

**Rapid Communication****The increased occurrence of *Oncorhynchus gorbuscha* (Walbaum, 1792) in the Faroe Islands**

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**OPEN ACCESS****Abstract**

In 2019, there was an unexpected occurrence of invasive pink salmon in the Faroe Islands (centered at 62°00'N; 06°47'W). Fish were captured by local recreational anglers during the period from late July 2019 to late September 2019. In this brief report, we detail the biological characteristics of the captured pink salmon and discuss the potential of a self-reproducing pink salmon population in the Faroe Islands. This report adds to the overall understanding of pink salmon distribution in the North Atlantic region and mirrors similar reports of odd-year invasive pink salmon populations.

**Key words:** non-native species, invasive species, gonadal development, sea louse, sandeel

**Introduction**

The native habitat of the pink salmon *Oncorhynchus gorbuscha* (Walbaum, 1792) includes the northern Pacific Ocean and adjacent regions of the Bering Sea and Arctic Ocean (Heard 1991) with spawning typically occurring along the west coast of North America and east coast of Asia. Pink salmon are the smallest by size and most abundant species of migratory Pacific salmon (Gjelland and Sandlund 2012; Niemelä et al. 2016).

Pink salmon are anadromous, with a strict two-year life cycle. Though dependent on latitude, fry typically emerge between April and June. Fry emerge seawater ready, exhibit a silvery colour, and are approximately 3 cm in length and 0.2 g in weight (Sackville et al. 2012). Before migrating to the open ocean, most pink salmon populations spend a variable period in the estuarine and up to a few months in the coastal environment (Heard 1991; Peacock et al. 2014). Pink salmon spend 13 to 15 months at sea before returning in the late summer to mid-autumn to spawn and die in the river where they hatched. Spawning occurs in late summer to mid-autumn on gravel substrates located in the lowermost or intertidal sections of rivers and streams (Heard 1991). Although pink salmon typically return to spawn near their hatching site, the short timeframe spent at their natal site as juveniles has been speculated to result in a weak olfactory imprinted

homing instinct. Up to 15% of pink salmon are estimated to migrate to rivers other than the hatching site for spawning (Heard 1991; Sandlund et al. 2019).

Mature pink salmon range from 40–55 cm and 1–2.5 kg in size (Heard 1991; Niemelä et al. 2016) and females produce 1200–1900 roe (Heard 1991; Sandlund et al. 2019). Due to their two-year life cycle, populations mainly comprise either odd or even-year stocks (referring to the year of spawning) which can co-exist, but are reproductively separate from each other (Heard 1991).

Prior to 2017, pink salmon were not frequently observed outside their native or introduced range. In 2017 occurrences increased substantially, and pink salmon were reported at a variety of locations including: the eastern coast of Canada, Iceland, Great Britain, Ireland, France and the western and southern coasts of Norway (Armstrong et al. 2018; ICES 2018; Mo et al. 2018; Millane et al. 2019). The reason for this sudden burst of reports throughout the North Atlantic is not well understood, but warmer temperatures and other favourable physical conditions may have allowed for successful reproduction at non-native spawning grounds (Nielsen et al. 2013).

As part of a stocking program, more than 220 million pink salmon roe from the southern part of Sakhalin Island (50°69'N; 142°95'E) in the Pacific Ocean were transported to northwest Russia between the years of 1956–1979 (Gordeeva et al. 2015). These introductions resulted in large catches of adult pink salmon during the 1970s, especially in the White Sea (Niemelä et al. 2016). Self-reproducing populations did not appear to establish until the River Ola (59°35'N; 151°16'E), which is located north of the White Sea in eastern Russia, was chosen as the donor population. This suggested that the River Ola population was better adapted than the roe from the Sakhalin Island to the hydrothermal conditions in the recipient rivers (Gordeeva et al. 2015). According to Niemelä et al. (2016) the translocation of pink salmon roe from the Pacific Ocean to northwest Russia ended in 1998, while releases of fry from local catches ended in 2000. Consequently, catches in the White Sea, Barents Sea and North Atlantic Ocean region after 2001 originate from self-reproducing populations (Niemelä et al. 2016).

Pink salmon have been caught sporadically in the Faroe Islands; however, these catches are mostly unverified. In autumn 2017 five pink salmon catches were reported (one by photo, Figure 1). As a result of this increase in reported pink salmon catch in the Faroe Islands, local anglers were encouraged to report and donate potential pink salmon catches in 2018 and 2019 as part of a citizen science project. This report aims to detail the biological characteristics of the captured pink salmon and discuss the potential of a self-reproducing pink salmon population in the Faroe Islands.

## Materials and methods

This project was initiated as an outreach citizen science project involving local recreational anglers. Study information was publicly disseminated via



**Figure 1.** Male pink salmon, with a pronounced humped back, caught on 6 August 2017 at a river draining in to “Sundalagið” (See also Figure 2). Picture taken by the angler F. Danberg.

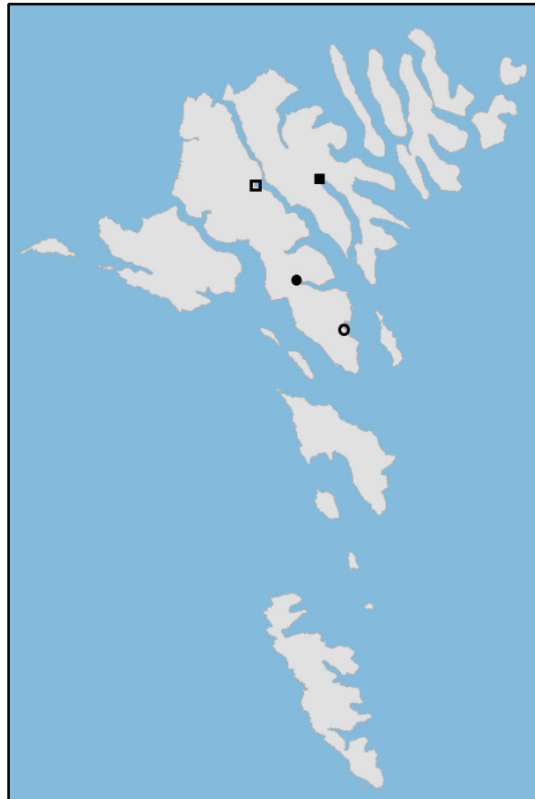
radio announcements and commonly visited local websites with anglers encouraged to contact the study authors when they caught a pink salmon. Salmon were killed by the angler and delivered to the study team within the same day. Following delivery, weight (g), length (mm), and number of sea lice were recorded for each salmon. Sex, maturity (i.e. gonad development), and gut contents were determined following dissection.

### Results and discussion

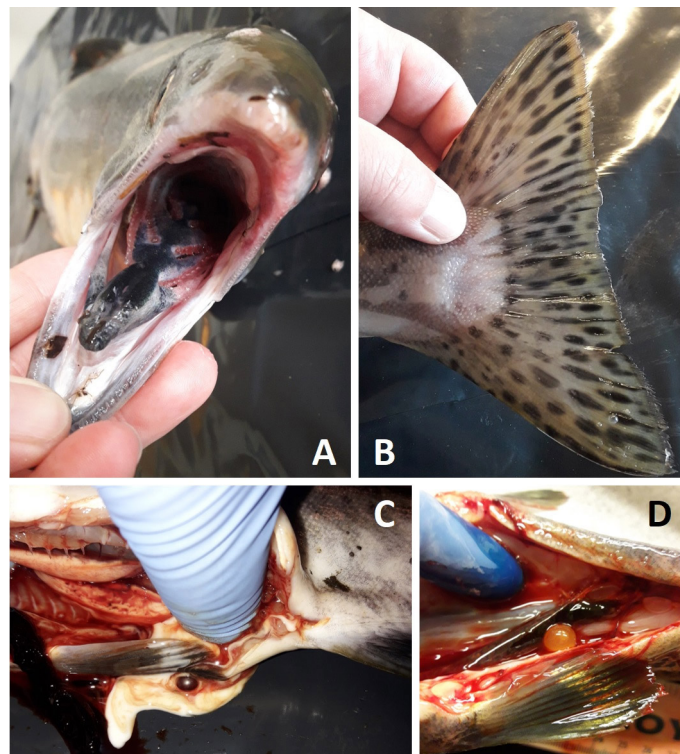
Although this project was initiated in the spring of 2018, no pink salmon were reported before July 2019. This delay indicates the specimens were from an odd-year population, and is concurrent with observations in several other regions in the North Atlantic (Armstrong et al. 2018; ICES 2018; Mo et al. 2018; Millane et al. 2019; Nielsen et al. 2020). In total, six pink salmon were reported in 2019. The first pink salmon was caught on 22 July 2019 at the river mouth of “Kaldbaksfjørður” (lat 62.06402, long -6.91291), while the remaining five were all caught at the river mouth of “Skálafjørður” (lat 62.19693, long -6.84672) (Figures 2 and 3). The last report occurred on the 20<sup>th</sup> of September, when a pink salmon was found floating spent and moribund in the river “Fjarðará” (lat 62.19932, long -6.85507) draining into “Skálafjørður”.

Salmon weights ranged from 420.0 to 1780.0 g, while lengths ranged from 39.6 to 56.8 cm (Table 1). The sex ratio was 1:1, and all specimens were sexually mature, ranging from well-developed sperm and roe sacs to spent (Figure 3). Fish caught later in the year were more mature and had less carotenoid pigmentation of the muscle than those caught earlier in the year.

Pink salmon number 1 (July 22) was the only specimen with identifiable stomach contents including sandeel (*Ammodytes* sp.) and crustacean larvae, and was also infested with an ectoparasitic sea louse *Caligus elongatus* (Nordmann, 1832). Pink salmon number 2 (August 2) and number 3 (August 9) also had sea lice, but of a different species *Lepeophtheirus salmonis* (Krøyer, 1838). The final three pink salmon, number 4 and 5 (August 20), and number 6 (September 20), had empty stomachs and no sea lice. As the sandeel and sea lice are saltwater species, their absence might indicate that the salmon had spent time in freshwater.



**Figure 2.** Locations on the Faroe Islands where pink salmon has been caught. Open and solid symbols indicate catches in 2017 and 2019, respectively. Circles are rivers mounting in to “Sandágerð” and “Kaldbaksfjørður”, respectively, while squares are rivers mounting in to “Sundalagið” and “Skálafjørður”, respectively.



**Figure 3.** Pink salmon caught in the Faroe Islands in 2019; their characteristics and gonadal development. A: White mouth with black gums. B: Large oval-shaped black spots on the tail. C: Spawning male caught August 20. D: Spent female caught September 20 with a single roe left in the abdomen..

**Table 1.** Results from the examinations of the Pink salmon.

Date	Location	Total weight (g)	Total length (cm)	Sex	Gonadal development	Sea lice	Stomach contents
22.07.2019	Kaldbaksfjørður	1780	56.8	Male	Sperm sacs	One <i>C. elongatus</i>	Two sandeel and crustacean larvae
02.08.2019	Skálafjørður	1185	52.8	Male	Sperm sacs	One adult female and one preadult <i>L. salmonis</i>	None
09.08.2019	Skálafjørður	1480	51.0	Female	Roe sacs	Three preadult <i>L. salmonis</i>	None
20.08.2019	Skálafjørður	936	45.6	Female	Spawning	None	None
20.08.2019	Skálafjørður	688	43.0	Male	Spawning	None	None
20.09.2019	Skálafjørður	420	39.6	Female	Spent	None	None

Despite the increased public awareness of pink salmon in the Faroe Islands through the citizen science project, the number of pink salmon reports did not increase substantially from 2017 to 2019, i.e. five and six specimens, respectively. This finding is consistent with observations from Norway, but in contrast to Greenland, where the burst in pink salmon reports occurred in 2019 (Hindar et al. 2020; Nielsen et al. 2020).

The rivers in the Faroe Islands are small and mostly consist of steep mountainside paths carved by rainfall runoff. No exact measurements of water discharge are currently available for Faroese rivers, but an estimate of  $\sim 2.6 \text{ m}^3 \text{ s}^{-1}$  (SV Erenbjerg *unpublished data*) has been made for the “Sundalagið” river where pink salmon were caught in 2017. In the White Sea, pink salmon appear to avoid spawning in rivers with a mean annual discharge of less than  $3\text{--}4 \text{ m}^3 \text{ s}^{-1}$ . However, high numbers of spawning pink salmon and juveniles have been observed in small rivers throughout eastern Finnmark, northern Norway (Sandlund et al. 2019). Therefore, the possibility of a self-reproducing pink salmon population in the Faroe Islands cannot be excluded.

It is not possible to conclude from the data collected in this study if the pink salmon caught in 2019 were the result of reproductive success in locally established populations. To our knowledge, no pink salmon alevins or fry have been observed in the Faroe Islands to date. Although the pink salmon in 2017 and 2019 were not caught in the same rivers, which might have indicated pink salmon seeking out their native rivers, the locations are within the same region, i.e. from rivers draining into the strait between the two largest islands. However, since the appearance of individuals or small schools in an estuary does not necessarily indicate that these fish will migrate to the nearby river, homing cannot be excluded entirely (Heard 1991). If pink salmon are reproducing locally, an increase in the number of catches might be expected. However, the number of catches did not increase substantially from 2017 to 2019, which may suggest that the salmon in this study did not originate from local reproduction.

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