Canada

Government of Newfoundland and Labrador

Towards a Cod Recovery Strategy

Some Essential Factors and Considerations

A Consultation Paper

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1. Introduction

The Canada-Newfoundland and Labrador Action Team for Cod Recovery was formed by the government of Canada and the government of Newfoundland and Labrador in August 2003. This Action Team was formed in response to the closures of the northern cod (2J3KL) and northern Gulf (4RS3Pn) cod fisheries and is mandated to develop a stock recovery and long-term management strategy for the four cod stocks adjacent to the province of Newfoundland and Labrador - the two above plus 2GH and 3Ps. Federal-provincial Action Teams (with similar mandates) have also been established in the Maritimes and Quebec to ensure that an integrated approach for cod stock recovery is developed for stocks that span, or for which interest spans, provincial boundaries.

The Canada-Newfoundland and Labrador Action Team is also mandated to increase understanding of the current status of cod stocks, to identify and evaluate current cod-related science priorities and information; and to increase cooperation amongst all appropriate groups and individuals in the identification and implementation of conservation management measures to rebuild these stocks.

The Canada-Newfoundland and Labrador cod recovery initiative is not part of the annual groundfish management plan process. As directed in its Terms of Reference, the Action Team will not be making recommendations on TAC levels, or other management measures, for these stocks in 2005. A consultation workshop in February 2005 will generate feedback on major cod recovery issues. The Action Team will then develop a draft recovery strategy that will form the basis for community consultations later in the winter of 2005. This initiative is also a separate activity from the DFO consultation process which was recently held on the designation of the Laurentian North and the Newfoundland and Labrador cod populations by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The activities of the Canada-Newfoundland and Labrador Action Team are proceeding as a separate and distinct fisheries management activity.

This paper will set the range and scope of the upcoming consultation workshop. The document is based on a critical assessment of the research, information and options for stock recovery that have been developed by the Action Team for Cod Recovery. It presents pertinent information on the current state of these stocks, indicates some possible conditions or states of rebuilt stocks and suggests a number of possible rebuilding targets or objectives. It also identifies core fisheries management measures and issues that must be addressed before a final rebuilding strategy can be developed and implemented.

2. Status of Cod Stocks

The following section on the status of the 2GH, 2J3KL, 4RS3Pn and 3Ps cod stocks presents a summary of the biological information that is most directly related to stock rebuilding. It is based on current (2004) information from DFO Stock Status Reports and additional analytical documentation prepared by the Action Team. The information is the best currently available from the stock assessment process and supporting activities.

Human efforts to restore depressed groundfish stocks are in largely uncharted territory. Actual fishery management experience with sustained recovery of such stocks is minimal. The precise state of some of these cod stocks has long been a matter of some difference between fish harvesters and fisheries scientists, especially in the case of 4RS3Pn and 2J3KL. A similar situation exists as to the causes of the various stock declines. The nature of these differing perceptions of stock status centres on most of the parameters directly relevant to stock rebuilding. However, the most significant differences involve the actual (or precise) current size of these stocks and not the fact that they are in a depressed state. This points to the need to engage all parties in a realistic discussion of all the elements that might be involved in a stock recovery initiative.

2.1 Northern Labrador Cod – 2GH

The cod of northern Labrador were at one time considered part of the Labrador – East Newfoundland stock complex, but they have been considered separately for management purposes since the early 1970s, in part because the effect of fisheries in the 1960s was more severe than in the south. Landings were relatively small (< 5,000 mt) during 1955-1964, but increased dramatically to 60-90,000 mt in 1965-1969 due to a pulse of fishing by distant-water fleets. Landings then declined to less than 5,000 mt in most years during the 1970s and early 1980s, to less than 1,000 mt during the latter half of the 1980s and to zero in 1991. The quota had been set at 20,000 mt in 1974 and remained so until it was reduced to 1,000 mt in 1993. The reduction in landings through the 1980s was due to the low availability of fish, not quota restriction. The stock was officially closed to directed commercial fishing in 1996.

Little is known about the historic and recent trends in biomass of this stock. Indeed, it is not clear that the stock is a discrete unit. Most of the fish caught in the area may have come from the most northern portion of the northern cod stock complex, which declined dramatically in the late 1960s due to intensive fishing. There have been no attempts since the early 1970s to use the landings to estimate the biomass of fish in the area, and the research surveys are not very informative because coverage has been infrequent and generally not at the appropriate season and depth. No significant catches were obtained during surveys in 1996-2001. It appears that the biomass of cod in this area is at an extremely low level.

2.2 Southern Labrador – East Newfoundland (northern) Cod – 2J3KL

Landings from this long-exploited stock increased through the 18th and 19th centuries to about 300,000 mt during the early decades of the 20th century. As distant water vessels began fishing this stock in the 1950s, total landings rose to the peak of 810,000 mt in 1968, then declined to 140,000 mt by 1978. After extension of jurisdiction in 1977, catches rose to around 240,000 mt during the early 1980s. However, the stock declined later in that decade and in July 1992, Canada declared a moratorium on directed fishing. In 1998, a small fishery was opened for inshore vessels. Initially, good catch rates were experienced in many areas, but in succeeding years, these catches and good catch rates became increasingly concentrated in only a few areas. In the spring of 2003, 2J3KL was again closed to both directed commercial and recreational fishing. This closure was maintained in 2004.

The total biomass of this stock was about 3 million mt in the early 1960s. It declined to 0.5 million mt by the mid-70s but increased again to about 1 million mt in the mid-1980s. The abundance of the offshore population of this stock complex has been extremely low since the mid-1990s. The various inshore populations or aggregations appear to have been more productive than the offshore components since the early 1990s. These inshore populations sustained the small directed fishery throughout the 1998 to 2002 period. Localised aggregations now occur mainly from southern Bonavista Bay to western Trinity Bay, but also as far north as White Bay and as far south as St. Mary's Bay. The largest and densest of these occurs in Smith Sound during winter. This inshore distribution appears to correspond rather closely to the locations of some of the more successful commercial, sentinel and recreational fisheries on this stock.

The overall spawning stock biomass (SSB) declined from about 1.5 million mt in 1962 to some 125,000 mt in 1977. It was about 400,000-500,000 mt during most of the 1980s, but declined rapidly after 1988 to the very low levels that still exist. The SSB in offshore areas declined to a very low level by the mid-1990s. For the past decade, it has been at 1-2% of the level during the 1980s. The inshore SSB increased to a post-moratorium peak in the late 1990s and then declined during the re-opened inshore fishery. Estimates of this SSB in 2003 range from as low as 15,000 mt to perhaps somewhat higher than 20,000 mt.

2.3 Northern Gulf Cod - 4RS3Pn

Cod landings in this area peaked at more than 100,000 mt in 1983; the long-term average being around 75,000 mt. Catches decreased until 1993; and the fishery was closed from 1994 to 1996. A reduced fishery, conducted exclusively by fixed gears, commenced in 1997 with a TAC of 6,000 mt. Fisheries continued, with allowable catches generally around the 7,000 mt level, until 2003 when a second moratorium was imposed. The fishery reopened in 2004 with a TAC of 3,500 mt.

Since 1974, the total biomass of the stock increased from about 300,000 mt to some 604,000 mt in 1983, but declined to 36,000 mt by 1994. It recovered somewhat to 62,000

mt by 2003. The SSB has essentially followed the trend in total biomass; peaking at 379,000 mt in 1983 and then falling to 11,000 mt by 1994. It has since recovered to the mid-30,000 mt range.

The Science estimates of measurable parameters indicate that this stock, in essence, has not improved since the start of the 1990s. Stock abundance, the levels of SSB and of recruitment have not recovered to anything approaching levels of the 1970s and 1980s. The 2004 SSB estimate of 38,000 mt is slightly higher than the 2003 estimate of 35,000 mt. A catch of 3,500 mt in the 2004 fishery is estimated to reduce the SSB by just over 5 per cent. Condition and growth have improved in recent years, and fish now mature at older ages.

It is important to note, however, that harvesters in this area strongly hold the view that this stock is currently in significantly better shape than indicated by these Science estimates of abundance and recruitment.

2.4 Southern Newfoundland Cod - 3Ps

Up to the early 1970s, reported landings from this stock were in excess of 50,000 mt with substantial catches by non-Canadian fleets. After extension of jurisdiction in 1977, landings dropped to around 30,000 mt until the mid-1980s when French fishing effort increased and total landings peaked at 59,000 mt in 1987. Landings then declined steadily to 36,000 mt in 1992.

A moratorium on fishing was imposed in August 1993, after 15,000 mt had been landed. The moratorium ended in 1997 with a quota set at 10,000 mt. This was increased to 20,000 mt in 1998 and to 30,000 mt in 1999. In 2000, the TAC was set at 20,000 mt for a new management year of April 1 to March 31. It was reduced to 15,000 mt in 2001 and has remained at this level since then.

Both the total and spawning stock biomasses of this stock declined from the late 1950s to extension of jurisdiction in 1977. The total biomass then increased from about 120,000 mt to 250,000 mt in 1985. It declined to just over 100,000 mt by 1993-94 but has since increased to around the 150,000 mt level. The SSB rose from less than 50,000 mt to a peak of just over 100,000 by 1985, declined to under 50,000 mt in the early 1990s and has since improved again to 120,000 mt. However, the current high level is due mainly to the strong 1997 and 1998 year classes and it now comprises a much higher percentage of smaller/younger females than in the 1970s and 1980s.

The total reported landings of 86,000 mt over the first four years of the reopened fishery effectively cropped off the surplus production created by the moratorium. This production was not sustained because of poor recruitment. Two strong year-classes produced in 1997 and 1998 are now entering the fishery. The spawning biomass is high (in a post-1990 sense), but consists of a high proportion of smaller/younger females. The age structure has improved, but it is not as extended as it was historically with relatively few fish greater than age 15.

2.5 Outlook

- **Northern Labrador Cod – 2GH**

The biomass of this cod stock is not known, but is thought to be extremely low. In the absence of information specific to the stock, it is suspected that circumstances are similar to those in the northern, offshore portion of 2J3KL. Because the cod off Labrador and eastern Newfoundland declined from north to south, it is anticipated that rebuilding will occur from south to north. That is, recovery of cod in the inshore and offshore areas of 2GH should not be expected until after recovery is well under way in the northern parts of 2J3KL.

- **Southern Labrador – Eastern Newfoundland (northern) Cod – 2J3KL**

The overall biomass of this cod stock is considered low and has not improved to any noticeable degree since the 1992 moratorium. Total mortality remains high, no significant recruitment is occurring in offshore areas and the age distribution of most remaining population components is very compressed, especially in the offshore area. This stock no longer populates large areas of its former range, both inshore and offshore. The stock continued to decline for a couple of years after the moratorium. There has been very little sign of recovery in the offshore, whereas there appears to have been some improvement in certain inshore components since the mid-1990s. This creates a distorted impression of this stock, which historically had a major offshore component. The 2003 SSR states: “Northern Cod productivity is impaired and serious harm has occurred”.

- **Northern Gulf Cod - 4RS3Pn**

Total mortality and fishing mortality have been high since the fishery re-opened in 1997. It is believed that cod in this stock have exhibited an elevated natural mortality rate since the mid-1980s. A significant improvement in recruitment and/or a large decline in natural mortality are required to significantly change the current status of this stock as compared to previous higher levels.

- **Southern Newfoundland Cod - 3Ps**

The conditions in this cod stock have been more positive than in the other stocks since the 1990’s. However, this stock is now only marginally better than at the time the fishery re-opened in 1997. Natural mortality does not seem to be unusually high but fishing mortality, especially in Placentia Bay, remains high. While production of 3Ps cod and growth of individual fish has been relatively good recently, recruitment remains well below the levels of the 1970s and 1980s. The age structure of the stock is still very contracted. The fishery supported by this stock since 1997 has been at 50 percent of the long-term average when both stock productivity and fishing mortality levels were higher than at present.

3. Factors Affecting Re-building

The lack of recovery of these four cod stocks cannot be traced to a single factor. These stocks live in cold environments and show low productivity compared to many other cod stocks further south, and in the Northeast Atlantic. During at least the first half of the 1990s, the ocean climate was particularly unfavourable for cod, and cod productivity declined. The current state of these stocks is due to a combination of several inter-related conditions – including natural and fishing mortality levels, the level of recruitment (re-productive capacity) and general fish condition.

These same stock characteristics and environmental conditions suggest that recovery to previous high levels will be a long and difficult process, if achievable at all. Man's ability to affect stock recovery is largely limited to controlling human actions. The most significant of these is the act of fishing itself which has been severely controlled since the moratoria with little or no recovery occurring, except in 3Ps. The previous section showed that the various stocks have low abundance, SSBs and recruitment levels compared to observed or estimated historical highs. The extent to which these stocks can, or should, be restored to such levels will be a central issue in any rebuilding initiative.

Overall, the status of 3Ps cod has been better than that of the other three stocks since the mid-1990s. Production was relatively good during the moratorium, growth of individual fish was good, natural mortality was not unusually high and recruitment improved in the late 1990s. While threats to recovery are reduced in comparison to the adjacent 2J3KL and 4RS3Pn cod stocks, this stock is supporting a fishery of about one-half of its long term average mainly on the basis of a few year classes.

- **Fishing Mortality**

A lack of fish caused a cessation of directed fishing on the 2GH stock long before the fishery was formally closed. There was no reopening of this stock during the late 1990s, so directed fishing was not a factor in the lack of recovery. In contrast, when fisheries were reopened on the other stocks, the level of catches (i.e. fishing mortality) took or exceeded surplus production, contributing to the cessation of stock rebuilding, or to the reversal of increases, as in 2J3KL and 4RS3Pn. The main factor affecting further rebuilding of the 3Ps stock at present is fishing mortality, especially in certain localised areas. While the exact level of discarding, misreporting, poaching and unreported catches in both commercial and recreational fisheries is unknown, many feel this represents another important source of mortality that could also contribute to the lack of recovery in these stocks. Currently, the 2GH stock lacks aggregations that can be fished, but this is not the case with the other three stocks. However, these stocks are not as productive as they were in the 1970s and 1980s and, therefore, they cannot sustain comparable levels of fishing mortality. This is especially true of 2J3KL and 4RS3Pn.

- **Natural Mortality**

There is no information on the rate of mortality sustained by 2GH cod. However, there is evidence that mortality from sources other than fishing is very high for the 2J3KL and 4RS3Pn stocks, but not for the 3Ps stock. Total mortality is especially high on juvenile fish in offshore areas of 2J3KL where few fish survive beyond age five. While the precise causes of this elevated mortality are not fully known, some tentative conclusions can be made.

The mortality implied by estimates of cod consumed or killed by seals is such that it could be contributing to the lack of recovery in all areas, with the possible exception of 3Ps. The estimates of cod consumed by seals may be low because the available diet data show the consumption to be primarily juvenile cod and do not include incidences of belly-feeding such as that reported frequently in northern 2J3KL during 1998-2000. Diet data of seals captured in inshore 2J3KL show their per capita consumption of cod has not declined with the collapse of this cod stock.

It is also thought that for some of these stocks, the energetic condition of cod was particularly low following spawning during the early 1990s. This could have been low enough to also result in higher natural mortality levels.

- **Reproductive Capability**

Studies of the reproductive potential of cod stocks indicate that first time spawners are generally less successful than repeat spawners, fish in poor energetic condition have lower fecundity, and small spawners have shorter durations of spawning. This means that larger, older spawners contribute more per kilogram to the reproductive potential of a stock.

There is little information on the spawners in 2GH, but it is thought that their numbers are exceedingly low. For the other three stocks, the small numbers of older fish and the high proportion of first time spawners at the beginning of the moratoria contributed to the slow initial rebuilding. Recruitment in offshore 2J3KL has been very low since the early 1990s. It appears that only inshore recruitment was better in the late 1990s than in the mid-1990s. There have been no significant signs that recruitment to the 4RS3Pn stock has improved over the last twelve years. There has been a persistent long-term decline in the strength of year classes produced in 3Ps from the mid-1970s to the mid-1990s, with no real indications that this has changed in recent years.

The lack of older spawners and poor energetic condition of fish also contributed to the disproportionately lower reproductive potential of the already depleted spawning biomass. Severe reductions in the size of some spawning components and/or a reduced area of spawning in 2J3KL and 4RS3Pn are contributing to the poor recovery of these cod stocks. Contracted age structure remains a problem, especially in offshore 2J3KL.

The 3Ps stock has the best age structure but even there, the proportion of young mature females is much higher than long-term levels.

- **Fish Condition and Individual Growth**

The conclusions of some cod condition and feeding studies are that 2J3KL cod may not be faring well in certain seasons and areas due to the low availability of capelin. While other studies and observations do not suggest any current problems with cod growth and condition, a concern remains that there may not be sufficient capelin to support a recovery of this cod stock to previous levels, especially in the offshore and in the north. That is where this stock has fared the worst since the early 1990s.

The condition level of 4RS3Pn cod decreased at the end of the 1980s and into the 1990s but appears to have recovered somewhat in recent years. In 3Ps, the weight at age for older fish is still smaller than in the 1970s. There is no recent information on condition and growth of cod in 2GH. Overall, these stocks are not as productive as they were in the 1970s and 1980s.

- **Summary**

Little is known about the cod in 2GH, but it is suspected that recovery is impeded by severe levels of the problems plaguing the other three stocks. These stocks suffered from increased total mortality and reduced recruitment (stock productivity) over most of the past two decades (except for the moratoria). Both conditions persist, although the situation in 3Ps is much less a concern. Significant and long-term recovery will not occur unless mortality (fishing and natural) is reduced well below current levels; and stocks become much more productive by generating substantial and sustained annual additions to their populations that survive beyond present life spans.

4. Primary Considerations for Recovery

4.1 Biological Considerations

Intuitively, a rebuilt cod stock should have most, or all, of the characteristics normally found in healthy or sustainable fish populations. Primarily, these would include such features as the abilities to reproduce, regenerate and sustain itself while maintaining some degree of maximum or optimal annual yield. Ideally, these features might be envisaged as those capabilities the stock would have if it were in long-term equilibrium and being fished consistently at a chosen reference level such as $F_{0.1}$. Several elements or considerations determine the scope and rate of such biological re-building progressions. Central to any rebuilding initiative are certain primary considerations or pre-conditions as well as the adoption of selected re-building targets or objectives.

- **Total Biomass and Population Growth**

Some assurance of surplus production that allows population growth (total biomass) is a necessary condition for rebuilding. A fish stock should produce continuing increases in its total biomass to be considered as recovering. If the stock is under moratorium, some real change from the existing low levels of total biomass should be projected to occur with high probability before fishing resumes. For lasting recovery to occur, there must be a sustained rate of population growth over some extended time-period. This requires the adoption of targets for biomass growth over time, some minimum threshold of biomass or projected increase before a fishery occurs and the existence of a high probability for sustained growth.

- **Reproductive Potential (Spawning Stock Biomass)**

A recovering or rebuilt stock must possess a sustained ability to reproduce. The spawning stock biomass should be at, or above, some critical level to ensure, with high probability, significant and ongoing improvement of both total and spawning stock biomass.

The health of separate spawning components and the age profile of a population also contribute to recruitment potential, and hence, the potential for recovery. Additional related criteria could include a proper mix of mature fish sizes to ensure strong reproductive potential per unit of spawning biomass. These types of criteria can be used to supplement SSB target levels.

- **Recruitment**

The level of annual recruitment determines the ongoing size of a fish stock and whether it increases or decreases in relation to annual removals from it. Good annual recruitment, or the addition of an adequate number of young fish (and their survival to maturity), is a necessary condition for stock rebuilding. To some degree, recruitment depends on the size of the spawning biomass as well as the reproductive potential of that biomass. A

very small spawning biomass is less likely to produce large recruitment than a larger one. Of course, other factors also affect the successful survival of eggs, larvae and juvenile fish (e.g. environmental conditions, presence of food, predators), but a high spawning biomass better ensures good recruitment under optimal environmental conditions.

What constitutes good recruitment could be judged in relation to what occurred at some previous point in the history of the stock, but this requires careful examination of current versus past spawning potential.

- **Geographical Distribution and Spawning Range**

It is best not to exploit a stock reduced to a very low density over a substantial portion of its historical range. Also, a stock should not be considered re-built until spawning is occurring in most of the traditional spawning localities and for close to the historical duration of spawning.

The degree of this repopulation could be tied to the magnitude and rate of the growth in stock size that has been adopted as a re-building objective.

- **Fish Condition and Growth**

Both condition and growth of individuals are important to a healthy stock. The growth rate of fish in the stock must be sufficiently high, and losses due to mortality (natural and other) low, in order to effectively increase the spawning stock biomass. This requires that fish condition be at a satisfactory level; i.e. individuals are healthy, growing at normal rate for the stock and not subject to high total mortality. In this context, fish condition may be as much a pre-condition for rebuilding as it is measure of stock recovery. In any case, the existence of good fish condition would increase the chance of a recovery to some level above the current low ones in these cod stocks.

4.2 Fishery Management Considerations

The following fishery management considerations are essential for any degree of these biological re-building requirements to occur.

- **Risk Avoidance**

Because little is really known about the pre-conditions, triggers or mechanisms that initiate and sustain stock re-building, risk avoidance should guide decision-making on management actions and implementation to maximize the chances of rebuilding. However, the need for starting some manner of rebuilding in these cod stocks seems to override the usual precautionary dictum of “when in doubt, take no action.”

- **Precautionary Framework**

A precautionary management framework that seeks to avoid incurring irreversible damage to the stock or perpetuating low stock levels must be adopted. Pre-agreed harvest or decision rules, including ensuing technical conservation measures, must be adopted to ensure commitment to stock re-building is continuous and not open for discussion annually.

- **Stock Re-building Research and Monitoring**

Continued research and monitoring focussed on stock re-building must take place to enhance the knowledge base necessary for cod recovery. It is important to determine the most appropriate indicators to monitor and study.

- **Enforcement and Control**

All necessary domestic and international enforcement and control measures should be in place to ensure sound fishing practices that avoid wasting the re-building resource.

5. Pathway To Stock Recovery

The preceding review of the salient facts of the past and current state of these four cod stocks identified some of the main factors that must be addressed to achieve stock recovery. The four stocks are characterised by reduced total and spawning biomasses. Little is known about the dynamics of the 2GH stock, but the others have impaired stock productivity and, with the possible exception of 3Ps, currently have total mortality levels higher than acceptable for stock recovery. It seems logical that the pathway to stock recovery must involve adopting all available measures that increase stock size; decrease current levels of total mortality; improve reproductive ability, age structure and fish condition and restore the former range of the species. Moving in these directions requires commitment to initiating and maintaining a number of stock management actions. This is an area where major scientific and environmental uncertainties and socio-economic concerns exist. Views of all interested parties are needed on the significant choices regarding the variety and scope of actions that would become part of the recovery strategy and plans.

5.1 Recovery Objectives

The level to which each stock parameter will be re-built and the periods involved must be addressed individually. This primarily involves the future or target size of the total biomass, the SSB, an acceptable level of recruitment, improved age structure and general fish condition in each stock. It also involves identifying the time period that will be required for achieving these levels of improvement. A key consideration in all this will

Summary of Key Stock Parameters

Parameter	**2J3KL**	**4RS3Pn**	**3Ps**
Total Biomass (mt)			
Historical Peaks	2,638,000 (62-65)	N/A	N/A
Post-1977 Peaks	1,019,000 (83-86)	604,000 ('83)	220,000 (80-83)
Current Level	46,000 (Inshore '03)	69,000 ('04)	150,000 ('04)
SSB (mt)			
Historical Peaks	1,415,000 (62-65)	N/A	N/A
Post-1977 Peaks	431,000 (81-84)	379,000 ('83)	100,000 (83-86)
Current Level	14,000 (Inshore '03)	38,000 ('04)	120,000 ('04)
Recruitment ('000 # @ 3 yr.)			
Historical Peaks	991,000 (64-67)	N/A	N/A
Post-1977 Peaks	363,000 (81-84)	206,000 ('80)	61,000 (78-81)
Current Level	38,000 (Inshore '03)	13,000 ('03)	14,000 ('03)
% Mature @ y5			
Historical Peaks	1.9 (62-65)	0.6 ('74)	N/A
Post-1977 Peaks	9.1 (83-86)	15.0 ('84)	14 (78-81)
Current Level	44.8 ('03)	40.0 ('03)	68.0 (03)
Weight @ y5 (kg.)			
Historical Peaks	0.88 (62-65)	1.0 ('74)	N/A
Post-1977 Peaks	1.17 (83-86)	1.03 ('84)	1.31 (78-81)
Current Level	1.5 ('00-'02)	1.21 ('03)	1.48 (00-03)
Conservation Levels (SSB)			
DFO Science	300,000	200,000	36,000
FRCC	--	90,000	
N/A: Data not sufficiently reliable to perform calculation			

be the acceptable level of human induced mortality on each stock from directed and/or by-catch fisheries. As a guide to these issues, the table on the previous page shows some previous and current levels of measurable stock parameters for the 2J3KL, 4RS3Pn and 3Ps stocks. Comparable data are not available for 2GH cod.

Included in the table are some SSB targets proposed by FRCC in draft Fisheries Resource Conservation Plan documents in 2002/2003 and others developed at a DFO National Gadoids Workshop in 2002 and during the 3Ps assessment in 2004. These numbers give some indications of possible levels to which SSB in these populations might be re-built over the long term.

In addition to these parameters other target indicators of stock recovery that should be assessed include: general fish condition, the range of ages in the stock and the extent to which the stock is re-populating traditional ranges and is spawning over much of that range.

Questions – Recovery Objectives

1. Are the historical highs realistic parameters to adopt for each of these stocks?
2. What targets should be adopted in the short, medium and long terms for each of these stock parameters?
3. What timeframes should be assigned to achieving these targets?
4. In the context of these targets - when should a directed fishery be permitted?
5. Should the primary objective be to first re-build the stock to permit some minimal level of fishery or vice-versa?
6. Can/should a stock be managed on basis of sub-components, e.g. inshore areas of 2J3KL separately from each other and the offshore areas?

5.2 Possible Management Measures

5.2.1 Managing Fishing Mortality

The 2J3KL, 4RS3Pn and 3Ps cod stocks have been subject to moratoria and/or restricted fisheries since the early 1990s. The 2GH stock also has not been fished since the early 1990s, even though it was not officially closed until 1996. A series of stringent management measures have been implemented over the last decade in an attempt to control the level of fishing mortality**.** These include by-catch rules, small fish protocols, at-sea observers, dockside monitoring and requirements to use more selective gear in groundfish and other fisheries. However, these severe reductions in fishing mortality have not resulted in significant re-building of the 2GH, 2J3KL or 4RS3Pn cod stocks and only a modest recovery in the 3Ps cod stock. In many instances, this lack of recovery has been exacerbated by a high level of natural mortality, especially that caused by predation. The extent to which mortality from fishing can be more effectively managed on all fronts should be further examined.

- **Controlling Removals by Fishing Activity**

The level of removals from a stock due to fishing activity is the only area where human activity is directly involved. Except in the offshore of 2J3KL (where total mortality is very high for young fish) and in offshore areas of 3Ps, mortality from all types of fishing activities could be an impediment to sustained stock recovery. By-catch remains high in some other directed fisheries, discarding is occurring, while DMP and observer coverage is not universal.

- **Harvesting Technology Measures**

Concerns about the effects of fishing activities on the recovery of these stocks invariably focus on problems of "excessive" by-catches; destruction of juveniles; habitat impairment; or the adverse targeting of a small, or the wrong, range of year classes in the stock. These all affect fishing mortality levels, stock regeneration and even the economics of fishing over the longer term.

Several changes in fishing gear have been introduced since 1992 to reduce fishing mortality from the by-catch of cod and the catch of juvenile cod. These include: small fish protocols and by-catch limits, Nordmore grates in all shrimp fisheries, increased mesh size in directed otter trawl cod fisheries, mandatory tagging and reporting of lost gillnets and increased Danish seine mesh size.

These types of changes in fishing gear have resulted in a decline in the by-catch of cod and in the catch of juvenile cod. However, the level of fishing mortality remains a concern in certain fisheries and with certain gear types.

- **Enforcement**

DFO's cod-related enforcement efforts currently include both directed and preventative enforcement. The former concentrates on measures to minimize the level of cod by-catch in other directed groundfish fisheries; and measures to ensure the accurate reporting (and recording) of cod catches. By-catch problems persist while there are shortages of at-sea-observers and related funding as well as gaps in DMP coverage. A certain lack of support for many of the existing cod management measures exists among commercial fish harvesters and the general public. Therefore, efforts at building voluntary compliance by harvesters have proven difficult. On the other hand, the public still have high expectations regarding response times to incidents of illegal fishing.

The basic purpose of enforcement is to protect fish resources and preserve conservation by creating sufficient deterrents or encouragement so that an adequate level of compliance exists. At present, it is not possible to effectively monitor the variety and levels of authorised and un-authorised fishing activities that takes place. An appreciation of the role of voluntary compliance and general conservation awareness by some industry participants and the public needs to be increased.

Foreign Fishery

Foreign fishing activity is a potential issue in the case of 2J3KL and 3Ps cod. In the latter case, Canada and France jointly manage the cod fishery under the 1972 treaty agreement and the 1994 Proces-Verbal. French authorities in St. Pierre et Miquelon (SPM) control their fishery and provide regular reports on the fishery to Canadian officials. In this area (and in 2GH and 4RS3Pn), foreign activity is not presently considered to be an issue.

There has been a moratorium on 2J3KL cod within the NAFO Regulatory Area (NRA) since 1992. In addition, there is a 5% cod by-catch limit in other fisheries, which include Greenland halibut and shrimp. In 2005, NAFO will regulate a number of fish stocks which were previously unregulated, i.e. 3O redfish, 3LNO thorny skate and 3NO white hake. The overall estimate of current annual by-catches of 2J3KL cod in the NRA is less than 100 mt.

General compliance by foreign fleets in the NRA has declined in recent years. The continuing low levels of foreign cod catch on the Nose of the Grand Bank in 3L are due in large part to the apparent absence of any meaningful quantities of cod in this area. A significant challenge to cod recovery could be that foreign fleets will fish illegally for this species if the quantities of cod in the Nose area increase in future.

This possibility is now being addressed through the Canadian Strategic Plan as part of the larger issue of overall non-compliance. This includes improving follow-up on incidents of non-compliance and a proposal to improve the observer program and the port inspection process. The Minister of Fisheries and Oceans recently announced the appointment of an Advisory Panel on the Sustainable Management of Straddling Fish Stocks in the Northwest Atlantic. A major international conference on related issues is also scheduled for May in St. John's.

Questions – Managing Fishing Mortality

1. Can/should certain existing measures, such as dockside monitoring, observers, gear restrictions and seasonal and area closures, be expanded?
2. Should allowable catch levels be adjusted downwards to provide some margin of safety against unavoidable by-catches, discarding, illegal fishing activities, etc.?
3. What would be the most effective available measures to manage mortality caused by fishing, generally and specifically, in each stock?
4. How should these best be implemented?
5. Is there scope for further reductions in fishing mortality through changes in gear selectivity, changing mesh/hook/bait sizes, seasonal gear restrictions, etc?
6. Are there additional enforcement measures that can be adopted to assist cod recovery - what might these specific measures be?
7. What additional initiatives can be used to increase public support for stock management measures, conservation etc?
8. How can increased voluntary compliance be achieved - who has a role in achieving this?
9. What are the most suitable or best courses of action to pursue in this area over the near and long term?

5.2.2 Managing Predator and Prey Species

- **Predators**

Cod are subject to predation through almost all of their life cycle. Species such as squid, other groundfish and some seabirds eat very small cod. Certain whales, various groundfish (most notably Greenland halibut and cod), harp and hooded seals prey on larger juveniles. Large cod probably have few natural predators, but seals can prey upon them by belly-feeding. In the Gulf of St. Lawrence, an increasing abundance of mackerel and herring appears to have also resulted in high predation on cod eggs and larvae.

Natural mortality is high in 2J3KL and 4RS3Pn, but not in 3Ps. (The level of mortality in 2GH is unknown.) Predators are thought to be the single most important cause of this increased natural mortality. While cod is not their main prey, harps seals are considered the biggest single predators of cod and could also compete with them for food because of the quantities of forage species they consume. Capelin is the main forage species for seals but is also prey for other species, including whales, other groundfish, squid and birds. As well, cod share other prey species, such as herring, Artic cod and sand launce with many other predators including harp seals.

The Objective-Based Fisheries Management (OBFM) approach for harp seals, adopted in 2003, uses reference points and control rules to establish a clearer basis for managing the harp seal hunt. The reference points are based on the maximum observed size of the herd of 5.5 million seals. Under OBFM, the Department is committed to maintaining the harp seal population at a level above the calculated 70% reference point - which is about 3.85 million animals. Also, a pilot project on “Seal Exclusion Zones” is being conducted in Smith Sound.

The ocean food web is very complex and our understanding of its dynamics is rudimentary. This makes it very difficult to assess and quantify any benefit that might accrue to cod from specific reductions in the abundance of harp seals. The possibility of damage from other species on the larval and pelagic stages of the stocks may also exist but is difficult to quantify.

- **Prey**

Concerns exist that inadequate supplies of forage species are also hindering cod recovery. This is related to fish condition and individual growth and the view that productivity, and even ability to survive harsh conditions, is impaired by a lack of adequate food supplies. Small cod feed mainly on planktonic crustaceans. Medium-sized and large cod feed on a wide variety of prey including capelin, Artic cod, herring, sand lance, toad crabs, small snow crabs, shrimp and other medium-sized fish. Cod also feed on smaller cod, but cannibalism is not an important aspect of the cod’s diet.

Capelin is the prey species that has received the most attention with regard to cod recovery. The role of capelin in cod recovery seems tied mostly to the situation in the northern cod stock area where the capelin stocks were viewed to be the largest and where most of the commercial catches have taken place. The question is a controversial one mainly because of uncertainties surrounding the growth and condition of cod. A general concern remains that there may not be sufficient capelin available to support a recovery of the northern cod stock to its former high biomass level - especially in the offshore and in the north.

In 2001, a review of information to the end of the 1990s concluded that there was no scientific evidence to support the view that the capelin fishery in 2 + 3KL had any impact on population abundance. It is not possible to evaluate if this conclusion holds in more recent years because there has been no formal scientific evaluation of the capelin stock since 2000.

The inshore fishery catches a relatively small amount of capelin and only during a short period prior to spawning. Consequently, it is difficult to assess the immediate benefit to cod of not catching these capelin. Predators, such as whales and birds, would eat some and a high proportion of capelin that survive to spawn die during or shortly after. The landed value of the 2004 capelin fishery was $4.3 million. This was the first substantial fishery for some years.

There has been no offshore fishery on capelin for almost two decades and the quota for the relatively small coastal fishery has been reduced to 29,000 mt.

Questions – Managing Predator/Prey Species

1. Are there realistic measures (e.g., increased annual harvest, seal exclusion zones, elimination of nuisance seals, etc) that might be taken to decrease the effects of predation by seals on cod?
2. How great would these interventions have to be to affect any measurable change?
3. What types of management measures should be directed at other species (e.g. mackerel and herring in 4RS3Pn) that are known to prey on cod?
4. For each stock, what measures should/could be taken to improve/preserve the main prey (forage) species for cod, i.e. capelin?
5. Could measures be taken to improve the abundance of other forage species?
6. Should/could these measures be phased with the identified or targeted recovery stages of each cod stock?
7. Are there other ways to reduce the effects of predators and to improve the state of forage species for cod?

5.2.3 Improving Spawning Success and Other Considerations

- **Spawning Grounds/Stock Aggregations**

For each of these cod stocks, some concern exists (or has been expressed) that the collapse of the stock itself, and/or fishing activity, have impaired spawning ranges and/or spawning durations due to the reduced number of ages in the spawning component. Increasing the amount of fish that reach spawning ages, the age distribution of spawners (hence duration of their spawning) and the range over which spawning occurs appear to be key components of any recovery initiative.

Before the moratoria, directed fishing was routinely carried out on spawning concentrations of all three cod stocks. However, various management measures were implemented to protect spawning grounds and spawning activity when these fisheries were re-opened in the mid 1990s. Most measures are intended to promote increased recruitment levels but, in some cases, are designed to protect particular sub-components of the stock.

The primary fisheries management tools used to protect spawning grounds, spawning aggregations or stock sub-components are closed areas and times. Some area closures apply to all gear types and fisheries, or they may only apply to a specific gear type, fishery, fish harvester (i.e. non-residents) or vessel class. Presently, there are two area or time closures in 2J3KL, one in 4RS3Pn and three in 3Ps.

There is a great deal of scientific uncertainty concerning where cod spawning actually occurs, or where it occurred historically. Implementation of closed areas will generally result in a displacement of fishing effort to alternate fishing grounds. Improvements in recruitment or stock status resulting from the implementation of closed areas are difficult (if not impossible) to quantify. However, improving the possibilities of increased spawning time and locations would raise (rather than guarantee) the chances of increased recruitment.

- **Enhancement**

Efforts at marine stock enhancement of Atlantic cod go back to the 1880s in Newfoundland and several other countries including Norway, the United States and Canada. Initial early efforts involved the release of hatched larvae. More recent proposals to enhance the reproductive potential of cod stocks in Newfoundland and Labrador include the release of grow-out cod and of hatchery-reared juvenile cod.

Investigations of the catch, grow-out and release approach in Placentia and Trinity Bays have shown increased fecundities in grow-out cod which are two to three times higher than in wild cod from the same area. These cod produce fertilized eggs and viable larvae, reintegrate with wild cod aggregations and remain members of the resident population.

A key unknown concerning the grow-out and release approach is the survival rate of the eggs and offspring produced by the released fish. Also, to have an impact on cod recovery, the "scale" of this type of approach would need to be enormous as 99.9% of cod mortality occurs within the first four months after spawning.

Several impediments to launching cod enhancement activities appear significant. The existing fishing mortalities and the apparent high level of natural mortality would also adversely affect enhancement efforts. The scale of any proposed cod enhancement initiative would be extremely small relative to the size of even the existing low natural spawning population. Experiences in other countries indicate a low probability of success, especially if continuing causes of poor stock recovery are not eliminated before an enhancement program is commenced. Production of juvenile cod is expensive; any adequately scaled inshore cod enhancement project will require significant levels of public investment.

However, the history of cod enhancement in this province goes back over a century. Local capacity to produce large numbers of juvenile cod for use in future enhancement programs will increase substantially when the commercial cod aquaculture hatchery in Bay Roberts is completed. The concept has a certain attraction even if the magnitude and scale of such an enhancement effort appear daunting in relation to the scale of the natural environment involved. Many see some merit in launching some form of enhancement effort, whether it is actual restocking with reared juveniles or the release of enhanced mature fish.

- **Expanding Age Structures**

One of the stock characteristics that can affect spawning success is the age structure of the fish population. Each of the stocks has a problem with age structure when compared with times that were more productive. Generally, these negative features involve the current lower numbers of older fish. While environmental forces may play a considerable role in causing these conditions, the question of the extent to which management actions can contribute to improving age structures of these fish stocks must be addressed. In simplistic terms, this requires the "growing old" of more fish in the future to expand the range of year classes in these stocks.

- **Climate Change**

Natural climate variation has impacted the distribution, migration and abundance of north Atlantic fishes in the past, and logic dictates similar responses in future. The responses of some species to specific environmental dynamics can be specified, although those dynamics in the north Atlantic are still uncertain. Any consideration of rebuilding of Newfoundland and Labrador marine ecosystems must take account of the effects of natural climatic variation and also recent enhanced climatic changes as a result of human activity since they may influence ecosystem structure, functioning and species composition as the basis for rebuilding. Although the reactions of some species (e.g. capelin) to environmental change can be specified, this cannot be adequately done for

most species and their interactions. Overall, rebuilding plans will likely not depend greatly on any predictions of climate change influences on the ecosystem, but plans should always be tempered by the inherent uncertainties of climate, and this is especially true in this era of rapid change.

Questions – Improving Spawning Success/Other Considerations

1. What possibilities exist, in each stock area, for further protection of spawning grounds and times and temporal aggregations of cod stocks, e.g. seasonal fishing and continuing area closures?
2. Should some scale of cod enhancement be pursued, at what cost and in what time frame?
3. What priority should enhancement efforts receive in the overall cod recovery initiative?
4. Alternatively, is enhancement more a symbolic effort that should be further examined only in that context?
5. What fishing measures or actions would best serve to improve age structures?
6. How can these be devised and implemented in the most effective manner?
7. Are there other initiatives that should be pursued to improve the overall likelihood of spawning success?
8. What role, if any, will climate change play in the recovery and future management of cod stocks?

5.3 Shaping the Management Framework

- **Pre-set Decision Rules**

The Precautionary Approach (PA) is a risk management approach for use when there is an absence of full scientific certainty regarding a fish stock, a potential risk of serious or irreversible harm to the stock and a need to make management decisions regarding a stock. Its most important components relate to the determination of Limit Reference Points and associated pre-agreed management actions for protection of fish stocks. The social and economic benefits desired by Canadians can also be achieved under PA using Target Reference Points that are associated with various states of the resource. Such targets identify the long-term goal of fisheries management and could serve to guide management when the resource is healthy. All these limits and targets must work together to avoid conditions that cause serious or irreversible harm to the resource.

In the nearly decade and a half since the first cod closure considerable time and effort has been spent in annual debates on the management of essentially non-recovering cod stocks. This focuses not on conditions or pre-requisites for re-building, but instead on why a commercial and/or recreational food fishery should be authorised. It seems, therefore, that an essential part of any recovery plan has to be a set of pre-agreed management actions or measures that will be taken when the stock falls below, or exceeds, certain specified minimal or critical thresholds. No action to open a fishery or raise (or lower) a quota would be taken until the thresholds are passed.

This approach requires the setting of specific stock thresholds that must be reached before increases (or decreases) can occur in the level of fishing, or other specific prohibitions, can be changed. The type and extent of management action that would be triggered by the passing through such critical thresholds would be specified in advance. These thresholds are not the same as the longer-term and higher order re-building targets discussed at the start of this section.

- **Shared Stewardship**

The re-building of cod stocks is an area of uncharted waters for governments, the fishing sector and the overall society of this province. Indeed, a complete and sustained groundfish rebuilding experience is difficult to find. One of the most pervasive challenges to recovery actions that has been displayed since the original moratoria is the often monumental differences that exist in perceptions of stock status. The other is the variances in expectations and un-stated lack of clearly articulated and agreed objectives for stock rebuilding on the part of industry participants, governments, other interest groups and the general public. The new Policy Framework for the Management of Fisheries on Canada's Atlantic Coast has a cornerstone of increased participation by licence holders in the direct management of resources as an important element in changing this counter-productive situation. Those involved in fisheries will have to take some measure of responsibility and accountability as they achieve increased involvement in decision-making for their own areas.

Shared stewardship, as envisaged in the Atlantic Fisheries Policy Framework, means that participants in the fishery will be effectively involved in fisheries management decision-making processes at appropriate levels. They will contribute their specialized knowledge and experience and will ultimately share in the accountability for outcomes. The movement towards shared stewardship will, by necessity, be evolutionary and long-term in nature. It is anticipated that participation by stakeholders most directly involved in the exploitation of specific stocks would initially take place through current fisheries management processes. However, in the medium to long-term, as resource users increase their ability to assume additional management responsibilities and demonstrate their commitment to sustainability, the department would delegate authority over specific decision-making areas to them.

The FRCC recommended in it's **2003/2004 Conservation Requirements for 2J3KL Cod Stocks** report that Coastal Fisheries Councils be formed to co-manage the coastal component of the northern cod stock. These Councils would be provided with designated operational decision-making powers to regulate local harvests, by-catches and local enforcement issues and would enhance (not replace) DFO's ability to foster a sustainable fishery.

Within the last decade, fish harvesters, processors and other stakeholders have played an increasingly important role in the fisheries management process. Stakeholders now play an integral part in the day-to-day management of fisheries through such activities as the

Integrated Fisheries Management Plan (IFMP) process, the development of annual Conservation Harvesting Plans (CHPs), the at sea observer program, the dockside monitoring program, the sentinel fisheries program and through the Regional Assessment Process (RAP) of Science.

Questions – Shaping the Management Framework

1. What would be the best measures or indicators of stock status (e.g., total or mature biomass, annual recruitment etc) for such thresholds/triggers?
2. What types of pre-set decision rules should be adopted?
3. In what sort of process are they best established?
4. Should they vary with the recovery stage of a stock?
5. Should this approach include allowing some minimal level of fishing before critical thresholds are reached or vice-versa?
6. What role can the concept of shared stewardship play in stock re-building, how can it be initiated and how quickly?
7. Should Coastal Fisheries Councils or some other similar arrangement, be adopted as a first step?
8. Are there other avenues that should be pursued in this regard?