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The application of small scale fishery closures to protect Atlantic cod spawning aggregations in the inshore Gulf of Maine

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ABSTRACT

Atlantic cod form spawning aggregations in locations and seasons that are persistent from year to year and individual fish have been shown to exhibit spawning site fidelity and home to specific spawning grounds each season. In the Gulf of Maine, cod are known to have historically occupied a mosaic of spawning grounds but many of these spawning components have been extirpated, primarily through overfishing, with a near complete loss of spawning along mid-coast and eastern Maine. The remaining spawning aggregations in the western Gulf of Maine are particularly vulnerable to over-exploitation owing to their proximity to shore, the predictability of their timing, the fine-scales upon which they operate, and the high density of fish within each aggregation. Broad scale management actions that are currently being discussed may allow an increased harvest from these spawning aggregations. In this paper we describe the creation of three small-scale area closures that serve to eliminate the exploitation and disturbance of discrete spawning aggregations of Atlantic cod and prevent the potential extirpation of these spawning components. Each closure was unique in the circumstances that surrounded their creation, including differences in the amount of prior protection from commercial and recreational exploitation, the timing and duration of the closure, the size of the closure area, the management body that had authority to enact the closure, the amount of monitoring that has occurred, and the amount of spatial or temporal modifications that have occurred since enactment. We believe the case for spawning closures for Atlantic cod has already been made by several authors and the purpose of this paper is not to present new science, but rather to show the path that was followed to create these spawning closures within the complicated array of fisheries management.

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1. Introduction

Recent efforts to manage and rebuild the Gulf of Maine (GOM) stock of Atlantic cod (*Gadus morhua*) have been based on reducing and controlling the fishing mortality rate (F) across the range of the stock (NEFMC, 1985). The assumption has been that a reduced F would result in growth of the stock to the target biomass, SSB_{msy} (the spawning stock biomass that produces maximum sustainable yield). This classical approach of simply controlling the fishing mortality rate to rebuild the stock has resulted in limited success. Despite reductions in landings and fishing effort, the most recent stock assessment for the GOM cod stock indicates that spawning stock biomass (SSB) has increased only slightly over the last fifteen years, and the stock remains in an overfished state (<1/2 SSB_{msy}) and overfishing continues to occur (F = 1.48) (Northeast Fisheries Science Center, 2012).

GOM cod is one of twenty demersal stocks regulated by the Northeast Multispecies Fishery Management Plan (FMP). From 1994 to 2009, the FMP relied on a complicated system of fishing effort controls. These included a series of large seasonal closed areas (henceforth referred to as "Rolling Closures") in the inshore GOM (Fig. 1) that were added in 1998 and 1999 in response to the ineffectiveness of more direct controls such as trip limits, minimum sizes, and days at sea limits (Murawski et al., 2000). While these closures were originally designed to reduce fishing mortality on seasonal aggregations of cod, over time the closures were modified to reduce fishing effort on a wide range of stocks. The closures targeted areas of high catch rates but were not explicitly intended to protect spawning aggregations. These closures only applied to commercial fishing vessels and did not constrain recreational activity, which included for-hire vessels. Beginning in 2010, management of the commercial fishery underwent a dramatic change, shifting

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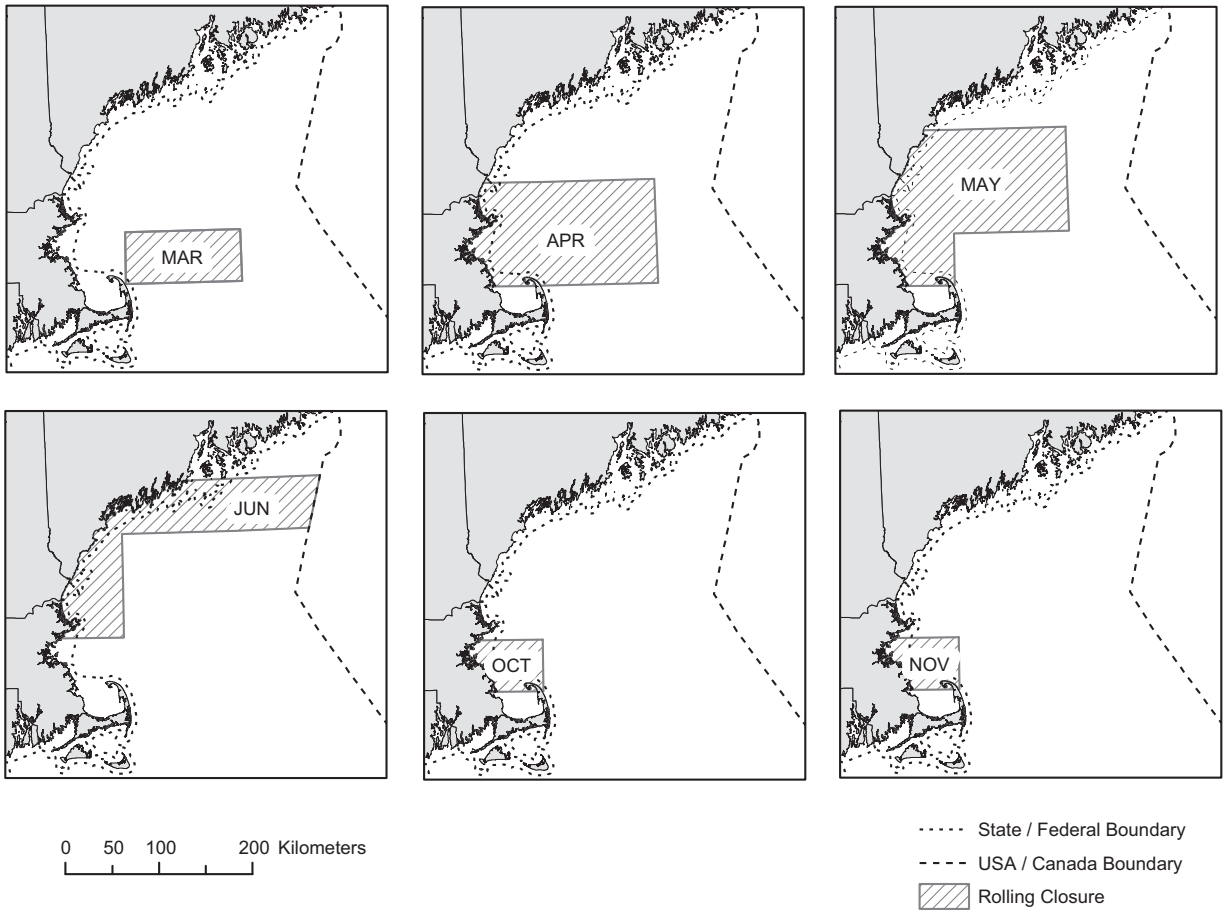

Fig. 1. The large seasonal closed areas (i.e., Rolling Closures) in the inshore GOM. These have been in place since the late 1990s under the Multispecies Fisheries Management Plan.

from primarily effort controls to a catch-share system that relies on quotas to control fishing mortality (NOAA, 2010). As a consequence, many commercial vessels in the catch-share system were given access to some of the Rolling Closures in nearshore areas.

Currently, managers are considering lifting additional Rolling Closures under the assumption that they are no longer necessary given that harvest is now controlled by hard quotas, as administered through catch shares. However, recent advances in the understanding of Atlantic cod population structure in the region (Wirgin et al., 2007; Ames, 2004; Kovach et al., 2010) have indicated that explicit protection of spawning aggregations needs to be considered and the protection afforded by Rolling Closures should be maintained perhaps on a smaller scale than previous closures.

Throughout their range, Atlantic cod form spawning aggregations in locations and seasons that are persistent from year to year (Robichaud and Rose, 2001; Wright et al., 2006; Vitale et al., 2008; Meager et al., 2010; Skjæraasen et al., 2011). Additionally, individual fish have been shown to exhibit spawning site fidelity and home to specific spawning grounds each season (Robichaud and Rose, 2001; Howell et al., 2008; Skjæraasen et al., 2011). In the GOM, cod are known to have historically occupied a mosaic of spawning grounds (Bigelow and Schroeder, 1953; Ames, 2004; O'Brien et al., 2005), and the stock has been described as a metapopulation, where individual spawning components function as subpopulations (Wright et al., 2006). However, many of the historic spawning components have been extirpated, primarily through overfishing, including nearly half of all spawning components in the GOM and a near complete loss of spawning along mid-coast and eastern Maine (Ames, 2004). Those spawning components that remain active are concentrated in the southern GOM and appear to occur on much smaller spatial scales than those described in historic documents (Bigelow and Schroeder, 1953). These well-defined spawning aggregations are particularly vulnerable to over-exploitation owing to their proximity to shore, the predictability of their timing, the fine-scales upon which they operate, and the high density of fish within each aggregation (Bigelow and Schroeder, 1953).

Although Atlantic cod in the GOM have been treated as a single stock for assessment and management purposes, recent genetic studies identify significant intra-specific diversity in US waters (Wirgin et al., 2007; Kovach et al., 2010). Much of this diversity is believed to be a result of the temporal and spatial variability in spawning (Howell et al., 2008; Kovach et al., 2010), spawning site fidelity (Perkins et al., 1997; Howell et al., 2008), and larval dispersal dynamics (Huret et al., 2007; Churchill et al., 2011). Therefore, the remaining spawning components demand robust protection from over-exploitation in order to maintain this diversity and prevent further collapse of population structure.

In recent years, additional protection has been applied to these aggregations by management agencies. Here we present three case studies where small scale spawning closures have been implemented, with each case varying in the circumstances surrounding their enactment. We describe the processes by which the areas were identified, how the closure boundaries were initially delineated and then spatially and temporally refined, the monitoring that has been conducted, and the benefits that we believe have been accrued as a result of these actions. We believe the case for spawning closures for Atlantic cod has already been made by several authors and the purpose of this paper is not to present new