

BRING THE NOISE

Making sense of patchiness in plankton

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Oceanography Centre**

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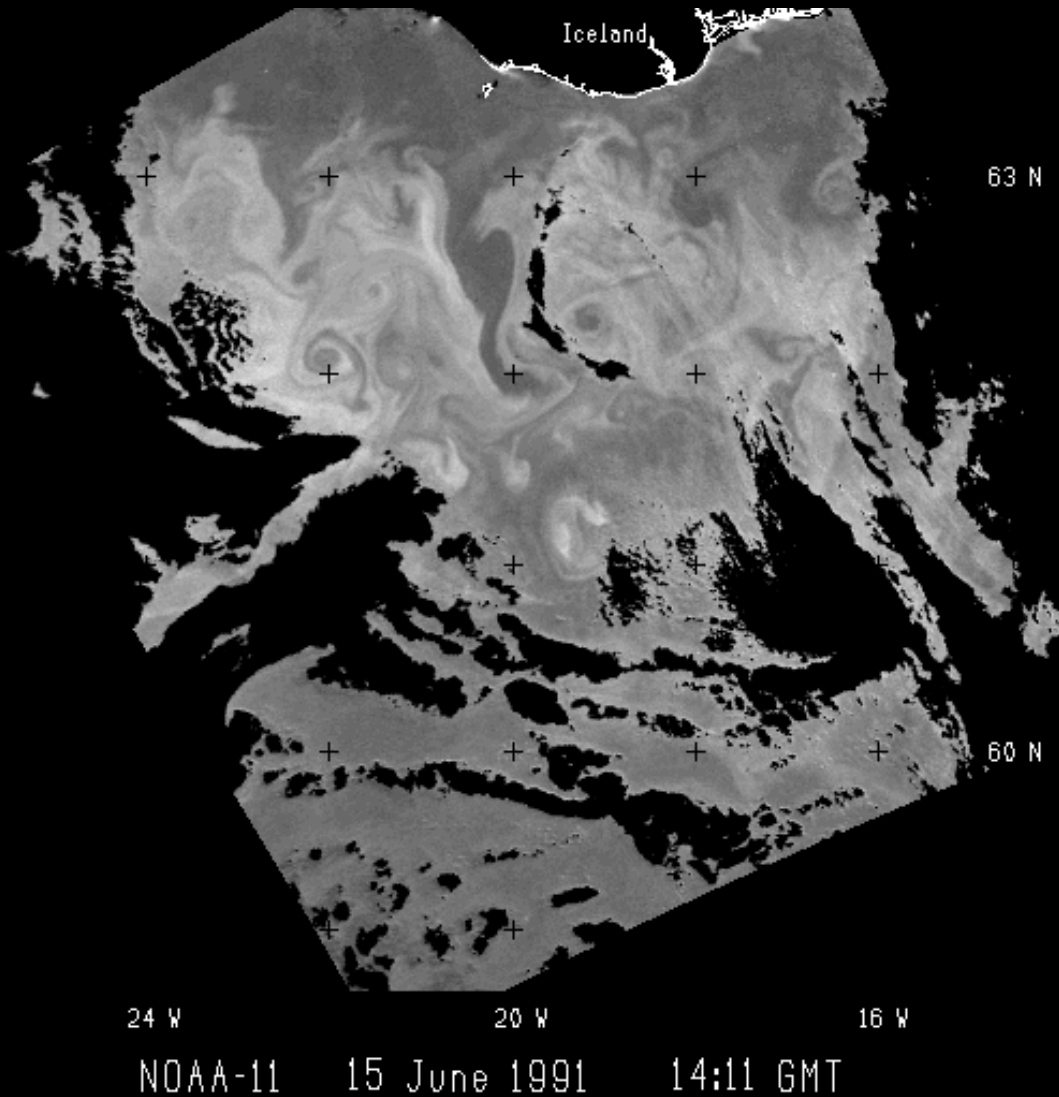


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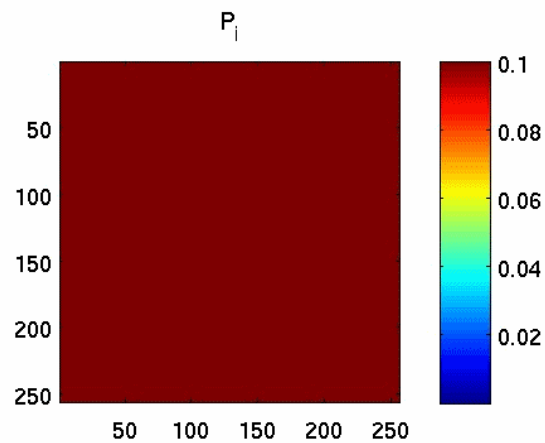
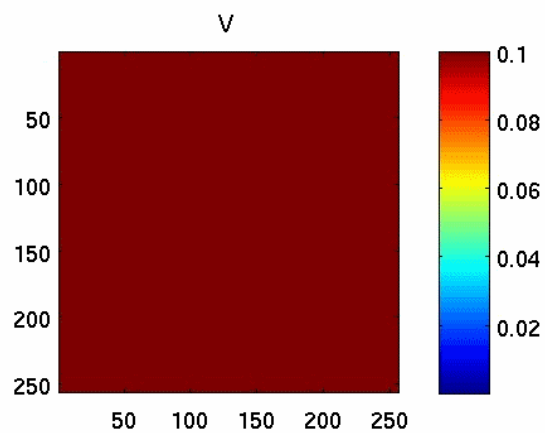
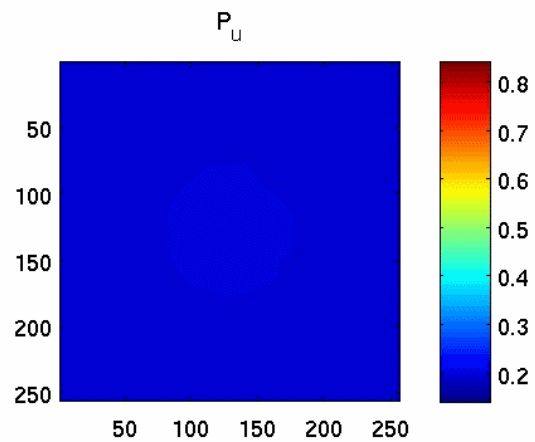
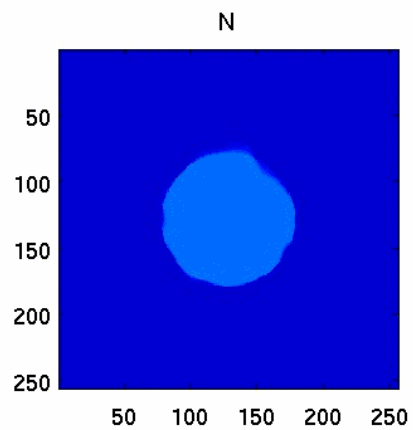
What we see

Data
from
Dundee
Satellite
Receiving
Station

Processed
by
Steve
Groom,
NEODAS,
PML

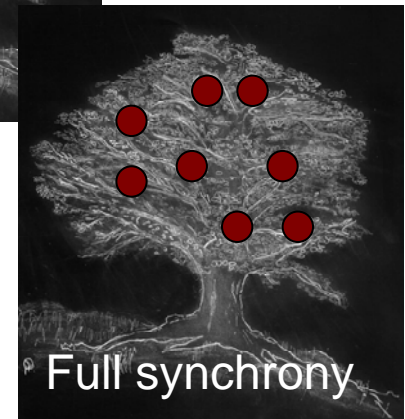
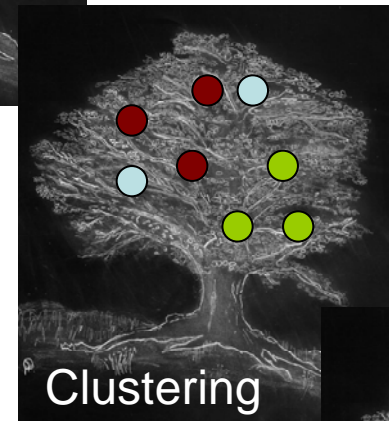
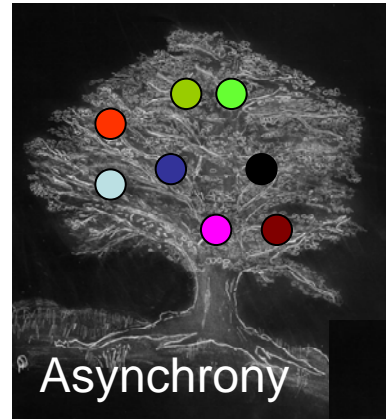


What our models do



The Wrong Sort of Patchiness?

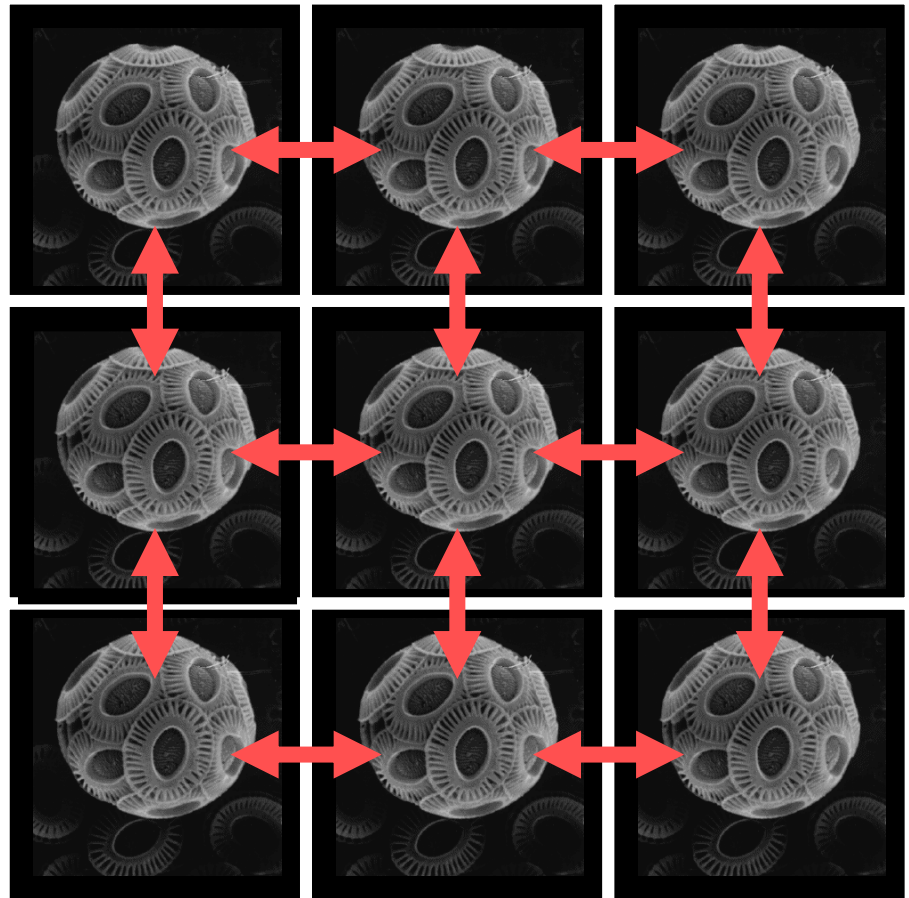
Synchronization theory



The Wrong Sort of Patchiness?

We can consider ocean ecosystems as a network of sub-populations connected by the stirring and mixing action of the currents.

This is, in fact, what ocean ecosystem modelling assumes



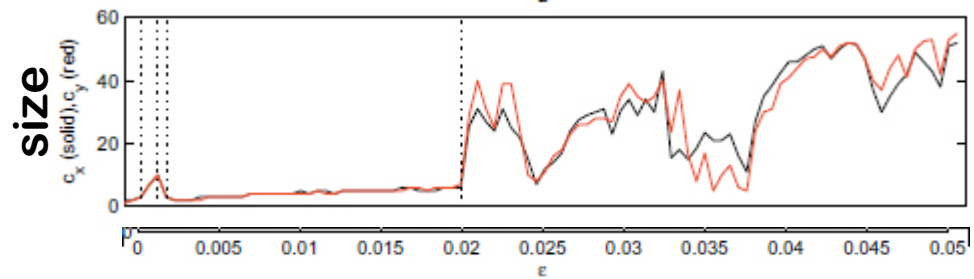
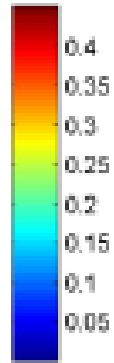
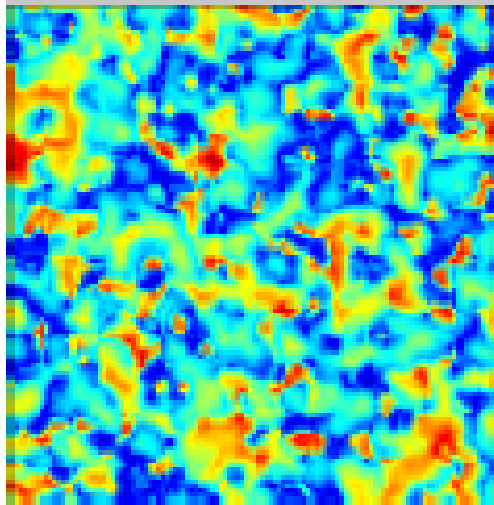
What can synchronisation theory tell us about patchiness?

The Wrong Sort of Patchiness?

For simplicity, consider:

- A simple nitrate-phytoplankton-zooplankton (NPZ) model**
- Oscillating populations with no seasonal cycle**
- Purely diffusion-like transport (initially)**
- Spatially varying growth rates (so different frequencies)**

The Wrong Sort of Patchiness?



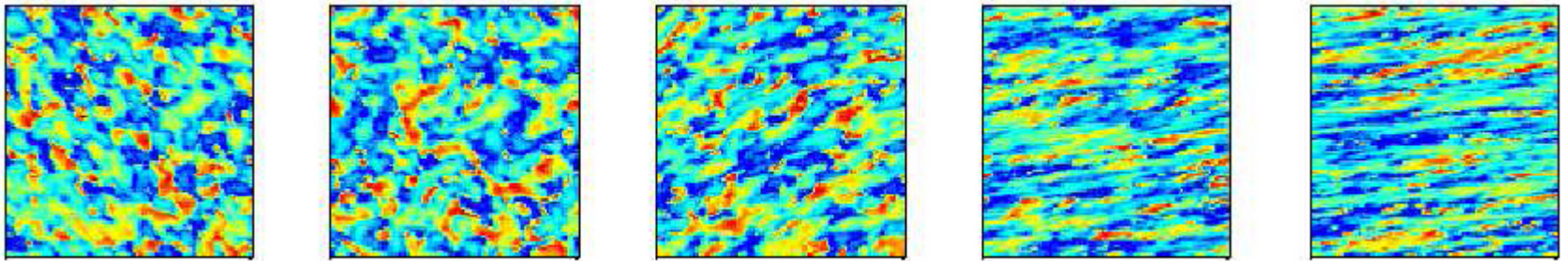
Occurrence and length-scale of model patchiness is sensitive spatial resolution.

Emergent spatial structure alters abruptly from patchy to homogeneous as this parameters is varied

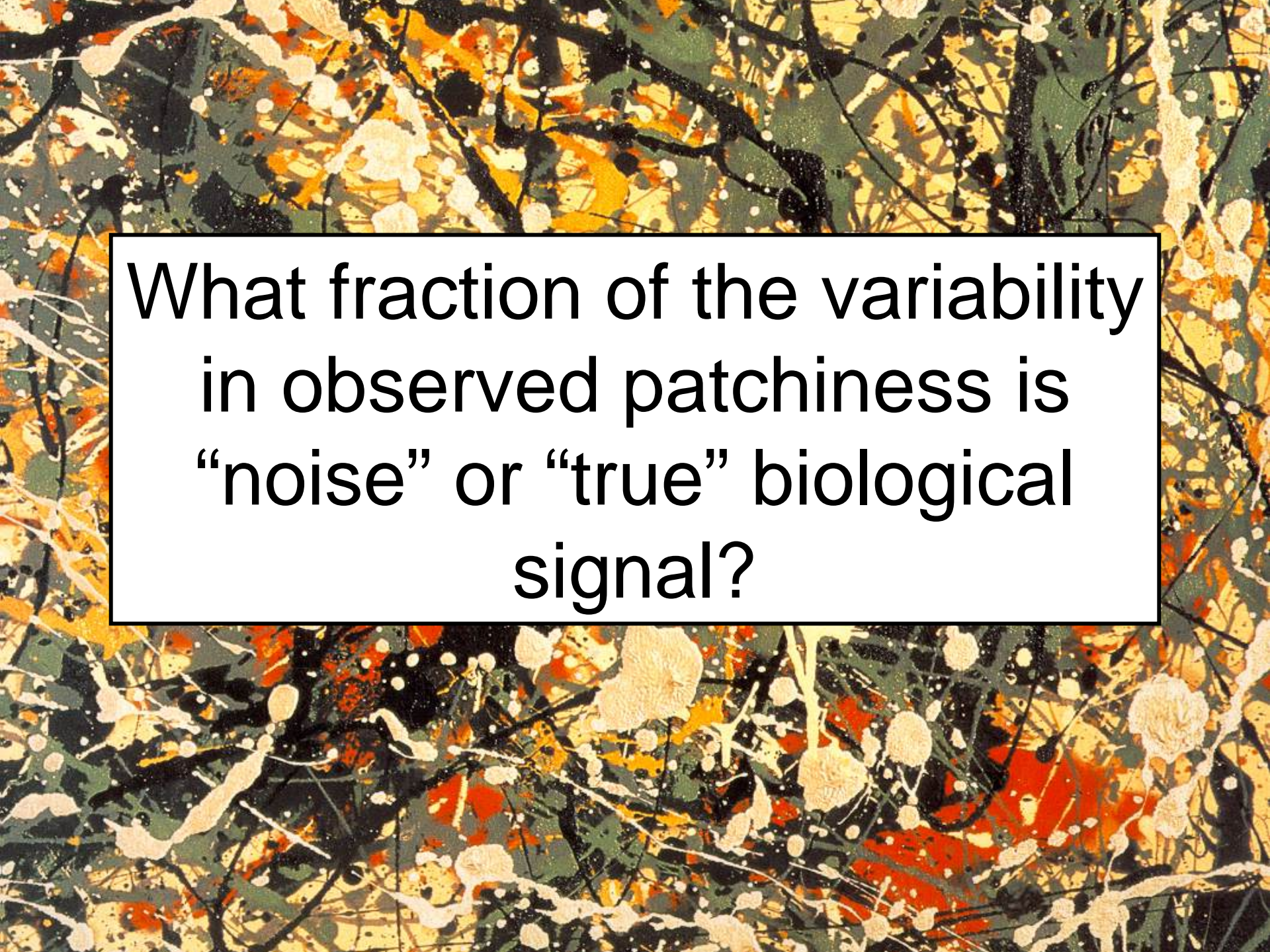
The Wrong Sort of Patchiness?

What if we include advection?

Increasing shear

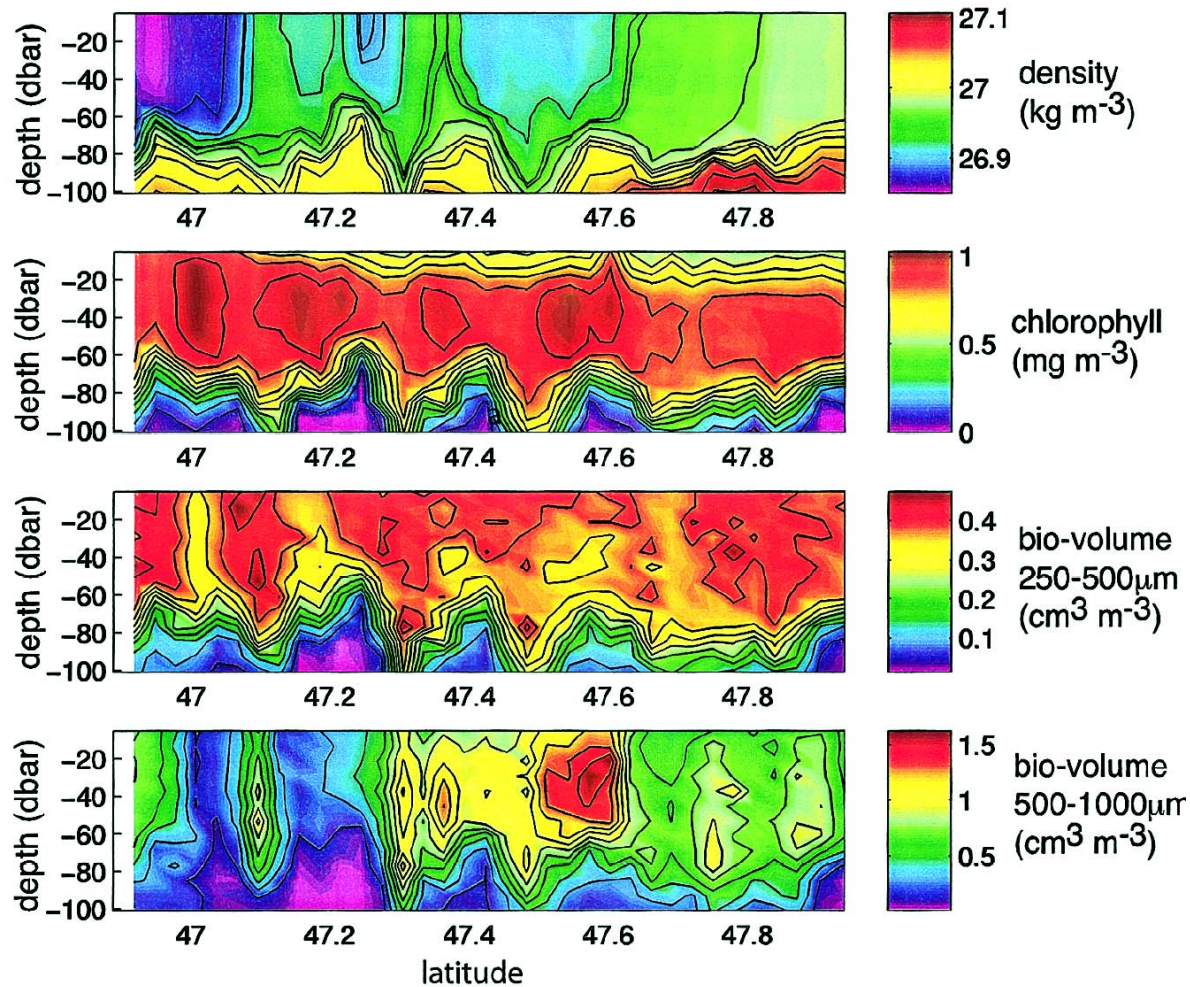


Patchiness is statistically steady state
but
individual patches distort, merge and break up

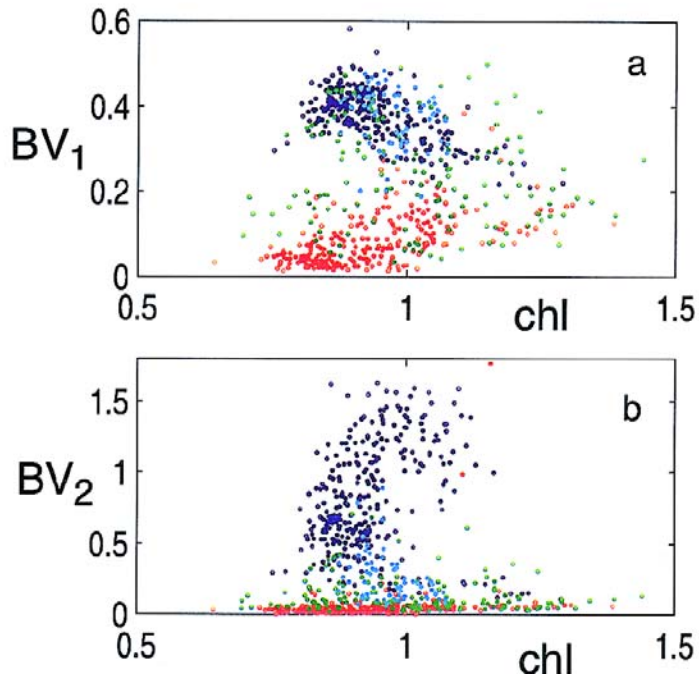


What fraction of the variability
in observed patchiness is
“noise” or “true” biological
signal?

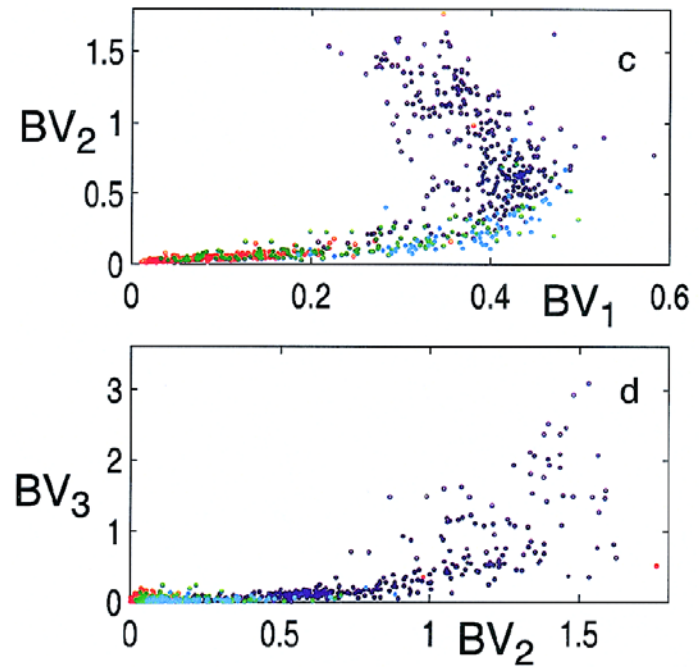
The Rest is Noise



The Rest is Noise

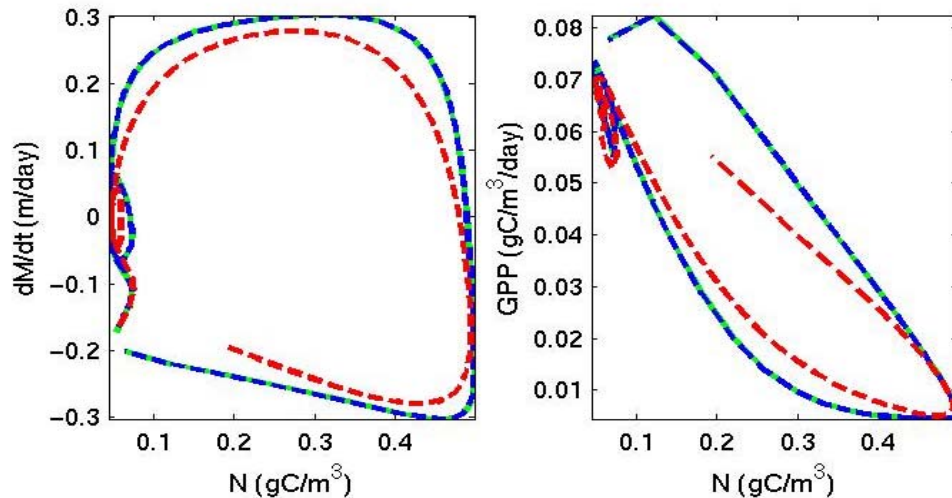
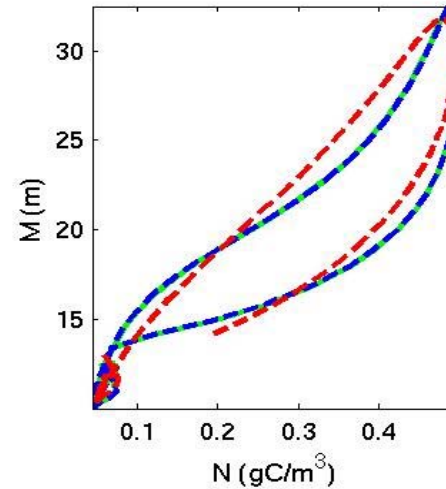
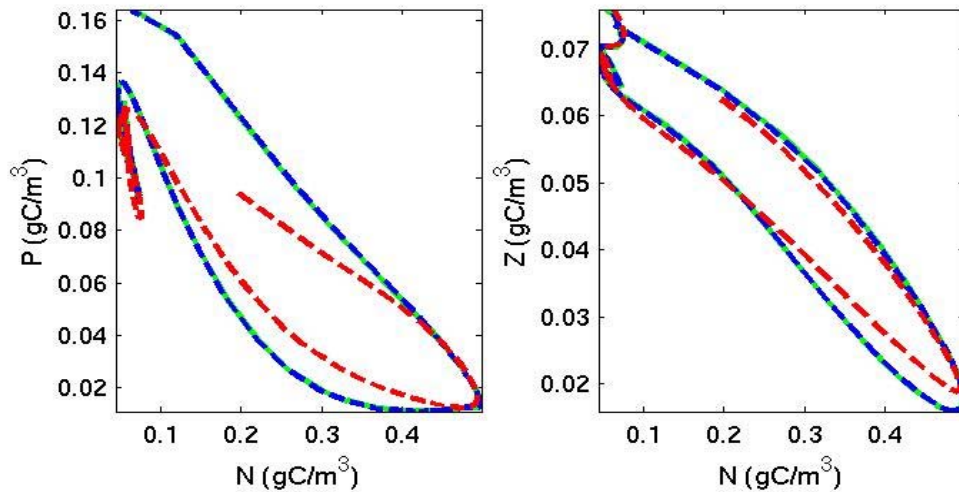


Surveys - B, C, E, F



data from 25-33m in the ML

The Rest is Noise



Green – model 'truth'
Red – time-series fit
Blue – phase space fit

Feedback

For advection of tracers:

$$\langle U.C \rangle = \langle (U_m + U') \cdot (C_m + C') \rangle$$

$$= U_m \cdot C_m + \langle U' \cdot C' \rangle$$

**Reynolds
Flux**

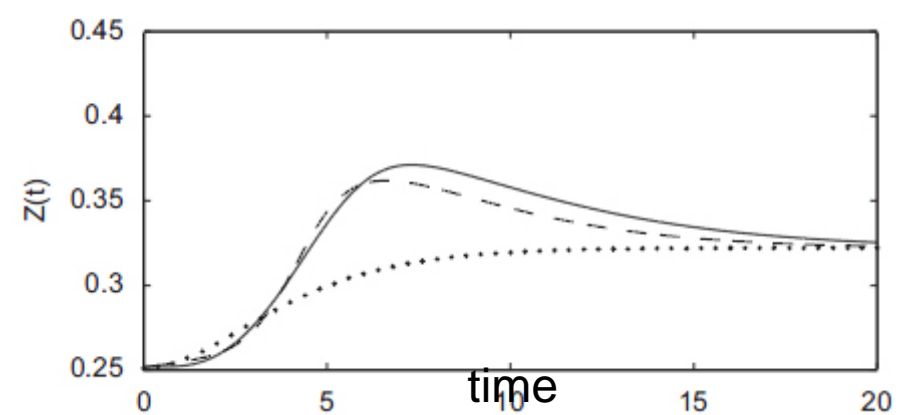
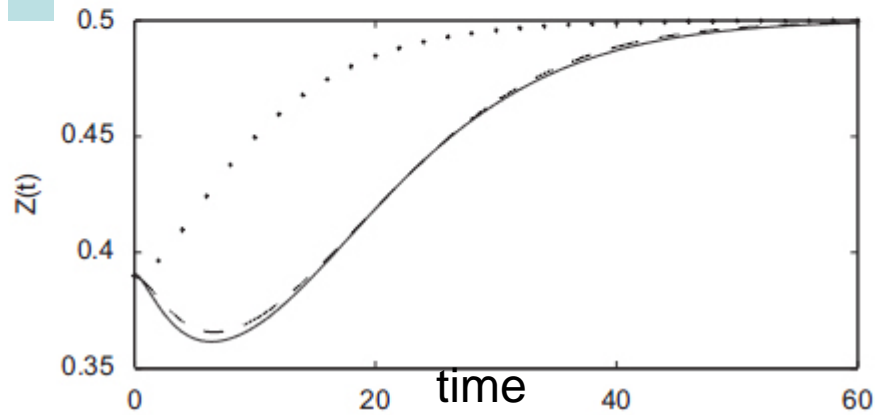
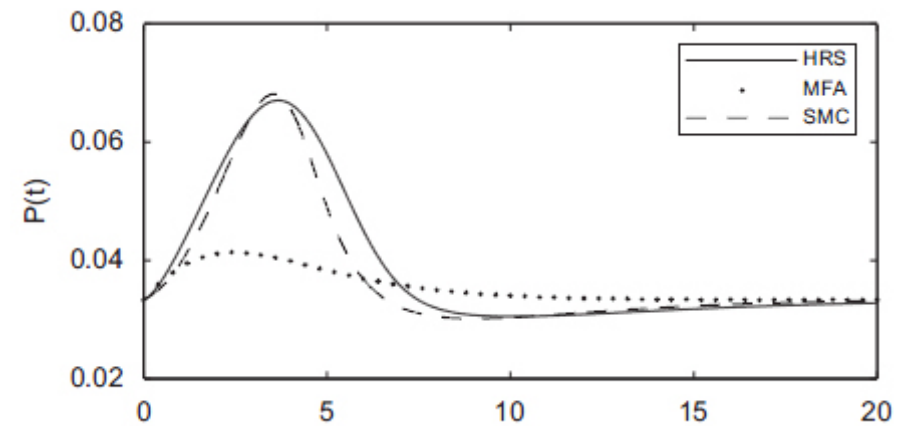
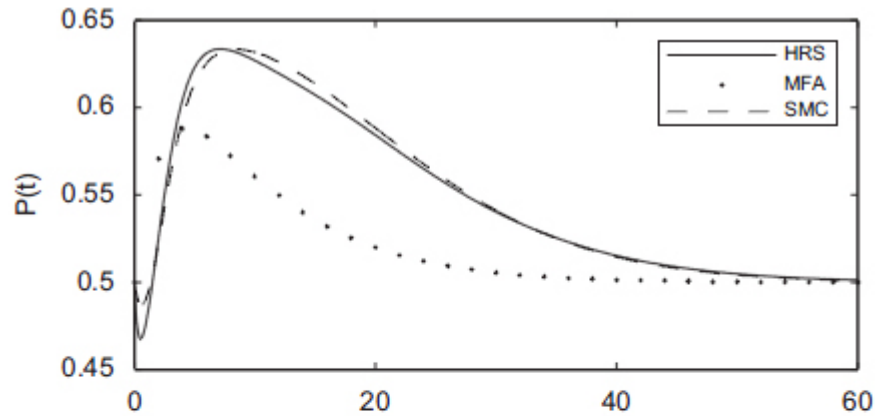
For biological interactions:

$$\langle P.Z \rangle = \langle (P_m + P') \cdot (Z_m + Z') \rangle$$

$$= P_m \cdot Z_m + \langle P' \cdot Z' \rangle$$

**Biological
Reynolds Flux**

Feedback



Weak non-linearity

Moderate non-linearity

Conclusions

- It is a mistake to regard plankton patchiness as the peacock of marine ecology, pretty but of no significance.
- The accurate reproduction of spatial variability provides a very stringent test of our models.
- Patchiness may tell us much more about the ecosystem dynamics than we have previously realised
- We have unwisely neglected the effects of sub-gridscale patchiness in our biogeochemical models