# FISH510.9 Principles of utilisation: The precautionary approach

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# Contents

# 1 Principles of utilisation

## 1.1 Rio Declaration On Environment and Development

Principle 15
... the precautionary approach shall be widely applied
Weak, but: ... PA shall be applied

Principle 15

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 or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

## 1.2 CODE OF CONDUCT FOR RESPONSIBLE FISHERIES

ARTICLE 6 - GENERAL PRINCIPLES
6.3 States should ... ensure that fishing effort is commensurate with ... sustainable utilization

- ... Sustainable !

6.5 ... apply a precautionary approach widely ... ... absence of ... scientific information ... not ... a reason for postponing ... measures

- ... PA shall be applied

6.9 ... the need for conservation ... taken into account in...the coastal zone

- ... account for conservation - coastally

ARTICLE 6 - GENERAL PRINCIPLES

6.1 States and users of living aquatic resources should conserveaquatic ecosystems. The right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources.

6.3 States should prevent overfishing and excess fishing capacity and should implement management measures to ensure that fishing effort is commensurate with the productive capacity of the fishery resources and their sustainable utilization. States should take measures to rehabilitate populations as far as possible and when appropriate.

6.5 States and subregional and regional fisheries management organizations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.

6.9 States should ensure that their fisheries interests, including the need for conservation of the resources, are taken into account in the multiple uses of the coastal zone and are integrated into coastal area management, planning and development.

## 1.3 ARTICLE 7 - FISHERIES MANAGEMENT

> 7.1.1 ... adopt measures for ... sustainable use of ... resources. ... measures, ... local, national, subregional or regional levels, ... ensure ... sustainability ... short term considerations should not compromise these objectives.
> ...which promote the objective of their optimum utilization...
>
> - ... sustainable and optimum utilization-not short term
>
> 7.2 Management objectives
> 7.2.1 ...long-term sustainable use of fisheries resources is the overriding objective of conservation and management, ..., adopt ... measures, ... to maintain or restore stocks at levels capable of producing maximum sustainable yield...
>
> - ... sustainable=1. objective
> - ... B>BMSY
>
> 7.5 Precautionary approach
> 7.5.3 ... should... determine: a. ... target reference points, ... b. ... limit reference points,... the action to be taken if they are exceeded; when a limit reference point is approached, ... ensure that it will not be exceeded.
> 7.5.4 ... new ... fisheries...cautious ... management measures, ... measures should, if appropriate, allow for the gradual development of the fisheries

ARTICLE 7 - FISHERIES MANAGEMENT

7.1.1 States and all those engaged in fisheries management should, through an appropriate policy, legal and institutional framework, adopt measures for the long-term conservation and sustainable use of fisheries resources. Conservation and management measures, whether at local, national, subregional or regional levels, should be based on the best scientific evidence available and be designed to ensure the long-term sustainability of fishery resources at levels which promote the objective of their optimum utilization and maintain their availability for present and future generations; short term considerations should not compromise these objectives.

7.2 Management objectives

7.2.1 Recognizing that long-term sustainable use of fisheries resources is the overriding objective of conservation and management, States and subregional or regional fisheries management organizations and arrangements should, inter alia, adopt appropriate measures, based on the best scientific evidence available, which are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors, including the special requirements of developing countries.

7.3.3 Long-term management objectives should be translated into management actions, formulated as a fishery management plan or other management framework.

7.5 Precautionary approach

7.5.1 States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

7.5.2 In implementing the precautionary approach, States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards, on non-target and associated or dependent species, as well as environmental and socio-economic conditions.

7.5.3 States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine: a.stock specific target reference points, and, at the same time, the action to be taken if they are exceeded; and b.stock-specific limit reference points, and, at the same time, the action to be taken if they are exceeded; when a limit reference point is approached, measures should be taken to ensure that it will not be exceeded.

7.5.4 In the case of new or exploratory fisheries, States should adopt as soon as possible cautious conservation and management measures, including, inter alia, catch limits and effort limits. Such measures should remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment should be implemented. The latter measures should, if appropriate, allow for the gradual development of the fisheries.

## 1.4 STRADDLING AND HIGHLY MIGRATORY FISH STOCKS

Article 5 - General Principles

coastal States and States fishing on the high seas shall

a) adopt measures to ensure long-term sustainability of straddling fish stocks and highly migratory fish stocks and promote the objective of their optimum utilization;

b) ensure that such measures are based on the best scientific evidence, available and are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield . . .

c) apply the precautionary approach in accordance with article 6;

h) take measures to prevent or eliminate overfishing and excess fishing capacity and to ensure that levels of fishing effort do not exceed those commensurate with the sustainable use of fishery resources;

Article 6 - Application of the precautionary approach

1. States shall apply the precautionary approach widely . . .

2. States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures.

3. In implementing the precautionary approach, States shall:

b) apply the guidelines set out in Annex II and determine, on the basis of the best scientific information available, stock-specific reference points and the action to be taken if they are exceeded;

c) take into account, inter alia uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality . . .

4. States shall take measures to ensure that, when reference points are approached, they will not be exceeded. In the event that they are exceeded, States shall, without delay, take the action determined under paragraph 3 (b) to restore the stocks.

## 1.5 STRADDLING AND HIGHLY MIGRATORY FISH STOCKS

ANNEX II

GUIDELINES FOR THE APPLICATION OF PRECAUTIONARY REFERENCE POINTS IN CONSERVATION AND MANAGEMENT OF STRADDLING FISH STOCKS AND HIGHLY MIGRA-

TORY FISH STOCKS

Two types of precautionary reference points should be used: conservation, or limit, reference points and management, or target, reference points. Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield. Target reference points are intended to meet management objectives.

. . .

Fishery management strategies shall ensure that the risk of exceeding limit reference points is very low. If a stock falls below a limit reference points or is at risk of falling below such a reference points, conservation and management action should be initiated to facilitate stock recovery. Fishery management strategies shall ensure that target reference points are not exceeded on average.

. . .

When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set. Provisional reference points may be established by analogy to similar and better-known stocks. In such situations, the fishery shall be subject to enhanced monitoring so as to enable revision of provisional reference points as improved information becomes available. 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 the biomass does not fall below a predefined threshold. For overfished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target.

**References**

%T Rio Declaration on Environment and Development %A Anon. %D 1992 %I %P ISBN: http://www.unep.org/Documents.M

%T Code of Conduct for Responsible Fisheries %A FAO %D 1995 %I %P ISBN: 9251038341 http://www.fao.org/docrep/005/

%T Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks %A Anon. %D 1995 %I %P ISBN: http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm

# 2 Reference points

## 2.1 General reference points

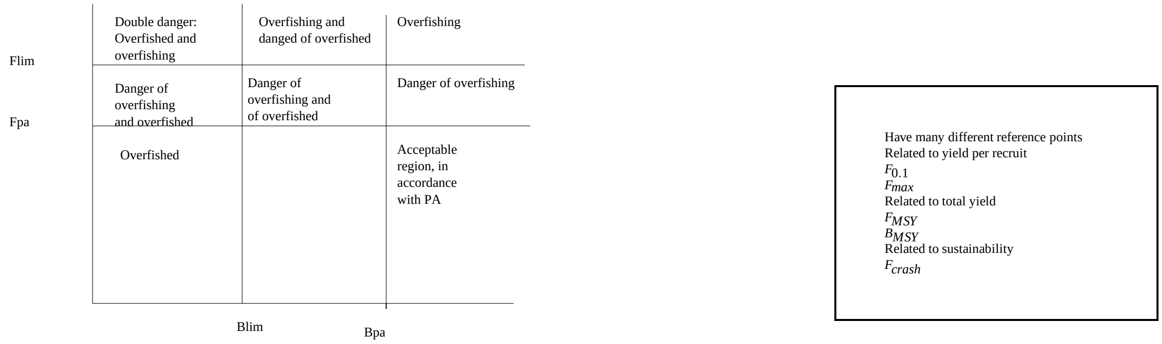



Figure 1: The effect of variable fishing mortality on yield-per-recruit (solid line) and the age composition of catches at low and high fishing mortality (histograms). The y/r-curve only deals with growth overfishing and gives F0.1 etc. It says nothing about sustainability.

Many reference points exist. These are designed to give indications of appropriate fishing mortality or biomass levels, whether target values or values to be avoided.

## 2.2 Production and replacement

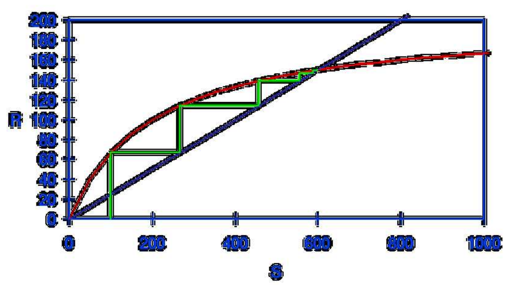



Figure 2: Production and replacement at low fishing mortality.

If a spawning stock starts at $S_0$, some average level of recruitment, $R_0$, will be produced, as determined by the relationship between spawning stock and recruitment. During its lifetime, a cohort of size $R_0$ contributes $S_1 = k * R_0$ to the spawning stock, where the constant $k = (S/R)$ is derived from the spawning stock biomass per recruit computations. $S_1$ then produces recruitment, $R_1$ according to the relationship between spawning stock and recruitment, and so on.

It should be noted that this ignores any time lags do to recruitment taking several years to enter the parent stock.

Higher fishing mortality rates give a lower value for k=(S/R) and thus more recruits are needed to counteract that mortality. A closer look reveals that the slope of the recruitment curve must be at least the same as that of 1/k if the stock is to be able to withstand the corresponding fishing mortality. If it does not, the stock will collapse. It should be mentioned that the term "collapse" is taken to mean an average decrease in the stock which eventually leads to zero individuals. Due to natural fluctuations this process can take a very long time and it is highly unlikely that fishing efforts will be maintained until the last fish has been caught.

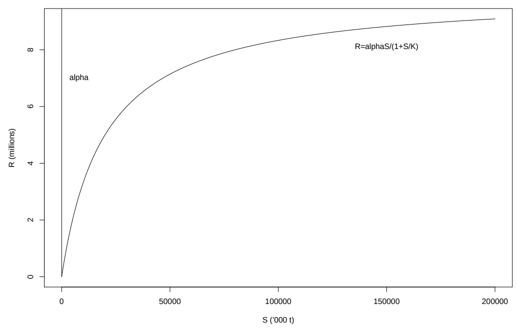
**Example:** The figure shows how a stock which starts at 100 thousand tonnes seeks a certain equilibrium when the spawning stock produces a certain amount of recruits which in turn produce a certain spawning stock.

**Example:** The figure shows the long-term effects of allowing recruitment to return only a spawning biomass which is lower than the spawning stock that produced these recruits.

Figure 3: Production and replacement at high fishing mortality.

## 2.3 Reference point: Fcrash

A simulated stock-

ll 


$F_{crash}$ = Fishing mortality corresponding to stock collapse.

recruitment curve along with the replacement line for Fcrash.

The fishing mortality which corresponds to a stcok collapse is denoted $F_{crash}$ or $F_{ext}$.

**Example:** A simulated stock-recruit curve and biomass-per-recruit curve are used to illustrate the collapse fishing mortality.

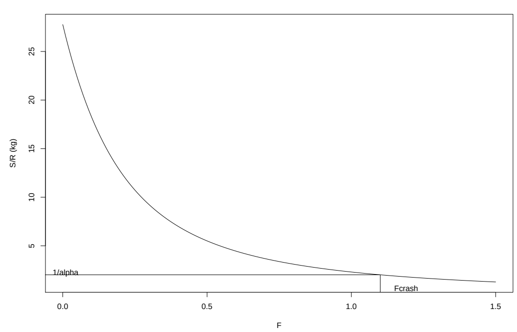



Figure 4: A simulated biomass-per-recruit curve indicating a fishing mortality corresponding to the slope of the S-R curve at the origing.

## 2.4 Limit reference points

$F < F_{crash}$
$B < B_{lim}$
$F_{crash}$ is the collapse fishing mortality - not sustainable.
$B_{lim}$ is a biomass limit reference point - recruitment becomes impaired.

Advisory bodies around the world have designed schemes to implement the Precautionary Approach in their advice. As a minimum requirement sustainability implies $F < F_{crash}$.

## 2.5 Precautionary reference points

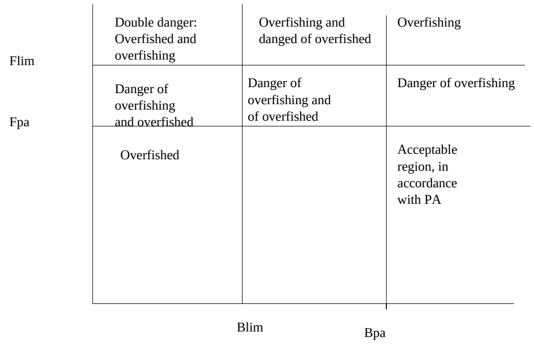



Figure 5: Designing reference points for advice - general

$F_{crash}$ is a typical **limit rerence point**, i.e. one to be avoided. In order to avoid $F_{crash}$, the target F must be designed so that it is on average considerably lower than $F_{crash}$.

This is usually implemented using a **precautionary reference point**, $F_{pa} < F_{crash}$. Annual fishing mortality should then on average not exceed $F_{pa}$.

If fishery management is to adhere to the precautionary approach (PA), each year's management controls must be set so that $F_y \leq F_{pa}$.

Similarly, if advisory bodies are to adhere to the PA, they must work in such a manner that their advice can be shown to be consistent with the principles of the PA. In particular, if management does not adhere to the PA, then an advisory body needs to design its own tools to ensure that the advice is precautionary.

## 2.6 The equilibrium yield curve

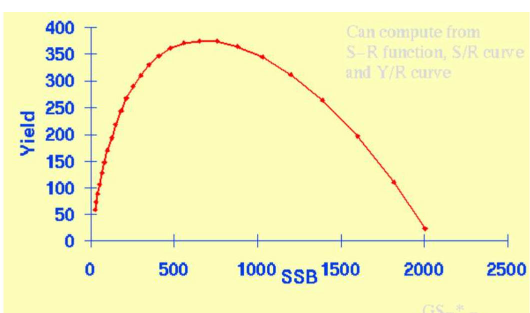



Figure 6: Equilibrium yield for cod in Icelandic waters (from Danielsson et al, 1996)

- Fix $F$
- Compute the yield per recruit ($Y/R$)
- Compute spawning stock biomass per recruit ($S/R$)
- Next compute $S$ using $S/R$ and $\alpha$, $K$
- Finally compute $R$ and then $Y$

Can do this for range of $F$ and plot $Y$ against $F$.
Maximum of this curve: $MSY$.
Corresponding $F$: $F_{MSY}$
Corresponding biomass: $B_{MSY}$

The methodology for yield-recruit computations and stock-recruit functions can be combined as follows.

For a given fishing mortality, compute the yield per recruit ($Y/R$) and spawning stock biomass per recruit ($S/R$). The spawning stock biomass is then computed in accordance for known $S/R$ and the coefficients in the Beverton-Holt curve. Finally, the long-term yield of the resource ($Y$) for this particular fishing mortality can be derived using the yield per recruit along with the number of recruits from the equilibrium spawning stock biomass.

This methodology can now be used to compute the equilibrium yield ($Y$) for a range of fishing mortality rates ($F$) and in this manner one can obtain a plot of equilibrium yield as a function of fishing mortality.

This curve is commonly termed a sustainable yield curve. The maximum of this curve is the maximum yield one can take in a sustainable manner, termed $MSY$.

The biomass corresponding to the maximum sustainable yield is denoted $B_{MSY}$ and the corresponding fishing mortality is $F_{MSY}$.

**Example:** The first figure gives the equilibrium yield curve for cod in Icelandic waters, estimated as a part of a general risk analysis for harvesting the stock.

**Example:** The second figure gives an example of equilibrium yield computations for a simulated stock.

# 3 Reference points in advice

## 3.1 Designing reference points for advice - general

Basic biological reference points:

Mortality-based

- $F_{MSY}$
- $F_{0.1}$
- $F_{max}$
- $F_{med}$
- $F_{crash}$

Biomass-based

- $B_{MSY}$
- $B_0$ and variants

The Rio Declaration, Code of Conduct, agreement on straddling stocks etc all dictate the use of reference points. Advisory bodies around the world have designed schemes to implement the Precautionary Approach in their advice. This is done by carefully selecting reference points and specifying how these can be used in order to maintain sustainable fisheries.

As a minimum requirement sustainability implies $F < F_{crash}$. Some regulations are much more strict.

Several questions arise: Can one specify **target reference points** or should an advisory body only suggest **limit reference points**?

## 3.2 Precautionary reference points

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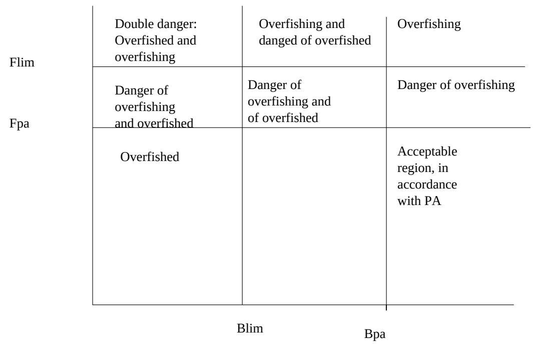


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Similarly, if advisory bodies are to adhere to the PA, they must work in such a manner that their advice can be shown to be consistent with the principles of the PA. In particular, if management does not adhere to the PA, then an advisory body needs to design its own tools to ensure that the advice is precautionary.

### 3.3 Choices of Fpa, Flim, Ftarget etc

Management choose $F_{target}$!
What if they do not?
What if management does not choose $F_{pa}$?
Advice needs to be in accordance with the PA!

It is of course up to management to choose a target fishing mortality ($F_{target}$) or a similar measure. If, however, management bodies do not do so, nor choose any precautionary values, then those providing advice have a dilemma in that the advice needs to be in accordance with the PA.

Thus it becomes incumbent on the advisory bodies to set forth PA values if management does not do so.

## 4 Harvest control rules

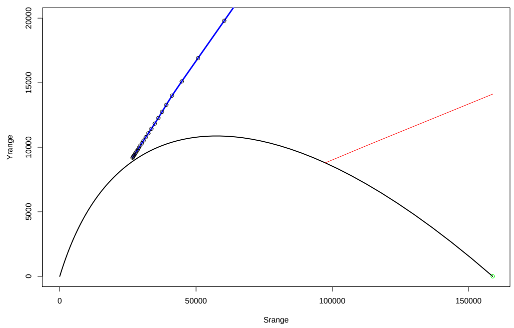
### 4.1 Target assumptions - harvest control rule

For medium-term need to assume some target, e.g.
$F = F_{0.1}$
$F = F_{max}$
or other harvest control rule

Medium-term prediction methods can be used to make projections regarding catch and stock development given assumptions on fishing mortality or methods of deciding harvests. It is, for example, easy to project the stock and catch based on $F_{0.1}$ , $F_{\max}$ etc.

The effects of a rule which specifies a catch quota are slightly more difficult to compute, since this requires the estimation of a fishing mortality rate corresponding to the catch quota.

## 4.2 Linking assessments and all projections




The medium-term projection is a natural extension of the short-term projection.

The equilibrium yield and biomass computations correspond to an infinite-horizon continuation of the medium-term projection.

It is often useful to include the following on a single plot with SSB on the x-axis and yield on the y-axis:

- the current level of biomass and yield
- the equilibrium biomass-yield curve
- the projection from the current point through the projections towards the equilibrium
- the historical trend of (S,Y)-pairs

## 4.3 Harvest control rules=management strategies

| | |
|---|---|
| CCL | Catch control law: Formula describing catch (quota) |
| HCR | Harvest control rule=Management strategy: CCL with other measures |
| MSE | Management strategy evaluation=Risk analysis of HCR=Medium term prediction of HCR |

A management strategy is a long-term policy of how to utilise a resource. The terminology harvest control rule is also used.

The important notion here is the MSE: Management Strategy Evaluation.

This is another phrase describing a (comprehensive) medium-term prediction, or risk analysis, undertaken to evaluate the effects of a management strategy.

# 5 Case studies

## 5.1 A case study on harvests, cod in Icelandic waters

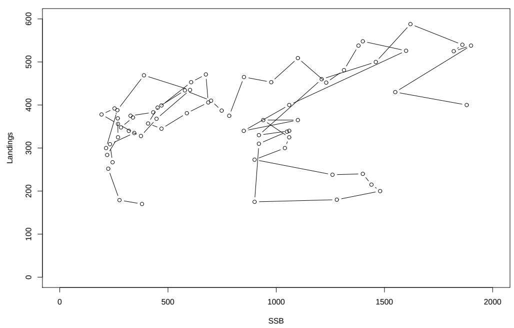



Figure 8: Landings and SSB of cod in Icelandic waters, from 1928 onwards.

Adoption of an HCR needs extensive evaluation.

A number of points are obvious based on catch and stock history.

A formal harvest control rule was adopted for cod in Icelandic waters in 1995. This was preceded by extensive simulation testing of the likely performance of a range of harvest control rules.

Simple plots of the main pieces of information make it clear without much modelling that there are limits on how much a stock can sustain. For this cod stock, for example, assessments have been made going back to 1928 and these indicate that for most of the 20th century the stock has been in decline. This immediately sets some upper bounds on any fixed catch rule and on any harvest fractions.

## 5.2 The history of the fishery

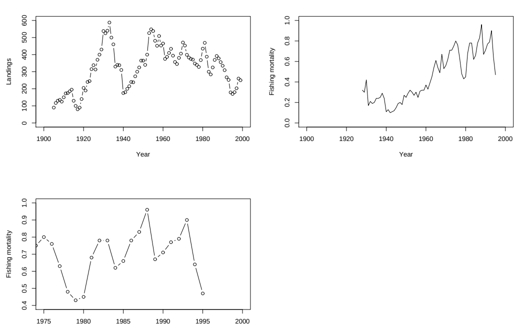



Figure 9: Fishing mortality of cod in Icelandic waters, from 1928 onwards.

The fishery was mostly increasing (in terms of effort) for most of the 20th century. Exceptions to this were the second world war, the extension of the fishery jurisdiction to 200 miles and the first adoption of a formal harvest control rule in 1994-5. Although the adoption of a quota system in 1984 may have done a little to reduce fishing mortality it did in fact not seem to be a real limit on fishing as the years went by.

## 5.3 Assessments at ICES

In 1992 ICES was asked to provide advice on the cod stock in Icelandic waters. Considerable work was undertaken to prepare data, conduct analyses etc.
ICES recommended a 40% reduction in fishing mortality.
The advice was adopted.
Analyses included estimation of reductions which guaranteed with over 90% probability that fishing effort would not need to be cut further (i.e. that the stock would come back up).

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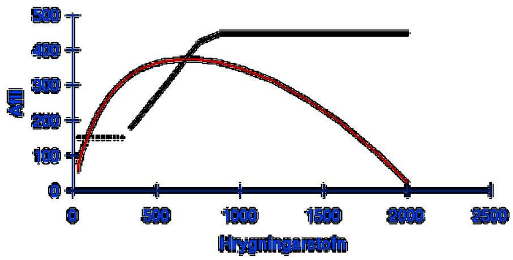
## 5.4 Harvest control rule and equilibrium catch




In 1993 a working group was established to investigate the possibility of adopting a formal harvest strategy for cod in Icelandic waters. The working group included biologists, economists and representatives from the fishing industry.

The group evaluated the biological and economic consequences of different strategies, took into account prejudices, and all known biological details.

A harvest control rule could be based on a fraction of biomass or on a number of other biological measurements.

Harvest control rules based on biomass were the main contenders in the Icelandic situation. The main reason for this is the simplicity involved and the ease with which these can be explained.

These HCRs can be plotted along with the equilibrium yield curve to indicate the long-term effects of implementing the HCR.

**Example:** The harvest control rule adopted for cod in Icelandic waters was in principle to catch 25% of the biomass each year.

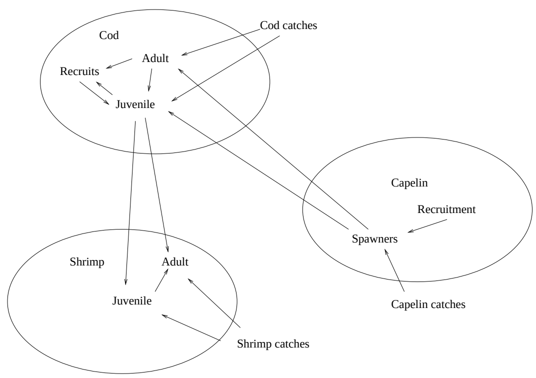
Specifically, this was to be computed as 25% of the biomass of 4 year old cod or older, but taken as an average of estimates in adjacent years. Initially it was suggested that this should be an average of the current year or the previous, but later on, during the implementation phase this was changed to 25% of the average of the current year and the projection one year into the future.

As it turned out, this simple change had drastic consequences. The reason for this is related to VPA convergence, since the projection is much more uncertain than the current year's estimate. During the first 10 years of using the HCR, the estimation error (measured as a retrospective pattern) was up to 60% for this projected average.

A politically important issue at the time was that catches should not be reduced below some minimal level. This corresponds to a minimum in the HCR, indicated with the lower horizontal line.

From a theoretical viewpoint it may be important not to allow catches to exceed a certain level and this is implied with the upper horizontal line.

## 5.5 Multispecies concerns




MSEs is a never-ending story. Having tested single-species assumptions, questions come up regarding food supply if the stock recovers, predation effects on other species etc.

A multispecies model was therefore set up.