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Modeling Snow Crab Diffusion Using a Finite Element Method

Snow crabs are an important asset to New Brunswick fisheries. As a cold-water species, their survival is highly sensitive to fluctuations in water temperature. Most snow crab mortality occurs during the larval phase, where only 1.5% of the larvae survive migration.

Being too small to move on their own, snow crab larvae are transported by water currents across the Gulf of St. Lawrence. Their small size also causes them to behave similarly to suspended particles in water, making diffusion an important factor in their movement.

The transport and dispersion of snow crab larvae can therefore be modeled using the advection-diffusion equation :

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} + v\frac{\partial C}{\partial y} = D\left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2}\right)$$

In this equation, the advection velocities u and v represent ocean current data provided by Fisheries and Oceans Canada. Because the available data was not sufficiently detailed for direct mathematical modeling, it was interpolated using the Kriging method. The model also includes a diffusion coefficient D and the larval concentration field C, which must be solved for numerically.

Since no realistic analytical solution exists for this system, numerical approximation techniques are required. A finite element method was therefore applied to solve the advection–diffusion equation on a computational mesh designed to simulate the conditions of the Gulf of St. Lawrence.