Communicating Scientific Information for Environmental Solutions: A Knowledge Management Perspective

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Introduction

A recent editorial in *Nature* (2010) stated "Scientists … can and must continue to inform policy-makers about the underlying science and the potential consequences of policy decisions …" (p. 141). The editor's statement emphasizes the importance of communication between scientists and policy makers so that the most credible and timely scientific information is brought to bear on decisions on global issues. Current environmental concerns, such as climate change and the health of the world's oceans, require strategic and informed policy responses. Environmental information, which could be used to help to solve the world's environmental crises, is growing rapidly in quantity. A sizeable portion of this information is published as grey literature, a genre of publication that can transmit knowledge to both scientific and policy making communities (Gefland, 2000). Grey literature is simply defined as "that which is produced by all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers" (Third International Conference on Grey Literature, 1997, iii). Though some types of grey literature are subject to rigorous peer review reflective of high quality research, use of grey literature can be hindered by misconceptions that its quality is low. Further, the massive volume of information available today creates challenges for achieving awareness of specific publications.

Intergovernmental environmental organizations, which often publish grey literature, produce thousands of scientific publications with policy implications in print and digital formats. The production, distribution, and use of this information has been understudied (MacDonald, Cordes, & Wells, 2007; McNie, 2007), which is a matter of concern for managing scientific knowledge, specifically in policy-making spheres. This paper presents findings from a study of the Gulf of Maine Council on the Marine Environment (GOMC) which has a complex governance arrangement guiding its publication practices. The conclusions highlight the complex life-cycle of scientific grey literature produced by this organization and sets out knowledge management implications arising from this research.

Background and Literature Review

Research documentation on grey literature, the structure and function of intergovernmental organizations, dissemination practices for communicating information, and assessment of the gap between scientific information and its use in decision-making reveals a number of challenges in communicating scientific information to relevant stakeholder groups. To date, much of the research on the use and influence of grey literature has relied on citation analysis (Hutton, 2009; Kousha & Thelwell, 2007; MacDonald, Cordes, & Wells, 2004; MacDonald, Cordes, & Wells, 2007). This method of analysis provides one quantifiable measure of use, but does not tell the whole story. Other methods are needed to determine the influence of grey literature in policy and decision making contexts. Though the current research literature does not often address other methods of analyzing use and influence of grey literature, it

does point to existing gaps between science and policy and strategies to deal with the problem. At its most basic level, grey literature is defined as any document not published by commercial publishers. In some instances, this literature is prepared "via thorough refereeing and review" by qualified experts (MacDonald, Cordes, & Wells, 2004). The Online Dictionary for Library and Information Science describes grey literature more comprehensively as: "Documentary material in print and electronic formats, such as reports, preprints, internal documents (memoranda, newsletters, market surveys, etc.), theses and dissertations, conference proceedings, technical specifications and standards, trade literature, etc., not readily available through regular market channels because it was never commercially published/listed or was not widely distributed" (ODLIS). The Dictionary notes grey literature may lack editorial review, which could influence its reliability. MacDonald, Cordes, and Wells (2004) suggest that because firm publishing rules do not govern grey literature, organizations like the Gulf of Maine Council on the Marine Environment "are not constrained in its dependence on this genre" and little attention may be paid to whether reliance on this genre is effective in fulfilling the mandates of organizations (p. 26). The proliferation of grey literature emphasizes the merits of further study of this genre in cases like the Gulf of Maine Council on the Marine Environment. As an intergovernmental organization, GOMC has the ability to transcend the Canada/United States boundary to manage and sustain the complex ecosystem that is the Gulf of Maine/Bay of Fundy region. Members of the Council represent governmental organizations at state/provincial and federal levels. GOMC maintains ties with the academic community, industry personnel, as well as a number of NGOs, which makes it ideally situated to act as a communication hub within the region, facilitating important discussion and funding important research on the Gulf of Maine.

Biermann and Bauer (2004) suggest that intergovernmental groups, which can act as conduits between different levels of government, different agencies within governments, and different educational and outreach groups, have a significant role to play in the dissemination of important environmental science research. The Gulf of Maine Council on the Marine Environment (GOMC) is just such a conduit. As questions regarding the state of the environment become increasingly important to answer, communication of scientific research on these matters grows in significance. A better understanding of the production, distribution, and use of the marine environmental grey literature published by GOMC will provide insight into the flow of information and current barriers hindering communication between groups involved in public policy, ranging from the general public to decision-makers.

The challenge GOMC faces in the dissemination and salience of its information is not uncommon with grey literature (McNie, 2007), a genre that has had to contend with many misconceptions about its quality (Farace, 1997). Traditionally, scholarly journals produced by commercial publishers and professional organizations have been the primary venue in scientific communication and are often considered the "gold standard" in research due to peer review and rigorous editing. It is clear, however, that recent trends in scientific publishing do not adhere to traditional publishing practices alone (Renear & Palmer, 2009). The current movement to open access journals and institutional

repositories is spurring researchers to turn to alternative publishing methods in order to place their findings in the hands of readers (Cronin, 2005; Borgman, 2007). This movement lends support to publishing in the grey genre.

Not only do misconceptions about grey literature still prevail (Farace, 1997), but also challenges in trying to bring the fields of science and policy-making closer together continue (Holmes & Savgard, 2008; McNie, 2007). In the face of unprecedented environmental problems, finding a means to bridge this divide is becoming increasingly important. With the current glut of information questions of what constitutes the "right" information and how scientific research can respond more effectively to the environmental policy concerns come up again and again (Lexmond, 2002; McNie, 2007; Mitchell, Clark, & Cash, 2006; Nutley, 2003). Intergovernmental organizations could offer answers to these questions. Not only do these organizations produce and consume information, they can also act as knowledge brokers, opening the lines of communication between different stakeholder groups, translating science into lay language, and serving as a venue for policy discussion (Biermann & Bauer, 2004; Donaldson, Eden, & Walker, 2006).

Understanding of the production, distribution, and use of GOMC's publications and their potential impact on public policy is based on assumptions about scientific communication and biases in publishing practices that need to be identified, questioned, and in some cases replaced by current social and technological realities (Hutton, 2009). Interviews with key GOMC informants document dissemination pathways of the Council's grey literature, assess barriers to the flow of information, and act as a baseline to begin to understand how scientific grey literature can influence public policy and facilitate information exchange across disciplines.

Methodology

The Gulf of Maine Council's 21-year history began in December of 1989 when the premiers of Canadian provinces of Nova Scotia and New Brunswick and the Governors of the American states of New Hampshire, Massachusetts, and Maine came together at the inaugural conference in Portland, Maine to discuss the potential of bi-national cooperation to deal with the environmental degradation of the Gulf of Maine/Bay of Fundy region (MacDonald, Cordes, and Wells, 2007). A working group, several high-level committees, and task forces carry out the work mandated by the Council (MacDonald & Wells, 2009). GOMC is an excellent case study organization because of its prolific publishing practices (over 300 publications to date) and attention to the communication and dissemination of marine environmental information to managers, policy-makers, non-governmental groups, industry leaders, and the general public. The organization continues to face issues of information dissemination, which could potentially limit the influence of its publications in policy spheres of the various jurisdictions.

Interviews for this study were conducted with Members of the GOMC Working Group. The Working Group, which reports to the top level of the Council (ministers, deputy ministers, commissioners, and other managers), was selected because of its Members' active nature and experience with the Council, their knowledge of the working processes and projects of GOMC, and their direct involvement in decisions about projects that resulted in

publications. The Working Group includes a representative for each state/province and federal government, as well the Canadian and US co-chairs of each of the Council's committees.

The following steps were taken to obtain and conduct an analysis of the data: 1) develop an interview protocol; 2) obtain ethics approval from the Dalhousie University Social Sciences and Humanities Research Ethics Board to conduct the study; 3) invite all current and selected previous Members of the GOMC Working Group, via emailed letter, to participate in the interviews; 4) interview nineteen Working Group Members, representing all levels of jurisdiction in the Council, i.e., provincial/state and federal representatives from both Canada and the United States. The participants included both men and women and long-standing as well as newer Working Group Members; 5) audio record all of the interviews; and 6) prepare transcripts of the interviews and employ NVivo qualitative data analysis software to aid in coding and analysis of the data.

Analysis of Results

Production

Since Hoornbeek (2000) noted that decisions made in the production phase of the publication process often decide the success or failure of a publication's dissemination, interviewees were asked how GOMC's current publication process worked. Their responses showed that understanding and opinions about the production of information were fragmented. Though some agreement about some aspects of the process occurred, a consensus about how and when those activities took place was not present. Figure 1 encompasses views from all of the interviewees, and confirms there is no single path from idea to publication. Ideas for a publication may originate in a variety of contexts ranging from expressions by an individual, to discussion in a meeting of a committee, a subcommittee, the Working Group, or the Council itself. The complexity of the production process was highlighted by one Working Group Member who stated: "There's a review process that's currently hard to figure out how to work with…it's just the processes seem wacky right now" (Working Group Member Q).

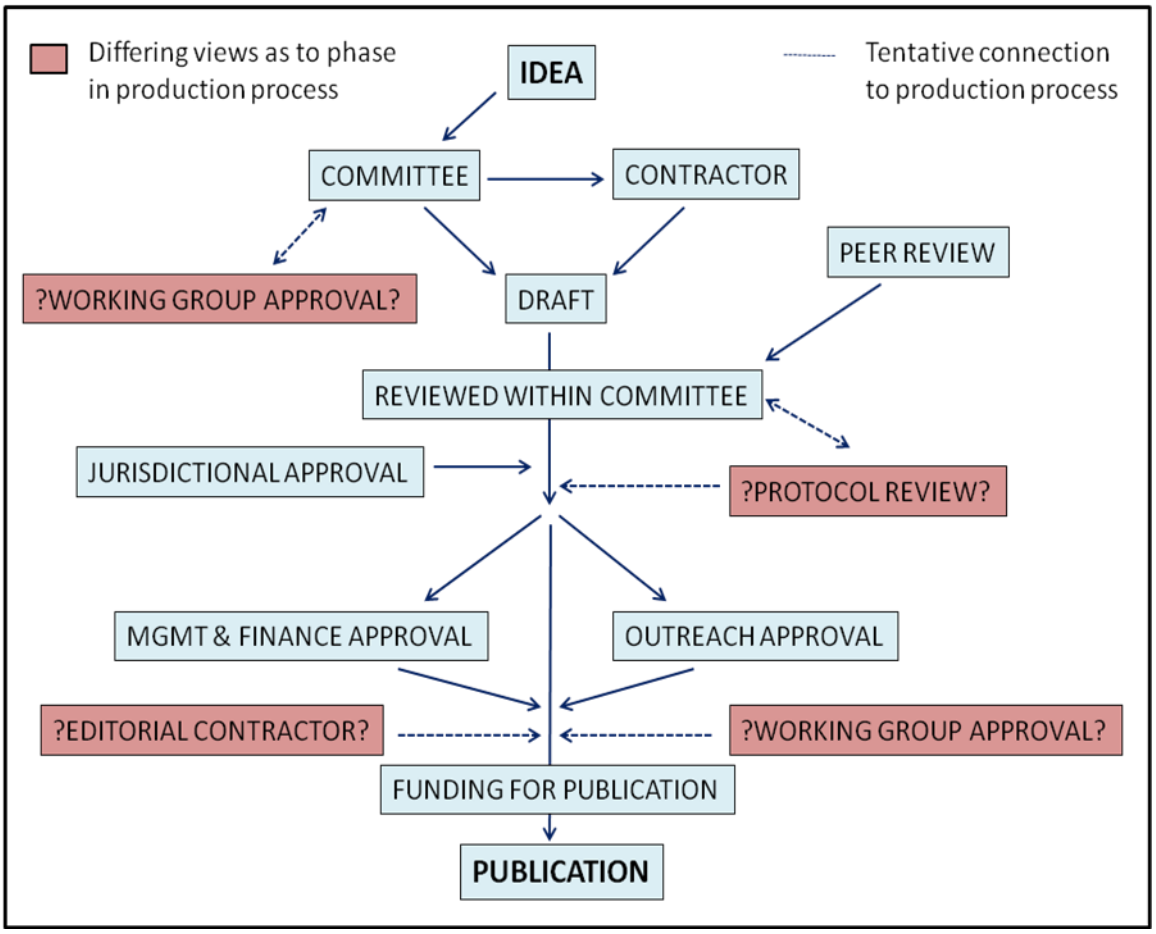

Figure 1. Steps in the Production Process Identified by Interviewees

No matter which path is followed as an idea moves towards publication, Working Group Members agreed that: 1) preparation of a publication is an iterative process, i.e., "...you know there was a lot of back and forth in getting that approved" (Working Group Member N); 2) each publication requires extensive input and collaboration, i.e., "...then there was lots and lots and lots of input from lots of people...who helped to provide content....that's true of almost all of the publications that I've been familiar with..." (Working Group Member D); and 3) each publication receives multilevel approval and possibly peer review, i.e., "A publication will be referred to ...the Management and Finance Committee ... and the Outreach Committee..." (Working Group Member R).

Though the Council handles a number of the aspects in the production process well, there is no certainty that consistency in publication practices occurs. Working Group Member M described the process as inefficient: "I must admit I'm not completely convinced that all the mechanisms that we're trying to use ... are working the way they should," and Working Group Member L described production as inconsistent: "...I would say like most organizations it's serendipity. It is the individual who helps put a report together, thinks of ways to disseminate it, in creative ways, in ways that might be responsive to the target audience."

Distribution

Over the course of conducting the interviews, it became clear that the publications of GOMC were distributed in multiple ways, with no one set strategy governing where each document should be sent. Every interviewee agreed that both the Council and Working Group "... definitely have a role, [though] sometimes it's not as carefully followed" (Working Group Member S) and no guidelines or methods for distribution are used, a pattern stressed by Working Group Member F who said rather boldly: "I don't think there's a really formalized method you know." The multi-jurisdictional character of GOMC contributes to the absence of either a formalized or single approach to distributing both print and digital publications. Nonetheless, a variety of methods are employed, if not always applied in every instance.

The informality of dissemination allows Working Group Members to be creative in how they promote awareness of publications. Working Group Members have been able to develop their own methods of dissemination that worked best for them, which ensures publications are distributed to personal networks of stakeholders. When publications were produced mostly in print format (prior to funding constraints and the Web as a primary means of distribution), Working Group Member E reported that dissemination occurred by "lugging a box of publications around and handing them out to everybody." Digital publications have presented a new means of distributing copies. For example, Working Group Member Q noted that she emails publications to organized lists of personal and professional contacts.

Personalized methods meant that many types of distribution were used by the interviewees (see Table 1). The most frequently used type of distribution was emailing or forwarding a publication to an interested individual, which was employed by virtually every Working Group Member. Member I referred to himself as an "aggressive forwarder," which described his practice of maximizing personal networks to pass on copies of GOMC's publications. Since GOMC's publications are available online, forwarding publications by e-mail is easily accomplished and is the most popular dissemination method.

Types of Distribution	**Working Group Members**
At meetings or conferences	A, D, H, I, N, O, Q, R
Based on an interest in the subject of a publication	B, D, E, F, J, K, O, P
By agencies within each jurisdiction (print copies only)	C, D, H, K, L, N, P, Q, R S
By GOMC Councilors	E

By Members of the producing committee	A, E, J, K, M, Q, S
By Members of the secretariat	M
By serendipity	L
By Members of the Working Group	E, R
Emailing or forwarding a publication to a user	B, C, D, E, F, I, N, O, P, R
Person-to-person (handing a document to another person)	B, E, H, N, P
Putting a publication on the Web site	C, I, J, O, S
By internal and external marketing or advertising	H, K, Q, R
By the postal system (mail)	F
Via a library (using a library as a point of access)	J, P
Word of mouth (talking about information in documents)	D, E, G, H, M, S

Table 1. Distribution Types Identified by Working Group Members

Some Working Group Members expressed concern that heavy reliance on informal distribution contributed to weaknesses in the process. Working Group Member R stated that the question of a distribution role was an "excellent" one since "we've run up against this with everything that we've tried to do all the way up to right now trying to get the word out about the *Gulf of Maine Times*." In her view, the distribution process was "hit or miss." In fact, occasionally many copies of some of GOMC's publications never made it beyond the storerooms of Working Group Members. Member D, for example, recounted that when his office moved "about five and half years ago... [he] purged literally dumpster loads of old Gulf of Maine Council documents." Even now that publications are posted on the Council's Web site, one Member classed this distribution "as sort of a minimal, minimal access..." (Working Group Member M). He was "not convinced that that was enough..." Another member summed up the concern as follows: "I think ... that sometimes we might print one thousand copies of something and when those thousand copies are gone we conclude that we were successful in disseminating the report" (Working Group Member L).

Use

Responses indicated that Working Group Members were very interested in evidence of use of GOMC's publications as a means of showing "the benefit of the Council" (Working Group Member K), but that they infrequently provided explicit examples of use. Working Group Member D had difficulty answering a question about evidence of use, and stated "I mean it's really hard for me to answer the question just because I don't remember how many times somebody has said to me [that he/she used a publication]…" While Working Group Members believed that awareness of GOMC publications was high among the sizeable number of individuals associated with the Council, the degree to which that awareness extends beyond those individuals was a matter of interest but uncertainty. As one Working Group Member phrased it, "...normally it's just off [the publication] goes, it could have been deleted, it could have been read, it could have been valued, I don't know...we all push a lot of information out there and hope it... sticks or its relevant or its used" (Working Group Member I).

Interviewees identified several types of use, the most prevalent being citations to GOMC publications by other reports (see Table 2). Working Group Member Q explicitly identified cited publications:

> Q: I have seen a number of reports that have been done by the US Geological Survey on aquatic habitats and such issues, which quote the Gulf of Maine Council reports like *Eel Grass*… and the *Salt Marsh* [*Monitoring Protocol*] one, those get used frequently along with the *Tides of Change*… they are part of a scientific discourse about, um, restoration and conservation efforts.

Other Working Group Members who mentioned citations knew that the GOMC reports were cited "quite a bit" (Member S), but most respondents did not provide details. Frequent requests for some publications and their application in educational contexts (the Gulf of Maine poster showing ocean currents, for example) suggested to Members that the publications were being used (Working Group Member K).

Types of Use	**Working Group Members**
By faculty at universities in the Gulf of Maine region	K, L, R
Cited by other reports	E, O, P, Q, S
By agencies with which the author(s) of a GOMC publication are affiliated	J
By industry or government	C, F, R
In legislation	D, F, S

By not-for-profit organizations	L
By individuals reported by word of mouth by colleagues outside of GOMC	A, K, N

Table 2. Types of Use of GOMC Publications

The next most common types of use of GOMC publications were use by industry or governments, in legislation, by universities, and by individuals who provided word of mouth accounts. Interviewees provided specific examples of use by industry and government, as well as use in legislation. For instance, Working Group Member F mentioned "snippets" from a GOMC publication on barrier removal (e.g., causeways or culverts) was employed in current projects, and noted that the *Stream Barrier Removal Monitoring Guide* was being used in a number of projects in one province and was being reviewed for a dam removal project in its initial stages. In another case, Working Group Member D stated that the *Gulf of Maine Salt Marsh Restoration Monitoring Protocol* was embedded in New Hampshire legislation to require research grant recipients conducting a restoration project ensure their grant was compliant with that protocol.

Specific examples of use, like those provided by Members F and D, were rarely given by interviewees. Instead, vaguely described use of publications by universities were mentioned (Working Group Members K, L, & R), or Working Group Members stated they noticed publications on the office bookshelves of a colleague (Working Group Member E). Although GOMC's mandate includes a public education and outreach component, only one Working Group Member mentioned use of its publications by not-for-profit groups (Working Group Member B), and none of the interviewees provided examples of use by the general public. Use of publications by these latter types of groups is particularly difficult to determine because extensive follow up with potential stakeholders is required to decide if GOMC publications were deemed useful. Even if use and influence is known at some levels, determining a publication's ultimate use in policy decisions is difficult to assess. Working Group Member K emphasized this issue concretely:

> K: we have a five or six page handout on [the] American Eel...and its status in the Gulf of Maine. So, I gave that to our pelagics advisor, fisheries advisor, and he found it very informative, a good synopsis and was quite impressed with it ... now he never told me like that changed how I[he] recommended to the minister what our position is on it ... but he found it informative in terms of getting his knowledge, in terms of playing that role as an advisor to the minister on that issue.

Though Working Group Member K knew that the pelagic advisor was influenced by *American Eels,* he did not know what impact, if any, it may have had beyond that point. Interest in learning more about whether GOMC's publications are used and what influence they have is high among Working Group Members. One interviewee succinctly stated,

"you'd think a twenty year old organization would have done more evaluation of the use of its publications...I don't think we've evaluated [use] in the past and impact of any kind of our publications, which is a huge problem" (Working Group Member N). This view was echoed by Working Group Member L: "certainly we have no evaluation procedure, we have no rigorous tracking procedure."

Conclusions

The Life Cycle of Scientific Grey Literature

Intergovernmental bodies often see their primary responsibility as offering solutions to problems through the production of expert information and publications. Through analysis of the interviews with Working Group members a deeper understanding of the path scientific information takes as it moves through the publication process has been developed. Though interviewees' understanding about the production of information is fragmented, they verified that many of GOMC's publications receive multiple levels of peer-review, which confirms that some types of scientific grey literature are rigorously reviewed much like the primary literature and largely undeserving of the stigma which marks them as poor quality. In fact, only one interview commented at all on the perceived low quality of grey publications. Working Group Members were less concerned about the publication genre and more concerned that adequate attention was being paid to promoting awareness of GOMC information to potential users. Working Group Member M made this perspective clear when he said: "I think there are enough mechanisms that the information can go in, it can be stored, and it can be accessed. I think the challenge is that next step that we talked a bit about, which is how do you then apply it, how do you then draw it in to other conversations?" In Member M's view more effort needs to be focused on promoting user engagement with the information to increase the use of publications.

Distribution is largely achieved through the many different personal distribution methods employed by Working Group Members. Members are actively engaged in distribution, which has fostered creativity and a sense of personal pride in the work of the Council. This dynamic process highlights that no single approach to distribution is as effective as multiple and varied means; yet, some concern was raised that without a formalized dissemination strategy that targets specific individuals and organizations dissemination of GOMC information would be limited to the personal networks of Working Group Members who are already aware of environmental degradation in the Gulf of Maine/Bay of Fundy region.

Distribution of information is often constrained by insufficient material and human resources within an organization to support dissemination. Intergovernmental groups may be unable to implement communication strategies, especially when a dissemination role and appropriate personnel are absent in the organization. Once a work is published by an intergovernmental body, attention typically moves rapidly to other projects rather than allocating additional resources to advertise and disseminate publications of completed initiatives. Application of best practices for distribution and promotion of new publications may be outside an organization's general scope and interest. As a consequence, methods for tracing the use and influence of the publications are rarely put to use.

The interview data analysis identified seven types of use of GOMC publications (see Table 2), yet, specific examples were rarely provided by interviewees, indicating that use is particularly difficult to confirm because extensive follow up with potential stakeholders to enquire if they have used GOMC publications is required. Interviewee responses demonstrated that while Working Group Members were sure publications were being used, their understanding of the influence of GOMC information was limited. Interest in learning more about the influence publications have is high among Working Group Members. Interviewees suggested that GOMC has not rigorously evaluated the use and influence of information, primarily because it has not been within the capacity of the organization to do so (Working Group Member L). Adequately evaluating the influence of publications requires comprehensive study of stakeholders, a process which generally has to be contracted out and is costly for the organization.

Making GOMC information more easily visible and interpretable and its significance more obvious for required decisions and policies is a challenging task. This matter is a translation issue lying at the intersection of environmental science, communication, policy, and management (Holmes and Clark, 2008; Tribbia and Moser, 2008) and gaining an understanding of this complex activity can only be achieved by continued and evolving research.

Implications for Knowledge Management

Studying the internal organizational processes influencing the dissemination of information is closely linked to increasing application of best practices for knowledge management. Understanding the production, distribution, and use of publications (processes that are involved in knowledge management) encourages linking conclusions to further research on the influence of scientific information for management and policy decisions, which may help GOMC to measure the productivity of the organization. Publications, in print and digital formats, are one of the main means by which GOMC fulfills its mandate. Understanding the internal processes that promote publication is one of the first steps to measuring whether or not GOMC is achieving its organizational goals.

Interviewees noted specific instances where current practices were hindering adequate knowledge management. GOMC stores its meeting documentation on its Web site; however, these documents are rarely used to confirm past activities and determine what suggestions were made for future action. Working Group Member L identified meeting documents as a "vastly under-utilized resource," which has led to the repetition of ideas from year to year:

> L: I can say that like many organizations we tend to re-invent, you have a good idea this year, I have a new idea next year, it's remarkably similar to yours, but I don't really even remember that you had that idea. That re-invention process is obviously expensive, it's not very efficient and as a result [while] the meeting documents are a good source of material you would have to dig through, you'd have to know that they're there and then you'd have to make the decision to dig through them to see if there was anything relevant.

The structure of the Council, which includes a rotating Secretariat and a Working Group Chair that changes jurisdictions every year, encourages re-invention, and may fail to make use of past knowledge to support current ideas. The meeting documents, though arranged chronologically, are not easily searchable, which deters reviewing their contents to address key concerns that reoccur.

Working Group Member Q stated that the changing leadership of the Council creates challenges for promoting knowledge management efforts within GOMC:

> Q: It seems that having rotational leadership which changes annually causes maybe 6 months of trying to figure out what's going on and then 6 months of performing and then going back that way. So if you looked at organizational development which is forming, storming, norming and performing, this group goes back and forth between norming and performing.

Organizational development is partially held back by the dynamic nature of the Council's leadership, which can decrease publication activity and deter productivity. Structural barriers to knowledge management are very difficult to overcome as they are embedded directly in the constitution that established GOMC as an intergovernmental body. Establishing the capacity within GOMC to review meeting documentation from year to year could significantly promote better knowledge management practices and decrease occasional costly repetition of ideas that hinders organizational output.

This study demonstrates that Members internal to an organization can provide valuable insights regarding the lifecycle and flow of information as it moves from an idea through to release of a publication. It is clear that such insights answer not only information management questions related to the production, distribution, and use of scientific grey literature, but also knowledge management questions related to the information embodied in individuals or organizational processes that have the potential to enhance the productivity of GOMC.

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