Resource management in the Arctic

Accommodating multiple uses in economic models

Outline

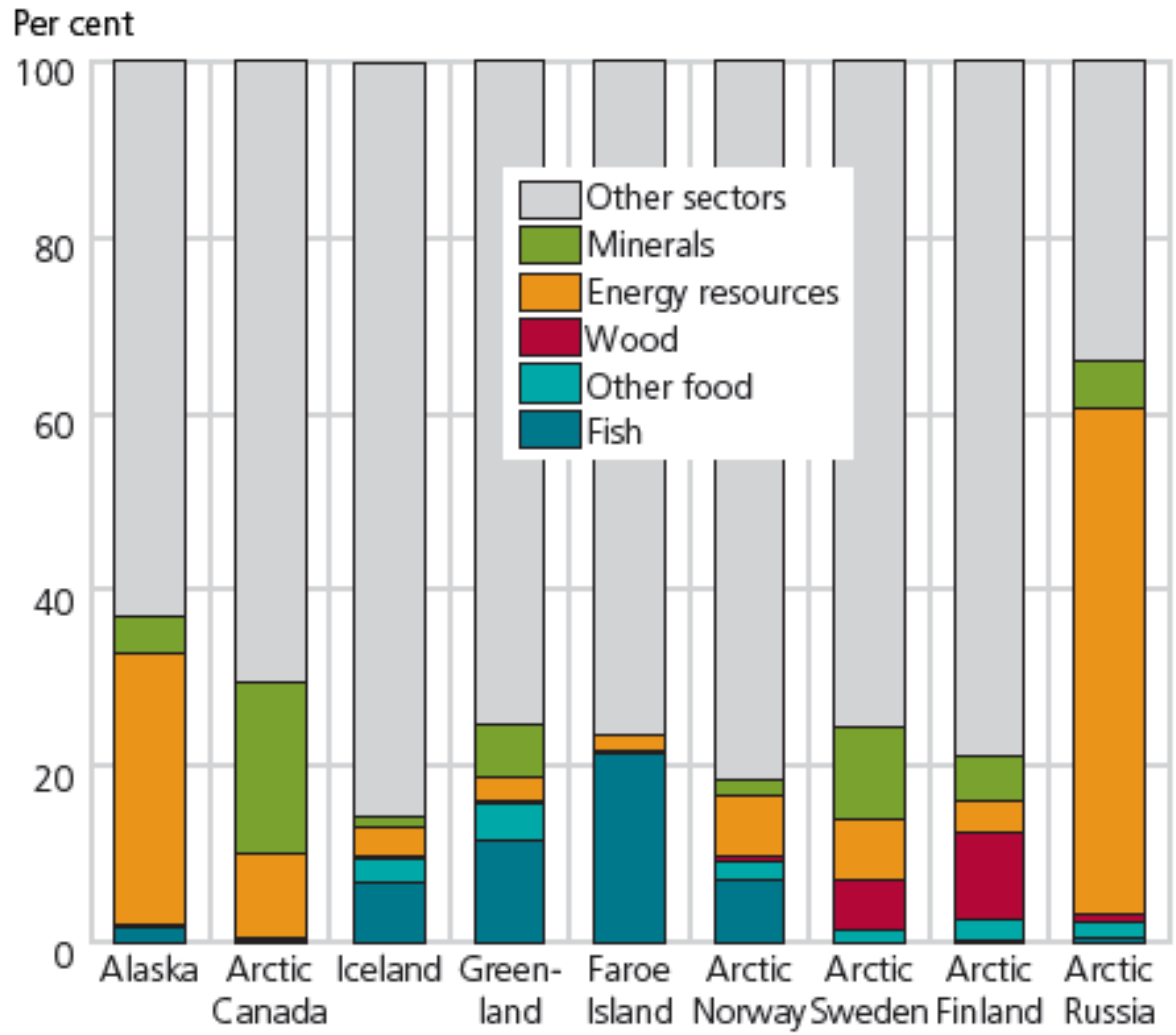
- Introduction: The Arctic
  - Resources
  - Users
- Ways to deal with multiple uses
  - Constraints
  - Net benefit maximization (multi-products)
  - Weighting and trade-offs
- Example: Oil ship routing, Ecosystems & Fisheries

The Arctic

Picture: Ansgar Walk

Importance of resources within Arctic economies

Figure 4.51 **Value added in natural resource based industries in Arctic regions. 2005. Per cent of regional GDP**



Aslaksen et al. (2009). In: The economy of the North 2008.

Other important sectors

Tourism

© Ansgar Walk

Transport

© Marcus Bengtsson

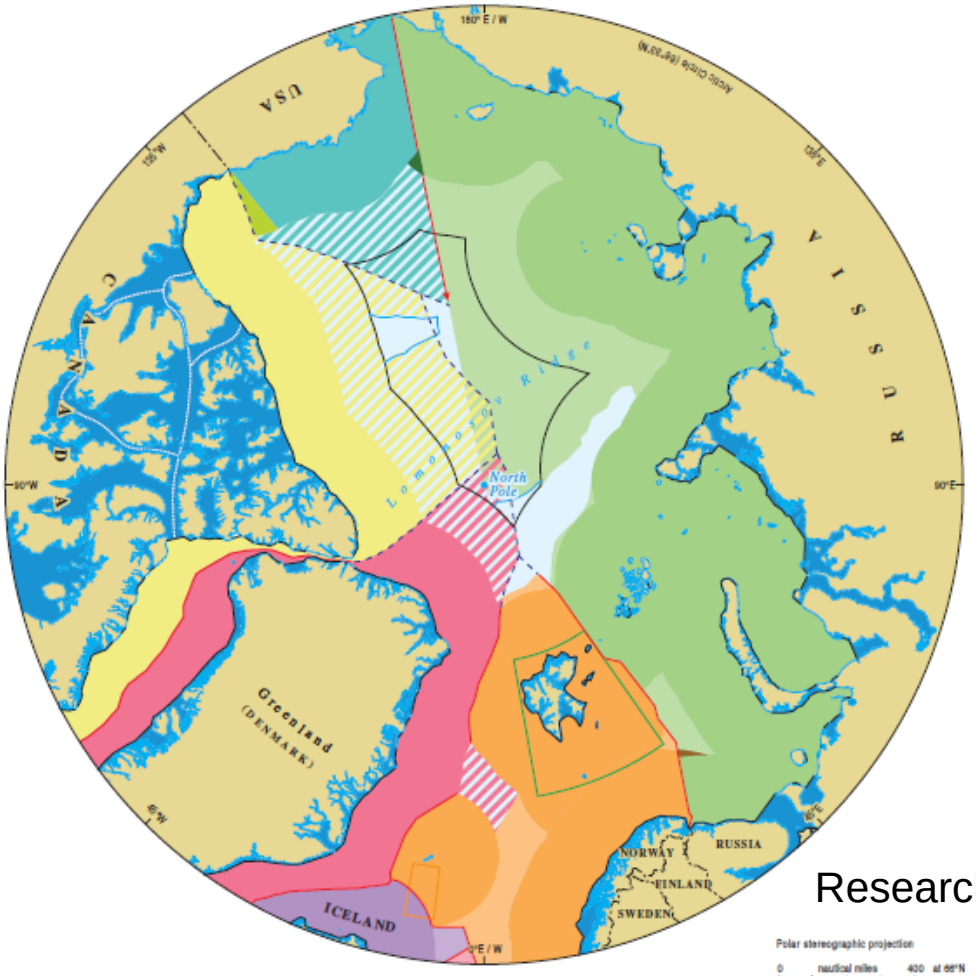
Hydropower

© Rhero

Reindeer herding

© Mats Anderson

Who owns the Arctic and its resources?



International Boundaries
Research Unit, Durham University

Resources in the Arctic

- Many important natural resources present
- Large parts of the economy dependent on ecosystems & resources
- Many players present (resource users and countries)
- Many interlinkages

Exploring links between uses

Many of these resources are interlinked:

- Forestry, Reindeer herding & Pipelines
- Oil extraction (with spill risks) & Fisheries
- Multi-ecosystem services produced from a single ecosystem

Ignoring these links may lead to biased policy recommendations and ignored trade-offs

Exploring links between uses

Comparatively little work:

- Some multi-species fisheries or marine protected area models incorporating effects on tourism
- Some models incorporating none-use value or conservation
- Some work on trade-offs between ecosystem services

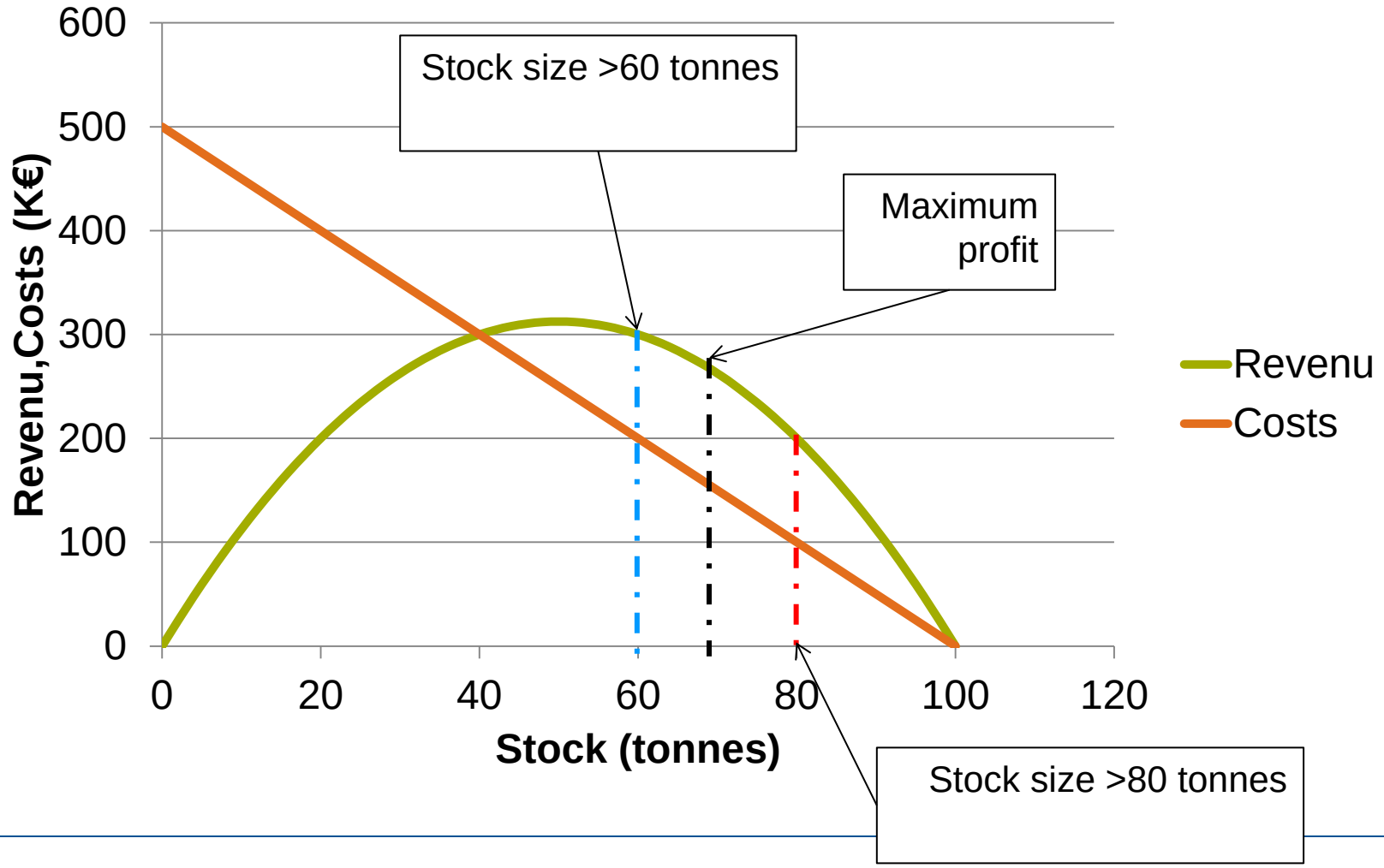
Ways to incorporate multiple uses

Simplest way: constraints

Specify some minimum (or maximum) conditions that must be met:

- A minimum stock size
- Areas closed to fishing
- A maximum level of bycatch (multi-species model)

Constraints in the Gordon-Schaefer model



Constraints: Advantages & Disadvantage

Advantages:

- Easy to implement
- Motivation external to model
- Cost of constraint can be calculated

Disadvantages:

- Model infeasibilities
- Benefits unspecified
- Can be arbitrary

Multiple uses: weighing via net benefits

Procedure:

- Develop separate models for different uses
- Both uses share one or more variables (e.g. Fishing effort, marine reserve size, oil extraction)

Apply weights:

- Specify net benefits for both uses
- Sum & maximize total net benefits

Example: Marine protected areas multiple use

Marine protected areas affecting two uses: fisheries & species conservation

Fisheries:

- MPAs increase growth rate
- MPAs decrease catch area

Conservation:

- A larger area contains more species
- A larger area is more expensive to monitor

Punt et al. (2010)

A numerical example

Variable	Fisheries only	Conservation only	Combined
MPA size	38%	80%	40%
Fisheries profits	1.46	0	1.44
Conservation benefits	0.38	0.46	0.4
Combined welfare	1.84	0.46	1.86

Punt et al. (2010)

Net-benefits maximization

Advantages:

- Economic framework complete
- “Optimal solution”

Disadvantages:

- Valuation is hard
- Gets complex very quickly

Multiple uses: weighing via restrictions

Procedure:

- Develop separate models for different uses
- Both uses share one or more variables (e.g. Fishing effort, marine reserve size, oil extraction)

Apply weights:

- Maximize net benefits of one use under restrictions of the other
- Vary minimum level of other use
- Develop production frontier

Example: trading off aquaculture and nursery

A model of wild shrimp harvest and aquaculture in Vietnam.

Mangrove in Vietnam offers 2 potential uses:

- Conversion to aquaculture
- Conserve such that it offers nursery for wild shrimps (which can then be harvested)

Maximize nursery function profits subject to minimum level of aquaculture profits

Source: Zavalloni et al. (2014)

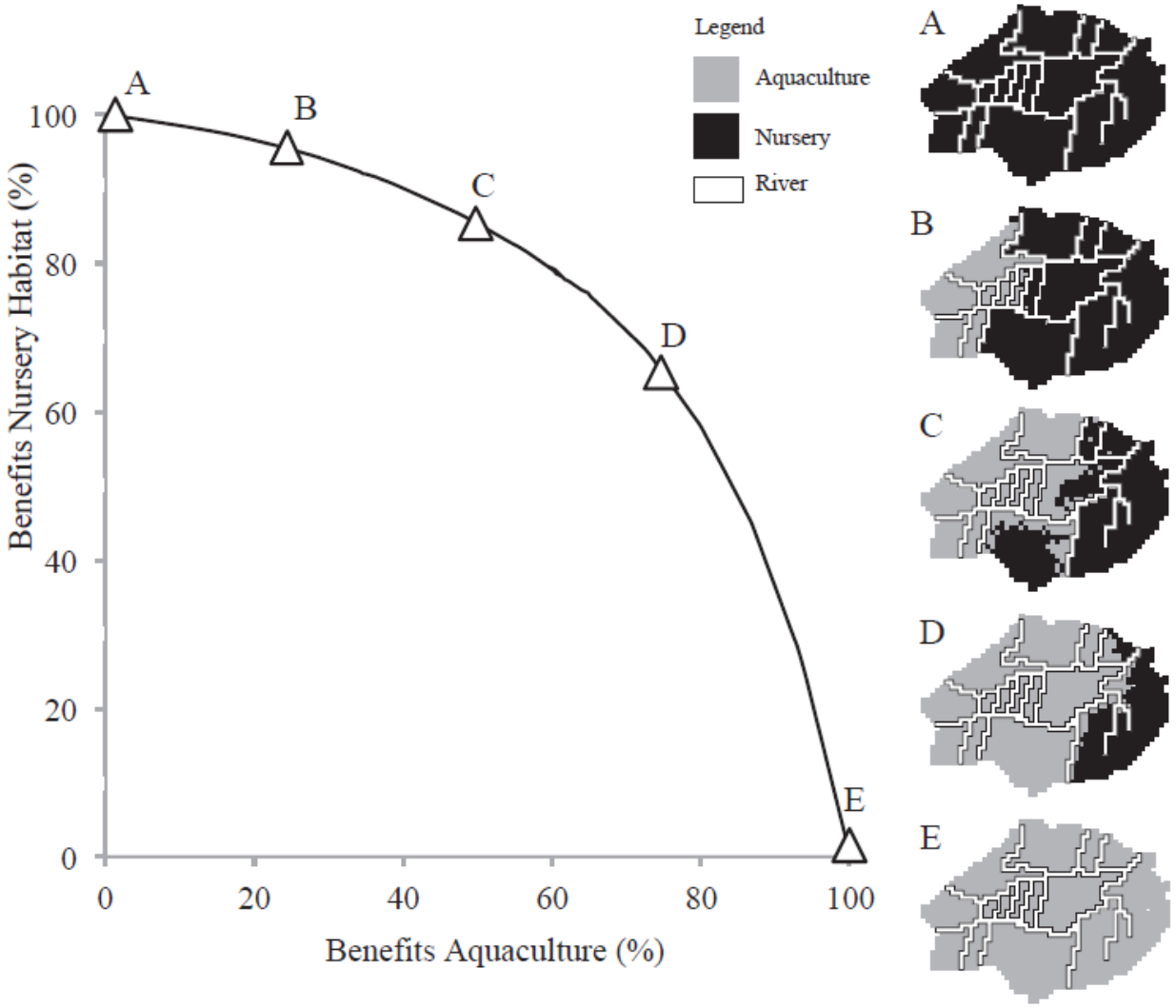
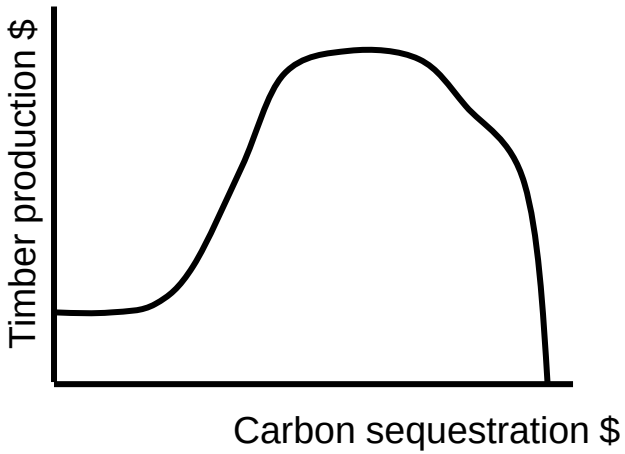


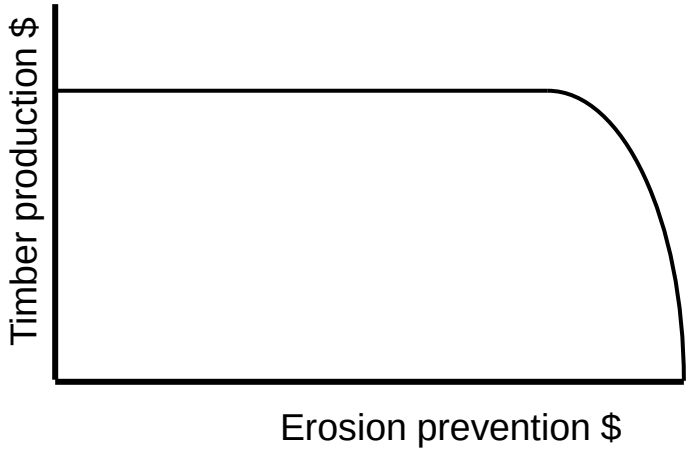
Fig. 5. Production Possibilities Frontier for the PI scenario. Maps for selected points.

Spatial Trading-off Aquaculture & Nursery habitat in Vietnam

Source: Zavalloni et al. (2014)

Production frontiers may have other shapes!





Advantages & disadvantages of weighing

Advantages:

- Uses and their trade-offs more explicitly modeled
- Possible to find optimum without previously set targets (no implicit valuation)

Disadvantages:

- Valuation of certain uses may be hard
- Number of uses to account for is often limited to a few

A multiple use model for the Arctic

Many resources in the Arctic, many interconnections

One has captured the imagination for centuries:

The Northeast Passage

The Northeast passage

- Estimated 40% shorter but not necessarily more profitable (Liu & Kronbak, 2010)
- Francois et al (2013) estimate with a trade and transport model:
  - Reduced CO_2 emissions from shorter transport offset by trade increase
  - Only small increase in overall GDP
- Lassere & Pelletier (2012):
  - Shipowners intentions: increase destination traffic (& some bulk)
  - Current infrastructure insufficient for container trade

Interlinkages between NE passage and usages

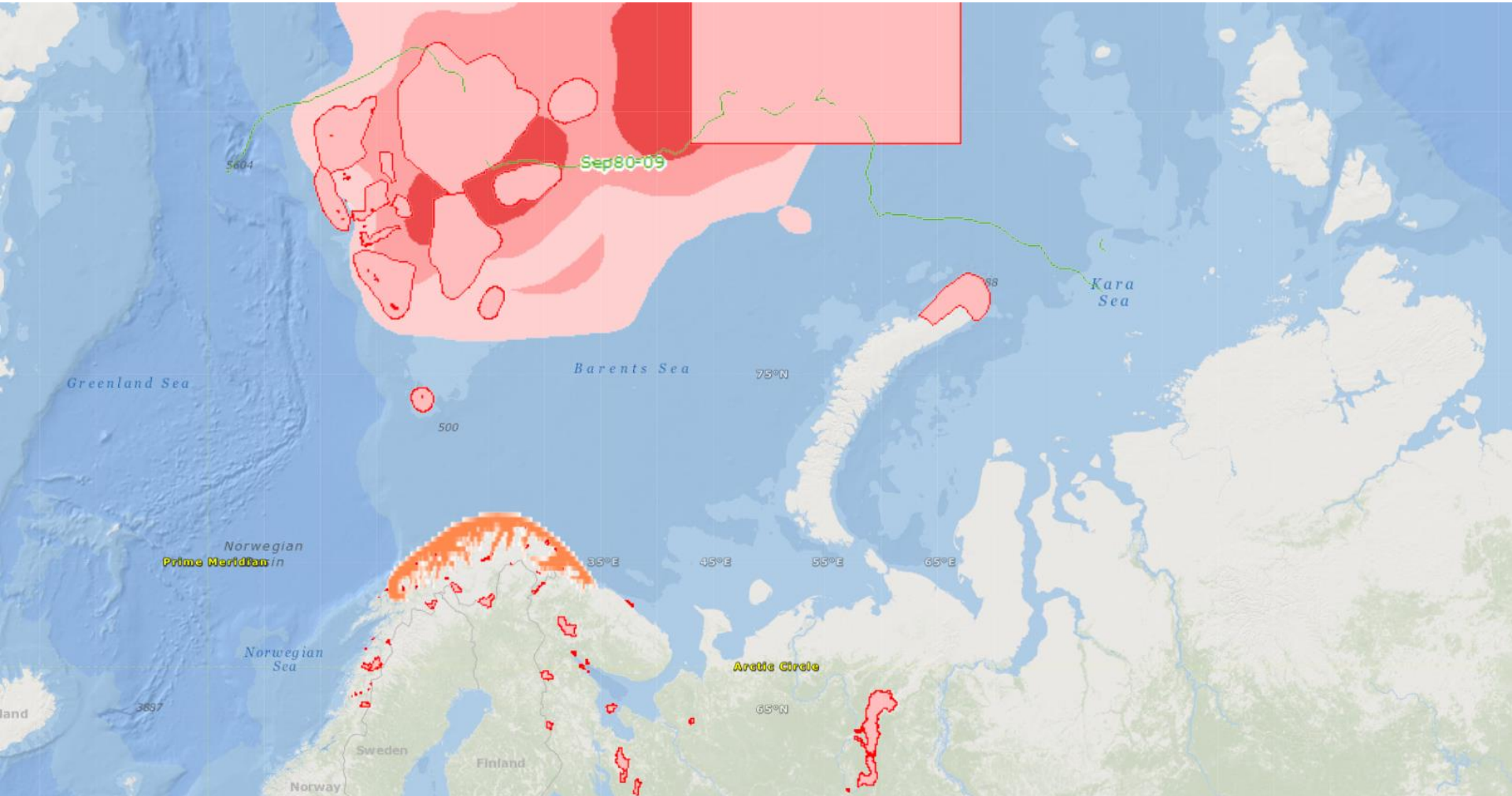
Economic:

- Shorter distances & increased traffic

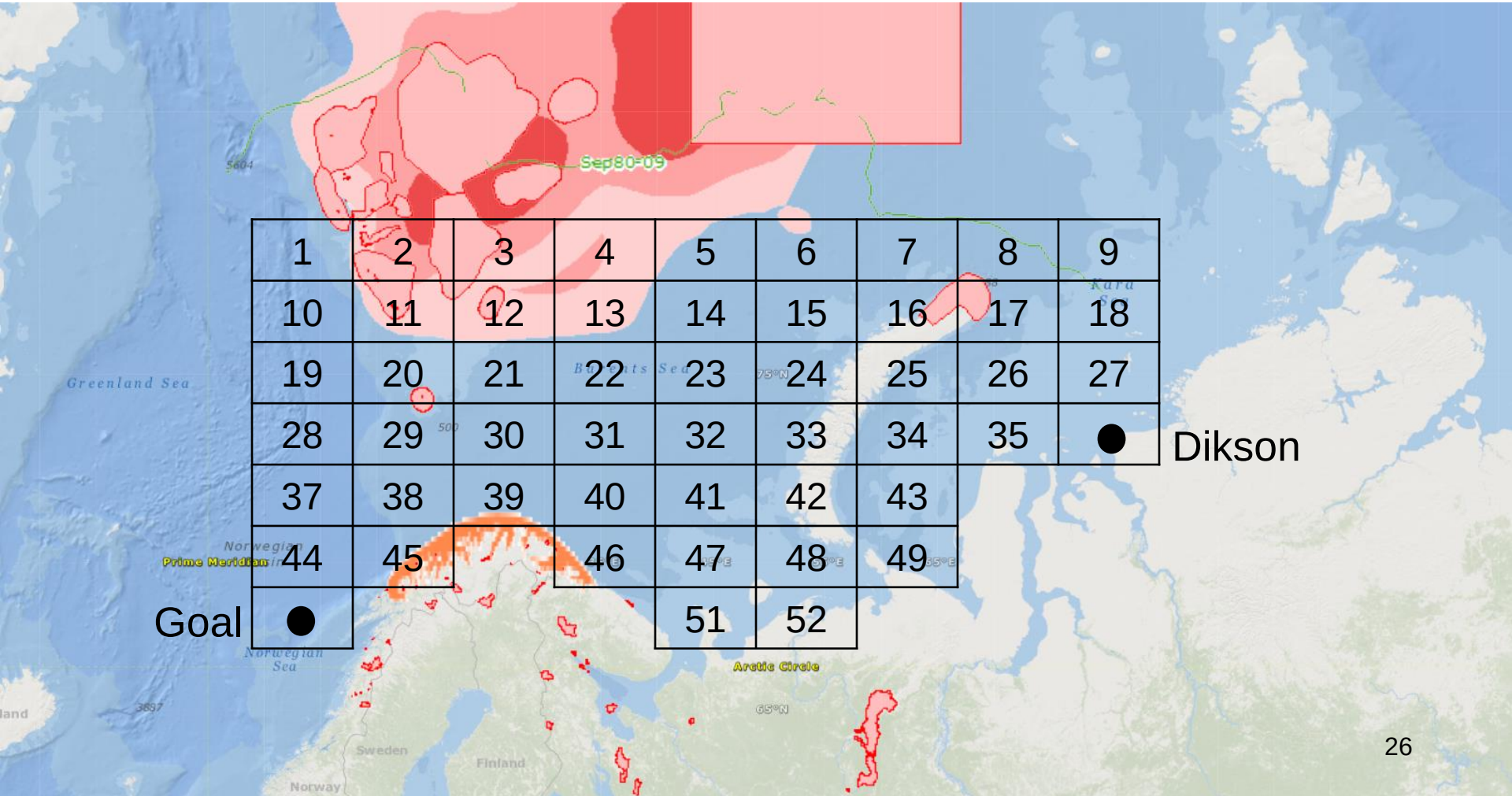
Environmental

- Risk of oil spills
- Vulnerable ecosystems
- Effects on fisheries

Maps of the Barents sea



Planning an optimal path through BS



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28	29	30	31	32	33	34	35	●
37	38	39	40	41	42	43		
44	45		46	47	48	49		
●				51	52			

Model

Minimize costs of travelling from Dikson to Goal cell, considering:

- Fuel costs
- Expected costs of oil spills
- No traphic in protected & spawning areas

Modeling oil spill costs

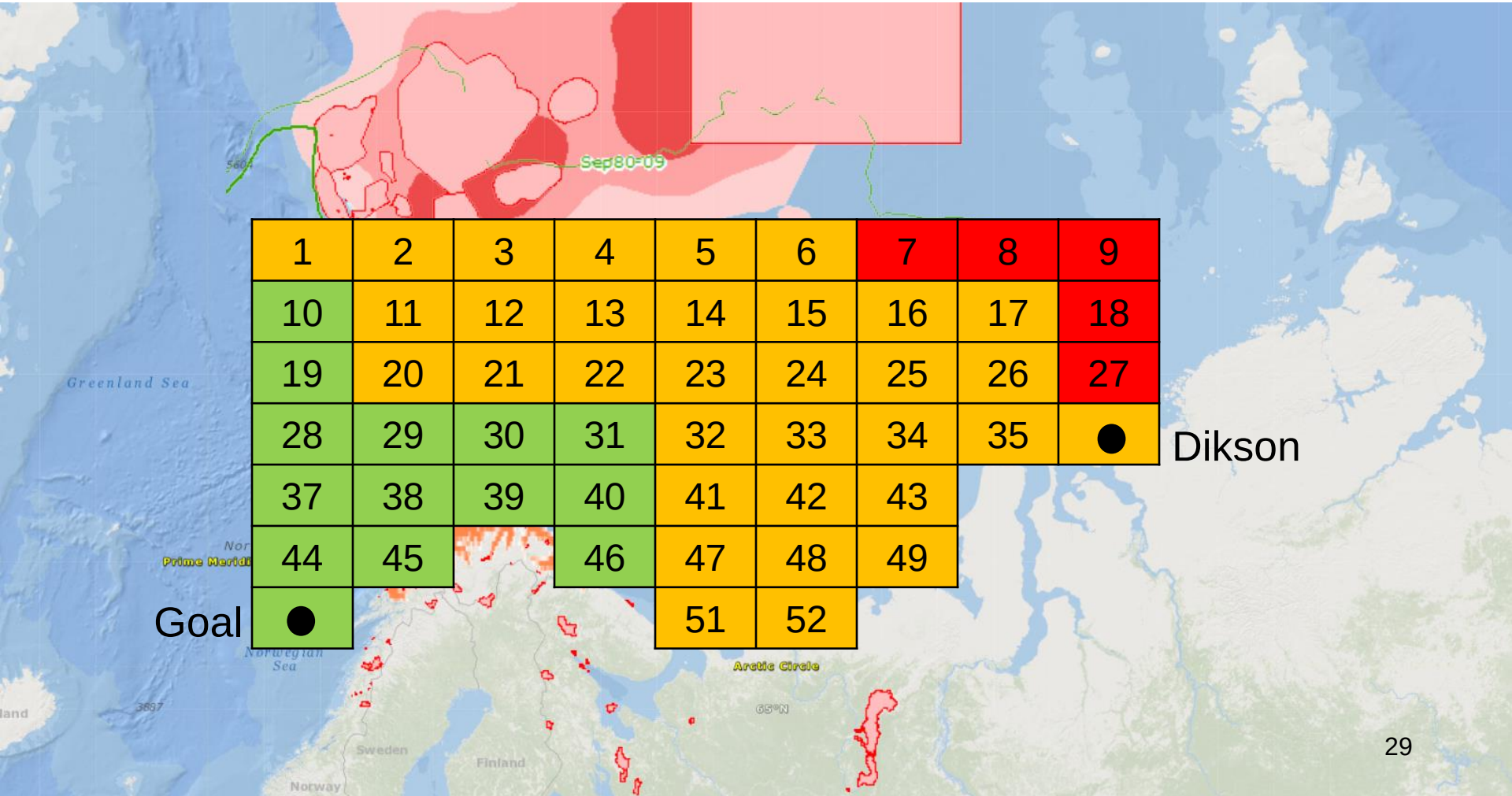
Costs of oil spills:

- High in case of fisheries spawning areas
- High in case of polar bear areas
- Medium in bordering cells of protected areas, polar bear, fish spawn
- Low otherwise

Probability of oil spills:

Spatial dependent probability. The closer to the ice border the higher.

Probability of oil spills



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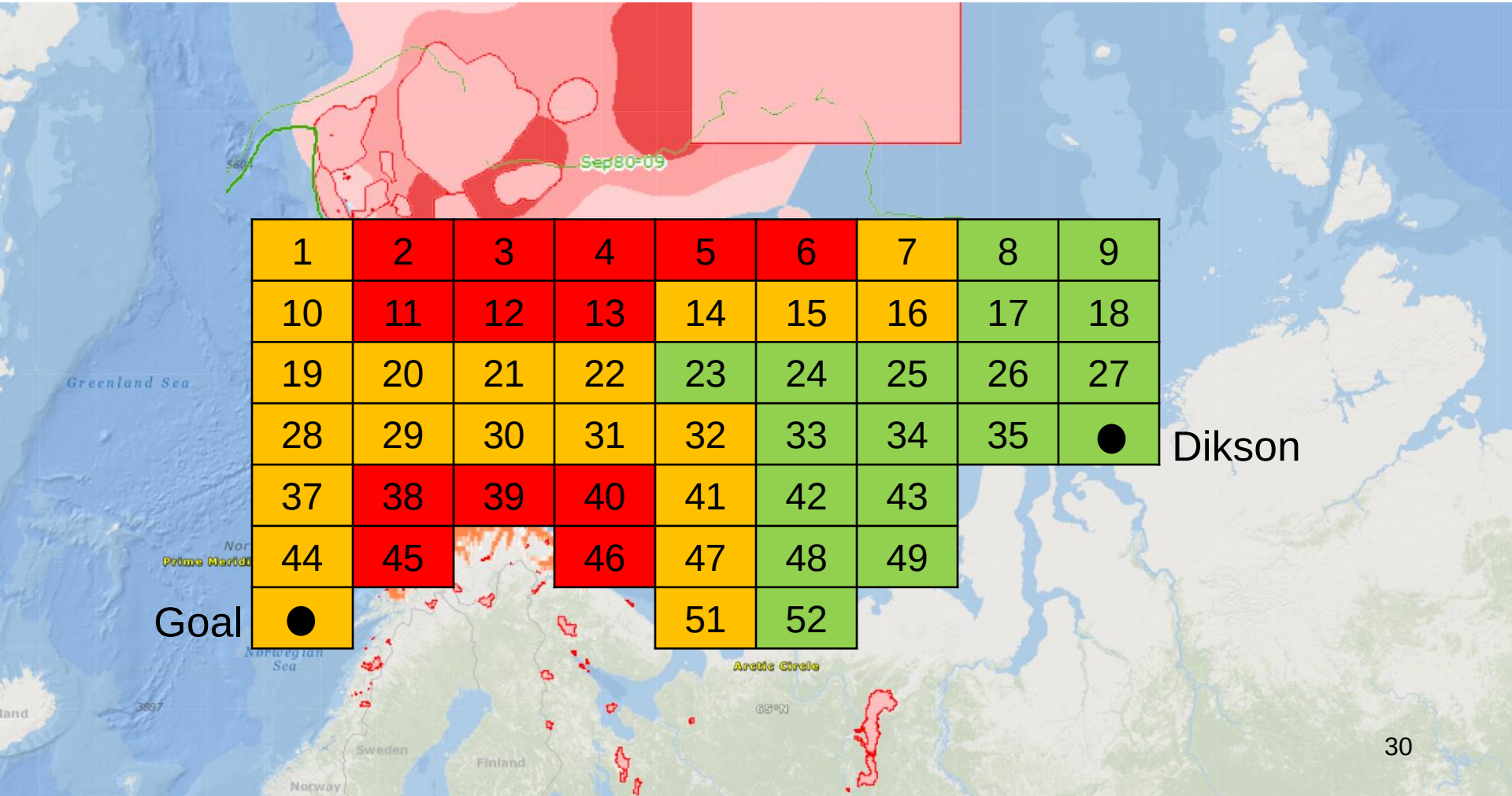
Costs of oil spills



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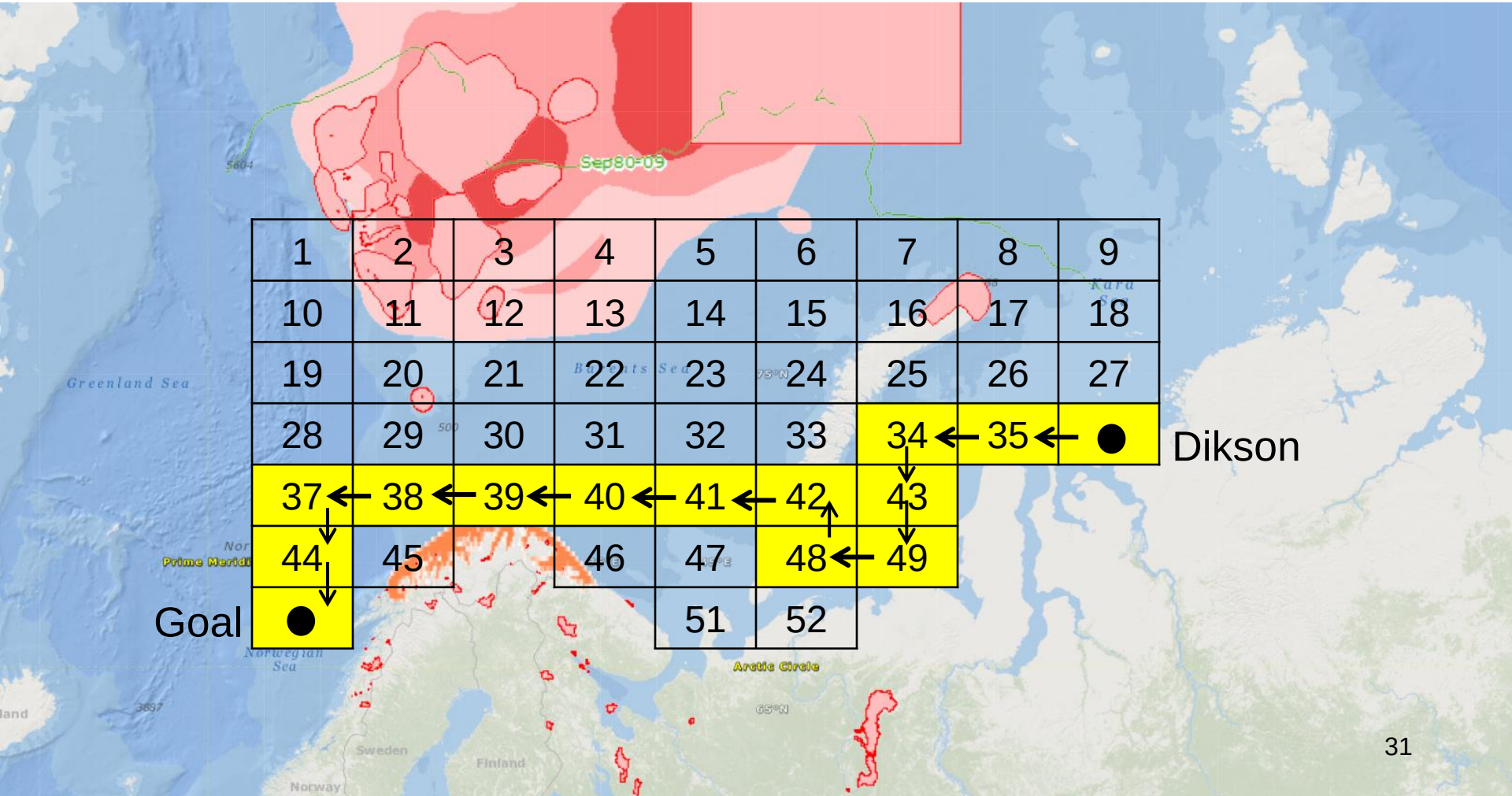
Without constraints



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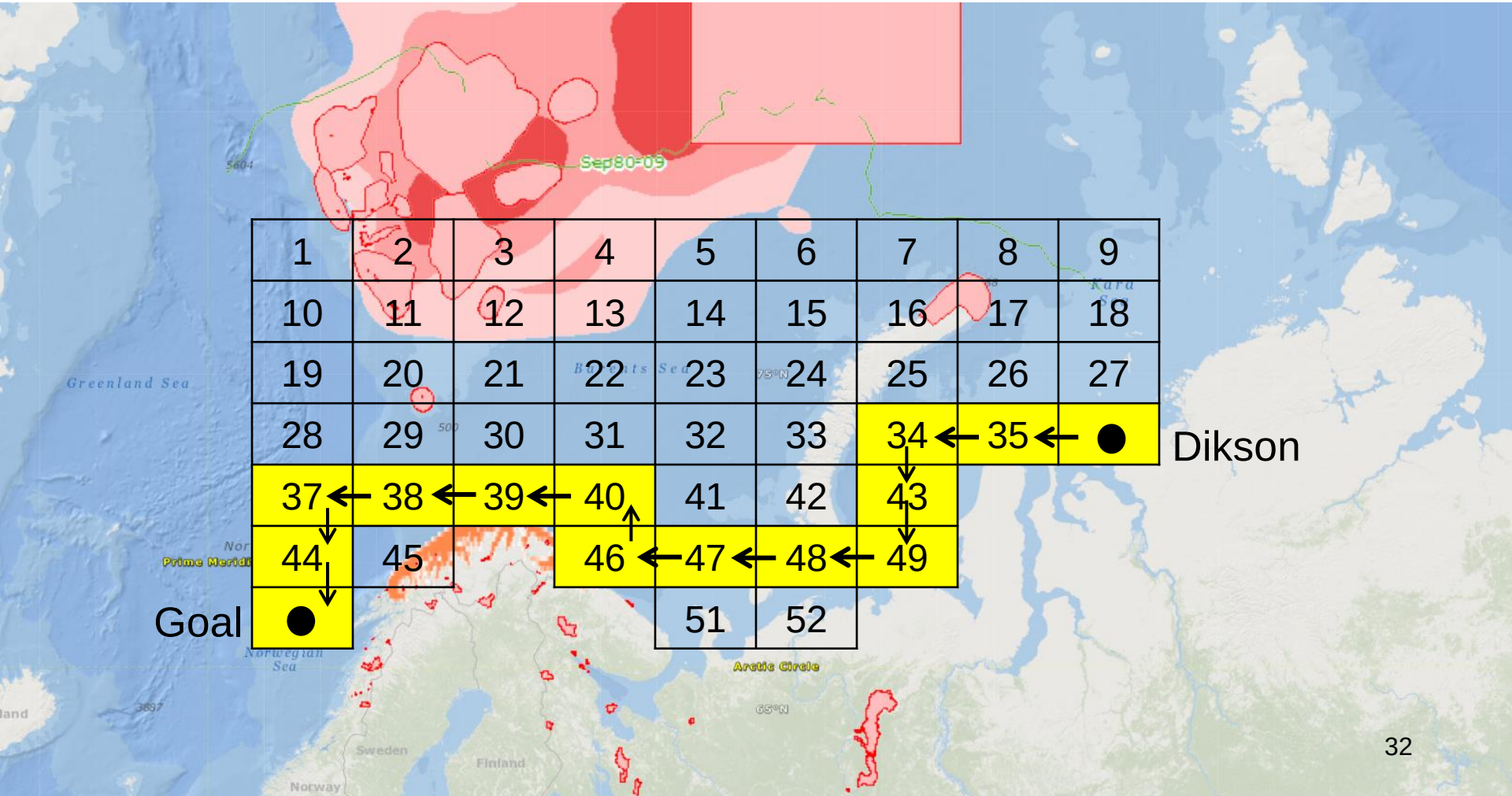
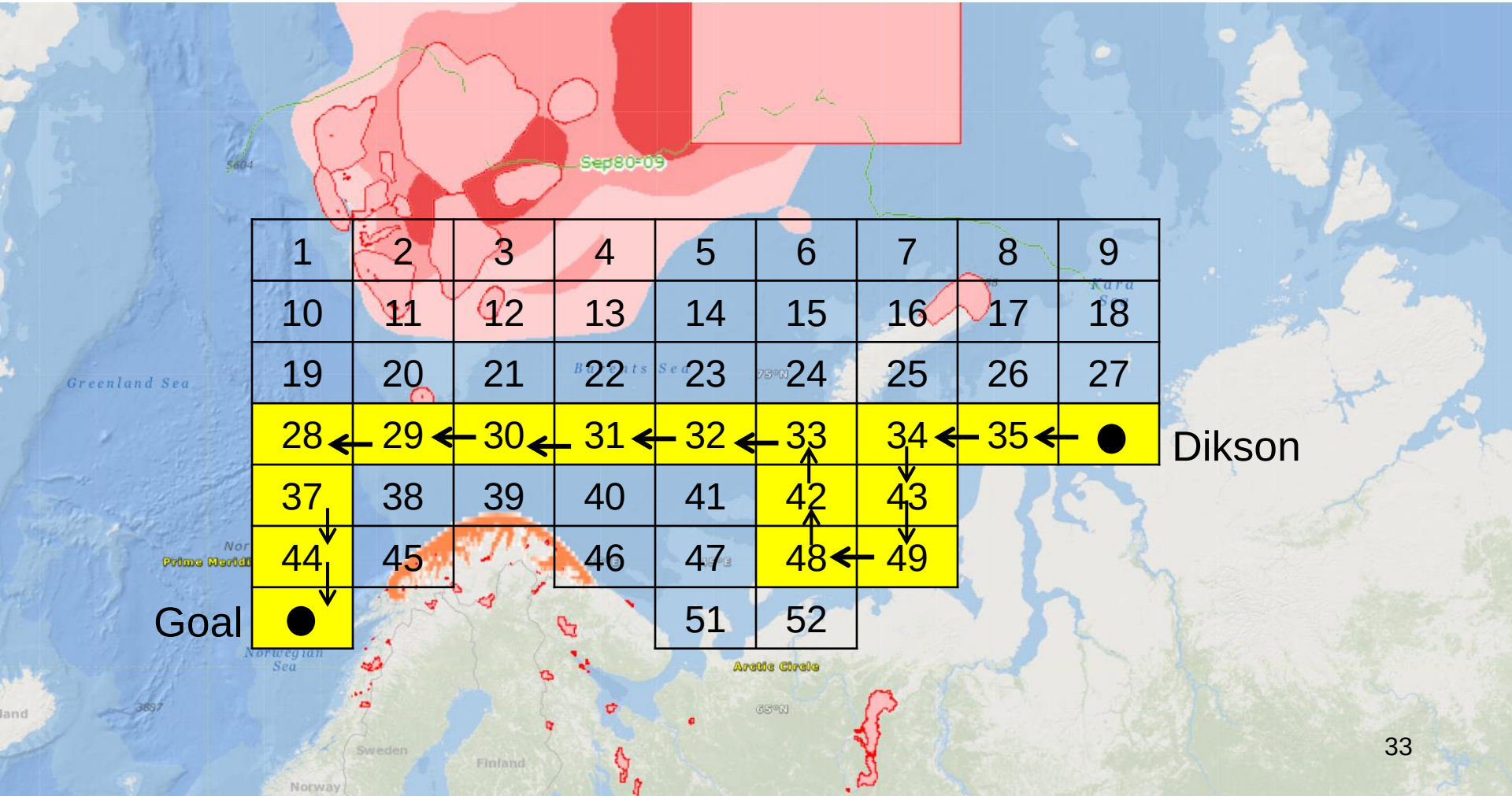
With expected oil spill costs



Blocking protected & spawning areas



Conclusions

- The artic has many valuable interlinked resources
- Accommodating linkages in economic models can be relatively simple
- Let us explore further possibilities together

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