Consequences of increased mobility and quicker development in warmer waters on the dispersal trajectories of fish larvae

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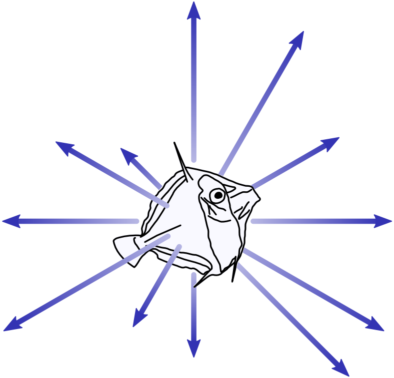
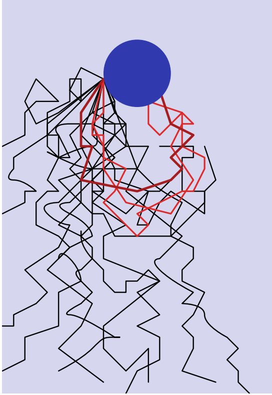
Where to go?



- **Choice** between possible decisions
- Gain/Cost **balance** for each decision
- Choose **"optimal"** decision
- optimal = maximizes recruitment probability

Why "optimize"?



Probabilistic With **random** swimming, few trajectories lead to recruitment. Select those, without having to compute all possibilities

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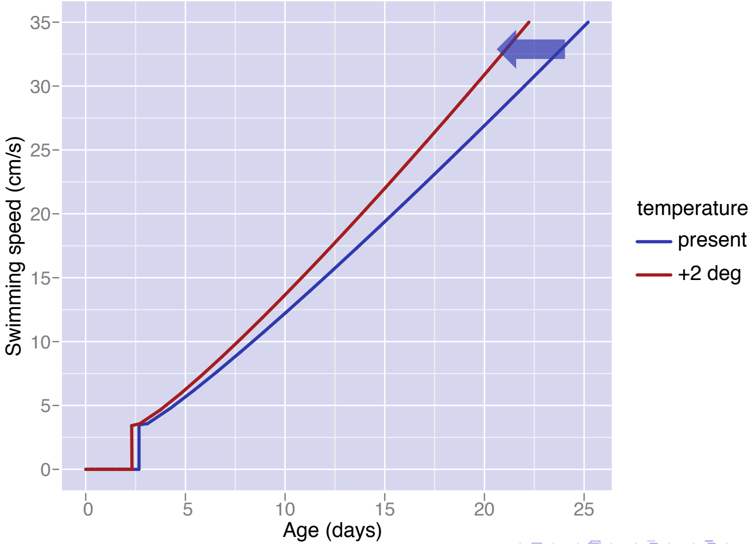
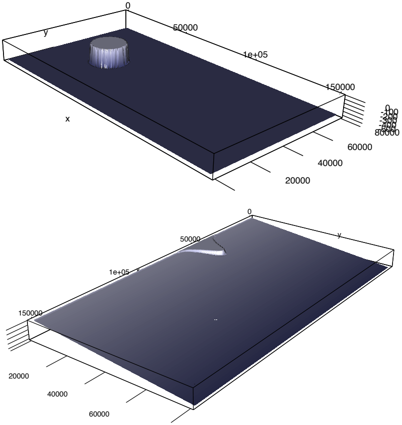
Evolutionary High mortality during larval phase, hence high **selective pressure** for orientation behavior favoring recruitment

Influence of temperature

Fisher *et al* 2005 MEPS & O'Connor 2007 PNAS



Various model systems



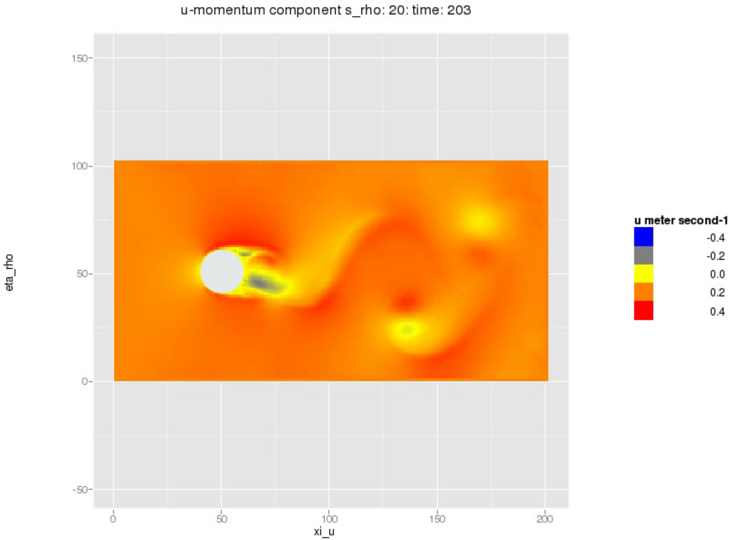
- **Coral-reef** larva
  Pomacentrus amboinensis
  PLD = 25 days
  speed = 3.5 → 35 cm.s^{-1}
  endurance = 46.33 hours

- **Cold temperate** larva
  PLD = 4 + 23 days
  speed = 0.5 → 5 cm.s^{-1}
  endurance = 15 hours

Focus on **self-recruitment** in each case

ROMS flow

Dong *et al* 2007 Journal of Physical Oceanography



ROMS flow

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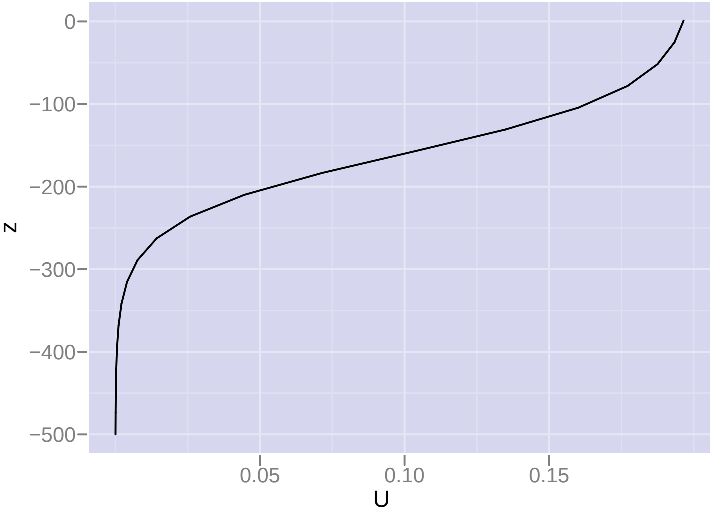
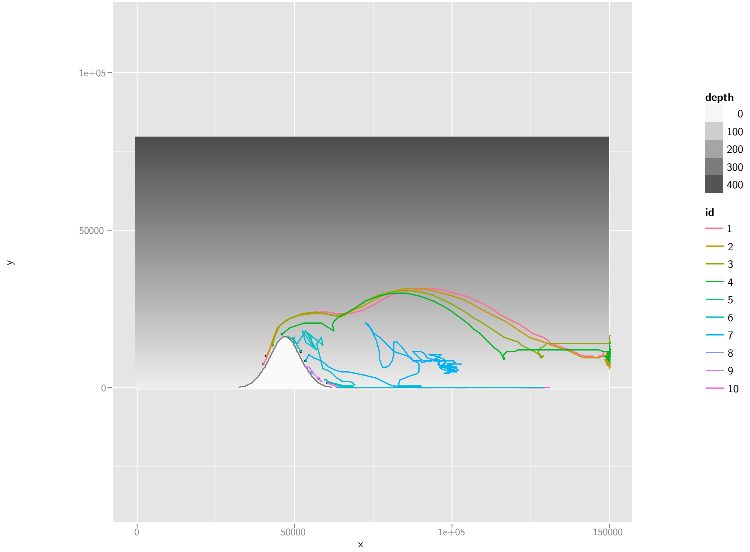
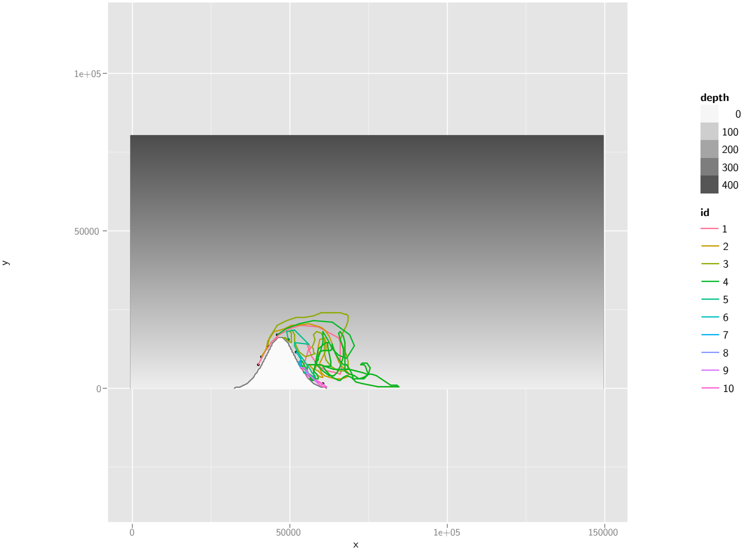


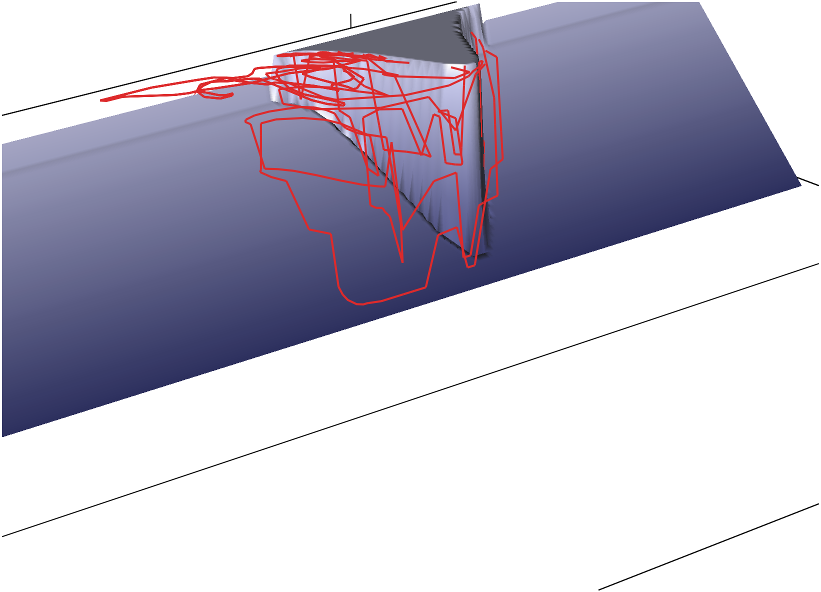
Passive vs. active larvae



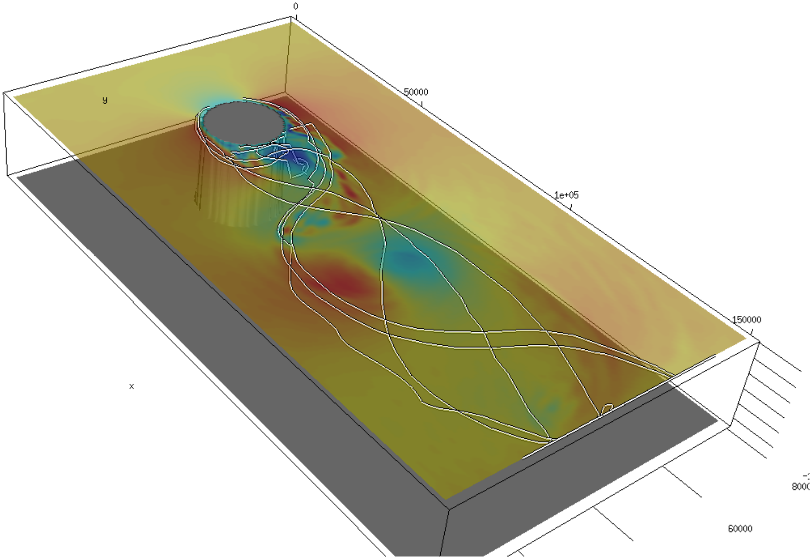
Passive vs. active larvae



Exploitation of the 3D of the flow



Mechanisms of recruitment with faster development



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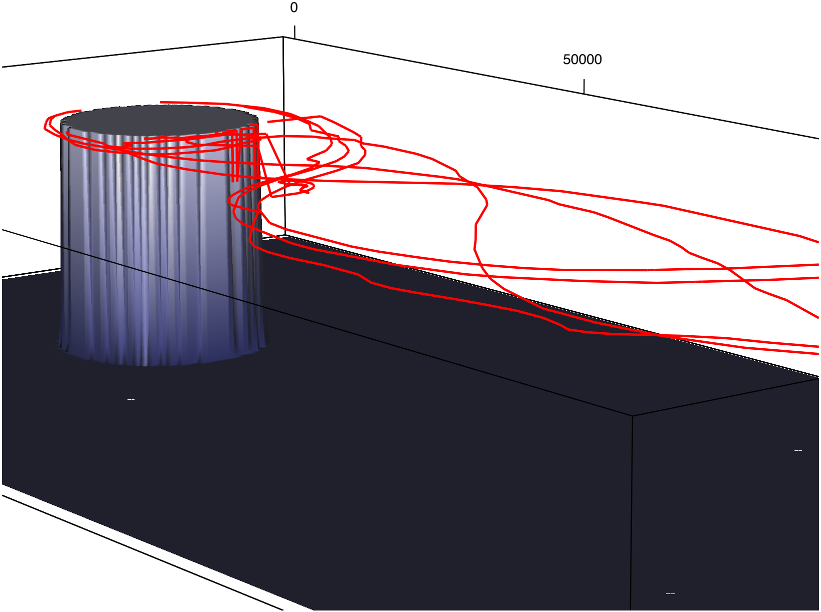

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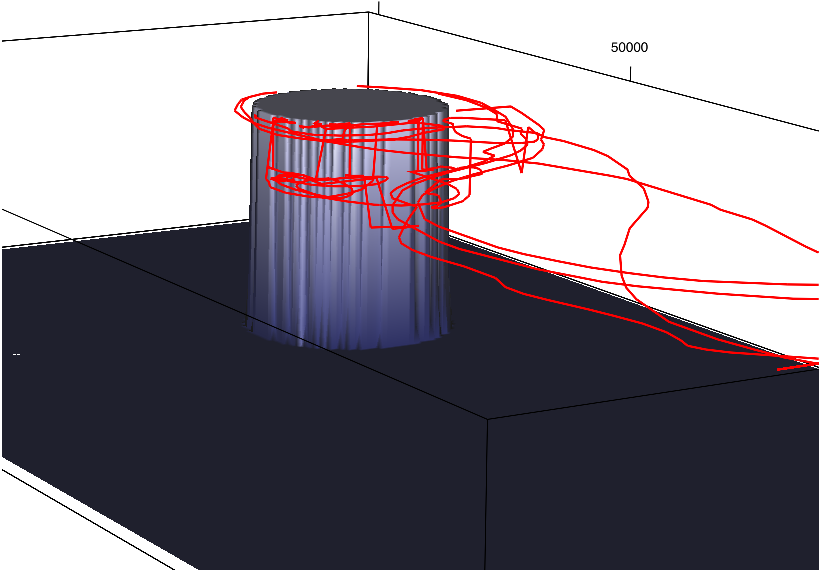

Overall influence of temperature

		Coral-Reef		Temperate	
		present	+2°C	present	+2°C
	PLD (d)	25	22.1	27	21.7
Prom.	success (%)	95	95	72	**75**
	recruit. rate $\times 10^{-3}$	1.9	**2.2**	0.15	**0.44**
	mean dist (km)	16.5	**22.4**	43.5	33.1
Island	success (%)	95	95	45	**48**
	recruit. rate $\times 10^{-3}$	1.9	**2.2**	0.092	**0.28**
	mean dist (km)	17.1	**18.5**	18.1	**20.1**

Main findings

- **Swimming** has a large influence
- Exploitation of **vertical** heterogeneities is the most energetic efficient behavior
- Swimming **early** makes a difference
- Higher temperature ⇒ Faster development ⇒
  - higher **self-recruitment**
  - **longer** distances from origin

Future of the method

Limits Has to work on a **grid**

- Decisions cannot be interpolated
- Limits in space and time resolution

Perspectives Arbitrarily **complex environment**

- Inclusion of predation and feeding
- Influence of faster energetic resources consumption in warm water?

Thank you for your attention

and many thanks to
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Michel de Lara
Claire B. Paris
for help and inspiration

Optimization procedure

Irisson *et al* 2004 Journal of Theoretical Biology

Decisions are computed **backwards** in time, from a given final gain:

$$\begin{cases} G(X,T) & = & \mathbf{1}_{\{X \in \text{recruitment zone}\}} \\ G(X,t) & = & \max_d [\ G(f(X_t,d,t),t+1) - C(d)\ ] \\ d^*(X,t) & \in & \arg\max_d [\ G(f(X_t,d,t),t+1) - C(d)\ ] \end{cases}$$

where the **advection** model is

$$f(X_t,d,t) = X_{t+1}$$

and the **cost** function associated with swimming is

$$C(d) \sim d.speed^3$$