Putting the Pieces Together

Designing Expert Judgment Processes for Natural Resource Decision Making

Executive Summary

As natural resource management shifts toward ecosystem-level protections and regulations, managers increasingly rely on expert judgment processes to report on the resources and ecosystems that are the focus of these policies. Here we refer to expert judgment as a process leading to assertions based on specialized knowledge and experience. In the broader challenge of crafting a constructive role for science in decision-making, expert judgment is an important tool.

However, while there are many examples from which to draw, there is no widely-used framework for developing expert judgment processes for natural resource decision making. Processes differ greatly, from highly structured to informal and ad hoc; from qualitative to quantitative; from open and transparent to anonymous and opaque. While there may be good reasons for such diversity, distilling the lessons from wide-ranging experiences can, we believe, help to avoid mistakes, and secure positive outcomes from expert judgment processes related to natural resource management.

Through background research, a series of interviews with practitioners, and a workshop, we have compiled a variety of lessons learned and other guidance on conducting expert judgment processes. We have organized this guidance into a framework that includes recommendations for good-practice in planning and executing an expert judgment process, from the scoping of key questions to the communication of results, and everything in between.

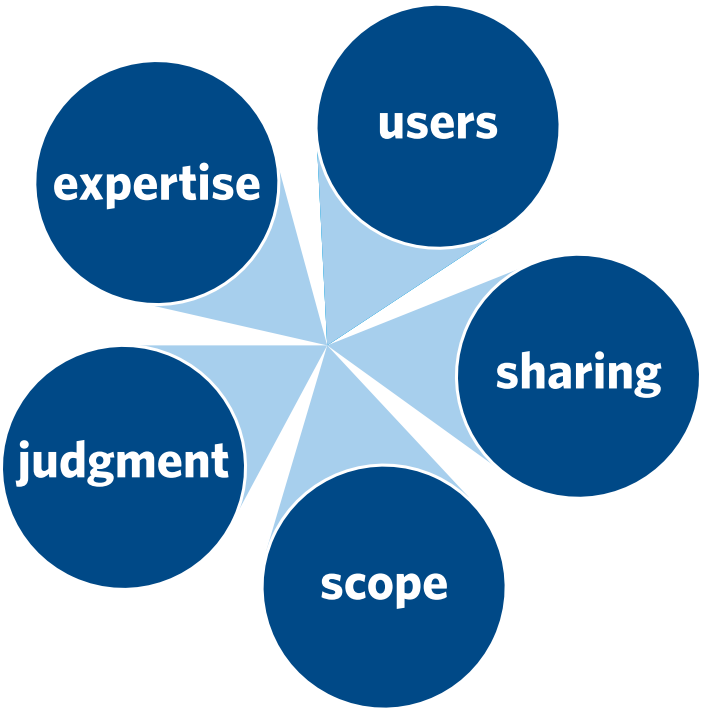


Figure 1. Five important components of an expert judgment process.

EXPERT JUDGMENT GUIDING VALUES

CREDIBILITY
LEGITIMACY
SALIENCE
TRANSPARENCY
ACCESSIBILITY
SCIENTIFIC RIGOR

USING THIS FRAMEWORK

Especially when viewed in its context of politics, institutions, and various kinds of knowledge and decision making processes, each expert judgment challenge will be unique. So the framework does not specify a single formula for success; rather, it provides an approach and guidelines for thinking through five different components of any process. We hope that practitioners will use this framework as a guide to planning a process that works well for their goals, constraints, and broader context. To that end, we have also produced an expert judgment planning worksheet that operationalizes the framework (Appendix A).

COMPONENTS OF THE EXPERT JUDGMENT FRAMEWORK

Guiding Values: When planning expert judgment processes, important values to consider include: credibility, legitimacy, salience, transparency, accessibility, and scientific rigor. The relative importance of these values will depend, among many other things, on the goals of the expert judgment process and the political context in which the results will land.

Process Components: We recommend carefully considering five different components of any expert judgment process.

Scope: What question(s) will the experts be addressing?

Sharing: How will results be presented and disseminated? What will people do with the results?

Judgment: What process will be used to extract and work with expert opinion? What will experts be asked to do?

Users: Who are the 'clients' for this information and what is their role in the process?

Expertise: Who qualifies, and who should participate? What kinds of knowledge and experience are needed?

Introduction

There is a shift underway in conservation and natural resource management from a historical focus on single species, to an emphasis on ecosystem-level protections and regulations. This is accompanied by a growing need for assessments of complex environmental systems to support evaluation of management effectiveness and to inform management decisions. For example, to assess the performance of MPAs in protecting marine ecosystems, decision-makers need scientific information on the status and trends of ecosystems as well as an assessment of the role of the MPAs in changing ecosystem condition. Similarly, implementing an environmental restoration plan requires not just data about how the system is doing, but interpretation of those data by experts with potentially divergent yet valid perspectives. In these examples and many others, assessments cannot be made solely using quantitative approaches. As a result, managers increasingly rely on expert judgments, in which a diverse group of experts is asked to consider a broad range of scientific data and results, and to use this information in their evaluation of a particular question about a resource, habitat or ecosystem.

Currently, despite some common theoretical underpinning, there is no widely-used framework for developing expert judgments for natural resource decision making. Practices vary greatly: from highly structured to informal and ad hoc; from qualitative to quantitative; from open and transparent to anonymous and opaque. The outcomes of expert judgment processes also vary. Some are held up as essential resources for science-informed decision-making, while others fade immediately into obscurity. Some are regarded as authoritative knowledge, while others stir controversy and skepticism among scientists or other stakeholder groups.

There may be good reasons for the diversity of approaches to expert judgment, but the absence of standards and guidelines remains a problem. At a minimum, guidance on the pros and cons of various approaches to expert judgment, and on ways to work toward desired outcomes, can help to reinforce utility of this important tool for integrating science with decision making. The goal of this document is to provide that guidance. In the following pages, we distill the experiences of practitioners as reported to us in interviews, as well as our own experiences implementing expert judgment, into a framework that we hope will help others avoid old mistakes and learn from past successes as they implement expert judgment processes in their own unique contexts.

There is no single "right answer" to the question of how to elicit, assemble, and share knowledge about a complex socio-ecological system. But while we cannot reduce expert judgment to a simple or universal formula, we can provide useful ways of thinking about the process, so that your own unique formula is more likely to be successful. Thus our framework breaks expert judgment processes down into basic components which are common to most of the examples we have encountered. Discussing and planning each of these components in turn can help to develop an effective process that is consistent with your project's goals and underpinning values.

ORIGINS OF THE EXPERT JUDGMENT FRAMEWORK

This framework arose from review of academic literature and reports focused on expert judgment, a series of semi-structured interviews with academics and practitioners who have been involved in expert judgment processes, and a workshop held at the National Center for Ecological Analysis and Synthesis (NCEAS) in January 2012. Throughout the document we refer to some of the examples that informed our thinking (see below).

The interviews and workshop have been useful in mapping and organizing the range of issues encountered by practitioners implementing expert judgment processes. However, we acknowledge that one or two semi-structured interviews cannot fully represent the complexity of each case considered here. Our aim is to represent these views as instructive insights, rather than comprehensive accounts. We are actively working to develop more in-depth case studies from among these and other examples. At the same time, we will be applying this framework in our own practice and refining it based on new findings.

EXAMPLES USED IN DEVELOPING THE FRAMEWORK

Program: Chesapeake Bay Program (CBP)
Product: Various
http://www.chesapeakebay.net/

Program: Great Barrier Reef Marine Park Authority (GBRMPA)
Product: Outlook Report
http://www.gbrmpa.gov.au/

Program: NOAA National Marine Sanctuaries (NMS)
Product: Sanctuary Condition Reports (multiple)
http://sanctuaries.noaa.gov/

Program: Puget Sound Partnership (PSP)
Product: State of the Sound (SOS) Reports
http://www.psp.wa.gov/

Program: Santa Monica Bay Restoration Commission (SMBRC)
Product: State of the Bay (SOTB) Reports, Vital Signs
http://www.smbrc.ca.gov/

Program: Australia Department of Environment
Product: State of the Environment Report
http://www.environment.gov.au/topics/science-and-research/state-environment-reporting/soe-2011

USING THIS DOCUMENT AS A PLANNING AND EVALUATION TOOL

We have designed this document to be actively, iteratively used in the course of designing and planning an expert judgment process. In other words, don't just read it once and put it aside. Use it to structure meetings, or a series of meetings about the process, and treat it as a worksheet to be filled in as components of your process fall into place. We encourage you to revisit the key questions to see how answers have changed, and what this means for the ultimate outcomes. You can also use this document to reflect back on an expert judgment process and extract key lessons learned for the next iteration. For all of these purposes, we provide a sample worksheet based on the framework at the end of this document.

While there is no single best recipe for expert judgment, we have learned that implementing expert judgment successfully is about more than good science; it's also about good process. Our aim with this framework is to support practitioners in making both of these elements work together, for products that meet the needs of the project. We also recognize that this is a rapidly evolving field. We will continue to hone our own practices, while learning from others as best we can. Please visit http://calost.org/expert-judgment or contact us at expertjudgment@calost.org to learn more about our programs, or relate your experiences and other feedback.

Definitions

Expert judgment, also referred to as 'best professional judgment', is used in a variety of fields, including risk assessment, decision sciences, resource management and regulatory decision-making. Before discussing the range of approaches to, and interpretations of expert judgment, we offer the following definitions of the terms "expert," and "expert judgment." These are not the only legitimate definitions but are provided here to clearly define the scope and intent of this framework.

Expert: an expert is *a person with specialized knowledge and experience*. Expertise might be based on formal training, in-depth experience, or a combination of those elements.

There are many ways to further narrow the boundaries around this term. We suggest taking this broad definition as a starting point, and then working through the questions in the "Expertise" section below to refine it appropriately.

Expert judgment: *a process leading to assertions based on specialized knowledge and experience.* Whether expressed through a formal process or not, expert judgment is inevitably used to make assessments or decisions about complex problems with technical components.

Many see expert judgment as essential in cases where empirical evidence is lacking or insufficient. On the other hand, having large amounts of data does not obviate the need for expert judgment. Questions about the interpretation of scientific evidence, the appropriate framing of scientific findings, and the use of findings in a management or other decision making process will all require expert judgment in some form.

Expert Judgment: Putting The Pieces Together

Through a workshop, interviews, background research and practical experience, we have identified five process components that are important to consider in designing expert judgment processes. In the following pages we present a series of questions that can guide thinking about each of these components. These questions, organized by these five process components, form the core elements of the framework.

It is important to point out that these process components do not appear in order of priority, nor are they meant to imply any chronological sequence. In our view, they are all important, and deserve consideration throughout the planning and implementation of an expert judgment process. For example, even if sharing the results of expert judgment comes at the end of the process, it is important to consider this challenge early on in the design and implementation to avoid missed opportunities, and help to define the scope of the judgment question.

However, it is unrealistic to expect clear, final answers to all of the questions in the early stages of expert judgment planning. Many questions may need revisiting over time as the process evolves.

GUIDING VALUES

In addition to process components, we have identified values to guide the design and implementation of expert judgment processes. The relative importance of these values will depend, among many other things, on the goals of the expert judgment process and the political context in which the results will land. For example, in a politically charged environment with controversy virtually guaranteed, legitimacy might be of much greater concern than in situations where the results are expected to inform non-contentious or obscure aspects of management or governance. We recommend consideration of these values throughout the development of an expert judgment process, and reference them periodically throughout the following discussion of our five process components that make up our framework.

In planning an expert judgment process it is worth discussing how these values are linked, or perhaps even in tension. For example, credibility might depend on a combination of factors such as the rigor of the underlying methods and transparency

PROCESS DESIGN CASE STUDY: MARINE INVASIVE SPECIES VECTORS

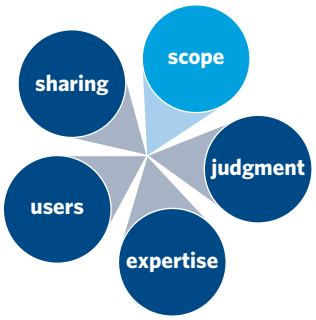
The California Ocean Protection Council contracted with the Ocean Science Trust to fund research on six vectors of marine invasive species, and then use the results to assess these vectors based on the relative risk they pose to the state. With many types of data, high uncertainty, and multiple valid framings of the issue, this task was a ripe example to employ expert judgment. OST staff used the expert judgment planning worksheet (see Appendix A) to design an expert judgment process that would take best advantage of the scientific information available, deliver useful products to the state, and ensure the scientific credibility of the products.

Addressing each of the questions posed by the expert judgment framework in a brainstorming session at the outset helped us characterize our goals more clearly and identify challenges for which we did not yet have a solution. In cases where we did not know the answer to a framework question, we could at least plan a process to address that gap in our thinking. For example, we were confident about our scope, and the question that our expert judgment process needed to answer. But we realized that we needed initial discussion among the experts before we could decide the best approach to condensing data and expert knowledge into simple representations of vector risk. We made sure to build discussions of this issue into the first expert workshop, and ended up bringing in additional expertise to aid in developing a Bayesian Network Model (under development as of this writing), which will combine quantitative and qualitative information associated with the expert judgment process.

More information: http://calost.org/science-initiatives/?page=aquatic-invasive-species

in the process. On the other hand total transparency could reduce the ability of scientists to have open discussions about disagreements, for fear of public backlash. So transparency and scientific rigor could in some cases be in tension. Similarly, salience is a combination of relevance and timeliness. For a process to be timely, it might be necessary to curtail certain aspects, such as the range of data brought to bear on the issue, which could impact other guiding values. A tight timeline might also force a narrower range of expertise, simply because the expert group needs to remain small in order to move forward efficiently.

Discussing these guiding values separately helps to avoid conflating them. For example, scientific rigor is linked with credibility, but even with highly rigorous methods, credibility can be compromised if the results are not communicated properly. Similarly, a highly transparent process (i.e. explaining carefully how the process was conducted) is not the same as making results accessible, and vice versa. In applying the framework, we recommend that practitioners avoid taking any of these principles for granted. Which are most important? Which are likely to pose particular challenges? Having these discussions early on can help to design an effective process.



SCOPE

While the scope of an expert judgment process might seem obvious at the outset, we recommend taking time to discuss the central purpose of the activity, as well as its impetus and broader context. This document makes the assumption that expert judgment processes are conducted with some sort of impetus, such as a management need, a reporting requirement, or communications goal. Both positive and negative experiences reported to us in interviews suggest that careful consideration of the goals and broad context of an expert judgment process are crucial to its design and implementation. Academic literature on expert judgment and on the use of science in decision making make similar arguments about the importance of context.

What is being judged or assessed?

An obvious first-order consideration is the actual question being posed to the group of experts. What question are they being asked to answer, and, equally important, what questions are they not being asked to answer? The charge to experts may range from the designation of a specific quantity, to a qualitative assessment such as a grade on a report card, to the specification of indicators or criteria for informing a qualitative assessment. Clarity about the specific task is crucial for keeping an expert group on track. So if the experts are judging ecosystem health, for example, it is important to consider whether they are expected to come up with an acceptable definition of ecosystem health as part of the judgment process, or instead to estimate ecosystem health using a definition determined by a management authority or other external source.

Who will see and/or use the results?

Equally important is the intended use of the results of expert judgment. Results may have multiple uses. For example, NOAA's National Marine Sanctuary Condition Reports inform the public about the sanctuaries, fulfill reporting requirements set out by Congress, and serve as a reference for sanctuary managers as they develop management plans and pursue other tasks. Each of these requirements influences the process and products associated with the Condition Reports.

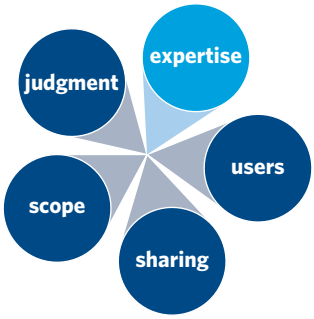
What will the results be used for?

Specificity with respect to intended use is important. It is not enough to simply state that the results will inform management. How will they do so? Will it be indirect, through education of the public? Will the products

help managers to frame research questions, or must they answer very targeted questions about specific management actions? Even if definitive answers to these questions are not available, consideration of the range of potential uses may help to ensure that the expert judgment process is constructive and useful.

What is the broader context of the process?

Beyond the direct use and impact of results, one should also consider the broader context: the longevity and maturity of the system to be supported, and the other information streams involved. What other groups are contributing information related to the question at hand? This might impact the selection of experts, the formatting and transmission of results, and the timeline of the process. Is this to be a one-off, or an iterative process? An adaptive management regime co-evolving with imperfect and uncertain data and scientific results has very different implications from an isolated, targeted process. An early expert judgment process in the former context might be more aimed at developing relationships, buy-in, and credibility, with a view to slowly building the process over time as new data, capacity, and requirements enter the picture. The process might become more formal, elaborate, and rigorous as the system matures.



EXPERTISE

What kinds of knowledge are needed?

Many criteria may be used in order to define who qualifies as a relevant expert. A first-order consideration is the extent to which a candidate possesses specialized knowledge of direct relevance to the issue at hand. This may be defined in terms of discipline (e.g. an economist, chemist, engineer), preferred methodology (e.g. statistical or dynamical modeling), academic degree (MBA, PhD), problem focus (conservation, decision making), experience or seniority (time in the private sector, level of responsibility, tenure), or geography (where the has person worked).

Any of the above considerations might be structured as minimum qualifications (e.g. experts must have an engineering degree, or they must have done research on the California coast), or as indicators of the breadth in expertise needed (e.g. at least one expert each from economics, engineering, and chemistry). The Gulf of the Farallones National Marine Sanctuary, for its Condition Report, sought to assemble a group that included expertise on every major habitat found in the Sanctuary, as well as key species. All of the experts were scientists, though not all possessed PhDs, and not all worked at universities. This process included criteria for breadth and minimum qualifications or professional background. However, it did not involve a systematic approach to disciplinary perspective, such as an intentional balance between fisheries biology and marine ecology.

EXPERT SELECTION AND THE IMPORTANCE OF CONTEXT

The Chesapeake Bay Program (CBP), which involves the jurisdiction of six different states, has used expert judgment for a variety of purposes, and their approach to expert selection has been directly related to the purpose. For processes aimed at defining regulatory requirements, the Program made sure that the expert group included decision makers in state agencies who eventually would be directly involved with implementing regulatory measures. Thus, the group included scientific expertise, and management expertise related to the use of science in regulatory decision making. It also meant that key users would have a deeper understanding of the result than if they had merely been handed a report. For reporting ecosystem condition to the broader public, direct participation by decision makers was less relevant for the Chesapeake Bay Program, but they did bring in science communication expertise to inform the presentation of the results early on in the process.

It is important to recognize that there are multiple valid perspectives on a complex issue such as the management and assessment of natural systems. One practitioner noted that "every discipline is essentially a mobilization of bias," not to imply that their results are inherently flawed, but rather that scientists ask different questions in different ways. Thinking through those differences can be helpful in thinking through expert selection.

What other political, social, and organizational factors might guide the selection?

Beyond a candidate's expertise, there may be a variety of factors that guide expert selection, such as the level of familiarity and trust with the convening organization (or conversely, professional distance), ability to work constructively with others, availability, and reputation. These considerations should not be taken lightly. A person's ability to tolerate other points of view may be very important to the eventual outcome of the process. The Puget Sound Partnership explicitly references this quality in its call for new members of the Science Panel that informs State of the Sound (SOS) reports. The status of participants, and the role they play among their peers may also be very important to the long-term reputation of the program.

In our interviews with practitioners, we observed an apparent tension between credibility and inclusiveness playing out in the selection of experts. The Santa Monica Bay's Technical Advisory Committee has reduced the diversity of its membership. Whereas it once involved scientists

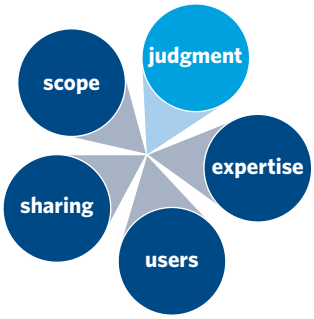
and managers, it has moved toward a model that includes only currently practicing and publishing scientists. In our conversations with SMBRC staff, they noted that this shift was aimed at bolstering the scientific credibility of the body.

Are transparency and accountability important factors in the selection?

We found that selection of experts is often fairly informal, and based on personal trust and prior experience. Experts involved in the elicitation may be brought in because of past work with the organization or personal connections with staff. This can lead to a more comfortable situation for the managers in charge, but it can also lead to problems with the breadth and perceived legitimacy of results. One interviewee, for example, expressed discomfort with the potential for conflict of interest when dealing with a limited set of experts whose research may be directly impacted by the results of the assessment. If users or other stakeholders distrust the process by which experts are selected, they may also distrust the results of the expert judgment process.

What roles are experts expected to fill, and are those clear to participants?

Whether a group is made up entirely of plant biologists, or a wide range of disciplinary, professional, and civic representatives, experts need to know why they have been selected, and what they are expected to contribute. Our contact at the Chesapeake Bay Program emphasized this in his account of panels assembled to inform regulatory thresholds for water quality. The non-scientists in the room needed to understand that they were not just there to observe, but to work on the task at hand. They were expected to bring data, experience and any other relevant information actively to bear on the problem. When roles are not explicit, misunderstandings among the group can lead to confusion and a lack of trust. Scientists may question the relevance of a participating non-scientist, or a non-scientist may incorrectly believe that they are only meant to observe the process passively. This is not to assert that all involved must participate equally, but that thinking through and clearly defining the various roles from the outset may be advisable.



JUDGMENT

What mix of methods is appropriate?

There is a variety of quantitative approaches available for extracting and aggregating expert opinions. These approaches, variously aim to reduce bias, develop probabilistic and/or model-based approaches to decision making, and assess and weight the relative expertness of the participants. Though one of our interviewees was considering adding more quantitative rigor to deliberations through incorporation of Bayesian Belief Networks (which combine quantitative and qualitative forms of expert judgment in a probabilistic framework), nobody we spoke with had used highly quantitative technical approaches.

The alternative to quantitative approaches involves well-informed deliberation by experts, and synthesis of the results in a qualitative framework. In all of our case studies, expert opinion was primarily aggregated through discussion and eventual agreement among experts and/or the practitioners running the expert judgment process, after some period of information gathering, analysis, and reporting. It should be noted that such processes are not necessarily devoid of quantitative methods. For example, quantitative analysis and/or modeling might directly inform one subcomponent of an otherwise qualitative, deliberative process. Nor are they necessarily less rigorous or elaborate than the methods referenced above. But qualitative, deliberative processes are more likely to be products of their specific ecological, managerial, and political contexts, and therefore may be less susceptible to generalization. This has obvious advantages (e.g. likely salience of results, flexibility with respect to data availability), and disadvantages (e.g. reduced potential for cross-comparison and replication).

It is beyond the scope of this guide to discuss the variety of expert elicitation methods in depth. We recommend defining an approach based on responses to other questions in this guide, as well as careful consideration of the capacity of the organizers of the expert judgment process. Where capacity is lacking, bringing in a consultant to facilitate, for example, a process following the "classical model" (in which expert judgments are weighted based on a relative measure of expertise) may be valuable in its contribution to the overall results, as well as the learning it promotes among experts and organizers alike. However, it is also important to consider the audience, and whether elaborate technical processes are needed.

How will the range of views on particular questions be condensed into assessments?

In many cases, deliberative processes aim to arrive at a succinct answer to one or more questions. For example, each National Marine Sanctuary Condition Report must respond to 17 specific questions with a grade from "good," to "poor." Similarly, the GBRMPA Outlook report rates targeted "assessment components" from "very good" to "very poor." Both systems support the grades with narrative statements and other information. The Chesapeake Bay Program issues a report card grading each region on overall progress toward a desired end-state, thus further condensing across a range of indicators into a single letter grade.

Whether in the form of a grade, a ranking, a narrative statement, or other summary, arriving at such an answer requires condensation of a range of perspectives into something that comports with the appropriate balance of guiding values. As mentioned, some of those values may be more important than others for the particular context, and some may be more challenging than others (See "Guiding Values" above).

CONDENSATION: LINKS BETWEEN TRANSPARENCY AND CREDIBILITY

Two State of the Sound (SOS) reports released by the Puget Sound Partnership in 2007 and 2009 illustrate very different approaches to both process and product. In 2007 the range of expert opinion and scientific data were condensed via a centrally controlled, relatively opaque process. The resulting SOS report was controversial among both scientists and the general public. In this case transparency and credibility are clearly related. The more recent SOS report relies much more heavily on judgments and actual text delivered by the Science Panel in a separate report called "Ecosystem Status and Trends." This change increases the perceived (and presumably actual) role of a panel of experts in making specific judgments about key indicators of ecosystem condition. In both cases scientists played a role in contributing expert judgment, but it was the process of condensation that proved controversial, and needed to be more transparent.

Who is responsible for arriving at condensed answers?

An important question in designing a process is the extent to which responsibility for condensation falls on the participating experts or on the managers running that process. If participating experts are simply interviewed on a one-on-one basis, or surveyed individually, the task of condensation falls largely to the managers. In that situation, the expert need not agree with other experts, or negotiate his or her position in contention with other views (though such issues may arise in the review process). Such an approach may be desirable if there is concern about the ability of participants to express their opinions freely in a workshop format, or insufficient resources to bring people to the table physically.

With a workshop format managers may still take on responsibility for condensation after the fact, or instead push participants to reach succinct answers as part of the proceedings. The NMS Condition Reports provide an interesting survey of the different participatory formats, as they have varied depending on available resources and complexity of the task. The Florida Keys Condition Report relied entirely on interviews either in person or by phone. The Gulf of the Farallones Condition Report included both formats, as managers communicated extensively with individual experts in the lead-up to a workshop.

How will the organizers track the provenance of information provided by experts?

The Gulf of the Farallones NMS used a workshop to elicit expert judgment. However, during this process it was not always clear where the final conclusions were coming from in terms of personal experience, data, scientific literature, etc. When questions about this arose later on, the NMS staff were forced to go back to their expert group for clarification, and in some cases amend the conclusions that appeared in the final report. There is no easy answer to the question of what counts as legitimate input to an expert judgment process, and it may not be necessary to specify this in detail. However, regardless of the elicitation mechanism, it is advisable to track the source of the various statements contributed by experts, so that a full explanation can be provided in the final product. This may help to avoid costly delays, and breaches in credibility and transparency.

What kinds of external and internal review are warranted or required?

Most of the processes we examined involved extensive review of the products of an expert judgment process. Generally the first step is review by the experts themselves to ensure that their views are represented accurately in the final assessment or judgment. But other review mechanisms may be warranted, or indeed legally required. The NMS Condition Reports are deemed "Influential Scientific Information" by the U.S. Office of Management and Budget (OMB), and therefore by law must be sent out for external review. All of the examples we looked at involved some kind of expert review by individuals that did not participate in the expert judgment process.

Another common feature of the process is review by key individuals whose support of, and participation with the program are important. The chance to understand and even react to the views of these "critical friends," as they were called internally by one organization, in advance of the results becoming public can be helpful to practitioners concerned about proactively engaging with the public's concerns. The NMS Condition Reports also involve a "courtesy review" period for a range of important stakeholders.

Another potential review mechanism during longer processes can happen during deliberation rather than after the final report has been assembled. For example, it may be useful to check with key decision-makers or other experts about the implication of a particular finding, to determine whether further refinements, a re-framing, or additional discussion may be warranted.

How will agreement and disagreement be managed?

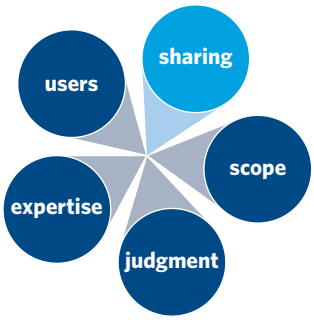
Although an expert judgment workshop may work toward agreement, full consensus may not be realistic when it comes to interdisciplinary perspectives on complex environmental systems. Indeed it is questionable whether consensus is ever a useful, and realistic, goal of expert judgment processes in this context. So, if not working toward consensus in an expert judgment workshop, one must carefully consider alternative realistic goals and strive to be clear about these throughout the process. Just as it is important that participants know why they were selected (as mentioned above), it is also important that the group understand what it is expected to achieve in the course of the workshop (and how this fits into the larger context, as discussed under "Scope"), and policies regarding disagreement.

Recognizing the unlikelihood of consensus, we must consider how to deal with, and get past, disagreement. One interviewee noted that simple majority rule may be problematic, as we often desire statements with more weight than barely half of the experts in the room. Rather than devise hard and strict standards involving a vote, or particular thresholds for agreement, it may be enough to develop a clear way of tracking and documenting disagreement, so that it can be addressed later on, or reported along with the final assessment.

What is the appropriate format for in-person discussion among experts?

Several interviewees emphasized the importance of a skilled moderator/facilitator. Good moderators use a range of tools to keep groups focused, defuse tension, access the full range of opinion within a group, and move past intractable debates. Different moderators will have different kinds of skills. The credibility of a moderator among the expert group is an important consideration.

One interviewee emphasized to us that, while it may seem obvious and trivial, openly valuing the time commitment of participants is of central importance. As mentioned above, participants should be clear on why they were chosen, what is expected of them, and how their input will be used. They also need to feel valued in an immediate sense, whether this means providing adequate free time, good food, or a comfortable environment in which to work and relax.



SHARING THE RESULTS:

This component refers to both the process of sharing results, which brings up issues such as audience, and relationships to key users; and the product that is shared, such as an online resource, or a glossy report. We reviewed a range of products that share the results of expert judgment, and also asked our interviewees questions about the thinking behind these products.

Who is the audience, and what will they want from the report (or other output)?

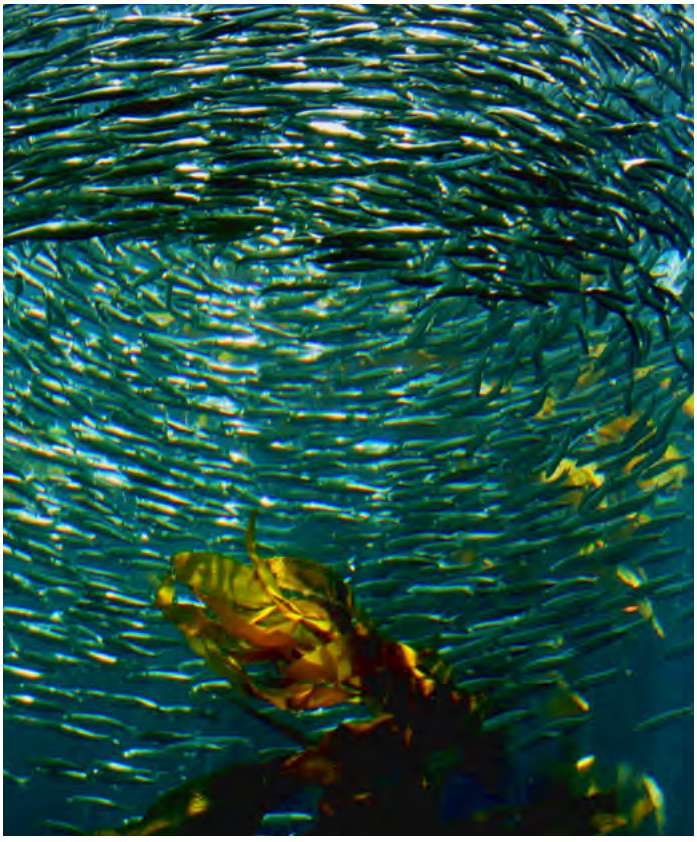
This question is closely related to issues raised under the topic of "Scope" (Who will see and/or use the results? What will the results be used for? What is the broader context of the process?). These questions help to define the appropriate scope of the expert judgment process, and they also inform the format, structure, and timing of the results. In some cases, the most important members of the audience might be in the room, participating in the process. In other cases, having no concept of the process itself, the primary audience may only learn about the results through reading a glossy report, or hearing about it in the news. This is important to consider early on in the planning process.

How will the audience move from simple ideas to in-depth explanations?

In reporting on expert judgment processes there is a tension between the need to communicate simple ideas quickly, and the need to demonstrate rigor and depth. The reports and online tools associated with our examples reflect a variety of approaches to these imperatives. A common one involves eye-catching graphical representations of highly condensed assessments (e.g. "water quality is poor but improving"), supported by a series of shorts statements, which are in turn supported by a longer narrative in the full version of the report (or online content). Appendices and other supporting materials provide additional depth or more technical explanations of the assessment and its underpinning science. A common theme among our interviewees was the increased comfort of experts when the structure of the products could be explained at the beginning of the process and participants could see how simplified or graphical representations of results would be underpinned by more lengthy technical explanations.

How is the information framed and structured?

One important consideration for the representation of results is the degree of conceptual distance between an abstract concept (such as "good health," or a grade of "B+") and tangible, visible, real-world phenomena. Many of our contacts commented on the challenge of multiple ways that final assessments/judgments might be interpreted. One option is to reduce the conceptual distance by defining concepts as narrowly and specifically as possible, to avoid confusion and misinterpretation. But there may be a tradeoff here with broader relevance and accessibility.



THE POLITICS OF FRAMING

Grades, or other high-level assessments can function as entry-points to more detailed information, and there are many ways to approach this. The Puget Sound Partnership (PSP), for example, has developed an online "Vital Signs" dashboard that allows users to very quickly drill into the components of ecosystem health most interesting to them. The dashboard itself is merely a guide to important dimensions of a complex system; it provides neither grades nor other assessments of ecosystem condition. The user can see statements about the importance or status of these components, and quickly access data associated with them. In some cases these data track progress toward a goal associated with restoration of the Sound.

The Chesapeake Bay EcoCheck Report Card takes a very different approach. Its high-level entry-point is a map showing grades for different regions of the Bay. The user can click on a grade to learn about the data behind it, and how the health of that region is changing.

The major differences between these examples begin with the framing of the user experience. Chesapeake Bay takes a regional approach, allowing users to compare one place to another. Stemming from the policy goals of managers at the Chesapeake, this approach is meant to encourage healthy competition among different jurisdictions around the Bay. Puget Sound is focused more on educating users about all the different factors affecting the Sound as a whole, and there is no consistent means of comparing one place to another. The Chesapeake Bay report card is immediately normative, providing very stark contrasts between regions. The Puget Sound approach relies more on neutral scientific statements allowing the user to come to her own conclusion, based on which content she accesses, and how she feels about the data presented. Each approach has politics, and has advantages and disadvantages. And each has arisen through processes unique to the context in which it was produced.

Who should be involved in developing reporting tools?

Our contact at the Chesapeake Bay Program noted that the development of high density reporting systems such as a report card or color bar is not necessarily a task suited to scientists or managers, whatever strong opinions they might have on the topic. Especially when the general public is a primary audience, experts in science communication and/or graphical design can play an important role in developing an effective system.

What are the relevant types of uncertainty, and how should they be represented?

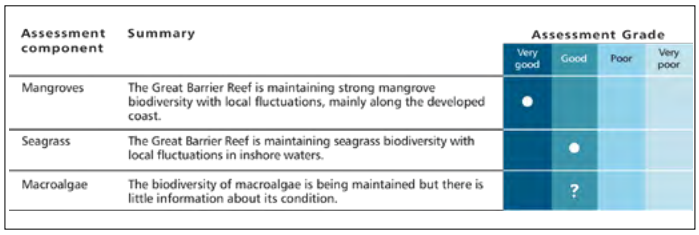
The cases we examined have not dealt comprehensively with the problem of representing uncertainty in high-level, graphical assessments. This was flagged by one of our contacts at NOAA, who indicated that future NMS Condition Reports will be incorporating uncertainty more explicitly.

There are many types of uncertainty, some of which seem to be more prominent in these reports than others. For example, indications of missing data are fairly common. In its summary tables, GBRMPA normally uses a black dot to indicate a rating of ecosystem components, but replaces the dot with a question mark when data are considered inadequate (though it is not clear whether consistent standards were applied in making this designation). Similarly, the Santa Monica Bay Restoration Commission uses a dashed line on its color bars to indicate limited data availability, and also adds to this an indication of geographic variability. Australia's State of the Environment Report focuses on confidence levels, both in the grade of each item, and in the trend of that grade over time (Figure 2).

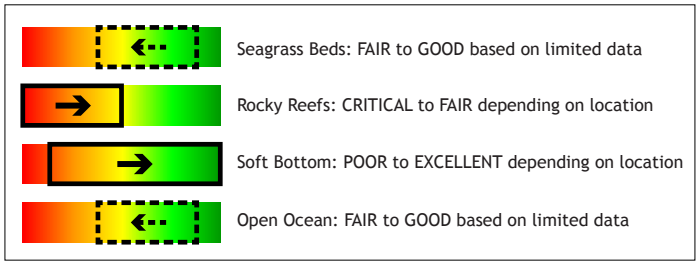
But probabilities, error bars, or other statistical measures rarely appear in high level assessments. This is probably due to the qualitative nature of these expert judgments, and the incommensurability of the various kinds of information that have been brought together to make them. It will rarely be possible to fully represent uncertainty in highly condensed reports, but thinking through the relevant types of uncertainty that might be reported is a valuable exercise.

How will the reporting tool evolve over time?

Many of our case studies have set up reporting tools that can show progress over time, as future reports are assembled. But consistent reporting can be difficult to maintain given a variety of external pressures. The Puget Sound Partnership invested heavily in a color bar system for its 2007 report, and subsequently abandoned it for the 2009 report. This is apparently due to a change in management responsibility for the report (and not a judgment that the 2007 system was ineffective). This raises the larger point that these processes, over time, rely on institutional memory in order to remain consistent. Explicit documentation of why the system was chosen, and attention to adaptability of the system as needs change, may be helpful in dealing with change in the long term. Investments in new tools should be made with some consideration of the stability or staying power of the current system.



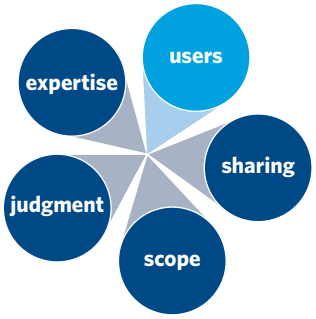
A. Great Barrier Reef Outlook Report 2009, p. 32



B. SMBRC State of the Bay 2010, p. ix

C. Australia State of the Environment 2011, p. 29

Figure 2. There are many types of uncertainty could be represented in expert judgment. The Great Barrier Reef Outlook Report (A) notes a lack of data in some of its judgments using a question mark. The Santa Monica Bay Restoration Commission's State of the Bay Report (B) also notes a lack of data with a dotted line, and adds an indication of geographic variability with the range of values encompassed by the black border on the color bar. Australia's State of the Environment Report (C) indicates confidence levels in both the grade and the trend in the grade for each feature.



USERS

Issues concerning who will use the results of expert judgment and how have already come up in previous sections, particularly those dealing with scope and the sharing of results. Perception of results was an important topic of discussion in our interviews, but we also recognize that a full accounting of this issue would require interviews with users and expert participants (we only focused on managers or conveners of expert judgment processes). Despite this short-coming, we can offer some insights about user perceptions based on our interviews.

How is scientific credibility perceived?

Scientific credibility frequently came up as an issue in our discussions with practitioners about external perceptions of expert judgment processes and products. For example, when the Farallones Condition Report was released, there were immediate requests for information on the science and data underpinning the findings. The Santa Monica Bay Restoration Commission also perceived scientific credibility to be an issue, and moved to limit their technical advisory committee to only practicing scientists. Our contact at Chesapeake Bay also advised that in the early stages of an iterative expert judgment process, scientific credibility may be important for getting buy-in among scientists who are not participating, but observing the proceedings closely.

Perceptions of credibility are formed based on a wide range of factors related not just to data, methods, and expertise, but also process, personalities, and external politics. Thinking through these carefully can help to avoid unnecessary lapses in credibility.

How will critical stakeholders be involved?

Buy-in from stakeholders was also a critical element of public perception, and most of our interviewees described deliberate action to work on this issue in the lead-up to releasing results. Whether a review period for "critical friends," or direct participation by various constituencies, most interviewees felt that some kind of avenue for participation beyond a core group of experts was necessary to avoid backlash later in the process. This does not mean that these groups need to be involved in the specific expert judgment process, but their role in the larger process should be considered.

How will the process be perceived (as apart from the results)?

What sort of process will have the greatest legitimacy in the eyes of users and stakeholders? There may be trade-offs between top-down and bottom-up processes, or scientist- vs. management-driven processes, but it is not always clear how to navigate these issues. Some may feel that increased credibility comes from isolating the scientific proceedings and relying on increased authority and credibility. For others the key is opening up that process to a wider notion of valid knowledge and participation. The centrally controlled 2007 report from PSP led to a backlash among the public and scientists. GBRMPA used a process internal to the management authority, and did not experience any notable backlash. The SMBRC increased its threshold for "expertness" to bolster its credibility. Norms have recently shifted toward more democratic, participatory processes, but some might actually prefer a technocratic, science-led approach.

Can the results be framed to minimize unhelpful conflict?

The actual content of the expert judgment (as opposed to the process by which it was conducted) may be a major factor in the public reaction. If the results indicate particular management actions which adversely affect one group, there may be little that the program can do to manage that group's negative reaction. However, one can consider different framings of potentially negative results, and how to bring people on as constructive participants, rather than victims of changing policies.

NEXT STEPS

We hope this guide serves as a useful tool in planning for, and evaluating the conduct of expert judgment processes related to natural resource management. We will continue to use it in our own planning, and also to evaluate other case studies we encounter as we collaborate with other organizations addressing similar challenges.

Contact us to share your experience implementing or participating in expert judgment, and learn more about individual case studies by visiting our expert judgment webpage: http://calost.org/expert-judgment. Updated versions of this guide together with additional products from our expert judgment work will be posted on this webpage.

Appendix A: Expert Judgment Planning Worksheet

Use this worksheet to brainstorm your expert judgment process. Refer to the planning document for guidance in thinking through each of the questions. Remember that even if your team doesn't have immediate answers to these questions at the outset, you can still identify ways that you will come up with the answers later in the process. We recommend referring back to your initial answers periodically as the expert judgment process plays out.

Scope

While the scope of an expert judgment process might seem obvious at the outset, we recommend taking time to discuss the central purpose of the activity, as well as its impetus and broader context.

What will be judged?

What question will experts be asked to answer, and what questions will they *not* be asked to answer?

Who will see and/or use the results? Who are the audiences? How will different audiences use the results?

What will the results be used for?

It is not enough to simply state that the results will inform management. *How* will they do so?

What is broader context of the process?

Is this a one-off project, or a gradually evolving, iterative process? What other information streams are involved?

Expertise

What kinds of knowledge are needed?

What criteria will be used to define who qualifies as a relevant expert?

What other political, social, and organizational factors might guide the selection?

For example, what is the level of familiarity and trust with the convening organization (or conversely, professional distance)? What do you know about their ability to work constructively with others, availability, and general reputation?

Are transparency and accountability important factors in the selection?

Should you make expert selection criteria explicit?

What roles are experts expected to fill, and are those clear to participants?

Can you make various participant roles explicit, thereby avoiding misunderstandings, confusion and a lack of trust?

Judgment: how to elicit and work with expertise

Judgment refers to the process by which the organizers will elicit and work with expert opinion.

What mix of methods is appropriate?

Based on factors such as user expectations, mix of quantitative and qualitative elements of the problem, and internal and external capacity, how will you extract and work with expert opinion?

How will the range of views on particular questions be condensed into assessments?

Will you use a rating or grading system? Narrative statements? Will there be a geographic component?

Who is responsible for arriving at condensed answers?

Will the organizers bring results together, or must the experts agree on a final answer?

How will the organizers track the provenance of information provided by experts?

Will it be possible for experts to provide a detailed account of the basis of their answers?

What kinds of external and internal review are warranted or required?

Will you use external review by other experts? Input from "critical friends"?

How will agreement and disagreement be managed?

Is consensus a realistic or even appropriate goal? How will you deal with and get past disagreements among experts?

What is the Appropriate Format for In-Person Discussion Among Experts?

Will a facilitator be needed? What time commitment from experts and others will be realistic?

Sharing the results

This component refers to both the process of sharing results, which brings up issues such as audience, and relationships to key users; and the product that is shared, such as an online resource, or a glossy report.

Who is the audience, and what will they want from the report (or other output)?

This question is closely related to issues raised under the topic of "Scope" (Who will see and/or use the results? What will the results be used for? What is the broader context of the process?).

How will the audience move from simple ideas to in-depth explanations?

How will you deal with the tension between communicating simple ideas quickly, and demonstrating rigor and depth?

How will the information be framed and structured?

Can grades, or other high-level assessments can function as entry-points to more detailed information?

Who should be involved in developing reporting tools?

Do you need to involve experts in science communication and/or graphical design? When and how?

What are the relevant types of uncertainty, and how should they be represented?

Can uncertainty be represented graphically? Quantitatively? Through narrative statements?

How will the reporting tool evolve over time?

Should the long term sustainability and evolution of the expert judgment reporting tool be considered?

Users: Perception and Utilization of Results

How is scientific credibility perceived?

Perceptions of credibility are formed based on a wide range of factors related not just to data, methods, and expertise, but also process, personalities, and external politics. What do you know about your audience and intended users?

How will critical stakeholders be involved?

Should they have a role in your expert judgment process, or some other related activity?

How will the process be perceived (as apart from the results)?

What sort of process will have the greatest legitimacy in the eyes of users and stakeholders?

Can the results be framed to minimize unhelpful conflict?

Can you bring in potential critics as constructive participants, rather than victims of changing policies?

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The California Ocean Science Trust (OST) is a non-profit organization established pursuant to the Coastal Ocean Resources Stewardship Act of 2000 to provide scientific guidance to the state on ocean policy issues. Additional information on the California Ocean Science Trust can be found at www.calost.org. The MPA Monitoring Enterprise (www.monitoringenterprise.org), is a program within OST that leads the design and implementation of scientifically rigorous, impartial and cost-effective monitoring of the network of marine protected areas established in California under the Marine Life Protection Act (MLPA). Working with scientists, stakeholders, managers and decision-makers, we are pioneering scientific and practical assessments of the changing condition of ocean ecosystems and the performance of MPA networks, and developing innovative approaches for sharing monitoring results so that decision-makers and stakeholders have timely, credible information for making sound management decisions. OST's expert judgment project is supported with funds from the David and Lucile Packard Foundation.

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