

Modeling the influence of the Biobío River discharge on the early life stages of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) in the Gulf of Arauco, Chile

S03-P10 (ECOP)

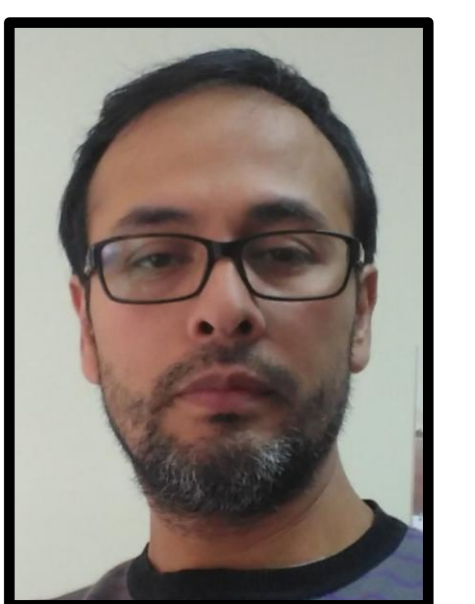
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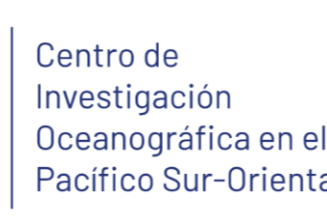
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Introduction: The Biobío River discharge, one of the most important in terms of flow in Chile, is one of the most significant variables influencing the hydrodynamics of the Gulf of Arauco (GA, 37°S). However, how the river's freshwater discharges affect the extension of its plume and the retention/transport of planktonic species residing in the Gulf, is still unknown. By combining an individual-based model (IBM, Ichthyop) with a hydrodynamic model (CROCO), developed for the central Chilean coastal zone (35°–38°S), the current study evaluates the impact of the Biobío River discharges on the distribution and survival of anchovy and common sardine eggs and larvae in the GA.

Methods: The coupled IBM was initiated using the distribution of eggs collected during DEPM cruises carried out during the spawning seasons between 2014 and 2018 (September-October). Simulations were validated using *in situ* data in the Biobío River influence area (river plume). The river plume's influence region (estimated from Potential energy Anomaly, PEA >40 Jm⁻³) was linked to average monthly discharges and to the abundance of anchovy early life stages throughout the study period (*in situ* and simulated). The relationship between the model variables was determined using a General Linear Model (GLM).

Results: Simulation results showed that temporal variation in spawning modulates larval survival. In the early phases, natural mortality was the primary cause of death, followed by advection mortality. Northward larval movement from the spawning area (GAL) was prevalent. The spawning area demonstrated a significant retention capacity during the study period (2014-2018), particularly in 2015 (Figure 1; Table 1).

Table 1. Egg and Larval survival in different areas (spawning/retention) and years during the reproductive period (September and October).

		Survival (%)							
		<i>Engraulis ringens</i>							
		Eggs				Larvae			
Year	Area	GAL	GAR	PR	Total	GAL	GAR	PR	Total
2014	GAL	13.3	2.2	5.9	21.4	8.6	14.2	9.34	32.2
2015	GAL	15.9	6.0	7.3	29.2	12.3	19.7	12.2	44.2
2016	GAL	3.7	3.3	5.6	12.7	2.2	12.1	10.6	24.8
2018	GAL	6.2	2.1	5.4	13.7	4.6	15.7	8.3	28.6
		<i>Strangomera bentincki</i>							
2014	GAL	13.9	2.4	6.8	23.1	4.2	1.2	4.9	10.3
2015	GAL	15.7	5.3	4.7	25.7	7.1	2.0	10.1	19.3
2016	GAL	5.2	2.7	6.1	14.0	2.4	2.7	7.0	12.1
2018	GAL	4.8	0.6	0.6	6.0	3.2	1.0	0.6	4.8

GAL: Spawning/retention area within the Gulf of Arauco;
GAR: Retention area in the outer sector of the Gulf of Arauco;
PR: Pre-recruitment area to the north of the Gulf of Arauco)

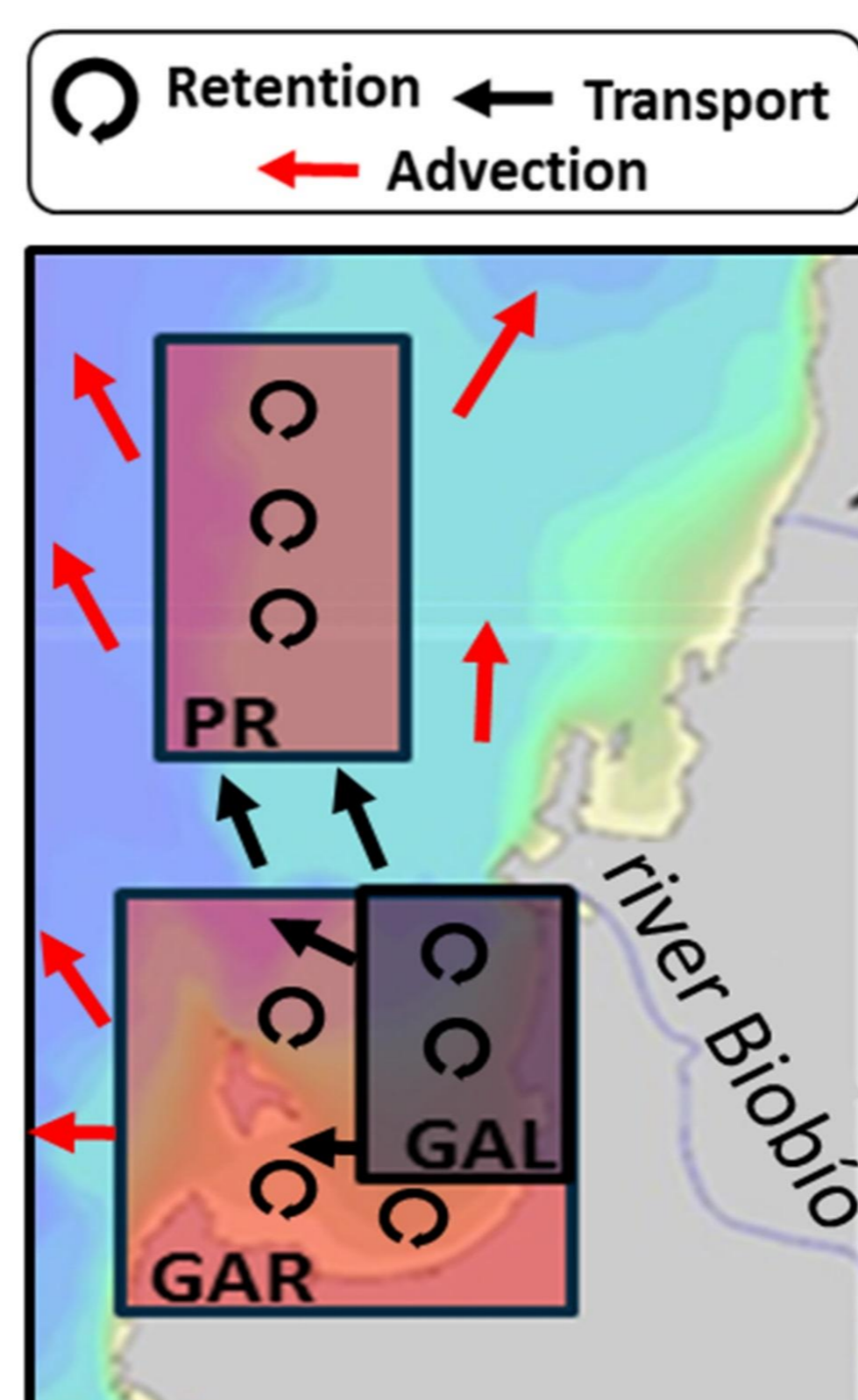


Figure 1. Conceptual model of connectivity and retention of early stages of anchovy and common sardine.

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The *in situ* and resulting model distribution of eggs were similar, with the main abundances located south of the Biobío River mouth, in association with stratified waters (Figure 2). The Biobío River influence-area, delimited by high PEA values (PEA >40 Jm⁻³), included the most important egg retention.

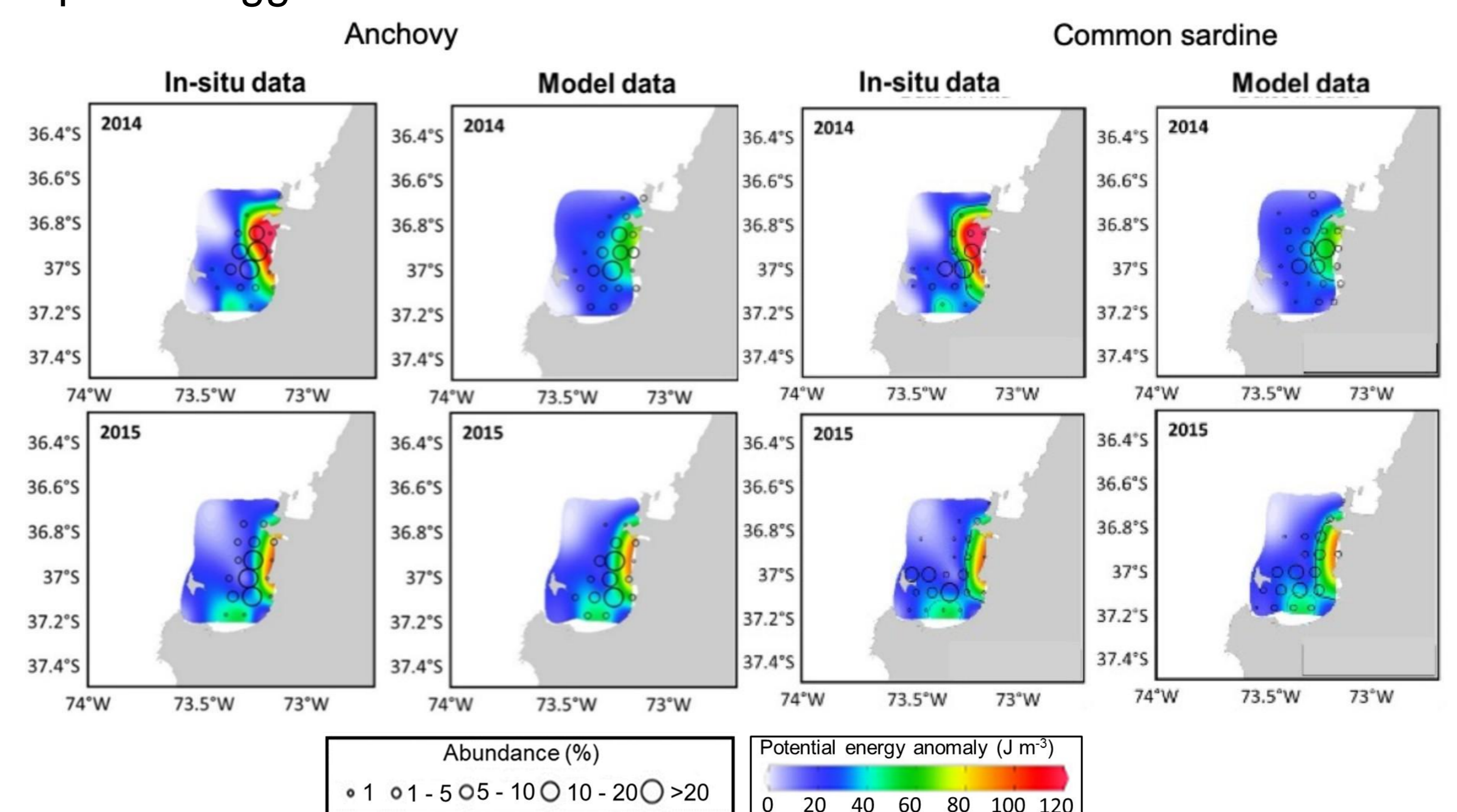


Figure 2. Anchovy and common sardine egg abundance overlap (%) on potential energy anomaly (PEA) horizontal sections in the Gulf of Arauco: *in situ* data and model.

The relationship of the Biobío River influence-area (PEA > 40 Jm⁻³) with the monthly average discharges and with the abundance of anchovy eggs presented a good linear fit as determined by *in situ* data (Figure 3).

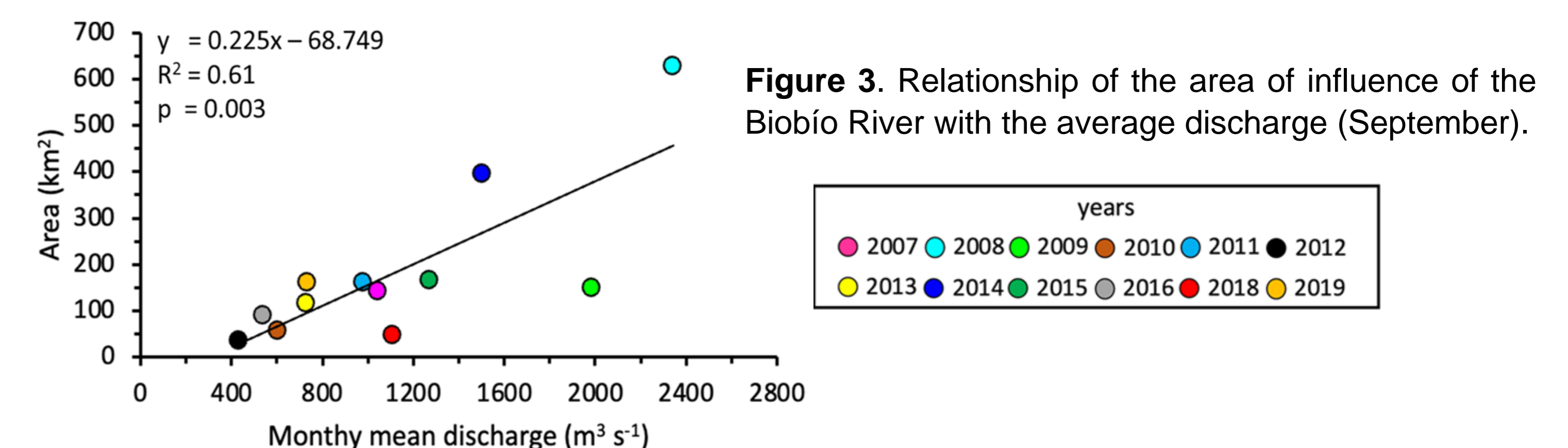


Figure 3. Relationship of the area of influence of the Biobío River with the average discharge (September).

A parabolic function described the relationship between the river area of influence and egg abundances. The optimum estimated Biobío River's area of influence was 338-357 km², leading to a retention rate of anchovy eggs >20%. The optimum area of influence for common sardine eggs was 306-372 km², with retention rates also over 22% (Figure 4).

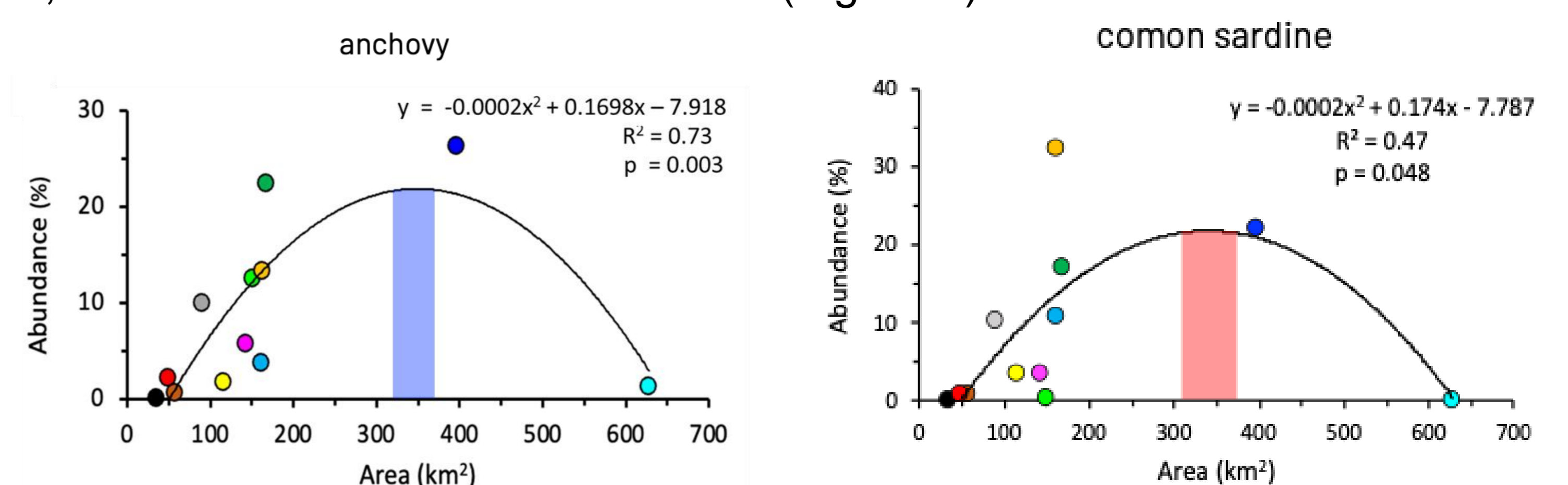


Figure 4. Relationship of the area of influence of the Biobío River with the abundance of eggs anchovy (left panel) and common sardine (right panel), associated with the area of influence for *in situ* data

In conclusion, the abundance of anchovy and common sardine early life stages in the GA is controlled by the Biobío River plume and discharge.