What do we need to understand for science support of sound policy?

An example using development in a changing Arctic Ocean

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How does Science inform Policy in the REAL world

Starting Assumptions based on 30+ years of experience

- Good policy will take into account ecological, economic AND social outcomes of options and choices
- Science is disciplinary, and even “integrated” projects are usually done in pieces
- Science can’t “understand” everything, and often there will be gaps in crucial places, but ability to advise can exist long before full “understanding”

The Glib Answer to the title would be that we need to understand A LOT!

- More serious answer – analyse the four key components of the title:
  - Need to Understand
  - Develop sound policy
  - Changing
  - Arctic Ocean
- Important to keep <u>all four</u> 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 deal 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?
  - Change is happening; documented in many properties – ecological, economic, and social
    - So the baseline is both poorly quantified and changing.
  - Many of the environmental causes not currently under management control; economic ones have global drivers
- Understanding?
  - 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
  - Must USE what we know and acknowledge what we don't

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** (those affected) and **relevance** (policy-makers) matter as much as **credibility**
- It has inertia:
  - Hard to get going, hard to change direction, hard to stop when the time is right

Is there is clear policy direction?

<u>Each three-year Council Chairmanship brings its own priorities.</u>

Swedish Chairmanship - 2009-2011

Canada Chairmanship = 2012-1014

Priorities are high level but products of months of planning and discussion so THE EXACT WORDS MATTER

Consistent themes of policy statements of last 3 Chairmanships

- The Arctic WILL BE USED - and sooner not later.
  - How to make those uses <u>sustainable</u> in ALL THREE DIMENSIONS
  - How to <u>manage</u> the industries sustainably (MCS in a remote part of the world)
- Indigenous peoples are a concern
  - 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 and won’t be given time to acquire them.
- We don’t have evidence-based management benchmarks (Limits, PA buffers etc), but needed for rule-based management systems
- Equilibrium-based concepts (e.g. MSY) even less helpful in the Arctic than elsewhere as policy foundations
- Resilience *may* be less, and tolerances to perturbations 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 that 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.

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 be 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!

What we can do moderately well?

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

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.

We MUST deal with traditional knowledge

- View as alternative assessments, not hole-pluggers

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.
- Low functional redundancy (discussed later)
- Trophodynamic models especially problematic

Diversity – Stability – Resilience
Modelling Challenges for Science & Policy

- 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

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 2nd 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 all Chairmanships

- 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".

And Science has a choice of roles

Jeremiah
on the
mountaintop

Guru
on the
mountaintop

Team member
or maybe
Co-conspirator