Chapter 7
Challenge of Integrating Natural and Social Sciences to Better Inform Decisions: A Novel Proposal Review Process

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Abstract Many reports have called for changes to how science funding agencies support research efforts so that more knowledge is linked with decisions. However, few of these reports have delved into the messy details of how to actualize this goal. The purpose of this chapter is to focus in on one example of a funding organization attempting to better bridge the gap between science and action. The mechanisms for making these connections are discussed in detail, as are the views of various people involved in the proposal review process: program managers, peer reviewers and panelists. Several lessons emerge from this qualitative research. Perhaps the most important lesson is that bridging activities require the same level of focus and expertise that is given to the generation of new knowledge about natural systems. This requires a change in how resources are allocated and it also requires the involvement of a class of professionals that have, to a significant degree, been excluded from many environmental research endeavors. This lesson and others have important implications for scientists seeking to solve problems as well as for research program managers and the higher echelon managers of science agencies who make decisions about how resources are allocated.

Keywords Science and technology policy • Decision support • Sustainability science • Research and development • Boundary organizations • Policy-relevant science

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1 Introduction

Previous chapters have already established that our society faces significant challenges. Further, traditional approaches to the conduct of applied science – science that is funded with the express purpose of addressing resource management issues – may not be the most effective use of taxpayer dollars (e.g., (NRC 1995, 2006; Urban Harbors Institute 2004; Jacobs et al. 2005; McNie 2007; RATF 2007; Sarewitz and Pielke 2007)). For our funding organization, known as the NERRS Science Collaborative, (NERRS stands for the National Estuarine Research Reserve System), these reports are especially resonant, because our own evaluative efforts (Riley et al. 2011) have revealed a list of lessons learned that closely mirrors those found in these and other publications. For example, the main principles spelled out in the recent National Research Council (NRC) report, "Informing Decisions in a Changing Climate" (NRC 2009) show considerable overlap with our lessons learned. Hereafter, I will refer to this document as "Informing." The six principles in "Informing" are: (1) begin with users' needs; (2) give priority to process over products; (3) link information producers and users; (4) build connections across disciplines and organizations; (5) seek institutional stability; and (6) design processes for learning. (See, especially, the overlap between these principles and the hypotheses in NRC 2006).

The staff at our organization is also especially qualified to note the difficulty involved in integrating these lessons learned into the way we do our jobs. We have heard loud and clear that we need to provide more opportunities for producers and users of information to work together (Urban Harbors Institute 2004; USCOP 2004; Coastal States Organization 2007). That, in itself, is a challenge. When do you get the users and the producers together? How often? How do you know which people to involve? These are difficult questions for a science funding organization, and especially for one that distributes funds through a competitive grants process. These sorts of organizations often lack the agility and discretion of research divisions that are internal to a science agency. And yet these organizations represent a significant percentage of the science that is conducted to address environmental challenges.

But there's a further complication. The NRC report clearly emphasizes "process" over "products." This is one of those phrases that has more and more significance the longer you look at it. As noted in earlier chapters in this book, the traditional science paradigm is focused on the quality of the scientific end product…not the process. Of equal import are the many publications that have noted the importance of a particular kind of expertise associated with managing this process (Cash et al. 2002; Jacobs et al. 2005; NRC 2006; Karl et al. 2007; RATF 2007). This is not just about meeting facilitation, but about structuring a process involving users that is appropriate to the problem being addressed. This is not a skill that is taught to natural scientists or decision makers…nor even all social scientists. Moreover, it is difficult, even for process experts, to agree on one publication or guidance document that clearly and pragmatically explains how to navigate the many choices that arise in structuring a collaborative process (e.g., Von Korff et al. 2010).

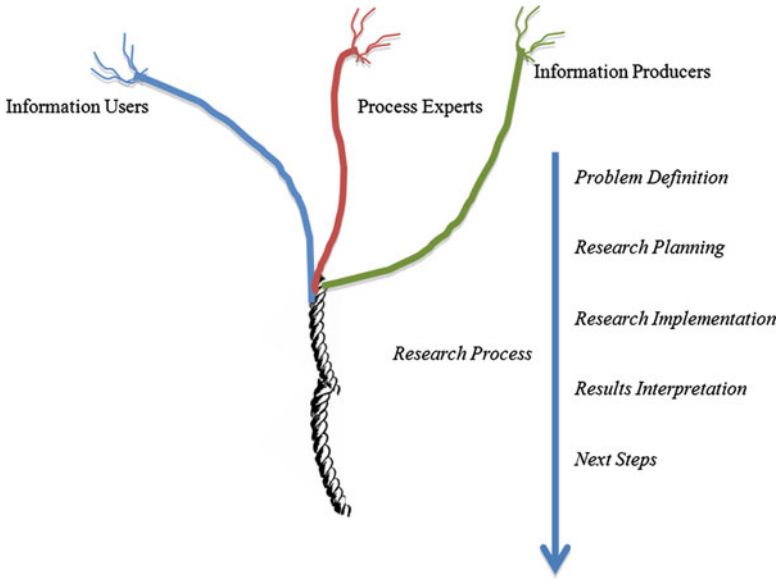

Fig. 7.1 "Braiding the Rope"

I should state at this early juncture that I am not using the term "collaboration" or "collaborative process" in its usual manner. By these terms, I refer to interactions and working partnerships between knowledge producers and knowledge users: for example, between a fisheries scientist and a fisher, or between a hydrologist and a municipal land use planner. I am not using the term "collaboration" to refer to scientists from different disciplines working together.

The challenge to funding organizations is bringing these disparate groups together: the information producers, the users and the process experts. These three veins of system actors have to be weaved into one strand in a way that dovetails with the basic steps of a research endeavor: problem definition, research planning, research implementation, results interpretation and assessment of next steps. I will refer to this challenge as "braiding the rope." (See Fig. 7.1). Braiding the rope is a challenge in any context, but may be especially challenging for funding agencies, which must deal with more rigid timelines and budgetary constraints than, say, a watershed organization or privately funded research institute.

So…what is a competitive grants based funding organization to do?

Two general answers to the question above may spring to mind: two options on opposite sides of a continuum. Option (1) Ask for teams of information producers and decision makers to submit plans to work together…and then use a separate step – after the review stages – to bring process experts into the picture. Option (2) Ask for teams of information producers, decision makers and process experts – all up front – and review the proposals according to the evidence that they can balance the information production

side with the process requirements side. While other options surely exist along or even at angles to this continuum, I submit this as a model for orientation purposes.

What follows is the story of our organization's first attempt to address the recommendations of "Informing" (as well as previous reports and publications) and focus on process. Through the telling of this story, I hope to shed light on where on the above continuum applied science funding agencies may want to take aim. But in addition, I hope to provide insight into the challenges faced by our science system (comprised of funders, information producers and users, and process experts) in building sustainable science-based efforts to manage natural resources. Within this chapter, you will find many notable findings. Since these findings come from an inductive case study, they could be turned into hypotheses to be tested in a more focused manner. Some of the most notable findings are:

- There was considerable consensus – across social and natural science disciplines and including policy makers – that more effort is required to connect science to decision makers. Nobody explicitly refuted the idea that our current system of generating and disseminating scientific knowledge was inadequate in light of our challenges.
- Having said that, there was considerable difference in how natural scientists versus social scientists (and process experts) viewed the nature of the problem and how to fix it.
- In addition to seeing the world differently, there seemed to be an awareness gap between the natural scientists and the process experts. Specifically, the process experts were aware of the importance of natural science but natural scientists were often unaware or dismissive of collaborative process experts.
- Natural scientists saw collaborative processes – deeper involvement of intended users in research planning and implementation – as being at tension with well-planned and credible science. Collaborative process experts, on the other hand, did not see credible natural science and credible collaborative processes as mutually exclusive.
- Reflecting the NRC's (2009) notion to focus on "process over products," a subset of the collaborative process experts seemed to question the creation of scientific products…even more useful scientific products…as the *sine qua non* output of research. Rather, they pointed at the creation and/or nurturing of relationships – especially between scientists and decision makers – as a more important output, especially with respect to environmental sustainability.
- There is evidence that funding organizations can change relationships and approaches to science, simply by constructing a review process that forces increased communication between natural and social scientists and between scientists and decision makers.
- There is also evidence that funding opportunities that make increased demands with regard to collaborative processes may alienate some natural scientists.

Is our case study generalizable to other contexts? In our experience, funding applied science since 1997, these lessons learned are generalizable, at least to some extent. Put it this way: there is little evidence to believe that the people interviewed and surveyed for this analysis are not representative of the perspectives at play in the

halls of the directorates where funding priorities are set. If that is the case, this chapter may point to part of the reason why funding agencies have been somewhat sluggish in responding to many calls for changes in how research dollars are allocated to better address pressing resource management issues. Let's take, for example, the National Oceanic Atmospheric Administration (NOAA), which is the home of our organization, the NERRS Science Collaborative. Consider this rather damning statement from the preface to an NRC report on climate change and social sciences (NRC 2010). "NOAA recently completed a review of its progress since a highly negative report in 2004 on its social science capability detailed its inadequate expertise and resources. The 2009 review…found that not only had NOAA failed to make significant progress, it had actually lost ground over the 5-year period.")

Why are NOAA and other federal agencies slow to respond to continuing calls for change? Is it possible that part of the problem is the composition of natural scientists and engineers versus social scientists and process experts in the major funding agencies? Since humans are driven by their values and habits (Poliakoff and Webb 2007), and since the major science agencies are dominated by engineers and natural scientists, should we be surprised at our nation's continued failure to maximize our production of decision-relevant science? This is a hypothesis that requires further exploration.

It is hoped that what follows will provide further dimension to these questions and assertions. The chapter is broken up into the following sections:

- Background on our funding organization and the RFP at the center of this case study.
- Qualitative data from our analysis of our most recent RFP, which represents a quantum leap (for us, at least) in terms of explicit measures to create decision-relevant science.
- A comparison of our approach with that of the David and Lucille Packard Foundation (Science and Conservation Division).
- A synopsis of lessons learned woven into the excellent guidance provided in the "Informing" document.

2 Background on the Collaborative and the RFP

The NERRS Science Collaborative is a competitive grants program, funded by NOAA, that began in 2009 and has the mission of supporting the development and application of science to address pressing coastal management issues. Grants are meant to go to 28 estuarine Reserves around the United States, or to partners (e.g., from academia, non-profits, etc.) working in concert with the Reserves. The mandate of the Reserves System is to conduct research, stewardship and education in order to better address estuarine and coastal management issues.

In deciding how to best "braid the rope," the Collaborative began by reviewing our theory of change – (what we expect to happen and the main mechanisms and

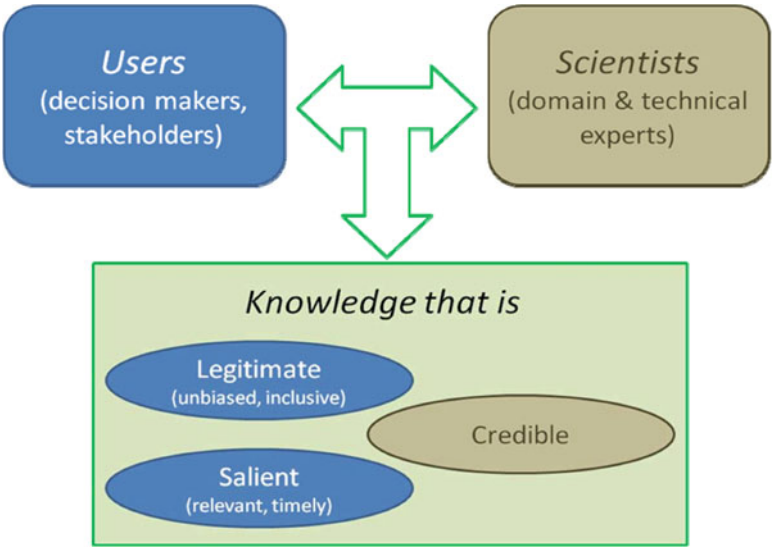

Fig. 7.2 Reproduced with permission from the Packard Foundation

assumptions underlying our expectations). This theory of change is essentially the same as that represented in Fig. 7.2, taken from the David and Lucille Packard Foundation's document "Linking Knowledge with Action" (Packard Foundation 2010). The assumption in this model is that joint production of knowledge is the best way to create knowledge that is credible, salient (i.e., relevant) and legitimate (i.e., trusted and fair). For more information on these terms and concepts (see Cash et al. 2002, 2003; NRC 2009). After considerable debate, we determined that the best way to achieve joint production of knowledge would be by making sure that information producers and users as well as process experts were together from the very beginning: that is, from the proposal stage. As will be discussed later in this article, the Packard Foundation is testing a slightly different approach.

To accomplish this, the Request for Proposals (RFP), released in January, 2010, emphasized two kinds of methods: applied science, which could include natural sciences and/or social sciences, and methods related to the collaborative processes. These two aspects of the proposal were given equal weighting in the review process. In addition, all proposals needed to indicate an "integration lead" whose job it would be to "balance the perspectives of the researchers and intended users throughout the project" (NERRS Science Collaborative 2010). (Let me take a moment to acknowledge that some of these terms – applied science, social science, collaborative process experts – are confusing. They mean different things to different people. Also, they don't have clean divisions. For example, many process experts are also social scientists. The "Informing" report would replace the phrase "applied science" with "science *for* decision support," and replace the focus on "process" with "science *of* decision support." For this paper, however, I will continue to use "applied science"

Table 7.1 Data collection and analysis methods

– Read through all 116 peer reviews (29 proposals times four reviews each), looking for patterns in how the reviewers reacted to the proposals. Analytical methods were based on a qualitative analysis approach called "grounded theory." In grounded theory and similar methods, analysts concern themselves with a specific phenomenon – e.g., What constitutes a truly collaborative process? – but do not set up a limited number of variables or explanations (i.e., hypotheses) before gathering data. Instead, theories are developed from the data, which are revisited in an iterative process of honing on potential explanations for observed phenomena (Strauss and Corbin 1990; Charmaz 2006)
– Conducted in-depth interviews with six applied science peer reviewers and six collaborative process peer reviewers; (stratified random sampling was used in the former case and random sampling in the latter). Coded according to "grounded theory" principles (see above)
– Analyzed evaluative surveys from the ten panelists. Coded according to "grounded theory" principles (see above)
– Asked all 87 peer reviewers which funding programs effectively combine research on natural and social systems; then, conducted interviews with the two programs that were mentioned most

to refer to research about either the natural or human component of the ecosystem; the term "collaborative process" refers specifically to the activities related to connecting knowledge to intended users).

The review approach also reflected our emphasis on a balanced process. We made it clear to all applicants that each proposal would be reviewed by two applied science peer reviewers – (e.g., restoration ecologists, engineers, etc.) and two collaborative process peer reviewers. After the peer review process, applicants had an opportunity to rebut the peer review comments. Finally, a multi- and interdisciplinary panel of ten people was brought in to reconcile all the information and make recommendations for the proposals that best reflected the goals of the RFP.

That was the plan. So, what happened? The short answer is that we received 35 Letters of Intent, 29 full proposals and we funded seven 3-year projects with a cumulative price tag of $4.5 million (average funding request of $642,000). These projects began in September of 2010, and, ostensibly, all provided a detailed plan to collaborate with intended users; considered human as well as non-human barriers to utility; and involved experts in the writing of the proposal and the implementation of the project objectives. All projects had an identified "integration lead" who will strive to balance the perspectives of the various scientists and stakeholders. Many of them included neutral facilitation resources.

However, can we yet say whether these projects represent a truly different way of conducting science? Or is it possible that the ambitious goals in the proposal will be diluted in the implementation phase? Of course, it is too early to say. On the other hand, we knew that our effort was somewhat unusual and we wanted to adaptively manage our program, so we collected information to better understand the most salient challenges to "braiding the rope" so that we might be able improve in the future. See Table 7.1 for details on our analytical methods.

With regard to "braiding the rope," the short answer is that virtually everyone involved in the process – natural scientists, social scientists, collaborative process experts, decision makers who served on the panel – everyone agreed, in principle, with the goal of greater collaboration between information producers and information users. People agreed that we, as a system of actors, need to think harder about how to get science used.

Taking that general consensus, however, and moving toward agreement on how science agencies should achieve that goal is a completely different story. There is considerable diversity, confusion, perhaps even conflict around determining the best methods for braiding the rope. As noted earlier, if the conflict and confusion about conducting applied science in this group is representative of what's happening within government funding agencies, one could conclude that this is a serious problem for us as a society in terms of addressing climate change and other pressing challenges.

The basic area of confusion/conflict is that people are in favor of more collaboration in science, but there is a lack of agreement about *why* collaboration adds value, *what* collaboration means in this context and, finally, *how* a competitive grants program should foster collaboration. While this is less the case with those who spend more of their time in the collaborative process world, we saw some interesting differences in this group as well, especially with regard to the question of why collaborative science is undertaken in the first place. First, I will review what we heard from those who work close to or in the world of collaborative processes. Then, I will go over the salient perspectives of the information producers, most of whom happened to be natural scientists or decision makers with natural science backgrounds.

3 Collaborative Process Perspective, Part 1: The Program Manager

Since the heart of this paper concerns ways for funding agencies to better braid the rope, let us start with input we received from two programs that, according to the community involved in this process, do this effectively: the National Science Foundation (NSF) and NOAA. As part of our review process, we asked all 87 of our peer reviewers (58 on the applied science side; 29 on the collaborative process side) if they were aware of programs that effectively integrated natural and social science, especially in the context of a competitive grants program. Of the 58 biophysical reviewers, ten responded that ours (the NERRS Science Collaborative) was the only program they were aware of and eight suggested other programs. Of the 29 collaborative process reviewers, 12 suggested other programs. NSF received 21 nods from reviewers, most of these (12) were specifically regarding the Coupled Natural and Human Dynamics program (CNH). NOAA received six nods, most of these (4) regarding the Climate Program (see Table 7.2).

We followed up with interviews with program managers from the NOAA Climate Program (Adam Parris) as well as program managers from NSF-CNH

Table 7.2 Programs effective at integrating natural and social sciences

Programs	Times mentioned by reviewers
NSF CNH	12
NSF ULTRA-Ex	2
NSF Geography and Env. sciences	1
NSF Ecology of infectious diseases	1
NSF EPScOR	2
NSF Decision making under uncertainty	1
NSF (no department mentioned)	2
US Long-term ecological research network	1
NOAA Climate and societal interactions	3
NOAA RISA	1
NOAA Sea grant	2
NASA ROSES	1
Social sciences/humanities research council (Canada)	1

(Sarah Ruth and Thomas Baerwald). The interviews concentrated on four questions: (1) Why integrate natural and social sciences? (2) What are the main challenges to integration? (3) What evidence do you see that the integration is actually occurring? (4) What do you think of the idea of having two applied science reviewers and two collaborative process reviewers?

Regarding the rationale for integrating natural and social sciences, both NOAA and NSF agency representatives noted that environmental challenges are rarely related to only one discipline; that is, the problems cross jurisdictions and scales and therefore require integrated solutions and research efforts. In terms of the challenges to integration, a common comment was that current academic and government structures and incentives foster a silo-based approach and organization. This is difficult to address, although NSF program managers noted that the CNH program has actually helped break down silos at their agency.

With regard to evidence of success, both programs noted strong reputations and high proposal submission rates as indicators that their approaches had merit. Parris, speaking for the NOAA program, noted that impacts of the projects were currently being researched and that early indications were that projects were having a significant influence on target audiences. The CNH representatives acknowledge the importance of broader impact as a key criterion, but also pointed to NSF's emphasis on strong scholarly work and the publication record of funded researchers.

Finally, in terms of comments on our review process (two applied science and two collaborative process reviewers), both programs noted that it was essential to have different disciplines involved in the review process. Both also noted that, when picking reviewers, it was a good idea to seek out people who themselves had a strong track record in integrated research. In addition, the NOAA manager encouraged the inclusion of decision makers in the review process as a way to increase the relevance of the research. NSF program managers also emphasized the importance of panels over "mail-in" reviews; they noted that significant learning occurred when folks were able to exchange ideas and perspectives.

In speaking with the NSF program managers, I noted the irony that NSF was regarded as being far more effective in integrating social and natural science than NOAA, one of the "mission" agencies. Speaking for NSF, Baerwald noted his frequent comment that, even though NSF is not considered a "mission" agency, it still has a mission. On the other hand, when I mentioned the results of this survey to a scientist who was familiar with NSF-CNH, this scientist disputed the idea that CNH and the Collaborative were trying to achieve similar goals. In his view, CNH was still mostly interested in creating scholarly benefit, whereas our RFP was heavily imbued with an emphasis on intended user benefit.

Coming back to the confusion around why collaboration adds value, what collaboration entails and how it should be achieved, these interviews give us the beginnings of answers to the "why" and "how" questions. Collaboration is done to improve the value of the science and to better address natural resource management challenges. In terms of "how," an interdisciplinary approach is required. You will see these answers expanded upon as I analyze feedback from the collaborative process reviewers, both from the interviews we conducted and from the qualitative comments in the peer reviews themselves.

4 Collaborative Process Perspective, Part 2: The "Experts"

So, first of all, who are these experts and how did we find them? We started with an excellent review paper (McNie 2007), which led us to specific journals (e.g., "Ecology and Society," "Society and Natural Resources") where we searched for authors who fit the profile of the "scholar-practitioner," or the "pracademic." We wanted to find people with real-world experience participating in and observing collaborative research endeavors. Of the 29 reviewers, 28 of them were based at 4-year colleges or universities, mostly in departments such as geography, public affairs, planning and natural resources. We noted that these reviewers described their expertise in varying ways, with the phrases and terms "participatory," "public engagement," "collaborative," "community-based," and "deliberative decision-making" showing up most often on their web sites.

The best data on *why conduct collaborative science* comes from the six in-depth interviews we conducted with collaborative process reviewers. You will see that the perspectives are similar to those of the NOAA and NSF program managers. For example, at the end of one interview with a collaborative process peer reviewer, the reviewer was asked, "Anything to add?" to which he responded.

> No, I think it's [trying to be more collaborative] a really important thing. It's been long assumed that if people develop smart things, they'll be used, but people like me who do practitioner based social science research know that that's a fallacious argument. There's a lot of research that shows that tons of money just goes into reports that are shelved and so I think it's very important to be frontloading with collaboration.

This remark epitomized the views of the other five collaborative process reviewers, and, in fact, most of the applied science reviewers as well. (As noted earlier,

everyone agrees there's a problem; the question is what to do about it). However, one of the other reviewers also emphasized that collaborative processes can easily be done in a less than rigorous way, with negative consequences.

> The two proposals I read… one of them didn't address integration and collaboration at all. They assume that if you bring people together, you've done collaboration…that's wrong and it can do more harm.

So, collaborative processes are used in order to increase the value of science efforts. Yet the question of how we assign value to scientific activities comes up as a more difficult question in these interviews. In particular, interviewee responses forced us to ask: Should the goal of collaborative research be influencing one specific decision/endpoint, or should the goal be growth in relationships and learning around a particular issue? This is a key point that would impact how a funding program was implemented. Specifically, two of the six reviewers interviewed focused on the trust and relationships that occur when producers and users of information engage in a learning process together. In this scenario, the implied benefit is not so much coming to agreement on one particular decision, but rather a broad increase in understanding by all the participants. For example, information producers learn more about the concerns of certain stakeholders or perhaps become more aware of local knowledge around an issue; stakeholders, on the other hand, become more appreciative and aware of certain scientific endeavors that have already taken place or are in the planning stages. In theory, this then leads to a more educated and collaborative society, which has the potential to impact many decisions…including the decision that is the focus of the project, but not limited to it. One of the peer reviewers put it this way:

> The literature tells us that getting decision makers to use high quality science is partly about producing good science but it's also about building relationships. When I was reading the proposals, at least, I was looking at, 'OK, what is this project going to produce' but I was also asking, 'What are these folks going to have to say to each other two years after this project is over?' Is it going to occur to these people, when they need some random piece of information…oh, I can call this person and get some information.

Another collaborative process interviewer actually went a step further, noting that focusing on one specific decision would detract from the trust building and learning that might otherwise occur.

> The danger that maybe showed up in a couple of my proposals is that if a proposal is thinking about a very specific management decision, they're apt to emphasize the science and maybe downplay the collaborative side in the interest of getting to that decision.

This reviewer went on to break collaborative research into three types.

> There's the science; there's the collaborative process around the science; and then there's collaboratively developed science, actually to decision making, and I would say they are three different things. And perhaps your RFP emphasized really the first two of those. The fact is that very often neither the scientists nor the collaborative process people really know how to make those links to the real decision makers.

Confusion around this issue definitely emerged during the panel negotiations as well. Several of the ten panelists noted in their evaluations that, in their interpretation,

connecting science to decisions didn't require as much emphasis on process and extensive stakeholder interactions.

> You can have very effective science to management linkage by incorporating a key decision-maker into your PI team and research effort. You don't always need broad collaborative approaches.

Obviously, this panelist has a different conception of why collaborative processes are being invoked in the first place. I want to be clear that I am not deeming this perspective "wrong." But it is different from the views of the collaborative process reviewers quoted above, and would have significant implications on the strategies employed by the funding agencies as well as the project teams.

In contrast, one of the other panelists expressed concern at the other end of the conceptual spectrum. In essence, this panelist worried that if we, as a society, continue to seek proposals that are narrowly construed around specific decision makers and natural science issues, we will not be able to make the necessary changes to better address environmental issues. Our process, in this panelist's estimation, put proposals that emphasized stakeholder assessments and flexibility at a disadvantage.

> Most proposals did include a reasonable collaborative and integrative approach. However, per the discussion, a couple of proposals that were models of a true stakeholder participatory approach from the very beginning suffered because they could not adequately define the [natural] science. Given the conditions of the RFP, proposals such as these will never stand a chance of funding.

This panelist's concern is valid. However, the solution may not necessarily be in changing the RFP process so much as making it much clearer that proposals focused on better understanding social science barriers (e.g., stakeholder perceptions) are completely valid research proposals. A potential retort to this line of thinking is that this doesn't address the notion expressed by the NOAA and NSF program managers that natural and social science should be happening more simultaneously, since the issues themselves occur in that manner. This is also a valid point and gets at a much trickier question that we are just beginning to grapple with: How to guide applicants in setting up a process that both demonstrates flexibility with regard to stakeholder ideas, but also provides enough detail on the natural side so that reviewers can evaluate the validity of their methods? While this is no doubt challenging, published reports of case studies indicate that it is possible (e.g., Cockerill et al. 2006) and that "clarity and flexibility do not exclude each other" (Barreteau et al. 2010). As one of the collaborative process reviews put it:

> A more genuinely collaborative approach would involve alleged pollution creators…and direct pollution sufferers…in both carrying out the monitoring and deliberating over the solutions. Such an approach could still incorporate the technical innovations that currently form the core of the applicants' proposal. But it would avoid the well-known problems in terms of both internal validity and stakeholder acceptance.

This discussion touches on an important related issue, concerning the perceived limitations of short (i.e., 3 years or less) collaborative science projects. Is 3 years really enough to achieve any significant goals from a collaborative standpoint? This question was actually put to peer reviewers in the interviews. While some noted that

1 year might not be long enough, most thought that the allowed time periods for the proposals (1, 2 or 3 years) was appropriate. However, this was often followed with the caveat that other funding will be necessary to continue to nurture the relationships that were supported by our funding.

Again, are we only interested in one particular decision or product, or are we also interested in building collaborative capacity for the future? (In this case, collaborative capacity can be thought of as the willingness and capability – implying some process expertise – for both producers and users of knowledge to work productively together). This is not black and white, of course, but rather exists on a continuum, and as the needle leans toward trying to increase collaborative capacity, both the funding agencies and applicants have to realize that the process never really ends, at least according to some of the interviewees.

> That's a big challenge of this work; it's never really done like a discreet research project that ends with a peer reviewed publication. Yes, it's a great approach; it can only help, but it doesn't end in three years.
>
> (Note that the above thought comes from an extension person who served as an applied science reviewer, not a collaborative process reviewer.)

One of the collaborative reviewers noted that our RFP model requires that much of the collaboration happen outside – before and after – the time limits of our process and funding.

> In having conversations with others about collaborative research, I have come to the fairly strong opinion that most of the best collaborative partnerships and work take place in the context of a long-term relationship. Not all projects have to follow that model, and not everyone's going to agree with me, but my own experience has been that this has been a major factor. So what happens is that if someone's trying to write a really strong collaborative proposal, they have to do a lot of preliminary legwork and relationship building before even thinking about writing a proposal. That then places a whole burden on people to do unfunded work, unless they're building on a project with folks they already know. So that's the sort of chicken and egg problem that you guys are stuck in the middle of.

This same reviewer went on to note that, because of this tension, the NERRS system is well-placed to respond to our RFP because of their ongoing mission to maintain relationships with decision makers from their regions. Coincidentally, this approach mimics that of the Research Coordinator at the Elkhorn Slough Reserve, near Monterey, CA. This Reserve has actually obtained funding from more than one funding agency focused on significant collaboration. In response, the Research Coordinator at the Reserve has come to the realization that the best course of action is to have continuous, on-going collaborative conversations on various issues so that the Reserve and various working groups will be well primed to apply to collaborative RFPs when they arrive (K. Wasson, 2010, personal communication). Ultimately, this becomes a more efficient model than trying to start up a collaboration from scratch when a new RFP comes around.

In summation, on the question of "why" conduct collaborative science, there is little dissension with the idea that it can lead to greater linkages to decision making, which is the ostensible reason that the science was funded in the first place. Further exploration with these reviewers and others would be necessary to more

Table 7.3 Collaborative science guidance from the 2010 RFP

By "collaborative approach" we mean one that integrates intended users of the science in the development of the proposal and implementation of the project. When this is done in an explicit way, with the appropriate resources, it can enhance the likelihood that intended users perceive project results as credible, relevant, and legitimate – three qualities that are often required to successfully link science to decision making. More resources on this topic are available in the Collaborative Approach to Science Primer, beginning on page 15
From the Collaborative Approach to Science Primer
Based on our experience and the literature, we believe that projects with the strongest chance of connecting science to decision making have the following characteristics:
• Investigators involve intended users of project results in the problem at every critical stage of the project;
• The project team has allocated appropriate resources to manage the interactions between investigators and intended users;
• The project team, including subcontractors, has the appropriate expertise to manage interactions and balance perspectives between researchers and intended users
The following models have been applied effectively to address coastal management problems. While there are subtle differences to these approaches, all provide explicit mechanisms to integrate a variety of perspectives, including those of project investigators and intended users, at critical stages of the project. You are not obligated to use these approaches in your proposal. Rather, they are provided as examples to illustrate the level of rigor that reviewers will expect you to apply to collaborative processes
Consensus building web.mit.edu/dusp/epp/music/pdf/JFF_KeySteps.pdf
Collaborative learning model oregonstate.edu/instruct/comm440-540/CL2pager.htm
Structured decision making www.structureddecisionmaking.org/steps.htm

satisfactorily understand what the long-term and intermediary outcomes of collaboration are. Some of these reviewers focused on relationships and learning as opposed to knowledge linking to specific decisions.

In terms of the question related to *what characteristics define collaborative science*, I address this by looking at what collaborative process peer reviewers found most wanting in the proposals they reviewed, and their articulation of what was missing. (Our in-depth interviews with the six collaborative process reviewers focused on why and how to collaborate: not on what the basic characteristics of collaboration are).

For context, it's important to know how we tried to answer this question in the RFP. In this guidance, we attempted to walk the line between being explicit about collaborative principles but not micromanaging and prescribing a particular process, out of respect for the fact that the 28 Reserves are very different and might have different ways of working. Table 7.3 has a summation of the key advice we noted in the RFP.

In the way of foreshadowing, I can say that none of the results below contradict the definition of collaboration given in Gray (1989), most often used by people in the field as a starting point for discussion on what collaboration entails. This definition notes that collaboration creates "a richer, more comprehensive appreciation of the problem among stakeholders than any one of them could construct alone."

Table 7.4 Most common collaborative process criticisms

Category	# of Collab process reviews	# of Applied science reviews
Reviewer wanted more details on collaborative processes	34	11
Reviewer wanted more expertise related to collaborative processes/social science	25	4
Reviewer wanted more information on non-technical barriers	23	9
Reviewer felt that applicants confused collaboration with unilateral info dissemination	19	2
Reviewer wanted more evidence that intended users were involved in problem definition	18	5
Reviewer took issue with the content (not amount) of the collaborative process details	15	2
Concern for how products of research will be used	15	15
Reviewer said proposal showed applicants were not familiar with collaborative methods	14	2
Reviewer wanted a broader group of intended users to be involved in the project	14	2
Reviewers felt more money should have been allocated to the collaborative process	10	5
Totals	187	57

The results of this analysis are shown in Table 7.4. I will go through the top five rows in more detail, offering examples of how reviewers articulated what they thought was missing. These top five rows account for 119 of 187 negative comments made by collaborative reviewers (or 60%).

4.1 Rigor…and That Means Details!

Peer reviewers clearly articulated that a *collaborative process requires detailed forethought and planning*. In general, reviewers used amount of details as a measure of the seriousness with which applicants addressed collaboration and as a measure of their ability to carry collaborative processes out. The following quotes give a sense of how collaborative reviewers reacted to a lack of details:

> The proposal talks of treating stakeholders as equal partners, but that isn't really what concerns me. It's okay if there is inequality, because people have different things to contribute. But what is important is that they have some idea of what the different people are going to do. The whole stakeholder aspect of this proposal is vague and unspecified. In a really strong proposal there would be a clear outline of what would happen at each meeting and how the progress would be measured with clear objectives and criteria for evaluating success.

> The sentence I think is strongest in this section [relates to exchanging information between stakeholders and investigators]. I would recommend that the proposal unpack this statement a little more and think more about how this will actually be done, and done in a systematic and structured way, not simply haphazardly.

> While some project team members may have understanding and expertise in collaborative approaches to outreach, communications, and research partnerships, the lack of detail and integration in the present proposal suggests that this dimension is an add-on to the monitoring activities, not a full collaboration.

4.2 "Get the Right People on the Bus"

This quotation is taken from the Jim Collins book "Good to Great" (Collins 2001) and refers to the importance of having the right people on the team in order to get the job done. This is articulated clearly by one of the collaborative process peer reviewers. The following quote is taken from an interview.

> One thing the [natural science] experts don't think about is that the collaborative process is a skill in and of itself, same way being hydrologist is a skill. Same way you have to scale [the natural science] side, you have to scale the collaborative components. But you need someone who knows what that means in the process.

With regard to expertise, the collaborative process peer review criticisms can be put into two general categories: (1) the proposal did not recognize the importance of specific expertise; (2) the proposal made a gesture toward satisfying collaborative process requirements, but the overall effect was less than what would be required to maximize chances of success. Below are some peer review reactions that fit in the former category.

> As noted above, the proposal is strong in engaging a number of government entities and scientists/researchers, but falls a bit short in the lack of social scientists involved and/or collaborative/public participation specialists involved in the project.

> The proposal would be strengthened if senior project personnel included a social scientist well versed in collaborative approaches and/or public engagement in natural resource decision-making.

> Were the project to be substantially adjusted to take into consideration my above concerns [related to better collaborative processes], however, the lack of someone with substantial experience managing deliberative decision-making processes would become conspicuous.

In contrast, here are reactions to proposals that made some effort, but not enough to convince the peer reviewers. As you'll see, reasons include a lack of evidence that the appointed person really has the expertise; conflating facilitation expertise with the experience necessary to design a collaborative research project; getting a qualified person but not giving them the resources to do the job.

> The team is very strong in biophysical sciences, and very weak in social sciences. I have confidence that they can undertake the biophysical analysis piece of the project, and no confidence that they can conduct a social survey, benefit cost analysis or risk assessment, given the information provided in the proposal. [Name Removed], with a planning background, is perhaps the one who might be able to do the social science work, yet he is not supported in the budget so it is not clear what his participation in this project will be.

> Scientific and technical skills are excellent. Skills for collaboration are lacking. Facilitation does not necessarily equal true collaboration.

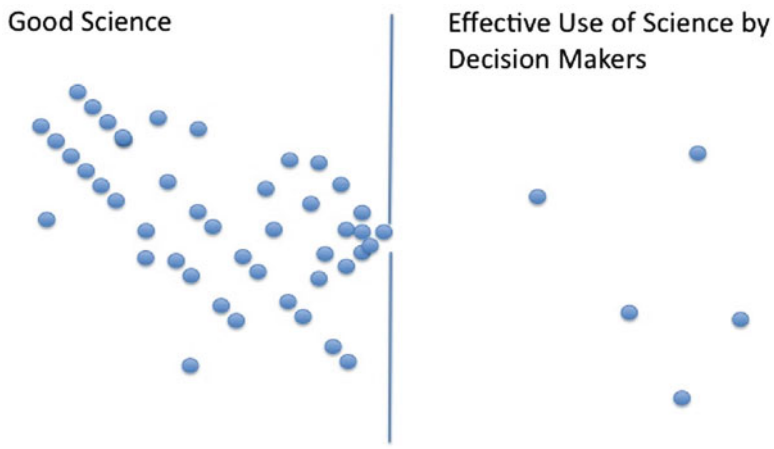

Fig. 7.3 This figure depicts a situation wherein many research projects generate credible science (left side of the figure), but there are far less instances of credible science linking to decisions (right side of the figure.)

> I do not see skills represented on the team to carry out collaborative processes, only past participation in other processes (which is not evidence of practical skills at running such processes or theoretical knowledge of the barriers to collaboration).

In following up with folks from the Reserves after the RFP process was concluded, we were surprised by the amount of confusion circulating around the issue of expertise, and especially around the issue of the role of social science in collaborative processes. The confusion came from multiple sectors – the Reserves all have different "sector" coordinators, including: research, education, stewardship and the coastal training program, which is responsible for linking activities at the Reserve to decision makers. The coastal training program coordinators were intimidated by the idea that they were now expected to be social scientists. Although they are constantly engaged in activities around better understanding decision makers, many of them think of "social science" as something different, more laden with ivory tower connotations. Research coordinators, too, struggled with the idea. This was best articulated by one research coordinator, who referred to a schematic I had shown during a presentation (Fig. 7.3). In this figure, crowded dots on the left side of the diagram represent credible science and much fewer dots on the right side of the diagram represent effective use of science by decision makers. The research coordinator noted that she didn't disagree with the implications of the schematic. However, she said that we have to be clear whether collaborative processes are about conducting social science that could, potentially, become another stranded dot on the left, or whether it is instead an effort to break down the bottleneck allowing information to flow back and forth. (K. Wasson, 2010, personal communication).

Her clarification is right on point; the latter conceptualization is, in fact, how we conceived the role of the collaborative process expert, whether you want to term their activities "social science" or not. It is also possible, however, that the main goal of the project could be to better understand a social science issue, such as stakeholder conceptions of risk regarding sea level rise, etc. In this case, the project would still require a collaborative process piece in order to make sure that the social science knowledge doesn't languish on the left side of the diagram.

4.3 Lack of Understanding of Natural Systems Isn't the Only Barrier

A collaborative process does not assume that the only problem is a lack of information about the resource. It assumes, in contrast, than even if everyone has the desired natural system information, there will be some barriers to using the information to make decisions; usually these barriers have to do with the logistical limitations on the part of the intended users, differences in values and/or socio-economic issues. In the case of these 29 proposals, especially when those proposals were lead by a natural scientist, the "problem" to be solved was often depicted as a lack of information about the natural system. Then, it was either implied or noted explicitly that, once the appropriate information was provided to the decision makers, these users of information would change their actions or behaviors accordingly.

This is not surprising. As the old idiom goes, the challenges that are most interesting to a hammer tend to be nails. Why would a natural scientist go to the trouble of writing a proposal and then ask for resources to attack a problem with tools that he is only partially able to provide? It is understandable that a natural scientist would see a coastal management problem through her lens, which would tend to shape problems into deficits in understanding of natural systems. By the same token, a social scientist might see all problems as a deficit of understanding of human and organizational motivations and behaviors.

The following peer reviewer quotations articulate the need to look more deeply into human barriers, not just barriers related to understanding the natural system.

> The basic assumption running throughout the proposal is that once the science is produced, then the "truth" will be obvious and embraced by all [the stakeholders]. But the collaborative literature, as well as political science, economics, sociology, psychology and public administration, among others, suggest that good information is only the start of the decision-making process and that all kinds of barriers get in the way of embracing, much less applying the science.

> In my experience, knowledge deficit is rarely the reason why actions are not happening. More likely, people know what needs to be done, it's just too controversial or too expensive to do. More information can certainly help, but the people involved in the decision-making need to confirm that this is indeed the major obstacle.

4.4 Collaboration Does Not Mean One-Way Information Dissemination

The peer reviewers articulated that a collaborative process plans for respectful interchanges between various people involved with a natural resource issue. Learning is happening in both directions and, therefore, a collaborative process should seek to specifically facilitate this kind of learning and perhaps, as the reviewer below suggests, set learning and trust building as explicit objectives that are evaluated within the project.

> The project objectives could be stronger if they included increased collaborations as outcomes in and of themselves. As articulated, the objectives are to collect the data and then disseminate the data to relevant decision makers and 'stakeholders.' Certainly this is the model most common in applied science settings -- and the model we generally find in terms of academic and agency collaborations.

As shown in the quotations that follow, specific planning for multidirectional learning was absent in many proposals. Instead reviewers saw ramped up dissemination of information and educating of the public.

> There seems to be a belief that making materials and reports available to anyone who might be interested is collaborative and sufficient for interest groups to make the effort to know, understand and be willing to behave in ways consistent with the research findings. This is a mistaken and often costly belief.

> All that's really discussed is public education/outreach. I don't see collaboration, which is two-way. This reads like a one-way process.

> There is also little indication how the results of the study would help overcome problems with the implementation of the current approaches other than to provide more information that might improve our understanding of how the ecological system functions. While there is potential for the project to do this, it still reads like a more traditional scientific proposal with an outreach component tacked on than one designed collaboratively to help improve coastal management decision making.

4.5 Collaboration Means That the Problem Itself Is Defined in a Collaborative Way

Collaborative processes have to start with the problem formulation and carry through all the other stages. If the problem is not defined collaboratively, it is possible to do everything else right and end up with knowledge that is not used, for the simple fact that it answers a question to which people don't need the answer (Sarewitz and Pielke 2007; Mitroff and Silvers 2010). The quotations below show how reviewers articulated their concerns that the science being proposed might not be addressing the real problem of interest to intended users.

> It is unclear to which extent applicants have confirmed their understanding of the nature of the problem and their proposed approach with intended users.

> It is less clear that the proposed research addresses the core obstacles to moving restoration forward. Though this work may be a priority of the NERR…it is less clear that this would address other constituencies' concerns.

> Frankly, I'm concerned that this project has moved ahead with the assumption that more ecological information is needed, but they have not really field-checked this assumption at all.

Finally, to understand *how* a program like the Collaborative can foster increased collaboration, we must return to the in-depth interviews of the peer reviewers. All six of the interviewees agreed with our choice to involve both collaborative process reviewers and reviewers who specialized in the applied science problem being tackled by the proposal. At the same time, two of the six reviewers registered concern for how we would reconcile such discrepant viewpoints as we would surely get. And three of the six reviewers suggested that we try to provide an opportunity for the two sets of reviewers to talk to and learn from each other, echoing the value put on panels by the NSF program managers. One of the peer reviewers put it this way:

> If you're thinking about building capacity, then the reviewers that participated are a form of capacity for the future, and if you just do it as a sort of blind one sided exercise, than it's not going to be as rich an experience than if you had some process for debriefing.

Other suggestions included being more clear in the RFP what we mean by collaboration and perhaps listing some resources where applicants could find out more information. (We attempted to do both these things, but clearly we need to do it better).

Before we move on to the perspectives of the applied scientists in the process, let us sum up what the program managers and collaborative process experts have said about collaborative process.

Why conduct collaborative science? So that more science is used and natural resource issues are better addressed by applied science endeavors. This (science being used) may happen by better linking science projects to actual decisions and decision makers, and/or it may happen because science projects serve as hubs around which producers and users of information can learn and increase their collaborative capacity, with regard to one or other decisions.

What constitutes collaborative science? Collaborative science involves detailed plans, created by experienced practitioners with specific training, to create an environment in which producers and users learn from each other – at every step of the research process…including the problem definition stage – so that knowledge generated by the science address information gaps as well as values-based, socio-economic and other barriers that can prevent the science from being used.

How should funding organizations foster collaboration? Involving both applied scientists and collaborative process experts is strongly recommended, and efforts should be taken to allow people with different perspectives to learn from each other. (A more detailed discussion of "how" comes later in the chapter).

Now, let us turn our attention to the applied science side of the review process to compare their perspectives with those of the collaborative process reviewers.

5 The Natural Science Perspective

One might think that it's unnecessary for natural scientists to be on the same page as the collaborative process experts. After all, why not let the natural scientists do what they do well and leave the collaboration component to those who have that specific training and interest? However, there are several points we should consider. Natural scientists often play an important role in the natural resource management process and are therefore important stakeholders. In addition, natural scientists are often the predominant applicants to competitions that come from the big science agencies (e.g., NOAA, NSF) despite repeated calls for more social science (NOAA Science Advisory Board 2001, 2009; NRC 2007). And finally, most of the people who hold key decision making positions at science agencies have a natural science background. For example, Jane Lubchenco at NOAA is a marine ecologist; Marcia McNutt at the US Geological Survey is an oceanographer; and Subra Suresh at NSF is an engineer. It makes sense – and most social scientists would agree – to better understand the views of key decision makers and stakeholders. I offer this information as a sample of the applied natural scientist population.

So, who are these natural scientists? The 58 natural science reviewers were almost all trained in natural or physical sciences, such as: ecology, biology, geology, engineering, etc. Among the exceptions to this rule, five of them worked in extension, two were policy analysts and two were watershed organization directors. Thirty-five of the 58 reviewers were associated with 4-year colleges or universities; the other 23 involved a mix of government, NGO and private organizations.

In terms of the questions regarding "why," "what" and "how," the most noteworthy differences between the two sets of reviewers come in the discussion of how organizations like the Collaborative can foster the integration virtually all members of the sampled population agree should occur. Two of the six reviewers implied that the focus on the collaborative process was overdone.

> Not sure you need the collaborative reviewers if the RFP is tight. The NERRS should make their problems clear and the science should gather data to solve those problems.

> It's better if you can pick people who can do both [applied science and collaborative processes]. I don't think there are any more ivory tower scientists; we're all doing collaboration. What if you have two people who love the collaborative process and the science people don't love it. Should the proposal move forward? Not if the science is weak but if the science is good and the collabortative process is not, it should go forward and you should tell them how to fix the collaborative process. They just need a little extra help with that. I was concerned about the weighting for this reason.

The second quotation is especially important because it expresses a view that we have encountered from many different people since we broached the idea of putting process on an equal plane with the scientific product. Often, people are very willing to converse about the importance of collaboration and integration, but they react strongly against the notion that quality science should be weighted equally to the collaborative process.

Moreover, I cannot agree with the idea that the collaborative process reviewers may not be necessary in the review process. Without a doubt, this would have resulted in much less criticism of the collaborative methods. Table 7.4 shows that of the 244 negative comments tabulated, 187 of them (77%) came from the collaborative process reviewers. These comments point to another interesting aspect of this comparison of two sets of reviewers from two different worlds. Two out of six applied science reviewers (33%, albeit of a very small sample size) were not convinced of the need for their collaborative counterparts. In contrast, none of the collaborative reviewers expressed the opinion that the applied science component wasn't necessary.

This lack of awareness or respect for the other sector's expertise arose in another aspect of the review process. Both the applied science and collaborative process peer reviewers were invited to comment on all the criteria, not just the criteria that corresponded to their expertise. In going through the peer reviews, we noted that, quite often, the collaborative process peer reviewers either declined to comment on the applied science methods, or they included a caveat such as "…but this isn't really my area of expertise." In fact, of the 29 collaborative peer reviewers, 12 of them (41.3%) made that choice. On the applied science side, only 1 of 58 reviewers (1.7%) made an analogous comment. This also suggests that one group of reviewers has a much greater awareness of the other group, or at least a greater respect for their singular knowledge on a certain subject.

Some of the comments from the collaborative process peer reviews seemed to be a reaction to this lack of awareness, which they perceived in the way certain proposals were written.

> In this regard, the proposal shows no understanding of the literature on collaboration, the barriers to collaboration, or a specific method to undertake a meaningful collaboration with a broad range of stakeholders. A great deal of research has been done on this, but the PIs appear to be unaware of it. (Imagine if the reverse was true, with social scientists proposing a well articulated collaborative process and saying that science will inform it, without showing any knowledge of the science. Would this be funded? I assume not.)

> Yes they have a study likely to be fine when it comes to understanding and applying the natural science developed in this project if the only people involved in the project and implementation were natural scientists. The crippling problem here is the lack of attention and understanding of social science and the collaborative design, process and leadership literature.

One heartening result from the interviews was a clear interest on the part of both kinds of peer reviewers to learn more about how the other side saw the proposals. As noted earlier, three of the six collaborative process reviewers suggested that the peer reviewers not write in a vacuum but rather have a chance to hear the other perspective. Two of the six applied science peer reviewers echoed this sentiment. In fact, the quotation below is from the same reviewer who noted that there are "no more ivory tower scientists."

> I would like to see the results of your RFP process to see if I was off. I'd like to know if my opinion was similar to the other peer reviewers and compare the collaborative reviews with the [applied science] reviewers.

This feedback suggests that, while biophysical and collaborative process experts may see the world in very different ways, there is a willingness to learn from each other.

6 The Packard Foundation: Compare and Contrast

At the outset of the article, I introduced the central problem of how funding organizations can respond to numerous calls for change by better braiding the rope (see Fig. 7.1). In order to address that question, we used the analysis of our RFP and review process to better understand why collaboration adds value, what collaboration consists of, and how funding organizations might begin to put ideas into practice. The salient ideas from our analysis of peer reviews and peer review/program manager interviews can be found in Table 7.5.

Breaking down what is meant by an appropriate process is critical because the funding organizations that have been the target of many injunctions to change can be broken down into three general categories: (1) those who are making significant efforts to change; (2) those who don't think change is really necessary; and (3) those who think they've made the appropriate changes, but perhaps have not. In some respects, this last group warrants the most concern, for two reasons. They create the false impression that efforts are underway to address identified gaps. Secondly, if they are not aware of best practices, a failure on their part can be attributed to the theory, when in fact the fault could lie with the implementation.

At the beginning of this chapter, I laid out a simplistic mental model with two options for addressing the principles prescribed in the "Informing" report: Option (1) Ask for teams of information producers and decision makers to submit plans to work together…and then use a separate step – after the review stages – to bring process experts into the picture. Option (2) Ask for teams of information producers, decision makers and process expert – all up front – and review the proposals according to the evidence that they can balance the information production side with the process requirements side.

Table 7.5 Synopsis of lessons learned from peer review

Why conduct collaborative science?
– More science links to decision making
– More interactions between producers and users of knowledge leads to a society that is more capable of living sustainably
What constitutes collaborative science?
– Detailed plans, created by experienced practitioners with specific training, to create an environment in which producers and users learn from each other
– Learning occurs at every step of the research process…including the problem definition stage
– Interactions are planned so that they acknowledge any values-based, socioeconomic and other barriers that can prevent the science from being used
How should funding organizations foster collaboration?
– Involving different disciplines in the review process is a must
– Efforts should be taken to allow reviewers and panelists with different perspectives to learn from each other

Note: The above process needs to take into account the possibility that natural and social scientists as well as collaborative process experts will see the world in very different ways

You have just read a case study implementation of Option 2, which has potential advantages and disadvantages. As alluded to earlier, the NERRS Science Collaborative shares its theory of change with the Science and Conservation Division of the Packard Foundation, a private philanthropic organization based in California (Packard 2010). Like the Collaborative, Packard invests in projects of up to 3 years, and, like the Collaborative, Packard began a new approach to funding research in 2009. Packard plans to continue on its chosen course for several years before taking stock, assessing gains made, and determining how to adaptively manage its program in the future. In contrast to the Collaborative, however, Packard has gone with Option 1.

(I am grateful to Kai Lee of the Packard Foundation for the time he took to discuss the ideas below with me).

Rather than attempting to frontload its projects with process experts, the Packard foundation instead is using a much more iterative approach with its grantees. Packard works with applicants to make sure that the team involves both information producers and the appropriate decision makers, and that some effort has already gone into learning about the needs of those decision makers. Packard then works with the applicants to collaboratively establish expected deliverables, depending on the goals of the project. Packard has created a template of "elements" and "questions to guide monitoring" as part of its "Linking Knowledge with Action" strategy (Packard 2010). For example, one of the elements relates to the joint production of knowledge. Potential monitoring questions within that element include: "Does knowledge process secure effective collaboration from decision makers, stakeholders, and researchers?" "Do potential users believe that the information process took account of concerns and insights of relevant stakeholders and was procedurally fair (Legitimate)?" Significantly, Packard builds into the process funding gates that allow it to terminate funding if it is shown that the research team is unable to achieve the collaboratively established milestones.

With regard to process expertise, this is something that Packard can introduce as is appropriate as the project matures. This can either be done through outside contractors or through Packard's program officers. In either case, Packard strives for these process people to be accountable to both the research teams as well as the funders. This joint accountability of third-party "integrators" or "boundary spanners" has been found to be critical for linking knowledge with action in that it avoids the common problem of the integrators being "captured" by either information producers or users (Clark 2008).

From our perspective, the approach being tried by Packard has many attractive elements. It is possible that the potential disadvantages of the Collaborative's approach could be avoided with the Packard paradigm. The most significant potential disadvantage is that some or all of the seven funded projects – though they were reviewed most highly within their cohort of proposals – may still not be strong enough with regard to collaborative processes to have a net positive impact on the intended users. How could this happen? Although we hope this is not the case, it is possible that the Integration Leads for some of these projects are not sufficiently experienced – or enabled by the rest of the team – to manage the process sufficiently well. After all, this is a new and innovative approach to applied science. We have

seen – and other funding organizations have also seen – instances in the past where applicants succeeded in writing convincing proposals but then were either unable or extremely challenged to implement their planned activities. As noted by one of the collaborative process reviewers, a poorly planned and implemented collaborative process can be worse than no collaborative process at all.

Another disadvantage relates to the joint accountability discussion above. The role of the Integration Lead in our process is to balance the perspectives of the different actors in the system. But powerful personalities can easily overwhelm an Integration Lead, which is a newer and less understood role than the traditional principal investigator (Clark 2008). It could be that the Packard model is a more effective way to mitigate traditional power struggles that occur in research endeavors.

Another potential disadvantage is that relying on process experts is risky if different parts of the country seem to have a greater abundance of them than others. A scientist from the Gulf of Mexico asked me for help in finding someone with experience in overseeing a collaborative (participatory) process. After several hours on the Internet and several calls to other collaborative process experts, I was only able to turn up one person within a 2 h drive of the scientist's lab. (In contrast, the Great Lakes and areas in Canada seem to have almost an over-abundance of collaborative process experts). I then spoke with an extension agent from one of the Gulf states, and described the type of person I was looking for. He replied that extension agents could certainly help with the on-the-ground facilitation and connection to decision makers. However, with regard to someone who could direct the whole process more holistically, he was less able to help. He also noted that the kind of people I was talking about tended to make intended users a little uneasy, as if they were study subjects rather than people. Ideally, he noted, the collaborative process team would have a holistic person in the background and an extension-type (or NERRS coastal training program coordinator) as the familiar face of the project.

A final disadvantage is the risk that the process burden involved in our approach may intimidate and scare off applicants, and these could be applicants with strong relationships with decision makers as well as a track record of producing highly credible scientific information. We have seen some evidence of this "intimidation" happening within the Reserve systems; some potential applicants read our RFP and elected not to pursue funding because they found the process difficult and/or alien. In contrast, such applicants could find the Packard approach more welcoming in its incremental and iterative introduction of the process deliverables.

Of course, there are potential advantages to the Collaborative's approach as well. If proposals are diligent in bringing together the proper resources and expertise early, projects will get off to excellent starts, with problems being clearly and collaboratively established with the appropriate stakeholders at the proposal stage. As discussed earlier, getting the problem right is critical. The famous statistician Tukey is quoted as noting, "Better a poor answer to the right question than a good answer to the wrong question." The importance of getting the problem defined collaboratively is also stressed in many of the NRC reports on creating

decision-relevant knowledge (e.g., NRC 2006, 2007). In addition, interactions will waste no time establishing good working relationships between project investigators and target audiences, increasing the relevancy and legitimacy of the research (Cash et al. 2002, 2003).

Another potential advantage is simply the opposite side of one of the disadvantages: the risk of being thrown into the deep end of the pool. Yes, one may sink, but one may also get some good practice swimming. Because of the shortage of funding for applied science, we have seen some teams take on the challenges associated with building interdisciplinary teams – including process experts – despite considerable reservations. Before awards were announced we heard from several teams that they had seen tangible benefits that would have lasting impact…even if their proposal was unsuccessful. For example, one staffer at an East Coast Reserve noted that, since the release of the RFP, the Research Coordinator and the Coastal Training Program Coordinator had greatly improved their working relationship and had already collaborated on other proposals as a result. In addition, we have heard from several natural scientists that, since working on collaborative projects (including previous RFPs), they have changed their attitudes regarding the involvement of facilitators and collaborative processes in general. One research coordinator noted, "Natural scientists may not enjoy these collaborative processes, but they do enjoy seeing their science get used more." (J. Fear, 2010, personal communication).

Finally, we have seen a significant increase – from all sectors in the Reserves – in requests for information regarding collaborative processes, since the release of this RFP. Below are two of many quotations regarding the influence of the NERRS Science Collaborative on attitudes regarding integrating natural and social science within the Reserves. These quotations come from survey and interview work implemented as part of a dissertation project (Robinson 2010).

> The NERRS Science Collaborative is really going to help going a long way toward breaking down some of those barriers where people can start to see the benefit of integrating the social sciences and natural sciences

> So, if the RFPs that are put out request that you need to incorporate social science, that probably is going to happen because otherwise you're not going to get funded....that definitely has influence of how you plan or conduct your research…that's something we've seen within the NERRS system now with the science collaborative.

Of course there are more ways to braid the rope than the ones exemplified by the Collaborative and Packard. One hybrid approach between the two extremes is to have the process reviewers make concrete suggestions to the funders as to how much continued oversight a project will need to adequately deal with process issues (P. Stern, 2010, personal communication). Also, as we have discussed, some NSF, NOAA and other programs are implementing innovative approaches to better linking science with action. For example, a program within NOAA called CSCOR (Center for Sponsored Coastal Ocean Research) tasks their program managers to work with project investigators to set up "management advisory groups," which make suggestions on how to modify and package scientific activities to maximize research utility. This requires a great deal of effort on the behalf of program

managers (E. Turner, 2011, personal communication). For more information on other innovative programs, see the "Informing" report, to which we will now turn our attention in a more focused manner, in order to put the lessons learned from this study into a broader context.

7 Adding Empirical Resolution to NRC's Guidance

The goal of this chapter is not to determine one superior paradigm but rather, through the analysis of the Collaborative's RFP as well as the comparison with the Packard approach, to add some pragmatic granularity to the principles that have been espoused by many reports and publications, especially the "Informing" report. Below, I go through each of the report's principles in turn and add corollaries related to how a funding agency might approach implementing the suggested ideal. This is not to suggest that the report is deficient. In fact, if all this chapter accomplishes is that more people read that report, especially Chap. 2, it will have been worth the ink and the paper.

Some might protest that the NRC report was written explicitly for climate change, and not all decision-relevant science is addressing that particular issue. True, but the issues that make climate change so challenging – e.g., scale issues, human values, dynamism of the problem – are common to most "wicked" problems (Rittel and Webber 1973) in which the cause and the solution involve the human dimension.

In reviewing the six principles below, everything in normal print is paraphrased from Chap. 2 of the "Informing" report. Everything in italics relates to lessons learned from our analysis.

1. Begin with user's needs
   - One-time, sporadic efforts DO NOT qualify.
     - *Our case study would seem to add that efforts—no matter how frequent the interactions—that are not well thought out, could also fail to produce the desired results.*
   - Relationships are key.
     - *This was confirmed in our independent case study.*
   - Communication must be two-way.
     - *Again, independently confirmed in our case study.*
   - Trust building should be a goal of the interactions.
     - *Our case study showed that having explicit goals for the collaborative process is sometimes neglected, especially when process experts haven't been consulted.*

- It is especially critical to define the problem collaboratively.
  - *For funding agencies, this is logistically challenging, with potential trade-offs associated with the Collaborative's approach—trying to build a full team, with process experts, from the beginning—as well as Packard's approach, which relies more on iterative guidance from the funder. Think carefully about this part of the process.*

2. Give priority to process over products
   - Poorly managed interactions between information producers and users will decrease connections between science and decision making.
     - *Confirmed in our study.*
     - *There is confusion around who and where the experts are to help us avoid poorly managed interactions. As noted earlier, some folks in extension and Sea Grant have the skills, but some of them do not. Also, some parts of the country may seem to be more rife with these practitioners than others.*
     - *The good news is: these people are out there. The bad news is: they may be underutilized and, as they become more utilized, we may find as a society that we need more of them.*
   - Dedicated time and expertise within the research project are required.
     - *See above.*
     - *May want to consider contingent funding, establishing clear deliverables and striving for joint accountability for the integrators.*
     - *Plan and prepare for resistance to the process emphasis. Our case study points to the possibility that many in the scientific community do not see the need for process expertise.*
   - Develop a culture of learning among participants.
     - *This point can cause confusion in an agency's strategic approach. As shown earlier, some may interpret "decision-relevant knowledge" as meaning that the research was used to support one decision, and maybe even one decision maker. Another perspective is to maximize relationship building and learning through the conduct of the research. These are important distinctions and would have important ramifications for how RFPs are written and metrics established. Make sure your colleagues are on the same page with regard to this.*
   - Leadership is critical.
     - *Power in a research project is often left unaddressed. We tried to address it with an Integration Lead; Packard addresses it through continued involvement and joint accountability of certain team members. This requires careful consideration, especially given the history of science policy in the United States (Stokes 1997), which has been discussed in other chapters in this book.*

3. Link information producers and users
   - Boundary organizations can be helpful in bridging different disciplines.
     - *Our study certainly found evidence of silo-based thinking getting in the way of producing decision-relevant science.*
     - *Again, does one try to build the boundary spanner into the competitively granted projects or put more resources into managing the process from the funder side?*
4. Build connections across disciplines and organizations
   - It takes time and care to collaborate between scientific disciplines, between funding agencies, between information producers and users. Yet if we don't take these steps, the science will have less chance of linking to decision making.
     - *Addressed earlier.*
   - It is also important to build connections between scales, so that national assessments and research can be made relevant at the local level and vice versa.
5. Seek institutional stability
   - Collaborations take time. This doesn't require institutionalization of new efforts, but that can be helpful.
     - *As noted earlier, we have seen reports that Reserves are adopting the approach of "always collaborating" so that they can take advantage of RFPs when they arise.*
   - Extension funds provide some resources and institutional stability.
     - *We have found this as well although the familiarity with collaborative process methods varies from place to place. In some cases, resources and personnel may need to augmented, or existing personnel may seek additional training.*
     - *As part of the Collaborative, the University of New Hampshire is piloting a new curriculum to train Masters students and full-time professionals in the skills required to direct a collaborative process.*
6. Design processes for learning
   - Points in this section have been addressed above.

8 Conclusions

This chapter has presented qualitative research data on the subject of applied research in our science funding agencies. It is my hope that some program managers who have been seeking explicit advice on how to improve how they foster decision-

relevant science will find helpful material within these pages. No doubt, some program managers will read this chapter with a healthy dose of skepticism. As well they should. This is one case-study, after all, and generalizing observations from one case study to other contexts must always be done with caution, whether the research is qualitative or quantitative. Some may react that this paper is full of subjectivity. Although I have tried to present alternative theories and explanations, I have to admit to my bias; there is no doubt about that. In 2005, after 7 years of funding applied science, what I saw was that highly credible work was simply not being used because we had ignored issues related to relevance and legitimacy (Cash et al. 2002). Yes, I know that research impacts are famously difficult to track and it may take years before seeds of knowledge begin to sprout results (Tornatzky and Fleischer 1990). However, our program and many other programs like it are not only meant to solve the problems decades from now. Much of our research is actually supposed to help create solution alternatives in the near future. It is with respect to that aspect of our mission that this chapter is addressed.

I close by again asking: whether you agree with the assumptions in this chapter or not, why is so much good science not being used by decision makers? And why have we been so slow at the national funding agency level in changing our culture? Is it because our natural science and engineering products aren't good enough? I think we have to admit that it is possible that some of the questionable assumptions we saw in our study – relating to how science leads to decision making and what expertise must be engaged to produce decision-relevant knowledge – exist not only within academia and other stakeholder groups, but also within the relatively small cadre of scientists and policy makers who set science and policy strategies in this country. If that is true and if left unaddressed, it may be difficult to improve our theory of change and the way dollars are allocated to address environmental challenges.

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