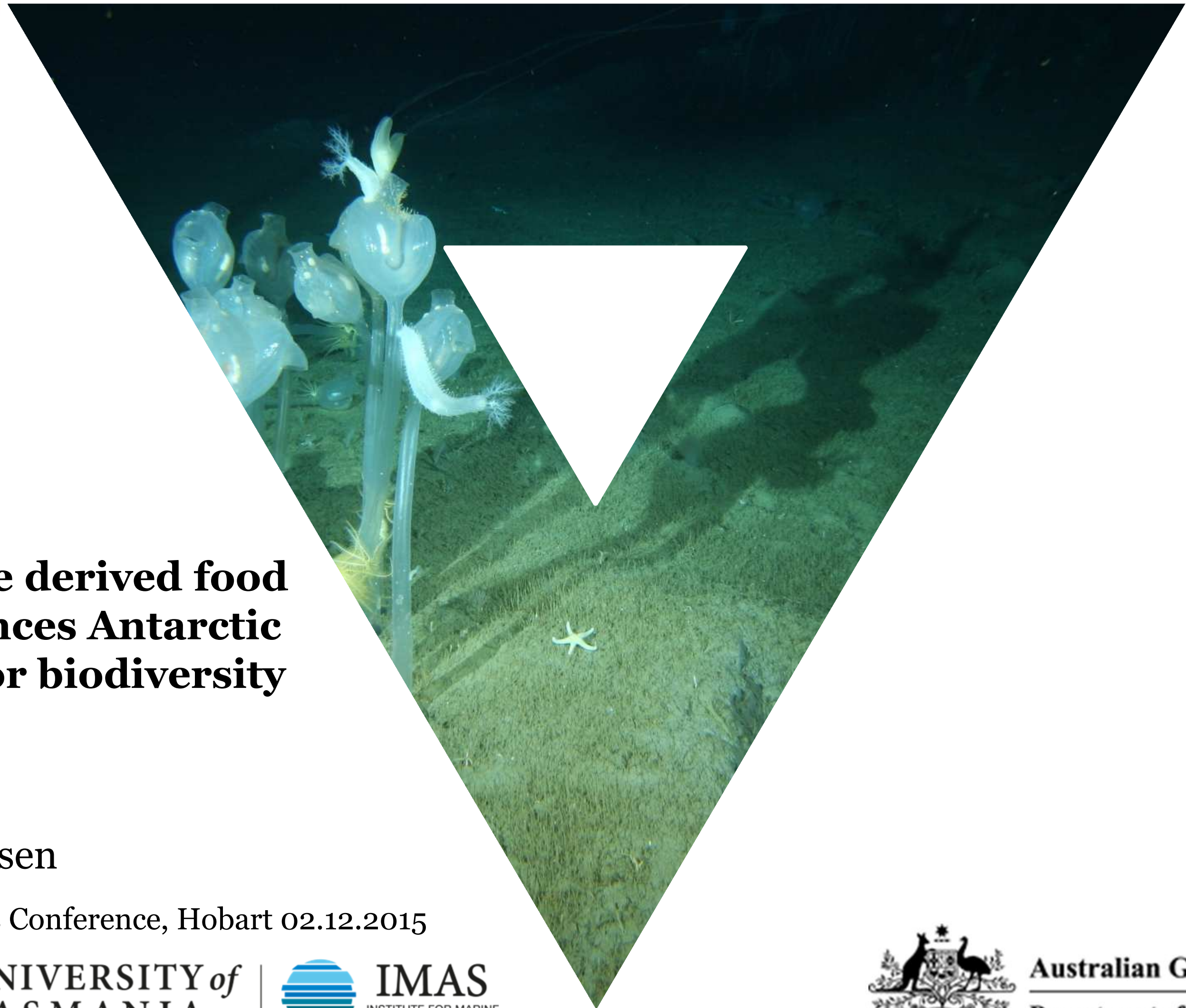
Biodiversity Modelling in the Southern Ocean using sparse data



Surface derived food influences Antarctic seafloor biodiversity

Jan Jansen

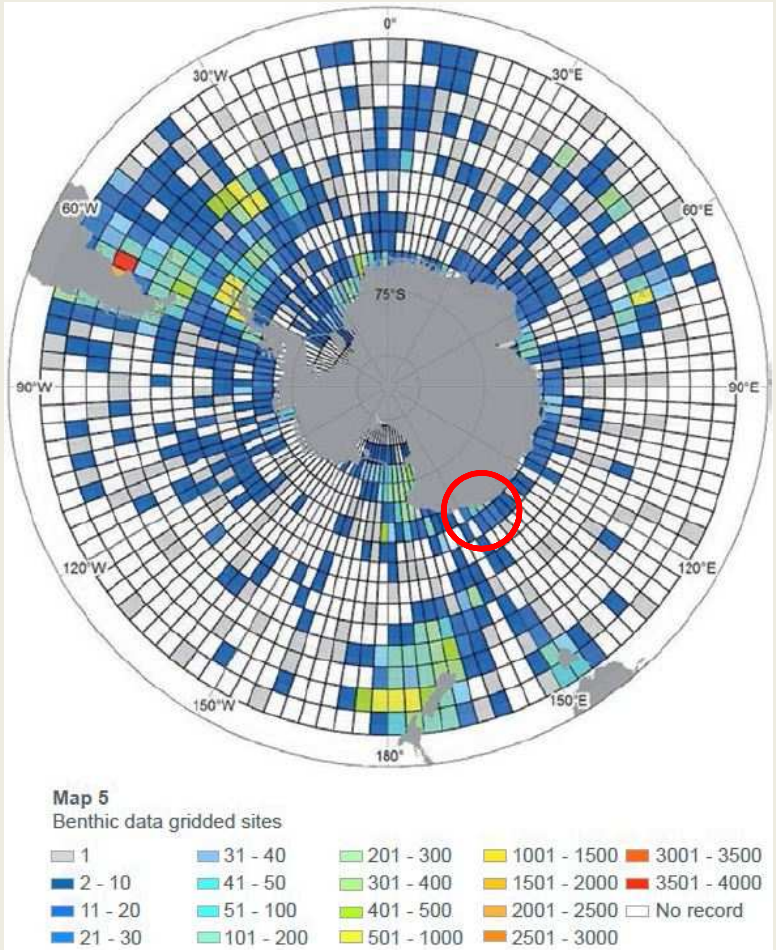
Biometrics Conference, Hobart 02.12.2015

UNIVERSITY *of* TASMANIA
IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

Australian Government
Department of the Environment
Australian Antarctic Division

Background

- Sparse biological data

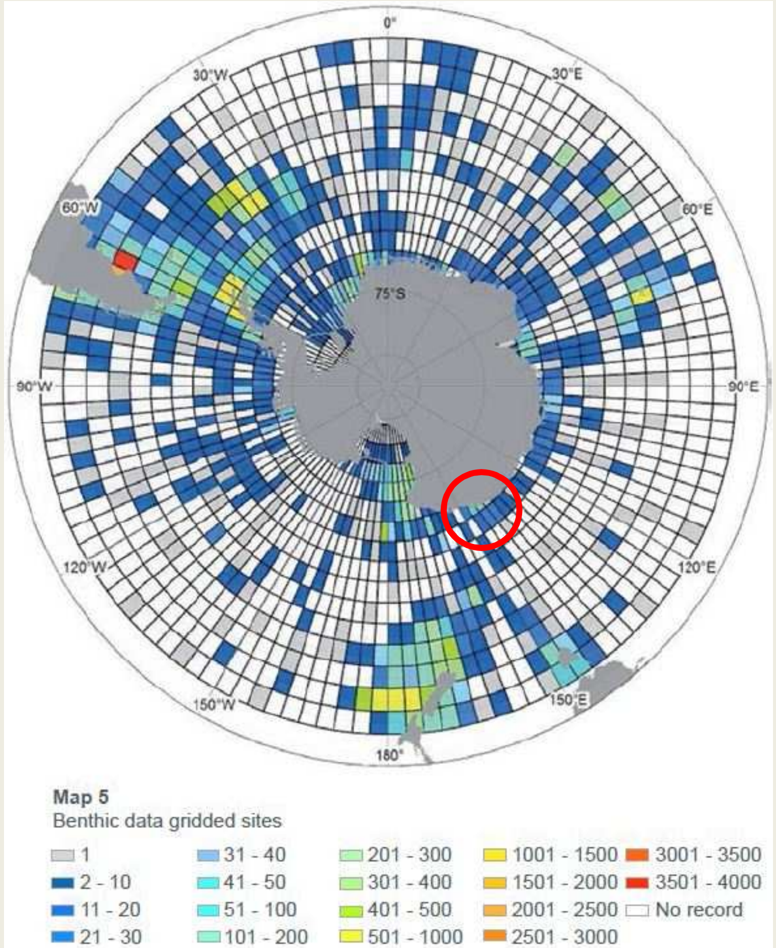


Southern Ocean Biogeographic Atlas (2014)

Background

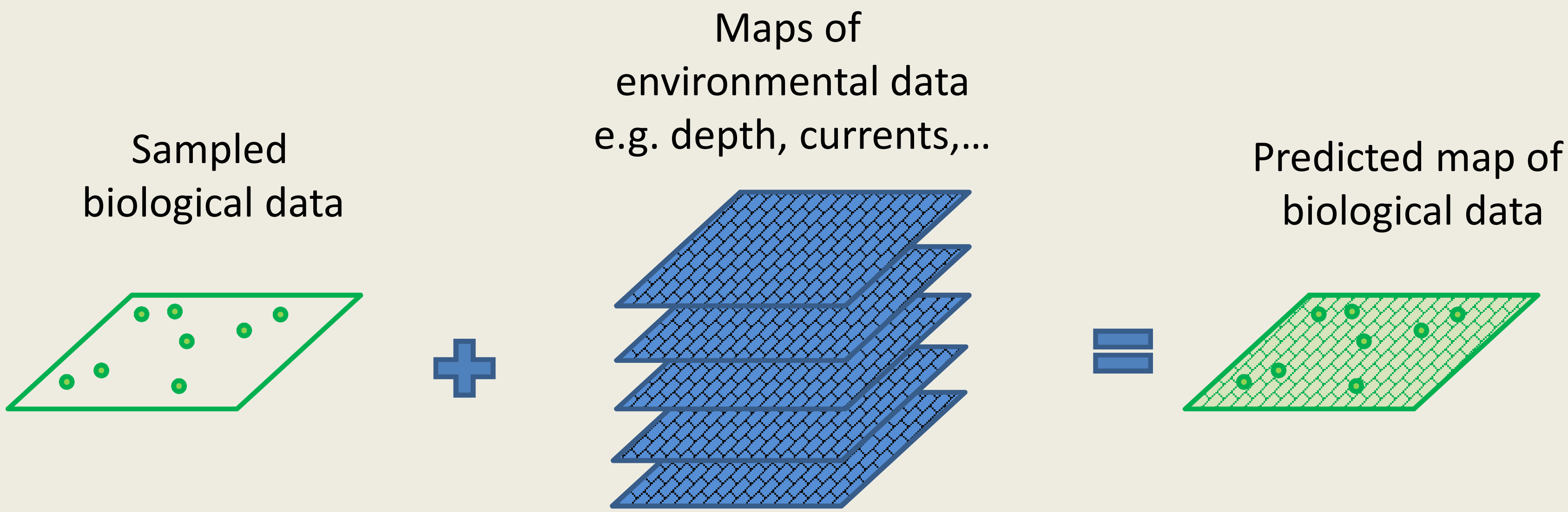
- Sparse biological data

- Remotely sensed and modelled data are: more easily accessible, cheaper and have broad coverage

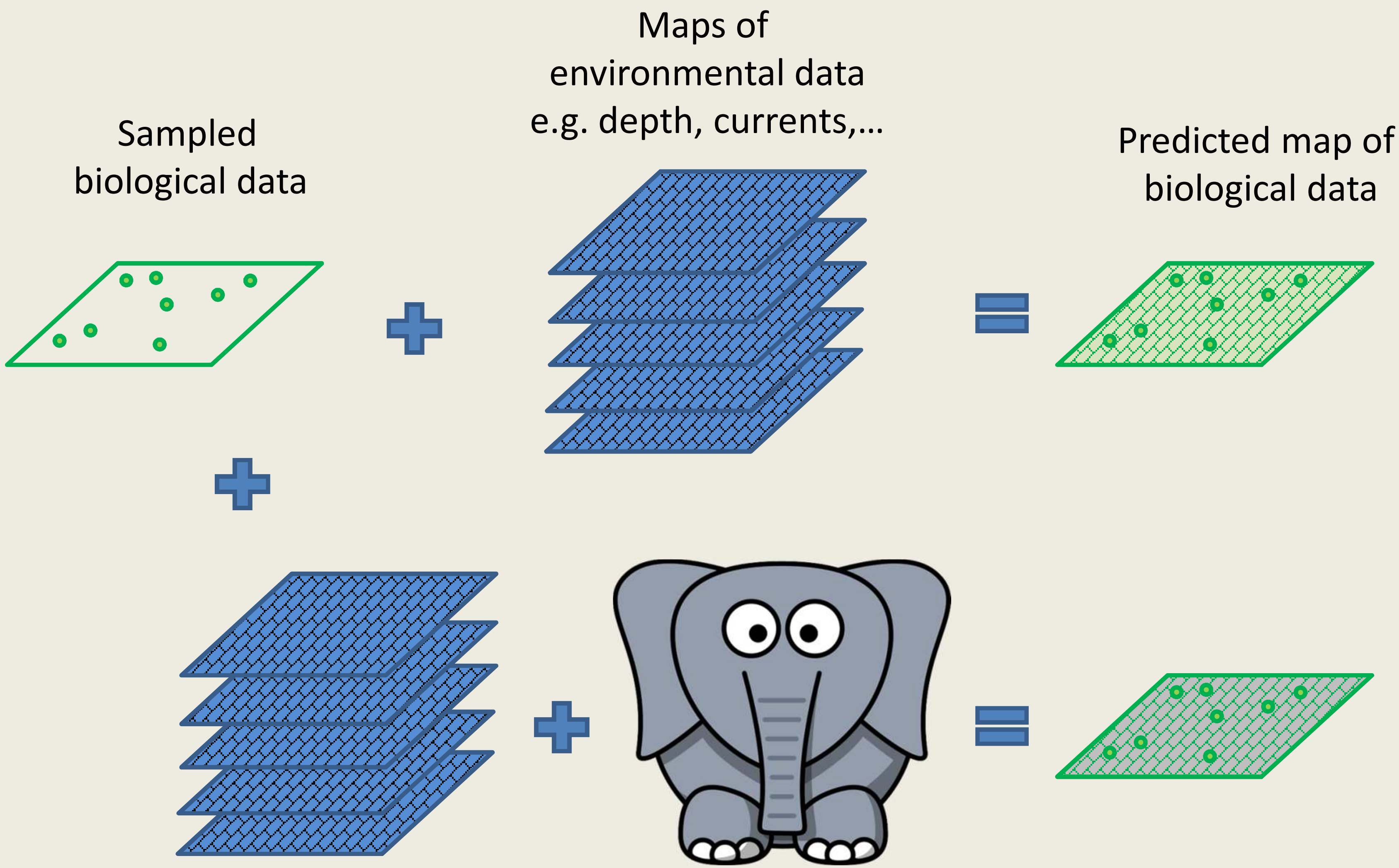


Southern Ocean Biogeographic Atlas (2014)

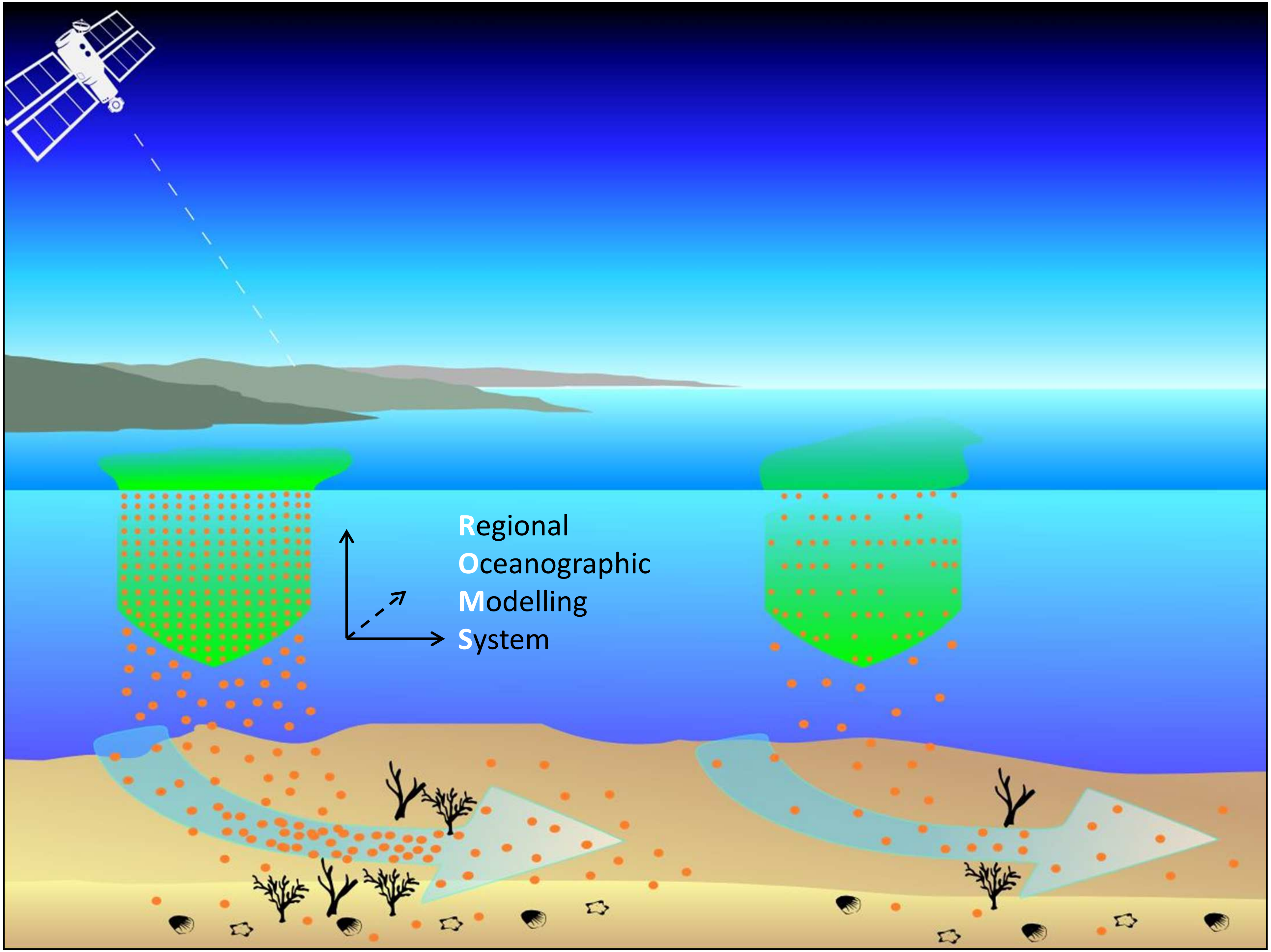
Ecoregionalisation

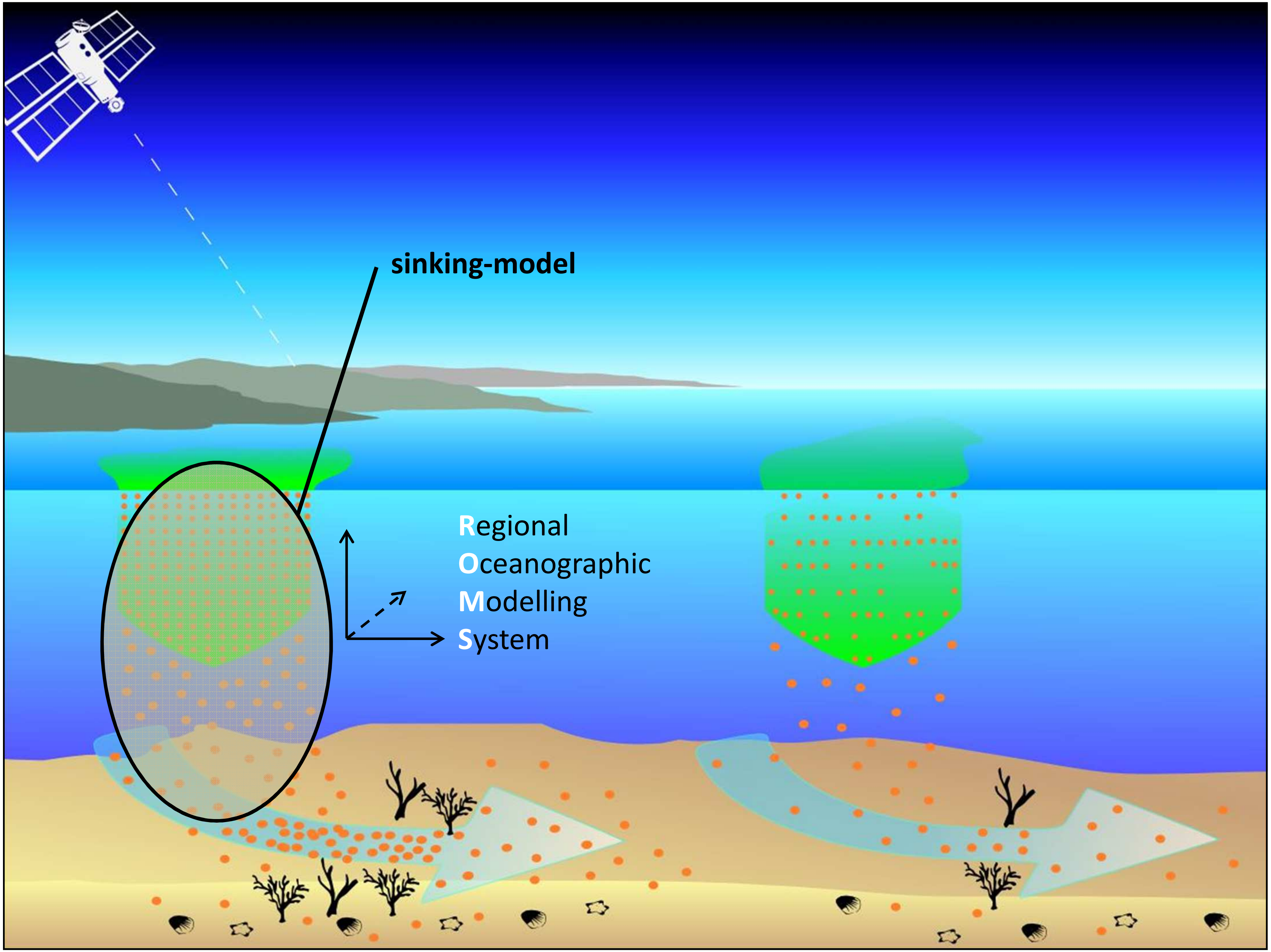


Ecoregionalisation

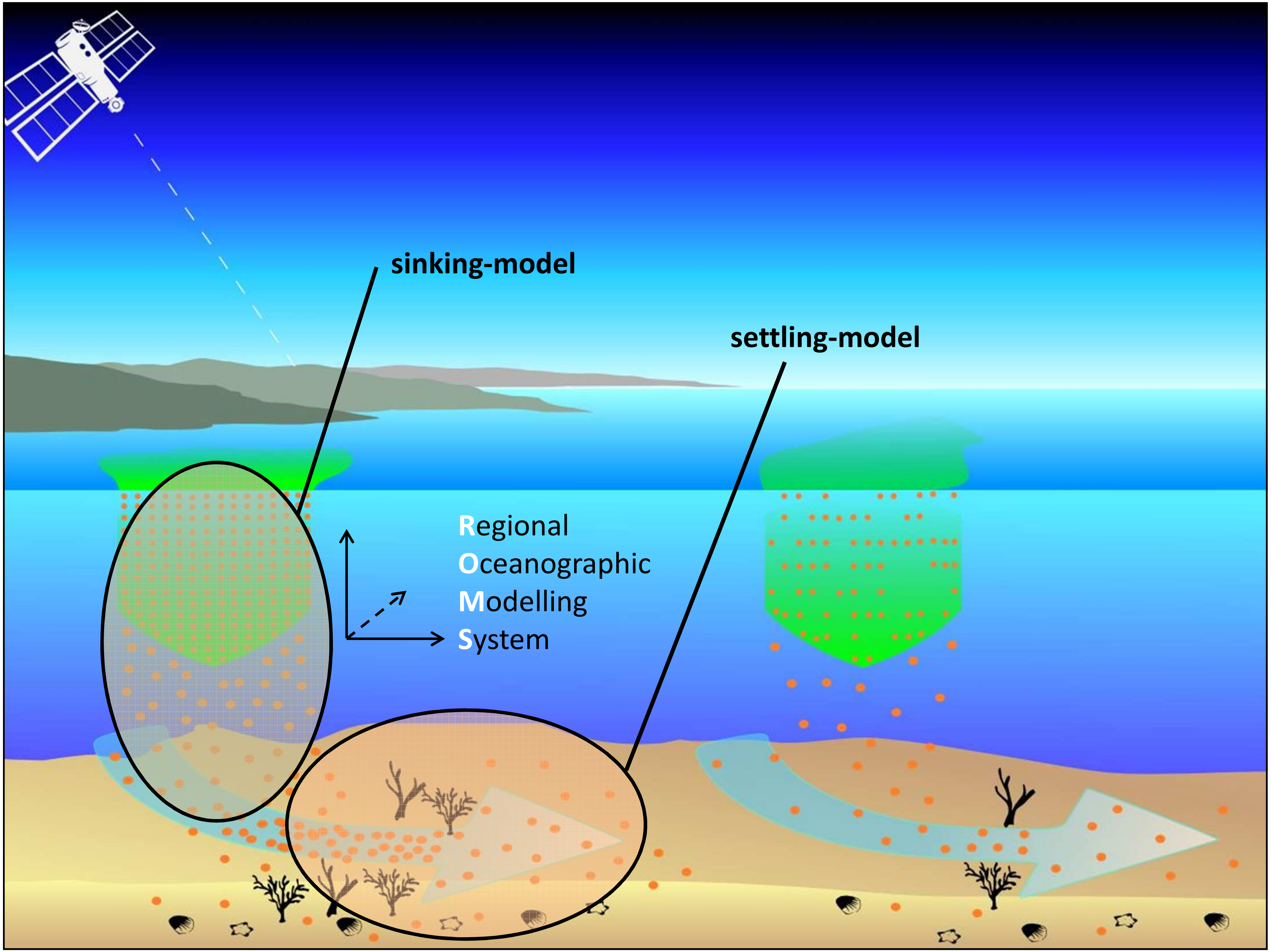


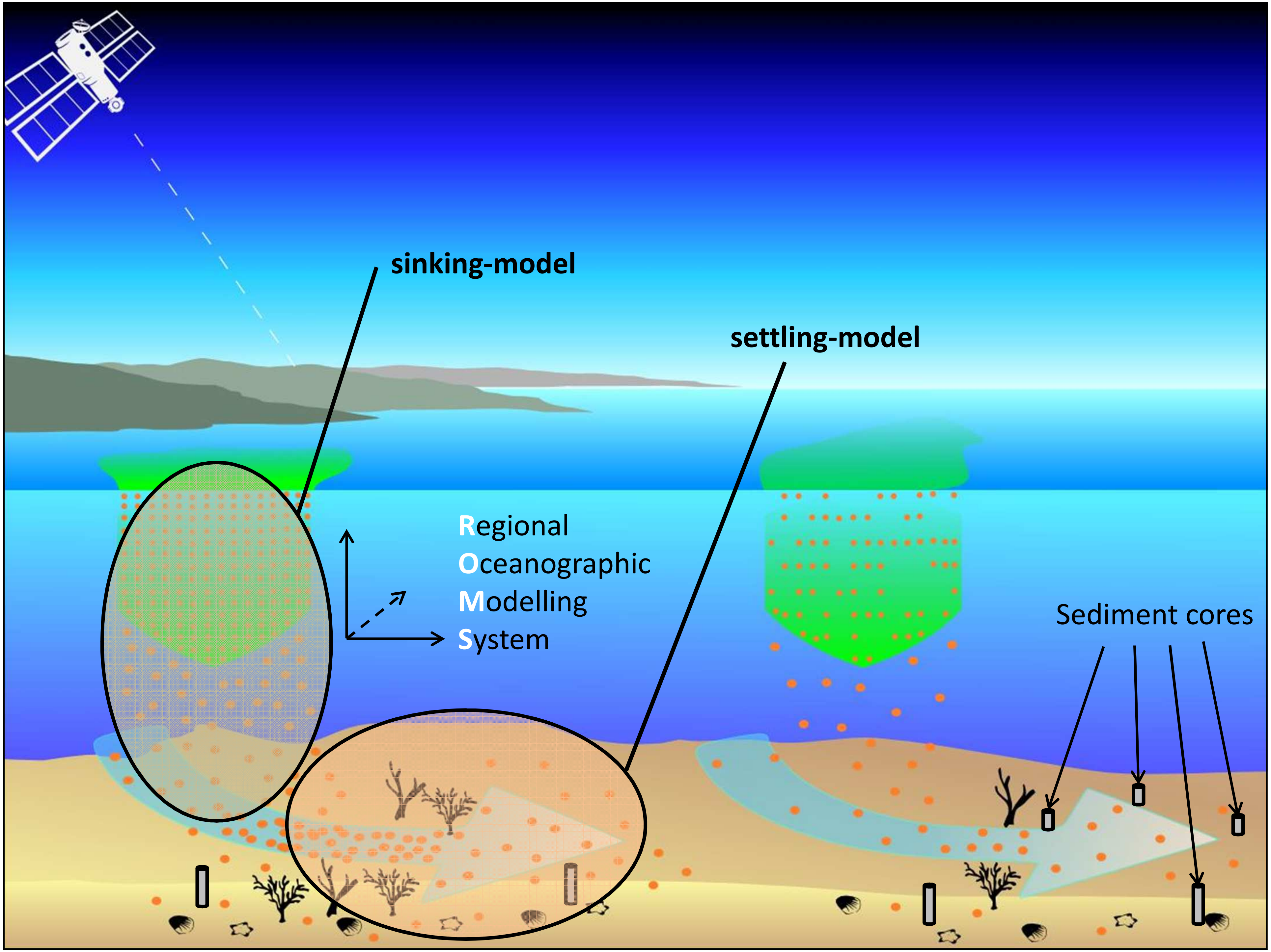
Problem with current global carbon-models (e.g. Lutz et al. 2007):
resolution too coarse & no regional currents


Regional
Oceanographic
Modelling
System



sinking-model
Regional
Oceanographic
Modelling
System

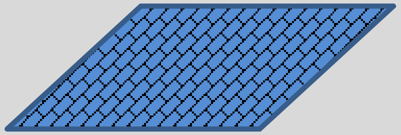

sinking-model
settling-model
Regional
Oceanographic
Modelling
System

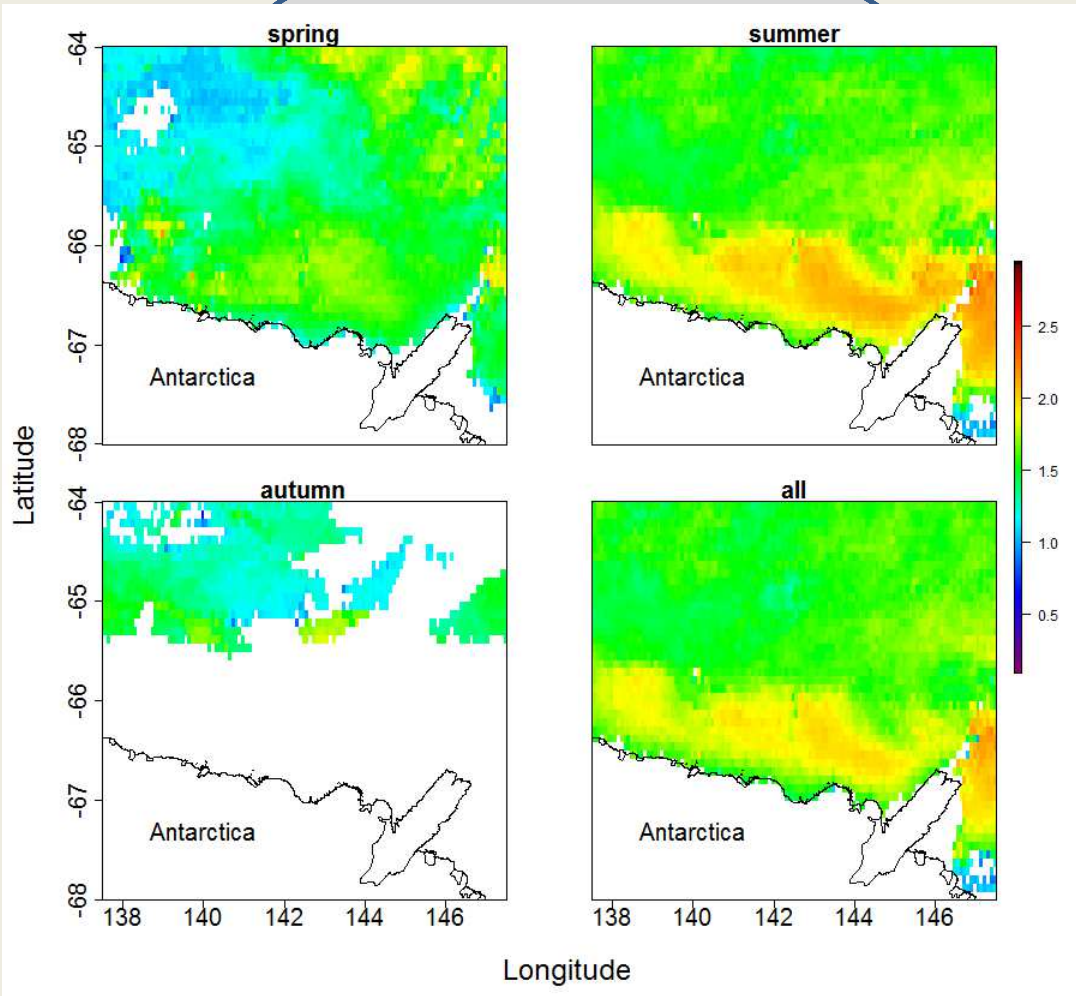

sinking-model
settling-model
Regional
Oceanographic
Modelling
System
Sediment cores

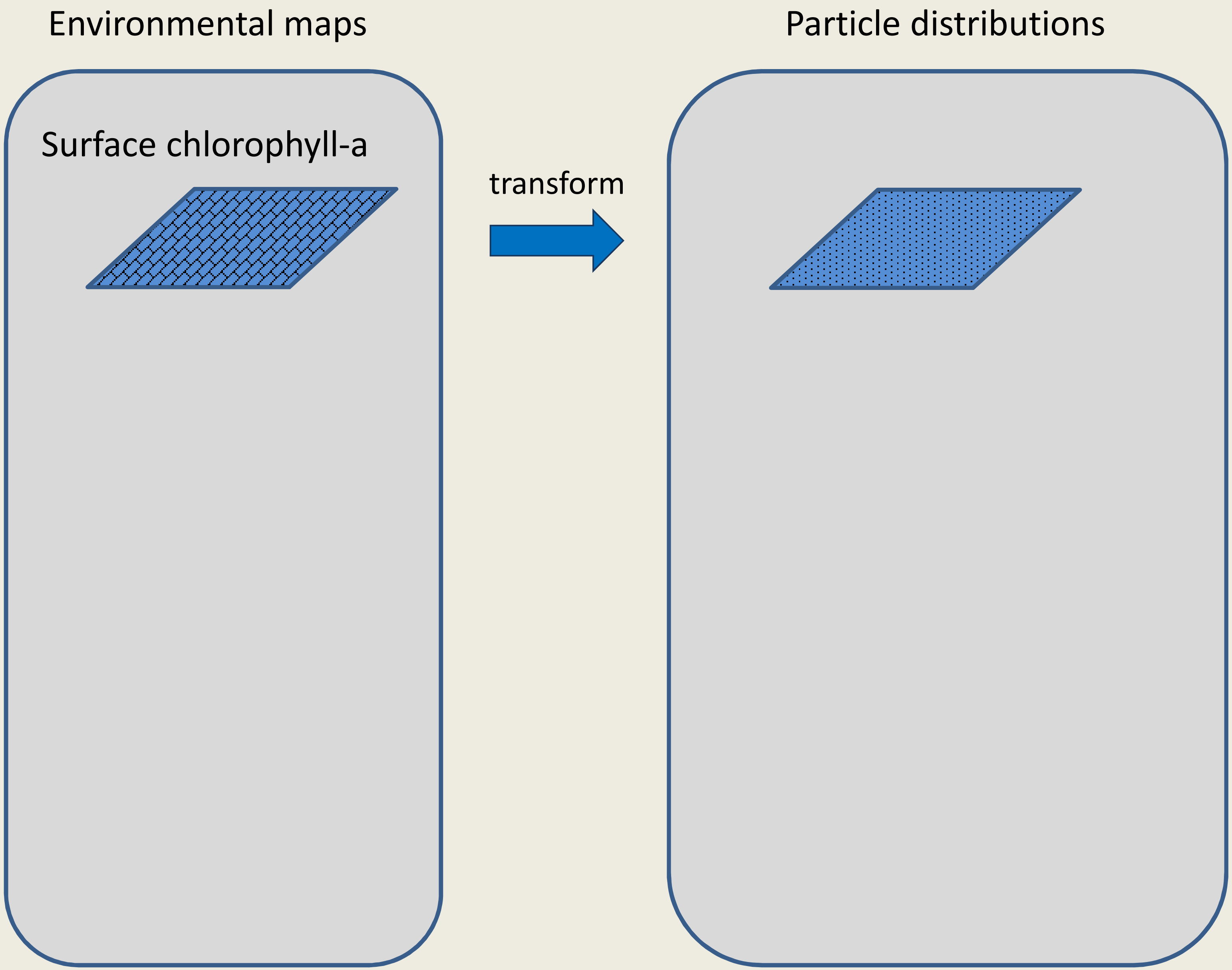
Environmental maps

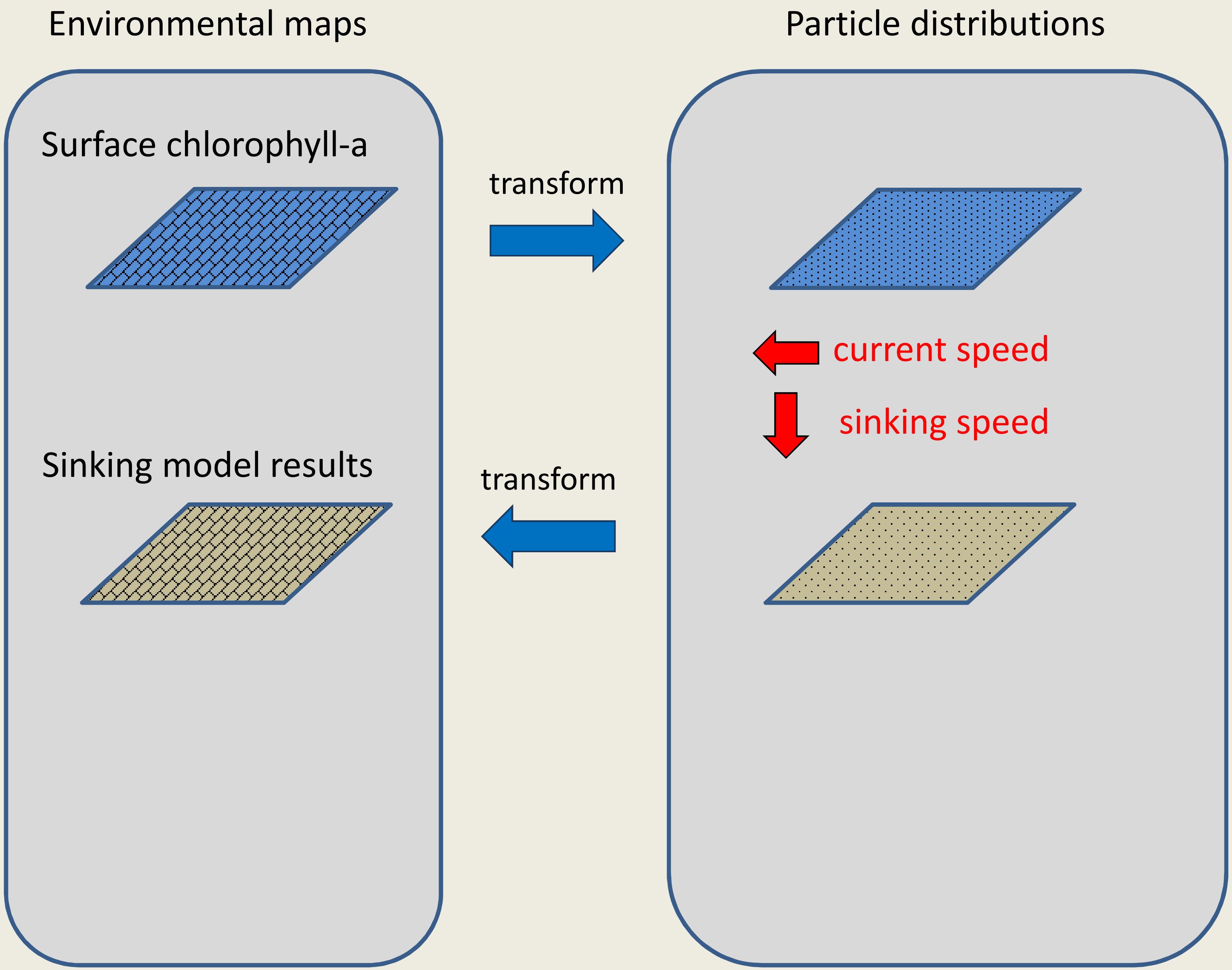
Particle distributions

Surface chlorophyll-a

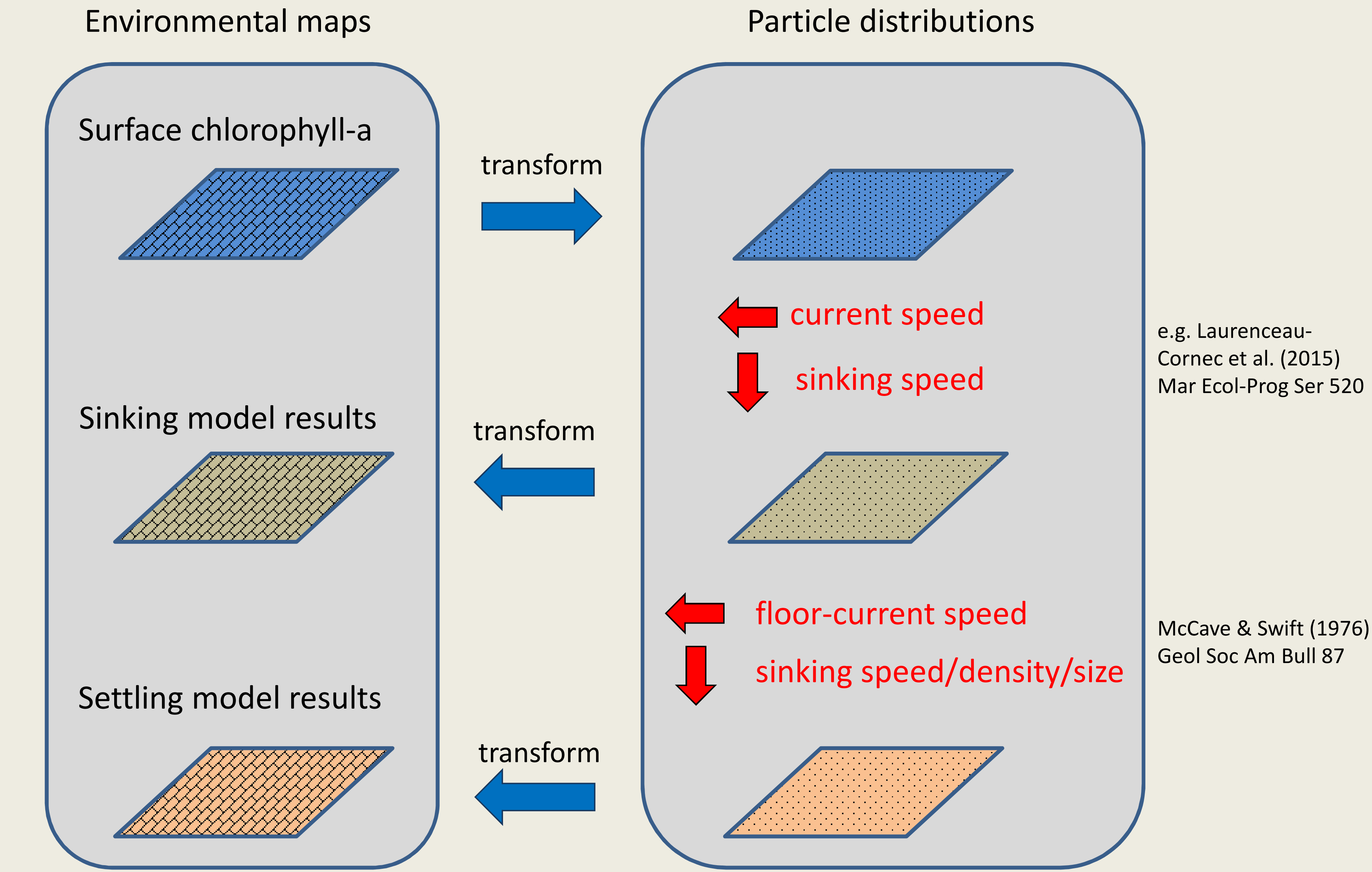





Environmental maps
Particle distributions
Surface chlorophyll-a
transform

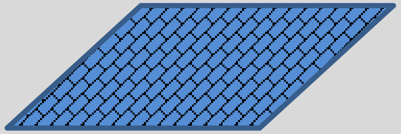


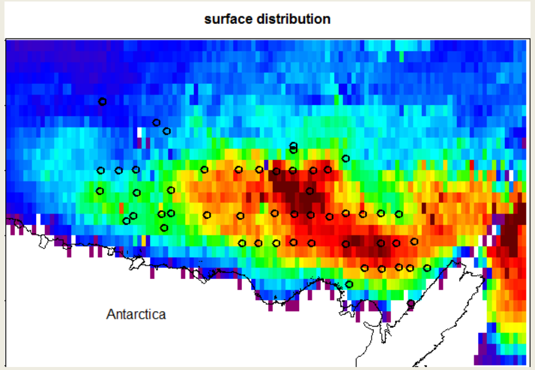
e.g. Laurenceau-Cornec et al. (2015) Mar Ecol-Prog Ser 520

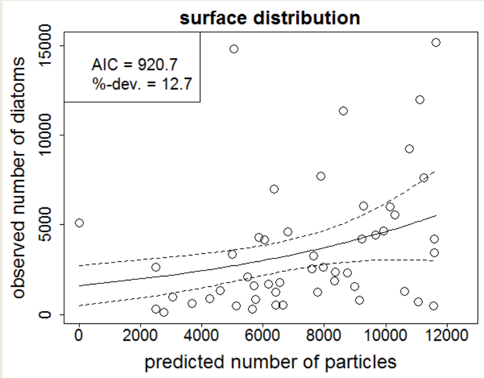


Environmental maps
Particle distributions
Surface chlorophyll-a
transform
current speed
sinking speed
Sinking model results
transform
floor-current speed
sinking speed/density/size
Settling model results
transform
e.g. Laurenceau-Cornec et al. (2015) Mar Ecol-Prog Ser 520
McCave & Swift (1976) Geol Soc Am Bull 87

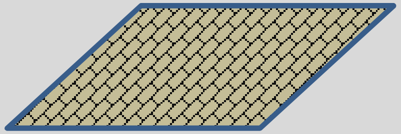
Surface chlorophyll-a



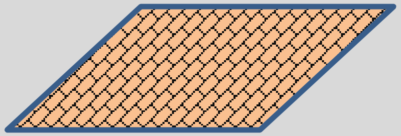




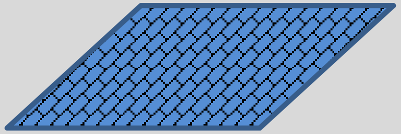
Sinking model results

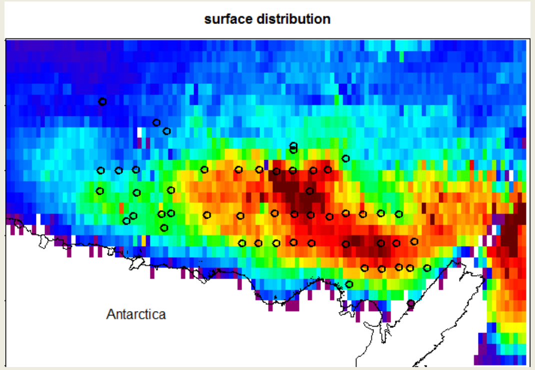


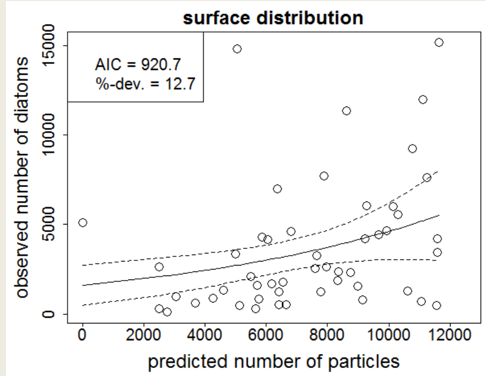
Settling model results



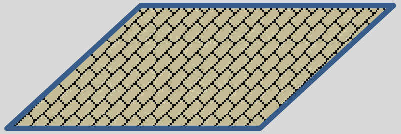
Surface chlorophyll-a

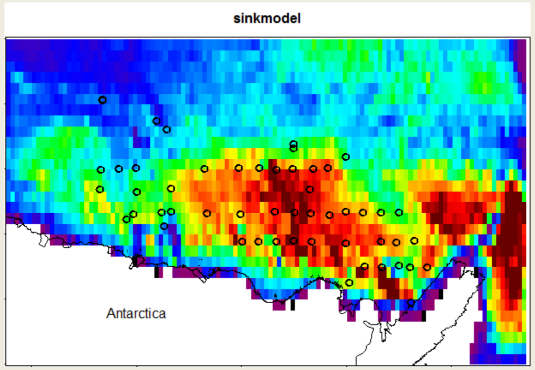


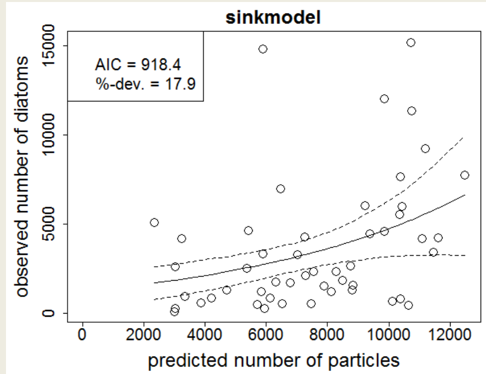




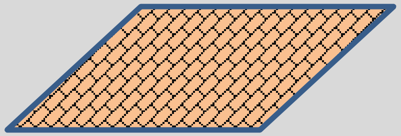
Sinking model results



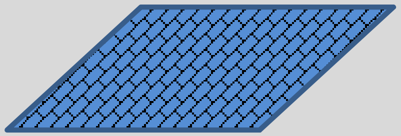


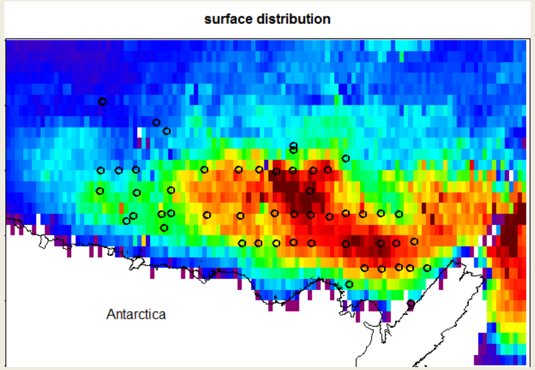


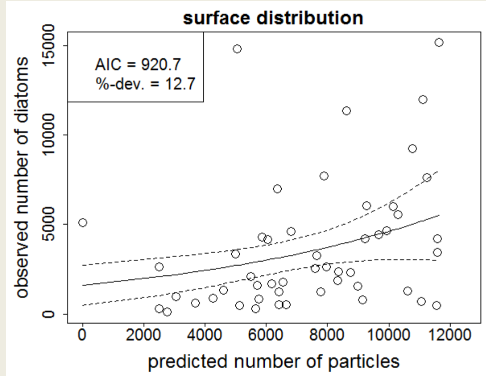
Settling model results



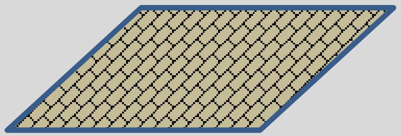
Surface chlorophyll-a

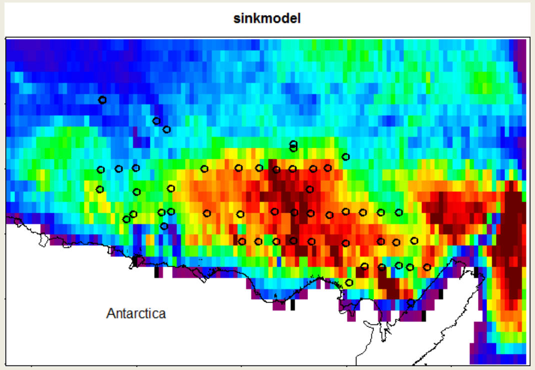


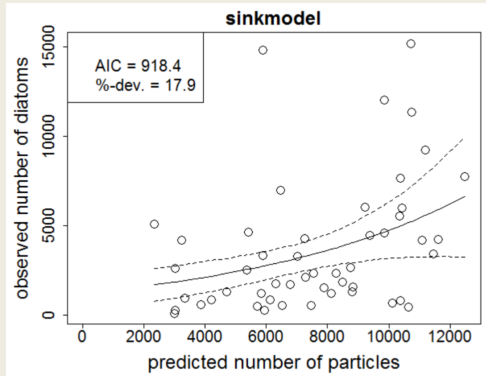




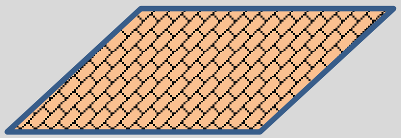
Sinking model results

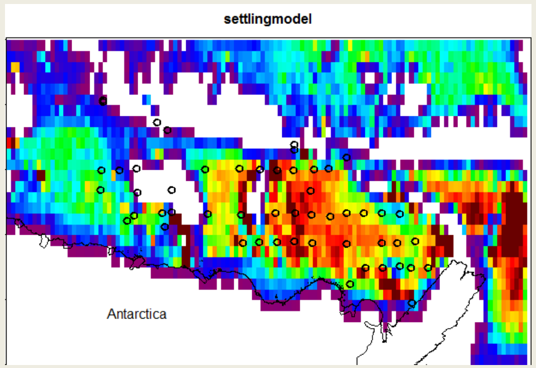


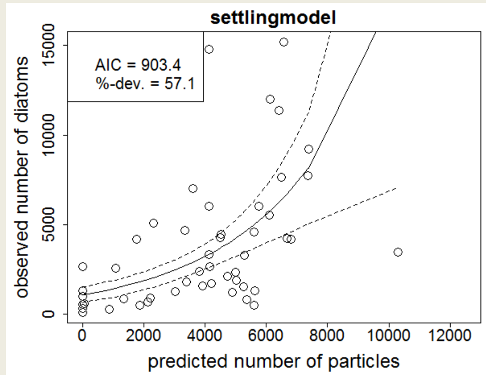


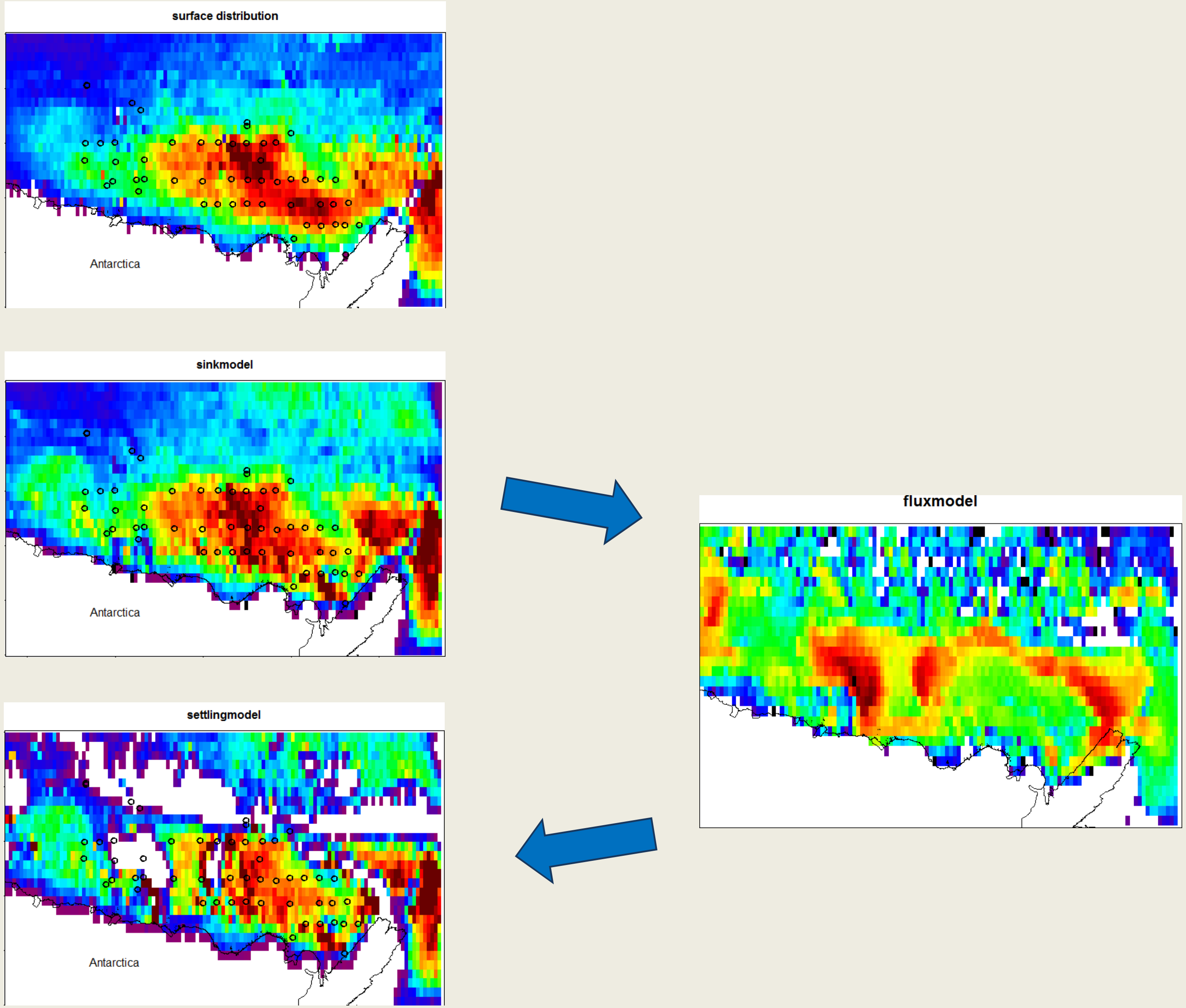


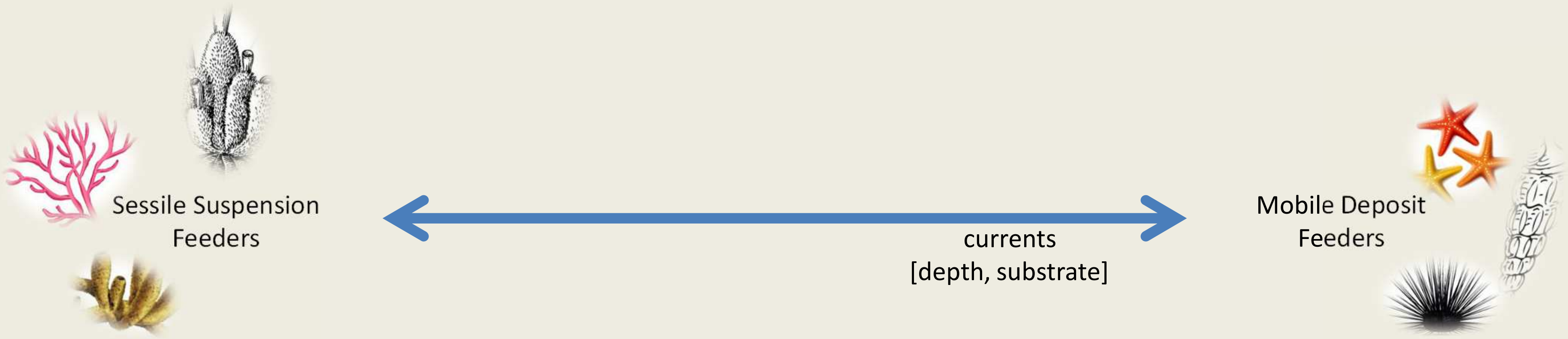
Settling model results



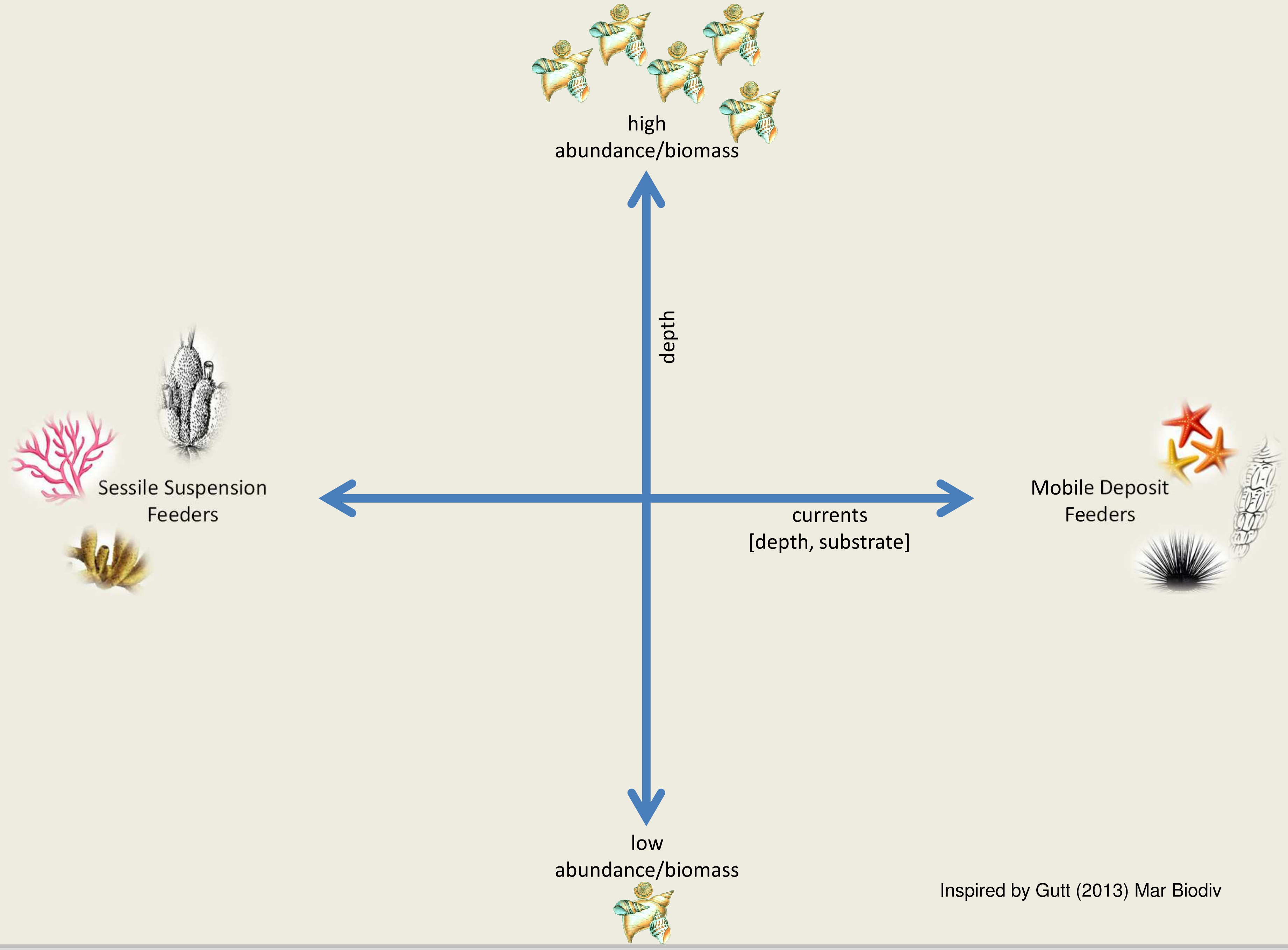





surface distribution
Antarctica
sinkmodel
Antarctica
settlingmodel
Antarctica
fluxmodel



Inspired by Gutt (2013) Mar Biodiv



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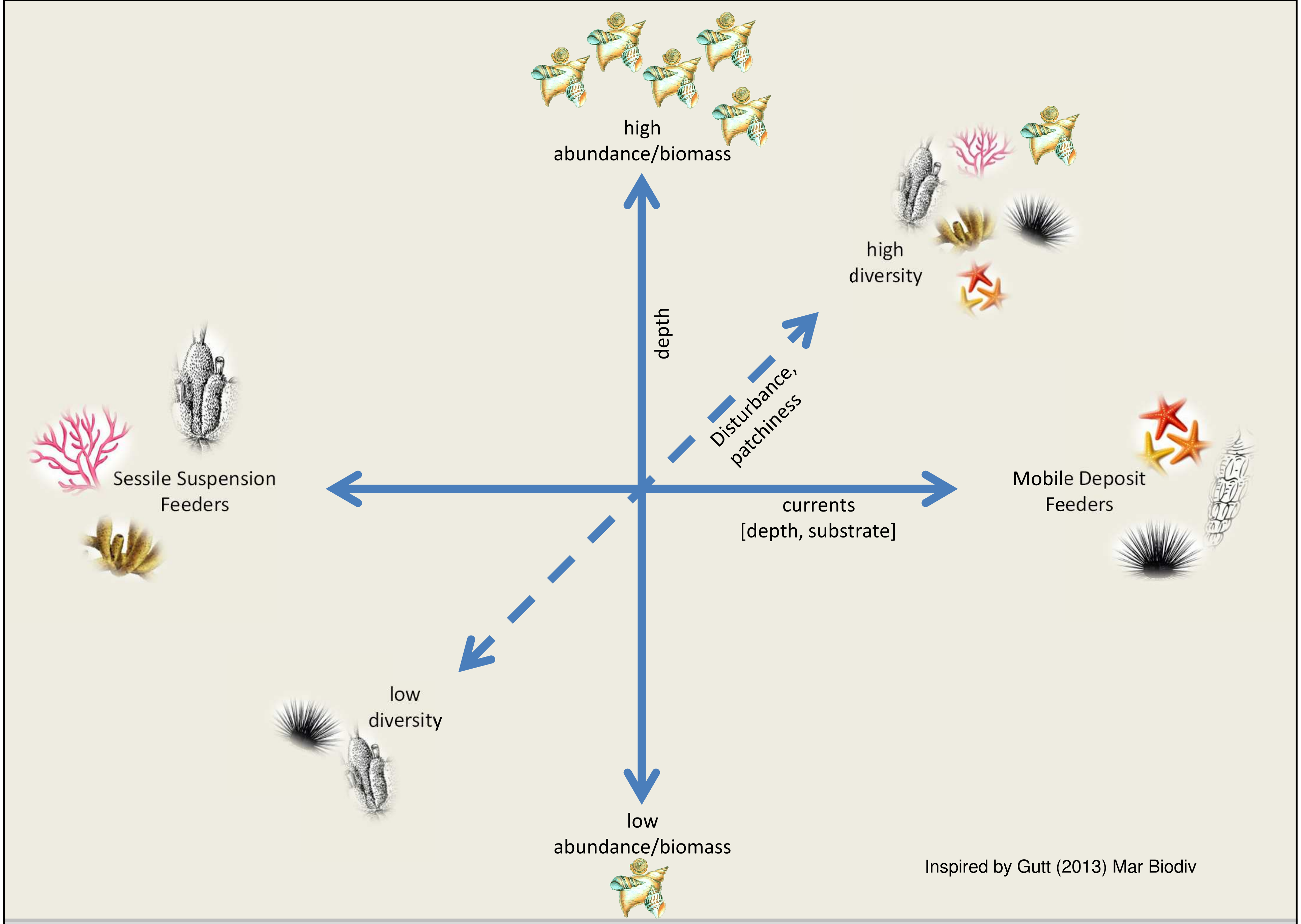
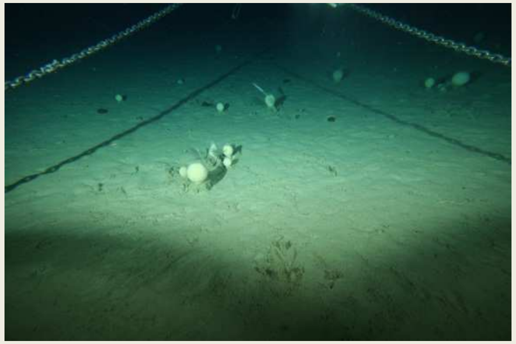
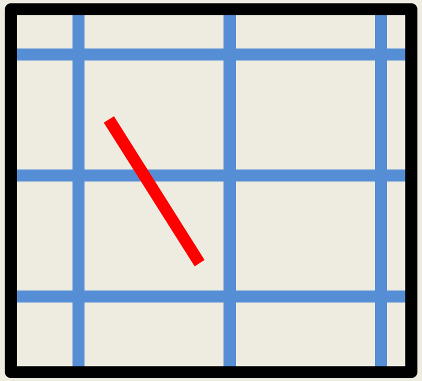

high
abundance/biomass
high
diversity
depth
Disturbance,
patchiness
Sessile Suspension
Feeders
Mobile Deposit
Feeders
currents
[depth, substrate]
low
diversity
low
abundance/biomass
Inspired by Gutt (2013) Mar Biodiv

biological data

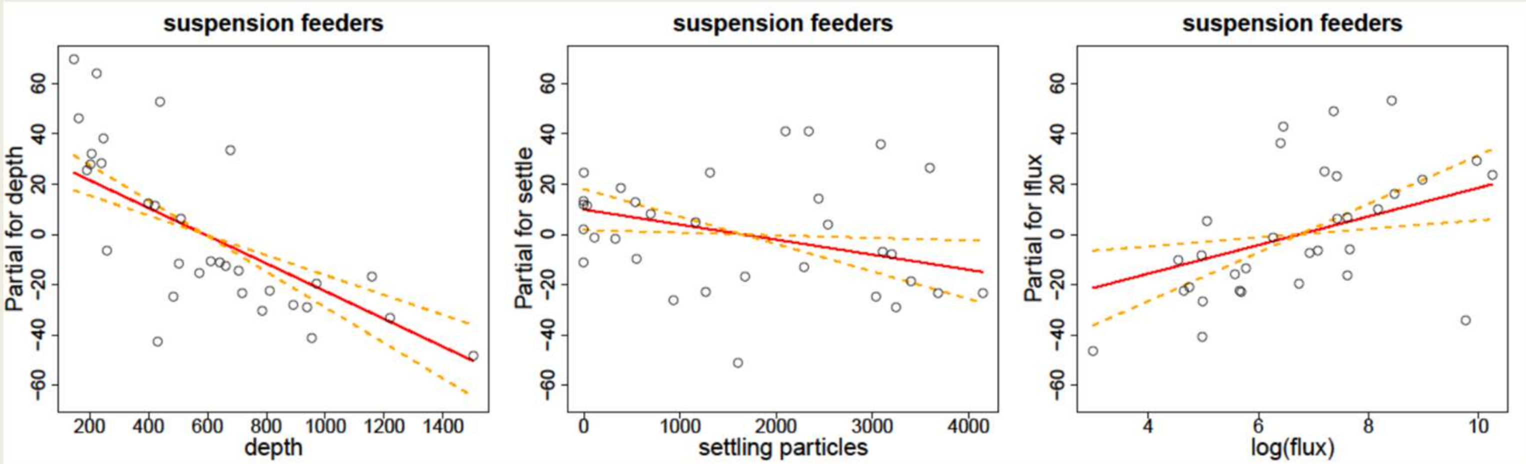


- 32 transects, ~3000 images, 170-1550m depth
- transects are split by environmental cells
- %-cover for each species
  (ordinal, but treated as numeric)
- basic functional traits for each species



Results from a weighted multiple linear regression

adj. $R^2 = 0.642$

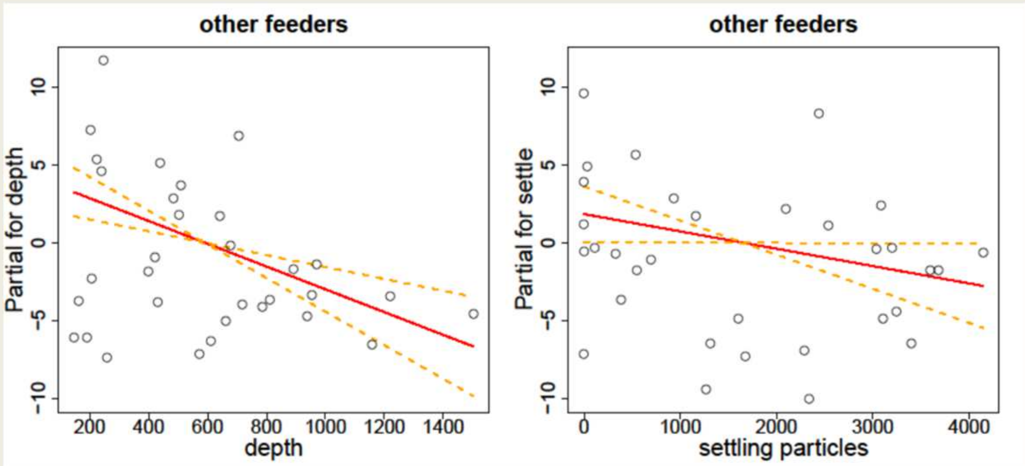


p < 0.001

p = 0.022

p = 0.008

adj. $R^2 = 0.342$



p < 0.001

p = 0.048

weights =
#pictures per cell

Summary

- Predicting seafloor food availability is possible
  - Needs regional oceanographic models
  - Needs surface productivity
  - sediment cores for validation
- Can be directly related to biological measures and functional groups


Thanks for listening
Question-time ☺
Thanks to:
Nicole Hill
John McKinlay
Craig Johnson
Piers Dunstan
Mike Sumner
Simon Wotherspoon
Ben Raymond
Ben Galton-Fenzi
Marc Eleaume
Alix Post
Leanne Armand

Call:
lm(formula = cover_SF ~ depth + settle + lflux, data = lm.data, weights = N)

Weighted Residuals:

Min	1Q	Median	3Q	Max
-336.69	-87.05	12.18	54.61	332.20

Coefficients:

	Estimate Std.	Error	t value	Pr(>|t|)
(Intercept)	50.559606	14.699410	3.440	0.00184 **
depth	0.055260	0.007826	7.061	1.11e-07 ***
settle	-0.005998	0.002476	-2.422	0.02215 *
lflux	5.692220	1.988587	2.862	0.00787 **

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 147.6 on 28 degrees of freedom
Multiple R-squared: 0.6762, Adjusted R-squared: 0.6415
F-statistic: 19.49 on 3 and 28 DF, p-value: 5.045e-07

- Sinkmodel (Phytoplankton composition and sinking speed)
  - Beans et al. 2008
  - Laurenceau et al. 2015
- Settlingmodel (settling equation and particle size/density)
  - Jenkins&Bombosch 1995
  - McCave&Swift 1976
  - Ierland&Peperzak 1984
  - Beaulieu 2003

$$p_0 p' = p_i C W_d \cos\theta \left(1 - \frac{U^2}{U_c^2}\right) He \left(1 - \frac{U^2}{U_c^2}\right)$$

p_0 = density of seawater (1030kg/m^3),

p_i = density of the settling particles (held constant at 1100kg/m^3),

C = concentration of particles/cell,

W_d = velocity at which particles settle onto the seafloor (one of the four sinking velocities we‘ve chosen),

U^2 = velocity given from ROMS for each cell.

U_c^2 = critical plume velocity and calculated by the following expression:

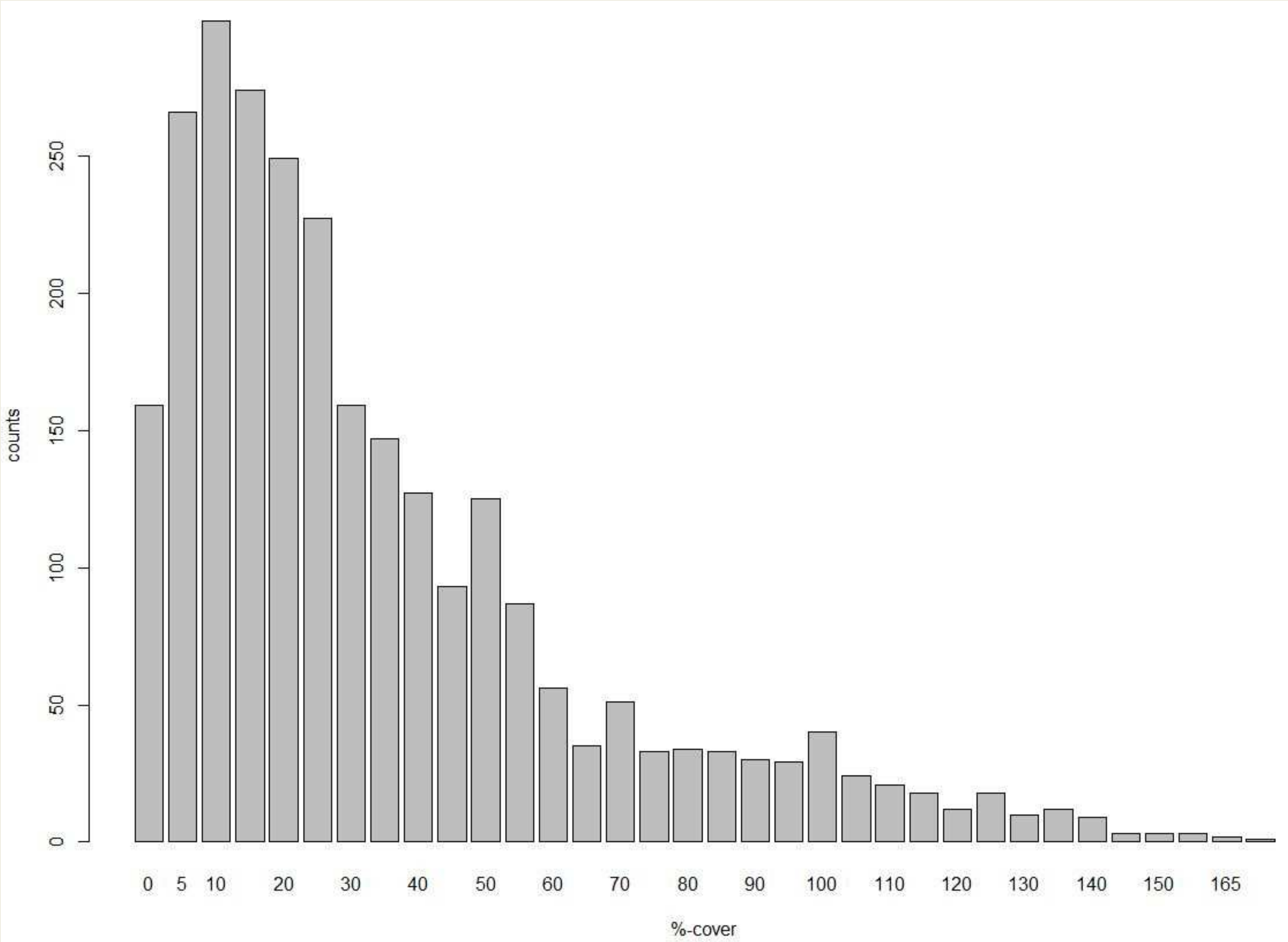
$$U_c^2 = \frac{0.05(p_0 - p_i) g 2 r_c}{p_0 K}$$

g=9.81m/s^2, and the drag coefficient K=2.5*10^{-3}.

The effective radius of settling particles, which is the radius of a sphere having the same volume as the idealised disc shaped diatom is calculated through:

$$r_c = \left(\frac{3}{2}\varepsilon\right)^{\frac{1}{3}} r$$

Where r is the radius of the particles and E is assumed to be 1 for our modelling purposes.


counts
0
50
100
150
200
250
0
5
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
165
%-cover