Recognising Stakeholder Conflict and Encouraging Consensus of 'Science-Based Management' Approaches for Marine Biodiversity Beyond National Jurisdiction (BBNJ)

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Areas beyond national jurisdiction (ABNJ) encompass the seabed, subsoil and water column beyond coastal State jurisdiction and marine biodiversity beyond national jurisdiction (BBNJ) is rich and varied. From providing sustenance and supporting livelihoods, to absorbing anthropogenic carbon dioxide emissions, ABNJ ecosystems are vital to the wellbeing of humankind. However, an enhanced understanding of BBNJ and its significance has not equated to its successful conservation and sustainable use. Negotiations for a new international legally binding instrument for the conservation and sustainable use of BBNJ have scoped applicable principles for a future agreement, including the use of best available science and science-based approaches. But there remains a lack of convergence on what science-based approaches would look like, or how they would be operationalised. In order to negotiate and implement a meaningful BBNJ treaty that can meet conservation and sustainable use objectives, stakeholder perceptions must be identified, and areas of divergence must be overcome. This study uses Q-methodology to reveal and analyse the diversity of perceptions that exist amongst key stakeholders regarding what it means to operationalise science-based approaches for the conservation and sustainable use of BBNJ. The Q-study features 25 stakeholder interviews and 30 Q-study participants revealing four different perceptions, each of which represent a different interpretation of what science-based management means in the context of BBNJ. Across these perceptions, there were areas of stakeholder consensus (e.g., regarding the benefits of integrative management, the application of precautionary approaches when data are insufficient, and the issues pertaining to the trustworthiness and credibility of science) and areas of stakeholder conflict (e.g., regarding the definition, function and authority of science within current and future BBNJ governance processes). Key implications of this study include the evidencing of fundamental tensions between differing perceptions of the authority of science and between conservation and sustainable use objectives, that may be fueling stakeholder conflict, and the subsequent proposal of integrative and highly participatory management approaches to operationalise science-based management of BBNJ.

Keywords: marine biodiversity, BBNJ, stakeholders, science-based approaches, Q-methodology, marine biodiversity beyond national jurisdiction, marine governance, science-policy interface

INTRODUCTION

Areas beyond national jurisdiction[1] (ABNJ) encompass more than 64% of the ocean's surface and 95% of its volume. Once perceived as too vast to possibly incur human induced harm, it is now recognised that ABNJ are under threat. Based on the limited sampling of deep-sea ecosystems, it is evident that many deep-sea species mature slowly and produce fewer offspring than those located in shallow-water, and as such are characterised by increased levels of vulnerability (Gage and Tyler, 1991). Anthropogenic threats and pressures on ABNJ ecosystems, such as resource exploitation (e.g., fisheries, potential future deep-sea mining and bioprospecting Halpern et al., 2008) and global climate change (e.g. ocean acidification and deoxygenation (Sweetman et al., 2017; Levin et al., 2020) can impact biodiversity. There also exists a discrepancy between the pace of increasing human activities in ABNJ and scientific understanding of its unique ecosystems (Blasiak and Yagi, 2016). Indeed, recent work has highlighted huge uncertainties in our understanding of deep and open-ocean ecosystems, such as the mesopelagic realm (St John et al., 2016). While technological advancements may claim to have enabled the proliferation of deep-sea research and subsequently the volume of scientific evidence (Visalli et al., 2020), merely accumulating more evidence does not necessarily equate to improved management in practice (Fazey et al., 2014).

In response to increasing global concern for marine biodiversity beyond national jurisdiction (BBNJ), international actors are currently negotiating a new implementing agreement under the *United Nations Convention on the Law of the Sea* for the conservation and sustainable use of BBNJ (hereafter, the BBNJ Agreement) (United Nations General Assembly, 2017). Through the ongoing negotiating sessions for a new BBNJ Agreement, potential governance principles and approaches have emerged, including emphasis on, "*a science-based approach, using the best available scientific information and knowledge*"(United Nations, 2018). Science-based approaches, or evidence-based approaches are now regarded as central to environmental governance and aim to embed science in the content, outcomes and process of decision-making (Rousseau, 2012; Bainbridge, 2014). Despite the seemingly clear stakeholder approval of using a science-based approach (Earth Negotiations Bulletin, 2019) it is not clear what this would look like in practice. Consequently, the ambiguity surrounding the operationalisation of this term represents a significant bottleneck to creating functional governance structures for ABNJ. Resolving this ambiguity is not purely a matter of agreeing on definitions. Policy decisions are never objective – they unavoidably reflect the socio-economic, cultural, and institutional contexts and values under which they arise (Rosenau, 1993). Understanding stakeholder values and priorities, along with what stakeholders deem to be socially and politically acceptable, is essential for effective environmental governance (Addams and Proops, 2000; Loring and Hinzman, 2018). This is especially true for BBNJ

governance, where the scientific data are limited and the inherent transboundary nature of BBNJ results in a wide range of stakeholders, each with unique sets of values. Designing and implementing successful governance structures and policies for ABNJ requires negotiators to balance diverse perceptions and find a "*sweet spot*" between an Agreement that is robust enough to adequately protect BBNJ, but not so demanding as to impede State and stakeholder participation (De Santo et al., 2019). While understanding stakeholder perceptions is particularly important for BBNJ governance, to date initiatives to understand and overcome divergence are poorly documented and are often employed on an *ad hoc* basis.

To address this knowledge gap, this study uses Q-methodology to analyse the breadth and nature of existing stakeholder perceptions regarding operationalising science-based management of BBNJ and identifies key areas of conflict and consensus that may affect future policy design decisions. As Q-methodology is an emerging methodological approach in marine studies, this paper begins with a brief introduction to Q-methodology, followed by our study design, results, and discussion. This research will highlight the trends, opportunities and management implications suggested by these data. Findings of this research include four emergent factors which represent four different perceptions of how science-based approaches should be operationalised for BBNJ governance, as well as key areas of stakeholder consensus and conflict.
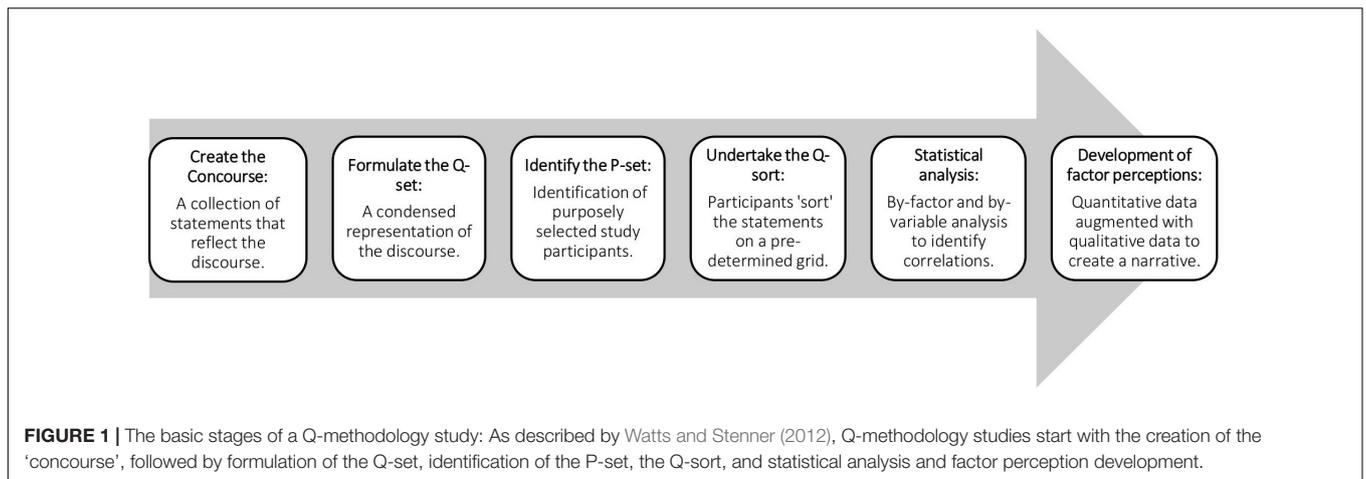
METHODOLOGY AND MATERIALS

Q-Methodology

Q-methodology is a quali-quantitative methodology that originated in the field of psychology (Brown, 1980) but is now used in a wide array of fields to understand the range of stakeholder perceptions in reference to contested issues [e.g., education (Rodl et al., 2020), medicine (Hammami et al., 2020), and environment (Moros et al., 2020)]. Q-methodology combines statistical analysis in the form of a data-reduction technique applied to pseudo-ranking data with the analysis of qualitative data obtained during the ranking exercise to reveal core perceptions. The combination of quantitative and qualitative data additionally enables researchers using Q-methodology to analyse the apparent scope for compromise between different stakeholder perceptions because it reveals specific areas of consensus and conflict that exist in relation to the focus of the study. As such, Q-methodology is apt for investigating complex policy topics (Cairns et al., 2014). **Figure 1** illustrates the six general stages of a Q-methodology study, as outlined by Watts and Stenner (2012).

Detailed Methods
Identifying the Concourse
The concourse is a collection of perceptions about the issue in question, taken verbatim from real-world sources, known as 'statements', that together represent as completely as is possible the entire spectrum of perceptions that exist in relation to the contested issue.

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[1]As mandated by the United Nations Convention on the Law of the Sea, areas beyond national jurisdiction refers to the seabed, subsoil and adjacent water column beyond the 200 nautical mile lines and extended continental shelves that delineate coastal State jurisdiction (United Nations, 1982).

FIGURE 1 | The basic stages of a Q-methodology study: As described by Watts and Stenner (2012), Q-methodology studies start with the creation of the 'concourse', followed by formulation of the Q-set, identification of the P-set, the Q-sort, and statistical analysis and factor perception development.
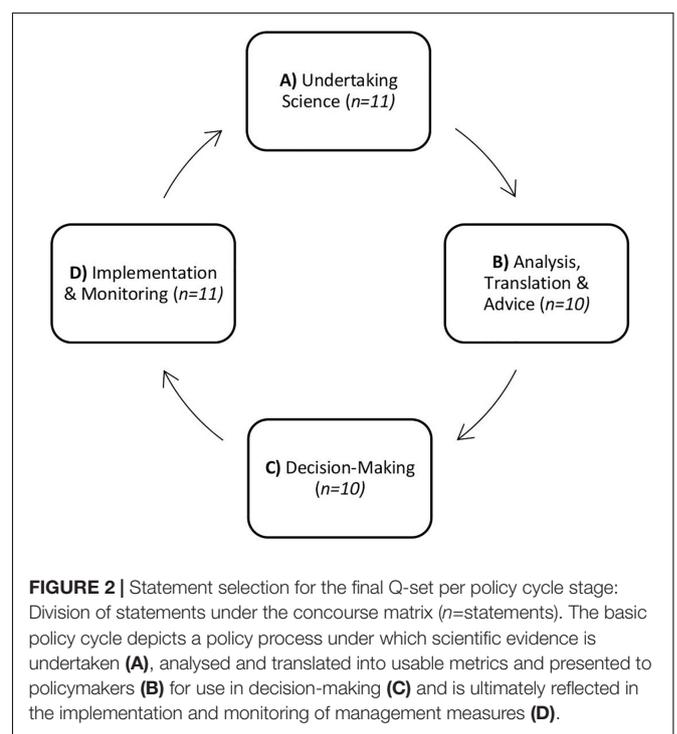
The concourse for this study was identified exclusively from semi-structured interviews with stakeholders actively engaged in BBNJ issues. Semi-structured interviews were conducted at the second session of the intergovernmental conference for BBNJ (New York City, March 2019) as well as via online video conferencing (April-June 2019). In total, twenty-five stakeholder interviews were conducted with participants spanning the employment demographic groups of non-governmental organisation (NGO), intergovernmental organisation (IGO), science researcher, law and policy researcher, ABNJ industry experts, and state/delegations. Prior to the commencement of interviews, this research received approval by appropriate ethics committees and all participants were provided with written documentation of their rights as a participant. Interviews were transcribed verbatim and transcripts were supplied to participants who were given an opportunity to amend factual errors or areas of miscommunication. From the final interview transcripts, a total of 403 statements were extracted to form the concourse.

Creating the Q-Set

The Q-set is the collection of statements selected from the concourse that participants will eventually 'sort' during the Q-sort. The Q-set is formed by taking a representative sample of the statements within the concourse that together, represents the diversity of issues and strengths of opinion found within the concourse.

This study uses the steps of the basic policy cycle to categorise the statements in the concourse. These steps are: (1) undertaking science; (2) analysis, translation and advice; (3) decision-making; and (4) implementation and monitoring. The policy cycle was used as it allows for the investigation of stakeholder perceptions of the flow of science throughout the entire policy cycle. Statements within each of the stages were identified, via thematic coding, and were divided into sub-issues. Duplicate statements and statements deemed unsuitable were eliminated. The remaining statements were screened for ease of communicability through a pilot study. Statements flagged as unclear or confusing were either removed or altered to improve

FIGURE 2 | Statement selection for the final Q-set per policy cycle stage: Division of statements under the concourse matrix (*n*=statements). The basic policy cycle depicts a policy process under which scientific evidence is undertaken **(A)**, analysed and translated into usable metrics and presented to policymakers **(B)** for use in decision-making **(C)** and is ultimately reflected in the implementation and monitoring of management measures **(D)**.

the clarity, whilst taking care not to change the latent meaning of the statement. The final Q-set consisted of forty-two statements (*n* = 42) spanning the basic policy cycle stages, as shown in **Figure 2**.

Identifying the P-Set

The P-set is the collection of key stakeholders who are asked to participate in the Q-study. The way in which the study participants are chosen highlights the most significant difference between Q-methodology and other, more conventional forms of surveying human attitudes (i.e., 'R' studies). The individuals who constitute the P-set are chosen very intentionally because they are knowledgeable stakeholders. In Q-methodology, the goal of the research is to use a set of relevant people and a sample of

opinion statements to draw conclusions about the 'population' of perceptions from which the sample was taken. Q-methodology is not designed to produce results that can be generalised to a larger population (of humans), and therefore requires a smaller number of human participants to produce statistically meaningful results than traditional 'R' studies (Watts and Stenner, 2012).

The P-set was comprised of individuals with a high level of knowledge of the BBNJ process. To ensure that a wide range of perceptions were captured in the Q-study, care was taken to ensure that the P-set consisted of participants from a wide range of employment demographic groups (as stated above). Criteria for participation were: (1) participation in the BBNJ negotiations (gleaned from personal contact or via the official participant list for the conference); (2) an occupation that is directly related to BBNJ issues; and (3) the authoring of BBNJ relevant peer-reviewed publications. The standard of eligibility was the fulfilment of one or more criteria. Of the originally identified potential participants, thirty participants (*P-set=30*) agreed to participate in the Q-study, including 17 participants who participated in the semi-structured interviews.

The Q-Sort

During the Q-sort stage, participants rank the Q-set statements based on their relative level of agreement with the opinion expressed in the statement by placing the statement onto a pre-defined grid. The grid is structured in a quasi-normal distribution, labelled on a continuum across the columns in the grid (Watts and Stenner, 2012). Because this continuum exists across columns, but not the rows, the data generated represent pseudo-ranking data. Each completed grid represents a single data point in the study and is accompanied by qualitative data explaining the reasons the statements were sorted in a particular way.

Our Q-sort was conducted online, utilising HTMLQ software[2] and used an eleven-point quasi-normal distribution grid with a score continuum of −5 to +5 (**Figure 3**). A shallow kurtosis was chosen for grid design, as the P-set were deemed to be highly knowledgeable, and therefore a shallow distribution would allow for the investigation of nuances within the discourse (Watts and Stenner, 2012). The grid was labelled 'Most UNLIKE How I Think' corresponding to the ranking of −5 and 'Most LIKE How I Think' corresponding to the ranking of +5. Prior to commencement, participants were provided with an information package with detailed instructions and participant information. Participants were asked to provide explanations for the placement of the highest and lowest ranking statements.

Statistical Analysis

The statistical analysis stage of a Q-methodology study uses a multivariate data reduction technique to produce a correlation matrix which represents the level of association between Q-sorts (Brown, 1980). The outcome is a set of 'factors', which each represent a broad perception. Q-sorts that share similar sorting patterns end up 'loading' onto the same 'factors' in similar ways.

Q-sorts that load in a statistically significant way[3] onto a factor are referred to as 'factor exemplars' and become the focus of the qualitative analysis (Watts and Stenner, 2012). Q-sorts that load onto more than one factor are considered confounded and factors that do not load strongly onto any factor are considered outliers. During the analysis, the emergent correlation scores for individual statements are standardised into z-scores. The ranking implied by these z-scores is used to generate an 'idealised' Q-sort and corresponding factor scores for each statement for each factor. Z-scores are also used to test and analyse the degree of difference (i.e., consensus and/or conflict) between each of the factors extracted during the analysis and statements that are characterised by polarised sorting (i.e., a statement in which different participants either strongly agree or strongly disagree with) can be seen as areas of conflict between participants. Identified factors are tested against the following criteria:

(1) Eigenvalues: The eigenvalue for each factor must be greater than one for a factor to be accepted, as an Eigenvalue of less than one accounts for less study variance than one Q-sort (Kaiser, 1960) (Yeomans and Golder, 1982).

(2) Percentage of explanatory variance: The cumulative variance of extracted factors must be greater than 35% (Kilne, 1994).

(3) Number of Q-sorts flagged: A minimum of two Q-sorts must be flagged per factor (Watts and Stenner, 2012).

(4) Humphrey's rule: The cross-product of each factor's two highest loadings (either positive or negative) must exceed twice the standard error value (Eq. 1) (Humphreys and Maontanelli, 1975).

$$Humphrey's\ Rule\ Threshold = \frac{2}{\sqrt{n}},$$

$$where\ n = number\ of\ statements \qquad (1)$$

This study's Q-sort data were input into a matrix which underwent a principle components analysis with a varimax rotation using the qmethod package in R Studio. Pearson's correlation coefficient was used in the data reduction process. The initial correlation matrix between Q-sorts were tested against the aforementioned criteria and 5 different possible factor solutions were identified. Preliminary analysis was undertaken for each viable factor solution and researcher abduction was applied in order to determine the best solution. All possible factor solutions were examined and compared to determine if a significant component of the discourse was included with the addition of more factors. This reduction exercise included analysis of

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[2]HTMLQ is an open source application created by Aproxima and released under the Massachusetts Institute of Technology license Copyright (Aproxima Gesellschaft Für Markt- Und Sozialforschung Weimar, 2014-2015).

[3]The R package qmethod, used in this study, applies two tests by default to determine whether a Q-sort has loaded onto a factor in a statistically significant way. The first test compares the factor loading for a Q-sort with a particular, minimum threshold. This threshold is set to be $1.96 * 1/\sqrt{n}$, where 'n' is the number of statements in the Q-methodology study. The second test compares the strength with which a Q-sort has loaded onto one factor with the strength with which the same Q-sort has loaded onto the other factors extracted in the analysis. Only those Q-sorts that load by a sufficiently large margin onto a single factor (as compared to the other factors) are considered to have passed this test. Q-sorts must pass both tests to be considered statistically significant by R.

FIGURE 3 | Quasi-normal distribution grid utilised in Q-study: Participants 'sort' statements (*n*) by placing them into a column of a pre-defined, quasi-normal distributed grid based on their personal perceptions.

the number of total Q-sorts included or excluded under each solution (i.e. the solution that had the least number of outlying and confounded Q-sorts) and the uniqueness and/or similarity between the factor's perceptions.

Development of Factor Perceptions

The development of factor perceptions relies on researcher abduction, by which quantitative results (which identify the number of factors, the idealised Q-sorts, the factor exemplars, and the specific consensus and conflict issues) are augmented with qualitative data to form a narrative describing the perceptions that are reflected in the emergent factors (Brown, 1980).

The development of factor perceptions involved the examination of the idealised Q-sort and factor scores for each statement per factor, the identification of distinguishing statements, and considerations of polarised sorting of statements amongst factors. Qualitative data in the form of pre-study semi-structured interviews of Q-study participants and in-situ sorting explanations by the P-set of the most and least salient statements were gathered from factor exemplars. Through the augmentation of the statistical outputs with qualitative data, abduction was used to create a social discourse or factor perception for each factor.

Key Assumptions

This methodology generates an indicative 'snap-shot' of stakeholder perceptions regarding science-based approaches to BBNJ. The perceptions revealed through Q-methodology will evolve over time as the context, scope and direction of the BBNJ negotiations change and evolve. Thus, it is assumed that perceptions identified in this study may change overtime. Furthermore, undertaking the Q-study online (as opposed to in-person) has unique trade-offs. Online studies are accessible and alleviate the spatial and temporal constraints of in-person studies, however the researcher is not able to investigate subtle

TABLE 1 | Composition of factors (F), illustrating the employment demographic group of factor exemplars and the total number of exemplars per factor (in bold).

Employment Demographic Group	F1	F2	F3	F4
NGO	2	2	0	0
IGO	2	0	2	0
Science Researcher	3	0	1	2
Law & Policy Researcher	1	2	0	0
State/Delegate	1	2	1	1
Industry Experts	1	1	0	1
Total	**10**	**8**	**4**	**4**

participant reactions to statements or ask further questions about sorting behaviour. As such, this study primarily utilises quantitative results and augments these with qualitative data.

RESULTS

Overview

It was determined that a 4-factor solution was the qualitatively optimal solution and reflected the breadth of identified perceptions. Under this solution, one Q-sort was an outlier and an additional three Q-sorts were confounded. In total, ten exemplars loaded onto Factor 1, eight onto Factor 2, and four onto each Factor 3 and 4 (**Table 1**). It is notable that none of the employment demographic groups loaded exclusively onto a single factor, highlighting heterogeneity of perception within, as well as across, each of these categories of stakeholder. The z-scores, idealised Q-sort scores (IQS) and distinguishing statements for the 4-factor solution (hereafter, the Q-results) were produced for each factor (**Table 2**). Together, the factors explain 50.94% of the variance in the data. The qualitative analysis of each factor resulted in the following emergent perceptions:

TABLE 2 | *Z*-scores (ZSC) and idealised Q-sort scores (IQS) for factors (F).

Statements	F1		F2		F3		F4		Significance					
	ZSC	IQS	ZSC	IQS	ZSC	IQS	ZSC	IQS	F1:F2	F1:F3	F1:F4	F2:F3	F2:F4	F3:F4
In order to regulate human interactions in the ocean, science must provide baseline data.	1.06	3	0.34	1	0.92	3	0.67	2						
The role of science in the BBNJ process is to assist in monitoring once an instrument has been put into place.	−2.34	−5	−0.42	−1	−0.56	−2	−0.66	−2	****	****	****			
Science-based management of BBNJ would look like having a rigorous EIA process.	−0.43	−1	0.60	2	−0.12	−1	−0.64	−2	***			*	***	
We need more data from people in local communities who are actually experiencing the impacts.	0.56	2	−0.49	−2	−0.39	−2	−0.12	0	***	**	*			
Traditional knowledge is just as credible for some elements as Western knowledge is for others.	0.65	2	0.44	1	−1.59	−4	−0.05	0		****	*	****		***
Data is perceived as having hidden agendas if it comes from a conservation-oriented source.	−0.62	−2	−0.88	−2	−0.86	−3	−0.54	−1						
It is problematic that a lot of our data is collected by ABNJ industry.	−0.91	−3	−0.47	−1	−0.26	−1	−1.47	−4						
We do not have a global scientific community big enough to tackle all the BBNJ knowledge gaps.	−1.36	−4	−0.14	0	−1.95	−5	−1.91	−5	****	*		****	****	
We do not have enough data to implement ecosystem-based approaches in ABNJ.	−0.97	−3	−1.98	−5	−2.32	−5	−0.96	−3						
A major problem is that we currently use the data that we do have ineffectively.	−0.07	0	−0.79	−2	0.17	0	0.39	1	**			**	***	
You cannot do ecosystem-based management under the current sectoral management regime.	−1.90	−5	1.74	5	−0.27	−1	−1.64	−4	****	****		****	****	***
In order to define science-based management, we need to bring more disciplines into the discourse.	−0.06	0	0.13	0	−0.58	−2	1.78	5		****	*	****	****	
Marine spatial planning is a useful tool for implementing science-based management.	0.80	3	0.37	1	0.52	1	0.93	3						
Lack of data should not stop us from making sensible management decisions.	1.53	4	1.60	5	1.21	4	1.35	4						
We must consider what a country needs as opposed to imposing science on them.	0.24	1	0.31	0	−1.08	−3	0.57	1		***		***		****
Summaries for policymakers are either too simplistic without much content or too complex for policymakers to understand.	−0.20	−1	−1.46	−4	0.03	0	−1.80	−5						
Science-based management is hindered by the lack of communication between different departments within states.	0.12	0	0.39	1	0.57	1	2.21	5			****		****	****
Scientists have difficulties communicating their science to different audiences.	0.71	3	−0.23	0	−0.26	−1	−0.71	−3	***	***	****			
If a policymaker fails to listen to scientific advice, it is a political failure not a scientific failure.	0.21	1	−1.14	−3	−1.22	−3	−1.44	−4	****	****	****			

(Continued)

TABLE 2 | Continued

Statements	F1		F2		F3		F4		Significance					
	ZSC	IQS	ZSC	IQS	ZSC	IQS	ZSC	IQS	F1:F2	F1:F3	F1:F4	F2:F3	F2:F4	F3:F4
Even when the science is clear, it is difficult to get the policymakers to take that science on-board.	0.36	1	0.72	2	1.49	4	−0.25	−1		***	*	**	**	****
Barriers are overcome by scientists and policymakers getting to know one another in informal settings.	0.97	3	−0.45	−1	0.63	1	1.39	4	****			***	****	*
It makes it difficult to use science when scientists disagree amongst themselves.	−1.63	−4	−1.08	−3	−0.60	−2	−1.11	−3						
It is a challenge to articulate the science into a real-world management response.	−0.51	−2	−0.34	−1	−0.29	−1	1.11	3			****		****	***
People will always pick and choose the scientific evidence that supports their priorities.	−0.21	−1	−1.31	−4	1.16	4	0.70	2	***	***	**	****	****	
Policymakers are not clear enough about what science they need.	0.06	0	−1.13	−3	−0.03	0	−0.64	−2						
The problem with science is that as humans we like to be certain, and science is inherently not.	−0.73	−3	−1.44	−4	0.76	2	0.51	1	**	****	***	****	****	
Often, policymakers do not understand what is feasible from the scientific community.	0.47	1	−0.68	−2	0.68	2	−0.29	−1						
Side events provide a good opportunity for the uptake of science by policymakers.	0.67	2	−0.99	−3	0.80	3	0.07	0	****		*	****	***	*
NGOs are an important vehicle for bringing science into the BBNJ process.	−0.04	0	0.52	1	0.93	3	−0.22	0						
In the negotiations we have diplomats and politicians but not enough scientists.	−0.50	−1	−0.08	0	0.61	1	−0.66	−2		***		*		***
I think there is a strong presence of science within the BBNJ negotiations.	−1.37	−4	−1.81	−5	−1.74	−4	0.87	3			****		****	****
Currently, we are getting a more developed perspective of the science.	−0.51	−1	0.09	0	−1.45	−3	−0.55	−1	*	**		****	*	**
The more you can put science on an equal footing within the decision-making hierarchy, the better.	−0.71	−3	0.88	2	1.57	5	−0.48	−1	****	****		*	***	****
We need a science body at the global level to provide common scientific standards.	0.63	2	1.31	3	0.65	2	−0.92	−3	**		****	*	****	***
Strengthening the financing mechanisms of a BBNJ instrument is crucial.	−0.67	−2	1.13	3	1.50	5	0.10	0	****	****	**		***	***
The best available science needs to be widely available for everyone to access.	1.86	5	1.51	4	0.53	1	1.38	4		***		**		*
Data sharing should be an obligation under a BBNJ Agreement.	1.85	4	1.34	4	−0.09	0	0.10	1	*	****	****	****	***	
It is crucial that a BBNJ Agreement enhances the transfer of marine technology between states.	0.37	1	1.09	3	0.27	0	0.76	2						
A BBNJ instrument must be flexible to accommodate the science that will come in the future.	2.10	5	0.81	2	0.98	3	0.77	2	****	***	***			
We should coordinate existing scientific programmes to drive the implementation of a BBNJ Agreement.	−0.15	0	1.00	3	0.52	0	0.04	0						

(Continued)

Statements	F1		F2		F3		F4		Significance					
	ZSC	IQS	ZSC	IQS	ZSC	IQS	ZSC	IQS	F1:F2	F1:F3	F1:F4	F2:F3	F2:F4	F3:F4
We need to manage BBNJ at an ocean basin scale because ecosystems are ecologically connected across ocean basins.	1.21	4	1.42	4	0.67	2	1.24	3						
While we need some form of global science body, the science needs to be driven from a regional level.	−0.55	−2	−0.44	−1	−1.51	−4	0.14	1	***	*	***			****

Asterisks signify statistically significant differences between pairs of factors in the strength of perception pertaining to each statement. *p-value of < 0.05; **p-value of < 0.01; ***p-value of < 0.001; ****p-value of < 0.0001.

Factor 1: Enhancing Not Undermining

Science-based management can be operationalised by enhancing the existing system through a more effective science-policy interface and a greater dissemination of knowledge. Factor 1 does not see sectoral management as the most significant barrier, but instead highlights communication failures as an impediment to science-based approaches.

Factor 2: The Global Idealist

Successful science-based management requires top-down approaches in order to enhance equality amongst states and to fix the currently fragmented regime. Factor 2 suggests that science-based approaches cannot be achieved under the current sectoral regime, and that an adequately funded global science body is necessary to achieve BBNJ objectives.

Factor 3: Trust in Science

Political barriers, such as actor bias, hinder science-based management and therefore a future BBNJ Agreement should use science as a neutral platform. Factor 3 suggests that science-based approaches can be achieved by enhancing the authority of science within the decision-making process amongst all stakeholders.

Factor 4: More Than Just Science

Science-based management can be achieved by including more disciplines, particularly socio-economic research. Factor 4 suggests a bottom-up approach which can better account for socio-economic interests and priorities.

Each of these are elaborated on below, with special attention paid to the core themes within each perspective.

Factor 1: Enhancing, Not Undermining

Factor 1 explains 16.14% of the study variance and has an eigenvalue of 4.84. The composite reliability score for Factor 1 is 98%. Ten participants are exemplars for this factor, accounting for one-third of the total P-set. There are no apparent employment demographic connections defining the composition of Factor 1, with exemplars from all six employment demographic groups.

The Status Quo… but Better!

The ranking of the statement, *'you cannot do ecosystem-based management under the current sectoral regime'* is particularly

significant to interpret Factor 1. With an IQS of -5, exemplars suggest that ecosystem-based approaches can be successful under sectoral management through the enhancement of cross-sector communication and data sharing. Exemplars recommended that barriers to science-based management approaches could be overcome by individual sectors having more consideration of the impacts that they have on other sectors. Factor 1 takes a realist view, noting that sectoral management is unavoidable, with sectoral organisation the norm for industry, academia and governments. Factor 1 exemplars posit that some actors use the limitations of a sectoral regime as an excuse for inaction. Instead, it is suggested that ecosystem-based management and other science-based approaches could be successful under the sectoral regime if the sectors have common strategies and objectives, which a future BBNJ Agreement could provide.

A Well-Connected Science-Policy Interface

The perception revealed in Factor 1 is that poor communication between scientists and policymakers is a significant barrier to implementing science-based approaches in ABNJ. With an IQS of +3, the statement, *'scientists have difficulties communicating their science to different audiences'*, is a distinguishing statement for Factor 1 (compared to Factor 2: 0, Factor 3: −1, Factor 4: −3). One factor exemplar noted that, *"there is a big divide between… the science being produced and how much of this science is actually being translated into language metrics that managers and policy makers can understand and then apply."* Furthermore, Factor 1 is also distinguished by its indifference to the statement, *'if a policymaker fails to listen to scientific advice, it is a political failure not a scientific failure'* (compared to Factor 2: −3, Factor 3: −3, Factor 4: −4). As such, Factor 1 suggests that science-based approaches are hindered by the failure of scientists to communicate properly and policymakers to listen. Indeed, one factor exemplar posited that science-based management of BBNJ, *"would be a system where the science can directly influence the policy and vice versa."*

Dissemination of Knowledge Through Obligatory Data Sharing

Factor 1 suggests that enhanced data sharing procedures are vital to the success of science-based management. This is demonstrated through the corresponding IQS of +5 for the statement, *'the best available science needs to be widely available*

for everyone to access.' Furthermore, a distinguishing statement for Factor 1 is, 'data sharing should be an obligation under a BBNJ Agreement' (IQS +4), which signifies a desire for enhanced responsibility to share data. Factor exemplars emphasised that data sharing is fundamental for all aspects of a future BBNJ Agreement to support decision-making. One exemplar posited that when creating ocean laws and policies, "the laws of nature should be our model," concluding that, "this is why good science is needed by decision-makers." Moreover, Factor 1 emphasises the importance of the dissemination of data for informing policy decisions, with one exemplar noting that, "the further you get towards knowledge and advice, the more diversified become the possible policies that can be chosen."

Factor 2: The Global Idealist

Factor 2 explains 15.42% of the study variance and has an eigenvalue of 4.61. The composite reliability score for Factor 2 is 97%. It is the second most densely populated factor group and has eight factor exemplars. Notably, no individual from the science researcher or IGO employment demographic groups loaded significantly onto this factor. Furthermore, Factor 2 is the only factor that does not have an exemplar from the science researcher demographic group.

BBNJ and Equality

Factor 2 emphasises the importance of equality between states. Similar to Factor 1, this includes data sharing, but the emphasis on equality of access is broader for Factor 2, than just ensuring access to scientific data. While Factor 1 exemplars referenced informing policy as the benefits of data sharing, an emergent viewpoint from Factor 2 is that data sharing is to enhance equality of access to marine technology and data amongst states. One factor exemplar noted that, "the non-availability of science...would be detrimental to the maximization of the common good, unfair, unethical". Factor 2 emphasises global equality, as is demonstrated through the highest corresponding IQS amongst factors (+3) for the statement, 'it is crucial that a BBNJ Agreement enhances the transfer of marine technology between states'. Factor exemplars posited that, "for equity and adequate management in all parts of the globe, technology transfer is very important". Factor 2 has a corresponding IQS of +3 for the statement, 'strengthening the financing mechanisms of a BBNJ instrument is crucial' (compared to Factor 1: −2). Indeed, Factor 2 exemplars explicitly reference financial capacity as a prerequisite to conduct scientific observations, build global capacity and transfer technology between states and posited that, "in science there are gaps in terms of how much science we can conduct, due to funding and capacity."

The Status Quo Does Not Work

The results suggest that Factor 2 has a globalised perception of operationalising science-based management, with factor exemplars demonstrating an inclination for a centralised, top-down approach. Factor 2 emphasises the failure of the current sectorally managed regime to implement science-based approaches, such as ecosystem-based management. With a corresponding IQS of +5, the statement, 'you cannot do ecosystem-based management under the current sectoral management regime' is a distinguishing statement for Factor 2 and contrasts with that of Factor 1 (−5). Factor exemplars expressed doubt that, "rational integrated management" could take place under the currently fragmented regime. Instead, a cross-sectoral and holistic approach was touted as the ideal to address the geographical, thematic and institutional gaps that exist under the current regime. The distinguishing statement, 'we need a science body at the global level to provide common scientific standards' has the highest corresponding IQS (+3) of all four factor groups. One factor exemplar posited that, "the scientific method...can provide us with some common ground in order to proceed when we have differences in opinions."

Factor 3: Trust in Science

Factor 3 explains 9.93% of the study variance and has an eigenvalue of 2.98. The composite reliability score for Factor 3 is 94%. There are four factor exemplars for Factor 3, consisting of participants from the IGO, science researcher and state/delegation employment demographic groups. No participants from the NGO or law/policy researcher demographics loaded significantly onto Factor 3.

Science-Based Management Is Hindered by Politics

With a corresponding IQS of −5 for both of the statements, 'we do not have enough data to implement ecosystem-based approaches in ABNJ' and, 'we do not have a global scientific community big enough to tackle all the BBNJ knowledge gaps', Factor 3 does not perceive the current status of available scientific data as a barrier. Indeed, factor exemplars suggest that, "we have enough knowledge and enough scientists to start the job". Instead, Factor 3 emphasises that the barriers to operationalising science-based approaches for BBNJ are political in nature. Factor 3 has a corresponding IQS of +4 for the distinguishing statement, 'even when the science is clear, it is difficult to get the policymakers to take that science on-board' (compared to Factor 1: 1, Factor 4: −1). Highlighting the political nature of BBNJ resource use, one factor exemplar posited that you cannot, "ask for a science-based approach and then overlook the science and establish quotas based on your national interests," and continued that, "it may not give you the quotas that you desire or the mining sites that you desire but I do not think you can have it both ways." This viewpoint is further demonstrated by the corresponding IQS of +4 for the statement, 'people will always pick and choose the scientific evidence that supports their priorities' (compared to Factor 1: −1, Factor 2: −4).

Barriers Can Be Overcome by Putting Science on an Equal Footing

Factor 3 calls for an enhanced role of science, scientists and research within the decision-making process. Significant to the viewpoint of Factor 3 is the statement, 'in the negotiations we have diplomats and politicians but not enough scientists,' which distinguishes Factor 3 only. Factor exemplars commented that, "the scientific community is the only actor who can provide the necessary knowledge to gather and synthesize this information and make it actionable for policymakers." It was further posited that the scientific community has been, "absent in these negotiations."

Factor exemplars noted that the minimal presence of science in the negotiations is, *"one of the biggest weaknesses of the BBNJ process."* Moreover, it was suggested that while scientists play an important role, they are, *"tucked away at the back of the room".* As such, Factor 3 suggests that science-based approaches can be achieved by enhancing the role and authority of science and scientists. This is further supported by the corresponding IQS of +5 for the distinguishing statement, *'the more you can put science on an equal footing within the decision-making hierarchy, the better'* (compared to Factor 1: −3, Factor 4: −1).

Factor 4: More Than Just Science

Factor 4 explains 9.45% of the study variance and has an eigenvalue of 2.83. The composite reliability score for Factor 4 is 94%. There are four factor exemplars for Factor 4, including participants from the employment demographic groups of ABNJ industry experts, state/delegate and science researcher.

De-Centralised Approaches Account for Socio-Economic Interests

Factor 4 demonstrates an aversion to a centralised approach to science-based management. As such, the statement, *'we need a science body at the global level to provide common scientific standards'* distinguishes Factor 4 with an IQS of −3 (compared to Factor 2: +3). The view that we should enhance the current system as opposed to imposing a top-down governance structure is further demonstrated by the corresponding IQS of −4 for the statement, *'you cannot do ecosystem-based management under the current sectoral management regime'* (compared to Factor 2: +5). Factor exemplars note that, *"as long as sectors are talking together and interacting at a national, regional and global level it is entirely possible to not only do ecosystem based management but do it better".* Factor 4 posits that enhanced integration and interactions between sectors is the optimal solution because it can consider, *"other elements, like social elements and economic interests and priorities".* The distinguishing statement, *'in order to define science-based management, we need to bring more disciplines into the discourse',* further demonstrates this with a corresponding IQS of +5 (compared to Factor 1: 0, Factor 2: 0, Factor 3: −2). Factor exemplars highlight the need to include a wide scope of disciplines, including socio-economic research. To facilitate a wider inclusion of disciplines, Factor 4 suggests that ABNJ industry can play a role in data collection, which is demonstrated by the corresponding IQS of −4 for the statement, *'it is problematic that a lot of our data is collected by ABNJ industry'.*

It Is Not Only About Making the Science Available, but Making the Right Science Available

Distinguishing Factor 4 only, the statement, *'it is a challenge to articulate the science into a real-world management response',* has a corresponding IQS of +3 (compared to Factor 1: −2, Factor 2: −1, Factor 3: −1). However, Factor 4 suggests that it is not the sole fault of policymakers. Coupled with the lowest IQS amongst factors for the statements, *'if a policymaker fails to listen to scientific advice, it is a political failure not a scientific failure'* and, *'even when the science is clear, it is difficult to get the policymakers*

to take that science on-board,' Factor 4 highlights the importance of the availability of policy-relevant and salient science. One factor exemplar suggested that while policymakers may be clear about the science that they need, external factors such as personal research interests, institutional incentives to publish novel work and poor understanding of how policy functions, amongst others, could negatively influence the undertaking of salient research. Factor exemplars posited that, *"if the science is presented and is sufficiently tuned to the policymakers understanding, then there is not a problem"* and continued, *"the problem is making sure that the right science is available."*

Identified Areas of Consensus and Conflict

One indication of the level of consensus and conflict between factors comes from the relative perception of each statement by each factor. Statements for which there is not a significantly different relative ranking across the factors can be considered to be areas of consensus. All other statements represent areas of varying degrees of conflict. Another way to conceive of relative consensus is to consider the standard deviation between factor z-scores per statement. As demonstrated in **Table 3**, the Q-results highlight three true consensus points, three areas of broad consensus, and three areas of broad conflict. Each of these areas of consensus/conflict were identified using a combination of quantitative and qualitative information.

Areas of Consensus

Areas of consensus emerged regarding the application of integrative approaches to operationalise science-based management. The statement, *'marine spatial planning is a useful tool for implementing science-based management'* enjoys true consensus across factors with a standard deviation of ±0.26 amongst factor z-scores. The IQS for this statement range from +1 to +3, which suggests a neutral-positive perception of the use of marine spatial planning to operationalise science-based approaches for BBNJ. Participants expressed perceived benefits of MSP in ABNJ, suggesting that, *"if you have an integrated approach to MSP then you will be able to understand not only what you have and what is going on, but the different uses, conflicts and opportunities."* Participants posited that while MSP has not received much focus in the negotiations, the basic principles that characterise MSP are being discussed. It was noted that you cannot achieve BBNJ objectives without some degree of integration, spatial planning, stakeholder cooperation and area-based management tools (ABMTs).

The perceived benefits of integrative approaches also emerged regarding the statement, *'we need to manage BBNJ at an ocean basin scale because ecosystems are ecologically connected across ocean basins',* which enjoyed broad consensus amongst factors. With IQS ranging from +2 to +4, participants posited that integrative approaches that took into consideration ecological connectivity were vital to meet conservation and sustainable use objectives. One participant noted that, *"oceans are complex ecosystems and you cannot manage oceans without a real understanding on how the big flows and processes interconnect."* Another noted that, *"interconnectivity is an essential characteristic*

TABLE 3 | Identified consensus and conflict statements: Statements sorted by standard deviation (variance across factor z-scores for each statement), with corresponding idealised Q-sort scores (IQS) for each factor (F) and category of consensus or conflict (Trend).

Statement	IQS				SD	Trend
	F1	F2	F3	F4		
Data is perceived as having hidden agendas if it comes from a conservation-oriented source.	−2	−2	−3	−1	0.17	True Consensus
Lack of data should not stop us from making sensible management decisions.	+4	+5	+4	+4	0.18	True Consensus
Marine spatial planning is a useful tool for implementing science-based management.	+3	+1	+1	+3	0.26	True Consensus
We need to manage BBNJ at an ocean basin scale because ecosystems are ecologically connected across ocean basins.	+4	+4	+2	+3	0.32	Broad Consensus
It makes it difficult to use science when scientists disagree amongst themselves.	−4	−3	−2	−3	0.42	Broad Consensus
It is problematic that a lot of our data is collected by ABNJ industry.	−3	−1	−1	−4	0.46	Broad Consensus
We do not have enough data to implement ecosystem-based approaches in ABNJ.	−3	−5	−5	−3	0.58	Broad Consensus
The more you can put science on an equal footing within the decision-making hierarchy, the better.	−3	+2	+5	−1	1.09	Broad Conflict
I think there is a strong presence of science within the BBNJ negotiations.	−4	−5	−4	+3	1.27	Broad Conflict
You cannot do ecosystem-based management under the current sectoral management regime.	−5	+5	−1	−4	1.66	Broad Conflict

of ocean ecosystems." Other participants highlighted that governing BBNJ at an ocean basin scale would not only reflect ecosystems, but would also reflect similar political desires and capacities of coastal states, and that governing BBNJ at an ocean basin scale is, *"where political realities and coastal states interests best align."*

Consensus also emerged regarding the application of precautionary approaches for ABNJ. The treatment of the statement, *'lack of data should not stop us from making sensible management decisions'* enjoys true consensus, with a standard deviation of ±0.18 amongst factor z-scores and IQS ranging from +4 to +5. These data suggest approval for precautionary approaches to be employed when data are lacking. Participants noted that, *"to be proactive, we should make management decisions even when anecdotal evidences indicate necessity for management."* Furthermore, it was highlighted that this is an important aspect of the precautionary approach and that one should always strive to make the best possible decisions with the data available. Another participant suggested that, *"'best available science' should not mean that we wait for perfect information before acting"* and other participants posited that waiting for, *"the 'right amount' of information…has delayed management and conservation actions throughout global and regional frameworks."*

Similarly, the broad disagreement with the statement, *'we do not have enough data to implement ecosystem-based approaches in ABNJ'* (IQS ranging from −3 to −5) demonstrates broad consensus within these data about the capacity to take actions to manage BBNJ, rather than deferring it to the future. Participants posited that, *"even with limited data we can implement an approach based on precaution".* One participant noted that the existing data is, *"more than enough to support the implementation of ecosystem-based approaches"* but continued that, *"what we are lacking is the appropriate set of legal and policy tools that enable and sustain those approaches."*

Complementary to this is the general disagreement with the statement, *'it makes it difficult to use science when scientists disagree amongst themselves'* (IQS ranging from −2 to −4). This shared disagreement demonstrates that there is broad consensus within these data regarding the usefulness of scientific

data, despite uncertainty within that data. Participants noted that, *"there will always be some scientists who disagree."* Other participants suggested that, *"this is the nature of science- scientists make hypotheses and…others test them."* It was furthered that science is not the only discipline that faces disagreements or uncertainty, and that disagreement should not be used as an excuse for non-action in relation to the conservation and sustainable use of BBNJ.

Lastly, consensus emerged regarding perceived trust and credibility of scientific data collected by different key stakeholder groups. With a standard deviation of ±0.17 between factor z-scores, the disagreement with the statement, *'data is perceived as having hidden agendas if it comes from a conservation-oriented source'* is a point of true consensus amongst factors. As shown in **Table 3**, the IQS range from −1 to −3 and demonstrate that this statement has a neutral-negative perception across all factors. Similarly, broad consensus emerged in relation to the treatment of the statement, *'it is problematic that a lot of our data is collected by ABNJ industry'.* With IQS ranging from −1 to −4, these data suggest that participants perceived industry-sourced data as credible.

Areas of Conflict
These data suggest that there is conflict amongst stakeholder perceptions surrounding the status and authority of science in relation to BBNJ governance. The statement, *'you cannot do ecosystem-based management under the current sectoral management regime'* demonstrates broad conflict within these data, which is demonstrated by a standard deviation amongst factor z-scores of ±1.66. This statement does not distinguish all factors but presents conflict in perceptions between Factor 1 and Factor 4 versus Factor 2. Exemplars from Factor 1 and 4 (IQS of −5 and −4, respectively) noted that science-based approaches, such as ecosystem-based management, were completely possible under sectoral management (which they considered to be the reality of ocean governance), and in some instances the superior option to a centralised regime. Other participants ranked this statement negatively because they believed that sectoral barriers represented one of many obstacles, and that blaming the sectoral

regime, *"seems to provide an excuse."* In contrast, exemplars from Factor 2 who agreed with this statement suggest that sectoral management is a significant barrier to operationalising science-based approaches and is plagued with fragmentation, both geographically, thematically and substantively. Participants noted that while there has been some improvement, *"many sectoral bodies cannot or are reluctant to undertake ecosystem-based approaches."* It was furthered that, *"we need a cross sectoral approach…to be able to effectively address all regions and all features of the marine biodiversity in ABNJ."*

There is also conflict surrounding perceptions of the current role of science, and the role that it *should have* in the context of a BBNJ Agreement. These disagreements exist despite the aforementioned consensus surrounding the usefulness of existing scientific data and the importance of a precautionary approach to managing BBNJ. For example, perceptions differed in relation to the statement, *'I think there is a strong presence of science within the BBNJ negotiations.'* Factors 1, 2 and 3 disagree with the statement (IQS of −4, −5, −4, respectively), while Factor 4 moderately agrees with it (IQS of +3). Some participants disagreed because they felt that science had been under-represented in the BBNJ negotiation process. This is illustrated by the quote from a Factor 3 exemplar: *"there has been a very weak presence of science throughout the Preparatory Committees and the Intergovernmental Conferences."* Other participants disagreed with the statement because they were uncertain about how science was being used in practice. For example, a Factor 1 exemplar noted that, *"although there is a consensus…regarding the importance of science, it is quite unclear how science is utilized in decision making."*

However, Factor 1 and 4 disagree with the statement, *'the more you can put science on an equal footing within the decision-making hierarchy, the better,'* whereas Factors 2 and 3 agree with it. Considering these two insights together shows that while Factors 1,2 and 3 perceive science to have a weak presence within the BBNJ negotiations, they differ as to whether this is a problem that needs to be addressed going forwards. Exemplars from Factors 2 and 3 who had a positive perception of this statement posited that, *"the alternative to putting science on an equal footing…is the current status quo which allows a wide range of industries to operate without supervision in the high seas."* It was further noted that putting science onto an equal playing field would, *"avoid politicization of the decision making process when considering proposals for new ABMTs."* Exemplars from Factors 2 and 3 further posited that putting science on an equal footing was important because making decisions that are, *"based on the best available science will ensure that the best decisions are taken for the effective long term conservation of marine biodiversity."* This suggests that the perspectives connected with Factors 2 and 3 are associated with a particular value system – one that in the evaluation of any trade-off would, by default, prioritise marine biodiversity. In contrast, Factors 1 and 4 seem to hold value systems that do not give such exclusive primacy to marine biodiversity. For example, exemplars posited that, *"science needs to underpin the BBNJ negotiations but needs to be balanced with economic needs and societal expectations."* Seeing this as a potential area of conflicting value system is an important insight.

DISCUSSION

This study uses Q-methodology to investigate stakeholder perceptions of science-based management of BBNJ. Thirty highly knowledgeable stakeholders ranging from six different employment demographic groups undertook the Q-study, which produced four factors. Factor 1 emphasises a desire to enhance the existing system through a more effective science-policy interface. In contrast, Factor 2 favours a global, centralised approach to science-based management and has a strong focus on global equality, enhanced funding and technology transfer between states. Factor 3 emphasises the importance of enhancing science in the decision-making hierarchy and the use of science to neutralise perceived political bias. Factor 4 suggests that operationalising science-based approaches is a bottom-up task that requires wider input from other disciplines, including socio-economic research. Ultimately, these findings point to a significant level of disagreement amongst key stakeholders regarding the operationalisation of science-based approaches for the conservation and sustainable use of BBNJ.

Achieving the consensus required to effectively implement science-based approaches for BBNJ will not be an easy feat but is of paramount importance. When mandating the negotiating sessions for a BBNJ Agreement, the UN General Assembly Resolution 72/249 stipulated that actors, *"shall exhaust every effort in good faith to reach agreement on substantive matters by consensus"* (United Nations General Assembly, 2017). While areas of consensus can be used as rallying points to build momentum behind desired policy options or to maintain enthusiasm during difficult discussions, a tactic employed to good effect by the President of the Conference, achieving consensus is not an end in itself. Consensus is crucial as participatory processes, such as consensus-built decision-making, can support the acceptance and implementation of future regulatory measures (Maisley, 2013). When trying to build consensus, it is important to understand where there are conflicting perceptions, as well as the differing motivations attached to the polarised views. Identifying areas of stakeholder conflict and the underlying causation can aid in achieving a mutually agreeable (and more abideable) middle ground for BBNJ management options. Here, we highlight the key implications of our study of stakeholder perceptions and the minute nuances and motivations that may drive these perceptions, to unearth ways forward for operationalising science-based approaches for BBNJ.

Implications of Identified Conflict

When investigating existing stakeholder perceptions of science-based approaches for BBNJ, our study highlights significant conflict around:

(1) The authority, status, and definition of 'science' within the BBNJ process.
(2) The extent to which conservation goals or sustainable use goals are emphasised by stakeholders.

Regarding (1), all four factors displayed differing perceptions of the ideal role and authority of science under a future BBNJ Agreement. This finding reflects a well-known science-policy conundrum. Frequently, scientists are asked to provide scientific evidence and advice on complex environmental issues, yet their role in the policy process is often *ad hoc* or undefined (Spruijt et al., 2014). While the authority and role of science often remains uncertain, the perceived importance of science in decision-making is well recognised. However, mere appreciation that science is an important tenet of decision-making will not operationalise science-based approaches. Our study shows that opposition to the current sectoral governance structure is coupled with a higher prioritisation of the need for a global science body and a call for putting science on an equal footing in the decision-making hierarchy. Interestingly, this identified area of conflict closely reflects the polarised debate surrounding a 'duty to not undermine' that has afflicted the negotiations since they began (Scanlon, 2017). Brought into fruition through UN General Assembly Resolution 69/292 (United Nations General Assembly, 2015) it is widely recognised that a future BBNJ Agreement shall not reduce the effectiveness of existing instruments, frameworks and bodies. The duty to not undermine and the complexity of the existing policy and institutional landscape highlight a significant challenge for implementing science-based approaches under a future Agreement. The draft text offers potential modalities that could support science-based approaches for BBNJ, such as a Scientific and Technical Body feeding into and supporting a Conference of the Parties, and a Clearing House Mechanism. Our results suggest that defining the role of science and framing it within an institutional structure is important for moving science-based approaches from aspirations to obligations.

Regarding (2), our results suggest that the underlying conflict around the role and authority of science may be fueled by the extent to which a particular stakeholder/stakeholder group is motivated by the 'conservation' of BBNJ or the 'sustainable use' of BBNJ. Notably, participants with aligned values regarding the benefits of a sectoral approach to governance believe that this approach is beneficial for incorporating socio-economic concerns. Opponents of sectoral governance highlight that preservation of species and ecosystem health objectives cannot be met under a decentralised and fragmented regime. However, ocean management is inherently a societal activity (Christie, 2011), and therefore management must reflect diverse activities and goals (i.e., both conservation and sustainable use objectives). As such, it follows that both BBNJ governance and the science that informs decision-making should accurately reflect the diversity of ocean users and their priorities. Scientific evidence is crucial for informing both the conservation and sustainable use of marine biodiversity and can act as a neutral mediator between the two factions. As Harden-Davies (2018) posits, science can offer universally applicable principles that can be applied to BBNJ governance and, "*can offer a safe "port" in a sometimes stormy sea of discussions.*" The promotion of more disciplines within the BBNJ process, could ensure that there is available and salient science that reflects varying stakeholder priorities to support the BBNJ process. However, our results suggest that there are differing perceptions regarding which disciplines should be included (and/or excluded) when defining 'best-available science.' Notably, similar divergence exists in the negotiations. The draft text presents two possible options- a narrow definition calling for the, "*use of the best available 'science'*" and a more inclusive definition calling for the, "*use of best available 'scientific information and relevant traditional knowledge of indigenous peoples and local communities'*"(United Nations, 2019). Our results suggest that the promotion of inclusive terminology that reflects diverse knowledge systems and stakeholder values, may help enhance support for science-based approaches under a future BBNJ Agreement. Indeed, there is evidence that existing international processes, such as the UN's Convention on Biological Diversity and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) have been successful in incorporating diverse knowledge systems into their science-policy processes (Tengö et al., 2017).

Implications of Identified Consensus

When investigating emergent stakeholder consensus regarding science-based management of BBNJ, our study highlights apparent consensus regarding:

(1) The perceived trust and credibility of science and precautionary approaches.
(2) The perceived benefits of integrative and participatory management approaches for BBNJ.

Regarding (1), our results highlight areas of consensus regarding certain basic principles, including the application of precautionary approaches and the trustworthiness and credibility of science. In what is now a rapidly changing ocean, scientific evidence is often complex, incomplete or uncertain, which can complicate science-policy interactions. While scientific uncertainty and gaps in understanding are often considered the crux of successful science-policy interfaces (Esch et al., 2018), our findings suggest that precaution in the face of uncertainty is becoming entrenched within international fora. Indeed, a key finding of this research is the general appreciation and call for precautionary approaches when data are insufficient. Furthermore, participants were generally accepting of non-academic sources of scientific data, which has significant implications for the BBNJ knowledgebase. Consensus emerged around the perceived credibility of conservation and industry-oriented sources. Regarding conservation-oriented data, our results reflect similar findings concerning the perceived usefulness of the workshops and side events provided by civil society throughout the BBNJ process (Blasiak et al., 2017). Moreover, our findings regarding the perceived credibility of industry-sourced data present unique opportunities for implementing science-based approaches for BBNJ. While data collected from industry stakeholders, such as fisheries, oil and gas or deep-sea mining, is often perceived as less credible, our work suggests that BBNJ stakeholders may be open to

utilising these data sources. Ocean industries operate tens of thousands of maritime vessels and platforms worldwide, which can potentially provide valuable infrastructure for cost effective data collection (Holthus, 2018; Murray et al., 2018).[4] Apart from supporting science-based management by bolstering the BBNJ knowledgebase, framing ABNJ industries as valuable stakeholders could also enhance multi-stakeholder engagement in the BBNJ process which could help align fundamental values between the 'conservation' and 'sustainable use' of BBNJ.

Regarding (2), our Q-results highlight consensus regarding the application of integrative and participatory management approaches. There appears to be general participant agreement regarding the application of integrative approaches, such as MSP, to operationalise science-based management of BBNJ. While MSP has received minimal attention within the negotiations thus far, this approach to marine governance could be considered under ABMTs (Wright et al., 2019). Within the Q-results, the application of MSP received a neutral-positive reaction from participants and was generally supported in interview data. This highlights an opportunity to build on stakeholder support through enhanced communication of the benefits that MSP could provide. The neutral-positive ranking could suggest that the introduction of MSP as a tool to operationalise science-based management would not receive strong pushback or opposition. Indeed, many of the core components that make up MSP are already included in the negotiations, albeit under different branding. This is significant because integrated and inclusive governance approaches could enhance scientific coordination in ABNJ and provide an avenue for overcoming the aforementioned conflict regarding the role and authority of science. It also corresponds with an internationally recognised awareness that stakeholder involvement is a prerequisite for the perceived legitimacy of international environmental regulations (Maisley, 2013). Building on these findings, integrative and highly participatory management approaches could provide an optimal platform to institutionalise science-based management approaches for BBNJ and should be actively promoted in the negotiations.

Implications for the BBNJ Negotiations

It has long been recognised that value systems can drive conflict (Druckman et al., 1988). This suggests that the BBNJ process and the future BBNJ Agreement will inevitably be a consensus reflection of the underlying values held by key stakeholders. Therefore, there is significant merit in explicitly and formally addressing these value systems as a part of progressing the BBNJ negotiations, rather than allowing them to implicitly influence the process. Our results suggest that BBNJ stakeholders generally value scientific input, despite uncertainty. This not only provides a strong foundation for delegations to push for the inclusion of

robust science-based approaches, but also presents a unified rallying point. With only one scheduled negotiating session remaining, negotiators will inevitably have to engage in difficult discussions, rife with divergence. Notwithstanding the fact that much is ultimately down to States' political will and realpolitik, recognising and openly addressing areas of divergence will be an important element of participatory decision-making, both for the negotiations and under a future BBNJ regime.

CONCLUSION

While there is a general consensus that science-based approaches are beneficial, it is important to understand what this entails and enshrine these approaches within a robust international BBNJ Agreement. This study uses Q-methodology to assess existing stakeholder perceptions of operationalising science-based management approaches for BBNJ. Ultimately, we highlight areas of conflict amongst stakeholder perceptions, especially regarding the role, authority and definition of science within the BBNJ process. Despite these obvious areas of conflict, areas of stakeholder consensus also emerged. Our study suggests a general acceptance of scientific uncertainty and the application of precaution, as well as a perceived benefit of integrative approaches. Key implications of this research include the evidencing of fundamental tensions between differing perceptions of the authority and definition of science and between conservation and sustainable use objectives, which may be fueling stakeholder conflict. Furthermore, this research highlights actionable ways forward and suggests that integrative and highly participatory management approaches are required to operationalise effective science-based management of BBNJ. Insights can help resolve conflict and build a stronger BBNJ Agreement.

DATA AVAILABILITY STATEMENT

The raw statistical data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by GeoSciences Ethics Committee, University of Edinburgh. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CG, JR, and DJ conceived the study and research question. CG was the lead investigator of the research and designed and undertook the data collection and analysis. CB provided

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[4]However, there are barriers to free and open access to industry collected datasets, which would need to be overcome to fully optimise multi-stakeholder benefits (Murray et al., 2018).

Q-methodology expertise. JR procured the funding for the research. CG led the writing and drafted the text for the manuscript. All authors contributed to the draft text and revision of the manuscript.

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