Zooplankton Transport and Distributions in the Gulf of Lion: Estimates from a Lagrangian Model and Optical Remote Sensing Data

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Introduction

Zooplankton transport and distributions are critically dependent on the physical environments and individual behavior [1,2].

Individual based models (IBMs) are powerful tools to study zooplankton behavior [3]. Phytoplankton is important for IBMs as food of zooplankton and can be derived from remote sensing data [4].

We use a Lagrangian model coupled with the Symphonie (described by Hu et al.[5] and references therein) and an IBM to estimate the zooplankton transport and distributions in the GoL.

Individual based model

Following Carlotti and Wolf [3], the weight depends on ingested food (in a range 0.05-100 gC):

$$Weight(t+1)=Weight(t)+Ingestion-Egestion-Respiration$$

$$Ingestion=Mean(Grazing)\times dt$$

$$Grazing=1.72\times2.1^{(T/10)}\times(Weight)^{0.8}\times min(1,max(Food-5,0)/100)$$

$$Egestion=0.3\times Ingestion$$

$$Respiration=(0.01\times(Weight)^{0.8}\times3.4^{(T/10)})\times dt+0.02\times Ingestion$$

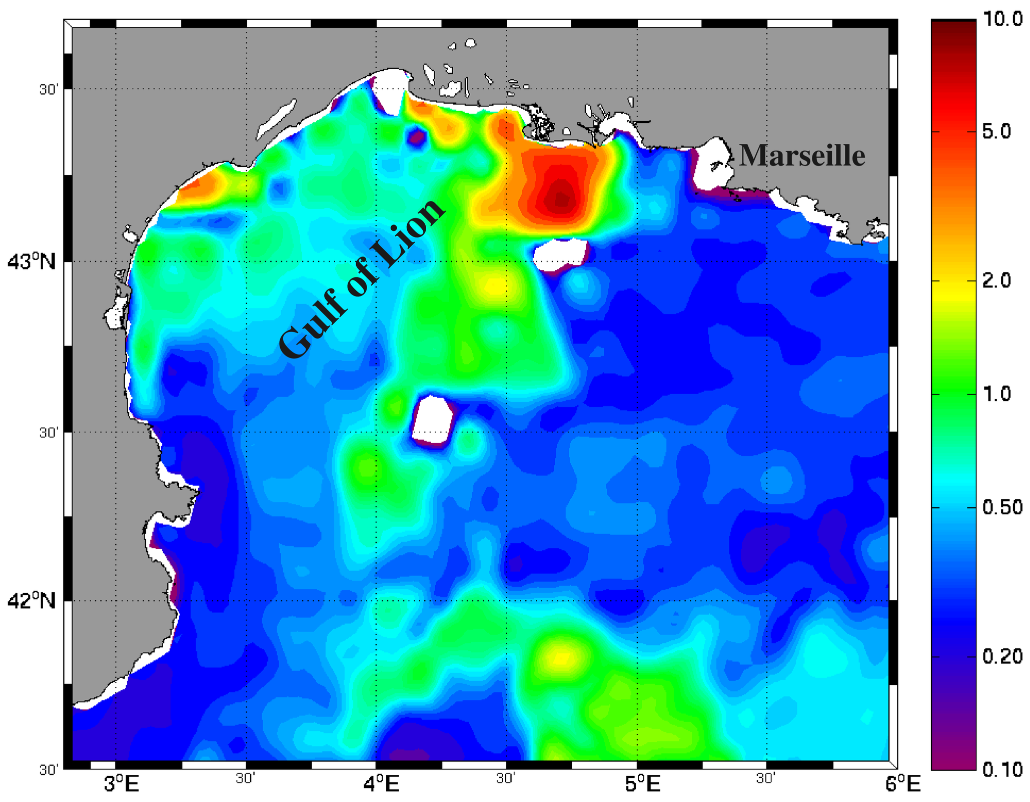
$dt=1hour$. Temperature (T) is calculated by the Symphonie and food concentrations ($Food$) are estimated from SeaWiFS data.

Food concentrations

The 8-day composited surface chlorophyll-a concentration data from SeaWiFS are used.

The vertical distributions of phytoplankton are assessed based on the surface chlorophyll-a concentrations by using the functions derived by Uitz et al. [4]

Chlorophyll-a values are converted to carbon concentrations using a constant C:Chl=50.



Interpolated 8-day composited surface phytoplankton density map for the model region from May 1 to May 9, 2001. Values are in mgm^{-3}.

Lagrangian particle tracking model

The equation $d\vec{x}/dt=\vec{u}(\vec{x},t)$ is integrated with an advanced fourth-order accurate Adams-Bashford-Moulton predictor-corrector scheme [1].

$$\vec{u}=\vec{u}_{sym}+\vec{u}_{swim}$$

$\vec{u}_{sym}$ is interpolated in time and space of the daily average velocity fields from the Symphonie.

$\vec{u}_{swim}$ is treated in two ways:

(i) passive particles: $\vec{u}_{swim}=0$;

(ii) swimming particles:

$$\vec{u}_{swim}=43\sqrt[3]{Weight-0.05}$$

6-8 am: Downward swimming for particles with the depth < 50m (on 6 am);

6-8 pm: all particles swim to the layer where the maximum food concentrations located.

In the remaining time $\vec{u}_{swim}=0$

Parameters and settings:

Time step: 300s

Particle numbers: 1340 each time

Starting time: First days of each month from May to October, 2001

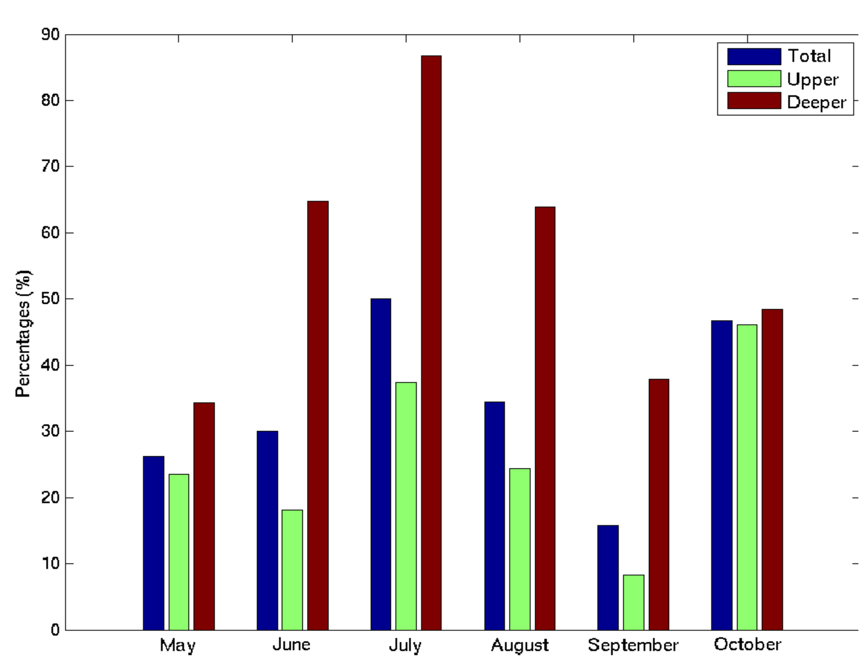
Simulating time: 40$days$

Release location: In a rectangle area of 50×18km (the center 4.8ºE, 43.2ºN) in the Rhone river plume

Initial depths: 5m, 20m, 50m and 80m

Results and Discussions

Passive particles spread in the GoL but with notable differences depending on the month and the initial depths of release. About 16% to 50% of individuals remain in the GoL and the percentages of particles released at deeper layers are higher than those at upper layers.

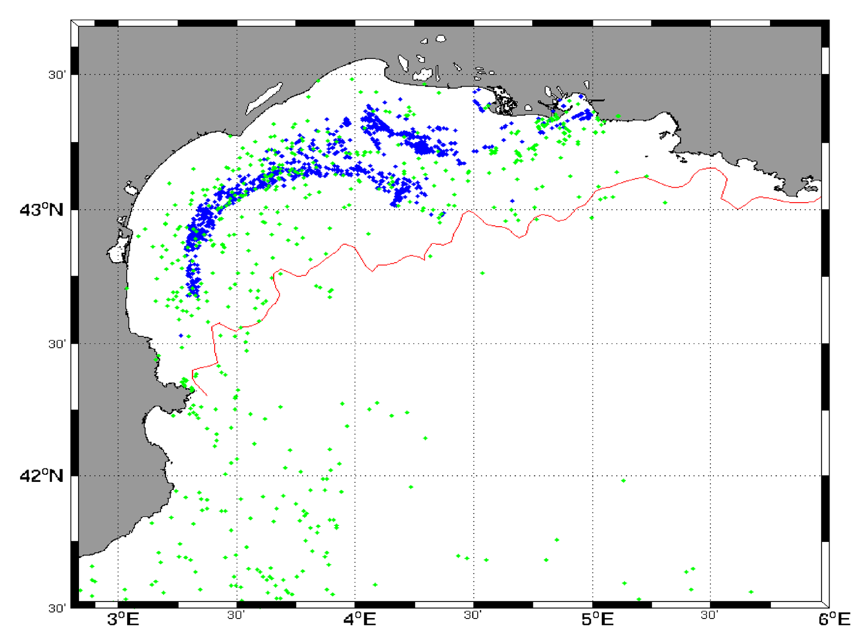


Percentages of particles remaining in the GoL. Upper and Deeper represent percentages of particles released upper and deeper than 45m, respectively. Total remarks all particles.

Compared to simulations of passive particles, simulations with swimming behavior show less spreading in particle distribution patterns. An increase is observed in the number of particles on the shelf from June to September and however, a decrease in October.

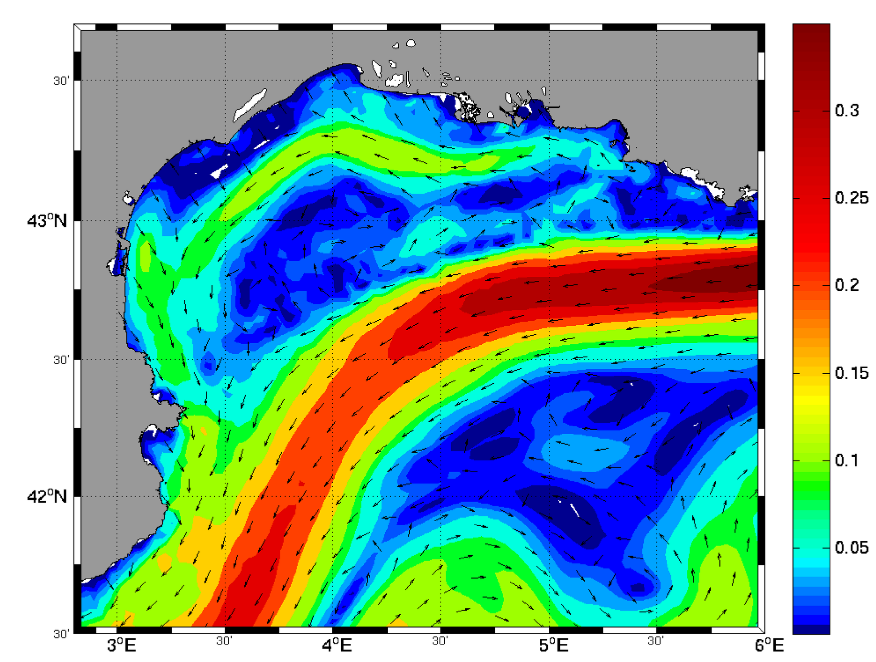
May	June	July	August	September	October
0	+70	+45	+65	+65	-28

Differences in particles remaining in the GoL of simulations with swimming behavior and those of passive particles (%)



Final distributions of particles in June: passively (Green) and with swimming behavior(Blue). Red line remarks the 200m isobath.

Vertical migration is one reason why more particles remaining in the GoL from June to September. It can also explain the decrease in October combined with the flow fields. A strong current is observed in the Rhone river plume with the intensity about 0.1ms^{-1}. The current flows westwards and then southwards, which will carry particles quickly out of the GoL.



The intensity of the monthly average currents (ms^{-1}) at 50m in October. Black arrows represent directions of currents.

Conclusions

The Lagrangian model has been proved to be an efficient tool to simulate the transport and distributions of zooplankton combined with phytoplankton concentrations from SeaWiFS and has been implemented in the GoL. The particle transport and distributions are strongly related to the hydrodynamic structures and zooplankton swimming behavior connected with food.

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