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A First Look at the Science-Policy Interface for Ocean Governance in the Wider Caribbean Region

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Weak governance is a root cause of the problems constraining the sustainable management of shared living marine resources within the Wider Caribbean Region (WCR). Integral to any fully functioning policy cycle in governance is the communication of marine science data and information, through the stages of the policy cycle, ultimately for use in decision-making. The networks of ties between science and policy constitute science-policy interfaces. Connecting science to policy is a major issue confronting the world today in efforts to achieve sustainable development. In order to develop a regional science-policy interface for ocean governance in the WCR we must first understand what currently exists. In this paper we describe the process and product of an interview investigation of the marine science-policy interface in the WCR. Policy discussions that used marine science extensively were infrequent. Constraints on use of science included low capacity, science not being provided in policy-relevant format, not having easy access to databases, and low policy demand for science. There is little transboundary marine science information sharing except through informal social networks. The absence of a culture of evidence-based policy-making in the region must be addressed before there will be any significant change in use of properly packaged marine science. External influences, political context, science and evidence, links, and networks are used to systematize the key learning.

Keywords: Caribbean, marine, science, policy, interface

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INTRODUCTION

According to the panel of 20 distinguished scientists from around the world who consulted with 400 more during the United Nations Environment Programme (UNEP) Foresight Process on Emerging Environmental Issues for the twenty-first century, the cross-cutting issue labeled "Broken Bridges: Reconnecting Science and Policy" is the fourth most pressing one confronting the world today in efforts to achieve sustainable development (UNEP, 2012). In essence, critical scientific knowledge is not being communicated effectively to audiences ranging from decision-makers to the general public. The panel found that public confidence in the environmental science that is communicated is diminishing due to deepening distrust of scientific outputs. There is increasing resistance among policy decision-makers against easily accepting scientific advice. Climate change provides many examples (Beck, 2012). Failed communication, however, is said to be more often at the root of

the problem than real issues with the quality of the science (Holmes and Clark, 2008; Jarvis et al., 2015a). Few scientists are trained to communicate science in a way that policy makers and advisors can readily receive in order to translate information into action (Cvitanovic et al., 2015b). Some scientists do not see such communication or the correction of misinformation, masquerading as science, as their role (Rose and Parsons, 2015). When policy makers and advisors seek out scientific information, it is often inaccessible to them (Cvitanovic et al., 2014). This is an alarming global perspective, but what is the Caribbean situation with marine science and policy?

Science-policy interfaces are as important for governance of marine resources as in any other area of natural resource governance, and may be more challenging than most because of the transboundary nature of many ocean resources. Many living marine resource management issues in the Wider Caribbean Region (WCR) are transboundary in nature and ecosystem approaches must be addressed through regional and sub-regional policy processes (Fanning et al., 2009, 2011). The geopolitical complexity of the region has resulted in a complex set of ocean governance arrangements for living marine resource issues. Ocean governance encompasses diverse legal-institutional arrangements exemplified at the global level by the United Nations Convention on the Law of the Sea and its associated binding and non-binding instruments and organizations. Broadly speaking, their aim is to facilitate transboundary communication, peaceful use of seas and oceans, and sustainable utilization of marine resources within—and ocean governance is a growing global concern (Töpfer et al., 2014). In the WCR the focus of ocean governance is more on the institutional than the legal dimensions of ecosystem-based marine resource management (Mahon et al., 2010, 2014). There are over 25 different organizations involved in various aspects of the policy processes for this (Mahon et al., 2013). Consequently, the science-policy interface in the WCR comprises many entry points for the uptake of science in decision-making. Despite the significant amount of scientific research in the region in the past few decades there does not appear to be significant uptake of scientific information by the relevant policy processes (Chakalall et al., 2007).

Several factors must be understood in order to adequately address barriers to crossing the interface. For example, we need to know what policy-makers demand of marine science for it to be useful? If they received policy-useful scientific information, how exactly would it be actually used? UNEP (2012) suggests that policy makers demand minimal natural or social science mainly for legitimizing prior decisions based mainly on non-scientific evidence. However, complex decision-making arenas call for appropriate science to inform decisions and policy that allow for increasing complexity and uncertainty. However, policy decisions will seldom be based on science/evidence alone (Cook et al., 2012; Addison et al., 2015). Factors that influence how science is provided and accepted include: experience, judgment, lobbyists and pressure groups, values, resources, policy context, pragmatics, and contingencies (Jones and Walsh, 2008). To analyze the science-policy interface Jones and Walsh (2008) provide a framework that emphasizes:

- understanding the political context of the design and communication of research
- providing high quality evidence and key findings through a credible messenger
- fostering engagement between researchers and policy-makers on research products.

Policy-science interfaces have been investigated for some time. Jones et al. (2008) found that studies of developing country science-policy interfaces were scarce. Few of them offered practical strategies for improving interfaces. Consistent with their findings, there has been no major research on marine science-policy interfaces in the WCR despite the debates on data, information, decision-making, and political will at regional level meetings (e.g., Fanning et al., 2011). The science-policy interface global study by Jones et al. (2008) addressed access to research information for policy in developing countries, the science communications that policy makers found useful, and how organizations can broker communication in networks of science and policy actors. Many factors must be considered to understand information exchange among science providers, brokers and policy actors.

Our study, previously documented in a technical report (McConney et al., 2012), was carried out in the context of the Caribbean Large Marine Ecosystem and Adjacent Areas (CLME) Project which aimed to improve the management of shared living marine resources within the WCR (Fanning et al., 2013). The CLME Project Causal Chain and Transboundary Diagnostic Analyses identified weak governance as a root cause of the problems facing these social ecological systems (Mahon et al., 2013). The CLME Project therefore had a strong emphasis on assessing living marine resource governance systems and on proposing ways of strengthening them. Governance was addressed in the CLME Project using the LME Governance Framework (Fanning et al., 2009). The framework is based on nested policy processes that must be complete.

Policy cycles may function on a single level or span multiple levels of governance (e.g., national, sub-regional/regional, international/global) through linking and nesting (Fanning et al., 2013). Integral to any fully functioning policy cycle is the communication of marine science data and information, through the stages of the cycle, ultimately for use in marine policy decision-making (Grorud-Colvert et al., 2010). The networks of ties between science and policy constitute science-policy interfaces. They are "social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making" (van den Hove, 2007,p. 807).

In this study we investigate how policy makers and advisers in the WCR relate to and make use of marine science at the regional level. We examine what scientific information they seek from regional sources and what makes them perceive knowledge sources to be credible. Current information sharing and future priority information demands are addressed. The results provide a first look at the WCR marine science-policy gap. We suggest how the gap can be further investigated and closed.

MATERIALS AND METHODS

With the policy cycle providing the conceptual and analytical framework, the connections between the "analysis and advice" and the "decision-making" stages were of particular interest for examining the science-policy interface, as shown in **Figure 1**. The investigation was mainly to determine if and how national level policy actors incorporated marine science within mainly a regional marine policy context. This operationalized the lateral and vertical transboundary and nested policy cycle linkages of the conceptual governance framework.

Prior researchers (e.g., Rosenström, 2006; Jones et al., 2008; Addison et al., 2015) have used mixed qualitative and quantitative methods, such as interviews and surveys, to elicit the perceptions and experiences of policy actors at the science-policy interface. Our respondents comprised policy-makers and their advisers in nation-states and territories (hereinafter all called "countries") of the CLME project. Using the list of 44 CLME countries as a sample frame, the researchers selected a purposive sample of 16 (36%) to visit based on criteria including geography (island/continental), official language (Spanish/English/French), size (large/small), political status (territory/nation), membership in (sub-)regional organizations, and the logistic practicalities of travel and budget. A list of substitute countries, selected with the same criteria, was available should visits to the first choices prove impractical. Policy-makers and their advisers in the ministries concerned with environment, fisheries, foreign affairs, and tourism in each country were identified. The CLME project engaged with these four government portfolios that were likely to be actual or potential users of marine science in their policy cycles. Our interest was especially at the decision-making stage and at the regional level.

The study was compliant with the University of the West Indies Policy and Procedures on Research Ethics. To ensure a high response rate the CLME project focal points in the countries assisted with setting up of interview appointments in advance of our 2–3 day visits to the countries. Opportunities were taken at regional conferences to interview delegates who fit the selection criteria. These events increased the number of countries and organizations covered. Respondents included top personnel in regional organizations working on marine science and policy. Interviews were conducted face-to-face in order to probe responses in this exploratory research. We emphasized understanding perspectives and experiences given the absence of prior research or detailed information in the WCR on our topic.

Our research employed a short interview guide comprising mainly open ended questions to solicit a wide range of views, supplemented by some closed choices where prior knowledge was available (McConney et al., 2012). We designed the survey to be easily understood by non-scientists and to be administered in about 30 min. The content was adapted from similar instruments (e.g., Jones et al., 2008). Previous research conducted by the authors on communication in the WCR (Mahon et al., 2010) informed research design. We were aware, for example, that short interviews were much more likely to be agreed to, completed without interruption, and made the respondent more amenable to re-interview. A limitation compared to a longer and more in-depth interview was the loss of qualitative richness. This was addressed by a concurrent mixed methods design (Creswell, 2009) in which simple quantitative analysis (descriptive statistics) supplemented the mainly qualitative analysis in this exploratory study.

Each interview started with a statement read out on research purpose and confidentiality as ethics required. The interviewer next described a scenario in which the respondent was participating in a regional meeting on marine policy. This reduced the likelihood of responses being made at the level of national or international (outside WCR) meetings, rather than

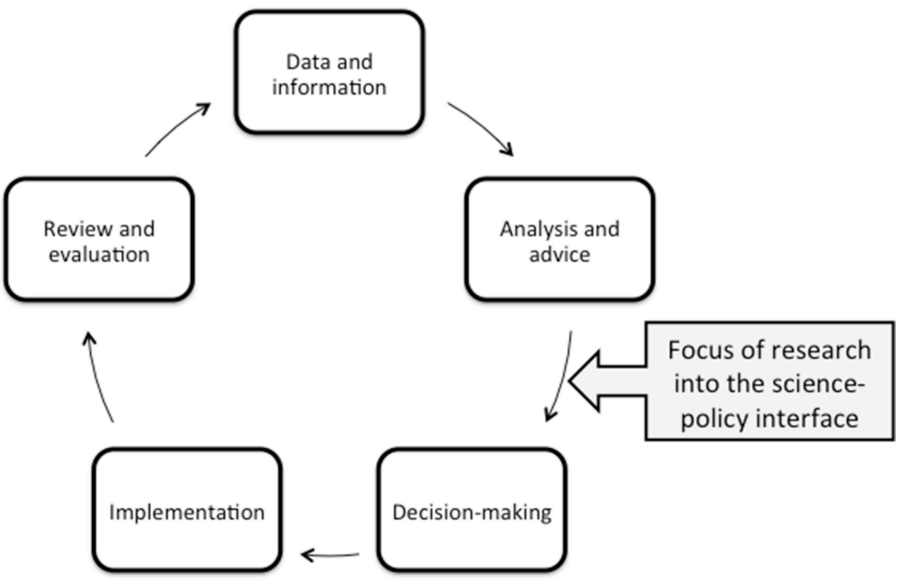

FIGURE 1 | Investigation of science-policy interface in the basic policy cycle.

regional. The respondent confirmed that the scenario was clear before the interview proceeded. To validate this we sought an example drawn from the respondent's experience to ensure that responses were based on practical expertise. Interviewers also stressed that "science" in this study referred to both natural and social science as well as information based on systematic data collection and analysis (a stage of the policy cycle).

Table 1 shows the main topics of the interview, and the questions associated with each of them. A visualization palette of text, tables, and charts supplemented the questions posed on preferred format of information presentation.

The instrument was administered in either English or Spanish, with the latter being done in some cases with the assistance of an interpreter. The interviewers were members of the research team and noted responses directly in writing, with a few cases of audio recording where translation was necessary. The noted responses were typically summarized for validation prior to the interviewer asking if any major information had been missed or if the respondent had more to add. There was no need to return to any of the respondents for more information.

Interviews were conducted with from one to five persons, with the leading speaker as the main respondent. Group interviews remained consistent with the research design. In these, the minister or senior policy adviser called on others to provide supplementary input. The interviewer actively encouraged this diversity to enrich the discussion and provide additional insight. Points made could be tied to the various speakers. In a few cases respondents provided documents or referred the interviewer to supplementary sources of information that were subsequently obtained.

The data collected were entered into Excel worksheets by each interviewer and combined to form a single data set. Data entry by the interviewers facilitated the editing and analysis. Qualitative data from open-ended questions were sorted, coded, and analyzed to produce descriptive statistics that aided the interpretation of the qualitative data. Interviewers collectively agreed on the codes and data analyses. Reporting response percentages from open-ended questions was kept broad-brush. This was deemed most appropriate to the exploratory nature of this research that was not based on random sampling or statistical design. In many cases response descriptions are reported as "few," "some," or "most" to convey results, respectively, within the bottom, middle, and top thirds of their frequency distribution. Interview notes captured nuances of responses, and were used extensively to interpret the results. The results in all cases are taken as being indicative, but not statistically representative, of the situation across the WCR. Findings were shared with a CLME project meeting in 2012. These results are reported in the next section based on McConney et al. (2012). The main findings are later discussed and linked to the literature.

RESULTS

Twenty countries (45% of the region) and four regional organizations were actually surveyed (**Figure 2**). Thirteen of the twenty countries (mainly the islands) had English as their official language. Five of the eight continental countries in Central and South America were Spanish-speaking and one was Dutch.

One hundred and three respondents participated in 72 interviews across the organizations and ministries investigated (**Table 2**). Most were in fisheries and environment organizations.

The interviews targeted seven ministers, and 65 policy advisers, and senior technical staff. Ministers were generally said to be too busy, but most of those interviewed had a keen personal interest in marine matters. When ministers were unavailable, the interviews were conducted with their advisers who were also

TABLE 1 | Interview topics and questions.

Topic	Question
Typical meeting situation	As in the scenario, can you describe a situation when marine science information was very useful in a regional policy meeting? What was it that made the science information so useful in that case?
Main purpose, context	What are the main purposes for which you or delegations most often use regional marine science information in regional marine policy meetings? In what types of contexts do people demand it?
Source organizations	In terms of providing regional marine science information for policy, which regional organizations stand out as the most credible sources of information that is useful for decision-making? Why?
Constraints on information use	What, if anything, constrains the use of regional marine science information by you or delegations?
Public perception sources	Policy-makers and advisers usually value public perception and local knowledge when making national level marine policy decisions. What sources and types of information, if any, provide or substitute for public perception and local knowledge at regional level meetings in the Caribbean?
Information sharing	Some say national authorities (environment, tourism, fisheries etc.) do not or cannot readily share data and information to collaboratively develop regional marine science information. Comment?
Regional vs. international	What, if anything, are the differences between *regional* and *international* policy meetings in terms of demand for and use of regional marine science information? If there are differences, why is this?
Demand for information	What is the nature of marine science information that you have used to participate effectively? For different types of information we are interested in frequency and format
Top information demands	Looking ahead to the next 5 years, of the various types of regional marine science information that we have discussed, and any others that come to mind, what would be your top three (3) in terms of future overall value for decision-making at regional level?
Any other points to make	Is any other aspect of getting marine science information into regional policy important to take into account in designing useful Wider Caribbean marine science-policy interfaces

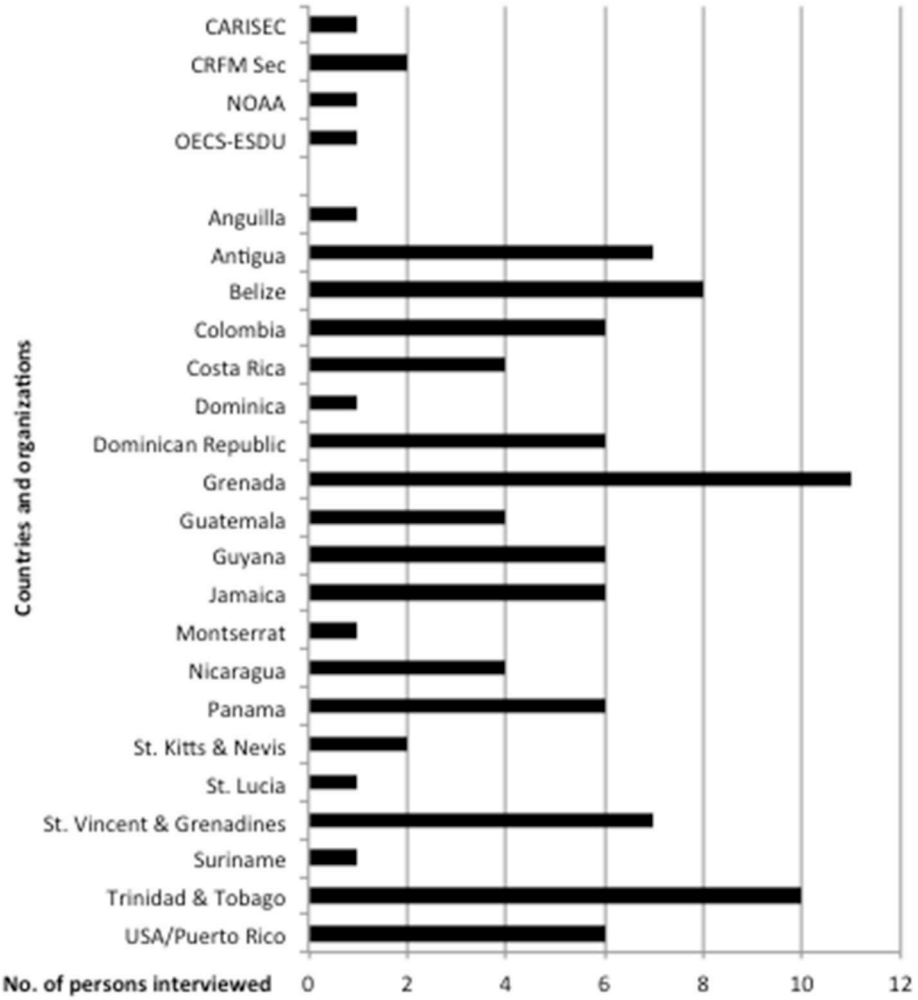

FIGURE 2 | Distribution of respondents among the 20 countries and four organizations (Adapted from McConney et al., 2012).

TABLE 2 | Numbers of interviews and respondents by category.

Respondent category	Interviews	Respondents
Regional organizations	5	5
National ministries		
Environment	18	26
Fisheries	29	38
Tourism	9	19
Foreign affairs	11	15
Total	72	103
Main respondent type	Minister	Adviser
($n = 72$)	7	65

target respondents. Almost half of the policy advisers were high level (Vice-Ministers and Permanent Secretaries) who interact directly and frequently with policy makers. Lower level policy advisers were the heads of administrative, technical or planning units. The following sections report and explain the results based on the topics and questions set out in **Table 1**.

Meetings of the Science-Policy Interface

This question helped to confirm with respondents the legitimacy of a regional marine policy meeting scenario that included science. Respondents were generally familiar with the term "science-policy interface" and appreciated the need to know more about it in order to improve how it worked within the context of regional ocean governance. Although, respondents said that they understood the scenario, some had difficulty keeping to a regional focus and could not easily identify meetings that met the criteria. Most identified meetings by the acronyms of host organizations. The Caribbean Regional Fisheries Mechanism (CRFM) was the most frequently identified, particularly for its Ministerial Council meetings that directly addressed sub-regional fisheries policy (**Figure 3**).

The United Nations Environment Programme (UNEP), Organization of the Fishing and Aquaculture Sector of the Central American Isthmus (OSPESCA in Spanish), and the

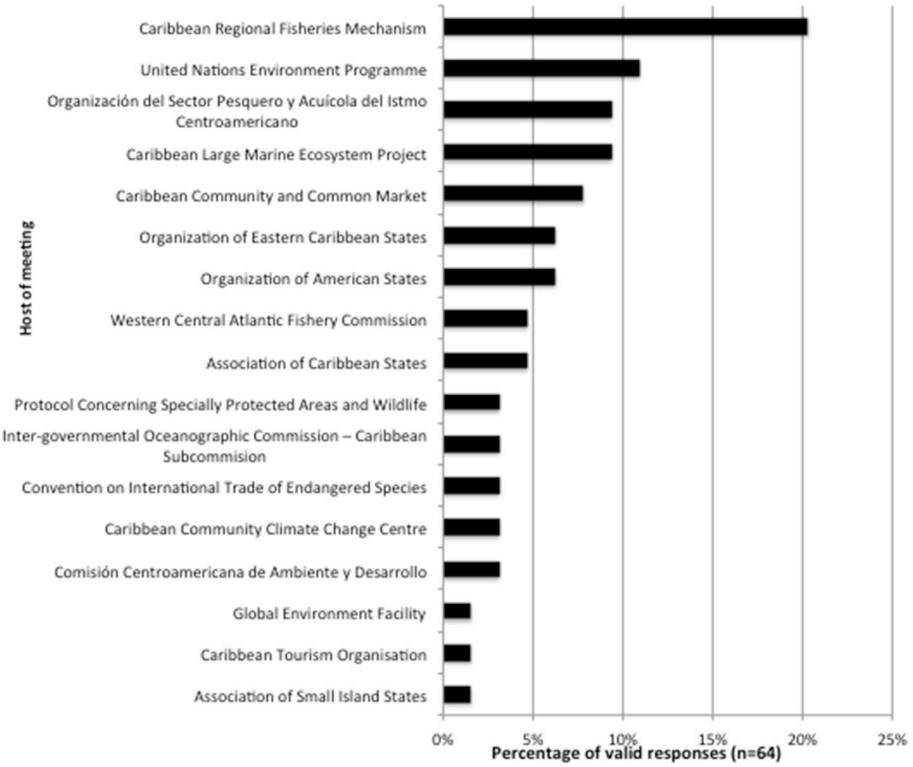

FIGURE 3 | Organizations identified with hosting regional marine policy meetings (Adapted from McConney et al., 2012).

CLME project were mentioned about half as often as CRFM. For OSPESCA, high-level meetings on the harmonized lobster closed season were common examples. Also named were some specialized *ad hoc* meetings (e.g., of the Convention on International Trade of Endangered Species on Conch), rather than a regular or institutionalized series of policy meetings. High-level policy advisers admitted that they had little experience of regional marine policy meetings compared to technical meetings. Respondents found it difficult to explain why science information had been useful in their examples, but this was directly addressed next.

TABLE 3 | Main uses of marine science at regional policy meetings.

Use of marine science	Response % ($n = 53$)
Background	38
Decisions	30
Negotiation	23
Awareness	6
Funding	4

Science Purpose and Context

It is important to distinguish normative views on the use of marine science from actual use. We were interested primarily in the latter. Marine science was used mainly as background information, as input into decision-making and for negotiation (**Table 3**). Much less mentioned were general awareness raising and funding.

Background science information included explaining the nature of an issue, its general context or possible solutions. Decision-making included choices among management measures or resource allocation in the case of managed fisheries. Science-informed decisions also included trade-offs between conservation and livelihoods or economic uses of areas. Negotiation was linked to the decision-making but also included working out marine programs with other countries or international agencies and conflict management. Funding was related to the observation that proposals containing good science tended to be more readily accepted for funding and that this was sometimes in competition with other entities in the region. Most of the examples offered illustrated science being used to gain national advantage over competing countries rather than to formulate regional policy or solve regional problems.

Respondents stressed that policy discussions seldom used marine science extensively. The reason for their difficulty in responding was often explained by the comment that science (of any type) is so rarely used in regional policy meetings that it could be considered irrelevant to policy. Respondents usually followed such explanations with the opinion that this state of affairs was undesirable, but was deeply institutionalized in the region.

Source Organizations and Credibility

Perceptions of the quality of science, and hence its credibility, depend in part on the credibility of the source of the information as well as the information itself. Respondents identified CRFM, The University of the West Indies (UWI), Western Central Atlantic Fishery Commission (WECAFC), and OSPESCA as the top four organizations most credible as regional sources of marine scientific information (**Table 4**).

After these the next most frequent response was that there were no credible sources regionally, followed by universities in general and minor mention of several others. Credibility was due to features such as maintaining academic standards of quality assurance, having a well-respected "brand" name from long length of good service to the region, formal organizational mandate, frequency of interaction with others, a history of information sharing, and a culture of research.

There was, however, considerable uncertainty about the types of information available from the sources and many respondents admitted that either their knowledge of the organizations was second hand or they thought none were credible. Respondents who said the latter explained that in their experience more useful information on the region came from extra-regional sources such as foreign government agencies and big international NGOs. They added that low credibility was due to some regional organizations being too political or having a limited capacity for science.

Reasons were offered to explain the credibility of various organizations. Their mandate for academic research and peer-reviewed publication made universities in general quite credible. OSPESCA was considered highly transparent, with all types of information easily accessible and kept reasonably up to date. It also actively encouraged information sharing. Several agencies of the Caribbean Community (CARICOM) also reportedly shared credible information. CRFM was judged credible mainly due to the prominence of its mandate as a regional fisheries body. WECAFC, as an organ of the Food and Agriculture Organization of the United Nations, was considered credible for reasons similar to the CRFM and the quality assurance that was said to characterize UN bodies. The latter also applied to the UNEP Caribbean Environmental Programme along with global linkages that respondents thought ensured objectivity, balance and neutrality. A few others were considered credible because they were interactive and accountable, as reflected in presence at regional meetings.

Besides universities, most of the above agencies are users and distributors, rather than producers, of scientific information. The information that they provide is based on science but they rarely conduct scientific research. They broker information, facilitate communication, and serve as boundary partners within policy and science arenas.

What Constrains Information Use

Even if scientific information is available it may not be used due to various constraints that we sought to investigate. Respondents reported constraints on information use (**Figure 4**). Topping the list were low capacity to use science, science not being formatted for policy uses, little access to databases or other direct information sources, and limited policy demand for science. Externally generated constraints included a preponderance of outdated and poor quality scientific information that was often slow to be supplied, costly, scarce, and not useful for reducing uncertainty. Constraints within user agencies included uncertainty about what science information is available or not being able to get it unless one's social network included contacts at the source.

Science sources and users both reported low science capacity. Not knowing the potential uses of science in marine policy was a major capacity deficiency among policy actors. The root cause of low capacity was related to basic lack of awareness of the roles of science at policy level, but this was said to be due to poor communication of science from scientists and the technical intermediaries in the ministries. Some respondents added that even with such awareness the absence of a culture of evidence based or informed policy-making must be addressed before one could expect to see any significant change in use of science, even if properly packaged.

TABLE 4 | Science information sources and credibility.

Organizational feature contributing credibility	Organization					
	CRFM	UWI	WECAFC	OSPESCA	All other sources	Total (%) (n = 47)
Many global links	0	0	0	0	2	2
Culture of research	0	9	0	0	2	11
Known to share info	2	0	0	9	2	13
Name well-known	15	0	2	0	0	17
Organization mandate	15	0	0	0	2	17
Frequent interaction	4	2	2	0	9	17
High quality assurance	2	11	6	2	2	23
Total (%)	38	21	11	11	19	100

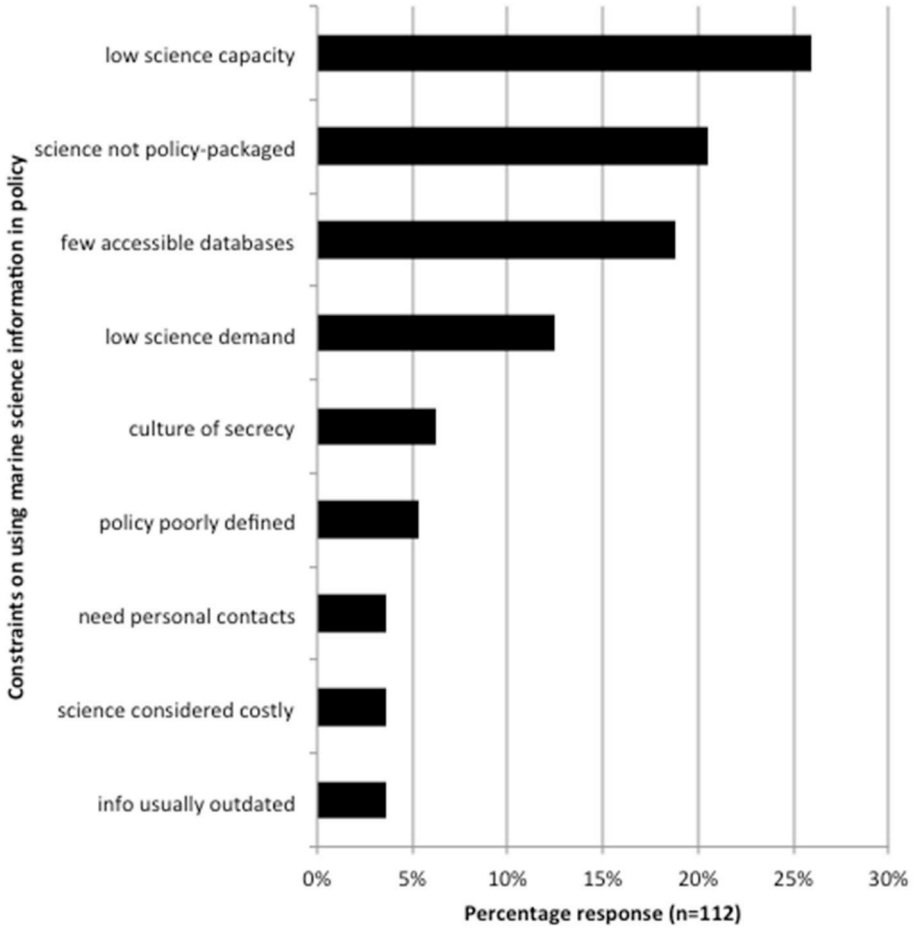

FIGURE 4 | Constraints on using marine science in policy (Source: McConney et al., 2012).

Sources of Public Perception

Unlike many scientists, actors in policy arenas often pay considerable attention to public perception. However, it may be challenging to determine where to obtain accurate information on such public perceptions. Respondents said that there were no good regional level sources of information on public perception when it came to marine matters. Policy makers and advisers overwhelmingly relied on national perceptions that they compared with colleagues. That is, they asked colleagues what public opinion was in their countries and compared notes to form a regional image. In particular, ministers conferred among themselves for political interpretation of public views rather than rely solely on information from technical or administrative policy advisers. This often took place at meetings, but some information exchange occurred electronically by email or telephone among the closest of colleagues. Less often, the respondents used mass media reports, special studies, NGOs and personal social networks that extended to other countries.

It was mainly in the Central American countries that respondents described policy meetings at which NGOs were present at the table to make direct inputs from interested civil society organizations if not the general public. In the insular Caribbean, the Caribbean Network of Fisherfolk Organizations (CNFO) was highlighted in the case of fisheries but said to be currently a weak voice for the fishing industry. Many respondents said that media reports were not a reliable guide to public perceptions or opinion. They also suggested that regional perceptions might not be relevant since most decisions are taken from national, and not regional, perspectives.

Regional Information Sharing

The conceptual multi-level regional governances framework is based upon lateral transboundary networks of entities. Many of the ties are based on information. Knowing if or how information flows is an essential aspect of understanding the science-policy interface. Most respondents said that there was little transboundary sharing of marine science information except through informal social networks. Instead of developing formalized networks for information sharing, respondents reported strong organizational cultures that hindered the transboundary sharing of information (**Figure 5**).

Reasons were offered for the limited sharing of marine science information. Fear of the information making the source "look bad" was prominent. The root causes for this included exposing

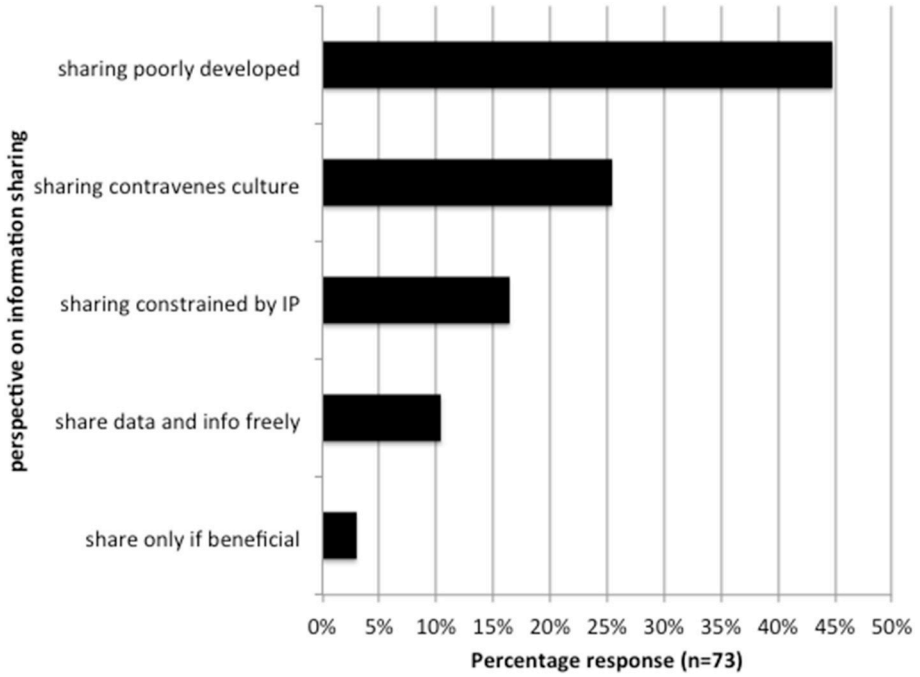

FIGURE 5 | Views on sharing information regionally (Adapted from McConney et al., 2012).

poor quality data and analysis, incomplete data, incompatible data, inability to properly understand or generate scientific documents, and the embarrassing release of "sensitive data." The latter could be almost anything. Real or alleged concern over intellectual property matters was a recent additional constraint. Civil servants typically did not share technical and scientific data and information unless directed to do so or there were clear precedents for doing so on the specific topic and with the specific data recipient. In the public service, there were few incentives to share information, and often the considerable "red tape" actively discouraged it. Information exchange tended to occur only where it was mandated either legally or administratively, and institutionalized such as by the monthly to annual provision of statistics of all sorts to national, regional or international bodies. Very little of this sharing was directly between countries.

Some of the above reflect the poor development of sharing mechanisms which is largely a technical matter of designated contact persons, data protocols, administrative procedures, quality checks, joint analyses and reporting, training and the like. These must be distinguished from the culture of not sharing which meant that even if all of the above were in place on paper they would not routinely be used in practice. Respondents spoke of the need to have clearly identified mutual benefits from sharing. The relatively few respondents who reported free sharing of information were mainly from Central America. Others reported few constraints on transboundary information sharing once it was done at aggregate level so as to maintain source confidentiality especially related to costs and earnings data.

Regional vs. International levels

The conceptual multi-level regional governances framework is also based upon vertical transboundary networks of entities. Next we examined a higher level of governance by investigating international marine policy meetings. "International" is commonly understood as being a higher level encompassing beyond the WCR but not always being as broad in scope as global. Responses to this question were quite similar. Respondents usually had more experience of the use of marine science information in policy meetings at the international level than at the regional level. They said that regional marine science was perceived to be of better quality when packaged for policy-making at international level meetings. There seemed to be more demand for good marine science from within the region at international meetings than at regional meetings. The sources, at international meetings, of such regional science were often international, not regional, agencies. These sources often re-packaged information from the region and added their own advocacy-oriented interpretations, especially in the case of big NGOs. Many respondents pointed out, however, that "region" needed to be clearly specified since information on the insular Caribbean typically gets "lost" or ignored if Latin America and the Caribbean is the geographic area of analysis. An occasional exception was if the issue was of special concern to small island developing states (SIDS), or a matter of poverty or disasters (e.g., for Haiti).

Climate change meetings were highlighted as having a high content of regional marine science actively used for policy purposes especially *in fora* such as the Alliance of Small Island States (AOSIS). The dynamics of the marine science-policy

interface at international meetings was said to be vastly different from regional meetings in numerous ways since there was a high policy pull for science and competing science providers from developed countries and big NGOs. However, even in AOSIS, the Caribbean SIDS were said to sometimes be less prepared with policy-packaged science than the other SIDS regions. It was observed that even when regional marine science was at the disposal of Caribbean delegates, they tended not to use it much in international meetings, the exception being at times the delegates from Central America. Part of the reason, it was suggested, was that the Caribbean delegates at international policy meetings were often not scientists, or did not possess the technical background to be comfortable with scientific data.

Demand for Science at Regional Meetings

Different actors at different meetings will demand science in different formats. We needed to study aspects of this multi-dimensional variability by focusing on information type, frequency, and format. Many respondents prefaced their responses on the demand for science with the caution that, since the use of marine science was very situation dependent, their generalizations were not universally applicable. The marine science used depended on variables such as the economic sector, topic and its context, purpose of the meeting, interests of the countries and organizations attending, preparation required, host organization, levels and backgrounds of the delegates present at the time, and so on. Bearing these in mind and the limited closed response options, the results in **Table 5** show that few meetings included information related to marine sector GDP, employment and EEZ matters. Some meetings included tourism, ecosystem health, and the marine mandates of organizations. Most meetings included marine science related to disaster risk reduction or management, climate change and fisheries.

Regarding the preferred format for communicating marine science information to policy makers and advisers, the responses favored almost equally all options shown on the visualization palette. These options were text, indicators, tables, charts, maps, and process graphics. However, time-series charts or other graphics showing trends in a simple fashion were very highly favored. All formats were reportedly appropriate for any minister, depending on the specific topic and information complexity.

Data tables were generally not preferred unless policy makers had business or accounting experience. Ordinary text and bulleted slides were reportedly useful for reference. Relationship graphics were said to be most useful for those ministers and topics for which communicating concepts was more important than statistics. However, respondents warned that complex graphics could be easily rejected as "pretty pictures."

TABLE 5 | Relative demand of regional policy meetings for different types of information.

Most meetings	Some meetings	Few meetings
Climate change	Formal mandate	Exclusive economic zones
Fisheries	Ecosystems	Gross domestic product
Disasters	Tourism	Employment

Data and information on maps were growing preferences for some communications. Additional media used included video or computer simulation such as animating time-series information. A few respondents said oral briefings eclipsed all others in effectiveness of communication. They said that policy-makers demanded concise information for understanding with lengthier reference documents. If oral briefings were not properly conducted issues with information use were likely to occur using any visual format. Comments on the extent to which policy-makers did, or did not, understand science were wide-ranging and defied drawing a single conclusion.

Top Information Demands

Devising strategies for closing the gaps in the science-policy interface requires knowledge about the future demand for science information, as this is where attention should be focused. Hence questions also addressed the future demand for different types of scientific information. In listing information types, some respondents were more specific than others in their identification. They said, "status of fish stocks" was needed rather than fisheries management general information. Respondents both took climate change to include disaster risk management and reduction, and separated them. A spectrum from specificity to generality was also evident in responses that ranged from marine biodiversity to simply ecosystem health. Accordingly, results should be interpreted cautiously and generalized where possible. The top 10 marine science information demands, based on frequency of mention, are shown in **Figure 6** for future policy use.

The top 10 list reflects the importance of interdisciplinarity as bio-physical/ecological, socio-economic, and governance information types are all named. The demand for social science relating to the governance or institutional arrangements for marine matters such as sustainable fisheries management, biodiversity conservation, climate change adaptation, and the like is less obvious than that related to natural science or economics. Although, information concerning disasters was in demand in most current meetings, it was not high in the demand ranking for future information that science could provide due to their perceived unpredictability.

Any Other Views on Science-Policy Interface

With the last two questions we sought any additional information that respondents wished to share. Respondents made the observations listed below (McConney et al., 2012) in no particular order.

- Policy-makers must first buy into science
- Need culture of evidence-based policy
- Need public awareness of marine science
- Capacity-building by regional universities
- Easier access to information is the key
- Information must match scales of policy-making
- Ocean governance not taken seriously
- Poor appreciation of governance issues
- Strengthen regional governance first

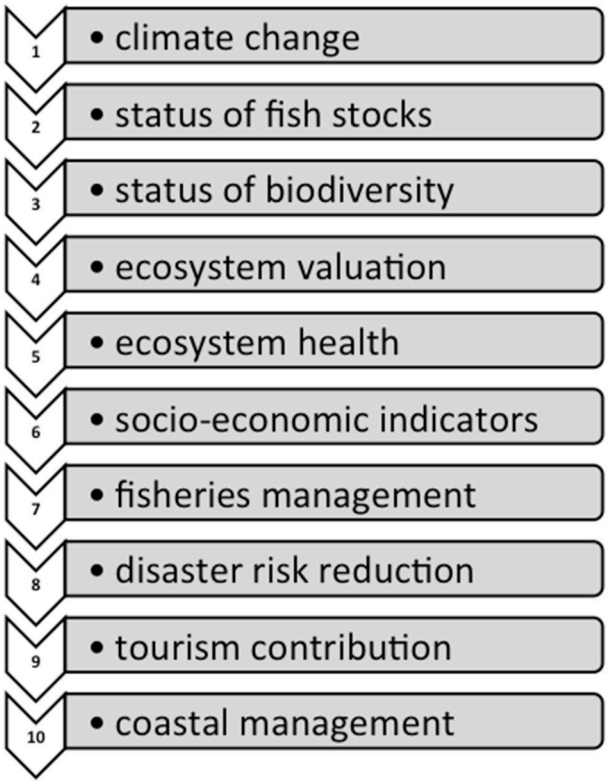

FIGURE 6 | Top 10 regional demands for marine science information use in future policy (Source: McConney et al., 2012).

- Weak sub-regional bodies are constraint
- Politics may overshadow policy-making.

Responses that the science-policy interface needing attention were common. Respondents who had no additional comments often said that their earlier responses had been comprehensive. Observations listed above reflect the gap between marine science and policy. There are only a few places of strong connection such as in meetings concerning climate change. Underpinning and sustaining this gap are fundamental deficiencies such as the low level of science use in organizational culture and the low capacity for understanding science that pervades society, as well as the policy domain for marine matters. According to respondents, weaknesses are intergenerational and institutional such that the youth of today are not expected to grow up much different despite the increasing use of technology in everyday life as distinct from using or appreciating science. Respondents who were most fervent in their earlier responses often reiterated and reinforced the need for better communication at multiple levels by multiple means to reach diverse target audiences if any changes were to take place in the interfaces between marine science and policy.

DISCUSSION

This exploratory study of the marine science-policy interface in the WCR used regional meetings as the focus of investigation. Caution was exercised in interpreting the findings from the primarily qualitative mixed methods research that was based on a purposive sample. Results are not necessarily representative, but indicate areas of interest and concern across the WCR. Lessons learned and preliminary conclusions drawn are subject to validation in future detailed studies of more specific topics or target audiences. For this exploratory research we use the UK Overseas Development Institute Research and Policy in Development (RAPID) Context, Evidence, Links Framework for Analysis (Overseas Development Institute, 2004) to structure the following discussion. These facets overlap and inter-connect to a large extent, but the WCR science-policy interface is primarily about the emerging role of science in policy influence, and we focus on this aspect. Given the 44 nation-states and territories in the WCR, and overlapping or nested mandates and policy cycles of the 25 major regional marine governance organizations (Mahon et al., 2013), we can expect the science-policy interface to become a complex area of enquiry even if at present there is limited evidence of science influencing policy.

There can be many reasons for the failure of policy processes to use the "best available scientific information," a principle reflected in most of the multilateral environmental agreements to which Caribbean states are party (Cash et al., 2003; Watson, 2005; Rosenström, 2006). The results reflect several of them reported in the literature such as considerations of the structure of the science-policy interface (Haas and Stevens, 2011), access to information (Cvitanovic et al., 2015a), the relevance of information to policy questions (Weichselgartner and Kasperson, 2010; Jasanoff, 2011), the credibility of the research (Gilson and McIntyre, 2008), the way the information is formulated for uptake by policy makers (Jones and Walsh, 2008), receptiveness to science among decision-makers (Agardy, 2015), and the role of agents in bridging science-policy gaps (Holmes and Lock, 2010; Bednarek et al., 2015). We recommend that these be among the areas for future science-policy research.

External Influences

The social-ecological system boundaries of the WCR marine science-policy interface are often fuzzy. However, geographically, politically, institutionally, ecologically, socially, and otherwise for practical purposes we use the WCR boundaries employed by the CLME project. Within this project area there are many finer scale national and organizational marine jurisdictions and ecosystems that are nested, and whose boundaries overlap, and these impact upon the WCR marine science-policy interface (Fanning et al., 2011). While within the WCR there are intra-regional influences external to the small-scale systems, here we discuss what actors and other factors external to the WCR influence the science-policy interface. Regional actors may perceive influences as good, bad or neutral. The results indicated that there are many external influences.

Chief among the influences is agenda setting. The results indicate that future high policy demands on regional science reflect mainly global, rather than regional, issues and agreements. The greater familiarity that respondents had with international (extra-regional) compared to regional (WCR) marine policy

meetings suggests that, implicitly or explicitly, they will be subject to diverse high-level external influences. Climate change, one of the priority future demand topics, is of particular concern. Betzold et al. (2012) describe how external influences contributed to fragmentation of AOSIS in global climate talks due to the impacts of science used as a political tool. Given the diversity within the WCR it will be challenging to establish and maintain a coherent and cohesive science-policy interface unless regional marine science is used to a greater extent, in both regional and international meetings, than reported in the results.

Credibility is a factor in meeting the above challenge. The reported perception that there are few credible regional sources of marine scientific information adds an element of deep concern. In some cases governments from outside the region and international NGOs are making impacts on policy with compelling science from conservation perspectives coupled with persuasive advocacy (e.g., the Caribbean Challenge Initiative and blue economy agendas). This can divert regional attention and resources away from regional priorities, calling regional science credibility, relevance and value into question. The Caribbean Community Climate Change Center counters the credibility gap in part by a very active online information push, exploiting both formal channels and social media. Initiatives that close the scientific knowledge gaps between scientists, policy-makers and the public are now seen as essential to establishing the credibility required for policy influence (Jefferson et al., 2015; Rose and Parsons, 2015).

None of the external influences identified by respondents in this study were entirely negative. It is advantageous for the region's policy making and advising delegates to have access to international actors and to be exposed to international factors that shape the science-policy interface at the global level. The science-policy interface at the regional level should not be strengthened in ways that may simultaneously weaken or disconnect external international interfaces. Interfaces should be supported or strengthened by more meaningful regional engagement that fits regional marine affairs into the global environment. Collaboratively scaling science to policy is an ongoing challenge worldwide (Overseas Development Institute, 2004; Rudd, 2014).

The research results reveal opportunities for learning about successful arrangements at international science-policy interfaces. Preparing science products to be actively used in policy is prominent at the international level and problematic in the region. For example, Conservation International is a big NGO that has staff dedicated to managing science-policy interfaces and which has publications suitable for most audiences that address interfaces from both sides (e.g., Karrer et al., 2011). Several other NGOs, UN, and other agencies have offices in the region and, as results show, are taken as part of the regional organizational assemblage. They effectively use science to influence policy (Grorud-Colvert et al., 2010). Regional organizations should design decision support systems to incorporate international best practices not only from science and technology perspectives, but also for suitable advocacy, information management and communication research. Organizations in the WCR should transfer such skills from international actors and projects to the regional science-policy interfaces. Crossing organizational and institutional barriers is a key challenge for progress both within and between the science and policy domains (Cvitanovic et al., 2015a).

Political Context

There were few ministers in the study. Additional research is needed on how ministers see the policy-science interface and what changes they would like to make. According to most policy advisers, few ministerial policy makers demand much marine science. They say that this is due to limited appreciation of, and experience with, marine science in the WCR, as elsewhere (Rose and Parsons, 2015). Demand may not increase until the context for policy decision-making becomes evidence-based, evidence-informed, or evidence-aware, and this provides incentives for improving the marine science-policy interface (Weichselgartner and Kasperson, 2010). One approach to this is to cultivate political champions and high-level communities of practice at the science-policy interface. In effect, this is high-level knowledge brokering (Godfrey et al., 2010).

Policy cycles and institutional arrangements for marine policy decision-making are also relevant. According to respondents these arrangements are scarce and poorly developed at the regional level since fisheries and other regional organizations are mainly advisory and have low science capacity to the point of some not being considered credible sources of science information. Outreach to key actors of the science-policy interface is needed at all stages of the marine policy processes in the region in order to sensitize them to areas for improvement. There is opportunity to do so in the CLME Strategic Action Programme (CLME, 2013). The leaders and secretariats of regional fisheries bodies such as WECAFC, OSPESCA, and CRFM, as well as leaders of national level fisheries authorities, should spearhead the outreach, using the multi-media initiative of the Caribbean Community Climate Change Centre described previously as an example. In this communication, particular attention must be paid to both the actual and perceived advantages and disadvantages to incorporating more science or evidence into policy cycles (Holmes and Lock, 2010; Rose and Parsons, 2015).

Results suggested that changes at the policy-making level are necessary but not sufficient for comprehensive improvements. Elected policy makers respond primarily to the voting public and public perceptions are often more important at the science-policy interface than scientist realize (Beck, 2012; Jefferson et al., 2015). Hence, the general public also needs to be targeted in communication campaigns on the use of marine science, on national science programs and on the science in organizational work plans (Jarvis et al., 2015b). Extended communication campaigns, monitored and evaluated within the policy cycles of their issues can assist. Successful campaigns can open windows of opportunity for policy influence to be taken advantage of to effectively and efficiently transform science-policy interfaces.

We found that the limited engagement of citizens resulted in poor knowledge of their perceptions of marine science and policy at the regional level. This can be addressed by promoting

citizen science (Jarvis et al., 2015a). Engaged and informed citizens will demand mechanisms for even greater input, such as via civil society organizations, into marine policy. They will be better equipped to provide public opinion at the regional level on which to base policy decision-making. One means of engagement could be via the existing and proposed national inter-sectoral consultative mechanisms on marine matters that draw upon a wide range of stakeholders, such as the National Council on Ocean and Coastal Zone Management in Jamaica. This governance structure can be replicated. Where there are no national inter-sectoral consultative mechanisms, alternative multi-stakeholder sectoral bodies such as the Fisheries Advisory Committees found in several countries can be used as the seed for such expansion. A regional multi-level mechanism requires linking and scaling up such national and sub-national participatory initiatives across connected policy cycles as envisaged in the marine ecosystem-based regional governance framework (Fanning et al., 2011).

Science and Evidence

Respondent perceptions of the organizational sources suggest that simultaneous with addressing the low capacity to produce and use scientific information, urgent action is needed to make scientific information of all types (i.e., both natural and social science, and interdisciplinary studies) more available from regional databases and publications to many levels and types of users. These are not just matters of quality assurance, intellectual property and technology. Measures could include CRFM, OSPESCA and WECAFC disseminating more communication products from existing databases and challenging organizations such as the Caribbean Network of Fisherfolk Organizations, for example, to actively use the information in regular interaction with resource user groups.

Science is only one of several sources of decision-making information (Cook et al., 2012) so science in many formats communicated via several channels is more likely to have policy influence (Grorud-Colvert et al., 2010). Organizations should create opportunities for open source construction of new products from combined open data and information. This would encourage information consumers to become familiar with the data products. Communication research is needed to inform the most appropriate design from end-user and end-use standpoints (Watson, 2005; Grorud-Colvert et al., 2010). The generation of appropriate evidence for informing policy is a major concern globally (Holmes and Lock, 2010; Cvitanovic et al., 2014). The research results give guidance on the types of information expected to be in most demand and some characteristics of the use of information. Reed et al. (2014) give guidance on how to mobilize knowledge to meet user demands. They state that scientific research must be designed with knowledge exchange in mind to meet the needs of long-term stakeholders who are full partners in the co-generation of knowledge. Tangible and practical benefits achieved early in the process provide incentives for sustaining such communication.

Respondent responses on the demand for information and their comments on the science-policy interface suggest that much improvement can be based on the current science and policy processes. There is no need for a complete overhaul as there is some confidence in existing systems. However, if there is a greater future demand for scientific evidence from policy-makers, then WCR sources need to go deeper into the processes for producing and packaging marine science (Agardy, 2015). Science information must be more timely and relevant in order to address policy issues on several time-scales. Scale mis-matches in time, space, institutions and jurisdiction can retard science-policy interface development (Watson-Wright, 2005).

Decision-making situations can be either resilient or vulnerable to deficiencies in the science-policy interface. Some policy cycles are more adaptive than others to cope with changes in the nature and dynamics of the science policy-interface between stages (Mahon et al., 2014). The results of this exploratory study suggest that the WCR marine science-policy interface needs to be investigated more thoroughly from a resilience perspective in order to design the most strategic interventions for successfully institutionalizing evidence-based adaptive capacity. For example, an initial strategy may be to mainstream an overarching concern such as climate change which receives much adaptation funding, Climate change already provides examples of good regional science and can incorporate other top areas of information demand such as fisheries management and ecosystem health. Marine science can be incorporated into the emerging re-formulations of sustainable development such as in blue and green economy, and other recent dialog (UNEP, 2012).

Links and Networks

The study results based on the RAPID analytical framework lead us to examine networks at the science-policy interface, and especially the important role of brokers (Godfrey et al., 2010). Regional organizations were identified as key actors at the science-policy interface. However, the potential for strategic positioning as brokers or boundary organizations between the national and international marine policy arenas was neither utilized nor appreciated by the majority of respondents. There is seldom much interaction between marine scientists and policy actors in the Caribbean, or anywhere else in the world (Rose and Parsons, 2015). Typically, in the WCR, marine scientists communicate via an individual or agency that has indirect links to the policy apparatus. Exceptions include forums requiring expert scientific input and certain high-level negotiations in which science and policy need to be intimately linked in ways that everyone can understand (Jasanoff, 2011; Beck, 2012). The broker or boundary actor or agency that communicates between science and policy also translates messages between them (Godfrey et al., 2010; Bednarek et al., 2015). For most fisheries, tourism or biodiversity meetings in the WCR there will be technical intermediaries such as secretariats at the regional level. The literature on science-policy interfaces points out the need to know who these brokers are and how they communicate both science and policy bi-directionally (Fritz, 2010). This may include interpreting communication to serve their own agendas or reflect their organizational cultures. Future stakeholder analyses must consider who the brokers are in the regional marine science-policy interface at all stages of policy cycles and how they

exercise power or influence uptake (Agardy, 2015). This will identify key actors in regional to global information management systems.

The marine science-policy interface is much about communication networks and effecting change through shared evidence that leads to collective action at the regional level. The results showed that formal science information sharing was limited, but personal networks played an important part in what sharing did take place. Therefore, social network analysis can be instructive especially in the light of the important transboundary social networks, epistemic communities and communities of practice for regional information exchange. If more formal networks and processes are to either replace or institutionalize informal practices, then designers and change agents need to understand currently existing networks, including their structures, dynamics, and the purposes that they serve. Network analyses that map relationships and policy influence can inform decisions and improve management of the science-policy interface (Cvitanovic et al., 2015a).

There may already be some progress with networking, at least among the region's SIDS, given the recent expert group meeting to discuss the science-policy interface in SIDS that was held in March 2015 in St. Lucia (http://sids-l.iisd.org/news/expert-group-meeting-discusses-science-policy-interface-in-sids/). Representatives of SIDS governments, academia and regional and international entities considered clusters of issues including: poverty, economic growth, social development; food security, health, water, human settlements; climate change, energy, disaster risk reduction; and oceans and biodiversity (marine and terrestrial). They identified good practices and key challenges common to all three SIDS regions, including: unpredictable funding for SIDS-owned initiatives; "brain drain;" and failure to capitalize on the SIDS diaspora. The meeting's discussions highlighted the need for: effective communication between policy makers, the research community and scientific experts; a robust engagement of stakeholders including civil society, the private sector and local communities for the successful implementation of policy; integrated approaches to scientific research and policy-making; enhancing inter-regional exchange; and using SIDS-based data, statistics and research, as well as indigenous knowledge.

CONCLUSION

Addressing the science-policy interface is key to governance reform (Fritz, 2010) and as a means of understanding and addressing complexity (Jones, 2011; Cvitanovic et al., 2015a). Many developing countries lag in this area and urgent action is required to close the gap. A global blueprint will not succeed due to the diversity of situations (Jones et al., 2008). Increasing regional and national level awareness of the roles of culture and politics, a better understanding of science, knowing if or how organizations interact, and appreciating the different roles of science in policy are all necessary to effect well-informed and managed change (Stahl and Cimorelli, 2005; Watson-Wright, 2005; Mahon et al., 2010). Such information, used systematically, can lower the formidable barriers to improving science-policy interfaces (Weichselgartner and Kasperson, 2010).

Our exploratory study of the marine science-policy interface in the WCR contributes to the broad aim of improving ocean governance globally. It provides directions for tactical and strategic action by stakeholders at many levels and implemented on several different scales within the Caribbean Large Marine Ecosystem (Mahon et al., 2014). The main point is that change is necessary according to the respondents. Taking no action to improve the science-policy interface is not a viable option if the goals and targets for sustainable development that the region and its nation-states have subscribed to are to be achieved. This point is echoed at the global level (Cvitanovic et al., 2015a).

The Global Environment Facility International Waters Science forum known as the Large Marine Ecosystems the Open Ocean Working Group has reported (2012a,b) on science-policy interface issues in LME projects worldwide. Noting many deficiencies in the use of science in LME projects in addition to the lack of articulation with policy, the reports argue for better communication of science throughout the Global Environment Facility process analytical and planning stages. The Working Group advises that short to long term influences of science on policy be well-documented. Based on the findings and conclusions from our study (McConney et al., 2012) we recommend:

- Strengthening regional science-policy interfaces be done in ways that do not weaken useful international interfaces
- Incorporating into regional information systems the best practices from communication research, science and technology, information management and advocacy
- Enhancing the capacity of organizations in the region with skills transferred from adept international actors and projects
- Reaching out to sensitize science-policy key actors at all stages of major marine policy cycles to areas in which they can assist improvement
- Targeting the general public in communication campaigns to encourage use of marine science
- Establishing pathways for greater public input into marine policy, such as via civil society organizations, through more coherent regional public opinion
- Making all types of marine scientific information from regional databases more available
- Investigating the marine science-policy interface thoroughly from a resilience perspective to inform strategic interventions for building adaptive capacity
- Conducting stakeholder analyses to characterize the power and influence of brokers at the science-policy interfaces of all policy cycles stages
- Using information from network analyses to inform decisions and improve management of marine science-policy interfaces.

Most of the above recommendations can be incorporated into ongoing regional ocean governance initiatives (CLME, 2013). The recommendations resonate deeply with investigations from around the world that highlight the urgent need to repair or strengthen marine science-policy interfaces in ocean governance (UNEP, 2012; Cvitanovic et al., 2015a).

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