An overview of spatial invasive species questions for the Arctic

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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
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)
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...

Oahu, net dmg
Indicating best EDRR searches for BTS
Kaiser & Burnett, ERE(2010)
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
Why RKC here?
Discovery?
Human dispersal?
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)
Important ecological areas in the Arctic Ocean

- Seabirds
- Marine mammals
- Fish
- Core areas
- Mixed areas

Data from arkgis.org
Transport

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

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?
Passenger ships in 2012

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.
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?

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?!)

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. Community monitoring may have multiple useful policy dimensions.