**Frank et al 2016:**

*Harp seal population trends and diet*

*The NL harp seal population, a major predator of capelin, experienced a sustained increase from a low of ~1.7 million in 1977 to ~7 million animals in the mid- to late 2000s (Fig. 11A). Contrary to expectation based on observations in the Barents Sea, there was no evidence of a slowing of seal population growth following the reported 1991 collapse of capelin. Indeed, the rate of population increase continued undiminished until the mid-1990s. The slowing in the rate of population increase that occurred post-1998 has been attributed to increased rates of exploitation (Templeman 2010). Moreover, while large numbers of weakened or starving harp seals were observed following the collapse of capelin in the Barents Sea, there have been no reports of such occurrences in NL prior to or after 1991. In fact, Stenson (2012) estimated that the annual consumption of capelin by harp seals increased from ~0.5 Mt in 1991 to ~1.4 Mt in 2008. Notably, Stenson’s estimate of capelin consumption by seals in 2008 alone (1.4 Mt) exceeded, by 8-fold, the post-1991 average biomass of NL capelin as assessed by the acoustic survey (Fig. 2). When the seal consumption estimates of capelin calculated by Stenson (2012) are combined with estimates of capelin consumption by fish (includes cod, turbot, American plaice, redfish and yellowtail flounder) and whales (species unspecified), it ranged from 2.8 to 3.4 Mt (DFO 2015a).*

**Response:**

Frank et al (2016) argue that the absence of an obvious response in northwest Atlantic harp seals supports their contention that the capelin stocks off NL did not collapse. One of their arguments is that a large number of starving harp seals were observed following the collapse of capelin in the Barents Sea (Haug and Nilssen 1995) while there were no reports of similar sightings in the NW Atlantic. However, there are significant differences between the two situations. In the Barents Sea, the collapse of capelin during the mid 1980s was accompanied by a decline (collapse?) in other forage fish that are eaten by harp seals, particularly herring (ref). Barents Sea capelin also declined between 1992 and 1993 without a similar ‘invasion’ of starving seals. This was likely due to the availability of alternate prey (herring and polar cod, *Boreogadus saida*) for the seals (Nilssen et al 1998). As Frank et al (2016) indicate, ‘starving’ harp seals were not reported in Newfoundland waters during the early 1990s, when capelin biomass declined. During this period, however, alternate prey, particularly *B. saida* and herring were still available and were consumed by harp seals (Stenson 2012). Also, total consumption of capelin declined during the 1990s due primarily to the significant decline in the Atlantic cod (Carscadden et al 2001). This could actually increase the amount of capelin available to harp seals.

While the harp seals did not show catastrophic mortalities, they have been impacted by the decline in capelin. Since the 1980s, pregnancy rates of harp seals have declined while inter-annual variability has increased, ranging from ~20% to 75% over the past 3 decades (Stenson et al 2014, 2016). Also, beginning in 1987, harp seals have shown indications of late term abortions. Stenson et al (2016) found that while the general decline in fecundity is a reflection of density-dependent processes associated with increased population size, including the late term abortion rates into their model allowed them to explain the large inter-annual variability. Changes in the abortion rates, in turn, are influenced by ice cover in late January and capelin biomass. Buren et al (2014) showed that capelin abundance is correlated with ice conditions suggesting that late January ice conditions also reflect changes in environmental conditions that influence a number of prey species. Abundance of Northwest Atlantic harp seals has been relatively stable for the past decade. While, as pointed out by Frank et al (2016), higher catches in the Canadian commercial hunt between 1996 and 2008, contributed to reductions in the rate of population growth, these lower pregnancy rates have also had a major impact on the population dynamics of this population (Hammill et al 2015).

Buren, A.D., M. Koen-Alonso, P. Pepin, F. Mowbry, B. Nakashima, G. Stenson, N. Ollerhead, W.A. Montevecchi. 2014. Bottom-up regulation of capelin, a keystone forage species. PLoS One 9(2):e87589. Doi:10.1371/journal.pone.0087589.

Carscadden, J.E., K.T. Frank, and W.C. Leggett. 2001. Ecosystem changes and the effects on capelin (*Mallotus villosus*), a major forage species. Can. J. Fish. Aquat. Sci. **58**: 73–85

Hammill, M.O., G.B. Stenson, T. Doniol-Valcroze and A. Mosnier. 2015. Conservation of Northwest Atlantic harp seals: past success, future uncertainty? Biological Conservation. 192:181-191.

Nilssen, K.T., T. Haug, T. Øristsland, L. Lindblom and S. A. Kjellqwis . 1998. Invasions of harp seals *phoca groenlandica* erxleben to coastal waters of Norway in 1995: ecological and demo-graphic implications. Sarsia 83:337-345.

Haug, T. & K.T. Nilssen 1995. Ecological implications of harp seals *Phoca groenlandica* invasions in northern Norway. – Pp. 545-556 in Schytte-Blix, A., L. Walløe & Ø. Ulltang (eds). – *Whales, seals, fish and man*. Elsevier Science B.V.

Stenson, G.B. 2012. Estimating consumption of prey by harp seals, *Pagophilus groenlandicus,* in NAFO divisions 2J3KL. Canadian Science Advisory Secretariat Res. Doc. 2012/156.

Stenson, G. B., D. Wakeham, A. Buren and M. Koen-Alonso. 2014. Density-dependent and density-independent factors influencing reproductive rates in Northwest Atlantic harp seals, *Pagophilus groenlandicus*. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/058.

Stenson, G.B., A.D. Buren and M. Koen-Alonso. 2016. The impact of changing climate and abundance on reproduction in an ice-dependent species, the Northwest Atlantic harp seal, *Pagophilus groenlandicus*. ICES. J. Mar. Sci. 73:250-262.