%
1962	-14%	-14%	-11%	-4%
1963	-14%	-14%	-11%	-4%
1964	-14%	-14%	-11%	-5%
1965	-14%	-14%	-11%	-5%
1966	-14%	-13%	-10%	-5%
1967	-13%	-13%	-10%	-5%
1968	-13%	-13%	-10%	-5%
1969	-13%	-13%	-10%	-5%
1970	-13%	-13%	-10%	-5%
1971	-13%	-12%	-10%	-5%
1972	-12%	-12%	-9%	-5%
1973	-12%	-12%	-10%	-5%
1974	-13%	-12%	-10%	-5%
1975	-13%	-13%	-10%	-5%
1976	-13%	-13%	-10%	-5%
1977	-14%	-13%	-10%	-5%
1978	-13%	-13%	-10%	-5%
1979	-13%	-13%	-10%	-5%
1980	-13%	-12%	-10%	-5%
1981	-12%	-12%	-9%	-5%
1982	-12%	-12%	-9%	-5%
1983	-12%	-11%	-9%	-5%
1984	-12%	-11%	-9%	-5%
1985	-11%	-11%	-9%	-5%
1986	-11%	-11%	-8%	-4%
1987	-10%	-9%	-7%	-4%
1988	-9%	-9%	-6%	-3%
1989	-9%	-9%	-7%	-2%
1990	-10%	-10%	-7%	-2%
1991	-12%	-12%	-9%	-3%
1992	-15%	-14%	-10%	-3%
1993	-19%	-18%	-13%	-3%
1994	-23%	-22%	-16%	-3%
1995	-26%	-25%	-19%	-5%
1996	-27%	-26%	-20%	-7%
1997	-27%	-27%	-20%	-8%
1998	-27%	-26%	-20%	-8%
1999	-25%	-25%	-19%	-8%
2000	-23%	-23%	-18%	-8%
2001	-21%	-21%	-16%	-8%
2002	-19%	-18%	-15%	-7%
2003	-16%	-16%	-13%	-6%
2004	-14%	-14%	-11%	
2005	-13%	-12%		
2006	-11%			

Table 8c: Retrospective estimates of ASPIC parameters, 2008-2004

	K	B1/K	*r*	MSY	Fmsy	$F_{2003/}$Fmsy	$B_{2003+1/}$Bmsy
$ASPIC_{2008}$	283800	0.70	0.344	24440	0.172	0.0342	1.645
$ASPIC_{2007}$	254600	0.77	0.410	26100	0.205	0.0286	1.820
$ASPIC_{2006}$	255400	0.77	0.408	26040	0.204	0.0287	1.816
$ASPIC_{2005}$	261300	0.75	0.392	25630	0.196	0.0298	1.781
$ASPIC_{2004}$	269700	0.72	0.371	25040	0.186	0.0320	1.710

Table 9: Summary of the $ASPIC_{2008}$ results from bootstrapped analysis

Param name	Point estimate	Bias corrected	Estimated bias in pt estimate	Estimated relative bias	Bias-corrected approximate confidence limits 80% lower	80% upper	50% lower	50% upper	Inter-quartile range	Relative IQ range
B1/K	0.7033	0.770	0.067	9.5%	0.502	1.216	0.585	0.906	0.322	0.458
K	283800	289451	5651	2.0%	236600	383900	259300	329500	70220	0.247
MSY	24440	25051	611	2.5%	21780	26600	22850	25330	2484	0.102
Ye(2008)	5519	6606	1087	19.7%	2178	15670	3295	9964	6669	1.208
Y.@Fmsy	45950	46200	250	0.5%	33400	52700	40480	49300	8821	0.192
Bmsy	141900	144725	2825	2.0%	118300	192000	129600	164800	35110	0.247
Fmsy	0.172	0.181	0.009	5.0%	0.117	0.225	0.139	0.196	0.058	0.334
B./Bmsy	1.880	1.836	-0.044	-2.4%	1.552	1.959	1.756	1.933	0.177	0.094
F./Fmsy	0.038	0.039	0.001	2.4%	0.033	0.053	0.035	0.043	0.008	0.215
Ye./MSY	0.226	0.276	0.051	22.4%	0.080	0.694	0.129	0.428	0.299	1.322

Table 10a: B/Bmsy bias corrected trajectory 1959-2013 from ASPIC $_{2008}$ bootstrap results, with associated 80% CL's.

Year	Point estimate	Estimated bias	Bias corrected	Approx 80% lower CL	Approx 80% upper CL
1959	1.407	0.134	1.541	1.003	2.431
1960	1.246	0.066	1.312	0.867	1.995
1961	1.222	0.035	1.257	0.856	1.830
1962	1.222	0.015	1.237	0.858	1.714
1963	1.235	0.002	1.237	0.866	1.641
1964	1.206	-0.008	1.198	0.841	1.554
1965	1.295	-0.014	1.281	0.923	1.596
1966	1.287	-0.019	1.268	0.913	1.542
1967	1.323	-0.022	1.301	0.954	1.552
1968	1.288	-0.025	1.263	0.935	1.486
1969	1.320	-0.026	1.294	0.973	1.502
1970	1.301	-0.026	1.275	0.958	1.461
1971	1.353	-0.026	1.327	1.008	1.502
1972	1.267	-0.026	1.241	0.944	1.395
1973	1.225	-0.025	1.200	0.908	1.344
1974	1.156	-0.024	1.132	0.856	1.269
1975	1.167	-0.022	1.145	0.861	1.288
1976	1.207	-0.020	1.187	0.903	1.340
1977	1.227	-0.019	1.208	0.928	1.365
1978	1.272	-0.018	1.254	0.966	1.419
1979	1.343	-0.018	1.325	1.034	1.495
1980	1.392	-0.019	1.373	1.099	1.546
1981	1.423	-0.021	1.402	1.131	1.569
1982	1.395	-0.021	1.374	1.124	1.524
1983	1.389	-0.021	1.368	1.134	1.509
1984	1.396	-0.020	1.376	1.145	1.509
1985	1.434	-0.019	1.415	1.183	1.549
1986	1.429	-0.018	1.411	1.189	1.536
1987	1.279	-0.017	1.262	1.084	1.358
1988	0.891	-0.017	0.874	0.810	0.920
1989	0.679	-0.015	0.664	0.659	0.737
1990	0.591	-0.012	0.578	0.565	0.657
1991	0.524	-0.010	0.514	0.490	0.601
1992	0.470	-0.007	0.463	0.421	0.551
1993	0.394	-0.005	0.389	0.333	0.489
1994	0.348	-0.002	0.345	0.269	0.470
1995	0.413	0.002	0.416	0.304	0.572
1996	0.522	0.009	0.532	0.371	0.710
1997	0.662	0.017	0.679	0.465	0.906
1998	0.818	0.022	0.840	0.559	1.112
1999	0.982	0.021	1.003	0.664	1.321
2000	1.137	0.014	1.151	0.760	1.482
2001	1.279	0.002	1.281	0.854	1.611
2002	1.420	-0.011	1.409	0.961	1.719
2003	1.543	-0.025	1.518	1.083	1.805
2004	1.645	-0.035	1.610	1.172	1.860
2005	1.730	-0.042	1.688	1.283	1.905
2006	1.797	-0.046	1.751	1.380	1.934
2007	1.849	-0.046	1.803	1.477	1.955
2008	1.880	-0.044	1.836	1.552	1.959
2009	1.903	-0.041	1.862	1.615	1.962
2010	1.900	-0.037	1.863	1.659	1.941
2011	1.898	-0.032	1.866	1.696	1.928
2012	1.896	-0.028	1.869	1.714	1.919
2013	1.895	-0.023	1.872	1.740	1.913

Table 10b: F/Fmsy bias corrected trajectory 1959-2012 from ASPIC $_{2008}$ bootstrap results, with associated 80% CL's.

Year	Point estimate	Estimated bias	Bias corrected	Approx 80% lower CL	Approx 80% upper CL
1959	1.380	0.032	1.412	0.843	1.973
1960	0.881	0.032	0.913	0.571	1.278
1961	0.776	0.032	0.808	0.534	1.127
1962	0.714	0.031	0.745	0.514	1.038
1963	0.918	0.043	0.961	0.681	1.321
1964	0.336	0.015	0.351	0.255	0.481
1965	0.744	0.031	0.775	0.580	1.058
1966	0.532	0.021	0.553	0.421	0.754
1967	0.852	0.032	0.885	0.684	1.205
1968	0.554	0.020	0.574	0.449	0.772
1969	0.773	0.026	0.799	0.629	1.069
1970	0.444	0.014	0.458	0.363	0.604
1971	1.075	0.031	1.106	0.884	1.455
1972	0.951	0.028	0.979	0.786	1.283
1973	1.146	0.034	1.180	0.949	1.544
1974	0.785	0.023	0.808	0.647	1.060
1975	0.616	0.017	0.633	0.503	0.833
1976	0.690	0.019	0.708	0.558	0.933
1977	0.541	0.014	0.555	0.438	0.737
1978	0.377	0.009	0.386	0.305	0.517
1979	0.421	0.009	0.430	0.343	0.572
1980	0.466	0.009	0.475	0.382	0.631
1981	0.705	0.013	0.718	0.582	0.942
1982	0.633	0.010	0.644	0.525	0.841
1983	0.580	0.008	0.588	0.485	0.769
1984	0.427	0.005	0.432	0.358	0.564
1985	0.588	0.006	0.593	0.496	0.773
1986	1.298	0.010	1.308	1.105	1.682
1987	3.030	0.022	3.052	2.650	3.827
1988	2.802	0.022	2.824	2.514	3.409
1989	2.176	0.018	2.194	1.950	2.586
1990	2.142	0.019	2.161	1.891	2.543
1991	2.130	0.021	2.151	1.824	2.552
1992	2.593	0.039	2.632	2.126	3.204
1993	2.355	0.068	2.423	1.753	3.039
1994	0.618	0.025	0.644	0.443	0.865
1995	0.174	0.008	0.182	0.122	0.254
1996	0.031	0.001	0.033	0.021	0.047
1997	0.035	0.002	0.037	0.023	0.054
1998	0.041	0.002	0.043	0.028	0.066
1999	0.089	0.005	0.094	0.062	0.146
2000	0.106	0.006	0.112	0.076	0.176
2001	0.044	0.003	0.046	0.032	0.072
2002	0.034	0.002	0.035	0.026	0.055
2003	0.034	0.002	0.036	0.027	0.055
2004	0.015	0.001	0.016	0.013	0.024
2005	0.015	0.001	0.016	0.013	0.023
2006	0.011	0.000	0.011	0.010	0.016
2007	0.038	0.001	0.039	0.033	0.053
2008	0.037	0.001	0.037	0.032	0.050
2009	0.108	0.001	0.109	0.095	0.141
2010	0.108	0.001	0.108	0.096	0.138
2011	0.108	0.000	0.108	0.097	0.135
2012	0.108	0.000	0.108	0.098	0.133

Table 11: Bias corrected B/Bmsy trajectories from two consecutive ASPIC projections under a constant catch of 5000 ton

Year	$ASPICP_{2008}$	$ASPICP_{2007}$
2007	1.803	1.894
2008	1.836	1.918
2009	1.862	1.906
2010	1.863	1.901
2011	1.866	1.897
2012	1.869	1.895
2013	1.872	1.896

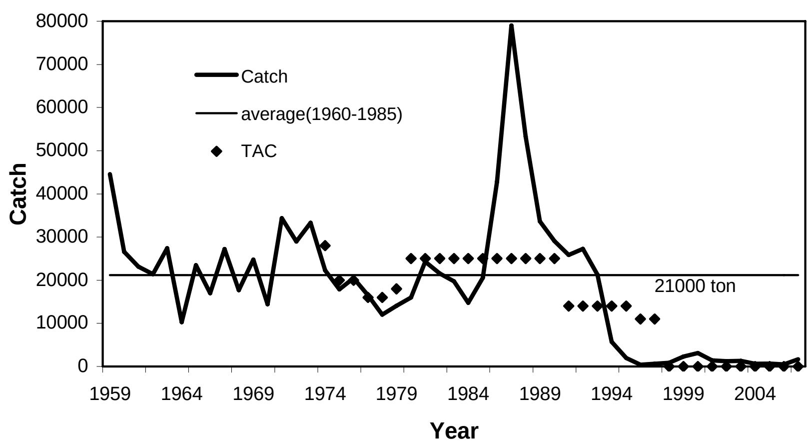


Fig. 1: redfish catch and TAC's in Div. 3LN

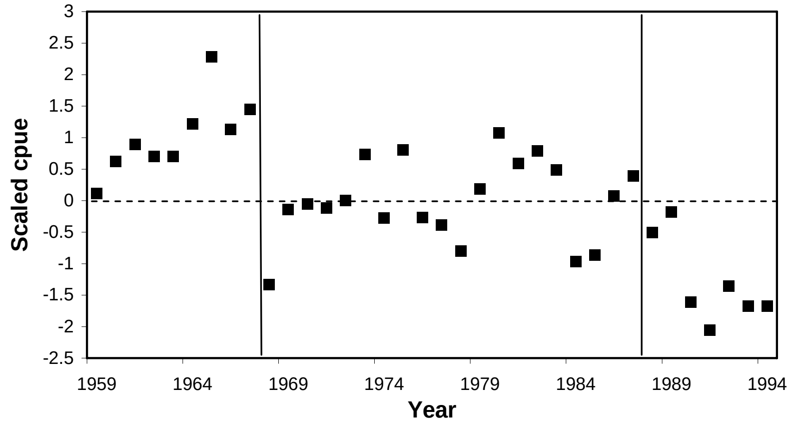


Fig. 2: Redfish Div. 3LN cpue 1959-1994

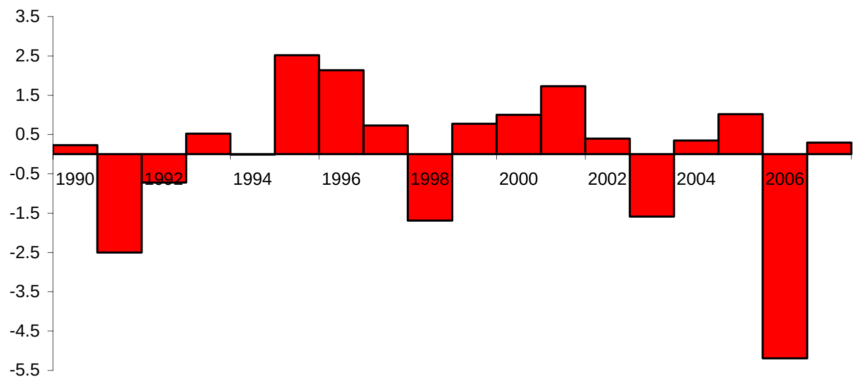


Fig. 3: Annual annomalies of the mean length of the commercial catch, 1990-2007

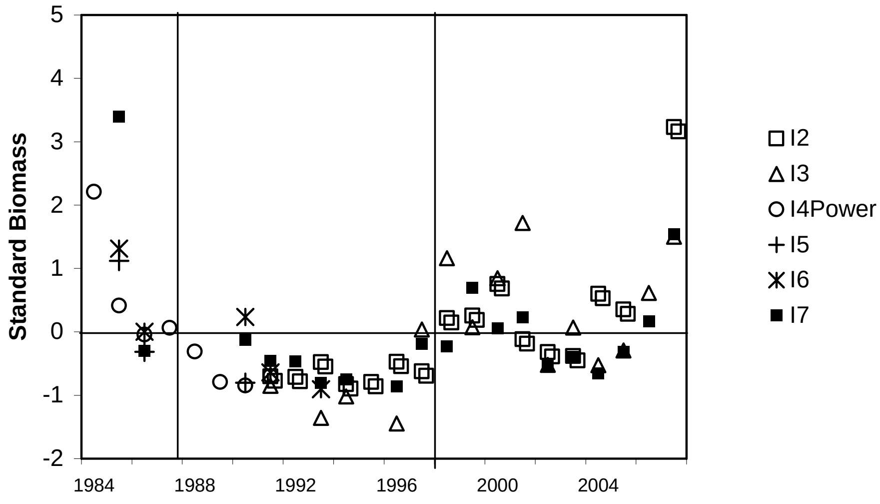


Fig. 4a: Standardized Survey Biomass

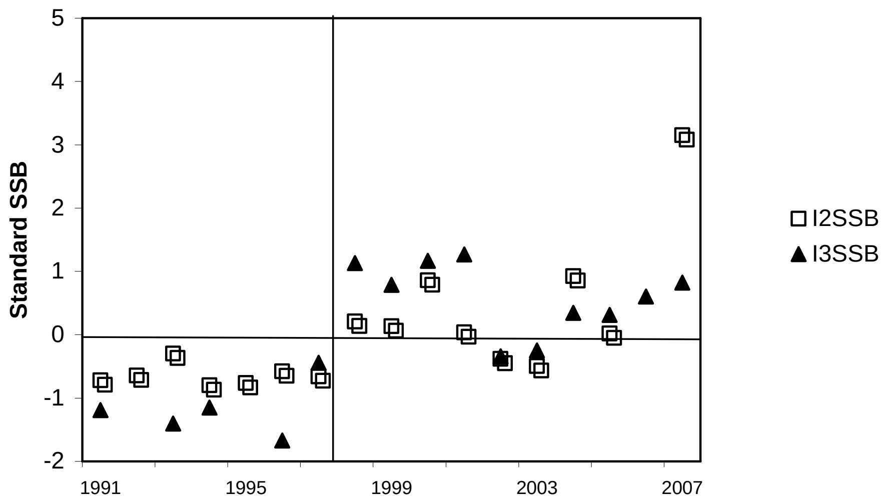


Fig. 4b: Standardized survey female SSB

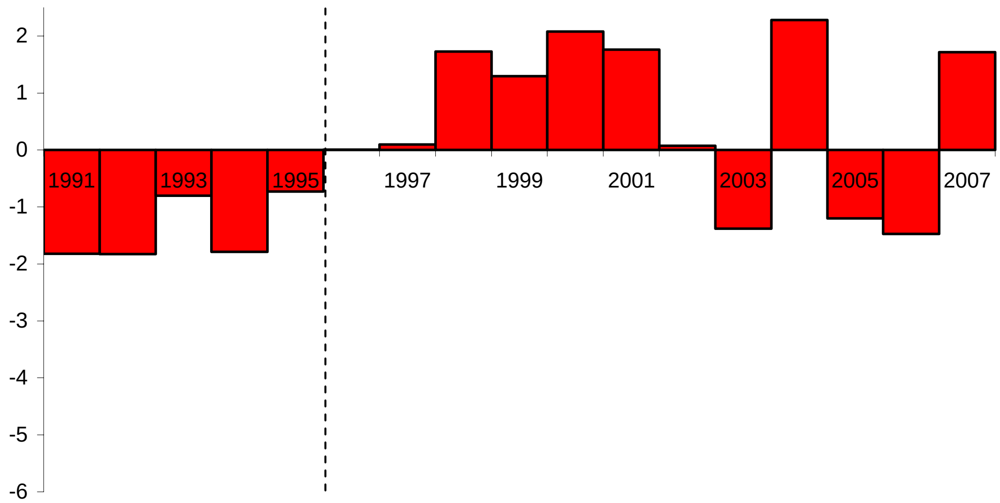


Fig. 5a: Annual annomalies of the mean length on the spring survey stock, 1991-2007

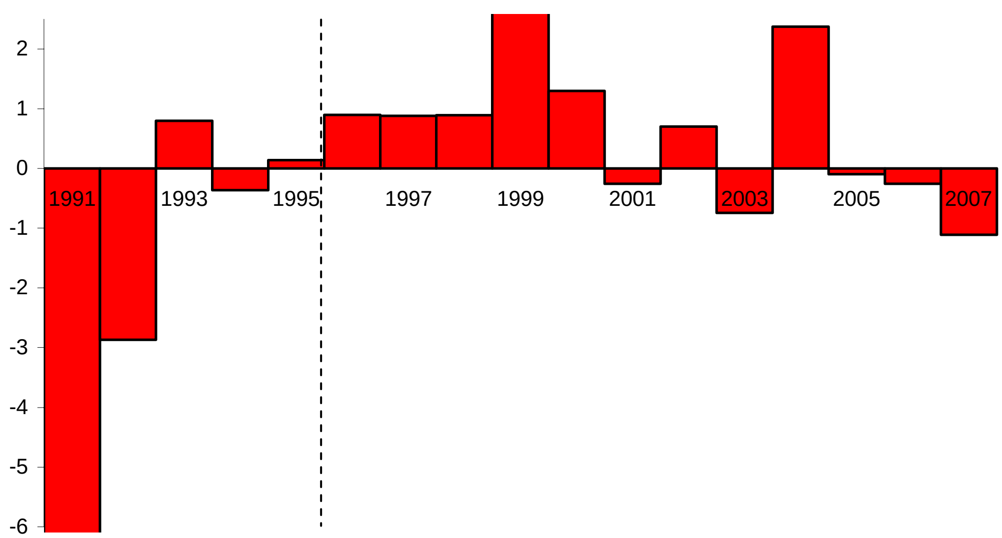


Fig. 5b: Annual annomalies of the mean length on the autumn survey stock, 1991-2007

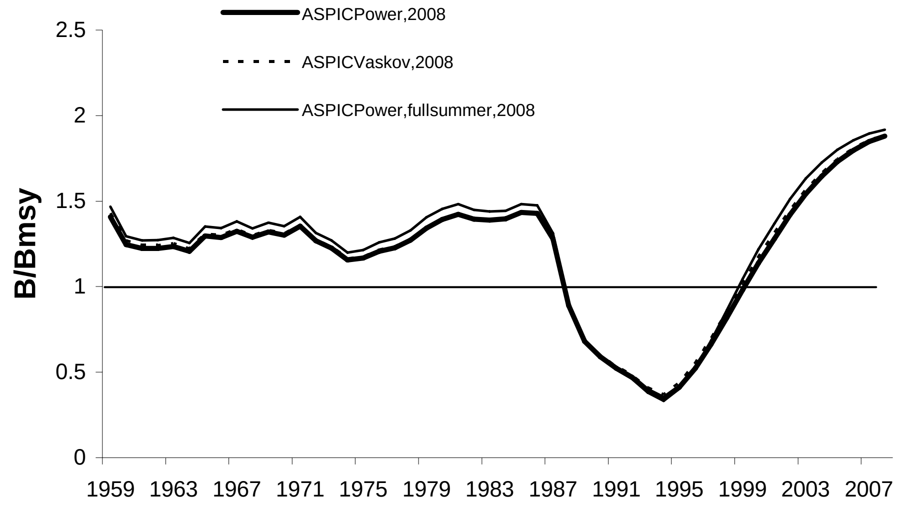


Fig. 6a : B/Bmsy trends for 3 $ASPIC_{2008}$ formulations

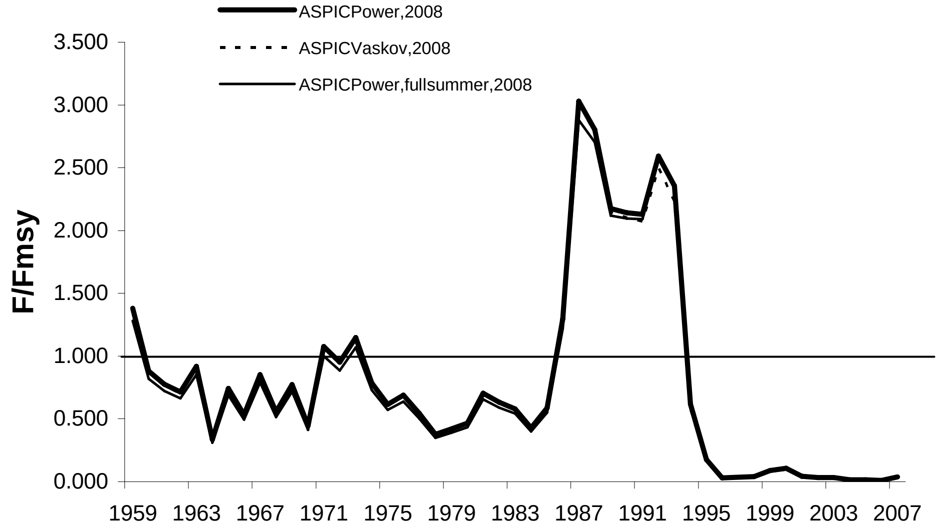


Fig. 6b : F/Fmsy trends for 3 $ASPIC_{2008}$ formulations

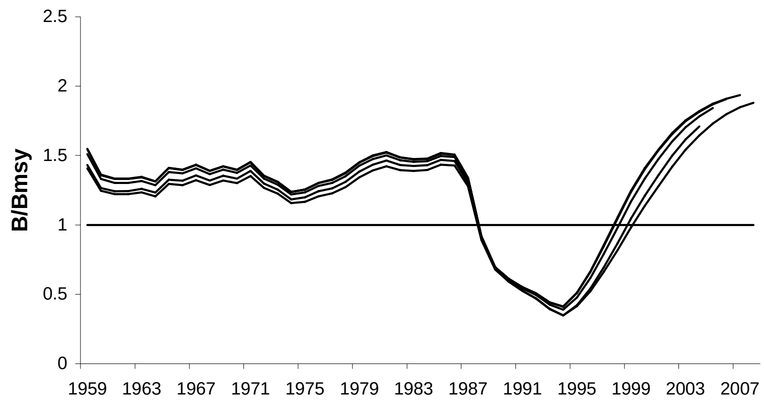


Fig. 7a: Retrospective B/Bmsy for ASPIC, 2008-2004

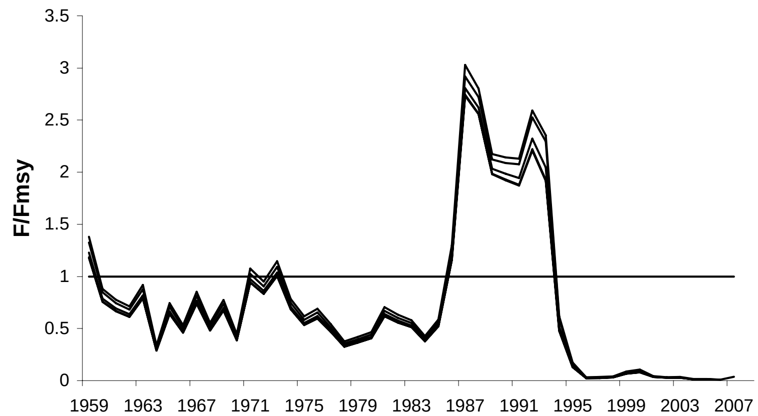


Fig. 7b: Retrospective F/Fmsy for ASPIC 2008-2004

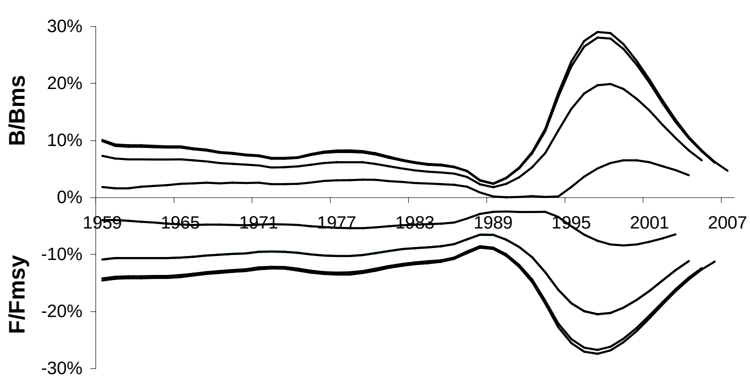


Fig 7c:Trends in bias for retrospective ASPIC 2007-2004 referred to ASPIC 2008

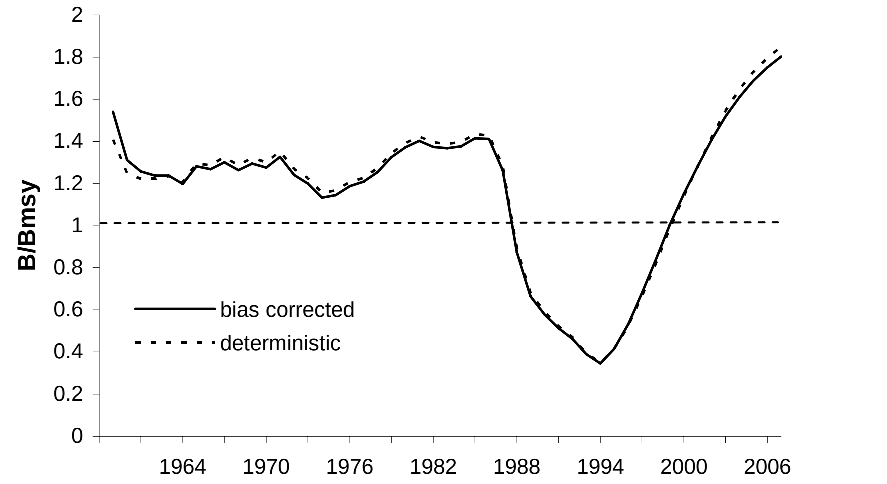


Fig. 8a: B/Bmsy deterministic and bias corrected trajectories

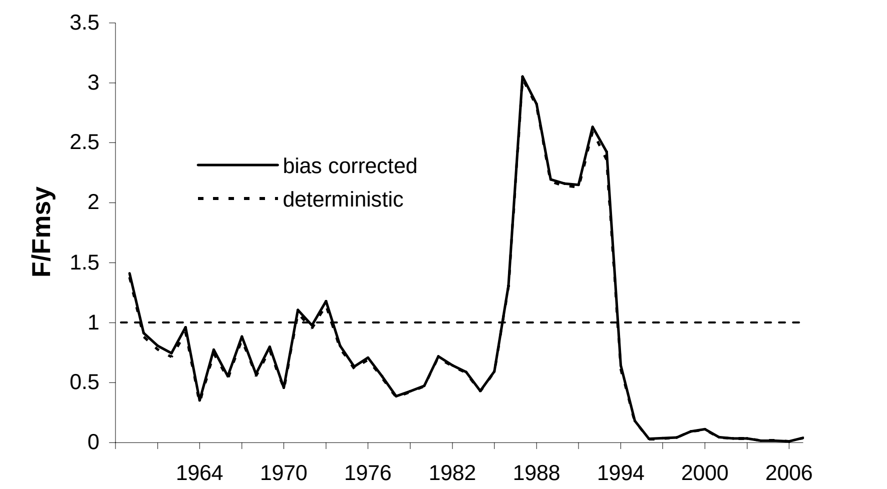


Fig. 8b: F/Fmsy deterministic and bias corrected trajectories

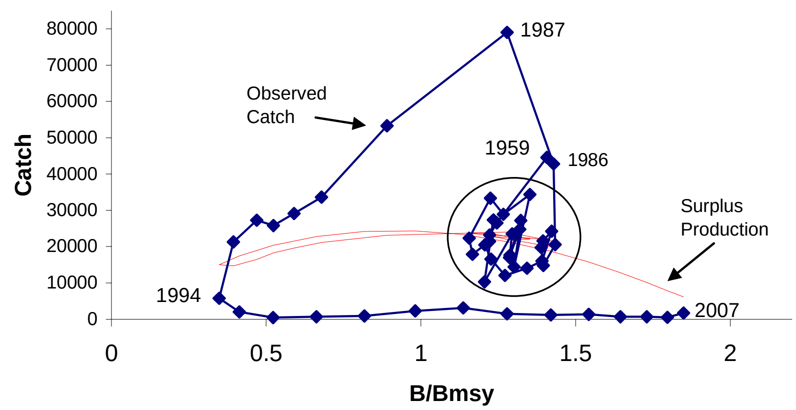


Fig. 9: Catch versus Surplus Production

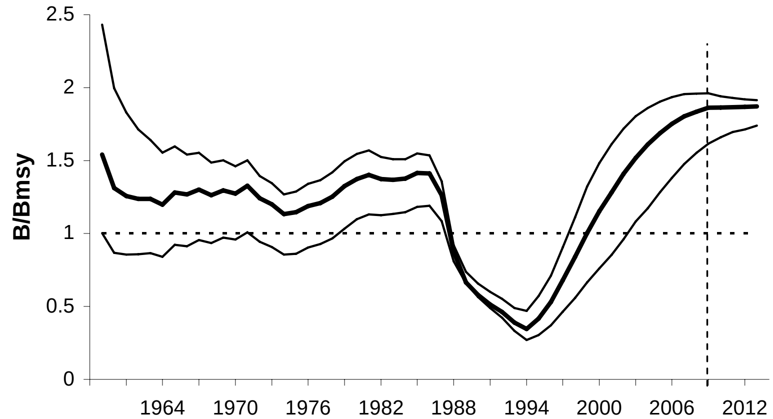


Fig. 10a: B/Bmsy trajectory and 2008-2013 projection under 5000 ton Yield (Bias corrected point estimates with approximate 80% CL's)

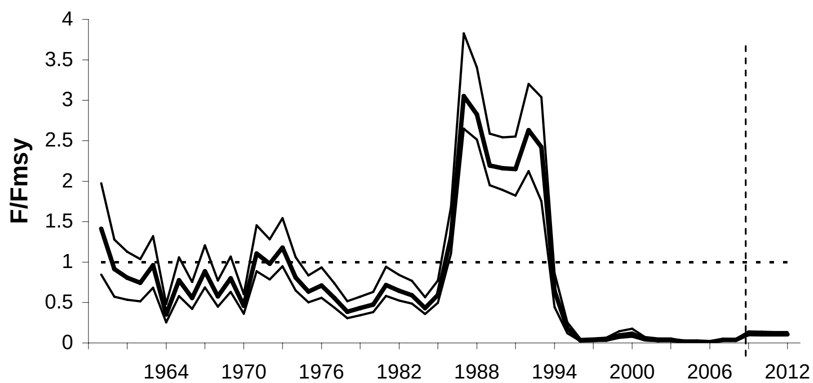


Fig. 10b. F/Fmsy trajectory and 2007-2012 projection under 5000 ton Yield (Bias corrected point estimates with approximate 80% CL's)

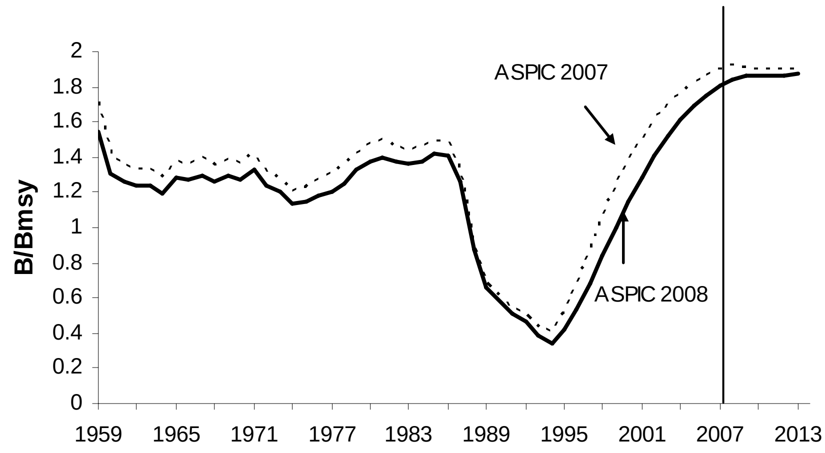


Fig. 11: B/Bmsy bias corrected trajectories and medium term projections under 5000 ton Yield from ASPIC 2008 and ASPIC 2007

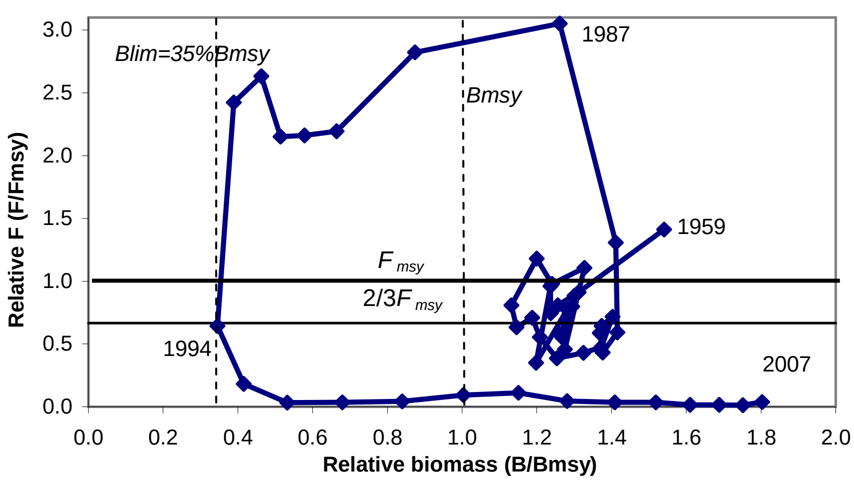


Fig. 12 : Stock trajectory under a precautionary framework

Appendix 1:

ASPIC input file for the ASPICPower2008 formulation, including the complete series of each biomass index.

```
BOT                                                               ## Run type (FIT, BOT, or IRF)
"3LN redfish"
LOGISTIC YLD SSE                                                  ## See notes at end of this file
2                                                                 ## Verbosity on screen (0-3); add 10 for SUM & PRN
files
1000
## Number of bootstrap trials, <= 1000
0 20000                                                           ## 0=no MC search, 1=search, 2=repeated srch; N trials
1d-8                                                              ## Convergence crit. for simplex
3d-8    6                                                         ## Convergence crit. for restarts, N restarts
1d-4    24                                                        ## Conv. crit. for F; N steps/yr for gen. model
6d0                                                               ## Maximum F when cond. on yield
0d0                                                               ## Stat weight for B1>K as residual (usually 0 or 1)
7                                                                 ## Number of fisheries (data series)
1d0  1d0  1.d0   1.d0   1.d0    1.d0    1.d0                       ## Statistical weights for data series
0.5d0                                                             ## B1/K (starting guess, usually 0 to 1)
2.0d4                                                             ## MSY (starting guess)
2.000E+05                                                         ## K (carrying capacity) (starting guess)
9.007E-06  0.658d0  1.0d0  0.658d0  0.322d0  0.275d0   0.275d0       ## q (starting guesses -- 1 per data series)
1 1 1 1 1 1 1 1 1 1                                               ## Estimate flags (0 or 1) (B1/K,MSY,K,q1...qn)
0.5d4  5.0d4                                                      ## Min and max constraints -- MSY
1.0d5  5.0d5                                                      ## Min and max constraints -- K
3941285                                                           ## Random number seed (large integer)
49                                                                ## Number of years of data
'Statlant CPUE'                                                   ## Title for first series
'CC'
1959      1.426     44585
1960      1.602     26562
1961      1.697     23175
1962      1.631     21439
1963      1.632     27362
1964      1.812     10261
1965      2.185     23466
1966      1.781     16974
1967      1.893     27188
1968      0.922     17660
1969      1.338     24750
1970      1.367     14419
1971      1.346     34370
1972      1.387     28933
1973      1.643     33297
1974      1.290     22286
1975      1.669     17871
1976      1.292     20513
1977      1.251     16516
1978      1.106     12043
1979      1.451     14067
1980      1.761     16030
1981      1.594     24280
1982      1.661     21547
1983      1.556     19747
1984      1.049     14761
1985      1.084     20557
1986      1.413     42805
1987      1.523     79031
1988      1.208     53266
1989      1.322     33649
1990      0.825     29105
1991      0.668     25815
1992      0.912     27283
1993      0.801     21308
1994      0.802     5741
1995      -0.001    1989
1996      -0.001    451
1997      -0.001    630
1998      -0.001    899
1999      -0.001    2318
2000      -0.001    3141
2001      -0.001    1442
2002      -0.001    1216
2003      -0.001    1334
2004      -0.001    637
2005      -0.001    659
2006      -0.001    496
2007      -0.001    1728
'3LN spring survey'
'I1'
1959      -0.001
1960      -0.001
1961      -0.001
1962      -0.001
1963      -0.001
1964      -0.001
1965      -0.001
1966      -0.001
1967      -0.001
1968      -0.001
1969      -0.001
1970      -0.001
1971      -0.001
1972      -0.001
1973      -0.001
1974      -0.001
1975      -0.001
1976      -0.001
```

```
1977      -0.001
1978      -0.001
1979      -0.001
1980      -0.001
1981      -0.001
1982      -0.001
1983      -0.001
1984      -0.001
1985      -0.001
1986      -0.001
1987      -0.001
1988      -0.001
1989      -0.001
1990      -0.001
1991          10642.0
1992          10066.0
1993          22573.0
1994          4162.0
1995          5856.0
1996          22812.0
1997          14928.0
1998          59402.0
1999          61496.0
2000          87842.0
2001          41573.2
2002          30958.9
2003          27700.0
2004          79631.0
2005          66462.0
2006      -0.001
2007          218847.0
'3LN autumn survey'
'I2'
1959      -0.001
1960      -0.001
1961      -0.001
1962      -0.001
1963      -0.001
1964      -0.001
1965      -0.001
1966      -0.001
1967      -0.001
1968      -0.001
1969      -0.001
1970      -0.001
1971      -0.001
1972      -0.001
1973      -0.001
1974      -0.001
1975      -0.001
1976      -0.001
1977      -0.001
1978      -0.001
1979      -0.001
1980      -0.001
1981      -0.001
1982      -0.001
1983      -0.001
1984      -0.001
1985      -0.001
1986      -0.001
1987      -0.001
1988      -0.001
1989      -0.001
1990      -0.001
1991          37886.0
1992      -0.001
1993          19233.0
1994          31757.0
1995      -0.001
1996          15968.0
1997          70660.0
1998          112225.0
1999          71986.0
2000          100461.0
2001          132565.7
2002          50122.6
2003          71889.0
2004          49907.0
2005          58561.0
2006          91883.4
2007          124758.0
'3LN Power russian survey'
'I1'
1959      -0.001
1960      -0.001
1961      -0.001
1962      -0.001
1963      -0.001
1964      -0.001
1965      -0.001
1966      -0.001
1967      -0.001
1968      -0.001
1969      -0.001
1970      -0.001
1971      -0.001
1972      -0.001
1973      -0.001
1974      -0.001
1975      -0.001
1976      -0.001
```

```
1977      -0.001
1978      -0.001
1979      -0.001
1980      -0.001
1981      -0.001
1982      -0.001
1983      -0.001
1984          215883.0
1985          93996.0
1986          62975.0
1987          70298.0
1988          44884.0
1989          12268.0
1990          8365.0
1991          18680.0
1992      -0.001
1993      -0.001
1994      -0.001
1995      -0.001
1996      -0.001
1997      -0.001
1998      -0.001
1999      -0.001
2000      -0.001
2001      -0.001
2002      -0.001
2003      -0.001
2004      -0.001
2005      -0.001
2006      -0.001
2007    -0.001
'3L winter survey'
'I0'
1959      -0.001
1960      -0.001
1961      -0.001
1962      -0.001
1963      -0.001
1964      -0.001
1965      -0.001
1966      -0.001
1967      -0.001
1968      -0.001
1969      -0.001
1970      -0.001
1971      -0.001
1972      -0.001
1973      -0.001
1974      -0.001
1975      -0.001
1976      -0.001
1977      -0.001
1978      -0.001
1979      -0.001
1980      -0.001
1981      -0.001
1982      -0.001
1983      -0.001
1984      -0.001
1985          90245.0
1986          36568.0
1987      -0.001
1988      -0.001
1989      -0.001
1990          18202.0
1991      -0.001
1992      -0.001
1993      -0.001
1994      -0.001
1995      -0.001
1996      -0.001
1997      -0.001
1998      -0.001
1999      -0.001
2000      -0.001
2001      -0.001
2002      -0.001
2003      -0.001
2004      -0.001
2005      -0.001
2006      -0.001
2007    -0.001
'3L summer survey'
'I1'
1959      -0.001
1960      -0.001
1961      -0.001
1962      -0.001
1963      -0.001
1964      -0.001
1965      -0.001
1966      -0.001
1967      -0.001
1968      -0.001
1969      -0.001
1970      -0.001
1971      -0.001
1972      -0.001
1973      -0.001
1974      -0.001
1975      -0.001
1976      -0.001
```

```
1977      -0.001
1978      -0.001
1979      -0.001
1980      -0.001
1981      -0.001
1982      -0.001
1983      -0.001
1984      -0.001
1985          161038.0
1986      -0.001
1987      -0.001
1988      -0.001
1989      -0.001
1990          92840.0
1991          37572.0
1992      -0.001
1993          20838.0
1994      -0.001
1995      -0.001
1996      -0.001
1997      -0.001
1998      -0.001
1999      -0.001
2000      -0.001
2001      -0.001
2002      -0.001
2003      -0.001
2004      -0.001
2005      -0.001
2006      -0.001
2007    -0.001
'3L autumn survey'
'I1'
1959      -0.001
1960      -0.001
1961      -0.001
1962      -0.001
1963      -0.001
1964      -0.001
1965      -0.001
1966      -0.001
1967      -0.001
1968      -0.001
1969      -0.001
1970      -0.001
1971      -0.001
1972      -0.001
1973      -0.001
1974      -0.001
1975      -0.001
1976      -0.001
1977      -0.001
1978      -0.001
1979      -0.001
1980      -0.001
1981      -0.001
1982      -0.001
1983      -0.001
1984      -0.001
1985      98233.0
1986      17119.0
1987      -0.001
1988      -0.001
1989      -0.001
1990      20743.0
1991      13665.0
1992      13424.0
1993      6011.0
1994      7173.0
1995      -0.001
1996      4691.0
1997      19544.0
1998      18522.0
1999      38861.0
2000      24917.0
2001      28568.7
2002      11888.0
2003      15007.0
2004      9293.0
2005      16650.0
2006      27218.4
2007    57546.0
```

Appendix 2:

ASPIC2008 results on FIT mode

```
3LN redfish                                                                                              Page 1
                                                                                 Monday, 05 May 2008 at 17:09:11
ASPIC -- A Surplus-Production Model Including Covariates (Ver. 5.16)
                                                                                                FIT program mode
Author:     Michael H. Prager; NOAA Center for Coastal Fisheries and Habitat Research         LOGISTIC model mode
            101 Pivers Island Road; Beaufort, North Carolina  28516  USA                        YLD conditioning
            Mike.Prager@noaa.gov                                                                SSE optimization

Reference:  Prager, M. H. 1994. A suite of extensions to a nonequilibrium           ASPIC User's Manual is available
            surplus-production model.  Fishery Bulletin 92: 374-389.                           gratis from the author.

CONTROL PARAMETERS (FROM INPUT FILE)                                                        Input file: aspic.inp
-----------------------------------------------------------------------------------------------------------------
Operation of ASPIC:  Fit logistic (Schaefer) model by direct optimization.
Number of years analyzed:                      49           Number of bootstrap trials:                        0
Number of data series:                          7           Bounds on MSY (min, max):       5.000E+03     5.000E+04
Objective function:                 Least squares           Bounds on K (min, max):         1.000E+05     5.000E+05
Relative conv. criterion (simplex):     1.000E-08           Monte Carlo search mode, trials:        0         20000
Relative conv. criterion (restart):     3.000E-08           Random number seed:                             3941285
Relative conv. criterion (effort):      1.000E-04           Identical convergences required in fitting:        6
Maximum F allowed in fitting:               6.000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS)                                           error code   0
-----------------------------------------------------------------------------------------------------------------
Normal convergence

WARNING: Negative correlations detected between some indices.  A fundamental assumption of ASPIC is that all indices
         represent the abundance of the stock.  That assumption appears to be violated.
Number of restarts required for convergence:     47


CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)
-----------------------------------------------------------------------------------------------------------------
                                       |
 1  Statlant CPUE                      |   1.000
                                       |      36
                                       |
 2  3LN spring survey                  |  -0.019   1.000
                                       |       4      16
                                       |
 3  3LN autumn survey                  |  -0.748   0.593   1.000
                                       |       3      14      15
                                       |
 4  3LN Power russian survey           |   0.108   0.000   0.000   1.000
                                       |       8       1       1       8
                                       |
 5  3L winter survey                   |   0.178   0.000   0.000   0.908   1.000
                                       |       3       0       0       3       3
                                       |
 6  3L summer survey                   |   0.885  -1.000   1.000   0.840   1.000   1.000
                                       |       4       2       2       3       2       4
                                       |
 7  3L autumn survey                   |   0.326   0.806   0.759   0.794   0.959   0.930   1.000
                                       |       7      15      15       4       3       4      19
                                       -------------------------------------------------------------------------
                                               1       2       3       4       5       6       7


GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)
-----------------------------------------------------------------------------------------------------------------
                                                 Weighted           Weighted      Current     Inv. var.    R-squared
Loss component number and title                       SSE      N         MSE       weight        weight      in CPUE

Loss(-1)  SSE in yield                          0.000E+00
Loss(0)   Penalty for B1 > K                    0.000E+00      1         N/A    0.000E+00           N/A
Loss(1)   Statlant CPUE                         2.732E+00     36   8.035E-02    1.000E+00     2.040E+00        0.097
Loss(2)   3LN spring survey                     6.901E+00     16   4.929E-01    1.000E+00     3.325E-01        0.274
Loss(3)   3LN autumn survey                     3.165E+00     15   2.435E-01    1.000E+00     6.732E-01        0.239
Loss(4)   3LN Power russian survey              3.778E+00      8   6.297E-01    1.000E+00     2.603E-01        0.231
Loss(5)   3L winter survey                      4.514E-01      3   4.514E-01    1.000E+00     3.631E-01        0.402
Loss(6)   3L summer survey                      6.723E-01      4   3.362E-01    1.000E+00     4.876E-01        0.787
Loss(7)   3L autumn survey                      7.542E+00     19   4.437E-01    1.000E+00     3.694E-01        0.124
.............................................................................................
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:       2.52420119E+01          2.774E-01    5.267E-01
Estimated contrast index (ideal = 1.0):            0.7660          C* = (Bmax-Bmin)/K
Estimated nearness index (ideal = 1.0):            1.0000          N* = 1 - |min(B-Bmsy)|/K
```

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User/pgm guess	2nd guess	Estimated	User guess
B1/K	Starting relative biomass (in 1959)	7.033E-01	5.000E-01	6.568E-01	1	1
MSY	Maximum sustainable yield	2.444E+04	2.000E+04	1.613E+04	1	1
K	Maximum population size	2.838E+05	2.000E+05	1.800E+05	1	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	----	0	1
---------	Catchability Coefficients by Data Series ---------------					
q(1)	Statlant CPUE	8.795E-06	9.007E-06	8.557E-04	1	1
q(2)	3LN spring survey	2.336E-01	6.580E-01	1.012E+00	1	1
q(3)	3LN autumn survey	3.946E-01	1.000E+00	6.978E-01	1	1
q(4)	3LN Power russian survey	3.231E-01	6.580E-01	7.339E-01	1	1
q(5)	3L winter survey	2.590E-01	3.220E-01	1.001E+00	1	1
q(6)	3L summer survey	6.668E-01	2.750E-01	6.196E-01	1	1
q(7)	3L autumn survey	1.296E-01	2.750E-01	1.140E+00	1	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	2.444E+04	----	----
Bmsy	Stock biomass giving MSY	1.419E+05	K/2	K*n**(1/(1-n))
Fmsy	Fishing mortality rate at MSY	1.722E-01	MSY/Bmsy	MSY/Bmsy
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2008)/Bmsy	1.880E+00	----	----
F./Fmsy	Ratio: F(2007)/Fmsy	3.791E-02	----	----
Fmsy/F.	Ratio: Fmsy/F(2007)	2.638E+01	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2008	4.595E+04	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.880E+00	----	----
Ye.	Equilibrium yield available in 2008	5.519E+03	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	2.258E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	Statlant CPUE	1.958E+04	Fmsy/q(1)	Fmsy/q(1)

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1959	0.238	1.996E+05	1.876E+05	4.458E+04	4.458E+04	2.186E+04	1.380E+00	1.407E+00
2	1960	0.152	1.769E+05	1.751E+05	2.656E+04	2.656E+04	2.310E+04	8.809E-01	1.246E+00
3	1961	0.134	1.734E+05	1.734E+05	2.318E+04	2.318E+04	2.323E+04	7.758E-01	1.222E+00
4	1962	0.123	1.735E+05	1.744E+05	2.144E+04	2.144E+04	2.316E+04	7.139E-01	1.222E+00
5	1963	0.158	1.752E+05	1.731E+05	2.736E+04	2.736E+04	2.326E+04	9.180E-01	1.235E+00
6	1964	0.058	1.711E+05	1.776E+05	1.026E+04	1.026E+04	2.288E+04	3.355E-01	1.206E+00
7	1965	0.128	1.837E+05	1.832E+05	2.347E+04	2.347E+04	2.238E+04	7.439E-01	1.295E+00
8	1966	0.092	1.826E+05	1.853E+05	1.697E+04	1.697E+04	2.215E+04	5.319E-01	1.287E+00
9	1967	0.147	1.878E+05	1.852E+05	2.719E+04	2.719E+04	2.216E+04	8.524E-01	1.323E+00
10	1968	0.095	1.828E+05	1.851E+05	1.766E+04	1.766E+04	2.217E+04	5.539E-01	1.288E+00
11	1969	0.133	1.873E+05	1.859E+05	2.475E+04	2.475E+04	2.209E+04	7.730E-01	1.320E+00
12	1970	0.077	1.846E+05	1.884E+05	1.442E+04	1.442E+04	2.181E+04	4.443E-01	1.301E+00
13	1971	0.185	1.920E+05	1.856E+05	3.437E+04	3.437E+04	2.211E+04	1.075E+00	1.353E+00
14	1972	0.164	1.798E+05	1.767E+05	2.893E+04	2.893E+04	2.297E+04	9.510E-01	1.267E+00
15	1973	0.197	1.738E+05	1.687E+05	3.330E+04	3.330E+04	2.356E+04	1.146E+00	1.225E+00
16	1974	0.135	1.641E+05	1.648E+05	2.229E+04	2.229E+04	2.380E+04	7.850E-01	1.156E+00
17	1975	0.106	1.656E+05	1.685E+05	1.787E+04	1.787E+04	2.358E+04	6.158E-01	1.167E+00
18	1976	0.119	1.713E+05	1.727E+05	2.051E+04	2.051E+04	2.329E+04	6.896E-01	1.207E+00
19	1977	0.093	1.741E+05	1.774E+05	1.652E+04	1.652E+04	2.291E+04	5.407E-01	1.227E+00
20	1978	0.065	1.805E+05	1.856E+05	1.204E+04	1.204E+04	2.211E+04	3.767E-01	1.272E+00
21	1979	0.072	1.905E+05	1.942E+05	1.407E+04	1.407E+04	2.112E+04	4.207E-01	1.343E+00
22	1980	0.080	1.976E+05	1.998E+05	1.603E+04	1.603E+04	2.037E+04	4.658E-01	1.392E+00
23	1981	0.121	2.019E+05	1.999E+05	2.428E+04	2.428E+04	2.036E+04	7.053E-01	1.423E+00
24	1982	0.109	1.980E+05	1.975E+05	2.155E+04	2.155E+04	2.068E+04	6.333E-01	1.395E+00
25	1983	0.100	1.971E+05	1.976E+05	1.975E+04	1.975E+04	2.067E+04	5.802E-01	1.389E+00
26	1984	0.073	1.981E+05	2.009E+05	1.476E+04	1.476E+04	2.022E+04	4.266E-01	1.396E+00
27	1985	0.101	2.035E+05	2.032E+05	2.056E+04	2.056E+04	1.989E+04	5.875E-01	1.434E+00
28	1986	0.223	2.028E+05	1.915E+05	4.280E+04	4.280E+04	2.141E+04	1.298E+00	1.429E+00
29	1987	0.522	1.814E+05	1.515E+05	7.903E+04	7.903E+04	2.403E+04	3.030E+00	1.279E+00
30	1988	0.483	1.264E+05	1.104E+05	5.327E+04	5.327E+04	2.314E+04	2.802E+00	8.910E-01
31	1989	0.375	9.632E+04	8.980E+04	3.365E+04	3.365E+04	2.113E+04	2.176E+00	6.787E-01
32	1990	0.369	8.380E+04	7.888E+04	2.910E+04	2.910E+04	1.961E+04	2.142E+00	5.905E-01
33	1991	0.367	7.430E+04	7.038E+04	2.582E+04	2.582E+04	1.823E+04	2.130E+00	5.236E-01
34	1992	0.447	6.671E+04	6.110E+04	2.728E+04	2.728E+04	1.650E+04	2.593E+00	4.701E-01
35	1993	0.406	5.593E+04	5.255E+04	2.131E+04	2.131E+04	1.474E+04	2.355E+00	3.941E-01
36	1994	0.106	4.937E+04	5.393E+04	5.741E+03	5.741E+03	1.504E+04	6.181E-01	3.479E-01
37	1995	0.030	5.867E+04	6.620E+04	1.989E+03	1.989E+03	1.746E+04	1.744E-01	4.134E-01
38	1996	0.005	7.414E+04	8.384E+04	4.510E+02	4.510E+02	2.031E+04	3.123E-02	5.224E-01
39	1997	0.006	9.400E+04	1.049E+05	6.300E+02	6.300E+02	2.273E+04	3.487E-02	6.624E-01
40	1998	0.007	1.161E+05	1.277E+05	8.990E+02	8.990E+02	2.414E+04	4.089E-02	8.181E-01
41	1999	0.015	1.393E+05	1.504E+05	2.318E+03	2.318E+03	2.430E+04	8.949E-02	9.819E-01
42	2000	0.018	1.613E+05	1.716E+05	3.141E+03	3.141E+03	2.333E+04	1.063E-01	1.137E+00
43	2001	0.008	1.815E+05	1.917E+05	1.442E+03	1.442E+03	2.139E+04	4.368E-02	1.279E+00
44	2002	0.006	2.015E+05	2.105E+05	1.216E+03	1.216E+03	1.871E+04	3.355E-02	1.420E+00
45	2003	0.006	2.190E+05	2.264E+05	1.334E+03	1.334E+03	1.575E+04	3.421E-02	1.543E+00
46	2004	0.003	2.334E+05	2.397E+05	6.370E+02	6.370E+02	1.282E+04	1.543E-02	1.645E+00
47	2005	0.003	2.456E+05	2.505E+05	6.590E+02	6.590E+02	1.012E+04	1.528E-02	1.730E+00
48	2006	0.002	2.550E+05	2.589E+05	4.960E+02	4.960E+02	7.835E+03	1.113E-02	1.797E+00
49	2007	0.007	2.624E+05	2.647E+05	1.728E+03	1.728E+03	6.147E+03	3.791E-02	1.849E+00
50	2008		2.668E+05						1.880E+00

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Statlant CPUE

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Statist weight
1	1959	1.426E+00	1.650E+00	0.2377	4.458E+04	4.458E+04	0.14576	1.000E+00
2	1960	1.602E+00	1.540E+00	0.1517	2.656E+04	2.656E+04	-0.03958	1.000E+00
3	1961	1.697E+00	1.525E+00	0.1336	2.318E+04	2.318E+04	-0.10656	1.000E+00
4	1962	1.631E+00	1.534E+00	0.1230	2.144E+04	2.144E+04	-0.06161	1.000E+00
5	1963	1.632E+00	1.522E+00	0.1581	2.736E+04	2.736E+04	-0.06969	1.000E+00
6	1964	1.812E+00	1.562E+00	0.0578	1.026E+04	1.026E+04	-0.14869	1.000E+00
7	1965	2.185E+00	1.611E+00	0.1281	2.347E+04	2.347E+04	-0.30486	1.000E+00
8	1966	1.781E+00	1.630E+00	0.0916	1.697E+04	1.697E+04	-0.08875	1.000E+00
9	1967	1.893E+00	1.629E+00	0.1468	2.719E+04	2.719E+04	-0.15035	1.000E+00
10	1968	9.220E-01	1.628E+00	0.0954	1.766E+04	1.766E+04	0.56862	1.000E+00
11	1969	1.338E+00	1.635E+00	0.1331	2.475E+04	2.475E+04	0.20053	1.000E+00
12	1970	1.367E+00	1.657E+00	0.0765	1.442E+04	1.442E+04	0.19263	1.000E+00
13	1971	1.346E+00	1.632E+00	0.1852	3.437E+04	3.437E+04	0.19287	1.000E+00
14	1972	1.387E+00	1.554E+00	0.1638	2.893E+04	2.893E+04	0.11351	1.000E+00
15	1973	1.643E+00	1.484E+00	0.1973	3.330E+04	3.330E+04	-0.10185	1.000E+00
16	1974	1.290E+00	1.450E+00	0.1352	2.229E+04	2.229E+04	0.11680	1.000E+00
17	1975	1.669E+00	1.482E+00	0.1061	1.787E+04	1.787E+04	-0.11877	1.000E+00
18	1976	1.292E+00	1.519E+00	0.1188	2.051E+04	2.051E+04	0.16190	1.000E+00
19	1977	1.251E+00	1.560E+00	0.0931	1.652E+04	1.652E+04	0.22064	1.000E+00
20	1978	1.106E+00	1.633E+00	0.0649	1.204E+04	1.204E+04	0.38946	1.000E+00
21	1979	1.451E+00	1.708E+00	0.0724	1.407E+04	1.407E+04	0.16290	1.000E+00
22	1980	1.761E+00	1.757E+00	0.0802	1.603E+04	1.603E+04	-0.00200	1.000E+00
23	1981	1.594E+00	1.758E+00	0.1215	2.428E+04	2.428E+04	0.09786	1.000E+00
24	1982	1.661E+00	1.737E+00	0.1091	2.155E+04	2.155E+04	0.04499	1.000E+00
25	1983	1.556E+00	1.738E+00	0.0999	1.975E+04	1.975E+04	0.11064	1.000E+00
26	1984	1.049E+00	1.767E+00	0.0735	1.476E+04	1.476E+04	0.52134	1.000E+00
27	1985	1.084E+00	1.787E+00	0.1012	2.056E+04	2.056E+04	0.49980	1.000E+00
28	1986	1.413E+00	1.685E+00	0.2235	4.280E+04	4.280E+04	0.17577	1.000E+00
29	1987	1.523E+00	1.332E+00	0.5218	7.903E+04	7.903E+04	-0.13399	1.000E+00
30	1988	1.208E+00	9.706E-01	0.4827	5.327E+04	5.327E+04	-0.21879	1.000E+00
31	1989	1.322E+00	7.898E-01	0.3747	3.365E+04	3.365E+04	-0.51517	1.000E+00
32	1990	8.250E-01	6.937E-01	0.3690	2.910E+04	2.910E+04	-0.17330	1.000E+00
33	1991	6.680E-01	6.190E-01	0.3668	2.582E+04	2.582E+04	-0.07614	1.000E+00
34	1992	9.120E-01	5.373E-01	0.4466	2.728E+04	2.728E+04	-0.52900	1.000E+00
35	1993	8.010E-01	4.622E-01	0.4055	2.131E+04	2.131E+04	-0.54997	1.000E+00
36	1994	8.020E-01	4.744E-01	0.1064	5.741E+03	5.741E+03	-0.52515	1.000E+00
37	1995	*	5.823E-01	0.0300	1.989E+03	1.989E+03	0.00000	1.000E+00
38	1996	*	7.374E-01	0.0054	4.510E+02	4.510E+02	0.00000	1.000E+00
39	1997	*	9.225E-01	0.0060	6.300E+02	6.300E+02	0.00000	1.000E+00
40	1998	*	1.123E+00	0.0070	8.990E+02	8.990E+02	0.00000	1.000E+00
41	1999	*	1.323E+00	0.0154	2.318E+03	2.318E+03	0.00000	1.000E+00
42	2000	*	1.509E+00	0.0183	3.141E+03	3.141E+03	0.00000	1.000E+00
43	2001	*	1.686E+00	0.0075	1.442E+03	1.442E+03	0.00000	1.000E+00
44	2002	*	1.851E+00	0.0058	1.216E+03	1.216E+03	0.00000	1.000E+00
45	2003	*	1.991E+00	0.0059	1.334E+03	1.334E+03	0.00000	1.000E+00
46	2004	*	2.108E+00	0.0027	6.370E+02	6.370E+02	0.00000	1.000E+00
47	2005	*	2.203E+00	0.0026	6.590E+02	6.590E+02	0.00000	1.000E+00
48	2006	*	2.277E+00	0.0019	4.960E+02	4.960E+02	0.00000	1.000E+00
49	2007	*	2.328E+00	0.0065	1.728E+03	1.728E+03	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish   Page 5

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1959     0.1458                                             |======
1960    -0.0396                                           ==|
1961    -0.1066                                         ====|
1962    -0.0616                                           ==|
1963    -0.0697                                          ===|
1964    -0.1487                                       ======|
1965    -0.3049                                 ============|
1966    -0.0888                                         ====|
1967    -0.1503                                       ======|
1968     0.5686                                             |=======================
1969     0.2005                                             |========
1970     0.1926                                             |========
1971     0.1929                                             |========
1972     0.1135                                             |=====
1973    -0.1018                                         ====|
1974     0.1168                                             |=====
1975    -0.1188                                        =====|
1976     0.1619                                             |======
1977     0.2206                                             |=========
1978     0.3895                                             |================
1979     0.1629                                             |=======
1980    -0.0020                                             |
1981     0.0979                                             |====
1982     0.0450                                             |==
1983     0.1106                                             |====
1984     0.5213                                             |=====================
1985     0.4998                                             |====================
1986     0.1758                                             |=======
1987    -0.1340                                        =====|
1988    -0.2188                                    =========|
1989    -0.5152                        =====================|
1990    -0.1733                                      =======|
1991    -0.0761                                          ===|
1992    -0.5290                        =====================|
1993    -0.5500                       ======================|
1994    -0.5252                        =====================|
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
2004     0.0000                                             |
2005     0.0000                                             |
2006     0.0000                                             |
2007     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) 3LN spring survey

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1959	0.000E+00	0.000E+00	--	*	4.381E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	4.089E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	4.051E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	4.072E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	4.042E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	4.147E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	4.278E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	4.328E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	4.325E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	4.323E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	4.342E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	4.401E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	4.335E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	4.126E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	3.940E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	3.850E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	3.936E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	4.034E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	4.142E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	4.335E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	4.535E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	4.667E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	4.668E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	4.614E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	4.615E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	4.692E+04	0.00000	1.000E+00
27	1985	0.000E+00	0.000E+00	--	*	4.745E+04	0.00000	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	4.473E+04	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	3.537E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	2.577E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	2.097E+04	0.00000	1.000E+00
32	1990	0.000E+00	0.000E+00	--	*	1.842E+04	0.00000	1.000E+00
33	1991	1.000E+00	1.000E+00	--	1.064E+04	1.644E+04	-0.43479	1.000E+00
34	1992	1.000E+00	1.000E+00	--	1.007E+04	1.427E+04	-0.34893	1.000E+00
35	1993	1.000E+00	1.000E+00	--	2.257E+04	1.227E+04	0.60941	1.000E+00
36	1994	1.000E+00	1.000E+00	--	4.162E+03	1.260E+04	-1.10741	1.000E+00
37	1995	1.000E+00	1.000E+00	--	5.856E+03	1.546E+04	-0.97092	1.000E+00
38	1996	1.000E+00	1.000E+00	--	2.281E+04	1.958E+04	0.15270	1.000E+00
39	1997	1.000E+00	1.000E+00	--	1.493E+04	2.450E+04	-0.49532	1.000E+00
40	1998	1.000E+00	1.000E+00	--	5.940E+04	2.982E+04	0.68931	1.000E+00
41	1999	1.000E+00	1.000E+00	--	6.150E+04	3.512E+04	0.56008	1.000E+00
42	2000	1.000E+00	1.000E+00	--	8.784E+04	4.007E+04	0.78492	1.000E+00
43	2001	1.000E+00	1.000E+00	--	4.157E+04	4.477E+04	-0.07411	1.000E+00
44	2002	1.000E+00	1.000E+00	--	3.096E+04	4.915E+04	-0.46226	1.000E+00
45	2003	1.000E+00	1.000E+00	--	2.770E+04	5.288E+04	-0.64657	1.000E+00
46	2004	1.000E+00	1.000E+00	--	7.963E+04	5.598E+04	0.35236	1.000E+00
47	2005	1.000E+00	1.000E+00	--	6.646E+04	5.850E+04	0.12756	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	6.046E+04	0.00000	1.000E+00
49	2007	1.000E+00	1.000E+00	--	2.188E+05	6.181E+04	1.26423	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish Page 7

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991    -0.4348                                    =========|
1992    -0.3489                                      =======|
1993     0.6094                                             |============
1994    -1.1074                       ======================|
1995    -0.9709                          ===================|
1996     0.1527                                             |===
1997    -0.4953                                   ==========|
1998     0.6893                                             |==============
1999     0.5601                                             |===========
2000     0.7849                                             |================
2001    -0.0741                                            =|
2002    -0.4623                                    =========|
2003    -0.6466                                =============|
2004     0.3524                                             |=======
2005     0.1276                                             |===
2006     0.0000                                             |
2007     1.2642                                             |=========================
                   -------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 3 (NON-BOOTSTRAPPED) 3LN autumn survey

Data type I2: Abundance index (end of year) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1959	0.000E+00	0.000E+00	--	*	6.978E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	6.842E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	6.844E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	6.912E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	6.750E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	7.248E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	7.205E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	7.410E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	7.211E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	7.389E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	7.284E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	7.576E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	7.092E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	6.857E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	6.473E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	6.533E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	6.758E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	6.867E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	7.120E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	7.517E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	7.795E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	7.966E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	7.812E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	7.778E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	7.814E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	8.029E+04	0.00000	1.000E+00
27	1985	0.000E+00	0.000E+00	--	*	8.003E+04	0.00000	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	7.159E+04	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	4.989E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	3.800E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	3.306E+04	0.00000	1.000E+00
32	1990	0.000E+00	0.000E+00	--	*	2.931E+04	0.00000	1.000E+00
33	1991	1.000E+00	1.000E+00	--	3.789E+04	2.632E+04	0.36425	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	2.207E+04	0.00000	1.000E+00
35	1993	1.000E+00	1.000E+00	--	1.923E+04	1.948E+04	-0.01263	1.000E+00
36	1994	1.000E+00	1.000E+00	--	3.176E+04	2.315E+04	0.31630	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	2.925E+04	0.00000	1.000E+00
38	1996	1.000E+00	1.000E+00	--	1.597E+04	3.708E+04	-0.84261	1.000E+00
39	1997	1.000E+00	1.000E+00	--	7.066E+04	4.580E+04	0.43353	1.000E+00
40	1998	1.000E+00	1.000E+00	--	1.122E+05	5.497E+04	0.71368	1.000E+00
41	1999	1.000E+00	1.000E+00	--	7.199E+04	6.365E+04	0.12313	1.000E+00
42	2000	1.000E+00	1.000E+00	--	1.005E+05	7.161E+04	0.33850	1.000E+00
43	2001	1.000E+00	1.000E+00	--	1.326E+05	7.948E+04	0.51154	1.000E+00
44	2002	1.000E+00	1.000E+00	--	5.012E+04	8.638E+04	-0.54433	1.000E+00
45	2003	1.000E+00	1.000E+00	--	7.189E+04	9.207E+04	-0.24745	1.000E+00
46	2004	1.000E+00	1.000E+00	--	4.991E+04	9.688E+04	-0.66329	1.000E+00
47	2005	1.000E+00	1.000E+00	--	5.856E+04	1.006E+05	-0.54120	1.000E+00
48	2006	1.000E+00	1.000E+00	--	9.188E+04	1.035E+05	-0.11912	1.000E+00
49	2007	1.000E+00	1.000E+00	--	1.248E+05	1.053E+05	0.17003	1.000E+00

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.0000                                             |
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.0000                                             |
1991     0.3643                                             |===============
1992     0.0000                                             |
1993    -0.0126                                            =|
1994     0.3163                                             |=============
1995     0.0000                                             |
1996    -0.8426           ==================================|
1997     0.4335                                             |=================
1998     0.7137                                             |=============================
1999     0.1231                                             |=====
2000     0.3385                                             |==============
2001     0.5115                                             |====================
2002    -0.5443                       ======================|
2003    -0.2474                                   ==========|
2004    -0.6633                  ===========================|
2005    -0.5412                       ======================|
2006    -0.1191                                        =====|
2007     0.1700                                             |=======
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 4 (NON-BOOTSTRAPPED) 3LN Power russian survey

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1959	0.000E+00	0.000E+00	--	*	6.060E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	5.656E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	5.604E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	5.633E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	5.591E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	5.736E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	5.917E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	5.987E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	5.983E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	5.981E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	6.006E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	6.088E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	5.996E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	5.707E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	5.451E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	5.326E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	5.444E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	5.580E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	5.730E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	5.997E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	6.273E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	6.456E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	6.457E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	6.382E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	6.384E+04	0.00000	1.000E+00
26	1984	1.000E+00	1.000E+00	--	2.159E+05	6.490E+04	1.20188	1.000E+00
27	1985	1.000E+00	1.000E+00	--	9.400E+04	6.564E+04	0.35911	1.000E+00
28	1986	1.000E+00	1.000E+00	--	6.298E+04	6.188E+04	0.01757	1.000E+00
29	1987	1.000E+00	1.000E+00	--	7.030E+04	4.893E+04	0.36237	1.000E+00
30	1988	1.000E+00	1.000E+00	--	4.488E+04	3.565E+04	0.23022	1.000E+00
31	1989	1.000E+00	1.000E+00	--	1.227E+04	2.901E+04	-0.86066	1.000E+00
32	1990	1.000E+00	1.000E+00	--	8.365E+03	2.548E+04	-1.11395	1.000E+00
33	1991	1.000E+00	1.000E+00	--	1.868E+04	2.274E+04	-0.19662	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	1.974E+04	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	1.698E+04	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	1.742E+04	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	2.139E+04	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	2.709E+04	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	3.389E+04	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	4.124E+04	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	4.859E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	5.543E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	6.193E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	6.799E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	7.315E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	7.744E+04	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	8.093E+04	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	8.363E+04	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	8.551E+04	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish Page11

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4

```
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    ------------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     1.2019                                             |========================
1985     0.3591                                             |=======
1986     0.0176                                             |
1987     0.3624                                             |=======
1988     0.2302                                             |=====
1989    -0.8607                            =================|
1990    -1.1140                       ======================|
1991    -0.1966                                         ====|
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
2004     0.0000                                             |
2005     0.0000                                             |
2006     0.0000                                             |
2007     0.0000                                             |
                   ------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 5 (NON-BOOTSTRAPPED) 3L winter survey

Data type I0: Abundance index (start of year) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1959	0.000E+00	0.000E+00	--	*	5.169E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	4.580E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	4.491E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	4.492E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	4.537E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	4.431E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	4.757E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	4.729E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	4.863E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	4.733E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	4.850E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	4.781E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	4.973E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	4.655E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	4.501E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	4.248E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	4.288E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	4.436E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	4.507E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	4.673E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	4.934E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	5.116E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	5.229E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	5.127E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	5.105E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	5.129E+04	0.00000	1.000E+00
27	1985	1.000E+00	1.000E+00	--	9.024E+04	5.270E+04	0.53789	1.000E+00
28	1986	1.000E+00	1.000E+00	--	3.657E+04	5.253E+04	-0.36216	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	4.699E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	3.274E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	2.494E+04	0.00000	1.000E+00
32	1990	1.000E+00	1.000E+00	--	1.820E+04	2.170E+04	-0.17574	1.000E+00
33	1991	0.000E+00	0.000E+00	--	*	1.924E+04	0.00000	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	1.728E+04	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	1.448E+04	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	1.278E+04	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	1.519E+04	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	1.920E+04	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	2.434E+04	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	3.006E+04	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	3.608E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	4.177E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	4.700E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	5.217E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	5.670E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	6.043E+04	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	6.359E+04	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	6.604E+04	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	6.794E+04	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish Page13

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 5
                   -1       -0.75     -0.5      -0.25       0        0.25      0.5       0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.5379                                             |======================
1986    -0.3622                               ==============|
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990    -0.1757                                      =======|
1991     0.0000                                             |
1992     0.0000                                             |
1993     0.0000                                             |
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
2004     0.0000                                             |
2005     0.0000                                             |
2006     0.0000                                             |
2007     0.0000                                             |
                   -------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 6 (NON-BOOTSTRAPPED) 3L summer survey

Data type I1: Abundance index (annual average) Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1959	0.000E+00	0.000E+00	--	*	1.251E+05	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	1.167E+05	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	1.156E+05	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	1.163E+05	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	1.154E+05	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	1.184E+05	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	1.221E+05	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	1.235E+05	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	1.235E+05	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	1.234E+05	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	1.240E+05	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	1.256E+05	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	1.237E+05	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	1.178E+05	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	1.125E+05	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	1.099E+05	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	1.124E+05	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	1.152E+05	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	1.183E+05	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	1.238E+05	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	1.295E+05	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	1.332E+05	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	1.333E+05	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	1.317E+05	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	1.318E+05	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	1.339E+05	0.00000	1.000E+00
27	1985	1.000E+00	1.000E+00	--	1.610E+05	1.355E+05	0.17297	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	1.277E+05	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	1.010E+05	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	7.358E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	5.987E+04	0.00000	1.000E+00
32	1990	1.000E+00	1.000E+00	--	9.284E+04	5.259E+04	0.56833	1.000E+00
33	1991	1.000E+00	1.000E+00	--	3.757E+04	4.693E+04	-0.22236	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	4.074E+04	0.00000	1.000E+00
35	1993	1.000E+00	1.000E+00	--	2.084E+04	3.504E+04	-0.51958	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	3.596E+04	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	4.414E+04	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	5.590E+04	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	6.994E+04	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	8.512E+04	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	1.003E+05	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	1.144E+05	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	1.278E+05	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	1.403E+05	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	1.510E+05	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	1.598E+05	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	1.670E+05	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	1.726E+05	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	1.765E+05	0.00000	1.000E+00

* Asterisk indicates missing value(s).

```
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 6
                   -1       -0.75     -0.5      -0.25      0        0.25      0.5      0.75       1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual   -------------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     0.1730                                             |=======
1986     0.0000                                             |
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.5683                                             |=======================
1991    -0.2224                                    =========|
1992     0.0000                                             |
1993    -0.5196                        =====================|
1994     0.0000                                             |
1995     0.0000                                             |
1996     0.0000                                             |
1997     0.0000                                             |
1998     0.0000                                             |
1999     0.0000                                             |
2000     0.0000                                             |
2001     0.0000                                             |
2002     0.0000                                             |
2003     0.0000                                             |
2004     0.0000                                             |
2005     0.0000                                             |
2006     0.0000                                             |
2007     0.0000                                             |
                  -------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 7 (NON-BOOTSTRAPPED) 3L autumn survey

Data type I1: Abundance index (annual average) Series weight: 1.000

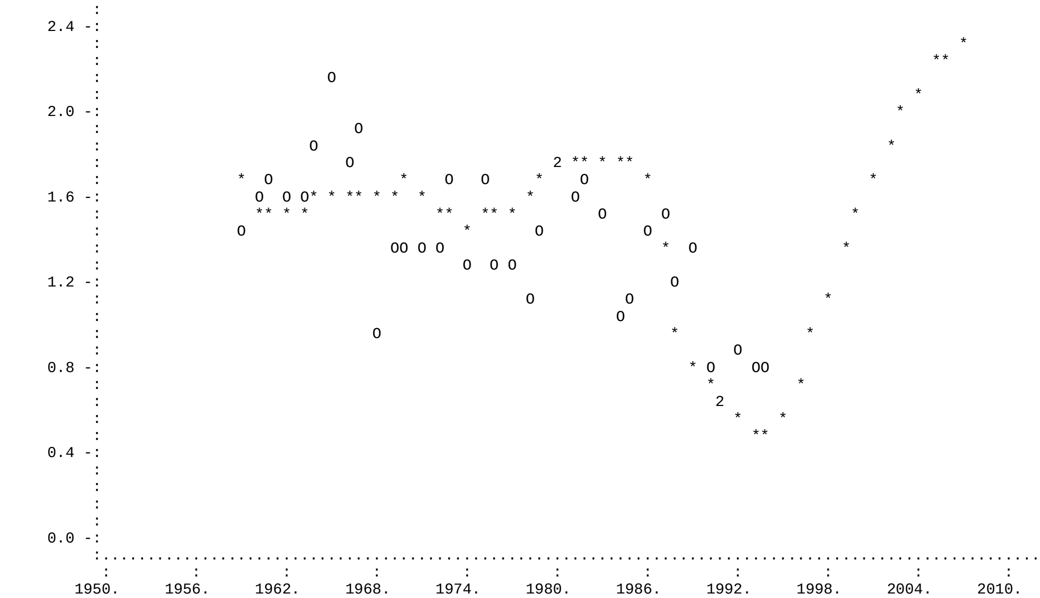
Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Statist weight
1	1959	0.000E+00	0.000E+00	--	*	2.431E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	2.269E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	2.248E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	2.259E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	2.243E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	2.301E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	2.373E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	2.401E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	2.400E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	2.399E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	2.409E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	2.442E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	2.405E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	2.289E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	2.186E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	2.136E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	2.184E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	2.238E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	2.298E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	2.405E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	2.516E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	2.589E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	2.590E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	2.560E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	2.561E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	2.603E+04	0.00000	1.000E+00
27	1985	1.000E+00	1.000E+00	--	9.823E+04	2.633E+04	1.31676	1.000E+00
28	1986	1.000E+00	1.000E+00	--	1.712E+04	2.482E+04	-0.37143	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	1.963E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	1.430E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	1.164E+04	0.00000	1.000E+00
32	1990	1.000E+00	1.000E+00	--	2.074E+04	1.022E+04	0.70776	1.000E+00
33	1991	1.000E+00	1.000E+00	--	1.366E+04	9.120E+03	0.40432	1.000E+00
34	1992	1.000E+00	1.000E+00	--	1.342E+04	7.917E+03	0.52803	1.000E+00
35	1993	1.000E+00	1.000E+00	--	6.011E+03	6.809E+03	-0.12467	1.000E+00
36	1994	1.000E+00	1.000E+00	--	7.173E+03	6.989E+03	0.02600	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	8.579E+03	0.00000	1.000E+00
38	1996	1.000E+00	1.000E+00	--	4.691E+03	1.086E+04	-0.83986	1.000E+00
39	1997	1.000E+00	1.000E+00	--	1.954E+04	1.359E+04	0.36319	1.000E+00
40	1998	1.000E+00	1.000E+00	--	1.852E+04	1.654E+04	0.11302	1.000E+00
41	1999	1.000E+00	1.000E+00	--	3.886E+04	1.949E+04	0.69017	1.000E+00
42	2000	1.000E+00	1.000E+00	--	2.492E+04	2.223E+04	0.11401	1.000E+00
43	2001	1.000E+00	1.000E+00	--	2.857E+04	2.484E+04	0.13982	1.000E+00
44	2002	1.000E+00	1.000E+00	--	1.189E+04	2.727E+04	-0.83031	1.000E+00
45	2003	1.000E+00	1.000E+00	--	1.501E+04	2.934E+04	-0.67041	1.000E+00
46	2004	1.000E+00	1.000E+00	--	9.293E+03	3.106E+04	-1.20670	1.000E+00
47	2005	1.000E+00	1.000E+00	--	1.665E+04	3.246E+04	-0.66758	1.000E+00
48	2006	1.000E+00	1.000E+00	--	2.722E+04	3.354E+04	-0.20895	1.000E+00
49	2007	1.000E+00	1.000E+00	--	5.755E+04	3.430E+04	0.51752	1.000E+00

* Asterisk indicates missing value(s).

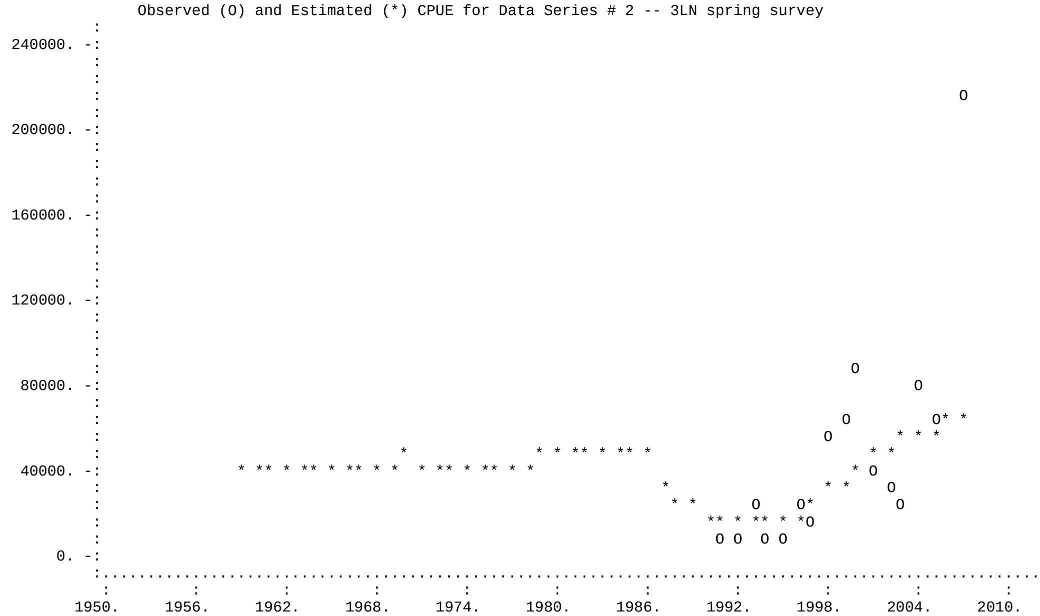
```
3LN redfish                                                                                                   Page17

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 7
                   -2       -1.5       -1       -0.5        0        0.5        1        1.5        2
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1959     0.0000                                             |
1960     0.0000                                             |
1961     0.0000                                             |
1962     0.0000                                             |
1963     0.0000                                             |
1964     0.0000                                             |
1965     0.0000                                             |
1966     0.0000                                             |
1967     0.0000                                             |
1968     0.0000                                             |
1969     0.0000                                             |
1970     0.0000                                             |
1971     0.0000                                             |
1972     0.0000                                             |
1973     0.0000                                             |
1974     0.0000                                             |
1975     0.0000                                             |
1976     0.0000                                             |
1977     0.0000                                             |
1978     0.0000                                             |
1979     0.0000                                             |
1980     0.0000                                             |
1981     0.0000                                             |
1982     0.0000                                             |
1983     0.0000                                             |
1984     0.0000                                             |
1985     1.3168                                             |==========================
1986    -0.3714                                      =======|
1987     0.0000                                             |
1988     0.0000                                             |
1989     0.0000                                             |
1990     0.7078                                             |==============
1991     0.4043                                             |========
1992     0.5280                                             |===========
1993    -0.1247                                           ==|
1994     0.0260                                             |=
1995     0.0000                                             |
1996    -0.8399                            =================|
1997     0.3632                                             |=======
1998     0.1130                                             |==
1999     0.6902                                             |==============
2000     0.1140                                             |==
2001     0.1398                                             |===
2002    -0.8303                            =================|
2003    -0.6704                                =============|
2004    -1.2067                     ========================|
2005    -0.6676                                =============|
2006    -0.2089                                         ====|
2007     0.5175                                             |==========
                   -------------------------------------------------------------------------------------
```

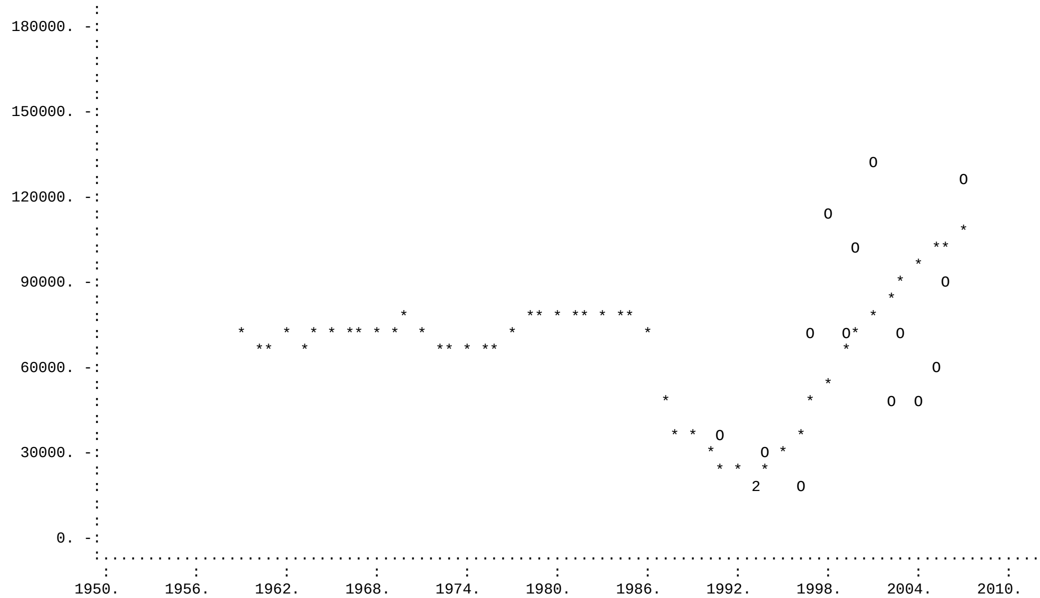
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Statlant CPUE



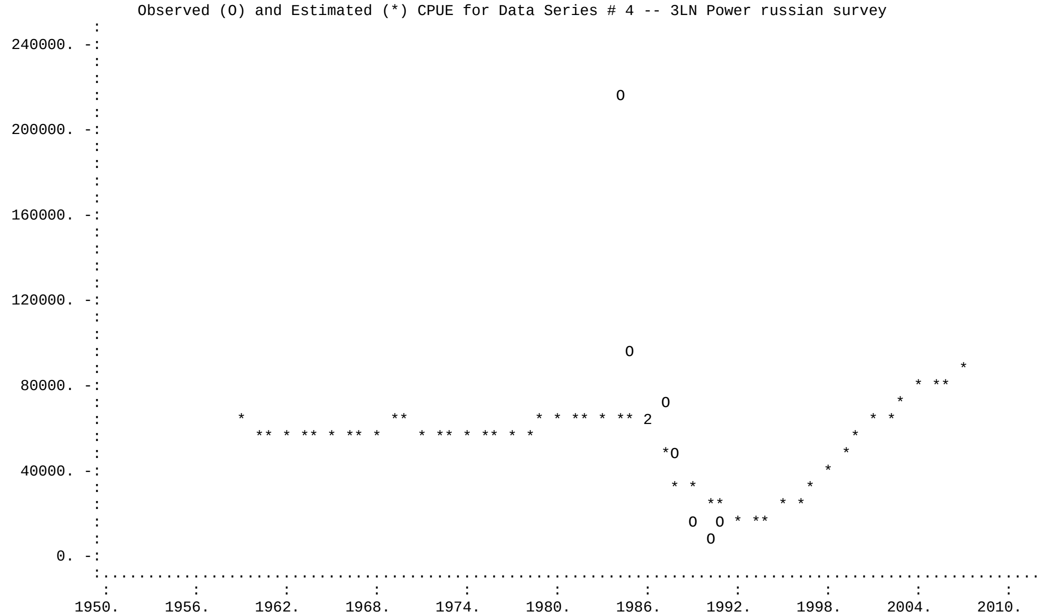
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- 3LN spring survey



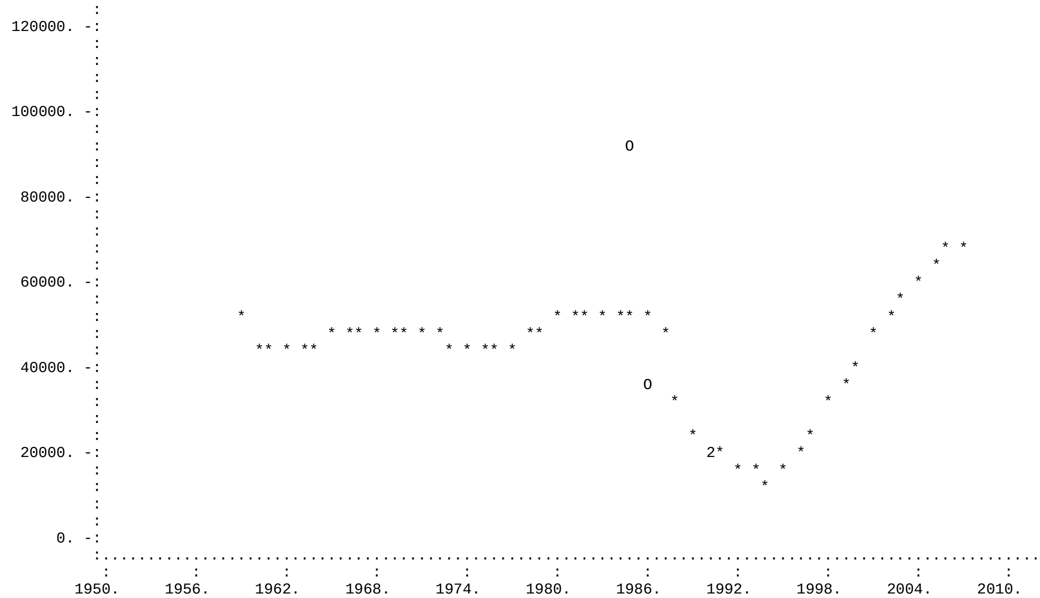
Observed (O) and Estimated (*) CPUE for Data Series # 3 -- 3LN autumn survey



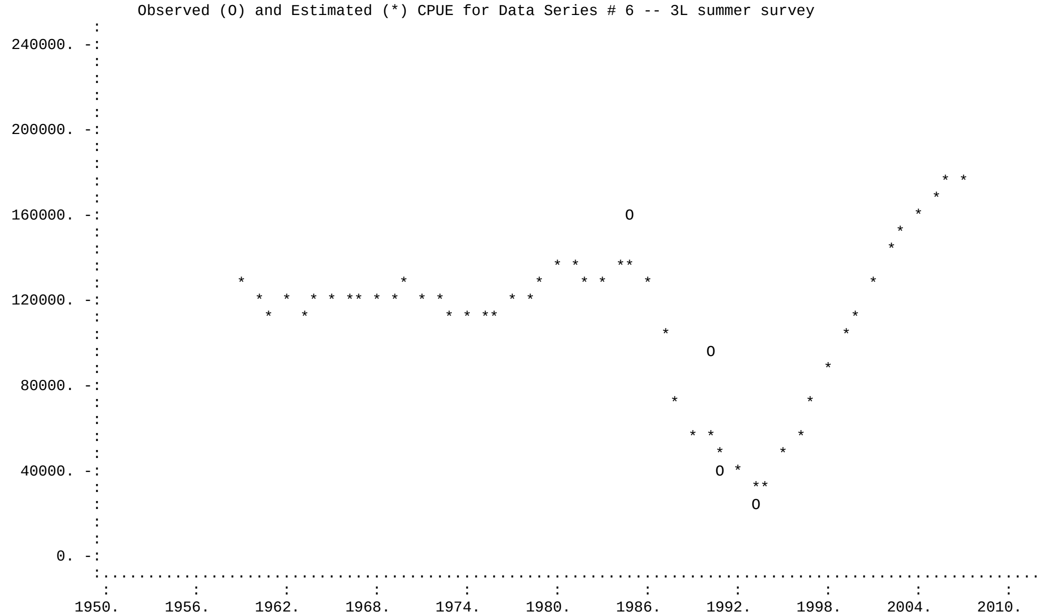
Observed (O) and Estimated (*) CPUE for Data Series # 4 -- 3LN Power russian survey



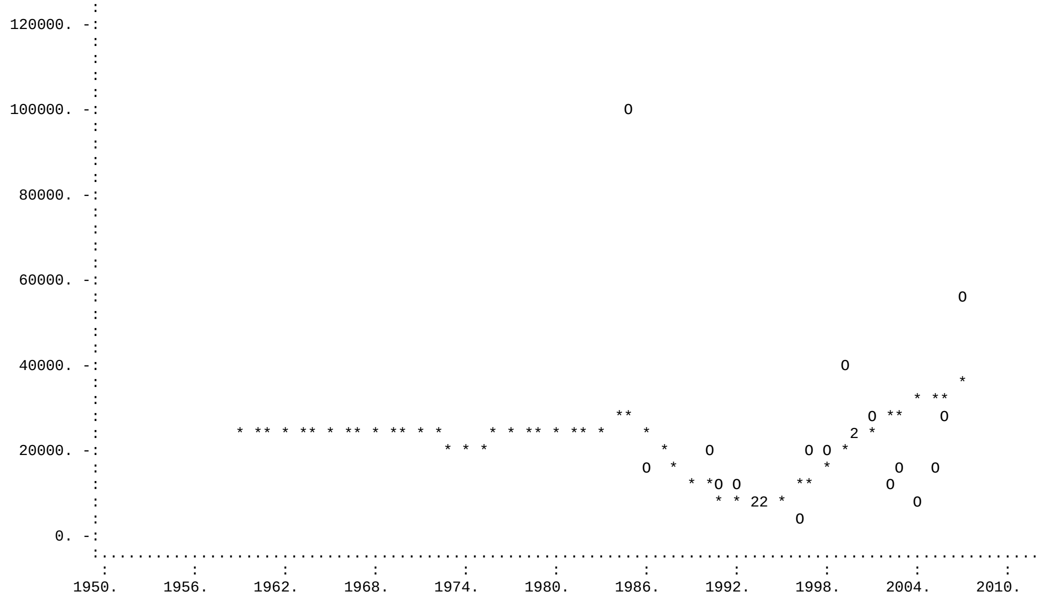
Observed (O) and Estimated (*) CPUE for Data Series # 5 -- 3L winter survey



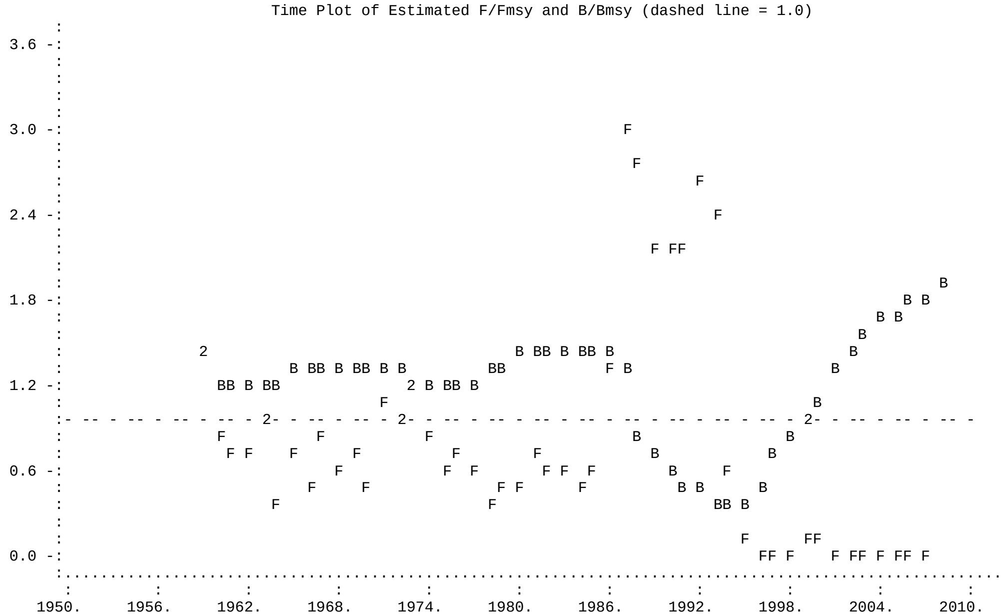
Observed (O) and Estimated (*) CPUE for Data Series # 6 -- 3L summer survey



Observed (O) and Estimated (*) CPUE for Data Series # 7 -- 3L autumn survey



Time Plot of Estimated F/Fmsy and B/Bmsy (dashed line = 1.0)



Elapsed time: 0 hours, 0 minutes, 11 seconds.

Appendix 3

ESTIMATES FROM BOOTSTRAPPED ANALYSIS

Param name	Point estimate	Estimated bias in pt estimate	Estimated relative bias	Bias-corrected approximate confidence limits 80% lower	80% upper	50% lower	50% upper	Inter-quartile range	Relative IQ range
B1/K	7.033E-01	6.704E-02	9.53%	5.015E-01	1.216E+00	5.846E-01	9.064E-01	3.218E-01	0.458
K	2.838E+05	5.651E+03	1.99%	2.366E+05	3.839E+05	2.593E+05	3.295E+05	7.022E+04	0.247
q(1)	8.795E-06	3.444E-07	3.92%	6.678E-06	1.038E-05	7.505E-06	9.528E-06	2.023E-06	0.230
q(2)	2.336E-01	9.439E-03	4.04%	1.815E-01	2.910E-01	2.031E-01	2.596E-01	5.651E-02	0.242
q(3)	3.946E-01	1.864E-02	4.72%	2.984E-01	4.807E-01	3.377E-01	4.300E-01	9.230E-02	0.234
q(4)	3.231E-01	1.311E-02	4.06%	2.385E-01	4.288E-01	2.739E-01	3.738E-01	9.988E-02	0.309
q(5)	2.590E-01	1.454E-02	5.62%	1.689E-01	3.781E-01	2.050E-01	3.163E-01	1.114E-01	0.430
q(6)	6.668E-01	1.911E-02	2.87%	4.329E-01	9.140E-01	5.232E-01	7.848E-01	2.616E-01	0.392
q(7)	1.296E-01	5.160E-03	3.98%	1.020E-01	1.536E-01	1.111E-01	1.401E-01	2.892E-02	0.223
MSY	2.444E+04	6.111E+02	2.50%	2.178E+04	2.660E+04	2.285E+04	2.533E+04	2.484E+03	0.102
Ye(2008)	5.519E+03	1.087E+03	19.69%	2.178E+03	1.567E+04	3.295E+03	9.964E+03	6.669E+03	1.208
Y.@Fmsy	4.595E+04	2.495E+02	0.54%	3.340E+04	5.270E+04	4.048E+04	4.930E+04	8.821E+03	0.192
Bmsy	1.419E+05	2.825E+03	1.99%	1.183E+05	1.920E+05	1.296E+05	1.648E+05	3.511E+04	0.247
Fmsy	1.722E-01	8.557E-03	4.97%	1.165E-01	2.251E-01	1.386E-01	1.961E-01	5.753E-02	0.334
fmsy(1)	1.958E+04	2.733E+02	1.40%	1.443E+04	2.428E+04	1.671E+04	2.205E+04	5.341E+03	0.273
fmsy(2)	7.374E-01	2.792E-02	3.79%	4.987E-01	1.039E+00	6.019E-01	8.882E-01	2.863E-01	0.388
fmsy(3)	4.365E-01	1.135E-02	2.60%	2.957E-01	5.889E-01	3.611E-01	5.143E-01	1.532E-01	0.351
fmsy(4)	5.331E-01	1.760E-02	3.30%	3.880E-01	7.131E-01	4.543E-01	6.172E-01	1.629E-01	0.306
fmsy(5)	6.651E-01	4.732E-02	7.12%	4.270E-01	9.999E-01	5.339E-01	8.274E-01	2.934E-01	0.441
fmsy(6)	2.583E-01	1.900E-02	7.36%	1.793E-01	3.777E-01	2.101E-01	3.148E-01	1.047E-01	0.405
fmsy(7)	1.329E+00	3.205E-02	2.41%	9.316E-01	1.755E+00	1.098E+00	1.537E+00	4.391E-01	0.330
B./Bmsy	1.880E+00	-4.436E-02	-2.36%	1.552E+00	1.959E+00	1.756E+00	1.933E+00	1.770E-01	0.094
F./Fmsy	3.791E-02	9.033E-04	2.38%	3.285E-02	5.267E-02	3.518E-02	4.333E-02	8.155E-03	0.215
Ye./MSY	2.258E-01	5.052E-02	22.37%	8.041E-02	6.938E-01	1.294E-01	4.280E-01	2.986E-01	1.322
q2/q1	2.656E+04	6.371E+02	2.40%	1.971E+04	3.482E+04	2.270E+04	3.060E+04	7.898E+03	0.297
q3/q1	4.486E+04	1.321E+03	2.94%	3.458E+04	5.965E+04	3.839E+04	5.168E+04	1.329E+04	0.296
q4/q1	3.673E+04	6.501E+02	1.77%	2.671E+04	4.913E+04	3.065E+04	4.226E+04	1.161E+04	0.316
q5/q1	2.944E+04	9.384E+02	3.19%	1.976E+04	4.503E+04	2.399E+04	3.705E+04	1.305E+04	0.443
q6/q1	7.582E+04	2.824E+02	0.37%	5.326E+04	1.088E+05	6.434E+04	9.263E+04	2.829E+04	0.373
q7/q1	1.474E+04	3.042E+02	2.06%	1.145E+04	1.842E+04	1.278E+04	1.643E+04	3.652E+03	0.248

INFORMATION FOR REPAST (Prager, Porch, Shertzer, & Caddy. 2003. NAJFM 23: 349-361)

Unitless limit reference point in F (Fmsy/F.): 26.38
CV of above (from bootstrap distribution): 0.1544

NOTES ON BOOTSTRAPPED ESTIMATES:

- Bootstrap results were computed from 1000 trials.
- Results are conditional on bounds set on MSY and K in the input file.
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The default 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- Bias estimates are typically of high variance and therefore may be misleading.

Trials replaced for lack of convergence: 0
Trials replaced for q out-of-bounds: 31
Trials replaced for K out-of-bounds: 28
Trials replaced for MSY out of bounds: 0
Residual-adjustment factor: 1.0535

Elapsed time: 4 hours, 10 minutes, 41 seconds.

Appendix 4:
control file of ASPIC projection 2008-2012

```
'Projection with 5000 Y'   ## Projection title
'aspic.bio'     ## BIO file to read
'red3LN.prj'     ## Projection file to write
0d0                  ## Not used at present; set to 0d0
0                     ## Years to drop at start of plots
5                     ## Years of projections
1700 Y                 ## Specification for projection year 1.
5000 Y                 ## Specification for projection year 2.
5000 Y                 ## Specification for projection year 3.
5000 Y                 ## Specification for projection year 4.
5000 Y                 ## Specification for projection year 5.
```

Note: the years of projection should have on each line:
1. A real number, the projected yield or effort.
   - If yield, it is in the same units as for the initial fit.
   - If effort, it is a unitless number: the multiple of the effort in the last year of the fit.
2. A character*1 indicator of whether the number is effort or yield.
   - This should be the capital letter 'Y' or 'F'.
3. Comments if desired may follow the letter, but must be delimited from it by at least one space.

Appendix 5:

.prj file with ASPIC projection results 2008-2012 under a constant 2009-2012 catch of 5000 ton

Results from ASPICP.EXE, version 3.16 — 07 May 2008 at 16:18.29
3LN redfish — Page 1
Projection with 5000 Y

USER CONTROL INFORMATION (FROM INPUT FILE)

Control (CTL) file read was:	aspicp.ctl
Biomass (BIO) file read was:	aspic.bio
Output file (this file) written was:	aspicp.prj
Production-model type:	Logistic
Number of years of projections:	5
Type of confidence intervals:	Bias-corrected percentile
Confidence interval smoothing:	ON

Year	Input data	User data type
2008	1.700E+03	TAC
2009	5.000E+03	TAC
2010	5.000E+03	TAC
2011	5.000E+03	TAC
2012	5.000E+03	TAC

TRAJECTORY OF RELATIVE BIOMASS B/Bmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1959	1.407E+00	1.341E-01	9.53%	1.003E+00	2.431E+00	1.003E+00	2.431E+00	6.437E-01	0.458
1960	1.246E+00	6.592E-02	5.29%	8.668E-01	1.995E+00	8.668E-01	1.995E+00	5.590E-01	0.449
1961	1.222E+00	3.453E-02	2.83%	8.561E-01	1.830E+00	8.561E-01	1.830E+00	5.062E-01	0.414
1962	1.222E+00	1.508E-02	1.23%	8.580E-01	1.714E+00	8.580E-01	1.714E+00	4.476E-01	0.366
1963	1.235E+00	1.881E-03	0.15%	8.657E-01	1.641E+00	8.657E-01	1.641E+00	4.145E-01	0.336
1964	1.206E+00	-7.737E-03	-0.64%	8.412E-01	1.554E+00	8.412E-01	1.554E+00	3.847E-01	0.319
1965	1.295E+00	-1.369E-02	-1.06%	9.229E-01	1.596E+00	9.229E-01	1.596E+00	3.651E-01	0.282
1966	1.287E+00	-1.907E-02	-1.48%	9.128E-01	1.542E+00	9.128E-01	1.542E+00	3.404E-01	0.265
1967	1.323E+00	-2.223E-02	-1.68%	9.540E-01	1.552E+00	9.540E-01	1.552E+00	3.140E-01	0.237
1968	1.288E+00	-2.480E-02	-1.93%	9.345E-01	1.486E+00	9.345E-01	1.486E+00	2.921E-01	0.227
1969	1.320E+00	-2.553E-02	-1.93%	9.727E-01	1.502E+00	9.727E-01	1.502E+00	2.754E-01	0.209
1970	1.301E+00	-2.620E-02	-2.01%	9.583E-01	1.461E+00	9.583E-01	1.461E+00	2.564E-01	0.197
1971	1.353E+00	-2.568E-02	-1.90%	1.008E+00	1.502E+00	1.008E+00	1.502E+00	2.564E-01	0.189
1972	1.267E+00	-2.608E-02	-2.06%	9.437E-01	1.395E+00	9.437E-01	1.395E+00	2.294E-01	0.181
1973	1.225E+00	-2.495E-02	-2.04%	9.081E-01	1.344E+00	9.081E-01	1.344E+00	2.161E-01	0.176
1974	1.156E+00	-2.371E-02	-2.05%	8.557E-01	1.269E+00	8.557E-01	1.269E+00	2.077E-01	0.180
1975	1.167E+00	-2.155E-02	-1.85%	8.606E-01	1.288E+00	8.606E-01	1.288E+00	2.117E-01	0.181
1976	1.207E+00	-1.972E-02	-1.63%	9.026E-01	1.340E+00	9.026E-01	1.340E+00	2.096E-01	0.174
1977	1.227E+00	-1.884E-02	-1.54%	9.278E-01	1.365E+00	9.278E-01	1.365E+00	2.055E-01	0.168
1978	1.272E+00	-1.829E-02	-1.44%	9.658E-01	1.419E+00	9.658E-01	1.419E+00	2.078E-01	0.163
1979	1.343E+00	-1.839E-02	-1.37%	1.034E+00	1.495E+00	1.034E+00	1.495E+00	2.189E-01	0.163
1980	1.392E+00	-1.943E-02	-1.40%	1.099E+00	1.546E+00	1.099E+00	1.546E+00	2.113E-01	0.152
1981	1.423E+00	-2.059E-02	-1.45%	1.131E+00	1.569E+00	1.131E+00	1.569E+00	2.049E-01	0.144
1982	1.395E+00	-2.141E-02	-1.53%	1.124E+00	1.524E+00	1.124E+00	1.524E+00	1.880E-01	0.135
1983	1.389E+00	-2.093E-02	-1.51%	1.134E+00	1.509E+00	1.134E+00	1.509E+00	1.787E-01	0.129
1984	1.396E+00	-1.993E-02	-1.43%	1.145E+00	1.509E+00	1.145E+00	1.509E+00	1.757E-01	0.126
1985	1.434E+00	-1.873E-02	-1.31%	1.183E+00	1.549E+00	1.183E+00	1.549E+00	1.803E-01	0.126
1986	1.429E+00	-1.801E-02	-1.26%	1.189E+00	1.536E+00	1.189E+00	1.536E+00	1.707E-01	0.119
1987	1.279E+00	-1.728E-02	-1.35%	1.084E+00	1.358E+00	1.084E+00	1.358E+00	1.316E-01	0.103
1988	8.910E-01	-1.698E-02	-1.91%	8.104E-01	9.202E-01	8.104E-01	9.202E-01	4.369E-02	0.049
1989	6.787E-01	-1.496E-02	-2.20%	6.585E-01	7.371E-01	6.585E-01	7.371E-01	3.766E-02	0.055
1990	5.905E-01	-1.234E-02	-2.09%	5.652E-01	6.567E-01	5.652E-01	6.567E-01	4.582E-02	0.078
1991	5.236E-01	-9.757E-03	-1.86%	4.896E-01	6.005E-01	4.896E-01	6.005E-01	5.514E-02	0.105
1992	4.701E-01	-7.056E-03	-1.50%	4.214E-01	5.513E-01	4.214E-01	5.513E-01	6.285E-02	0.134
1993	3.941E-01	-4.846E-03	-1.23%	3.330E-01	4.892E-01	3.330E-01	4.892E-01	7.921E-02	0.201
1994	3.479E-01	-2.475E-03	-0.71%	2.689E-01	4.703E-01	2.689E-01	4.703E-01	9.969E-02	0.287
1995	4.134E-01	2.361E-03	0.57%	3.040E-01	5.720E-01	3.040E-01	5.720E-01	1.314E-01	0.318
1996	5.224E-01	9.475E-03	1.81%	3.714E-01	7.098E-01	3.714E-01	7.098E-01	1.778E-01	0.340
1997	6.624E-01	1.709E-02	2.58%	4.645E-01	9.056E-01	4.645E-01	9.056E-01	2.422E-01	0.366
1998	8.181E-01	2.194E-02	2.68%	5.586E-01	1.112E+00	5.586E-01	1.112E+00	3.130E-01	0.383
1999	9.819E-01	2.119E-02	2.16%	6.643E-01	1.321E+00	6.643E-01	1.321E+00	3.676E-01	0.374
2000	1.137E+00	1.405E-02	1.24%	7.595E-01	1.482E+00	7.595E-01	1.482E+00	4.014E-01	0.353
2001	1.279E+00	2.284E-03	0.18%	8.542E-01	1.611E+00	8.542E-01	1.611E+00	4.210E-01	0.329
2002	1.420E+00	-1.141E-02	-0.80%	9.607E-01	1.719E+00	9.607E-01	1.719E+00	4.115E-01	0.290
2003	1.543E+00	-2.461E-02	-1.59%	1.083E+00	1.805E+00	1.083E+00	1.805E+00	3.870E-01	0.251
2004	1.645E+00	-3.522E-02	-2.14%	1.172E+00	1.860E+00	1.172E+00	1.860E+00	3.479E-01	0.212
2005	1.730E+00	-4.224E-02	-2.44%	1.283E+00	1.905E+00	1.283E+00	1.905E+00	3.068E-01	0.177
2006	1.797E+00	-4.573E-02	-2.54%	1.380E+00	1.934E+00	1.380E+00	1.934E+00	2.614E-01	0.145
2007	1.849E+00	-4.617E-02	-2.50%	1.477E+00	1.955E+00	1.477E+00	1.955E+00	2.184E-01	0.118
2008	1.880E+00	-4.436E-02	-2.36%	1.552E+00	1.959E+00	1.552E+00	1.959E+00	1.770E-01	0.094
2009	1.903E+00	-4.099E-02	-2.15%	1.615E+00	1.962E+00	1.615E+00	1.962E+00	1.433E-01	0.075
2010	1.900E+00	-3.684E-02	-1.94%	1.659E+00	1.941E+00	1.659E+00	1.941E+00	1.100E-01	0.058
2011	1.898E+00	-3.215E-02	-1.69%	1.696E+00	1.928E+00	1.696E+00	1.928E+00	8.626E-02	0.045
2012	1.896E+00	-2.750E-02	-1.45%	1.714E+00	1.919E+00	1.714E+00	1.919E+00	7.096E-02	0.037
2013	1.895E+00	-2.318E-02	-1.22%	1.740E+00	1.913E+00	1.740E+00	1.913E+00	5.726E-02	0.030

NOTE: Confidence intervals are approximate.
At least 500 to 1000 trials are recommended when estimating confidence intervals.

Results from ASPICP.EXE, version 3.16 07 May 2008 at 16:18.29
3LN redfish Page 2
Projection with 5000 Y

TRAJECTORY OF RELATIVE FISHING MORTALITY RATE F/Fmsy (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1959	1.380E+00	3.151E-02	2.28%	8.434E-01	1.973E+00	8.434E-01	1.973E+00	5.879E-01	0.426
1960	8.809E-01	3.163E-02	3.59%	5.711E-01	1.278E+00	5.711E-01	1.278E+00	3.687E-01	0.418
1961	7.758E-01	3.202E-02	4.13%	5.335E-01	1.127E+00	5.335E-01	1.127E+00	3.099E-01	0.399
1962	7.139E-01	3.112E-02	4.36%	5.144E-01	1.038E+00	5.144E-01	1.038E+00	2.722E-01	0.381
1963	9.180E-01	4.280E-02	4.66%	6.807E-01	1.321E+00	6.807E-01	1.321E+00	3.404E-01	0.371
1964	3.355E-01	1.520E-02	4.53%	2.551E-01	4.812E-01	2.551E-01	4.812E-01	1.200E-01	0.358
1965	7.439E-01	3.121E-02	4.19%	5.800E-01	1.058E+00	5.800E-01	1.058E+00	2.457E-01	0.330
1966	5.319E-01	2.117E-02	3.98%	4.207E-01	7.535E-01	4.207E-01	7.535E-01	1.661E-01	0.312
1967	8.524E-01	3.243E-02	3.80%	6.841E-01	1.205E+00	6.841E-01	1.205E+00	2.503E-01	0.294
1968	5.539E-01	2.004E-02	3.62%	4.488E-01	7.720E-01	4.488E-01	7.720E-01	1.555E-01	0.281
1969	7.730E-01	2.609E-02	3.38%	6.293E-01	1.069E+00	6.293E-01	1.069E+00	2.057E-01	0.266
1970	4.443E-01	1.369E-02	3.08%	3.630E-01	6.042E-01	3.630E-01	6.042E-01	1.164E-01	0.262
1971	1.075E+00	3.126E-02	2.91%	8.840E-01	1.455E+00	8.840E-01	1.455E+00	2.749E-01	0.256
1972	9.510E-01	2.755E-02	2.90%	7.858E-01	1.283E+00	7.858E-01	1.283E+00	2.395E-01	0.252
1973	1.146E+00	3.373E-02	2.94%	9.486E-01	1.544E+00	9.486E-01	1.544E+00	2.831E-01	0.247
1974	7.850E-01	2.326E-02	2.96%	6.465E-01	1.060E+00	6.465E-01	1.060E+00	1.963E-01	0.250
1975	6.158E-01	1.748E-02	2.84%	5.030E-01	8.329E-01	5.030E-01	8.329E-01	1.590E-01	0.258
1976	6.896E-01	1.873E-02	2.72%	5.583E-01	9.332E-01	5.583E-01	9.332E-01	1.820E-01	0.264
1977	5.407E-01	1.401E-02	2.59%	4.375E-01	7.372E-01	4.375E-01	7.372E-01	1.463E-01	0.271
1978	3.767E-01	9.035E-03	2.40%	3.051E-01	5.169E-01	3.051E-01	5.169E-01	1.043E-01	0.277
1979	4.207E-01	9.202E-03	2.19%	3.425E-01	5.719E-01	3.425E-01	5.719E-01	1.169E-01	0.278
1980	4.658E-01	9.248E-03	1.99%	3.817E-01	6.309E-01	3.817E-01	6.309E-01	1.239E-01	0.266
1981	7.053E-01	1.271E-02	1.80%	5.819E-01	9.419E-01	5.819E-01	9.419E-01	1.772E-01	0.251
1982	6.333E-01	1.023E-02	1.62%	5.254E-01	8.405E-01	5.254E-01	8.405E-01	1.540E-01	0.243
1983	5.802E-01	8.155E-03	1.41%	4.847E-01	7.688E-01	4.847E-01	7.688E-01	1.377E-01	0.237
1984	4.266E-01	5.051E-03	1.18%	3.576E-01	5.636E-01	3.576E-01	5.636E-01	9.904E-02	0.232
1985	5.875E-01	5.727E-03	0.97%	4.961E-01	7.731E-01	4.961E-01	7.731E-01	1.360E-01	0.231
1986	1.298E+00	1.035E-02	0.80%	1.105E+00	1.682E+00	1.105E+00	1.682E+00	2.783E-01	0.214
1987	3.030E+00	2.178E-02	0.72%	2.650E+00	3.827E+00	2.650E+00	3.827E+00	5.626E-01	0.186
1988	2.802E+00	2.199E-02	0.78%	2.514E+00	3.409E+00	2.514E+00	3.409E+00	4.349E-01	0.155
1989	2.176E+00	1.839E-02	0.85%	1.950E+00	2.586E+00	1.950E+00	2.586E+00	3.104E-01	0.143
1990	2.142E+00	1.862E-02	0.87%	1.891E+00	2.543E+00	1.891E+00	2.543E+00	3.292E-01	0.154
1991	2.130E+00	2.086E-02	0.98%	1.824E+00	2.552E+00	1.824E+00	2.552E+00	3.720E-01	0.175
1992	2.593E+00	3.871E-02	1.49%	2.126E+00	3.204E+00	2.126E+00	3.204E+00	5.592E-01	0.216
1993	2.355E+00	6.821E-02	2.90%	1.753E+00	3.039E+00	1.753E+00	3.039E+00	6.494E-01	0.276
1994	6.181E-01	2.548E-02	4.12%	4.430E-01	8.650E-01	4.430E-01	8.650E-01	2.195E-01	0.355
1995	1.744E-01	7.565E-03	4.34%	1.220E-01	2.540E-01	1.220E-01	2.540E-01	7.218E-02	0.414
1996	3.123E-02	1.395E-03	4.47%	2.121E-02	4.683E-02	2.121E-02	4.683E-02	1.357E-02	0.435
1997	3.487E-02	1.663E-03	4.77%	2.332E-02	5.412E-02	2.332E-02	5.412E-02	1.598E-02	0.458
1998	4.089E-02	2.113E-03	5.17%	2.775E-02	6.571E-02	2.775E-02	6.571E-02	1.920E-02	0.470
1999	8.949E-02	4.963E-03	5.55%	6.185E-02	1.461E-01	6.185E-02	1.461E-01	4.234E-02	0.473
2000	1.063E-01	6.161E-03	5.80%	7.585E-02	1.756E-01	7.585E-02	1.756E-01	4.840E-02	0.455
2001	4.368E-02	2.530E-03	5.79%	3.218E-02	7.227E-02	3.218E-02	7.227E-02	1.858E-02	0.425
2002	3.355E-02	1.852E-03	5.52%	2.564E-02	5.513E-02	2.564E-02	5.513E-02	1.319E-02	0.393
2003	3.421E-02	1.728E-03	5.05%	2.713E-02	5.506E-02	2.713E-02	5.506E-02	1.203E-02	0.352
2004	1.543E-02	6.854E-04	4.44%	1.263E-02	2.419E-02	1.263E-02	2.419E-02	4.830E-03	0.313
2005	1.528E-02	5.739E-04	3.76%	1.285E-02	2.327E-02	1.285E-02	2.327E-02	4.282E-03	0.280
2006	1.113E-02	3.400E-04	3.06%	9.520E-03	1.630E-02	9.520E-03	1.630E-02	2.747E-03	0.247
2007	3.791E-02	9.033E-04	2.38%	3.285E-02	5.267E-02	3.285E-02	5.267E-02	8.155E-03	0.215
2008	3.676E-02	6.474E-04	1.76%	3.226E-02	4.978E-02	3.226E-02	4.978E-02	7.144E-03	0.194
2009	1.076E-01	1.299E-03	1.21%	9.544E-02	1.414E-01	9.544E-02	1.414E-01	1.877E-02	0.174
2010	1.077E-01	7.746E-04	0.72%	9.629E-02	1.376E-01	9.629E-02	1.376E-01	1.719E-02	0.160
2011	1.078E-01	3.134E-04	0.29%	9.714E-02	1.352E-01	9.714E-02	1.352E-01	1.597E-02	0.148
2012	1.079E-01	-8.419E-05	-0.08%	9.766E-02	1.330E-01	9.766E-02	1.330E-01	1.511E-02	0.140

Note: no yield(s) were estimated in the projection.

NOTE: Confidence intervals are approximate.
At least 500 to 1000 trials are recommended when estimating confidence intervals.

Results from ASPICP.EXE, version 3.16 07 May 2008 at 16:18.29
3LN redfish Page 3
Projection with 5000 Y

TRAJECTORY OF ABSOLUTE BIOMASS (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1959	1.996E+05	1.903E+04	9.53%	1.333E+05	3.154E+05	1.333E+05	3.154E+05	8.884E+04	0.445
1960	1.769E+05	1.034E+04	5.85%	1.162E+05	2.730E+05	1.162E+05	2.730E+05	7.990E+04	0.452
1961	1.734E+05	6.015E+03	3.47%	1.156E+05	2.549E+05	1.156E+05	2.549E+05	7.276E+04	0.420
1962	1.735E+05	3.198E+03	1.84%	1.182E+05	2.452E+05	1.182E+05	2.452E+05	6.652E+04	0.383
1963	1.752E+05	1.201E+03	0.69%	1.244E+05	2.412E+05	1.244E+05	2.412E+05	5.978E+04	0.341
1964	1.711E+05	-2.502E+02	-0.15%	1.248E+05	2.345E+05	1.248E+05	2.345E+05	5.484E+04	0.321
1965	1.837E+05	-1.368E+03	-0.74%	1.411E+05	2.419E+05	1.411E+05	2.419E+05	5.039E+04	0.274
1966	1.826E+05	-2.183E+03	-1.20%	1.452E+05	2.373E+05	1.452E+05	2.373E+05	4.821E+04	0.264
1967	1.878E+05	-2.748E+03	-1.46%	1.542E+05	2.412E+05	1.542E+05	2.412E+05	4.617E+04	0.246
1968	1.828E+05	-3.103E+03	-1.70%	1.534E+05	2.355E+05	1.534E+05	2.355E+05	4.378E+04	0.240
1969	1.873E+05	-3.317E+03	-1.77%	1.613E+05	2.394E+05	1.613E+05	2.394E+05	4.313E+04	0.230
1970	1.846E+05	-3.420E+03	-1.85%	1.614E+05	2.368E+05	1.614E+05	2.368E+05	3.998E+04	0.217
1971	1.920E+05	-3.448E+03	-1.80%	1.695E+05	2.416E+05	1.695E+05	2.416E+05	3.768E+04	0.196
1972	1.798E+05	-3.384E+03	-1.88%	1.583E+05	2.275E+05	1.583E+05	2.275E+05	3.605E+04	0.201
1973	1.738E+05	-3.269E+03	-1.88%	1.541E+05	2.195E+05	1.541E+05	2.195E+05	3.483E+04	0.200
1974	1.641E+05	-3.151E+03	-1.92%	1.457E+05	2.074E+05	1.457E+05	2.074E+05	3.264E+04	0.199
1975	1.656E+05	-3.064E+03	-1.85%	1.488E+05	2.068E+05	1.488E+05	2.068E+05	3.078E+04	0.186
1976	1.713E+05	-3.030E+03	-1.77%	1.561E+05	2.110E+05	1.561E+05	2.110E+05	2.897E+04	0.169
1977	1.741E+05	-3.038E+03	-1.75%	1.600E+05	2.146E+05	1.600E+05	2.146E+05	2.817E+04	0.162
1978	1.805E+05	-3.080E+03	-1.71%	1.667E+05	2.197E+05	1.667E+05	2.197E+05	2.693E+04	0.149
1979	1.905E+05	-3.158E+03	-1.66%	1.765E+05	2.276E+05	1.765E+05	2.276E+05	2.590E+04	0.136
1980	1.976E+05	-3.228E+03	-1.63%	1.834E+05	2.332E+05	1.834E+05	2.332E+05	2.569E+04	0.130
1981	2.019E+05	-3.229E+03	-1.60%	1.873E+05	2.371E+05	1.873E+05	2.371E+05	2.582E+04	0.128
1982	1.980E+05	-3.107E+03	-1.57%	1.825E+05	2.326E+05	1.825E+05	2.326E+05	2.588E+04	0.131
1983	1.971E+05	-2.891E+03	-1.47%	1.810E+05	2.315E+05	1.810E+05	2.315E+05	2.530E+04	0.128
1984	1.981E+05	-2.635E+03	-1.33%	1.810E+05	2.313E+05	1.810E+05	2.313E+05	2.527E+04	0.128
1985	2.035E+05	-2.376E+03	-1.17%	1.848E+05	2.335E+05	1.848E+05	2.335E+05	2.569E+04	0.126
1986	2.028E+05	-2.093E+03	-1.03%	1.832E+05	2.330E+05	1.832E+05	2.330E+05	2.671E+04	0.132
1987	1.814E+05	-1.692E+03	-0.93%	1.610E+05	2.095E+05	1.610E+05	2.095E+05	2.651E+04	0.146
1988	1.264E+05	-1.201E+03	-0.95%	1.082E+05	1.532E+05	1.082E+05	1.532E+05	2.407E+04	0.190
1989	9.632E+04	-8.564E+02	-0.89%	8.026E+04	1.206E+05	8.026E+04	1.206E+05	2.200E+04	0.228
1990	8.380E+04	-6.207E+02	-0.74%	6.970E+04	1.058E+05	6.970E+04	1.058E+05	2.027E+04	0.242
1991	7.430E+04	-4.167E+02	-0.56%	6.189E+04	9.473E+04	6.189E+04	9.473E+04	1.893E+04	0.255
1992	6.671E+04	-2.163E+02	-0.32%	5.583E+04	8.630E+04	5.583E+04	8.630E+04	1.704E+04	0.255
1993	5.593E+04	-3.087E+01	-0.06%	4.414E+04	7.488E+04	4.414E+04	7.488E+04	1.664E+04	0.298
1994	4.937E+04	1.353E+02	0.27%	3.723E+04	6.889E+04	3.723E+04	6.889E+04	1.747E+04	0.354
1995	5.867E+04	3.731E+02	0.64%	4.421E+04	8.015E+04	4.421E+04	8.015E+04	1.944E+04	0.331
1996	7.414E+04	7.105E+02	0.96%	5.593E+04	9.686E+04	5.593E+04	9.686E+04	2.224E+04	0.300
1997	9.400E+04	9.695E+02	1.03%	7.157E+04	1.183E+05	7.157E+04	1.183E+05	2.377E+04	0.253
1998	1.161E+05	8.450E+02	0.73%	8.881E+04	1.416E+05	8.881E+04	1.416E+05	2.753E+04	0.237
1999	1.393E+05	9.720E+01	0.07%	1.095E+05	1.648E+05	1.095E+05	1.648E+05	2.879E+04	0.207
2000	1.613E+05	-1.261E+03	-0.78%	1.309E+05	1.859E+05	1.309E+05	1.859E+05	2.798E+04	0.173
2001	1.815E+05	-2.964E+03	-1.63%	1.525E+05	2.030E+05	1.525E+05	2.030E+05	2.491E+04	0.137
2002	2.015E+05	-4.670E+03	-2.32%	1.825E+05	2.267E+05	1.825E+05	2.267E+05	2.159E+04	0.107
2003	2.190E+05	-6.060E+03	-2.77%	2.063E+05	2.510E+05	2.063E+05	2.510E+05	2.324E+04	0.106
2004	2.334E+05	-6.910E+03	-2.96%	2.200E+05	2.717E+05	2.200E+05	2.717E+05	2.551E+04	0.109
2005	2.456E+05	-7.159E+03	-2.92%	2.303E+05	2.861E+05	2.303E+05	2.861E+05	2.655E+04	0.108
2006	2.550E+05	-6.865E+03	-2.69%	2.362E+05	2.974E+05	2.362E+05	2.974E+05	2.863E+04	0.112
2007	2.624E+05	-6.151E+03	-2.34%	2.392E+05	3.062E+05	2.392E+05	3.062E+05	3.252E+04	0.124
2008	2.668E+05	-5.157E+03	-1.93%	2.350E+05	3.097E+05	2.350E+05	3.097E+05	3.688E+04	0.138
2009	2.701E+05	-4.020E+03	-1.49%	2.343E+05	3.158E+05	2.343E+05	3.158E+05	4.330E+04	0.160
2010	2.696E+05	-2.840E+03	-1.05%	2.302E+05	3.218E+05	2.302E+05	3.218E+05	4.775E+04	0.177
2011	2.693E+05	-1.699E+03	-0.63%	2.282E+05	3.261E+05	2.282E+05	3.261E+05	5.170E+04	0.192
2012	2.691E+05	-6.507E+02	-0.24%	2.266E+05	3.301E+05	2.266E+05	3.301E+05	5.453E+04	0.203
2013	2.689E+05	2.834E+02	0.11%	2.265E+05	3.341E+05	2.265E+05	3.341E+05	5.722E+04	0.213

NOTE: Confidence intervals are approximate.
At least 500 to 1000 trials are recommended when estimating confidence intervals.

Results from ASPICP.EXE, version 3.16 07 May 2008 at 16:18.29
3LN redfish Page 4
Projection with 5000 Y

TRAJECTORY OF ABSOLUTE FISHING MORTALITY RATE (BOOTSTRAPPED)

Year	Point estimate	Estimated bias	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
1959	2.377E-01	1.078E-02	4.53%	1.521E-01	3.600E-01	1.521E-01	3.600E-01	1.061E-01	0.446
1960	1.517E-01	9.142E-03	6.03%	1.015E-01	2.287E-01	1.015E-01	2.287E-01	6.504E-02	0.429
1961	1.336E-01	8.596E-03	6.43%	9.255E-02	1.980E-01	9.255E-02	1.980E-01	5.367E-02	0.402
1962	1.230E-01	7.948E-03	6.46%	8.848E-02	1.775E-01	8.848E-02	1.775E-01	4.404E-02	0.358
1963	1.581E-01	1.047E-02	6.62%	1.153E-01	2.206E-01	1.153E-01	2.206E-01	5.167E-02	0.327
1964	5.779E-02	3.597E-03	6.23%	4.300E-02	7.700E-02	4.300E-02	7.700E-02	1.653E-02	0.286
1965	1.281E-01	7.278E-03	5.68%	9.753E-02	1.630E-01	9.753E-02	1.630E-01	3.314E-02	0.259
1966	9.160E-02	4.892E-03	5.34%	7.094E-02	1.135E-01	7.094E-02	1.135E-01	2.211E-02	0.241
1967	1.468E-01	7.485E-03	5.10%	1.139E-01	1.770E-01	1.139E-01	1.770E-01	3.281E-02	0.223
1968	9.540E-02	4.613E-03	4.84%	7.433E-02	1.120E-01	7.433E-02	1.120E-01	2.038E-02	0.214
1969	1.331E-01	6.031E-03	4.53%	1.034E-01	1.535E-01	1.034E-01	1.535E-01	2.692E-02	0.202
1970	7.651E-02	3.183E-03	4.16%	6.026E-02	8.726E-02	6.026E-02	8.726E-02	1.441E-02	0.188
1971	1.852E-01	7.415E-03	4.00%	1.463E-01	2.099E-01	1.463E-01	2.099E-01	3.382E-02	0.183
1972	1.638E-01	6.584E-03	4.02%	1.291E-01	1.854E-01	1.291E-01	1.854E-01	3.005E-02	0.183
1973	1.973E-01	7.959E-03	4.03%	1.559E-01	2.223E-01	1.559E-01	2.223E-01	3.602E-02	0.183
1974	1.352E-01	5.298E-03	3.92%	1.076E-01	1.513E-01	1.076E-01	1.513E-01	2.378E-02	0.176
1975	1.061E-01	3.804E-03	3.59%	8.519E-02	1.172E-01	8.519E-02	1.172E-01	1.732E-02	0.163
1976	1.188E-01	3.930E-03	3.31%	9.582E-02	1.298E-01	9.582E-02	1.298E-01	1.805E-02	0.152
1977	9.312E-02	2.862E-03	3.07%	7.576E-02	1.010E-01	7.576E-02	1.010E-01	1.329E-02	0.143
1978	6.487E-02	1.823E-03	2.81%	5.381E-02	7.014E-02	5.381E-02	7.014E-02	8.596E-03	0.132
1979	7.245E-02	1.891E-03	2.61%	6.108E-02	7.822E-02	6.108E-02	7.822E-02	9.027E-03	0.125
1980	8.022E-02	2.002E-03	2.50%	6.799E-02	8.634E-02	6.799E-02	8.634E-02	9.827E-03	0.123
1981	1.215E-01	2.985E-03	2.46%	1.033E-01	1.315E-01	1.033E-01	1.315E-01	1.478E-02	0.122
1982	1.091E-01	2.612E-03	2.39%	9.273E-02	1.187E-01	9.273E-02	1.187E-01	1.329E-02	0.122
1983	9.993E-02	2.262E-03	2.26%	8.532E-02	1.091E-01	8.532E-02	1.091E-01	1.219E-02	0.122
1984	7.348E-02	1.536E-03	2.09%	6.364E-02	8.070E-02	6.364E-02	8.070E-02	8.937E-03	0.122
1985	1.012E-01	1.987E-03	1.96%	8.826E-02	1.118E-01	8.826E-02	1.118E-01	1.273E-02	0.126
1986	2.235E-01	4.452E-03	1.99%	1.941E-01	2.500E-01	1.941E-01	2.500E-01	3.043E-02	0.136
1987	5.218E-01	1.278E-02	2.45%	4.411E-01	6.014E-01	4.411E-01	6.014E-01	8.559E-02	0.164
1988	4.827E-01	1.523E-02	3.16%	3.904E-01	5.715E-01	3.904E-01	5.715E-01	9.648E-02	0.200
1989	3.747E-01	1.305E-02	3.48%	2.962E-01	4.490E-01	2.962E-01	4.490E-01	8.469E-02	0.226
1990	3.690E-01	1.277E-02	3.46%	2.889E-01	4.416E-01	2.889E-01	4.416E-01	8.638E-02	0.234
1991	3.668E-01	1.246E-02	3.40%	2.856E-01	4.389E-01	2.856E-01	4.389E-01	8.684E-02	0.237
1992	4.466E-01	1.687E-02	3.78%	3.402E-01	5.491E-01	3.402E-01	5.491E-01	1.141E-01	0.256
1993	4.055E-01	2.038E-02	5.03%	2.978E-01	5.244E-01	2.978E-01	5.244E-01	1.259E-01	0.311
1994	1.064E-01	5.728E-03	5.38%	7.693E-02	1.404E-01	7.693E-02	1.404E-01	3.338E-02	0.314
1995	3.004E-02	1.258E-03	4.19%	2.259E-02	3.968E-02	2.259E-02	3.968E-02	9.074E-03	0.302
1996	5.379E-03	1.668E-04	3.10%	4.189E-03	7.033E-03	4.189E-03	7.033E-03	1.474E-03	0.274
1997	6.006E-03	1.521E-04	2.53%	4.876E-03	7.928E-03	4.876E-03	7.928E-03	1.540E-03	0.256
1998	7.042E-03	1.712E-04	2.43%	5.871E-03	9.053E-03	5.871E-03	9.053E-03	1.598E-03	0.227
1999	1.541E-02	4.080E-04	2.65%	1.322E-02	1.931E-02	1.322E-02	1.931E-02	3.034E-03	0.197
2000	1.831E-02	5.516E-04	3.01%	1.612E-02	2.214E-02	1.612E-02	2.214E-02	2.945E-03	0.161
2001	7.522E-03	2.523E-04	3.35%	6.724E-03	8.658E-03	6.724E-03	8.658E-03	8.827E-04	0.117
2002	5.778E-03	2.076E-04	3.59%	5.079E-03	6.204E-03	5.079E-03	6.204E-03	5.803E-04	0.100
2003	5.892E-03	2.194E-04	3.72%	5.078E-03	6.235E-03	5.078E-03	6.235E-03	6.025E-04	0.102
2004	2.657E-03	9.923E-05	3.73%	2.268E-03	2.818E-03	2.268E-03	2.818E-03	2.706E-04	0.102
2005	2.631E-03	9.590E-05	3.65%	2.255E-03	2.816E-03	2.255E-03	2.816E-03	2.740E-04	0.104
2006	1.916E-03	6.682E-05	3.49%	1.640E-03	2.086E-03	1.640E-03	2.086E-03	2.129E-04	0.111
2007	6.529E-03	2.150E-04	3.29%	5.641E-03	7.336E-03	5.641E-03	7.336E-03	8.152E-04	0.125
2008	6.331E-03	1.950E-04	3.08%	5.443E-03	7.245E-03	5.443E-03	7.245E-03	9.267E-04	0.146
2009	1.853E-02	5.325E-04	2.87%	1.571E-02	2.151E-02	1.571E-02	2.151E-02	3.057E-03	0.165
2010	1.855E-02	4.952E-04	2.67%	1.542E-02	2.181E-02	1.542E-02	2.181E-02	3.363E-03	0.181
2011	1.857E-02	4.565E-04	2.46%	1.523E-02	2.202E-02	1.523E-02	2.202E-02	3.595E-03	0.194
2012	1.859E-02	4.198E-04	2.26%	1.502E-02	2.209E-02	1.502E-02	2.209E-02	3.742E-03	0.201

NOTE: Confidence intervals are approximate.
At least 500 to 1000 trials are recommended when estimating confidence intervals.

```
Results from ASPICP.EXE, version 3.16                                                      07 May 2008 at 16:18.29
3LN redfish                                                                                                 Page 5
Projection with 5000 Y
```

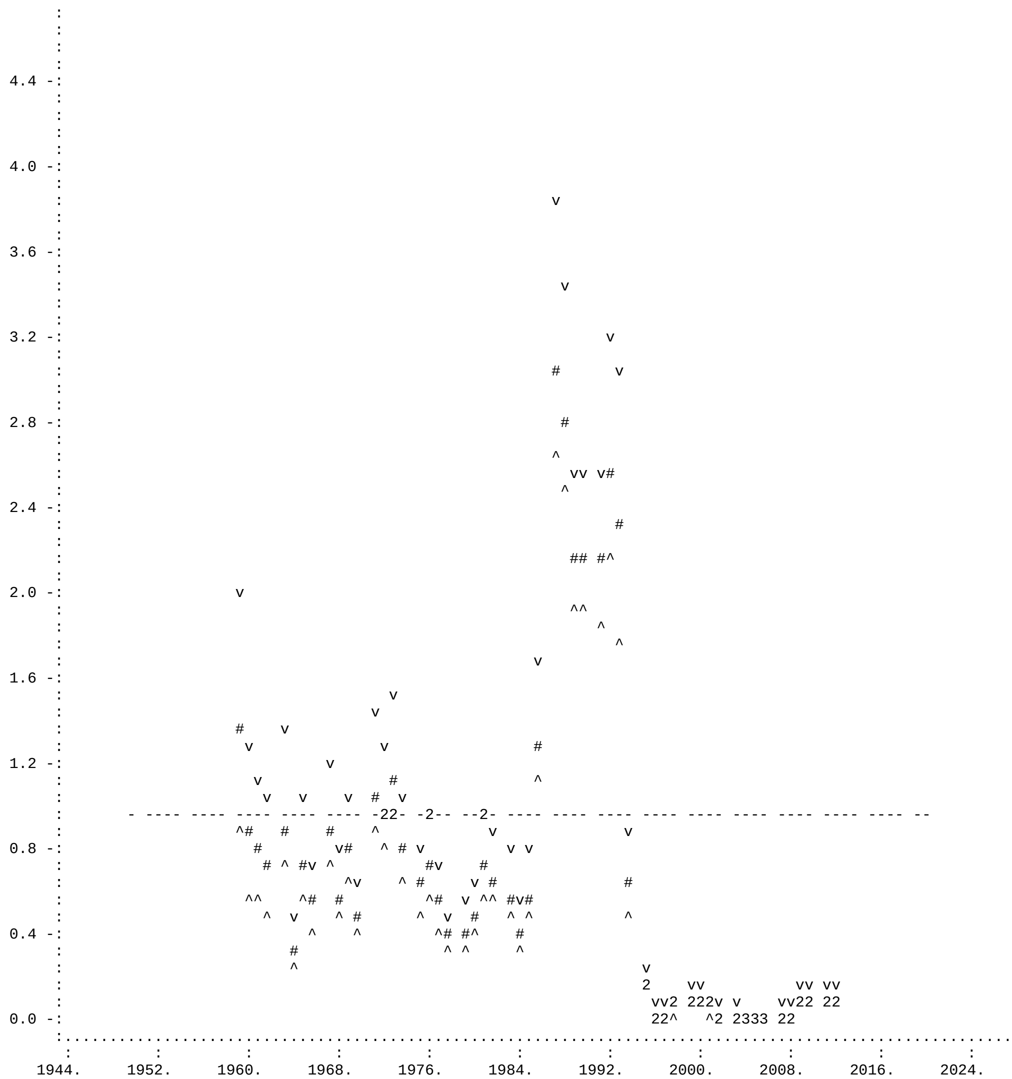
```
                   Time Plot of B/Bmsy (#) with Bias-Corrected (BC) 80% Confidence Interval (^v)
                   (Dashed reference line is 1.0)

           :
           :
           :
           :
     2.75 -:
           :
           :
           :
           :
     2.50 -:
           :                   v
           :
           :
           :
     2.25 -:
           :
           :
           :
           :
     2.00 -:                    v
           :                                                                             v vvvv v
           :                                                                            v   ### #22
           :                     v                                                     v   #
           :                                                                          v  #
     1.75 -:                                                                            #         ^
           :                      v                                                 v           ^^
           :                        v                                                  #      ^
           :                          v                                            v         ^
           :                         v v v               vv    vv                     #     ^
     1.50 -:                              vv  v         v  v vv                   v        ^
           :                                v                  ##
           :                   #               v      v  ### ##                     #    ^
           :                                  # v   vv  #         v
           :                          ## ####      v              #              v #    ^
     1.25 -:                    #   #          # v   ##
           :                     ##  #          #   #          ^^
           :                                     # #      ^  ^^                   #    ^
           :                                             ^ ^      ^            v      ^
           :                                            ^
     1.00 -:       - ---- ---- 2--- ---- ---- 2--- ---- ---- ---- ---- ---- ---- 2--- ---- ---- ---- ---- --
           :                             ^^^^  ^     ^^                             ^
           :                          ^^        ^   ^              2          v
           :                    ^^^ ^^           ^ ^                               ^
           :                                                       ^           #
     0.75 -:                                                        v             ^
           :                                                        #        v
           :                                                        ^v        #  ^
           :                                                         # v
           :                                                         ^  v   v  ^
     0.50 -:                                                           2 v   #
           :                                                            # v   ^
           :                                                            ^#  #
           :                                                             ^#  ^
           :                                                                ^
     0.25 -:                                                              ^
           :
           :
           :
           :
     0.00 -:
           :.........................................................................................................
            :         :         :         :         :         :         :         :         :         :         :
         1944.     1952.     1960.     1968.     1976.     1984.     1992.     2000.     2008.     2016.     2024.
```

NOTE: Estimates beginning in 2009 depend on the user projection data listed on page 1.

```
Results from ASPICP.EXE, version 3.16                                        07 May 2008 at 16:18.29
3LN redfish                                                                                   Page 6
Projection with 5000 Y
```

Time Plot of F/Fmsy (#) with 80% Bias-Corrected (BC) Confidence Interval (^v)
(Dashed reference line is 1.0)



NOTE: Estimates beginning in 2008 depend on the user projection data listed on page 1.