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A Discussion of the NAFO Precautionary Approach Framework

By

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**Abstract**

In 2004, the Fisheries Commission of the Northwest Atlantic Fisheries Organization (NAFO) adopted a precautionary approach (PA) framework for the management of NAFO fish and shellfish stocks. The framework, which operates on a single stock at a time, identifies five zones into which a stock can be classified, depending on the status of the stock with respect to fishing mortality and biomass. The framework specifies various reference points which define zones, as well as corresponding recommended strategies and management actions associated with each zone. In NAFO, scientists working within Scientific Council have responsibility to provide advice on stock status and reference points, while it is managers working within Fisheries Commission who specify the management objectives, courses of action, time horizons, and acceptable levels of risk. Development and implementation of the framework has sometimes been accomplished through special NAFO Working Groups comprising scientists and managers. A recent initiative within NAFO has been the development of conservation plans and rebuilding strategies for some depleted stocks, which have drawn on the current PA framework in establishing harvest control rules. This process has also resulted in some questions around the adequacy of the existing framework. This paper will document the development of the NAFO precautionary approach framework, the current status of implementation and its many challenges. The paper will also discuss implementation in the context of the recently developed rebuilding strategies for depleted groundfish stocks such as Atlantic cod and American plaice on the Grand Bank.

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## Introduction

This paper documents the development of the Precautionary Approach Framework (PAF) within the Northwest Atlantic Fisheries Organization (NAFO), from 1997 to the present. NAFO is the regional fisheries management organization for much of the northwest Atlantic Ocean (Fig. 1), including the productive Grand Bank and Flemish Cap areas. NAFO came into being in 1979 following extension of jurisdiction, as a successor to ICNAF, and now consists of 12 members, or contracting parties, including Canada, USA, European Union, Russia, Norway, and Japan. It is headquartered in Dartmouth, Canada. The constituent bodies of NAFO include the Scientific Council (SC), which provides scientific advice on the fishery resources, and the Fisheries Commission (FC), which manages the fishery resources entirely within or straddling the NAFO Regulatory Area, i.e. the area outside the exclusive economic zones (EEZ) jurisdiction of the Coastal States. There are eighteen such stocks within NAFO at present, mostly demersal finfish stocks such as cod, flatfish, and redfish, but also including some shrimp, capelin, and squid stocks (Table 1).

Many of the stocks under NAFO management were overfished through the 1980's and early 1990's, leading to severe resource depletion and closure of directed fishing for many of these by the mid 1990's. Subsequent to the adoption of the UN Fish Stock Agreement in 1995, NAFO began to discuss a precautionary approach to fisheries management, leading to the eventual adoption of the precautionary approach framework (PAF) shown in Fig. 2. This PAF identifies five zones into which a stock can be classified, depending on the status of the stock with respect to fishing mortality and biomass. Various reference points on the two axes, identified as limits and buffers, define the zones, and the PAF provides recommendations for corresponding harvest control rules (HCR) and management actions for each zone.

The paper focuses exclusively on PA development within NAFO. To examine the details, the authors followed the outline below, as proposed by the ICES Theme Session convenors for documenting and discussing the frameworks.

### 1) Documenting the NAFO PA framework

- a) The legal basis: It may not be a legal basis *per se*, but development of the PAF in NAFO was in response to the 1995 UN Fish Stock Agreement (NAFO, 1997a). In 1997, in replying to a request from FC at the NAFO annual meeting in 1996, SC reviewed the development, evolution and application of the precautionary approach in fisheries management, including in ICES and other jurisdictions, and “endorsed the precautionary approach as described in Article 6 and Annex II of the UN Agreement of the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. In addition, the Council intends to use the practical guidance given ... on how to exercise such precaution.” (NAFO, 1997b). In 2004, a version of the PA that was advised by SC was formally adopted by Fisheries Commission (NAFO, 2004a). It should be noted that individual NAFO member states may have legal requirements for their nationally managed fisheries that are not necessarily reflected in the NAFO PAF.
- b) History of fisheries development and stock status: There is no specific provision in the NAFO PA framework regarding whether the aim is to correct past sins or to prevent fishing in the future. Many stocks in NAFO were severely depleted and under moratorium when the PAF development began in 1997, so this obviously influenced the thinking considerably. Aspects of rebuilding stocks

and preventing overfishing in future are meant to be incorporated in the NAFO approach, although the latter aspect is more obvious in the PAF. Early discussion on the PA in NAFO focused on development of reference points for stocks, and associated decision (harvest control) rules based on stock status relative to these reference points.

- c) Status of knowledge about fisheries: Data rich, data moderate, and data poor situations were explicitly considered in the initial discussions of the PAF (Serchuk et al., 1997), as well as in subsequent deliberations (NAFO, 2004b). Stocks representing all three situations are present in NAFO, ranging from stocks with data-rich age-structured assessment models, such as American plaice and cod on the Grand Bank, to those which are data-poor, having only catch and or limited survey data (e.g capelin on the Grand Bank). In data rich stocks, it has been possible to evaluate the outcome of a modeled population against the reference points for biomass and fishing mortality. For some data poor stocks, a proxy for Blim exists, based for example on a time series of survey data, against which the current status of the stock (survey index) can be evaluated (e.g witch flounder in 2J3KL). Table 1 shows the eighteen NAFO managed stocks, noting which are currently open or closed to fishing, and the stocks for which PA reference points, HCR, and/or rebuilding plans currently exist. It should be noted that it is not possible to categorize each stock according to PA-Zone, due mainly to the lack of reference points and estimates of fishing mortality for many stocks.

Initial discussions aimed at implementing the PA within NAFO suggested developing approaches for a stock with a closed fishery (3NO cod), one with an open fishery (3LNO yellowtail), and one with only limited data (3M shrimp) (NAFO, 1998a). The latter two were actually part of an FC pilot program to implement the PA.

One factor which has been contemplated but not specifically addressed in the PAF is the impact of changes in stock productivity on calculation of reference points. It has been recognized that reference points calculated on the long-term average productivity of the stocks are much different than those from just the more recent (lower productivity) time periods, and that, in some cases, the stocks are as much as 90% below the long-term reference points for biomass.

- d) Balance between the priority given to fisheries and marine conservation: Considering that NAFO is strictly a fisheries management organization, the focus of the PAF has been on that aspect alone. Other more recent measures (outside the PAF) have begun to address ecosystem level issues, although these have tended thus far to focus on very specific measures such as protection of corals and sponges, closure of seamounts, etc. Concerns over the balance between fishery yields and conservation was very much evident in early discussions on the PAF within NAFO, where it was suggested in 1998 that “the Precautionary Approach cannot mean conservation at any cost; economic and social aspects need to be considered” (NAFO, 1998a).

Given that a number of depleted NAFO stocks have been slow to recover, at least partly due to by-catch fishing mortality (Shelton and Morgan, 2005), and the fact that NAFO FC has set TACs above the PA-based advice for some stocks in recent years, the argument can be made that the emphasis has been more on short term fisheries objectives rather than on longer term rebuilding objectives. This was also evident in the development of the harvest control rule adopted by FC in 2010 for the Greenland halibut stock in NAFO waters, following a management strategy evaluation (MSE) (Shelton and Miller, 2009; Shelton, 2011). On the other hand, and notwithstanding the difficulties with by-catch, the PAF calls for no directed fishing when a stock is below Blim (in the critical zone), and adherence to this principle in almost all cases has prevented NAFO fisheries currently under moratorium from reopening at small stock sizes. This principle has not always been

applied, for example, to adjacent stocks in the Canadian EEZ, where some different approaches to fishing cod at stock sizes below Blim have been implemented.

e) Scope of frameworks: The scope, or at least the current application, of the NAFO PAF is essentially limited to a single species, fisheries-oriented approach. However, the PAF document adopted (NAFO, 2003b) states that “Ensuring no major stock is fished harder than the single-species Fmsy has often been recommended as a good first step towards ecosystem-based management. Ecosystem-based management will likely require even more conservative fishing mortality targets than “traditional” single species-based management.” It also recognizes multi-species concerns by noting the impossibility of achieving Bmsy for all stocks in an assemblage, and by advising that flexibility is required to account for technical interactions that result in unavoidable by-catch of depleted stocks.

There has been little or no socioeconomic analysis applied in the NAFO PA context. Initially there was considerable discussion of how or whether some related management measures aimed at conservation (closed areas, gear restrictions, by-catch limits, etc.) fit into the PA, but there was no explicit inclusion of these factors in the eventual PAF although NAFO has introduced area closures for other reasons.

## **2) Historical background in development of PAF in NAFO.**

Included in SC’s initial report on the PA in 1997 was a plan for implementation (NAFO 1997b), calling for the SC Chair to propose that FC adopt a draft PA framework proposed by SC (Serchuk et al. 1997 – see Fig. 4). FC endorsed the proposed action plan in 1997 (NAFO, 1998b), although the PA framework proposed by SC was not formally adopted at that time. It was agreed to have a joint WG meeting of scientists and managers in 1998 to facilitate productive discussions. Beginning in 1997, FC’s requests to SC for advice on stocks under NAFO management included specific requests for PA reference points, as well as other PA-worded requests (NAFO, 1998b), and SC began developing reference points and incorporating PA elements in its advice starting in 1998 (NAFO, 1998c).

Development of the PA progressed slowly through various joint FC-SC WG sessions in 1998-2002. Much of the debate focused on elements of the framework, on defining the roles of scientists and managers in the process, and on understanding and harmonizing the terminology used in PA development in various national and international fora, such as ICES and ICCAT (ICES, 2000). The WG also defined steps for the implementation of a PA for 2 stocks (3NO cod and 3LNO yellowtail), with the main elements being to determine PA reference points, and harvest control rules consistent with those reference points.

At an SC Workshop on the PA in March-April 2003, the NAFO PA framework was considered (NAFO, 2003a), in light of specific concerns expressed at a 2002 NAFO meeting of technical experts (NAFO, 2002). To address these concerns, a revised PA framework was proposed (Shelton et al., 2003), outlined in Fig. 2 and described above. The accompanying documentation pointed out how the revised framework attempted to address specifically each concern, such as no directed fishing below Blim,  $F_{lim} \leq F_{msy}$ , etc. Following further review and discussion by SC at its meetings in 2003, it proposed that the revised PAF as outlined be adopted, which it was (by FC in 2004). There has been no further development of the framework since then, although FC has posed some questions to SC on HCRs and reference points, and efforts on rebuilding plans for some stocks have recently begun (NAFO, 2011, 2012).

### 3) Describe national and regional factors that may explain differences between frameworks.

- a) Fishing mortality corresponding to overfishing: The limit for fishing mortality,  $F_{lim}$ , cannot be greater than  $F_{msy}$  in the NAFO PAF, corresponding to the UNFA definition. A buffer around this value,  $F_{buf}$ , is defined in the PAF as: “A fishing mortality rate below  $F_{lim}$  that is required in the absence of analyses of the probability that current or projected fishing mortality exceeds  $F_{lim}$ . In the absence of such analyses,  $F_{buf}$  should be specified by managers and should satisfy the requirement that there is a low probability that any fishing mortality rate estimated to be below  $F_{buf}$  will actually be above  $F_{lim}$ . The more uncertain the stock assessment, the greater the buffer zone should be. In all cases, a buffer is required to signify the need for more restrictive measures.” In the PAF, overfishing is indicated to be occurring if  $F$  is above  $F_{buf}$  (see Fig 2 and definition of Zones 2 and 4). In practice,  $F_{buf}$  has not been defined for any stocks, although there are a few for which the probability of exceeding  $F_{msy}$  has been estimated and provided in advice to FC.
- b) A target biomass corresponding to Maximum Sustainable Yield: No specific biomass target is set in the NAFO PAF. The PAF documentation (NAFO, 2003b) notes that “the de-emphasis of  $B_{msy}$  avoids the problem of the impossibility of maintaining all stocks in a multi-species assemblage simultaneously at their respective single-species  $B_{msy}$ ”. However, it does state that in the safe zone, “target reference points are selected and set by managers based on criteria of their choosing (e.g. stable TACs; socio-economic considerations)”.  $B_{buf}$  currently delineates the start of the safe zone in the PAF, but in practice is only required for those stocks for which the risk of being below  $B_{lim}$  cannot be estimated, and is not explicitly identified as a target reference point. The earlier version of the framework proposed in 1997 did contain a provision for a target reference point (Fig 4), and current interim rebuilding plans for two NAFO stocks acknowledges a long-term objective to rebuild stocks to levels “at or near  $B_{msy}$ ” (NAFO, 2011).
- c) The biomass to be avoided that would correspond to an overfished or depleted stock or a stock at risk of impaired productivity (e.g. recruitment overfishing): In the PAF, this reference point is denoted as  $B_{lim}$ , and is defined as “A biomass level, below which stock productivity is likely to be seriously impaired, that should have a very low probability of being violated.” The selection of a value for  $B_{lim}$  depends on a number of factors, including whether or not a stock-recruit relationship exists (or can be detected). SC gave this aspect of the PAF much consideration, and devoted a workshop to the topic in 2004 (NAFO, 2004b). This workshop considered, among other topics, the definition of serious harm, and various methods and proxies for calculating limit reference points. It also applied the proposed methods to several test cases (NAFO stocks) and proposed a rule-based, systematic approach to defining LRPs for NAFO stocks. The advice from this WS has been applied in calculating the existing reference points for most of the NAFO stocks.
- d) Risk tolerance for overfishing, stock depletion (below the biomass defined in c), and/or failure to recover to the target biomass (defined in b): The PAF states that the fishing mortality limit,  $F_{lim}$ , is a fishing mortality rate that should only have a low (<20%) probability of being exceeded. It also states that “Management action should be such that there is a very low (5-10%) probability that biomass will decline below  $B_{lim}$  within the foreseeable future (5-10 years).” These risk criteria have not been sufficiently tested through application within NAFO, partly because a number of stocks with  $B_{lim}$  estimates are already below  $B_{lim}$ . This risk tolerance in the NAFO PAF may become important in determining whether or not a fishery reopens in the future. No  $B_{lim}$  has been established for 2+3KLMNO Greenland halibut, but Shelton and Miller (2009) evaluated the risk associated with candidate management strategies of causing the SSB to fall below 40%  $B_{msy}$  (as a proxy for  $B_{lim}$ ) over the long term (20 years) as one of the performance measures.

- e) The time period required for recovery of stocks that need to be rebuilt: No time lines are specified in NAFO PAF for stock rebuilding. The timeline specified in d) above (foreseeable future i.e. 5-10 years) refers only to preventing stock decline below Blim. Trying to establish reasonable projected timelines for rebuilding the depleted stocks in NAFO has proved challenging, as only a few stocks (e.g. 3M cod, 3LNO yellowtail, 3LN redfish) have recovered after prolonged periods of no directed fishing, while others have remained at low levels, their recovery often impeded by mortality from by-catch. Factors other than by-catch also seem to be important for some stocks (e.g. 3NO capelin) which have remained at low levels despite very low catches.

#### **4) Implementation of the PA in NAFO.**

Implementation of the PA in NAFO has generally been slow to occur, and reasons for this have included the lack of reference points and/or related harvest control rules. It is therefore difficult in this paper to compare implementation over a number of stocks. There are some cases where PA implementation has occurred, at least partially, most notably for yellowtail flounder on the Grand Bank (see Fig. 3). For other stocks with ongoing fisheries, where Blim is available (e.g. 3LN redfish, 3M cod – see Table 1), probabilities of current stock size being below Blim are estimated to be very low. In other cases where fisheries are open (e.g. 3LNOPs skate, 3NOPs white hake, 2+3KLMNO Greenland halibut), no estimates of Blim are available. In several other cases (e.g. 3NO cod, 3LNO American plaice, 3M shrimp), probabilities of being below Blim are estimated to be high, and directed fisheries remain closed.

Blim is the key reference point in applying the NAFO PAF, as it is the biomass level separating the collapsed and cautionary F zones, and has been used in NAFO as a decision point for considering whether to allow directed fishing to occur. It is the reference point most available for NAFO stocks (Table 1), and although not all stocks have a Blim based on a stock-recruitment relationship, several have proxies for Blim based on trawl survey indices.

Bbuf, the boundary of the PAF which separates the cautionary F zone from the safe zone (Fig 2), has not been defined for any NAFO stocks, and therefore has not been used in management of the stocks. As noted in the PAF, this reference point is only necessary when the probability of going below Blim is not available. However, the recent development of rebuilding plans for some NAFO stocks has raised questions around the need for additional reference points, either as milestones for stock rebuilding, and/or as points where changes in HCRs can be applied.

#### **5) Scientific integrity of frameworks (are they science based, or do they overstretch science?)**

The NAFO PAF is Science-based, as the version adopted in 2004 by FC was the one proposed by SC, without modification. As noted above, much of the earliest development of the PAF in NAFO occurred in WG sessions consisting of scientists and managers. Data and/or model limitations are the main reasons why reference points have not been defined for many stocks, although proxies have been used in many cases. The recent development of HCRs in the rebuilding plans for 3NO cod and 3LNO American plaice has raised some questions around the scientific basis of the HCRs, including their “testability”, and has pointed to MSE as the preferred tool in development of HCRs.

## Discussion

Throughout the introduction and early development of its PAF, NAFO had to work through a number of basic issues. These included the roles and responsibilities of scientists and managers in the PA process, whether or not to include other “best management practices” directly in the PAF language, how best to define limit ref pts, how specific the HCR associated with the PAF needed to be (i.e. formulaic or general guidelines), how the PAF might apply to stocks with different levels of data availability, etc. Sorting out these issues, combined with refinements to the actual PAF first proposed in 1997, took place over a number of meetings and years, before the current PAF was adopted in 2004. The current PAF is quite similar to the original version, in that it uses similar reference points and zones for stock status. One key improvement in the current version is in the accompanying descriptions and documentation, much of which was provided to address specific concerns that had been raised about the original PAF.

A number of factors have affected implementation of the PA in NAFO, beyond the initial concerns with the specifics of the framework. Although PA-based advice has been sought by FC since 1997, it has not always been possible for SC to provide the necessary advice on PA ref pts and related stock status, due mainly to data-related issues. Also, SC has occasionally provided PA-based advice that either has not been followed immediately by FC in managing the stocks (e.g. 3M shrimp – moratorium advice rejected in 2009), or has been phased in over a longer period (e.g. 3L shrimp). There are few stocks open to fishing for which actual HCRs have been applied, although there is increased emphasis on this aspect since 2010, with the best example being the Greenland halibut stock and the MSE used to produce a survey-based HCR for TACs from 2011 onward.

More recently, NAFO has developed conservation plans and rebuilding strategies (CPRS) for some depleted stocks, again through a WG consisting of fisheries managers and scientists. This has focused some attention on the PAF, in particular on the concepts of reopening criteria, rebuilding targets, reference points, and HCRs. The interim plans (NAFO, 2011) developed thus far for cod and American plaice on the Grand Bank have a long term objective of rebuilding spawner biomass to the Safe Zone of the PAF, at or near Bmsy. However, Bmsy is neither explicitly stated as a target reference point, nor are any timelines stated for the rebuilding objectives. Achieving a very low risk (5-10%) of not falling below Blim in the next 5-10 years has not been fully articulated in the CPRS even though this is a fundamental aspect of risk management under the NAFO PAF. However, the CPRS do note that when the stock is above Blim but not yet in the safe zone, “TACs should result in a low probability of SSB declining below Blim throughout the subsequent 3-year period”.

The concept of buffer reference points, which is an element in both the original and current versions of the PAF, has never really been implemented in NAFO, and Bbuf or Fbuf have not been defined for any NAFO stocks. Although this reference point does delineate the start of the safe zone in the PAF, it is not required in, instances where the risk of exceeding the limit reference points can be provided. Target reference points are not defined explicitly in the PAF, but have been discussed in the development of the CPRS, particularly in the context of MSY-based ref pts. In the interim CPRS adopted by FC for the two stocks mentioned above, a new biomass reference point, BISR, (intermediate stock reference point) was introduced, with a

proposed value of 2 x Blim. SC was asked to review the specifics of this reference point and had no concerns in principle with additional reference points in the PAF, but was not able to provide a definitive response on B<sub>isr</sub> until its properties are better defined (NAFO, 2012). The NAFO default Blim under a Schaefer production model is 30%B<sub>msy</sub> (NAFO 2004b). If B<sub>isr</sub> is meant to be 2 x Blim, this would generate B<sub>isr</sub>=60%B<sub>msy</sub>. More typically 80%B<sub>msy</sub> is considered a lower boundary for acceptable SSB consistent with sustainable fisheries management in other PA frameworks. Further work on B<sub>isr</sub> as a reference point is required.

The recent work within NAFO on MSE and CPRS, combined with ongoing development of the PA in other fora such as ICES, has sparked some interest within NAFO to re-examine and possibly update its PAF. As stocks slowly recover and fisheries reopen (e.g. 3M cod, 3LN redfish), the need for accurate reference points and implementable harvest control rules within a precautionary approach framework will likely increase. The issue of whether or not productivity has changed such that reference points based on historical data may no longer apply is also an issue for some stocks such as Grand Bank American plaice.

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Table 1. Stocks under NAFO management, with relevant PA information.

Species	Stock	2012 TAC (t)	Reference points	HCR (if Biomass > Blim)	Rebldg Plan
Cod ( <i>Gadus morhua</i> )	3L *	0	no	no	no
	3M	9280	Blim	no	no
	3NO	0	Limits, and MSY-based	yes	yes/interim
American plaice ( <i>Hippoglossoides platessoides</i> )	3M	0	no	no	no
	3LNO	0	Limits, and MSY-based	yes	yes/interim
Witch flounder ( <i>Glyptocephalus cynoglossus</i> )	2J3KL	0	Blim	no	no
	3NO	0	no	no	no
Greenland halibut ( <i>Reinhardtius hippoglossoides</i> )	2+3KLMNO	16326	no	yes (MSE-based)	yes
Yellowtail flounder ( <i>Limanda ferruginea</i> )	3LNO	17000	Limits, and MSY-based	Not explicit (TACs set at $\leq 2/3$ Fmsy)	no
Redfish ( <i>Sebastes sp</i> )	3M	6500	no	no	no
	3LN	6000	Limits, and MSY-based	no	no
	3O	20000	no	no	no
White hake ( <i>Urophycis tenuis</i> )	3NO *	5000	no	no	no
Thorny skate ( <i>Raja sp</i> )	3LNO *	8500	no	no	no
Capeln ( <i>Mallotus villosus</i> )	3NO	0	no	no	no
Northern shrimp ( <i>Pandalus borealis</i> )	3M	0	Blim	no	no
	3LNO	12000	Blim	no	no
N shortfin squid ( <i>Illex illecebrosus</i> )	3+4	34000	no	no	no

\* adjacent portion of stock assessed and managed by Canada

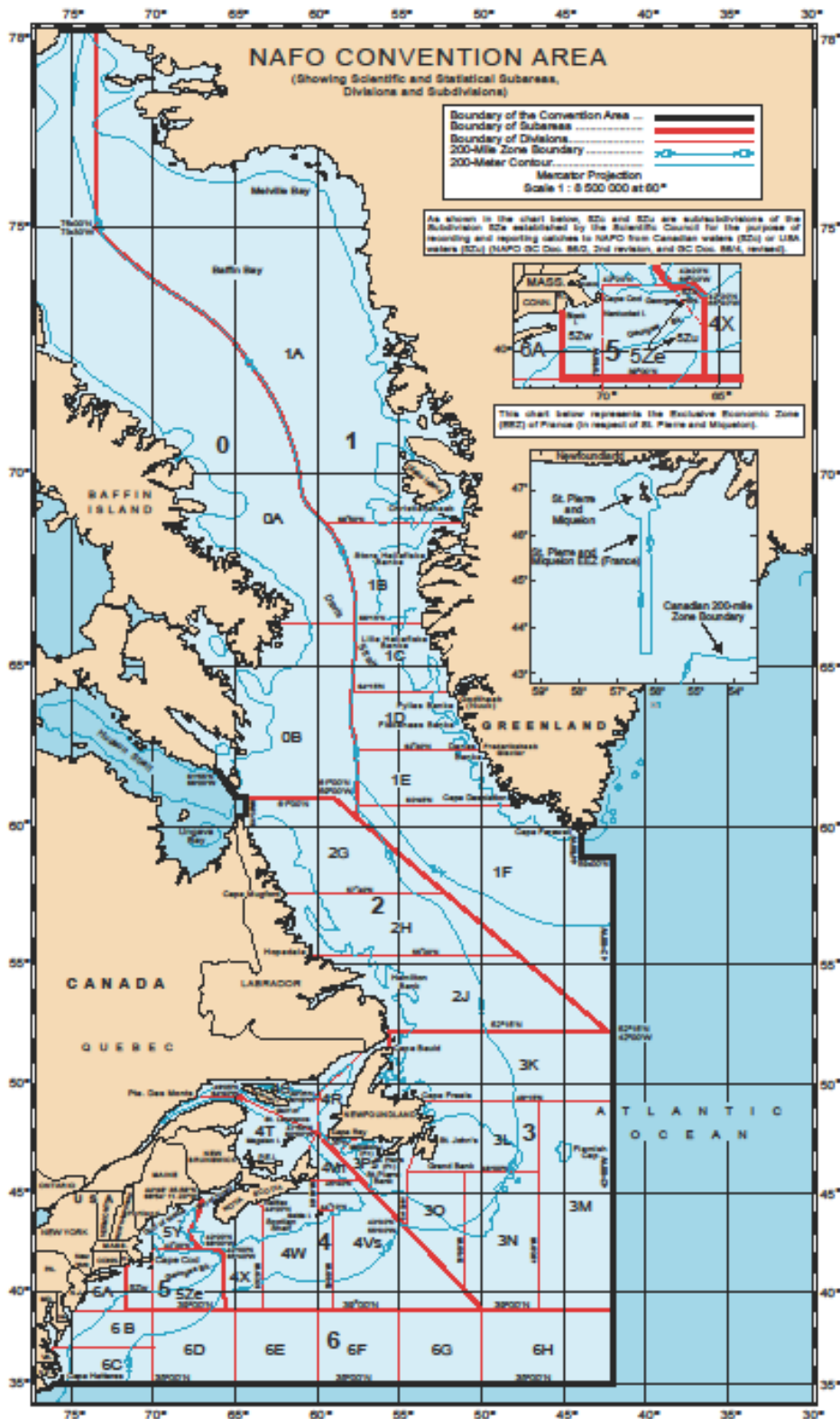
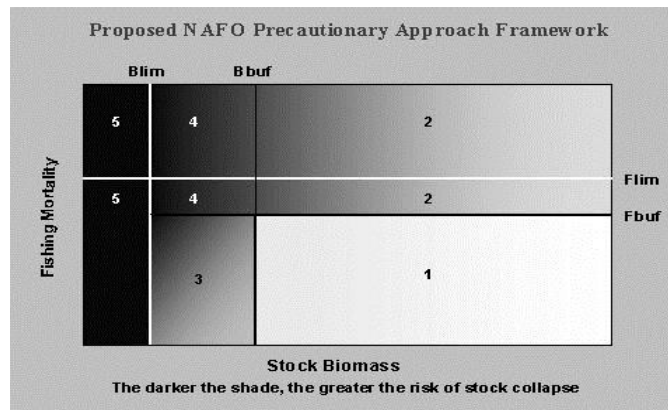


Fig 1 – Map of NAFO Convention Area



<b>MANAGEMENT STRATEGIES AND COURSES OF ACTION (TIME HORIZONS AND ACCEPTABLE RISK LEVELS SPECIFIED BY MANAGERS)</b>	
<b>Zone 1</b>	<b>Safe Zone:</b> Select and set fishing mortality from a range of F values that have a low probability of exceeding $F_{lim}$ in a situation where stock biomass (B) has a low probability of being below $B_{lim}$ . In this area, target reference points are selected and set by managers based on criteria of their choosing (e.g. stable TACs; socio-economic considerations).
<b>Zone 2</b>	<b>Overfishing Zone:</b> Reduce F to below $F_{buf}$ .
<b>Zone 3</b>	<b>Cautionary F Zone:</b> The closer stock biomass (B) is to $B_{lim}$ , the lower F should be below $F_{buf}$ to ensure that there is a very low probability that biomass will decline below $B_{lim}$ within the foreseeable future.
<b>Zone 4</b>	<b>Danger Zone:</b> Reduce F to below $F_{buf}$ . The closer stock biomass (B) is to $B_{lim}$ , the lower F should be below $F_{buf}$ to ensure that there is a very low probability that biomass will decline below $B_{lim}$ within the foreseeable future.
<b>Zone 5</b>	<b>Collapse Zone:</b> F should be set as close to zero as possible.

Fig. 2 – Schematic of current NAFO PA Framework, with brief explanations of the various zones

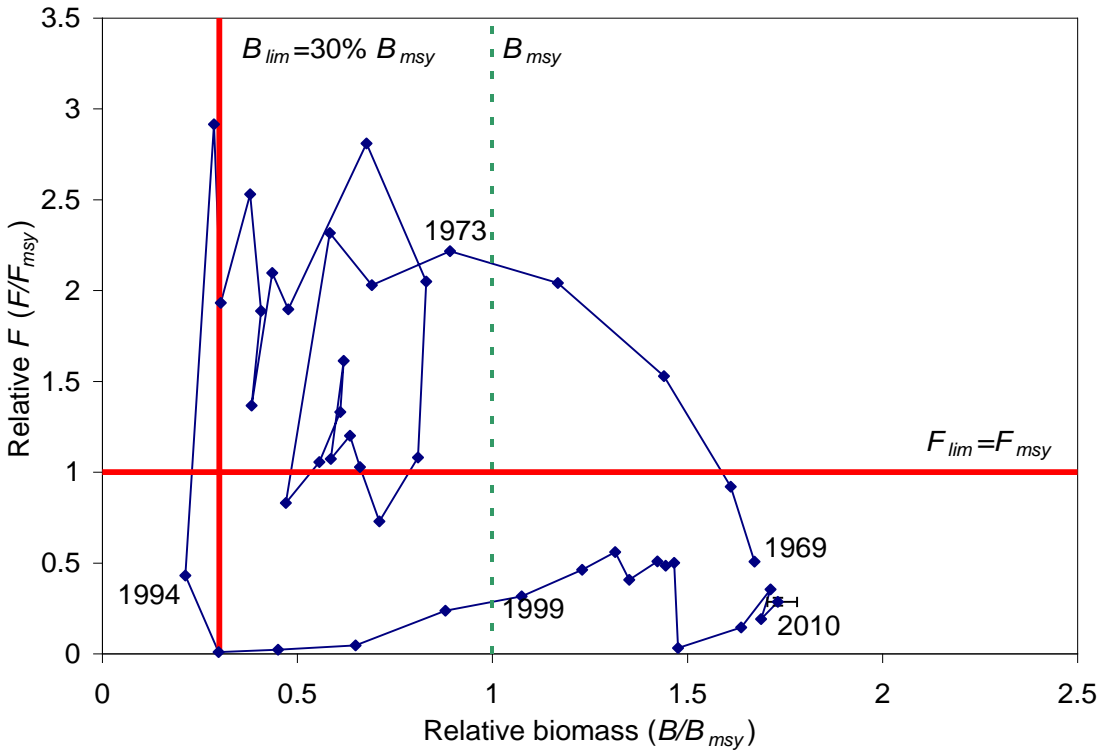


Fig. 3 – Yellowtail PA plot, with current relative estimates of Fishing mortality and biomass overlaid on the NAFO PA framework.

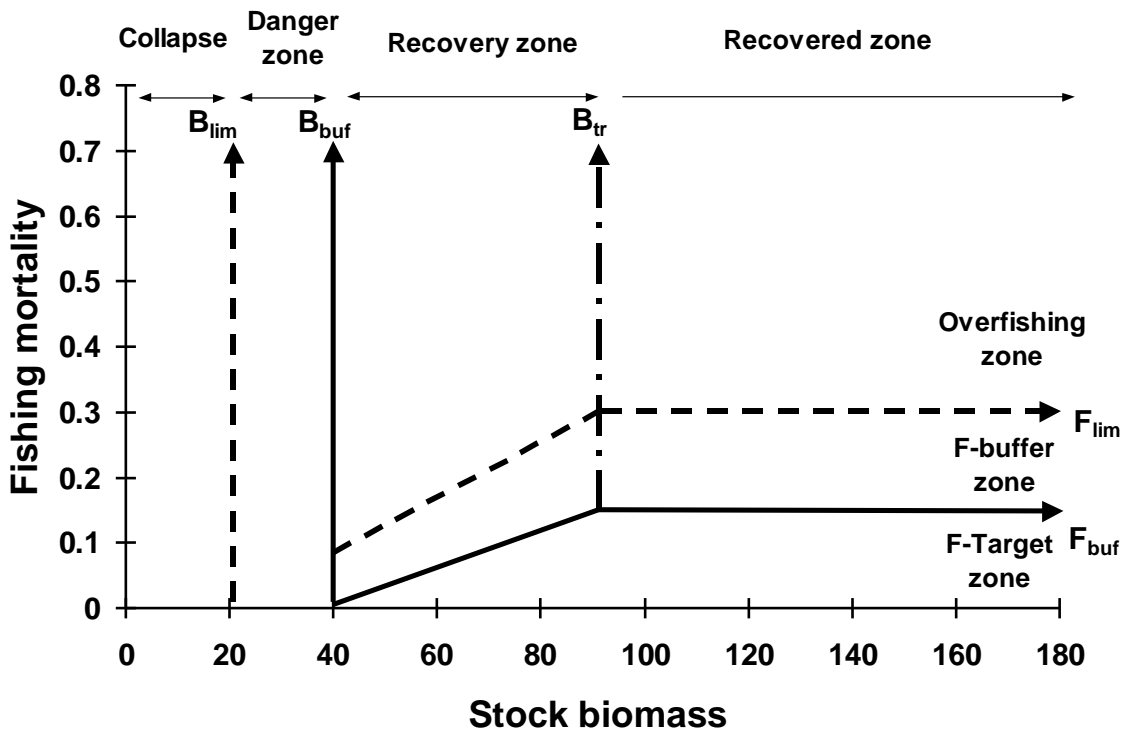


Fig 4 – Initial (1997) NAFO PA Framework.