Pink Salmon as Sentinels for Climate Change in the Arctic

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The Pacific Arctic Region (PAR), that includes the northern Bering Sea (NBS), across the Chukchi Sea to the East Siberian and Beaufort seas, is experiencing significant warming and extremes in seasonal sea ice extent and thickness (Frey et al. 2014). Over the past decade, record summer sea ice minima (2007, 2011, 2012) have occurred and climate models predict that the southern Chukchi Sea will be sea ice free for five months (July to November) within a decade or two (Overland et al. 2014). These shifts to the PAR ecosystem are likely to have large impacts on the ecology of upper trophic level species (UTL, fishes, birds, and mammals; see Sigler et al. 2011). Because the UTL are typically top predators, they must adapt via biological responses to physical forcing and thereby become "sentinels" to ecosystem variability and reorganization (Moore et al. 2014). As such, there will likely be fishes that do better under climate warming and those that may not.

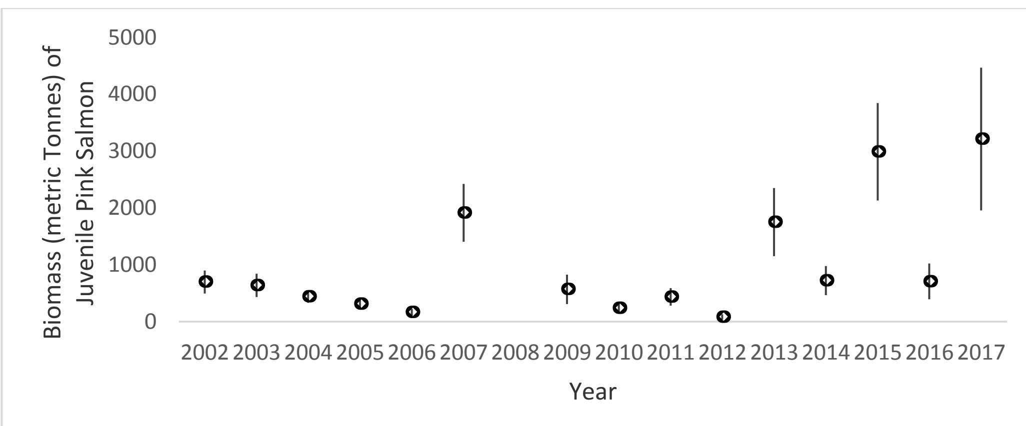

Fig. 1. Biomass (metric tonnes) of juvenile pink salmon captured in the northeastern Bering Sea during 2002 to 2017; there was no survey during 2008.

Pacific salmon have a historic presence in the Arctic but have typically occurred in low numbers (Craig and Haldorson 1986; Bockstoce 1988; Nielson et al. 2013). More recent information, however, indicates that Pacific salmon have become more prevalent in subsistence catches in the Arctic (Beaufort Sea region) (Dunmall et al. 2013; Carothers et al. 2013; Stephenson 2006; Dunmall et al. 2018). Using a community-based monitoring approach to assess trends in salmon presence across the Canadian Arctic, both reported abundances and the geographic distribution of occurrences are generally increasing (Dunmall et al. 2013; Dunmall et al. 2018). Subsistence harvests of pink salmon, specifically, have increased in even-numbered years since 2004 (Dunmall et al. 2013; Dunmall et al. 2018). As there are no self-sustaining populations of pink salmon suspected in the Canadian Arctic at this time, the source populations for these vagrants are currently unknown.

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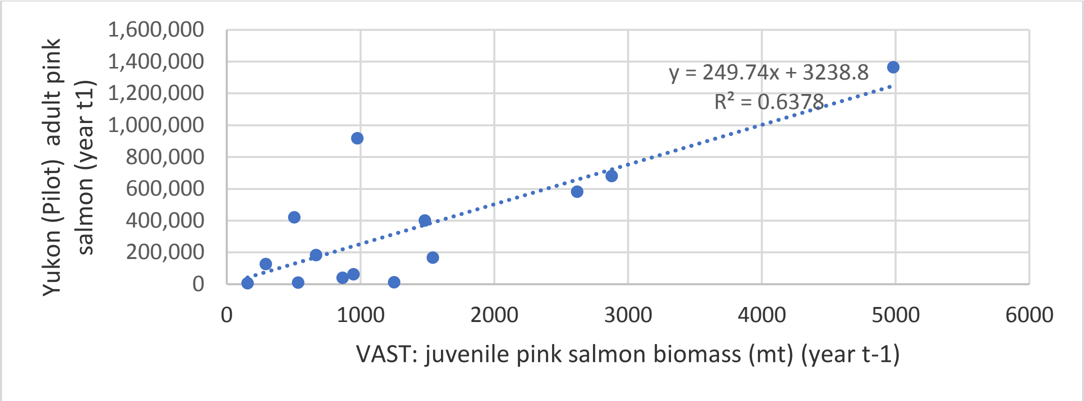

Fig. 2. The relationship between juvenile pink salmon biomass (metric tonnes) captured in the northeastern Bering Sea and subsequent (one year later) adult returns of pink salmon as indexed at Pilot Station on the Yukon River.

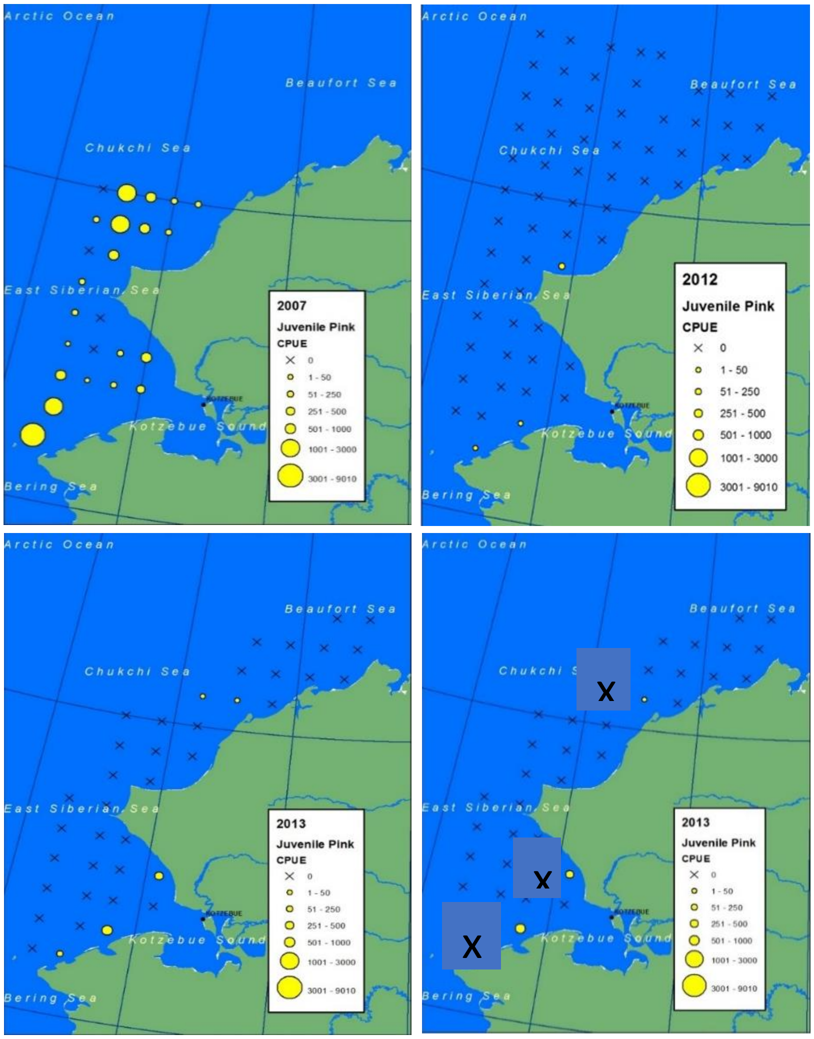

Fig. 3a–d. Juvenile pink salmon catch per unit effort (CPUE) within the Chukchi Sea during August to September 2007 (a), 2012 (b), 2013 (c), and 2017 (d). The "x" indicates stations where fish sampling occurred by no juvenile pink salmon were captured; the exception is 2017 where sampling for juvenile salmon occurred only within the nearshore (two sampling stations nearshore; no samples taken further offshore).

A juvenile pink salmon abundance index (Fig. 1) that is obtained from annual integrated ecosystem surveys conducted in the NBS (see Murphy et al. 2017 for details on the survey) is related to adult pink salmon returns the following year to the Yukon River (Fig. 2). The result suggests that pink salmon production is increasing within the NBS region. However, the juvenile pink salmon index obtained from similar surveys in the Chukchi Sea illustrates that catches can be high, such as during 2007 (Fig. 3a), but have typically been very low as seen during 2012, 2013, and 2017 surveys (Fig. 3b–d). The large catch of juvenile pink salmon during 2007 coincided with higher adult returns to the Beaufort Sea coast in 2008 (Dunmall et al. 2013; Dunmall et al. 2018); but it is unclear if these juveniles were the product of successful spawning in the Arctic. Nevertheless, these overall changes may be indicative of a changing PAR marine environment, suggesting that Pink salmon could be a potential candidate as a "sentinel" species for Arctic change (Dunmall et al. 2013).

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