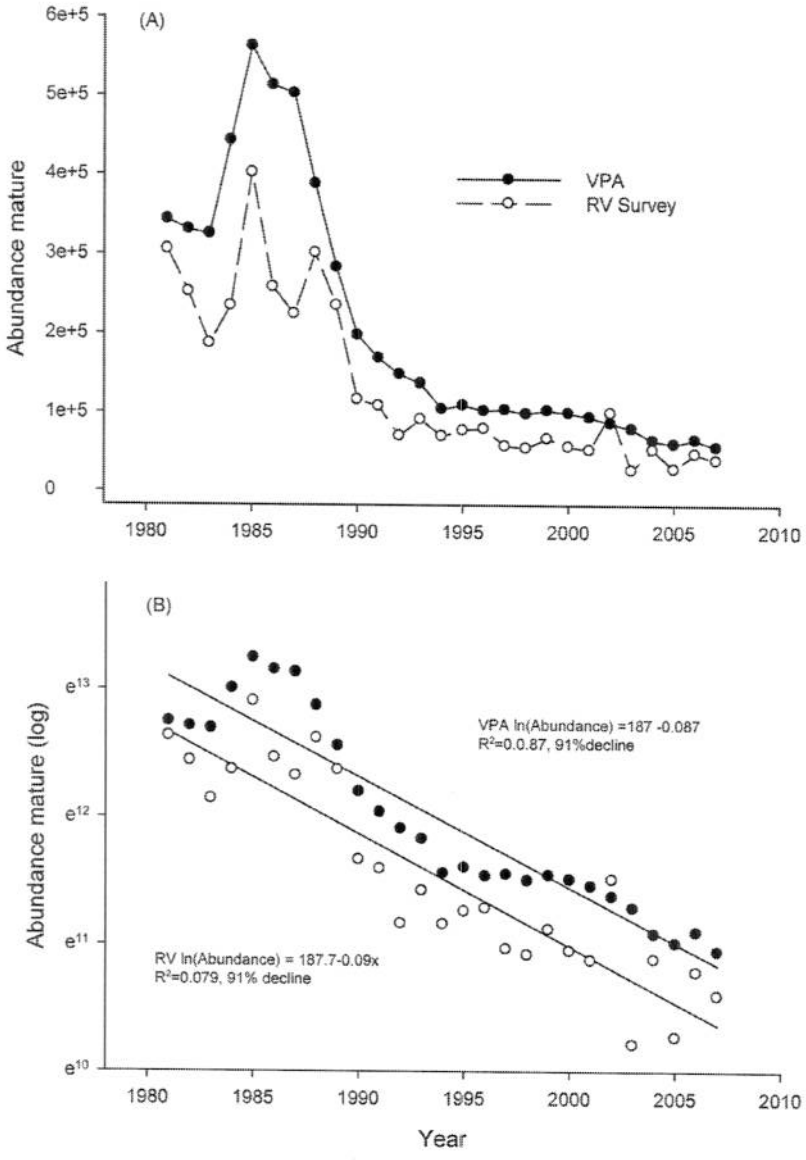

Figure 10. Temporal variation in the estimated number of mature individuals in the Laurentian South DU (A). Data from the 4TVn, 4Vn, and 4VsW stocks are shown in Appendix 1. (B) Plot of $\log_e$ (abundance, N_t) versus time (t, in years) for the Laurentian South DU and the estimation of the 3-generation rate of decline.

Age at maturity	Generation time (yr)	Data source	Data type	Time period	Rate of change
4.0	9.0	VPA	number of individuals	1981-2001(2007)	−90%
4.0	9.0	RV	number of individuals	1971-2007	−91%

Area of occupancy: Area of occupancy for the years 1991 to 2007 declined from approximately 140,000 km^2 to approximately 92,000 km^2.

Southern DU

Cod in this DU combine the stocks identified for management purposes by DFO as: (1) Bay of Fundy/Western Scotian Shelf (NAFO 4X and the Canadian portion of NAFO 5Y); and (2) Eastern Georges Bank ($5Z_{jm}$). Temporal trends in abundance for each of these stocks are presented separately in Appendix 1. Calculated from the means for each of its constituent stocks (Appendix 1), generation time is estimated to be 7.5 yr for this DU, yielding a three-generation time period of 22.5 years. Abundance data represent the sum of the VPA estimates and RV survey estimates of mature population size for each of the stocks included in this DU (see Appendix 1 for details). The time period for which data were available for all stocks was 1978 to 2008 for the VPA, 1978 to 2007 for the NMFS Autumn survey, 1986 to 2008 for the DFO survey. These data are from Worcester *et al.* (2009) and Clark *et al.* (2008) and are included here for the purpose of estimating rates of population decline only. The 2009 assessment of the 4X cod stock indicates that spawner biomass has been declining continuously since 1996 and at the beginning of 2008 was at its historic lowest level, 9,000t (DF0 2009f). Recently mortality other than reported landings has been high, estimated at 0.70 (46%).

The Southern DU has declined 59%-64% over the past three generations (Figure 11).

Age at maturity	Generation time (yr)	Data source	Data type	Time period	Rate of change
2.5	7.5	VPA	number of individuals	1985-2007	–64%
2.5	7.5	Various Surveys	number of individuals	1985-2007	–59% to –39%

Area of occupancy for this DU has been relatively stable across the time period of observation ranging from approximately 23,000 km^2 in the early 1970s to approximately 24,000 km^2 in recent years.

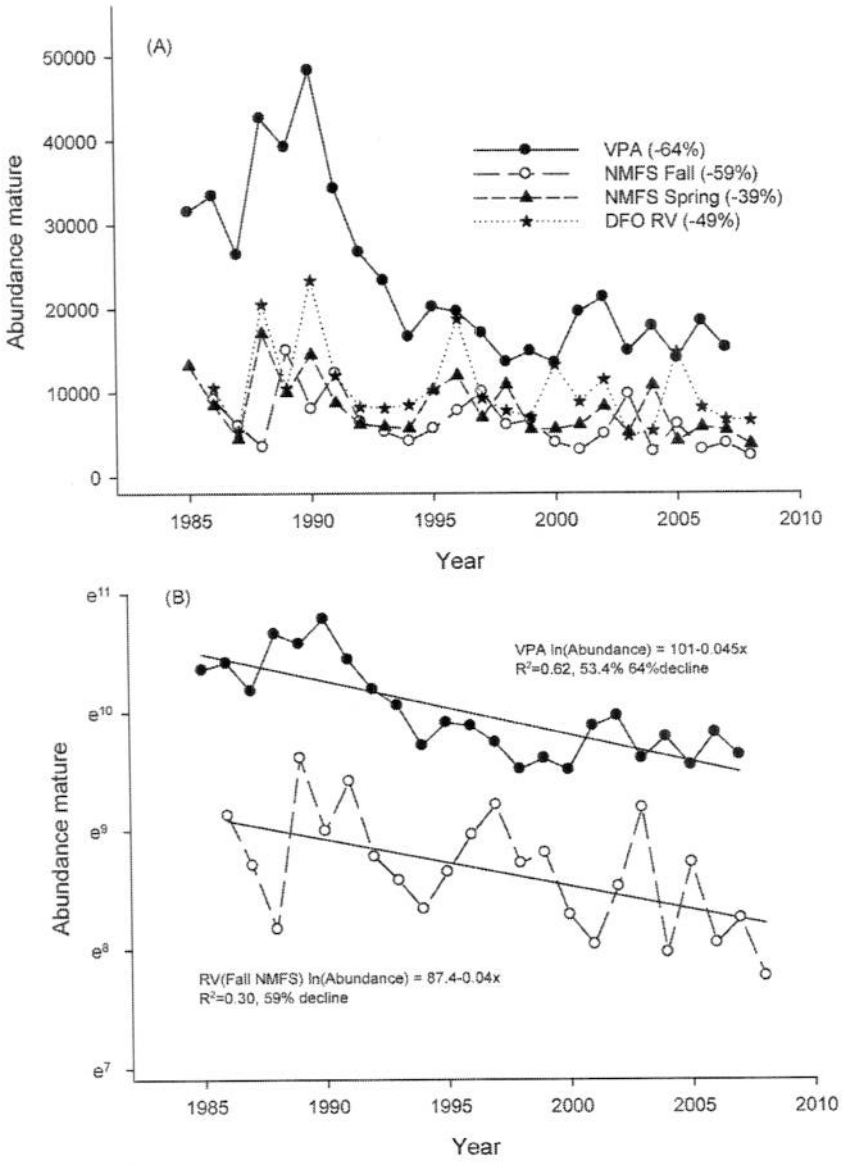

Figure 11. Temporal variation in the estimated number of mature individuals in the Southern DU (A). Data from the 4X and 5Zjm stocks are shown in Appendix 1. (B) Plot of $\log_e$ (abundance, N_t) versus time (t, in years) for the Southern DU and the estimation of the 3-generation rate of decline. Both panels show the data for the various 5Zjm surveys combined with the single 4X survey.

LIMITING FACTORS AND THREATS

The factor responsible for the decline of Atlantic Cod in the 1990s was primarily overfishing (Hutchings and Myers 1994; Hutchings 1996; Myers *et al.* 1997b; Shelton and Lilly 2000; Hutchings and Ferguson 2000a,b; Bundy 2001; Fu *et al.* 2001; Smedbol *et al.* 2002; Worcester *et al.* 2009), though several studies suggest a potential role for unfavourable climatic conditions (Rose *et al.* 2000; Rose 2004; Halliday and Pinhorn 2009). At present, fishing pressure continues to be the primary threat range-wide. However, natural mortality predominates in some areas (Scotian Shelf and southern Gulf of St. Lawrence) resulting in predictions of possible extinctions in the near future (e.g., Swain and Chouinard, 2008).

Fishing pressure

Directed harvest, substantial bycatch, discarding, and to a lesser extent illegal fishing continues in many regions despite record lows in abundance and high total mortality, and clearly threatens rebuilding and continued persistence of cod populations in Canadian waters.

Although a moratorium exists in the offshore of the Newfoundland and Labrador DU, along the northeast coast of Newfoundland fishing pressure was present for the period 2006-2008 in the form of a directed "stewardship" fishery and a recreational fishery for cod. Exploitation rates in many coastal Newfoundland areas are often high (>30%, Worcester *et al.* 2009) based on mark-recapture estimates (DFO 2002; Brattey and Healey 2007). A summary of these estimates is provided in the table below (these data were obtained from Table 6 in Brattey and Healey 2007, and Worcester *et al.* 2009). Exploitation rates for 2007 are available for some inshore Newfoundland areas and range from 6-7% (Worcester *et al.* 2009). It seems likely that these high rates of exploitation have directly contributed to recent declines in abundance observed in estimates from Smith Sound, Trinity Bay (see Appendix).

Tagging location coastal Newfoundland	Exploitation rates in 1999	Exploitation rates in 2002	Exploitation rates in 2006
Notre Dame Bay	30-63%	12-20%	10-35%
Bonavista Bay	6-18%	14-19%	5%
Trinity Bay	4-13%	10-27%	4-15%
Placentia Bay	8-15%	4-27%	25%

High exploitation rates have recently been identified as a direct threat to rebuilding in the offshore regions of the Newfoundland and Labrador DU (Shelton and Morgan 2005; Worcester *et al.* 2009). This threat to recovery comes both through a reduction in overall population growth rate in the inshore, as well as through fishing mortality on the offshore portion (3NO, Shelton and Morgan 2005), and the migratory/offshore stock during summer periods inshore (2J3KL, Worcester *et al.* 2009). Prior to the cod

collapses in the early 1990s, it was estimated that cod populations could increase in abundance at exploitation rates less than 18%. As such, exploitation rates reported above exceeding this value permit little or no population growth. Moreover, maximum rates of population increase for northern cod have been estimated at between 10 to 30% per annum (Myers *et al.* 1997a; Hutchings 1999). Given that the range in exploitation rate estimates typically falls within this 10-30% range of maximum population growth, population recovery will not occur, irrespective of the number of individuals in the population.

Since 2003 a positive trend in abundance has been observed in the offshore component of the Newfoundland and Labrador DU (Appendix 1). Brattey *et al.* (2008a) report that cod currently offshore in 2J3KL may undergo spring/summer feeding migrations to the inshore. Tagging and telemetry studies have revealed cod tagged 170 Nm offshore on their traditional over-wintering grounds migrated inshore to the northeast Newfoundland coast in 2008 consistent with the hypothesis that the inshore fishery is a potential threat to offshore rebuilding. This link between offshore recruitment and inshore fishing mortality is supported by the observation that the closure of the fishery in 2003 and lower landings in 2004-2005 coincided with a decline in mortality, improved survival in the offshore and a rise in Sentinel catch rates during this period. Accordingly it is clear that the present moratorium in the offshore is not sufficient to protect this stock until rebuilding has occurred (DFO 2009a) and further restrictions in the inshore are required immediately to protect the present increasing trend in abundance.

High exploitation is impacting abundance and recovery elsewhere as well. Total mortality in the Laurentian North DU based on estimates of its constituent regions is >0.55 of which the main factor is fishing pressure (DFO 2009b,c). In the southern gulf (4TVn) fishing mortality has been estimated at 0.08, and though low is unsustainable given the dramatic increases in natural mortality (DFO 2009d).

Fishing pressure in the 4X component of the Southern DU remains well above recommended levels with fishing mortality estimated at 0.35 (DFO 2009f). In addition to the direct harvest, bycatch of cod in many regions continues to pose a significant threat to rebuilding (Shelton and Morgan 2005) and in some regions contributes to continued declines (Worcester *et al.* 2009). Bycatch is associated with many fisheries including Haddock, Winter Flounder, Shrimp, and Lobster (Worcester *et al.* 2009). And though there is substantial uncertainty regarding the magnitude of these harvests, it seems unequivocal that these are influencing present rates of declines (Shelton and Morgan 2005; Worcester *et al.* 2009).

In summary, it seems clear that across the range in Canadian waters, overfishing, both direct harvest and bycatch, remains a significant threat to the stability and persistence of cod populations.

Natural mortality

Despite the clear influence of fishing pressure on cod survival, the most important factor contributing to the current low productivity of some stocks (e.g., 4TVn) is elevated natural mortality (Swain and Chouinard 2008). Historical estimates of natural mortality (M) suggest a range of values between 0.07 to 0.40, and value of 0.2 has been commonly used in stock assessments (Sinclair 2001). Despite regional restrictions in fishing pressure, total mortality remains high (>0.2) in many areas (Table A2) consistent with elevations of M and estimates of M which do exist indicate some areas are experiencing natural mortality rates of 0.60-0.70. Natural mortality appears most severe in stocks south of the Laurentian Channel (i.e. the southern Gulf of St. Lawrence (4T), eastern Scotian Shelf (4VsW) and western Scotian Shelf/Bay of Fundy (4X) stocks). To the north, M is estimated to be slightly elevated in some regions, but overall values are lower than to the south of the Channel. Until recently, offshore northern cod (2J3KL) were also experiencing high M; however, M has declined in recent years (DFO 2009e).

Population projections for the southern Gulf of St. Lawrence indicate that even without harvest, the spawner stock biomass of 4TVn will decline by at least 10%, with a 53% probability of a 15% decline or greater (Chouinard *et al.* 2008) over 2009. Long-term stochastic projections (Swain and Chouinard 2008) for current conditions suggest the stock will be extinct (i.e., less than 1000 t) within 40 years in the absence of fishing, and within 20 years with fishery removals at the 2007-2008 level. If natural mortality continues to increase, Swain and Chouinard (2008) warn these projections may be overly optimistic. The dominant source of natural mortality remains up for debate; however, several hypotheses have been proposed and evaluated (DFO 2009e). These include disease, the impact of contaminants, starvation, effects of life history change, impact of increased seal abundance, other sources of predation (DFO 2009e). The applicability of these projections to neighbouring stocks remains unclear but available evidence indicates similar sources of M may be influencing other areas as well (4VsW and 4X; DFO 2009e).

That Grey Seal predation may be the source of an elevated M appears probable. Trzcinski *et al.* (2006) modelled the impact of Grey Seal predation on eastern Scotian Shelf cod populations and concluded that since the fishery closure, Grey Seals have been responsible for a significant component of the natural mortality (~30%) experienced and were playing a role in the lack of recovery. Similarly, previous cod assessments (Smedbol *et al.* 2002; DFO 2009e) have concluded, based on seal feeding behaviour and trends in the abundance of both seals and cod, that predation by seals is a factor contributing to the high total mortality of cod in the offshore and the high natural mortality of adult cod in the inshore. The DFO has recently suggested that Grey and Harp Seal predation may be a direct influence on cod recovery and declines, and seals are thought to be a significant source of mortality in at least seven of the managed stock areas (4X, 4TVn, 4VsW, 3Pn, 4RS, 2J3KL, Worcester *et al.* 2009). The observation that in several cases, the trends in high natural mortality of cod are mirrored in other marine fish such as White Hake, American Plaice, and several Skate species, supports a hypothesis of an ecosystem level change in dynamics and not a species-specific hypothesis.

Total mortality (Z) is comprised of both natural mortality and fishing related mortality and was estimated for all Fisheries and Oceans management units (Table A2). In several regions fishing pressure is much reduced in comparison to historic levels; accordingly, much of Z may be attributed to natural mortality. The estimated population ranges are below and range from 30-75% annual total mortality. Estimates of the size of natural mortality are available for 4TVn (M=0.60), and 3Pn4RS (M=0.28). Overall the uniformity and magnitude of these estimates suggests that total mortality has reached an unsustainable level, and it seems that in many regions the primary factor driving these values is mortality due to natural causes.

Designatable Unit	Range of Z estimates for DFO managed stocks	Range of annual mortality among stocks (%)
Newfoundland and Labrador	0.346-0.519	29-40%
Laurentian North	0.792-0.899	55-59%
Laurentian South	0.722-0.791	51-57%
Southern	0.437-1.420	35-76%

In addition to ecological sources of mortality (i.e predation, starvation, etc.) the direct and indirect influences of climatic variation on cod population productivity remain poorly understood. Halliday and Pinhorn (2009) document a strong relationship between cod biomass and the North Atlantic Oscillation (NAO) and suggest cod population fluctuations over the last century can be largely attributed to environmental causes. The proposed mechanism is that positive NAO anomalies are associated with lower temperatures, which influence population parameters and migration / distribution parameters resulting in poor condition and sharp increases in natural mortality (e.g., Dutil and Lambert 2000). Some supporting evidence exists. Mann and Drinkwater (1994) observed an association between the NAO index and the productivity of Northern cod in the early 1990s, and Drinkwater (2002) indicates that the NAO often explains as much if not more of the variance in biological time series than local oceanographic factors. Finally, further correlative evidence is present during the late 1980s and early 1990s when high values of M were observed in many stocks, which has been identified as a seven-year period of high NAO anomalies. Though intriguing, and appealing in its ability to explain past population fluctuations, at present there is little direct mechanistic evidence that this has played a dominant role and future exploration of the link between cod population productivity and climatic variation is needed.

The alteration of essential habitat may also play a large role in influencing recovery and decline rates. If physical structure is critically important to the survival of juvenile cod as many studies suggest (Laurel *et al.* 2003a, 2003b, 2004), notably in the form of plants, bottom heterogeneity, and corals, then reductions in suitable habitat may also be affecting recruitment and recovery. Eelgrass in the nearshore has been shown to provide important habitat to juvenile cod, providing a refuge from predators (Laurel *et al.* 2003). The recent discovery of Green Crab (*Carcinus maenas*) in Placentia Bay

Newfoundland, and their well documented negative impact on Eelgrass beds (e.g., Davis *et al.* 2002), may present a significant threat to juvenile cod habitat and survival. In addition to the nearshore where the link to habitat has been clearly established, the reduction of physical heterogeneity in deeper waters, and the loss of potentially important deep-sea corals, can be attributed to the bottom-trawling for groundfish (Collie *et al.* 1997, 2000; Kaiser and de Groot 2000) and may also represent a loss of habitat though mechanistic link remains to made.

In summary, the primary cause of the reduction of Atlantic Cod throughout its range and primary threat at present remains over-exploitation. However, in some areas, the rate of decline appears independent of harvest and is primarily associated with elevations in natural mortality which are becoming increasingly important. Identifiable threats to the stability and recovery of present Atlantic Cod populations include directed fishing (a consequence of the setting of quotas and the allowance of recreational or food fisheries), unreported fishing (a consequence of illegal fishing, catch misreporting, discarding), and bycatch from other fisheries for bottom-dwelling species (Haddock, Lobster, Winter Flounder, etc.). There is increasing evidence that natural unaccounted for mortality represents a significant unidentified threat in many stocks and requires immediate attention as the projected rates of decline are unprecedented even for cod (Swain and Chouinard 2008). At present, natural mortality threatens to drive cod in the southern Gulf of St. Lawrence (Laurentian South DU) to extinction within decades. Additional threats to recovery include altered biological ecosystems, and concomitant changes to the magnitude and types of species interactions (such as an increase in cod mortality attributable to seal predation). These ecosystem-level changes appear to have resulted in increased mortality among older cod. Selection against late maturity and rapid growth rate, induced by previously high rates of exploitation, may also be contributing to the higher mortality (effected by earlier maturity; Beverton *et al.* 1994) and slower growth observed in some areas today. Whatever the cause, it seems clear the natural mortality in addition to exploitation pressure now pose significant threats to many cod populations throughout Canadian waters.

SPECIAL SIGNIFICANCE OF THE SPECIES

Given its historical and contemporary importance to society, few species have been of greater significance in Canada. After the short-lived Viking-based settlements on Newfoundland's Northern Peninsula in the late tenth century, it was cod that brought the first Europeans to Newfoundland waters in the late fifteenth century, an economic venture that spawned one of the first permanent settlements in British North America (1612; Cupids, Newfoundland). Until the early 1990s, Atlantic Cod was the economic mainstay for Newfoundland and Labrador, as it was for a large part of the population in the Maritimes and along Quebec's north shore and Gaspé Peninsula. From a biological perspective, the Atlantic Cod, which numbered approximately 2.5 billion spawning individuals as recently as the early 1960s, was one of the dominant species of the marine food web in the Northwest Atlantic.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

In Canada, Atlantic Cod is protected federally by the *Fisheries Act* and by the *Oceans Act*. Conservation Harvesting Plans are in place for the Southern Gulf of St. Lawrence, and as of 2003, three Federal/Provincial Cod Action Teams have been established (Newfoundland and Labrador, Maritimes, Quebec) with a mandate to promote recovery. Several of the cod populations in Canadian waters are managed jointly with other countries. For example, the Eastern Georges Bank cod stock is jointly managed by Canada's DFO and the National Marine Fisheries Service in the United States, and cod inhabiting 3Ps are fished jointly with France. The cod stocks inhabiting the offshore waters south of the Arctic DU inside 200 miles are managed by Canada and outside by the Northwest Atlantic Fisheries Organization (NAFO). In most regions quotas as well as seasonal and gear restrictions have been incorporated into the management framework (Worcester *et al.* 2009). Although biologically relevant reference points for stock abundance have been identified in several areas, these are currently not used in the management of these stocks.

Other Status Designations: IUCN: Vulnerable; Global Heritage Status Rank: G5

ASSESSMENT OF RISK

The report suggests that Atlantic Cod in Canada be recognized as six DUs, in accordance with known genetic, ecological, and demographic data, and in accordance with COSEWIC's guidelines (COSEWIC, March 25, 2008).

Regarding the assignment of risk, only the primary cause of the reduction in Atlantic Cod (fishing) can be deemed reversible and understood. However, fishing continues in many of the populations (although it has been restricted spatially and temporally in some parts of some populations, such as Eastern Scotian Shelf). Fishing in the Laurentian South DU for instance ceased from 1994-1997, in 2003, and again in 2009. In the Laurentian North population, excessive fishing mortality has reduced the breeding part of the population, particularly in the Northern Gulf area. For the Newfoundland & Labrador DU, it is evident, based on harvest rates estimated by the DFO, that fishing is delaying recovery in parts of this population's range. Moreover, both the Southern and Laurentian South DU have experienced increases in the rate of decline since 2003 independent of fishing mortality, likely associated with increases in natural mortality (not unaccounted fishing mortality), and the Laurentian South DU seems at imminent risk of an extinction in 20-40 years.

There are several additional factors that may influence one's perception of risk. The first concerns the downgrading of risk when there is a possibility of "rescue", that is, immigration to a portion of the DU within Canada from outside of Canadian waters. It is not clear that such a downgrading is warranted when the neighbouring population(s) is also at risk. In the present case, there are no data that would allow one to evaluate the levels of immigration or emigration into or out of the Canadian and foreign portions of

the Arctic Marine DU. And though rescue is possible from American populations of cod in the extreme southern part of the Southern DU, the American populations are also at low levels, and such contributions are likely minimal. A second factor that might influence perception of risk pertains to changes in the life history of cod in some parts of its Canadian range, notably for the Newfoundland & Labrador DU. The high exploitation rates experienced by cod in the late 1980s and early 1990s were sufficiently high to affect genetic selection responses to life history traits, favouring earlier maturity and slower growth (Sinclair *et al.* 2002, Olsen *et al.* 2004) as a consequence. These life history changes represent a significant reduction in population growth rate of up to 30% (Hutchings 2005). This reduction results from a truncation of the age structure, the reduced success of young spawners, and an associated reduction in the expected number of lifetime reproductive events. Given the absence of cod aged 10 yr and older on the Northeast Newfoundland Shelf in recent years, the expected number of lifetime reproductive events for cod in this area is clearly less than 5 and may well be as few as 2 or 3. Although fecundity has been shown to be compensating to some degree (Fudge and Rose 2008) with current estimates at 75% of historic levels, the considerable reduction in lifetime breeding events and changing demography (i.e., increase in proportion of first time spawners, and resulting lower reproductive success) can be expected to have rather serious consequences to the persistence of this and other similarly affected populations, irrespective of the absolute numbers of individuals in each population.

For the Newfoundland and Labrador DU, it is important to note that this population represents over 75% of the historic biomass in Canadian waters and has undergone the largest declines with minimal sign of recovery. Moreover, the slight increases of abundance in recent years represent less than 8% of 1980s levels and 2% of the historic biomass, and any substantial recovery will likely require a rebuilding of the offshore. At present, the inshore fishery though small, represents a significant threat to rebuilding of the stock as a whole, the magnitude of which remains unclear as long as total catch rates are unknown. When assessing risk for the Laurentian North DU, it is important to note that the two stocks in this population have previously shown positive signs of recovery following severe reductions in fishing pressure. This is in contrast to cod in other areas, such as the Newfoundland & Labrador DU and the Eastern Scotian Shelf component of the Laurentian South DU, where reductions in fishing pressure have not been associated with a significant recovery. Also, 3Ps seems dominated by a few year classes, and Brattey and Healey (2006) cautioned that as the dominant 1997 and 1998 year classes leave the fishery, the result could be an increase in fishing mortality for younger year classes which should be accounted for. The 2009 assessment indicates that spawner biomass in this stock has in fact declined by a factor of 3 since 2004. For the Laurentian South DU, it is the rate of change here which is noteworthy. Cod in the southern Gulf have undergone a 100-200% increase in the decline rate in just a few years and this rate of change is largely of unknown causes, though predation may be implicated.

TECHNICAL SUMMARY – ARCTIC LAKES

Gadus morhua
Atlantic Cod
Arctic Lakes population
morue franche
population des lacs de l'Arctique
Range of Occurrence in Canada: Southwest Baffin Island, Nunavut

Demographic Information

Generation time (average age of parents in the population)	10.0 yrs
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 or 5 years, or 3 or 2 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Unknown
Are the causes of the decline understood?	Unknown
Have the causes of the decline ceased?	Unknown
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown
Are there extreme fluctuations in number of populations?	Unknown

Extent and Area Information

Estimated extent of occurrence	<20 km²
[Observed, inferred, or projected] trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	<20 km²
[Observed, inferred, or projected] trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	Unknown
Is the total population severely fragmented?	Yes, probability of migration among lakes is likely very low.
Number of current locations	3
Trend in number of locations	none
Are there extreme fluctuations in number of locations?	no
Trend in [area and/or quality] of habitat	Unknown

Number of mature individuals in each population

Population	N Mature Individuals
Total	Unknown
Number of populations (locations)	three

Quantitative Analysis

	None

Threats (actual or imminent, to populations or habitats)

Increased angling pressure in Ogac Lake has been identified as a concern by local inhabitants.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Newfoundland and Labrador population is at a historic low, as is cod in Greendland.	
Is immigration known?	High genetic differentiation would be consistent with no migration
Would immigrants be adapted to survive in Canada?	Unknown, lakes are distinct habitats
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	Unlikely

Current Status

COSEWIC: Special Concern (April 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	N/A

Reasons for designation:

This designatable unit (DU) exists in 3 isolated lakes on Baffin Island, Nunavut. The combined surface area of the 3 lakes is less than 20 km^2. Rescue from other DUs is not possible. One of the lakes, Ogac Lake, is accessible for fishing and large numbers of the species may be removed from the lake if fishing increases.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion A as two population estimates spanning > 40 years indicate no change in abundance in one lake.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): None undertaken.

TECHNICAL SUMMARY – ARCTIC MARINE

Gadus morhua
Atlantic Cod — morue franche
Arctic Marine population — population marine de l'Arctique
Range of Occurrence in Canada: Nunavut, Northwest Atlantic Ocean
This population includes the Northwest Atlantic Fisheries Organization (NAFO) Divisions 0A and 0B.

Demographic Information

Generation time (average age of parents in the population)	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 or 5 years, or 3 or 2 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	Unknown
Are the causes of the decline understood?	Unknown
Have the causes of the decline ceased?	Unknown
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown
Are there extreme fluctuations in number of populations?	Unknown

Extent and Area Information

Estimated extent of occurrence	50,000 km²
[Observed, inferred, or projected] trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	Unknown
[Observed, inferred, or projected] trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	Unknown
Is the total population severely fragmented?	Unknown
Number of current locations	N/A
Trend in number of locations	N/A
Are there extreme fluctuations in number of locations?	N/A
Trend in [area and/or quality] of habitat	Unknown

Number of mature individuals in each population

Population: Arctic Marine	**N Mature Individuals**
Total	Unknown
Number of populations (locations)	Unknown

Quantitative Analysis

	None

Threats (actual or imminent, to populations or habitats)

Unknown

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Newfoundland and Labrador and Greenland populations are at low levels.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Likely
Is rescue from outside populations likely?	Unknown

Current Status

COSEWIC: Data Deficient (April 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Data Deficient	N/A
Reasons for designation: Information to establish any COSEWIC status category with assurance is not available. Data on distribution, abundance, habitat, and changes over time are insufficient.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY – NEWFOUNDLAND AND LABRADOR

Gadus morhua
Atlantic Cod — morue franche
Newfoundland and Labrador population — population de Terre-Neuve-et-Labrador
Range of Occurrence in Canada: Newfoundland and Labrador, Northwest Atlantic Ocean
This population includes the Northwest Atlantic Fisheries Organization (NAFO) Divisions 2GHJ and 3KLNO

Demographic Information

Generation time (average age of parents in the population)	11.0 yrs
Observed percent reduction in total number of mature individuals over the last 3 generations	97-99%
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	Yes
Have the causes of the decline ceased?	No
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	620,000 km²
[Observed, inferred, or projected] trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unhnown
Index of area of occupancy (IAO)	318,000 km²
[Observed, inferred, or projected] trend in area of occupancy	Rapid decline as the population declined in the early 1990s
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	N/A
Trend in number of locations	N/A
Are there extreme fluctuations in number of locations?	N/A
Trend in [area and/or quality] of habitat	Unknown

Number of mature individuals in each population

Population	N Mature Individuals
Total	Approx. 40,000,000
Number of populations (locations)	Unknown

Quantitative Analysis

	none

Threats (actual or imminent, to populations or habitats)

- directed commercial and recreational fishing
- fishing during spatial overlap between inshore residents and offshore migrants in northern cod stock
- fisheries bycatch
- illegal fishing and other sources of unreported bycatch
- fishing-induced natural changes to the ecosystem
- predation by Harp Seals and other predators on the northern cod stock
- habitat alteration is possible but un-evaluated threat

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Laurentian North is at low level	
Is immigration known? Yes	
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Probably
Is rescue from outside populations likely?	Low

Current Status

COSEWIC: Endangered (April 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	A2b

Reasons for designation:

This designatable unit (DU) includes the cod management units 2GH, 2J3KL and 3NO, located in the inshore and offshore waters of Labrador and eastern Newfoundland, and the Grand Banks. Cod in this area have declined 97-99% in the past 3 generations and more than 99% since the 1960s. The area of occupancy declined considerably as the stock collapsed in the early 1990s. The main cause of the decline in abundance was overfishing, and there has been a large reduction in the fishing rate since 1992. However, the population has remained at a very low level with little sign of substantive recovery. The most recent surveys indicate an increase in abundance over the past 3 years; however, this change in abundance is very small compared to the measured decline over the past 3 generations. The extremely low level of abundance and contracted spatial distribution makes the population vulnerable to catastrophic events, such as abnormal oceanographic conditions. Threats from fishing, predation, and ecosystem changes persist. There is no limit reference point (LRP) for the 2J3KL management unit but the population in this area is considered to be well below any reasonable LRP value. The offshore 2J3KL fishery is under moratorium and there is an inshore stewardship fishery with no formal total allowable catch (TAC). The fishery in the 3NO management unit is also under moratorium. There is an LRP for this management unit and the population is well below this value.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b as there has been a measured decline of 97-99 % over the past 3 generations. While the causes of the decline are understood, threats persist, they are not fully understood, and they are not clearly reversible.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet the criterion.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet the criterion.
Criterion D (Very Small Population or Restricted Distribution): Does not meet the criterion.
Criterion E (Quantitative Analysis): Not undertaken.

TECHNICAL SUMMARY – LAURENTIAN NORTH

Gadus morhua
Atlantic Cod — morue franche
Laurentian North population — population nord-laurentienne
Range of Occurrence in Canada : Newfoundland and Labrador, Quebec, Atlantic Ocean
This population includes the Northwest Atlantic Fisheries Organization (NAFO) Divisions 3P and 4RS.

Demographic Information

Generation time (average age of parents in the population)	10.0 yrs
Observed, percent reduction in total number of mature individuals over the last 3 generations.	76 - 89%
Percent reduction in total number of mature individuals over the next 3 generations.	Unknown
Percent reduction in total number of mature individuals over a 3 generation period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	Yes
Have the causes of the decline ceased?	No
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	155,000 km²
trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	90,000 km²
trend in area of occupancy	increase
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	Unknown
Trend in number of locations	Unknown
Are there extreme fluctuations in number of locations?	Unknown
Trend in [area and/or quality] of habitat	Unknown

Number of mature individuals in each population

Population	N Mature Individuals
Total	Approx. 60,000,000
Number of populations (locations)	Unknown

Quantitative Analysis

	None

Threats (actual or imminent, to populations or habitats)

- directed commercial and recreational fishing
- fisheries bycatch
- illegal fishing and other sources of unreported bycatch
- fishing-induced natural changes to the ecosystem
- predation by Harp Seals and other predators on the Northern Gulf stock
- habitat alteration is possible but an un-evaluated threat.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Newfoundland and Labrador population is at historic low, Laurentian South population is at historic low and declining.	
Is immigration known?	Yes
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Likely
Is rescue from outside populations likely?	Low

Current Status

COSEWIC: Endangered (April 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	A2b

Reasons for designation:
Populations in this designatable unit (DU) have declined 76-89% in the past 3 generations. The main cause of the decline in abundance was overfishing and there is no indication of recovery. This DU includes the cod management units 3Ps and 3Pn4RS. A limit reference point (LRP) has been estimated for the 3Pn4RS management unit. The abundance for this management unit has been relatively stable over the past decade, but it is well below the LRP, and directed fisheries continue. Abundance in southern Newfoundland (3Ps) is declining. The assessment indicates that this management unit is at the LRP, and directed fisheries continue.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b as there has been a measured decline of 76-89 % over the past 3 generations. While the causes of the decline are understood, threats persist, and they are not clearly reversible.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet the criterion
Criterion C (Small and Declining Number of Mature Individuals): Does not meet the criterion.
Criterion D (Very Small Population or Restricted Distribution): Does not meet the criterion.
Criterion E (Quantitative Analysis): Not undertaken.

TECHNICAL SUMMARY – LAURENTIAN SOUTH

Gadus morhua
Atlantic Cod — morue franche
Laurentian South population — population sud-laurentienne
Range of Occurrence in Canada: Quebec, Prince Edward Island, Nova Scotia, New Brunswick, Atlantic Ocean
This population includes the Northwest Atlantic Fisheries Organization (NAFO) Divisions 4TVW

Demographic Information

Generation time (average age of parents in the population)	9.0 yrs
Observed percent reduction in total number of mature individuals over the last 3 generations.	90%
Projected percent reduction in total number of mature individuals over the next 3 generations.	87-98% (based on projections for 4T)
Percent reduction [or increase] in total number of mature individuals over any period, including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	no
Are there extreme fluctuations in number of populations?	no

Extent and Area Information

Estimated extent of occurrence	Approx-120,000 km²
Trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	95,000 km²
Trend in area of occupancy	Declining
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	N/A
Trend in number of locations	N/A
Are there extreme fluctuations in number of locations?	N/A
Trend in [area and/or quality] of habitat	Unknown

Number of mature individuals in each population

Population	N Mature Individuals
Total	Approx 48,000,000
Number of populations (locations)	Unknown

Quantitative Analysis

The population will continue to decline in the absence of fishing	Yes

Threats (actual or imminent, to populations or habitats)

- natural mortality (i.e., predation by Grey Seals and other predators)
- directed commercial and recreational fishing
- fisheries bycatch
- illegal fishing and other sources of unreported bycatch
- fishing-induced natural changes to the ecosystem
- habitat alteration is possible but an un-evaluated threat.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Both Laurentian North and Southern stocks continue to be at historic low abundances.	
Is immigration known?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Likely
Is rescue from outside populations likely?	Low

Current Status

COSEWIC: Endangered (April 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	A2b+3b+4b; E

Reasons for designation:

Populations in this designatable unit (DU) have declined by 90% in the past 3 generations. The main cause of the rapid decline in abundance during the early 1990s was overfishing. Commercial fisheries were curtailed in 1993 and the abundance stabilized for a number of years. However, increased natural mortality and continued small catches have caused the abundance to decline again. Quantitative analysis of population demographic parameters indicate the population will continue to decline in the absence of fishing if the current elevated level of natural mortality persists. This DU includes the cod management units 4TVn (November – April), 4Vn (May – October) and 4VsW. A limit reference point (LRP) has been estimated for the 4TVn management unit and the current status is assessed to be well below the LRP. An LRP has not been estimated for the 4VsW management unit; however, it is considered to be at a critically low level.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b+3b+4b as the population has declined by 90% over the past 3 generations and it is forecast that the remaining 10% will decline by a further 90% in the next 3 generations under current conditions and in the absence of fishing.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion.
Criterion D (Very Small Population or Restricted Distribution): Does not meet criterion.
Criterion E (Quantitative Analysis): Meets criterion E for Endangered. The Southern Gulf of St. Lawrence portion of the DU is projected to become extirpated (< 1000 t) in 40 years (4.4 generations). The Eastern Scotian Shelf portion of the DU is forecast to decline in the absence of fishing.

TECHNICAL SUMMARY – SOUTHERN

Gadus morhua
Atlantic Cod
Southern population

morue franche
population du Sud

Range of Occurrence in Canada: New Brunswick, Nova Scotia, Atlantic Ocean
This population includes the Northwest Atlantic Fisheries Organization (NAFO) Division 4X and the Canadian portions of NAFO 5Y and 5Z.

Demographic Information	
Generation time (average age of parents in the population)	7.5 yrs
Observed percent reduction in total number of mature individuals over the last 3 generations.	Approx. 64%
Percent reduction in total number of mature individuals over the next 3 generations.	Unknown
Percent reduction or increase in total number of mature, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown
Are there extreme fluctuations in number of populations?	Unknown

Extent and Area Information	
Estimated extent of occurrence	120,000 km²
[Observed, inferred, or projected] trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	23,000 km²
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	N/A
Trend in number of locations	N/A
Are there extreme fluctuations in number of locations?	N/A
Trend in [area and/or quality] of habitat	Unknown

Number of mature individuals in each population	
Population	**N Mature Individuals**
Total	5,000,000-15,000,000
Number of populations (locations)	Unknown

Quantitative Analysis	
	None

Threats (actual or imminent, to populations or habitats)

- directed commercial and recreational fishing
- fisheries bycatch
- natural mortality (i.e., predation by Grey Seals and other predators)
- illegal fishing and other sources of unreported bycatch
- fishing-induced natural changes to the ecosystem
- habitat alteration is possible but an un-evaluated threat.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Georges Bank US population is at historic low, as is Laurentian South population	
Is immigration known?	Yes
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Likely
Is rescue from outside populations likely?	Low

Current Status

COSEWIC: Endangered (April 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2b

Reasons for designation:

Populations in this designatable unit (DU) have declined by 64% in the past 3 generations and the decline is continuous. Commercial fishing is ongoing and is an important contributor to the decline. As well, there is evidence of an unexplained increase in natural mortality in the 4X portion of the DU. Rescue from the US population is unlikely given the low abundance of the species in that area. This DU includes the cod management units 4X5Y and 5Zjm. There is a directed fishery for the species in the 4X5Y area, and although there is no limit reference point (LRP), recent fishery management advice indicates that this management unit is at a critically low level. There is also a directed fishery in the 5Zjm management unit and this fishery is co-managed with the United States.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b as there has been a 64% decline in abundance over 3 generations. The causes of decline have not ceased, they are not fully understood, and they may not be reversible.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet the criterion.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet the criterion.
Criterion D (Very Small Population or Restricted Distribution): Does not meet the criterion.
Criterion E (Quantitative Analysis): Not undertaken.

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Treble, M. 2008. Research Scientist, Department of Fisheries & Oceans, Winnipeg, MB.

INFORMATION SOURCES

Andersen, Ã.i., O.F. Wetten, M.C. De Rosa, C. Andre, C. Carelli Alinovi, M. Colafranceschi, O. Brix, and A. Colosimo. 2009. Haemoglobin polymorphisms affect the oxygen-binding properties in Atlantic Cod populations. Proceedings of the Royal Society B: Biological Sciences 276:833-841.

Baird, J.W., Bishop, C.A., Brodie, W.B., and E.F. Murphy. 1992. An assessment of the cod stock in NAFO divisions 2J3KL. NAFO Scientific Council Research Document 92/18.

Beacham, T.D. 1983. Growth and maturity of Atlantic Cod (*Gadus morhua*) in the southern Gulf of St. Lawrence. pp. 35 Canadian Technical Reports in Fisheries and Aquatic Sciences 1142: 31 p.

Beacham, T.D., Brattey, J., Miller, K.M., Le, K.D., and R.E. Withler. 2002. Multiple stock structure of Atlantic Cod (*Gadus morhua*) off Newfoundland and Labrador determined from genetic variation. ICES Journal of Marine Science 59: 650-665.

Benoît, H.P. 2006. Standardizing the southern Gulf of St. Lawrence bottom-trawl survey time series: results of the 2004-2005 comparative fishing experiments and other recommendations for the analysis of the survey data. *Department of Fisheries and Oceans Canadian Stock Assessment Secretariat Research Document* 2006/008.

Bentzen, P., Taggart, C.T., Ruzzante, D.E., and D. Cook. 1996. Microsatellite polymorphism and the population structure of Atlantic Cod (*Gadus morhua*) in the northwest Atlantic. Canadian Journal of Fisheries and Aquatic Sciences 53: 2706-2721.

Beverton, R.J.H., Hylen, A., and O.J. Ostvedt. 1994. Growth, maturation, and longevity of maturation cohorts of Northeast Arctic cod. ICES Journal of Marine Science Symposium 198: 482-501.

Bigg, G.R., C.W. Cunningham, G. Otterson, G.H. Pogson, W.R. Wadley, and P.W. Williamson. 2008. Ice-age survival of Atlantic Cod: agreement between paleoecological models and genetics. Proceedings of the Royal Society B: Biological Sciences 275: 163-172.

Billerbeck, J.M., Orti, G., and D.O. Conover. 1997. Latitudinal variation in vertebral number has a genetic basis in the Atlantic silverside, *Menidia menidia*. Canadian Journal of Fisheries and Aquatic Sciences 54: 1796-1801.

Bishop, C.A., E.F. Murphy, M.B. Davis, J.W. Baird and G.A. Rose. 1993. An assessment of the cod stock in NAFO divisions 2J+3KL. NAFO SCR Doc. 93/86.