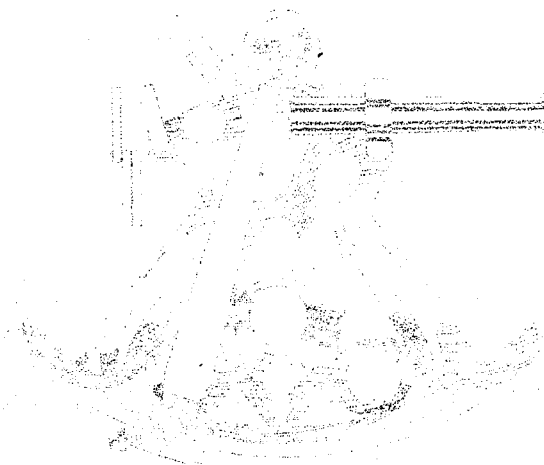


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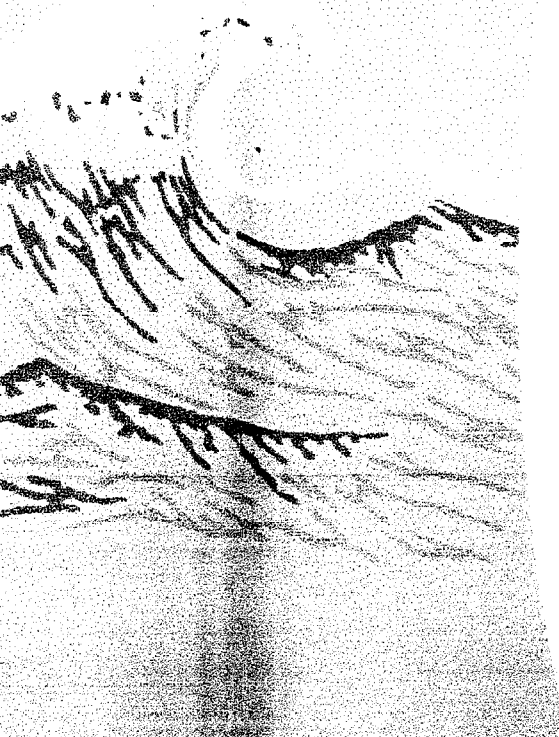
COUNCIL



**CONSIDERATIONS ON
RE-OPENING A CLOSED
FISHERY**

**A FRCC DISCUSSION PAPER
Prepared by the
Stock Assessment
Subcommittee
FRCC95.TD.1**

July 1995



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28 July, 1995

Dear Groundfish Stakeholder:

The mandate of the Fisheries Resource Conservation Council is the conservation of fishery resources. This requires the rebuilding of stocks to optimum levels and maintaining them at or near such levels. When the Council began its work, many groundfish stocks were seriously depleted and the fisheries that exploited them had to be closed. As some stocks show signs of recovery, as is believed by fishermen to be the case in area 4T, pressure mounts for fisheries to begin again. How to deal with this situation is a major challenge. The Council's response is to propose criteria and a process that can be used to help determine when a fishery should re-open.

The past two and one half years have been extremely difficult for the Atlantic groundfish industry and decisions taken on fishery closures were based on a prudent approach, intending to "err on the side of caution." The resulting hardship cannot be overstated and the Council, often identified as the bearer of bad news, knows full well how difficult the decisions were. We all want to see a rapid return to healthy fisheries but we are not willing to consider shortcuts or to recommend openings prematurely.

Over the past eight months the FRCC has given very careful consideration to the preparation of the document before you. It now requires a thorough analysis and comprehensive comment from stakeholders. This is a beginning - but a beginning that will hopefully set the course for sustainable fishing at optimum levels for generations to come.

In judging the ability of a fish stock to sustain a re-opened fishery it is necessary to look at various stock status indicators: primary biological - such as total and spawning biomass, recruitment and age structure; secondary biological - such as geographical distribution, fish condition and weight at age; environmental and ecological conditions - such as physical and biological environment and habitat; and finally, trends. These are addressed in detail in the paper. Also, examples are provided on how the indicators can be applied to a fishery and I urge you to read them carefully.

.../2

As you study this document you should consider what indicators are most appropriate for the stocks in your area; Are there other indicators that should be considered? What are your views on the thresholds for those indicators?

Ultimately we will revise the document based on the input received and produce a set of criteria and a process which the FRCC will use over the next number of years in preparing our advice to the Minister of Fisheries and Oceans on the various closed stocks.

The Council is grateful for the work provided by its Stock Assessment Subcommittee, the advice of DFO scientists and the views expressed by stakeholders during our many consultations on groundfish stocks. It is now time to go to the next step and prepare for when closed fisheries can be re-opened. How we do this will be extremely important as the basis for optimal and sustained fisheries in the future.

We invite you to study this discussion paper and give us your views.

Yours sincerely,

A handwritten signature in black ink, appearing to read "H.M. Clarke". The signature is written in a cursive, slightly slanted style.

H.M. Clarke
Chairman

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1. INTRODUCTION

In 1993, following a sharp decline in groundfish catches, scientific assessments showed that many stocks had fallen to unprecedented low levels. This was indicated by low spawning-stock biomass, declining weight-at-age, reduced geographical distribution, and no evidence of strong new year classes. As a first step towards conserving what remained of the stocks, the Fisheries Resource Conservation Council (FRCC) recommended closure of directed fisheries in a number of areas. The hope was that, over a period of time, these closures would allow rebuilding of the depleted fish populations.

When fisheries are closed, it is important to continue to assess their status regularly in order to determine when stocks have recovered. A decision to re-open a fishery must be based on reliable information about the status of fish stocks and their ability to support sustainable fisheries. The decision to re-open a fishery must also include discussions with stakeholders and the interested public. Their participation in the process is critical.

The purpose of this paper is to stimulate discussion on some of the issues involved in re-opening a fishery.

2. BACKGROUND

The Fisheries Resource Conservation Council (FRCC), which advises the Minister of Fisheries and Oceans on the conservation of Atlantic fisheries resources, has been considering the question of how to re-open a closed fishery for some time. Its Stock Assessment Subcommittee was asked to lead this discussion, which began within the Council itself. Members of the Stock

Assessment Sub-Committee then met with scientists from the Department of Fisheries and Oceans to hear their views on biological criteria for stock status, as well as other issues involved in re-opening a fishery.

A short paper (FRCC.94.TDI), outlining some preliminary thoughts on the issue of re-opening fisheries, was circulated during the Council's September 1994 public consultation meetings. This paper expands on the issues raised in the earlier one.

It is our goal to stimulate stakeholder and public involvement in discussions on re-opening fisheries. We invite feed-back on all the issues in this paper, as well as suggestions on how to progress most effectively. Specific points for discussion, on which the FRCC would like stakeholder input, are suggested at the end of the paper.

A point to make at the outset is that this discussion is framed within the general conservation objectives that relate to the FRCC's mandate. These are:

"(1) to rebuild stocks to their 'optimum' levels and maintain them at or near these levels (subject to natural fluctuations), with 'sufficient' spawning biomass to allow continuing strong production of young fish;

(2) to manage the pattern of fishing over the size and ages present in fish stocks, catching fish of optimal size."

In particular, we are concerned here with developing methods for re-opening a fishery, perhaps at an initially low level of exploitation, so that stock recovery may continue during fishing.

The FRCC's mandate is conservation of fishery resources which support sustainable fisheries. Setting social and economic objectives for the fishery, or deciding on catch allocations and sharing rules is the responsibility of the Department of Fisheries and Oceans, in concert with industry.

As we proceed through the paper, we will indicate clearly where the FRCC has a role to play in re-opening fisheries and where decisions are to be taken by others, such as industry, other stakeholders, the Minister of Fisheries and Oceans and DFO staff. The reader is also referred to the accompanying flow chart (Figure 1) which illustrates the steps to be taken in re-opening fisheries, and who takes them.

Re-opening fisheries involves a number of steps requiring consideration of: the nature of biological indicators of stock status; the criteria for re-opening; target values for stock indicators; the actual method of starting to fish again; and the objectives of the fishery. Each one of these steps is discussed below, beginning with a review of possible stock status indicators in the following section.

3. STOCK STATUS INDICATORS

What biological factors are most important in assessing the status of a fish population? Which of these factors must be considered to determine if a stock is so depleted that a fishery must remain closed, or "healthy" enough to withstand harvesting? These questions are clearly within the FRCC's mandate and will be explored in this paper.

To answer them, the appropriate indicators of the status of the fish stocks must be identified and the most important ones defined for each particular stock of concern.

Biological indicators include properties of individual fish, as well as characteristics of the whole population.

For example, "condition" is a numerical index which describes the health of individual fish (Figure 2). The status of the population as a whole is described by properties such as its total biomass, its spawning biomass, its age structure, recruitment and aspects of its geographical distribution.

Factors external to the fish population, such as fleet size and technical capacity, environmental conditions, or the abundance of food or predators, may also have to be taken into account when making re-opening decisions.

Some biological indicators, such as total biomass, are important in determining the status of almost any fish stock. The relative importance of other biological indicators or environmental factors may be different for different stocks. **Some basic understanding of which indicators contribute to the status of the stocks, as well as their inter-relation, based on science and traditional knowledge, is thus an essential first step towards appropriate conservation measures and a sustainable fishery.**

Before determining precisely what criteria are required for re-opening, a set of biological, and other, "indicators" must be agreed upon by those involved in the fishery. As noted above, these must be based on the key indicators of fish populations, as well as on the ecosystem and environmental features which affect it. The types of indicators most useful in establishing biological criteria and stock status will vary from stock to stock.

A. Primary Biological Indicators

The first kind of biological indicators are those which refer to the abundance and the age structure of the population. They are determined from data obtained by scientific surveys, catch estimates, sentinel fisheries or traditional knowledge. Primary biological indicators are of utmost importance in establishing biological criteria and determining the status of the stock and its surplus production.

Total Biomass: The total biomass is a measure of the total size of the population. It is the total weight of the population; it is composed of juveniles, the smallest of which (pre-recruits) are too small to catch and have not yet been recruited to the fishery; slightly older fish (recruits) which are large enough to be caught; and adult spawners. The total biomass of the population depends on the total number of fish, as well as on the age (and weight) structure of the population. In most cases, a greater harvest can be taken from a population with a large total biomass than one with a smaller total biomass, all other factors being the same.

Spawning Biomass: Spawning biomass is the biological "capital" of the total population which will produce "interest" in future individuals. It is that segment of a fish population that reproduces. There is no simple relationship between spawning biomass and recruitment, but the probability of large recruitment is higher when the spawning biomass is larger. On the contrary, a very small spawning biomass is unlikely to ensure future large recruitment. For a sustainable fishery, the spawning biomass should not fall below a certain threshold.

Recruitment: Recruitment refers to the entry of new individuals into the fishery. It is the number of fish reaching commercial size,

which can legally be caught when the fishery is open. Recruitment depends to some degree on the size of the spawning biomass; a very small spawning biomass is less likely to produce large recruitment than a larger spawning biomass. However, other factors affect the successful survival of eggs, larvae and juvenile fish, such as environmental conditions and the presence of food and predators.

Age Structure: This is an important factor in assessing the reproductive potential of the stock because: i- older individuals produce more eggs; ii- the presence of a range of age classes may prevent wide fluctuations in recruitment; iii- in some species, a broad age-structure, with several year classes, may be necessary to provide a stable level of both catches and egg production.

B. Secondary Biological Characteristics

A second class of biological characteristics of a fish stock consists of properties which may be quantitatively measured, either through scientific surveys, catches, or fishers' observations, but which are more difficult to interpret as indicators of the status of the stock, or as biological criteria for decision making.

Geographical Distribution: Changes in the geographical distribution of the population can be important. It would be risky to exploit a stock reduced to occupying only a small fraction of its original range. That would be especially true if it turned out that the remaining population consisted of isolated, vulnerable sub-stocks. The number of sub-stocks in a population is referred to as the "richness" of a population. Local abundance from sub-stocks may function as seed-stock to repopulate depleted areas. Re-opening should await confirmation of a sufficiently broad geographic distribution of a stock, so as to

Considerations on Re-Opening a Closed Fishery

avoid depleting concentrated sub-stocks. The definition of a sufficient geographical distribution will likely be the subject of extensive discussion.

Fish Condition: The condition of individual fish may indicate the physiological strength or weakness of the population, which may be important to reproductive capacity, vulnerability to fishing, or yield of a fishery. This is illustrated in Figure 2. There is natural variability in physiological indices resulting from environmental factors and with the life and reproductive cycle of the animals. Consequently, the overall influence of fish condition on stock status is difficult to interpret.

Weight at Age: The weight which is reached by a certain age can be used as an indicator of fish growth. This indicator has the advantage of being easy to measure.

C. Environmental and Ecological Conditions

A third set of characteristics of stocks refers to their environmental and ecological situation. This might include water temperatures, oxygen levels, the presence of food resources, the effect of predators. It is difficult to interpret their impacts on stocks quantitatively. However, because such conditions are generally perceived as important to stocks, they should be kept in mind when considering re-opening options. As knowledge of the ecology of the stocks improves, it may become possible to better quantify the influence of these indicators.

The Physical Environment: The physical environment of a fish stock may be of crucial importance. Much has been said about possible impacts of low temperatures and salinity variations on recruitment in the cod fishery. Links between biological characteristics, such as egg and juvenile

survival, recruitment, natural mortality, condition factor and environmental variables are as yet unclear.

The Biological Environment: Similarly, predator-prey relationships, including the fishery itself, may be viewed as obvious by some (e.g. seals eat cod; cod and seals eat capelin), but may hide unexpected complexities and remain to be quantified with reliability (for example, seals eat cod and hake, but hake also eats cod and thus more seals may mean less hake and thus more cod). This is an important area for continuing research. It is not clear how relative abundances of prey and predators should enter into the definition of biological decision-making criteria.

Habitat: Habitat factors are also important. Disturbances or degradation of habitat which supports fish populations can greatly affect those populations and, hence, the sustainability of fisheries. Habitat deterioration may also have more impact on a weak, recovering stock than on a healthy population. Assessing habitat factors would involve determining the extent of knowledge of spawning and nursery areas and whether such areas should be protected.

D. Trends

In predicting the future state of a fishery, trends in the stock status indicators may be as important as knowledge of current values (for example, whether biomass has been increasing or decreasing in recent years). There is a need to improve the interpretation of the significance of trends, especially in the presence of large inter-annual variability.

4. RE-OPENING CRITERIA

Several steps are involved in the re-opening of a fishery:

- a. First, the most important indicators of stock status must be chosen from the above list.
- b. Second, for each of the indicators chosen, a specific level (threshold) must be decided upon at which point some amount of fishing can be permitted; for example, when the stock recovers to a certain total biomass, or age structure, and so forth. 'Optimum' or long-term target values for indicators levels should also be agreed upon.
- c. Third, if some level of fishing can be permitted, what should that level of exploitation be? For example, how many fish can be caught while ensuring continuing recovery toward some sustainable level of exploitation?

Both scientific expertise and public consultation will contribute to answering these questions for each stock. To facilitate this discussion, examples for specific stocks have been developed and are presented later in this document. These examples will also be discussed in public consultations.

Many indicators may contribute to the definition of the overall stock status thresholds. As in school, where a student must pass all courses to graduate, it may be decided that the threshold is reached only if all indicators have reached a sufficient level. On the other hand, some indicators may be much more important than others, so that in other cases the status threshold may be reached if only a few indicators are sufficiently high.

For each stock, a set of re-opening rules will have to be arrived at to establish a safe threshold to re-open the fishery.

Once the threshold has been reached, fishing can begin — but only at a low level at first, to avoid over-harvesting the stock. Re-opening the fishery will be a gradual process, not just a matter of starting-up the fishery "like it was". On the other hand, it makes no sense to re-open a fishery to catch only a few kilograms of fish; the threshold will have to be defined so that a minimum, but viable level of harvesting can take place.

Re-opened fisheries will go through an initial developmental phase. If all goes well, as the stock continues to recover toward target indicator values, a higher level of exploitation may be appropriate. Throughout the process of development phase and increasing exploitation rates, managers must carefully develop a fishing plan for this, based on conservation advice.

If it should happen at some future time that the indicators show that the stock is again seriously declining, a decision may have to be made to close the fishery, following perhaps a different set of criteria. The decision to re-open a fishery would be made only if stock status was clearly better than when the fishery was closed.

Furthermore, given the natural variability of the environment and of fish populations, it will also be wise to study how stock characteristics might behave in future years under a variety of conservation options and environmental variability. One way to compare conservation options is to calculate, for a variety of situations, the likelihood of unfavourable events. For example, how likely is it that, because of adverse environmental conditions or because of uncertainties in

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assessment, the stock should fall below acceptable threshold levels and the fishery should have to be closed again.

Threshold levels for re-opening fisheries must be designed so as to avoid another crash of the stock! The FRCC may thus request that detailed calculations of the consequences of suggested conservation options be performed by DFO scientists.

The essential objectives of any fishery are conservation and sustainability. These are central to the FRCC's mandate. Additional objectives are socio-economic, aiming at such goals as maximum employment, maximum return on investment, or highest long-term yields, for example. These objectives are determined by the industry and are not part of the FRCC's mandate. However, such objectives, once selected, will have consequences on the exploited stocks and on the manner of fishing. The objectives of the fishery will thus partially determine the range of available conservation options.

Once relevant indicators have been identified and levels set to arrive at a decision to re-open, acceptable and enforceable rules to conduct the fishery must be developed so that it can proceed within its conservation objectives. The selection of such management rules is not part of the FRCC's mandate, although its advice may be sought regarding conservation implications of fishing and management methods.

5. A SIMPLE EXAMPLE OF RE-OPENING CRITERIA

It was noted above that discussion about re-opening must be based on: (1) a set of criteria which determine when a stock status is adequate to re-open a fishery, and (2)

decisions on harvesting levels, accompanied by a fishing plan. Here we focus on how these might be used in practice.

Clearly, the recovery of a fish stock requires net growth of the population, which in turn requires a sufficient number of spawners (measured by the Spawning Stock Biomass), and survival of enough young fish to a size at which they can be fished (the Recruitment). We thus take as primary, or essential, biological indicators the spawning biomass and an index of recent recruitment. We also consider, as a secondary indicator, an index of fish health: the weight at a given age.

The two stocks to which we will apply these criteria are the southern Gulf of St. Lawrence cod stock (4TVn) and the eastern Scotia Shelf cod stock (4VsW). For these two stocks, the above indicators are defined more precisely as follows:

- a. **Spawning stock biomass:** the total weight of all fish of age 5 years and older for 4TVn cod, and 6 years and older for 4VsW cod.
- b. **An indicator of recent recruitment** is calculated as the average number of fish in the year classes that would normally contribute to the fishery. In the specific examples discussed here, an index of the year-class abundance is obtained at age 3 for 4TVn cod and at age 1 for 4VsW cod. In each case, the indicator of recent recruitment was obtained by averaging the index for three consecutive years, so as to obtain a measure of the year-classes that would normally contribute to the fishery in a given year.

- c. A rough fish health index may be taken as the **average weight of fish at age 7**, as measured in research surveys.

Let us consider **4TVn cod first**. For reference, the values taken by the three indicators over a historical period of 35 years are plotted in Figure 3. The first two indicators are derived from the results of a population analysis using information from the commercial fishery and indicators of abundance. In the absence of catch data, when the fishery is closed, information would have to come solely from scientific surveys, or sentinel fisheries. Indicator values based on scientific surveys since 1978 are shown in Figure 4. In both figures, the level of the indicators at the time (1993) that the fishery was closed is shown by a dotted line; the level selected as a re-opening criterion is shown as a solid line.

As criteria for re-opening, we have selected as an example (this is one of the crucial points where scientific advice and public consultation are necessary) the following conditions:

- a. the spawning biomass must have increased significantly from the level it had at the time the fishery was closed (the dotted line in the upper panel of Figures 3 and 4). The target level selected here is half-way between the level at closing and the average level over the historical period. This target level is shown as a solid line in Figures 3 and 4. While some might argue that this level is too low for re-opening and others might feel it is too high, remember that this is just an example, designed to focus discussion on these very questions!

- b. average recent recruitment, as defined above, must **also** have recovered from its value when the fishery was closed, again to a level half-way to the historical average (see middle panel in Figures 3 and 4).

In this example, the above two criteria must **both** be satisfied before a re-opening decision is considered. The third criterion is used for additional guidance.

- c. fish growth, as characterized by weight at age 7, should be above some historical level. The appropriate graph is the lower panel in Figures 3 and 4.

Projections of future levels of spawning biomass and recruitment are shown as open squares in the upper panels of Figure 3. These projections are based on today's assessment of the population and are subject to considerable uncertainty. Nevertheless, they provide a basis for discussion on what to expect.

In this example, there is an indication of future increase of spawning biomass towards the threshold level. However, projected recruitment keeps falling away from the selected threshold. Because we have decided that both indicators must reach assigned threshold levels, the decision must be not to re-open at this time. Remember however that this is only an example for the sake of discussion!

The second example is for the 4VsW cod stock. The same indicators are used and the information is presented in the same graphical form in Figures 5 and 6. Again, the choice of indicators and re-opening criteria would lead to a decision not to re-open at this time.

Considerations on Re-Opening a Closed Fishery

Another stock for which discussion of re-opening criteria is highly topical is southern Newfoundland, 3Ps cod. One would like to be able to define solid criteria, similar to those given in the above examples. However, there are serious difficulties in selecting appropriate biological indicators and defining threshold levels in this fishery. In the past, surveys have been conducted by Canada and France in this area. Each one of these surveys showed great variability (see for example Fig. 7); between the two of them and commercial catch data, it was possible to arrive at an assessment of the stock status. Currently, however, there remains only the Canadian research surveys. Fisheries scientists cannot identify reliable indicators. This is a clear instance of the need for a broad dialogue leading to a new approach in the assessment of this stock, to be initiated through the forthcoming consultations.

When all conditions or criteria are met, the level of the fishery will depend upon prospects for continuing stock rebuilding. To determine the level of fishing, expected recruitment and projected natural mortality (including by predation) will be assessed in relation to its ability to allow continuing stock growth. Any fishing will certainly be at a level below $F_{0.1}$ during the initial stages. Deliberations on re-opening will also have to keep in mind the need for some practical fishing level.

6. CONCLUSIONS

This paper has proposed a process for developing re-opening criteria and for using these criteria in decision-making; its main purpose is to stimulate discussion on all the issues associated with the re-opening process. Many questions arise within the re-opening discussion; for example:

- a. Which indicators are the most important? The most reliable? Which indicators are easiest to apply?
- b. How will it be possible to have enough information about indicators in a closed fishery? For which indicators do we have the best current information?
- c. How will scientific and traditional (fishers') knowledge be blended in assessing indicator levels? How will we incorporate findings of sentinel fisheries in the process?
- d. Must all indicator levels be above a certain value to reach a stock status threshold or could there be some trade-off between them?
- e. How will thresholds be determined? Should they be historical levels, or a fraction thereof, or a recent average which reflects current environmental conditions?
- f. Should one strive for the most conservative decision rules or for those that are the simplest to apply and enforce?
- g. When will stock status be good enough to completely open the fishery?
- h. Are there conditions under which the proposed framework might not lead to practical rules?
- i. How can harvester and other industry groups be most effective in participating in this process?

These are only a few of the possible questions which must be considered for each stock.

To conclude, we remind all readers that this discussion paper is presented as an invitation to join the debate about re-opening fisheries. The FRCC is committed to its general conservation objectives of rebuilding the stocks and maintaining them at high sustainable levels. The FRCC is also committed to the idea that the process of re-opening a sustainable fishery must involve extensive consultation and a partnership between all interested parties.

APPENDICES

Considerations on Re-Opening a Closed Fishery

FIGURE 1: A flow chart of the decision process in re-opening a closed fishery

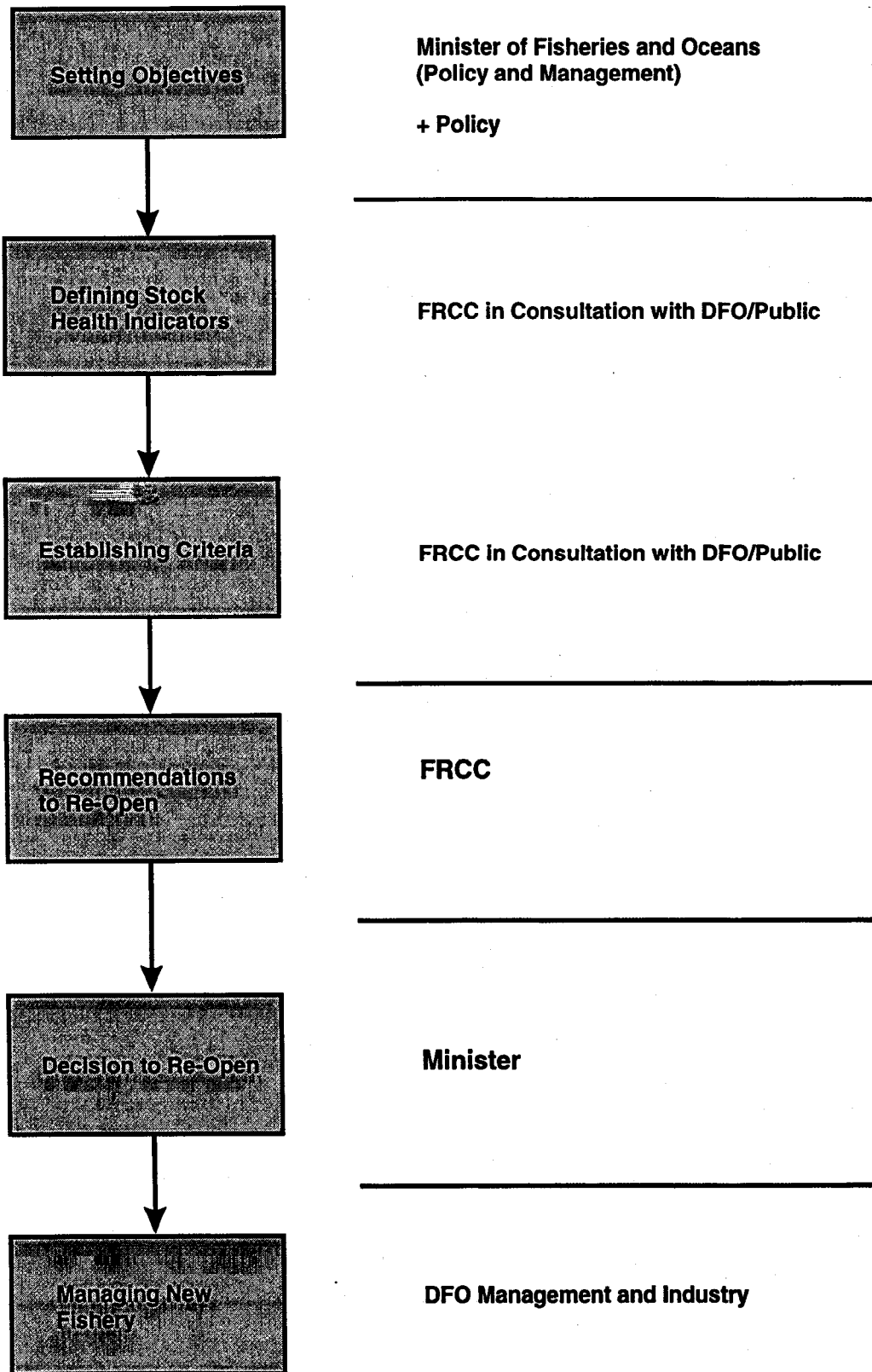
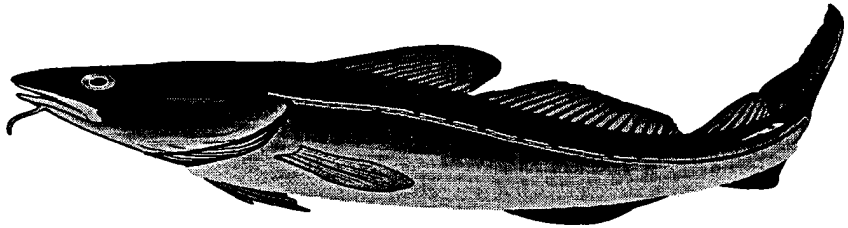
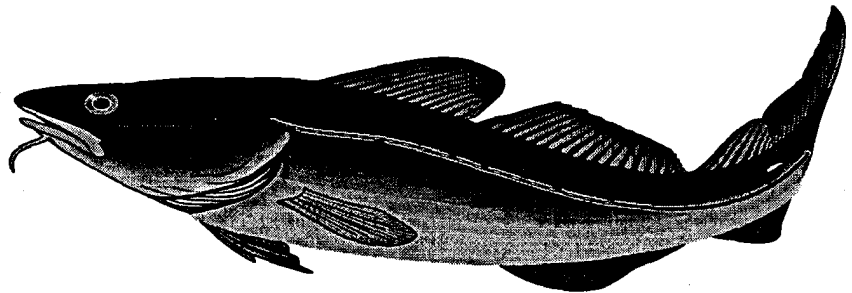


FIGURE 2: Individual fish condition: a measure of fish weight compared to their length.

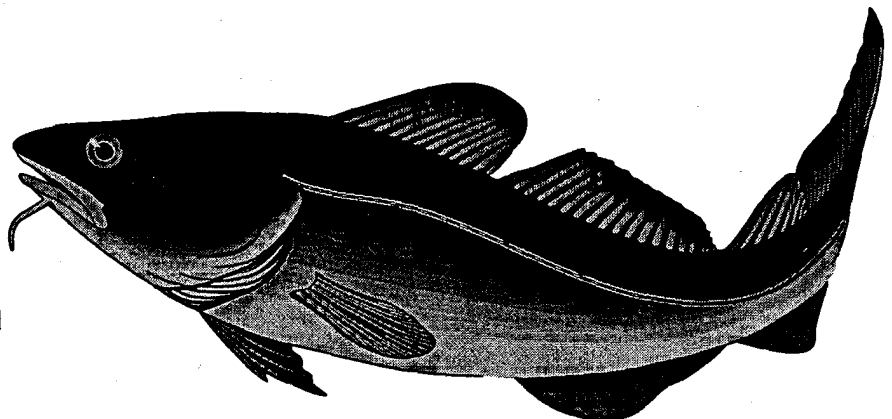
Poor Condition



Good Condition



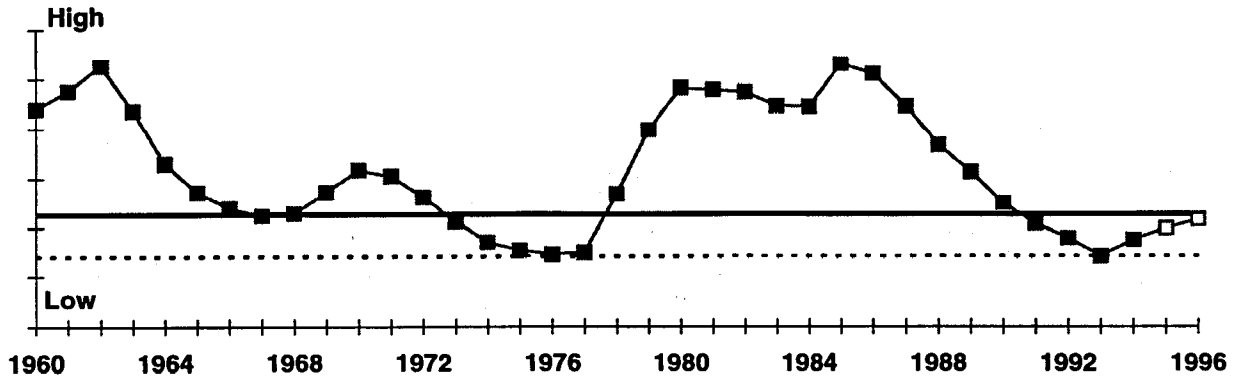
Excellent Condition



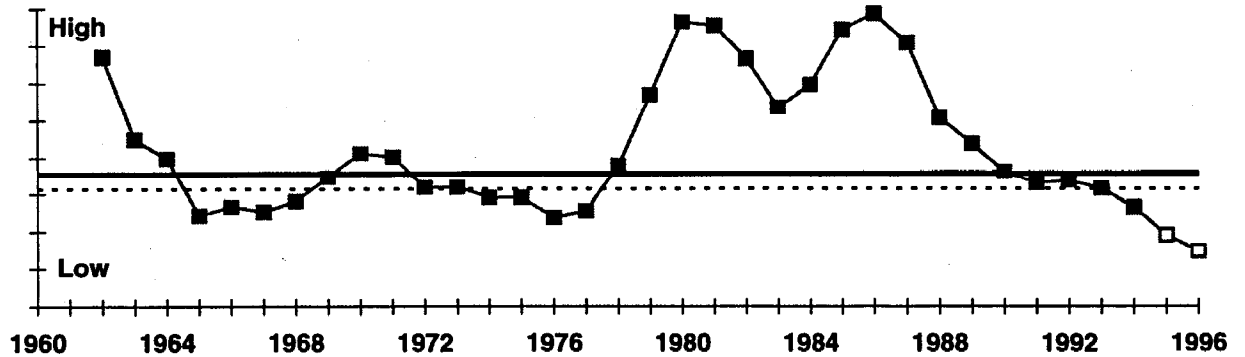
Considerations on Re-Opening a Closed Fishery

FIGURE 3: Sample criteria for re-opening of a 4TVn cod fishery based on information from age-structured analysis from catch data; at the top, spawning biomass, middle, recruitment; bottom, fish growth. In all plots, the dotted line is the level at closing the fishery, the solid line is the target for re-opening.

Spawning Biomass (SSB)



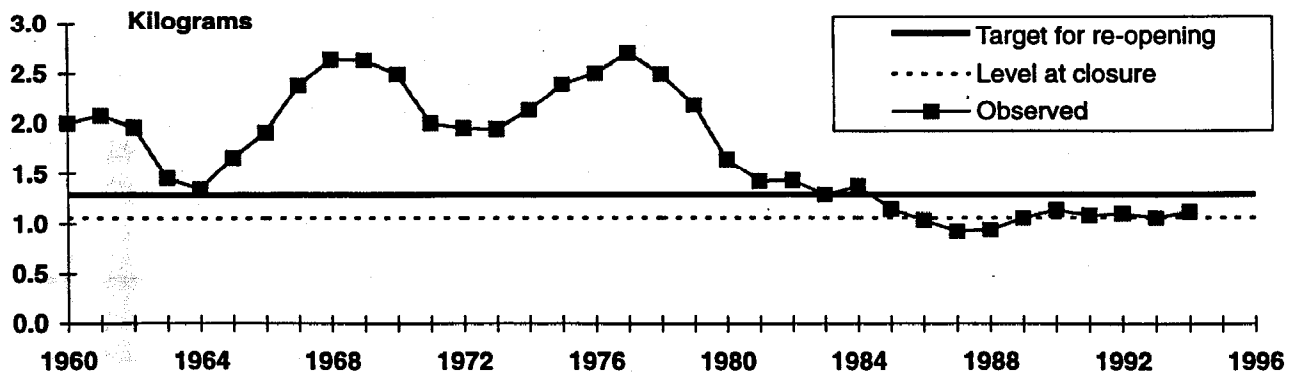
Recruitment Criteria



Essential (above)

Desirable (below)

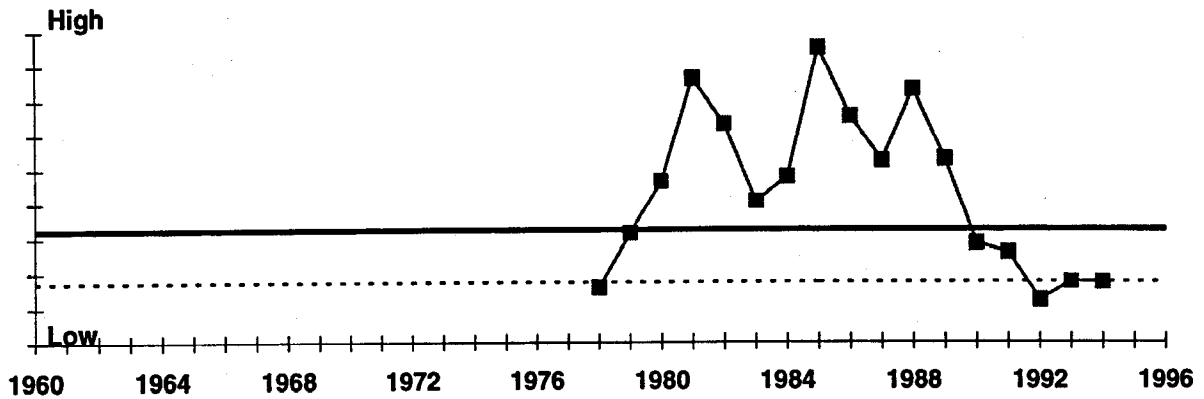
Fish Growth (weight at age 7)



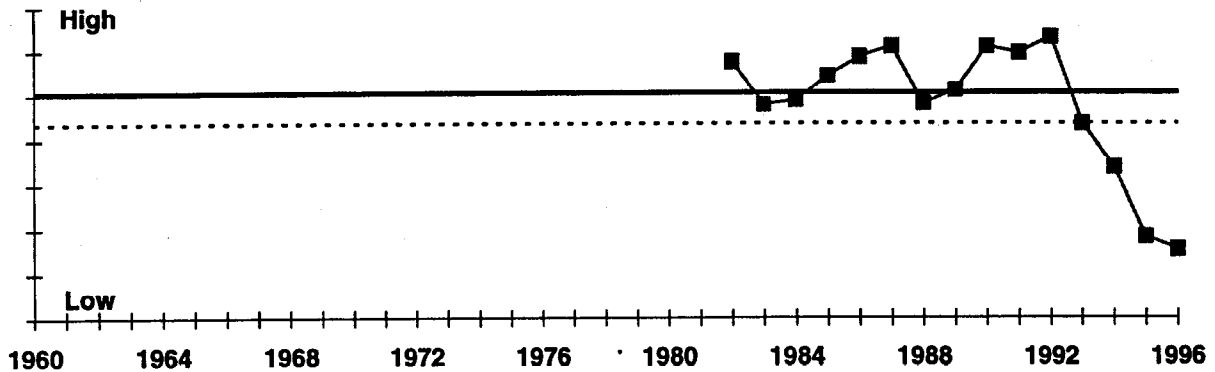
(from age-structured analysis; data provided by DFO-Science)

FIGURE 4: As in Figure 3, but using, in the top two panels, information from scientific surveys.

Abundance of spawners (measured by survey)

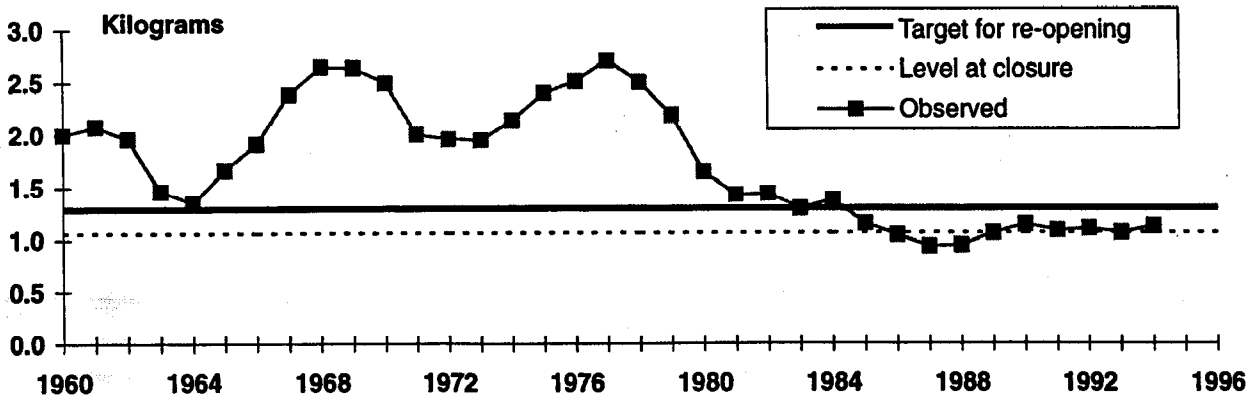


Recruitment Criteria (from ages 2 and 3 in survey)



Essential (above)
Desirable (below)

Fish Growth (weight at age 7)

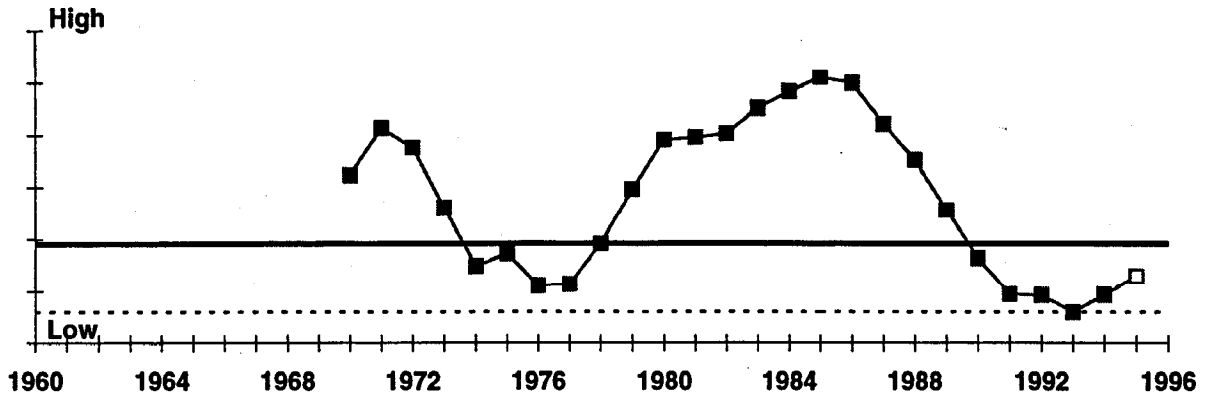


(from survey indices; data provided by DFO-Science)

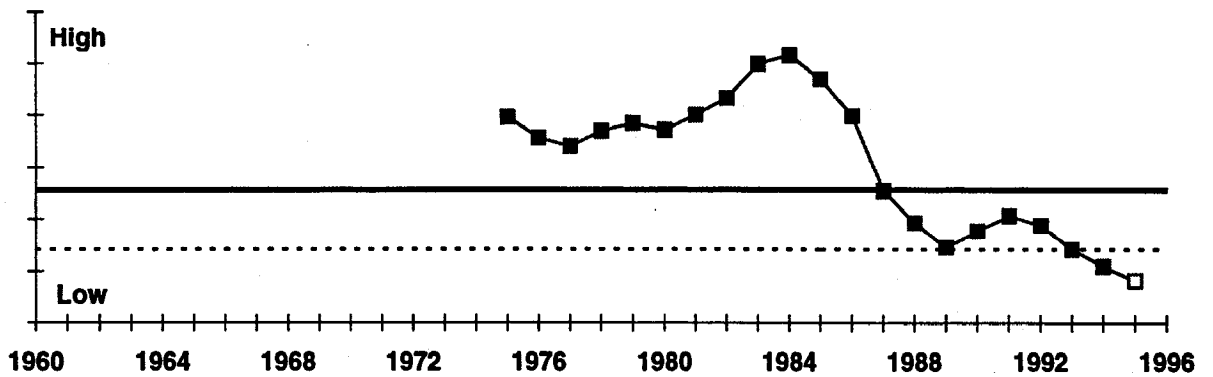
Considerations on Re-Opening a Closed Fishery

FIGURE 5: As in Figure. 3, but for 4VsW cod.

Spawning Biomass (SSB)



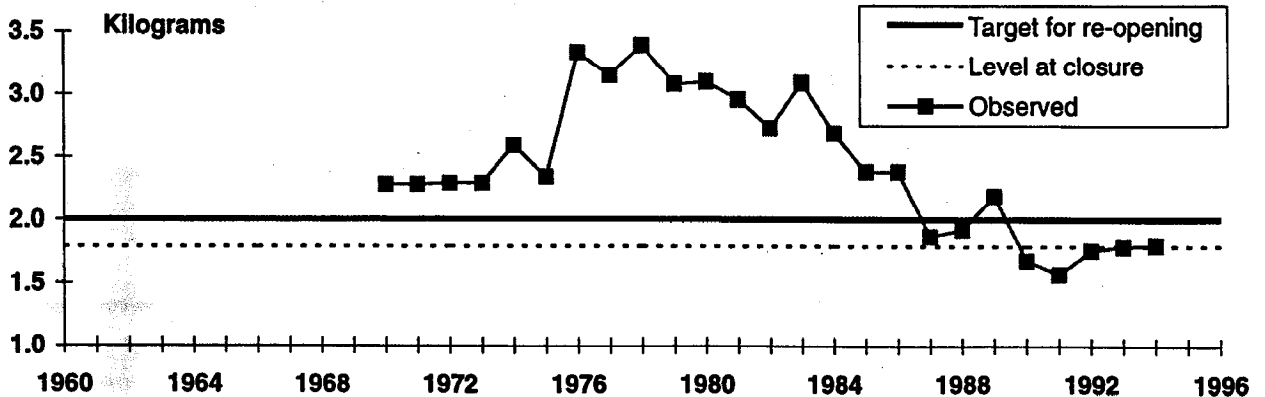
Recruitment Criteria



Essential (above)

Desirable (below)

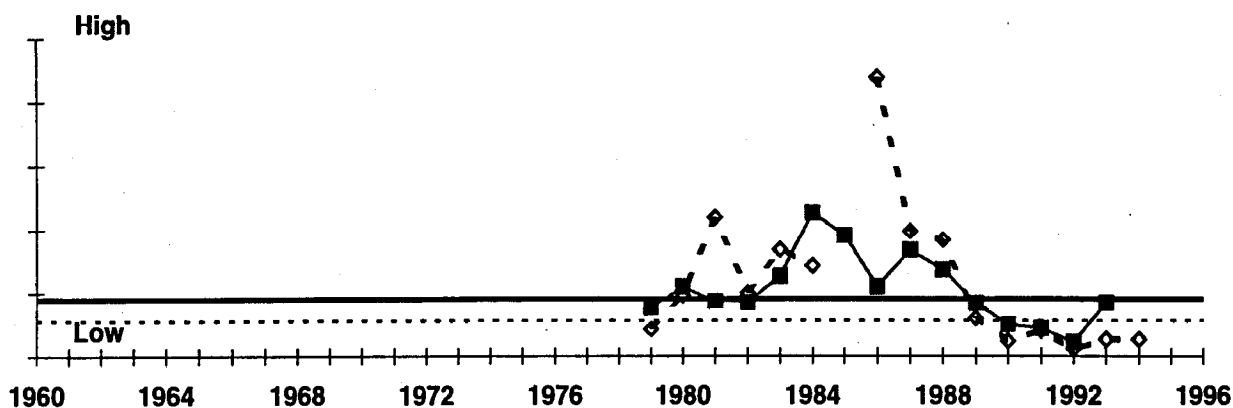
Fish Growth (weight at age 7)



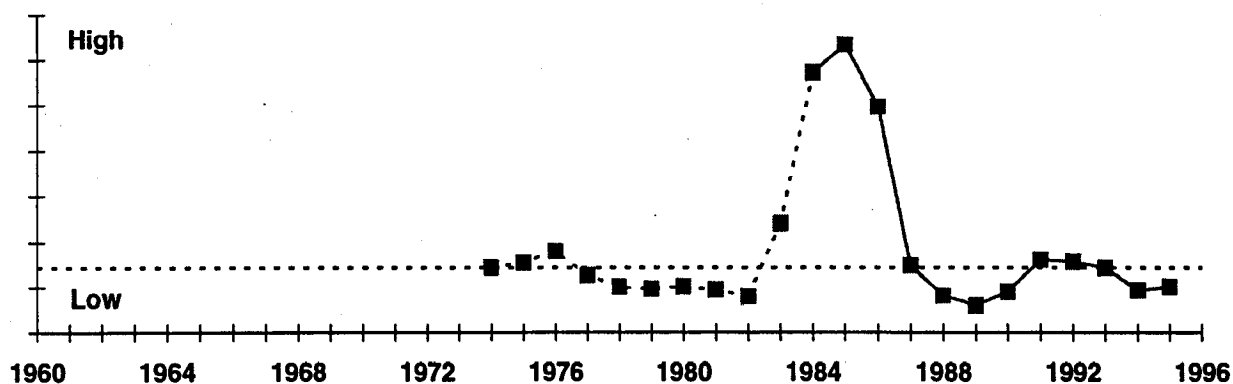
(from age-structured analysis; data provided by DFO-Science)

FIGURE 6: As in Figure 4, but for 4VsW cod.

Abundance of spawners (measured by survey)



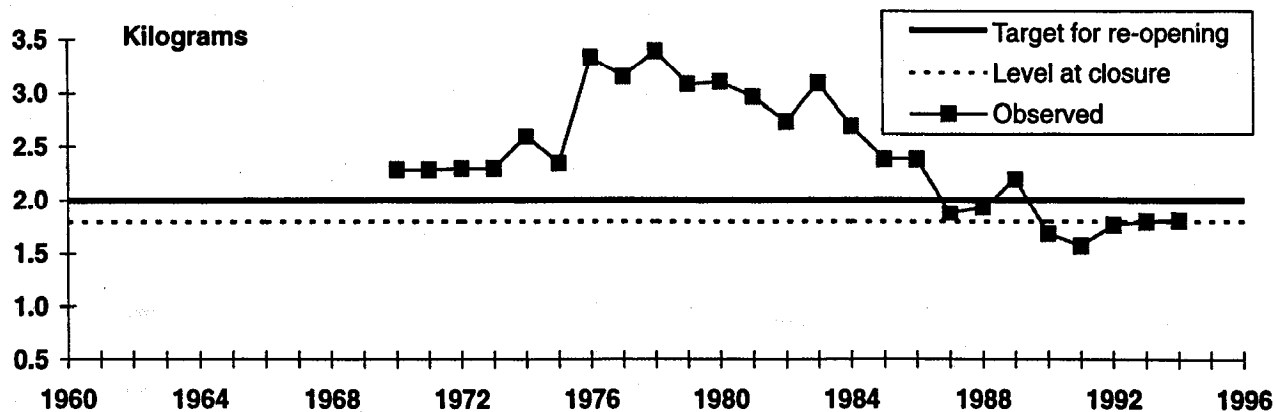
Recruitment Criteria (from ages 2 and 3 in July survey)



Essential (above)

Desirable (below)

Fish Growth (weight at age 7)



(from survey indices; data provided by DFO-Science)

FIGURE 7: An example of the variability in research survey data for 3Ps cod.

