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The status of redfish (*S. mentella and S. fasciatus*) in Divisions 3LN and two medium term scenarios (*when recruitment is low, Risk Based Management Strategy or common sense?*)

by

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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. Both species, occurring on Div. 3LN and managed as a single stock, don't belong to isolated local populations but, on the contrary, are part of a large Northwest Atlantic complex ranging from the Gulf of Maine to south of Baffin Island.

The ASPIC assessment of this stock is based on the logistic form of a non-equilibrium surplus production model (Schaeffer, 1954; Prager, 1994), adjusted to a standardized commercial catch rate series (Power, 1997) and to all stratified-random bottom trawl surveys conducted in various years and seasons in Div. 3L and Div. 3N from 1978 onwards. Both CPUE and surveys were used with all observations within each series.

The 2020 assessment proceed on the threshold of the new 2014 approach, with MSY fixed at 1960-1985 average catch and the rest of the approved 2014 assessment framework updated.

ASPIC results present a stock stable from the 1960's to the first half of the 1980's while sustaining an average yield of 21 000t. Stock declined with a sudden rise of the catch over the late 1980's first half of the 1990's, and started to gradually recover after catches fell to a residual level in response to stock collapse. The maximum observed sustainable yield (*MSY*) of 21 000 t is linked to a F_{msy} at 0.11/year and a B_{msy} at 185 000 t. There is a high probability (>90%) that the stock was at least 38% above B_{msy} at the beginning of 2020, after crossing 2019 under a fishing mortality not higher than 46% F_{msy}.

From medium term stochastic projections there is a high probability (CL's 80%) that catch on 2020-2025 at HCR 2019-2020 TAC of 18 100t will keep fishing mortality until 2025 below F_{msy} and biomass above

B_{msy} till the beginning of 2021 (*status quo* HCR2020 scenario). However, analysis of the majority of recent data (2016-2019) from ongoing surveys and commercial fisheries suggests that the 3LN redfish management unit has stop growing or may even been declining. No evidence of good recruitments is also in line with that hypothesis. Therefore an alternate catch projection has also been performed aiming to quantify the likelihood of another possible 2021-2025 stock trajectory under a lower catch seiling of 13 730 t, the equilibrium yield available at present (Ye_{2020} scenario). On this second scenario the 2020 TAC of 18 100 t will also be effectively taken in the interim year.

For both HCR 2020 and Ye_{2020} scenarios there is a very high probability level (>90%) that biomass will arrive at the beginning of 2026 above B_{msy} while fishing mortality will stay below F_{msy} . However the second option will allow biomass level roughly to be kept at its present level, avoiding the beginning of a marginal decline predicted by the HCR 2020 option and already suggested by the majority of recent observed data.

At present the stock is kept at a safe zone and is moderately exploited. Nevertheless this management unit is also passing through low productivity times and the end of this regime is (still) not forseen. Under the present circunstances, a medium term risk based management strategy that goes beyond what the stock can offer and sustain now is not a precautionary strategy. And therefore, and so far, management should be based on bi-annual assessments and short term equilibrium yield projections.

Introduction

There are two species of the genus *Sebastes* with distribution overlapping in several areas of Northwest Atlantic, namely on the Gulf of St. Lawrence, Laurentian Channel, off Newfoundland and south of Labrador Sea: the deep sea redfish (*Sebastes mentella)*, with a maximum abundance at depths greater than 350m, and Acadian redfish (*Sebastes fasciatus*), preferring shallower waters of less than 300m (DFO, 2008). They have been commercially fished on the slopes of the Grand Bank, both on Div. 3LN (north-south east) and Div. 3O (south-west).

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. Therefore, they are reported collectively as "redfish" in the commercial fishery statistics. *S. mentella* and *S. fasciatus* are also treated as a single species in the Grand Bank surveys carried out by Canada, Russia and more recently by EU-Spain.

Either redfish species occurring on Div. 3LN don't belong to isolated local populations but, on the contrary, are part of a large Northwest Atlantic complex ranging from the Gulf of Maine to south of Baffin Island. This complex is centred on the Gulf of St. Laurence (GSL)- Laurentian Channel – western slope of the Grand Bank system, where the GSL is a main nursery area for *S. fasciatus* and *S. mentella* local populations, due to current patterns that favours larval drift from main regions of larval extrusion towards the gulf.

As regards redfish occurring on the Gran Bank of Newfoundland, differences observed in the "state of the stock" between Div. 3O and Div. 3LN suggests that it would be prudent to keep Div. 3LN as a separate management unit. Being so, beaked redfish in Div. 3LN has been considered by NAFO Scientific Council as a management unit composed by the ensembles *S. mentella – S.fasciatus* aggregations overlapping on the north-south east parts of the Grand Bank.

Within this management unit, relative abundance of *S. mentella – S.fasciatus* may vary with the income and survival of juveniles from either species, though *S. fasciatus* tend to be more abundant in the south (Div. 3N) while *S. mentella* is more abundant in the northern division (3L).

Commercial Fishery

Nominal catches and TAC's

Between 1959 and 1960 reported catches drop from 44 600 to 26 600 t, oscillating over the next 25 years (1960-1985) around an average level about 21 000 t. Catches rise afterwards to a 79 000 t high in 1987 and fall steadily to a 450 t minimum reached in 1996. Catches were kept at a low level (450-3 000 t) until 2009.

The NAFO Fisheries Commission (FC) implemented a moratorium on directed fishing for this stock in 1998. In June 2009 the Scientific Council confirmed the upward trend of the stock as shown by spring and autumn surveys (NAFO, 2009). The Fisheries Commission endorsed the Scientific Council recommendations from 2011 onwards and catches steadily increased being at 13 050t in 2019, the highest level recorded since 1993 (Table 1, Fig. 1). Since the reopening in 2010, Canada, followed by Russia and EU-Portugal are the main partners of a fishery mostly deployed northwards in Div. 3L until 2018, but evenly split between the two divisions last year.

The 2011-2016 catches were taken from the NAFO STATLANT 21 data base. The 2017 catch was estimated with the CDAG method (COM-SC CESAG-WP 18-01 (Rev.2)) whereas the CESAG method provided the catch estimates for 2018 (COM-SC CESAG-WP 19-03 (Revised)) and 2019 (COM-SC CESAG-WP 20-05 (Revised)).

The perception of the recent stock status, with biomass above B_{msy} and fishing mortality below F_{msy}, justified the adoption by the FC on the 36th Annual Meeting – September 2014 of a Risk-Based Management Strategy (MS) for redfish in Divisions 3LN (Ávila de Melo *et al*., 2014; FC Working Paper 14/23). This MS was designed to reach 18 100 t of annual catch by 2019-2020 through a stepwise biannual catch increase of constant magnitude.

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" (divisions 3L-3M-3N border, southwest of the Flemish Cap bank).

South Korea left the area by the end of 1993 and from 1994 onwards the other fleets reduced their effort substantially on the north and south east of the Grand Bank. The quick decline of catch rates was the main reason for this reduction of redfish fishing effort, and justified its partial shift southwest 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, southward through Flemish Pass till the canyons of southern Grand Bank in Div. 3N. EU-Portugal and EU-Spain bottom trawl fleets were the main fleets responsible for the 3LN redfish by-catch during the moratorium years.

Since its reopen in 2010 Canada, Russia and EU-Portugal are the main partners of a fishery mainly deployed northwards, on Div. 3L. However, the fishery has been increasing in the south, and on 2019 Div. 3L and Div. 3N had equal shares of the overall catches for the first time in many years.

Commercial CPUE

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. That 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 over longer periods of time*.

ASPIC assessments recovered 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). The catch rate series for Div. 3LN is presented on Table 2 and Fig. 2 (standardized to zero mean and unit standard deviation in the figure). Catch rate for Div. 3LN increased on the first years of the time series, 1959 till 1967, oscillated around the average on the intermediate years and declined after 1987. On the final years of this CPUE series, 1990-1994, catch rates were stable at a minimum level.

Commercial catch@length

Most of the commercial length sampling data available for the 3LN beaked redfish came, since 1990, from the Portuguese fisheries and have been annually included in the Portuguese research reports on the NAFO SCS Document series (Vargas *et al.*, 2020). Taking into account that the majority of the length sampling was from depths greater than 250m, most of these data should represent *S. mentella* catches. Length data from Spain and Russia were used to estimate the length composition of the commercial catches for those fleets in several years (González *et al*., 2020; Fomin *et al*., 2020, Pochtar *pers comm.* 2020). The 1990-2019 per mille length composition of the Portuguese trawl catch was applied to the rest of the commercial catches (Table 3a). Commercial length weight relationships used to get catch numbers at length were derived from redfish sampling on board of Portuguese vessels fishing on divisions 3L and 3N (Table 3b).

The overall mean length of the 1990-2019 catch (arithmetic mean of the annual mean lengths of the commercial catch) was used to derive length anomalies of the 3LN catch over this period (Table 3a, Fig. 3). The proportion of small redfish (less than 20cm) in the catch is presented as well on the bottom of Table 3a. The purpose of the length anomalies was to detect possible shifts in the length structure of the catch that could reflect changes in the length structure of the exploitable stock.

Above average mean lengths, apparent stable catch at length with no clear trends towards smaller or larger sizes, proportion of small redfish (<20cm) usually below 1% are observed on most of the years of the 1990-2005 interval. However, well below average mean lengths, coupled with of small redfish numbers in excess of 10% in the catch, occurred afterwards on several years between 2006 and 2016 (Table 3a, Fig. 3). Under a low exploitation regime such interlinked events should reflect an average level of recruitment over those years well above the low recruitments from the 1990's first half of the 2000's. Average proportion of small redfish in the commercial catch rose from 1.0% (1990-2005) to 13.3% (2006-2016).

However, proportion of small redfish fell to 0.7% on average over the last 3 years (2017-2019) while the mean length in the catch roughly increased 2.3cm, from 24.8cm (2006-2016) to 27.1cm (2017-2019), with larger sizes being the bulk of the catch (Table 3a). An important increase on the numbers of small redfish in the catch can reflect the income of one or more good recruitments but, on the contrary, a noticeable decline on this indicator, as observed on recent years, can signal that year classes coming in the fishery are now much weaker. And that exploitable stock is again basically relying on the survival and growth of the year classes recruited bacwards.

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). No survey was carried out on Div. 3N in spring 2006 and autumn

2014. In the spring of 2017 there were problems with 3L survey coverage and none of the redfish 3L strata were sampled (Rideout and Ings, 2020; Rideout 2020). 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 Doubleday stratification for Sub area 3 (Dooubleday, 19819. On 1984 standard tows were set to half hour at 3.5 knots, with a proper bottom trawl survey gear. 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) and since 2008 this "Power revised" 1984-1991 Russian survey series is incorporated in the input framework of the redfish 3LN ASPIC assessment (Ávila de Melo *et al.*, 2008). Between 1992 and 1994 the coverage of NAFO Sub area 3 by the Russian bottom trawl series became irregular and in 1995 was discontinued.

In 1995 EU-Spain started a new stratified-random bottom trawl spring (May-June) survey on NAFO Regulatory Area of Div. 3NO. All strata in the NRA were covered every year following the standard stratification, first till 732m and from 1998 onwards till the 1464 m depth contour(González *et al*, 2020)In 2003 the Spanish survey was extended northwards to some strata in Div. 3L, but it was only in 2006 that an adequate prospecting survey was first conducted in Division 3L with over 100 valid hauls (Róman *et al*, 2020).

Details on the two Canadian survey series, as well as on the Russian series and the two Spanish surveys can be found on previous assessments (Ávila de Melo *et al.*, 2014).

Survey biomass and female spawning biomass

All survey biomass series from stratified-random bottom trawl surveys used in the 2020 ASPIC assessment are presented in Table 4. The 1991-2019 spring and autumn female SSB Canadian survey indices for Div. 3LN combined are included on Table 4. In order to turn the survey series comparable and facilitate the detection of trends in stock dynamics, the survey biomass series used in the assessment framework and the female SSB survey series were standardized to zero mean and unit standard deviation and so presented on Fig. 4a and 4b.

From the late 1970s to the beginning of the 1990s Canadian surveys in Div. 3L and Russian bottom trawl surveys in Div. 3LN suggest that stock size suffered a substantial reduction. Redfish bottom biomass from surveys in Div. 3LN remained well below average level over the 1990's and early 2000's, but since 1997 those indices start to show some dynamics of increase. The inconsistent dynamics turn to clear increases of survey biomass indices on 2007-2015, but the majority of the ongoing surveys on Div. 3LN went down afterwards (2016-2019). Considering the broader 3LN picture given by the observed points from all available bottom trawl survey series occurring between 1978 and 2019 (Fig. 4a), 91% of the biomass indices were above the average of their own series on 1978-1985, went down to just 3% on 1986-2006, increase up to 77% above average on 2007-2015 and finaly record a limited decline to 64% above average between 2016 and 2019.

In order to estimate spring and autumn female spawning survey biomass by division, Div. 3L and Div. 3N female maturity at length vectors (Power 2001; Ávila de Melo et al., 2005) were applied to the 1991-2019 female abundances at length of the spring and autumn Canadian surveys. Female spawners and stock abundance at length by division were used to calculate SOP female spawning and stock biomass for Div. 3L and Div. 3N, using female and sex combined length weight relationships derived from data collected on board of the Canadian 3LN autumn surveys, 1997-2004 (Power, *pers. comm.*, 2005), of the 3N Spanish survey, 2005, and of the 2006-2019 3LN Spanish surveys (González, *pers. comm.*, 2020). The SOP ratios (SSB/stock biomass) by division were then applied to the respective swept area survey biomasses to give the spring and autumn female SSB in Div. 3L and Div. 3N.

Both 1991-2019 Canadian spring and autumn standardized female SSB survey series for Div. 3LN show trends that match with their correspondent total biomasses (Fig.4b). But, more recently (2016-2019),

all SSB indices were kept at or above average, which is not the case for survey total stock biomass that meanwhile went down. This late contrast between survey indicators suggest that female spawning component is showing so far a stronger resilience than total stock to remain (at least) around its average size.

Survey abundance@length

Spring and autumn survey abundance@ length, for Div. 3LN combined, are presented in Table 5a and 5b, respective length anomalies in Fig. 5a and 5b. The overall 1991-2019 mean length for each survey series (arithmetic mean of the annual mean lengths of the survey abundances@length) was used to derive a string of spring and autumn survey length anomalies that somehow could signal changes in the stock length structure over time (Table 5a and 5b last line, Fig. 5a and 5b).

During the first half of the 1990's, , most length anomalies on both surveys were negative, with few slightly positive exceptions recorded in autumn. Mean lengths on the majority of years between 1996 and 2004 were above the mean on both seasons, reflecting a shift on the stock length structure towards larger individuals probably justified by a higher survival of the main year classes crossing the stock through this time interval, coupled with a regular income of weak year classes. Between 2005 and 2015 mean lengths generally fall and stay below average, just as observed on the commercial catch@length one year ahead, 2006-2016(Fig. 5a and 5b and Fig. 3). Over recent years (2016-2019) mean lengths return to increase above average on both surveys.

At times of low by-catch/low exploitation, and after a low productivity regime that prevailed for more than 15 years, the 2005-2015 negative pattern the occurrence of average to above average recruitments by then, that would impact the length structure of both surveys and commercial catch. At the same time larger sizes (=>20cm) increase their abundance as well until 2015, confirming that good recruitments and high survival rates were occurring simultaneously (Fig. 5c and 5d). From 2016 onwards that combined picture was not valid anymore at least on surveys, with exploited numbers@lenght (=>20cm) declining in spring and autumn series (Fig. 5c).

Between 2006-2007 and 2009 the recruitment index (numbers of redfish<20cm/ numbers of redfish =>20cm) increased rapidly in Canadian surveys, reaching maximum values (Fig. 5d). The recruitment index drop as fast as it went up on the following years and is at low to very low levels since 2012-2013. Nevertheless, unusual high numbers of very small redfish, 5 to 10cm, have been observed between 2015 and 2017 on Canadian spring and autumn surveys (Table 5a and 5b), some of the numbers within these lengths and years at maximum historical records. These pulses of pre-recruits observed recently still need to be confirmed as good recruitments, which so far didn't occur.

The general picture for the most recent years (2016-2019) taken from all these indicators of stock biomass and numbers@lenght given by surveys and fisheries is that the stock is not growing. And has either reach a stable level or even start making a downward turn. This general picture from observed data need to be taken into to consideration next, when analyzing the ASPIC assessment results and when choosing a catch level for projection, corresponding to a medium term management strategy alternate to the one still in place.

ASPIC assessment suite

Brief history and background for the pre fixed *MSY* option

A non-equilibrium surplus production model (ASPIC; Prager, 1994) is used to assess the status of the stock since 2008. The ASPIC operating model is a non-equilibrium implementation of Schaefer's model, among others.

Until 2012 the model was adjusted to an array of Canadian, Russian and Spanish surveys series arranged under the formulation adopted on the *"The 2nd Take of the 2008 Assessment of Redfish in NAFO Divisions 3LN,"* (Ávila de Melo and Alpoim, 2010). However, the model was showing an increasing unfitness to survey biomass increases, observed by the second half of the 2000's-early 2010's, on all ongoing surveys. The

approved framework of the 2012 assessment ends up excluding the 3N Spanish survey and several inter annual biomass bumps along the thresholds of Canadian survey series, either on spring (3LN combined) or autumn (3L and 3N separate) (Ávila de Melo *et al*, 2012).

On the next assessment (Ávila de Melo *et al*, 2014) the purpose was to reach an inclusive approach that would incorporate most, if not all, the survey points available for the two divisions with no haircuts, and at the same time delivering a "realistic" output. In other words, resulting on key parameters and biomass and fishing mortality trajectories in line with the perception of stock and fishery dynamics one has from historical survey and commercial time series. To achieve this goal two of the five input frameworks running on the exploratory analysis preceding the 2014 assessment were allowed to run with maximum sustainable yield fixed at a user starting guess of 21 000 t. This *MSY proxy* is the average level of sustained catch for the 1960-1985, when the stock experienced an apparent stability, suggested by the STATLANT CPUE series and historic surveys, and before stock decline in response to a sudden rise of catch from that previous average level.

From the 2014 exploratory analysis the better framework to run redfish 3LN assessment had MSY pre fixed at 1960-1985 average catch of 21 000 t. This framework also kept negative correlated STATLANT CPUE series and all "outliers" in their respective survey series, with Canadian autumn surveys on Div. 3L and Div. 3N from 1991 onwards assembled in one combined 3LN Canadian autumn series. On 2016, exploratory analysis allowed the inclusion of the 3L Spanish survey and so, since then, all surveys on divisions 3L and 3N, historic and ongoing series, are in the input of the assessment.

Input series

The 2020 redfish 3LN ASPIC assessment use the updated arrangement of input series in place since 2016 (Ávila de Melo *et al*, 2016), with MSY fixed at 1960-1985 average catch.

All input series consist of annual observed values and were given equal weight in the analysis. Each Canadian series is referred by its season and division(s), while the Russian and Spanish series are also referred by their country name. The input series of the assessment are

I1 (Statlant CPUE and catch)	Statlant cpue for Div. 3LN,1959-1994 and catch for Div. 3LN 1959-2019
I2 (3LN spring survey)	Canadian spring survey biomass for Div. 3LN, 1991-2005, 2007-2016, 2018-2019
I3 (3LN autumn survey)	Canadian autumn survey biomass for Div. 3LN, 1991-2013, 2015-2019
I4 (3LN Power russian survey)	Russian spring survey biomass for Div. 3LN , 1984-1991 (Power and Vaskov,1992)
I5 (3L winter survey)	Canadian winter survey biomass for Div. 3L, 1985-1986 and 1990
I6 (3L summer survey)	Canadian summer survey biomass for Div. 3L, 1978-1979, 1981,1984-1985, 1990-1991and 1993
I7 (3L autumn survey)	Canadian autumn survey biomass for Div. 3L, 1985-1986, 1990
I8 (3N spring spanish survey)	Spanish survey biomass for Div. 3N, 1995-2019
I9 (3L summer spanish survey)	Spanish survey biomass for Div. 3L, 2006-2019

The CPUE series and the short survey series (Russian survey, Canadian summer, autumn and winter surveys on Div. 3L), reflect the stock dynamics from the early 1960's until the first half of the 1990's, while the spring and autumn Canadian surveys reflect the stock dynamics from the 1990's till nowadays. Trends within the two periods differ and overlap of series mostly belonging to different intervals is short. The negative correlations found between "old" and "new" series are expected (and disqualified to halt the ASPIC assessment). Unfitness between observed and estimated STATLANT CPUE series is also expected, as the observed series lay over the first half of the assessment interval ending in 1994 while the correspondent estimated STATLANT CPUE series is extended until the last year of the model run (2019).

Basic assumptions on ASPIC fit mode

In this assessment the new ASPIC version 7.03 (Prager, 2015) 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 and catchability coefficients, ASPIC fit generate iteratively an expected series for each observed series of the input framework. Key parameters of the model are found by a minimization routine that gathers the sums of log squared residuals within each series.

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 biomass and fishing mortality at MSY (B_{msy} and F_{msy} respectively). That is why normalized estimates are used in the trajectories of biomass and fishing mortality. In a production model, such as the one used in this assessment, fishing mortality refers to catch/biomass ratio.

A detailed summary of the ASPIC model (Prager, 1994) is available at the 2003 assessment of redfish in Div. 3M (Ávila de Melo *et al.*, 2003).

Input file settings

ASPIC model requires from the user a set of initial definitions/starting guesses/constraints and data series, all of them included in a single input file. On ASPIC 7.03 input format has changed, but the updated 2019 input file is arranged on version 5 format and then converted to the new format using the utility program ASPIC5to7.

Control parameters are kept from the 2014 assessment and line-by-line details of all input settings can be found on the correspondent SCR Doc. (Ávila de Melo *et al*, 2014), with the exception of the user guess catchabilities for the nine input series that support the assessement, wich were the estimate catchabilities from 2018 ASPICfit (Ávila de Melo *et al*, 2018, Appendix 2).

The 1959-2010 catches used are the catches adopted by STACFIS for this stock. The 2011-2016 catches were taken from the NAFO STATLANT 21 data base. The 2017 catch was estimated with the CDAG method (COM-SC CESAG-WP 18-01 (Rev.2)) whereas the CESAG method provided the catch estimates for 2018 and 2019 (COM-SC CESAG-WP 19-03 (Revised) and COM-SC CESAG-WP 20-05 (Revised), respectively).

All data series have now 61 years' length (1959-2019). Input.a7inp file for the 2020 framework is on Appendix 1.

Assessment results

(*Just for illustrative purposes 2020 ASPIC fit run previously with MSY free and a preliminary 2019 catch figure of 11 208 t (NAFO Cir. Letter 10 February 2020, Ref No.: NAFO/20-45). Performance was flaw, with 310 restarts required for convergence, and results unrealistic, with a never sustained MSY level of 35 270 t on top, B_{2020} further away up B_{msy} and F_{2019} further away down F_{msy}.*)

ASPIC2020 run first on deterministic (FIT) mode. Results are presented on Appendix 2. Relative biomass and fishing mortality fit trajectories are plotted on Fig.'s 6a and 6b against the previous ones (2016 and 2018). An amplified picture of relative fishing mortality trajectories 1996 onwards by the three more recent assessments can be found on Fig. 6c.

As regards correlation among input series, all three short 3L survey series from the 1980's –early 1990's have good correlations with the Russian survey covering the same period of stock decline. On this former period good correlation also show up between Statlant CPUE series and 3L summer survey as well as between 3L autumn and winter surveys. As for the ongoing surveys, correlations among series are relatively good between Canadian 3LN spring and autumn, between the 3N and 3L Spanish surveys and also between both Spanish and Canadian 3LN autumn.

In terms of biomass dynamics results showed a good nearness index, crossing twice B_{msy}, and a good contrast index as well, but correlation between observed series and expected model results continue to be in general average to weak. A long time interval (61 years) and a variety high number of survey data sets (8 surveys, differing in time, season and covered area) are unavoidable obstacles difficult to overcome, and will always impact downward the diagnostics of ASPICfit. However, retrospectively speaking the performance of the model in terms of biomass and fishing mortality delivery is well illustrated by the good fit between trajectories from the three last assessments (2020, 2018, 2016), (Fig.'s 6a and 6b). On the outcome of the 2020 ASPICfit assessment a safe picture prevails: the stock biomass is now landing (by the beginning of 2020) at a level away above B_{msy} and fishing mortality has been kept well below F_{msy} on 2019 despite its gradual increase since 2009 (Fig. 6c).

The fixed MSY approach to ASPIC allowed once again a model run ending normally, with a small number of restarts required for convergence (30). And, despite all caveats, this approach continues to deliver an outlook of the stock and of fishing mortality in line with the recent past, using the broadest input framework available (all surveys and all observations on board).

To investigate whether or not there was statistical evidence of model misspecification, a Wald-Wolfowitz runs-test, first performed on last assessment (Brandão and Butterworth, 2018), was carried out again on the residuals of the fits of the surplus production model to the four survey series that cover recent years: 3LSpain, 3NSpain, 3LNspring and 3LNautum (results of residual analysis Table 6, runs of residual patterns of the surveys analyzed on Fig.'s 7a12bcd). Results were obtained from Nuno M. Brites R code (http://www.R-project.org/) and using the R package 'randtests' (https://github.com/cran/randtests/blob/master/R/runs.test.R).

The respective p-values, under the null hypothesis of residuals randomness, shown independence of the residuals for three of the four series analyzed, and were, respectively, 0.0282, 0.5447, 0.2164, and 0.1282, i.e. the hypothesis of independence of residuals is rejected at the 5% level only for the 3LSpain residuals. The 2018 results for 3LSpain are presented for comparison with the new ones (Fig.'s 7a1 and 7a2): model misspecification, decided by a p-value bellow the significance level, is no longer valid if the decision is based on the p-value (exact), given by an alternate test that doesn't requires Z to be normally distributed at low sample sizes (which is the case for 3LSpain, the most recent survey tested). So, even for the only nonrandom survey in the pack, improving performance towards residual randomness is recorded from 2018 to 2020. Emphasizing what was already the conclusion the first time this test was applied that, quote, "viewed overall, these results offer weak support only for considering the model fit to the data to be unsatisfactory" (Butterworth *pers comm.*, 2018).

The assessment switched afterwards to bootstrap mode (BOT, 1000 trials) to measure variability around parameter point estimates using bootstrap methods to calculate very high and high probability confidence limits, here associated with 80% and 60% CL respectively. Estimates from bootstrap analysis are presented in Appendix 3 (with main results and relative IQ range from ASPIC2018 and ASPIC 2016 within brackets for consistency check). The bootstrap run smoothly with no trials replaced either for lack of convergence, or with *q* at bound and only seven trials replaced with *B1/K* at bound.

For reasons already explained in previous assessments (Ávila de Melo *et al*, 2014 and 2016) the best available estimator of central tendency is the point estimate. Being so, on the recent ASPIC version 7.03 (Prager, 2015), both estimated bias in point estimate and estimated relative bias were removed from the bootstrap output summary table (Appendix 3). Prager kept in the revised ASPICbot output the point estimates now associated with the bias-corrected confidence limits, since they are within these limits as well. A description of how these bias corrected confidence intervals are computed can be found in Prager (1994) and in Efron and Gong (1983).

Bootstrap results confirm a stock at the beginning of 2020 with a very high probability to be above *Bmsy* and a fishing mortality in 2019 with a very high probability to be well below F_{msy} (Appendix 3). There is a smooth progression from 2016 to 2018 and 2020 of very similar estimates of key parameters (B_{msy}, F_{msy} , *B1/*K), with results following a reverse retrospective pattern that generally under estimate biomass and overestimate fishing mortality (Fig.'s 6a and 6b). This pattern is triggered by a discrete overestimate revision of catchabilities that is present in all input series from one assessment to the next. All point estimates are within inter-quartile ranges with relative values of same order of magnitude, or narrower, than on the earlier assessments runned with the same survey data sets. All these features of the 2020 ASPICbot results high lights the consistence and the conservative approach of the stock status given by the 3LN redfish assessment.

From ASPIC assessment results the maximum observed sustainable yield (*MSY*) of 21 000 t can be a long term sustainable yield if fishing mortality stands at a level of 0.112/year. The correspondent B_{msy} for this stock is at the level of 187 000 t.

Catch versus surplus production trajectories are presented on Fig. 8: between 1960 and 1985 catches form a scattered cloud of points around the surplus production curve. On 1986-1987 catch rise well above surplus production and, though declining continuously since then, was still above equilibrium yield in 1993. Catch was first well below surplus production on 1995 and has been kept far from that roof until 2009. 2010 is the start of a slow catch increase towards surplus production and by 2019 equilibrium yield was almost reached.

Stock/fishing mortality trajectory within a Precautionary Approach framework

The stock trajectory (2020ASPIC point estimate) has been placed within the precautionary approach frame (Fig. 9). The NAFO SC Study Group recommendations from the meeting in Lorient in 2004 (NAFO, 2004), 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}. With the Schaeffer model used in the ASPIC assessment this biomass corresponds to (roughly) 30% B_{msy}.

The stock stayed the first two and a half decades (1960-1985) between B_{msy} and 1.3 B_{msy} , sustaining fishing mortalities around F_{msy}. When exploitation rises to well above F_{msy} (1987-1994) stock biomass fell below B_{msy} (1990) and further to below B_{lim}, staying on the bottom between 1993 and 2000. From 1993 till 1996 ffishing mortality dropped to well below F_{msy} , being kept at very low to low levels ever since. And therefore biomass was allowed to increase, reaching and surpassing B_{msy} by 2009.

ASPIC medium term catch projections (2021-2015) beyond the end of the actual management strategy

Background for catch projection

The medium term 2015-2020 catch projections extended from the 2014ASPICbot results gave the background for "The Risk-Based Management Strategy (MS) for 3LN Redfish" adopted by the Fisheries Commission on the 36th Annual Meeting – September 2014 (Ávila de Melo *et al*., 2014; FC Working Paper 14/23) This RBMS was designed to reach 18 100 t of annual catch by 2019-2020 under a Harvest Control Rule (red 3LN HCR) that hold to a stepwise constant catch increase every two years, between 2015 and 2020.

Since then, the following assessments monitored the impact of the MS on the stock, though between 2015 and 2019 catches never reached the predicted TAC´s, or even the correspondent Ye's (equilibrium yields). Meanwhile, based on the results of bi-annual assessments, 3LN redfish has stand on recent years (2015-2020) with biomass sizes above B_{msy} and fishing mortalities well below F_{msy} at a very high probability level (>90%).

Two alternate stochastic medium term catch projections (2021-2025) are now performed aiming to quantify the likelihood of the stock to continue to be exploited below F_{msy} until 2025 and arrive at the beginning of 2026 still on the safe zone above B_{msy} . The first projection drives the stock under a 2021-2025 catch at the HCR 2019-2020 TAC of 18 100 t (*status quo* HCR2020 scenario) while the second scenario drives the stock under a lower 2021-2025 catch ceiling of 13 730 t, the equilibrium yield available at present (Ye_{2020} scenario). Both scenarios assume that the 2020 TAC of 18 100 t will be effectively taken.

The justification to put this second scenario on the table lies on the trends shown by the more recent observed data: ongoing surveys biomasses on Div. 3LN went down or stabilized between 2016-2019 while recruitment indices to the exploited stock (given by numbers@lengths <20cm in surveys and commercial catch) dropped to low/very low levels. At present biomass size seems to be basically sustained by the survival and growth of the cohorts living already through the exploited stock and not by the income of new (and significant) year classes. Until a consistent signal of new recruitment pulse shows up, there will be a common sense argument in favour of considering on medium term projections an alternate conservative catch option, at the surplus production level that the stock is able to deliver now.

ASPIC projection framework

ASPICP, the ASPIC auxiliary program for projections, provided point estimates (with associated bias corrected 80% and 50% confidence limits) of biomass and fishing mortality for the assessment time interval,1959-2019, extended to the projection years, 2020-2025, with 2020 catch at the present 2020 HCR TAC. ASPICP reads the results from the 1000 trials of the $ASPIC_{bot}$ 2020 assessment stored in a .bio file and project each of these trials six years ahead with each of the two 2021-2025 catch options: 1) the *status quo* HCR2020 option of 18 100 t or 2) the Ye_{2020} option of 13 730 t.

ASPICP read the specifications for these two medium term catch projections from two control files with a .ctl extension. The control file format is presented and explained on Appendix 4 (with the *status quo* HCR2020 option 18 100 t). To run ASPICP the .ctl files for each option were dragged and dropped to the available ASPICP shortcut.

Projection results

The 1959-2025 ASPICP results with the two projection scenarios were stored in .prj files and are presented on Table 7and Fig. 10a and 10b (HCR 2020 option 18 100t) and Table 8 and Fig. 11a and 11b (Ye_{2020} option 13 730 t).

Comparisons of results between the two options are presented in Table 9a and Fig. 12 (for B_{msy} 2020-2026) and Table 9b (for F_{msy} 2020-2025).

Either the HCR 2020 option or the Ye_{2020} will maintain biomass at the beginning of 2026 above B_{msy} while keeping fishing mortality till 2020 below F_{msy} at a very high probability level (>90%). However the second option will allow biomass level roughly to be kept at its present level, avoiding the beginning of a marginal decline predicted by the HCR 2020 option and already suggested by the majority of recent observed data.

Conclusion

At present the stock is kept at a safe zone and is moderately exploited. Nevertheless this management unit is passing through low productivity times and the end of this regime is (still) not forseen. And cannot be predicted, due to the apparent lack of a stock-recruitment relationship on these species. Under the present circumstances, a medium term risk based management strategy that goes beyond what the stock can offer and sustain now is not a precautionary strategy. And therefore, and so far, management should be based on bi-annual assessments and updated short term equilibrium yield projections.

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REFERENCES

Alpoim, R. and Vargas, J., 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., Power, D. and Alpoim, R., 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. and Alpoim, R., 2010. The 2nd take of 2008 assessment of redfish in NAFO Divisions 3LN: going further on the exploratory analysis of ASPIC formulations. *NAFO SCR Doc.* 10/29, Serial No. N5787, 21 pp.

Ávila de Melo, A.M., Alpoim, R. and González-Troncoso, D., 2012. An ASPIC Based Assessment of Redfish (*S. mentella and S. fasciatus*) in NAFO Divisions 3LN (*can a surplus production model cope with bumpy survey data?*). *NAFO SCR Doc.* 12/032, Serial No. N6059, 63 pp.

Ávila de Melo, A.M., Brites, N., Alpoim, R. and González-Troncoso, D., 2014. An ASPIC Based Assessment of Redfish (*S. mentella and S. fasciatus*) in NAFO Divisions 3LN (*assuming that the highest apparently sustained historical average level of catch is a sound proxy to MSY*). *NAFO SCR Doc.* 14/22, Serial No. N6317, 78 pp.

Ávila de Melo, A.M., Brites, N., Alpoim, R. , González-Troncoso, D., and Fomin, K., 2016. A Revised Update of the 2014 ASPIC Assessment of Redfish (*S. mentella and S. fasciatus*) in Divisions 3LN (*how the the stock is coping with the actual Management Strategy and its likely impact on the next coming years*). *NAFO SCR Doc.* 16/33, Serial No. N6576, 69 pp.

Ávila de Melo, A.M., Alpoim, R., González Troncoso,D., González F., and M. Pochtar, 2018. The status of redfish (*S. mentella and S. fasciatus*) in Divisions 3LN at present and the likelihood its follow up in the near

future (*under the ongoing Management Strategy or a status quo TAC scenario*). *NAFO SCR Doc.* 18/033, Serial No. N6822, 68 pp.

Brandão, A. and Butterworth, D., 2018. Wald-Wolfowitz runs test for independence in time series of residuals for recent 3LN redfish abundance indices. SC WP 18/016, 5pp.

COM-SC CESAG, 2018. Application of the CDAG method to all NAFO managed stocks for 2017. COM-SC CESAG-WP 18-01 (Rev.2), 8pp.

COM-SC CESAG, 2019. Application of the CDAG method to all NAFO managed stocks for 2018. COM-SC CESAG-WP 19-03 (Revised), 8pp.

COM-SC CESAG, 2020. Application of the CDAG method to all NAFO managed stocks for 2019. COM-SC CESAG-WP 20-05 (Revised), 8pp.

DFO. 2008. Advice on the stock definition of redfish (Sebastes fasciatus and S. mentella) in Units 1 and 2. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/026.

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

Efron, B., Gong, G., 1983. A Leisurely Look at the Bootstrap, the Jacknife, and Cross-Validation. *The American Statististian*, Vol. 37, No. 1, (Feb., 1983), pp. 36-48.

Fomin, K. and Pochtar, M., 2020. Russian research report for 2019. *NAFO SCS Doc.* 20/13, Serial No. N , 52 pp.

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, p. 2272-2275.

González-Costas, F., Ramilo, G., Román, E., Lorenzo, J., Gago, A., González-Troncoso, D., Sacau, M., Duran, P., Casas, M. and J. L. del Rio, 2020. Spanish Research Report for 2019. NAFO SCS Doc. 20/07. Serial Number N7045, 42 pp.

González-Troncoso, D., A Gago and I. Garrido, 2020. Yellowtail flounder, redfish (*Sebastes spp.*) and witch flounder indices from the Spanish Survey conducted in Divisions 3NO of the NAFO Regulatory Area. NAFO SCR Doc. 20/009, Serial No. N7053, 35 pp.

Mainly, B. F. J., 1997. Randomization, bootstrap and Monte Carlo methods in biology (second edition). *Texts in Statistical Science,* Chapman & Hall, London, 399pp.

NAFO, 2004. Report of the NAFO Study Group on Limit Reference Points Lorient, France, 15-20 April, 2004. *NAFO SCS Doc.* 04/12, Serial Number N4980, 72 pp.

NAFO, 2009. Northwest Atlantic Fisheries Organization Scientific Council Reports 2009. Dartmouth, Nova Scotia, Canada, 325 pp.

NAFO, 2014. 36th ANNUAL MEETING-SEPTEMBER 2014, Risk-Based Management Strategy for 3LN Redfish, Proposal by Canada. FC Working paper 14/23 2pp.

Power, D. and Vaskov, A.A., 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. 37 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.

Prager, M.H., 1994. A suite of extensions to non-equilibrium surplus-production model. *Fish. Bull. U.S.*, 92: 374-389, 29pp.

Prager, M.H., 2015. User's Guide for ASPIC Suite, version 7: A Stock Production Model Incorporating Covariates, and auxiliary programs. Michael H. Prager — Prager Consulting Portland, Oregon, USA, 33pp.

Rideout, R.M., 2016. Spatial distribution patterns of NAFO demersal fish stocks based on data from the Canadian multi-species surveys of Divisions 2HJ3KLNO. *NAFO SCR Doc.* 16/20, Serial Number N6563, 45pp.

Rideout, R.M., 2020. Do spatial coverage issues in the 2019 Canadian (NL) RV bottom trawl surveys influence the suitability of survey indices for use in NAFO stock assessments?. *NAFO SCR Doc.* 20/004, Serial Number N 7046, 15pp.

Rideout, R.M. and Ings, D.W., 2018. Temporal and spatial coverage of Canadian (Newfoundland and Labrador region) Spring and Autumn multi-species RV bottom trawl surveys, with an emphasis on surveys conducted in 2017. *NAFO SCR Doc.* 18/017, Serial Number N6801, 36pp.

Rideout, R.M. and Ings, D.W., 2020. Temporal And Spatial Coverage Of Canadian (Newfoundland And Labrador Region) Spring And Autumn Multi-Species RV Bottom Trawl Surveys, With An Emphasis On Surveys Conducted In 2019. *NAFO SCR Doc.* 20/002, Serial Number N7041, 59pp.

Román-Marcote, E., D González-Troncoso and M. Alvarez, 2020. Results for the Atlantic cod, roughhead grenadier, redfish, thorny skate and black dogfish of the Spanish Survey in the NAFO Div. 3L for the period 2003-2019. NAFO SCR Doc. 20/014, Serial No. N7059, 76 pp.

Schaefer, M.B., 1954. Some aspects of the dynamics of populations important to management of the commercial marine fisheries. *Bull. Inter-Am. Trop. Tuna Comm*. 1(2): p. 27-56.

Valentin, A., Power, D., Sévigny, J-M., 2015. Understanding recruitment patterns of historically strong juvenile year classes in redfish (Sebastes spp.): The importance of species identity, population structure, and juvenile migration . *Canadian Journal of Fisheries and Aquatic Sciences* 72(5): p. 774-784.

Vargas, J., Alpoim, R., Santos, E. and Ávila de Melo, A.M., 2020. Portuguese Research Report for 2019*. NAFO SCS Doc.* 20/09, Ser. No N7050, 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	3425	18009	21439		a
1963	8191	12906	27362		a
1964	3898	4206	10261		a
1965	18772	4694	23466		
1966	6927	10047	16974		
1967	7684	19504	27188		
1968	2378	15265	17660		a
1969	2344	22356	24750		a
1970	1029	13359	14419		a
1971	10043	24310	34370		a
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	30342	40949	79031	25000	b
1988	22317	23049	53266	25000	b
1989	18947	12902	33649	25000	b
1990	15538	9217	29105	25000	b
1991	8892	12723	25815	14000	b
1992	4630	10153	27283	14000	b
1993	5897	9077	21308	14000	bc
1994	379	2274	5741	14000	bc
1995	292	1697	1989	14000	
1996	112	339	451	11000	
1997	151	479	630	11000	
1998	494	405	899	0	
1999	518	1318	2318	0	b
2000	657	819	3141	0	bc
2001	653	245	1442	0	b
2002	651	327	1216	0	b
2003	584	751	1334	0	
2004	401	236	637	0	
2005	581	78	659	0	
2006	53	444	496	0	
2007	118	1546	1664	0	
2008	220	377	597	0	
2009	57	994	1051	0	
2010	260	3688	4120	3500	
2011	2418	1254	3672	6000	
2012	2781	1535	4316	6000	
2013	4446	1786	6232	6500	d
2014	4245	1450	5695	6500	d
2015	8620	1320	9940	10400	d
2016	6741	1945	8686	10400	d
2017	7790	4026	11815	14200	e
2018	7300	3979	11279	14200	f
2019	6357	6693	13050	18100	g
2020				18100	

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.
d STATLANT 21A catches as updated on September 13th 2019.
e COM-SC CESAG-WP 18-01 (Rev.2) Application of the CDAG method to all NAFO managed stocks for 2017
f COM-SC CESAG-WP 19-03 (Revised) Application of the CESAG method to all NAFO managed stocks for 2018
g COM-SC CESAG-WP 20-05 (Revised) Application of the CESAG method to all NAFO managed stocks for 2019

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

	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 and by-catch, 1990-2019.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
10																			0.1			1	2	0.3		23	4			
11														0.03					0.2	3	13	3	5	18	13	60	48			
12	12													0.03					0.2	10	30	21	14	17	37	202	96			1
13	6													1					0.1	23	49	69	30	133	94	198	223			
14	21													1			0.003		0.1	33	154	117	52	96	180	358	222			
15	28	28												5			10		2.6	51	268	224	78	166	212	459	316	11		1
16	73	103	9									1	0.3	8			24		14	**362**	506	281	95	420	330	566	394	11		3
17	199	394	28			2				0.3	1	2	1	21	1	2	34		80	**670**	768	371	139	460	400	795	492	62	15	3
18	286	1034	412		5	2		0.01	1		1	1	1	44	2	4	65	0.3	103	**747**	**935**	430	201	793	576	1321	767	268		9
19	445	2157	1291	5	6	3	1	0.3	2	16	4	4	3	90	6	9	99	43	96	**495**	**1383**	**766**	426	**1313**	907	**2032**	962	255	109	31
20	720	3313	2375		16	14	4	2	13	47	6	18	14	151	15	11	**182**	143	43	**357**	**1737**	**1253**	890	**2221**	1880	**3529**	2093	489	731	166
21	1309	3780	2943	235	287	9		11	57	80	10	52	41	**218**	28	13	**300**	77	**133**	**428**	**2284**	**1942**	**1564**	**3518**	2891	**5416**	**4042**	799	**3078**	671
22	2081	**4922**	3600	714	683	65	6	17	**151**	150	26	102	81	**269**	35	11	**347**	149	**239**	**475**	**3084**	**2545**	**2235**	**4913**	3865	**8176**	**6959**	1368	**5517**	1928
23	3212	**7340**	**4358**	1141	594	64	17	34	**277**	128	46	118	101	**277**	41	16	**340**	212	**303**	**552**	**2188**	**1959**	**1778**	**3468**	3425	**8021**	**7758**	2346	**7862**	2966
24	**4164**	**7575**	**5552**	2565	708	99	9	64	**296**	120	85	114	132	**258**	54	35	**210**	170	**253**	**311**	**1183**	**1099**	**1231**	**2335**	2125	**4873**	**5939**	**3251**	**7902**	3124
25	**5216**	**6944**	**4981**	**5237**	**944**	100	9	**98**	**248**	178	**195**	114	154	**261**	85	61	**147**	**221**	**224**	268	831	593	992	**1605**	1510	**3485**	**4980**	**3865**	**6523**	3540
26	**5560**	**5981**	**5145**	**5115**	**1297**	277	12	**118**	**221**	**318**	**364**	126	**204**	**309**	**157**	**138**	**111**	**206**	**138**	271	769	450	746	**1719**	1118	**2558**	**3693**	**4290**	**4429**	**3357**
27	**5410**	**6197**	**4579**	**5433**	**1404**	**330**	35	**144**	**218**	**555**	**546**	**170**	**248**	**324**	**190**	**181**	99	**134**	81	193	584	371	670	1156	990	**1534**	**2731**	**4366**	**3528**	**4035**
28	**5217**	**5322**	**4063**	**5004**	**1182**	**300**	**75**	**114**	**173**	**712**	**943**	**188**	**289**	**286**	**184**	**201**	88	**521**	32	194	580	462	646	1270	**1066**	**1602**	**2309**	**3828**	**2662**	**3818**
29	**4712**	**3354**	**4637**	**4437**	**1188**	**263**	**76**	**114**	**154**	**673**	**1003**	**179**	**289**	**245**	**184**	**223**	62	**425**	42	140	490	445	620	642	**916**	1477	**1514**	**2813**	1927	**3736**
30	**4751**	**4043**	**3911**	**3283**	**1011**	**310**	**182**	**114**	**120**	**520**	**1027**	**236**	**294**	**225**	**178**	**176**	60	**368**	44	96	416	434	714	691	**1159**	1757	1326	**2221**	1193	**3840**
31	**4551**	2695	3711	**2964**	**912**	**313**	**197**	**154**	**129**	**413**	**564**	**289**	**295**	**204**	**107**	**109**	35	**335**	31	64	296	608	691	864	**975**	1415	772	**1635**	610	**2570**
32	**3943**	2478	2187	2313	**944**	**309**	**98**	**146**	**119**	**434**	**315**	**303**	**276**	189	**108**	**91**	28	**594**	37	49	276	674	641	598	**862**	1207	615	1367	412	**2125**
33	3082	1582	1355	2291	596	226	**67**	**131**	**110**	**383**	**237**	**298**	**216**	196	95	83	19	**316**	58	40	242	535	681	517	673	843	412	1583	340	1571
34	2737	1179	1569	1527	526	189	30	71	66	**268**	**217**	**218**	132	149	73	71	17	**252**	83	37	215	223	392	304	438	539	203	1082	146	921
35	2100	928	1604	1059	363	182	35	24	19	141	129	**212**	83	112	51	63	10	124	62	11	208	170	265	141	345	511	158	896	69	873
36	1681	831	1895	923	202	106	23	19	18	89	60	121	37	62	36	56	5	110	39	13	137	85	157	167	222	315	90	524	11	522
37	1416	580	1571	766	196	160	7	14	11	82	78	82	18	41	17	31	2	4	31	2	70	46	101	70	123	153	43	262	7	303
38	1128	482	1303	807	158	171	5	10	8	51	50	55	11	22	10	15	1	2	12	1	69	54	105	48	122	91	33	132		196
39	729	363	1114	489	124	100	11	3	3	37	47	30	3	14	9	8	0.01	23	9	2	32	19	40	16	57	25	21	36		120
40	458	292	790	505	69	144	2	4	3	23	23	18	2	7	5	8	0.3	22	1	0.4	17	17	33	5	48	29	5	28		21
41	321	188	558	320	49	63	3	1	2	19	12	10	1	2	2	4	0.003	0.4	1	0.5	7	10	20	6	26	33	5	0		12
42	255	117	420	306	23	1	1	1	0.1	13	15	7	2	3	1	2	0.003	0.2	0	1	3	5	11	4	10	4	2	0		8
43	227	68	203	137	15	3	2	2	0.1	3	9	4	2	2	2	6		0.5	3	0.02	0.1	5	7	4	2	4	2			7
44	157	83	85	175	7	3	2	1	1	3	1	3	1	2	1	3		0.1	0.05	0.2			2		1	3	0.4			3
45	84	33	76	107	1	3	2	0.1			2	1		0.1	1	1		0.1	1	0.3			1				1			1
46	58	8	32	9	3			0.1	0.0	0.2	1	1		2	0.2	0.3				0.1			0.4			1	0.1			0.4
47	24		9	47	0.2						0.5	0.2		0.04	1	2										1				
48	11	2	8	5		3		0.1								0.04														
49	6		1		0.1														1											
50																									1		0.2			
51	1	25			2									0.3							0.03									
52	2																										0.2			
53	1																										0.01			
54	2													0.3																
no ('000)	66410	74421	66375	47918	13517	3815	910	1411	2422	5457	6020	3076	2929	3999	1681	1632	2295	4454	2199	5901	19825	16289	16274	29702	27598	53616	49232	37786	47070	40481
weight (tons)	29105	25815	27283	21308	5741	1989	451	630	899	2318	2617	1442	1216	1334	637	659	497	1664	597	1051	3948	3672	4316	6232	5695	10467	8457	11816	11278	13050
mean weight (g)	438	347	411	445	425	521	496	446	371	425	435	469	415	334	379	404	217	365	271	178	199	225	265	210	206	195	172	313	240	322
mean length	29.3	26.6	28.4	29.6	29.1	31.6	31.2	29.8	27.4	29.9	30.1	30.8	29.5	27.5	29.5	30.1	23.9	29.4	25.4	22.0	23.4	24.4	25.9	24.2	25.0	24.3	24.5	27.8	25.2	28.3
length anomalies	1.86	-0.9	0.9	2.2	1.6	4.1	3.8	2.4	-0.1	2.4	2.6	3.4	2.0	0.0	2.0	2.6	-3.6	1.9	-2.0	-5.4	-4.1	-3.1	-1.6	-3.3	-2.5	-3.2	-3.0	0.3	-2.2	0.8
%lengths <20cm	1.6%	5.0%	2.6%	0.0%	0.1%	0.2%	0.1%	0.0%	0.1%	0.3%	0.1%	0.2%	0.2%	4.2%	0.5%	0.9%	**10.1%**	1.0%	**13.5%**	**40.6%**	**20.7%**	**14.0%**	6.4%	**11.5%**	**10.0%**	**11.2%**	7.2%	1.6%	0.3%	0.1%

Table 3b. length weight relationships from 3LN Sebastes sp. Portuguese commercial sampling data used in the computation of 3LN catch at length (Alpoim and Vargas, 2004; Vargas et al., 2005-2020)

Sebastes sp.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
a	0.1115	0.1115	0.1115	0.1115	0.1115	0.1115	0.1115	0.1115	0.1115	0.0689	0.0979	0.0769	0.0447	0.0095	0.0208	0.0208	0.0611	0.0207	0.0207	0.0207	0.0214	0.0214	0.0214	0.0360	0.0462	0.0116	0.0290	0.0279	0.0069	0.0305
b	2.4353	2.4353	2.4353	2.4353	2.4353	2.4353	2.4353	2.4353	2.4353	2.5588	2.4602	2.5298	2.6885	3.1279	2.8851	2.8851	2.5597	2.8946	2.8946	2.8946	2.8659	2.8659	2.8659	2.6998	2.5880	3.0190	2.7011	2.7896	3.2255	2.7598

Table 4. Survey biomass ('000 t) from stratified bottom trawl surveys on Div. 3L and Div.3N included in the 2020 ASPIC framework, survey female SSB from spring and autumn Canadian surveys on Div. 3LN (1991-2019)

	Canadian				Russian				Spanish	
	Div. 3LN		Div. 3LN		Div. 3LN	Div. 3L	Div. 3L	Div. 3L	Div. 3N	Div. 3L
	$I2_{springcomb}$	$I2_{springSSB}$	$I3_{autumncomb}$	$I3_{autumnSSB}$	$I4_{Powercomb}$	$I5_{winter}$	$I6_{summer}$	$I7_{autumn}$	$I8_{spring}$	$I9_{summer}$
1978							311.2			
1979							227.8			
1980										
1981							261.4			
1982										
1983										
1984					215.9		277.7			
1985					94.0	90.2	161.0	98.2		
1986					63.0	36.6		17.1		
1987					70.3					
1988					44.9					
1989					12.3					
1990					8.4	18.2	92.8	20.7		
1991	10.6	1.5	37.9	4.7	18.7		37.6			
1992	10.1	1.8	*136.4*	15.4						
1993	22.6	4.3	19.2	3.6			20.8			
1994	4.2	0.6	31.8	5.9						
1995	5.9	0.8	90.7	15.9					46.1	
1996	22.8	11.6	16.0	2.6					6.6	
1997	14.9	1.8	70.7	10.7					4.8	
1998	59.4	11.5	112.2	14.5					22.5	
1999	61.5	15.2	72.0	12.6					46.5	
2000	87.8	17.3	100.5	16.6					68.9	
2001	41.6	7.0	132.6	13.8					53.9	
2002	31.0	5.8	50.1	9.4					7.6	
2003	27.7	3.7	71.9	9.6					11.0	
2004	79.6	26.2	49.9	11.4					27.0	
2005	66.5	8.8	58.6	11.2					146.9	
2006			91.9	12.9					87.8	70.1
2007	218.8	39.4	124.8	16.8					87.6	31.4
2008	144.0	23.4	198.5	27.4					68.1	75.6
2009	183.4	20.7	246.7	29.6					735.7	103.7
2010	165.3	21.5	461.5	55.5					359.5	266.8
2011	173.7	22.2	562.3	64.1					418.3	170.6
2012	322.0	45.5	596.0	89.7					265.2	481.5
2013	271.5	48.1	288.8	41.1					429.5	235.2
2014	271.7	38.3							178.1	216.4
2015	480.6	60.1	425.9	64.6					523.5	130.4
2016	654.2	201.7	215.2	54.0					117.3	98.8
2017			192.0	41.4					265.9	56.6
2018	106.0	20.9	191.4	32.1					292.8	40.3
2019	136.5	28.3	285.9	49.6					174.6	54.0

Table 5a. 3LN spring survey abundance at length, 1991-2019 (thousands).

Length	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006[1]	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4															40									25		19		0	0
5												62		31				416	46	258			146	183		331		0	35
6						466		20	16	185	109	170	293	804	108		154	1966	479	137	559	41	695	1350	946	1247		1756	107
7						228		40	656	795	1511	472	2057	2400	540		3452	2942	974	562	781	1055	1772	968	**8495**	2957		3737	588
8						149	685	8	3280	378	1302	1073	1682	1236	950		9327	3135	954	936	858	1039	1106	826	5173	**13159**		6084	1506
9	849					298	360	39	5877	89	483	1526	1524	2209	2891		2625	3381	371	1361	1073	1596	1791	1039	673	**19021**		4463	2803
10	1149			562		296	251	113	1343	166	240	2518	1197	4107	4892		886	4258	994	2423	1342	1921	1896	1266	249	**6234**		932	2293
11	798	381	122	355		478	730	533	309	403	116	1085	417	2911	7296		1683	5317	1695	2902	2464	2178	2225	1377	812	2529		889	4644
12	558	2988	1304	540		806	722	455	430	191	451	1645	1448	1653	8756		2296	2432	3642	2871	1701	2852	1761	1610	1127	1195		1887	6035
13	2524	7925	2396	500	108	920	540	172	517	412	345	838	1101	1330	9684		1908	1286	16098	2256	2458	2581	2303	1708	614	469		3590	4671
14	322	5192	5646	536	272	413	1871	561	369	353	1073	517	1278	639	7710		1928	5396	12659	4892	3568	3658	1807	1527	333	563		6105	4754
15	699	2862	11059	1329	278	716	1859	896	175	2458	1738	766	2609	1235	7437		3631	3841	11260	8481	4481	5998	4327	1149	285	1693		8359	3510
16	2250	382	13647	1790	966	846	1126	1506	774	2199	1681	1371	3559	1335	7357		5993	15866	75231	14345	8907	9617	2467	1438	928	1116		3819	3881
17	3865	419	8796	3123	2847	1588	1201	2046	703	2157	3337	2580	6189	2764	8647		14186	45719	197691	26140	17787	52512	3940	4388	125	2833		3349	4751
18	6226	1111	2719	3084	4285	4356	1860	2121	3455	3525	5257	6444	8643	3668	16472		24586	77478	325440	108928	56811	96670	12330	9410	13442	2199		1714	4510
19	7749	2480	2474	1403	5014	9476	3280	2849	2988	7017	8267	8161	15473	8995	31506		26943	50553	310284	219289	115709	194730	20116	63952	81532	2881		2203	3123
20	4522	2574	3839	829	2703	10910	4708	9472	5379	13198	9589	11326	21089	11905	33702		26003	48021	164370	234599	144823	289679	103824	187959	388738	9037		7700	6161
21	3482	3559	5754	922	1815	12119	6367	24848	16817	22002	14393	13958	23750	16956	33182		43665	49072	92564	178663	221969	398075	210629	323755	672239	24064		23479	28377
22	5148	1690	5301	783	1335	13844	7008	34265	31067	42769	15551	14932	19290	16584	30967		68143	78864	60965	74436	128066	315995	237958	340216	734832	57932		51117	60644
23	7253	1732	5708	1181	1257	16629	8191	31121	38232	53557	15590	15582	15120	20423	30644		87375	88837	65881	72484	85379	190758	182210	246336	479788	90423		86587	117718
24	6187	2721	4756	1498	1359	12502	10669	28376	45394	53956	14839	16034	10814	17004	28561		96975	87288	76912	66508	62237	140353	147932	176273	291258	85384		80283	100177
25	3366	2865	3398	1748	1004	8318	9469	21275	21482	34350	10166	12606	8036	14657	24305		78847	61337	55777	61001	46547	94274	114790	78067	107567	75116		65998	79878
26	1963	3250	3701	1564	1600	5649	7757	19512	30227	27846	10041	11224	6889	24397	18438		90996	54230	30388	38296	44947	63492	62515	62684	41933	91635		51864	48881
27	1426	2411	4478	1057	1693	5106	4047	16075	21654	21918	11330	8887	5102	38936	20027		81118	34946	17043	18645	37756	45182	45089	33608	24506	94097		33940	35183
28	953	1834	3283	803	1437	4901	2760	12716	15663	13775	10217	7496	3552	43216	15249		36969	28227	14167	18908	32300	32808	40858	24604	23673	136263		20535	27936
29	1038	1506	2876	731	1154	4264	1871	9632	14331	15612	10385	6419	2778	24426	11907		38023	19445	13076	11302	24988	33669	28454	15455	15087	155045		12479	20373
30	607	1048	2606	482	721	3323	1797	6120	6698	14650	9523	3741	2701	18145	8832		30266	12314	8659	10701	16753	26246	25858	11811	23284	143012		9465	13177
31	534	1014	2969	318	474	2231	1354	6513	5732	12804	10450	3588	2176	13713	5769		30137	10571	6011	4704	10141	18307	15530	9541	17648	156646		7075	10877
32	417	809	3087	244	548	1564	991	6157	4322	10277	8884	2235	2356	9706	3036		21974	7018	4096	4110	8774	14817	14990	7287	16682	107686		5151	7856
33	369	825	2621	138	264	762	640	5687	3259	6538	5183	1382	1972	3487	2012		9163	7747	3448	2908	4925	5029	9922	4668	13284	108921		3635	9442
34	399	540	2161	156	144	337	438	3287	2024	5043	3035	996	1009	5391	1617		8158	4329	2327	2565	2999	4685	9065	4326	11634	71850		2508	10212
35	251	544	1502	109	105	163	160	967	877	3301	990	455	640	2249	832		7223	1860	1609	1804	1662	1757	10028	3835	6786	75698		1146	3809
36	190	366	880	135	113	105	77	660	534	895	296	227	227	476	592		9422	1361	839	1035	1367	1276	5801	3451	4792	52144		1044	3779
37	222	216	696	127	151	118	42	402	273	709	378	93	82	877	222		1894	786	312	394	788	958	3558	1381	1913	50189		767	2146
38	159	219	669	82	101	28	88	82	102	396	116	43	35	75	112		1945	386	235	197	848	548	1831	770	1486	21874		391	1980
39	130	300	726	31	70	55	4	82	67	186	155	59	35	43	86		193	325	90	31	224	897	1406	206	657	3972		158	678
40	118	220	483	46	62	28	0	216	79	183	23		94	23	12		115	189	55	54	71	167	1275	174	199	8478		168	641
41	45	77	371	0	15	15	0	15	51	16		15		4	15		59		28		119	81	865	11	81	5889		74	169
42	88	85	215	9	46	4	0	20	66	47	63	15		15	8		24	53	50			15	1637	1256	29	2803		23	93
43	69	85	83	49	27	35	15	201	0	31	28		15	15			8			76		48	463		552	149		12	
44	45	77	189	29	31		31	12	27	31	28				15		23	60				97	12		12				
45	57	62				15	15	15		31	15			8									417			3050			
46		46	51			15	46		31									34					401						22
47		4	20		15		15																						39
48	11	31	31																15										
49		31																					401						
50																													
51																													
52																							445						
53																							401						
abundance (millions)	66.0	54.5	110.6	26.3	32.0	124.1	83.0	249.1	285.3	374.5	187.2	160.5	175.2	318.1	384.4		868.3	821.3	1576.7	1199.2	1096.3	2055.7	1337.3	1629.9	2993.4	1689.8		514.5	637.5
mean length (cm)	21.6	21.6	22.6	21.5	22.7	23.4	23.5	25.1	24.7	25.3	25.2	23.5	22.0	25.7	22.2		25.1	22.9	20.3	21.6	22.6	22.5	24.1	23.1	22.8	29.3		23.7	24.4
length anomalies (cm)	-1.9	-1.9	-0.9	-2.0	-0.8	-0.1	0.0	1.7	1.2	1.9	1.7	0.0	-1.4	2.2	-1.3		1.7	-0.6	-3.2	-1.9	-0.8	-1.0	0.6	-0.4	-0.7	5.8		0.7	1.4

[1] Survey data only from Division 3L, no survey on Div. 3N

Table 5b. 3LN autumn survey abundance at length, 1991-2019 (thousands).

Length	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014[1]	2015	2016	2017	2018	2019
4																						127	0.0						
5				15	240	56	86	17		117	445	232	1090	34	0	84	234	31	96	1384	57	263	417		712	421	**1580.7**	153.7	
6					256	359	330	0	251	481	937	915	2427	85	133	1418	512	641	624	1110	318	1405	4539		2832	735	**16181.0**	498.9	235.7
7	203				138	88	395	39	50	673	755	873	2185	61	162	1831	2222	2359	318	1405	727	926	2902		**35136**	499	19057.6	3651.7	743.2
8	1298				111	72	386	47	37	602	2114	1614	2714	620	908	466	2914	2745	871	3377	878	2332	4879		**86942**	6970	2504.5	6102.7	903.6
9	1236				241	146	468	252	421	620	3146	1275	2095	1280	2236	829	8313	2359	3452	3788	2878	6976	5697		**33864**	22014	1713.4	6281.7	1910.7
10	7263		93	31	292	250	306	214	171	388	4323	1129	2855	1719	1574	1458	8498	4100	9932	4676	2265	9925	5439		5654	**50160**	4045.4	4354.9	3121.6
11	22235	371	63	31	213	349	249	203	402	215	2846	2840	1839	1046	3957	1709	7527	5543	5206	6612	1841	8539	8460		2409	12041	13016.0	2124.4	2681.4
12	62419	62	372		241	106	175	275	786	202	1266	2255	1123	1131	9942	3083	6352	4861	4025	7947	1925	6516	12917		1685	7325	19814.3	4471.4	2578.0
13	109337	3189	457	335	304	274	366	596	868	320	1056	2072	1488	1436	11090	3970	5871	27297	9473	10315	3250	5463	12133		1763	1941	21313.7	6333.9	3482.6
14	33876	27936	1775	551	513	1419	728	912	2472	587	445	2545	1451	1015	10309	8256	9046	28768	20311	11133	4187	6377	15089		2479	970	19947.0	8870.3	4767.0
15	14030	104298	1333	2362	967	722	1104	1768	1548	3635	407	1884	1929	538	8461	13286	21881	23691	17750	8561	8268	5234	28083		3107	1493	9834.2	9630.8	9889.6
16	7809	113966	3259	3697	1611	919	1405	4159	717	4671	11018	2159	8240	879	6083	20912	40243	116528	35720	12943	14606	3150	12974		3043	1134	8193.6	8954.8	15946.0
17	7860	106448	5283	12985	9645	825	1848	8155	1144	5480	31421	4694	15193	1984	5713	27177	51164	228751	138765	18474	46427	9778	15860		4208	1105	7944.6	7670.9	46786.2
18	16191	95896	8707	28684	37932	2227	2095	12225	3185	7035	57695	9082	25813	5468	7248	23009	43358	221311	396982	77810	103647	24081	34943		4920	1136	8079.5	5001.2	58102.9
19	32214	71577	6425	29295	72192	5062	8438	17373	6536	11926	74228	13661	38672	8222	10928	24342	35091	141084	421539	269160	432556	116751	92467		28086	3178	15464.6	2345.5	61906.0
20	27189	113846	3906	15292	78316	6479	21672	46005	9068	31680	80538	12568	45262	9790	15982	26793	45870	78263	279787	459453	996936	315398	109915		96233	16383	41884.4	6548.6	36930.8
21	15810	148628	5306	7701	43397	6621	47562	88726	15347	50184	65575	16481	42849	13134	25645	36447	55971	63995	138841	499979	1198226	664907	283174		285478	71859	102483.7	24542.8	63201.9
22	7915	153395	6375	5119	27652	6123	52500	124662	23121	66781	130029	20168	39683	13632	23899	49628	61550	55482	67350	303473	587045	653151	454374		521322	156747	186946.8	103635.4	138322.7
23	6139	89704	6578	6494	20117	6743	44777	92991	29000	60123	118427	23529	39374	16732	29785	71774	84212	89011	53177	261470	300782	501477	309498		455999	203674	206449.5	175899.6	236541.7
24	8377	28658	5164	5456	10296	4864	31865	56410	26969	52986	85149	25353	31785	15458	20362	67361	81986	80398	65248	260734	126712	314858	193667		350489	151521	151608.1	188184.2	229437.8
25	8943	14222	3947	6808	12898	4429	24356	30123	29819	50534	64519	21326	21398	13066	15824	34947	57418	66252	46806	165444	97731	203720	122411		221208	87514	106462.2	120878.4	200465.4
26	6602	13410	4120	8670	8517	4370	21375	23090	27515	40188	39693	19872	18032	10432	12713	32335	39981	49866	39922	120859	82802	152183	64144		115600	64422	91853.9	99713.9	124483.6
27	4022	14699	4361	7830	17364	2890	21141	20596	25585	21851	33743	16470	17605	9397	10857	19109	26128	48823	34957	95155	49339	135137	32163		95100	25728	52375.1	65106.0	89372.1
28	3776	8768	4240	8402	17495	2707	14031	18336	24801	17424	20396	10503	13962	12135	12471	11651	19087	37469	24861	72543	35075	76038	23430		62113	16853	34502.9	33366.0	54050.6
29	2526	4855	3503	7625	16330	2678	8032	13397	16323	16387	14957	7230	7798	13950	12659	10147	13206	21724	24372	38007	30904	67575	16618		44305	16202	29017.3	18777.5	23000.6
30	2110	3340	2765	6195	12717	2242	6138	7942	11346	12127	11093	5122	4910	12267	9865	7475	7643	18374	14245	26788	35523	46137	14071		31552	12743	21133.6	12395.2	16565.1
31	1960	3229	1949	4553	16297	3409	4994	6250	7641	10199	9147	5109	3755	9066	7347	9531	6404	11854	10895	15934	17230	29841	8793		35300	12982	18870.0	10961.0	13075.9
32	1314	2389	1901	2709	10628	2210	4035	5730	6315	7165	5261	4608	3523	6787	5214	7469	4180	6793	7953	14869	11668	28059	8562		5061	13155	18091.4	6614.2	9005.2
33	1212	3299	1671	1603	7262	1220	2107	3878	5642	5026	4354	3862	3360	4636	4905	4870	3623	6389	6675	9280	4838	18841	5790		8421	18683	15925.1	4790.0	5002.8
34	1117	1431	1286	916	3447	559	1673	4512	4545	3369	2776	2701	2182	2959	3942	2096	2183	5268	3627	5875	2164	7507	2538		3360	15952	10825.6	3305.2	3562.5
35	1287	716	1044	610	1966	217	653	2048	3256	1303	1679	1451	1175	1760	2720	1118	1067	2385	2538	1885	1869	4530	2229		1893	16454	7594.0	2117.1	3177.0
36	1184	595	800	297	1171	118	499	1080	1539	1092	675	560	506	1259	1456	537	416	970	2183	2310	1332	2698	1220		1439	7863	8653.3	1024.8	3069.9
37	1005	385	460	211	335	64	308	426	339	499	636	325	182	765	1298	444	847	784	1772	1299	817	5530	653		698	6419	5261.2	980.9	2708.1
38	1166	401	427	257	398	14	243	247	184	329	282	85	111	392	385	136	275	654	700	1374	138	5691	208		323	4494	4009.5	446.9	2226.8
39	787	228	308	274	572	22	176	85	272	227	215	67	115	666	228	55	40	0	300	372	136	1938	257		479	2031	1234.2	525.8	1548.2
40	662	93	237	119	75	22	164	17	67	151	180	136		308	60	116	17	391	250	389	0	954	375		63	557	1376.5	217.1	710.5
41	221	124	155	0	20	22	191	40	82	67	81			76	85	61	103		129	208	0	1509			62	53	553.0	43.8	207.6
42	135	77	132	15	24		45			67		17		232	60			263	505	195	0	630				664	218.5	161.3	66.4
43	102	31	37	32	32			35	50		4	21		99					92		45	571				664	255.9	161.0	130.2
44	128	46	99			42		17	50	4		17										525			274	212	155.3	0.0	109.7
45	46	15	69	15	36	28		17	50	76		17					63	131	46	83		355				71	23.0	35.2	11.4
46	24	46			12	14				18	17					16						216				125	441.6	79.3	0.0
47	15	15	15	8		12			17													355					58.4	19.4	0.0
48									17									62				77					0.0	39.6	43.7
49		15																				77				53	223.8	35.2	
50	15																					77					0.0		
51																						0					0.0		
52																				1022		0					0.0		17.9
53																						77					22.2	39.6	25.1
abundance (millions)	422	1130	89	175	432	71	327	593	288	487	882	245	407	195	297	526	755	1456	1892	2797.7	4205.1	3448.4	1910.9		2553.6	1035.3	1287.2	957.1	1470.1
mean length (cm)	16.9	20.2	23.9	22.7	23.2	24.0	24.1	23.6	25.8	24.4	22.8	23.8	22.3	25.4	23.0	22.8	21.9	20.8	20.6	22.7	21.8	23.4	22.6		23.0	23.8	23.1	23.8	23.5
length anomalies (cm)	-6.0	-2.7	1.0	-0.2	0.3	1.1	1.2	0.7	2.9	1.5	-0.1	0.9	-0.6	2.5	0.1	-0.1	-1.0	-2.1	-2.3	-0.2	-1.1	0.5	-0.3		0.1	0.9	0.6	1.4	1.1

[1] Survey data only from Division 3L, no survey on Div. 3N

Table 6. Wald-Wolfowitz runs test for independence in redfish biomass time series of residuals for ongoing 3LN surveys.

H0: random residuals vs H1: nonrandom residuals
(alpha ---> 5%)

	3Lspain	**3Lspain**$_{\text{(Brandão and Butterworth, 2018)}}$	3Nspain	3LNspring	3LNautumn
N	14	**12**	25	27	28
Period of years	2006-2019	**2006-2017**	1995-2019	1991-2019	1991-2019
Number of runs	4	**3**	12	11	11
p-value	**0.0282**	**0.0167**	0.5447	0.2164	0.1282
p-value exact	0.0559	**0.0303**	0.6951	0.3008	0.1813
Decision (based on p-value)	**Nonrandomness**	**Nonrandomness**	Randomness	Randomness	Randomness
Decision (based on p-value exact)	Randomness	**Nonrandomness**	Randomness	Randomness	Randomness

Table 7 (HCR option). B/Bmsy and F/Fmsy point estimate and bias corrected trajectories with 2020ASPICprj. 2020-2026 relative B and F projections under 2020 red 3LN HCR for 2020-2025. (catch 2020 = 18100 t 2020 TAC; 2021 - 2025 = 18100 t)

	Relative B trajectory and 2020-2026 projection under red 3LN HCR			Relative F trajectory and 2020-2025 projection under red 3LN HCR		
Year	Point estimate	Approx 80% lower CL	Approx 80% upper CL	Point estimate	Approx 80% lower CL	Approx 80% upper CL
1959	1.441	1.163	2.481	1.554	0.927	1.917
1960	1.298	1.055	2.124	0.990	0.622	1.214
1961	1.259	1.030	1.953	0.883	0.583	1.077
1962	1.240	1.020	1.838	0.826	0.569	1.002
1963	1.231	1.018	1.754	1.076	0.766	1.299
1964	1.192	0.989	1.651	0.401	0.295	0.482
1965	1.245	1.037	1.663	0.905	0.686	1.083
1966	1.225	1.026	1.597	0.656	0.509	0.781
1967	1.241	1.044	1.577	1.061	0.841	1.257
1968	1.202	1.016	1.504	0.696	0.561	0.821
1969	1.215	1.031	1.493	0.981	0.803	1.153
1970	1.190	1.014	1.442	0.570	0.474	0.667
1971	1.221	1.044	1.457	1.386	1.166	1.616
1972	1.144	0.983	1.355	1.228	1.041	1.428
1973	1.100	0.947	1.294	1.488	1.268	1.727
1974	1.033	0.891	1.212	1.031	0.881	1.196
1975	1.026	0.883	1.198	0.823	0.706	0.955
1976	1.043	0.897	1.212	0.936	0.807	1.089
1977	1.045	0.898	1.209	0.744	0.645	0.867
1978	1.069	0.917	1.230	0.525	0.458	0.612
1979	1.116	0.958	1.276	0.591	0.518	0.688
1980	1.152	0.989	1.307	0.656	0.580	0.763
1981	1.176	1.011	1.325	0.993	0.884	1.152
1982	1.155	0.997	1.293	0.891	0.798	1.031
1983	1.149	0.994	1.279	0.817	0.736	0.943
1984	1.153	1.000	1.277	0.601	0.545	0.693
1985	1.184	1.028	1.304	0.827	0.753	0.951
1986	1.182	1.030	1.295	1.820	1.667	2.082
1987	1.063	0.931	1.157	4.216	3.901	4.781
1988	0.747	0.662	0.803	3.925	3.665	4.423
1989	0.557	0.498	0.595	3.158	2.962	3.535
1990	0.461	0.413	0.492	3.312	3.103	3.696
1991	0.379	0.339	0.405	3.620	3.370	4.059
1992	0.303	0.270	0.328	5.174	4.699	5.763
1993	0.206	0.185	0.232	6.293	5.338	7.245
1994	0.124	0.103	0.157	2.253	1.742	2.780
1995	0.119	0.094	0.158	0.747	0.558	0.959
1996	0.135	0.105	0.183	0.144	0.107	0.189
1997	0.164	0.125	0.219	0.166	0.124	0.219
1998	0.198	0.150	0.266	0.198	0.146	0.262
1999	0.237	0.178	0.317	0.432	0.320	0.578
2000	0.275	0.204	0.371	0.508	0.373	0.689
2001	0.315	0.231	0.433	0.200	0.144	0.271
2002	0.372	0.275	0.518	0.143	0.103	0.196
2003	0.438	0.321	0.607	0.134	0.097	0.183
2004	0.513	0.373	0.707	0.055	0.040	0.075
2005	0.601	0.433	0.817	0.048	0.036	0.067
2006	0.697	0.506	0.933	0.032	0.024	0.044
2007	0.801	0.570	1.043	0.093	0.072	0.131
2008	0.903	0.639	1.153	0.030	0.024	0.042
2009	1.013	0.718	1.262	0.047	0.038	0.066
2010	1.120	0.808	1.367	0.169	0.139	0.230
2011	1.208	0.894	1.446	0.140	0.118	0.188
2012	1.295	0.981	1.520	0.154	0.132	0.202
2013	1.372	1.056	1.582	0.212	0.185	0.272
2014	1.433	1.126	1.620	0.185	0.165	0.233
2015	1.492	1.198	1.660	0.314	0.284	0.388
2016	1.522	1.244	1.671	0.269	0.246	0.326
2017	1.556	1.291	1.685	0.360	0.334	0.430
2018	1.570	1.322	1.682	0.341	0.320	0.402
2019	1.584	1.354	1.681	0.392	0.371	0.455
2020	1.588	1.377	1.671	0.547	0.521	0.625
2021	1.566	1.380	1.636	0.554	0.532	0.624
2022	1.547	1.385	1.606	0.561	0.541	0.622
2023	1.530	1.387	1.580	0.566	0.550	0.621
2024	1.514	1.387	1.557	0.572	0.557	0.622
2025	1.501	1.386	1.537	0.577	0.564	0.622
2026	1.489	1.385	1.520			

Table 8 (Ye2020 option). B/Bmsy and F/Fmsy point estimate and bias corrected trajectories with 2020ASPICprj. 2020-2026 relative B and F projections under 2020 red 3LN HCR for 2020-2025. (catch 2020 = 18100 t 2020 TAC; 2021 - 2025 = 13730 t Ye 2020 from 2020ASPICfit)

	Relative B trajectory and 2020-2026 projection under Ye 2020 option			Relative F trajectory and 2020-2025 projection under Ye 2020 option		
Year	Point estimate	Approx 80% lower CL	Approx 80% upper CL	Point estimate	Approx 80% lower CL	Approx 80% upper CL
1959	1.441	1.163	2.481	1.554	0.927	1.917
1960	1.298	1.055	2.124	0.990	0.622	1.214
1961	1.259	1.030	1.953	0.883	0.583	1.077
1962	1.240	1.020	1.838	0.826	0.569	1.002
1963	1.231	1.018	1.754	1.076	0.766	1.299
1964	1.192	0.989	1.651	0.401	0.295	0.482
1965	1.245	1.037	1.663	0.905	0.686	1.083
1966	1.225	1.026	1.597	0.656	0.509	0.781
1967	1.241	1.044	1.577	1.061	0.841	1.257
1968	1.202	1.016	1.504	0.696	0.561	0.821
1969	1.215	1.031	1.493	0.981	0.803	1.153
1970	1.190	1.014	1.442	0.570	0.474	0.667
1971	1.221	1.044	1.457	1.386	1.166	1.616
1972	1.144	0.983	1.355	1.228	1.041	1.428
1973	1.100	0.947	1.294	1.488	1.268	1.727
1974	1.033	0.891	1.212	1.031	0.881	1.196
1975	1.026	0.883	1.198	0.823	0.706	0.955
1976	1.043	0.897	1.212	0.936	0.807	1.089
1977	1.045	0.898	1.209	0.744	0.645	0.867
1978	1.069	0.917	1.230	0.525	0.458	0.612
1979	1.116	0.958	1.276	0.591	0.518	0.688
1980	1.152	0.989	1.307	0.656	0.580	0.763
1981	1.176	1.011	1.325	0.993	0.884	1.152
1982	1.155	0.997	1.293	0.891	0.798	1.031
1983	1.149	0.994	1.279	0.817	0.736	0.943
1984	1.153	1.000	1.277	0.601	0.545	0.693
1985	1.184	1.028	1.304	0.827	0.753	0.951
1986	1.182	1.030	1.295	1.820	1.667	2.082
1987	1.063	0.931	1.157	4.216	3.901	4.781
1988	0.747	0.662	0.803	3.925	3.665	4.423
1989	0.557	0.498	0.595	3.158	2.962	3.535
1990	0.461	0.413	0.492	3.312	3.103	3.696
1991	0.379	0.339	0.405	3.620	3.370	4.059
1992	0.303	0.270	0.328	5.174	4.699	5.763
1993	0.206	0.185	0.232	6.293	5.338	7.245
1994	0.124	0.103	0.157	2.253	1.742	2.780
1995	0.119	0.094	0.158	0.747	0.558	0.959
1996	0.135	0.105	0.183	0.144	0.107	0.189
1997	0.164	0.125	0.219	0.166	0.124	0.219
1998	0.198	0.150	0.266	0.198	0.146	0.262
1999	0.237	0.178	0.317	0.432	0.320	0.578
2000	0.275	0.204	0.371	0.508	0.373	0.689
2001	0.315	0.231	0.433	0.200	0.144	0.271
2002	0.372	0.275	0.518	0.143	0.103	0.196
2003	0.438	0.321	0.607	0.134	0.097	0.183
2004	0.513	0.373	0.707	0.055	0.040	0.075
2005	0.601	0.433	0.817	0.048	0.036	0.067
2006	0.697	0.506	0.933	0.032	0.024	0.044
2007	0.801	0.570	1.043	0.093	0.072	0.131
2008	0.903	0.639	1.153	0.030	0.024	0.042
2009	1.013	0.718	1.262	0.047	0.038	0.066
2010	1.120	0.808	1.367	0.169	0.139	0.230
2011	1.208	0.894	1.446	0.140	0.118	0.188
2012	1.295	0.981	1.520	0.154	0.132	0.202
2013	1.372	1.056	1.582	0.212	0.185	0.272
2014	1.433	1.126	1.620	0.185	0.165	0.233
2015	1.492	1.198	1.660	0.314	0.284	0.388
2016	1.522	1.244	1.671	0.269	0.246	0.326
2017	1.556	1.291	1.685	0.360	0.334	0.430
2018	1.570	1.322	1.682	0.341	0.320	0.402
2019	1.584	1.354	1.681	0.392	0.371	0.455
2020	1.588	1.377	1.671	0.547	0.521	0.625
2021	1.566	1.380	1.636	0.417	0.401	0.470
2022	1.569	1.400	1.629	0.416	0.402	0.464
2023	1.571	1.417	1.624	0.416	0.403	0.458
2024	1.573	1.435	1.619	0.415	0.404	0.453
2025	1.575	1.450	1.615	0.415	0.405	0.449
2026	1.577	1.463	1.611			

Table 9a. B/Bmsy point estimate and lower bias corrected 80% CL with ASPICP2020. 2020-2026 relative B projection under 2020 HCR (18100t) and Ye2020 (13730t).

	Relative B trajectory and 2020-2026 projection under 2020 HCR (18500t)		Relative B trajectory and 2020-2026 projection under Ye 2020 (13730t)	
Year	Point estimate	Approx bias corrected 80% lower CL	Point estimate	Approx bias corrected 80% lower CL
2020	1.588	1.377	1.588	1.377
2021	1.566	1.380	1.566	1.380
2022	1.547	1.385	1.569	1.400
2023	1.530	1.387	1.571	1.417
2024	1.514	1.387	1.573	1.435
2025	1.501	1.386	1.575	1.450
2026	1.489	1.385	1.577	1.463

Table 9b. F/Fmsy point estimate and lower bias corrected 80% CL with ASPICP2020. 2020-2025 relative F projection under red 3LN 2020 HCR (18100t) and Ye2020 (13730t).

	Relative F trajectory and 2020-2025 projection under 2020 HCR (18500t)		Relative F trajectory and 2020-2025 projection under Ye 2020 (13730t)	
Year	Point estimate	Approx bias corrected 80% upper CL	Point estimate	Approx bias corrected 80% upper CL
2020	0.547	0.625	0.5466	0.6249
2021	0.554	0.624	0.4171	0.4702
2022	0.561	0.622	0.4164	0.4641
2023	0.566	0.621	0.4158	0.4583
2024	0.572	0.622	0.4153	0.4531
2025	0.577	0.622	0.4148	0.4488

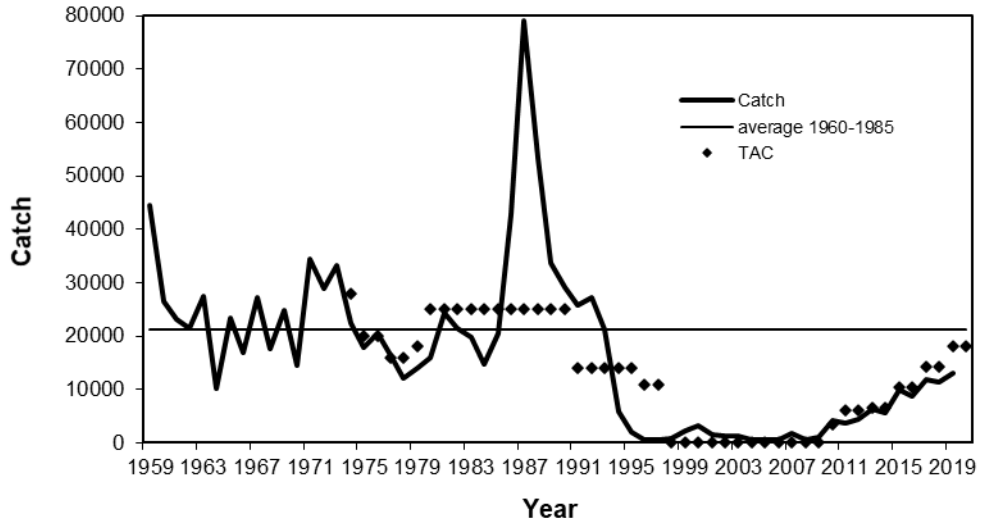

Fig. 1: redfish catch and TAC's in Div. 3LN, 1959-2019

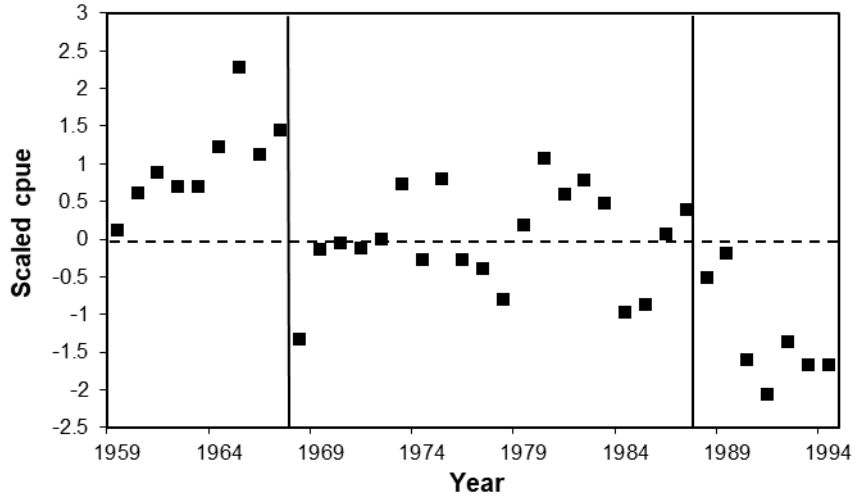

Fig. 2: Redfish Div. 3LN cpue 1959-1994

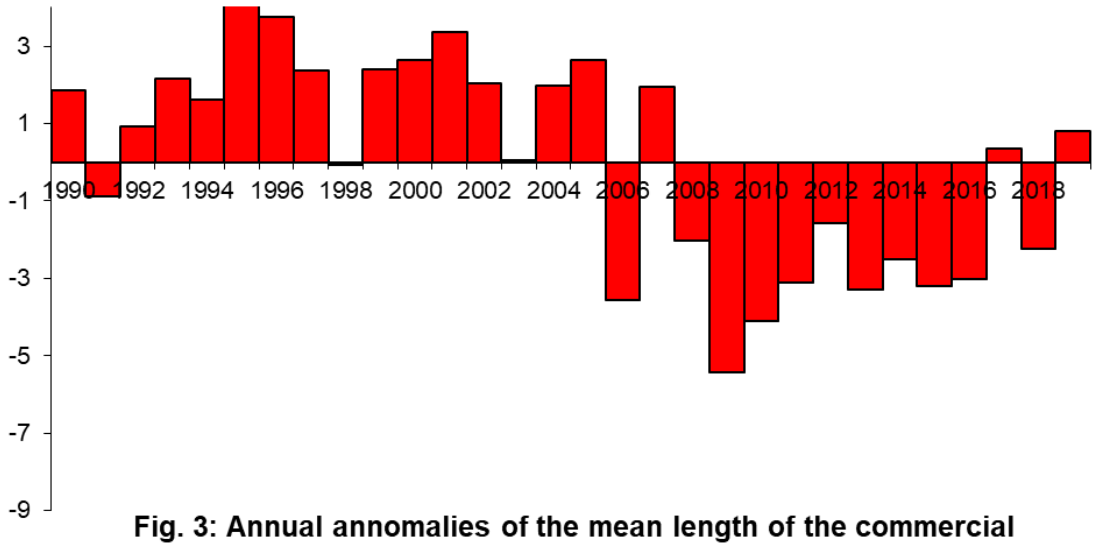

Fig. 3: Annual annomalies of the mean length of the commercial catch, 1990-2019

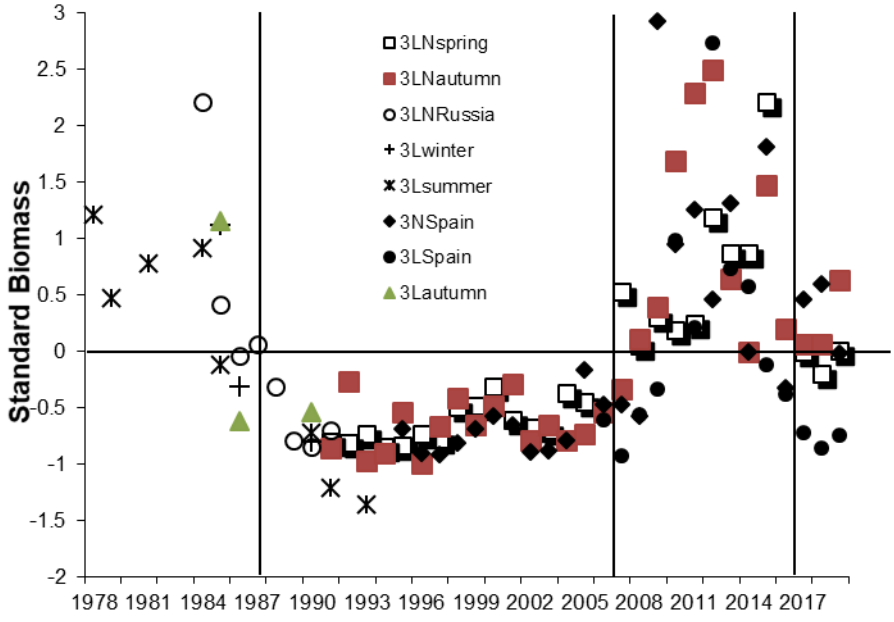

Fig. 4a: Standardized biomass from bottom trawl surveys included in ASPIC framework, 1978-2019

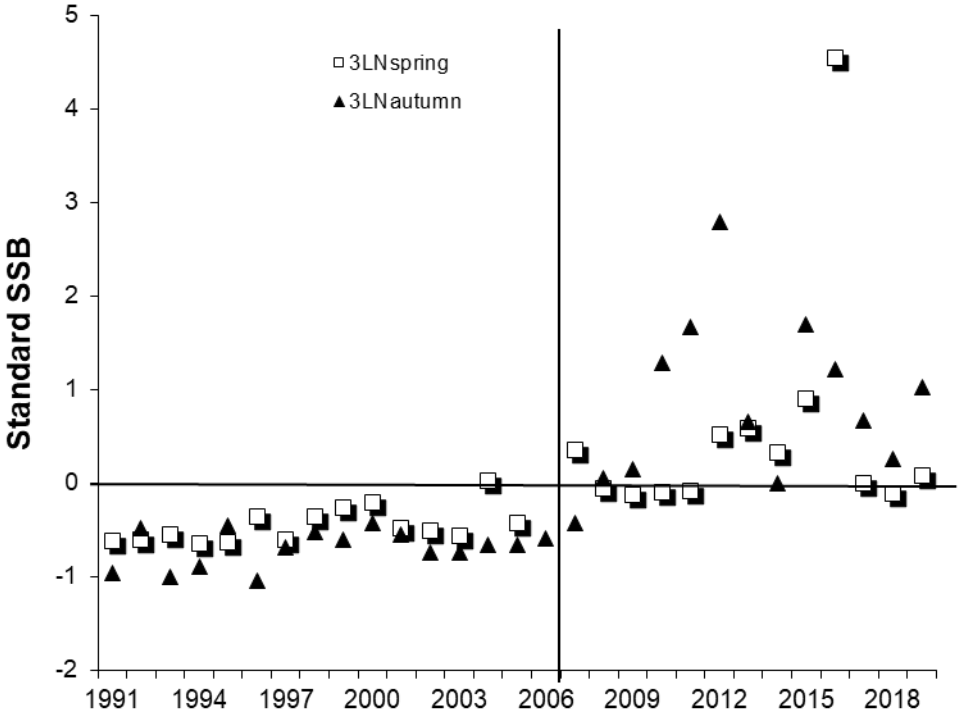

Fig. 4b: Standardized survey female SSB from spring and autumn Canadian surveys on Div. 3LN, 1991-2019

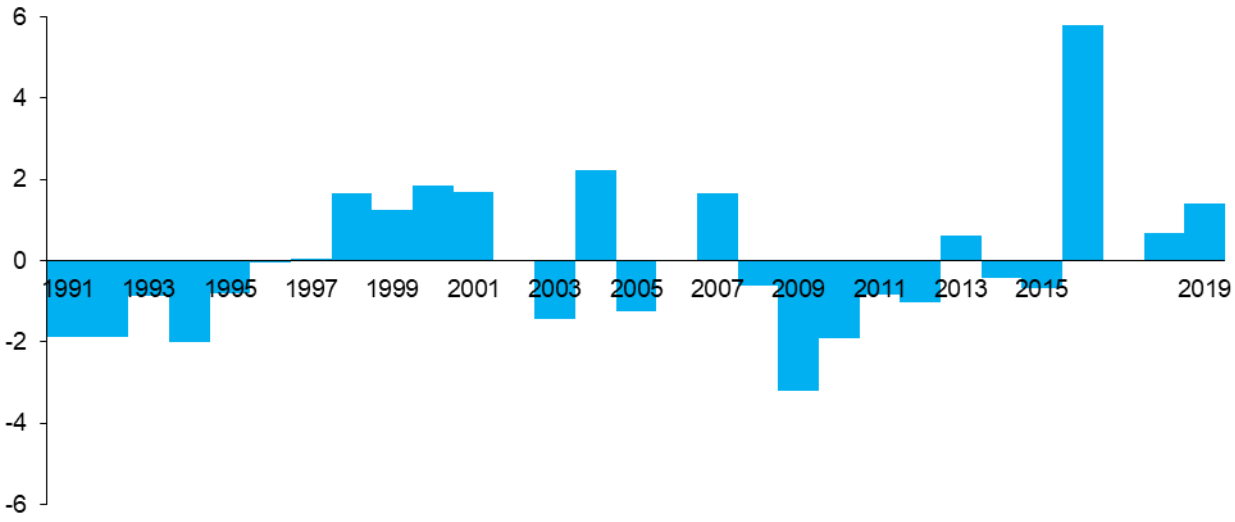

Fig. 5a: Annual annomalies of the mean length on the spring survey stock, 1991-2019

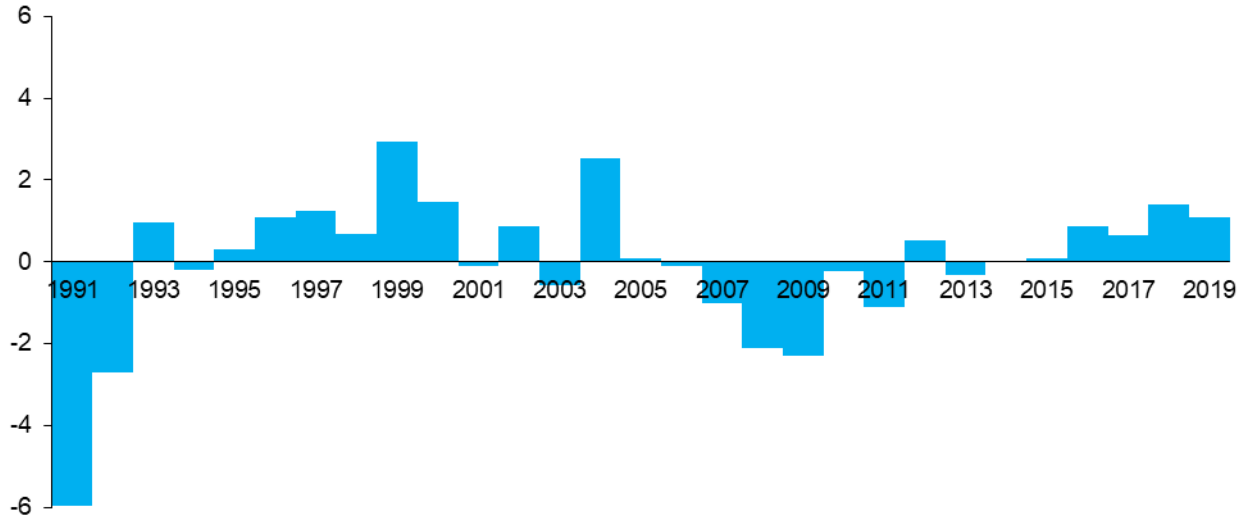

Fig. 5b: Annual annomalies of the mean length on the atumn survey stock, 1991-2019

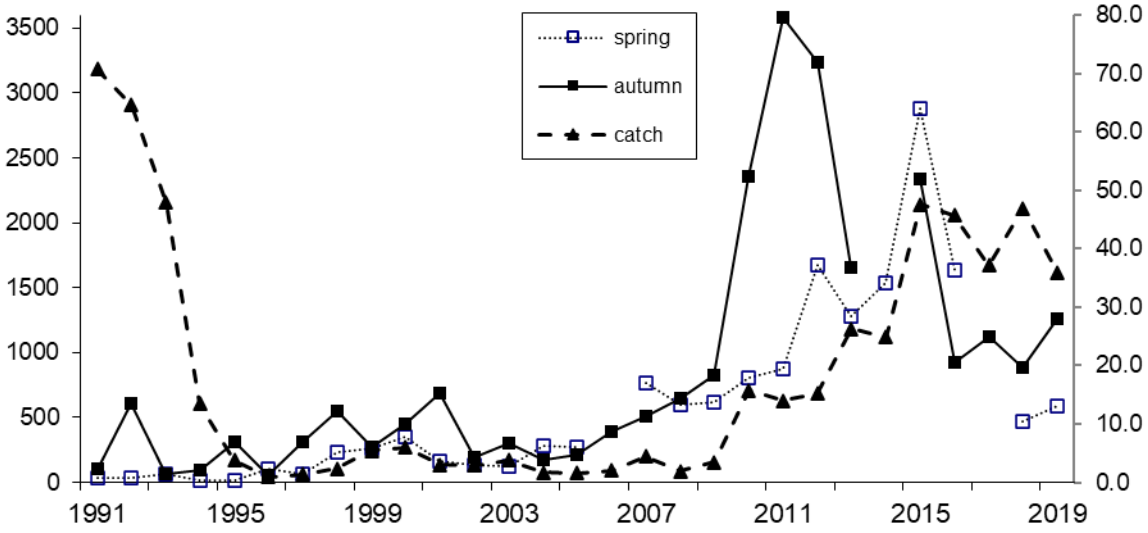

Fig. 5c: lenghts =>20cm numbers in the catch and survey abundance (10^6), 1991-2019

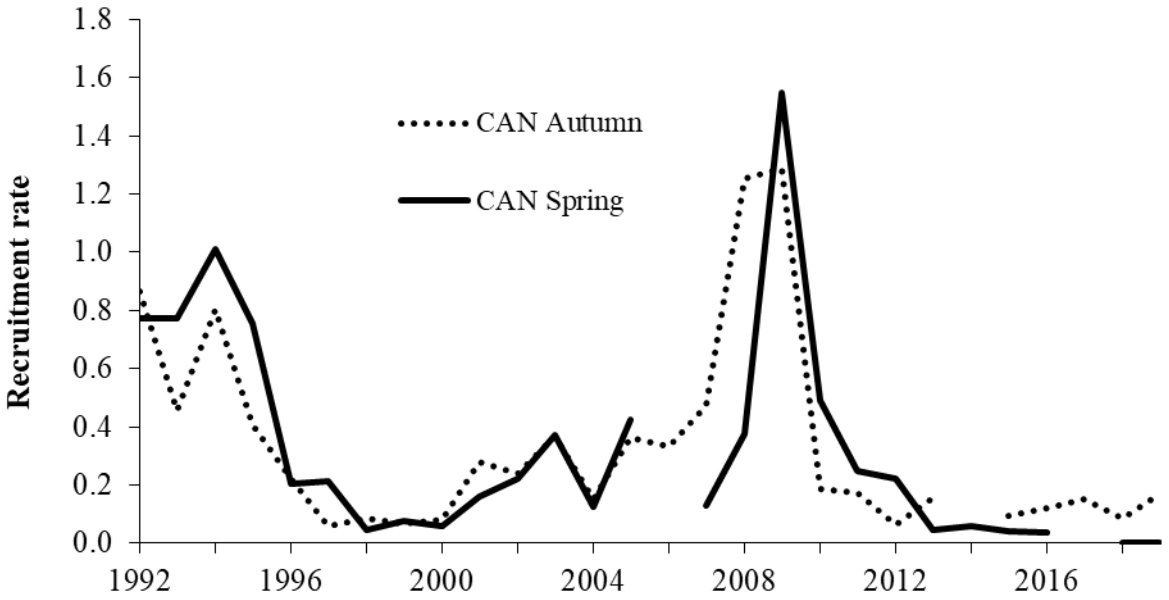

Fig. 5d: Recruitment rate (lenghts <20cm/lenghts =>20cm) in the survey abundance, 1992-2019

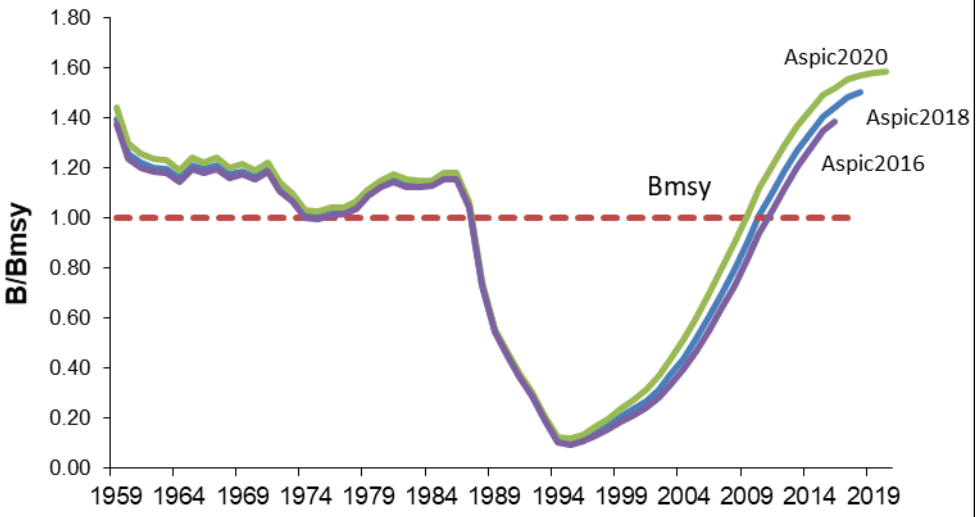

Fig. 6a: B/Bmsy from ASPICfit, 2020-2018-2016

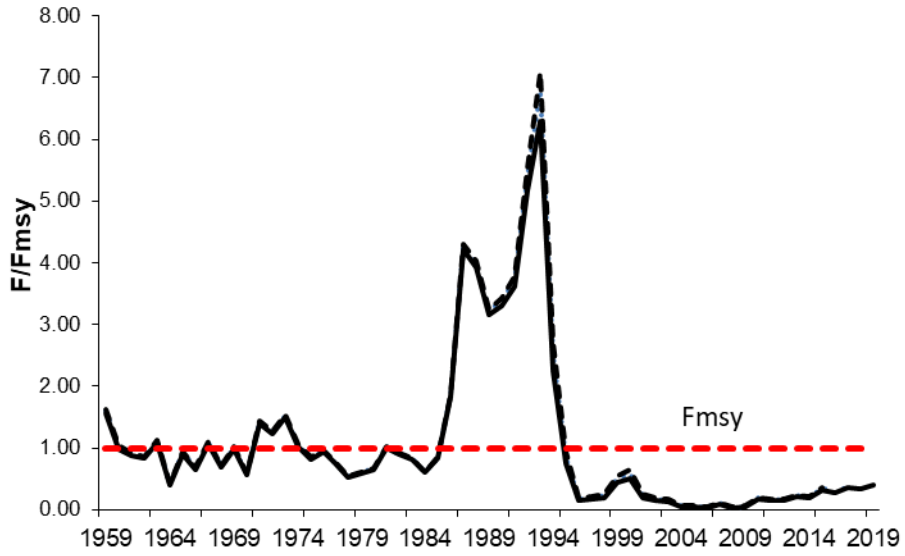

Fig. 6b: F/Fmsy from ASPICfit, 2020-2018-2016

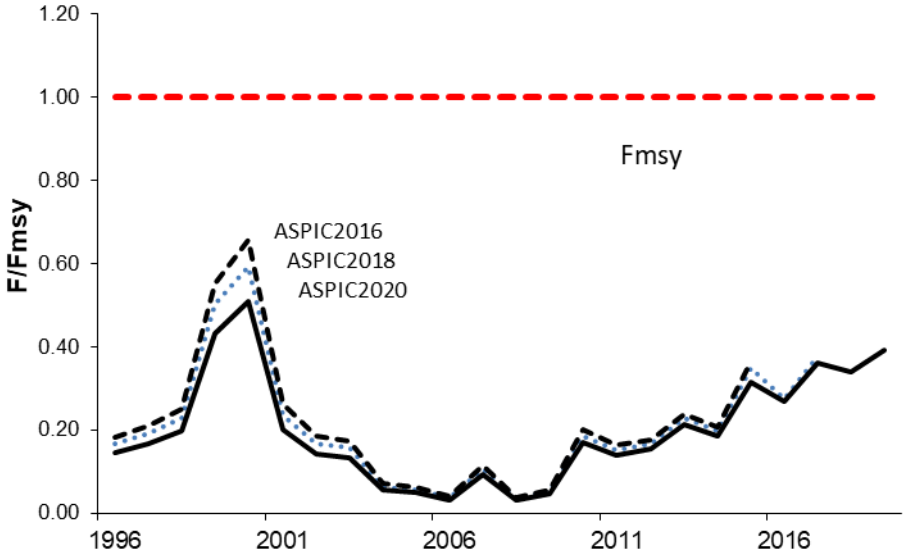

Fig. 6c: F/Fmsy from ASPICfit, 2020-2018-2016 (since 1996)

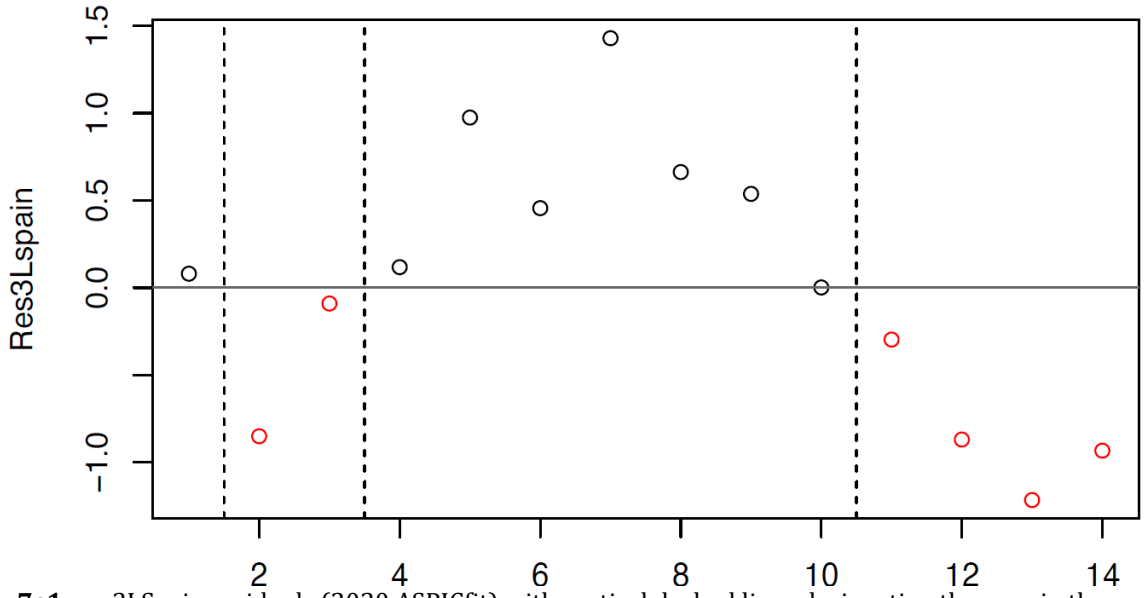

Fig. 7a1. 3LSpain residuals (2020 ASPICfit) with vertical dashed lines designating the runs in the series.

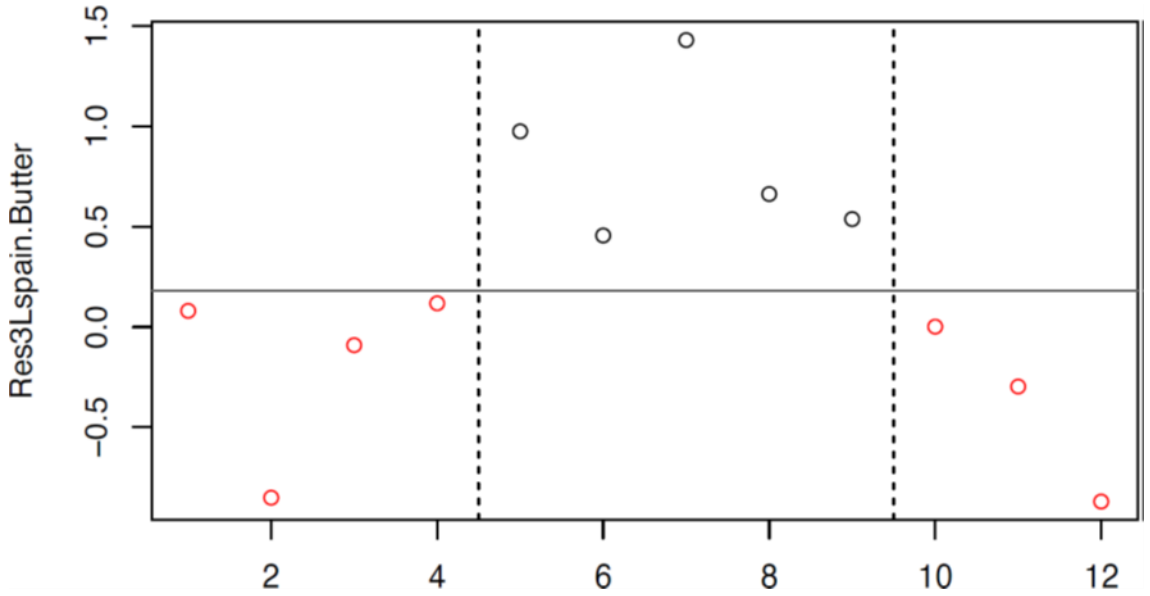

Fig. 7a2. 3L Spain residuals (2018 ASPICfit) with vertical dashed lines designating the runs in the series (Brandão and Butterworth, 2018).

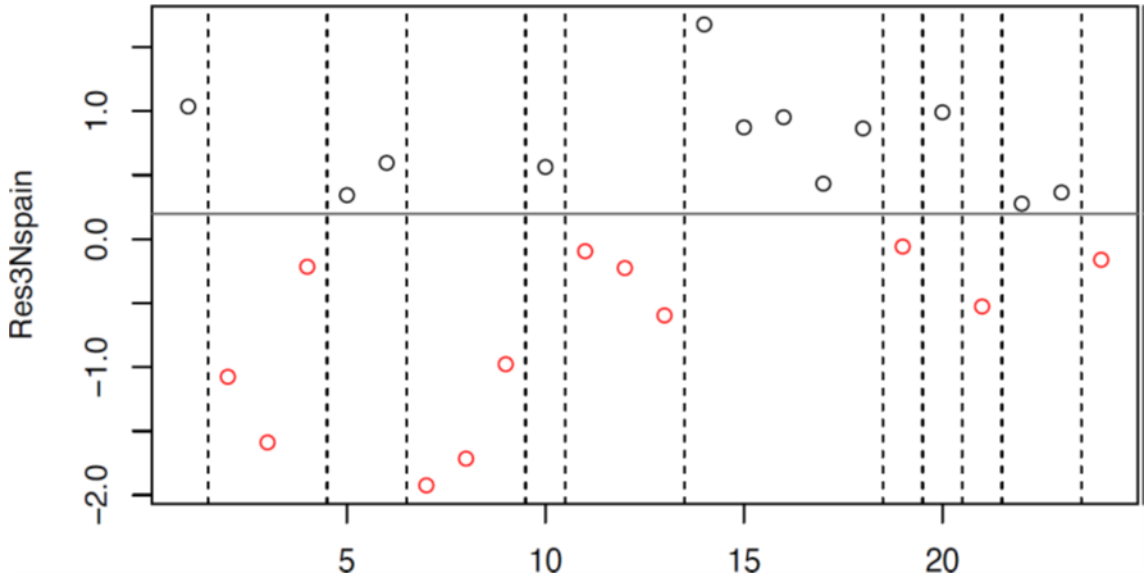

Fig. 7b. 3NSpain residuals (2020 ASPICfit) with vertical dashed lines designating the runs in the series.

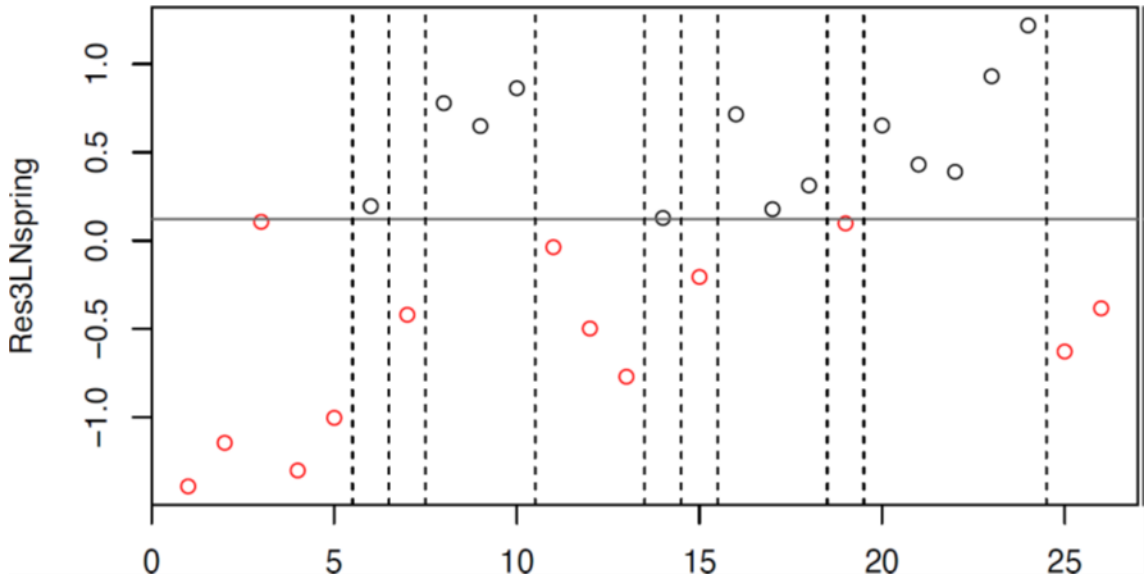

Fig. 7c. 3LN spring residuals (2020 ASPICfit) with vertical dashed lines designating the runs in the series.

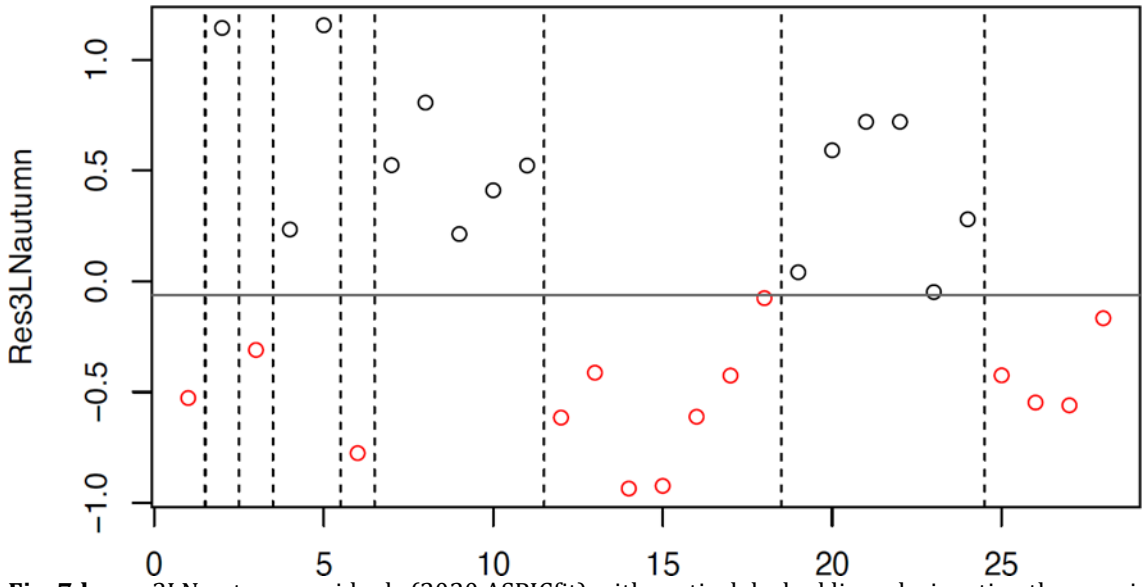

Fig. 7d. 3LN autumn residuals (2020 ASPICfit) with vertical dashed lines designating the runs in the series.

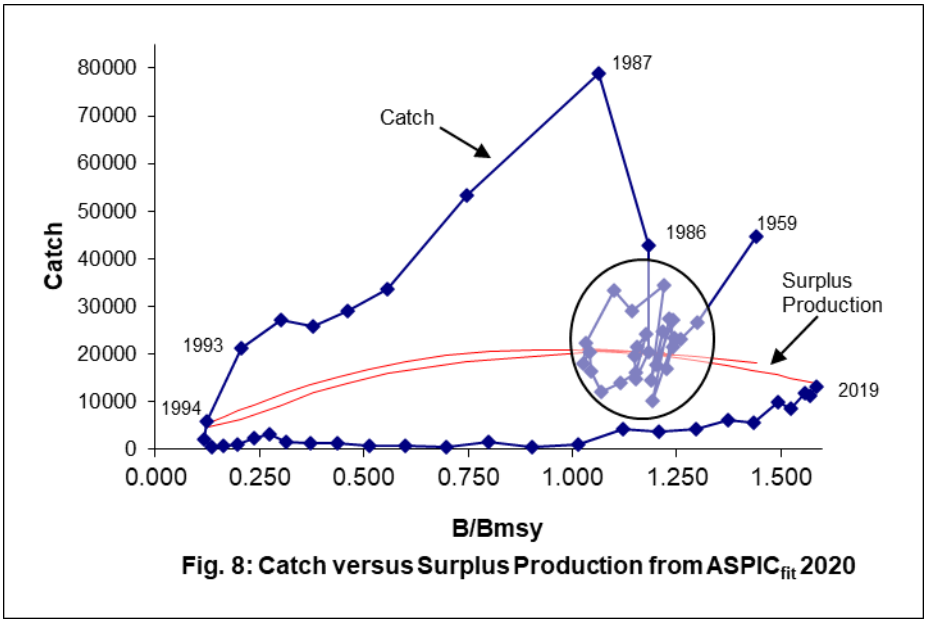

Fig. 8: Catch versus Surplus Production from ASPIC$_{fit}$ 2020

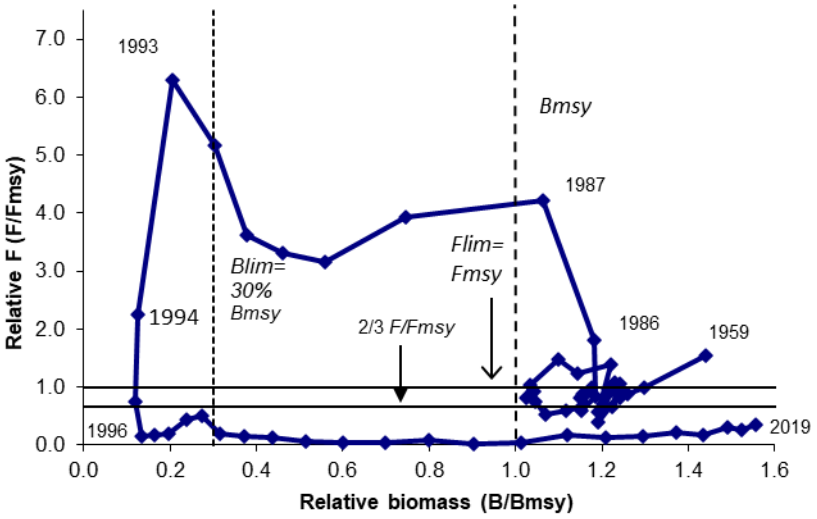

Fig. 9: Stock trajectory under a precautionary framework for ASPIC$_{fit}$ 2020

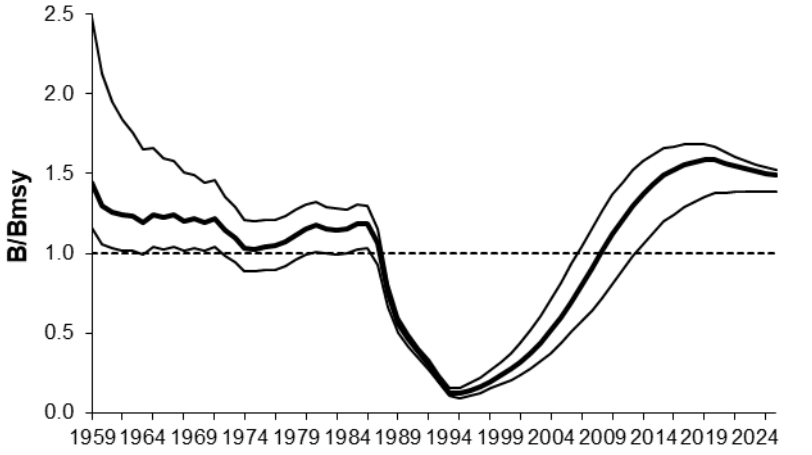

Fig. 10a: B/Bmsy trajectory and 2020-2026 projection under 2020 red 3LN HCR. Results from ASPICP 2020 (point estimates with approximate 80% bc CL's)

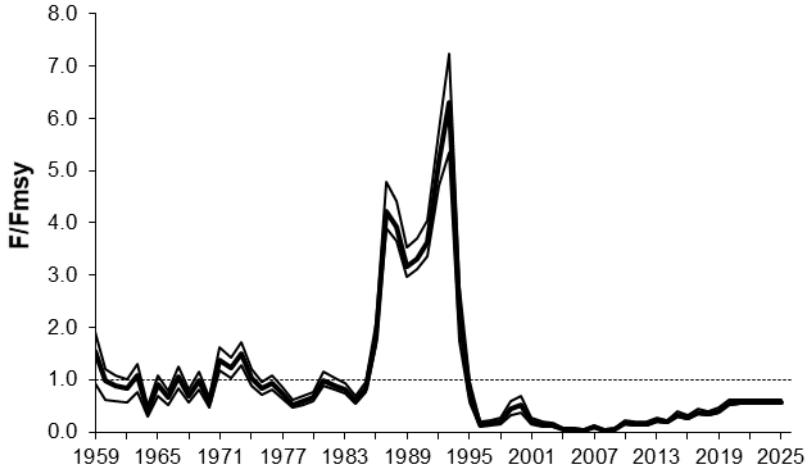

Fig. 10b: F/Fmsy trajectory and 2020-2025 projection under 2020 red 3LN HCR. Results from ASPICP 2020 (point estimates with approximate 80% bc CL's)

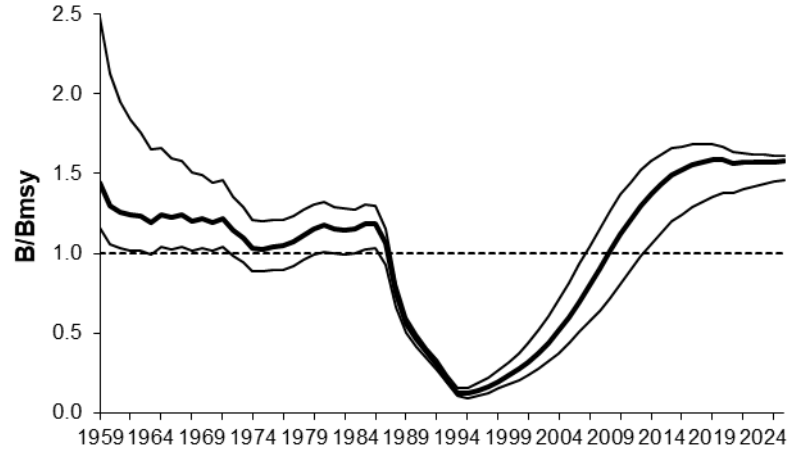

Fig. 11a: B/Bmsy trajectory and 2020-2026 projection under 2020 red 3LN HCR for 2020 and Ye 2020 for 2021-2025. Results from ASPICP 2020 (point estimates with approximate 80% bc CL's)

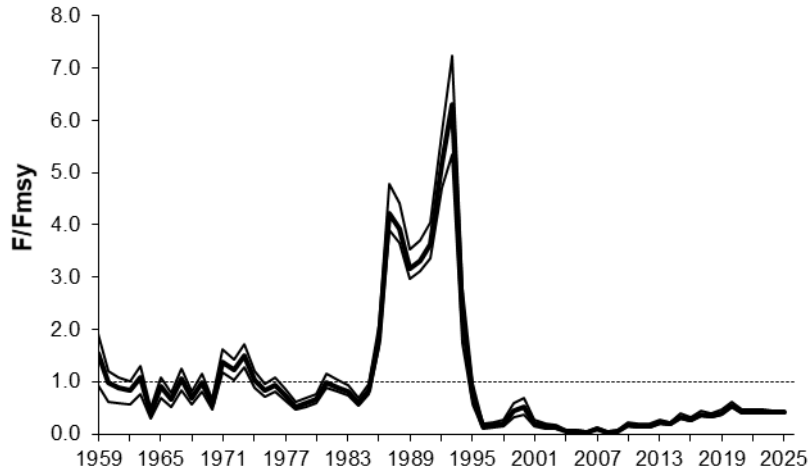

Fig. 11b: F/Fmsy trajectory and 2020-2025 projection under 2020 red 3LN HCR for 2020 and Ye 2020 for 2021-2025. Results from ASPICP 2020 (point estimates with approximate 80% bc CL's)

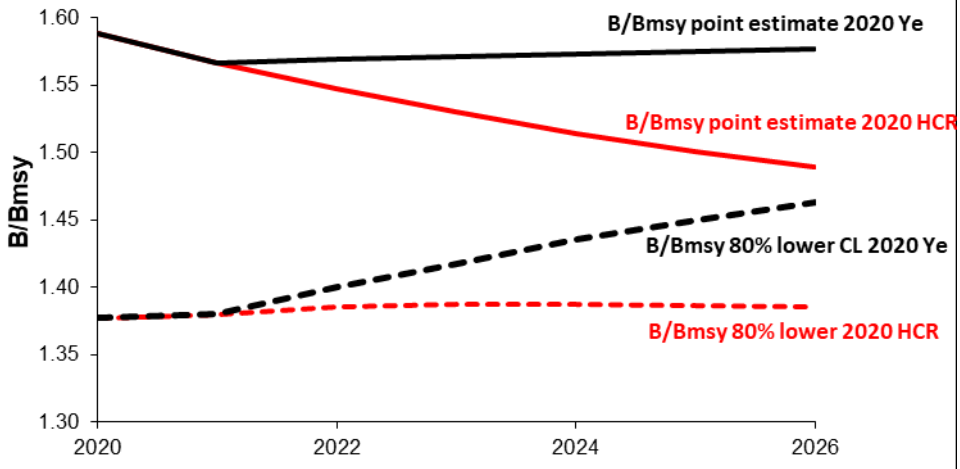

Fig. 12: B/Bmsy 2020-2026 projection under 2020 HCR (18100t) versus Ye2020 (13500t). Results from ASPICP 2020 (point estimates with approximate lower 80% bc CL's)

Appendix 1: Input .a7inp file of 2020 framework

```
ASPIC-V7
# File generated by aspic5to7 v.0.62, at 2020-05-02 19:59:34
"3LN redfish"
# Program mode (FIT/BOT), verbosity, [if BOT] N bootstraps, [opt] user percentile:
FIT  2
# Model shape, conditioning (YLD/EFT), obj. fn. (SSE/LAV/MLE/MAP):
LOGISTIC  YLD  SSE
# N years, N series:
61  9
# Monte Carlo mode (0/1/2), N trials:
0  20000
# Convergence criteria (3 values):
1.00E-08  3.00E-08  1.00E-04
# Maximum F, N restarts, [gen. model] N steps/yr:
6.00E+00  18  24
# Random seed (large integer):
3941285
# Initial guesses and bounds follow:
# 'B1K', guess, estflag, min, max, ['penalty', penalty], or [priorname, prior params]
B1K   5.00E-01  1  5.00E-02  3.00E+00  penalty  0.00E+00
#B1K  5.00E-01  1  5.00E-02  3.00E+00  prior uniform  5.00E-02  3.00E+00
# 'MSY', guess, estflag, min, max, [if MAP] priorname, prior params
MSY   2.10E+04  0  5.00E+03  5.00E+04  prior uniform  5.00E+03  5.00E+04
# 'Fmsy', guess, estflag, min, max, [if MAP] priorname, prior params
Fmsy  8.40E-02  1  4.20E-03  8.40E-01  prior uniform  4.20E-03  8.40E-01
# q, guess, estflag, seriesweight, min, max, [if MAP] priorname, prior params
q     8.24E-06   1  1.00E+00  1.37E-07  8.24E-04   prior uniform  1.37E-07  8.24E-04
q     7.81E-01   1  1.00E+00  1.30E-02  4.69E+00  prior uniform  1.30E-02  4.69E+00
q     1.30E+00  1  1.00E+00  2.17E-02  7.79E+00  prior uniform  2.17E-02  7.79E+00
q     3.13E-01   1  1.00E+00  5.21E-03  1.20E+00  prior uniform  5.21E-03  1.20E+00
q     2.46E-01   1  1.00E+00  4.10E-03  1.20E+00  prior uniform  4.10E-03  1.20E+00
q     1.01E+00  1  1.00E+00  1.68E-02  6.05E+00  prior uniform  1.68E-02  6.05E+00
q     2.28E-01   1  1.00E+00  3.79E-03  1.20E+00  prior uniform  3.79E-03  1.20E+00
q     7.68E-01   1  1.00E+00  1.28E-02  4.61E+00  prior uniform  1.28E-02  4.61E+00
q     6.02E-01   1  1.00E+00  1.00E-02  3.61E+00  prior uniform  1.00E-02  3.61E+00
# Parameters for GENGRID or GENFIT go here.
DATA
# NOTE: Nominal CVs added by aspic5to7.
```

"Statlant CPUE"
CC

1959	1.4260E+00	4.4585E+04	3.0000E-01
1960	1.6020E+00	2.6562E+04	3.0000E-01
1961	1.6970E+00	2.3175E+04	3.0000E-01
1962	1.6310E+00	2.1439E+04	3.0000E-01
1963	1.6320E+00	2.7362E+04	3.0000E-01
1964	1.8120E+00	1.0261E+04	3.0000E-01
1965	2.1850E+00	2.3466E+04	3.0000E-01
1966	1.7810E+00	1.6974E+04	3.0000E-01
1967	1.8930E+00	2.7188E+04	3.0000E-01
1968	9.2200E-01	1.7660E+04	3.0000E-01
1969	1.3380E+00	2.4750E+04	3.0000E-01
1970	1.3670E+00	1.4419E+04	3.0000E-01
1971	1.3460E+00	3.4370E+04	3.0000E-01
1972	1.3870E+00	2.8933E+04	3.0000E-01
1973	1.6430E+00	3.3297E+04	3.0000E-01
1974	1.2900E+00	2.2286E+04	3.0000E-01
1975	1.6690E+00	1.7871E+04	3.0000E-01
1976	1.2920E+00	2.0513E+04	3.0000E-01
1977	1.2510E+00	1.6516E+04	3.0000E-01
1978	1.1060E+00	1.2043E+04	3.0000E-01
1979	1.4510E+00	1.4067E+04	3.0000E-01
1980	1.7610E+00	1.6030E+04	3.0000E-01
1981	1.5940E+00	2.4280E+04	3.0000E-01
1982	1.6610E+00	2.1547E+04	3.0000E-01
1983	1.5560E+00	1.9747E+04	3.0000E-01
1984	1.0490E+00	1.4761E+04	3.0000E-01
1985	1.0840E+00	2.0557E+04	3.0000E-01
1986	1.4130E+00	4.2805E+04	3.0000E-01
1987	1.5230E+00	7.9031E+04	3.0000E-01
1988	1.2080E+00	5.3266E+04	3.0000E-01
1989	1.3220E+00	3.3649E+04	3.0000E-01
1990	8.2500E-01	2.9105E+04	3.0000E-01
1991	6.6800E-01	2.5815E+04	3.0000E-01
1992	9.1200E-01	2.7283E+04	3.0000E-01
1993	8.0100E-01	2.1308E+04	3.0000E-01
1994	8.0200E-01	5.7410E+03	3.0000E-01
1995	-1.0000E-03	1.9890E+03	3.0000E-01
1996	-1.0000E-03	4.5100E+02	3.0000E-01
1997	-1.0000E-03	6.3000E+02	3.0000E-01
1998	-1.0000E-03	8.9900E+02	3.0000E-01
1999	-1.0000E-03	2.3180E+03	3.0000E-01
2000	-1.0000E-03	3.1410E+03	3.0000E-01
2001	-1.0000E-03	1.4420E+03	3.0000E-01
2002	-1.0000E-03	1.2160E+03	3.0000E-01
2003	-1.0000E-03	1.3340E+03	3.0000E-01
2004	-1.0000E-03	6.3700E+02	3.0000E-01
2005	-1.0000E-03	6.5900E+02	3.0000E-01
2006	-1.0000E-03	4.9600E+02	3.0000E-01
2007	-1.0000E-03	1.6640E+03	3.0000E-01
2008	-1.0000E-03	5.9700E+02	3.0000E-01
2009	-1.0000E-03	1.0510E+03	3.0000E-01
2010	-1.0000E-03	4.1200E+03	3.0000E-01
2011	-1.0000E-03	3.6720E+03	3.0000E-01
2012	-1.0000E-03	4.3160E+03	3.0000E-01
2013	-1.0000E-03	6.2320E+03	3.0000E-01
2014	-1.0000E-03	5.6950E+03	3.0000E-01
2015	-1.0000E-03	9.9400E+03	3.0000E-01
2016	-1.0000E-03	8.6860E+03	3.0000E-01
2017	-1.0000E-03	1.1815E+04	3.0000E-01
2018	-1.0000E-03	1.1279E+04	3.0000E-01
2019	-1.0000E-03	1.3050E+04	3.0000E-01

"3LN spring survey"
I1

1959	-1.0000E-03	3.0000E-01	
1960	-1.0000E-03	3.0000E-01	
1961	-1.0000E-03	3.0000E-01	
1962	-1.0000E-03	3.0000E-01	
1963	-1.0000E-03	3.0000E-01	
1964	-1.0000E-03	3.0000E-01	
1965	-1.0000E-03	3.0000E-01	
1966	-1.0000E-03	3.0000E-01	
1967	-1.0000E-03	3.0000E-01	
1968	-1.0000E-03	3.0000E-01	
1969	-1.0000E-03	3.0000E-01	
1970	-1.0000E-03	3.0000E-01	
1971	-1.0000E-03	3.0000E-01	
1972	-1.0000E-03	3.0000E-01	
1973	-1.0000E-03	3.0000E-01	
1974	-1.0000E-03	3.0000E-01	
1975	-1.0000E-03	3.0000E-01	
1976	-1.0000E-03	3.0000E-01	
1977	-1.0000E-03	3.0000E-01	
1978	-1.0000E-03	3.0000E-01	
1979	-1.0000E-03	3.0000E-01	
1980	-1.0000E-03	3.0000E-01	
1981	-1.0000E-03	3.0000E-01	
1982	-1.0000E-03	3.0000E-01	
1983	-1.0000E-03	3.0000E-01	
1984	-1.0000E-03	3.0000E-01	
1985	-1.0000E-03	3.0000E-01	
1986	-1.0000E-03	3.0000E-01	
1987	-1.0000E-03	3.0000E-01	
1988	-1.0000E-03	3.0000E-01	
1989	-1.0000E-03	3.0000E-01	
1990	-1.0000E-03	3.0000E-01	
1991	1.0642E+04	3.0000E-01	
1992	1.0066E+04	3.0000E-01	
1993	2.2573E+04	3.0000E-01	
1994	4.1620E+03	3.0000E-01	
1995	5.8560E+03	3.0000E-01	
1996	2.2812E+04	3.0000E-01	
1997	1.4928E+04	3.0000E-01	
1998	5.9402E+04	3.0000E-01	
1999	6.1496E+04	3.0000E-01	
2000	8.7842E+04	3.0000E-01	
2001	4.1573E+04	3.0000E-01	
2002	3.0959E+04	3.0000E-01	
2003	2.7700E+04	3.0000E-01	
2004	7.9631E+04	3.0000E-01	
2005	6.6462E+04	3.0000E-01	
2006	-1.0000E-03	3.0000E-01	
2007	2.1885E+05	3.0000E-01	
2008	1.4398E+05	3.0000E-01	
2009	1.8338E+05	3.0000E-01	
2010	1.6535E+05	3.0000E-01	
2011	1.7369E+05	3.0000E-01	
2012	3.2198E+05	3.0000E-01	
2013	2.7151E+05	3.0000E-01	
2014	2.7175E+05	3.0000E-01	
2015	4.8056E+05	3.0000E-01	
2016	6.5421E+05	3.0000E-01	
2017	-1.0000E-03	3.0000E-01	
2018	1.0597E+05	3.0000E-01	
2019	1.3650E+05	3.0000E-01	

"3LN autumn survey"
I2

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	-1.0000E-03	3.0000E-01
1979	-1.0000E-03	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	-1.0000E-03	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	-1.0000E-03	3.0000E-01
1985	-1.0000E-03	3.0000E-01
1986	-1.0000E-03	3.0000E-01
1987	-1.0000E-03	3.0000E-01
1988	-1.0000E-03	3.0000E-01
1989	-1.0000E-03	3.0000E-01
1990	-1.0000E-03	3.0000E-01
1991	3.7886E+04	3.0000E-01
1992	1.3641E+05	3.0000E-01
1993	1.9233E+04	3.0000E-01
1994	3.1757E+04	3.0000E-01
1995	9.0728E+04	3.0000E-01
1996	1.5968E+04	3.0000E-01
1997	7.0660E+04	3.0000E-01
1998	1.1222E+05	3.0000E-01
1999	7.1986E+04	3.0000E-01
2000	1.0046E+05	3.0000E-01
2001	1.3257E+05	3.0000E-01
2002	5.0123E+04	3.0000E-01
2003	7.1889E+04	3.0000E-01
2004	4.9907E+04	3.0000E-01
2005	5.8561E+04	3.0000E-01
2006	9.1883E+04	3.0000E-01
2007	1.2476E+05	3.0000E-01
2008	1.9849E+05	3.0000E-01
2009	2.4671E+05	3.0000E-01
2010	4.6149E+05	3.0000E-01
2011	5.6228E+05	3.0000E-01
2012	5.9599E+05	3.0000E-01
2013	2.8875E+05	3.0000E-01
2014	-1.0000E-03	3.0000E-01
2015	4.2586E+05	3.0000E-01
2016	2.1518E+05	3.0000E-01
2017	1.9203E+05	3.0000E-01
2018	1.9139E+05	3.0000E-01
2019	2.8591E+05	3.0000E-01

"3LN Power russian survey"
I1

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	-1.0000E-03	3.0000E-01
1979	-1.0000E-03	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	-1.0000E-03	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	2.1588E+05	3.0000E-01
1985	9.3996E+04	3.0000E-01
1986	6.2975E+04	3.0000E-01
1987	7.0298E+04	3.0000E-01
1988	4.4884E+04	3.0000E-01
1989	1.2268E+04	3.0000E-01
1990	8.3650E+03	3.0000E-01
1991	1.8680E+04	3.0000E-01
1992	-1.0000E-03	3.0000E-01
1993	-1.0000E-03	3.0000E-01
1994	-1.0000E-03	3.0000E-01
1995	-1.0000E-03	3.0000E-01
1996	-1.0000E-03	3.0000E-01
1997	-1.0000E-03	3.0000E-01
1998	-1.0000E-03	3.0000E-01
1999	-1.0000E-03	3.0000E-01
2000	-1.0000E-03	3.0000E-01
2001	-1.0000E-03	3.0000E-01
2002	-1.0000E-03	3.0000E-01
2003	-1.0000E-03	3.0000E-01
2004	-1.0000E-03	3.0000E-01
2005	-1.0000E-03	3.0000E-01
2006	-1.0000E-03	3.0000E-01
2007	-1.0000E-03	3.0000E-01
2008	-1.0000E-03	3.0000E-01
2009	-1.0000E-03	3.0000E-01
2010	-1.0000E-03	3.0000E-01
2011	-1.0000E-03	3.0000E-01
2012	-1.0000E-03	3.0000E-01
2013	-1.0000E-03	3.0000E-01
2014	-1.0000E-03	3.0000E-01
2015	-1.0000E-03	3.0000E-01
2016	-1.0000E-03	3.0000E-01
2017	-1.0000E-03	3.0000E-01
2018	-1.0000E-03	3.0000E-01
2019	-1.0000E-03	3.0000E-01

"3L winter survey"
I0

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	-1.0000E-03	3.0000E-01
1979	-1.0000E-03	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	-1.0000E-03	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	-1.0000E-03	3.0000E-01
1985	9.0245E+04	3.0000E-01
1986	3.6568E+04	3.0000E-01
1987	-1.0000E-03	3.0000E-01
1988	-1.0000E-03	3.0000E-01
1989	-1.0000E-03	3.0000E-01
1990	1.8202E+04	3.0000E-01
1991	-1.0000E-03	3.0000E-01
1992	-1.0000E-03	3.0000E-01
1993	-1.0000E-03	3.0000E-01
1994	-1.0000E-03	3.0000E-01
1995	-1.0000E-03	3.0000E-01
1996	-1.0000E-03	3.0000E-01
1997	-1.0000E-03	3.0000E-01
1998	-1.0000E-03	3.0000E-01
1999	-1.0000E-03	3.0000E-01
2000	-1.0000E-03	3.0000E-01
2001	-1.0000E-03	3.0000E-01
2002	-1.0000E-03	3.0000E-01
2003	-1.0000E-03	3.0000E-01
2004	-1.0000E-03	3.0000E-01
2005	-1.0000E-03	3.0000E-01
2006	-1.0000E-03	3.0000E-01
2007	-1.0000E-03	3.0000E-01
2008	-1.0000E-03	3.0000E-01
2009	-1.0000E-03	3.0000E-01
2010	-1.0000E-03	3.0000E-01
2011	-1.0000E-03	3.0000E-01
2012	-1.0000E-03	3.0000E-01
2013	-1.0000E-03	3.0000E-01
2014	-1.0000E-03	3.0000E-01
2015	-1.0000E-03	3.0000E-01
2016	-1.0000E-03	3.0000E-01
2017	-1.0000E-03	3.0000E-01
2018	-1.0000E-03	3.0000E-01
2019	-1.0000E-03	3.0000E-01

"3L summer survey"
I1

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	3.1116E+05	3.0000E-01
1979	2.2779E+05	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	2.6138E+05	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	2.7771E+05	3.0000E-01
1985	1.6104E+05	3.0000E-01
1986	-1.0000E-03	3.0000E-01
1987	-1.0000E-03	3.0000E-01
1988	-1.0000E-03	3.0000E-01
1989	-1.0000E-03	3.0000E-01
1990	9.2840E+04	3.0000E-01
1991	3.7572E+04	3.0000E-01
1992	-1.0000E-03	3.0000E-01
1993	2.0838E+04	3.0000E-01
1994	-1.0000E-03	3.0000E-01
1995	-1.0000E-03	3.0000E-01
1996	-1.0000E-03	3.0000E-01
1997	-1.0000E-03	3.0000E-01
1998	-1.0000E-03	3.0000E-01
1999	-1.0000E-03	3.0000E-01
2000	-1.0000E-03	3.0000E-01
2001	-1.0000E-03	3.0000E-01
2002	-1.0000E-03	3.0000E-01
2003	-1.0000E-03	3.0000E-01
2004	-1.0000E-03	3.0000E-01
2005	-1.0000E-03	3.0000E-01
2006	-1.0000E-03	3.0000E-01
2007	-1.0000E-03	3.0000E-01
2008	-1.0000E-03	3.0000E-01
2009	-1.0000E-03	3.0000E-01
2010	-1.0000E-03	3.0000E-01
2011	-1.0000E-03	3.0000E-01
2012	-1.0000E-03	3.0000E-01
2013	-1.0000E-03	3.0000E-01
2014	-1.0000E-03	3.0000E-01
2015	-1.0000E-03	3.0000E-01
2016	-1.0000E-03	3.0000E-01
2017	-1.0000E-03	3.0000E-01
2018	-1.0000E-03	3.0000E-01
2019	-1.0000E-03	3.0000E-01

"3L autumn survey"
I2

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	-1.0000E-03	3.0000E-01
1979	-1.0000E-03	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	-1.0000E-03	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	-1.0000E-03	3.0000E-01
1985	9.8233E+04	3.0000E-01
1986	1.7119E+04	3.0000E-01
1987	-1.0000E-03	3.0000E-01
1988	-1.0000E-03	3.0000E-01
1989	-1.0000E-03	3.0000E-01
1990	2.0743E+04	3.0000E-01
1991	-1.0000E-03	3.0000E-01
1992	-1.0000E-03	3.0000E-01
1993	-1.0000E-03	3.0000E-01
1994	-1.0000E-03	3.0000E-01
1995	-1.0000E-03	3.0000E-01
1996	-1.0000E-03	3.0000E-01
1997	-1.0000E-03	3.0000E-01
1998	-1.0000E-03	3.0000E-01
1999	-1.0000E-03	3.0000E-01
2000	-1.0000E-03	3.0000E-01
2001	-1.0000E-03	3.0000E-01
2002	-1.0000E-03	3.0000E-01
2003	-1.0000E-03	3.0000E-01
2004	-1.0000E-03	3.0000E-01
2005	-1.0000E-03	3.0000E-01
2006	-1.0000E-03	3.0000E-01
2007	-1.0000E-03	3.0000E-01
2008	-1.0000E-03	3.0000E-01
2009	-1.0000E-03	3.0000E-01
2010	-1.0000E-03	3.0000E-01
2011	-1.0000E-03	3.0000E-01
2012	-1.0000E-03	3.0000E-01
2013	-1.0000E-03	3.0000E-01
2014	-1.0000E-03	3.0000E-01
2015	-1.0000E-03	3.0000E-01
2016	-1.0000E-03	3.0000E-01
2017	-1.0000E-03	3.0000E-01
2018	-1.0000E-03	3.0000E-01
2019	-1.0000E-03	3.0000E-01

"3N spanish survey"
I1

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	-1.0000E-03	3.0000E-01
1979	-1.0000E-03	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	-1.0000E-03	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	-1.0000E-03	3.0000E-01
1985	-1.0000E-03	3.0000E-01
1986	-1.0000E-03	3.0000E-01
1987	-1.0000E-03	3.0000E-01
1988	-1.0000E-03	3.0000E-01
1989	-1.0000E-03	3.0000E-01
1990	-1.0000E-03	3.0000E-01
1991	-1.0000E-03	3.0000E-01
1992	-1.0000E-03	3.0000E-01
1993	-1.0000E-03	3.0000E-01
1994	-1.0000E-03	3.0000E-01
1995	4.6084E+04	3.0000E-01
1996	6.5580E+03	3.0000E-01
1997	4.7530E+03	3.0000E-01
1998	2.2540E+04	3.0000E-01
1999	4.6459E+04	3.0000E-01
2000	6.8928E+04	3.0000E-01
2001	5.3855E+04	3.0000E-01
2002	7.6200E+03	3.0000E-01
2003	1.1031E+04	3.0000E-01
2004	2.7016E+04	3.0000E-01
2005	1.4692E+05	3.0000E-01
2006	8.7830E+04	3.0000E-01
2007	8.7602E+04	3.0000E-01
2008	6.8059E+04	3.0000E-01
2009	7.3574E+05	3.0000E-01
2010	3.5954E+05	3.0000E-01
2011	4.1830E+05	3.0000E-01
2012	2.6524E+05	3.0000E-01
2013	4.2953E+05	3.0000E-01
2014	1.7805E+05	3.0000E-01
2015	5.2346E+05	3.0000E-01
2016	1.1727E+05	3.0000E-01
2017	2.6590E+05	3.0000E-01
2018	2.9282E+05	3.0000E-01
2019	1.7464E+05	3.0000E-01

"3L spanish survey"
I1

1959	-1.0000E-03	3.0000E-01
1960	-1.0000E-03	3.0000E-01
1961	-1.0000E-03	3.0000E-01
1962	-1.0000E-03	3.0000E-01
1963	-1.0000E-03	3.0000E-01
1964	-1.0000E-03	3.0000E-01
1965	-1.0000E-03	3.0000E-01
1966	-1.0000E-03	3.0000E-01
1967	-1.0000E-03	3.0000E-01
1968	-1.0000E-03	3.0000E-01
1969	-1.0000E-03	3.0000E-01
1970	-1.0000E-03	3.0000E-01
1971	-1.0000E-03	3.0000E-01
1972	-1.0000E-03	3.0000E-01
1973	-1.0000E-03	3.0000E-01
1974	-1.0000E-03	3.0000E-01
1975	-1.0000E-03	3.0000E-01
1976	-1.0000E-03	3.0000E-01
1977	-1.0000E-03	3.0000E-01
1978	-1.0000E-03	3.0000E-01
1979	-1.0000E-03	3.0000E-01
1980	-1.0000E-03	3.0000E-01
1981	-1.0000E-03	3.0000E-01
1982	-1.0000E-03	3.0000E-01
1983	-1.0000E-03	3.0000E-01
1984	-1.0000E-03	3.0000E-01
1985	-1.0000E-03	3.0000E-01
1986	-1.0000E-03	3.0000E-01
1987	-1.0000E-03	3.0000E-01
1988	-1.0000E-03	3.0000E-01
1989	-1.0000E-03	3.0000E-01
1990	-1.0000E-03	3.0000E-01
1991	-1.0000E-03	3.0000E-01
1992	-1.0000E-03	3.0000E-01
1993	-1.0000E-03	3.0000E-01
1994	-1.0000E-03	3.0000E-01
1995	-1.0000E-03	3.0000E-01
1996	-1.0000E-03	3.0000E-01
1997	-1.0000E-03	3.0000E-01
1998	-1.0000E-03	3.0000E-01
1999	-1.0000E-03	3.0000E-01
2000	-1.0000E-03	3.0000E-01
2001	-1.0000E-03	3.0000E-01
2002	-1.0000E-03	3.0000E-01
2003	-1.0000E-03	3.0000E-01
2004	-1.0000E-03	3.0000E-01
2005	-1.0000E-03	3.0000E-01
2006	7.0066E+04	3.0000E-01
2007	3.1410E+04	3.0000E-01
2008	7.5567E+04	3.0000E-01
2009	1.0368E+05	3.0000E-01
2010	2.6675E+05	3.0000E-01
2011	1.7063E+05	3.0000E-01
2012	4.8147E+05	3.0000E-01
2013	2.3516E+05	3.0000E-01
2014	2.1641E+05	3.0000E-01
2015	1.3042E+05	3.0000E-01
2016	9.8807E+04	3.0000E-01
2017	5.6557E+04	3.0000E-01
2018	4.0350E+04	3.0000E-01
2019	5.4019E+04	3.0000E-01

Appendix 2 ASPIC Fit 2020 results

3LN redfish
Saturday, 02 May 2020 at 20:00:36

ASPIC -- A Surplus-Production Model Including Covariates (BETA Ver. 7.03)

FIT program mode

Author: Michael H. Prager
Prager Consulting
http://www.mhprager.com

LOGISTIC model mode
YLD conditioning
SSE optimization

Reference: Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fishery Bulletin 92: 374-389.

ASPIC program and user's guide
available gratis at www.mhprager.com

CONTROL PARAMETERS (FROM INPUT FILE) Input file: C:/...h3LN/ASPIC3LN/2020/ASPIC20 fit/ASPIC20q2018estimatefit.a7inp

Operation of ASPIC: Fit logistic (Schaefer) model by direct optimization.

Number of years analyzed:	61	Number of bootstrap trials:	0
Number of data series:	9	Objective function:	Least squares
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:	18
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 should be checked.
Number of restarts required for convergence: 30

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	27						
3	3LN autumn survey	0.700	0.589	1.000					
		4	26	28					
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	0.733	-1.000	1.000	0.964	1.000	1.000		
		8	2	2	4	2	8		
7	3L autumn survey	-0.108	0.000	0.000	0.751	0.959	1.000	1.000	
		3	0	0	3	3	2	3	
8	3N spanish survey	0.000	0.448	0.680	0.000	0.000	0.000	0.000	1.000
		0	23	24	0	0	0	0	25
9	3L spanish survey	0.000	0.135	0.789	0.000	0.000	0.000	0.000	0.195	1.000
		0	12	13	0	0	0	0	14	14
		1	2	3	4	5	6	7	8	9

GOODNESS-OF-FIT AND WEIGHTING (NON-BOOTSTRAPPED ANALYSIS)

Objective function component: label and source of variance	Weighted SSE	N	Weighted MSE	Current weight	Inv. var. weight	R-squared in CPUE
Loss(-1) Unmatched yield	0.000E+00					
Loss(0) Penalty on B1 > K	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1) Statlant CPUE	6.770E+00	36	1.991E-01	1.000E+00	1.756E+00	-0.271
Loss(2) 3LN spring survey	1.314E+01	27	5.255E-01	1.000E+00	6.655E-01	0.407
Loss(3) 3LN autumn survey	1.021E+01	28	3.926E-01	1.000E+00	8.906E-01	0.520
Loss(4) 3LN Power russian survey	3.471E+00	8	5.784E-01	1.000E+00	6.046E-01	0.262
Loss(5) 3L winter survey	4.357E-01	3	4.357E-01	1.000E+00	8.026E-01	0.416
Loss(6) 3L summer survey	8.122E-01	8	1.354E-01	1.000E+00	2.583E+00	0.744
Loss(7) 3L autumn survey	1.454E+00	3	1.454E+00	1.000E+00	2.406E-01	0.250
Loss(8) 3N spanish survey	2.055E+01	25	8.934E-01	1.000E+00	3.914E-01	0.217
Loss(9) 3L spanish survey	7.877E+00	14	6.564E-01	1.000E+00	5.327E-01	-0.080
TOTAL OBJECTIVE FUNCTION, MSE, RMSE:	6.47136764E+01		4.590E-01	6.775E-01		

Estimated contrast index (good=0.5, best=1.0): 0.7347 ..... Mean of B coverage proportions > and < Bmsy
Estimated nearness index (best=1.0): 1.0000 ..... Proportional closeness of any B to Bmsy

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	User guess	2nd guess	Min bound	Max bound	Estim?
B1/K	Starting relative biomass (in 1959)	7.204E-01	5.000E-01	2.874E+00	5.000E-02	3.000E+00	1
MSY	Maximum sustainable yield	2.100E+04	2.100E+04	2.100E+04	2.100E+04	2.100E+04	0
Fmsy	Fishing mortality rate at MSY	1.136E-01	8.400E-02	1.029E-01	4.200E-03	8.400E-01	1
phi	Shape of production curve (Bmsy/K)	0.5000	0.5000	-----	-----	-----	0
q(1)	Statlant CPUE	8.136E-06	8.240E-06	5.320E-06	1.370E-07	8.240E-04	1
q(2)	3LN spring survey	6.805E-01	7.810E-01	3.892E-01	1.300E-02	4.690E+00	1
q(3)	3LN autumn survey	1.145E+00	1.300E+00	6.335E-01	2.170E-02	7.790E+00	1
q(4)	3LN Power russian survey	3.111E-01	3.130E-01	1.408E-01	5.210E-03	1.200E+00	1
q(5)	3L winter survey	2.452E-01	2.460E-01	1.585E-02	4.100E-03	1.200E+00	1
q(6)	3L summer survey	9.956E-01	1.010E+00	3.353E-01	1.680E-02	6.050E+00	1
q(7)	3L autumn survey	2.263E-01	2.280E-01	2.499E-01	3.790E-03	1.200E+00	1
q(8)	3N spanish survey	6.981E-01	7.680E-01	9.636E-01	1.280E-02	4.610E+00	1
q(9)	3L spanish survey	4.675E-01	6.020E-01	1.685E-01	1.000E-02	3.610E+00	1

MANAGEMENT and DERIVED PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Logistic formula	General formula
MSY	Maximum sustainable yield	2.100E+04	----	----
Bmsy	Stock biomass giving MSY	1.849E+05	K/2	K*n**(1/(1-n))
K	Carrying capacity	3.697E+05	2*Bmsy	Bmsy/phi
n	Exponent in production function	2.0000	----	----
g	Fletcher's gamma	4.000E+00	----	[n**(n/(n-1))]/[n-1]
B./Bmsy	Ratio: B(2020)/Bmsy	1.588E+00	----	----
F./Fmsy	Ratio: F(2019)/Fmsy	3.917E-01	----	----
Fmsy/F.	Ratio: Fmsy/F(2019)	2.553E+00	----	----
Y.(Fmsy)	Approx. yield available at Fmsy in 2020	3.232E+04	MSY*B./Bmsy	MSY*B./Bmsy
	...as proportion of MSY	1.539E+00	----	----
Ye.	Equilibrium yield available in 2020	1.373E+04	4*MSY*(B/K-(B/K)**2)	g*MSY*(B/K-(B/K)**n)
	...as proportion of MSY	6.540E-01	----	----
---------	Fishing effort rate at MSY in units of each CE or CC series ---------			
fmsy(1)	Statlant CPUE	1.396E+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	0.177	2.664E+05	2.526E+05	4.458E+04	4.458E+04	1.815E+04	1.554E+00	1.441E+00
2	1960	0.112	2.399E+05	2.362E+05	2.656E+04	2.656E+04	1.938E+04	9.898E-01	1.298E+00
3	1961	0.100	2.327E+05	2.310E+05	2.317E+04	2.317E+04	1.969E+04	8.834E-01	1.259E+00
4	1962	0.094	2.293E+05	2.284E+05	2.144E+04	2.144E+04	1.983E+04	8.262E-01	1.240E+00
5	1963	0.122	2.277E+05	2.239E+05	2.736E+04	2.736E+04	2.006E+04	1.076E+00	1.231E+00
6	1964	0.046	2.204E+05	2.253E+05	1.026E+04	1.026E+04	1.999E+04	4.009E-01	1.192E+00
7	1965	0.103	2.301E+05	2.282E+05	2.347E+04	2.347E+04	1.984E+04	9.051E-01	1.245E+00
8	1966	0.074	2.265E+05	2.279E+05	1.697E+04	1.697E+04	1.986E+04	6.556E-01	1.225E+00
9	1967	0.120	2.293E+05	2.256E+05	2.719E+04	2.719E+04	1.998E+04	1.061E+00	1.241E+00
10	1968	0.079	2.221E+05	2.234E+05	1.766E+04	1.766E+04	2.009E+04	6.960E-01	1.202E+00
11	1969	0.111	2.246E+05	2.222E+05	2.475E+04	2.475E+04	2.014E+04	9.806E-01	1.215E+00
12	1970	0.065	2.200E+05	2.229E+05	1.442E+04	1.442E+04	2.011E+04	5.696E-01	1.190E+00
13	1971	0.157	2.256E+05	2.184E+05	3.437E+04	3.437E+04	2.030E+04	1.386E+00	1.221E+00
14	1972	0.140	2.116E+05	2.073E+05	2.893E+04	2.893E+04	2.069E+04	1.228E+00	1.144E+00
15	1973	0.169	2.033E+05	1.969E+05	3.330E+04	3.330E+04	2.090E+04	1.488E+00	1.100E+00
16	1974	0.117	1.909E+05	1.903E+05	2.229E+04	2.229E+04	2.098E+04	1.031E+00	1.033E+00
17	1975	0.093	1.896E+05	1.912E+05	1.787E+04	1.787E+04	2.097E+04	8.228E-01	1.026E+00
18	1976	0.106	1.927E+05	1.930E+05	2.051E+04	2.051E+04	2.096E+04	9.358E-01	1.043E+00
19	1977	0.085	1.932E+05	1.954E+05	1.652E+04	1.652E+04	2.093E+04	7.440E-01	1.045E+00
20	1978	0.060	1.976E+05	2.020E+05	1.204E+04	1.204E+04	2.081E+04	5.247E-01	1.069E+00
21	1979	0.067	2.064E+05	2.097E+05	1.407E+04	1.407E+04	2.062E+04	5.905E-01	1.116E+00
22	1980	0.075	2.129E+05	2.152E+05	1.603E+04	1.603E+04	2.043E+04	6.559E-01	1.152E+00
23	1981	0.113	2.173E+05	2.153E+05	2.428E+04	2.428E+04	2.043E+04	9.925E-01	1.176E+00
24	1982	0.101	2.135E+05	2.129E+05	2.155E+04	2.155E+04	2.052E+04	8.908E-01	1.155E+00
25	1983	0.093	2.124E+05	2.128E+05	1.975E+04	1.975E+04	2.052E+04	8.168E-01	1.149E+00
26	1984	0.068	2.132E+05	2.161E+05	1.476E+04	1.476E+04	2.040E+04	6.014E-01	1.153E+00
27	1985	0.094	2.188E+05	2.187E+05	2.056E+04	2.056E+04	2.030E+04	8.274E-01	1.184E+00
28	1986	0.207	2.186E+05	2.071E+05	4.280E+04	4.280E+04	2.067E+04	1.820E+00	1.182E+00
29	1987	0.479	1.965E+05	1.650E+05	7.903E+04	7.903E+04	2.058E+04	4.216E+00	1.063E+00
30	1988	0.446	1.380E+05	1.195E+05	5.327E+04	5.327E+04	1.831E+04	3.925E+00	7.465E-01
31	1989	0.359	1.030E+05	9.380E+04	3.365E+04	3.365E+04	1.589E+04	3.158E+00	5.574E-01
32	1990	0.376	8.529E+04	7.737E+04	2.910E+04	2.910E+04	1.389E+04	3.312E+00	4.614E-01
33	1991	0.411	7.007E+04	6.278E+04	2.582E+04	2.582E+04	1.183E+04	3.620E+00	3.790E-01
34	1992	0.588	5.609E+04	4.642E+04	2.728E+04	2.728E+04	9.206E+03	5.174E+00	3.034E-01
35	1993	0.715	3.801E+04	2.981E+04	2.131E+04	2.131E+04	6.214E+03	6.293E+00	2.056E-01
36	1994	0.256	2.292E+04	2.244E+04	5.741E+03	5.741E+03	4.788E+03	2.253E+00	1.240E-01
37	1995	0.085	2.196E+04	2.343E+04	1.989E+03	1.989E+03	4.986E+03	7.472E-01	1.188E-01
38	1996	0.016	2.496E+04	2.755E+04	4.510E+02	4.510E+02	5.792E+03	1.441E-01	1.350E-01
39	1997	0.019	3.030E+04	3.335E+04	6.300E+02	6.300E+02	6.891E+03	1.663E-01	1.639E-01
40	1998	0.022	3.656E+04	4.008E+04	8.990E+02	8.990E+02	8.116E+03	1.975E-01	1.978E-01
41	1999	0.049	4.378E+04	4.723E+04	2.318E+03	2.318E+03	9.357E+03	4.321E-01	2.368E-01
42	2000	0.058	5.082E+04	5.446E+04	3.141E+03	3.141E+03	1.055E+04	5.077E-01	2.749E-01
43	2001	0.023	5.823E+04	6.335E+04	1.442E+03	1.442E+03	1.192E+04	2.004E-01	3.150E-01
44	2002	0.016	6.871E+04	7.475E+04	1.216E+03	1.216E+03	1.354E+04	1.432E-01	3.716E-01
45	2003	0.015	8.103E+04	8.785E+04	1.334E+03	1.334E+03	1.521E+04	1.337E-01	4.383E-01
46	2004	0.006	9.490E+04	1.029E+05	6.370E+02	6.370E+02	1.686E+04	5.450E-02	5.134E-01
47	2005	0.005	1.111E+05	1.199E+05	6.590E+02	6.590E+02	1.839E+04	4.839E-02	6.011E-01
48	2006	0.004	1.289E+05	1.383E+05	4.960E+02	4.960E+02	1.965E+04	3.156E-02	6.970E-01
49	2007	0.011	1.480E+05	1.574E+05	1.664E+03	1.664E+03	2.052E+04	9.307E-02	8.006E-01
50	2008	0.003	1.669E+05	1.770E+05	5.970E+02	5.970E+02	2.094E+04	2.969E-02	9.026E-01
51	2009	0.005	1.872E+05	1.972E+05	1.051E+03	1.051E+03	2.089E+04	4.693E-02	1.013E+00
52	2010	0.019	2.070E+05	2.153E+05	4.120E+03	4.120E+03	2.042E+04	1.685E-01	1.120E+00
53	2011	0.016	2.233E+05	2.314E+05	3.672E+03	3.672E+03	1.965E+04	1.397E-01	1.208E+00
54	2012	0.018	2.393E+05	2.466E+05	4.316E+03	4.316E+03	1.865E+04	1.541E-01	1.295E+00
55	2013	0.024	2.537E+05	2.594E+05	6.232E+03	6.232E+03	1.758E+04	2.115E-01	1.372E+00
56	2014	0.021	2.650E+05	2.705E+05	5.695E+03	5.695E+03	1.649E+04	1.853E-01	1.433E+00
57	2015	0.036	2.758E+05	2.787E+05	9.940E+03	9.940E+03	1.559E+04	3.140E-01	1.492E+00
58	2016	0.031	2.814E+05	2.846E+05	8.686E+03	8.686E+03	1.488E+04	2.687E-01	1.522E+00
59	2017	0.041	2.876E+05	2.889E+05	1.181E+04	1.181E+04	1.434E+04	3.600E-01	1.556E+00
60	2018	0.039	2.902E+05	2.916E+05	1.128E+04	1.128E+04	1.400E+04	3.405E-01	1.570E+00
61	2019	0.044	2.929E+05	2.933E+05	1.305E+04	1.305E+04	1.378E+04	3.917E-01	1.584E+00
62	2020		2.936E+05						1.588E+00

3LN redfish
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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	2.055E+00	0.1765	4.458E+04	4.458E+04	0.36542	1.000E+00
2	1960	1.602E+00	1.922E+00	0.1124	2.656E+04	2.656E+04	0.18214	1.000E+00
3	1961	1.697E+00	1.879E+00	0.1003	2.317E+04	2.317E+04	0.10195	1.000E+00
4	1962	1.631E+00	1.859E+00	0.0939	2.144E+04	2.144E+04	0.13066	1.000E+00
5	1963	1.632E+00	1.822E+00	0.1222	2.736E+04	2.736E+04	0.10998	1.000E+00
6	1964	1.812E+00	1.833E+00	0.0455	1.026E+04	1.026E+04	0.01156	1.000E+00
7	1965	2.185E+00	1.857E+00	0.1028	2.347E+04	2.347E+04	-0.16270	1.000E+00
8	1966	1.781E+00	1.855E+00	0.0745	1.697E+04	1.697E+04	0.04046	1.000E+00
9	1967	1.893E+00	1.836E+00	0.1205	2.719E+04	2.719E+04	-0.03064	1.000E+00
10	1968	9.220E-01	1.817E+00	0.0791	1.766E+04	1.766E+04	0.67864	1.000E+00
11	1969	1.338E+00	1.808E+00	0.1114	2.475E+04	2.475E+04	0.30097	1.000E+00
12	1970	1.367E+00	1.813E+00	0.0647	1.442E+04	1.442E+04	0.28248	1.000E+00
13	1971	1.346E+00	1.777E+00	0.1574	3.437E+04	3.437E+04	0.27767	1.000E+00
14	1972	1.387E+00	1.687E+00	0.1395	2.893E+04	2.893E+04	0.19578	1.000E+00
15	1973	1.643E+00	1.602E+00	0.1691	3.330E+04	3.330E+04	-0.02503	1.000E+00
16	1974	1.290E+00	1.548E+00	0.1171	2.229E+04	2.229E+04	0.18238	1.000E+00
17	1975	1.669E+00	1.556E+00	0.0935	1.787E+04	1.787E+04	-0.07028	1.000E+00
18	1976	1.292E+00	1.570E+00	0.1063	2.051E+04	2.051E+04	0.19488	1.000E+00
19	1977	1.251E+00	1.590E+00	0.0845	1.652E+04	1.652E+04	0.23981	1.000E+00
20	1978	1.106E+00	1.644E+00	0.0596	1.204E+04	1.204E+04	0.39630	1.000E+00
21	1979	1.451E+00	1.706E+00	0.0671	1.407E+04	1.407E+04	0.16199	1.000E+00
22	1980	1.761E+00	1.751E+00	0.0745	1.603E+04	1.603E+04	-0.00591	1.000E+00
23	1981	1.594E+00	1.752E+00	0.1127	2.428E+04	2.428E+04	0.09459	1.000E+00
24	1982	1.661E+00	1.733E+00	0.1012	2.155E+04	2.155E+04	0.04219	1.000E+00
25	1983	1.556E+00	1.732E+00	0.0928	1.975E+04	1.975E+04	0.10697	1.000E+00
26	1984	1.049E+00	1.758E+00	0.0683	1.476E+04	1.476E+04	0.51640	1.000E+00
27	1985	1.084E+00	1.780E+00	0.0940	2.056E+04	2.056E+04	0.49570	1.000E+00
28	1986	1.413E+00	1.685E+00	0.2067	4.280E+04	4.280E+04	0.17602	1.000E+00
29	1987	1.523E+00	1.343E+00	0.4789	7.903E+04	7.903E+04	-0.12603	1.000E+00
30	1988	1.208E+00	9.720E-01	0.4459	5.327E+04	5.327E+04	-0.21737	1.000E+00
31	1989	1.322E+00	7.632E-01	0.3587	3.365E+04	3.365E+04	-0.54936	1.000E+00
32	1990	8.250E-01	6.295E-01	0.3762	2.910E+04	2.910E+04	-0.27043	1.000E+00
33	1991	6.680E-01	5.108E-01	0.4112	2.582E+04	2.582E+04	-0.26838	1.000E+00
34	1992	9.120E-01	3.777E-01	0.5877	2.728E+04	2.728E+04	-0.88155	1.000E+00
35	1993	8.010E-01	2.425E-01	0.7149	2.131E+04	2.131E+04	-1.19479	1.000E+00
36	1994	8.020E-01	1.825E-01	0.2559	5.741E+03	5.741E+03	-1.48011	1.000E+00
37	1995	*	1.907E-01	0.0849	1.989E+03	1.989E+03	0.00000	1.000E+00
38	1996	*	2.242E-01	0.0164	4.510E+02	4.510E+02	0.00000	1.000E+00
39	1997	*	2.713E-01	0.0189	6.300E+02	6.300E+02	0.00000	1.000E+00
40	1998	*	3.261E-01	0.0224	8.990E+02	8.990E+02	0.00000	1.000E+00
41	1999	*	3.843E-01	0.0491	2.318E+03	2.318E+03	0.00000	1.000E+00
42	2000	*	4.431E-01	0.0577	3.141E+03	3.141E+03	0.00000	1.000E+00
43	2001	*	5.155E-01	0.0228	1.442E+03	1.442E+03	0.00000	1.000E+00
44	2002	*	6.082E-01	0.0163	1.216E+03	1.216E+03	0.00000	1.000E+00
45	2003	*	7.148E-01	0.0152	1.334E+03	1.334E+03	0.00000	1.000E+00
46	2004	*	8.371E-01	0.0062	6.370E+02	6.370E+02	0.00000	1.000E+00
47	2005	*	9.754E-01	0.0055	6.590E+02	6.590E+02	0.00000	1.000E+00
48	2006	*	1.126E+00	0.0036	4.960E+02	4.960E+02	0.00000	1.000E+00
49	2007	*	1.281E+00	0.0106	1.664E+03	1.664E+03	0.00000	1.000E+00
50	2008	*	1.440E+00	0.0034	5.970E+02	5.970E+02	0.00000	1.000E+00
51	2009	*	1.604E+00	0.0053	1.051E+03	1.051E+03	0.00000	1.000E+00
52	2010	*	1.752E+00	0.0191	4.120E+03	4.120E+03	0.00000	1.000E+00
53	2011	*	1.883E+00	0.0159	3.672E+03	3.672E+03	0.00000	1.000E+00
54	2012	*	2.006E+00	0.0175	4.316E+03	4.316E+03	0.00000	1.000E+00
55	2013	*	2.111E+00	0.0240	6.232E+03	6.232E+03	0.00000	1.000E+00
56	2014	*	2.201E+00	0.0211	5.695E+03	5.695E+03	0.00000	1.000E+00
57	2015	*	2.267E+00	0.0357	9.940E+03	9.940E+03	0.00000	1.000E+00
58	2016	*	2.316E+00	0.0305	8.686E+03	8.686E+03	0.00000	1.000E+00
59	2017	*	2.351E+00	0.0409	1.181E+04	1.181E+04	0.00000	1.000E+00
60	2018	*	2.372E+00	0.0387	1.128E+04	1.128E+04	0.00000	1.000E+00
61	2019	*	2.386E+00	0.0445	1.305E+04	1.305E+04	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
1959	0.3654	|=======
1960	0.1821	|====
1961	0.1019	|==
1962	0.1307	|===
1963	0.1100	|==
1964	0.0116	|
1965	-0.1627	===|
1966	0.0405	|=
1967	-0.0306	=|
1968	0.6786	|==============
1969	0.3010	|======
1970	0.2825	|======
1971	0.2777	|======
1972	0.1958	|====
1973	-0.0250	=|
1974	0.1824	|====
1975	-0.0703	=|
1976	0.1949	|====
1977	0.2398	|=====
1978	0.3963	|========
1979	0.1620	|===
1980	-0.0059	|
1981	0.0946	|==
1982	0.0422	|=
1983	0.1070	|==
1984	0.5164	|==========
1985	0.4957	|==========
1986	0.1760	|====
1987	-0.1260	===|
1988	-0.2174	====|
1989	-0.5494	==========|
1990	-0.2704	=====|
1991	-0.2684	=====|
1992	-0.8816	==================|
1993	-1.1948	========================|
1994	-1.4801	==============================|
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	|
2008	0.0000	|
2009	0.0000	|
2010	0.0000	|
2011	0.0000	|
2012	0.0000	|
2013	0.0000	|
2014	0.0000	|
2015	0.0000	|
2016	0.0000	|
2017	0.0000	|
2018	0.0000	|
2019	0.0000	|

3LN redfish
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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	--	*	1.719E+05	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	1.607E+05	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	1.572E+05	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	1.554E+05	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	1.524E+05	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	1.533E+05	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	1.553E+05	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	1.551E+05	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	1.535E+05	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	1.520E+05	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	1.512E+05	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	1.516E+05	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	1.486E+05	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	1.411E+05	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	1.340E+05	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	1.295E+05	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	1.301E+05	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	1.313E+05	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	1.330E+05	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	1.375E+05	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	1.427E+05	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	1.464E+05	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	1.465E+05	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	1.449E+05	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	1.448E+05	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	1.470E+05	0.00000	1.000E+00
27	1985	0.000E+00	0.000E+00	--	*	1.488E+05	0.00000	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	1.409E+05	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	1.123E+05	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	8.129E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	6.383E+04	0.00000	1.000E+00
32	1990	0.000E+00	0.000E+00	--	*	5.265E+04	0.00000	1.000E+00
33	1991	1.000E+00	1.000E+00	--	1.064E+04	4.272E+04	-1.38974	1.000E+00
34	1992	1.000E+00	1.000E+00	--	1.007E+04	3.159E+04	-1.14357	1.000E+00
35	1993	1.000E+00	1.000E+00	--	2.257E+04	2.028E+04	0.10704	1.000E+00
36	1994	1.000E+00	1.000E+00	--	4.162E+03	1.527E+04	-1.29964	1.000E+00
37	1995	1.000E+00	1.000E+00	--	5.856E+03	1.595E+04	-1.00171	1.000E+00
38	1996	1.000E+00	1.000E+00	--	2.281E+04	1.875E+04	0.19620	1.000E+00
39	1997	1.000E+00	1.000E+00	--	1.493E+04	2.269E+04	-0.41866	1.000E+00
40	1998	1.000E+00	1.000E+00	--	5.940E+04	2.727E+04	0.77852	1.000E+00
41	1999	1.000E+00	1.000E+00	--	6.150E+04	3.214E+04	0.64899	1.000E+00
42	2000	1.000E+00	1.000E+00	--	8.784E+04	3.706E+04	0.86311	1.000E+00
43	2001	1.000E+00	1.000E+00	--	4.157E+04	4.311E+04	-0.03629	1.000E+00
44	2002	1.000E+00	1.000E+00	--	3.096E+04	5.086E+04	-0.49641	1.000E+00
45	2003	1.000E+00	1.000E+00	--	2.770E+04	5.977E+04	-0.76914	1.000E+00
46	2004	1.000E+00	1.000E+00	--	7.963E+04	7.001E+04	0.12880	1.000E+00
47	2005	1.000E+00	1.000E+00	--	6.646E+04	8.157E+04	-0.20483	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	9.414E+04	0.00000	1.000E+00
49	2007	1.000E+00	1.000E+00	--	2.188E+05	1.071E+05	0.71461	1.000E+00
50	2008	1.000E+00	1.000E+00	--	1.440E+05	1.205E+05	0.17840	1.000E+00
51	2009	1.000E+00	1.000E+00	--	1.834E+05	1.342E+05	0.31257	1.000E+00
52	2010	1.000E+00	1.000E+00	--	1.653E+05	1.465E+05	0.12119	1.000E+00
53	2011	1.000E+00	1.000E+00	--	1.737E+05	1.575E+05	0.09801	1.000E+00
54	2012	1.000E+00	1.000E+00	--	3.220E+05	1.678E+05	0.65174	1.000E+00
55	2013	1.000E+00	1.000E+00	--	2.715E+05	1.765E+05	0.43051	1.000E+00
56	2014	1.000E+00	1.000E+00	--	2.717E+05	1.841E+05	0.38960	1.000E+00
57	2015	1.000E+00	1.000E+00	--	4.806E+05	1.896E+05	0.92989	1.000E+00
58	2016	1.000E+00	1.000E+00	--	6.542E+05	1.937E+05	1.21731	1.000E+00
59	2017	0.000E+00	0.000E+00	--	*	1.966E+05	0.00000	1.000E+00
60	2018	1.000E+00	1.000E+00	--	1.060E+05	1.984E+05	-0.62709	1.000E+00
61	2019	1.000E+00	1.000E+00	--	1.365E+05	1.995E+05	-0.37973	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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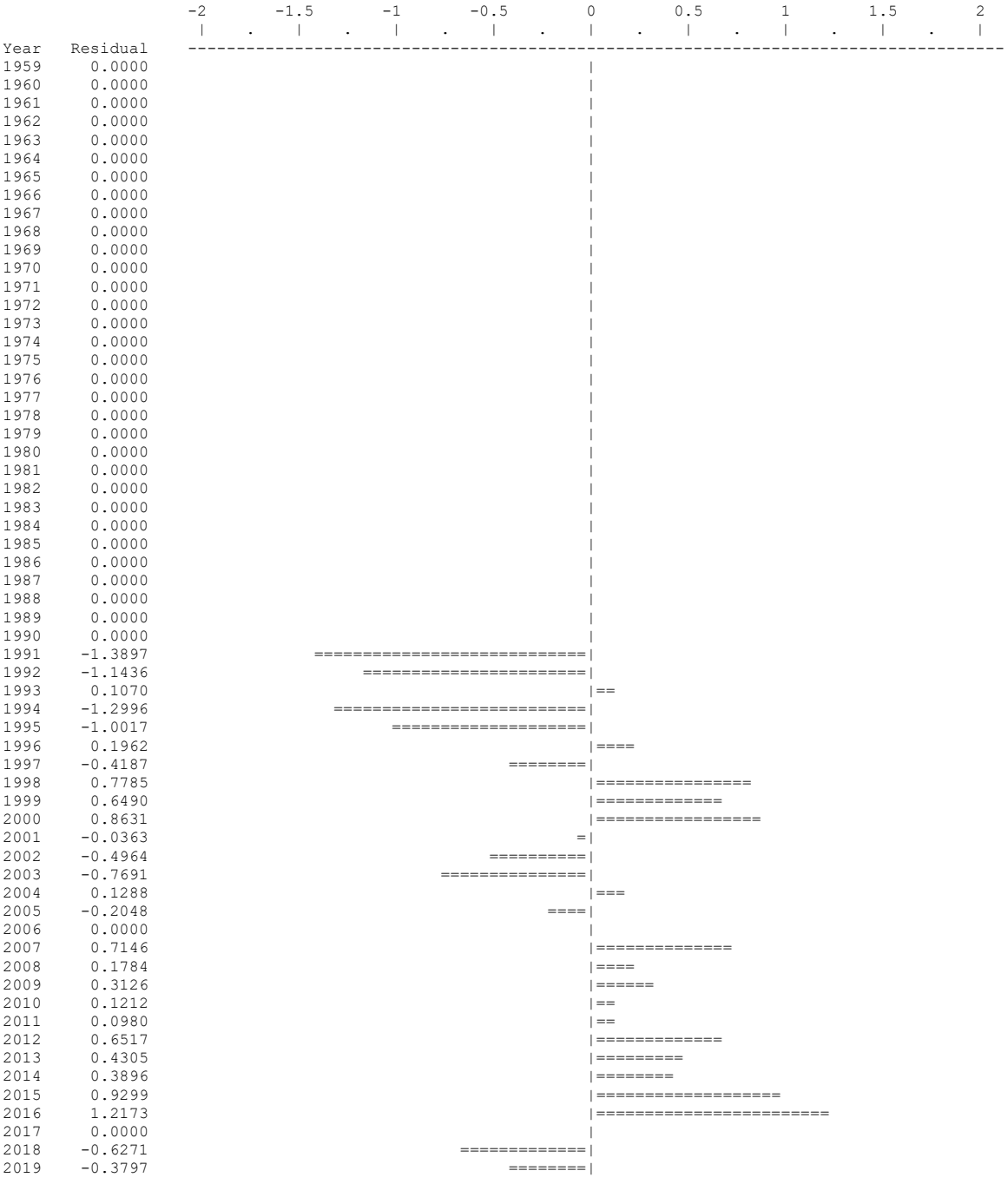
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2



3LN redfish
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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	--	*	2.746E+05	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	2.664E+05	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	2.624E+05	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	2.606E+05	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	2.522E+05	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	2.633E+05	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	2.592E+05	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	2.625E+05	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	2.542E+05	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	2.570E+05	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	2.518E+05	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	2.583E+05	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	2.422E+05	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	2.327E+05	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	2.185E+05	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	2.170E+05	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	2.206E+05	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	2.211E+05	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	2.262E+05	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	2.362E+05	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	2.437E+05	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	2.487E+05	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	2.443E+05	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	2.432E+05	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	2.440E+05	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	2.505E+05	0.00000	1.000E+00
27	1985	0.000E+00	0.000E+00	--	*	2.502E+05	0.00000	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	2.249E+05	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	1.580E+05	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	1.179E+05	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	9.762E+04	0.00000	1.000E+00
32	1990	0.000E+00	0.000E+00	--	*	8.020E+04	0.00000	1.000E+00
33	1991	1.000E+00	1.000E+00	--	3.789E+04	6.420E+04	-0.52738	1.000E+00
34	1992	1.000E+00	1.000E+00	--	1.364E+05	4.351E+04	1.14277	1.000E+00
35	1993	1.000E+00	1.000E+00	--	1.923E+04	2.623E+04	-0.31028	1.000E+00
36	1994	1.000E+00	1.000E+00	--	3.176E+04	2.514E+04	0.23368	1.000E+00
37	1995	1.000E+00	1.000E+00	--	9.073E+04	2.857E+04	1.15551	1.000E+00
38	1996	1.000E+00	1.000E+00	--	1.597E+04	3.468E+04	-0.77566	1.000E+00
39	1997	1.000E+00	1.000E+00	--	7.066E+04	4.185E+04	0.52381	1.000E+00
40	1998	1.000E+00	1.000E+00	--	1.122E+05	5.011E+04	0.80626	1.000E+00
41	1999	1.000E+00	1.000E+00	--	7.199E+04	5.817E+04	0.21317	1.000E+00
42	2000	1.000E+00	1.000E+00	--	1.005E+05	6.664E+04	0.41040	1.000E+00
43	2001	1.000E+00	1.000E+00	--	1.326E+05	7.864E+04	0.52225	1.000E+00
44	2002	1.000E+00	1.000E+00	--	5.012E+04	9.275E+04	-0.61538	1.000E+00
45	2003	1.000E+00	1.000E+00	--	7.189E+04	1.086E+05	-0.41277	1.000E+00
46	2004	1.000E+00	1.000E+00	--	4.991E+04	1.272E+05	-0.93552	1.000E+00
47	2005	1.000E+00	1.000E+00	--	5.856E+04	1.475E+05	-0.92364	1.000E+00
48	2006	1.000E+00	1.000E+00	--	9.188E+04	1.694E+05	-0.61179	1.000E+00
49	2007	1.000E+00	1.000E+00	--	1.248E+05	1.910E+05	-0.42582	1.000E+00
50	2008	1.000E+00	1.000E+00	--	1.985E+05	2.143E+05	-0.07652	1.000E+00
51	2009	1.000E+00	1.000E+00	--	2.467E+05	2.370E+05	0.04025	1.000E+00
52	2010	1.000E+00	1.000E+00	--	4.615E+05	2.556E+05	0.59072	1.000E+00
53	2011	1.000E+00	1.000E+00	--	5.623E+05	2.739E+05	0.71915	1.000E+00
54	2012	1.000E+00	1.000E+00	--	5.960E+05	2.903E+05	0.71921	1.000E+00
55	2013	1.000E+00	1.000E+00	--	2.888E+05	3.033E+05	-0.04920	1.000E+00
56	2014	0.000E+00	0.000E+00	--	*	3.157E+05	0.00000	1.000E+00
57	2015	1.000E+00	1.000E+00	--	4.259E+05	3.221E+05	0.27916	1.000E+00
58	2016	1.000E+00	1.000E+00	--	2.152E+05	3.292E+05	-0.42525	1.000E+00
59	2017	1.000E+00	1.000E+00	--	1.920E+05	3.321E+05	-0.54783	1.000E+00
60	2018	1.000E+00	1.000E+00	--	1.914E+05	3.352E+05	-0.56051	1.000E+00
61	2019	1.000E+00	1.000E+00	--	2.859E+05	3.361E+05	-0.16163	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 3

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
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	-0.5274	==========|
1992	1.1428	|======================
1993	-0.3103	======|
1994	0.2337	|=====
1995	1.1555	|======================
1996	-0.7757	==========|
1997	0.5238	|==========
1998	0.8063	|================
1999	0.2132	|====
2000	0.4104	|========
2001	0.5222	|==========
2002	-0.6154	==========|
2003	-0.4128	========|
2004	-0.9355	==========|
2005	-0.9236	==========|
2006	-0.6118	==========|
2007	-0.4258	========|
2008	-0.0765	==|
2009	0.0402	|=
2010	0.5907	|==========
2011	0.7191	|==============
2012	0.7192	|==============
2013	-0.0492	=|
2014	0.0000	|
2015	0.2792	|======
2016	-0.4253	========|
2017	-0.5478	==========|
2018	-0.5605	==========|
2019	-0.1616	===|

3LN redfish
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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	--	*	7.858E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	7.349E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	7.185E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	7.107E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	6.966E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	7.009E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	7.100E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	7.091E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	7.020E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	6.949E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	6.913E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	6.933E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	6.794E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	6.450E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	6.127E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	5.919E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	5.949E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	6.003E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	6.080E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	6.286E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	6.524E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	6.694E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	6.700E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	6.625E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	6.621E+04	0.00000	1.000E+00
26	1984	1.000E+00	1.000E+00	--	2.159E+05	6.722E+04	1.16668	1.000E+00
27	1985	1.000E+00	1.000E+00	--	9.400E+04	6.804E+04	0.32309	1.000E+00
28	1986	1.000E+00	1.000E+00	--	6.298E+04	6.443E+04	-0.02280	1.000E+00
29	1987	1.000E+00	1.000E+00	--	7.030E+04	5.134E+04	0.31429	1.000E+00
30	1988	1.000E+00	1.000E+00	--	4.488E+04	3.717E+04	0.18867	1.000E+00
31	1989	1.000E+00	1.000E+00	--	1.227E+04	2.918E+04	-0.86660	1.000E+00
32	1990	1.000E+00	1.000E+00	--	8.365E+03	2.407E+04	-1.05695	1.000E+00
33	1991	1.000E+00	1.000E+00	--	1.868E+04	1.953E+04	-0.04451	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	1.444E+04	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	9.273E+03	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	6.980E+03	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	7.291E+03	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	8.572E+03	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	1.037E+04	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	1.247E+04	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	1.469E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	1.694E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	1.971E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	2.325E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	2.733E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	3.201E+04	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	3.730E+04	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	4.304E+04	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	4.897E+04	0.00000	1.000E+00
50	2008	0.000E+00	0.000E+00	--	*	5.507E+04	0.00000	1.000E+00
51	2009	0.000E+00	0.000E+00	--	*	6.134E+04	0.00000	1.000E+00
52	2010	0.000E+00	0.000E+00	--	*	6.697E+04	0.00000	1.000E+00
53	2011	0.000E+00	0.000E+00	--	*	7.200E+04	0.00000	1.000E+00
54	2012	0.000E+00	0.000E+00	--	*	7.672E+04	0.00000	1.000E+00
55	2013	0.000E+00	0.000E+00	--	*	8.071E+04	0.00000	1.000E+00
56	2014	0.000E+00	0.000E+00	--	*	8.416E+04	0.00000	1.000E+00
57	2015	0.000E+00	0.000E+00	--	*	8.670E+04	0.00000	1.000E+00
58	2016	0.000E+00	0.000E+00	--	*	8.855E+04	0.00000	1.000E+00
59	2017	0.000E+00	0.000E+00	--	*	8.989E+04	0.00000	1.000E+00
60	2018	0.000E+00	0.000E+00	--	*	9.071E+04	0.00000	1.000E+00
61	2019	0.000E+00	0.000E+00	--	*	9.124E+04	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 4

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
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	1.1667	|=======================
1985	0.3231	|======
1986	-0.0228	|
1987	0.3143	|======
1988	0.1887	|====
1989	-0.8666	==================|
1990	-1.0569	====================|
1991	-0.0445	=|
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	|
2008	0.0000	|
2009	0.0000	|
2010	0.0000	|
2011	0.0000	|
2012	0.0000	|
2013	0.0000	|
2014	0.0000	|
2015	0.0000	|
2016	0.0000	|
2017	0.0000	|
2018	0.0000	|
2019	0.0000	|

3LN redfish
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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	--	*	6.530E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	5.882E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	5.706E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	5.620E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	5.581E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	5.402E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	5.640E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	5.552E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	5.622E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	5.446E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	5.505E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	5.392E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	5.532E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	5.187E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	4.985E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	4.681E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	4.649E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	4.725E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	4.736E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	4.844E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	5.059E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	5.220E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	5.328E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	5.233E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	5.208E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	5.227E+04	0.00000	1.000E+00
27	1985	1.000E+00	1.000E+00	--	9.024E+04	5.365E+04	0.52004	1.000E+00
28	1986	1.000E+00	1.000E+00	--	3.657E+04	5.359E+04	-0.38212	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	4.816E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	3.383E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	2.526E+04	0.00000	1.000E+00
32	1990	1.000E+00	1.000E+00	--	1.820E+04	2.091E+04	-0.13862	1.000E+00
33	1991	0.000E+00	0.000E+00	--	*	1.718E+04	0.00000	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	1.375E+04	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	9.318E+03	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	5.618E+03	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	5.384E+03	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	6.119E+03	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	7.428E+03	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	8.963E+03	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	1.073E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	1.246E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	1.427E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	1.684E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	1.986E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	2.327E+04	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	2.724E+04	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	3.159E+04	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	3.628E+04	0.00000	1.000E+00
50	2008	0.000E+00	0.000E+00	--	*	4.091E+04	0.00000	1.000E+00
51	2009	0.000E+00	0.000E+00	--	*	4.589E+04	0.00000	1.000E+00
52	2010	0.000E+00	0.000E+00	--	*	5.076E+04	0.00000	1.000E+00
53	2011	0.000E+00	0.000E+00	--	*	5.475E+04	0.00000	1.000E+00
54	2012	0.000E+00	0.000E+00	--	*	5.867E+04	0.00000	1.000E+00
55	2013	0.000E+00	0.000E+00	--	*	6.218E+04	0.00000	1.000E+00
56	2014	0.000E+00	0.000E+00	--	*	6.496E+04	0.00000	1.000E+00
57	2015	0.000E+00	0.000E+00	--	*	6.761E+04	0.00000	1.000E+00
58	2016	0.000E+00	0.000E+00	--	*	6.899E+04	0.00000	1.000E+00
59	2017	0.000E+00	0.000E+00	--	*	7.051E+04	0.00000	1.000E+00
60	2018	0.000E+00	0.000E+00	--	*	7.113E+04	0.00000	1.000E+00
61	2019	0.000E+00	0.000E+00	--	*	7.180E+04	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 5

Year	Residual	-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1
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	0.5200	|==========
1986	-0.3821	==========|
1987	0.0000	|
1988	0.0000	|
1989	0.0000	|
1990	-0.1386	======|
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	|
2008	0.0000	|
2009	0.0000	|
2010	0.0000	|
2011	0.0000	|
2012	0.0000	|
2013	0.0000	|
2014	0.0000	|
2015	0.0000	|
2016	0.0000	|
2017	0.0000	|
2018	0.0000	|
2019	0.0000	|

3LN redfish
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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	--	*	2.515E+05	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	2.352E+05	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	2.299E+05	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	2.274E+05	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	2.229E+05	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	2.243E+05	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	2.272E+05	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	2.269E+05	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	2.246E+05	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	2.224E+05	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	2.212E+05	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	2.219E+05	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	2.174E+05	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	2.064E+05	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	1.961E+05	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	1.894E+05	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	1.904E+05	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	1.921E+05	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	1.946E+05	0.00000	1.000E+00
20	1978	1.000E+00	1.000E+00	--	3.112E+05	2.011E+05	0.43631	1.000E+00
21	1979	1.000E+00	1.000E+00	--	2.278E+05	2.088E+05	0.08723	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	2.142E+05	0.00000	1.000E+00
23	1981	1.000E+00	1.000E+00	--	2.614E+05	2.144E+05	0.19818	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	2.120E+05	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	2.119E+05	0.00000	1.000E+00
26	1984	1.000E+00	1.000E+00	--	2.777E+05	2.151E+05	0.25539	1.000E+00
27	1985	1.000E+00	1.000E+00	--	1.610E+05	2.177E+05	-0.30166	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	2.062E+05	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	1.643E+05	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	1.189E+05	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	9.339E+04	0.00000	1.000E+00
32	1990	1.000E+00	1.000E+00	--	9.284E+04	7.703E+04	0.18673	1.000E+00
33	1991	1.000E+00	1.000E+00	--	3.757E+04	6.250E+04	-0.50885	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	4.621E+04	0.00000	1.000E+00
35	1993	1.000E+00	1.000E+00	--	2.084E+04	2.967E+04	-0.35349	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	2.234E+04	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	2.333E+04	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	2.743E+04	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	3.320E+04	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	3.990E+04	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	4.702E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	5.422E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	6.307E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	7.441E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	8.746E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	1.024E+05	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	1.193E+05	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	1.377E+05	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	1.567E+05	0.00000	1.000E+00
50	2008	0.000E+00	0.000E+00	--	*	1.762E+05	0.00000	1.000E+00
51	2009	0.000E+00	0.000E+00	--	*	1.963E+05	0.00000	1.000E+00
52	2010	0.000E+00	0.000E+00	--	*	2.143E+05	0.00000	1.000E+00
53	2011	0.000E+00	0.000E+00	--	*	2.304E+05	0.00000	1.000E+00
54	2012	0.000E+00	0.000E+00	--	*	2.455E+05	0.00000	1.000E+00
55	2013	0.000E+00	0.000E+00	--	*	2.583E+05	0.00000	1.000E+00
56	2014	0.000E+00	0.000E+00	--	*	2.693E+05	0.00000	1.000E+00
57	2015	0.000E+00	0.000E+00	--	*	2.774E+05	0.00000	1.000E+00
58	2016	0.000E+00	0.000E+00	--	*	2.833E+05	0.00000	1.000E+00
59	2017	0.000E+00	0.000E+00	--	*	2.876E+05	0.00000	1.000E+00
60	2018	0.000E+00	0.000E+00	--	*	2.903E+05	0.00000	1.000E+00
61	2019	0.000E+00	0.000E+00	--	*	2.920E+05	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 6

Year	Residual	-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1
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	0.4363	|=================
1979	0.0872	|===
1980	0.0000	|
1981	0.1982	|========
1982	0.0000	|
1983	0.0000	|
1984	0.2554	|==========
1985	-0.3017	============|
1986	0.0000	|
1987	0.0000	|
1988	0.0000	|
1989	0.0000	|
1990	0.1867	|=======
1991	-0.5089	====================|
1992	0.0000	|
1993	-0.3535	==============|
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	|
2008	0.0000	|
2009	0.0000	|
2010	0.0000	|
2011	0.0000	|
2012	0.0000	|
2013	0.0000	|
2014	0.0000	|
2015	0.0000	|
2016	0.0000	|
2017	0.0000	|
2018	0.0000	|
2019	0.0000	|

3LN redfish
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RESULTS FOR DATA SERIES # 7 (NON-BOOTSTRAPPED) 3L
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	--	*	5.429E+04	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	5.267E+04	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	5.188E+04	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	5.151E+04	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	4.986E+04	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	5.206E+04	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	5.124E+04	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	5.190E+04	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	5.027E+04	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	5.081E+04	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	4.977E+04	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	5.106E+04	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	4.788E+04	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	4.601E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	4.321E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	4.291E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	4.361E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	4.371E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	4.471E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	4.670E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	4.818E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	4.918E+04	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	4.830E+04	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	4.807E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	4.825E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	4.952E+04	0.00000	1.000E+00
27	1985	1.000E+00	1.000E+00	--	9.823E+04	4.946E+04	0.68612	1.000E+00
28	1986	1.000E+00	1.000E+00	--	1.712E+04	4.445E+04	-0.95427	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	3.123E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	2.332E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	1.930E+04	0.00000	1.000E+00
32	1990	1.000E+00	1.000E+00	--	2.074E+04	1.586E+04	0.26865	1.000E+00
33	1991	0.000E+00	0.000E+00	--	*	1.269E+04	0.00000	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	8.601E+03	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	5.186E+03	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	4.970E+03	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	5.648E+03	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	6.857E+03	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	8.274E+03	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	9.907E+03	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	1.150E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	1.318E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	1.555E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	1.834E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	2.148E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	2.515E+04	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	2.916E+04	0.00000	1.000E+00
48	2006	0.000E+00	0.000E+00	--	*	3.349E+04	0.00000	1.000E+00
49	2007	0.000E+00	0.000E+00	--	*	3.776E+04	0.00000	1.000E+00
50	2008	0.000E+00	0.000E+00	--	*	4.236E+04	0.00000	1.000E+00
51	2009	0.000E+00	0.000E+00	--	*	4.685E+04	0.00000	1.000E+00
52	2010	0.000E+00	0.000E+00	--	*	5.054E+04	0.00000	1.000E+00
53	2011	0.000E+00	0.000E+00	--	*	5.416E+04	0.00000	1.000E+00
54	2012	0.000E+00	0.000E+00	--	*	5.740E+04	0.00000	1.000E+00
55	2013	0.000E+00	0.000E+00	--	*	5.996E+04	0.00000	1.000E+00
56	2014	0.000E+00	0.000E+00	--	*	6.241E+04	0.00000	1.000E+00
57	2015	0.000E+00	0.000E+00	--	*	6.368E+04	0.00000	1.000E+00
58	2016	0.000E+00	0.000E+00	--	*	6.509E+04	0.00000	1.000E+00
59	2017	0.000E+00	0.000E+00	--	*	6.566E+04	0.00000	1.000E+00
60	2018	0.000E+00	0.000E+00	--	*	6.628E+04	0.00000	1.000E+00
61	2019	0.000E+00	0.000E+00	--	*	6.644E+04	0.00000	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 7

Year	Residual	-1 -0.75 -0.5 -0.25 0 0.25 0.5 0.75 1
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	0.6861	|==========
1986	-0.9543	==========|
1987	0.0000	|
1988	0.0000	|
1989	0.0000	|
1990	0.2686	|==========
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	|
2008	0.0000	|
2009	0.0000	|
2010	0.0000	|
2011	0.0000	|
2012	0.0000	|
2013	0.0000	|
2014	0.0000	|
2015	0.0000	|
2016	0.0000	|
2017	0.0000	|
2018	0.0000	|
2019	0.0000	|

3LN redfish
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RESULTS FOR DATA SERIES # 8 (NON-BOOTSTRAPPED) 3N
spanish 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	--	*	1.763E+05	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	1.649E+05	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	1.612E+05	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	1.595E+05	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	1.563E+05	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	1.573E+05	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	1.593E+05	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	1.591E+05	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	1.575E+05	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	1.559E+05	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	1.551E+05	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	1.556E+05	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	1.524E+05	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	1.447E+05	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	1.375E+05	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	1.328E+05	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	1.335E+05	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	1.347E+05	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	1.364E+05	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	1.410E+05	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	1.464E+05	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	1.502E+05	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	1.503E+05	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	1.486E+05	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	1.486E+05	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	1.508E+05	0.00000	1.000E+00
27	1985	0.000E+00	0.000E+00	--	*	1.527E+05	0.00000	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	1.446E+05	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	1.152E+05	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	8.339E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	6.548E+04	0.00000	1.000E+00
32	1990	0.000E+00	0.000E+00	--	*	5.401E+04	0.00000	1.000E+00
33	1991	0.000E+00	0.000E+00	--	*	4.382E+04	0.00000	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	3.240E+04	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	2.081E+04	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	1.566E+04	0.00000	1.000E+00
37	1995	1.000E+00	1.000E+00	--	4.608E+04	1.636E+04	1.03575	1.000E+00
38	1996	1.000E+00	1.000E+00	--	6.558E+03	1.923E+04	-1.07594	1.000E+00
39	1997	1.000E+00	1.000E+00	--	4.753E+03	2.328E+04	-1.58866	1.000E+00
40	1998	1.000E+00	1.000E+00	--	2.254E+04	2.798E+04	-0.21605	1.000E+00
41	1999	1.000E+00	1.000E+00	--	4.646E+04	3.297E+04	0.34304	1.000E+00
42	2000	1.000E+00	1.000E+00	--	6.893E+04	3.801E+04	0.59509	1.000E+00
43	2001	1.000E+00	1.000E+00	--	5.386E+04	4.422E+04	0.19702	1.000E+00
44	2002	1.000E+00	1.000E+00	--	7.620E+03	5.218E+04	-1.92384	1.000E+00
45	2003	1.000E+00	1.000E+00	--	1.103E+04	6.132E+04	-1.71541	1.000E+00
46	2004	1.000E+00	1.000E+00	--	2.702E+04	7.182E+04	-0.97771	1.000E+00
47	2005	1.000E+00	1.000E+00	--	1.469E+05	8.368E+04	0.56288	1.000E+00
48	2006	1.000E+00	1.000E+00	--	8.783E+04	9.657E+04	-0.09488	1.000E+00
49	2007	1.000E+00	1.000E+00	--	8.760E+04	1.099E+05	-0.22651	1.000E+00
50	2008	1.000E+00	1.000E+00	--	6.806E+04	1.236E+05	-0.59644	1.000E+00
51	2009	1.000E+00	1.000E+00	--	7.357E+05	1.376E+05	1.67634	1.000E+00
52	2010	1.000E+00	1.000E+00	--	3.595E+05	1.503E+05	0.87241	1.000E+00
53	2011	1.000E+00	1.000E+00	--	4.183E+05	1.615E+05	0.95140	1.000E+00
54	2012	1.000E+00	1.000E+00	--	2.652E+05	1.721E+05	0.43234	1.000E+00
55	2013	1.000E+00	1.000E+00	--	4.295E+05	1.811E+05	0.86366	1.000E+00
56	2014	1.000E+00	1.000E+00	--	1.780E+05	1.888E+05	-0.05876	1.000E+00
57	2015	1.000E+00	1.000E+00	--	5.235E+05	1.945E+05	0.98985	1.000E+00
58	2016	1.000E+00	1.000E+00	--	1.173E+05	1.987E+05	-0.52718	1.000E+00
59	2017	1.000E+00	1.000E+00	--	2.659E+05	2.017E+05	0.27640	1.000E+00
60	2018	1.000E+00	1.000E+00	--	2.928E+05	2.035E+05	0.36378	1.000E+00
61	2019	1.000E+00	1.000E+00	--	1.746E+05	2.047E+05	-0.15886	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 8

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
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	0.0000	|
1992	0.0000	|
1993	0.0000	|
1994	0.0000	|
1995	1.0358	|==========
1996	-1.0759	==========|
1997	-1.5887	==========|
1998	-0.2161	====|
1999	0.3430	|=======
2000	0.5951	|============
2001	0.1970	|====
2002	-1.9238	==========|
2003	-1.7154	==========|
2004	-0.9777	==========|
2005	0.5629	|==========
2006	-0.0949	==|
2007	-0.2265	=====|
2008	-0.5964	==========|
2009	1.6763	|================================
2010	0.8724	|=================
2011	0.9514	|===================
2012	0.4323	|=========
2013	0.8637	|=================
2014	-0.0588	=|
2015	0.9899	|====================
2016	-0.5272	==========|
2017	0.2764	|======
2018	0.3638	|=======
2019	-0.1589	===|

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RESULTS FOR DATA SERIES # 9 (NON-BOOTSTRAPPED) 3L
spanish 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	--	*	1.181E+05	0.00000	1.000E+00
2	1960	0.000E+00	0.000E+00	--	*	1.104E+05	0.00000	1.000E+00
3	1961	0.000E+00	0.000E+00	--	*	1.080E+05	0.00000	1.000E+00
4	1962	0.000E+00	0.000E+00	--	*	1.068E+05	0.00000	1.000E+00
5	1963	0.000E+00	0.000E+00	--	*	1.047E+05	0.00000	1.000E+00
6	1964	0.000E+00	0.000E+00	--	*	1.053E+05	0.00000	1.000E+00
7	1965	0.000E+00	0.000E+00	--	*	1.067E+05	0.00000	1.000E+00
8	1966	0.000E+00	0.000E+00	--	*	1.065E+05	0.00000	1.000E+00
9	1967	0.000E+00	0.000E+00	--	*	1.055E+05	0.00000	1.000E+00
10	1968	0.000E+00	0.000E+00	--	*	1.044E+05	0.00000	1.000E+00
11	1969	0.000E+00	0.000E+00	--	*	1.039E+05	0.00000	1.000E+00
12	1970	0.000E+00	0.000E+00	--	*	1.042E+05	0.00000	1.000E+00
13	1971	0.000E+00	0.000E+00	--	*	1.021E+05	0.00000	1.000E+00
14	1972	0.000E+00	0.000E+00	--	*	9.691E+04	0.00000	1.000E+00
15	1973	0.000E+00	0.000E+00	--	*	9.206E+04	0.00000	1.000E+00
16	1974	0.000E+00	0.000E+00	--	*	8.894E+04	0.00000	1.000E+00
17	1975	0.000E+00	0.000E+00	--	*	8.938E+04	0.00000	1.000E+00
18	1976	0.000E+00	0.000E+00	--	*	9.019E+04	0.00000	1.000E+00
19	1977	0.000E+00	0.000E+00	--	*	9.135E+04	0.00000	1.000E+00
20	1978	0.000E+00	0.000E+00	--	*	9.444E+04	0.00000	1.000E+00
21	1979	0.000E+00	0.000E+00	--	*	9.802E+04	0.00000	1.000E+00
22	1980	0.000E+00	0.000E+00	--	*	1.006E+05	0.00000	1.000E+00
23	1981	0.000E+00	0.000E+00	--	*	1.007E+05	0.00000	1.000E+00
24	1982	0.000E+00	0.000E+00	--	*	9.953E+04	0.00000	1.000E+00
25	1983	0.000E+00	0.000E+00	--	*	9.948E+04	0.00000	1.000E+00
26	1984	0.000E+00	0.000E+00	--	*	1.010E+05	0.00000	1.000E+00
27	1985	0.000E+00	0.000E+00	--	*	1.022E+05	0.00000	1.000E+00
28	1986	0.000E+00	0.000E+00	--	*	9.680E+04	0.00000	1.000E+00
29	1987	0.000E+00	0.000E+00	--	*	7.713E+04	0.00000	1.000E+00
30	1988	0.000E+00	0.000E+00	--	*	5.584E+04	0.00000	1.000E+00
31	1989	0.000E+00	0.000E+00	--	*	4.385E+04	0.00000	1.000E+00
32	1990	0.000E+00	0.000E+00	--	*	3.617E+04	0.00000	1.000E+00
33	1991	0.000E+00	0.000E+00	--	*	2.934E+04	0.00000	1.000E+00
34	1992	0.000E+00	0.000E+00	--	*	2.170E+04	0.00000	1.000E+00
35	1993	0.000E+00	0.000E+00	--	*	1.393E+04	0.00000	1.000E+00
36	1994	0.000E+00	0.000E+00	--	*	1.049E+04	0.00000	1.000E+00
37	1995	0.000E+00	0.000E+00	--	*	1.095E+04	0.00000	1.000E+00
38	1996	0.000E+00	0.000E+00	--	*	1.288E+04	0.00000	1.000E+00
39	1997	0.000E+00	0.000E+00	--	*	1.559E+04	0.00000	1.000E+00
40	1998	0.000E+00	0.000E+00	--	*	1.873E+04	0.00000	1.000E+00
41	1999	0.000E+00	0.000E+00	--	*	2.208E+04	0.00000	1.000E+00
42	2000	0.000E+00	0.000E+00	--	*	2.546E+04	0.00000	1.000E+00
43	2001	0.000E+00	0.000E+00	--	*	2.961E+04	0.00000	1.000E+00
44	2002	0.000E+00	0.000E+00	--	*	3.494E+04	0.00000	1.000E+00
45	2003	0.000E+00	0.000E+00	--	*	4.106E+04	0.00000	1.000E+00
46	2004	0.000E+00	0.000E+00	--	*	4.809E+04	0.00000	1.000E+00
47	2005	0.000E+00	0.000E+00	--	*	5.603E+04	0.00000	1.000E+00
48	2006	1.000E+00	1.000E+00	--	7.007E+04	6.467E+04	0.08020	1.000E+00
49	2007	1.000E+00	1.000E+00	--	3.141E+04	7.357E+04	-0.85115	1.000E+00
50	2008	1.000E+00	1.000E+00	--	7.557E+04	8.275E+04	-0.09075	1.000E+00
51	2009	1.000E+00	1.000E+00	--	1.037E+05	9.216E+04	0.11781	1.000E+00
52	2010	1.000E+00	1.000E+00	--	2.667E+05	1.006E+05	0.97494	1.000E+00
53	2011	1.000E+00	1.000E+00	--	1.706E+05	1.082E+05	0.45574	1.000E+00
54	2012	1.000E+00	1.000E+00	--	4.815E+05	1.153E+05	1.42959	1.000E+00
55	2013	1.000E+00	1.000E+00	--	2.352E+05	1.213E+05	0.66227	1.000E+00
56	2014	1.000E+00	1.000E+00	--	2.164E+05	1.264E+05	0.53739	1.000E+00
57	2015	1.000E+00	1.000E+00	--	1.304E+05	1.303E+05	0.00120	1.000E+00
58	2016	1.000E+00	1.000E+00	--	9.881E+04	1.330E+05	-0.29745	1.000E+00
59	2017	1.000E+00	1.000E+00	--	5.656E+04	1.351E+05	-0.87043	1.000E+00
60	2018	1.000E+00	1.000E+00	--	4.035E+04	1.363E+05	-1.21715	1.000E+00
61	2019	1.000E+00	1.000E+00	--	5.402E+04	1.371E+05	-0.93121	1.000E+00

* Asterisk indicates missing value(s).

3LN redfish
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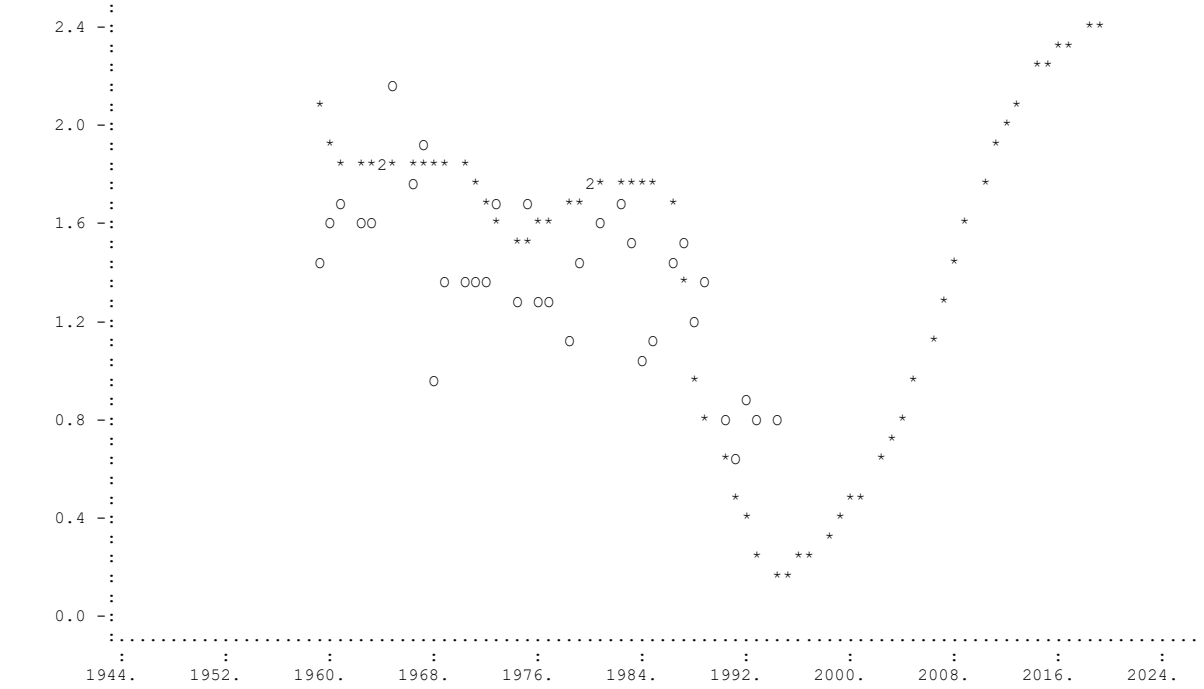
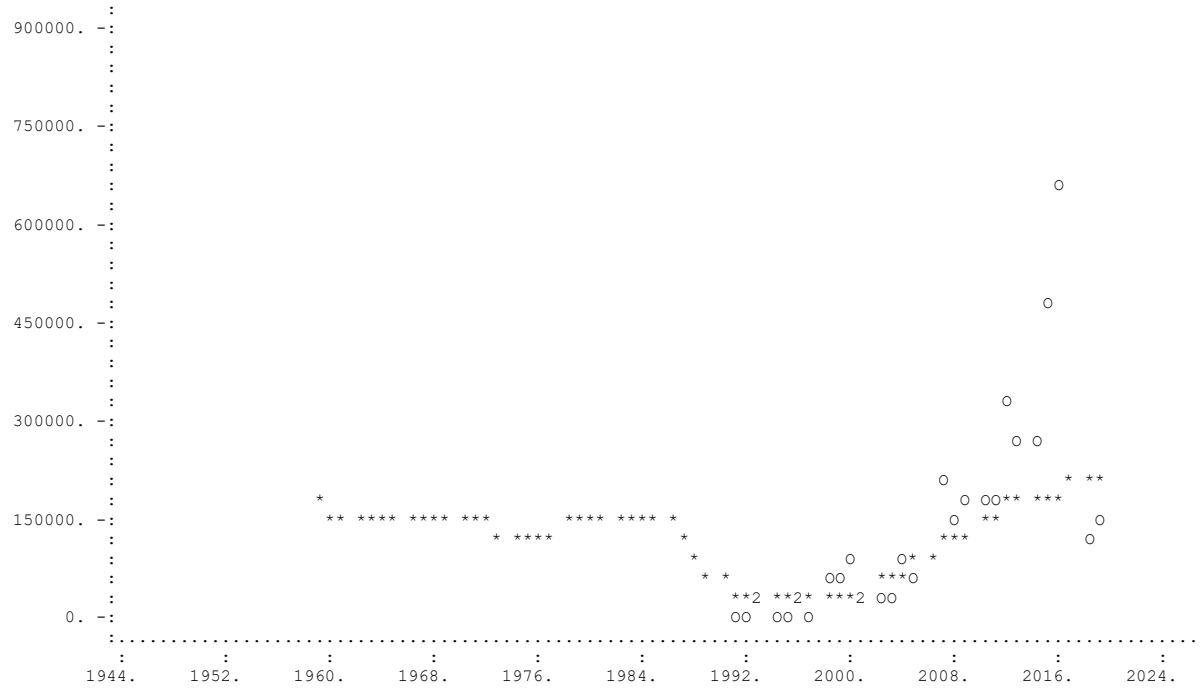
UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 9

Year	Residual	-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
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	0.0000	|
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	0.0802	|==
2007	-0.8511	================|
2008	-0.0908	==|
2009	0.1178	|==
2010	0.9749	|==================
2011	0.4557	|=========
2012	1.4296	|============================
2013	0.6623	|=============
2014	0.5374	|==========
2015	0.0012	|
2016	-0.2975	======|
2017	-0.8704	================|
2018	-1.2172	======================|
2019	-0.9312	==================|

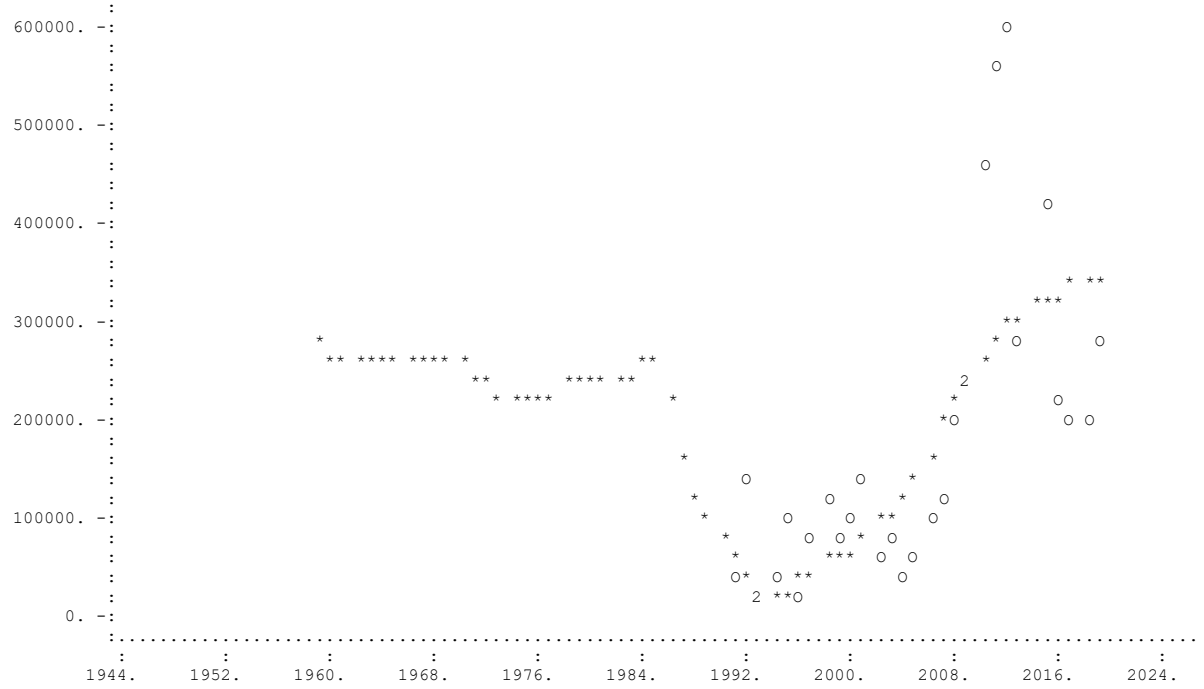
Observed (O) and Estimated (*) CPUE for Data Series # 1 -- Statlant CPUE



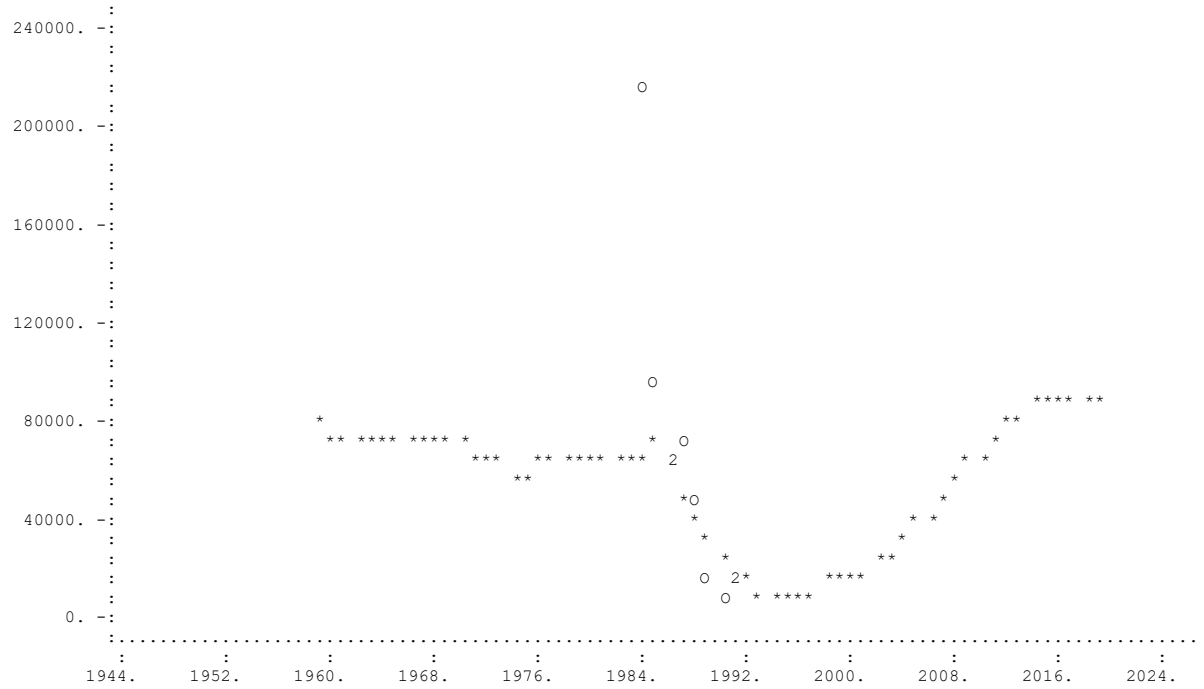
Observed (O) and Estimated (*) CPUE for Data Series # 2 -- 3LN spring survey

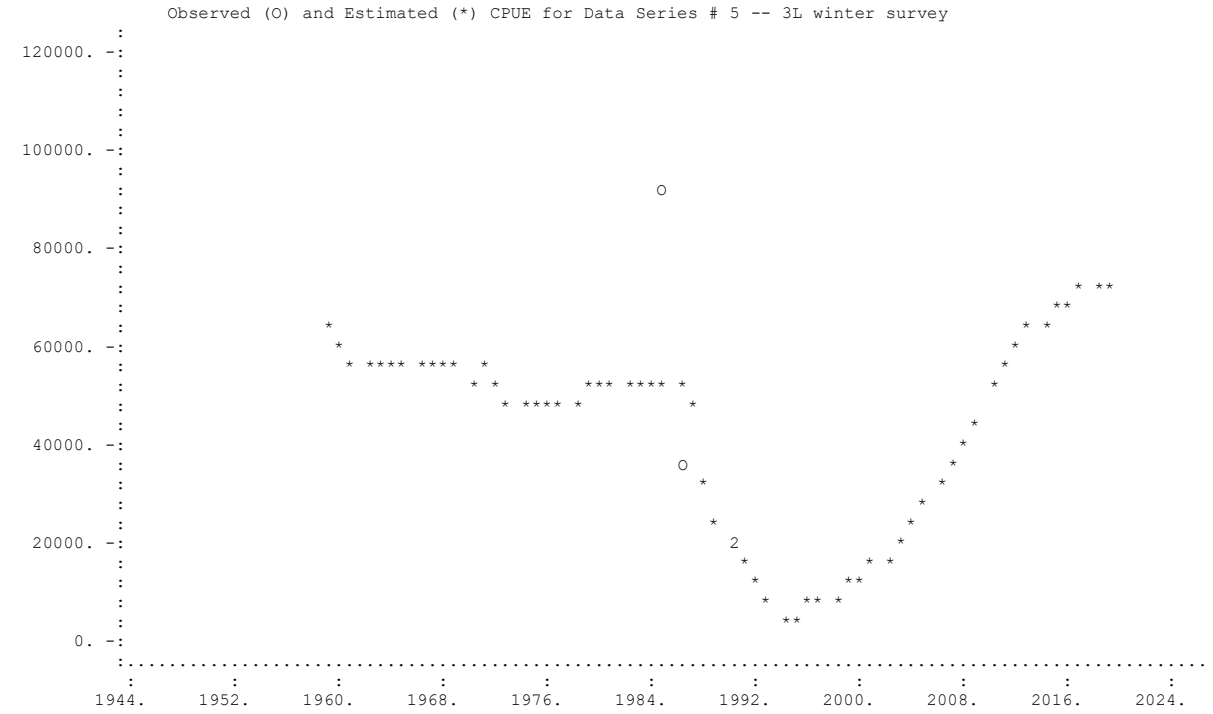


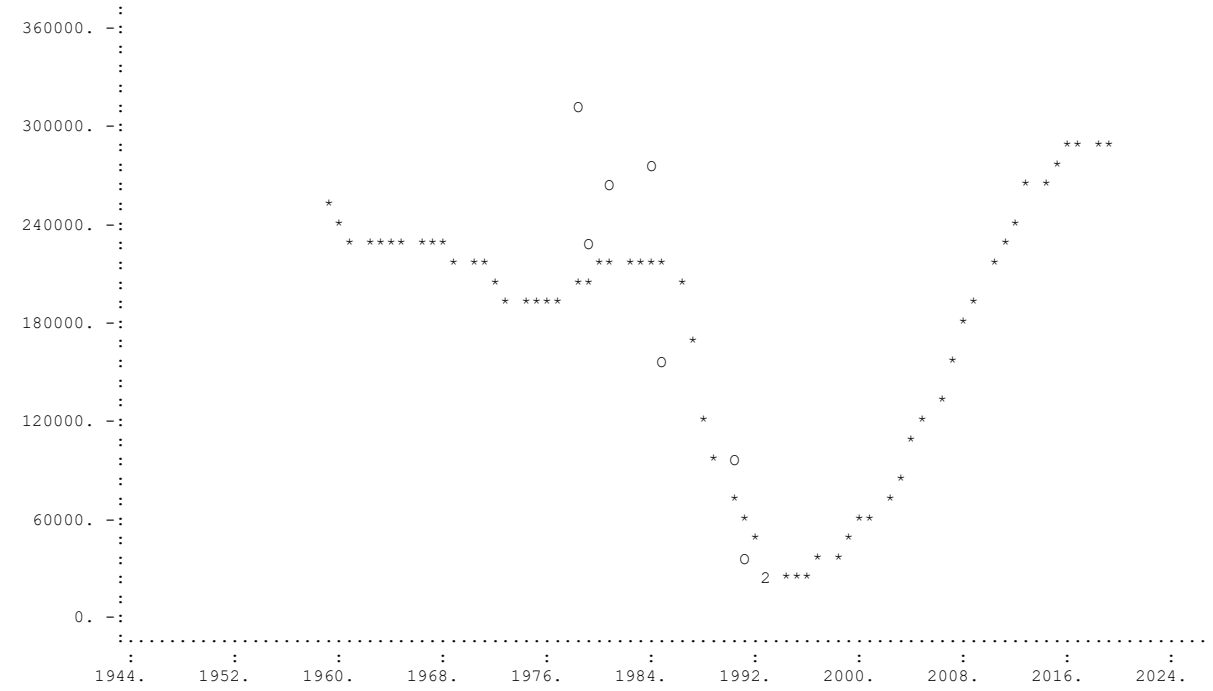
Observed (O) and Estimated (*) CPUE for Data Series # 3 -- 3LN autumn survey



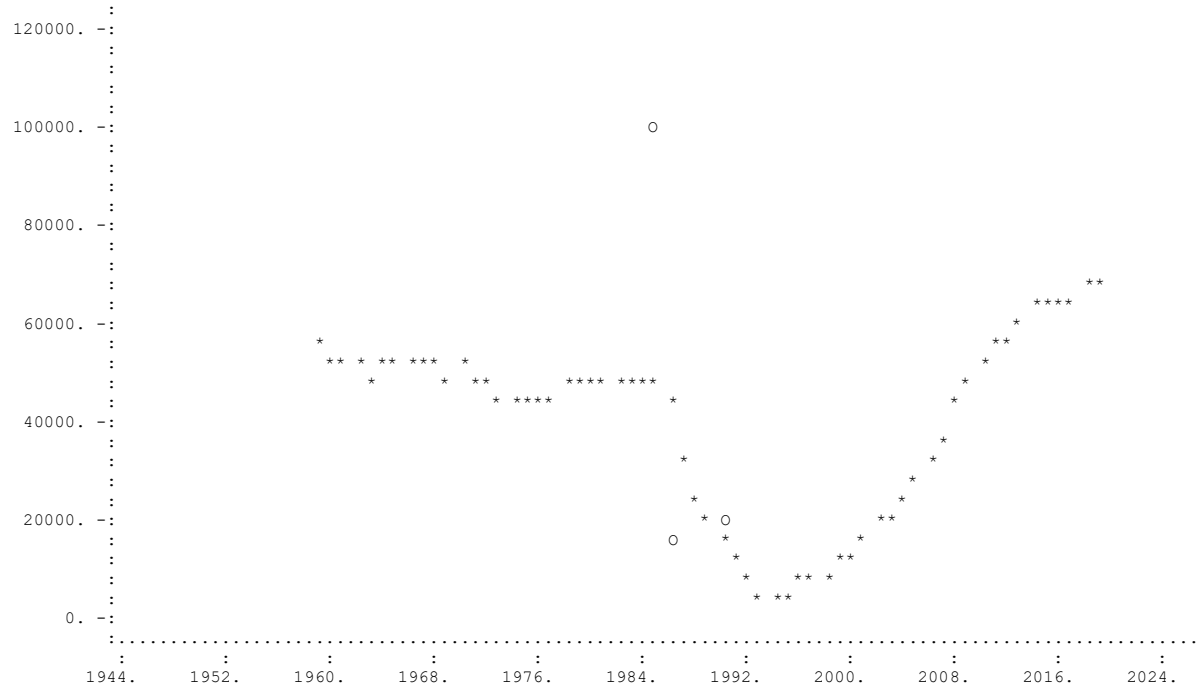
Observed (O) and Estimated (*) CPUE for Data Series # 4 -- 3LN Power russian survey



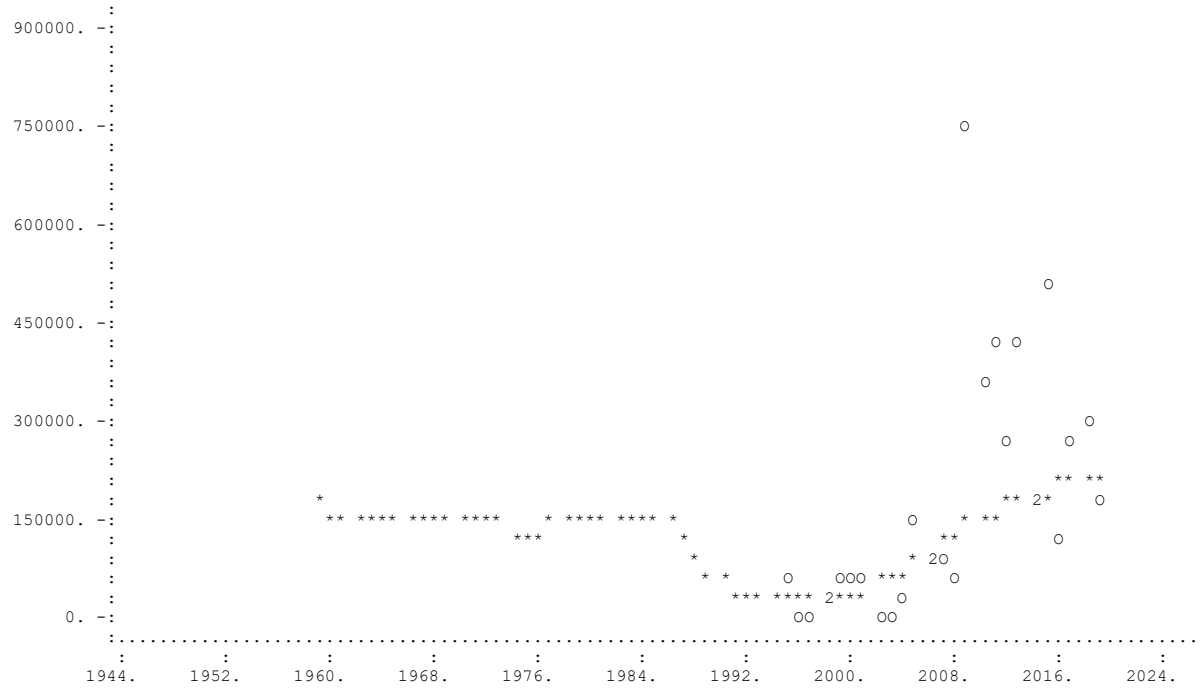

Observed (O) and Estimated (*) CPUE for Data Series # 5 -- 3L winter survey
120000.
100000.
80000.
60000.
40000.
20000.
0.
1944.
1952.
1960.
1968.
1976.
1984.
1992.
2000.
2008.
2016.
2024.


Observed (O) and Estimated (*) CPUE for Data Series # 6 -- 3L summer survey
360000.
300000.
240000.
180000.
120000.
60000.
0.
1944.
1952.
1960.
1968.
1976.
1984.
1992.
2000.
2008.
2016.
2024.

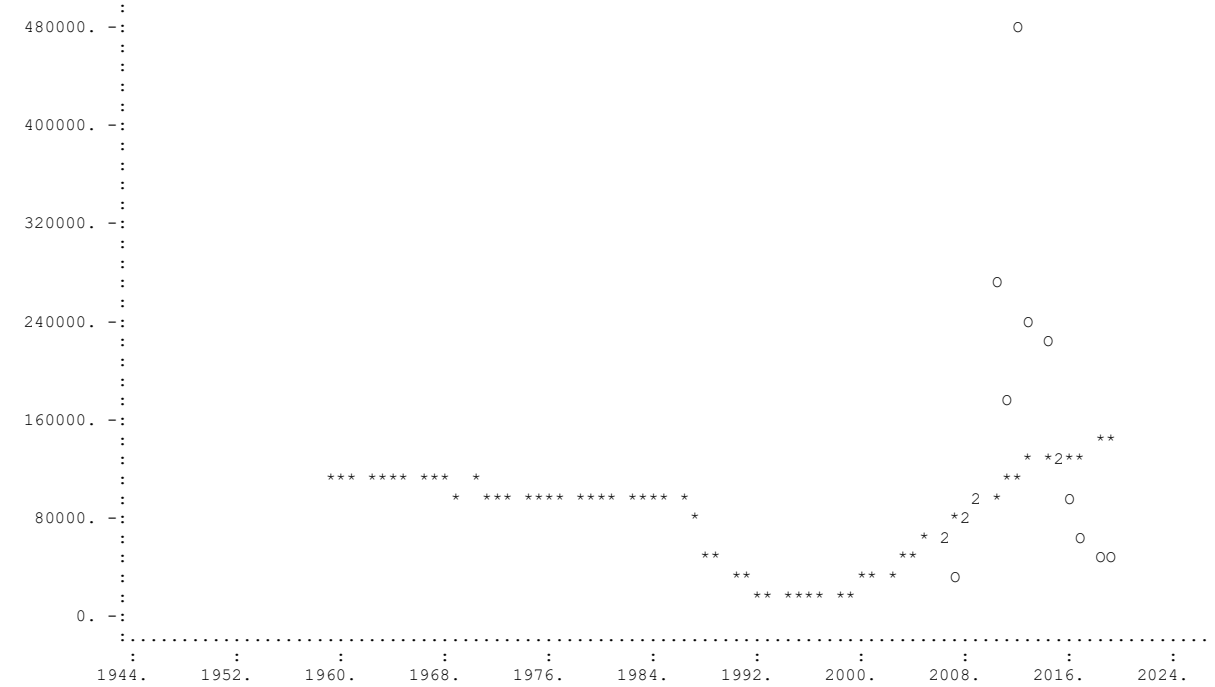
Observed (O) and Estimated (*) CPUE for Data Series # 7 -- 3L autumn survey



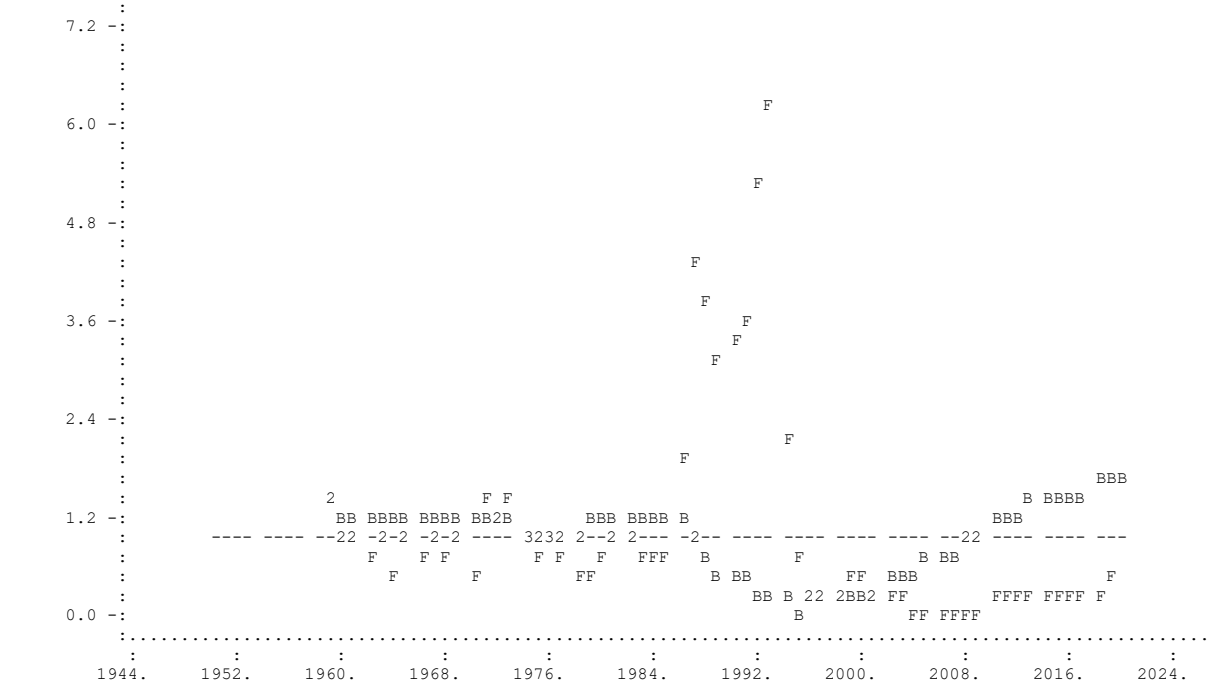
Observed (O) and Estimated (*) CPUE for Data Series # 8 -- 3N spanish survey



Observed (O) and Estimated (*) CPUE for Data Series # 9 -- 3L spanish survey



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



Elapsed time: 0 hours, 0 minutes, 8.892 seconds.

Appendix 3 ASPIC BOT 2020 results (some 2018/2016 key parameters and diagnostics in brakets)

Saturday, 02 May 2020 at 20:27:59

ASPIC -- A Surplus-Production Model Including Covariates (BETA Ver. 7.03)

BOT program mode

Author: Michael H. Prager
Prager Consulting
http://www.mhprager.com

LOGISTIC model mode
YLD conditioning
SSE optimization

Reference: Prager, M. H. 1994. A suite of extensions to a non equilibrium surplus-production model. Fishery Bulletin 92: 374-389.

ASPIC program and user's guide available gratis at www.mhprager.com

CONTROL PARAMETERS (FROM INPUT FILE) Input file: C:/...ASPIC3LN/2020/ASPIC20 bot 60CL/ASPIC20q2018estimatebot.a7inp

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Operation of ASPIC: Fit logistic (Schaefer) model by direct optimization with bootstrap.

Number of years analyzed:	61	Number of bootstrap trials:	1000
Number of data series:	9	Objective function:	Least squares
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:	18
Maximum F allowed in fitting:	6.000		

ESTIMATES FROM BOOTSTRAP ANALYSIS (Notation X. means terminal estimate of X)

Param name	Point estimate	Bias-corrected approximate confidence limits 80% lower	80% upper	60% lower	60% upper	Inter-quartile range	Relative IQ range	
B1/K	7.204E-01	5.817E-01	1.241E+00	6.189E-01	9.961E-01	2.944E-01	0.409	
	(6.976E-01)						(0.313)	2018
	(6.874E-01)						(0.256)	2016
MSY	2.100E+04	NA	NA	NA	NA	NA	NA	
Fmsy	1.136E-01	9.457E-02	1.272E-01	1.016E-01	1.241E-01	1.895E-02	0.167	
	(1.122E-01)						(0.174)	
	(1.116E-01)						(0.164)	
q(1)	8.136E-06	7.160E-06	9.664E-06	7.510E-06	9.200E-06	1.324E-06	0.163	
	(8.243E-06)						(0.161)	
	(8.305E-06)						(0.166)	
q(2)	6.805E-01	5.145E-01	8.633E-01	5.593E-01	7.917E-01	1.819E-01	0.267	
	(7.814E-01)						(0.296)	
	(7.995E-01)						(0.334)	
q(3)	1.145E+00	8.671E-01	1.448E+00	9.427E-01	1.324E+00	3.090E-01	0.270	
	(1.299E+00)						(0.295)	
	(1.466E+00)						(0.344)	
q(4)	3.111E-01	2.187E-01	4.119E-01	2.460E-01	3.754E-01	1.067E-01	0.343	
	(3.129E-01)						(0.320)	
	(3.141E-01)						(0.336)	
q(5)	2.452E-01	1.441E-01	3.955E-01	1.759E-01	3.392E-01	1.291E-01	0.527	
	(2.461E-01)						(0.504)	
	(2.469E-01)						(0.509)	
q(6)	9.956E-01	7.152E-01	1.317E+00	8.066E-01	1.204E+00	3.230E-01	0.324	
	(1.009E+00)						(0.325)	
	(1.018E+00)						(0.181)	
q(7)	2.263E-01	1.264E-01	3.559E-01	1.523E-01	2.969E-01	1.159E-01	0.512	
	(2.276E-01)						(0.510)	
	(2.284E-01)						(0.511)	
q(8)	6.981E-01	5.087E-01	8.809E-01	5.674E-01	8.019E-01	1.891E-01	0.271	
	(7.679E-01)						(0.306)	
	(8.442E-01)						(0.340)	
q(9)	4.675E-01	3.460E-01	5.821E-01	3.803E-01	5.308E-01	1.251E-01	0.268	
	(6.024E-01)						(0.320)	
	(7.513E-01)						(0.373)	
Ye(2020)	1.373E+04	1.154E+04	1.802E+04	1.203E+04	1.636E+04	3.350E+03	0.244	
Y.(Fmsy)	3.232E+04	2.861E+04	3.379E+04	3.030E+04	3.349E+04	2.458E+03	0.076	
Bmsy	1.849E+05	1.651E+05	2.221E+05	1.692E+05	2.067E+05	3.116E+04	0.169	
	(1.871E+05)						(0.181)	
	(1.882E+05)						(0.172)	
fmsy(1)	1.396E+04	1.112E+04	1.713E+04	1.194E+04	1.597E+04	3.338E+03	0.239	
fmsy(2)	1.669E-01	1.231E-01	2.212E-01	1.377E-01	2.013E-01	4.969E-02	0.298	
fmsy(3)	9.925E-02	7.725E-02	1.341E-01	8.448E-02	1.236E-01	3.102E-02	0.313	
fmsy(4)	3.651E-01	2.703E-01	5.361E-01	3.049E-01	4.711E-01	1.340E-01	0.367	
fmsy(5)	4.634E-01	2.930E-01	8.250E-01	3.424E-01	6.817E-01	2.481E-01	0.535	
fmsy(6)	1.141E-01	8.459E-02	1.612E-01	9.404E-02	1.446E-01	3.919E-02	0.343	
fmsy(7)	5.020E-01	3.245E-01	8.934E-01	3.742E-01	7.381E-01	2.873E-01	0.572	
fmsy(8)	1.627E-01	1.261E-01	2.275E-01	1.403E-01	2.051E-01	5.236E-02	0.322	
fmsy(9)	2.430E-01	1.901E-01	3.376E-01	2.105E-01	3.181E-01	8.069E-02	0.332	
B./Bmsy	1.588E+00	1.377E+00	1.671E+00	1.471E+00	1.654E+00	1.387E-01	0.087	
F./Fmsy	3.917E-01	3.708E-01	4.553E-01	3.751E-01	4.251E-01	3.737E-02	0.095	
Ye./MSY	6.540E-01	5.494E-01	8.582E-01	5.729E-01	7.788E-01	1.595E-01	0.244	

q2/q1	8.363E+04	6.096E+04	1.079E+05	6.594E+04	9.644E+04	2.451E+04	0.293
q3/q1	1.407E+05	9.967E+04	1.731E+05	1.095E+05	1.593E+05	3.949E+04	0.281
q4/q1	3.824E+04	2.561E+04	5.194E+04	2.921E+04	4.627E+04	1.363E+04	0.356
q5/q1	3.013E+04	1.628E+04	4.784E+04	2.016E+04	4.074E+04	1.622E+04	0.538
q6/q1	1.224E+05	8.315E+04	1.633E+05	9.344E+04	1.470E+05	4.291E+04	0.351
q7/q1	2.781E+04	1.470E+04	4.376E+04	1.837E+04	3.678E+04	1.473E+04	0.530
q8/q1	8.580E+04	6.020E+04	1.080E+05	6.751E+04	9.810E+04	2.368E+04	0.276
q9/q1	5.745E+04	3.948E+04	7.146E+04	4.394E+04	6.447E+04	1.689E+04	0.294

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

Unitless limit reference point in F (Fmsy/F.): 2.553
CV of above (from bootstrap distribution): 0.101

NOTES ON BOOTSTRAPPED ESTIMATES:

- Bootstrap results were computed from 1000 trials.
- Results are conditional on parameter bounds in the input file.
- If many trials were replaced, consider relaxing bounds and re-running.
- 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.

Trials replaced for lack of convergence: 0
Trials replaced for MSY at bound or MSY >= K: 0
Trials replaced for q at bound: 0
Trials replaced for B1/K at bound: 7
Trials replaced for Fmsy at bound: 0
Residual inflation factor: 1.0383

Elapsed time: 0 hours, 7 minutes, 32.260 seconds.

Appendix 4

```
ASPICP-V4
"2020-2025 ASPIC20q2018estimatebot.bio prj under red3LN HCR"
"ASPIC20q2018estimatebot.bio"
0           "CV on MSY during projections"
BC  1       "bias corrected and smooth CI's"
0           "no years skipped from the start in plots"
1  1  1     "AGRAPH open to plot results; write a .prb file; write a R
friendly version of the .prj file"
123456789   "random number seed only used when user CV of MSY is non zero"
18100  YABS "yield in same units as assessment"
18100  YABS
18100  YABS
18100  YABS
18100  YABS
%% END
```