Ichthyoplankton transport from the African coast to the Canary Islands: A case study using a high-resolution hydrodynamic model

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INTRODUCTION

Small pelagic fishes recruitment and fisheries catch in Canary islands are strongly linked to external larval supplies coming from the continent. Indeed, upwelling filaments can transport neritic larvae into the oceanic region, far away from their birthplace. The island of Gran Canaria (GC) constitutes the western boundary of the upwelling filaments stretching from the African coast to the offshore area. We used a numerical model to study in detail this mechanism of ichthyoplankton supplies to GC. There is a number of ichthyoplankton surveys in GC surrounding waters that allows us to validate the model results.

Material and Methods

The hydrodynamic model

We generate a 5-km Regional Ocean Modelling System (ROMS) solution of the circulation over an area covering the Canary archipelago and the coastal upwelling, from 23°to 32° N (fig. 1). The simulation is climatologically forced at the surface (heat fluxes, precipitation and wind stress), but reproduces mesoscale features, mainly filaments and eddies and their interactions, which have good qualitative agreement with observations. Boundary forcing (temperature, salinity and velocity) was provided from a parent ROMS simulation, itself forced by a monthly climatology.

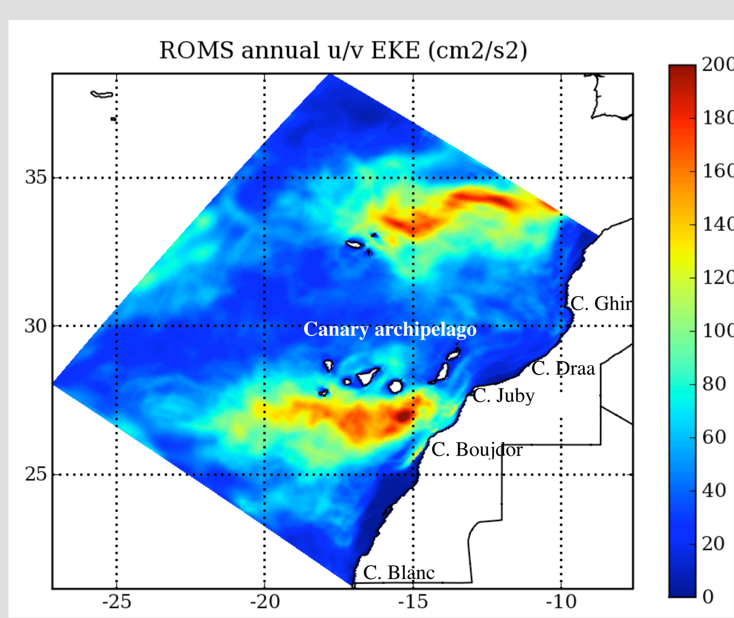

Figure 1: The hydrodynamic grid illustrated by the mean eddy kinetic energy (EKE). The high values south of Canary archipelago are the signature of an eddy field

The Lagrangian model

A Lagragian individual based model, *Ichthyop* (Lett et al, in press), is used to track the advection of virtual ichthyoplankton, from known anchovy and sardine spawning areas within the coastal upwelling to the island of Gran Canaria. We designed numerical experiments to measure the frequency of particle transport from the African shelf to the coastal waters around GC. The release area was delimited by Cape Draa and the Dakhla peninsula, and the offshore limit was the 200m isobath. This large area was subdivided in three zone by Cape Juby and Cape Boujdor. Particles were released every three days over the continental shelf (fig. 2), and the duration of transport was set to one month.

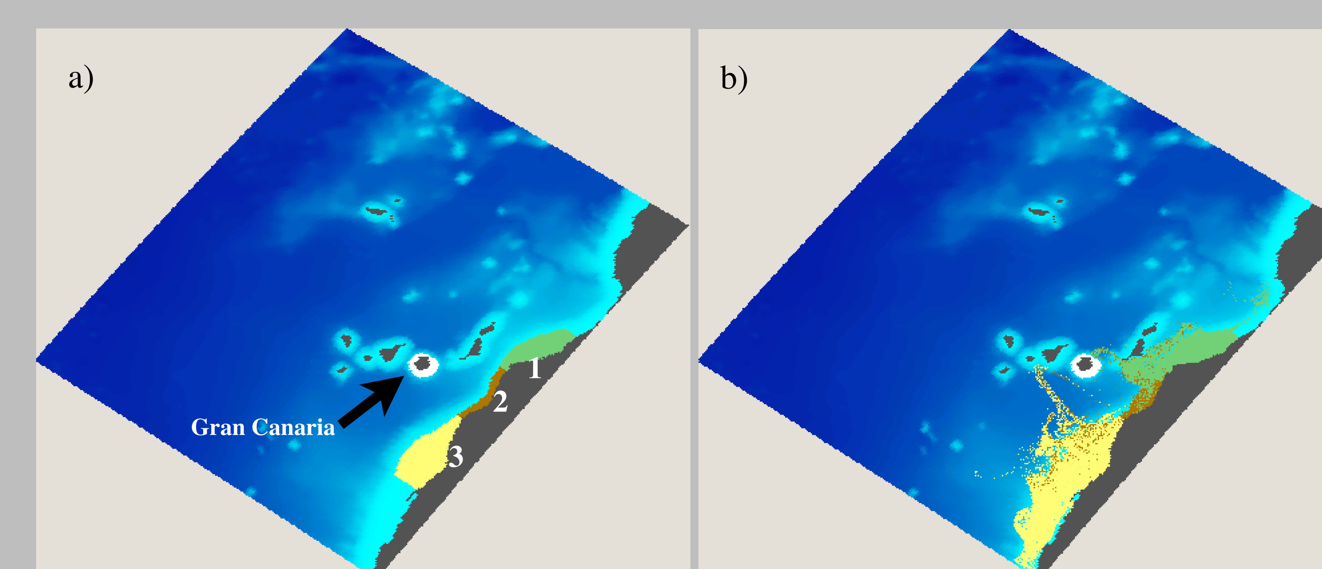

Figure2: The Lagragian model. (a) Release area (Shelf between Cape Draa to Dakhla) and target area (surrounding waters of Gran Canaria). (b) Exemple of particles transport after 30 days.

Results and Discussion

The arrival of particles in Gran Canaria was very discontinuous, occurring as punctual events. Most of these events followed a negative anomaly of the surface salinity (fig. 3) near GC. These salinity anomalies occurred mainly at the east of the island, and at equal frequency north and south but rarely west (fig. 3). The events of particles reaching GC can be observed as well on the concentrations map (fig. 4). They can be related to similar structures of sea temperature in subsurface (fig.5).

The addition of the 4 years of simulation makes clearly appear a maximum of particle transport to GC during the strongest upwelling season (summer), and at the upwelling relaxation time (fall) (fig. 6). Finally, the age of particles reaching GC show that transport is also faster during summer and fall, with a minimum of 12 days for particles released in zone 1 and 2 (fig. 7).

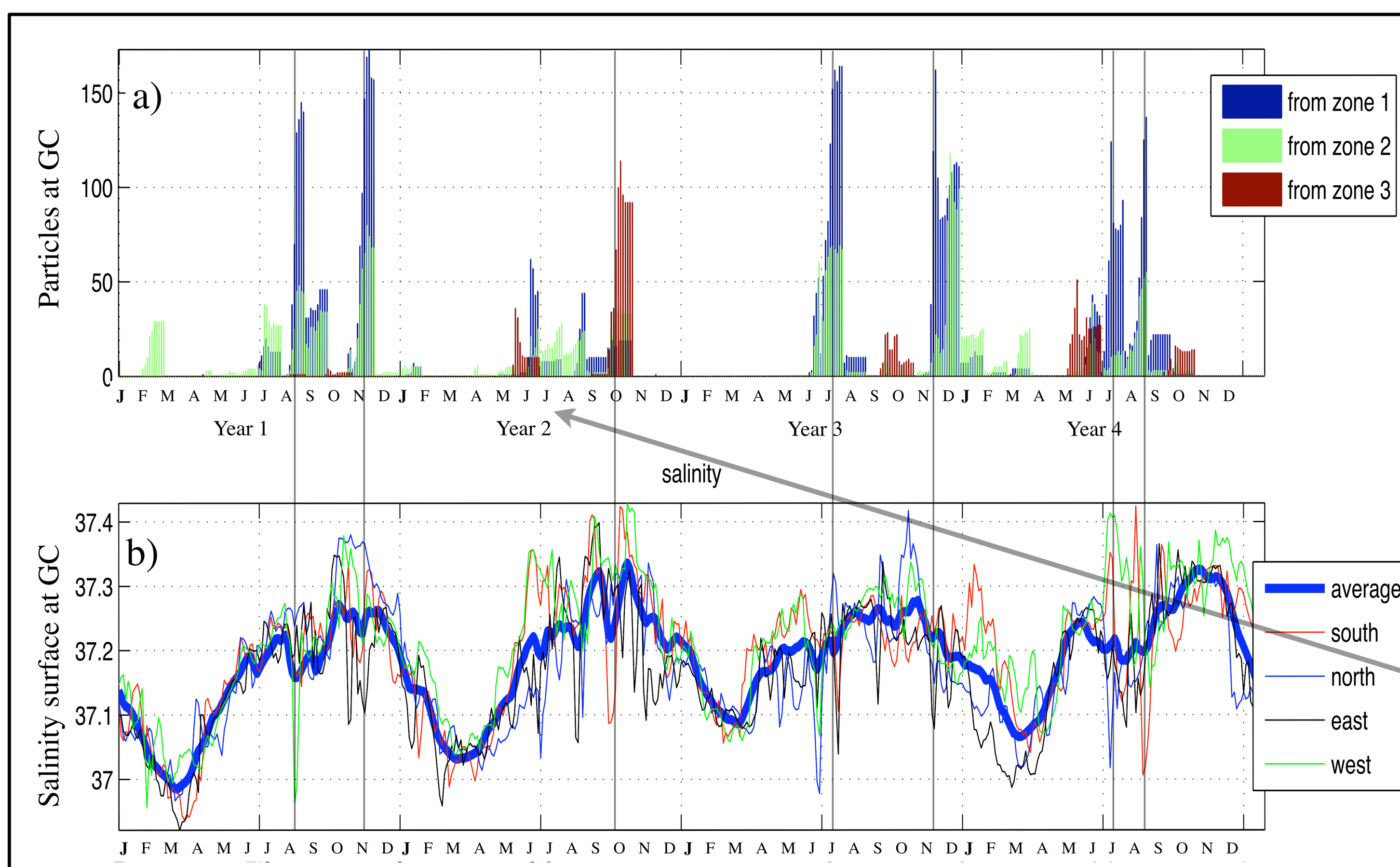

Figure 3: Time series of: (a) the number of particles present in the target area defined around GC (fig. 2). The color indicates the origin of the particles (release area 1 (blue), 2 (green) or 3 (red)). (b) Surface salinity around GC: average and at four points North, South, East and West of the island.

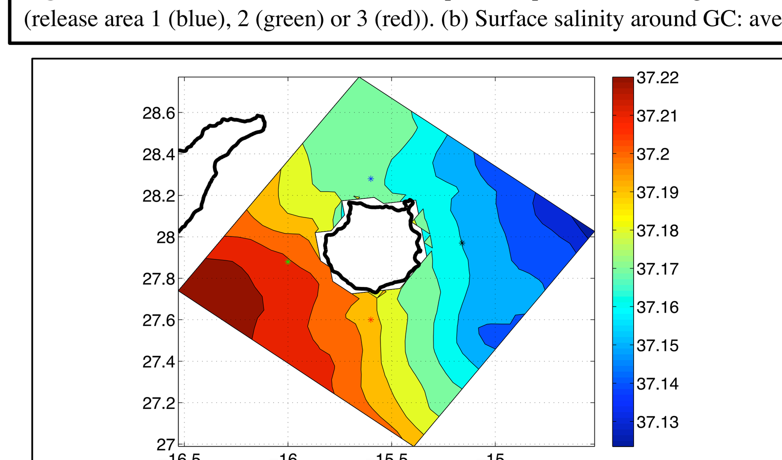

Figure 3bis: Average salinity around Gran Canaria (GC). The four points around the island indicate lacation for the salinity time serie in figure 3.

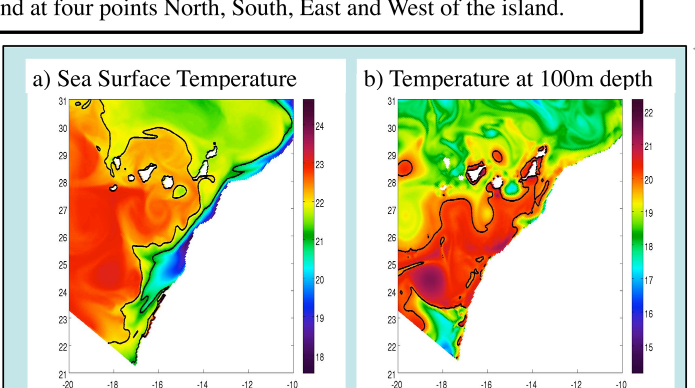

Figure 5: Temperature field from hydrodynamic model, Year 2 Month 7. (a) at sea surface; (b) at 100m depth. The filament observed at 100m corresponds with the particles transport visible at that month on figure 4.

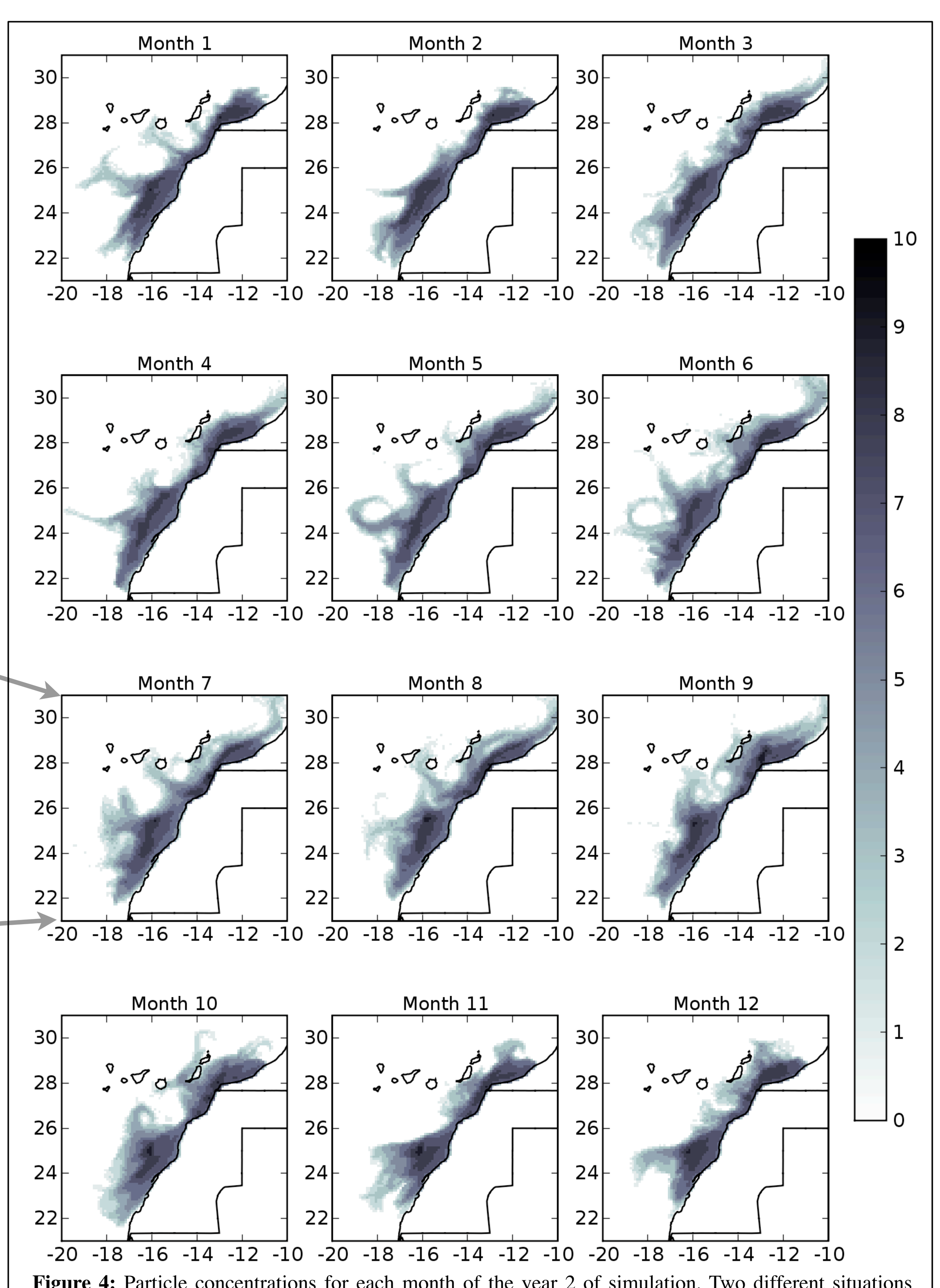

Figure 4: Particle concentrations for each month of the year 2 of simulation. Two different situations result in particles reaching Gran Canaria: (1) a filament stretching from Cape Boujdor (months 1,7 and 8) and (2) a filament stretching from Cape Juby (months 6 and 10).

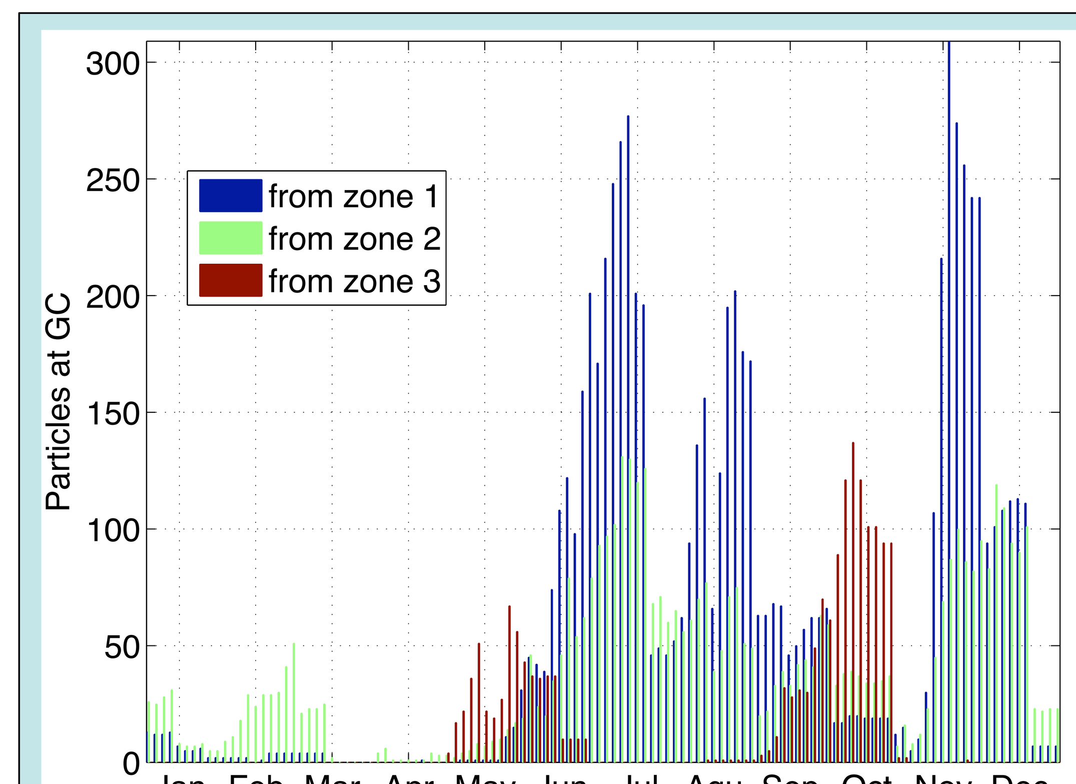

Figure 6: Climatology of particles at Gran Canaria: sum of the four years of simulation. The summer peak corresponds with the upwelling season, while the November-December peak may correspond with upwelling relaxation

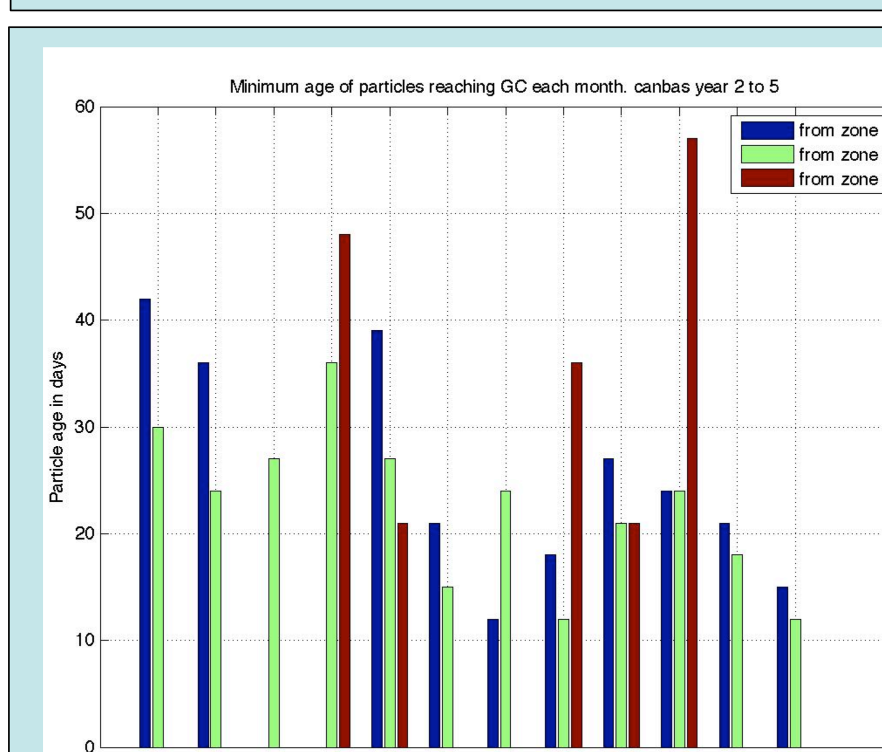

Figure 7: Minimum age of particles at Gran Canaria for each month, i.e. minimum travel duration from the release area over the shelf to GC.

Our results suggested that the main source for ichthyoplankton supply in GC during summer and fall is the continental shelf from Cape Draa to Cape Juby (zone 1). However, the smaller peak of transport to GC in late winter may concern ichthyoplankton coming from the shelf between Cape Juby and Cape Boujdor.

The spawning pattern of small pelagic fishes over the continental shelf is a caracteristic of each species: *Sardina Pilchardus* mainly spawns during winter all along the shelf while *Engraulis encrasicolus* spawns more during summer and between Cape Draa and Cape Juby (Berraho, 2007). These species are believed to spawn only over the continental shelf (Rodriguez et al., 2006). Then our model predicts a majority of anchovy ichthyoplankton transport to GC, which is in line with the field observations of ichthyoplankton near GC (Bécognée et al., 2006).

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