

Dispersal of marine organisms in the Baltic Sea

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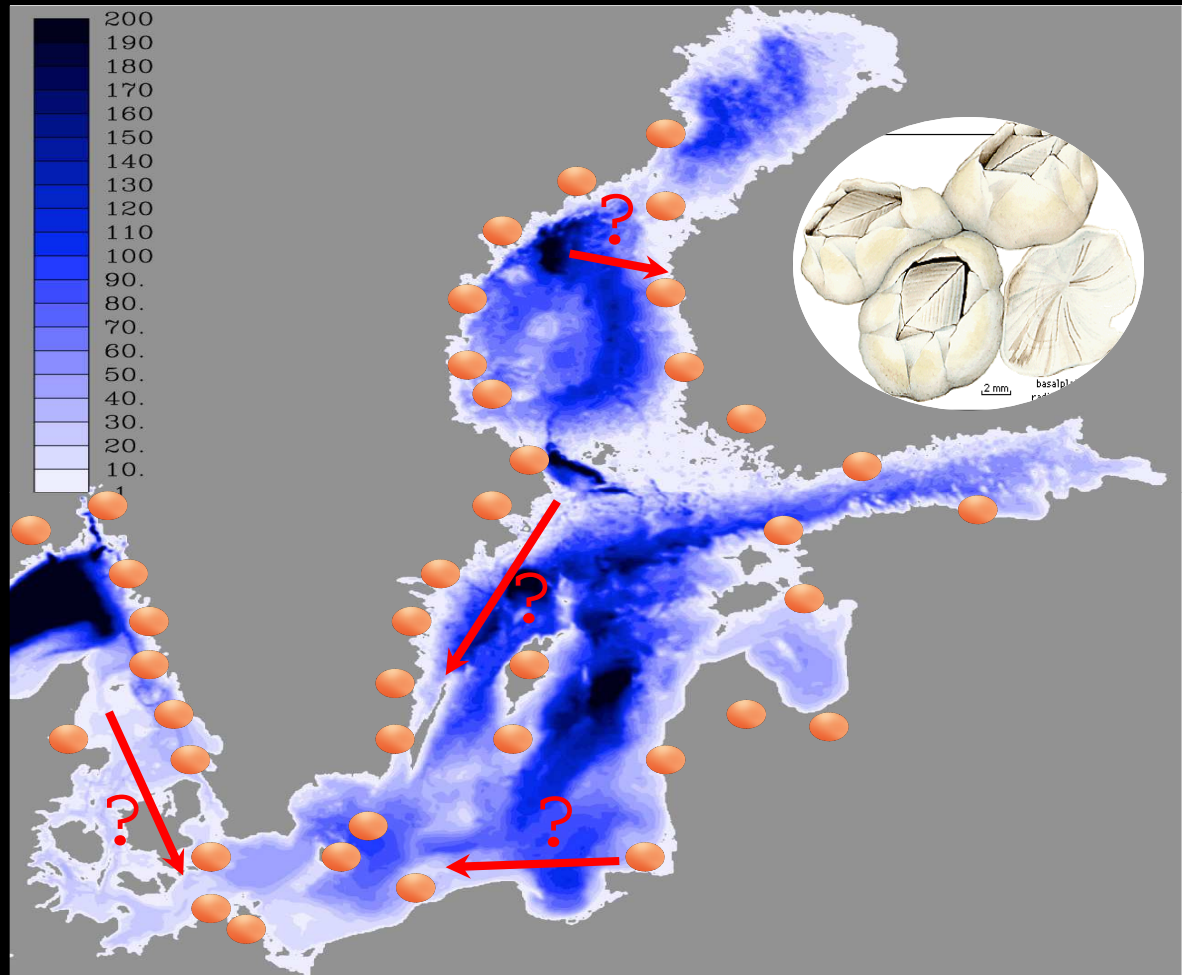
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*"The marine ecosystem in changing climate", SMHI
October 16th, 2009*

Dispersal of marine organisms

• *The*
challenge:

• How are marine
populations
connected
through
dispersal?



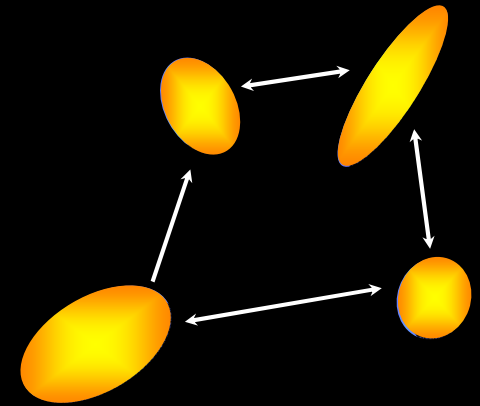
Dispersal &

connectivity affect:

evolutionary time
ecological time

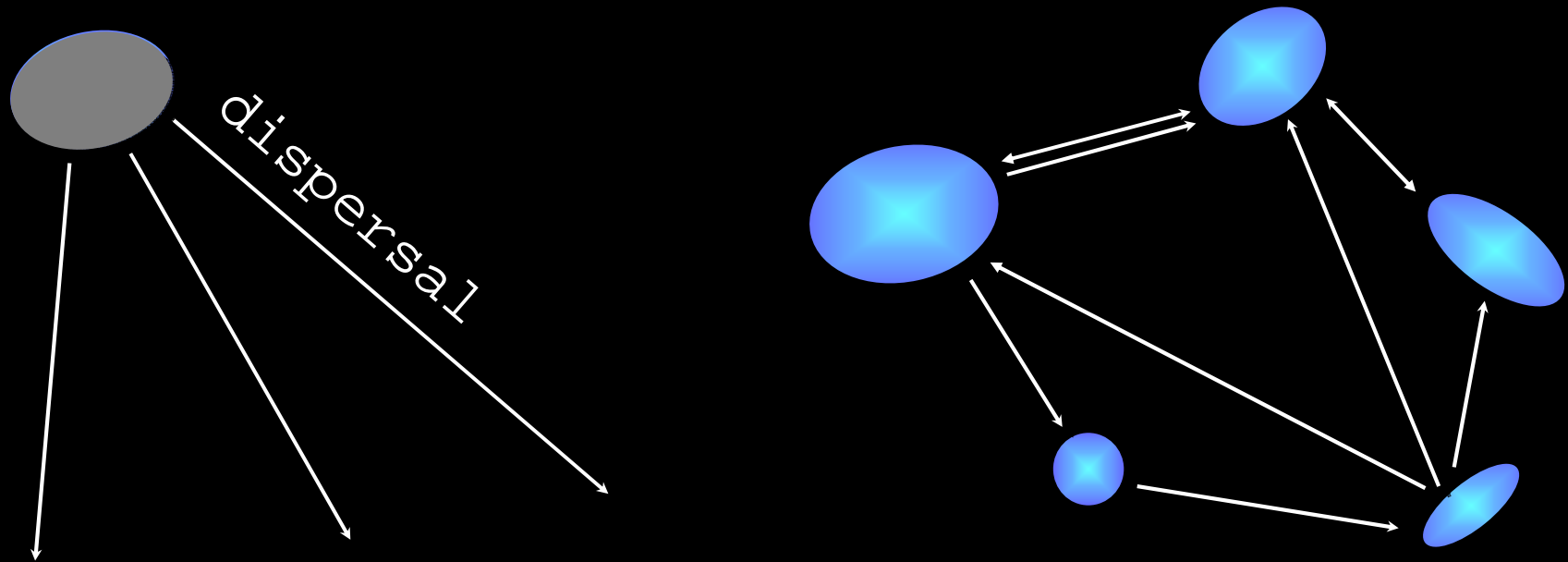


- Fluctuations in population size
- Local extinction
- Invasion of non-native species
- Evolution of local adaptations
- Evolutionary rate & speciation
- Management of exploited species
- Design of Marine Protected Areas (MPA)



Why is connectivity important when

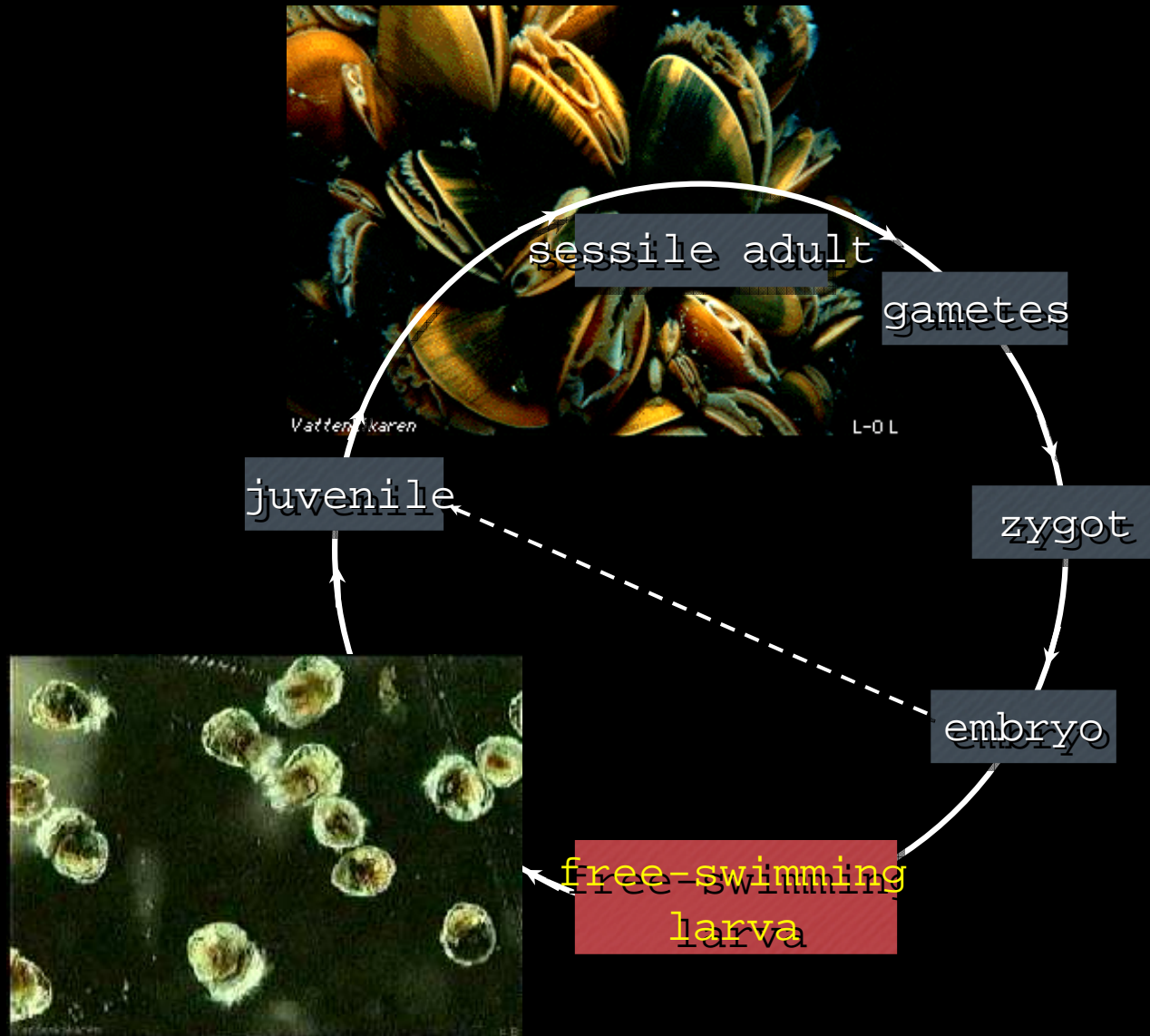
- designing MPAs?
- local recruitment of MPAs?
- isolated MPAs reduce risk of local extinction in networks



Many sedentary (or sessile) adults



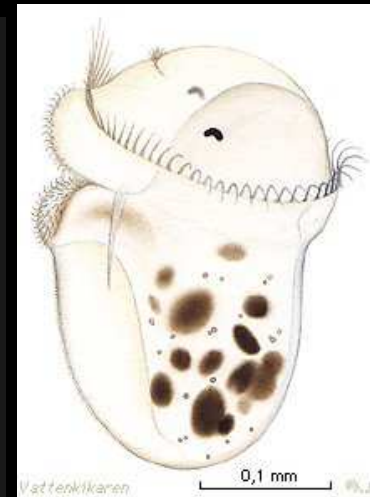
Typical life cycle



Marine dispersal is

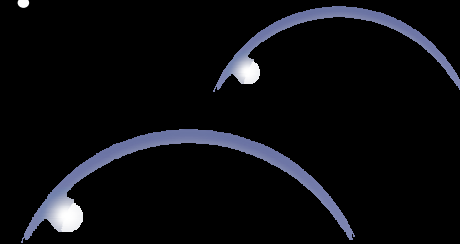
difficult to study

- Most marine propagules (spores & larvae) are numerous, sub-mm, and drift with ocean circulation
- Duration of planktonic dispersal: hours to weeks

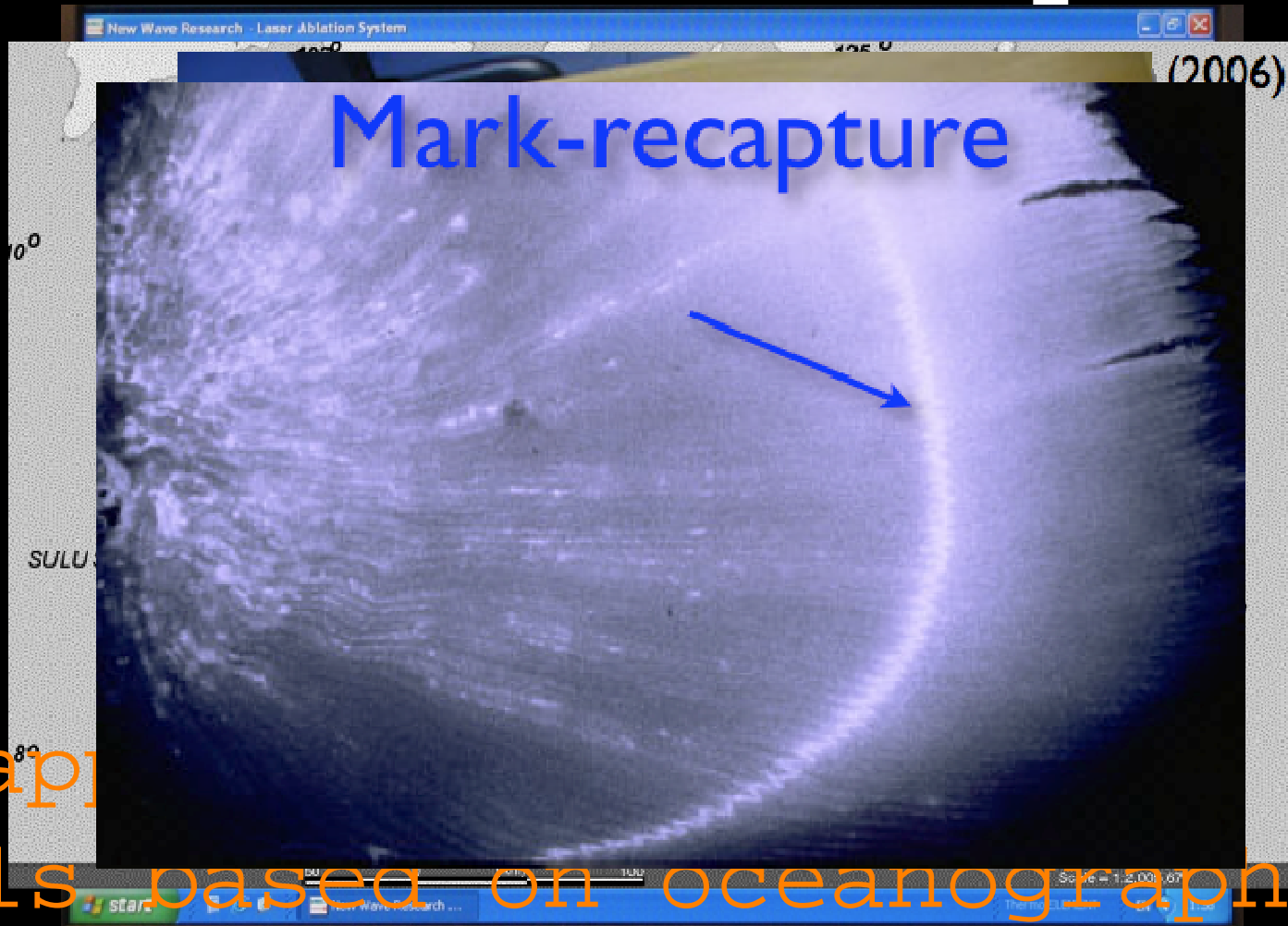


Marine dispersal is poorly understood

- Mean dispersal distance?
- Direction?
- Temporal and spatial variation in dispersal?

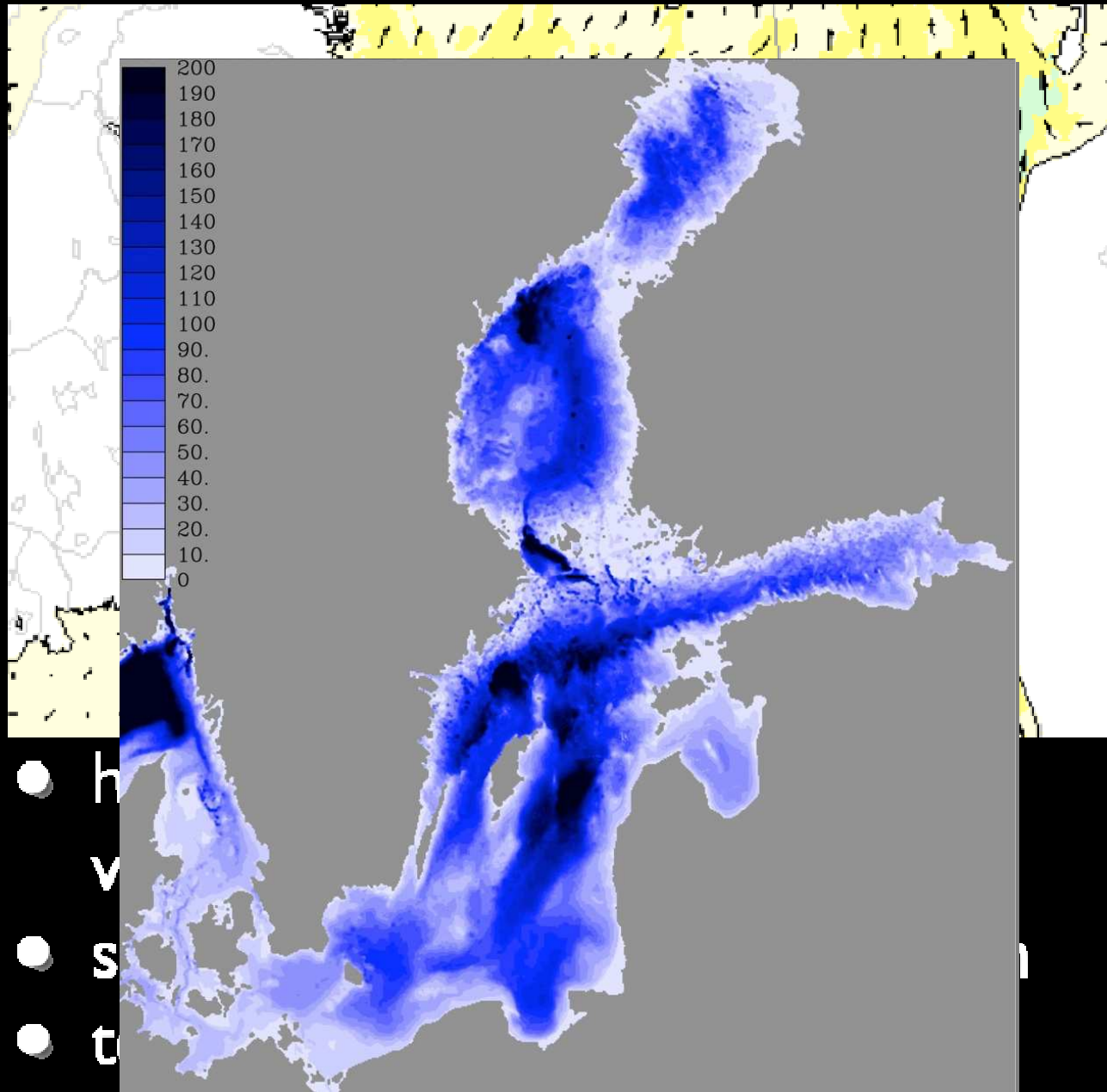


How can we study connectivity?

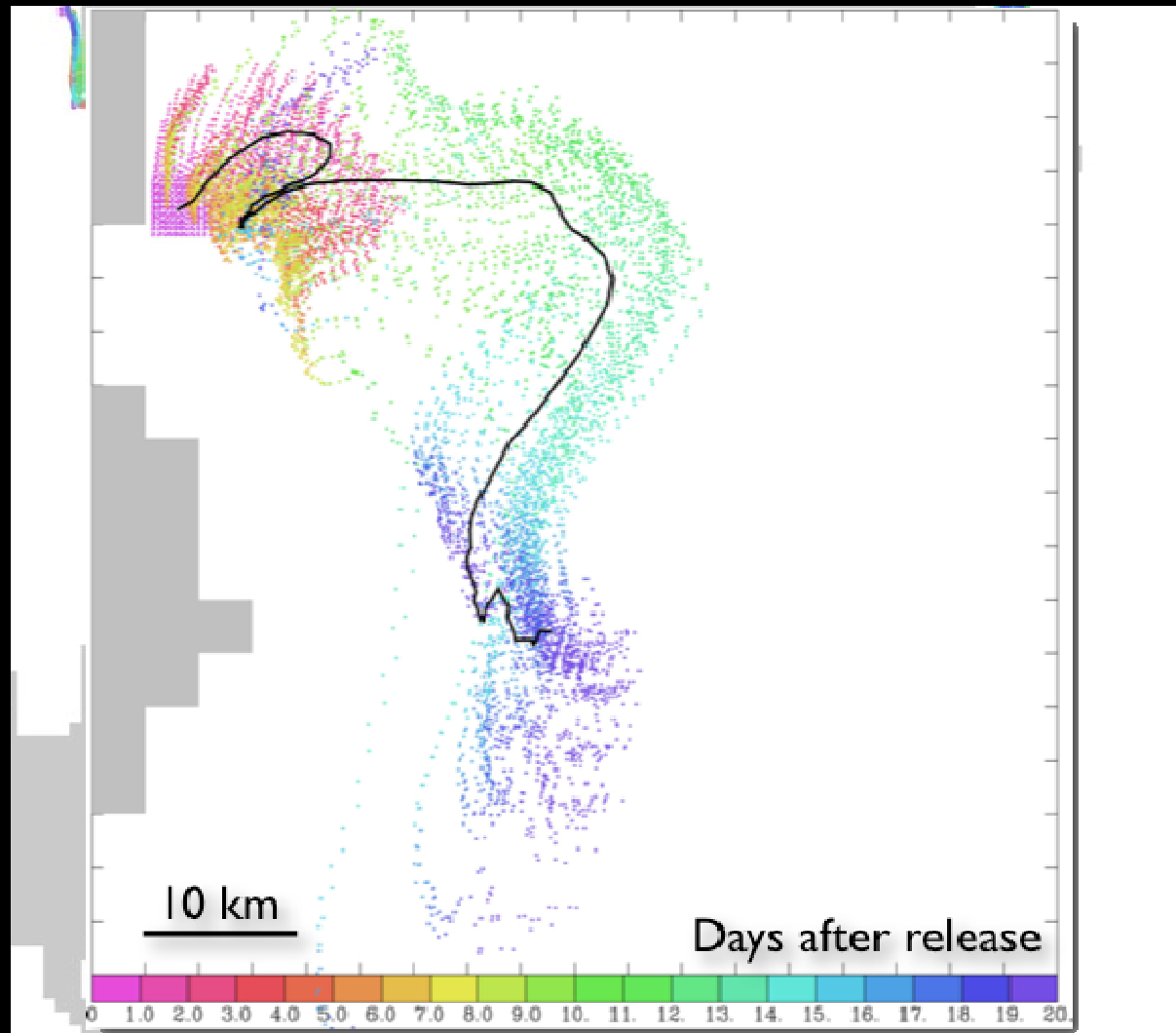


Our approach
Models based on oceanographic
circulation

Oceanographic model

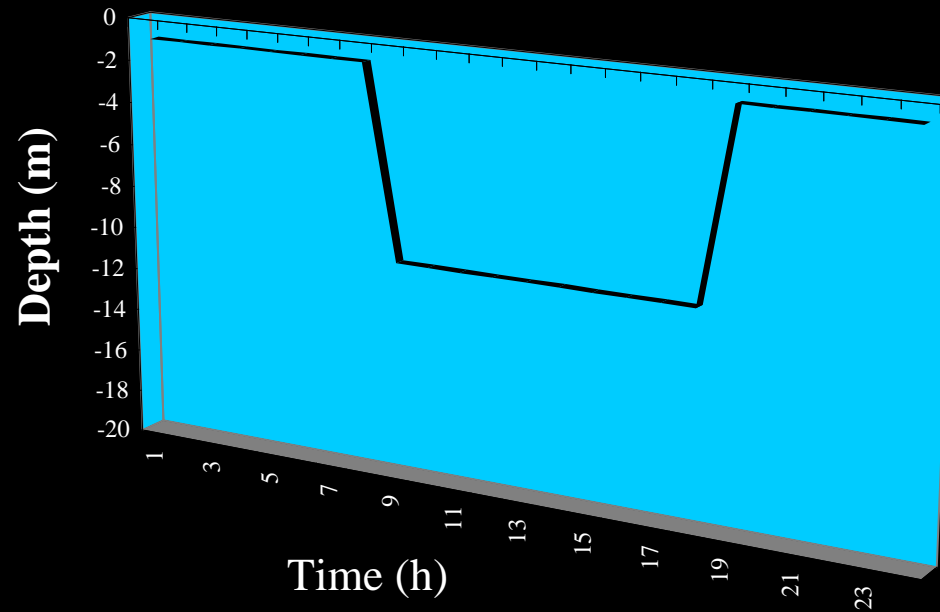
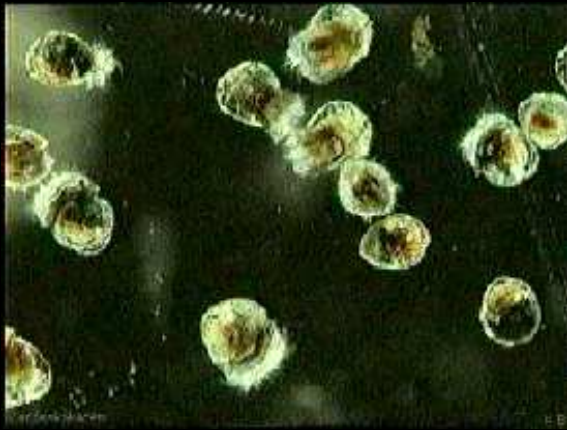


Multiple trajectories from each model grid



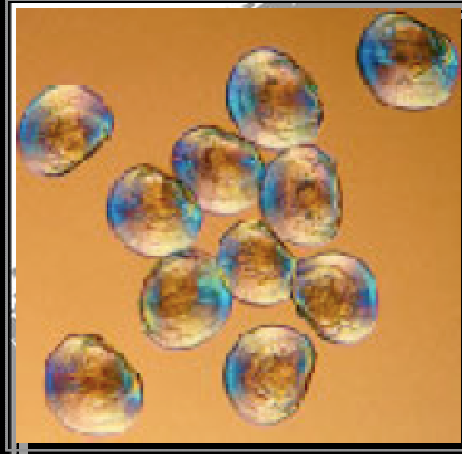
Biological models

Vertical migration & settling

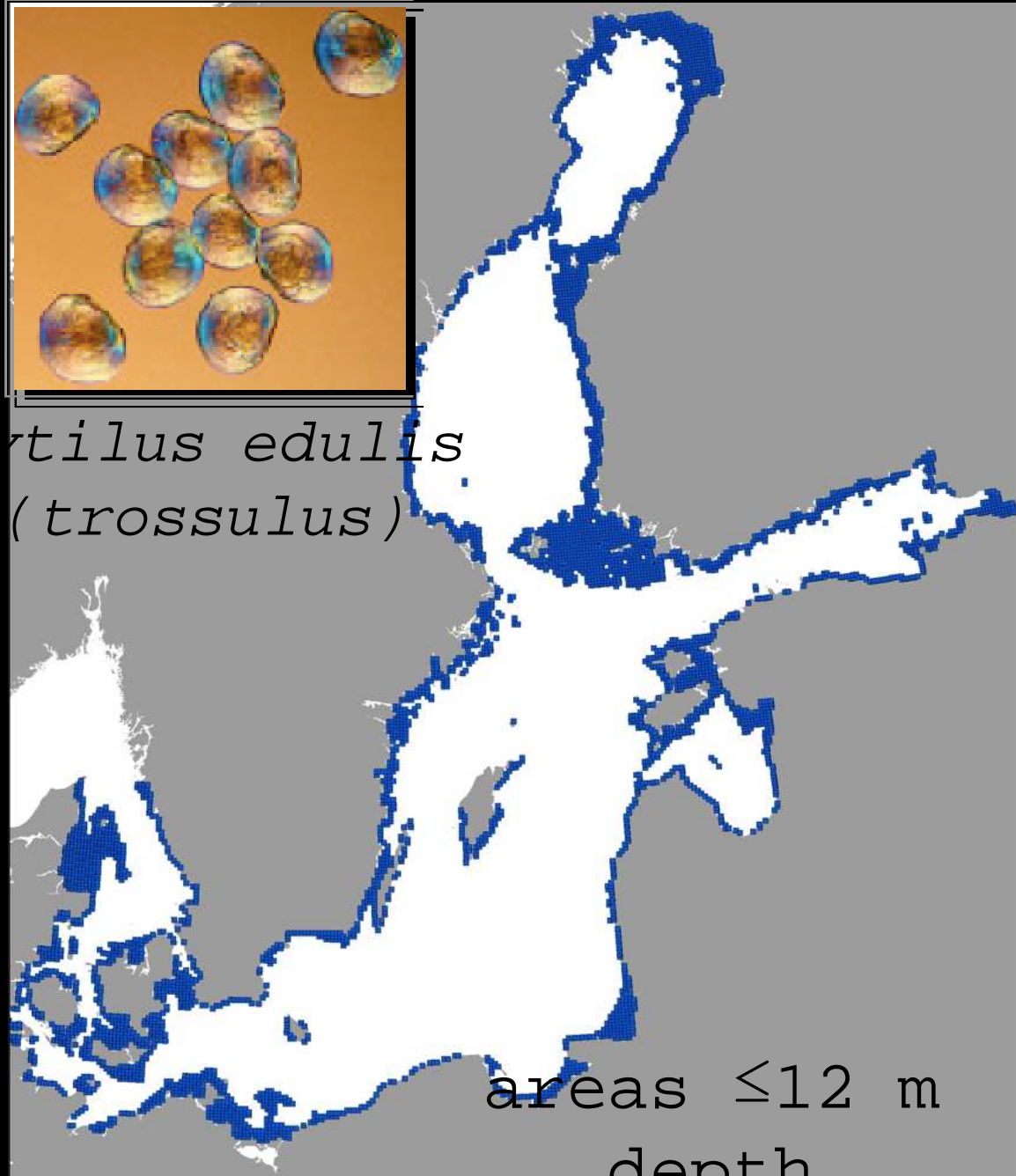


Poorly known indeed!

Model domain



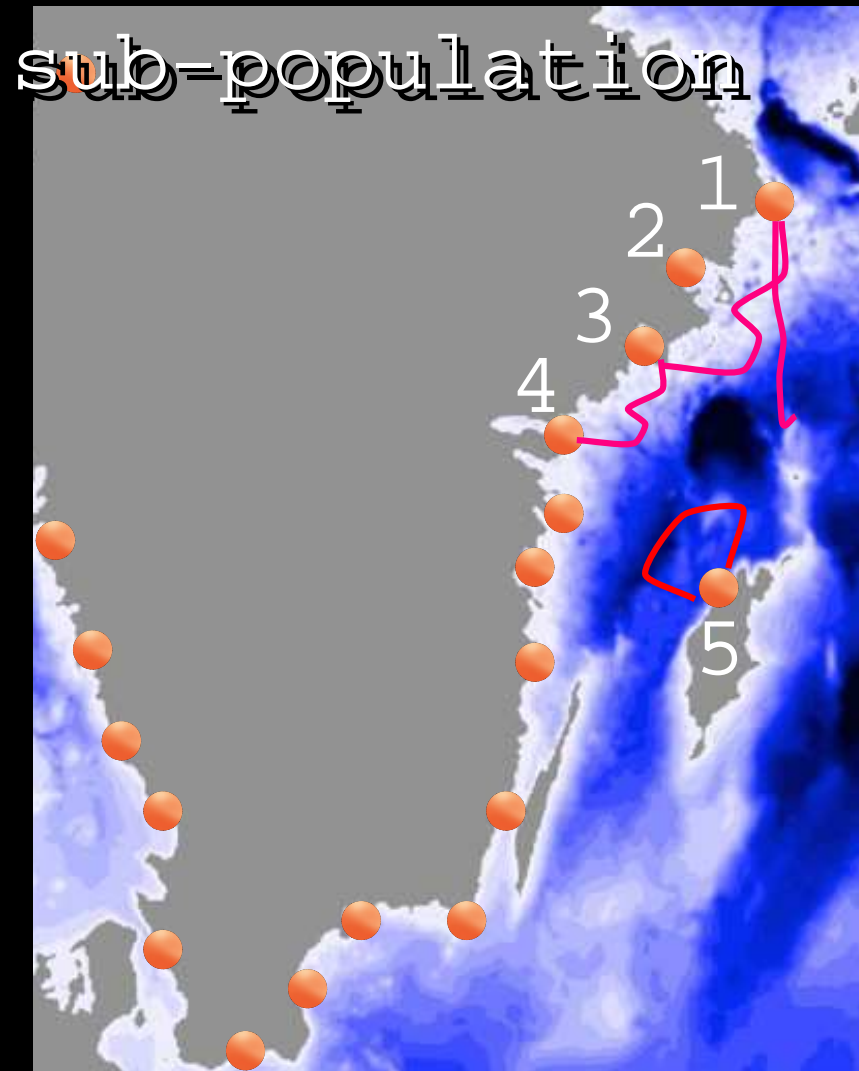
Crangon crangon
(*crangon*)



Sub-populations and the connectivity matrix

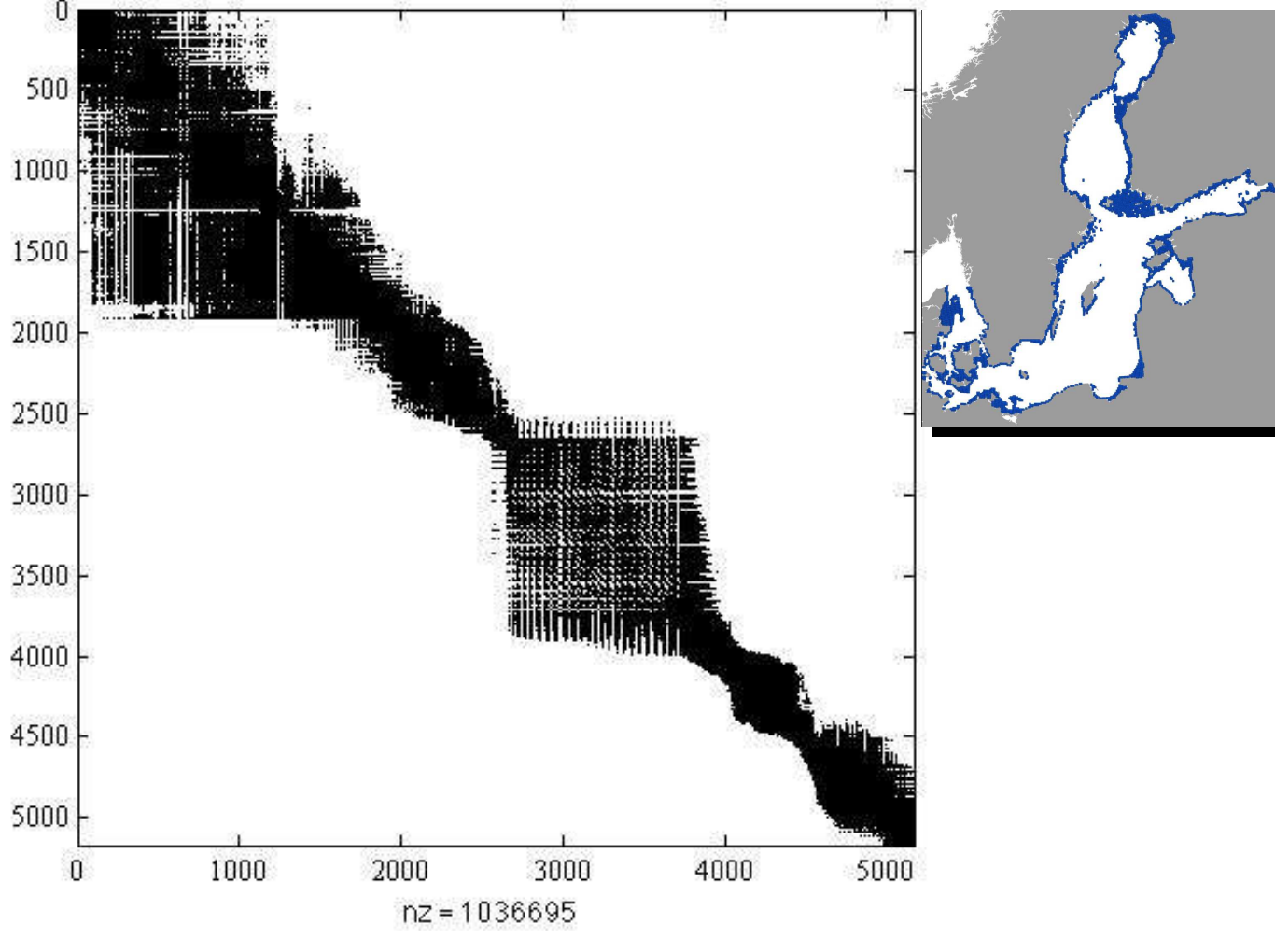
TO

	From				
	1	2	3	4	5
1	s	e ₂₁	e ₃₁	e ₄₁	e ₅₁
2	e ₁₂	s	e ₃₂	e ₄₂	e ₅₂
3	e ₁₃	e ₂₃	s	e ₄₃	e ₅₃
4	e ₁₄	e ₂₄	e ₃₄	s	e ₅₄
5	e ₁₅	e ₂₅	e ₃₅	e ₄₅	s

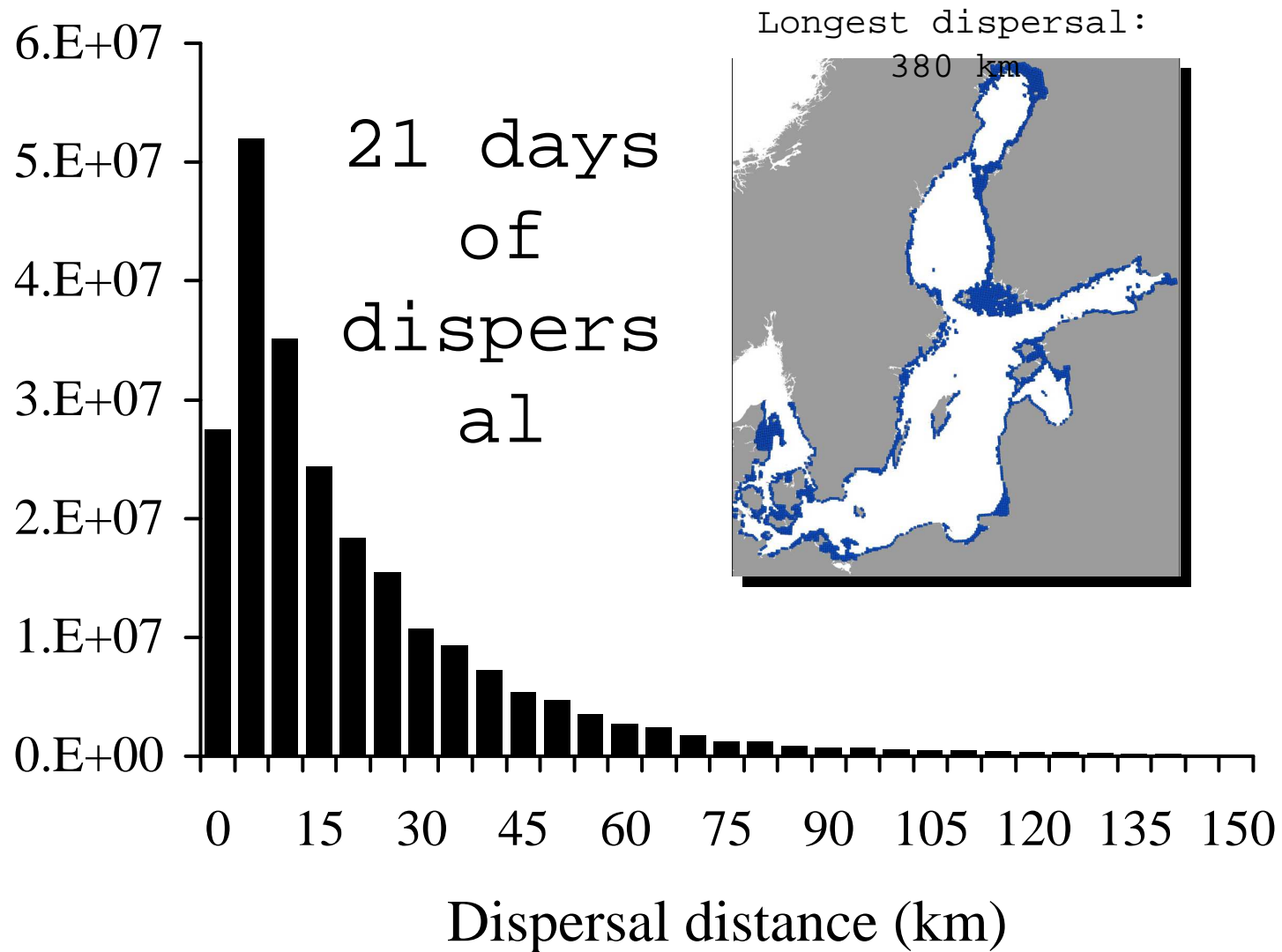


The connectivity matrix of the shallow Baltic Sea

27 million elements



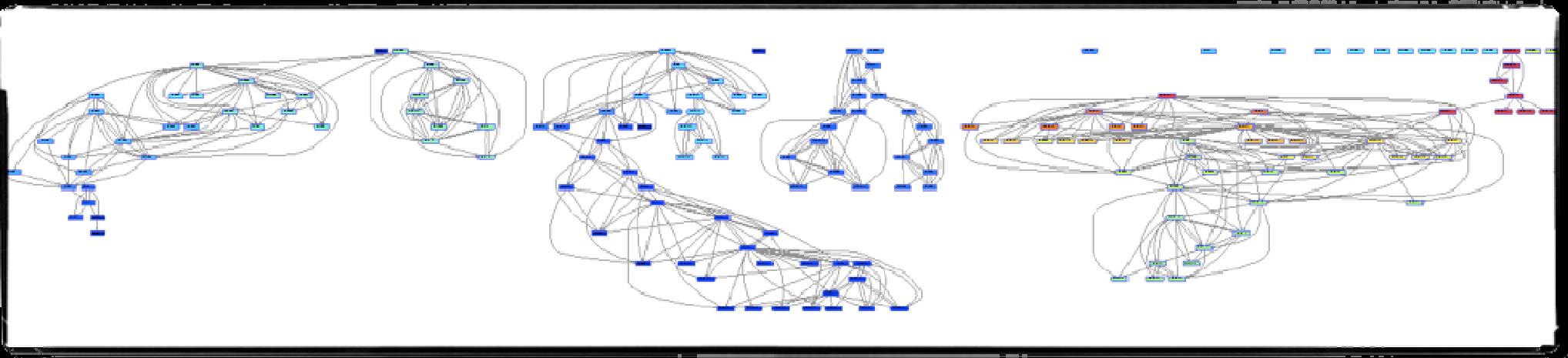
Larval dispersal



Can we use connectivity information to improve

MPA design?

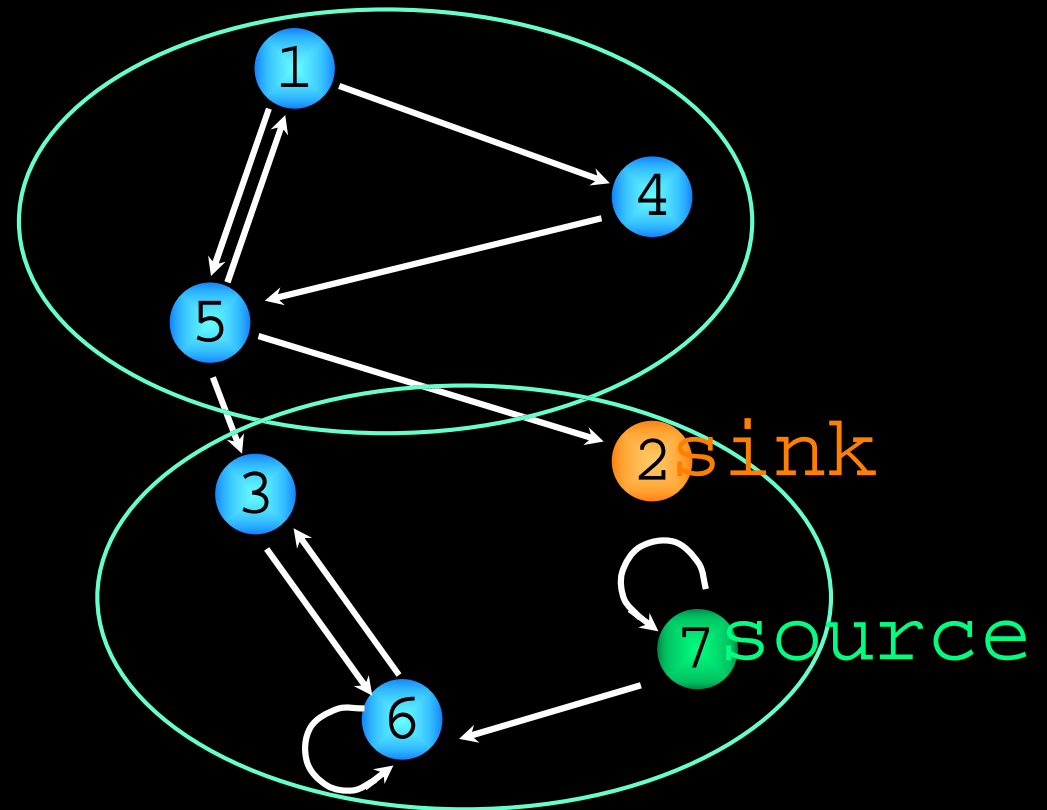
- Identify dispersal barriers
- Select networks of MPA that are internally connected
- Assess the connectivity of existing MPAs



We suggest a new framework for analysis of connectivity

Based on eigenvectors of the connectivity matrix

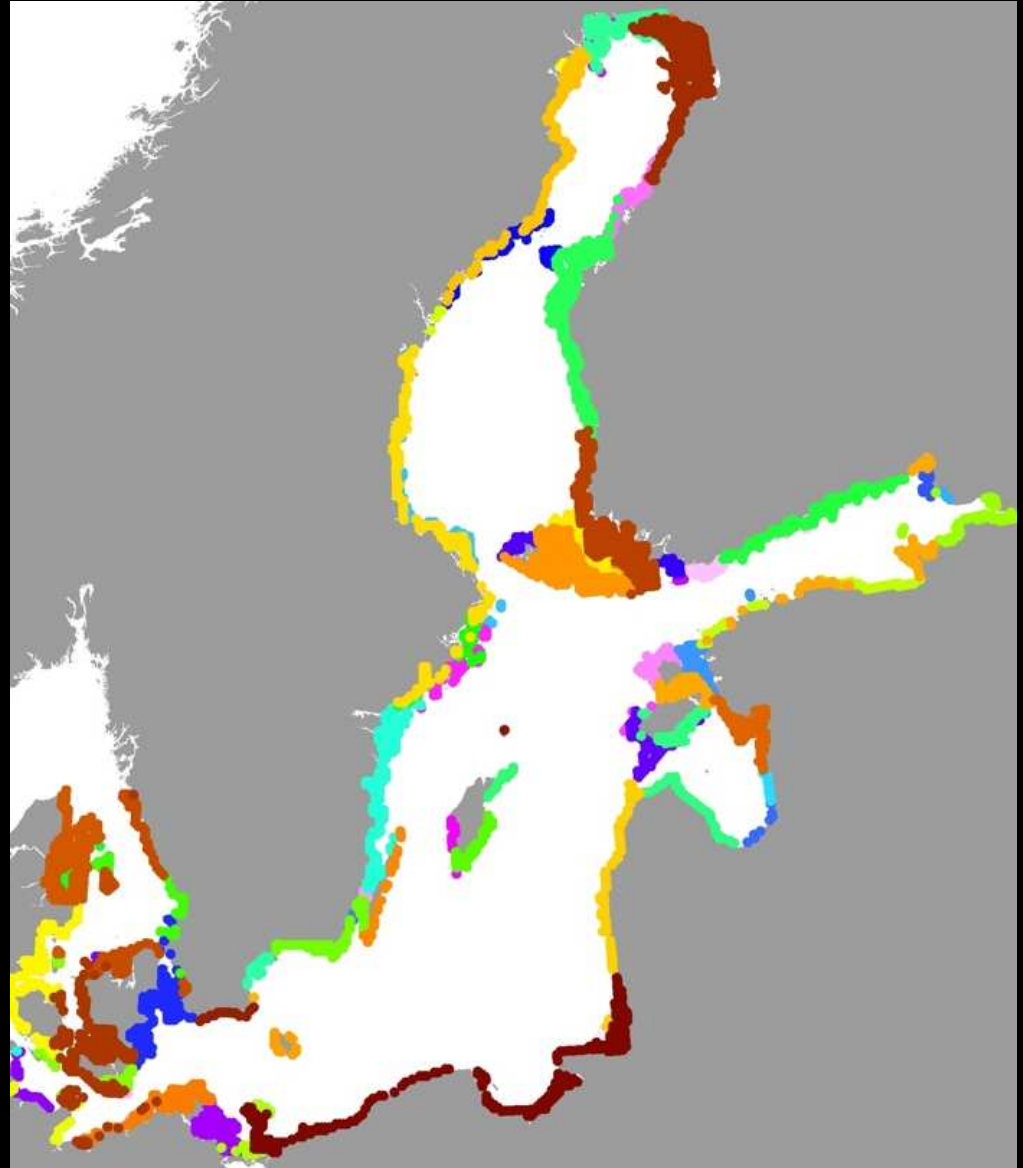
	1	2	3	4	5	6	7
1	0	0	0	0	0.3	0	0
2	0	0	0	0	0.3	0	0
3	0	0	0	0	0.3	0.5	0
4	0.5	0	0	0	0	0	0
5	0.5	0	0	1	0	0	0
6	0	0	1	0	0	0.5	0.5
7	0	0	0	0	0	0	0.5



- define sources & sinks
- identify well-linked regions

Internally linked regions

- May indicate gene flow
- May indicate local populations
- Stratification criterion for MPAs



Finding an 'optimum' MPA network

We propose that the optimum network consists of the subset of areas having the largest product of

dominant right- and left

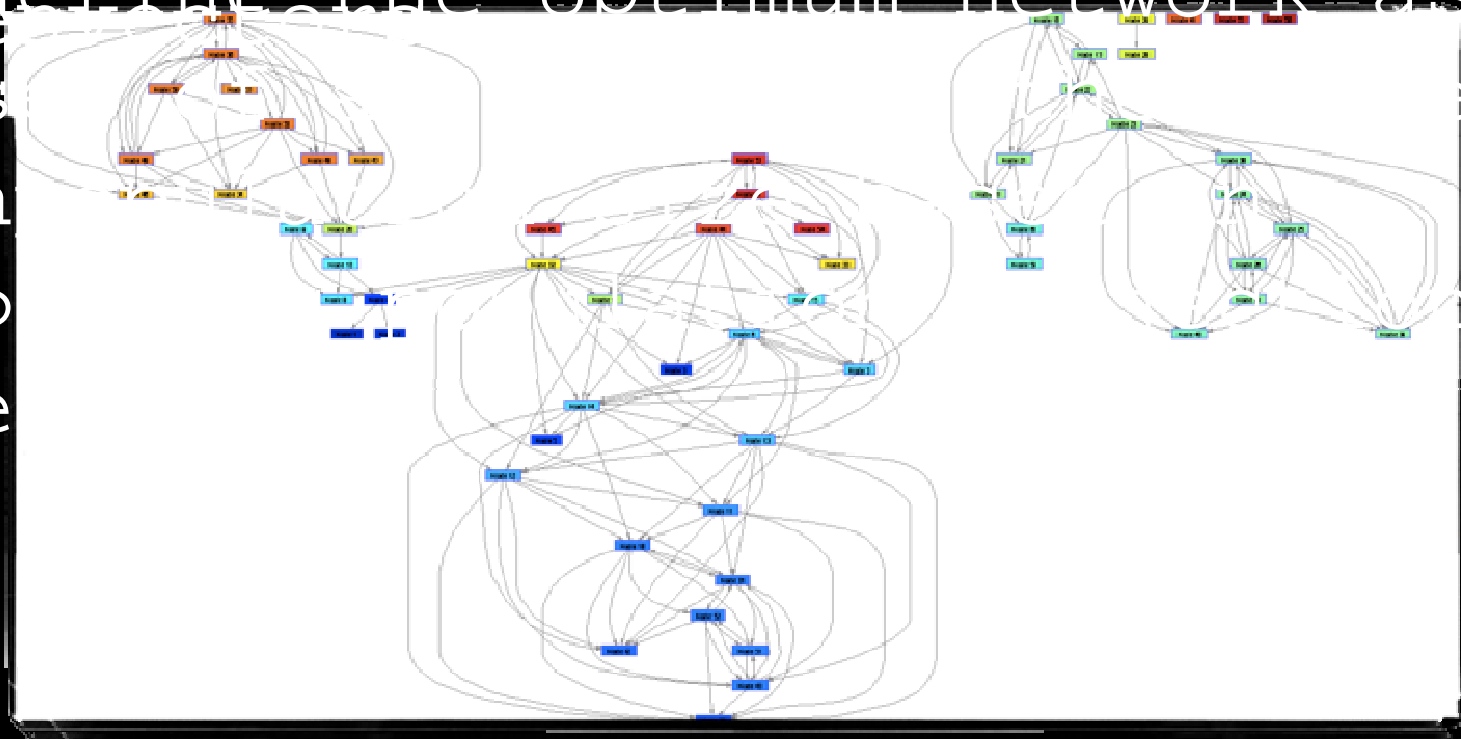
We define the optimum network as the

subset of areas having the largest

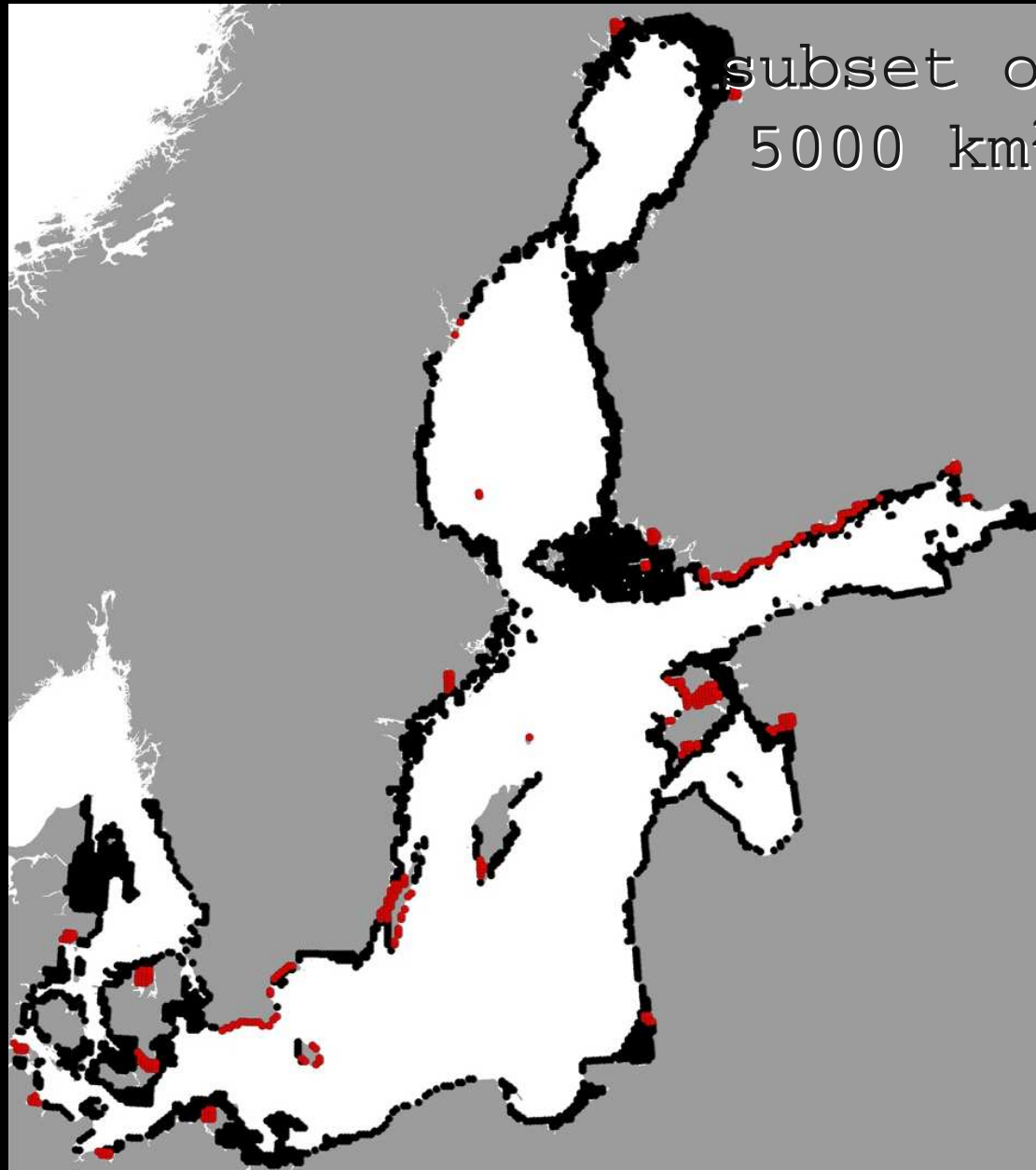
meta

simp

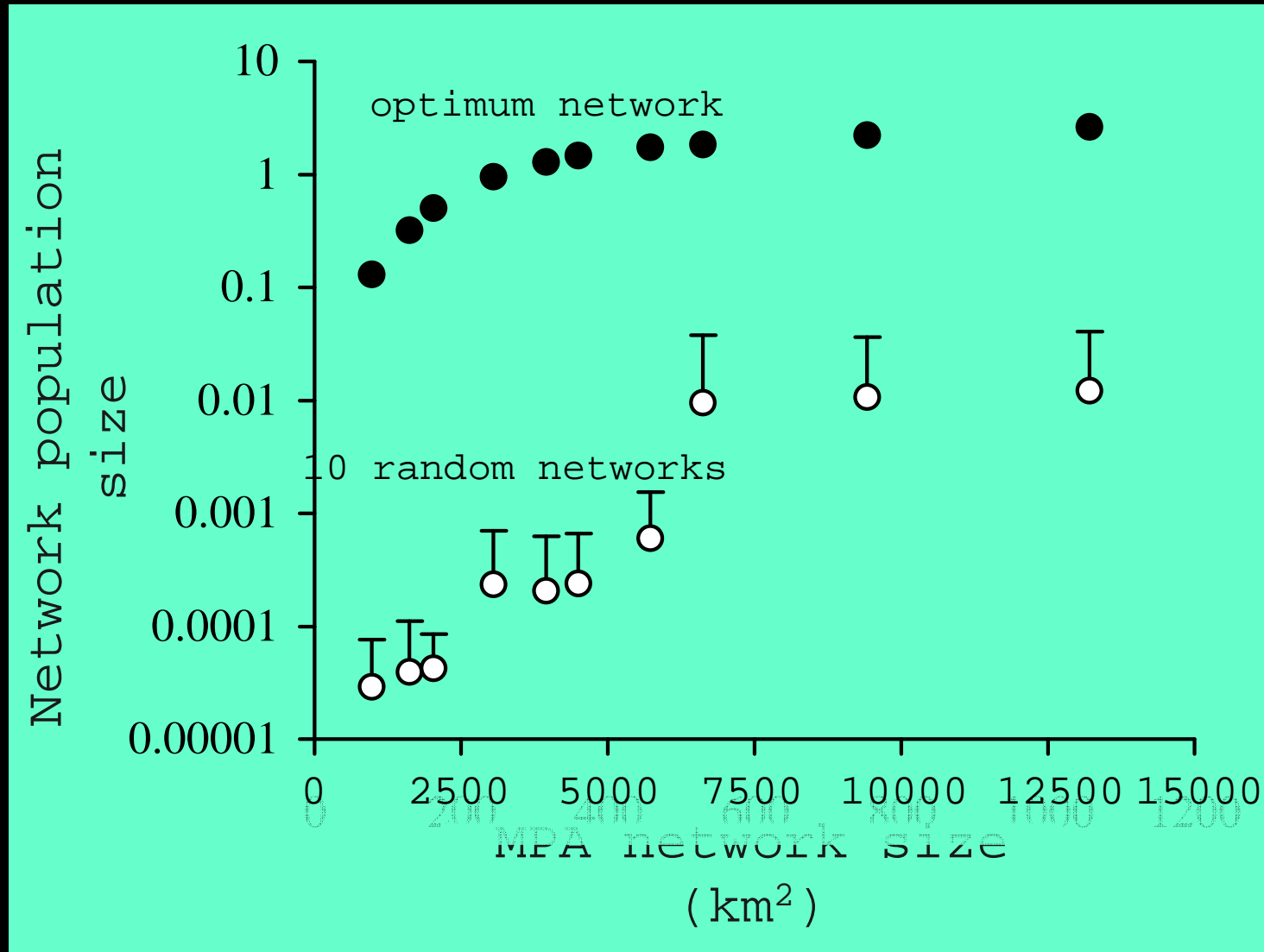
mode



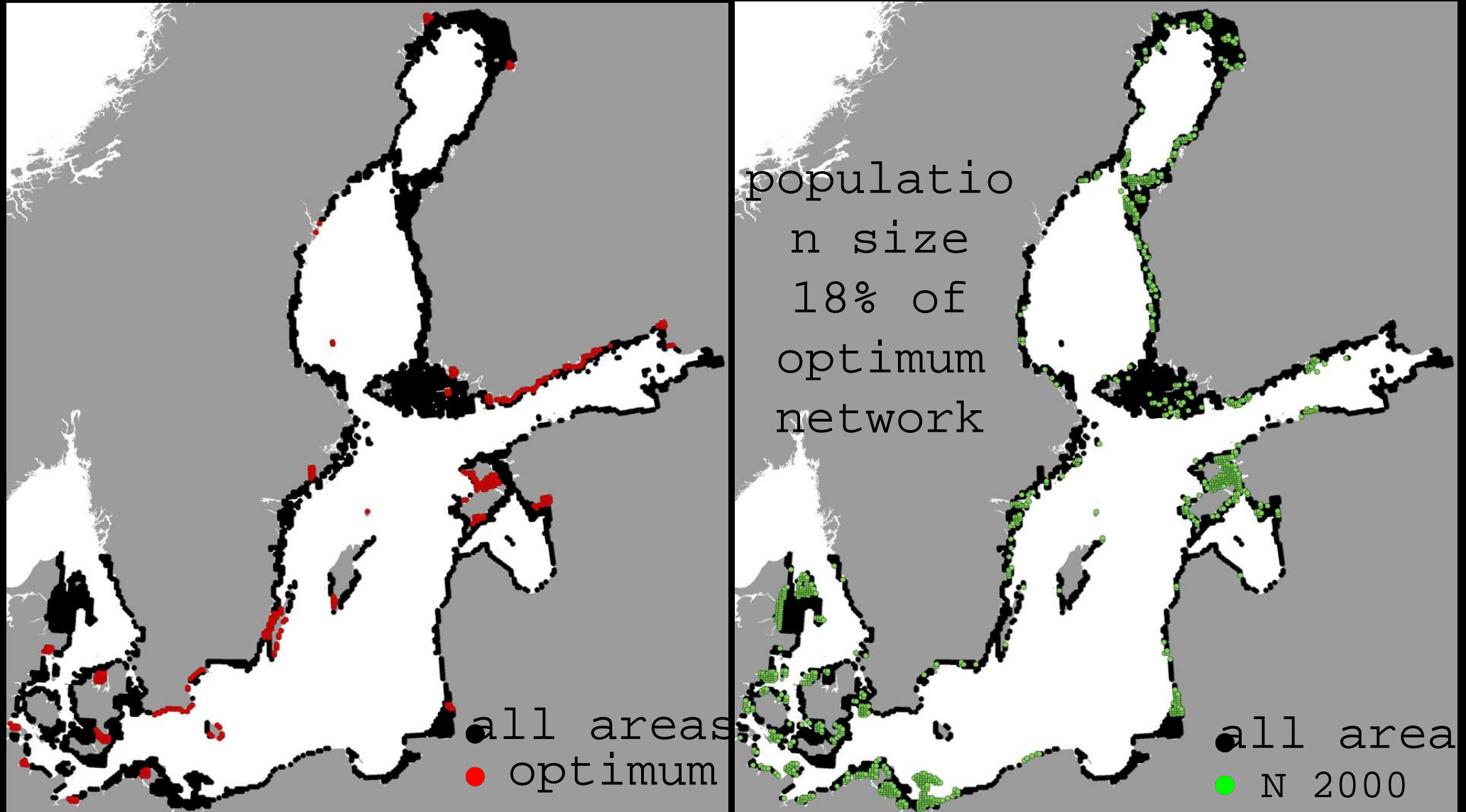
Optimum network



Optimum network: performance

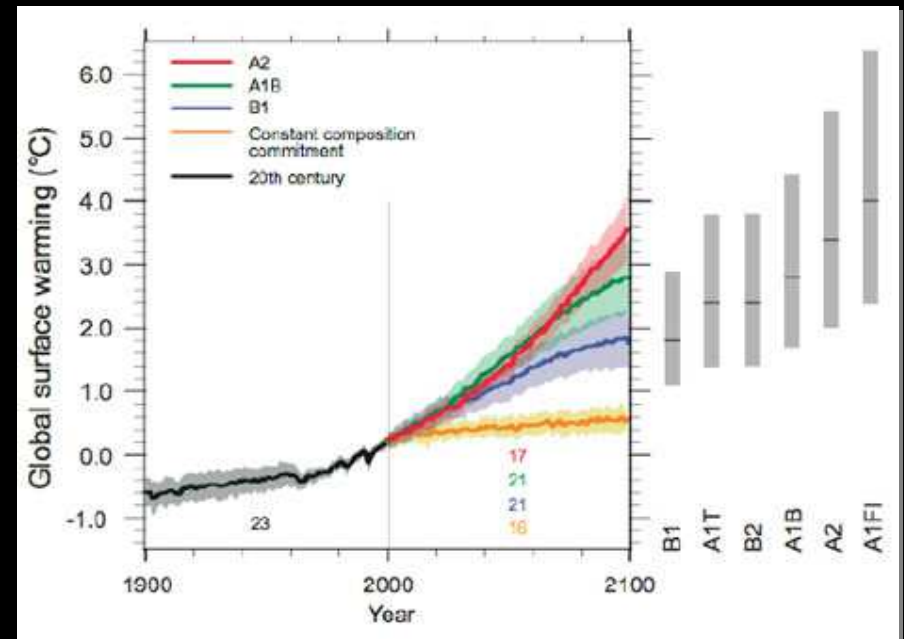


Optimum network vs Natura 2000



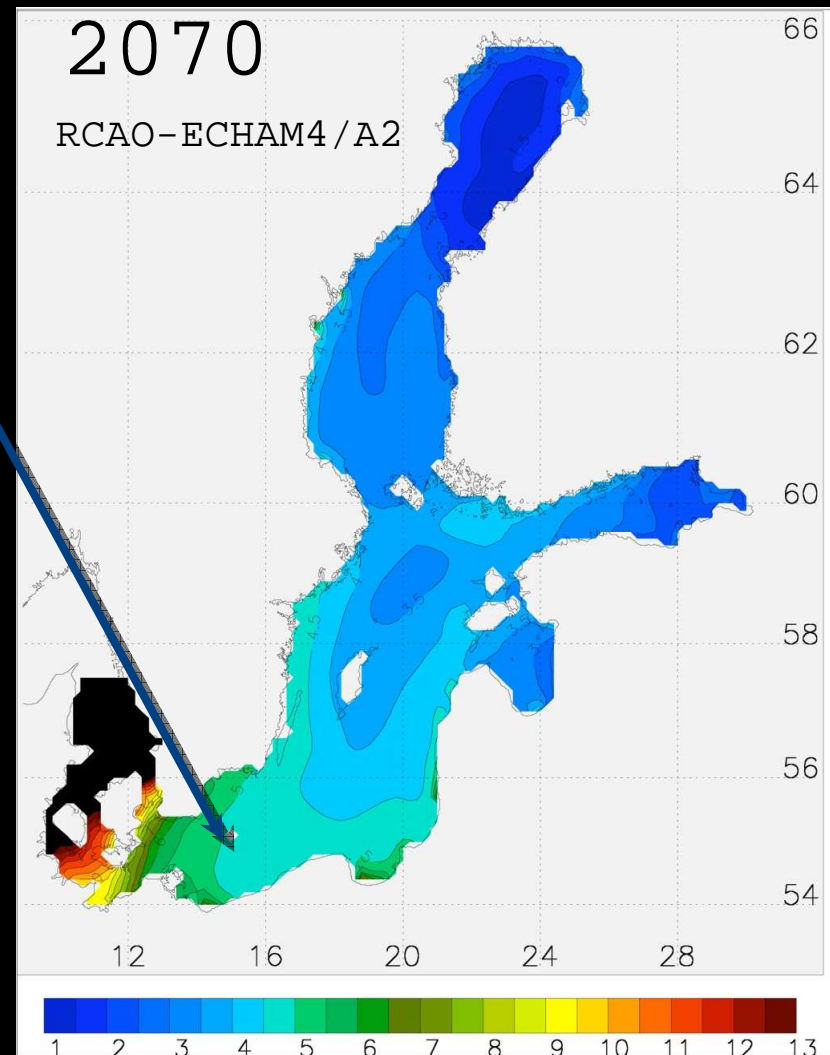
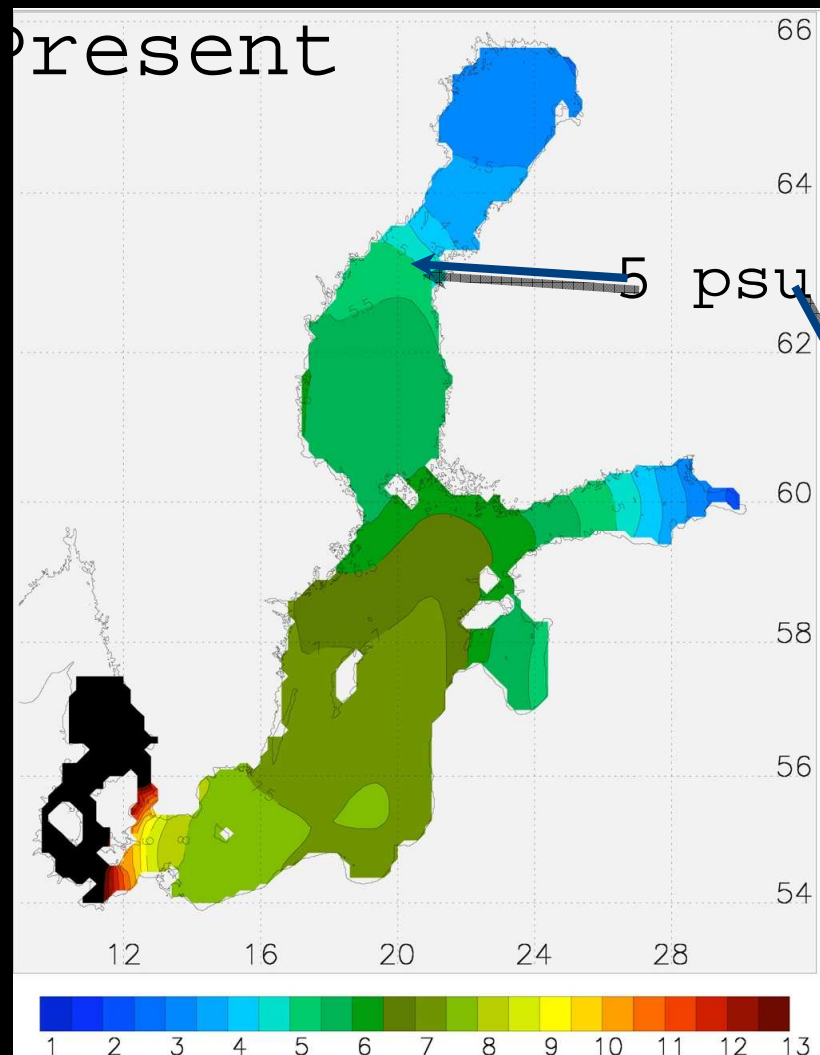
Will connectivity change with the climate?

- increased precipitation
- increased stratification
- changing wind fields



city fields for IPCC scenarios up to year

Predicted change in salinity



from Meier 2008, SMHI

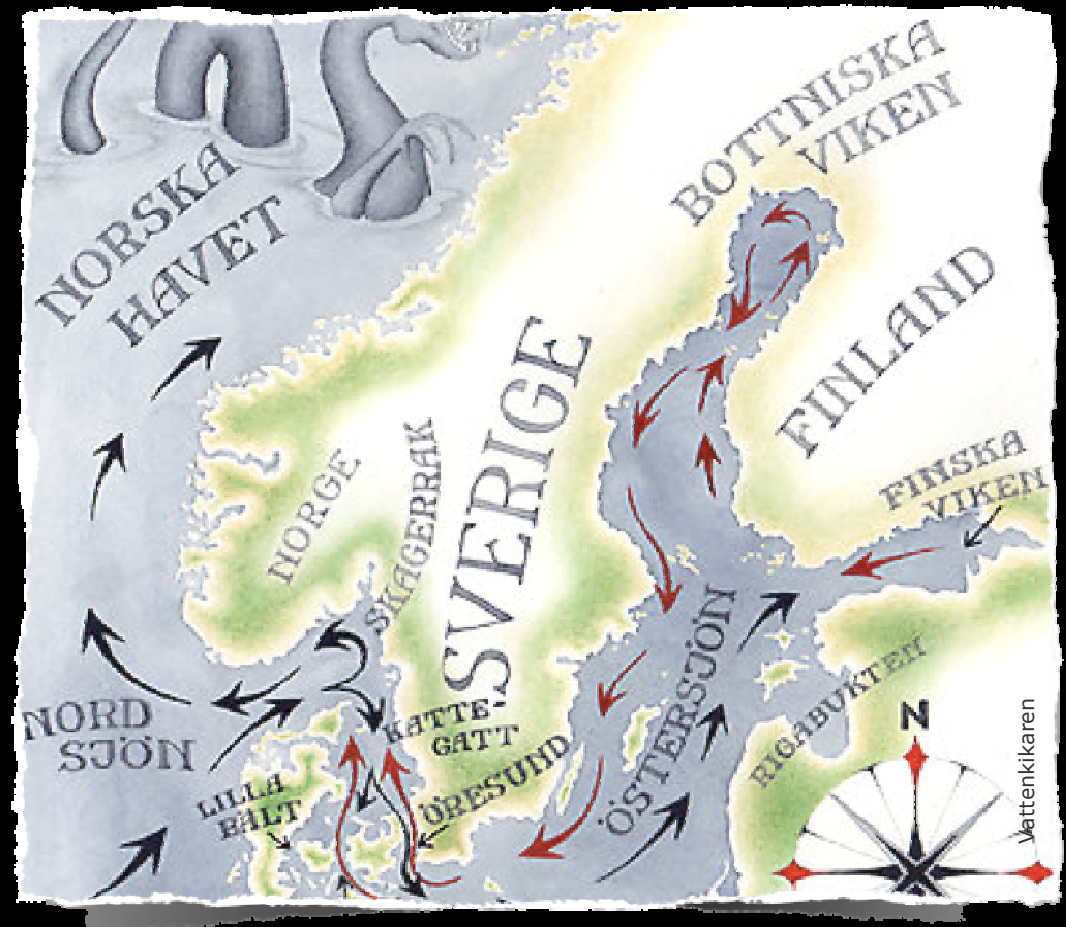
Conclusions

- Dispersal models based on ocean circulation models is a way forward
- Connectivity is presently not used when selecting MPAs
- Connectivity may significantly affect MPA performance
- Eigenvector analysis may be an easy way to link connectivity to MPA design



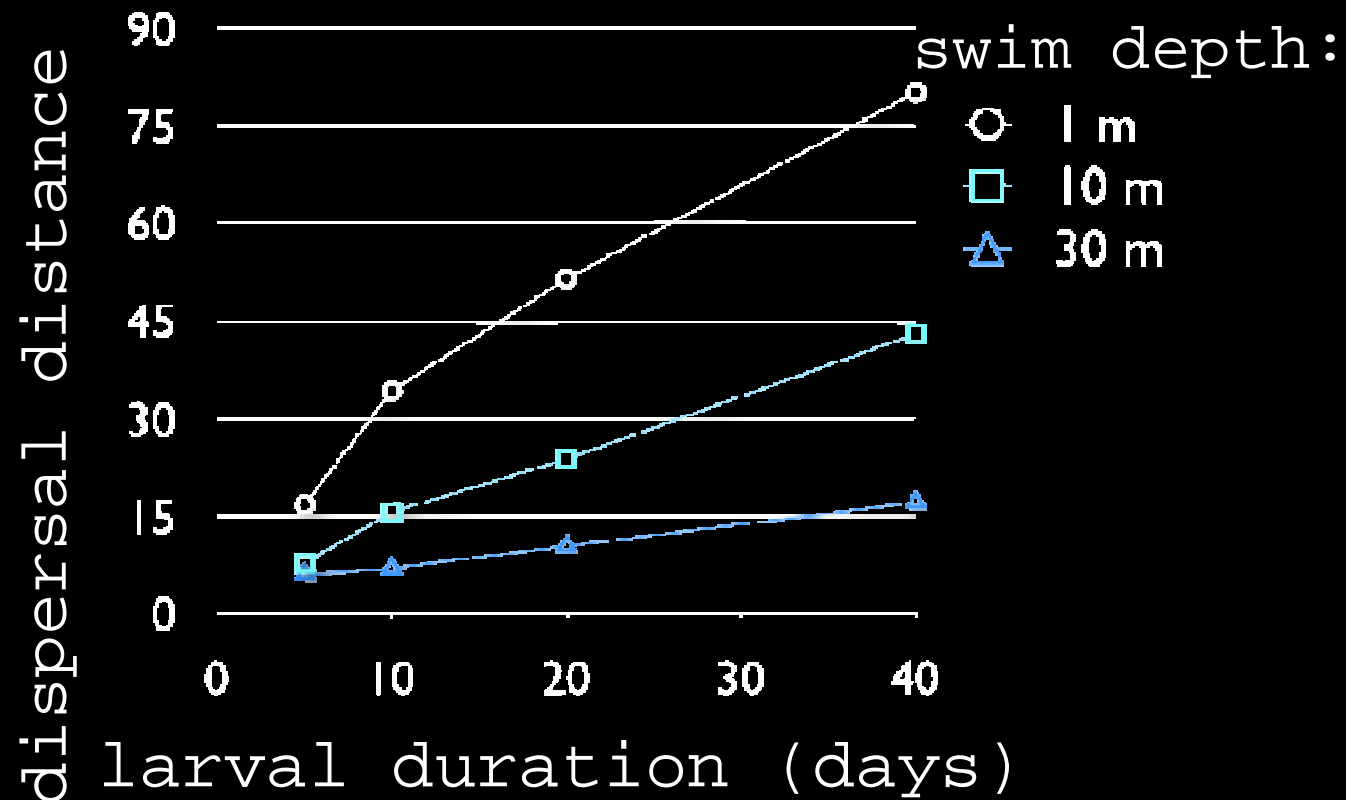
Ongoing Formas project: *“Larval dispersal and the design of marine reserve networks in Sweden”*

- Assess the importance of connectivity for MPA design
- Develop a tool to include connectivity as a criterion in design of MPA and no-take areas
- Include Skagerrak (+North Sea?)



Problems & Challenges

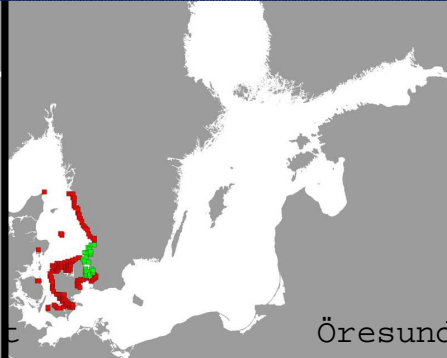
Larval behaviour - not only passive 'particles'



Spread of invasive species



Kattegat



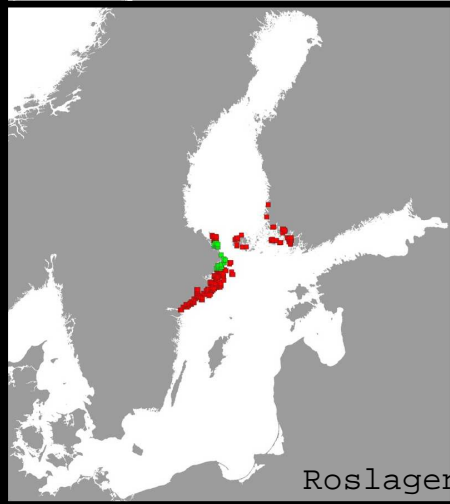
Öresund



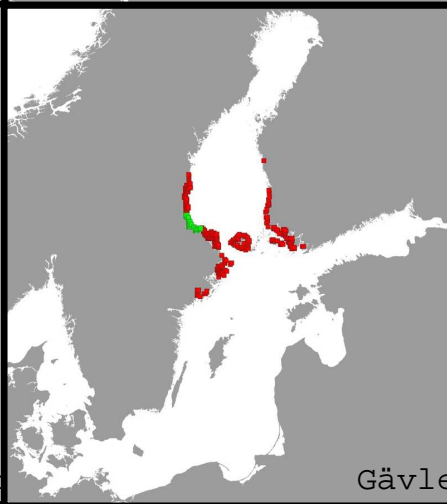
Hanö



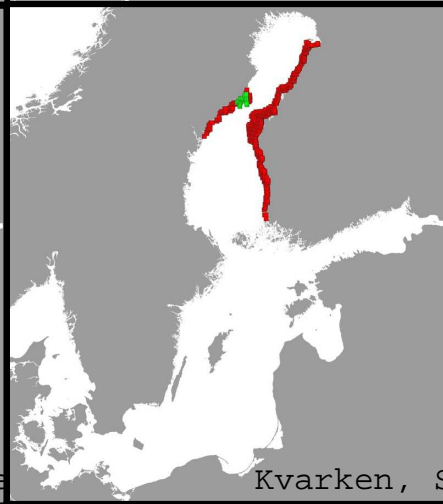
Öland



Roslagen



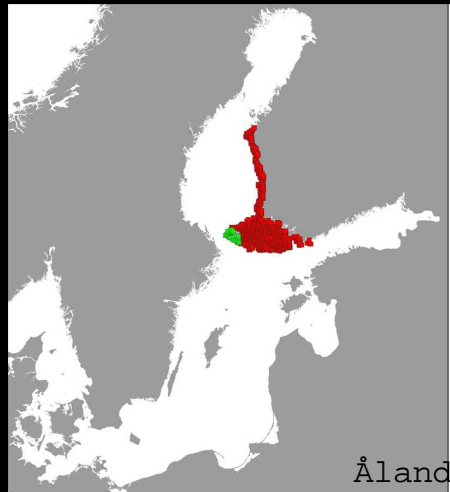
Gävle



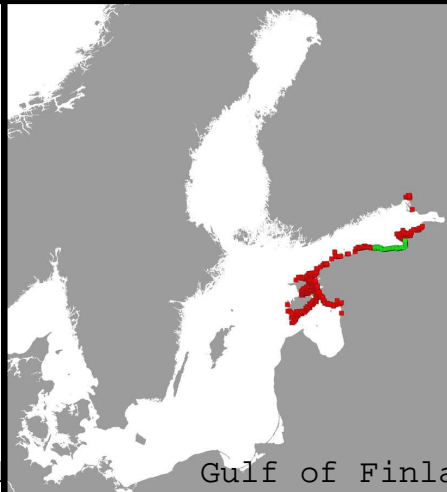
Kvarken, S



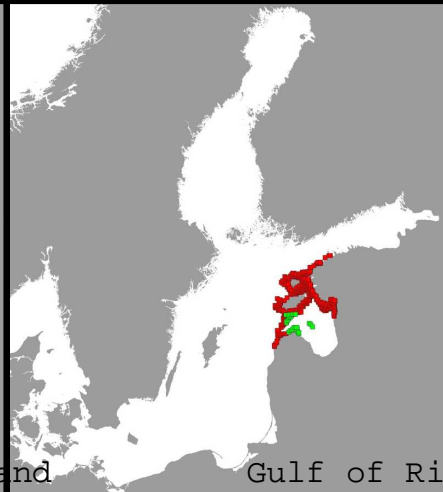
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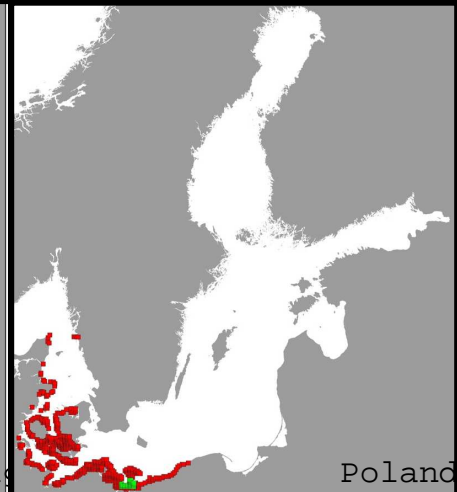
Åland



Gulf of Finland



Gulf of Riga



Poland

Thank you !

Collaborators:

Kristofer Döös, Stockholm University

Hanna Corell, Stockholm University

Per Moksnes, University of Gothenburg

Per Nilsson, University of Gothenburg

David Kleinhans, University of
Gothenburg

Martin Nilsson Jacobi, Chalmers