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SCIENTIFIC COUNCIL MEETING - JUNE 2000

REPORTS OF CWP INTERSESSIONAL MEETINGS

by

NAFO Secretariat

Attached are the Reports of the CWP Intersessional Meetings: 1) **Sub-Group on Publication of Integrated Catch Statistics for the Atlantic** held during 10-11 February 2000, and 2) **Working Group on Precautionary Approach Terminology** held during 14-16 February 2000, both at ICES Headquarters, Copenhagen, Denmark. The complete reports as submitted by the CWP Secretariat are distributed for information at June 2000 Meeting of the Scientific Council.

CWP-19/2 (A)

REPORT OF CWP INTERSESSIONAL MEETING:

SUB-GROUP ON PUBLICATION OF INTEGRATED CATCH STATISTICS FOR THE ATLANTIC

10-11 February 2000, ICES HQ, Copenhagen

REPORT TO CWP-19 OF THE MEETING OF THE CWP SUB-GROUP ON

PUBLICATION OF INTEGRATED CATCH STATISTICS FOR THE ATLANTIC

1. Opening

The CWP chairperson, D. Cross, opened the meeting of the Sub-group and outlined the background to the meeting and the recommendation in paragraph 89 of the report of CWP-18 which reads as follows:

"CWP found good grounds for further exploring the proposal of a single publication in electronic form of the entire database of North Atlantic catch statistics. CWP therefore recommended that Eurostat, FAO, ICCAT, ICES and NAFO investigate the possibility for producing a publication following the ICES proposal. ICES undertook to take the lead on this issue."

H. Lassen welcomed participants to ICES.

Participants:

T. Amaratunga (NAFO)
W. Brodie (NAFO)
D. Cross (Eurostat), Chairperson
R. Grainger (FAO), CWP Secretary
H. Lassen (ICES)
P. Miyake (ICCAT)
H. Sparholt (ICES)
M. Zarecki (ICES)

2. Identification of data sets

It was agreed to proceed with a joint dissemination on CD ROM of catch statistics for the Atlantic Ocean comprising individual data sets from different agencies and a first attempt at an integrated data set.

ICES and ICCAT catch statistics have been loaded as test data sets into the Fishstat Plus dissemination database system which has been developed by FAO. A procedure which will allow agencies to update their data sets in Fishstat is under development and will be released soon. It was agreed that Fishstat, which allows different data sets with their own data structures to be accessed through a user-friendly interface, provides a convenient vehicle for dissemination of the Atlantic catch statistics on CD ROM and as a downloadable system on the Internet.

It was agreed that the following data sets would be included:

- FAO annual nominal catch statistics by country, species and major fishing area for all Atlantic areas for 1950-1998
- ICES annual nominal catch statistics by country, species and statistical division for major fishing area 27 for 1973-1998
- NAFO annual nominal catch statistics by country, species and statistical division for major fishing area 21 for 1960-1998
- CECAF annual nominal catch statistics by country, species and statistical division for major fishing area 34 for 1972-1998
- GFCM annual nominal catch statistics by country, species and statistical division for major fishing area 37 for 1972-1998
- ICSEAF annual nominal catch statistics by country, species and statistical division for major fishing area 47 for 1970-1987 (ideally also data for years since 1987 if possible).

- ICCAT quarterly nominal catch and discard statistics by country, fishing gear, species, FAO major fishing area, ICCAT statistical division and 5 x 5 rectangle for the ICCAT convention area for 1950-1998.
- Subject to the agreement of CCAMLR, catch statistics for the Atlantic Antarctic in whatever form CCAMLR wished to present them, for the years 1977/78-1998/99.

It was agreed not to include statistics of other agencies (e.g. IBSFC, NEAFC, NASCO, IWC) in this first trial integrated data set given that most of those statistics are potentially covered by the above-mentioned statistics. However, consideration should be given to including them in subsequent releases.

3. Development of trial integrated data set and elimination of overlaps

The above-mentioned data sets contain overlaps. It was agreed that the trial integrated data set with no overlaps in coverage would be developed comprising the following:

- ICCAT annual nominal catch statistics by country, species (for tuna and tuna-like species only), FAO major fishing area, ICCAT statistical division and, where available, by 5 x 5 rectangle for the ICCAT convention area for 1950-1998 (the first integrated data set will not include discards).

- ICES annual nominal catch statistics by country, species (with the exclusion of tuna and tuna like species) and statistical division for major fishing area 27 for 1973-1998. FAO nominal catch statistics for area 27 would be included for the years 1950-1972.

- NAFO annual nominal catch statistics by country, species (with the exclusion of tuna and tuna like species) and statistical division for major fishing area 21 for 1960-1998. FAO nominal catch statistics for area 21 would be included for the years 1950-1959.

- CECAF annual nominal catch statistics (including aquaculture production until these are separated) by country, species (with the exclusion of tuna and tuna like species) and statistical division for major fishing area 34 for 1972-1998. FAO nominal catch statistics for area 34 would be included for the years 1950-1971.

- GFCM annual nominal catch statistics (including aquaculture production until these are separated) by country, species (with the exclusion of tuna and tuna like species) and statistical division for major fishing area 37 for 1972-1998. FAO nominal catch statistics for area 37 would be included for the years 1950-1971.

- Subject to the agreement of CCAMLR, annual nominal catch statistics by country, species (with the exclusion of tuna and tuna like species) and statistical division for major fishing area 48 for 1978-1998 (split years 1977/78 -1997/98). FAO nominal catch statistics for area 48 would be included for the years 1950-77.

- FAO annual nominal catch statistics by country, species (with the exclusion of tuna and tuna like species) and major fishing area for all Atlantic areas not included above for 1950-1998.

The integrated data set should have the following fields:

- Agency (data owner) – This field need not be shown in all screens.

- Country – A common country classification and coding will be required, but it may be necessary to allow different agencies to use different country names for the same entity (code). Alternatively, only ISO 3-alpha codes or abbreviated country names will be used. This requires further consideration.

- Species – a common classification will be necessary and it is proposed to use the list with Inter-agency 3-alpha identifier maintained by FAO.

- FAO major fishing area – ICCAT 5 x 5 rectangles will be assigned to FAO areas, and in ambiguous cases this will depend on where in the rectangle most catches are taken

- Sub-areas/divisions according to agency classification

- 5 x 5 rectangle – for ICCAT data only

- Catch by year in tonnes – utilising existing Fishstat symbols (e.g. for data not separately available, negligible quantities)

It is recognised that this trial integrated data set will probably not be a harmonised and consistent record of nominal catches. However, it will be an important first step in the integration of regional (mainly STATLANT) and FAO NS statistics in a systematic way in pursuit of a data set which will be as complete, detailed and accurate as possible by utilising the best data available, in line with the development planned within the Fisheries Global Information System (FIGIS) project. It will be essential to include “read me” texts or notes within Fishstat explaining the purpose of the trial integrated data set and warning of the inconsistencies and lack of harmonisation in this first attempt. It is hoped that the first trial integrated data set will make more explicit the inconsistencies and thus focus attention on their resolution.

4. Publication policy

Each agency will be provided with a master CD ROM to disseminate as it wishes. Some agencies will require the approval of their governing bodies prior to dissemination. The possibility of publication as a joint initiative of the CD ROM (with logos of all contributing agencies on it) will be investigated by ICES, ICCAT, FAO and NAFO, including the related costs. This will be discussed and decided by correspondence.

Agencies are responsible for the individual time series which originated with them and for which they are data owners. The responsibility for the design and structure of the integrated data set rests with the CWP Sub-group on Publication of Integrated Catch Statistics for the Atlantic, not with any one agency.

Eurostat reported that following the concern expressed at the CWP-18 Session that data available at no cost from responsible agencies were being compiled and sold by Eurostat, it had reviewed its policy on the dissemination of fishery statistics. Requests for data from privileged users (basically those national and international organisations contributing to Eurostat's programme of fishery statistics and journalists) are processed free-of-charge. Requests for other users of data are subject to a charge for the processing of the data. However, where it was known that the data were available free-of-charge from another agency, the customer is advised as to the other source of the data and is given the option of continuing with the processing by Eurostat with the appropriate charge or contacting the other agency for the information. The Sub-Group thanked Eurostat for this clarification of its dissemination policy and expressed satisfaction that it did not conflict with the policies of the other agencies.

The ICES Secretariat sought the advice of the other agencies on the policy to adopt with regard to requests for data from consultants. With the availability of data from several sources it was necessary for the agencies to adopt similar policies with regard to the availability of the data and the charges to be made for supplying the data. It was agreed that this would be a topic for inclusion in the agenda of the CWP-19 agenda."

5. Publication plan and timescale

Each agency will provide its data as listed in 2 above to FAO for inclusion in Fishstat as separate data sets and to Eurostat for updating the Fame[1] database. ICCAT needs to revise its Catdis data extensively before preparing the data for inclusion in the trial integrated data set and this is expected to be completed by the end of May 2000.

[1] Forecasting, Analysis and Modelling Environment

ICCAT also needs to assign some data to statistical divisions (e.g. for some small tuna and for Mediterranean tunas). Eurostat will prepare the trial integrated data set as described in 3 above with the exception of the ICCAT data and provide it to FAO for loading into Fishstat by mid April for initial testing. Eurostat will add in the ICCAT data to the integrated data set when available and provide this to FAO. FAO will prepare a test version of Fishstat containing all the data sets and provide this to all agencies by late June 2000. Following feedback from all agencies, a final version will be prepared in late August in time for release at ICES, ICCAT and NAFO annual meetings in the autumn.

FAO will investigate the possibility of including statistical maps and explanatory notes within Fishstat.

6. Other business

Elasmobranch statistics

Developments in agency programmes in relation to elasmobranch statistics were reported.

Eurostat reported that it intended to present to the next meeting of its Working Group "Fishery Statistics" proposals to add to the corresponding EU legislation the Elasmobranch species being added to the STATLANT 21A, 27A, 34A and 37A questionnaires. There is a simplified European Council procedure for achieving this but the large number of species being proposed for adding to the three latter questionnaires might be an obstacle to the use of this procedure. Other members of the Sub-Group shared the concern as to the large number of species involved, the resultant impact on the national data collecting systems and the difficulty of identification of the species. The Sub-Group recommended that the agencies concerned should give careful consideration to the necessity for such extensive species lists."

ICCAT started collecting catch, effort and biological data on sharks caught incidentally to the tuna fisheries since 1994. It identified species of sharks caught by tuna fisheries, selected 8 pelagic sharks and 15 coastal shark species for reporting. The reporting forms have been developed and sent to over 80 countries. At present, the data have been collected from over 20 countries. The estimates of historical catches have also been tried. Good catch and CPUE series data are now available on some oceanic shark species from several fisheries.

Some assessments have been tried. However, as ICCAT has mandate only on by-catch fishes of tuna fisheries, it resolved that FAO should take initial role as the center of the data collection. At the same time, since 1994, ICCAT has been asking that all the regional agencies take serious consideration in collecting data on sharks. Scientists involved in ICCAT research also took active role in participating process of developing FAO International Plan of Action for Management of Sharks and actually implementing the duties of regional agencies defined in the IPOA.

ICES will adopt the species coding for Elasmobranch fishes as described in the Report of the Study Group on Elasmobranch Fishes (ICES CM 1997/G:2, ICES CM 1998/G:12, ICES CM 1999/G:11 (Section 6.2) following ICES resolutions (C.Res. 1997/4:4, C.Res. 1998/4:3, and C.Res. 1999/4G02). The ICES General Secretary has informed FAO asking to have these coding added to the Statlant 27A form.

Identification posters for sharks has been produced by Bundesforschungsanstalt für Fischerei, Germany, NAFO, EC, FAO, New England Aquarium, Boston, USA, Centre for Marine Conservation, Washington D.C. USA and ICES. This has been done to enable the various reporting institutions in the ICES member countries to identify the various Elasmobranch fishes to the level given in the Statlant 27A addendum. A similar poster for rays and skates is also being produced.

For discussions at CWP-19 there are two questions regarding these new codes. The first one is on overlap between old and new Elasmobranch codes. For instance, the definition of the codes SKA and RAJ seem to overlap. The second question is to initiate a discussion on the response ICES receives to these new data requests, i.e. whether the reporting units in ICES member countries are able to assign the necessary effort for reporting Elasmobranch catches in details as requested.

FAO made an addendum to STATLANT 27A including 37 new codes according to the ICES resolutions. These new codes have after some discussion internally in ICES and between ICES and FAO been agreed to be appropriate. The addendum to Statlant 27A was sent out for the first time in January 1999 for reporting 1998 catches. In January 2000 a slightly revised addendum was sent out for reporting 1999 catches.

Similarly FAO sent an addendum with an expanded list of shark species for the STATLANT 21 questionnaires. Similar expanded lists will be attached to the STATLANT questionnaires for areas 34 and 37 that will be despatched in April 2000.

Some concern was expressed about the large number of elasmobranch species which are proposed for inclusion in the STATLANT inquiries for some areas, and for areas 34 and 37 in particular. It would be desirable to consult relevant agencies for their advice on this.

It was noted that there are overlaps in classification of several elasmobranch species items such as SKA, RAJ, SRX, BAI. Proposals for rationalisation should be discussed at CWP-19.

NAFO Scientific Council agreed it was important that the species for which data are required be printed on the STATLANT 21 A and B questionnaires. The list of elasmobranchs forwarded to CWP Secretariat for reprinting the STATLANT forms for year 2000 is shown in Table 1.

The Scientific Council reviewed distribution information from surveys on sharks in NAFO Sub-area 3. It was noted shark species are by-catches of the Greenland halibut fishery and the total catch is small. The main retained species is the black dogfish, the main discard is the boreal shark. Since 1996 the retained proportion of black dogfish has increased noticeably, as well as the proportion of total sharks. Black dogfish is the species with the highest biomass index and is found in the deepest waters. Its length range was mainly between 50 and 80 cm, with a mode around 62-63 cm. There was no evident geographic pattern in the length distribution observed during the studied period.

The Scientific Council noted that a manual for elasmobranch identification prepared by the Canadian Department of Fisheries and Oceans for the use by fishery observers would be useful for wider application. With the development of the Precautionary Approach, collection of data on the elasmobranch fisheries, distribution and biology should be accorded particular attention. It was agreed past and current data on these species should be reviewed at the June 2000 Meeting of the Scientific Council and a Designated Expert for elasmobranchs was appointed.

Effort definition

Paragraph 106 of the report of CWP-18 unfortunately contains an error. The text should read:

"NAFO inter-sessionally had proposed a new definition for the measure of effort for boat seines. CWP noted responses from regional organisations had suggested minor editorial changes. Accordingly, NAFO presented to CWP the new definition for adoption. CWP recommended acceptance of the new global definition which should read as follows: "Boat seines (Danish etc). Effort measure: hours fishing. Definition: number of times the gear was set or shot, times the estimated mean set or shot duration."

This will be officially noted at CWP-19 and the correct definition included in the report of that session.

CWP-19 planning meeting

The possibility of holding a planning meeting for CWP-19 immediately prior to the planned meeting of regional fishery bodies in February 2001 will be investigated.

Items which might be included in the agenda for CWP-19 include the following:

- Elasmobranch statistics – Overview of agency activities and coordination of activities in relation to CITES and the IPOA-SHARKS[2]
- Aids to elasmobranch species identification
- Elasmobranch species classification
- Joint dissemination of fishery statistics
- Charging and dissemination policies for supply of data
- Discard data availability and dissemination

Table 1: The list of elasmobranchs forwarded by NAFO to the CWP Secretariat for reprinting the STATLANT 21 form for year 2000.

CODE	SHORT NAME	COMMON NAME	LATIN NAME	ABBRE.	CATEGORY
462	PORBEAGLE	PORBEAGLE	*LAMNA NASUS*	POR	3
464	SHORTFIN MAKO	SHORTFIN MAKO SHARK	*ISURUS OXYRINCHUS*	SMA	3
470	SHARPNOSE SHARK	ATLANTIC SHARPNOSE SHARK	*RHIZOPRIONODON TERRAENOVAE*	RHT	3
472	BLACK DOGFISH	BLACK DOGFISH	*CENTROSCYLLIUM FABRICII*	CFB	3
473	BOREAL SHARK	BOREAL (GREENLAND) SHARK	*SOMNIOUSUS MICROCEPHALUS*	GSK	3
474	BASKING SHARK	BASKING SHARK	*CETORHINUS MAXIMUS*	BSK	3
452	SPINY DOGFISH	SPINY (PICKED) DOGFISH	S*QUALUS ACANTHIAS*	DGS	3
480	LITTLE SKATE	LITTLE SKATE	*RAJA ERINACEA*	RJD	3
484	BARNDOOR SKATE	BARNDOOR SKATE	*RAJA LAEVIS*	RJL	3
487	WINTER SKATE	WINTER SKATE	*RAJA OCELLATA*	RJT	3
488	THORNY SKATE	THORNY SKATE (STARRY RAY)	*RAJA RADIATA*	RJR	3
489	SMOOTH SKATE	SMOOTH SKATE	*RAJA SENTA*	RJS	3
490	SPINYTAIL SKATE	SPINYTAIL (SPINETAIL RAY)	*RAJA (BATHYRAJA) SPINICAUDA*	RJQ	3

[2] The FAO International Plan of Action for the Conservation and Management of Sharks

CWP-19/2 (B)

REPORT OF CWP INTERSESSIONAL MEETING:

WORKING GROUP ON PRECAUTIONARY APPROACH TERMINOLOGY

14-16 February 2000, ICES HQ, Copenhagen

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REPORT OF THE WORKING GROUP ON PRECAUTIONARY APPROACH TERMINOLOGY

1 2, 3, OPENING, AGENDA, TERMS OF REFERENCE

The WG convened at 1130 on February 14, 2000 at ICES Headquarters, in Copenhagen, Denmark. W. Brodie (NAFO Scientific Council Chairman) served as chair of the WG. Attendees represented FAO, ICCAT, ICES, or NAFO, and are listed in Annex I. The agenda as contained in Annex II was adopted and rapporteurs were appointed as necessary for the various agenda items. The terms of reference, attached to the agenda in Annex II, were reviewed. There was agreement prior to the meeting not to review detailed calculations on case studies, noting that this would have an impact on the second part of term of reference 2).

4 PRESENTATION OF AGENCY FRAMEWORKS

Each agency made a presentation on the precautionary approach, and the presenters' summaries are given below. Unless otherwise noted, NAFO refers to the Scientific Council of NAFO, and ICCAT refers to the Standing Committee on Research and Statistics of ICCAT. It was noted that ICCAT and NAFO encompass both scientific and management bodies, but that ICES is strictly a scientific body.

A) FAO:

An account was given of progress made in implementing the PA (see document by Garcia in Annex III). It recalled the historical developments leading to the elaboration of the PA since the beginning of the 1990s, in FAO, at UNCED and at the UN level, as well as to its institutionalisation in the UN Fish Stock Agreement (UNFSA) and the Code of Conduct for Responsible Fisheries. It also reported briefly on initiatives taken for the PA implementation in the IPHC, IWC, ICES, NAFO, NASCO, ICCAT, MHLC, SEAFO and APFIC, and on the views expressed on the issue at the International Tribunal on the Law of the Sea (ITLOS) in relation to the Southern Bluefin Tuna. Attention was also drawn on the work done at FAO in relation to the listing of fisheries resources by CITES in case of risk of extinction. In addressing efforts made at national level, less information was available.

The main issues noted in the 5 years of implementation (1995-2000) related to:

- The use of Marine Protected Areas (MPAs) as precautionary instruments;
- The definitions and use of reference points in relation to decision rules (control rules);
- The relationship between decision rules and trajectories (e.g. for rebuilding);
- The impact of ignorance on the perception of uncertainty and risk assessment;
- The use of Operational Management Procedures (OMPs);
- The role of science in the PA;
- The narrow (monodisciplinary) implementation of the PA;
- The problems in data-poor situations;
- The confusion between "precautionary measures " and "good practices";
- The presentation of results to non-scientists
- The demand for harmonisation, in terminology, methodology, definitions, and decision rules as well as on objectives, constraints, perception of (attitude to) risk, etc.

The presentation concluded on the need for institutional change (to be able to fully implement the PA) including change in research focus and modus operandi and drew attention to the convergence between the PA implementation process and the process of establishment of sustainability indicators systems with their implications in the perspective of ecolabelling.

There was also presentation of a brief note (see document by Garcia and de Leiva in Annex III) suggesting a way of standardising the precautionary information on stocks (as produced by ACFM) onto a single graph with the view to offer to non-specialist readers as well as policy-makers, an easily accessible summary of the situation every year as well as a better perception of the evolution of such a situation year after year.

B) ICCAT:

In 1997, ICCAT´s Standing Committee on Research and Statistics (SCRS) created an ad Hoc Working Group on the Precautionary Approach and directed it to explain what the PA means in the context of ICCAT stocks (tuna and tuna-like fishes), i.e. taking into account the life history characteristics of tunas and the environment in which they live.

This ad Hoc WG has proceeded along a slightly different track than either NAFO or ICES. The SCRS has noted that "*Annex II of the Straddling Stocks Agreement states that* $\boldsymbol{F}_{MSY}$ *should be a minimum standard for a limit reference point. This is potentially in conflict with the objectives of the ICCAT Convention, which imply that* $\boldsymbol{F}_{MSY}$ *is the targ*et." Because of this potential conflict, and given that it is not clear whether the quality and quantity of information available allows an $\mathbf{F}_{\mathrm{MSY}}$ management strategy to avoid sustainability problems with sufficiently high probability, the SCRS decided that it needs to conduct stock-specific evaluations using simulation methods. As a result, ICCAT has not yet made a decision on what reference points would be treated as limits in providing PA advice (note, however, that the SCRS routinely provides estimates of stock status relative to MSY benchmarks for all stocks with quantitative assessments).

In terms of nomenclature, the SCRS has used the following definitions:

- **A limit** is a conservation reference point based on a level of biomass ($\mathbf{B}_{\mathrm{lim}}$it) or a fishing mortality rate ($\mathbf{F}_{\mathrm{lim}}$it) that should be avoided with high probability because it is believed that the stock may be in danger of recruitment overfishing or depensatory effects if the reference points are violated. The level chosen to represent "high probability" depends on the severity of the consequences of the violation. The actual probability (risk) levels should be set by managers, in consultation with stock assessment scientists.

- **A target** is a management objective based on a level of biomass (Btarget) or a fishing mortality rate (Ftarget) that should be achieved with high probability on average. This generally means that the probability of exceeding the reference point should be around 50%. Targets should be set sufficiently far away from limits that they result in only a low probability that the limits will be exceeded.

- **A threshold** is a level of biomass (Bthresh) or a fishing mortality rate (Fthresh) between the limit and target reference points that serves as a "red flag" and may trigger particular management actions designed to reduce fishing mortality.

- **A harvest control rule** incorporates limit and target (and possibly threshold) reference points into a simple schematic that shows the action to be taken in terms of defining and setting fishing mortality rates or yields (y-axis) depending on the estimated biomass level (x-axis).

Reference: Anonymous. *In press*. Report of the meeting of the ICCAT *ad hoc* Working Group on Precautionary Approach (Dublin, Ireland – May 17 to 21, 1999). ICCAT Coll. Vol. Sci. Pap. COM-SCRS/99/11.

C) ICES:

A working paper (see document by Lassen and Sparholt in Annex III) described the ICES Framework for the implementation of the Precautionary Approach. This framework has been used for the formulation of advice since 1998 and is described in the introduction to the ICES ACFM report for 1999, CRR no 236, February 2000. This framework is built on an estimate of current stock status and advice on management measures, mostly in the form of catch options, that will maintain the stock status inside safe biological limits. Where the stock is outside safe biological limits ICES proposes measures and a timeframe that are expected to bring the stock inside safe biological limits.

In order for stocks and fisheries exploiting them to be within safe biological limits, there should be a high probability that 1) the spawning stock biomass is above the threshold where recruitment is impaired, and 2) the fishing mortality is below that which will drive the spawning stock to the biomass threshold which must be avoided. The biomass threshold is defined as $\mathbf{B}_{lim}$ ($_{lim}$ stands for limit) and the fishing mortality threshold as $\mathbf{F}_{lim}$. In order to have a high probability to avoid the thresholds, ICES calculates a buffer that when applied to the limit reference points provide estimates of the precautionary reference points $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ ($_{pa}$ stands for precautionary approach). This buffer depends on the natural variability of the stock, the precision of the assessment and the risk fishery management agencies are willing to accept. The greater the precision of the assessment, the smaller the distance between limit and precautionary reference points. If the assessment is less reliable, the distance will be greater. ICES has defined $\mathbf{B}_{pa}$ as the biomass below which action should be taken and $\mathbf{F}_{pa}$ as the fishing mortality above which management action should be taken. Therefore, although ICES sees its responsibility to identify limit reference points, it will suggest precautionary reference points. The adoption of precautionary reference points requires discussion with fishery management agencies.

ICES proposed in 1998 and 1999 a number of "lim" and "pa" reference points as a provisional step to the implementation of a precautionary approach. It was recognised that the estimates of thresholds could change as the concept evolved or with additional knowledge of stock and fishery dynamics.

Advice from ICES will be constrained by $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$. If fishery management decisions lead to $\mathbf{F}_{pa}$ being exceeded, then this would be regarded as overfishing and management would not be regarded as consistent with a precautionary approach. The development of a management plan to reduce fishing mortality to no greater than $\mathbf{F}_{pa}$ would be advised. Because $\mathbf{F}_{pa}$ would be set such that $\mathbf{B}_{pa}$ were unlikely to be reached, and because $\mathbf{B}_{pa}$ is chosen to provide a high probability of avoiding recruitment failure, if SSB were to fall below $\mathbf{B}_{pa}$, advice to reduce fishing mortality would be likely. This would depend, however, on whether or not $\mathbf{F}_{pa}$ were also being exceeded and on the prognosis for SSB trends and the probability of recovering to above $\mathbf{B}_{pa}$ in the short term. If SSB were predicted to remain below $\mathbf{B}_{pa}$ in the short to medium term, the development of a recovery plan would be advised. But in general, $\mathbf{B}_{pa}$ is the biomass threshold triggering advice for a reduction in F to a value below $\mathbf{F}_{pa}$.

$\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ are thus the main devices in the ICES framework for providing advice. They are thresholds which constrain advice or which likely trigger advice for the implementation of management/recovery plans. If the development of plans were proposed, fishery management agencies, scientists and other parties would need to work together on their development. Such plans might involve explicit harvest control rules or sets of decision rules.

D) NAFO:

A presentation on the Precautionary Approach within NAFO was reviewed. The PA framework was first defined within NAFO SC in 1997, (NAFO SCS Doc. 97/12), and is characterised by limit, buffer, and target reference points for spawning stock biomass and fishing mortality. In the NAFO framework, $\mathbf{F}_{lim}$ can be no higher than the fishing mortality rate which generates MSY. The target recovery level for biomass (B_{tr}) for overfished stocks is the total stock biomass which would produce MSY. $\mathbf{B}_{lim}$ is defined as the level of spawning biomass that the stock should not be allowed to fall below. Buffers (B_{buf} and F_{buf}) are defined for $\mathbf{B}_{lim}$ and $\mathbf{F}_{lim}$ to ensure that there is a high probability that the limit reference points are not reached. Within each of the biomass/fishing mortality zones defined by the reference points (collapsed, danger zone, recovery zone, recovered zone), specific courses of action are indicated.

The presentation also focussed on progress made in Scientific Council in applying the PA framework to a number of stocks (NAFO SCS Docs. 98/1, 99/4). It was noted that many NAFO stocks appear to have entered into a period of lower productivity, for reasons which are unclear, and that there were some large differences in reference points depending on the years chosen for analyses. Some stocks have remained at very low levels despite moratoria on fishing for several years. A full suite of limit and reference points have not yet been developed for any of the NAFO stocks, but substantial progress has been made on some stocks, particularly those with age-based analytical assessments. For other stocks where less data are available, other approaches, such as the traffic light method, have been used.

Within NAFO, there have been discussions on the PA framework between Scientific Council and the Fisheries Commission (NAFO FC Docs 98/2, 99/2). These have focussed on several aspects of the NAFO PA framework, including definitions of the roles of scientists and fisheries managers in relation to the PA. One of the issues has also been a request by managers to review terminology and concepts used with various fisheries agencies such as NAFO, ICES, FAO, ICCAT, etc. Further discussions are planned to review progress on development and implementation of the NAFO PA framework.

E) Other perspectives:

USA:. No formal presentations were made about the implementation of the PA nationally in the USA. However, a document entitled "Technical Guidance on the Use of Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act" (NOAA Technical Memorandum NMFS-F/SPO-31, 1998, 54p.; http://www.nmfs.gov/sfa/reports.html) was made available to participants. It was noted that U.S. legislation requires fisheries to obtain the "optimum yield", which is constrained to be no greater than MSY. This requirement in effect defines a conservation limit that is consistent with the various texts on the PA.

Canada: Implementation of the Precautionary Approach in Canada, progress report on science activities.

A workshop was held in November 1999 at the Pacific Biological Station in Nanaimo, British Columbia, Canada, as part of a Canadian research initiative aimed at developing concepts and tools for the implementation of the precautionary approach for Canadian fisheries. When the project was initiated, case studies were identified as the mechanism for gaining insight into the precautionary approach. Most of these case studies focused on exploring conceptual frameworks and on identifying the risks associated with different potential management strategies. The workshop report has been published in the Proceedings Series of the Canadian Stock Assessment Secretariat (Richards and Schnute, 2000) and is available on internet (http://www.dfo-mpo.gc.ca/ csas/csas/ proceedings/ proceedings99.htm). Other Canadian initiatives related to the precautionary approach include discussion papers under preparation by the Fisheries Resource Conservation Council and by the Fisheries Management Science Working Group in the Maritimes region. These explore approaches that take into account additional information (e.g. on growth, reproductive potential, geographical distribution, changes in migration patterns, environmental indicators, etc.) to gain insight into factors that may be influencing stock productivity and stock dynamics. Workshops are being planned at the national level to develop an approach applicable for the wide range of life histories represented by species under exploitation in Canada.

Reference:

Richards L.J. and J.T. Schnute. 2000. Science Strategic Project on the Precautionary Approach in Canada - Proceedings of the Second Workshop. Canadian Stock assessment Proceedings series 99/41, 96 pages.

European Commission: A presentation was made on the use of ICES and NAFO precautionary frameworks from a client perspective (European Commission). Relevant points from this presentation are included below.

5 DISCUSSION OF WHERE THERE ARE CONCEPT AND TERMINOLOGY DIFFERENCES BETWEEN AGENCY USAGE, AND HOW THESE DIFFERENCES COULD AFFECT PROVISION OF ADVICE UNDER THE PA

A summary of key characteristics of reference point terminology, definition, and technical basis is contained in Table 5.1. Terminology used for reference points of different types is given in the first three columns of this table. The columns headed 'Risk incurred on crossing reference point' describe the operational definition of the reference point, i.e. describing the nature of the risk which is flagged by each reference point. Identified under 'Uncertainties considered in setting reference point' are which types of uncertainty the reference point provides protection against when it is used operationally. Lastly, the technical basis for the reference point calculation is identified.

5.1 Terminology

Terminology for limit reference points is rather consistent between agencies as ICES, NAFO and ICCAT all use $\mathbf{B}_{lim}$ and $\mathbf{F}_{lim}$ terms to refer to biomass and fishing mortality limit reference points. For one species ICES uses U_{lim} (where U is a catch per unit of effort) which is a proxy for $\mathbf{B}_{lim}$.

Terminology for threshold reference points - the reference points outside which the stock is considered to be in an acceptable area within which targets may be set - differs between the agencies. ICES names these points $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$, NAFO names them F_{buf} and B_{buf}, ICCAT proposes to name them F_{thresh} and B_{thresh}. Conceptually these are similar in general terms but substantial differences exist both within and between agencies, which are described below.

Target reference points are not presently proposed by ICES nor acknowledged in its precautionary framework. NAFO has a conceptual definition of targets for fishing mortality and biomass (F_{target} and B_{target}) but at present only proposes B_{target} reference points for rebuilding purposes. ICCAT notes that the ICCAT Convention defines $\mathbf{F}_{MSY}$ and $\mathbf{B}_{MSY}$ as targets.

5.2 Definition

Table 5.2 compares the concepts and terminology used within NAFO and ICES PA frameworks, relative to the UNFSA. ICCAT has not yet formalized an operational framework for implementing the PA. It would thus be premature to make comparisons of ICCAT´s plans with the frameworks that ICES and NAFO have already developed. For this reason, ICCAT is not included in Table 5.2.

Operational definitions of reference points are indicated by the nature of the risk involved by crossing the reference point.

For the biomass limit reference point, the operational definition is in many cases that it is a marker of the biomass below which low recruitment can be expected. This has been used by both ICES and NAFO and is also proposed by ICCAT. However, in many cases ICES has also used this as a marker of the biomass below which recruitment is unknown. This alternative usage is not reflected in the nomenclature.

For fishing mortality limit reference points, the operational definition varies. ICES mostly uses $\mathbf{F}_{lim}$ to indicate a fishing mortality above which there is an unacceptable risk of the stock size declining below $\mathbf{B}_{lim}$ in some medium or long-term period. Hence it is a marker of the longer term risk of incurring recruitment overfishing. In the NAFO framework $\mathbf{F}_{lim}$ is taken as corresponding to $\mathbf{F}_{MSY}$, which means that it is used as a marker of decreasing stock stability and the loss of long-term yield. ICCAT has yet to develop a position on this topic but notes that the UNFSA guidelines for a fishing mortality limit are in potential conflict with the ICCAT Convention which implies using $\mathbf{F}_{MSY}$ as a target.

Definition of biomass threshold levels tends to be more consistent across agencies. Both ICES and NAFO use thresholds as markers of levels of probability, considered unacceptable, that a stock measured (or forecast) to be at the threshold level may actually be at or below the limit biomass, given some particular uncertainty assumptions. However, ICES also in some cases defines a threshold level as a marker of a region of unknown dependence of recruitment on stock size. This definition has been applied for some stocks with a history of only moderate exploitation. ICCAT's intended use of thresholds is as reference points that fall between limits and targets.

Definition of fishing mortality threshold levels is less consistent across agencies. ICES has defined $\mathbf{F}_{pa}$ in four different ways, as a marker of:

a) an unacceptable probability that stock is fished at $\mathbf{F}_{lim}$ when it is measured to be $\mathbf{F}_{pa}$, (i.e. for ICES, unacceptable long-term risk of recruitment overfishing)

b) a high probability of growth overfishing in short term

c) an unacceptable probability that SSB may fall below $\mathbf{B}_{pa}$ in medium term

d) an unacceptable probability that SSB may fall below $\mathbf{B}_{lim}$ in medium term

The NAFO definition is similar to (b) above in that the F threshold is conceptually an indicator of unacceptable probabilities of loss of long-term yield. The ICCAT definition is still not developed.

Biomass target reference points are proposed by NAFO as indicators of rebuilding to levels at which stock stability and long-term yields are not prejudiced, and a similar approach may be used by ICCAT. ICES occasionally proposes target reference points and advice on management consequences where such targets have been defined.

Fishing mortality target reference points have not yet been proposed by either ICES or NAFO. The use of $\mathbf{F}_{MSY}$ (or appropriate proxies) as a target is implicit in the ICCAT Convention.

5.3 Concepts and Usage

Significant differences in operational definitions of reference points in the ICES, NAFO and ICCAT areas were identified. It is recognised that such differences have quite normally been driven by differences in both the different institutional framework in which these scientific bodies operate, and by the different dynamics of the stocks for which they provide advice. One key difference is that the three organisations have made different interpretations of the clause of the UNFSA which states:

"The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that biomass does not fall below a predefined threshold. For overfished stocks, the biomass that would produce maximum sustainable yield can serve as a rebuilding target. "

Different interpretations arise because management agencies may also be committed to other objectives through other legal texts, and may have other obligations. The interpretation proposed by the NAFO Scientific Council has been that for all stocks an estimate of $\mathbf{F}_{MSY}$ or an appropriate proxy should be adopted as the value for the limit reference point $\mathbf{F}_{lim}$. The ICES interpretation of this clause has been less direct. ICES does not incorporate $\mathbf{F}_{MSY}$ in its PA framework. ICES considered that $\mathbf{F}_{MSY}$ is an extremely difficult parameter to estimate reliably and was therefore reluctant to use this value in the provision of management advice.

In addition to different institutional frameworks, experience with the dynamics of the local stocks has influenced the development of precautionary frameworks. Most NAFO stocks are severely depleted and the immediate management objective is to rebuild stocks towards $\mathbf{B}_{lim}$. In this context, the eventual target fishing mortality rate for a recovered stock is not an urgent issue. In the ICES area a significant proportion of the stocks are fished at an F likely to be higher than $\mathbf{F}_{MSY}$, but the first priority has been to provide advice which warns management agencies of risks associated with recruitment overfishing. The ICES form of advice has been designed on this basis, which has resulted in some apparent inconsistencies when providing advice on lightly exploited or moderately exploited stocks. For example, for depleted stocks ICES has in many cases chosen $\mathbf{B}_{lim} = \mathbf{B}_{loss}$ (the lowest observed spawning stock size), and based on this has proposed a "precautionary biomass" $\mathbf{B}_{pa}$ higher than this, the amount by which it is higher relating to the uncertainty in the assessment and perhaps also the variability of recruitment. This approach is predicated on the assumption that $\mathbf{B}_{loss}$ is a reasonable estimate of the region of stock dynamics where recruitment may decline. Applied to lightly exploited stocks, the framework can lead to precautionary reference points that may preclude a management strategy designed to maximise yield from the stock. In such cases yield per recruit considerations may be used (e.g. Use of $F_{0.1}$ as an indicator of the region where negligible gain in yield can be expected whilst risk of recruitment overfishing increases). However this is not at present formally recognised in the ICES PA framework.

In general terms, one would expect that management agencies are interested not only in the risks associated with recruitment overfishing, but also in the potential yields to be obtained. At present ICES uses its precautionary framework to provide advice on acceptable risks and provides advice on yield within the acceptable risk boundaries so defined. In contrast, NAFO has formally incorporated considerations of stock stability and yield in its formulation of reference points.

Some additional points of detail are noted with respect to concepts and usage:

1. ICCAT is in the process of developing a framework for the provision of scientific advice in conformity with the precautionary approach.

2. ICES, NAFO and ICCAT propose generally similar treatments for $\mathbf{B}_{lim}$. However, no distinction is made in the provision of advice as to whether $\mathbf{B}_{lim}$ represents a marker of a region of known, poor recruitment, or is a marker of unknown recruitment. The management consequences of both of these can be quite different depending on the level of stock depletion.

3. There is substantial variety of reference point usage within ICES. This is unavoidable for an agency that provides advice for a large number of stocks with very different dynamics, exploitation histories and institutional backgrounds. Use of different procedures is often obfuscated by the use of a common terminology.

4. As noted above, the NAFO proposal to adopt $\mathbf{F}_{MSY}$ as $\mathbf{F}_{lim}$ is different from the ICES approach. The F_{buf} and F_{target} reference points are conceptually retained by NAFO but they are not used in the advice because of the present low state of the NAFO stocks (with one exception, where F_{buf} was used).

5. The way in which fishing mortality and biomass reference points are coupled in the ICES framework is rather variable between stocks. $\mathbf{F}_{pa}$ or $\mathbf{F}_{lim}$ may be related to either $\mathbf{B}_{lim}$ or $\mathbf{B}_{pa}$ through probability statements or equilibrium calculations. In the NAFO framework, the $\mathbf{F}_{lim}$ and F_{buf} reference points are more related to the biomass target as they are defined so as to maintain the biomass at or above that target.

Table 5.1. Summary of reference point usage by ICES, ICCAT and NAFO. Where an institution has applied or may apply different usage in different stocks, these alternatives are listed as (a), (b) etc. These sub-heads are not necessarily consistent across columns in this table. Note: The symbol α is used to describe a multiplier calculated on the basis of obtaining a specified probability of exceeding a limit reference point given an assumed estimation uncertainty (σ). Often for a 5% risk the formula e.g. $B_{pa} = B_{lim} . \exp(0.645\sigma)$ is used. Otherwise, medium-term projections can be used to include future recruitment variability.

Type of Reference Point	**Name**			**Risk incurred on crossing reference point**			**Uncertainties considered in setting reference point**			**Technical Basis**		
	ICES	NAFO	ICCAT	ICES	NAFO	ICCAT	ICES	NAFO	ICCAT (Not yet operational)	ICES	NAFO	ICCAT (candidates)
Biomass Limit R.P.	$\mathbf{B}_{lim}$	$\mathbf{B}_{lim}$	$\mathbf{B}_{lim}$	(a) High probability of low recruitment	(a) High probability of low recruitment	High probability of low recruitment	Uncertainty in Stock-Recruit Relationship	Uncertainty in Stock-Recruit Relationship		(a) SSB at which recruitment seen to decline	(a) SSB at which recruitment seen to decline	(a) $0.2B_0$ (b) $(1-M)^*\mathbf{B}_{MSY}$ (c) $\alpha\mathbf{B}_{MSY}$
				(b) Unknown probability of low recruitment						(b) $\mathbf{B}_{loss}$		
	U_{lim}			Unknown probability of low recruitment						αUmax		
Fishing Mortality Limit R.P.	$\mathbf{F}_{lim}$	$\mathbf{F}_{lim}$	$\mathbf{F}_{lim}$	High probability of depleting stock below $\mathbf{B}_{lim}$ implying high probability of low recruitment		(a) High probability of depleting stock below $\mathbf{B}_{lim}$ implying high probability of low recruitment	Natural variability in recruitment, and growth	Natural variability in recruitment, and growth		(a) $\mathbf{F}_{loss}$ (b) by analogy with other stocks (c) subjectively from stock history (d) $\mathbf{F}_{med}$ (e) Consistent with $\mathbf{B}_{lim}$		(a) F_{crash} (b) αF_{SSBR} (c) $\mathbf{F}_{med}$ in overfished period
					High probability of exceeding $\mathbf{F}_{MSY}$, implying loss of longterm yield, increased instability.	(b) High probability of exceeding $\mathbf{F}_{MSY}$ implying loss of longterm yield, increased instability.					(a) $\mathbf{F}_{MSY}$ (b) subjectively from stock history	$\mathbf{F}_{MSY}$ or $\mathbf{F}_{MSY}$ proxies

Biomass Threshold R.P.	$\mathbf{B}_{pa}$	B_{buf}	B_{thresh}	(a) Unacceptable probability that stock is actually below $\mathbf{B}_{lim}$ when it is measured at $\mathbf{B}_{pa}$ (b) Unknown probability of low recruitment	(a) Unacceptable probability that stock is actually below $\mathbf{B}_{lim}$ when it is measured at B_{buf}	Definition being developed	(a) Assessment uncertainty (b) Assessment uncertainty and recruitment variability (c) Only natural variability included	(a) Assessment uncertainty (b) Assessment uncertainty and recruitment variability (c) Only natural variability included		(a) $\mathbf{B}_{pa}$=α$\mathbf{B}_{lim}$. (b) Medium-term forecasts (c) $\mathbf{B}_{loss}$	(a) B_{buf}=α$\mathbf{B}_{lim}$. (b) Medium-term forecasts	Undefined
	U_{pa}			Risk that bio-mass less than a given pro-portion of max-imum biomass			Survey Variability			U_{pa}=αU_{max}		
Fishing Mortality Threshold R.P.	$\mathbf{F}_{pa}$	F_{buf}	F_{thresh}	(a) unacceptable probability that stock is fished at $\mathbf{F}_{lim}$ when it is measured to be $\mathbf{F}_{pa}$ (b) High probability of growth overfishing (c) unacceptable probability that SSB may fall below $\mathbf{B}_{pa}$ in medium term (d) unacceptable probability that SSB may fall below $\mathbf{B}_{lim}$ in medium term	(a) unacceptable probability that stock is fished at $\mathbf{F}_{lim}$ when it is measured to be F_{buf} (b) High probability of loss of longterm yield	Definition being developed	(a) Assessment uncertainty (b) Assessment uncertainty, recruitment variability (and possibly also growth variability etc) (c) Uncertainty captured in calculation of $\mathbf{B}_{pa}$	(a) Assessment uncertainty (b) Assessment uncertainty, recruitment variability (and possibly also growth variability etc)		(a) $\mathbf{F}_{pa}$=α$\mathbf{F}_{lim}$. (b) $\mathbf{F}_{med}$ (c) $F_{0.1}$ or F_{max} (d) Equilibrium SSB >$\mathbf{B}_{pa}$ (e) $\mathbf{F}_{pa}$=α$\mathbf{F}_{loss}$ (f) High Probability of avoiding $\mathbf{B}_{pa}$ (g) Analogy with other stocks (h) $\mathbf{F}_{MSY}$ proxy ($F_{35\%SSBR}$)	(a) F_{buf}=α$\mathbf{F}_{lim}$.	Undefined
Biomass Target R.P	Not define d	B_{target}	B_{target}	Not used	Loss of long-term yield	Loss of long-term yield	Not used			Not used	$\mathbf{B}_{MSY}$ (proposed)	$\mathbf{B}_{MSY}$
Fishing Mortality Target R.P	Not define d	F_{target}	F_{target}	Not used	Undefined	Loss of long-term yield	Not used				Undefined	a)$\mathbf{F}_{MSY}$, according to ICCAT Convention b)$\mathbf{F}_{MSY}$ proxies, e.g. $F_{0.1}$

Table 5.2. Comparison of the concepts and terminology used under various jurisdictions.

UNFSA	**ICES PA Framework and practices**	**NAFO PA Framework and practices**
Provisions		
Implement improved techniques for dealing with risk and uncertainty (Article 6.3a) Take into account uncertainty (Article 6.3c)	PA reference points take uncertainty into account. Annual advice includes medium term projections on most stocks for which analytical assessments are available. Work ongoing to evaluate long term risks and management scenarios.	PA framework includes provision for buffer (applied to limit reference points) to take uncertainty into account. Risk analyses tools available to evaluate short term risks of falling below reference points. Work ongoing to evaluate long term risks and management scenarios.
Apply stock-specific reference points (Article 6.3b and Annex II)	Stock-specific limit reference points have been defined for most stocks for which there is an analytical assessment. Annual advice formulated in terms of $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ (see Table 1).	Work underway to define limit and target reference points under the PA framework for each stock managed by the Fisheries Commission. Current request of the Fisheries Commission for advice specifies target reference points for each stock.
Ensure that reference points are not exceeded when approached (Article 6.4)	PA framework recognizes buffers to be applied to the limit reference points to define $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$. No pre-agreed measures when reference points are approached (not the role of ICES to implement pre-agreed harvest control rule). Advice from ICES would include calls for reduced harvest rate and, where appropriate, recovery plans when biomass below $\mathbf{B}_{pa}$ or F exceeds $\mathbf{F}_{pa}$.	Buffers applied to the limit reference points to define F_{buf} and B_{buf}. PA framework also includes provision for harvest control rule whereby fishing mortality should be reduced when biomass falls below the target (B_{tr}).
Concepts and terminology:		
Precautionary reference points: two types (Annex II-2)	Advice formulated in terms of conservation reference points. Does not recognize explicitly target reference points; provides advice on any target specified by managers upon request. Target reference points to be determined by managers.	Calls for limit and target reference points. Target reference points to be determined by managers.
Conservation or limit reference points: to constrain harvesting within safe biological limits (Annex II-2)	Limit reference points expressed in terms of fishing mortality and biomass (Table 1). Reference points determined analytically or through inspection of recruit-spawner data and history of fishery.	Limit reference points expressed in terms of fishing mortality and biomass (Table 1). Use of analytical models complicated by "regime shift". Limit reference points determined from recruit-spawner data and fishing mortality trajectories.
Management or target reference points: intended to meet management objectives (Annex II-2)	Target reference points to be determined by managers. Scientists to describe and characterize uncertainty associated with current and projected stock status with respect to reference points. No explicit target reference points documented under the PA framework. Targets have been formulated by the Commissions in some cases and in these cases, ICES advises on measures to meet the targets. These cases are limited in number. The PA reference points could become *de facto* target reference points.	Target reference points to be determined by managers. Scientists to describe and characterize uncertainty associated with current and projected stock status with respect to reference points. PA framework includes provision for SSB target.
	Reference points are stock-specific.	Reference points are stock-specific.

Precautionary reference points should be stock specific to account for (Annex II-3): reproductive capacity; resilience other sources of mortality; major sources of uncertainty	Reproductive capacity accounted for in description of recruitment-SSB dynamics used in determination of limit reference points. Demersal stocks have been productive and, while they have experienced strong declines, they have been "relatively" resilient to high exploitation. Sources of uncertainty (Table 1) accounted for in the buffers applied to the limit reference points and through risk analyses.	Reproductive capacity accounted for in description of recruitment-SSB dynamics used in determination of limit reference points. Stocks have not been resilient to high exploitation; compounded by low productivity experienced in recent years. Lower resilience will likely translate into lower values for F reference points. Sources of uncertainty (Table 1) accounted for in the buffers applied to the limit reference points and/or in use of risk analyses. Changes in population dynamics parameters (e.g. natural mortality, maturity, growth) reflected in recent assessments.
Precautionary reference points shall be used to trigger pre-agreed conservation and management actions. (Annex II-4)	Conservation or management actions implemented in some constituencies through legislation or multinational agreements for a few stocks. If a stock drops below $\mathbf{B}_{pa}$, the ICES advice would normally be to reduce fishing mortality in order to rebuild the stock to $\mathbf{B}_{pa}$ in one year. If it is not possible to do it in one year, a recovery plan is advised.	Pre-agreed management actions under the PA framework to be determined by managers. NAFO Scientific Council to evaluate the implications of various management strategies considered by the Fisheries Commission.
Ensure that the risk of exceeding limit reference points is very low. (Annex II-5)	Ensured through the implementation of PA reference points. The difference between the PA and limit values is a function of uncertainty in the estimates. Medium term projections applied routinely when analytical assessments are available.	Ensured through implementation of buffers on the limit reference points. Extent of buffer is a function of uncertainty in the estimates. Managers to determine risk levels to be used in evaluating consequences of management actions; scientists to conduct risk assessments.
Fishery management strategies shall ensure that target reference points are not exceeded on average. (Annex II-5)	Targets have been formulated by the Commissions in some cases and in these cases, ICES advises on measures to meet the targets. These cases are limited in number. The PA reference points could become *de facto* management or target reference points.	PA framework includes provision for target reference point expressed in terms of biomass (B_{tr}). Also includes provision for harvest control rule whereby fishing mortality should be reduced when biomass falls below the target (B_{tr}).
If information is poor, use provisional ce points (Annex II-6).	Reference points have been established from proxies using stock size indices or data from other sources. Analytical assessment not possible for about half of the stocks considered by ICES.	Alternative ways are being explored for stocks that are in data moderate and data poor situations (e.g. traffic-light approach).
The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. (Annex II-7)	ICES does not incorporate $\mathbf{F}_{MSY}$ in its PA framework. The ICES experience is that $\mathbf{F}_{MSY}$ is difficult to estimate reliably. $\mathbf{F}_{pa}$ incorporates all elements (S-R relationship, growth, mortality) involved in the formal estimation of $\mathbf{F}_{MSY}$ but emphasizes the elements related to recruitment overfishing.	Maximum value for the limit fishing mortality is $\mathbf{F}_{MSY}$
For stocks which are not over-fished, fisheries management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield and that the biomass does not fall below a pre-defined threshold. (Annex II-7)	See above cell.	Maximum value for the limit fishing mortality is $\mathbf{F}_{MSY}$ PA framework has provision for harvest control rule that reduces fishing mortality when biomass limits are approached.
For over-fished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target.	$\mathbf{B}_{pa}$ generally serves as the lower limit of the rebuilding target. For the reasons given above, $\mathbf{B}_{MSY}$ is not applied in the ICES framework.	PA Framework recognizes a target Spawning Biomass Level (B_{tr} is greater or equal to $\mathbf{B}_{MSY}$).

5.4 Use of Reference Points in Harvest Control Rules and Recovery and Rebuilding Plans

Section 4, Annex II of the UNFSA states:

"Management strategies shall seek to maintain or restore populations of harvested stocks, and where necessary associated or dependent species, at levels consistent with previously-agreed reference points. Such reference points shall be used to trigger pre-agreed conservation and management action. Management strategies shall include measures which can be implemented when precautionary reference points are approached."

NAFO, ICES and ICCAT all consider that it is the responsibility of the management agencies concerned to pre-agree conservation and management action in the event that they consider such pre-agreements to be necessary. Again in all three agencies, it is presupposed that if a stock falls outside the "safe" or "target" area of its precautionary framework, action should be taken to

- decrease fishing mortality below the threshold value

- take action to allow biomass to increase towards a rebuilding target.

NAFO has in many instances illustrated a linear reduction in fishing mortality in its precautionary framework. However, as presently most NAFO stocks are below $\mathbf{B}_{\text{lim}}$, and such a linear reduction is not particularly germane to present conditions. In the ICES area, many stocks are presently between limit and threshold reference points, and a diversity of approaches has been taken to proposing recovery plans. These are usually stock-specific and to a greater or lesser extent are evolved in dialogue with management agencies.

ICES has evaluated a number of stock-specific recovery plans and medium-term management strategies. Many of these are based on simple constant-F harvesting strategies, but we also note the following examples:

a) Year on year catch reductions for Baltic sprat

b) Catch bounded by a maximum catch and a maximum fishing mortality, in the Atlanto-Scandian herring model, including also a linear reduction in fishing mortality as forecast stock size declines towards $\mathbf{B}_{\text{lim}}$

c) In -season changes to TAC s after surveys (e.g. Bay of Biscay anchovy; Jan Mayen Capelin)

d) Specific recovery plans involving closed areas, technical regulations, by-catch quotas etc. (e.g. Irish Sea cod).

It is difficult for managers to pre-agree to exploit fish stocks according to a specified harvest control rule for a variety of reasons, which may include:

- lack of information on the social and economic implications of their consequences. This is in part because scientific agencies only have competence in evaluating harvest rules in biological terms.

- The annual nature of the decision making process made by most customers of scientific advice can hinder pre-agreement of harvest strategies at present.

Nevertheless, evaluation of a variety of harvest rules by scientific agencies is seen as extremely helpful for managers in order to inform the annual decision-making process. For example, in the event that a stock falls below a threshold biomass, it would be helpful that managers be provided with catch options that correspond to some model of catch restriction for which the long-term consequences had already been evaluated as above. This could be in addition to advice provided in its present form of conventional catch option tables.

5.5 Data moderate/poor environments

About half the stocks assessed by ICES, more than 80% of the stocks assessed by the NAFO Scientific Council, and all stocks assessed by ICCAT are considered to be in data moderate or data poor situations where age based assessments are unable to be successfully applied or rely upon indirect ageing methods. In such cases alternative methods for assigning reference points are gradually being explored. For some stocks, ICES has introduced proxies to represent reference points using indices of stock size and other data sources. In ICES there is continued development of reference points. In the NAFO Scientific Council, surplus production models using survey indices as co-variates (ASPIC) have been explored in some data moderate situations whereas under data poor conditions, the "traffic light" approach has been evaluated. It is anticipated that these and other available methods will be examined in the context of all NAFO stocks in the near future. ICCAT has a long tradition of using a wide variety of simple assessment methods and a suite of proxies to reference points that are tailored to fit specific situations.

6 DISCUSSION OF POSSIBILITIES FOR COMMON USAGE OF CONCEPTS AND TERMINOLOGY.

The WG reviewed the general approach to implementing the precautionary approach and concluded that, although specific interpretations of the UNFSA guidelines differed, the objectives of the three scientific agencies share these common elements:

Reference points should be chosen in such a way as to allow managers to operate a fishery to take sustainable yields close to the estimated long-term maximum. Reference points should generally lead to stock dynamics which satisfy these conditions, in order of priority:

a. Low probability of recruitment overfishing.

b. The choice of thresholds should be made so as to avoid a recruitment collapse or to minimise risk when approaching an area where the stock dynamics are poorly known. Discussions during the meeting showed that there was some common ground in the various frameworks explored. For example, there is a point on comparison of $\mathbf{F}_{\mathrm{lim}}$ in the ICES framework with the $\mathbf{F}_{\mathrm{lim}}$ (=$\mathbf{F}_{\mathrm{MSY}}$) reference point in the NAFO framework. Some of ICES' clients may consider that an appropriate $\mathbf{F}_{\mathrm{MSY}}$ proxy might be considered as a 'limit' value for fishing mortality. However, as the short-term consequences of accidentally exceeding this reference point would be limited and generally reversible, a reasonable probability of exceeding the reference point (below 50%) in the short term could be considered acceptable. In the longer term, there should however still be a low probability that the long-term average fishing mortality should exceed $\mathbf{F}_{\mathrm{MSY}}$. This interpretation could also conform with both the UNFSA and the ICCAT Convention. Defined in this way, the distinction between $\mathbf{F}_{\mathrm{MSY}}$ used as a limit or target reference point becomes dependent on the time-scale involved. On another issue, the $_{\mathrm{PA}}$ reference points of ICES, the $_{\mathrm{Buf}}$ ref. pts. of NAFO, and the $_{\mathrm{Threshold}}$ concept of ICCAT all refer to the same idea, i.e.. to provide a buffer or safety margin to ensure that here is a high probability that the $_{\mathrm{Limit}}$ reference points on biomass or fishing mortality will not be reached.

There was considerable discussion on the issue of harmonisation among the various PA frameworks (particularly between those of NAFO and ICES). Included in the discussion was how much "technical" harmonisation is needed, or is actually possible considering the differences in the institutional objectives and in the respective historical developments and ecosystems. In addition, the issue of harmonisation has implications beyond the technical ones which extend into policy decisions. For instance, reference points depend on the objectives selected for the sector as well as the perception of (and attitude to) risk for resources and for the operators. Further, assuming that, whenever possible, harmonisation would be beneficial, the optimal degree of harmonisation and the time frame within which it should be achieved are essential considerations. Clearly, among managers in some organisations, the need for clarification of terms used in various PA frameworks has been an issue of concern. However, it was also recognised that there were a number of other initiatives on the PA underway in various organisations and national departments. Thus, even if it were possible, it may be premature to recommend a common approach to the PA. In many cases, work on the PA is very much in the exploratory stage.

7 OTHER BUSINESS, ADOPTION OF REPORT, CLOSING

There was no other business discussed by the Working Group. The draft report was adopted, after placing it on the ICES Website for review and comments by participants, which were received by Feb. 28, 2000. The WG agreed that the adopted report may be distributed by participants within their respective organisations prior to distribution of the final report by the CWP Secretariat.

In closing, the chair extended thanks to all participants for their work during the meeting, to ICES for hosting the meeting, and to Hans Lassen for his excellent hospitality to the WG members during the meeting. The WG also extended their thanks to the chairman for his work. The meeting adjourned at 1730 on Feb. 16.

ANNEX 1

List of attendees

NAME	Representing	E-MAIL ADDRESS
T. Amaratunga	NAFO	nafo@fox.nstn.ca
W.R. Bowering	NAFO	boweringr@dfo-mpo.gc.ca
W. Brodie (chair)	NAFO	brodieb@dfo-mpo.gc.ca
S.Garcia	FAO	serge.garcia@fao.org
J. Horbowy	ICES	horbowy@mir.gdynie.pl
T. Jakobsen	ICES	torej@imr.no
H. Lassen	ICES	hans@ices.dk
K. Patterson	NAFO	kenneth.patterson@cec.eu.int
V. Restrepo	ICCAT	victor.restrepo@iccat.es
D. Rivard	NAFO	rivardd@dfo-mpo.gc.ca

ANNEX 2

Agenda, including background material and terms of reference

CWP Intersessional meeting 2000

Working Group on Precautionary Approach Terminology

14-16 February 2000 at ICES Headquarters
Palægade 2-4, DK 1261 Copenhagen K, Denmark

AGENDA

1) Opening.

2) Adoption of agenda, appointment of rapporteur.

3) Review of terms of reference (attached).

4) Presentation of the agency frameworks for the PA. The presentations can use examples as necessary.

   a) FAO

   b) ICCAT

   c) ICES

   d) NAFO

   e) Other perspectives

5) Discussion of where there are concept and terminology differences between agency usage, and how these differences could affect provision of advice under the PA.

6) Discussion of possibilities for common usage of concepts and terminology.

7) Any other business.

8) Adoption of report.

9) Closing

Background material and terms of reference

20 October, 1999

For NAFO, ICCAT, FAO

Fisheries managers are increasingly concerned over the proliferation of definitions, concepts, nomenclature and abbreviations in relation to the implementation of the Precautionary Approach in the Fisheries Organisations and Scientific Organisations responsible for the North Atlantic. Relevant Organisations in this context are IBSFC, ICCAT, ICES, NAFO, NASCO and NEAFC. Concern has been expressed by managers that definitions, concepts, nomenclature and abbreviations are different in ICES and NAFO and also possibly in ICCAT. ICES has been told by EC - a major client commission of ICES - that the Commission would appreciate that ICES and NAFO make an effort to harmonise terminology and concepts. EC has pointed to the apparent illogical situation that stocks with identical status and population dynamics are treated differently in Northwest and in Northeast Atlantic.

There is some confusion in the terminology in use when presenting advice based on the Precautionary Approach around the North Atlantic. ICES raised the issue at the CWP meeting in July where the agencies were represented and it was agreed that FAO should take the lead on this issue. ICES has been approached by NAFO because the NAFO Fisheries Commission at its meeting in September found that this should urgently be dealt and this body suggested that the discussion be restricted to the application of the Precautionary Approach in the North Atlantic.

FAO has for several years been the lead organisation on Precautionary Approach issues while implementation of the Precautionary Approach has been the focus of extended discussions in the scientific forums of ICCAT, ICES and NAFO. I understand that it will be difficult for FAO to take the lead on the problem mentioned above in the near future and that FAO therefore welcomes other initiatives. Besides, the problem is strictly speaking at the moment a North Atlantic issue.

NAFO has informed ICES that the development of the Precautionary Approach within NAFO has involved both managers and scientists. At two meetings of a NAFO Fisheries Commission/Scientific Council Working Group, discussion took place on first results in evaluating precautionary reference points, and definition of the responsibilities of scientists and managers in the implementation process. ICES has discussed these issues with NAFO on various occasions with the aim to achieve common usage of the PA nomenclature.

The NAFO Scientific Council was requested to initiate the process of harmonisation between ICES, NAFO and FAO. As a result, discussion has been initiated between NAFO and ICES on this matter. Both parties consider it worthwhile to organise a meeting on the harmonisation of definitions, concepts, nomenclature and abbreviations in relation to the Precautionary Approach involving the above mentioned North Atlantic Fisheries Organisations and other interested Fisheries Organisations, and we would appreciate your perspective on this possibility.

Terms of Reference, participation and the agenda could be developed and agreed jointly by FAO, NAFO, ICCAT and ICES. As a start to these discussions ICES proposes that an Interagency meeting between FAO, NAFO, ICCAT and ICES be held at ICES HQ for 3 days in February 2000 [Tentatively in the period 14-18 February to be agreed].

ICES membership in such a meeting would be the ACFM chair or his designate, the Fisheries Adviser and the Fisheries Assessment Scientist.

Proposed TORs for the meeting are:

1) Review the terminology and definitions of concepts in use by the different agencies.
2) Identify where concepts are identical and where these differ. Explore consequences of such differences in concepts to the reference points used for providing scientific advice within the Precautionary Approach.

ANNEX 3

Documents

Garcia, S.M.	The precautionary approach to fisheries 1995 – 2000: Progress review and main issues.
Garcia, S.M. and De Leiva, I.	Proposal for a synoptic presentation of stateof stock and management advice in a precautionary indicators framework perspective.
Lassen, H. and Sparholt, H.	ICES framework for implementation of the Precautionary Approach.

THE PRECAUTIONARY APPROACH TO FISHERIES 1995-2000: PROGRESS REVIEW AND MAIN ISSUES[3]

S.M. Garcia[4]
FAO Fisheries Department

Introduction

The global quest for sustainability expressed by the UN Conference on Environment and Development (UNCED in 1992), the Rio Declaration and Agenda 21 have led to a general recognition of a number of situations and factors of non-sustainability in fisheries. In the process, the importance of the oceans for human survival has been highlighted and a particular concern has been expressed as to the capacity of fisheries to fulfil their role in the long term.

One reason for the relative failure of fisheries management (among many others) is uncertainty and ignorance about important bio-ecological as well as socio-economic processes involved in fisheries. Scientists and managers have now recognised formally the amount of uncertainty and risk still involved in strategic assessment as well as day-to-day advice, decision-making and implementation. This uncertainty relates to the data, parameters and processes involved in conventional fishery science and is aggravated by our poor understanding of natural variability of exploited populations and the perspective of ecosystem management and climate change. As a consequence, and following work undertaken at FAO[5] since 1990, in the pre-UNCED process and at UNCED itself (from 1990 to 1992) as well as at FAO and in the UN (from 1992 to 1995), the precautionary approach to fisheries was developed and institutionalised in the FAO Code of Conduct and the UN Fish Stock Agreement (both in 1995). Following such formal adoption significant efforts have been made at regional level in a number of very important international organisations dealing with fisheries to implement the approach or, at least, to develop the practical bases for its implementation.

Another reason for fishery management failure has been the exclusive use of the poorly determined and often variable Maximum Sustainable Yield (MSY), enshrined in UNCLOS, as the only explicit reference point for development and management targets. As a consequence, existing and new reference points to be used as limits or targets for development have been considered, improved, or developed and institutionalised (United Nations, 1994a; Caddy and Mahon, 1995; FAO, 1995a; Caddy, 1998).

The UNCED requirement to manage and conserve the ecosystems as a whole, for present and future generations, has highlighted our poor understanding of the ecosystem processes, stability, variability and resilience to human impacts and of the degree of reversibility of such impacts. The compliance with this requirement implies a very significant increase in information demand as well as a profound change in governance and in the respective roles of the various stakeholders. It also implies broadening the scope of the investigations towards more multi-disciplinary but less budget-demanding approaches. At the same time, there is a pressing demand of development actors for more active participation to decision-making as well as a strong requirement from the public at large for more transparency in scientific advice, decision-making, and performance appraisal. The combination of these requirements for more holistic science, more responsible decisions, and improved communication between science, industry, policy-makers, and the public has led to development of sustainability indicators frameworks. The development of such frameworks require *inter alia* a clarification of policy objectives; a selection of a comprehensive but parsimonious set of policy-relevant indicators; decisions about reference values (and natural constraints) against which to judge the position of the indicators; and societal value judgements in relation to such position, e.g. in terms of what is more or less acceptable and at what cost (Garcia, 1996; Garcia and Staples, 2000; FAO, 1999).

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[3] Paper prepared for the Center for Oceans Law and Policy Conference on Current Fisheries Issues and the Food and Agriculture Organization (FAO) of the United Nations, Rome (Italy, March 2000). Not to be cited without prior authorisation of the author.
[4] The views held in this paper are those of the author and do not represent those of the FAO
[5] As a consequence, the Rio Declaration and Agenda 21 requested the adoption and wide application of a precautionary approach in the aquatic environment in general and in fisheries in particular. FAO has also undertaken pioneering work in this area, developing a set of guidelines for a precautionary approach to capture fisheries and species introduction (Garcia, 1994; 1996; FAO, 1995)

The precautionary approach and the reference points issues have rapidly converged and will eventually merge because the precautionary approach requires the development of special reference points, the elaboration and use of which must take account of uncertainty about their exact value and resulting risk. The convergence of these two issues with the third one (sustainability indicators) may not have been perceived yet, by many if not most managers and scientists, but it is unavoidable because indicators, reference values (or reference points) and uncertainty (and precaution) are the key components of the sustainability framework of fisheries. Finally, at the end of this paper we will also illustrate the convergence between these three issues and the emerging one of ecolabelling.

In the following sections I will essentially review progress in the first two issues, precaution and reference points, describing briefly: (1) the historical developments of the PA and its institutionalisation; (2) the progress accomplished in their implementation at international and national level; and (3) the main issues emerging from, or underlined through, the last 5 years of implementation. In conclusion, I will address the relationship between the precautionary approach (with the use of reference points) and the concept of indicators of sustainability and between these and ecolabelling.

1. Historical developments and institutionalisation

The various phases and elements of the process leading to the formal adoption of the precautionary approach (PA) in fisheries has been initially described identifying the UNCED, FAO, United Nations, Egos, ICES, IMO, ICU, ICLARM, and CCAMLR contributions to such process (Garcia, 1996). It is generally agreed that the conventional fisheries management paradigm and tool box have always contained a number of “precautionary” elements leading to action being taken, in case of risk to the resources, before enough scientific data was available. It is also generally agreed, unfortunately, that during the last half century, these elements have been either scarcely used or poorly enforced. The formal process of re-discovery, comprehensive re-elaboration, discussion and negotiation, and progressive institutionalisation of the PA to capture fisheries started in FAO in the early 1990s at the edge of the preparatory process for UNCED. While this process dealt with both capture fisheries and species introduction, the present review concerns strictly the marine capture fisheries.

In a review of the FAO programme in marine fisheries management since 1945 to be presented in a pre-UNCED conference in Genova (Italy), Garcia (1992) identified some of the major implementation challenges to be faced in the period 1993-2000. Among them, the need to deal explicitly and effectively with uncertainty in scientific information; the need for a PA and reconsideration of the burden of proof; and the need to better define and normalise other “acceptable” levels of reference than unique sacrosanct Maximum Sustainable Yield (MSY) enshrined in UNCLOS. At the FAO Technical Consultation on High Seas Fishing (September 1992), looking at new needs and opportunities in management, Garcia (1992a) stressed again the uncertainty in the “best scientific evidence” required by UNCLOS as a basis for decisions and the need for a PA and a revision of the burden of proof. In the same paper, he also stressed the non-precautionary nature of MSY and the need for more and different reference points to be used as a basis for more precautionary management strategies. From then on, the two issues of precaution and reference points have been inseparable. The need for a PA to management was stressed again in a document prepared in 1993 by FAO for the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks (FAO, 1994, page 65) hereafter called the UN Fish Stocks Conference. A more complete analysis of the implications of the precautionary principle in fisheries research, management, and development was undertaken during 1993 (Garcia, 1994) and the considerations and proposals generated in this process, including references to precautionary target, limit and threshold reference points, were passed on to the UN Fish Stocks Conference at its March 1994 meeting (UN, 1994; Garcia, 1994a). In parallel, the Inter-American Conference on Responsible Fishing (Mexico City, July 1993) referred to the need to take precaution into account in the FAO Code of Conduct on Responsible Fishing, particularly in the high seas. This initial process is fully described in Garcia (1996). The guidance developed by FAO was first applied to the management of tropical shrimp fisheries by Garcia (1996a) showing the possibility to apply it also for data-poor situations.

The action initiated in the FAO process was followed, paralleled, and enhanced by various non-FAO initiatives: IUCN (Cooke, 1994) made a plea for the development of a precautionary approach. A large number of NGOs including Greenpeace intervened in favour of the precautionary approach both at FAO and in the UN Fish Stocks Conference spelling out aspects of the PA they considered particularly important.

The most significant process was the UN Fish Stocks Conference itself (1992-1995) as it lead, after much debate to the formal adoption of the approach and its codification. The "Precautionary Principle" was considered too radical (and equated with moratoria) at the first 1992 substantive session. Better understanding and consensus on the PA developed during the following sessions, with a direct contribution of FAO (UN, 1994; Garcia, 1994a). The approach was finally imbedded in the final Agreement (Article 6 and Annex II).

During the same period (1992-1995), FAO has also been deeply involved in the process of technical and institutional revision of the use of MSY and development of alternative and complementary reference points. The question of uncertainty in the estimates of these points and of the consequences for research and management were addressed, leading also to considerations of the issues related to precaution. These issues were addressed in another document prepared by FAO for the UN Fish Stocks Conference on the question of management reference points (FAO, 1993; United Nations, 1994) upgraded later on into an FAO technical paper (Caddy and Mahon, 1995). The papers suggested in particular to use Limit Reference Points (LRPs) as a way to increase the precautionary nature of management. A follow-up to this paper, focussing on data-poor situations was prepared by FAO (Caddy, 1998) for the Workshop on Precaution Limit Reference Points for Highly Migratory Fish Stocks in the Western and Central Pacific organised by the Secretariat of the Pacific Community (Honolulu, Hawaii, USA, 28-29 May 1998).

Following the very active process of scientific analysis and elaboration of guidance, communication, and development of consensus, and in line with the Principle 15 of UNCED[6], the formal requirement for a PA to fisheries, including the use of reference points, was institutionalised in 1995 in two major international fishery instruments:

The 1995 FAO Code of Conduct for Responsible Fisheries which provides for a wide application of the approach in its Article 7.5. This instrument is voluntary but its content is made compulsory when its principles as well as the spirit (and sometimes wording) of its provisions are introduced in national policy and legislation as well as regional instruments. Additional guidance for such application to fisheries operations, management, trade, post-capture practices, and research is provided in the technical guidelines elaborated by FAO in support of the implementation of the Code (FAO, 1995) and the series of scientific papers prepared for the 1995 FAO-Sweden Technical Consultation at which the FAO guidelines were developed (Lysekil, Sweden, 6-13 June 1995). These papers provide, together with a review of the approach and its implications for research, technology and management (Garcia, 1996), a series of seminal papers providing additional insight on the following aspects of the PA:

- The development of precautionary scientific advice with incomplete information (Hilborn and Peterman, 1996);
- Risk assessment and economic aspects of the PA (Huppert, 1996);
- Precautionary management reference points and management strategies (Rosenberg and Restrepo, 1996);
- How to assess the precautionary nature of management strategies (Kirkwood and Smith, 1996);
- Precautionary consideration in fishing technology and legislation (Fitzpatrick, 1996; Boutet, 1996)

The 1995 Agreement for the Implementation of the Provisions of the UN Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Stocks and Highly Migratory Fish Stocks (hereafter called the UN Fish Stock Agreement) in its Article 6. Some guidance on the implementation of the approach is also given in Annex II to the Agreement. The instrument is still not in force and to date still requires a number of ratifications to become binding. Its provisions are nonetheless being referred to and used extensively (see below). Hayashi (1999) has analysed the legal implications of the main provisions of the Agreement which he sees as a complement to UNCLOS provisions and which innovates in the area of the precautionary approach and the "compatibility principle" which emerged during the debate on the PA. Because of the "compatibility principle" in fact, the provisions of the Agreement relative to the PA are applicable both in the high seas and EEZs, a notable exception in an instrument covering otherwise exclusively the high seas (Hayashi, 1999).

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[6] Principle 15 of the UNCED Rio Declaration provides *that "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities,. Where there are threats of serious irreversible damage, lack of full certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".*

2. The PA implementation process

As mentioned above, a number of international organisations had adopted and sometimes implemented some elements of what was to be called later on "the precautionary approach" to fisheries, in most cases with limited success. Since the adoption of the PA by FAO and the UN, adoption in other arenas and practical process of its implementation has progressed at a remarkable pace compared to the pace of implementation of the precautionary principle in environmental international law (MacDonald, 1995). A number of reviews of the evolution and progress in implementation of the precautionary approach in fisheries have already been made (Garcia, 1996; ICES, 1997; Serchuk *et al*., 1997; Thompson and Mace, 1997; Mace and Gabriel, 1999). The following is an updated summary.

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

The concerns about uncertainty, risk and reversibility of fisheries impacts on resources and the ecosystem were already present in the Convention which was adopted in 1980 and entered into force in 1982 (Kirkwood and Smith, 1996; Parkes, 1999). In line with UNCLOS, the Convention refers to MSY as a reference point ("*the level that ensures the greatest net annual increment*") and requires maintenance of harvested, related, and dependant populations as well as restoration of depleted resources. More directly relevant to the PA was the requirement to "*prevent or minimise the risk of changes in the marine ecosystem which are not potentially reversible over 2 or 3 decades"*. Precautionary catch limits were already implemented for krill fisheries in 1991 and 1993. Management of this resource aims at ensuring that the probability that spawning biomass falls below a level at which recruitment "on average" might be impaired. The model used as a basis for management advice includes a wide range of expressions of uncertainty in input parameters. It is recognised, however, that further guidelines are needed (e.g. on the conduct of new fisheries or transition between exploratory and new fisheries) which should include agreed biological reference points for overfishing (Parkes, 1999).

In 1991, CCAMLR adopted a requirement for prior notification of intentions to start new fisheries to CCAMLR 3 months before its regular meeting to allow formal consideration of the proposal. There is, however, no mechanism by which CCAMLR could reject the proposal! Realising that there may be a need to start the control even earlier on, the Commission elaborated also, in 1993, rules for the prior notification of intentions to start exploratory fisheries. According to Mace and Gabriel (1999), once it is demonstrated through exploratory fishing that a new fishery could be established, exploratory fishing must cease and a stock evaluation is required before full fledged exploitation could be allowed. These measures intend to control development and prevent expansion of the fishery faster than acquisition of the data needed for their management limiting the allowed removals to *a "level not substantially above that necessary to obtain the information specified in the Data Collection Plan"* (Conservation Measure 65/XII). Precautionary catch limits were recommended for a number of exploratory fisheries for toothfish in 1996 and 1997. Calculated allowable yields, based on scarce information, were then multiplied by an arbitrary discount factor. In addition, vessels were required to carry observers on board and to bear a satellite transponder (Parkes, 1999). In practice, however, CCAMLR has insufficient enforcement capacity to ensure strict application of its principles and regulations, as illustrated by the growing problem of illegal, unreported and unregulated fishing (IUU) in the CCAMLR area (Parkes, 1999). It is also not clear that CCAMLR has identified a reliable system of holistic ecosystem indicators and related reference points and control rules.

The International Pacific Halibut Commission (IPHC)

Mace and Gabriel (1999) report that the IPHC can be said to have the longest run of successful stock conservation (despite obvious problems of overcapacity leading to very short fishing seasons) and consider that the IPHC records indicate implementation of a PA. However, most of the arguments given by the authors (no stock collapse, good yields, independent research, precedence given to spawning biomass on fishery yields) reflect more a reasonably successful implementation of **good practices** than of the PA *stricto sensu*. The tendency to confuse both will be discussed later on in this paper. More directly relevant to the PA though is the fact that the IPHC has established precautionary quotas in the face of uncertainty.

The International Whaling Commission (IWC)

Kirkwood and Smith (1996) recognise that while the IWC made no explicit reference to the PA it indeed developed, during the late 1980s and early 1990s, revised management procedures which are precautionary both in design and performance. The methodology and processes developed to simulate and test the management procedures and their robustness to uncertainty and alternative understandings of nature have deeply influenced the elaboration of the PA to management by FAO and are fundamental elements of it. These early developments in IWC are directly at the origin of the modern Operational Management Procedures (OMP) (Kirkwood and Smith, 1996; Butterworth *et al*. 1997).

The International Council for the Exploration of the Sea (ICES)

In 1992, the ICES Advisory Committee on Fisheries Management (ACFM) introduced new management procedures including explicitly the use of precautionary total allowable catches (Serchuk and Grainger, 1992). More recently, ICES has started a process of formal implementation of the FAO Guidelines in order to make the PA part of its standard practices. Faithful to its past role in the development of fishery science, ICES has been on the forefront of methodological development, particularly in the area of biological reference points (reflecting also in this its inherent difficulty to deal with non-biological aspects of fisheries). A number of study groups have met (ICES, 1997; 1998) and have produced a number of comprehensive reports. Standard limit and target reference points have been defined and adopted. The limit fishing mortality ($\mathbf{F}_{lim}$) has been equated to F_{crash} the fishing mortality at which, on the long term, the stock would collapse through recruitment failure (also called $F_{extinction}$ or F_{τ}). The limit biomass ($\mathbf{B}_{lim}$) is the biomass at which the stock is in immediate danger of collapse. As these are pretty risky limits to be reached in no case or with extremely low probability, precautionary thresholds ($\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$) are also established multiplying the limits by a safety factor ($\mathbf{F}_{pa} = \mathbf{F}_{lim}\ e^{-2\sigma}$)where σ reflects the variance in the estimate of $\mathbf{F}_{lim}$[7]. The ICES working groups have developed methods and guidelines to estimate these reference points (including in data limited situations) and have provided precautionary reference points as well as estimates of present stock status in relation to these reference points for the most important stocks of the ICES area. For the October 1998 session of the ACFM, the PA has been incorporated in the advice given for nearly all stocks and, depending on data available, “soft” and “hard” reference points have been considered. The last report of ACFM (ICES, 1999) indeed contained a “precautionary plot” showing stock trajectory in relation to reference points for all major stocks considered (Figure 1). The target area for management (at least as implied by the scientists) lies both above $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ but the relation between this area and the MSY reference is not clear.

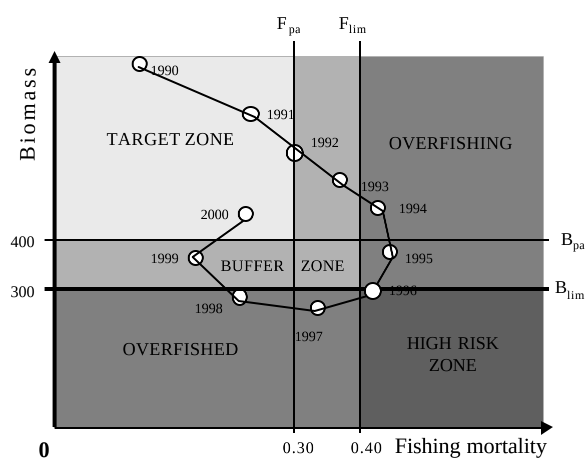

Figure 1. Theoretical example of the “precautionary plot” as used by ACFM to report on the trajectory of a fishery in terms of (spawning) biomass and fishing mortality

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7 Typically, σ tends to take a value around 0.2- 0.3 (Caddy, 1998, P. 11).

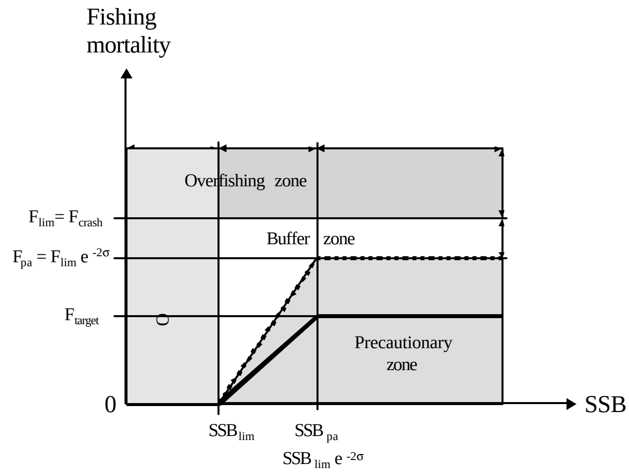

Figure 2: Schematic representation of the ICES framework for implementation of the PA .

Thick lines materialise the harvest control law. (Modified from ICES, 1977, p. 15)

The Northwest Atlantic Fisheries organisation (NAFO)

In parallel with ICES, an intense process has been undertaken in NAFO Scientific Council since June 1997 to develop the scientific basis to implement the PA. Dedicated meetings were organised in March 1998 (Scientific Council workshop), May 1998 and May 1999 (Joint Fisheries Commission and Scientific Council workshops). At the May meeting, it was agreed that in addition to RPs and control laws, other management tools and concepts were needed to enable the wide application of the PA. The May 1999 meeting recognised, however, that NAFO did not have the appropriate mechanisms to address such issues. It also raised the issue of harmonisation of PA terminology and concepts recognising that the present one was difficult to understand by managers and clients and differed between NAFO and ICES creating difficulties for managers participating in both fora. Focus was also put on the need for a simpler and more transparent representation. It also looked specifically at a number of case studies to establish RPs and control laws and assess the potential application of the “traffic light” approach (see below) to some stocks with limited information.

As in ICES, much of the effort has been placed in definitions of biological reference points and in methodology development and NARO recognises the need to adopt PRs in both mortality and biomass terms. However, taking a more precautionary stance than ICES and more in line with the UN Fish Stock Agreement, NAFO has adopted MSY as its statutory limit reference point (Serchuk *et al*., 1997). It has therefore set $\mathbf{F}_{lim}$ = $\mathbf{F}_{MSY}$ rather than F_{crash} , $F_{extinction}$ or F_{τ}. In addition, NAFO has established a precautionary level F_{buf} (for buffer F) below $\mathbf{F}_{lim}$ to reduce the probability that this limit is accidentally breached. The buffer zone (and resultant security factor) are proportional to the uncertainty on $\mathbf{F}_{lim}$. The fisheries capacity is aimed at F_{target} a value at or below the value selected for F_{buf}. Similarly two levels of biomass ($\mathbf{B}_{lim}$ and B_{buf}) are established. In addition, for depleted stocks, a biomass target for rebuilding (B_{tr}) is defined at a level that could produce MSY (i.e. at $\mathbf{B}_{MSY}$ level or higher). The plans are to:

- determine precautionary reference points for all stocks managed by NAFO;
- specify decision rules to achieve target reference points and avoid limit reference points;
- develop criteria to be used in consideration of possible fisheries re-opening;
- identify data collection and monitoring activities required to reliably evaluate resource status in relation to reference points; and
- define research requirements to improve quantification and evaluation of uncertainty (risk analysis) as well as methodological developments to reduce uncertainty.

The plans were also to implement the PA in formulating the 1999 management advice (Serchuk *et al*., 1999). NAFO Council has endorsed the PA as described in the 1995 UN Fish Stock Agreement and decided to use the FAO Guidelines to implement it. It has also initiated the development of a framework (Figure 3) and an action plan which was examined (and adopted) in September 1998**.**

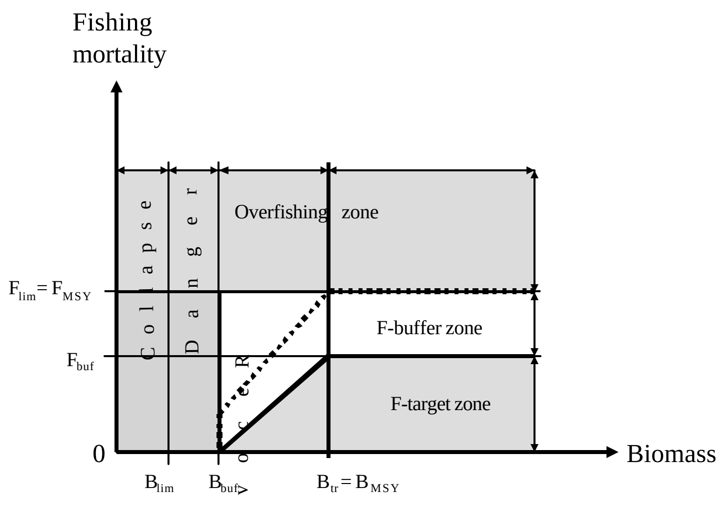

Figure 3: Schematic representation of the NAFO framework for implementation of the PA . Continuous and dotted thick lines materialise the control law (modified from Serchuk *et al*., 1999).

The North Atlantic Salmon Conservation Organisation (NASCO)

In its request for scientific advice from ICES, NASCO has requested that "*ICES provide catch options with an assessment of risks relative to the objective of exceeding stock conservation limits*". The principles of the PA were considered by a NASCO working group held in Brussels, Belgium, in January 1998 (NASCO, 1998). It recommended the wide application of the PA to salmon fisheries, closely echoing the FAO language. It recognised that the PA implied to further develop and define clear management objectives and to set management targets at higher stock level (then currently) to allow for uncertainties… and ensure a high probability of exceeding conservation limits. The WG proposed a fairly comprehensive process of implementation. The WG dealt with recovery strategies, new fisheries, unreported catches, introductions and transfers, and impacts of aquaculture and genetic engineering. It recognised and agreed with the broad scope of the PA as defined by FAO. It is not clear, however, whether the level of stock size and fishing mortality corresponding to MSY are taken by NASCO as a limit or a target reference point (Mace and Gabriel, 1999).

The International Commission for the Conservation of Atlantic Tunas (ICCAT)

Mace and Gabriel (1999) stress the fact that the ICCAT convention does even mention MSY and does not seem to recognise formally that fishing beyond MSY represents overfishing or overexploitation, two terms it does not use either. Nevertheless ICCAT evaluates state of stocks relative to MSY-based reference points and considers them overexploited when their biomass falls below the biomass corresponding to MSY. In October 1997, ICCAT Standing Committee on Research and Statistics (SCRS) agreed to establish an *ad hoc* working group on the precautionary approach to develop recommendations on the application of the PA to Atlantic tuna and tuna-like species. The working group met in Dublin (Ireland) in May 1999 (ICCAT, 1999). It reviewed the progress made in other international fora. It examined the issues of by-catch, migrations, selectivity, abundance estimates, habitat, environmental and ecological considerations, spatial patterns, data collection, measures of stock status, candidates for reference points (mainly MSY-related, including proxies), and debated on the opportunity to use MSY as a limit instead of as a target (as required by the UN Fish Stock Agreement). It also examined the issues of harvest control rules, simulation of management strategies, sources of uncertainty, communication between scientists and managers, and made a number of recommendations.

As a result of the recommendations of the 1996 ICCAT tuna symposium in the Azores, FAO with all tuna fishery bodies and the Secretariat of the Pacific Community (SPC) is organising in 2000 an Expert Consultation on Implications of the Precautionary Approach which will meet in Bangkok (Thailand). Their involvement in the Consultation reflects their recognition of the importance of the precautionary approach. ICCAT's working group will provide a significant input to the Consultation.

Multilateral High-level Conference (MHLC) in the Western and Central Pacific Ocean

An intergovernmental process started in the Western and Central Pacific in December 1994 with the objective of establishing a new regional fishery management organisation for tuna resources in the region. The process is governed to a large extent by the *Majuro Declaration* which was adopted in Marshall Islands in June 1997. The Declaration expresses the commitment of the parties concerned to establish a regime in line with the UN Fish Stocks Agreement, including the wide application of the PA. The Chairman's report (FFA, 1997, pp. 12-18) indicates that the PA must be applied to highly migratory stocks but that the meaning of the concept in relation to its application to these stocks is not clear and that while lack of data should not be used as a reason for not taking action, the PA should not be used to unduly restrict the fishery (p. 13).

To further the process, the Workshop on Limit Reference Points for Highly Migratory Fish Stocks in the Western and Central Pacific Ocean met in Honolulu (Hawaii, USA, in May 1998) at which FAO was asked to contribute an analysis of reference points to be used for such stocks particularly in data-poor situations (Caddy, 1998). The outputs of the Workshop constitute also a contribution to the Expert Consultation on Implications of the Precautionary Approach to tuna fisheries mentioned in the previous section. The main conclusions of the meeting were:

1. the PA management framework requires specification of both limit and target reference points;
2. avoidance of recruitment overfishing should be the major objective
3. specification of at least two LRPs: a minimum % of maximum SSB and a maximum level of fishing mortality.
4. best available science should be used and results presented so as to enable transparent decision-making;
5. utility and robustness of RP proxies should be tested through simulations;
6. research funding should be increased to facilitate all of the above.

The Fifth Session of the MHLC on the Conservation and Management of the Highly Migratory Fish Stocks in the Western and Central Pacific was held in Honolulu, Hawaii, USA, in September 1999. The draft Convention text to establish the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, available as Annex 5 of the related report (MHLC, 1999), addresses the PA in the Preamble as well as in its Article 5 – Conservation and Management of Highly Migratory Fish Stocks and, more substantively, in Article 6 – Application of the precautionary approach. At the Fifth Session of the Conference the Chair opted to delete article 1 of Annex I which dealt in detail with the application of the precautionary approach because of lack of agreement on its content and to cross-reference instead the draft Convention text to Annex II of the UN Fish Stocks Agreement (on the PA). The Sixth Session is scheduled for April 2000, with the final Session possibly in August 2000.

South East Atlantic Fishery Organisation (SEAFO)

The establishment of this organisation, in the area covered previously by the International Commission for Southeast Atlantic Fisheries, ICSEAF, was proposed in February 1997 within the framework of the UN Fish Stocks Agreement by Namibia with the support of South Africa, Angola and the United Kingdom on behalf of St Helena and its dependencies. Namibia's concern for a management organisation was based to a significant extent on self-interest in that it did not want high seas fishing on low-resilient straddling stocks to undermine the country's important domestic fishing industry. SEAFO's Convention area will be all waters beyond areas of national jurisdiction in the area. Fishery resources subject to management will largely be red crab (a discrete high seas stock), orange roughy, alfonsino, armourhead, wreckfish and possibly deepwater hake. Stocks subject to management by by ICCAT and cetaceans covered by IWC are excluded. The negotiation of the Convention is anticipated to be completed by December 2000.

The draft Convention, following the Fifth Session of the Meetings of Coastal States and Other Interested Parties (September-October 1999) refers to the PA in Article 3 General principles. In this connection Parties to the Convention shall apply the PA in accordance with Article 6 of the UN Fish Stocks Agreement and manage stocks on the basis of precautionary references points adopted by the Commission, in line with the principles set out in Annex 2 of the UN Fish Stocks Agreement. In the negotiation process, while there has been general agreement amongst the Parties that the PA should be adopted for management, there has been some disagreement on *how* the PA might be applied in practical terms.

The Asia-Pacific Fisheries Commission (APFIC)

Activities to apply the precautionary approach to marine capture fisheries in the developing world have been limited to the processes of creation of new commissions under the UN Fish Stock Agreement Agreement (the Majuro and SEAFO processes). Through its Bay of Bengal project, APFIC, which was established under FAO in the late 1940s, has developed an interesting reflection on the implications of the Precautionary Approach to Fisheries Management (PA2FM) for small scale fisheries, including at village level.

ITLOS and the Southern Bluefin tuna

In 1999, the International Tribunal on the Law of the Sea (ITLOS) dealt with a dispute between Australia-New Zealand and Japan regarding the alleged risk created by the unilateral Japanese Experimental Fisheries Programme (EFP) in the framework of the Commission for the Conservation of the Southern Bluefin Tuna (CCSBT). Two competing alternative and objective interpretations of the existing observations are available that cannot clarify whether, in the 1990s, the stock stabilised at the lowest levels ever observed in late 1980, is still decreasing further to record lows, or, on the contrary, has started to rebuild. In addition, the action (or the status quo) to be eventually decided on the basis of any of the two interpretations would have different social and economic consequences for the parties, exacerbating potentially the problem.

The Australia-New Zealand complaint referred *inter alia* explicitly to: (1) uncertainty about the state of the resource; (2) the "*serious biological concern*[8]" of "*irreparable damage*" caused by the EFP catches above the agreed Japanese quota and (3) the "*urgency*" of the situation. As a consequence, the two complainants requested such provisional measures[9] on the basis of the precautionary principle with explicit reference to the prudence required by UNCLOS Article 290(5). They also argued that Article 18 of the Vienna Convention on the Law of Treaties "*imposes an obligation on a State which has signed a treaty to refrain from acts which would defeat the object and purpose of that treaty...*". Therefore having signed the UN Fish Stock Agreement and adopted the Code of Conduct, Australia, New Zealand and Japan had to act in accordance with their provisions regarding the precautionary approach[10]. Taking an opposite stand, Japan's arguments were *inter alia* that: (1) the EFP was indeed aiming at reducing the uncertainty about the state of stocks; (2) there was no urgency (and no related risk of irreparable damage) that that could justify provisional measures (Japan, 1999: Paragraphs 14, 90, 95, 109). Japan, however, taking an opposite stand argued that the EFP was indeed aiming at reducing the uncertainty about the state of stocks (Japan, 1999: Paragraphs 14) and denied of any <u>urgency</u> or risk of <u>irreparable damage</u> that could justify provisional measures on the basis of UNCLOS Article 290(5) (Japan, 1999: Paragraphs 90, 95, 109).

ITLOS provided that "the parties should in the circumstances*, <u>act with prudence and caution</u> to ensure that effective conservation measures are taken to prevent serious harm to the stock of Southern Bluefin Tuna*" and as a <u>provisional measure</u>, prescribed that the parties "*should refrain from conducting an ESP involving the taking of a catch of SBT, except with the agreement of the other parties or unless the experimental catch is counted against its annual allocation..*". The Tribunal clearly avoided to refer explicitly to the precautionary approach and to determine

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[8] That the EFP might "increase the likelihood of recruitment failure and delay stock rebuilding without countervailing benefit" (Australia, 1999, para 10, 13).
[9] Australia (1999): Request for provisional measures, 1999: para 14, 20, 21.
[10] Stating that the UN Fish Stock Agreement is an articulation of the standard that should be applied by parties to UNCLOS and ... cannot be disregarded in the application of UNCLOS (Para. 68).

whether, as claimed by the complainants[11,12], it had acquired the status of customary international law. Neither the principle nor the approach are explicitly mentioned in UNCLOS. However, Judge Laing stated that *"It cannot be denied that UNCLOS adopts a precautionary approach" and that Article 116 (in association of Part V Articles) as well as Articles 119, 194.5 and 290.1*[13]*) underscores the salience of the approach in UNCLOS.* In addition, according to Judge Tullio Treves, *a precautionary approach seems inherent in the very notion of provisional measures contained in Article 290.*

Pending the final settlement of the dispute by the Arbitral Tribunal, this case will remain a historical case of application of the precautionary approach as an international standard for the implementation of UNCLOS fisheries provisions. The reference to urgency[14] (Article 290(5) of UNCLOS) as an additional justification is somewhat new in the context of precaution. The argument of reparability used in this case is very similar to the argument of reversibility used in the precautionary approach to fisheries management. Judge Laing, in his Separate Opinion, states that the Tribunal has based its conclusion and prescription in the face of scientific uncertainty but has not, *per se*, engaged in an explicit reversal of the burden of proof. He also indicated that the UN Fish Stock Agreement and the FAO Code of Conduct have had a reinforcing role in the Tribunal's decision.

The reference by ITLOS to UNCLOS Article 290 (1) which justifies provisional measures "to prevent serious harm to the marine environment" in relation to a stock of tuna underlines the fact that the living resources are considered as part of the environment[15]. It tends to make fisheries management a part of environmental management and may lead to a dangerous confusion between fisheries and ocean dumping, something the fisheries sector has clearly warned against when adopting the precautionary approach. On the other hand, MacDonald (1995) argues that the nature of issues, objectives and context, which are shaping the PA in fisheries are fundamentally different from what they are in the environmental sector *senso strictu* for which the precautionary principle was established. He therefore warns against the confusion which could be created by any attempt to confuse the two doctrines.

The indifferent references, in the documentation of this case, to the "Principle" or the "Approach" may also blur an established distinction between the principle (without operational guidance and referred to in the past to justify fisheries moratoria) and the explicit operational process adopted by UNCED and developed into operational procedures in the UN Fish Stock Agreement and the FAO Code of Conduct.

The IUCN and CITES approach to risk of extinction

These two international organisations have dealt for a long time with the issue of risk of extinction for various species and listed formally species according to the degree of risk they were facing and Annex 4 to the resolutions agreed at the 9th meeting of the Conference of the Parties held in 1994 at Fort Lauderdale (USA) is indeed concerned with the application of precautionary measures. It states that "*the Parties shall, in the case of uncertainty, act in the best interest of the conservation of the species*". Extinction being the ultimate risk for living resources, it is certainly a risk the precautionary approach should help avoiding. If it is scientifically established that a situation of substantial risk of extinction has been reached, it is clear that the most drastic measures available in the precautionary approach arsenal need to be used (including trade measures and moratoria). This issue is becoming very relevant as CITES is considering listing aquatic species subject to large scale exploitation (i.e. fisheries resources) which are also the support for millions of people's livelihood.

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11 Australia argued that *the precautionary principle should be observed and applied by State parties in meeting their obligations under Article 119 of UNCLOS in relation to the taking of conservation measures because the principle is unquestionably a norm of customary international law which constitutes a fundamental precept of international law*. This interpretation is refuted by Judge Laing in his Separate Opinion.

12 Australia (1999): Annex 2: Statement of claim and grounds on which it is based. Para. 63, 64

13 Article 290.1 refers to measures needed to "prevent serious harm to the environment"

14 According to Judge Tullio Treves, the urgency is that of stoping a trend towards ... collapse and is satisfied only in the light of the precautionary approach.

15 Judge Tullio Treves in its Separate Opinion, underlines that the statement of Para. 70 of the ITLOS Order indicates that the preservation of the living resources of the sea is an element of the protection and preservation of the marine environment.

Butterworth (1999a), looking at IUCN and CITES listing criteria in the perspective of the precautionary principle has argued that Annex 4 did not provide enough operational guidance and that, in order to avoid "false alarms" and undue social and economic disruptions, the degree of risk had to be assessed in terms of the objective probability that the feared "extinction" happens as a consequence of uncertainty, duly taking into account existing fishery management controls and the concept of reversibility.

FAO has produced a draft analysis of the implications of CITES listing criteria and interpretations for fisheries (FAO, 2000). The report offers a vision of the dimensions of risk for aquatic species in terms of *vulnerability* (related to their bio-ecology), *value* (as an item for consumption and trade) and *violability* (the inverse of the probability of compliance)[16]. It proposes a description of the relative role of conventional fisheries management, and fisheries ecosystem management (including the PA) and of CITES trade measures in relation to the degree of these risks

Implementation at national level

There is much less information available on the attempts and efforts to implement the PA at national level. The concept is now so well adopted (at least rhetorically) that it has become fashionable, for fishing industry representatives, fishery managers, scientists and NGOs to refer to it at every possible occasion. Mace and Gabriel (1999) note, however, that it is not easy to analyse the reality of the reference and the effectiveness of the efforts made at national level for its implementation. It is likely that the concept which has been developed at a normative international level (in FAO and at the UN) needs to percolate first at regional level as reflected in the above sections, where its operational and practical aspects can be further clarified and developed. Only then, when the regional basis for the implementation will have been developed should one expect the approach to spread more readily at national level. It is obvious nonetheless that in a number of countries a process has effectively started to integrate the PA in national fisheries policies and management procedures. Those at the forefront have a long standing experience with the regional organisations mentioned above in which they have played a key role in promoting the PA (United States, Canada, New Zealand, Australia and South Africa).

In USA, in front of the serious situation of many stocks[17], special efforts have been made to implement the PA (Restrepo, 1999). The 1996 Sustainable Fisheries Act fundamentally changed the 1994 Magnusson-Stevens Fisheries Conservation and Management Act (MSFCMA), the legislation on which US EEZ fisheries management is founded, by integrating the precautionary approach throughout its provisions. The National Standard Guidelines developed to assist the Regional Fishery Management Councils in its implementation state that "*Councils should take a precautionary approach to specification of OY (the Optimum Yield)*" and the National Marine Fisheries Service (NMFS) has developed National Standard Guidelines (NSG) in this respect as well as a Technical Guidance (TG) for the purpose (Restrepo *et al*., 1998). Management of the US portion of the North Pacific is considered as an example where the PA application has been very successful. The overfishing level was established in 1990 and harvest control laws with precautionary devices were established in 1996 (Thompson and Mace, 1997, in Serchuk *et al*., 1999). One particularity of the US approach is the use of <u>reference control laws</u> in addition to reference points.

In Canada, a precautionary approach has been applied to the Southern Gulf cod (Sinclair, 1997). Values of $\mathbf{F}_{MSY}$ and $\mathbf{B}_{MSY}$ previously unavailable have been calculated with their confidence limits using different models. Within the estimated range, conventional limit reference were calculated using a risk–adverse approach allowing a 20% probability for the limits to be violated. In the process a number of uncertainties related to the models used to represent the reality were detected. In addition, the Fisheries Resource Conservation Council (FRCC) (1999) developed criteria for re-opening fisheries following a moratorium. A list of stock status indicators has been developed. The FRCC acknowledged that the PA must be used to ensure both (1) fish stocks are in good enough shape before re-opening (e.g. in terms of stock size, recruitment, growth, condition factor, spawning stock size, geographical extension, and migration patterns); and (2) the re-opened fishery can operate in a conservationist manner, keeping fishing mortality at a low enough level. The "half-way point" (midway between the level when the

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16 This representation was developed in the FAO Report by R. Mahon, J.Pope, and J. Rice

17 On 279 stocks for which information is available, 96 are overfished or approaching overfishing and the status of 448 other stocks in relation to overfishing is not known (Matlock, 1999)

fishery had to be closed and the average level in the recent period before that was considered as signalling enough improvement. A "report card" is established for the stock which compares the position of the indicator set in relation to their respective half-way point. It is interesting to note that this more pragmatic and comprehensive approach (than the one used in ICES and NAFO) is very close to (and indeed constitutes) a ***sustainability indicators framework*** similar to those being promoted by FAO as a complement to conventional fisheries monitoring approaches (FAO, 1999; Garcia and Staples, 2000).

In Australia, the Australian Fisheries Management Authority (AFMA) overarching responsibilities are contained in the 1991 Fisheries Management Act, which provides that the AFMA must pursue the objective of: "Ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment.

In South Africa, the PA has been implemented essentially through the use of Operational management procedures (OMPs). In the South African pelagic fishery, the risk is expressed as the probability for the biomass to fall below 20% of the average non exploited biomass in a 20-year period. The OMPs formalise the uncertainty in decision rules and management processes, the robustness of which is tested through simulations to analyse risk in an explicit way.

3. Main issues

The experience in implementing the PA at national or regional level is still limited. However, a number of issues have emerged in its interpretation or implementation which will be briefly examined below. It is not pretended that these issues are new and indeed most of them had been foreseen and discussed extensively in the review of the implications of the PA to fisheries of Garcia (1996), based on available experience and literature in other domains of application of the PA. It should be noted also that some of the issues which emerged or increased visibility in the implementation process (e.g. uncertainty and risk) have been addressed well before the PA came to being. However, in line with the purpose of the section, we will refer only to the authors who addressed explicitly the issues in a PA context. In the following sections, I will briefly touch on the following issues: (1) UNCLOS and precaution; (2)The role marine reserves in relation to the PA; (3) Reference points, control rules and trajectories; (4) Rebuilding strategies and recovery plans; (5) Uncertainty, ignorance, indeterminacy, and risk; (6) Operational management procedures; (7) The role of science in relation to the PA; (8) Disciplinarily biased implementation; (9) Data-poor situations, simple methods and proxies; (10) Precautionary approach *stricto sensu* versus "good practices"; (11) Communication of results to non-scientists; and (12) Harmonisation and international cooperation.

UNCLOS and precaution

It has been usually considered that UNCLOS was particularly silent regarding uncertainty and precaution and this should not be surprising considering that its scientific basis was established in the developed in the 1960s and "frozen" by the difficult negotiation process in the early 1970s. Wilder (1996), analysing the role of UNCLOS in relation to precautionary action, concludes that the Law of the Sea is not really precautionary, a conclusion shared by Hayashi (1999) which considers that both the Code of Conduct and the UN Fish Stock Agreement innovate in this regard. Wilder recognises that UNCLOS deals with cross-boundary impacts (shared and highly migratory stocks). It implicitly accepts the concept of "no-harm" permitting any national action as long as it has no impact on the neighbouring countries. It recognises however the need for "*preventive action*" to avoid negative impact (Article 194) but it does not refer in any way to uncertainty or/and risk and to the need to take action in the absence of scientific certainty. In the process of implementation which this paper will review, additional views on this issue will be considered.

Marine reserves in the PA tool box

Because of the uncertainty regarding the nature and reversibility of the impact of fishing on ecosystems, critical habitats, and species as well as genetic biodiversity, it has been proposed to widen the use of marine protected areas (MPAs) (including no-take areas) as part of the PA. It has been argued that no-take areas could be used as a "bet hedging" device (Lauck *et al.,* 1998) and may have less negative impact on fisheries while providing better resource protection then conventional measures particularly for non-target species (Bohnsack, 1999; Lauck *et al*., 1998). Such areas are also offered as reference areas for determining fisheries impacts and outcome of ecosystem rebuilding strategies. The proposal has got the favour of a number of important environmental NGOs but the actual effectiveness of MPAs is still being tested.

Reference points, control rules and trajectories

In addition to the need to establish precautionary reference points corresponding to development and conservation objectives, the FAO Code of Conduct and the UN Fish Stock Agreement refer to the need to establish pre-agreed courses of action and to implement immediately the recovery plans that might be required. The purpose is to ensure the best and fastest response possible in case of problem, avoiding protracted political debates while a crisis is developing. As a consequence a precautionary management strategy should be based on:

- a set of reference point identifying the target(s) and the limit(s) with an estimate of the (agreed) probability that the limit be violated accidentally;

- a description of the course of action to be taken in any circumstances, such as the values of target fishing mortality corresponding to the various possible values of the stock biomass; and

- the time frame retained as acceptable for corrective action and which will depend on the biological characteristics of the stocks.

The FAO guidelines (FAO, 1995, Paragraph 32, 33) indicate the need to elaborate and agree on "decision rules" which specify in advance the action to be taken when deviations from expected situations are observed. The most practical way to implement this advice is to develop and agree on control rules (or decision rules or control laws) which summarise the management action foreseen in relation to stock status as well as environmental conditions. Examples of control laws corresponding to different management strategies are given in Figure 4.

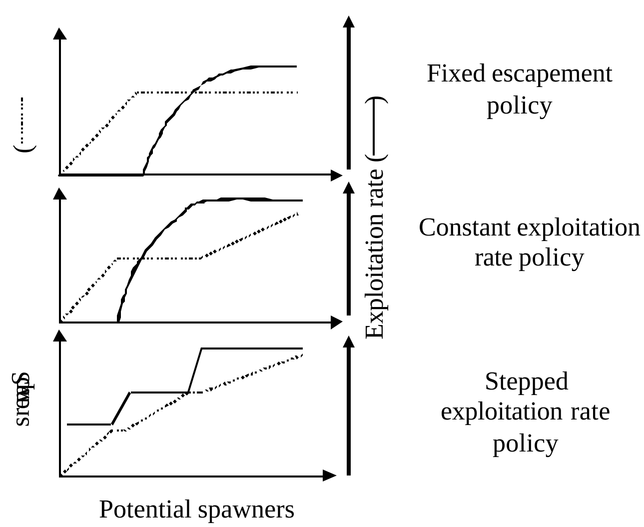

Figure 4: Example of control laws for different management strategies in relation to Spawners abundance, exploitation rate and escapement (from Powers, 1999).

Gabriel and Mace (1999) stress that alternative control rules should be examined and selected on the basis of explicit management performance criteria. It is also interesting to note the emerging role of threshold reference points. Garcia (1994; 1996) advocated the use of such points in addition to limit and target ones, with the view to give a warning that a limit reference point (which should only be rarely violated) is being approached and to trigger measures aiming at ensuring that the limit will not be violated. While this was not retained in the FAO or UN guidelines, the use of such action-triggering thresholds is indeed institutionalised in ICES (**F_{pa}** and **B_{pa}**)[18] and NAFO (F_{buf} and B_{buf}). In relation to the response to be given in a given situation, it is proposed that the degree of precaution in-built in the position of the reference point could be made inversely proportional to the expected rapidity and effectiveness of the action to be taken when the limit is approached or violated.

Gabriel and Mace (1999) stress that there is an almost universal adoption of evaluation procedures for reference points and related harvest control rules based on computer simulation. They propose that such simulations will show that the success or failure of a precautionary management system may be more directly related to the shape of the control rule and to observed (known) implementation errors than to the choice and precision of the reference points. This implies that the biological, MSY-based reference points are probably the easiest to implement, and could be useful enough in data-poor situation. It also means that the research focus should rapidly move from improving reference points to investigating the various types of control rules potentially available, including the aspects related to administrative uncertainty, implementation aspects, socio-economic impacts, and stakeholders' behaviour (compliance).

The efforts towards RP-based precautionary control rules have lead to progress in the research tools available. Spreadsheet-based software have been elaborated to simulate and test control laws based on biomass and fishing mortality limits (NAFO, 1999, p.2), allowing for by-catch mortality, and permitting to undertake risk assessment analysis. Another software (PASOFT) has been developed by MRAG (1997) to study and generate advice on the status of stocks as well as levels of fishing mortality and spawning stock biomass to be used in a PA framework without the use of parametric stock-recruitment relationships.

Rebuilding strategies and recovery plans

Some progress has been made about the requirements for recovering stocks. Powers (1999, P. 98), dealing with recovery plans, argues that it is important to relate explicitly recovery control rules with planned recovery trajectories (see below). Indeed defining a control rule consists in determining the appropriate trajectory, recovery period, target and threshold. Figure 5 shows the relationship. Rebuilding strategies are special cases of harvest control rules. When a stock has been accidentally driven below its limit reference level, a rebuilding strategy is needed (and should have been agreed beforehand).

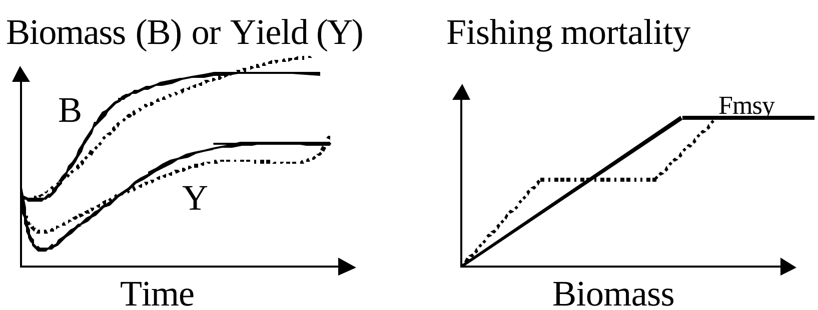

Figure 5: Alternative biomass (B) and yield (Y) trajectories (left) given 2 control rules (right). Solid and dashed lines correspond. Modified from Powers (1999)

According to Powers (1999), a recovery plan should include four necessary (and formally agreed) components:

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[18] F_{pa} is established at a level where the probability to accidentally violate the limit is 5% or lower.

- a threshold[19] measure (or measures) of the overfished state and periodic monitoring of the state of the resource in relation to that level;

- a recovery period which depends on stock characteristics and will be longer for longer lived slow growing species (Cadrin, 1999). It will also depend on the fishing activity allowed during the recovery. In extreme cases, a moratorium might be necessary (as in the Canadian cod fishery). In the USA, it is statutorily established that the measures should allow the stocks to recover within 10 years maximum, plus one generation time if recovery is not feasible within such limit;

- a recovery trajectory for the interim stock status relative to the overfished state. This is needed to ensure on course corrections to the controls of fishing activity to take account of uncertainties at the moment of the establishment of the control law as well as actual year-to-year variability. The trajectory will take account of the stock biology as well as the amount of socio-economic constraint the system can bear;

- the transition from the "recovery regime" to the "optimal yield regime" needs to be considered. An important point in that respect is that the "optimum" target should be far enough (and statistically distinguishable) from the threshold (or buffer) defining overfishing. This is necessary to avoid "convulsive" oscillations of the fishery around the limit, switching on and off the demanding recovery protocol every time the system "treads" on the limit. Without such a precaution, the fishery would indeed oscillate around the limit which would become the *de facto* target reference point in violation of the PA. This implies that the limit at which fishing is closed and the limit at which fishing is re-opened should not be the same, just as in a thermo-regulated machine (e.g. a deep-freezer) the temperature that switches on the compressor is different and higher that the temperature which switches it off. The distance between the two will depend on the precision with which the values can be estimated and the capacity of the fleet to increase and reduce capacity. The issue has been discussed by Caddy (1998, p.18 and 22). As a matter of fact, this consideration is also relevant for control laws applied to non-overfished stocks.

Uncertainty, ignorance, indeterminacy, and risk

The question of risk and uncertainty in fisheries is only about 10 years old (Walters, 1986). In its comprehensive review of the PA, Garcia (1996) reviews the various sources of uncertainty (*sensu lato*) addressed in the literature and recalls the definitions given by Wynne (1992) of risk (when probabilities can be assigned), uncertainty (when probabilities cannot be assigned), ignorance (identified lack of knowledge), and indeterminacy (when open causal chains defy prediction). The issue is rather complex and complicated by different interpretation of these terms as well as lax usage of the words. Hilden (1997) states that risk can be quantified, uncertainty cannot but can be reduced, and ignorance escapes recognition by definition. Uncertainty (or imprecise knowledge) can be dealt with through the PA. In theory, the risk attached to various courses of action can be assessed using various parametric or non-parametric statistical methodologies and combining the various known sources and levels of variance and known uncertainties (about parameter estimates or proxies or model approximations) related to the resource, the fishery system or its administration.

During the last 5 years, most of the related scientific developments have been in the domain of scientific risk assessment. The limitations of risk assessment**,** however, have been intensively discussed in the environmental protection arena. Santillo *et al.* (1998), for instance, states that the procedure involves risk identification and quantification and underlines the fact the risks related to ignored factors cannot therefore be assessed. As a consequence, risk assessment techniques would systematically underestimate risk. Ignorance (i.e. the state or fact of being ignorant) can result from genuine absence of cognisance of relevant information (one is ignorant of) or be self-inflicted through deliberate simplification of the information available, disregarding elements of information that one chooses to ignore. The second happens for instance when conventions are established and assumptions are adopted to facilitate common understandings or comparisons. Deciding to use a yield-per-recruit model, for instance, is a deliberate decision to ignore the fact that recruitment is probably not constant and independent of stock

[19] In USA, the word "threshold" is used to indicate a limit .

size. It is legitimate if there is no information proving the contrary but in any case it should be clear that the assumption is unlikely and this should be taken into account when evaluating the conclusions and resulting advice. Ideally the robustness of the advice to the underlying assumption should always be tested. Gabriel and Mace (1999) stress the paradox that in the process of acquiring more information, "*statistical uncertainty may appear to increase while the quality of information is increasing*". This comment underlines the fact that, through discovery, research transforms ignorance into uncertainty as new factors are discovered with their source of variability. It also underlines the fact that the general concern about risk assessment applies to fisheries and that such methodologies are needed but not necessarily able to measure total risk.

Hilden (1997, p. 24) stresses that the broadening of the fishery management paradigm to include the whole ecosystem, its species and genetic diversity, and its socio-economic processes has complicated the situation. *"The number of possible pathways multiplies and there is no longer one optimal solution, only different trade-offs based on subjective preferences"* (social values). This has significantly increased the amount of uncertainty and indeterminacy to be faced by (unpleased) policy makers and seriously complicates the establishment of policy objectives. For example, controlling and limiting access, allocating resources is the modern prescription to avoid overcapacity and overfishing. However, while allocating fishing rights to a specific fish resource is feasible, albeit with some difficulty, allocating the multiple resources of an ecosystem to a multiple system of interacting uses, would be a much more complicated process. In this respect, the emerging fisheries and ecosystem management paradigms are at angle.

As more and more fishery managers' decisions are being challenged in tribunals, and considering the level of indeterminacy inherent to the ocean ecosystem and fisheries, the question of the respective responsibility of scientific advisers and decision-makers, for over- or underestimating resource risk, leading respectively to undue socio-economic stress or resource damage, is an important one. According to Funtowics and Ravetz (1994) a more participative and open decision process, involving stakeholders and NGOs might be essential to facilitate "*the management of irreducible uncertainties in knowledge and ethics*". This points again to the necessity for more transparency and participation in decision-making.

The most computer-intensive approaches tested during the last decade to deal with uncertainty (e.g. for testing Operational Management Procedures, OPMs) handle risk in an explicit way. For example in the South African pelagic fishery, the risk is expressed as the probability for the biomass to fall below 20% of the average non exploited biomass in a 20 year period. However, this type of expression of risk calls for 4 questions (Francis, 1992): (1) is the threshold correct, and what alternative could be considered? (2) for how long should the simulation be made and are 20 years enough? (3) how should the risk be calculated? and (4) what level of risk is acceptable to industry and/or society? These questions are very important in that they tend to complete (or displace) the problem of uncertainty and precaution, from its exclusively "scientific focus" (as in ICES) to a "full picture" considering uncertainty and its consequences in the whole PA application process.

Operational management procedures (OMPs)

Harvest control laws, as described earlier, are fairly simple mathematical (or graphical) summaries of the management strategies indicating what action should be (will be) automatically taken in response to the various situations reflected by the indicators position in relation to the reference points. Many of them can be constructed for different management strategies and pathways. While the scientists are responsible for the analysis of the properties of the various alternative control laws, the ultimate effectiveness of such law will depend very much on the effectiveness of the process within which the control law is implemented. Such effectiveness depends significantly on communication and participatory processes.

OMPs which originate in the International Whaling Commission are implemented mainly in South Africa and Australia with a possibly more pragmatic approach in the latter. The Operational Management Procedures (OPMs) include control laws but deal with the entire process of data collection, stock assessment, elaboration of the advice, decision and implementation. They specify how the TACs are to be computed and with what data. The underlying assessment need not be very complex and can indeed be quite simple. (cf. Butterworth *et al*., 1997). The procedure may be revised regularly in cooperation or include a feed-back mechanism to adjust it more regularly. The performance of the whole procedure is usually thoroughly tested using computer programmes simulating (for decades) **all** the steps of the fishery management process, from the assessment to the implementation of the measures, with due regard to identified uncertainty sources and levels to test the robustness of the proposed procedures to "surprises" (i.e. low frequency events). It should also be "tested" directly with the persons concerned with their implementation (industry, NGOs, Administration, scientists) (Cochrane *et al*., 1998).

Role of science in applying the PA

The question of the role of the scientists in the implementation of the PA cannot be separated from the question of the relation between science and precaution (MacDonald, 1995). The precautionary principle was originally established to deal with the deficiencies of science and it was intended to leave to the policy maker the responsibility to deal with uncertainties. It was therefore argued that the principle was an "anti-scientific" device as it dispensed with scientific demonstration as a basis for action (cf. for example, Gray, 1990; Garcia, 1996). But the debate was not closed. The FAO guidance took an opposite stand from the onset, underlining, in line with the UNCLOS requirement, the PA had to "be based on" or "take account of" the best scientific evidence available, adding that new forms of science were necessary (Garcia, 1994). In particular, the existence of a risk of irreversible damage to the resources, which is needed to justify the recourse to precautionary measures, needs to be convincingly demonstrated, an issue always considered as paradoxical.

Outside fisheries, in the area of chemical and physical impacts on the environment and protracted debate about the precautionary principle, it is only recently that a significant role for science has been proposed and recognised (Gray and Bewers, 1996; Chapman, 1997; MacDonald, 1995). In fisheries, there is a strong tradition of using science as a basis for decision-making and the problem do not seem to arise. Science has been evolving rapidly to face the new PA requirements much in line with the FAO guidelines. The principal roles of science include (Fox, 1999):

Ensuring accurate and complete display of uncertainty using pre-defined terms and protocols that couple scientific uncertainty and management action;

Providing the background of that action and the options available, with their consequences, the choice of the action itself remains a manager's responsibility;

Contributing to the reversal of the burden of proof, forecasting the consequences of the various possible courses of action in terms of their probability and likely cost. Judging what probability (or risk) is acceptable is a responsibility of society;

Establishing the standards of proof .

The issue of "precautionary research"[20] and its meaning has been addressed by Mace and Gabriel (1999) who rightly indicate that *"it is not reasonable for scientists to add extra (non transparent) conservatism or precaution into the estimation process…"*. Caddy (1998) echoes this concern indicating that *"scientists cannot pre-empt the role of managers and should not bias their analysis in the search for results that are more "safe" for the fishery as a whole*". I would only add that this behaviour would not only be unreasonable but unethical. As clearly indicated in the FAO guidelines though, it is legitimate, however, for the scientist to identify all the possible sources of uncertainty and calculate the consequences of various options in terms of risk, for the fisheries and/or for the resource. It is also legitimate for him to draw the attention of the decision-maker on the solution, among all those examined, which offers the best protection to the resource (giving effect to the "benefit of doubt" concept). The key issue here is one of transparency and formality in the institutional process which will eventually select the degree of precaution and conservation considered appropriate in the circumstances. What is unethical is to force hidden considerations in the process.

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[20] A term used in the FAO Code of Conduct

Mace and Gabriel (1999) conclude that it is appropriate for the scientist to provide the "best" and not the "more conservative" assessment. Garcia (1996) discussed the criteria for identification of the "best scientific evidence" for which UNCLOS does not provide any guidance and attempts to relate it to the concept of "statistically sound analysis" found in UNGA Resolution 44/225 as well as to the concept of statistical power. The contribution of the precautionary approach to this debate would be that, when considering two equally (statistically) powerful and plausible interpretations of the available data, the most conservative one, giving to the resource the benefit of the doubt, is the one to be proposed for action, clearly indicating the criteria used for such selection, i.e. the degree of precaution. MacCall (1999) gives a number of examples of data transformations and assumptions as well as management tools (such as the establishment of biomass reserves) with favourable precautionary properties, reducing risk for the resources. Also, in terms of methodology, he indicates, *inter alia*, that it is preferable (safer, more conservative) to estimate reproductive capacity by actual spawning potential, taking account of aged-related fecundity and fertility, instead of by global spawning biomass. This is confirmed by Murawsky *et al*. (1999) who concludes that, as a consequence, it makes sense to protect juveniles until their first and possibly second spawning. It would make sense to the "precautionary scientist" to take into accounts these risk-reducing elements when making assessments and elaborating advice

It would therefore be precautionary for scientists, in formal assessment groups and committees, to examine from time to time the whole range of available knowledge and alternative assumptions and interpretations about the stock and the fishery. However, carrying forward all the possible calculations related to all possible alternative methods and interpretations of the data every time an advice is elaborated, as suggested above, would rapidly become unbearable. For recurrent work, a solution would be to formally adopt a reduced set of conventional values and tools chosen for their precautionary (conservative) nature. Their formal adoption would be made by through a fully informed management authority. In his paper about checks and balances in fisheries management. Caddy (1997) has indeed proposed that strategic decisions regarding long-term management objectives, limit reference points for exploitation and conservation, acceptable levels of risk (in case of failure) and tolerance levels (acceptable probability to accidentally violate the rule) be left to specially constituted Committees of Limits and Standards.

Biology-based implementation of the PA

The PA to capture fisheries as codified in the FAO guidelines is broad and applied to development planning, fish capture and processing, technology development and transfer, fisheries management, research, legal and institutional frameworks. It also refers to both bio-ecological, technological, social and economic risk. The UN Fish Stock Agreement, however, refers only to MSY and casts its guidance entirely in biological terms (Gabriel and Mace, 1999). Despite recognition of the need for a broadly based PA (Mace and Gabriel, 1999; Serchuk *et al*., 1999; NAFO, 1999a; NASCO, 1998) the focus of the work of the scientific community during the last 5 years has been practically exclusively on the biological aspects of the PA. Extensive work has been done in particular in ICES and NAFO as well as in USA to define and codify biological limit and target reference points in terms of biomass (or spawning biomass) and fishing mortality. The three types of models used to develop these RPs have been the standard spawner-recruit model (to deal with recruitment overfishing), the dynamic pool or yield-per-recruit model (to deal with growth overfishing) and the production model (combining both concerns). As a consequence, the RPs regularly used up to now can only help judging management performance from a biological point of view. A comprehensive review of the work undertaken is given by Gabriel and Mace (1999) and some elements have been mentioned in section 3 above.

It has been repeatedly stressed that a PA exclusively based on biological considerations cannot be effective (Caddy, 1998; Mace and Gabriel, 1999; Hilden, 1997, p.39) and several reference points covering the main dimensions of the fisheries are needed for proper evaluation of the state of fisheries and management plans.. The narrowness of this type of implementation is best illustrated by the present efforts to develop sustainability indicators frameworks for fisheries (Garcia and Staples, 2000; FAO, 1999). If posed in the classical multidimensional terms of sustainability, the performance of a fisheries management system requires reference to a nested set of indicators of ecological, biological, social, economic, institutional and legal nature with their related limit and target reference values. In comparison to this requirement the present implementation of the PA system can only appear poor and unlikely to lead to sustainability.

Data-poor situations, simple methods and proxies

A major problem with the implementation of a science-based PA is often the lack of data. In such circumstances, the PA establishes that, where there is a risk, conservative action should be taken without waiting for more definite information. This implies the use of proxies in data-poor or data-moderate situations and an analysis of such situations and advice on how to deal with information shortage, including the use of data-poor defaults is provided by Gabriel and Mace (1999). The problem has been systematically confronted also in NAFO (Serchuk *et al*., 1999) as well as ICES where limits and buffers have been based on analytical assessments (in data-rich situations) or replaced with values taken from similar resources elsewhere, or inferred from biological information or time series, or "rules of thumb". The available literature indicates that intensive work is being undertaken by the scientific community to improve the ways and means to take into account in the best possible way as many forms of uncertainty as possible (Gavaris, 1999; Ianelli, 1999) e.g. through the wider adoption of Bayesian methods. The report of the NMFS "data-moderate" and "data-poor" working groups (Restrepo, 1999, pp. 154-157) have identified the problems of proxies (e.g. for $\mathbf{F}_{MSY}$ or $\mathbf{B}_{MSY}$) and suggested that the data-poor methodologies promoted by FAO in the 1960s and 1970s for use in developing countries might usefully be re-examined for potential use in developing countries data-poor situations with appropriate modifications for the required precaution.

Where there is inadequate data for establishing a harvest control law, it may still be possible to set a single LRP corresponding to serious but not catastrophic conditions and then select TRP based on estimates of variance and probability of overshoot (Caddy and McGarvey, 1996; Caddy, 1998). The ICES (1997) Study group has agreed for instance that, pending acquisition of more detailed information, a fishing mortality which provides 30% of the virgin spawning stock biomass per recruit ($F_{30\%SSB/R}$) would be a reasonable first proxy LRP.

More recently Caddy (1998) elaborated a review of precautionary reference points and made suggestions for their use in data-poor situations. In particular he proposed to adopt a "traffic light" approach, based on a basket of limit reference points (in reality indicators and reference values) which could be considered "green", "yellow" or "red" depending on their value. The overall assessment (and the required, possibly pre-agreed action) would depend on the number of traffic lights set on "red". The approach has been considered by NAFO (1999) for the management of its shrimp stocks and "viewed positively as a first step" towards applying the PA to these stocks. This report refers also to stock-specific precautionary checklists, a tool characteristic of simple sustainability indicators frameworks. As a matter of fact the "traffic light" approach using green, yellow and red to represent levels of sustainability in a nested set of indicators had already been proposed by Garcia (1996) for systems of representation of value judgements in systems of sustainability indicators for capture fisheries. This convergence illustrates the progressive merging of the PA concerns into the broader concerns and representation systems for sustainability.

Precautionary approach versus "best practices"

One of the important aspect of the PA as promoted by FAO in its Code of Conduct and Guidelines is that it is not a special set of drastic procedures to apply only when something goes really wrong in a fishery. The guidelines recognise that uncertainty and risk are inherent to the fishing activity and its management, and that low levels of precaution on a routine basis would be better than drastic "cures". They therefore require precaution at all times, as an intrinsic property of modern exploitation and management system and to a degree proportional to the level of risk identified, suspected or perceived. As such, the PA aims at becoming an integral part of management "best practices" which it would improve.

Many risks incurred by stocks, however, are not related to uncertainty *per se* but to the fact that "best practices" are not used. For example, risk of overfishing would be reduced by formal caps being put on capacity. Implementation-related risk would be reduced by high levels of participation of stakeholders in decision-making. Ecosystem-wide management frameworks would be more able to protect the resource, e.g. through protection of non-target species, preservation of critical habitats, and due consideration of natural variability. These and many other aspects are therefore recommended for inclusion in responsible fisheries management systems and are explicitly considered in fisheries sustainability frameworks as determining components of governance performance (Garcia and Staples, 2000).

While they are clearly "risk reducing", these aspects are not necessarily related to uncertainty. Paradoxically, however, there seems to be sometimes a confusion between the precautionary approach and best practices. The PA recognises explicitly uncertainty and information gaps and takes steps to minimise the potential negative impacts of the uncertainty, giving to the resources the benefit of doubt. Best practices are those practices known for allowing to reach the objectives in the most efficient and cost-effective way. Precautionary measures, adopted when full information was lacking could therefore, with time, become good practice.

Even though it would obviously not be particularly responsible not to use known best practices for fisheries management, this does not mean that all "best practices" are precautionary in nature. As an example, it is well known[21] that decimating juveniles before they could grow and reproduce is biological nonsense, jeopardising stock growth and reproduction, and reducing resilience. Protecting them until they spawn makes therefore very good "husbandry" sense as recently re-confirmed by Myers and Mertz (1998) and should therefore be a "good management practice" but it cannot, in itself be considered precautionary. Similarly, MacCall (1999) showed that it was safer for scientists to monitor spawning potential - which takes into account actual age composition and age-related fertility and fecundity - than spawning biomass - which assumes that reproduction capacity is independent of age. This finding makes such common sense that the proposed scientific protocol should become good scientific practice. With this in mind, using spawning biomass as a proxy indicator for reproductive potential without any additional consideration would amount to choosing to ignore something which is established. If the data on spawning biomass were the only one unavailable, truly precautionary scientific analysis would need to take account of the known bias and risk and (1) elaborate a proxy closer to spawning potential, or (2) determine the minimum acceptable level of biomass taking explicitly the bias into account. On a related argument, ICES (1997, p. 9) recognised indeed that the PA "*dictates that unless it is scientifically demonstrated that there is no relationship between the parent stock and subsequent recruitment, such a relationship should be assumed to exist, even if the data are ambiguous. This represents a substantial change from past practice*…" gives the benefit of doubt to the stock, and is truly precautionary.

Recognising that the difference may not always be that clear, I would venture to state that "best practices" described what should be done while "precaution" dictates how it should be done. In its Separate Opinion following the ITLOS sentence, Judge Treves indicated that the very adoption of provisional measures in UNCLOS Article 290[22] was an implicit reference to precaution. Going further, Judge Laing argued that "*it cannot be denied that UNCLOS adopts a precautionary approach*" basing this view on preambular paragraph 4 as well as Articles 61-66 and 116-119. The first group of Articles deal with the best scientific evidence, the need for conservation, the associated and dependent species, the exchange of information, the optimum utilisation concept, the harvesting capacity of the coastal State and the surplus, the requirement for compliance, the conventional management measures, the need for cooperation on transboundary resources, marine mammals, anadromous resources, etc. The second group, focussing on high seas resources, addresses the right to fish in the high seas, the flag state responsibility, the need for cooperation, the reference to MSY and the need to qualify it in relation to environmental or socio-economic factors, associated and dependent species, and discrimination. All of these Articles, however, describe what would indeed be good practice, with no reference at all to uncertainty and risk, except perhaps for Article 11.1(b) which refers to the need to maintain populations "*above levels at which (species) reproduction may be seriously threatened*". This is a direct request to use reproduction-based limit reference points and the use of "*may*" indicate that the risk (or probability of a negative outcome) is sufficient to justify the measure. Otherwise, the fact that in a more than 20 years process of deliberation, the concept of MSY has never been questioned, creating a dangerous rigidity in UNCLOS, despite of the mounting scientific evidence regarding the related uncertainty and risks attached to it, would, in my view tend to indicate that the concept of precaution was largely foreign to the fisheries debate. When it will come into force, the UN Fish stock Agreement will formally correct this quasi-vacuum and indeed establish international principles and guidelines for precaution as an international standard for the implementation of UNCLOS.

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21 At least since Holt (1895). It is also part of traditional knowledge

22 Article 290.1(Provisional measures) provides that: If a dispute has been duly submitted to a court or tribunal which considers that prima facie it has jurisdiction under this Part or Part XI, section 5, the court or tribunal may prescribe any provisional measures which it considers appropriate under the circumstances to preserve the respective rights of the parties to the dispute or to prevent serious harm to the marine environment, pending the final decision.

The confusion may have been at least partly created by the FAO guidelines themselves which in addition to dealing with uncertainty-related risk has considered all sources of risk for the resource and the fishery, including those related to inappropriate technology for fishing and processing practices leading indeed to what appears to be guidelines on best practices as well as on precaution. A clarification could be proposed in the sense that the "best practices" are the measures, regulations, practices, methodologies, techniques, and institutions which are recommended for responsible fisheries management while the "precautionary approach" indicates the way in which these best practices should be implemented considering the uncertainty about the various elements of the system. As time goes by and understanding is consolidated, existing uncertainty is reduced and elements of the precautionary approach will become integral part of best practices. At the same time, new knowledge and experience will uncover new uncertainties (previously hidden under "ignorance") and open new areas for precaution.

Presentation of results to non scientists

With the rising of the public concern regarding fisheries, the scientist is more often solicited by its own structure as well as the media, for informed opinion, forecasts, interpretations. As the PA develops, fisheries scientists will meet a problem already encountered in other scientific areas dealing with uncertainty and risk. The dilemma is that any advice involves a probability to go wrong. A wrongly announced danger will lead to critics of scientific "alarmism". On the opposite, a wrong reassurance will be condemned for "irresponsibility". As a consequence, as stated by McGlade (1999) "*the credibility of research, based on the supposed certainty of its conclusions, is endangered by giving scientific advice on uncertain issues*". But a scientist cannot really refuse to advise and contribute his/her (incomplete) knowledge when asked, without being accused of obstructionism and of not performing his/her public functions.

With the adoption of the precautionary approach, risk assessment and bayesian methods, sophisticated simulation protocols, and operational management procedures, fishery research has become even more esoteric for the uninformed but concerned public. ICES (1997) expressed concern in relation to the fact that "*the fishing mortality rates in which ACFM expresses its advice are largely incomprehensible to non scientists. It does not give them a clear picture of the biological implications of proposals and, in this sense, it could be said that it is not precautionary*". This is a clear reference to the need for transparency required by the PA. Some efforts are being offered in the same report for an alternative terminology but much more efforts are needed in this area. There is a need to generate a language, including a graphics, understandable to the public at large and to non-specialised audience which includes parliamentarians. In this respect, efforts are needed to adopt some of the approaches recommended for the communication of sustainability indicators systems (FAO, 2000).

Harmonisation of and international cooperation on the PA

Target reference points reflect national objectives and may therefore vary between countries which have sovereign rights in the EEZ, subject only to the cooperation and the principle of compatibility[23] required for transboundary issues and stocks. However, in the area covered by regional or global fishery management organisations (RFMOs) as well as organisations of economic integration (e.g. EU) a certain degree of harmonisation of the concepts, measures and systems of representation would certainly facilitate management and its implementation by industry as well as integration of the results at large ecosystem level (e.g. North Atlantic or North Pacific shelf). In addition, indicators of stock status and biological limit reference points depend on the nature of the resource and substantial harmonisation is required to facilitate regional and global monitoring as well as comparative analysis of management performance at regional and global levels. The short experience available reveals three problems of standardisation: ***terminology***, ***methodology***, ***definitions*** and ***control laws***.

Terminology: there are two sources of difference in terminology: the concept underlying the construction of the RP and its function:

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[23] This principles embedded in the UN Fish Stock Agreement requires that measures established by the coastal state and the other fishing nations be "compatible" across the whole distribution range of the species.

The concept: The reference points may be labelled according to the concept or model on which they are based. For example, depending on whether they refer to a production model, a yield-per-recruit model or a stock-recruit relationship, the RPs may be respectively labelled with a reference to MSY (e.g. $\mathbf{F}_{MSY}$, $\mathbf{B}_{MSY}$), maximum or optimum yield (F_{MAX}, $_{F0.1}$), or to spawning biomass per recruit ($F_{20\%\ SPR}$ or $B_{20\%SPR}$). Harmonisation in this case would help comparing the degree of precaution of policies as well as stock status for similar resources.

The function: The RPs may also be labelled according to their function in the precautionary framework. They may materialise a limit not to be violated (e.g. $\mathbf{B}_{lim}$, $\mathbf{F}_{lim}$), the target adopted by the system for exploitation of rebuilding (e.g. B_{tr} or F_{tr}), a threshold at which action will be triggered (F_{thr}, B_{thr}), "buffer zone" protecting a limit (e.g. F_{buf}, B_{buf}).

The problem of harmonisation of terminology and concepts was raised by the NAFO Scientific Council at its session of April/May 1999 (NAFO, 1999). A proposal from NEAFC for a joint meeting of all the North Atlantic organisations to discuss the problem was considered. A decision was taken to ask ICES to organise a joint meeting of the concerned organisations, including ICCAT and FAO.

Methodology: the various types of RPs can be estimated using a number of models, sometimes using the same data differently, sometimes using different types of data. The method used tend to depend on the data availability and sometimes, e.g. in the developing world on analytical or computational capacity. In data-rich situations the "best" i.e. most sophisticated and data-demanding techniques can be used. In data-poor situations, simpler models as well as proxies will have to be used. It should be noted that simpler models can often be more robust to errors in the data or the assumptions. The use of different protocols for estimating the indicators and the reference values may be unavoidable but it will complicate harmonisation and reduce the potential for comparisons, between stocks or fisheries on different species in one area or of similar fisheries across areas.

Definitions: Concept-based names will usually explicit the detailed signification of the RP together with the methodology, at least to the initiated scientists working together in a regional mechanism. Function-based RPs, however, are more likely to be value-laden, bearing different meanings in different areas and fisheries depending on how they are obtained. For instance, the same terminology (e.g. $\mathbf{B}_{lim}$ or F_{lim}) could be used to indicate what is considered a limit, i.e. the signal that the fishery is entering in an "undesirable" state, but the definition of "undesirability" is very flexible and susceptible to all sorts of societal pressures. The F-limit in ICES corresponds to the expected "crash level". The F-limit in NAFO corresponds to the MSY level. The relationship between the two is unknown and they correspond to drastically different levels of risk.

Control laws: They represent the way in which the management framework (and indeed the sustainability framework) will be used in practice. They reflect the degree of precaution in policies and have direct implications for the degree of risk for the resources and the people. Examples of control laws have been given in section 3. It is clear that agreements on terminology, methodological protocols, and definitions will not lead to harmonised management (e.g. in line with the "compatibility principle") unless detailed control laws are also harmonised. This means indeed that the pre-agreed courses of action which the control law materialises are negotiated. It also implies that development objectives, agreement on potential consequences of errors, acceptable levels of risk, and indeed societal (and sometimes ethical) values are harmonised. A rather high stake as illustrated by the debate about whaling in the IWC or the Pacific Southern Bluefin case (cf. ITLOS in section 3).

Applying to this problem the solutions adopted for sustainability indicators systems implies that agreement must be reached, by region, and by type of resources on: (1) the most relevant indicators and related reference points; (2) a parsimonious and agreed selection of the most relevant indicators and RPs; and (4) a scale of value judgements to superimpose to the indicators scale as illustrated below:

Indicator scale B/B_{MSY}	**Reference points**	**Value judgement Stock state / Utility**
1.0	B_0, B_{virgin}	Excellent / Underexploited
0.8		Excellent / Underexploited
0.6		Good / Moderately exploited
0.5	$\mathbf{B}_{MSY}$, B_{target}	Acceptable / fully exploited
0.4		Medium / overexploited
0.3	B_{buf}	Poor / overexploited
0.2	$\mathbf{B}_{lim}$	Dangerous / depleted
0.1		Very dangerous / Collapsed
0.0		Very bad / Extinct

Discussion and conclusions

Where do we stand?

According to MacDonald (1995) the greatest obstacle to its establishment as a guiding principle in international law is a failure to understand its role in a period of shifting paradigms. He suggests that, ultimately, the principle may not be an established norm of customary international law but "*the temporary answer to a policy/management void that these shifts have created*". Following that perspective we can note that the main fundamental shift affecting the fisheries management paradigm results from the intrusion of the concepts of sustainability and responsibility and of a new environmental ethics with their hoist of new constraints and requirements regarding future generations and the ecosystem. The addition of the various new requirements are bringing the conventional paradigm of fisheries management much closer to the paradigm of general aquatic resources management and environmental protection. The resulting requirements have highlighted a significant information gap in front of which decisions must be made to conserve intact future options. Hence the need for precaution, in the normative but elusive form of a principle and in the operational but simplistic form of an approach. It is probably unavoidable and correct that precaution must be a societal and policy concern, fuzzily defined, but overwhelmingly present, as well as a set of technical norms and protocols for concrete action in relation to the concern.

The conclusion of the early efforts to implement the PA that the conventional governance of the fishery system in the North Sea is not precautionary (ICES, 1997, p. 6) is not really a surprise considering the present state of the fisheries resources in general. However, it has been seen in section 3 that the process of implementation is progressing well, particularly in the developed world and more particularly in the North Atlantic. The PA process has been developing in a small number of countries and regional fishery management and advisory organisations which are experimenting with the concept and developing protocols for its implementation. While the application is still only partial and largely confined to its biological elements, it has addressed the following technical elements:

- Determination of LRPs which materialises the biological constraints and minimum requirements for sustainability;
- Determination of the threshold (or "Pa" or "buffer") RPs to ensure that the LRPs are not accidentally violated;
- Improvement of methodology to evaluate uncertainty and the risk attached to it;
- Elaboration and evaluation of precautionary harvest control laws and rules and assessment of their robustness;
- Elaboration of rebuilding strategies and plans (and special control laws) for overfished stocks.

In addition, the intense activity developed during the last 5 years have addressed, *inter alia*, the following advisory elements of the PA:

- Incorporation of uncertainty about state of stocks into management scenarios;
- Improved communication with managers to explicit uncertainty consideration and their impact;
- Encourage policy-makers to explicit their objectives as a basis for establishing TRPs;

- Encourage policy makers to develop, adopt and implement precautionary fisheries management plans;
- Encourage policy-makers to implement recovery plans for deleted resources.
- A number of other elements of the PA have been identified which need substantially more effort to be generalised:
- Identification, analysis, systematic organisation and formal adoption of a limited number of reference points covering not only the biological aspects but also the ecosystem, economic, institutional and other social aspects;
- Further identification of related sources of uncertainty and their impact in terms of risk; including for the human component of the fishery system;
- Explicit relation of reference points to objectives of fisheries management and development policies as well as constraints imposed by the ecosystems and the human well-being;
- Appropriate co-representation of RPs as a means to convey in as simple a way as possible the issues, trade-offs, alternatives, etc., to the managers, industry, and the public;
- Systematic analysis of the robustness of management strategies and processes to uncertainty.

The ongoing efforts to identify, for most important resources, the present state in relation to agreed reference points can only highlight further the fact that a substantial proportion of the world stocks[24] are either fully exploited or overfished. Those fully fished stand close to MSY, the emerging international standard for a limit reference point, in a general context of increasing fishing efficiency and capacity. The risk for these stocks to become overfished in the near future is high if the appropriate action is not taken and the present situation is not particularly precautionary. Those which are overfished urgently need rebuilding strategies and plans for which governments and regional fishery management organisations will need to explicitly adopt reference values, time frames and trajectories facing all the possible and difficult socio-economic trade-offs involved in the various possible pathways for rebuilding.

However, the difficulties ahead should not hide the progress already made. In fisheries, contrary to the conclusion of MacDonald (1995) regarding the fate of the PA in the pollution arena, where "*its international status is still a subject of debate*":

International consensus on the PA has been reached surprisingly rapidly and embedded in the two major international instruments: The Code of Conduct and the UN Fish Stock Agreement.

The explicit link between the UN Fish Stock Agreement and UNCLOS gives to the PA, implicitly (as shown by ITLOS) and explicitly (as soon as the UN Fish Stock Agreement comes into force) a strong status in international law. In the meantime, the PA has already a significant moral force as part of the Code of Conduct.

The major institutional scientific mechanisms, at national and regional level, are working on the practical aspects of the implementation with surprisingly little philosophical debate.

One must probably conclude that the long tradition of applied fishery science and its close association to decision-making has been a determining factor. Fisheries scientists are used to taking risks in making forecasts with significant social and economic consequences. They seem to have easily accepted the high level policy requirement for the PA as a necessary, not-debatable, extension of their work.

The need for institutional change

The need for better management is obvious and so should be the fact that the information required will never be totally sufficient. Butterworth (1999) ventures to believe that "*fisheries is subject to a form of Heisenberg's uncertainty principle*" in that "*at a certain level, uncertainty or lack or predictability, is endemic, and fisheries management has to learn to live with it*". The implication of this statement recognising that no reasonable amount of research will ever resolve all the significant uncertainties or eliminate the great surprises the ocean ecosystem has

[24] According to the latest review by Garcia and De leiva (1999) about 50% of the stocks for which data is available are fully exploited and about 25% of them are overfished.

in reserve for us, is that the precautionary approach should become central to fisheries management. Instead of a simple add-on to conventional management it should shape it *de novo* into a significantly different system of governance. An effectively implemented PA would drastically change the conventional paradigm of fisheries research and management (Garcia, 1994, 1996; Mace and Gabriel, 1999). The recognition of and focus on uncertainty and risk should lead to better accounting of (and transparency about) what is poorly known as well as greater efforts to at least identify the major gaps in knowledge as well as the potential consequences, for the resources and, ultimately, for the people. The issue is exacerbated by the requirement to manage fisheries in an ecosystem context and, in the coastal zone, to integrate fisheries into coastal areas management. These, together with the requirement to take full account of social and economic implications (including in the long term) increase dramatically the information and research needs probably beyond the reach of present budgets, requiring new scientific approaches and institutional social processes.

The precautionary approach is likely to be supported when it addresses the needs of present generations (e.g. tends to reduce the current risk of collapse of fisheries). The real concern of the present generations and their willingness to pay for future generations remains to be seen. The recent past has shown that applications of precautionary principle were possible where: (1) those gaining from its applications were not the same as those losing from it (e.g. in the large scale pelagic driftnet issue); (2) public and political pressure left little alternative to those in the fishery (e.g. in the tuna-dolphin issue); or (3) when economic disaster offered no other alternative (e.g. the cod in Canada). Whether the approach will be generalised to less contrasted situations to become fully part of day-to-day good practice will depend on the capacity to detect problems early, to design solutions and pathways with acceptable socio-economic consequences and ensure equitable allocation of burden.

Tackling these difficulties will require evolved forms of governance and the precautionary approach has the potential to drastically improve management practices. However, alone or limited to its scientific aspects, it will only represent yet another step towards scientific sophistication along a 50-year old track which has produced large amounts of excellent science on a background of inexorably growing overexploitation, ecosystem degradation, economic dysfunction, and social distress. Hanna (1999) stresses that ”*the structure of fishery governance is typically rigid in form, often residual to an earlier time of expansion and development*”. She identifies this rigidity in front of the ocean uncertainty and global change as a main reason for failure, together with the obsession to stabilise yields and the use of fisheries as “sink” for excess labour and capital. She points out that in fisheries, the overwhelming characteristic is variability (and uncertainty), and to adapt to that environment the structure of fisheries governance must be shaped by it. One implication of this statement is that in order to be effective the PA should shape fisheries governance, not only affecting management-oriented science (this is already happening) but also widening management scope (to explicitly cover social and economic as well as ecosystem considerations), modifying structures (e.g. through better oversight and auditing mechanisms) and processes (e.g. through improved transparency and participation).

The report of the first ICES Study Group (ICES, 1977, p.6) recognises that a large part of the problem of implementing the PA is of institutional nature and stresses that ICES has an exclusively scientific advisory role and as such does have a complete control or even picture of the PA implementation in its area of competence. The report reminds of the more direct responsibility of the management agencies and of the Advisory Committee on Fisheries Management (ACFM) in this regard and of the elusive problem of the lack of transparent socio-economic objectives. It also recognises that “*precautionary management from ICES would not by itself ensure resource sustainability if there are no means to effectively implement the advice*”. Hilden (1997) addressed the same issue and, reviewing the functioning of the ACFM in relation to criteria for effective management systems, recognises that it provides information including on uncertainty and allows for examination of options but exclusively from a biological point of view. He reckons, however, that the persistent problems in the status of the stocks of the region indicate that the fundamental problem is at a more strategic level. According to him, assistance to strategic decision making is insufficient or non-existent. Significant developments are therefore necessary to promote institutional development and change and strategic decision support. In a similar vein, Cochrane *et al*. (1998), in front of the ineffective use of advanced operational management approaches in South Africa[25], reckoned that the lack of "ownership" of industry of these procedures is a problem and they suggest that developing procedures with their active participation and their parameters might have allowed for solutions which could have been both more appropriate and better accepted.

Following an argument made by Kirkwood and Smith (1996), to be effectively cautious a fishery management system must be precautionary "*in principle*" and "*in practice*". The first implies that the principles have been adopted and figure explicitly in the convention or national legislation. The second implies that the principles are implemented in practice in a way in which the measures produce effectively the level of precaution they are intended for. It is important, in particular to realise that it is not effective (and not precautionary!) to use only part of the PA tool box. Excellent intentions reflected in precautionary reference points can be defeated by sloppy control rules and modus operandi or ineffective enforcement and incentive structure. Caddy (1998) note that while "*most current work … is aimed at the definition of reference point, with relatively less emphasis or experience on how efficiently they will perform in a functioning management system*". He goes on suggesting that "*harvest control laws could be elaborated in more detail, negotiated with industry, and set to function largely independently of annual assessments in the form of fishery management procedures*"[26]. Mace and Gabriel (1999) recognised that "*marked changes in institutions, management procedures, and expectations need to occur before precautionary approaches can be fully embraced*". Much more and difficult work needs doing to improve the context in which precaution is implemented (promoting good practice) e.g. to improve data flows; better control access to the resource; identify and test alternative management strategies; improve enforcement; stimulate technological research towards more environment-friendly gear and practices.

Similarly, Rosenberg (1999) stresses the intense activity around the implementation of the PA during the last 5 years developing scientific consensus on protocols for incorporating uncertainty into scientific advice which he sees as a natural extension of the work already undertaken during the last decade on risk assessment and management. The challenge, however, is in the implementation of the advice into the action needed to effectively obtain the sought benefits. To progress further in that direction and putting priority also on the decision-making processes, Rosenberg recognises the need for progress in four areas: (1) the pre-agreement on the required measures; (2) the establishment of default action to be taken if agreement cannot be reached in due course; (3) a mechanism to incorporate new information as it is acquired; and (4) the ability to make rapid adjustments both up and down once the need has been demonstrated.

Sustainability indicators frameworks and ecolabelling

The necessary change and broadening of the present narrow basis of the PA and the need to improve governance points towards the adoption, in fisheries, of Sustainable Development Reference Systems (Garcia, 1996; FAO, 1999) of indicators as the unifying framework allowing all the dimensions of fisheries and their ecosystems to be monitored and reported on simultaneously. The process required for the elaboration of such systems may help trigger the evolution needed in conventional management systems and institutions. Garcia and Grainger (1997) have described a comprehensive framework for sustainability of fisheries with a nested set of solutions which includes but is not limited to the precautionary approach. Such frameworks should provide the basis for simple and transparent representation of sustainability and of progress in its direction as well as a straightforward assessment of performance of the new forms of fisheries governance developing in the wake of UNCED. Adopting standard indicators and reference values as well as common value judgement in the North Atlantic would allow for instance a synoptic examination of all the stocks of the ICEA and NAFO area or, better, of the entire North Atlantic shelf, to be visualised at one on a single representation system. Possibly showing both the present state as well as the trends in state, this would offer a much more comprehensible and dynamic representation of the state of things in the fishery sector than the semi-confidential information presently available.

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[25] Analysing the application of biology-based operational management procedures to the sardine/anchovy fishery of South Africa, Cochrane *et al*., (1998) conclude that more than 50% of the years in which OMPs were used, the TAC recommendations elaborated using the agreed procedure were overruled for socio-economic reasons. This illustrates once more, that management decisions in fisheries are not grounded in biology and that biology-based data alone is simply not effective.

[26] Such Operational Management Procedures (OMP) are already used regularly in South Africa (Butterworth *et al*, 1997)

The rising question of the role of consumers and of the market in fisheries development and management is being answered through proposals to establish ecolabelling in fisheries. It would not be appropriate here to develop such an important and sensitive theme but it is sufficient to state that effective ecolabelling of fisheries management systems or products, which require systems of sustainability indicators and reference values will require also serious considerations of uncertainty and precaution, particularly in data-poor situations and for rebuilding resources.

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PROPOSAL FOR A SYNOPTIC PRESENTATION OF STATE OF STOCK AND MANAGEMENT ADVICE IN A PRECAUTIONARY INDICATORS FRAMEWORK PERSPECTIVE[27]

S. M. Garcia and I. De Leiva[28,29]

Introduction

ICES and NAFO are undertaking a systematic effort to assess the stocks under their responsibility (and provide scientific advice for their management) following the precautionary approach to fisheries. The last report of the ICES Advisory Committee on Fisheries Management (ICES, 1999) in particular provides a "precautionary plot" for a number of stocks (Figure 1). This plot shows, for each stock, the trajectory of the fishery across a bivariate system of reference related to fishing mortality as the independent variable and spawning biomass as the dependent variable.

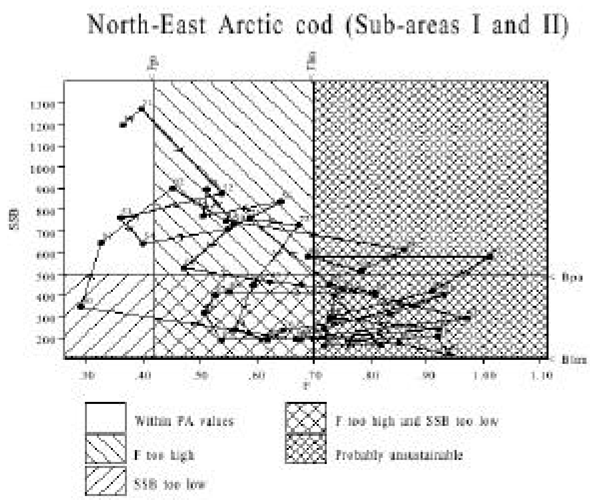

Figure 1: ACFM Precautionary Plot (from ICES, 1999)

As the observed trajectories can be fairly intricate, a simplified interpretation of this plot is given in Figure 2, using also the convention related to the ICES framework (and harvest control law) for implementation of the precautionary approach as seen in ICES (1977, p.15).

This representation, which indeed is a simple (bivariate) sustainability indicator framework (Garcia, 1996) similar to a "sustainability barometer" proposed by Prescot-Allen (1996) with one indicator of "pressure", the fishing mortality, and one indicator of "state", the spawning biomass. The NAFO approach is very similar in its principle even though it uses different definitions of the limit and threshold reference points. Using MSY as its limit reference point for fishing mortality, the NAFO approach is more cautious and in line with the UNIA Agreement. Reference values should reflect objectives and constraints and have implications in terms of action to be taken. A possible interpretation of the figure above, in management terms would be as follows. When:

- SSB indexes at or above $\mathbf{B}_{pa}$: The stock is in the management target area. The situation of the stock is good. The farther from the $\mathbf{B}_{pa}$ value the better.

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28 FAO Fisheries Department

29 The views expressed are those of the authors and not of the FAO

- SSB indexes are below $\mathbf{B}_{pa}$ and above $\mathbf{B}_{lim}$: The stock is in the “buffer zone”. The risk of recruitment failure is fairly high. The situation is not precautionary and corrective measures are needed.

- SSB indexes are below $\mathbf{B}_{lim}$: The situation is highly (unacceptably) risky and particularly drastic measures to cut F and protect both spawners and juveniles are needed.

- F indexes are at or lower than $\mathbf{F}_{pa}$: The fishing pressure is in the management target area. From a purely biological point of view, the situation is good. It could be unsatisfactory from an economic standpoint if the capacity mobilised was in excess of that required to generate that mortality (i.e. vessels are under-used).

- F indexes are between $\mathbf{F}_{pa}$ and $\mathbf{F}_{lim}$. The fishing pressure is in the “buffer zone”. The situation is not precautionary. There is excess fishing effort (and probably of capacity) and measures are needed to reduce fishing mortality and, eventually, fishing capacity.

- F indexes are above F_{lim}. The fishing mortality and probably the capacity are highly (unacceptably) risky. The situation needs immediate corrections to curb mortality. This may include moratoria.

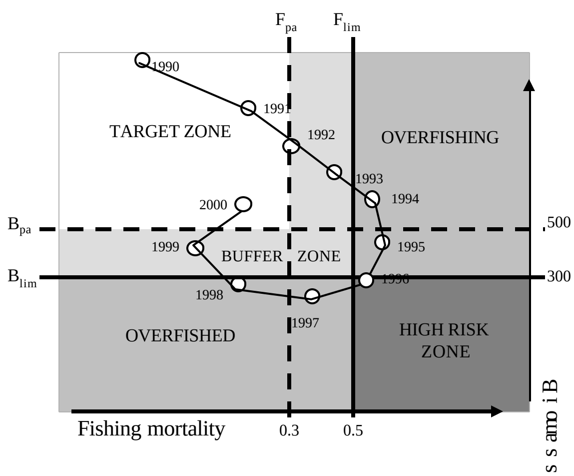

Figure 2: Schematic representation of an ICES/ACFM precautionary plot

Following the representation principles established for the sustainability barometer (Garcia, 1996), it has been considered that only when both SSB and F are over $\mathbf{B}_{pa}$ and $\mathbf{F}_{pa}$ respectively (i.e. in the target area) the situation is fully satisfactory in terms of sustainability (clear on Figure 2). When either B or F are beyond their acceptable limit, the situation is considered unsatisfactory (medium grey on Figure 1) as either overfishing prevails (F is too high), the stock is overfished (B is too low) or both (dark grey on Figure 1). The “buffer zone” (light grey) reflects an intermediate situation requiring active corrective management. The density of the shades of grey reflects the degree of risk (of recruitment collapse) in the fishery.

Because the fishery sector as a whole tends to operate as a system at macro level, with transfers of capacity between fisheries, and because the ecosystem approach imposes, *inter alia*, to assess fishery resources in a global and multispecies perspective, it would be useful to develop a similar but more synoptic representation of the “overall” trajectory of the entire fishery sector, for a large ecosystem, or at least for the main fisheries and stocks. However, the values of F and levels of biomass can be substantially different between stocks and joint representation requires some form of normalisation of the data. One of the possible normalisation approaches is described below.

Methodology

When data on F and B are available for many stocks, Garcia (1996) and Garcia and Staples (in Press) suggest to rescale the data, e.g. as a ratio to the reference values (e.g. F/ $\mathbf{F}_{lim}$ or B/$\mathbf{B}_{lim}$). This allows all the F and B data, for all stocks, to fall between 0 and 1 and be represented on a single bivariate plot in any given year. The normalisation problem is, however, more complex when like in this case, two reference values are used for each indicator, such as a limit value (e.g. $\mathbf{B}_{lim}$, $\mathbf{F}_{lim}$) and a threshold value (e.g. $\mathbf{B}_{pa}$ or $\mathbf{F}_{pa}$, as in ICES, or B_{buffer} and F_{buffer} as in NAFO). In such a case it is suggested that the normalised indicator could be referenced to both limits and their distance (e.g. measured relative to the position and extent of the buffer zone). This requires:

1. taking one of the reference values as origin of the data (e.g. F_{lim} and B_{lim}= 0) to rescale the annual indicator, and normalise it in relation to the limit value;

2. dividing the rescaled value by the precautionary interval or buffer zone ($F_{lim} - F_{pa}$) or (B_{lim} B_{pa}) to normalise it further in relation to the precaution (or buffer) interval (see Figure 2 below). In this representation, the values for SSB or F become relative measures of “stress” of the stock.

This simple protocol was applied to the data available in the last ACFM report (ICES, 1999) with the purpose to represent in a synoptic picture various stocks on one graph for a given year as well as the evolution of this synoptic picture over time, The stocks considered in this slide are those of this report for which $\mathbf{B}_{pa}$, $\mathbf{B}_{lim}$ and $\mathbf{F}_{lim}$ and $\mathbf{F}_{pa}$ have been defined (19 stocks) for a long enough period (see Annex).

Results

Annual synoptic view: relative positions and trends

The data available for 1970 have been processed and the data points positioned on the normalised plot (Figure 3, below). Some points are associated with an arrow simply to indicate that they stand out of scale. One can see that already in 1970 few stocks were at the edge of the target area, few in the overfishing area, and most in the buffer zone. In general the biomass was still above the Pa level.

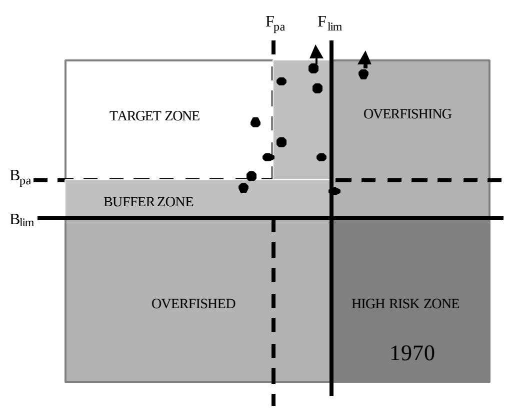

Figure 3: Synoptic normalised representation of the state of stock (1970)

More information could be added to such a representation, particularly to represent the direction of change in position from year to year, a proposal made by Garcia (1994) for dynamic systems of sustainability indicators. The data for 1998 have been represented in Figure 4.

On such a representation one gets a feeling not only for the position of the stocks in relation to the precautionary frames but also a sense of the way in which the situation is evolving, year after year. Each point is represented by an isosceles triangle. Its centre corresponds to the normalised coordinates. Its apex points in the direction of the trend, identified simply by the position of the 1998 point relative to the average 1994-1997. If there is no visible trend, the triangle is replaced by a circle. In a coloured representation, one could express also a value judgement about the direction. The judgement could then be represented by the colour of each triangle: green when the stock is improving in terms of both B and F; yellow, when only one of the two indicators evolves correctly; and red when both are worsening. Additional colours or shades could be used to differentiate between changes in B and F complicating the representation however.

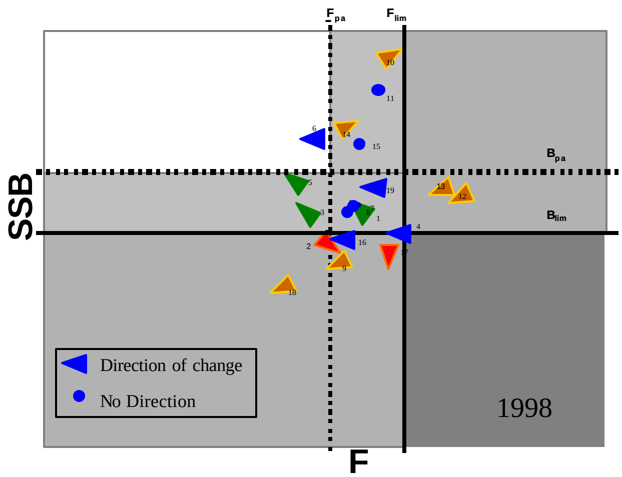

Figure 4: Synoptic normalised representation of the state and trend of the stocks in 1998

Multiannual trajectory

When this representation is available for many years, global trajectories of the whole set of stocks could be developed. The ACFM data for 1980, 1990, and 1998 for all stocks for which the required data was available have been processed as indicated above and positioned on the normalised system of reference for comparison with 1970 (Figure 5). Notice that the number of stocks for which the necessary data is available vary between years (11 stocks in 1970, 17 in 1980 and 19 in 1990 and 1998). A careful examination of the data scatters show a clear shift towards the right of F-limit (towards the overfishing area) in 1980, a further shift in the same direction in 1990, and perhaps an improvement towards less fishing pressure in 1998 (less points “in the red”). A full representation of all the data available would indicate whether the shift has been coherent but this is likely.

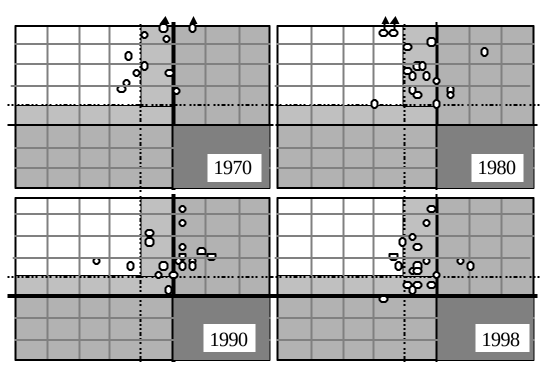

Figure 5: Synoptic normalised representation for different years.

In order to illustrate more clearly this trend, two additional simple treatments of the data have been tried. First, the % of stocks in each area (Target, Buffer, beyond one or two of the limits). These have been labelled as "good", "buffer", and "bad" on Figure 6 below.

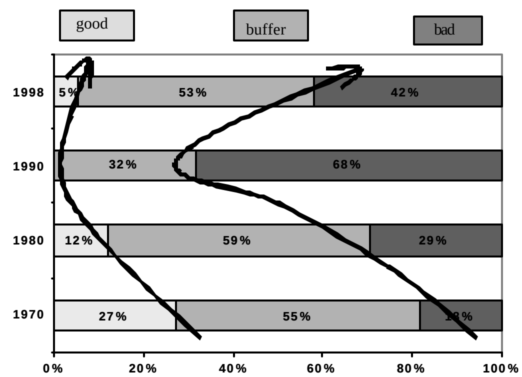

Figure 6: Evolution of the proportion of stocks in the various zones, 1970-98

The figure shows clearly the increase of overfishing from 1970 to 1990. It also shows an apparent reversal of the trend since 1990. A complete representation of all available years would give a more precise picture of this trend. The results could be further compacted (for representation) by looking at the trajectory of the "centre of gravity" of the scatter of each year (we used a simple arithmetic mean of B and F normalised values. The result is shown in Figure 7 below.

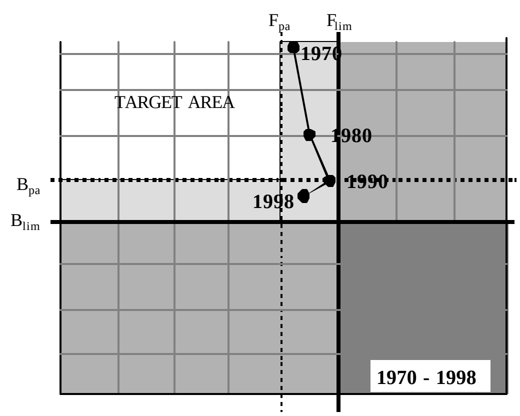

Figure 7: Shift in the "centre of gravity" of the stocks, 1970-1998

The picture indicates clearly that for nearly 30 years, the biomass of the stocks in the area have been brought close to the Pa and even below, between 1990 and 1998. It seems to show also the trend to increase fishing mortality levels (which have always been in excess of the "pa" level and came close to the limit in 1990) seem to have improved in 1998 without showing yet an improvement in biomass situations.

Discussion and conclusion

Using a graphical approach recommended for representation of systems of sustainability indicators in fisheries, a synoptic representation has been developed to summarise in a few graphs rather complex trajectories of individual stocks. The purpose of such representations would be to obtain a more global view of what happens in the area, offering a possibility to judge the performance of governance. The representations would also facilitate the transmission of large amounts of information to a non-technical audience. A number of considerations can be made:

(1) Trends would be clearer if all years were considered, something we could not do for lack of space.

(2) The global view would be more reliable if more stocks were included. As a matter of fact, limiting the analysis to only one reference would increase the number of data points.

(3) The points have not been weighed according to stock size or potential or value or employment generated but in principle this could be done if a particular perspective was required. The equal weight reflects perhaps better the performance of the institutions.

(4) We have used the "pa" and "lim" values as given. It is not obvious that they have exactly the same significance for all stocks and, for instance that their distance (normalised here to 100) represent the same degree of risk or precaution. Here we do not show how precautionary the exploitation system is but how it performs in relation to the precaution it has, itself, decided to apply.

One can easily see the potential benefits of harmonisation of reference limits between ICES and NAFO to represent synoptically larger areas and perhaps the entire North Atlantic.

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Prescot-Allen, R. (1996):Barometer of sustainability: What it's for and how to use it. The World Conservation Union (IUCN), Gland, Switzerland: 25 p.

List of stocks considered in this document

1. Hake - Northern stock (Division IIIa, Sub-areas IV, VI and VII, and Divisions VIIIa,b)
2. Whiting in Division VIIa (Irish Sea)
3. Cod in Sub-area IV (North Sea), Division VIId (Eastern English Channel) and Division IIIa (Skagerrak)
4. Cod in Division VIIa (Irish Sea)
5. Megrim (*boscii*) in Divisions VIIIc and IXa
6. Haddock in sub-area IV (North Sea) and Division IIIa
7. Saithe in Sub-area IV (North Sea), Division IIIa (Skagerrak) and Sub-area VI (West of Scotland and Rockall)
8. Sole in Division VIIe (Western English Channel)
9. Cod in Division VIa (West of Scotland)
10. Haddock in sub-areas I and II
11. Saithe in sub-areas I and II
12. Plaice in Division VIId (Eastern English Channel)
13. Cod in sub-areas I and II
14. Mackerel in Divisions VIIIc and IXa (Southern Component)
15. Cod in Divisions VIIe-k
16. Plaice in Sub-area IV (North Sea)
17. Whiting in Division VIa (West of Scotland)
18. Whiting in sub-area IV (North Sea) and DivisionVIId (Eastern English Channel)
19. Sole in Division VIIa (Irish Sea)

Not to be cited without prior reference to the authors **Working Paper**

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Precautionary Approach Terminology
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ICES Framework for the Implementation of the Precautionary Approach

Hans Lassen
Henrik Sparholt
ICES Secretariat
Palægade 2-4
DK 1261 Copenhagen K
Denmark

Introduction

ICES recognises that "changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values" (FAO 1996). ICES therefore considers that a precautionary approach should be applied to fishery management. Reference points, stated in terms of fishing mortality rates or biomass and management plans are key concepts in implementing a precautionary approach. They should be regarded as signposts giving information of the status of the stock in relation to predefined limits that should be avoided to ensure that stocks and their exploitation remain within safe biological limits.

It has to a large extent been possible to develop concepts, a quantitative framework with reference points and management models for single stock sustainability and precautionarity in relation to that. For the concept of ecosystem sustainability the situation is very different. There is still little clarity on the conceptual level given the complexity and natural variability of marine ecosystems. Reference points are far away from being defined given the limited understanding of the processes in the ecosystem, of the effects of human interaction and of what comprises a perturbation of the ecosystem which is unsustainable or irreversible.

The present position regarding reference points is that a full causal understanding of the processes in the system, which may be used as a basis for quantifiable reference points, is far away and it is unlikely that it will ever be achieved. It is thus necessary to base reference points on some generalising metrics of the state of the ecosystem and the impact of fisheries. Candidates are being discussed including various indices of size- and species composition and the abundance of sensitive species, and there is a growing literature and understanding on how such ecosystem metrics respond to fisheries. Some of the ecosystems in the Northeastern Atlantic have served as key cases in this development, mainly the North Sea, but also the Barents Sea and the Baltic.

The remainder of this paper is confined to defining precautionary reference points in a single species model context.

The Form of the ICES Advice and conceptual definitions of Reference Points

(Extract from the ACFM report for 1999, CRR no 236, February 2000)

The concept of safe biological limits was introduced in ICES advice in 1981 and further developed in 1986. At first the term was used in relation to management actions, whereas lately it has been used in relation to the state of a stock, and also of its exploitation. In its recent implementation of the concept, ICES has equated being within safe biological limits as being above MBAL and being outside safe biological limits as being below MBAL. This is a needlessly restricted interpretation of a concept which is clearly multi-dimensional involving at least reference points related to fishing mortality and biomass, but possibly also factors such as age-distribution in the stock and in the catch, geographical range, condition factor etc. The concept of safe biological limits is explicitly referred to in the UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks and ICES will continue to use it, but in an expanded way, consistent with the precautionary approach.

In order for stocks and fisheries exploiting them to be within safe biological limits, there should be a high probability that 1) the spawning stock biomass is above the threshold where recruitment is impaired, and 2) the fishing mortality is below that which will drive the spawning stock to the biomass threshold which must be avoided. The biomass threshold is defined as $\mathbf{B}_{lim}$ ($_{lim}$ stands for limit) and the fishing mortality threshold as $\mathbf{F}_{lim}$. In order to have a high probability to avoid the thresholds, management action must be taken before the thresholds are approached. The precision with which the thresholds and current status of the stocks are known, and the risk which is tolerable, are important factors in determining the distance away from the threshold that management action is required. The greater the precision of the assessment, the smaller the distance between limit and precautionary reference points. If the assessment is less reliable, the distance will be greater. ICES has defined $\mathbf{B}_{pa}$ ($_{pa}$ stands for precautionary approach) as the biomass below which action should be taken and $\mathbf{F}_{pa}$ as the fishing mortality above which management action should be taken. The distance between the limit and the precautionary approach reference points is also related to the degree of risk that fishery management agencies are willing to accept. Therefore, although ICES sees its responsibility to identify limit reference points, it will suggest precautionary reference points. The adoption of precautionary reference points requires discussion with fishery management agencies.

ICES proposed in 1998 and 1999 a number of "lim" and "pa" reference points as a provisional step to the implementation of a precautionary approach. It was recognised that the estimates of thresholds could change as the concept evolved or with additional knowledge of stock and fishery dynamics.

Formal conceptual definitions are provided below:

$\mathbf{F}_{lim}$

is the limit fishing mortality which should be avoided with high probability because it is associated with unknown population dynamics or stock collapse. There are very few stocks for which $\mathbf{F}_{lim}$ is accurately known. Some stocks in the ICES area have collapsed in the past when fishing mortality exceeded $\mathbf{F}_{lim}$, but generally speaking, the fishing mortality rate at which the probability of stock collapse becomes unacceptably high remains unknown. Therefore, there are uncertainties in the estimate of $\mathbf{F}_{lim}$, and there are also uncertainties in estimates of current fishing mortality.

$\mathbf{F}_{pa}$

In order to have a high probability that fishing mortality will be below $\mathbf{F}_{lim}$, a precautionary reference point, $\mathbf{F}_{pa}$ lower than $\mathbf{F}_{lim}$, is defined. Used as a constraint on fishing, $\mathbf{F}_{pa}$ is designed to ensure that there is a high probability that $\mathbf{F}_{lim}$ will be avoided and that the spawning stock biomass will remain above the threshold below which the probability of good to average recruitment is decreased. In other words, $\mathbf{F}_{pa}$ is a device to ensure that recruitment overfishing does not take place. It is the upper bound on fishing mortality rate to be used by ICES in providing advice. $\mathbf{F}_{pa}$, given uncertainties, must have a high probability of being below $\mathbf{F}_{lim}$, and it must have a high probability of being sustainable based on the history of the fishery; i.e., it should be set in the range, and imply a biomass, within those previously perceived to be acceptable. Fishing mortality rates in excess of $\mathbf{F}_{pa}$ will be regarded as "overfishing".

$\mathbf{B}_{lim}$

is the limit spawning stock biomass, below which recruitment is impaired or the dynamics of the stock are unknown. Stocks may become depleted due to reduced recruitment even if fishing mortality is successfully maintained at or below $\mathbf{F}_{pa}$. Furthermore, efforts to restrain fishing below $\mathbf{F}_{pa}$ may not be successful and biomass may decline as a result. Clearly, therefore, in addition to a constraint on fishing mortality, it is desirable to have a biomass-based constraint to prevent stock decline to values where expected recruitment is low or unknown.

$\mathbf{B}_{pa}$

Whereas $\mathbf{F}_{pa}$ defines an "overfishing threshold", a definition of when the stock is regarded as being in a "depleted state" is also necessary. A threshold in this respect, $\mathbf{B}_{pa}$, needs to be set to ensure a high probability of avoiding reducing the stock to a point, $\mathbf{B}_{lim}$, below which recruitment is impaired or the dynamics of the stock are unknown. $\mathbf{B}_{lim}$ is in general equal to previously defined MBAL values for those stocks where MBAL has been based on considerations of stock-recruitment relationships. $\mathbf{B}_{pa}$ is the biomass below which the stock would be regarded as potentially depleted or overfished. When SSB is below $\mathbf{B}_{pa}$, fishing mortality may need to be reduced below $\mathbf{F}_{pa}$. $\mathbf{B}_{pa}$ should be set to ensure a high probability that $\mathbf{B}_{lim}$ is not reached.

There have been made numerous proposals for operational definitions of such reference points.

Framework for advice

(Extract from the ACFM report for 1999, CRR no 236, February 2000)

Advice from ICES will be constrained by $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$. If fishery management decisions lead to $\mathbf{F}_{pa}$ being exceeded, then this would be regarded as overfishing and management would not be regarded as consistent with a precautionary approach. The development of a management plan to reduce fishing mortality to no greater than $\mathbf{F}_{pa}$ would be advised. If no such plan were developed, ICES would generally advise that management was not consistent with a precautionary approach. Because $\mathbf{F}_{pa}$ would be set such that $\mathbf{B}_{pa}$ were unlikely to be reached, and because $\mathbf{B}_{pa}$ is chosen to provide a high probability of avoiding recruitment failure, if SSB were to fall below $\mathbf{B}_{pa}$, advice to reduce fishing mortality would be likely. This would depend, however, on whether or not $\mathbf{F}_{pa}$ were also being exceeded and on the prognosis for SSB trends and the probability of recovering to above $\mathbf{B}_{pa}$ in the short term. If SSB were predicted to remain below $\mathbf{B}_{pa}$ in the short to medium term, the development of a recovery plan would be advised. But in general, $\mathbf{B}_{pa}$ is the biomass threshold triggering advice for a reduction in F to a value below $\mathbf{F}_{pa}$.

$\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ are thus the main devices in the ICES framework for providing advice. They are thresholds which constrain advice or which likely trigger advice for the implementation of management/recovery plans. If the development of plans were proposed, fishery management agencies, scientists and perhaps other parties would need to work together on their development. Such plans might involve explicit harvest control rules or sets of decision rules. If the development of plans were recommended, but not taken up, ICES would have to advise that management was not consistent with a precautionary approach. If plans were developed and not effectively implemented, again the advice would be that management was not consistent with a precautionary approach.

Note that if a stock is regarded as being in a depleted state, or even if overfishing is taking place, the development and effective implementation of a plan which is regarded as sufficient to reduce fishing mortality to no higher than $\mathbf{F}_{pa}$ and to rebuild SSB to above $\mathbf{B}_{pa}$, within a “reasonable” period, would satisfy the condition that management were consistent with a precautionary approach.

The framework is illustrated in the figure 1 below:

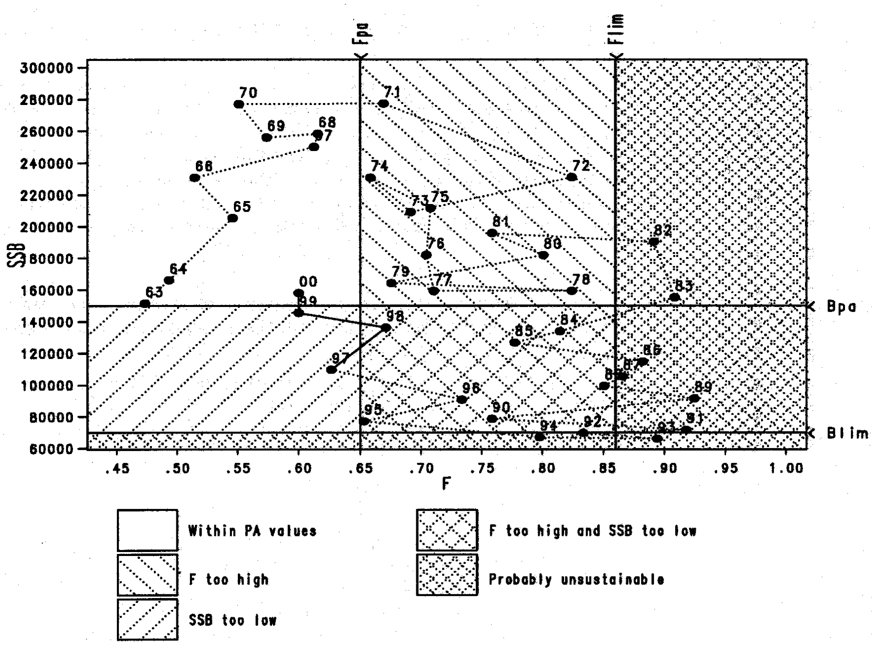

Figure 1. Precautionary Approach Plot for cod in the North Sea, Skagerrak and the Eastern Channel. The plot indicates the fishing mortality (F) and Spawning Stock Biomass (SSB) over the last 25 years.

How ICES uses Reference Points in formulating Advice

When formulating the advice ICES distinguishes between the state of the stock (based on the estimates of SSB and F) and the expectations of the SSB under various scenarios of future fisheries. These expectations are usually expressed as management option tables giving two year projections and 10 years medium term projections. Table 1 presents a proposal for a consistent formulation of the ICES advice. The 'limit' reference points are not used explicitly, F_{lim} and B_{lim} is used when calculating F_{pa}. The 'Rebuilding plan' that appears in Table 1 for various scenarios is not specified and depends on the severity of the situation and the biology of the stocks involved, i.e. is case specific. ICES is using a wide range of methods to calculate these reference points, see Table 2 for a summary.

The advice is formulated as a series of management option tables in which shading is used to indicate those options that are considered to be outside precautionary limits, i.e. $F > F_{pa.}$ The F is converted into an expected catch under that level of fishing mortality and this appears in the ACFM report as 2 year projections of the stock development under the specified fishing scenario.

Example of how ICES advice is presented in the ACFM report

Catch forecast for 2000: Basis: F(99) = F(96–98) = 0.92, Landings (99) = 89 000,SSB(2000)=141 000, SSB(99)=139 000.

F (2000)	Basis	Landings (2000)	SSB (2001)	Medium-term effect of fishing at given level
.37	0.4*F(98)	43,000	189,000	High probability of SSB increasing above the proposed $\mathbf{B}_{pa}$
.55	0.6*F(98)	60,000	169,000	About 25% probability of SSB increasing above the proposed $\mathbf{B}_{pa}$
$\mathbf{F}_{pa}$ = 0.6	0.65*F(98)	64,000	164,000	High probability of SSB remaining below the proposed $\mathbf{B}_{pa}$
.74	0.8*F(98)	75,000	151,000	High probability of SSB remaining below the proposed $\mathbf{B}_{pa}$
.92	1.0*F(98)	89,000	136,000	High probability of SSB remaining below the proposed $\mathbf{B}_{pa}$
1.1	1.2*F(98)	100,000	123,000	High probability of SSB remaining below the proposed $\mathbf{B}_{pa}$
1.29	1.4*F(98)	111,000	111,000	High probability of SSB remaining below the proposed $\mathbf{B}_{pa}$

Weights in ‘000 t. Shaded scenarios considered inconsist ent with the precautionary approach.

The shading in the management table is based on the reference points that are presented as follows

Reference points:

ICES considers that:	ICES proposes that:
$\mathbf{B}_{lim}$ is 160 000 t	$\mathbf{B}_{pa}$ be set at 240 000 t
$\mathbf{F}_{lim}$ is 0.96	$\mathbf{F}_{pa}$ be set at 0.6

Technical basis:

$\mathbf{B}_{lim}$: SSB below which recruitment is impaired	$\mathbf{B}_{pa}$: MBAL
$\mathbf{F}_{lim}$: $\mathbf{F}_{med}$98	$\mathbf{F}_{pa}$: 5 percentile of $\mathbf{F}_{med}$

Operational definition of Reference Points

The definition of reference points includes an account of the uncertainties in the knowledge of stock status, in the projections and in the implementation of management measures. These uncertainties are not all of them independent. In order to have operational definitions it is necessary to specify which uncertainties are to be included in the calculations and how. The text Table below summaries the uncertainties in the assessment and in the management process.

Classification of sources of uncertainty in the assessment and management process which will need to be taken into account in designing a precautionary approach.

TYPES OF UNCERTAINTY
There are several sources of uncertainty in the calculation of reference points, and in the evaluation of stock status relegate to these reference points. Five types of uncertainty arising from an imprecise knowledge of the state of nature are (Rosenberg and Restrepo, 1994): • Measurement uncertainty is the error in the observed quantities such as the catch or biological parameters; • Process uncertainty is the underlying stochasticity in the population dynamics such as the variability in recruitment; • Model uncertainty is the misspecification of model structure; • Estimation uncertainty can result from any, or a combination of the above uncertainties and is the inaccuracy and imprecision in abundance or fishing mortality rate; • Implementation uncertainty results from variability in the resulting implementation of a management policy, i.e. inability to exactly achieve a target harvest strategy. Note that sources of uncertainty include not only statistical error in detecting stock status and environmental trends or errors in population analysis, but also wrong decisions and an inefficient management framework; issues dealt with later in this paper.

The operational definitions of the reference points that have been used so far are specified based on single species models. There are studies based on multispecies models that indicate that the results would be different if such models were used.

Calculation procedures used within ICES

In order to calculate the reference point ICES uses several procedures depending on the available data. There are several software packages in use for calculating reference points including The CEFAS PASOFT, Aberdeen ICA/ICP, a spreadsheet program developed by DIFRES, Copenhagen, software developed by IMR, Bergen and a software developed by the Polish Sea Fisheries Institute. Some of the software have been developed for use in specific assessments taking specific features of those stocks in to account and therefore would differ from other packages. The general outline of the calculation procedures are described below

Procedure 1

1) Estimation of $\mathbf{B}_{lim}$ based on experience with low spawning stock biomass with impaired recruitment

   a) Derived from a S-R relationship, e.g MBAL $\mathbf{B}_{lim}$ is defined from the stock recruitment plot as the SSB level where recruitment seems to fail (MBAL)

2) Simulation of $\mathbf{F}_{pa}$ and $\mathbf{B}_{pa}$ based on $\mathbf{B}_{lim}$ defining the window in the F-SSB plane where recruitment is not impaired taking natural variability and assessment uncertainty into account

   a) Inclusion stock production considerations and of natural variability

      i) Recruitment

(1) Based on a parametric model of the error around a stock-recruitment curve, most often in the form $\log R = fct\{SSB(t-1)\} + \text{Log-Normal}(0,\sigma^2)$

(2) Based on bootstrapping the residuals from the Stock-recruitment fit,

$\log R = fct\{SSB(t-1)\} + \text{Bootstrap}\{\delta_1, \delta_2, \delta_3,...\}$ where δ_i is the residual of the i-th observation in the logarithmic S-R fit.

ii) Other natural processes and their natural variation, e.g. growth

(1) Variation of the mean weight at age by year is often not included in the simulations. There are examples, e.g. NE arctic cod where such variation is large and therefore of major importance. In these cases some allowance for uncertainties in the mean weight at age needs to be included in the simulations. However, these periods of good and bad growth have serial correlation and this should be included in the simulations

b) Assessment and implementation uncertainties

(1) Based on residuals in XSA or ICA/ICP analysis estimated based on the Hessian matrix

Procedure 2a

1. $\mathbf{B}_{lim} = \mathbf{B}_{loss}$
2. $\mathbf{F}_{lim}$ corresponds to $\mathbf{B}_{loss}$ (=$\mathbf{F}_{loss}$)
3. $\mathbf{B}_{pa}$ = exp(1.645*s) where s is the std.dev. in the log R series or a CV from the assessment uncertainty

Procedure 2b

1. $\mathbf{F}_{lim} = \mathbf{F}_{med}$
2. $\mathbf{F}_{pa} = \mathbf{F}_{med}$ * exp(-1.645*s) where s is the std dev in the log R series or a CV from the assessment uncertainty
3. $\mathbf{B}_{pa} = \mathbf{B}_{loss}$ exp(1.645*s) where s is the std dev in the log R series or a CV from the assessment uncertainty

Table 1. Some Commonly Used Reference Points

(Extract from: Updated Draft Report of the ICES Study Group on the Precautionary Approach to Fisheries Management, ICES CM 1997/Assess:7)

RP	Definition	Data Needs	Possible PA-Usage
$F_{0.1}$	F at which the slope of the Y/R curve is 10% of its value near the origin	Weight at age, natural mortality, exploitation pattern	
F_{max}	F giving the maximum yield on a Y/R curve	Weight at age, natural mortality, exploitation pattern	LIMIT [1]
F_{low}	F corresponding to a SSB/R equal to the inverse of the 10% percentile of the observed R/SSB	Data series of spawning stock size and recruitment, weight and maturity at age, natural mortality, exploitation pattern.	
F_{med}	F corresponding to a SSB/R equal to the inverse of the 50% percentile of the observed R/SSB	Data series of spawning stock size and recruitment, weight and maturity at age, natural mortality, exploitation pattern.	LIMIT [1]
F_{high}	F corresponding to a SSB/R equal to the inverse of the 90% percentile of the observed R/SSB	Data series of spawning stock size and recruitment, weight and maturity at age, natural mortality, exploitation pattern.	
F_{MSY}	F corresponding to Maximum Sustainable Yield from a production model or from an age-based analysis using a stock recruitment model	Weight at age, natural mortality, exploitation pattern and a stock recruitment relationship or general production models	LIMIT [1]
2/3 F_{MSY}	2/3 of F_{MSY}	as above	
$F_{20\% SPR}$	F corresponding to a level of SSB/R which is 20% of the SSB/R obtained when F=0	Weight and maturity at age, natural mortality, exploitation pattern.	LIMIT [1]
F_{crash}	F corresponding to the higher intersection of the equilibrium yield with the F axis as estimated by a production model; could also be expressed as the tangent through the origin of a Stock-Recruitment relationship.	Weight at age, natural mortality, exploitation pattern and a stock recruitment relationship	LIMIT [1]
F_{loss}	F corresponding to a SSB/R equal to the inverse of R/SSB at the Lowest Observed Spawning Stock –LOSS	Weight at age, natural mortality, exploitation pattern and a stock recruitment relationship	LIMIT [1]
F_{comfie}	F corresponding to the minimum of F_{med}, F_{MSY} and F_{crash}		LIMIT [1]
F >= M	Empirical (for top predators)	M and sustainable F:s for similar resources	
F < M	As above (for small pelagic species)	M and sustainable F:s for similar resources	
Z_{mbp}	Level of total mortality at which the maximum biological production is obtained from the stock	Annual data series of standard catch rate and total mortality	
B_{MSY}	biomass corresponding to Maximum Sustainable Yield from a production model or from an age-based analysis using a stock recruitment model	Weight at age, natural mortality, exploitation pattern and a stock recruitment relationship or general production models	LIMIT [1]
MBAL	A value of SSB below which the probability of reduced recruitment increases	Data series of spawning stock size and recruitment (not necessarily from an VPA)	LIMIT [1]
$B_{50\% R}$	The level of spawning stock at which average recruitment is one half of the maximum of the underlying stock-recruitment relationship.	Stock recruitment relationship (not necessarily from an VPA)	LIMIT [1]
$B_{90\% R, 90\% Surv}$	Level of spawning stock corresponding to the intersection of the 90th percentile of observed survival rate (R/S) and the 90th percentile of the recruitment observations	Data series of spawning stock size and recruitment	LIMIT [1]
$B_{20\% B\text{-}virg}$	Level of spawning stock corresponding to a fraction (here 20%) of the unexploited biomass. Virgin biomass is estimated as the point where the replacement line for F=0 intersects the stock-recruitment relationship or as the biomass from a spawning stock per recruit curve when F=0 and average recruitment is assumed	Weight at age, natural mortality, exploitation pattern and a stock recruitment relationship	LIMIT [1]
B_{loss}	Lowest observed stock size	Data series of spawning stock size	LIMIT [1]

[1] Not all limit reference points are intrinsically equal, and their interpretation depends on the specifics of each particular case they are applied to. For example, F_{max} can in some cases be considered as a target, when it is well defined and corresponds to a sustainable fishing mortality, while it would be a limit when it is ill defined and/or corresponds to unsustainable fishing mortality. Similarly F_{MSY}, that is suggested as a minimal international standard for a limit reference point in the UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, could in some particular cases be considered a target. F_{crash} on the other hand is an extremely dangerous level of fishing mortality at which the probability of stock collapse is high. The probability of exceeding F_{crash} should therefore be very low.

Table 2. ICES usage of reference points in formulating advice. Accepted Analytical Assessment

Current Estimates of F and SSB		State of stock	Future expectations Medium term projections (years) using $F=F_{pa}$ for all years			
			$SSB(2)_{expected}<B_{pa}$	$SSB(2)_{expected}<B_{pa}$	$SSB(2)_{expected}>B_{pa}$	$SSB(2)_{expected}>B_{pa}$
$F_{current}<F_{pa}$	$SSB_{current}>B_{pa}$		$SSB(10)_{expected}<B_{pa}$	$SSB(10)_{expected}>B_{pa}$	$SSB(10)_{expected}<B_{pa}$	$SSB(10)_{expected}>B_{pa}$
Y	Y	Inside safe biological limits	$F(advice) < F_{pa}$	$F(advice) = F_{pa}$	$F(advice) = F_{pa}$	$F(advice) = F_{pa}$
Y	N	Outside safe biological limit but harvested at a fishing mortality that is sustainable	$F(advice) << F_{pa}$ Rebuilding plan	$F(advice) <F_{pa}$ Rebuilding plan	$F(advice) < F_{pa}$	$F(advice) = F_{pa}$
N	Y	Harvested outside safe biological limits	$F(advice) = F_{pa}$	$F(advice) = F_{pa}$	$F(advice) < F_{pa}$	$F(advice) = F_{pa}$
N	N	Outside safe biological limits	$F(advice) << F_{pa}$ Rebuilding plan	$F(advice) < F_{pa}$ Rebuilding plan	$F(advice) < F_{pa}$	$F(advice) = F_{pa}$

Table 3. Precautionary Approach reference points as defined by ACFM 1999.

Reference point	Technical basis	Number of stocks
$\mathbf{B}_{lim}$	$\mathbf{B}_{pa}$	2
	$\mathbf{B}_{loss}$	36
	S-R plots	6
	MBAL	5
	Lowest that has produced outstanding y.c.	1
	20% of Umax	2
	Not defined	11
	Sum	63
$\mathbf{B}_{pa}$	$\mathbf{B}_{lim}$	28
	$\mathbf{B}_{loss}$	13
	S-R plots	7
	MBAL	6
	Lowest that has produced outstanding y.c.	1
	Not defined	8
	Sum	63
$\mathbf{F}_{lim}$	$\mathbf{F}_{loss}$	21
	$\mathbf{F}_{pa}$	3
	F that has let to stock decline	5
	$\mathbf{F}_{med}$	3
	$\mathbf{B}_{lim}$	1
	Not defined	30
	Sum	63
$\mathbf{F}_{pa}$	$\mathbf{F}_{lim}$	15
	$\mathbf{F}_{med}$	14
	Medium-term projections	16
	Historical experience	1
	By analogy to other stocks	2
	SSB/R in absence of fishing	1
	F0.1	1
	Not defined	13
	Sum	63