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An overview of spatial invasive species questions for the Arctic

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Spatial Issues in Arctic Marine Resource Management
Stockholm, Sept 4-6, 2014

Photo: kidsbritannica.com

Spatial Invasives in the Arctic

- What's new, and what's just complicated?
- A few invasions identified and well underway: Red King Crab and Snow Crab.
  - These are in stages of spatial containment and harvest control for Norway and Russia (more later), and demonstrate tradeoffs between market goods and costs of invasions
- Most Arctic invasions either
  - Have not yet occurred
  - Have not yet been discovered
    - The very process of these workshops has already brought some new Icelandic species on to the radar…
- Focus on both prevention and Early Detection Rapid Response

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Spatial Management of an Invasive

- Minimize

  Management costs + ecological and economic damages

- Management costs:
  - Spatially dependent
  - Dependent on invasion stage (from pre-arrival through accommodation)

- Ecological/economic damages:
  - population and spatial dependency (how many specimens, and where they are)

- KEY: intervene when & where net benefits of intervention are highest, not just where costs are lowest (or damages highest)

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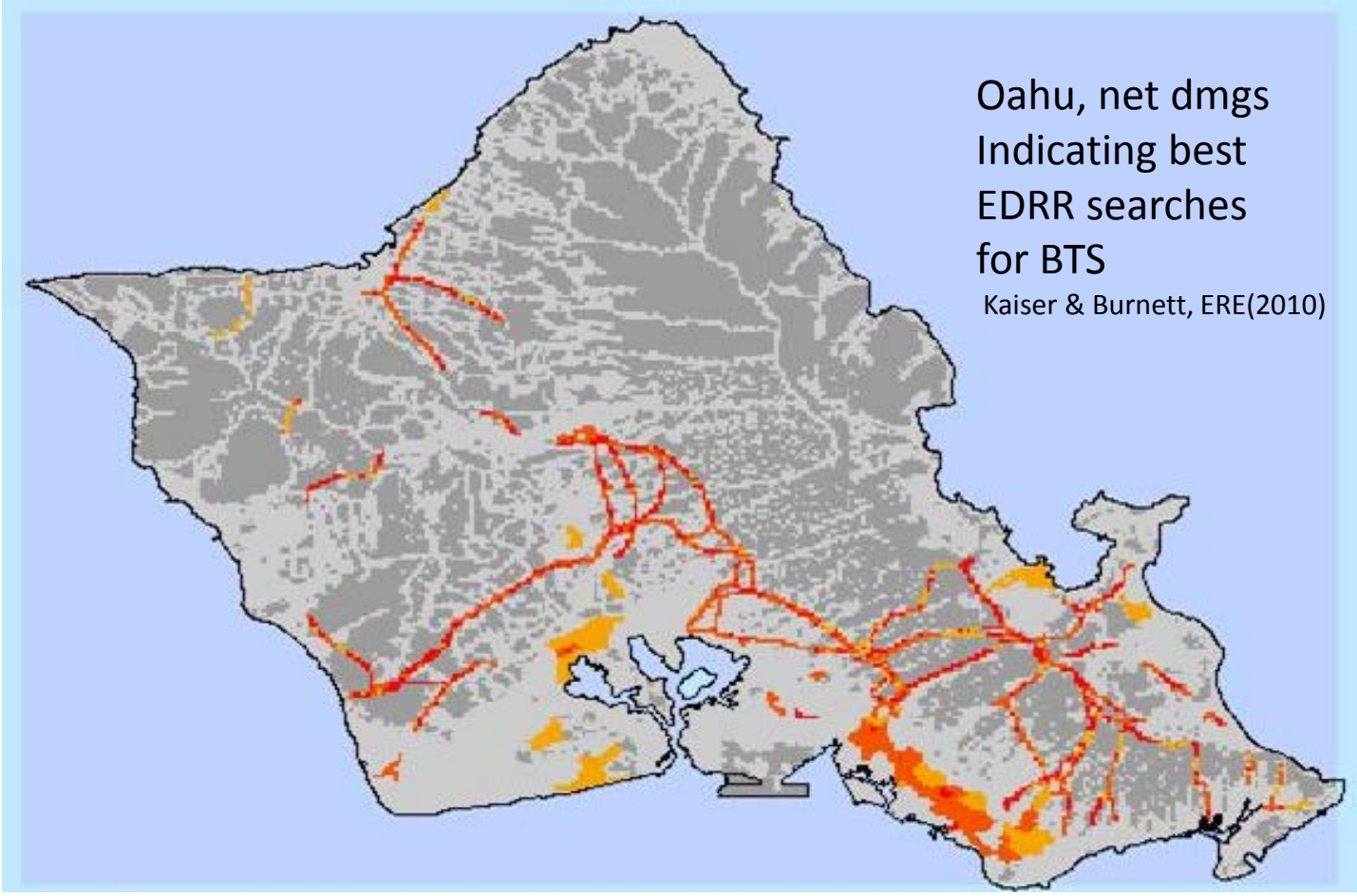
Use algorithms to solve

e.g. treat as mixed integer non-linear programming problems (MINLP), might allow for results like:

But this gets messy!

And the Arctic is vast and not well understood…



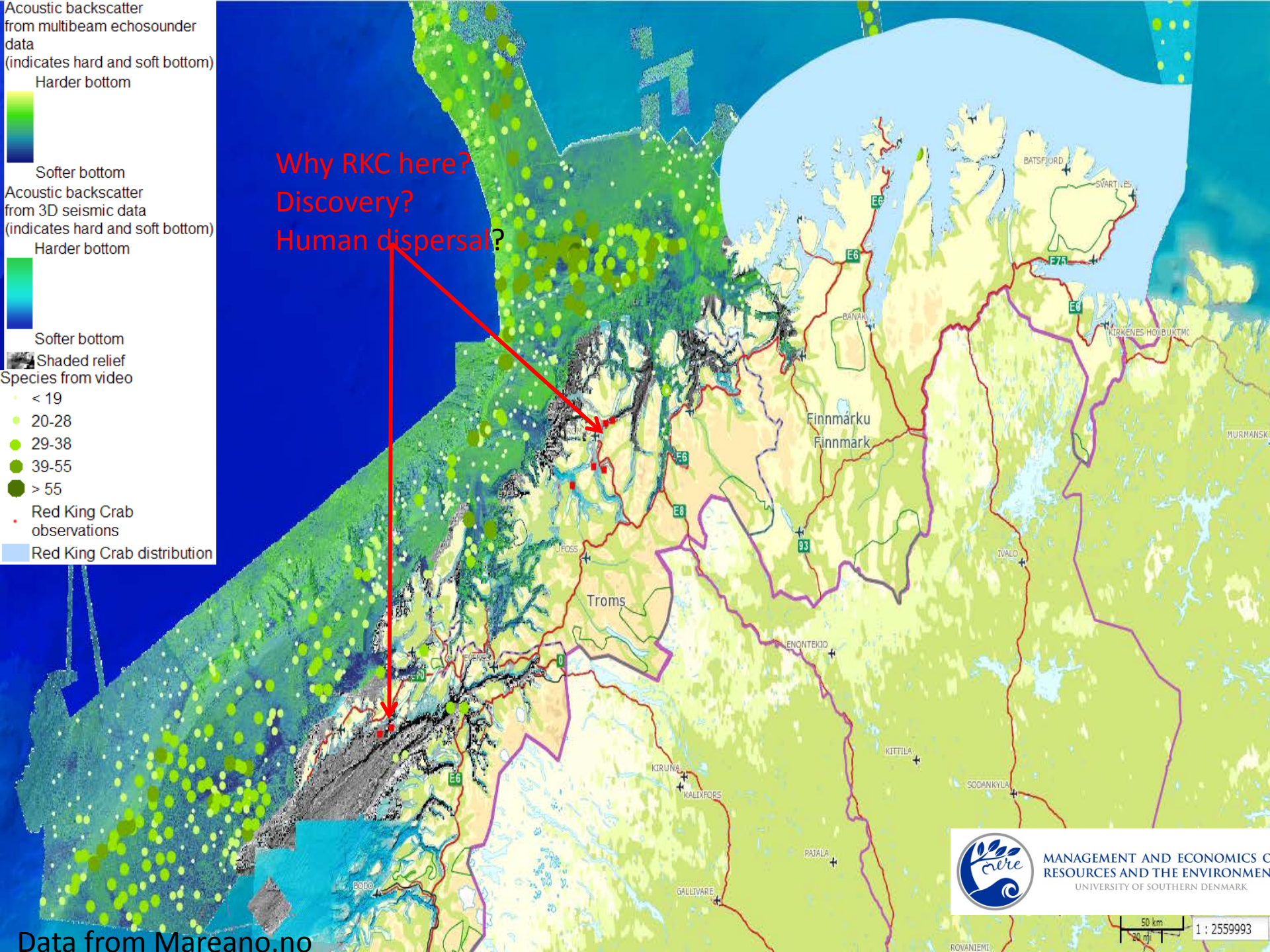
Arctic Context: RKC identified knowledge gaps

- Even for relatively well-studied RKC, still many questions pertinent to building bio-economic models and solutions
- from Falk-Petersen et al, 2011:
  - Stock-recruitment relationship for RKC, including survival of juveniles
  - Biological interactions at the larva and post-larva stages, incl. predation pressure on native plankton and benthic communities
  - Knowledge of the extent to which the RKC is predator-controlled
  - How to control RKC invasion through fishing
    - What can we learn from AK (native) fisheries crashes in the late 70s, early 80s?
  - Impact of juvenile and RKC on native communities, including their role as ecosystem engineers
  - Information on grab impact on commercial and non-commercial fish species, through egg predation or indirect interaction
    - including gear damage, damage to catch
  - Separate time-series of natural, human, and RKC impacts on the Barents Sea ecosystem
- As well as market interactions (including IUU, tourism and quality aspects)

- We will hear more about the state of the art on this later in the workshop!!

Arctic Context

- Spatial pattern of damages may not be highly correlated with human activities, which is perhaps a bit unusual.
  - Since biodiversity, climate regulation, related non-use values may be most important values preserved, repeated human activities in concentrated locations (ports, new infrastructure) may not identify the most important locations to detect invasions,
  - though likely best for preventing them.
- Information Costs of monitoring and action expected to be extremely high everywhere, must engage community resource users esp. outside of ports, new infrastructure



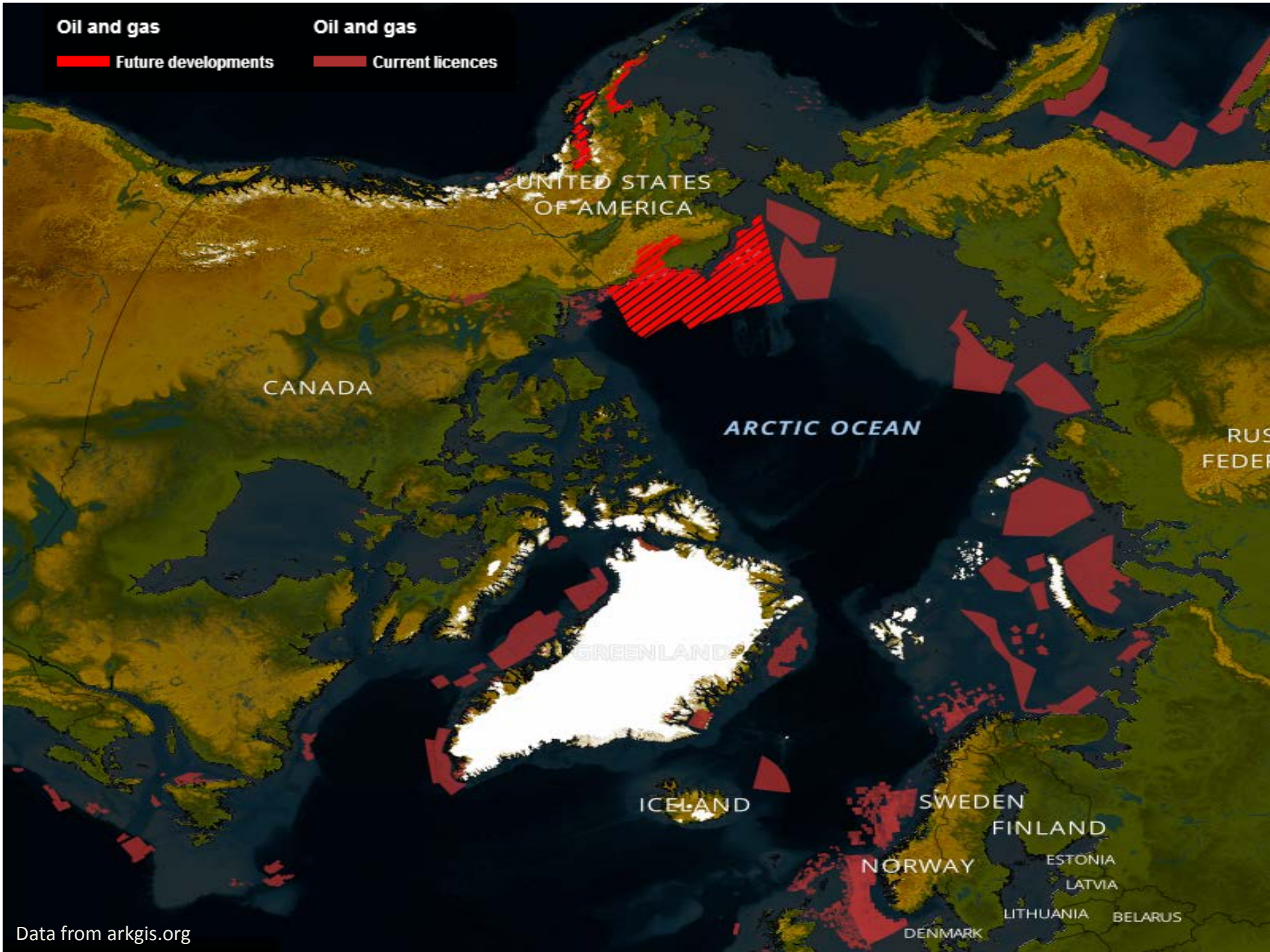
Data from Mareano.no

Human Activity Increasing in the Arctic

- 4 main areas:
  - Natural resource exploration (mostly oil and gas for marine),
  - Fisheries
  - Tourism
  - Transport
- Where does our attention need to be?

Oil and gas

- Infrastructure
- Transport to and fro infrastructure
- Pipelines (estimates suggest gas will be main asset)


Oil and gas
Future developments
Oil and gas
Current licences
UNITED STATES OF AMERICA
CANADA
ARCTIC OCEAN
GREENLAND
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
LITHUANIA
BELARUS
DENMARK
Data from arkgis.org


Beluga whale
Main Summer Distribution
Current Regular Annual Range
Narwhal
Main Summer Distribution
Current Regular Annual Range
Bowhead whale
Main Summer Distribution
Current Regular Annual Range
Historical Whaling Records (outside current range)
Walrus
Summer Distribution
Winter Distribution
Breeding areas
UNITED STATES OF AMERICA
CANADA
ARCTIC OCEAN
RUSSIAN FEDERATION
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
Data from arkgis.org


Protected Areas
Terrestrial
IUCN Class I-IV
IUCN Class V-VI
Not Reported / Not Applicable
Marine
IUCN Class I-IV
IUCN Class V-VI
Not Reported / Not Applicable
UNITED STATES OF AMERICA
CANADA
ARCTIC OCEAN
RUSSIA FEDERAT
GREENLAND
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
Data from arkgis.org


Important ecological areas in the Arctic Ocean
Seabirds
Marine mammals
Fish
Core areas
Mixed areas
UNITED STATES OF AMERICA
CANADA
ARCTIC OCEAN
GREENLAND
ICELAND
SWEDEN
FINLAND
ESTONIA
Data from arkgis.org

Transport

- Most ‘news’ has been about trans-Arctic cargo shipping:

Handout/ Nordic Bulk Carriers, news.nationalpost.com

Nordic Orion.
First bulk freighter to transit
NW Passage Arctic, Sept 2013
(Vancouver to Finland)

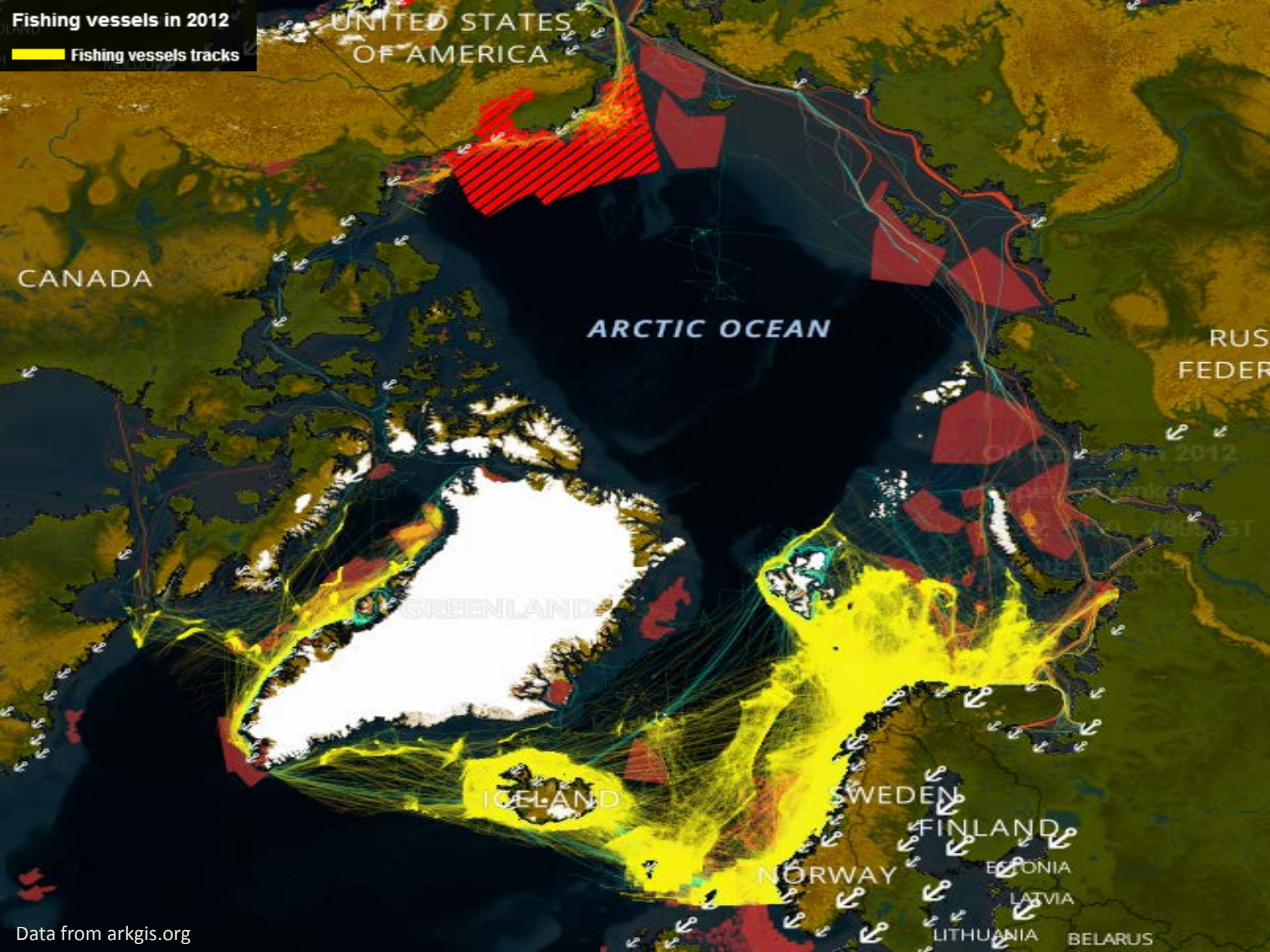
Carrying Coal.
This is the potentially more
Important issue: Feedback
Effects hastening the creation
Of favorable environmental
Windows for invasives to
Establish and flourish

But is this the most likely vector for successful introductions?


General cargo in 2012
General cargo
Bulkships in 2012
Bulkships
CANADA
ARCTIC OCEAN
GREENLAND
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
LITHUANIA
Data from arkgis.org


Gas tankers in 2012
Gas tankers
Oil tankers in 2012
Oil tankers
Offshore supply vessels in 2012
Offshore supply vessels
Other offshore supply vessels in
Other offshore supply vessels
CANADA
ARCTIC OCEAN
RUS
FEDER
GREENLAND
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
LITHUANIA
BELARUS
Data from arkgis.org

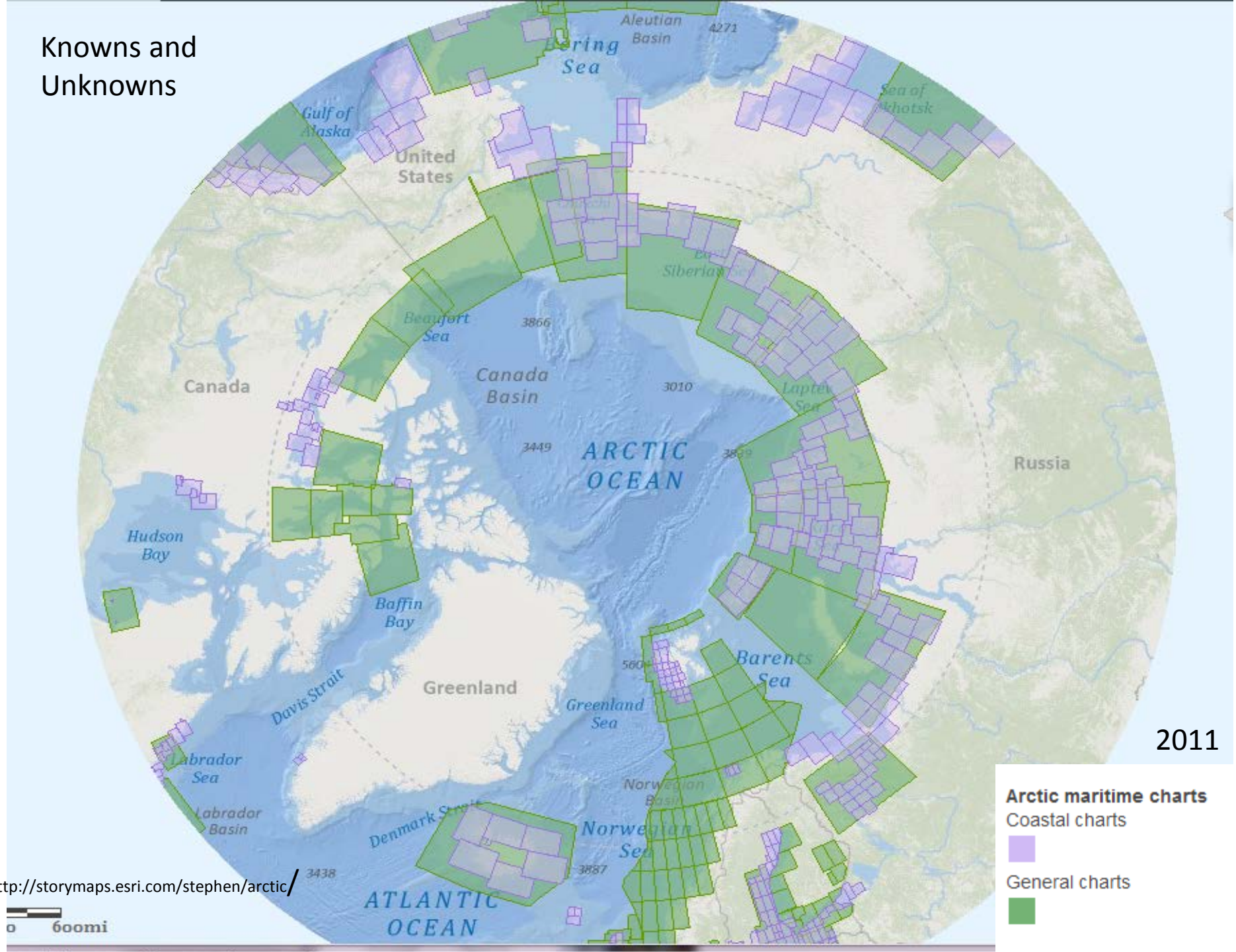

Gas tankers in 2012
Gas tankers
Oil tankers in 2012
Oil tankers
Offshore supply vessels in 2012
Offshore supply vessels
Other offshore supply vessels in
Other offshore supply vessels
Passenger ships in 2012
Passenger ships
CANADA
ARCTIC OCEAN
RUS
FEDER
GREENLAND
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
LITHUANIA
BELARUS
Data from arkgis.org


Fishing vessels in 2012
Fishing vessels tracks
UNITED STATES OF AMERICA
CANADA
ARCTIC OCEAN
RUS
FEDER
GREENLAND
ICELAND
SWEDEN
FINLAND
NORWAY
ESTONIA
LATVIA
LITHUANIA
BELARUS
Data from arkgis.org

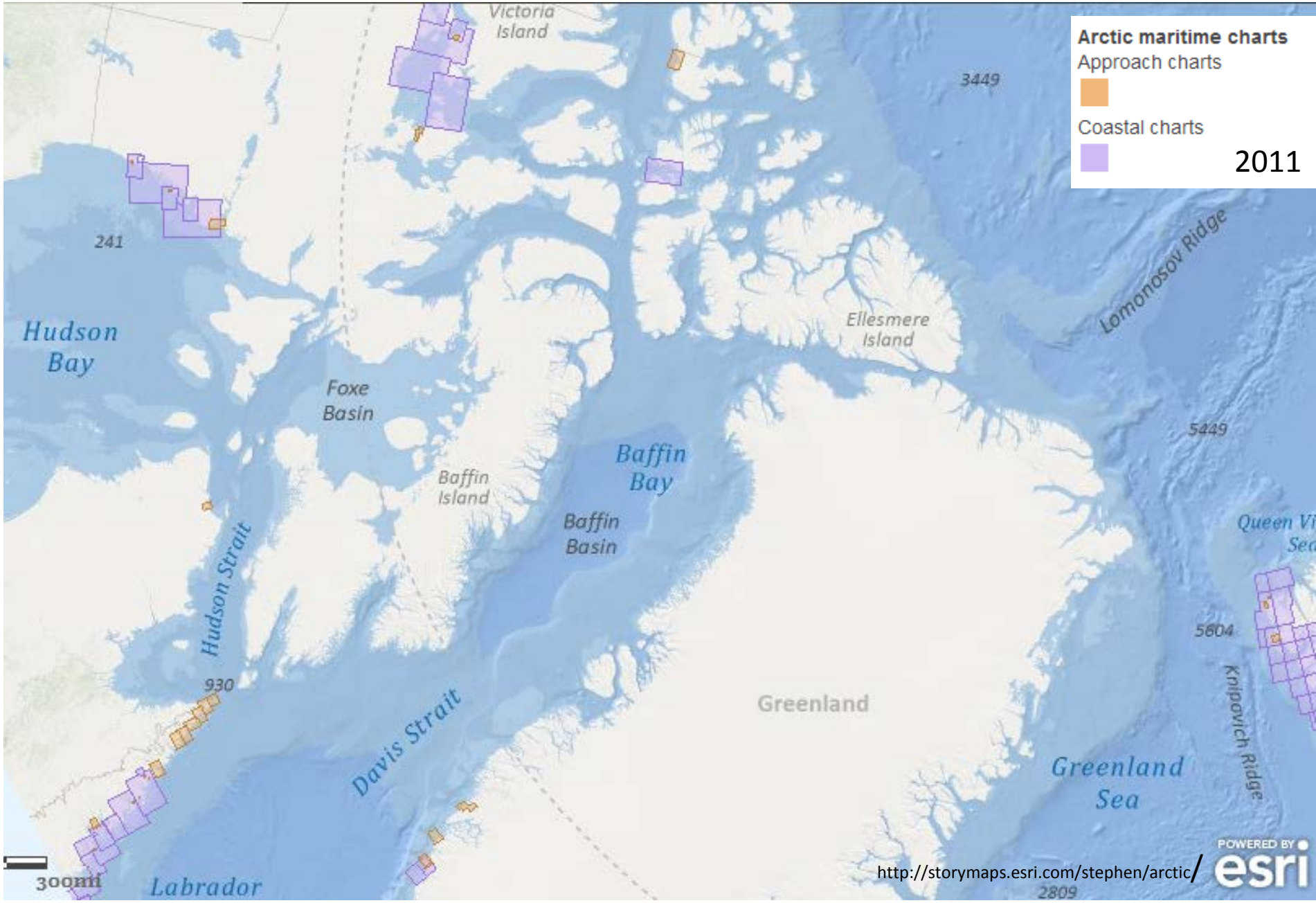
Working with Unknowns

- Uncertainty cannot be an afterthought
- One can combine numerical solution algorithms with tools like MC simulations to try to deal with these unknowns (through, e.g. draws from probability distributions), but the extent of what's unknown in the Arctic is extraordinary

Knowns and Unknowns



http://storymaps.esri.com/stephen/arctic/



Accounts for some human usage, but are these right locations for prevention, search? It depends. Subsistence communities, marine mammal habitat, etc. may have localized high net bens or costs

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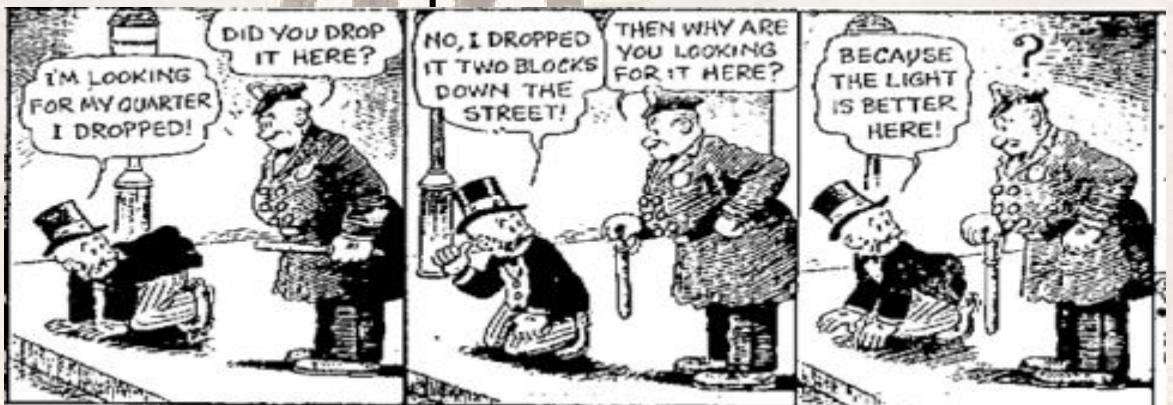
Early detection and Rapid Response in the Arctic will be paramount

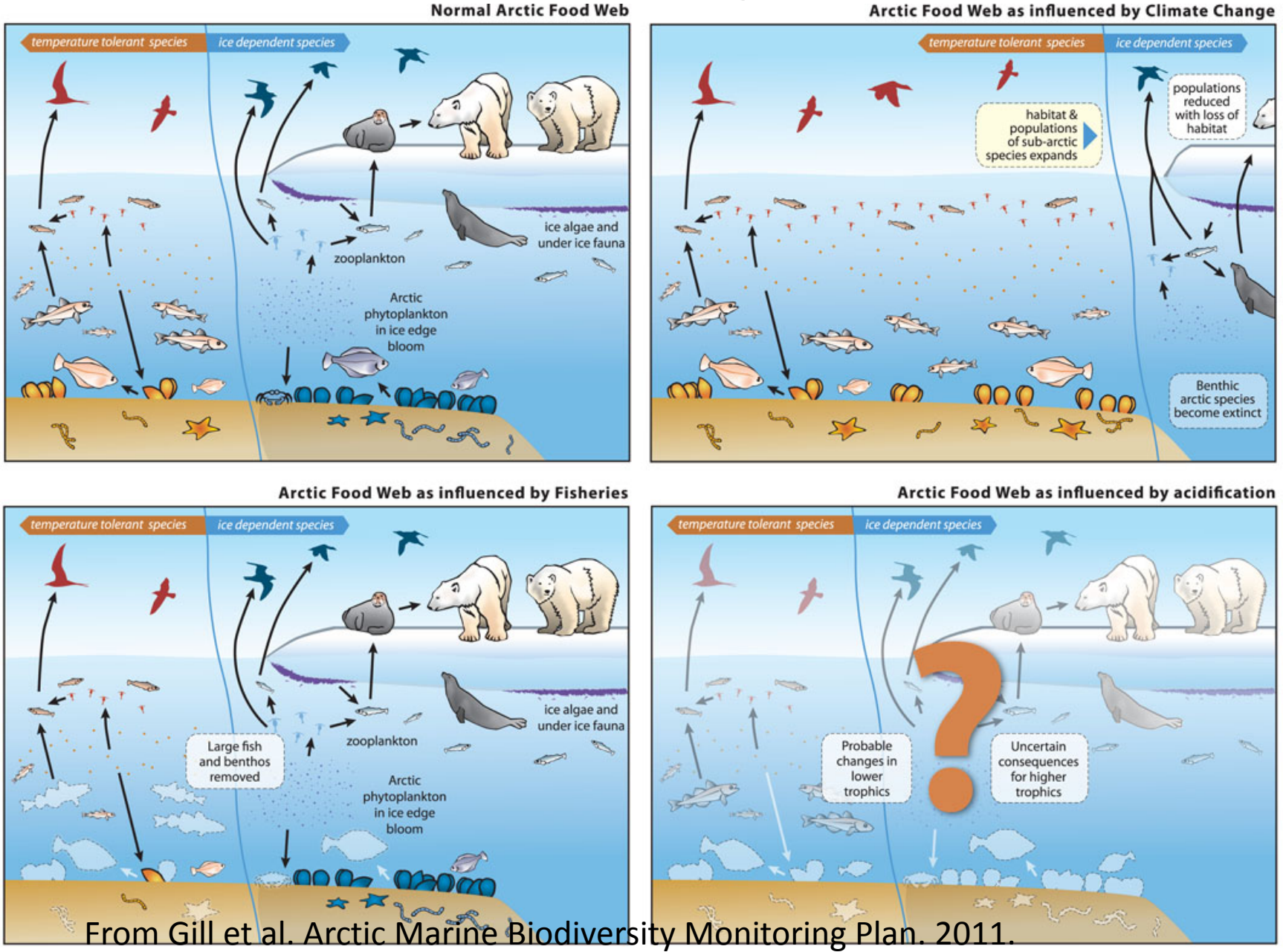
- Economies of scope
  - Monitoring, mapping, ecological knowledge
- Between prevention and control:
  - Pre-clearance
  - Quarantine
  - EDRR
  - Monitoring
  - Enforcement of preventative regulations
  - Others…including
    - Biases of research, based on differences in values, expected costs of the problem

Arctic Introductions

- Arctic is a lot like an island ecosystem
  - Isolated development; unique biota
  - resource limitations might drive purposeful introductions
  - Ecosystem still in place.
    - For conservation, this is different. This is not restoration work.
  - More complicated human responses due to private benefits, including purposeful spreading of species faster than unassisted spread would occur



Valuation: What's this worth, to whom?
In particular: How do (transitioning) cultural values matter?



From Gill et al. Arctic Marine Biodiversity Monitoring Plan. 2011.

Some Arctic Concerns/Conclusions

- Often unable to predict where to target prevention resources due to biological complexities that lead species to behave differently in new environments, so fail to target worst threats
- Shipping industry, tourism protective of low costs. 'Work with the man,' if possible. Technology forcing regulations?
- Do we have the right vectors?
  - Shipping: Ballast water and hull fouling. Climate matching?
  - Recreation: Income-driven; exotic experience driven. Slower moving. Bigger problem than we currently think?
  - Aquaculture: ecosystem transport, exotic experience, benefits expected to some
  - Wealthier communities in Arctic in general. Attraction of populations from different ecosystems, and their 'home environment'
- Coordination for purposeful introductions? (Will anyone add some more species as warming makes it likely they might take?!)

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Some Conclusions

- The Arctic is similar to other invasive problems, so remember:
- Prevention will fail: Expect the unexpected
  - Management decisions should not be taken in isolation of their substitutes
    - E.g. to decide about prevention, understand damages and control costs.
  - Identification of correct vectors – intentionality very much still an issue, and property rights not that well defined across communities, so sorting out governance is essential
  - Policy has to really begin to incorporate risks and uncertainties directly
- Working to preserve existing values (in undisturbed areas) will need different policies from problems in already deteriorating areas (Snow Crab vs. RKC?)
  - E.g. Direct investment in resilience
  - More explicit spatial containment
  - More Information of all ecological and economic processes
- Values differ. Without markets, governance will direct and determine outcomes for value preserved or lost. Stakeholder buy-in and awareness must be continuous and comprehensive. <u>Community monitoring may have multiple useful policy dimensions.</u>