What do we need to understand for development of sound policy for a changing Arctic Ocean

Jake Rice
Chief Scientist – DFO
Structure of talk

• What you will get
  – What policy makers strive to address & consider
  – How science supports policy efforts
  – What the “how” implies about Arctic science that is needed most

• What you will NOT get
  – Commercials for the type of research that I like
  – Rationales for moving the typical science we have been doing elsewhere into the Arctic
Short Answer about what we need to understand – A LOT!

• More serious answer – four key components of the title:
  – Need to Understand
  – Develop sound policy
  – Changing
  – Arctic Ocean

• Important to keep all four of those in sight

• HARD to keep them in balance, at least, because few of us straddle all four equally
Decomposition of the Science – Policy Challenge

• What is inescapable about each piece
  – What do Policy & Science HAVE to start with?

• What is implied for Policy by these inescapable features of context and ecosystems?
  – How do they interact as synergies or constraints?
  – Where are the barriers they present?
  – Where are the opportunities for progress?

• How might all this shape a Science agenda in a changing Arctic?
What’s INESCAPABLE about the Arctic?

• It’s an high stress climate / environment
• We are generally data poor (in the science world context)
• The ecosystems may have fewer species and linkages, at least in many ecological functions
  – Fewer parts may not make it simpler!
• It has always had high variance – seasonality, tides, spatial patchiness, etc
• We’re already there, we have been for centuries, and our presence will continue to increase.
• Although remote, it is very connected to some global stressors (pollution transport, etc)
What’s INESCAPABLE about Change and Understanding?

• Changing?
  – It’s happening; documented in many properties – ecological, economic, and social
    • So any new “baseline” is not just poorly quantified and already impacted, but is undergoing change NOW.
  – Many of the environmental causes not currently under management control; economic ones have global drivers

• Understanding?
  – Can be reached at many levels
  – Does not (and does not NEED to) progress equally on all fronts. (there can be rate-limiting knowledge)
  – Investment needed to move understanding up levels does not scale linearly
What’s INESCAPABLE about POLICY?

• It is NOT all about conservation and protection
  – Sustainable use is with us, like it or not
• It is not based solely on the natural sciences
• Hard and soft law matter (competencies)
• Legitimacy and relevance matter as much as credibility
• Policy and management will be sectoral
• Policy has inertia:
  – Hard to get going, hard to change direction, hard to stop with the time is right

Many key decisions will have been made by ~ 2020
Is there is clear policy direction? Arctic Council is place to start.

Each Council Chairmanship brings its own priorities. Swedish Chairmanship - priority to issues that will:

- “promote environmentally sustainable development of the Arctic,
- Maintain positive cooperation between the Arctic states and with the indigenous peoples of the region
- Activities and cooperation in the Arctic ... based on the rules of international law ...”

Specifics included oil emissions, climate change, resilience, biodiversity, environmental protection.
Priorities for Canada’s Chairmanship

“Development for the People of the North.”

- Responsible Arctic Resource Development
  - Circumpolar business network
  - Oil spill preparedness instrument
  - Mapping environmentally sensitive areas

- Safe Arctic Shipping;
  - Guidelines for tourism and cruise ship operations
  - International Polar Code under IMO

- Sustainable Circumpolar Communities.
  - Supporting traditional lifestyles and knowledge
  - Short-lived climate forcers
  - Best practices for climate change adaptation
Consistent themes of policy

• The Arctic WILL BE USED.
  – How to make those uses sustainable in ALL THREE DIMENSIONS
  – How to manage the industries sustainably (MCS in a remote part of the world)

• Indigenous peoples are a central theme
  – For knowledge, for protection of cultures and lifestyles, and for access & share of benefits

• Climate change is front and centre
  – Strategies for adaptation of traditional lifestyles
  – Implications for opportunities for development
How do the inescapable realities map onto these policy themes

• We don’t have data-based quantitative baselines of unperturbed states and won’t be given time to acquire them.
• We don’t have evidence-based management benchmarks (Limits, PA buffers etc), but if we want rule-based management systems, we will have to provide them in the near future.
• Equilibrium-based concepts (e.g. MSY) even less helpful here than for science inputs to policy elsewhere. (Shock – response?)
• Resilience may be less, and tolerances to perturbations certainly less well known.
• Projections needed, but basis for them weaker than for systems where it has been difficult to provide reliable projections.
• Social and economic dimensions can’t be “somebody else’s business” – there will not be time to “catch up later”.
So there are some new things we have to do

- Build adaptive management frameworks with weak baselines and weaker trigger points for control rules than is typical.
- Un-confound impacts of human uses from directional changes due to climate forcing, without time series.
- Inform assessment and “impact allocation” frameworks that accommodate both livelihoods and new development, when this is often the hardest aspect of support for industrial uses.
  - CAN’T be done without socio-ecological system view.
  - DOES require best use of what we DO know.
What do we REALLY mean by “understand”?

The unhelpful science response:

We need process-based understanding of end-to-end ecosystem dynamics and full valuation of goods and services. Until we get such understanding, precaution means that human uses should frozen at current levels, and recent increases rolled back.

Science help in the real world:

We need integrate traditional and experiential knowledge better than we usually do with such “science things” as we can do moderately well, focus on greatest vulnerabilities and threats, describe the risks, and let policy manage them.

LONG BEFORE WE CAN GUIDE POLICY TOWARDS THE RIGHT ANSWERS, WE WILL BE ABLE TO GUIDE THEM AWAY FROM MANY OF THE WRONG ONES. THAT IS USEFUL!
Really use and respect traditional and experiential knowledge

For the “western” scientists (and their institutions)

- Recognize that costs for salaries / contracts and travel for those who can synthesize cultural knowledge are still much less than ships and satellites.
- Familiarize ourselves with the disciplinary standards for quality assurance in social sciences.
- Create settings where traditional knowledge can produce excellent products and then merge results with those from Western science.
- View as alternative assessments, not hole-pluggers
  – Test their hypotheses, not just our own.
How to make most effective use of what we DO know?

This is not answered by just looking at the standard science agenda for well studied systems and importing it with a few tweaks.

The “inescapable realities” imply there are some things we CAN NOT be doing “moderately well” in the near future, and a lot of key policy development will be done in the near future.
No point wanting the “end to end” explanation for everything

• Remember lessons from 1st year physics about significant figures
  – Results only as accurate as most uncertain inputs

• One can reject many more false hypotheses with very good data on a few key properties than with “some” data and expert knowledge for a lot of parts of the ecosystem.
  – Strong inference is more powerful than just “scenarios”

• Explore scenarios, but to find out what parts of the system matter to success of policies, not behaviour of the parts that are most interesting to ecologists.
Modelling these systems
We WANT the projections, so we WANT the models

• For environmental forcers of population dynamics:
  – Don’t know asymmetries of optimal envt. windows, so hard to specify functional forms of relationships
  – Don’t know if outliers always have the same cause, so high leverage points in parameterizations may be not be determined by consistent drivers in the system

• Density dependence drives responses of population and ecosystem models
  – Challenge to represent carrying capacity of systems with few time series but lots of variance in space and time.

• Promise in life history and “sentinel” species models?
Special problems with trophodynamic models

• Patchiness of system will make sampling for trophodynamic parameterization prohibitive.
  – Food is patchy in space and time. Positive feeding clustered on the rich feeding opportunities.
  – Rich feeding opportunities may be narrow subset of the full diet of a species/size combination.
  – If predators aggregate around prey lodes, risk of cluster sampling a population that is cluster sampling its food.

• Power of testing formulation & parameters
  – Goodness of fit < Predict left out subset of data < split data, parameterize twice and compare parameters
How much diet data is “enough” for modelling - North Sea MSVPA

Independent estimation of suitabilities of predator age x prey age x quarter.

Need 600 - 1,000 observations for stable estimates.

Models can run with less but results are looking at noise more than signal.

Units are 1,000s of stomachs with EACH PAIRING of predator age x prey age x quarter
Diversity – Stability – Resilience Challenges for Science & Policy

- Functional redundancy buffering helps smooth environmental noise out of system (portfolio effect).
  - But may NOT be active compensation
- If Arctic systems have species-poor functional groups, drivers of variance may have effects amplified.
- If the systems are variable, poorly buffered, and face high environmental stress, then N may spend much time $<< K$ and much time $>> K$
- Low resilience and high density independent mortality.
- Equilibrium models and mass balance assumptions are questionable foundations for science informing policy.
If we may not track dynamic system responses, can we at least isolate tipping points

• Keeping policy from going badly wrong.
• Concept gaining traction in science and policy.
• Pathways of Effects may map qualitative linkages of uses to ecosystem perturbations.
• Which perturbations matter in system that may have high variance and low resilience?
• Describe (quantify?) risk of violating tipping point, not of a particular size of perturbation.
Can we develop a science of Arctic tipping points?

• For a relevant functional relationship (from PoE and general knowledge) can we locate neighborhood of maximum 2\textsuperscript{nd} derivative?
  – Do these have special properties in relatively component-poor systems?
  – Do these change with changing climate?

• Can risks be managed to stay away from them?
  – WHERE ARE THE TIPPING POINTS IN INDUSTRY SECTOR ECONOMICS AND SOCIAL LIVELIHOODS
  – Policies must avoid all three not just ecological ones!
Gives us insight into useful integrated assessments to support policy

- Emphasis is NOT on physics to fish integration.
- DO have to integrate sectoral pressures AND climate drivers on key components.
- Emphasis not on trade-offs or optimization of valuation of goods & services and industries.
- SHOULD seek plateaus where system is far from tipping points on all three sustainability dimensions.
  - Social, economic and ecological properties of system and uses have EQUAL status in useful integrated assessments.
  - INFORM choosing wise objectives, not guided by them.
The Social Dimension: Policy priority for Sweden & Canada

• Livelihoods must be priority in risk and integrated assessments, and hence in science.

• Traditional practices accommodated high stress, high variance of these systems.

• Climate alone will require changes. HOW?
  – Industries will add to (amplify?) pressure to adapt.

• Lessons to learn from small-scale fisheries
  – Climate (Sendai): flexibility is key to success
  – New sectors (Spatial): Governance is key. Science can be tool in hands of rich industries and rich ENGOs.
In the end ability to detect and adapt will be key

• What information nodes are reliable? (Science)
• What do they tell us? (Science)
• Have choices to respond. (Management)
  – Can only learn by doing, but must learn, not just do.
  – Need for regulatory flexibility without increasing risks of violating tipping points
• As we learn, exclude the bad outcomes (Policy)
  – “Enabling sustainable development” may promote particular vision for an industry sector, but for ecosystems and livelihoods focus on avoiding harm and not promoting a single vision of “good”.
Optimist or Pessimist?
Deal with the situation as it really is.

Amid the pressure of great events, a general principle gives no help - Georg Wilhelm Fredr. Hegel

Every man takes the limits of his own field of vision for the limits of the world. Arthur Schopenhauer

Science is organized knowledge. Wisdom is organized life – Immanuel Kant