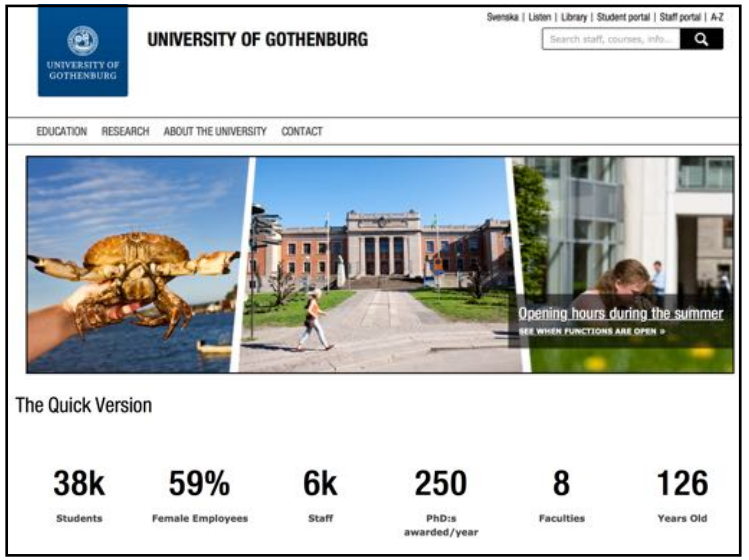
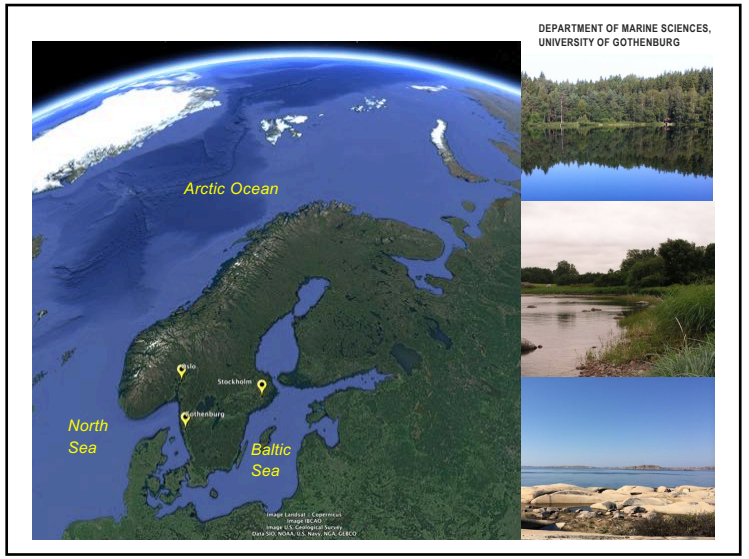
Research in the interface between science and governance of ecological resources

MATS LINDEGARTH, DEPARTMENT OF MARINE SCIENCES, UNIVERSITY OF GOTHENBURG, SWEDEN
mats.lindegarth@marine.gu.se



Short bio

- Professor in quantitative benthic ecology at the Department of Marine Sciences
- Master and PhD at UGOT
- Post-Doc University of Sydney, Australia
- General benthic ecology, EIA, statistical modelling, monitoring, benthic mapping, aquaculture, marine policy
- Also affiliated to *Centre for Sea and Society* and *The Swedish Institute for the Marine Environment*



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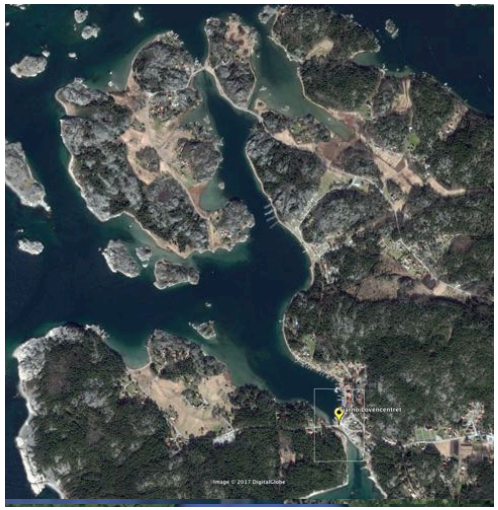
- City of Gothenburg, 1 million.
- Largest port in Scandinavia.
- In western Sweden, more than 15 000 people work in more than 2 000 maritime companies
- A regional maritime strategy in parallell to the EU maritime policy



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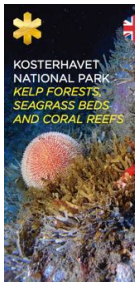

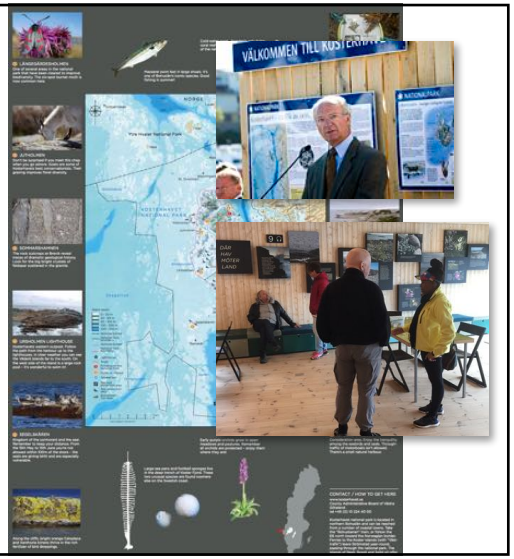

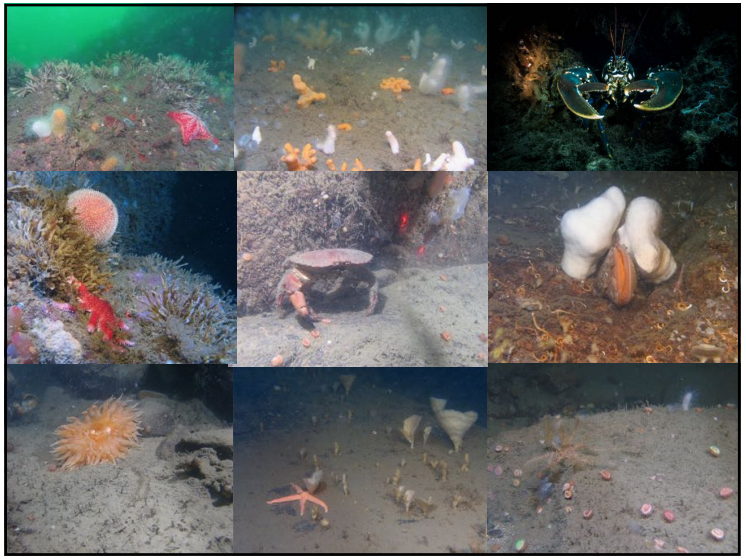

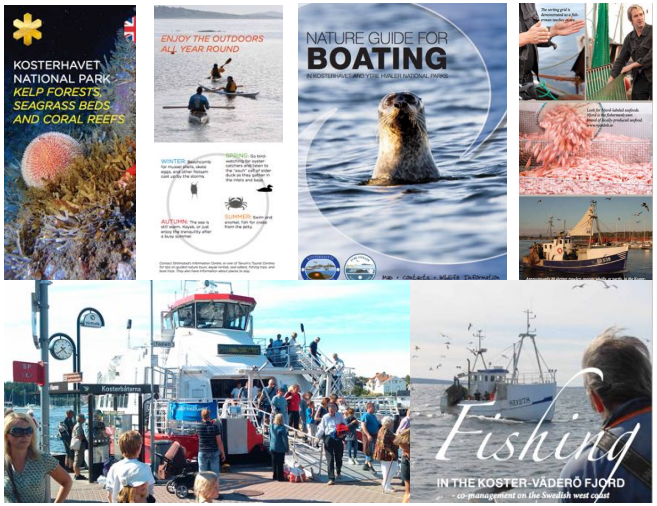

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Outline

- Global challenges for sustainability
- Policy responses in a European context
- Swedish perspectives
- Personal experience
  - Ecological status assessment & water quality
  - Ecological mapping & MSP
  - Aquaculture
- Some lessons from a UGOT-perspective

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UN sustainable development goals

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According to SDG14 we should…

- …prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
- …sustainably manage and protect marine and coastal ecosystems
- …minimize and address the impacts of ocean acidification
- …effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans
- …conserve at least 10 per cent of coastal and marine areas
- …prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing
- …increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources
- …increase scientific knowledge, develop research capacity and transfer marine technology,… in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries
- …provide access for small-scale artisanal fishers to marine resources and markets
- …enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea

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The SDG14 means...

- Great challenges for the managers, policy makers and business
- Important roles for science and academies
  - Develop new scientific knowledge and understanding
  - Education and capacity building
  - Engage in the society at different levels
- Transdisciplinarity is needed to cope with ecological, economic and social dimensions
- The SDG's are global but we need to develop and implement policies, regulations, actions, research etc. at regional, national and local levels

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The European context

- Development of common policies regarding environment, fisheries, maritime affairs etc…
  - CFP (Common fisheries policy)
  - IMP (Integrated maritime policy)
  - WFD, MSFD (Water Framework Directive and Marine Strategy Framework Directive)
  - REACH (Registration, Evaluation, Authorisation and restriction of Chemicals)
  - …and many more
- Implementation into national laws and regulations
  - National targets
  - National indicators and routines
- Great influence on governance practices since Sweden joined the EU in 1995.

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The Water Framework Directive

- Introduced in 2000 in order to…
  - Meet the increasing pressures on fresh- and marine water resources
  - Create an integrated water policy based on catchment areas
  - Develop common practices for management and status assessement
  - Achive good ecological status in 2027.
- Involves ground- and surface-water (lakes, streams and costal waters)
- The WFD defines general principles but need to be adapted to regional and local conditions

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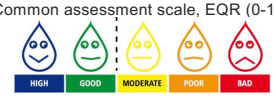
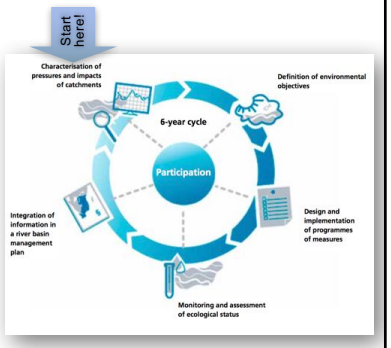
The Water Framework Directive

- Cyclic, adaptive management process
- Assessment of ecological status in lakes, stream or coastal areas ("water bodies")
- Biological, chemical and pysical "quality elements"
  - Fish
  - Benthic fauna
  - Benthic vegetation
  - Phytoplankton
- "One-out-all-out principle" for biological quality elements (precautionary principle)
- Common assessment scale, EQR (0-1)





Large number of water bodies

Habitat	BQE	No. assessed using complete data	No. assessed using expert methods	No. not assessed
Coastal	Benthic fauna	103	248	
	Macrophytes	61		
	Phytoplankton			
Lakes				6498
			53	6586
Strear			307	12960
		656	222	12969
	Phytobenthos	761	0	1386*

How can we monitor and assess status in all of those?

≈ 654 coastal

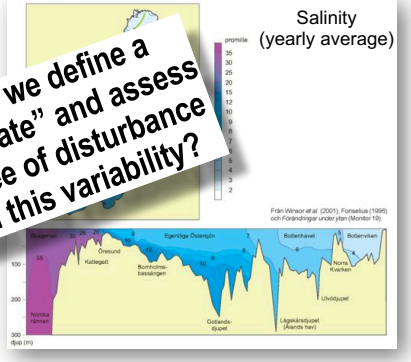
≈ 7 000 lakes

≈ 14 000 streams

Strong biogeographic gradients

Temperature (yearly average)

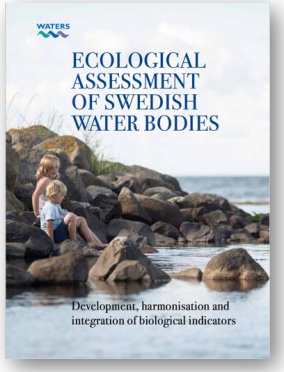
Salinity (yearly average)



How can we define a "natural state" and assess the degree of disturbance with all this variability?

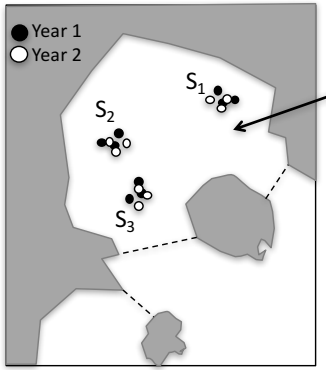
WATERS – Waterbody Assessment Tools for Ecological Reference conditions and status in Sweden

- Reliable and sensitive indicators for biological quality elements.
- Consistent methodology for defining references, class boundaries and uncertainty in estimation and classification.
- Develop a common framework for integrated assessment.
- Close interaction with national and regional authorities and users!



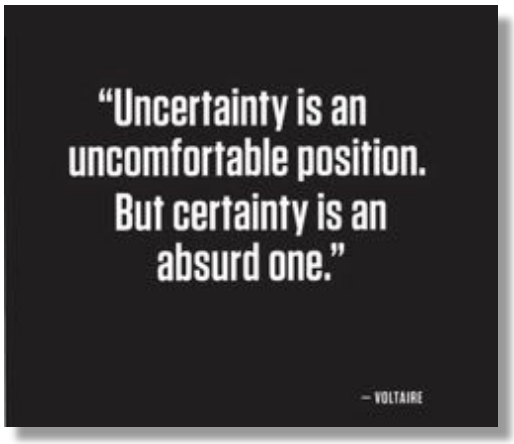
Harmonisation of methods

Status assessments are based on monitoring data

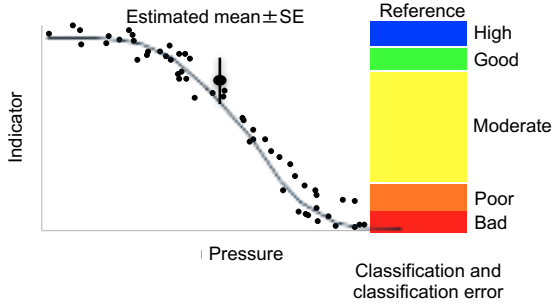


Water body with **3 stations**, each monitored with **3 samples** at each of **2 years**

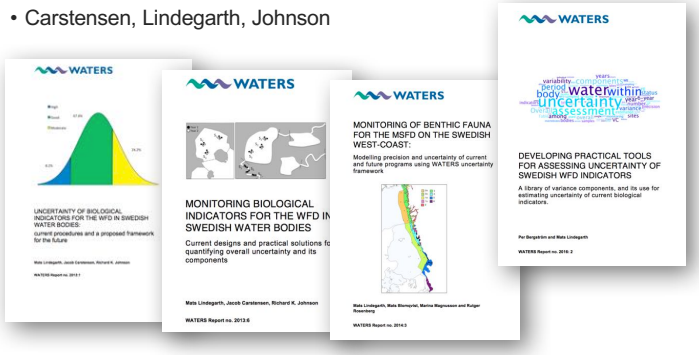
Assessment of a 6-yr period involves variability due to years, sites, samples, etc.

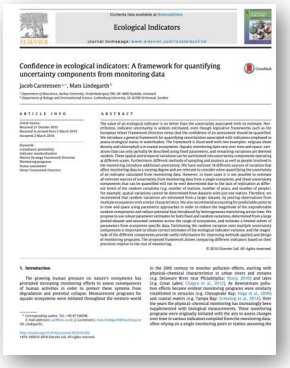


Two types of uncertainty



- A general method developed in a series of technical reports (www.waters.gu.se)
- Carstensen, Lindegarth, Johnson





General methodology based on:

1. Partitioning of sources of variability

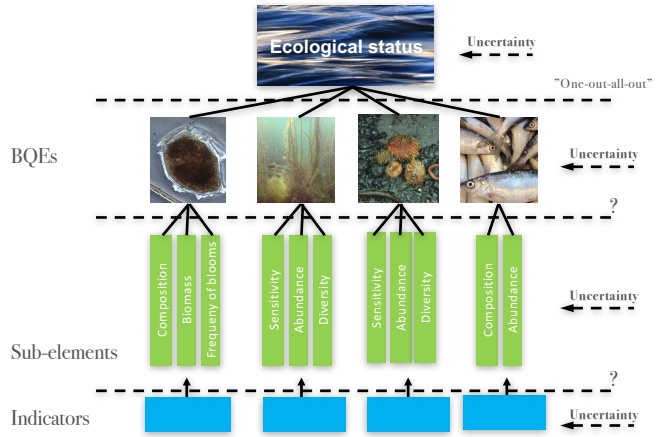
$$y = \mu + \underbrace{year + YEAR + season + SEASON{\times}YEAR + DIURNAL + IRREGULAR}_{temporal\ sources\ of\ uncertainty} + \underbrace{gradient + GRADIENT + PATCHINESS}_{spatial\ sources\ of\ uncertainty} + \underbrace{YEAR{\times}GRADIENT + SEASON{\times}GRADIENT}_{spatio-temporal\ interactions} + \underbrace{sampling\ devices + PERSON + instrument + REPLICATE}_{sampling\ and\ measurement\ uncertainties}$$

2. Asessment of overall uncertainty at relevant spatial and temporal scales through error propagation.

$$V[\bar{y}] = \frac{s_Y^2 * (1 - \frac{a}{\gamma})}{a} + \frac{s_S^2}{b} + \frac{s_{Y*S}^2}{ab} + \frac{s_\theta^2}{abn}$$

3. Confidence in classification of BQEs and overall uncertainty

Integrated assessment

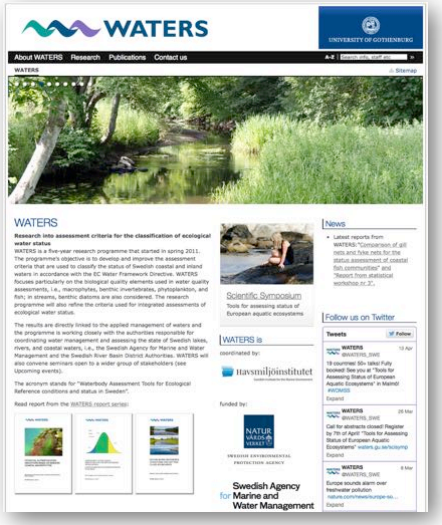


A tool for hierarchical classification

Indicators

Quality elements

Water bodies



Find out more at
www.waters.gu.se
(all reports in English and available online)

This was…

- An introduction to the status assessment according to the WFD
- Examples of need for development of science based tools necessary for practical management at regional scales
- Same principles can be applied to the MSFD

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The Integrated Maritime Policy

- The IMP seeks to provide a more coherent approach to maritime issues, with increased coordination between different policy areas.
- It focuses on issues that do not fall under a single sector-based policy and issues that require the coordination of different sectors and actors.
- Specifically it covers these cross-cutting policies:
  - Blue growth
  - Marine data and knowledge
  - Maritime spatial planning (MSP)
  - Integrated maritime surveillance
  - Sea basin strategies

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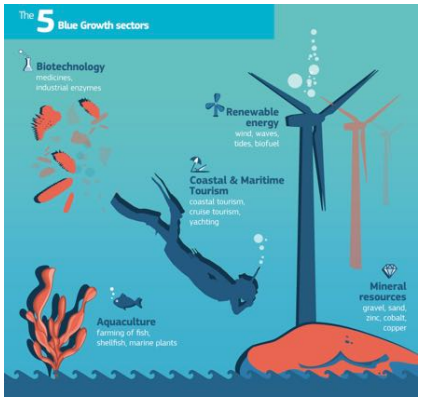
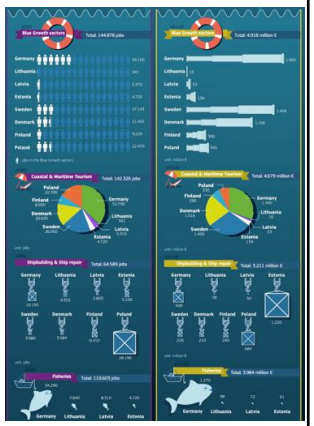
Strategies for "blue growth"

Jobs €





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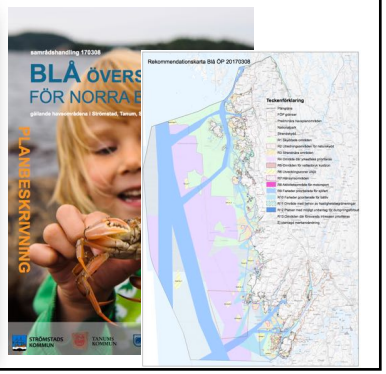
MSP -"the universal cure to all problems"

National MSP

Regional plan for "blue growth"



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Reconciling aims for conservation AND economic growth

- Focus on "ecosystem services"
- Reveals and illustrate the great diversity and magnitude in which the marine environment provides benefits to individuals and societies
  - Supporting
  - Regulating
  - Provisional
  - Cultural
- Report on assessment of services from Swedish seas

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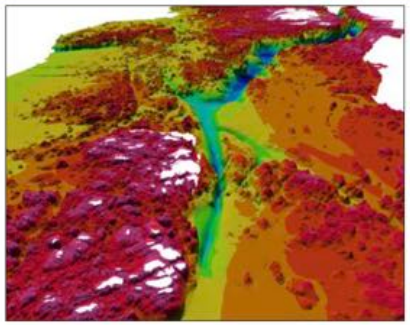
The MSP - process

- MSP is a participatory process involving many steps and stakeholders!
- Performance depends on the quality of information / data on existing conditions
- **What about spatial information on biodiversity and ecological processes?**

Methods for habitat mapping

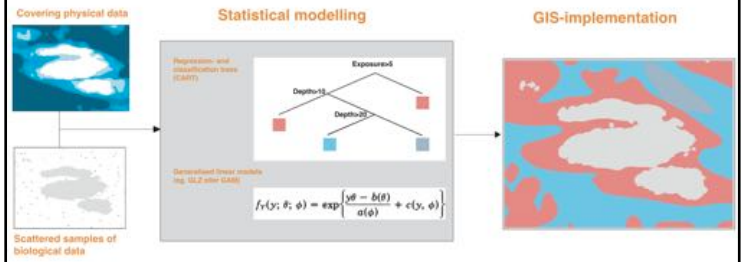


"DIRECT MAPPING"

- Bathymetry
- Bottom hardness
- Biodiversity?
- Ecological functions?

Sampling of benthic biota

Methods for habitat mapping



"PREDICTIVE MAPPING"

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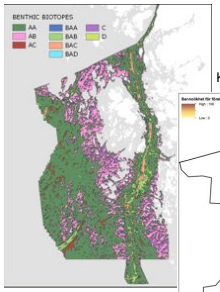
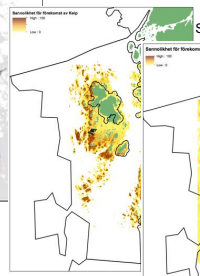
Applied to a range of areas (examples from Koster)

Available data in Kosterhavet

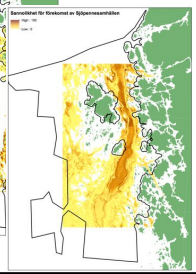
Benthic biotopes



Kelp occurrence



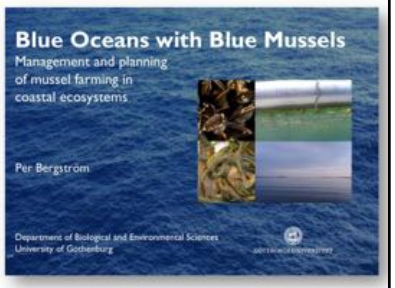
Seapen occurrence



www.prehab.gu.se

Modelling and mapping growth of blue mussels

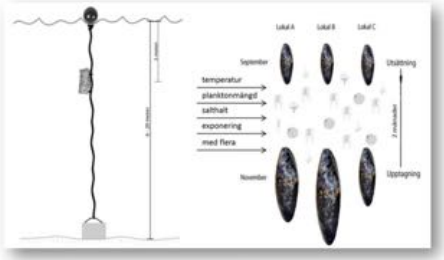
- Project on testing the potential use of musselfarming to mitigate eutrophication by local reduction of phytoplankton biomass
- Model, predict and map the geographic patterns of growth in Bohuslän
- High growth rates = increasing potential for eutrophication mitigation = increasing economic output from mussel-farming
- Result useful in MSP!



Bergström, Lindegarth and Lindegarth (accepted). Modelling and predicting the growth of the mussel, *Mytilus edulis*: implications for planning of aquaculture and eutrophication mitigation. Ecology and Evolution

Modelling and mapping growth of blue mussels

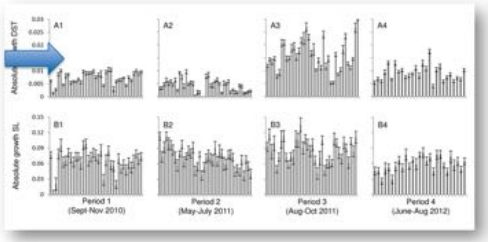
Empirical measurements of growth of transplanted mussels



Measurements at ≈120 sites at four times during a two-year period

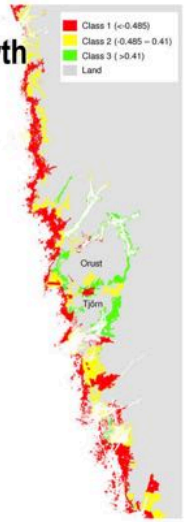
Modelling and mapping growth of blue mussels

Empirical measurements of growth of transplanted mussels



Resulting layer of spatial predictions for mussel growth

- Off-shore areas generally have lower growth rates
- Inner fjord areas, which have the most severe eutrophication problems have higher growth rates.
- 15% of the area is characterised as high growth areas.
- Largely coincides with farming permits.
- Useful in MSP and regional planning



Modelling and MSP

- High growth areas suitable for mussel-farming identified and used in local planning

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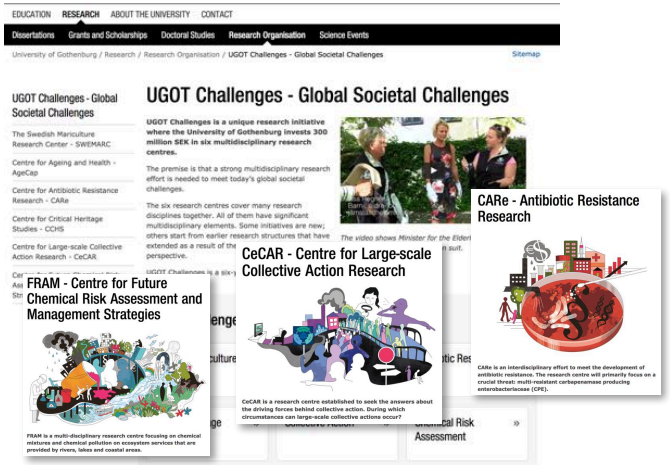
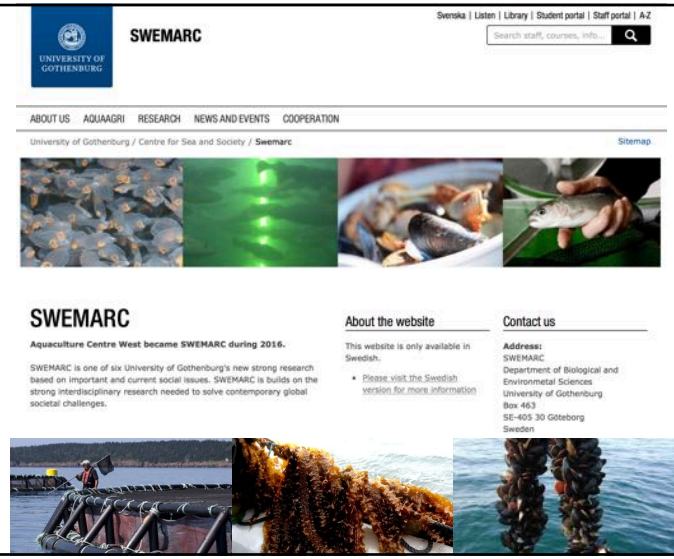
Lessons

- The pressures on marine resources will increase and so will the needs for sustainable solutions.
- The SDG's set the agenda for future research on sustainable development
- There are plenty of opportunities for the scientific community and academic institutions to contribute.
- Transdisciplinarity work and interactions with society are necessary.

Transdisciplinary research platforms at UGOT






Thank you for listening!