## Title:

Rebuttal to Frank et al 2016

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## Abstract

## Introduction

Forage fish play a crucial role in many ecosystems, acting as a conduit of energy between lower trophic levels and large vertebrate predators. Forage fish are small shoaling species that characteristically have rapid growth, short life expectancies, and population responses tightly linked to environmental control. These characteristics lead this group of species to exhibit boom and bust dynamics, i.e. their abundance changes rapidly and substantially and undergo phases of extremely high and extremely low abundances (Schwartzlose et al. 1999, Chavez et al. 2003, Alheit et al. 2009, Pikitch et al. 2012).

Capelin is the focal forage species in ecosystem of the northern Atlantic Ocean (Templeman 1948, Jangaard 1974, Vilhjálmsson 1994, Carscadden et al. 2001). The three most important capelin populations in the North Atlantic are in the Barents Sea, Iceland, and Newfoundland and Labrador (Canada). The Barents Sea capelin stock underwent three collapses during the last 4 decades, during the mid- to late 1980s, mid-1990s, and mid-2000s. The size of the stock fluctuated between 3-7 million tonnes during the boom and around 200 thousand tonnes during the bust phases. There is general agreement that ecosystem changes were the driving forces behind these dynamics (Gjøsæter et al. 2009). The Icelandic capelin stock underwent similar dynamics, with three bust phases in the last 4 decades, in the early 1980s, in the early 1990s, and during most of the 2000s. The size of the stock was around 1.5- 2 million tonnes during the boom and between 100 and 500 thousand tonnes during the bust phases (ICES 2017).The first two cases were due to a combination of poor recruitment and the stock being easily available to the fishing fleet, while the last case was likely associated to a climate-related shift in distribution (Pálsson et al. 2012, Carscadden et al. 2013).

Iceland: From Carscadden et al 2013:

In Iceland, there were near collapses in the early 1980s  
and 1990s (e.g. Vilhjalmsson, 1994) and in the last number of years  
(especially in 2009, see e.g. ICES, 2009) the stock has persistently  
remained at very low levels. In the first two cases, these collapses  
were caused by a combination of poor recruitment concurring with  
easy availability of capelin to the fishing fleet. In the last case, however, most 0-group capelin have apparently drifted west to the  
Greenland plateau from the Denmark Strait and at least west to  
Ammassalik (Carscadden et al., 2013).

considerably less than acoustic abundances  
observed in 1988-90 (DFO 2008)

The 2010 estimate of abundance from the spring acoustic survey in Div. 3L is the lowest  
in the series, about 10% of recent values and less than 1% of historic levels (DFO 2010)

an order of magnitude  
below estimates of the 1980s. (DFO 2013)

NL: bust – no boom

Buren, Murphy

Frank et al argue no bust – 2 hypotheses: stayed inshore or timing mismatch

Weight of evidence to asses evidence to support collapse vs non collapse

Pelagics – key in ecosystems.   
Boom and bust dynamics– controlled bottom up?   
Capelin – northern Atlantic – Barents, Iceland, Newfoundland. Saw boom and bust in Iceland and Barents  
Bust in NL in early 1990s, no boom

Capelin (*Mallotus villosus*) play a crucial role as the link between zooplankton and large vertebrates in the Newfoundland and Labrador Shelf marine ecosystem (Lavigne 1996). This marine ecosystem underwent drastic changes during the early 1980s and early 1990s (Hutchings & Myers 1994, Gomes et al. 1995, Lilly et al. 2000, Rice 2002, Koen-Alonso et al. 2010, Hammill et al. 2011), including major changes in the biology and ecology of capelin (Carscadden & Nakashima 1997, Carscadden et al. 2001, Nakashima & Wheeler 2002, DFO 2010)

Despite its prominent position in the ecosystem, the factors that regulate the population dynamics of the capelin stock have not been well understood. Buren *et al*. (2014) postulated that the ecosystem underwent a regime shift in the early 1990s and that the dynamics of the capelin stock are regulated by bottom-up forcers acting through mortality of pre-spawning capelin. In addition, Murphy *et al.* (2018)

Mullowney *et al*. (2016) analyzed virtually the same data set as Buren *et al*. (2014) (Figure 1), and reached different conclusions. These authors postulated that the mechanism that modulates capelin abundance on the Newfoundland and Labrador Shelf is survival through the juvenile stage (age 0), explained by an interaction between a match–mismatch index (of timing of capelin spawning and timing of the spring bloom) and abundance of juvenile stages of *C. finmarchicus*.

In this letter we repeat the analyses presented in Buren et al. (2014), assuming that capelin is regulated at the juvenile stage (Mullowney et al.’s (2016) conclusion), and compare the empirical support of both hypotheses (juvenile vs pre-spawning mortality). In addition, we critique Mullowney *et al*. (2016), breaking it down in 3 main sections, namely:, 1) the data Mullowney *et al*. (2016) used to analyze year class strength of capelin is not appropriate to test this hypothesis, 2) there are several flaws in the analyses carried out in Mullowney *et al*. (2016), and 3) Mullowney *et al*. (2016) made some inappropriate interpretations of their results and of the existing literature.

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