PART A

Scientific Council Meeting on Precautionary Approach, 27 April-1 May 1999

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Participants of Scientific Council Meeting, San Sebastian, Spain – 27 April-1 May 1999

Back row:	H. P. Cornus, D. E. Stansbury, D. Rivard, P. A. Koeller, J. C. Mah□, A. Uriarte, D. G. Parsons
Middle row:	S. X. Cadrin, A. Vazquez, . Nicolajsen, Y. Uozumi, T. Jakobsen, L. Motos
Front row:	H. Murua, R. K. Mayo, S. Junquera, D. B. Atkinson, H. Siegstad, W. B. Brodie, U. Sk□lad□ttir, E. de C□rdenas, A. Avila de Melo, O. A. J rgensen, R. Alpoim
Not in picture:	F. M. Serchuk, T. Amaratunga, D. C. A. Auby, I. Martin

REPORT SCIENTIFIC COUNCIL MEETING ON PRECAUTIONARY APPROACH

27 April-1 May 1999

Chairman: H. P. Cornus Rapporteur: T. Amaratunga

I. PLENARY SESSIONS

The Scientific Council met at Miramon, Parque Tecnologico de San Sebastian, San Sebastian, Spain, during the 27 April to 1 May 1999, to consider matters in its agenda regarding the Precautionary Approach.

Representatives attended from Canada, Denmark (in respect of Faroe Islands and Greenland), European Union (France, Germany, Portugal and Spain), Iceland, Japan, Norway and United States of America. The Assistant Executive Secretary was in attendance.

Opening session of the Council was called to order at 1015 hours on 27 April 1999.

The Chairman welcomed everyone to the Scientific Council Meeting on Precautionary Approach, and to San Sebastian. The Chairman extended a special thanks to the AZTI Foundation for hosting this meeting and to L. Motos (EU-Spain) for his hard work with the local arrangements. The Assistant Executive Secretary was appointed rapporteur.

In the review of the Provisional Agenda, the Chairman noted that Designated Experts and Experts working on the Precautionary Approach (PA) framework will take lead roles in the preparation of the final report.

The Chairman reported that this represents the first meeting of the Scientific Council dedicated to the Precautionary Approach, subsequent to the Scientific Council Workshop on the Precautionary Approach held during 17-27 March 1998, and the joint Scientific Council and Fisheries Commission Working Group Meeting held during 12-13 May 1998. Noting there were no changes to the Provisional Agenda as circulated, the Council **adopted** the agenda.

The Chairman reported that the computer network (LAN) for this meeting would be operating when each participant's computer was configured to be compatible with the server. The LAN configuration consisted of two working directories and a read-only directory for preparing the report.

The opening session was adjourned at 1045 hrs.

Subsequent plenary sessions during the day reviewed the available software and how they may be applied for consideration of the three case study stocks.

The sessions of the day ended at 1900 hrs.

The Council considered shrimp in Div. 3M and cod in Div. 3NO through sessions on 28 April 1999, and yellowtail flounder in Div. 3LNO during 29 April 1999. Information was also provided on a possible approach to derive reference points with an example for Greenland halibut in Div. 2J and 3KLMNO.

The concluding session was called to order at 1800 hrs on 1 May 1999. The Council reviewed and accepted the recommendations for the Joint Scientific Council and Fisheries Commission Working Group Meeting of 3-5 May 1999. The Council then reviewed and **adopted** the report of this meeting.

The meeting was adjourned at 2000 hrs.

Results of various analyses including reference points as available for case studies for cod in Div. 3NO, yellowtail flounder in Div. 3LNO and shrimp in Div. 3M, and other NAFO stocks are given in the report below.

The Agenda, List of Research (SCR) and Summary (SCS) Documents, List of Participants and the List of Recommendations for this meeting are given in Part E, this volume.

II. TUTORIAL ON SOFTWARE

1. Spreadsheet to Evaluate Harvest Control Rules

A spreadsheet was developed to provide some flexibility in simulating harvest control rules (HCR) or decision rules under PA-frameworks based on biomass targets and limits, as well as F targets and limits. In particular, the spreadsheet can be used to mimic HCRs under the ICES and NAFO PA frameworks, or simply to evaluate constant F-scenarios. It also permits accounting for fishing mortality resulting from by-catch in periods of moratorium and allows options for specifying the HCRs, as well as options for simulating the spawner-recruit process. Risk analyses are performed using an Add-in to Excel called Risk (Anon. 1997)[1].

This approach allows the user to specify uncertainty in: a) population dynamic parameters; b) in initial conditions of the state variables; and c) in the stock-recruit relationship. It also provides tools to calculate the probability of achieving limits or targets in the simulation years, to calcuate the time it takes to reach these targets and to evaluate other elements of interest to managers (e.g. number of closures after re-opening, recovery time).

The first applications of the model illustrate that the results of long term simulations are very sensitive to the characteristics of the spawner-recruit description. These characteristics can be described by resampling the empirical distributions of stock size and recruitment or by a parametric model such as Beverton-Holt or Ricker.

2. PASOFT Software

A presentation on the PASOFT software (MRAG, 1997)[2] was introduced to the Scientific Council. The package is intended to provide advice on the status of stocks and to suggest levels of fishing mortality and SSB for use under PA guidelines, without the use of parametric stock recruitment relationships. It includes an Excel add-in and two libraries of functions, subsets of the FishLab software developed at CEFAS, Lowestoft, UK, (MRAG, 1997).

Biological Reference Points (BRPs) are estimated based on equilibrium assumptions and using steady state vectors for selection, natural mortality, growth and maturity. Reference points correspond to properties of yield-per-recruit or spawner-per-recruit curves, stock recruit series, and both parametric and non-parametric stock recruitment relationships.

PASOFT (MRAG, 1997) simulates uncertainty in the biological reference points by Monte Carlo simulation. Parametric models are used for the parameters (i.e. selection, weight, natural mortality and maturity-at-age). Variation in selection pattern, F, is modelled as normal random deviate. Deviates for catch weight and stock weight are modelled as a log normal random variable. Natural mortality at age is modelled as normal random deviate by combining year and age effects. Uncertainty in the proportion mature, P, is modelled as a normal random variable after a logistic transformation.

Non-parametric methods are used for the stock and recruitment series. Recruitment is bootstrapped independently from the stock recruit pairs to provide Monte Carlo estimates of the entire recruitment series which can be used to estimate confidence intervals for the single variable statistics such as mean, geometric mean or median recruitment. Bootstrapping stock recruitment pairs provides estimates of the uncertainty

[1] Anon. 1997. Risk Advanced Risk Analysis for Spreadsheets. Palisade Co., Newfield, NY. 319 pages

[2] MRAG. 1997. Core program development for the modelling of fishery management strategies. Final Report of EC Study Project 94/110.

associated with reference points, which use a stock recruitment series in their estimation, i.e. F_{low}, F_{med}, F_{high}, F_{loss}, (G_{loss}, SPR_{loss}). The stock recruitment data are bootstrapped by randomly re-sampling with replacement to produce new data sets.

The Scientific Council appreciated the validity of this package for the objectives of the present meeting, i.e. estimation of BRPs for the stocks under consideration. However, several caveats were raised on the applicability of the methodology to stocks lacking a full SPA assessment. It was also noted the relatively scarce information the package provides on SSB based reference points.

3. Reference Points Derived by C/B Ratio

A simple method to project catches and to define biological reference points for stocks where information is restricted to total catch in weight, mean weight-at-age, and at least one abundance index by age was presented. This method permits the estimate of reference points defined by the levels of effort maximizing yield-per-recruit function as well as the $F_{0.1}$ level, for this function. The whole family of Biological Reference Points would be defined, if: a) the abundance index were representative of the spawning biomass level and b) a reliable stock recruitment relationship could be defined.

The method is a modification of the equations to estimate M proposed by several authors (see, for example, Paloheimo, 1961[3]). The approach relies on the assumed relationship between the Z-at-age vector and the total effort applied to the fishery each year defined as the ratio between total catch in the year and the biomass index.

In order to be able to apply this method, it is necessary to have at least one series of indices of abundance-at-age, mean weight-at-age and the series of catches (weight) for the stock. Neither data on the level of natural mortality are needed, nor data on the exploitation pattern.

The model residuals appear to be correlated for the various ages in a given year and present temporal trends. Such a correlation could be utilized to provide more precise forecasts of catches.

4. ASPIC Model

ASPIC, A non-equilibrium **S**urplus **P**roduction model **I**ncorporating **C**ovariates (Prager 1994[4], MS 1995[5]) fits a time series of stock biomass estimates to catch and biomass index data by assuming logistic population growth and minimizing observation errors. Model results can be arranged in the context of the PA framework. Estimates of logistic growth parameters (*r* and *K*) can be used to determine MSY reference points (B_{msy} □ $K/2$, F_{msy} □ $r/2$). Probability distributions of reference points, biomass estimates and F estimates can be evaluated by bootstrap results. Estimates of precautionary targets, F_{buf} and B_{buf} can be derived from a chosen percentile of the F_{msy} and B_{loss} (lowest observed biomass) estimates, respectively. Performance of the precautionary framework and other control rules can be assessed through stochastic projection.

The Council agreed that ASPIC can be a valuable tool for determining stock status, reference points, and performance of alternative harvest strategies. However, the model requires an informative time series of data with a wide range of catch and biomass indices to provide reliable estimates. Simulation exercises showed that ratios to MSY reference points (B_t/B_{msy} and F_t/F_{msy}) were generally more reliable than absolute estimates of biomass or F.

The Scientific Council discussed criteria for selecting among alternative ASPIC runs and assessing the reliability of results. The Council agreed that criteria should be based on comparing biomass estimates

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3 PALOHEIMO, J. E. 1961. Studies on estimation of mortalities, 1, Comparison of a method described by Berverton and Holt and a new linear formula. *J. Fish. Res. Board Can.*, **18**: 645-662.

4 PRAGER, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. *Fish. Bull.*, **92**: 374-389.

5 PRAGER, M. H. MS 1995. Users manual for ASPIC: a stock-production model incorporating covariates. *SEFSC Miami Laboratory Doc.*, MIA-92/93-55.

with age-based results, comparing reference point estimates with yield-per-recruit results, and comparing logistic growth parameter estimates to those from other stocks with similar life histories.

III. REFERENCE POINTS FOR CASE STUDIES

1. Cod in Divisions 3NO

The last time SPA was applied and accepted for Div. 3NO cod was in the 1998 assessment (Stansbury *et al*., MS 1998[6]). This assessment estimated population numbers at age for 1995. This preceded the change to the Campelen trawl and the conversion of Engels data to Campelen equivalent data. In the absence of recent catch-at-age data, it was decided for this workshop that the total yield for 1996 to 1998 be proportioned by age using a partial recruit vector from 1990-93. An ADAPT was applied to the converted survey data to estimate numbers-at-age in 1999.

Age 3 recruits were plotted against spawner biomass derived from the Campelen calibrated ADAPT using beginning of year mean weights-at-age from the commercial catches and model predicted maturities (Fig. 1).

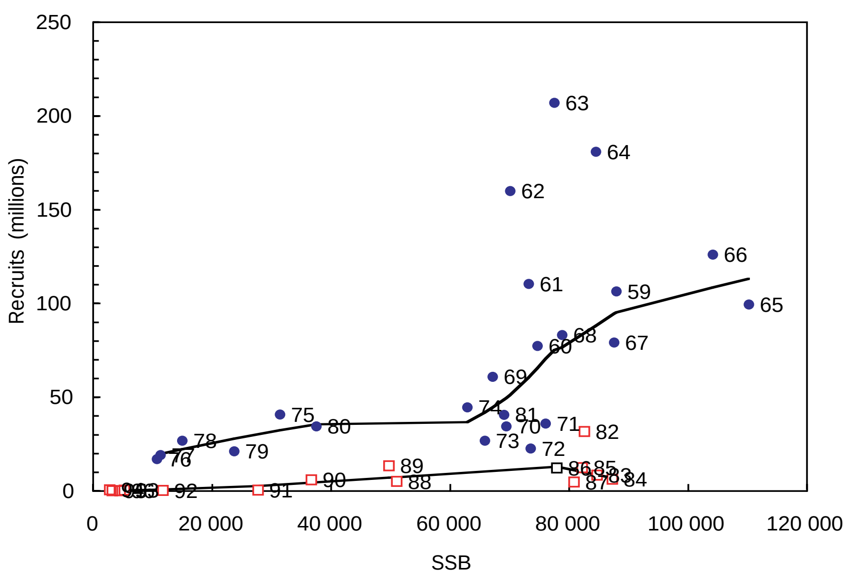

Fig. 1. Cod in Div. 3NO: SSB-recruit scatter plot. Solid line is a LOWESS smoother fitted to the data for two separate regimes. Data prior to 1982 and data including 1982 to 1996.

Figure 1 suggests there are two distinct time periods of productivity in this stock. A period of high productivity from 1959 to 1981 with mean recruitment of 72 million, and a period of extremely low productivity from 1982 to 1996, with a mean recruitment of 7 million.

Determination of B_{lim}. This stock was selected in order to explore re-opening criteria. The SSB and recruitment data over the 1959-95 period indicate a sharp decrease in the likelihood of obtaining high recruitment at SSBs below 60 000 tons. The Scientific Council therefore considers that 60 000 tons is the current best estimate of B_{lim}.

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6 STANSBURY, D. E., P. A. SHELTON, E. F. MURPHY, G. R. LILLY, and J. BRATTEY. MS 1998. An assessment of the cod stock in NAFO Divisions 3NO. *NAFO SCR Doc.*, No. 65, Serial No. N3057, 38 p.

In the recent period of low productivity, there is an indication of even further reduction in recruitment at about half the B_{lim} level. In view of the difficulty in determining if the current low productivity will persist in the immediate future, it is recommended that the Scientific Council review in detail the biological reference points in the context of the PA framework when the SSB has reached half the current estimate of B_{lim}.

Determination of B_{msy} and F_{msy}. A non-equilibrium surplus production model (ASPIC) was applied to catch and VPA estimates of Div. 3NO cod. Biomass estimates from the earliest years in the series (1959-66) did not fit the model, but provisional results with the entire time series were MSY □75 000 tons, B_{msy} □450 000 tons, F_{msy} □0.16, 1998 biomass □4 of B_{msy}. Truncating the analysis to 1967-97 improved model fit (R^2 □0.73; relative interquartile ranges 10), but results were similar; MSY □70 000 tons, B_{msy} □430 000 tons, F_{msy} □0.16, 1998 biomass □4 of B_{msy}. It appears that productivity during the early-1960s is incongruent with more recent productivity.

2. Yellowtail Flounder in Divisions 3LNO

A non-equilibrium surplus production model (ASPIC) was applied to catch, effort, and survey biomass indices of Grand Bank yellowtail flounder (Div. 3LNO). The data generally fit the model well but results from the Div. 3LNO yellowtail flounder example application were sensitive to the choice of biomass indices. The Scientific Council concluded that parameter estimates were useful for deriving precautionary reference points. The model suggests that a maximum sustainable yield (MSY) of 16 000 tons can be produced by a total stock biomass of 91 000 tons (B_{msy}) at a fishing mortality rate on total biomass of 0.18 (F_{msy}), and an estimated starting stock biomass was 70 of B_{msy} in 1998 (Fig. 2). Conditional non-parametric bootstrap estimates indicate that parameters were relatively well estimated.

Concerns were raised that ASPIC is limited to estimates of total biomass, but B_{lim} should be based on a threshold of SSB. Stock-recruit relationships, generated from survey data were examined. SSB was calculated as mature female biomass from annual maturity ogives, and recruitment estimates were taken from the same survey data. Scientific Council noted that there were a number of concerns with the survey data, and that the calculations had not yet been reviewed by STACFIS. Until these concerns are addressed and further analyses have been reviewed, Scientific Council emphasizes that the stock recruit relationship examined at this meeting must be treated as preliminary.

The ASPIC model results were used to provide reference points for illustrative purposes in the context of the Precautionary Approach framework (Fig. 3). F_{lim} was defined as the F_{msy} estimate (0.18) and F_{buf} was defined as the tenth percentile of the F_{msy} estimate (0.13). Noting the caveat expressed above, the low SSB values from the S/R curve for 1975, 1988 and 1989 were used to indicate a possible level of B_{lim}, and the ASPIC result (averaged for these 3 years) was 48 000 tons; B_{buf} was derived as the ninetieth percentile of the B_{lim} estimate (63 000 tons). B_{tr} was set at the B_{msy} level of 91 000 tons.

3. Shrimp in Division 3M

The Scientific Council reviewed the progress made in the application of the PA to shrimp stocks.

The report of the Scientific Council PA workshop in 1998 (NAFO SCR Doc. 98/76) stated that: "The precautionary, qualitative "Traffic Light" checklist proposed by Caddy (SCR Doc. 98/8), was viewed positively as a first step to applying the PA to Div. 3M shrimp □ ..". Following the Scientific Council 1998 PA Workshop, activities have continued to investigate the application of the PA framework to shrimp. It is evident that the identification of quantitative references, reference points, targets, limits, is not currently possible. Recent efforts have thus concentrated on the development of stock-specific checklists that would include multiple, qualitative indicators of resource status.

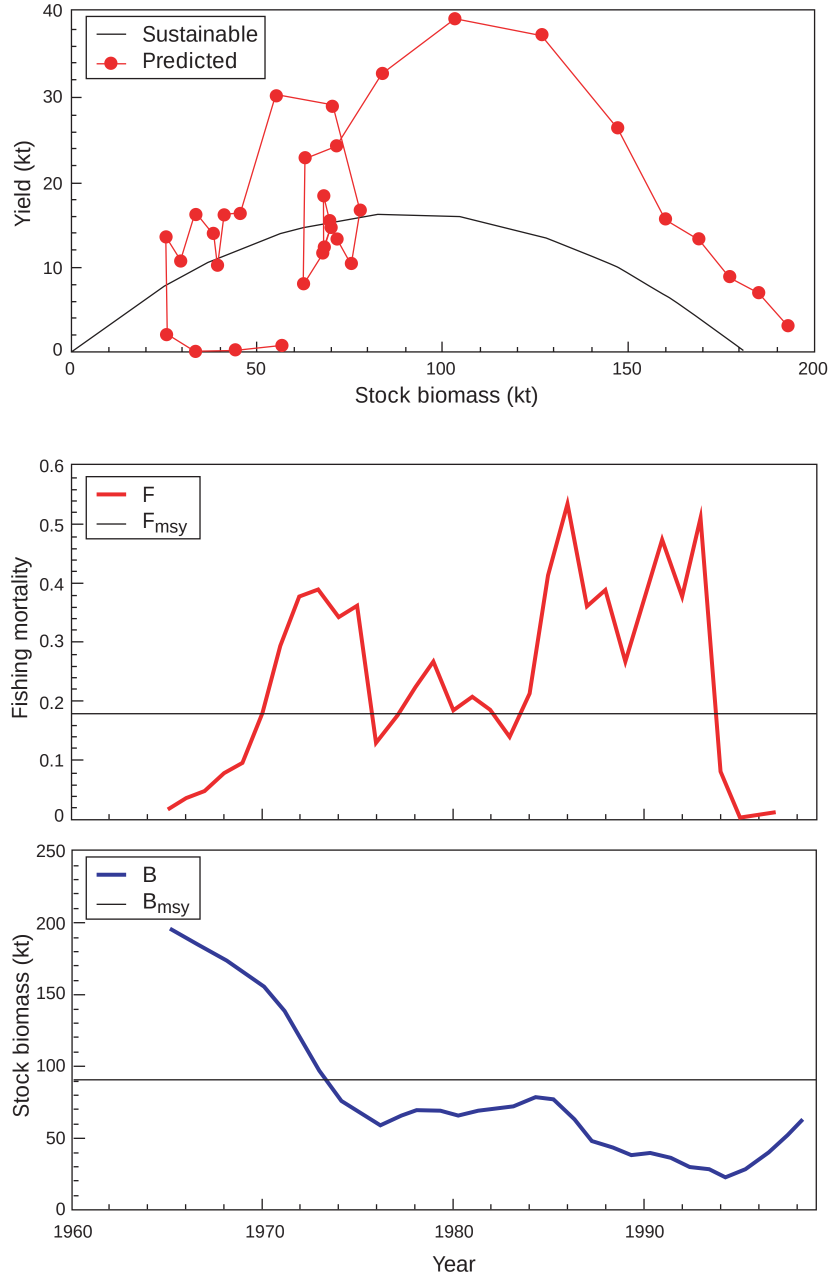


Fig. 2. Yellowtail flounder in Div. 3LNO: summary of results from surplus production analysis.

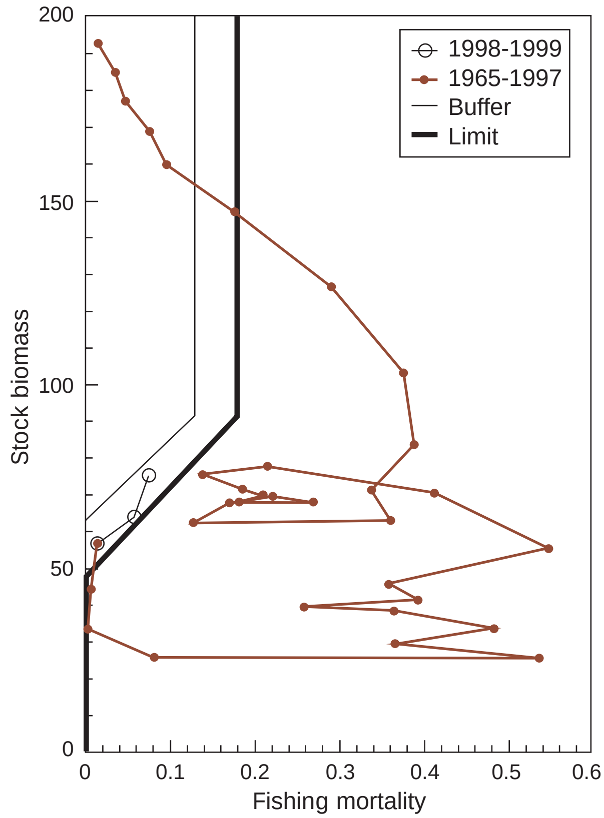


Fig. 3. Yellowtail flounder in Div. 3LNO: estimates of stock biomass and fishing mortality in comparison to the precautionary approach framework for illustrative purposes.

Stock assessments for shrimp on Scotian Shelf, in the Gulf of St. Lawrence and the Newfoundland-Labrador offshore area in 1998/99 were conducted using the Traffic Light approach and served as a first test of applying the method to the assessment-management process in these areas. The explanation and interpretation of indicators used in the assessments were viewed positively both by managers and industry representatives. A version of the spreadsheet was developed for shrimp in Div. 3M (Flemish Cap) for 1998 for consideration at this meeting.

The Traffic Light method does not provide direction to managers on the amount of change in TACs that might be associated with any "red", "green" or "yellow" assessment. A simple spreadsheet model of a hypothetical shrimp stock served to illustrate how the Traffic Light might be linked to harvest control rules. A number of stock indicators (e.g. SSB, recruitment, environment, average age, number of year-classes in the population) were simply assigned values of -1, 1 or 0 if a negative, positive, or no change in the parameter respectively had been observed, and the total score linked to arbitrary rules which were precautionary in that decreases in exploitation rates were greater than increases. Results suggested that it is worthwhile to attempt to use a definitive modelling tool like the HCR spreadsheet (see Section II above) to determine if the qualitative results from the Traffic Light method can be used to develop simple precautionary harvest control rules for shrimp stocks.

Recommendation. The Scientific Council **recommended** *investigating the use of an approach similar to that used in the HCR (Harvest Control Rules) spreadsheet to determine if the qualitative results obtained with the Traffic Light method can be linked to simple precautionary HCRs for shrimp stocks*.

IV. REFERENCE POINTS FOR OTHER NAFO STOCKS

The application of the method based on catch (C) to biomass (B) ratio described in Section II.3 above to the Greenland halibut population, in the NAFO Regulatory Area (Div. 2J+3KLMNO), is presented as a case example. In order to assess the sensitivity of this method, to the variability of the input parameters, a risk analysis was set up and performed. Standard errors for Z were estimated to range from 0.3 to 0.5 depending on ages/years. The year effect was proven to be the most sensitive input when estimating yearly Z values along cohorts. Yield-per-recruit curves constructed from this method resulted in a C/B_{max} ratio of 0.68 and a $C/B_{0.1}$ ratio of 0.48 (Fig. 4).

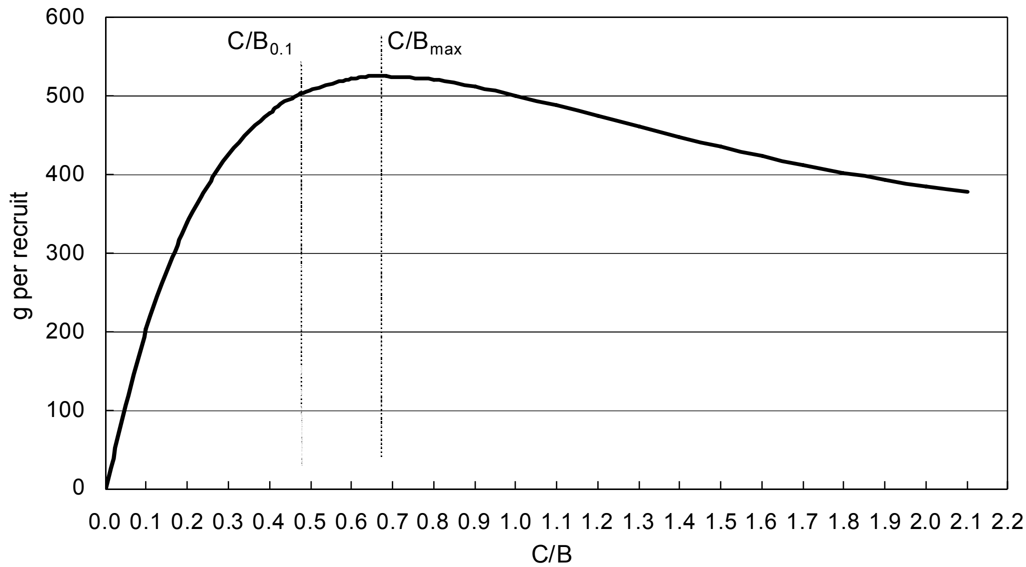


Fig. 4. Greenland halibut in Div. 2J and 3KLMNO: yield-per-recruit plot based on C/B ratio.

V. CONSIDERATION OF RECOMMENDATIONS FROM THE MAY 1998 MEETING OF THE JOINT SCIENTIFIC COUNCIL AND FISHERIES COMMISSION WORKING GROUP ON PRECUATIONARY APPROACH

The Council noted that many of the recommendations from the May 1998 Meeting of the Joint SC/FC Working Group on PA (see NAFO/FC Doc. 98/2) had been addressed by the Scientific Council at previous meetings. The two specific items that were outstanding were addressed as follows:

1. **Standardization of Concepts/Nomenclature/Abbreviations/Definitions Between ICES, NAFO and FAO**

   At the June 1998 meeting of the Scientific Council, the chairman was asked to attend the FAO meeting of FAO and non-FAO Fisheries Bodies and Agencies in order to raise this issue. The Scientific Council chairman attended this meeting in Rome on 11-12 February 1999. Seventeen regional fisheries bodies were represented at this meeting. Representatives of NAFO, the Chairman of the Fisheries Commission and Chairman of the Scientific Council, after consulting other representatives at this meeting, concluded that the forum was not appropriate to hold detailed discussions on the issue of harmonization terminology as the participants were mostly secretaries of the regional bodies who were not prepared to discuss the issue. However, there was a proposal by NEAFC to plan a joint meeting of North Atlantic regional fisheries bodies, including NAFO, to discuss common problems, including Precautionary Approach concepts.

2. **Review of the Harvest Control Rule Concept**

The Scientific Council reviewed the HCR concept as described in NAFO (see Fig. 1, NAFO Sci. Coun. Rep., 1997, p. 49, and copied below as Fig. 5). The NAFO PA Framework defines limit, buffer and target reference points for fishing mortality and biomass. The fishing mortality limit reference point (F_{lim}) is defined as a fishing mortality rate that should not be exceeded. In accordance with Annex II of the UN Agreement of the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, F_{lim} is equivalent to F_{msy}.

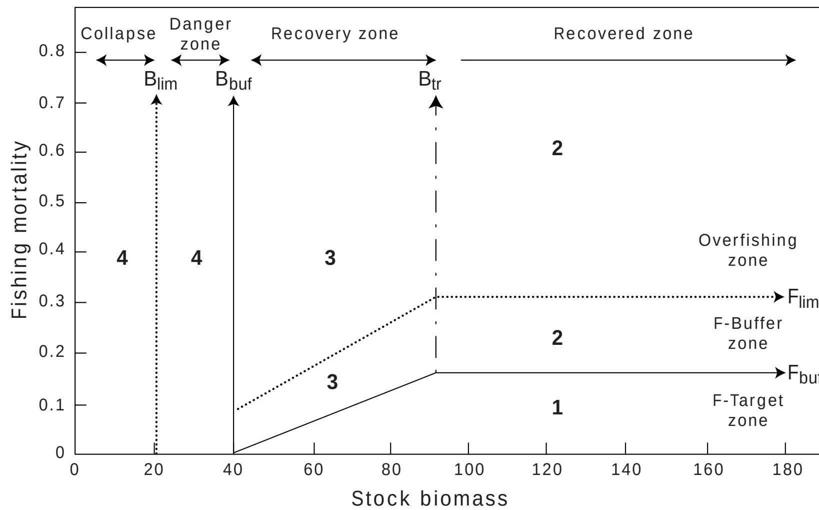


Fig. 5. The schematic of the framework for implementation of the precautionary approach (copied from Fig. 1 in NAFO Sci. Coun. Rep., 1997, p. 49).

The framework defines B_{lim} as a level of spawning stock biomass below which the stock should not be allowed to fall. This may be calculated from a stock-recruitment plot in cases where there is an indication of a high probability of reduced recruitment at low stock sizes. In the Northwest Atlantic, many stocks exhibit this characteristic, indicating a need for a risk-averse management strategy. When this pattern is less evident, or where stock-recruitment data are lacking, other indicators of low stock biomass, such as B_{loss}, may be used for B_{lim}.

Buffer reference points for both fishing mortality and biomass are specified to ensure that there is a high probability that the limit reference points are not exceeded. Buffer reference points are defined in the framework with respect to the limit reference points taking into account statistical uncertainty in the estimates of the limit reference points.

This approach is identical to that used by ICES in defining precautionary (PA) reference points. As such the NAFO buffer reference points should be considered as estimates of the limit reference points. After review and consideration of the roles and responsibilities of scientists and managers, the Scientific Council reiterates that the harvest control rule as defined in NAFO Sci. Coun. Rep., 1997, 12 is most appropriate for the NAFO stocks because of the drastic changes in recruitment observed on these stocks.

VI. PREPARATION FOR THE JOINT SCIENTIFIC COUNCIL AND FISHERIES COMMISSION WORKING GROUP ON PRECAUTIONARY APPROACH OF 3-5 MAY 1999

1. **Cod in Divisions 3NO** (see Annex 1)

After considerable discussion, the Scientific Council agreed to run several simulations to evaluate the time required to reach different buffers under two recruitment regimes. A mean maturity ogive was used for each regime. The Partial Recruitment vectors and mean weights were calculated for the whole time series. Time to reach B_{lim} (with no buffer) was estimated, together with the time to reach B_{buf} levels corresponding to the 5 and 16 probability of being below B_{lim}.

One set of simulations was to resample from all data (1959-96) in the SSB-recruitment scatter.

Settings for simulation runs

Input data:

Stock numbers-at-age	ADAPT Run with terminal year 1999
Partial Recruitment	ADAPT Run with terminal year 1999
Mean weight-at-age	ADAPT Run with terminal year 1999
Maturity ogive	ADAPT Run with terminal year 1999
Natural mortality-at-age	assumed 0.2
S/R Model	non-parametric based on observations

Variations allowed for input data:

Stock numbers-at-age	resampling from error distribution from ADAPT run
Recruitment	resampling from full range of observed data points

Harvest control rules:

Simulation 1	constant by-catch fishing mortality of 0.025 rebuilding target B_{lim}
Simulation 2	constant by-catch fishing mortality of 0.025 rebuilding target B_{buf} at 85 000 tons (16 risk to be below B_{lim})
Simulation 3	constant by-catch fishing mortality of 0.025 rebuilding target B_{buf} at 101 000 tons (5 risk to be below B_{lim})

Another simulation was conducted with recruitment resampling only for observed data points from 1981 onwards, using B_{lim} as the rebuilding target.

2. **Yellowtail Flounder in Divisions 3LNO** (see Annex 2)

Stochastic projections of the Fs prescribed by the control rule suggest that B_{msy} can be attained by the year 2001, after which the stock biomass is expected to approach an equilibrium of approximately 114 000 tons and yield approximately 15 000 tons of catch. Definition of F_{buf} and B_{buf} as the tenth and ninetieth percentiles of the F_{lim} and B_{lim} estimates respectively, is based on approximately ten percent risk of exceeding the limits. Stochastic projections of control rules that are based on greater risk (i.e. narrower buffer zones) suggest that rebuilding time increases substantially (e.g. 4 years to attain B_{msy} at 25 risk and 10 years to attain B_{msy} at 50 risk), and the level of biomass maintained by the harvest policy over the long term is substantially less (104 000 tons at 25 risk and 91 000 tons at 50 risk).

Stochastic projections were performed to assess the impact of current TACs (i.e. 4 000 tons in 1998 and 6 000 tons in 1999) and alternative TACs for 2000 with respect to the PA framework (see Annex 2, Fig. A, B and C). Distributions of projected biomass and F suggest that 1998 and 1999 TACs result in F being below F_{buf} and biomass, above B_{buf}. Projection of 6 000 tons in 1999 indicates that F decreases to below F_{buf}; projection of 8 000 tons in 2000 indicates that F is below F_{buf}; and projection of 10 000 tons in 2000 suggests that F approaches F_{buf}. Biomass increases to B_{msy} in 2001 under all three catch scenarios.

These scenarios do not consider the impact of by-catch of other species in the fishery for yellowtail flounder in Div. 3LNO.

3. **Shrimp in Division 3M** (see Annex 3)

The Scientific Council noted that stock assessments for shrimp on the Scotian Shelf, in the Gulf of St. Lawrence and the Newfoundland-Labrador offshore area in 1998/99 conducted using the "Traffic Light" approach were viewed positively by managers and industry representatives. The Scientific Council endorsed the use of the approach for NAFO stocks requiring qualitative assessment methods and its introduction at the joint Scientific Council and Fisheries Commission Working Group meeting of 3-5 May, 1999. For this purpose, the detailed spreadsheet developed for shrimp in Div. 3M (Flemish Cap) for 1998 (see Annex 3, A) was adapted for a retrospective analysis to 1993. This involved a consensus building exercise including independent evaluations by the shrimp biologists present, discussion of discrepancies, and agreement on the final annual assessments. The resulting spreadsheet time series (see Annex 3, B) facilitated identification of temporal changes in stock status, gaps in knowledge of shrimp biology, and inconsistencies in data interpretation.

VII. RECOMMENDATIONS FOR THE JOINT SCIENTIFIC COUNCIL AND FISHERIES COMMISSION WORKING GROUP MEETING OF 3-5 MAY 1999

1. **Cod in Divisions 3NO**

With respect to cod in Div. 3NO, the Scientific Council **recommended** that the best current estimate of B_{lim} is a spawning stock biomass of 60 000 tons estimated by applying annual maturity ogives to the population as determined by Virtual Population Analysis (VPA). The Scientific Council also made calculations on the probability levels corresponding to various risks of SSB being below B_{lim} for consideration by managers as possible B_{buf} reference points.

2. **Yellowtail Flounder in Divisions 3LNO**

With respect to yellowtail flounder in NAFO Div. 3LNO, the Scientific Council **recommended** that the results of the ASPIC model be used as the basis for setting some reference points in the PA framework at this time. The results of the model are also useful in evaluating current stock size in relation to these reference points. However, the Scientific Council concluded that the model could not be used directly to derive values for B_{lim} and B_{buf} at this time, due mainly to its inability to account for stock-recruitment relatonships. From the ASPIC results, B_{msy} was estimated at 91 000 tons, F_{lim} (defined as F_{msy}) was 0.18, and F_{buf} (defined as the tenth percentile of the F_{msy} estimate), was 0.13. Investigations on the stock recruit relationship, and on age-structured models, are continuing for this stock.

3. **Shrimp in Division 3M**

The Scientific Council **recommended** that the use of the traffic light approach be considered by managers as an interim means to evaluate Div. 3M shrimp and other data poor stocks.

VIII. APPOINTMENT OF SCIENTIFIC COUNCIL MEMBERS TO REPRESENT SCIENTIFIC COUNCIL AND FISHERIES COMMISSION WORKING GROUP MEETING OF 3-5 MAY 1999

The Council at its meeting during 6-18 September 1998, agreed that the number of Scientific Council participants would be limited. The Chairman noted the list needed to be finalized early so that participants could make their travel arrangements. Accordingly, the Chairman had communicated with members and proposed a list composed primarily of Designated Experts and PA Modelling Experts. The list (H. P. Cornus (SC Chairman), W. B. Brodie (SC Vice-Chairman and Designated Expert for Div. 3LNO yellowtail flounder), R. Mayo (Chairman STACFIS), D. E. Stansbury (Designated Expert for Div. 3NO cod), U. Skuladottir (Designated Expert for Div. 3M shrimp), F. Serchuk, D. B. Atkinson, D. Rivard, L. Motos, H. Siegstad, E. De Cardenas and D. G. Parsons) was finalized in advance of this meeting. It was noted that any member of the Scientific Council may also participate as part of Contracting Party delegations.

IX. OTHER MATTERS

1. The LAN System for Scientific Council Meetings

LAN. The Council was pleased with the LAN System set up by AZTI for this meeting. The configuration of the system will be used by the Secretariat to set up the LAN System for the 3-16 June 1999 Scientific Council Meeting in Dartmouth, Nova Scotia, Canada.

Participants were advised to keep record of the configurations used for their laptops during this meeting, so that their connection to the LAN during the June 1999 Meeting may be expeditious. It was noted that the Council may have to dedicate a few hours of the first day of the June 1999 Meeting for the network set-up, but this may be accomplished during preliminary discussions of Scientific Council and STACFIS (e.g. review of available data).

Virus Control. The Council noted virus controls were essential when using the LAN System. In particular, the Council experienced many viruses within the LAN System at this meeting, which caused considerable concern and delays. It was noted one or more viruses had corrupted some files circulated through the NAFO Secretariat.

The Council therefore **recommended** that:

a) *The Secretariat should install an auto virus check, and a comprehensive virus protection set up for the LAN System for the forthcoming June 1999 Meeting.*

b) *All computers (and software) being used on the LAN system of the June 1999 Meeting should be committed to an automatic virus check by an installed network anti-virus system, in a similar way to the one used in this meeting.*

2. Report of NAFO Observer at ICES

The Council was informed that H. P. Cornus (NAFO Observer) attended the 11th ICES Dialogue Meeting of 26-27 January 1999, Nantes, France, and his report was circulated to Scientific Council members. The purpose of the 11th ICES dialogue meeting was to promote the mutual understanding of managers and scientists in relation to scientific advice. The Precautionary Approach will be included in all ICES advice in the future, but this is not yet the case. In both NAFO and ICES, it was agreed that reference levels and risk are to be decided by the managers, but it is the role of scientists to take account of uncertainty in estimates of reference points when defining buffer (NAFO) and precautionary (ICES) reference points.

The Chairman highlighted that in the ICES considerations of the PA, two subject areas new to the NAFO method, "Form of the Advice" and "Confidence Building", were addressed.

With respect to "Form of Advice", the Council noted some new considerations regarding the Summary Sheet might arise at the 3-5 May 1999 Joint Working Group. It was agreed that the Summary Sheet format should be reviewed subject to the outcome of the Joint Working Group.

Similarly, matters with respect to "Confidence Building" may also arise during the Joint Working Group. Any points arising from these discussions will be considered during the June 1999 Meeting of the Scientific Council.

X. ADOPTION OF REPORT

At its concluding session on 1 May 1999, the Council considered its meeting report at the plenary by an interactive session on the LAN System. The Council therefore reviewed and modified the text of its report simultaneously. The Report as revised during the concluding session was then **adopted**.

XI. ADJOURNMENT

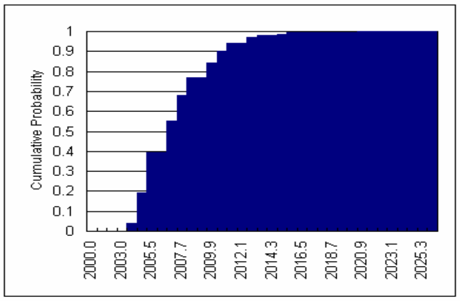
The Chairman thanked participants, especially the Designated Experts for their hard and long hours of work to bring a successful conclusion to this meeting. He also noted the great facilities and arrangements made by L. Motos and his colleagues at AZTI. Noting in addition the wonderful hospitality extend by the AZTI colleagues, the Chairman extended the Council's appreciation. In conclusion he extended thanks to the Secretariat and adjourned the meeting.

ANNEX 1. Cod in Divisions 3NO

A. Scenario: $F_{by\text{-}catch}$ is 0.025 - Resampling full range of recruitment.

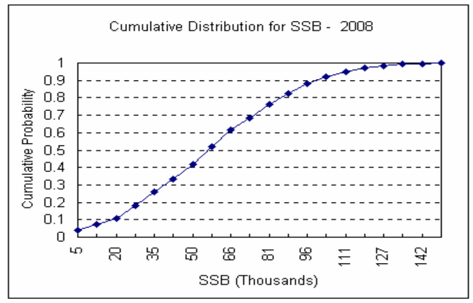
Distribution of First Year when B_{lim} is reached

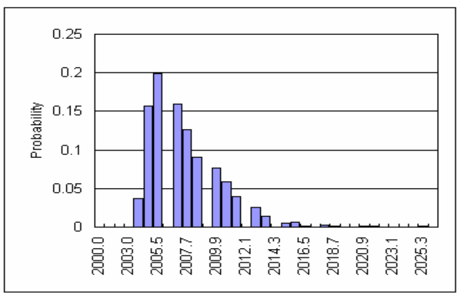
B_{lim}=60000=B_{buf}

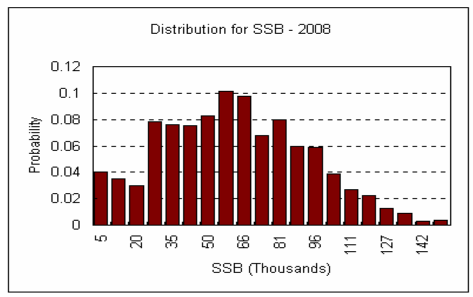


	Year to B_{lim}
Minimum =	2004
Maximum =	2026
Mean =	2008

Distribution of biomass when B_{lim} reached



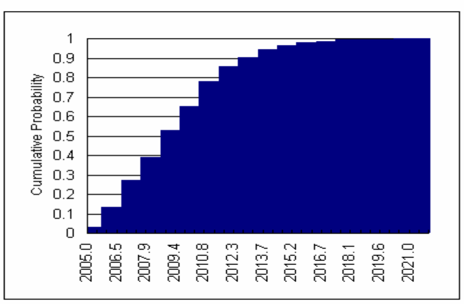




B. Scenario: $F_{by\text{-}catch}$ is 0.025 - Resampling full range of recruitment.

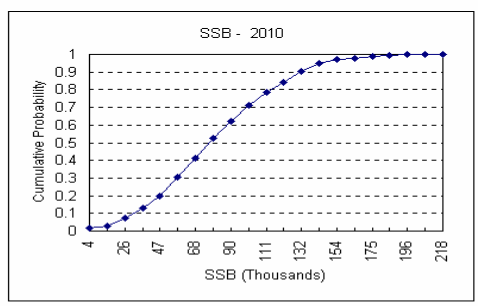
Distribution of First Year when B_{buf} is reached

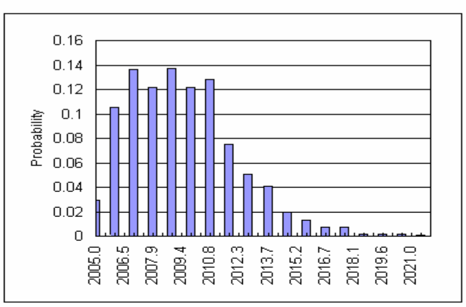
B_{lim}=60000; B_{buf}=85000

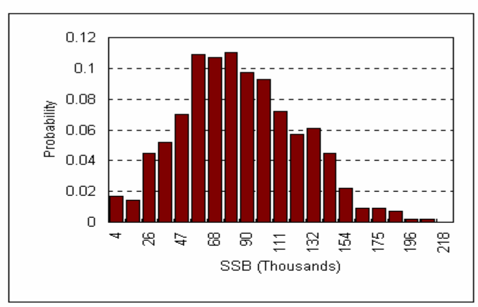


	Year
Minimum =	2005
Maximum =	2022
Mean =	2010

Distribution of biomass when B_{buf} reached







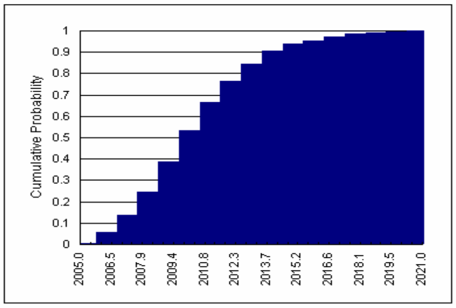
Annex 1. (continued)

C. Scenario: $F_{by\text{-}catch}$ is 0.025 - Resampling full range of recruitment.

Distribution of First Year when B_{buf} is reached

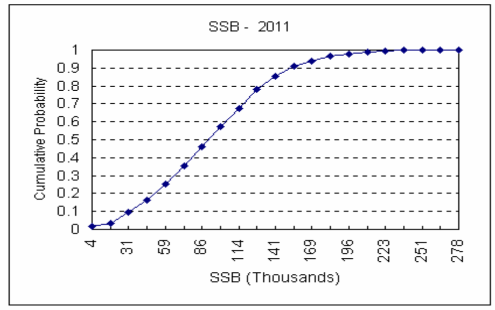
Distribution of biomass when B_{buf} reached

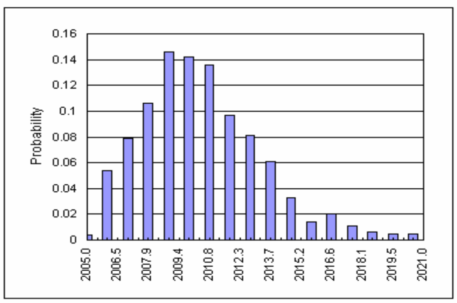
B_{lim}=60000; B_{buf}=101000

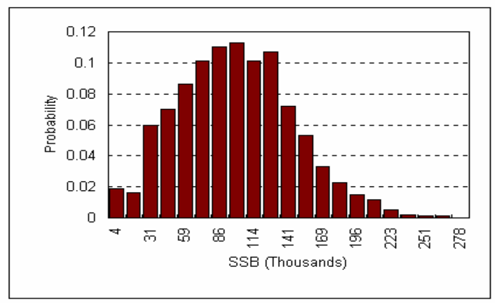


Year to B_{lim}

Minimum =	2005
Maximum =	2021
Mean =	2011





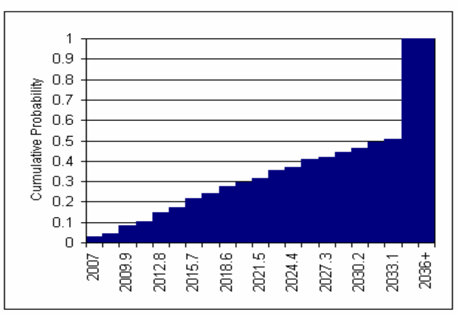


D. Scenario: $F_{by\text{-}catch}$ is 0.025 - Resampling recruitment since 1982

Distribution of First Year when B_{lim} is reached

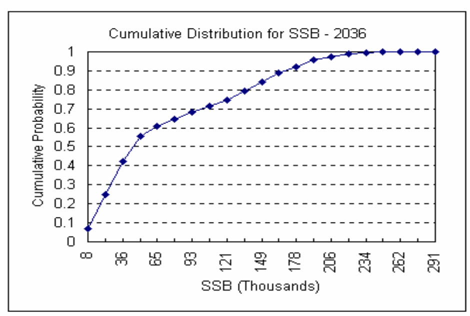
Distribution of biomass when B_{lim} reached

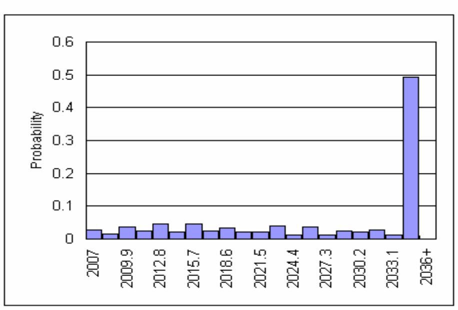
B_{lim}=60000=B_{buf}

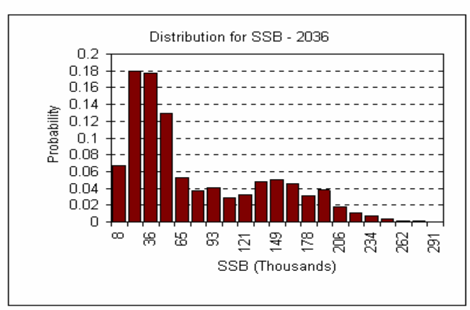


Year to B_{lim}

Minimum =	2007
Maximum =	2036
Mean =	2028







ANNEX 2. Yellowtail Flounder in Divisions 3LNO

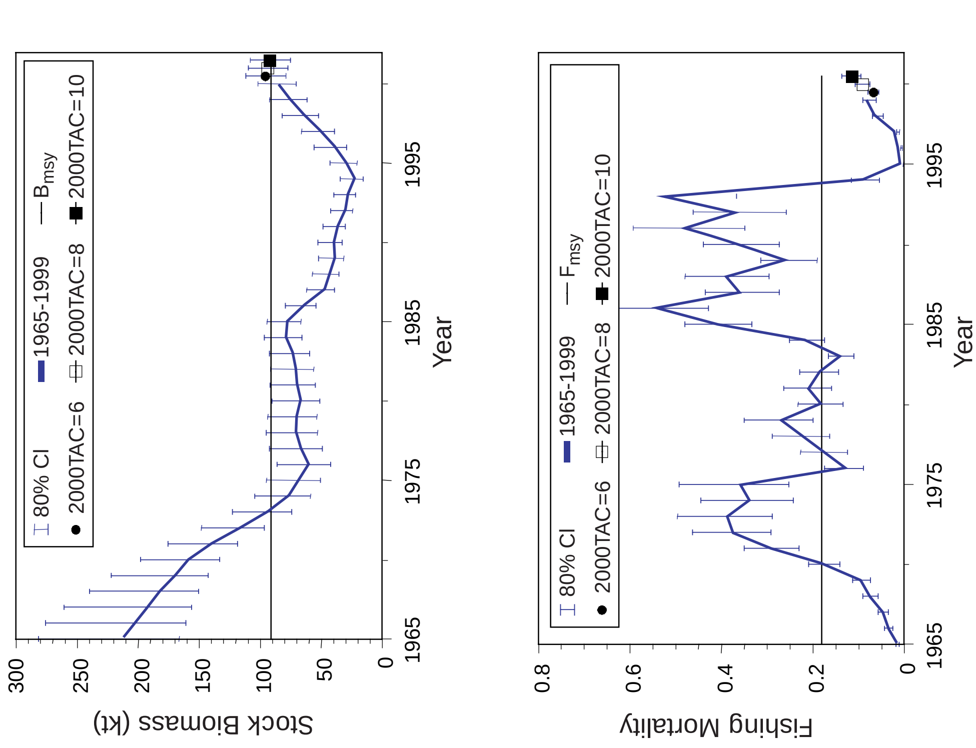


Fig. A. Projected stock biomass and fishing mortality of Div. 3LNO yellowtail flounder assuming three alternative TACs in 2000.

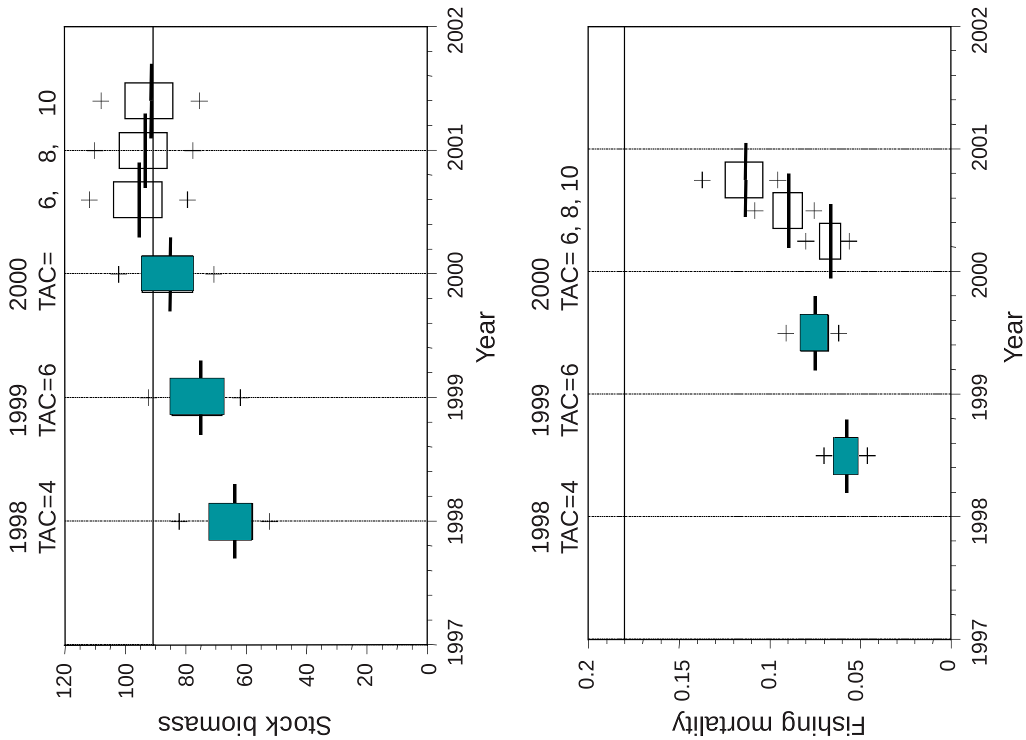


Fig. B. Projected stock biomass and fishing mortality of Div. 3LNO yellowtail flounder assuming three alternative TACs in 2000 (shaded boxes indicate results from 1998 and 1999 projections, open boxes indicate alternative 2000 projections).

Annex 2. (continued)

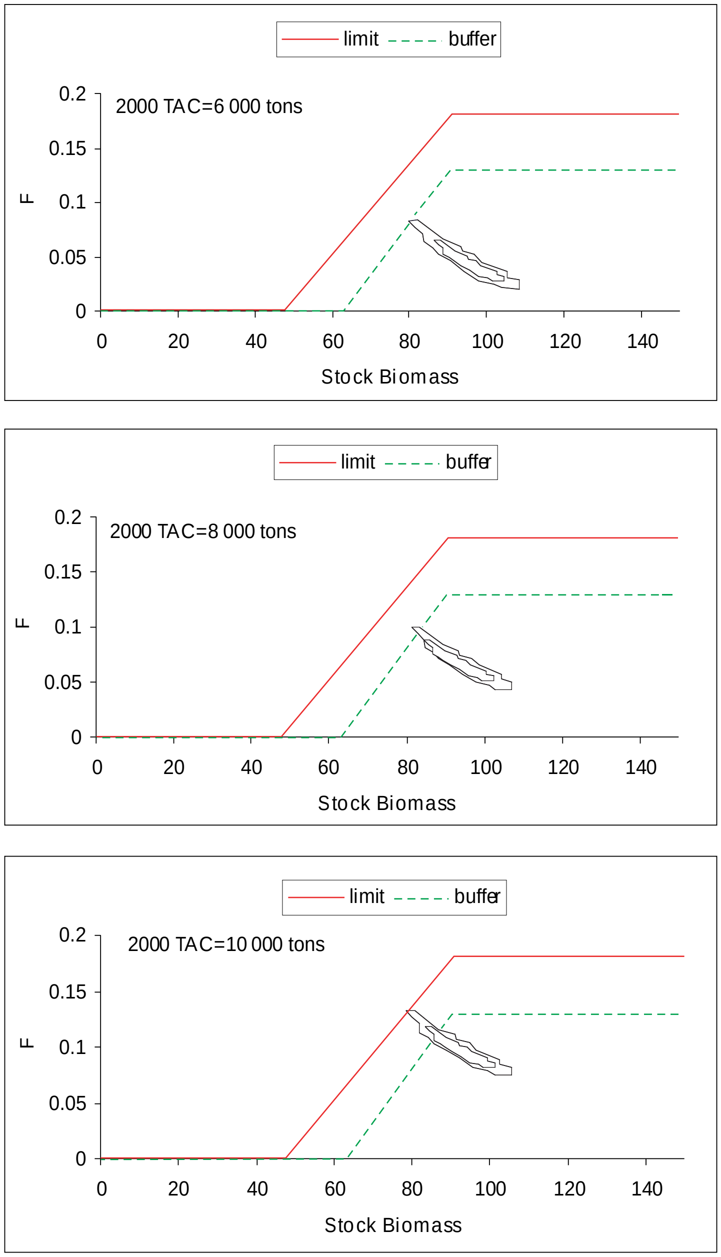


Fig. C. Stochastic projection of Div. 3LNO yellowtail flounder biomass and F under alternative TACs in 2000 (Blobs indicate 50 and 80 confidence regions).

ANNEX 3. Shrimp in Division 3M (for illustrative purposes)

A. 1998 Shrimp in Division 3M

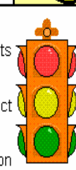
INDEX	OBSERVATION	INTERPRETATION	EVALUATION
FISHERY DATA			
Effort control	Effort regulations implemented since 1996 did not reduce exploitation.	Regulation effectively increased catch and effort.	
CPUE - KG/HR	Annual standardized CPUEs (single trawls only) was 399, 219, 268, 215, 224 and 285 kg per hr. for 1993 to 1998, respectively. Spatial and temporal patterns considered.	Difficult to interpret as an index of abundance due to changes in fishing patterns between years and developing technology.	
Catch composition	The percentage (numbers) of males in the catches increased from 44% in 1993 to 72% in 1995, decreased to 57% in 1997 and increased slightly to 62% in 1998.	The increase from 1993 to 1995 reflects the shift in distribution of fishing effort into shallower waters with the decline of the 1988 year class. Changes thereafter are mainly due to appearance of the 1993 and 1994 year-class.	
Sex inversion	Reduction in size of shrimp at sex inversion	Possibly reflective of reduced female abundance.	
By-catch	Prior to 1995, redfish by-catch was problematic. By-catch much lower during the 1995/98. Cod and Greenland halibut were taken only in small quantities.	It is not clear whether this decrease was due to the reduction of maximum bar spacings in sorting grates from 28 mm in 1994 to 22 mm in 1995 or to the absence of strong redfish recruitment.	
RESEARCH DATA			
Biomass index	Index of biomass from EU surveys was relatively stable from 1995 to 1997 with a large increase in 1998. Faroese surveys also indicated an increase from 1997 to 1998.	The 1998 EU survey estimate is not comparable to previous years and confidence intervals for estimates were not available from the Faroese surveys. Not able to estimate current or future stock size.	
Recruitment (males)	No reliable recruitment index from existing surveys.	Not possible to estimate size of year classes or predict recruitment in the absence of a time series of research surveys directed for shrimp.	
Spawning stock (females)	Female biomass index from EU surveys was stable between 1995-1997 with a possible increase in 1998.	The 1998 EU survey estimate is not comparable to previous years. Not able to estimate current female stock size.	
ANCILLARY DATA			
Immigration	Despite previous concerns for overfishing, recruitment has been maintained.	It is possible that recruitment and/or spawning biomass are being supplemented by immigration from adjacent areas and further north in Div. 2J3K..	
Environment	Colder than normal conditions from the late-1980s to 1995 moderated in 1996 and continued above normal through 1998.	Effects of temperature on shrimp production in the Flemish Cap area are uncertain.	
Predation	Not considered.		–
STOCK STATUS			
Current status	Considering the above indicies.		
Future prospects	Considering the above indicies.		

Despite uncertainty, the stock may be relatively stable, possibly showing an increase in 1998. There is still concern for the high proportion of males in the catch. Catch in 1999 should not exceed 30 000 tons.

Concerns regarding current status and/or future prospects

Uncertainty regarding the impact

Positive evaluation



Annex 3. (continued)

B. Shrimp in Division 3M - Retrospective

INDEX/YEAR	1993	1994	1995	1996	1997	1998
FISHERY DATA						
Effort control				Red	Red	Red
CPUE - KG/HR	Yellow	Red	Yellow	Yellow	Red	Yellow
Catch composition	Green	Red	Red	Red	Red	Yellow
Sex inversion			Yellow	Red	Yellow	Yellow
By-catch	Red	Red	Yellow	Green	Green	Green
RESEARCH DATA						
Biomass index	Green	Red	Yellow	Yellow	Red	Yellow
Recruitment (males)	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Spawning stock (females)	Green	Red	Red	Red	Red	Yellow
ANCILLARY DATA						
Immigration				Yellow	Yellow	Yellow
Environment	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Predation						
ALL INDICATORS						
Current status	Green	Red	Red	Red	Red	Yellow
Future Prospect	Yellow	Yellow	Red	Red	Red	Yellow

Concerns regarding current status and/or future prospects

Uncertainty regarding the impact

Positive evaluation