Evaluation of methods for assessing cumulative impacts on marine ecosystems

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Scientists' perspectives on global ocean research priorities

*Murray A. Rudd** (2014)

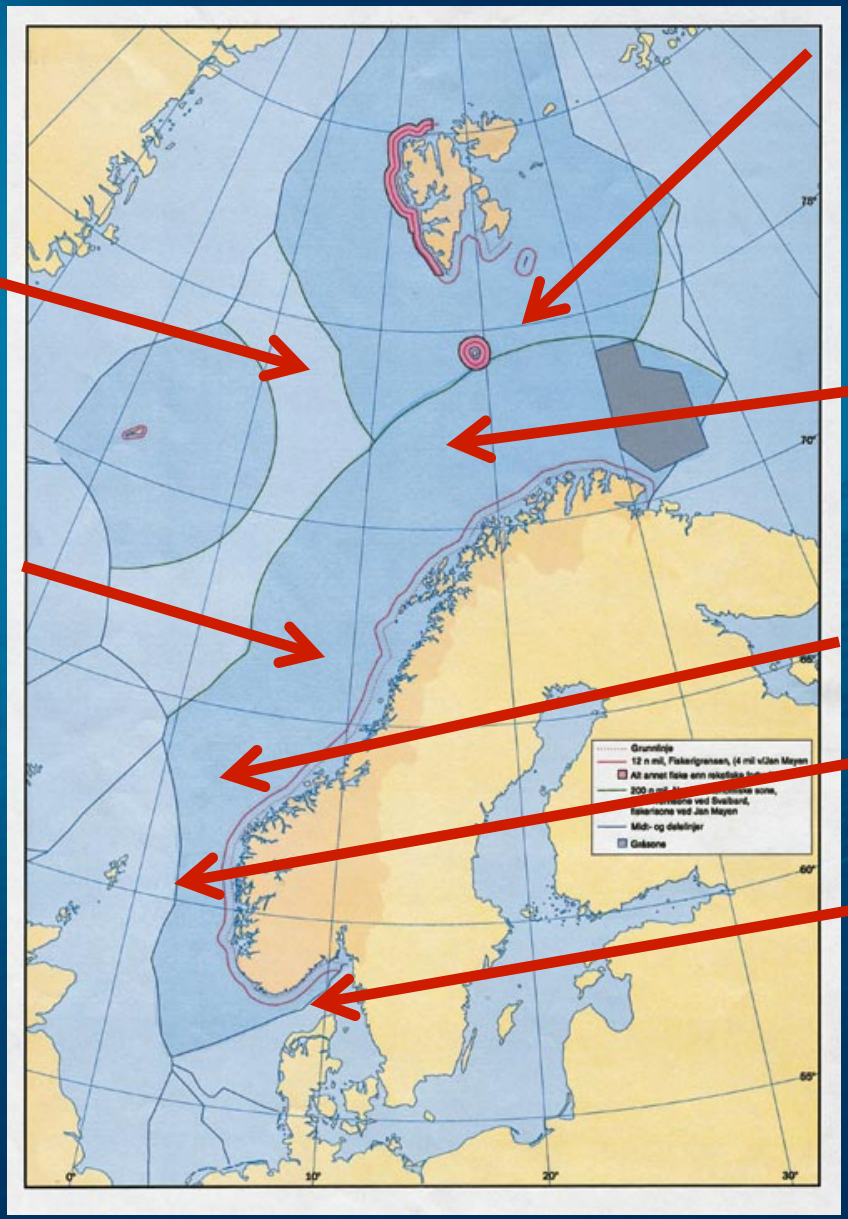
What is the most important research question for ocean governance and sustainability?

2179 scientists **94 countries**

Assessing cumulative impact of multiple stressors

Fisheries

Climate change
(and variation)



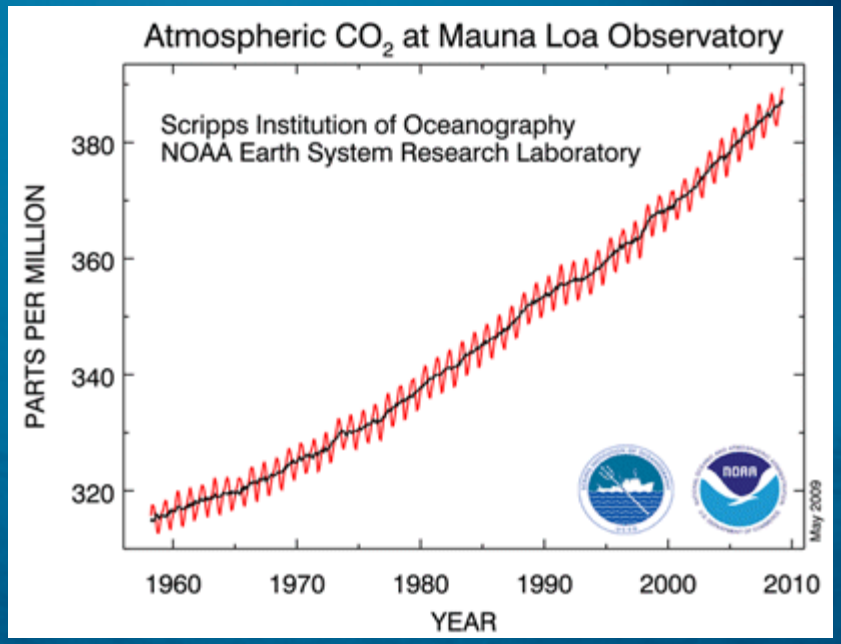
Intr. species

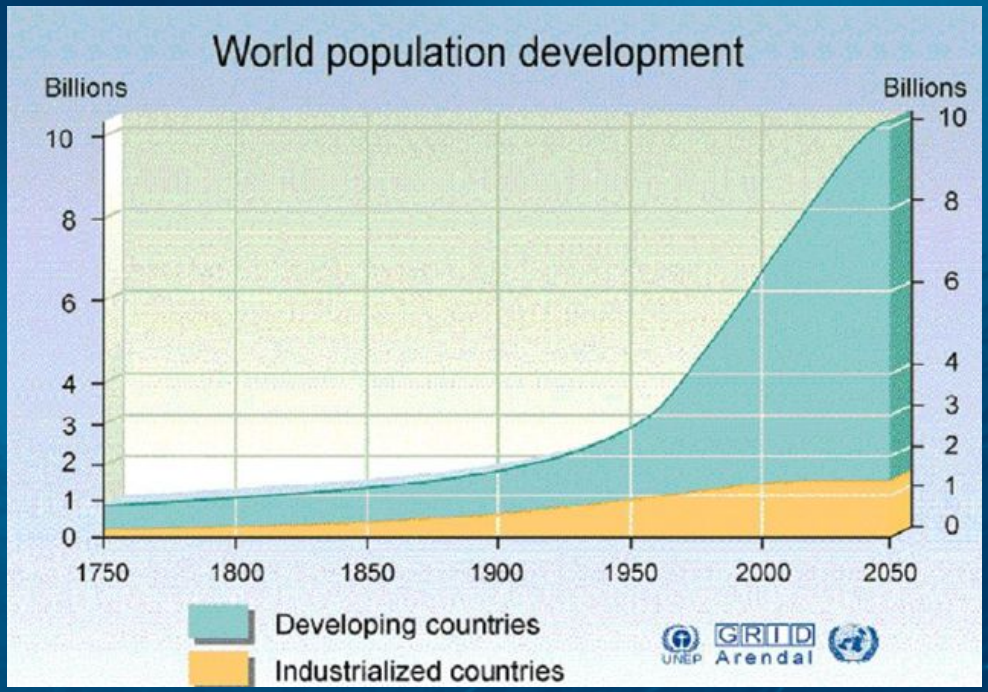
Ocean
acidification

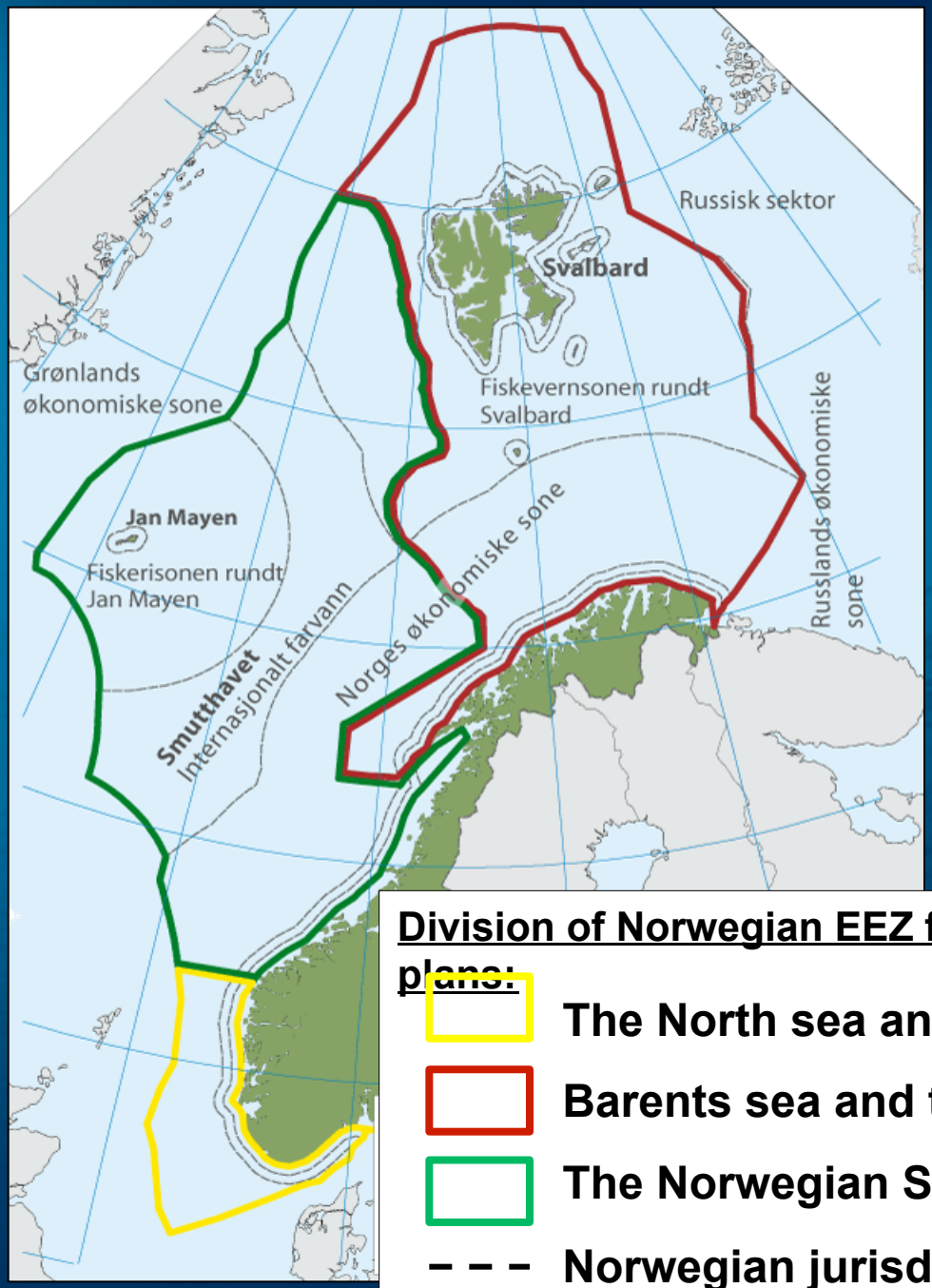
Oil&gas

Ship traffic

Other pollution


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
May 2009


World population development
Billions
Billions
10
8
6
4
3
2
1
0
1750
1800
1850
1900
1950
2000
2050
Developing countries
Industrialized countries
UNEP
GRID
Arendal



Division of Norwegian EEZ for management plans:

- The North sea and Skagerrak
- Barents sea and the Lofoten islands
- The Norwegian Sea
- – – – Norwegian jurisdiction

Two types of methods

- Based on spatially resolved quantitative indexes (CUMULEO, ODEMM, HARMONY)
- Based on qualitative assessments of combined effects of single factor impacts

Spatially explicit quantitative indexes

	CUMULEO	ODEMM	HARMONY
1. Scientific credibility: pressures, ecosystem components, impacts	moderatehigh moderate moderate - high	moderate - high moderate moderate	moderate - high moderate moderate
2. Spatial resolution and flexibility	high		high
3. Flexibility in data formats	moderate	high	high
4. Transparency	moderate	moderate	moderate-high
5. Clarity	moderate-high	moderate-high	high
6. Temporal aspect	low - moderate	low	low
7. Flexibility for different purposes	high	high	high
8. Efficacy of the method	moderate (-high)	moderate - high	high

Korpinen S. 2015. OSPAR Case Study on Cumulative Effects: Evaluation of the methods and analysis of their outcomes. Report to CEFAS, Final version 2 January 2015. 30 p.

HARMONY

$$I = \sum_{i=1}^{n} \sum_{j=1}^{m} P_i \times E_j \times \mu_{i,j}$$

I= Impact index value

Data or modelled

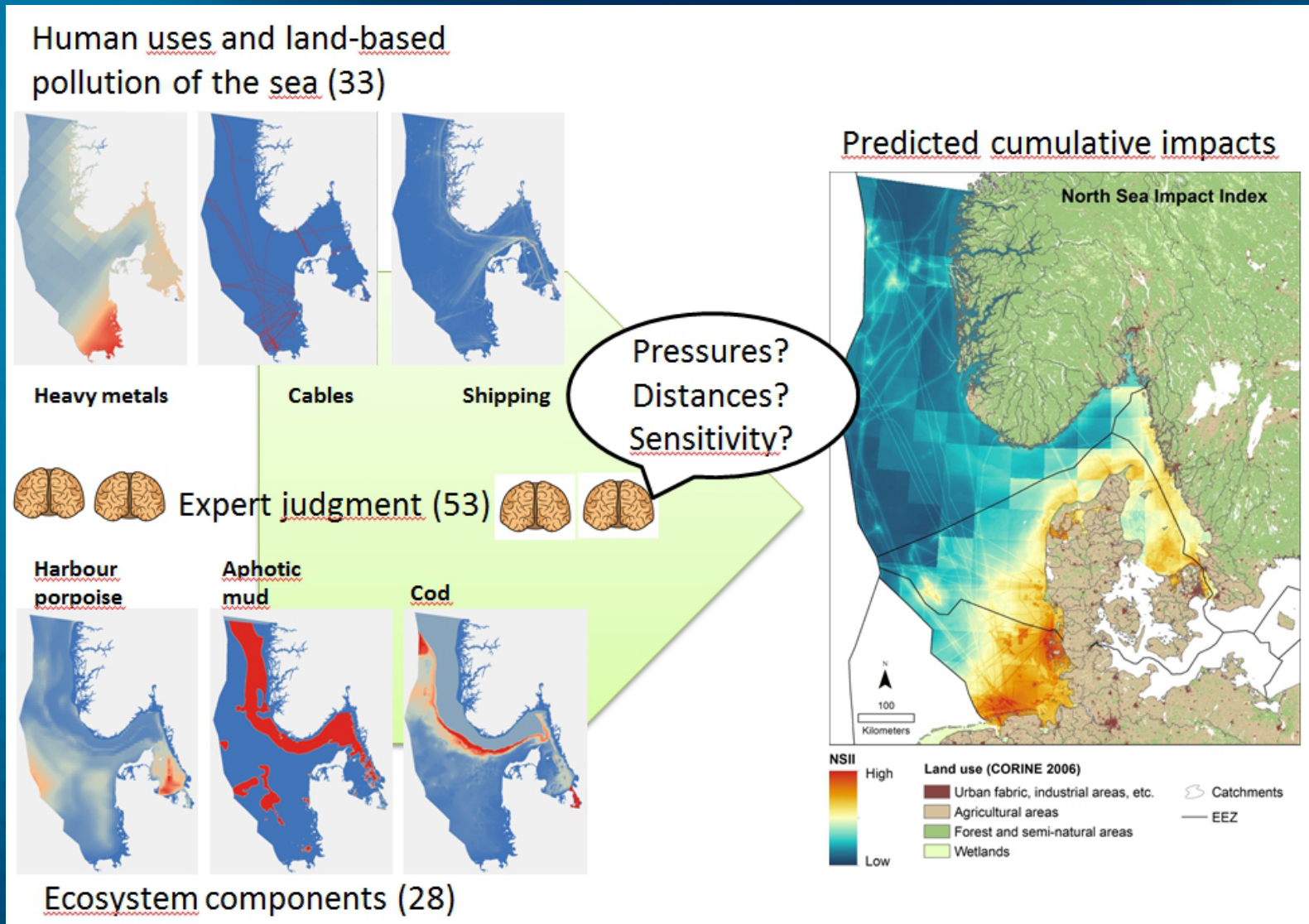
P_i = estimated value of pressure i

E_j= presence or absence of ecosystem component

Experts

μ_{ij}= weight score for P_i on E_j

Halpern et al 2008 Science 319: 348-352



J.H. Andersen, A. Stock (eds.), M. Mannerla, S. Heinänen and M. Vinther. 2011. Human uses, pressures and impacts in the eastern North Sea. Danish Centre for Environment and Energy (DCE), Aarhus University, Denmark. 137 pp. - DCE Technical Report No. ###, 2012

HARMONY, critique

$$I = \sum_{i=1}^{n} \sum_{j=1}^{m} P_i \times E_j \times \mu_{i,j}$$

1

2

Cumulative effects are:
-Additive (26 %)
-Synergistic (36%)
-Antagonistic (38%)

Crain, Ecol Lett 2008, 11: 1304-15

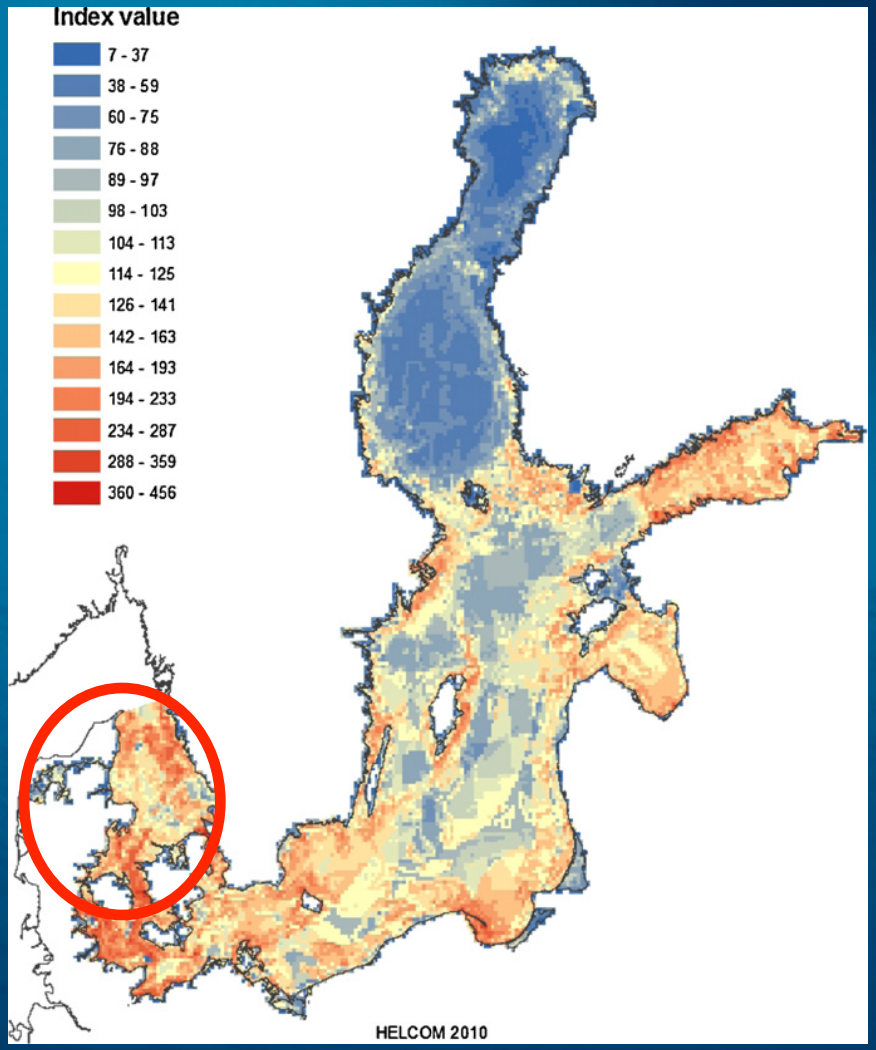
3 Lack of spatially resolved data on pressures and components / errors in modelled data

4 Impact occurs elsewhere than pressures

Heath (2008) Nature, 321: 1446

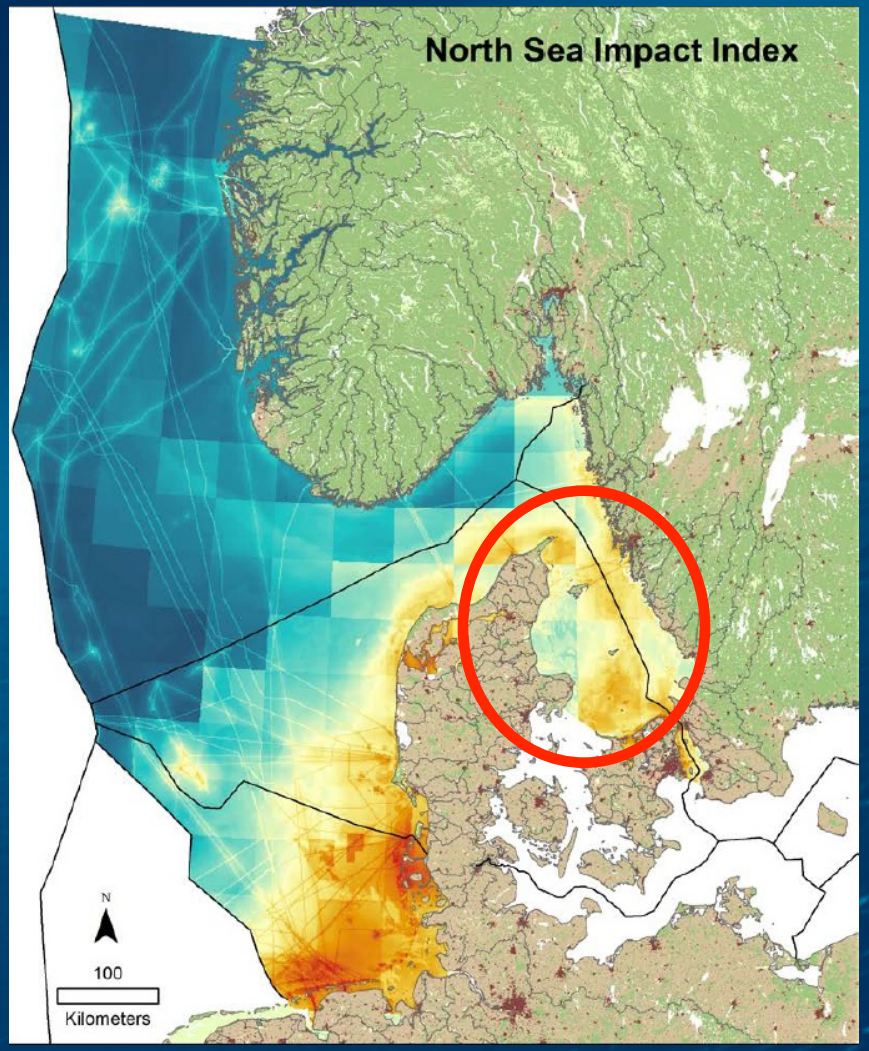
Worry: Biased estimates

HOLAS



S. Korpinen et al. / Ecological Indicators 15 (2012) 105–114

HARMONY



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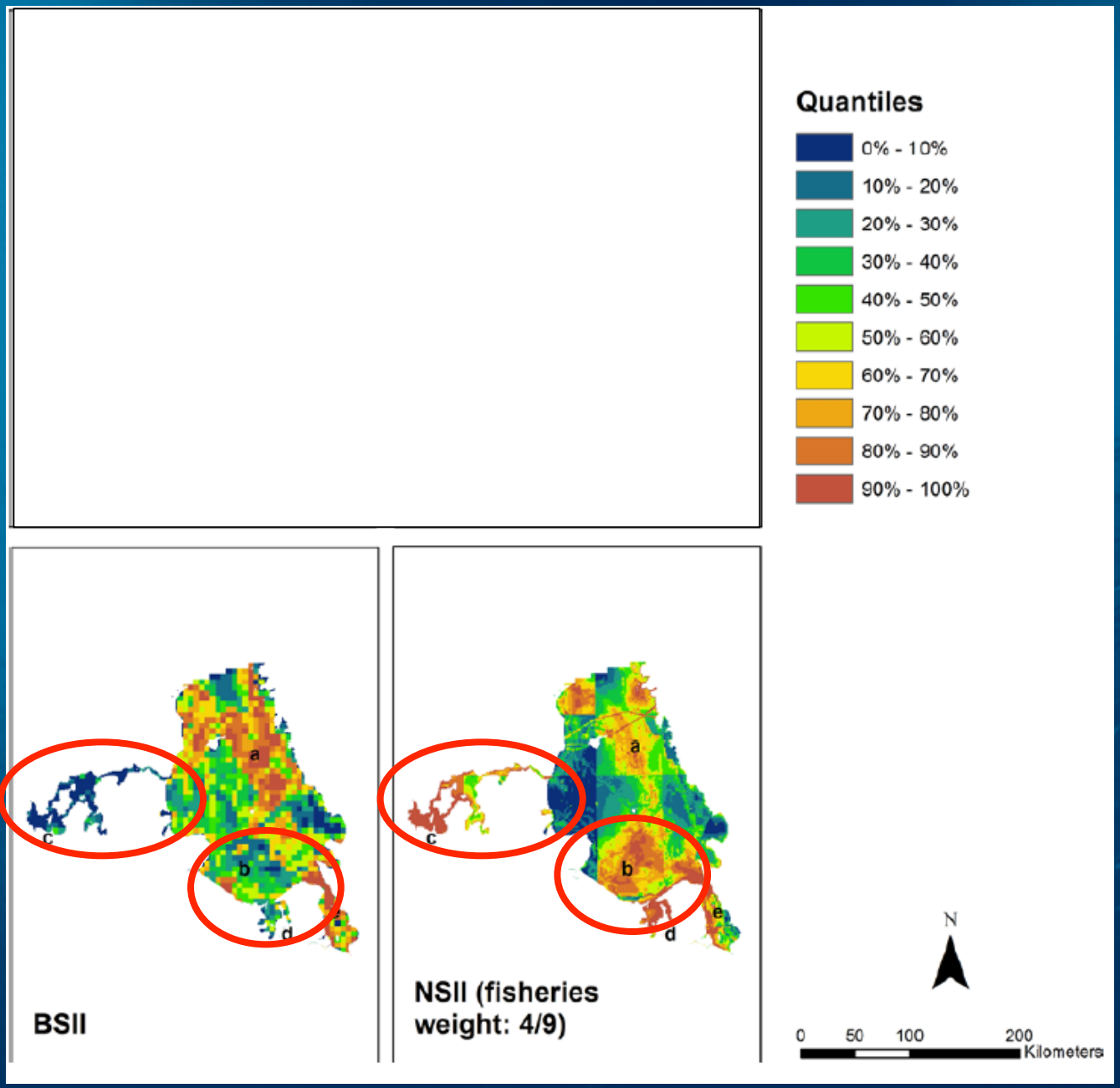
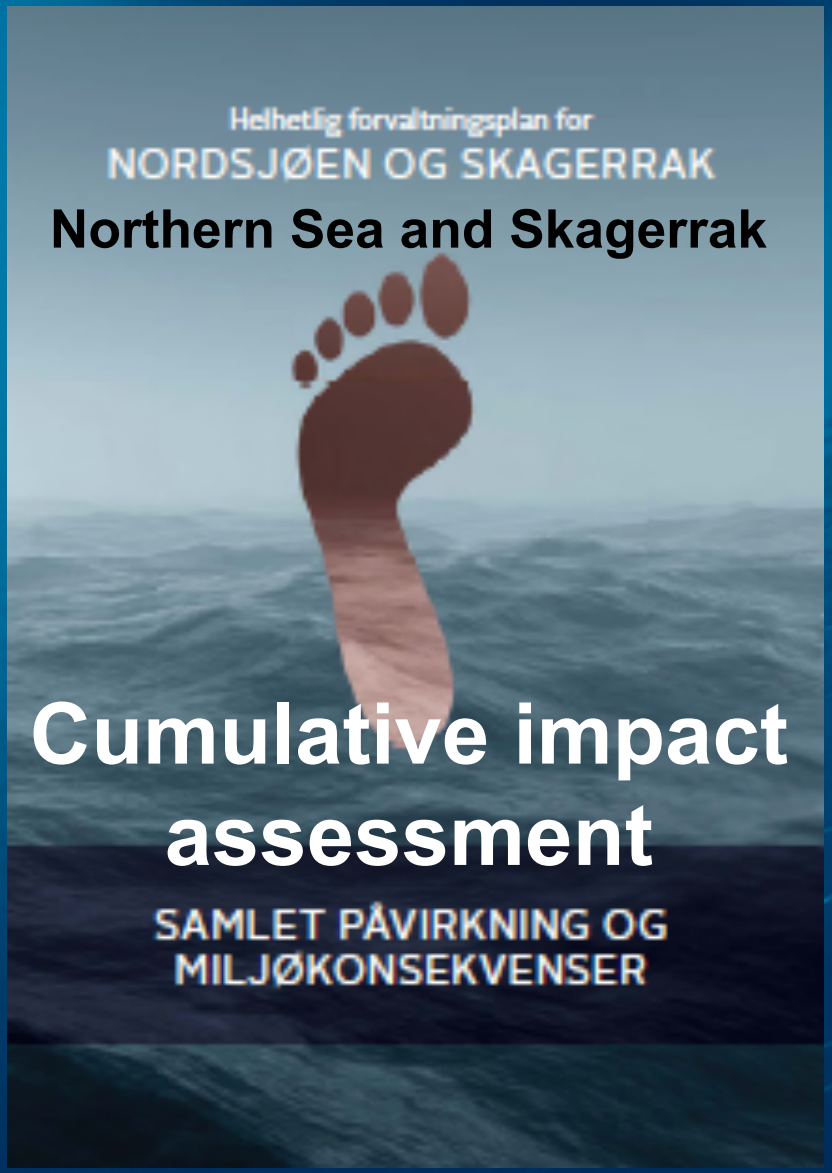
HOLAS HARMONY

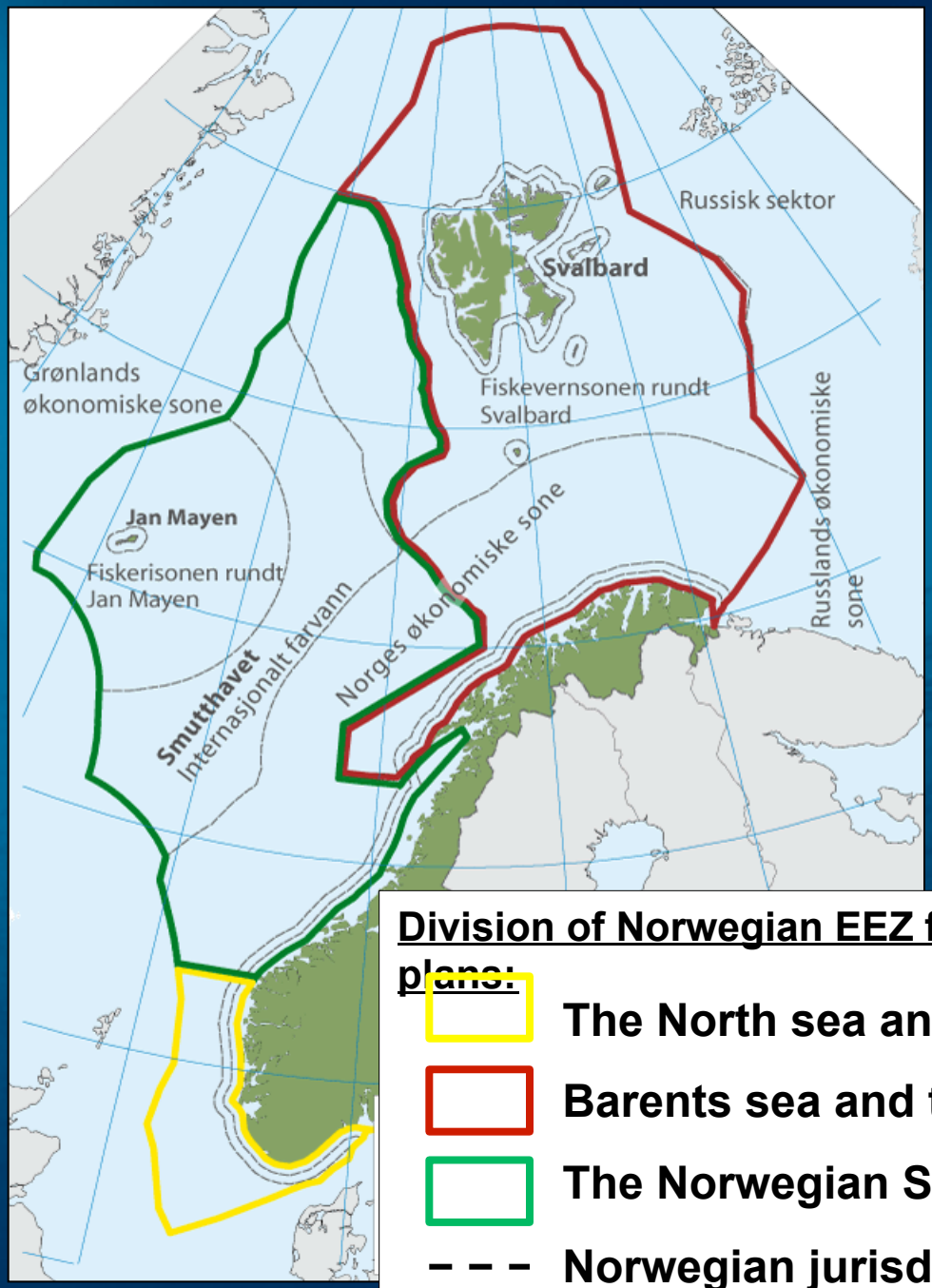


Qualitative assessment

- Assess state of ecosystem: what elements are in “bad” condition? (based on indicators and other information)
- Evaluate how pressures can impact the ecosystem (preferably based on peer reviewed studies)
- Evaluate qualitatively how pressures may be responsible for elements in bad condition (preferably citing peer reviewed literature)

Example: Cumulative impact assessment for the Northern Sea and Skagerrak





Division of Norwegian EEZ for management plans:

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1. State of ecosystem

Component	
Plankton	state
Benthos	state
Fish	state
Seabirds	state
Marine mammals	state
Nature types	state

2. POTENTIAL impact of pressures

Pressure	Plankton	Benthos	Fish	etc
Fishing	?	?	?	
Petroleum	?	?	?	
Ship traffic	?	?	?	
Chronic pollution	?	?	?	
Climate change	?	?	?	
etc				

3. How do human activities impact the ecosystem

4. Risk of acute impact

Activity	Plankton	Benthos	Fish	etc
Petroluem	?	?	?	
Ship traffic	?	?	?	
etc				

5. How may humans impact in the future?

What does management need to consider?

Examples of issues to consider for management for the North Sea

Bottom impact from trawling

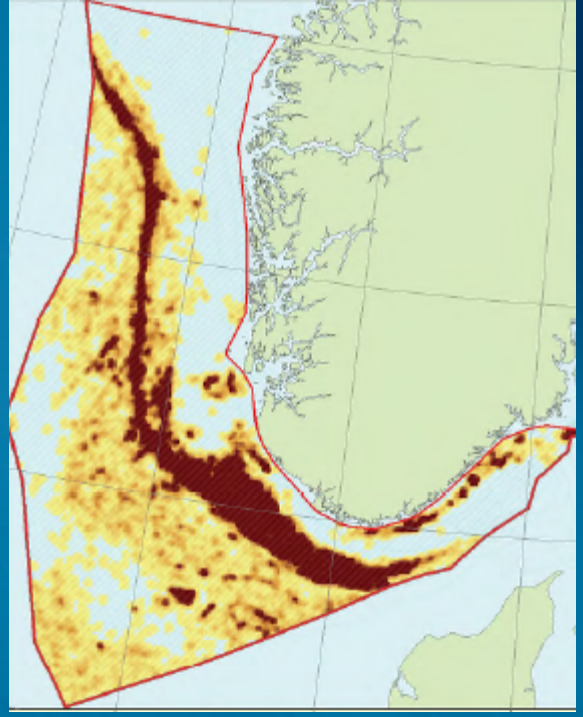
Other bycatch

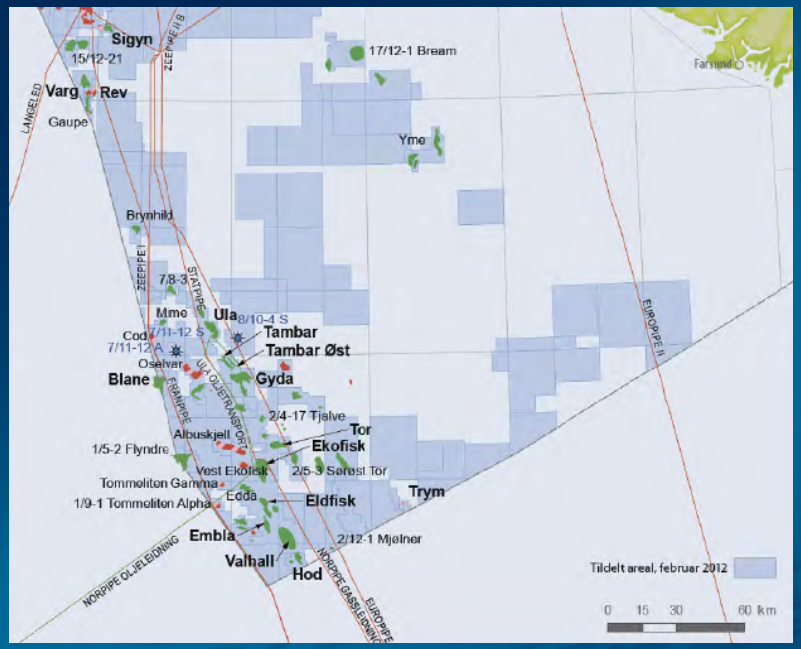
Introducing species with ships

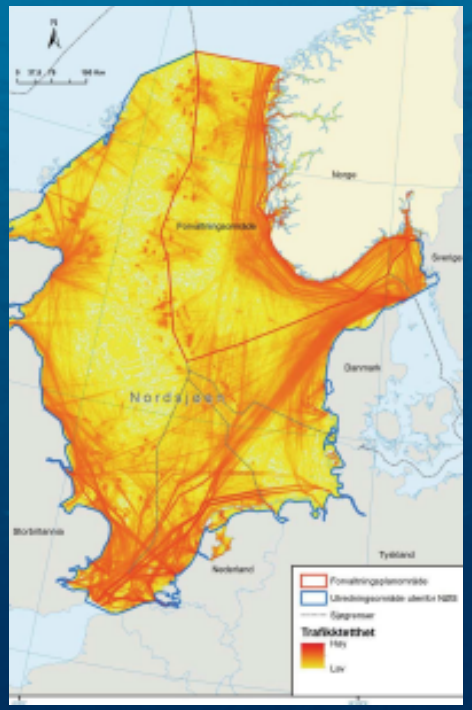
Oil spills for petroleum activities

Marine litter

Etc.




Sigyn
15/12-21
Varg
Rev
Gaupe
17/12-1 Bream
Yme
Brynhild
7/8-3
Mime
Ula
8/10-4 S
Tambar
Tambar Øst
Cod
7/11-12 S
7/11-12 A
Oselvar
Blane
Gyda
2/4-17 Tjalve
Albuskjell
Tor
Ekofisk
1/5-2 Flyndre
Vest Ekofisk
2/5-3 Sørøst Tor
Tommeliten Gamma
Edda
Eldfisk
Trym
1/9-1 Tommeliten Alpha
Embla
2/12-1 Mjølner
Valhall
Hod
ZEEPIPE II B
LANGELED
ZEEPIPE I
STATPIPE
FRAMPIPE
UKT OLJETRANSPORT
EUROPIPE II
NORPIPE OLJELEDNING
NORPIPE GASSLEDNING
Tildelt areal, februar 2012
0 15 30 60 km


Norge
Sverige
Danmark
Nederland
Tyskland
Storbritannia
Nordsjøen
Trafikktetthet
Høy
Lav

Conclusion for the Barents and Norwegian Seas

- Limited number of important pressures (climate change, fishing and possibly ocean acidification and pollution)
- Lack of spatially resolved data
- Thus: limited gains from HARMONY approach + potential problems with biased estimates from HARMONY approach
- Better served with the qualitative assessments

Regional IEA ICES groups

Barents Sea ecosystem overview


Thank you