Sjóvarfalsdrivið smittu samband millum aliøkir í Føroyum

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Abstract

Sea lice infestations are an increasing challenge in the ever-growing salmon aquaculture sector and cause large economic losses. The high salmon production in a small area creates a perfect habitat for parasites. Knowledge of how salmon lice planktonic larvae disperse and spread the infection between farms is of vital importance in developing treatment management plans to combat salmon lice infestations. Using a particle tracking model forced by tidal currents, we show that Faroese aquaculture farms form a complex network. In some cases as high as 10% of infectious salmon lice released at one farm site enter a neighboring fjord containing another farm site. Farms were characterize as emitters, receivers or isolated, and we could identify two clusters of farms that were largely isolated from each other. The farm characteristics are a valuable input for the development of management plans for the entire Faroese salmon industry.

Introduction

The increased salmon production has elevated the density of the naturally occurring salmon lice in waters with salmon farming primarily due to the large growth in the number of hosts. The high density further increases the chances of transmitting salmon lice between hydrodynamically connected farms and salmon lice are currently the main inhibitor for further growth in the salmon aquaculture industry.

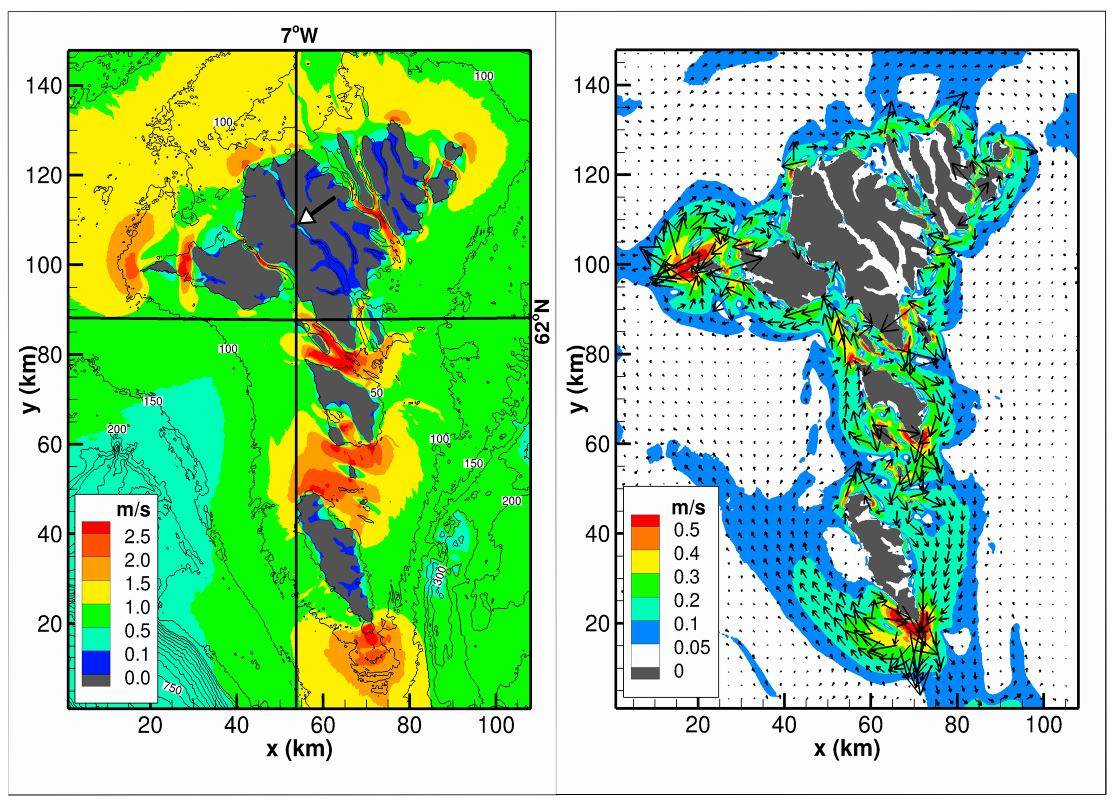

Figure 1: **(Right)** Maximum tidal current velocity provided as the sum of semi-major axis of the 6 dominating constituents and **(Left)** Residual tidal current velocity around the Faroe Islands (Simonsen & Niclasen, 2011). Thin contour lines provides the water depth. White arrow head shows the location of the large narrow strait and the vectors indicate the direction. Colorbar show the current velocity.

The purposes of this study was to

- find the dispersion distances and patterns of particles imitating salmon lice.
- identifying salmon lice transmission characteristics between Faroese salmon farms.

Materials and Methods

Hydrodynamic data

is from an implementation of the barotropic mode of the Regional Ocean Model System (ROMS), where 6 tidal constituents and residual current are obtained.

Particle Tracking Model

uses a simple Euler scheme:

$$x_q(t+\Delta t) = x_q(t) + u(x,y,t)\Delta t + R\sqrt{6D_h\Delta t} \quad (1)$$

$$y_q(t+\Delta t) = y_q(t) + v(x,y,t)\Delta t + R\sqrt{6D_h\Delta t}, \quad (2)$$

Particle salmon lice properties

- Naupulii phase 3.7 days & copepodid phase 13 days.
- Mortality 0.17 per day

Results

Examples of particle dispersion patterns are illustrated in dispersion maps showing the mean age over the simulation period of particles released from three farms (Fig. 2).

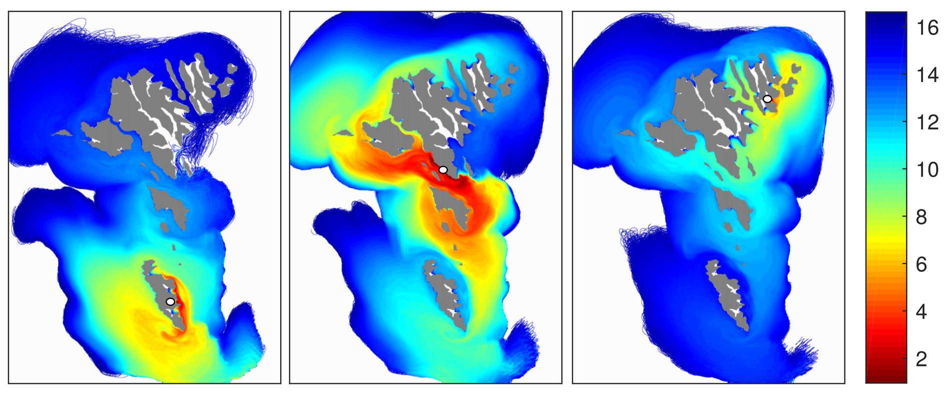

Figure 2: Mean age of particles in every grid cell over a 2000 hour simulation period. 900 particles are released every hour from farm 2, 5 and 21 (white dot) shown in **(a)**, **(b)** and **(c)**, respectively. Colorbar indicates mean age in days.

The maximum Euclidean distance traveled by a particle varies greatly between farms. Particles can easily travel more than 20 km during the nauplii phase and over 50% of particles from most farms travel over 50 km (in Faroese summer conditions; Fig. 3a). In several farms approximately 10% of the particles travel at least 80 km.

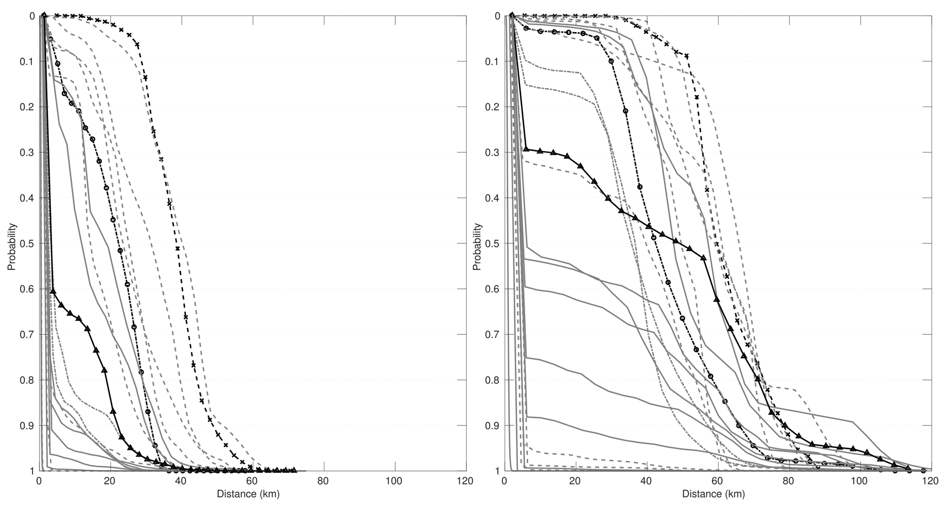

Figure 3: The cumulative frequency of the maximum Euclidean distance attained by particles released from all Faroese farm sites. **(a)** and **(b)** shows the cumulative frequency of the maximum distance attained by napulii and copepodid, respectively.

The relative distribution of nauplii and copepodid particles is shown with a heat map (Fig. 4). No clear "cold" spots, i.e. areas with relatively low density of copepodids, are in the coastal regions. The highest density is found around the northern group of islands, which is also where the majority of the farms are located.

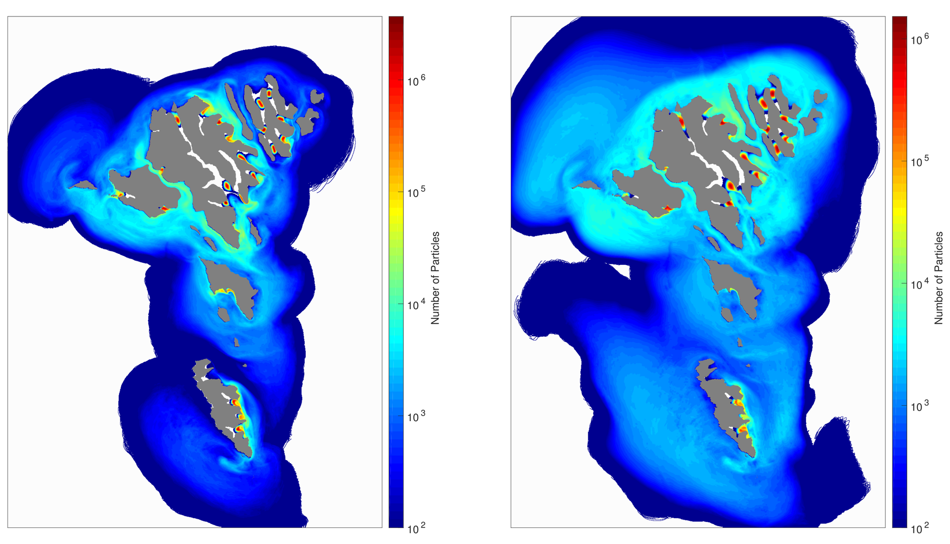

Figure 4: Relative density distribution attained by particles released from all Faroese farm sites. **(a)** and **(b)** shows the number of nauplii and copepodid particles, respectively. Colorbar indicates number of particles on a logarithmic scale.

The proportion and mean age of infectious salmon lice larvae that disperse between Faroese salmon farms is summarized in three connectivity matrices (Fig. 5).

The connectivity matrices reveal generally a high connection between farms although the range of connectivity is quite diverse. The diagonal line indicates the degree of self-infection and is dependant on the strength of exposure in the area.

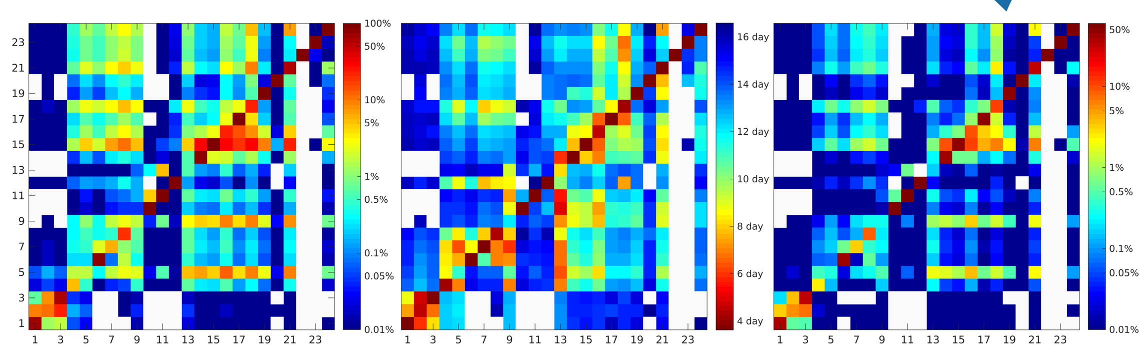

Figure 5: Connectivity matrix's with emitting farms on x-axis and receiving farms on the y-axis. **(a)** Percentage of unique infectious larvae released from one farm site entering any other farm site or its initial release site. **(b)** Mean age of the connections. **(c)** Connectivity including mortality. Colorbar indicates the percentage in **(a)** and **(c)**, scale is logarithmic. Colorbar in **b** indicates the mean age in days. White color indicates that there is no signal.

Discussion

Identifying critical nodes in the farm network is highly valuable information when developing a management plan. We were able to identify farms either as emitters, receivers, or isolated.

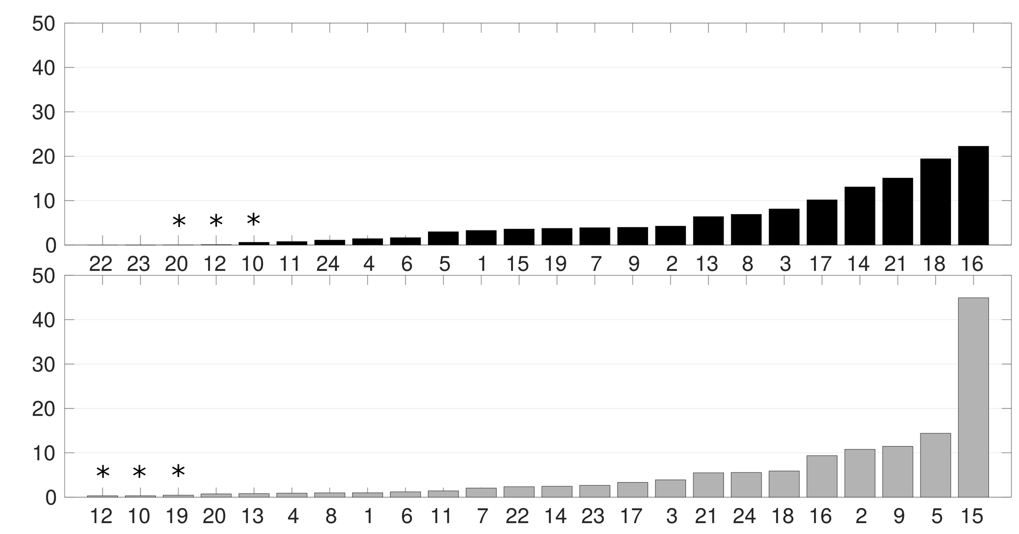

Figure 6: Barplot of % of salmon lice which farms emit (upper panel) and receive (lower panel) to and from other farms accounting for mortality and excluding self-infection."*" indicates the three highly isolated farms. Percentage is normalized with total amount of particles released from one farm.

The trend in the Faroe Islands in resent years has been to place farms further out in the fjord to obtain better growth condition due to higher water exchange, less local bed load and less sea lice self infection. By placing farms further out, the connectivity between farms increases. In this way, the benefit to the individual farm increases the challenge for the entire farm network. Also the placement of potential new farm sites is problematic as there are no obvious salmon lice "cold spots" close to Faroese coast (Fig. 4), emphasizing the need for a holistic management approach.

Conclusion

This study presents the first model which can to a certain degree, realistically simulate the mean dispersion patterns in an archipelago with a circulation dominated by tidal currents. The tidal currents and the residual current due to their highly dominating influence on water currents on the Faroe shelf are the main drivers for the connectivity between farms sites as well as acting as a retention mechanism for the resident sea lice population.

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