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ABSTRACT

In 2011 unprecedented massive influxes of pelagic sargassum seaweed took the Caribbean completely by surprise. The floating sargassum disrupted fishing operations, impacted fish catches, and caused significant hardship to fisherfolk. Stranded sargassum covered beaches and the rotting weed produced pungent smells threatening tourism and invoking difficult and expensive coastal clean-ups. Several years later the Caribbean is still struggling to come to terms with how to manage this new and continuing threat, which is also potentially a huge source of raw material for innovation and entrepreneurship opportunities. Communication has been a key element in this struggle to respond and adapt to sargassum. Exchanging information among a broad range of government, civil society, private sector, academic and other stakeholders has been an ongoing challenge. Mobilising knowledge has been key from the start, and science communication remains a cross-cutting and very transdisciplinary process. We examine some of the lessons learned from the communication associated with sargassum influxes since 2011. There is no clear science-policy interface for decision-making on sargassum. Uncertainties surrounding sargassum ecology, oceanography, biochemistry, economics, medical and social science all test the status and communication of science among Caribbean stakeholders. The drivers of information sharing, the credibility of both popular and scientific sources, their reach to diverse audiences through networks, and several other factors combine to determine information flows.

Keywords: Sargassum; knowledge uncertainty; science; policy; information.

INTRODUCTION 1.0

Pelagic sargassum seaweeds (Sargassum spp.) form extensive floating mats in the Sargasso Sea in which S. fluitans and S. natans are the most abundant species supporting large, biologically diverse communities [1]. In recent times sargassum has also accumulated in the equatorial Atlantic from where huge quantities are periodically transported by ocean currents into the Caribbean [2]. Since 2011 these unprecedented and hard-to-predict influxes of sargassum, linked to ocean eutrophication and climate change [3], have been having intermittent but devastating impacts on Caribbean coastal social-ecological systems. The phenomenon has been called the "recurrent great Atlantic Sargassum belt" [4]. The belt has often extended from West Africa to the Gulf of Mexico and, in June 2018, "contained >20 million metric tons of sargassum biomass" [4]. Even before this article in Science increased media attention, international and regional news agencies were reporting on the emerging sargassum crisis. Yet, national and regional scientific information sharing and evidence-based policy responses to sargassum influxes remain inadequate, especially in the smaller islands.

About a dozen small island nation-states and overseas territories in the eastern Caribbean are on the frontline of the periodic sargassum influxes. The countries receive many tons of wet sargassum per kilometre of exposed (usually windward) beach per day during influx events [5]. Such huge volumes of sargassum, piled up to 2 metres deep along shorelines and clogging waters up to 200 metres offshore, are suffocating endangered marine mammals and turtles, smothering and abrading coral reef, seagrass and mangrove communities [6]. As sargassum decomposes it consumes dissolved oxygen and releases pungent toxic gases causing fish kills and other biodiversity losses [7]. Accumulations of stranded seaweed emitting foul odours reduce the aesthetic value of these islands' iconic beaches and nearshore waters, affecting public health and livelihoods with economic impacts on tourism, fisheries and hence small island economies. It is generally agreed that sargassum strandings, unless better managed, will erode the significant progress made in the eastern Caribbean towards conserving coastal biodiversity and critical ecosystems that sustain livelihoods. The need for increasing the capacity to cope responsibly, learn and adapt is clear and supported at high political levels. Communication barriers at the science-policy interface in the eastern Caribbean may constrain the development of such capacity [8].

Communication of marine science is integral to adaptive policy at all stages of policy cycles, but actual use of marine science in Caribbean policy cycles is infrequent [9]. Appropriate science is needed to inform decisions, learning and adaptation in enabling policy that foresees increasing complexity and uncertainty. This paper examines

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communication within the policy cycle that addresses the sargassum phenomenon, providing insight into science-policy interfaces in general. The next sections set out the methods used in this exploratory, qualitative research followed by the results. These findings on marine science-policy communication apply to a range of complex issues [10] beyond sargassum and the Caribbean region.

METHODS 2.0

An analytical framework for investigating multi-level governance has been developed and used in previous applied research which has at its core the concept of the basic five-stage policy cycle [11]. The framework posits that transboundary marine issues are best addressed by nested policy cycles with vertical and lateral linkages that form governance networks. Communication by networks of actors in all stages of policy cycles is critical at any marine science-policy interface. Investigating sargassum policy cycle communication patterns requires understanding the types of information exchanged, and the actors involved, as well as the policy outputs and outcomes [12].

For this brief exploratory investigation, the authors determined the information exchanged at various stages of the sargassum policy cycle in the eastern Caribbean by reviewing secondary data on policy processes and events along with the timeline of sargassum influxes. Also taken into account were the economic sectors most impacted by sargassum and engaged in the policy cycle by perusing the content of communications, but also relied heavily on the observations of the authors who have been engaged in sargassum research since the first influx. Quantitative analysis was unnecessary given the limited information perused in the exploratory investigation. Most of the information was in English for the Lesser Antilles countries of the Caribbean Community.

RESULTS 3.0

The timeline of sargassum influxes and policy-related events most relevant to the eastern Caribbean is shown in Figure 1 for 2010 to 2019. Managers and policy advisers commonly communicated with scientists at these events even if policy decision-makers were absent.

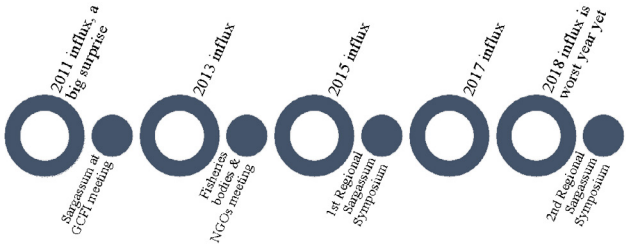

Figure 1. Sargassum influx and policy-related event timeline

The economic sectors most impacted by sargassum are shown in Figure 2 based on the actors and agencies mentioned in communications, attending events and observed in field activities.

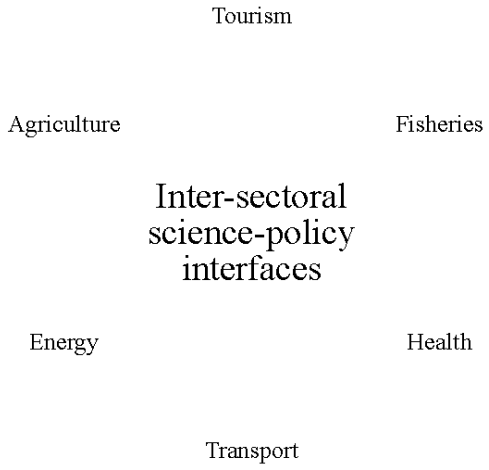

Figure 2. Economic sectors at the sargassum science-policy interface

As a situation summary, the sectors are illustrated interfacing within a single science-policy domain. They also interface in subsets of the overall policy domain in which, for example, fisheries may engage with agriculture but not necessarily tourism or health which interact in another sub-domain. Thus, the sectors communicate, coordinate or collaborate mainly with each other in clusters or network cliques that create unevenness and gaps in information sharing.

The following sections briefly examine observed communication in each of the policy cycle stages. Examples of the nature of the communication and the key actors involved at each stage in the policy cycle are shown in Figure 3, but information exchanges and actors involved are variable as described.

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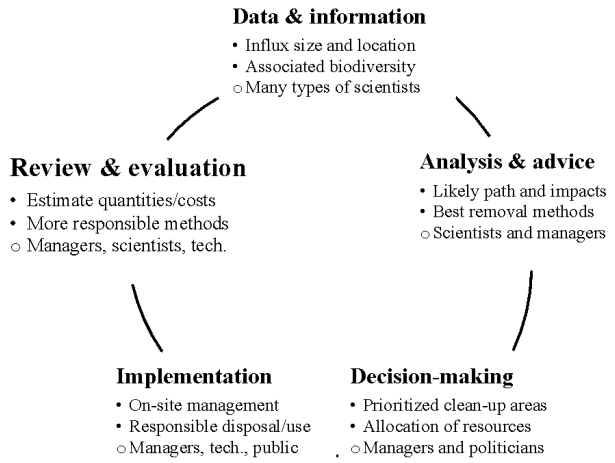

Figure 3. Communication topics and actors in the sargassum-related sub-regional policy cycle

3.1 DATA AND INFORMATION

'Data and information' is the most science-infused stage, encompassing natural, social and inter-disciplinary science. Communication among scientists is mainly online with discussion groups, email listservs and websites set up specifically for sargassum but with little or no policy content or membership. Caribbean peer-reviewed publications on sargassum are scarce and not accessed by most policy personnel, but technical reports are more widely read. Communication in person at various meetings facilitates information exchange, but such events are few. Most prominent for sargassum are the meetings of the Gulf and Caribbean Fisheries Institute and the Association of Marine Laboratories of the Caribbean. There has been an increase in online conferencing. Good policy communication relies on the use of consistent non-jargon terms (e.g. influxes, not incursions, inundations or invasions), but this has not been settled. Information inconsistency on the Caribbean sargassum phenomenon is compounded by some scientists and news media maintaining emphasis on the Sargasso Sea and not the newly blooming area or belt. There are inconsistency, uncertainty and information gaps on the species composition of sargassum, chemical content including health risks if consumed and many other characteristics as may be expected in an emerging area of science.

3.2 ANALYSIS AND ADVICE

'Analysis and advice' features the most overt interaction between science and policy. It is where scientists are specifically engaged to advise based on formal terms of reference or they interact with managers on a more informal basis. Managers, here, include senior private sector personnel and public officers in economic sectors as well as civil society organisation leaders. However, as no single agency nationally or sub-regionally is responsible for sargassum, the communication of science to policy has been very fragmented. Two regional sargassum symposia and a few other fora have specifically attempted to bridge the interface. There is also a communication gap between sargassum scientific research and the development of processes and products for sargassum clean-up, use as a raw material, etc. especially in the smaller islands which offer no science funding and entrepreneurs do not normally network with scientists. This affects policy by limiting information, and the coherence of it, required for decision-making.

3.3 DECISION-MAKING

'Decision-making' illustrated the classic constraint of science not being packaged and presented for policy use. The increasing use of visualisation via interactive maps, relationship diagrams, slides and videos is evident in more science communications, but some still require translation. In countries that had established inter-sectoral sargassum management committees, the science membership was minimal or absent. Policy-decisions on responses to influxes as major hazards, sometimes in a state of national emergency, tended to be reactive and neither precautionary nor environmentally responsible, especially in the early influxes when, for example, heavy machinery was customarily used on beaches.

3.4 IMPLEMENTATION

'Implementation', as suggested above, seldom involved science although scientists published guidelines for responsible responses to varying sargassum threat levels in order to conserve biodiversity and reduce environmental damage. These guidelines were disseminated but not followed through to ensure uptake and institutionalisation as the communication outcome.

3.5 REVIEW AND EVALUATION

'Review and evaluation' is not a prominent stage in the cycle for either science or policy. Among conservation ecologists (e.g. for sea turtles, marine mammals) there is keen interest to monitor the impacts of implementation, but caution in communicating findings that could be perceived as critical of the policy decisions and decision-makers who may then alienate and exclude science. A communication pathway through which science informs learning and adaptation is not clear.

DISCUSSION 4.0

The networks of ties and interactions between the actors in science and policy constitute science-policy interfaces in which formal and informal communications of all types feature prominently [9]. In

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this exploratory examination of the science-policy interface for the sargassum seaweed phenomenon in the Caribbean we have seen that a social-ecological surprise caught scientists off-guard and that communication both among scientists and with actors in the policy domain has been somewhat chaotic and uncoordinated even ten years on. Dissecting the policy cycle into its stages, even in a simplified manner, provides insight into where science can be or is most effective at the interface, and hence also where improvements are urgently needed.

There is some evidence of science communication in all five stages of the policy cycle, with the sectors of fisheries and tourism especially being in the frontline in the small islands of the eastern Caribbean. However, the use of science is concentrated in the data and information stage, with some in analysis and advice, but this rapidly attenuates thereafter. There is evidence that science can contribute to decisions, implementation, review and evaluation especially when learning and adaptation are the aims but, for sargassum, communication is much weaker at these stages.

At the science-policy interface ineffective communication is generally said to be more often the reason for ignoring science than real issues with the quality of the science itself [13]. Scientists are often not trained to communicate science in a way that policy advisers and decision-makers can readily translate their information into policy action [14]. This appears to be the situation in the Caribbean where stakeholders are diverse and mobilising knowledge within and among islands is constrained by barriers including costs of travel for meetings, limited internet penetration, limited transboundary collaboration and others. Packaging marine science for active uptake at all stages of the policy cycle is seen at the international level. For example, some big non-governmental organisations have guidelines on managing the science-policy interface from both sides [15]. Such guidelines could be tested in the Caribbean and adapted to fit the cultural and political context. The absence of a culture of evidence-based policy-making in the region must be addressed by learning-by-doing for there to be a significant change in the use of properly packaged science. Solving the sargassum crisis presents an opportunity for such transformative change given the seriousness of the problems across several sectors and countries and the need for science to contribute answers, especially to inform the responsible use of sargassum seaweed as an input to revenue generating socio-economic activity [16].

CONCLUSIONS 5.0

This paper highlighted the importance of maintaining the interface between science and policy in complete policy cycles that seek to address the sargassum phenomenon. Improving the Caribbean marine science-policy interface is essential for finding sustainable solutions to this wicked problem. Lessons learned are relevant to other problems and places coping with uncertainty in social-ecological systems. Since 2011, influxes have changed the perception of sargassum from that of an essential floating habitat to that of a severe and perpetual threat to well-being in the eastern Caribbean [4]. The several hypotheses proposed to explain the phenomenon and events held to develop response strategies to influxes have not inspired confidence in marine science in the Caribbean as uncertainties persist and sustainable solutions remain unattainable. However, several marine science actors in the region addressing sargassum are now paying more attention to communicating science in order to influence policy as well as public perceptions of the problem.

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