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Contribution to the Themed Section: '*Case studies in operationalizing ecosystem-based management*'

Editor's Choice

International perceptions of an integrated, multi-sectoral, ecosystem approach to management

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The Ecosystem Approach to Management (EAM) has emerged over the past decades, largely to promote biodiversity conservation, and more recently sectoral tradeoffs in the management of marine ecosystems. To ascertain the state of practice of EAM operationalization, a workshop was held, which included a pre-workshop online survey. The survey gauged international participants' perspectives regarding capacity, knowledge, and application of EAM. When asked about the subject, most survey respondents had a general understanding of EAM, and provided a clear definition. Major perceived challenges to EAM objectives by those surveyed included limited knowledge, conflicting interests, insufficient communication, and limited organizational legal frameworks or governance structures. Of those directly involved in an ecosystem approach, the majority responded that processes were in place or developed for application of integrated knowledge toward assessing key issues within their respective sectors (i.e. fisheries, conservation, energy), and that capacity was generally high. Our results show that most respondents, irrespective of sector or geography, see value in considering an integrated, broader ecosystem approach as they manage their sector. Although many participants were from the North Atlantic region, our results suggest that much of the international community is converging toward continued understanding of broad-scale, integrated approaches to marine resource management.

Keywords: ecosystem approach to management, ecosystem-based management, multisector; ocean use, sector tradeoffs.

Introduction

There have been numerous calls for conducting an Ecosystem Approach to Management (EAM) of marine systems, also known as Ecosystem-Based Management (EBM), in the literature for the past decade or more (Christensen *et al.*, 1996; Larkin 1996; Botsford *et al.*, 1997; McLeod and Leslie, 2009; Curtin and Prellezo, 2010). The term EAM is used here. Elements of why, when, and what pertaining to EAM have been discussed in the literature (de la Mare, 2005; Hirshfield, 2005; Apitz *et al.*, 2006; Arkema *et al.*, 2006; Murawksi, 2007; Curtin and Prellezo, 2010), as well as some clarifying elements of linguistic uncertainty (Link and Browman, 2014). It is clear that the discipline and practice of EAM is now at the point of exploring the how-to of executing EAM, and continues to evolve from its original intent of conserving biodiversity (CBD, 2004), into other avenues such as addressing sectoral tradeoffs in marine ecosystem management (FAO, 2009). Certainly many elements of the suggested protocols, processes, and applications are congealing around accepted, recommended best-practices (ICES, 2005; Crowder and Norse, 2008; Pitcher *et al.*, 2009; Tallis *et al.*, 2010; Poe *et al.*, 2013; Long *et al.*, 2015). It therefore seemed timely to examine if there are lessons learned from nascent examples where EAM has been attempted, and to build upon past review efforts (Bianchi and Skjoldal, 2008).

A workshop held in January of 2016 sought to take stock of the state of practice of EAM in the marine environment, from multiple geographies and multiple jurisdictions (ICES, 2016). This workshop was supported by the Atlantic Ocean Research Alliance (AORA) Coordination and Support Action, and the European Union's Horizon 2020 research and innovation program. Complementary support for the workshop came from the Food and Agricultural Organization (FAO), Canadian Department of Fisheries and Oceans (DFO), National Oceanic and Atmospheric Administration (NOAA), and International Council for the Exploration of the Seas (ICES), with additional contributions from the OSPAR (Oslo-Paris) Commission and the Baltic Marine Environment Protection Commission – Helsinki Commission (HELCOM), and was aimed at a multi-sectoral suite of personnel associated with studying, managing and using various components of the ocean. The workshop sought to bring together a diverse group of experts, practitioners, stakeholders, and affected parties to discuss a myriad of considerations relative to EAM (*sensu* Browman and Stergiou, 2004; McLeod and Leslie, 2009; ICES, 2016). Of particular emphasis was the state of practice and identification of major impediments for fuller adoption and implementation of EAM.

Prior to this workshop, an online survey was distributed to all participants. The survey was designed to capture the perspectives from a wide-range of disciplines and ocean-use sectors concerning the state of application of EAM. Here we present those results as illustrative of how operational EAM is at the present moment, with additional input into the state of practice of the discipline.

Methods

An online survey was developed to solicit input from workshop participants, including responses from individuals specifically targeted by workshop organizers (Supplementary Table S1), to examine perceptions of capacity, knowledge, and application of EAM within specific case studies, and allow for subsequent discussion at the workshop. The survey consisted of 27 questions (Supplementary Table S2), and additionally asked respondents about their opinions regarding a range of EAM options. This targeted survey approach is commonly adopted (Evans and Mathur, 2005), had careful question design for its intended audience, planned intersection among questions, and sought to solicit thorough input and commentary beyond the ranking responses (Fowler, 2013). Such approaches have been used before in similar contexts in order to gauge regional and international stakeholder perspectives on environmental policies and EAM (Quinn and Theberge, 2004; Jennings and van Putten, 2006; Lawrence *et al.*, 2010; Biedron and Knuth, 2016). The poll was conducted online via a Sharepoint application, with an emailed link sent to all registered workshop participants and case study presenters.

Individuals within specific occupational roles from pre-defined sectors including conservation, fisheries, oil and gas, and renewable energy were surveyed as to their engagement and understanding of an integrated, multisector ecosystem approach, its value, and overall application within their respective sectors. Those who were directly involved in an ecosystem approach to science or management were queried as to their specific regional case studies, the processes involved in carrying out their work, and in applying the generated knowledge toward integrated multi-sectorial EAM arrangements, applications, decision making, and capacity. Additionally, all respondents were asked to rank and score effective ways to improve an ecosystem approach, with their range of responses pre-binned into four selected categories of improvements, and to comment upon perceived impediments and challenges to EAM.

Responses were quantified and summarized into common overarching themes, and reported as frequencies or percentages of those surveyed (Fowler, 2013). Although further statistics are possible, here we report on basic summary statistics to elucidate major themes and patterns.

Results

The majority of survey participants ($n = 51$) were scientists and researchers (58%) from the fisheries and conservation sectors (Figure 1). Most respondents were from the European Union (EU), Norway, Canada, and the United States, although there were a few from other locales (e.g. South Africa, South America, Australia). All representatives from the fisheries sector were directly involved in an ecosystem approach to science or management, while involvement was more evenly divided among members of the conservation community, and resource managers. Overall, there was low survey participation from NGO representatives, and members of the industrial, commercial, oil and gas, and renewable energy sectors. Main outputs, products, and services identified within participant sectors (Table 1) included fisheries, marine transportation, food supply and aquaculture, and petroleum and renewable energy. However, 21% of those surveyed did not provide an answer. When asked about their knowledge of the subject, most survey respondents had a general understanding of EAM, and were able to provide a clear definition (55%), although nearly 40% of respondents chose not to answer this question. Participants emphasized that key components to the ecosystem approach included sustainable human uses, spatial or areal considerations, marine systems, and integrated management frameworks (Figure 2). Complementary workshop discussions (see ICES, 2016) also highlighted the importance of goals that included: sustainability and resilience, environmental stewardship, human well-being, and jurisdictional, social, and

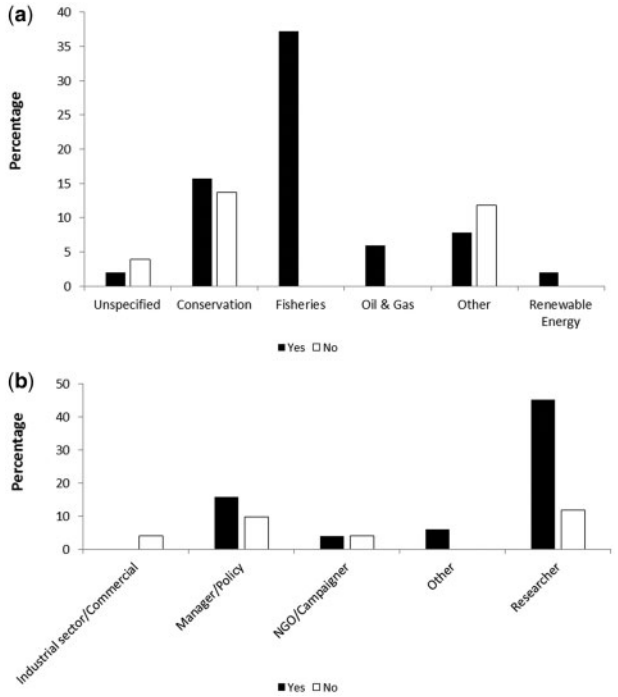

Figure 1. Percent (of total) of surveyed participants ($n = 51$) from their respective **(a)** sectors, **(b)** roles, and their direct involvement in an ecosystem approach (Yes/No).

Table 1. Main outputs, products, and services identified by survey participants ($n = 51$) within their sectors.

Major sector output	Frequency	Percentage
No answer	24	21.2
Fisheries	19	16.8
Marine transportation	14	12.4
Food supply and aquaculture	12	10.6
Petroleum and renewable energy	10	8.8
Tourism	9	8.0
Conservation and ecosystem services	7	6.2
Education and research	7	6.2
Recreation	6	5.3
Economies	5	4.4

Values denote the frequency and cumulative percent breakdown of their multiple responses within collective themes.

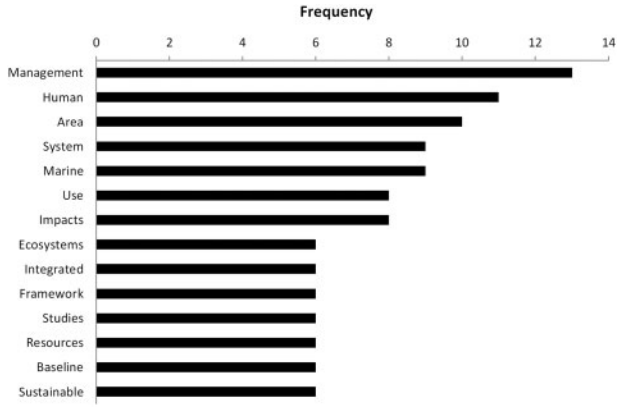

Figure 2. Major terms used by survey participants ($n = 51$) to describe an ecosystem approach.

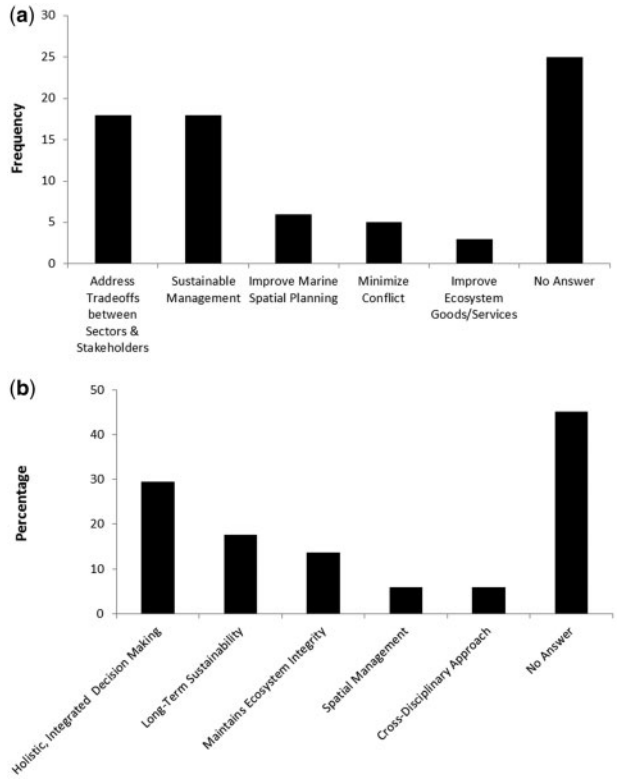

Figure 3. (a) Survey participants' ($n = 51$) perceptions of the benefits of integrated cross-sector management. Values denote the frequency of their multiple responses within collective themes. **(b)** Percent breakdown of survey participants' identification of the main value of an ecosystem approach.

geo-spatiotemporal components for multi-sector management. Adding to the definition, additional components within a given system should include ecosystem functions, interactions and services, and human dimensions, while applied processes should account for increased knowledge, participatory approaches, adaptive management, and cross-sectoral tradeoffs based on values. Participants commented that the knowledge that is generated from an ecosystem approach should be applied toward enhancing understanding of the given system, and for assessing tradeoffs in conjunction with a participatory approach by stakeholders and sectoral representatives.

Among multiple answers provided by each survey participant, major perceived benefits of integrated cross-sector management included the ability to address tradeoffs between sectors and stakeholders, and a means to work toward sustainable resource management (Figure 3a). When participants were asked to identify the main value of an ecosystem approach (Figure 3b), common replies included the ability to allow for holistic, integrated decision making, create long-term sustainability, and maintain ecosystem integrity. However, most frequently there was no response to either of these two questions.

Table 2. Perceived impediments and challenges to EBM objectives, and average scored rankings (±1 SE; Scores ranged from 1 -low to 5 -high) of survey-suggested effective improvements to an ecosystem approach, by participants (n = 51).

Perceived impediments and challenges	**Percentage**
Lack of knowledge	28.2
Conflicting interests and timelines	15.4
Lack of communication or collaboration	12.8
Lack of organizational or legal framework	12.8
Environmentally unsustainable practices	7.7
Lack of resources	7.7
Scientifically unsound management strategies	5.1
Suggested Improvements to an Ecosystem Approach	**Score**
Improved science/knowledge to inform decisions	4.3 ± 0.19
Improved planning of marine areas use	4.1 ± 0.16
Improved stakeholder consultation	3.9 ± 0.17
Improved legal frameworks	3.8 ± 0.21

Table 3. Responses of surveyed participants directly involved in an ecosystem approach ($n = 21$) as to the development of processes in their sector for focused integrated knowledge.

Integrated knowledge focus	**Developed processes**	**Limited/in development**	**No formal processes**
Impacts of various activities on marine ecosystems	61.9	33.3	4.8
Ecological, social, and economic tradeoffs of ecosystem strategies	47.6	19.0	33.3
Directly assessing human impacts and applied decision making	57.1	38.1	4.8
Sector-level management in a multi-sector EAM framework	52.4	23.8	23.8
Capacity for EBM	61.9	28.6	9.5

When responses were synthesized, major perceived impediments and challenges to EAM objectives by those surveyed (Table 2) included lack of knowledge, conflicting interests, lack of communication, and a lack of organizational or legal frameworks. However, additional commentary from participants highlighted that "definition of conflict" also emerged as a critical component. Of the four factors posed regarding effective improvements to the ecosystem approach, all factors were ranked and scored as equally important to surveyed participants.

Of those surveyed who were directly involved in an ecosystem approach to science or management ($n = 21$), the majority of individuals responded that processes were in place or developed to allow for application of integrated knowledge toward assessing several key issues within their respective sectors (Table 3). Over 60% of these respondents answered that processes exist to generate knowledge on marine ecosystem impacts of human and natural activities. However, 38% also responded that these processes still need more development, and while certain means to generate knowledge on ecological and socioeconomic tradeoffs are currently in place in some areas (48%), further work is needed. Additionally, participants responded that less formalized processes exist to incorporate sector-level management into a multi-sector EAM framework, including processes that allow for data and information uptake, advice formulation, decision implementation, process review, and application of this information to assess impacts and decision-making. Respondents from the United States and Europe did generally remark that its incorporation played a medium to strong role in their regions. However, most respondents (71%), irrespective of sector or geography, saw great value in considering a broader range of issues as they manage their sector. Although the majority of respondents answered that processes were in place to allow for direct assessment of human impacts and the quality of applied decision making, 43% replied that processes were still limited or non-existent. Overall, EAM capacity within science, policy, and management fields was perceived to be well developed and high, with European and United States respondents indicating that their capacities were strongest. Globally speaking, however, many regions are still developing their EAM capacities, with 62% of respondents characterizing their capacities as "good to high", with emerging international frameworks and processes to facilitate and integrate knowledge in varying stages of development (Table 4).

Additionally, of those directly involved in ecosystem approaches, their described categorical case study subjects (Figure 4) were mostly working on marine resource planning, an Ecosystem Approach to Fisheries (EAF), or environmental management, and specific science and management within identified regional ecosystems. The majority of US oil and gas sector interests are applied to marine resource planning, while the conservation sector was most focused on specific regional ecosystems. Often case studies were specific within a given sector, with the fisheries sector predominantly focused on EAF, while a few members of the conservation sector also focused on EAF, marine resource planning, and the design of Marine Protected Areas. Although most participants were from fisheries and conservation sectors, it warrants noting that most groups or sectors were at least represented and covered a wide range of issues.

Discussion

A variety of case studies from multiple sectors was examined in this survey, and our results suggest that most respondents, irrespective of sector, or geography, see value in considering an integrated, broader ecosystem approach as they manage their sectors. Most of the international community is converging on an understanding of EAM despite linguistic, process, and operational uncertainty (Arkema *et al.*, 2006; Barnes and McFadden, 2007; Curtin and Prellezo, 2010; Link and Browman, 2014), and there is mutual agreement on the importance of more holistic approaches to marine EBM within a given region. There is sufficient capacity to move forward with EAM in some regions, including the United States and western Europe, but current limitations to implementation include a continued lack of formalized legal frameworks for assessing tradeoffs among sectoral objectives (Apitz *et al.*, 2006; Tallis *et al.*, 2010), and perceived lack of knowledge (but see Patrick and Link, 2015). Our findings reveal that processes are in place in many regions and sectors to operationalize an ecosystem approach, particularly the development and implementation of Integrated Ecosystem Assessments (Levin *et al.*, 2009, 2013; ICES 2015). These processes may be less pronounced when applied directly toward ecological and socioeconomic tradeoffs, as observed in past critiques (Crowder

Table 4. Responses of surveyed participants directly involved in an EAM ($n = 21$) as to the details of its operationalization in their regions.

Region	Set up of multi-sectoral arrangement	Processes to facilitate generation of knowledge	Processes to integrate knowledge into EAM	Multi-sector processes for data uptake, advice, and decision implementation
Australia	Legislated and scientific institutional frameworks.	End-to-end ecosystem models and collaboration with resource managers/industry.	Science-led collaborations, mechanisms, and research on use/adoption of risk management standards, and on how to operationalize EBM.	Variable depending on legislative or policy framework. Research plays an important role in decisions.
Canada	Network of RFMOs (including NAFO) to deliver effective EAF.	Developing assessments to examine socioeconomic and stakeholder tradeoffs. Using multispecies ecosystem models.	Science products reviewed and used for elaboration of scientific advice through working groups, although much knowledge is still being identified.	Scientific advisory councils advising RFMO fishery commission, with input a critical component in decision making.
Europe	Research networks approach biodiversity issues, and integrate ecosystem-based approaches into environmental and fisheries management.	Developing models and metrics to measure socioeconomic tradeoffs between environmental efforts, and risk management processes.	Multi-disciplinary working groups assessing integrated impacts with datasets on environmental/human impacts/pressures and cross-sector integration.	Decision making and review within legislative and regulatory, managerial frameworks and committees, but implementations being developed.
South Africa	Comprised of intergovernmental commissions, NGOs, institutions, industrial and fishing alliances.	Fund academic and some governmental research through institutions and initiatives.	None mentioned	Departmental governmental framework, but mostly ad-hoc practices and participation in international forums for fisheries and seafood safety management.
USA	Federal agencies working in fisheries management, conservation, marine energy.	Government research into human activities, community engagement, ecosystem characterization, integrated ecosystem assessments, and ecosystem services tradeoffs.	Fund scientific study, multisector review, support cross-sectoral assessments and scientific investigation of system-level ecological and socioecological impacts.	Formalized, localized review of fisheries management plans and actions, stakeholder engagement, managerial bodies and councils to examine tradeoffs. Available information is regularly used in decision making.

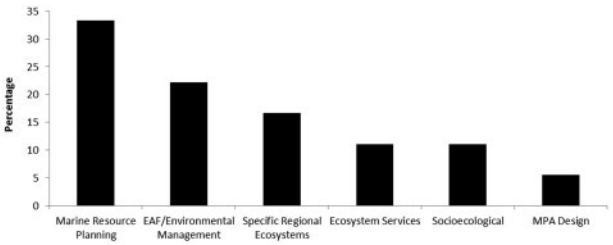

Figure 4. Percent breakdown of specific case study categories for surveyed participants directly involved in an EAM ($n = 18$).

and Norse, 2008; Thrush and Dayton, 2010; Poe *et al.*, 2013), but protocols and examples for doing so are continuing to emerge. There is strong agreement among participants that continued development of EAM toward assisting in minimization of conflicts, and in resolving sectoral tradeoffs, is key to its success. Additionally, these findings improve upon a past assessment of international EBM implementation (Pitcher *et al.*, 2009) that characterized only four of 33 evaluated countries as "adequate", and no country as "good" for EBM implementation, but could also reflect individual bias in self assessment and be dependent on geography.

The main impediments to implementing EAM were perceived lack of knowledge, conflicting interests, lack of organizational/legal framework, and lack of communication. Subsequent discussion at the workshop highlighted that "lack of framework" and "definition of conflict" emerged as critical considerations to overcome for future, additional application of EAM. However, the discussion highlighted that the lack of information and communication impediments are continually being overcome (ICES, 2016). The challenges for establishing a clear governance structure to adopt EAM remain, but key steps are being taken in many jurisdictions. For instance, explicitly examining and incorporating ecosystem considerations (often phrased in the context of ecosystem goods and services) is a core facet of the Marine Strategy Framework Directive in the EU (O'Higgins and Gilbert, 2014), Oceans Act in Canada (Jessen, 2011), Australia Oceans Policy (Vince *et al.*, 2015), the Norwegian Integrated Management plans (Olsen *et al.*, 2007, 2015), the National Ocean Policy (National Ocean Council, 2013), and Ecosystem-Based Fisheries Management Policy (NOAA, 2016) in the United States. The overarching IEA approach (Levin, *et al.*, 2009, 2013; ICES, 2015) holds promise as a means to have an analytical framework from which conflicts and tradeoffs can be usefully and equitably addressed.

Responses from surveyed participants were largely from researchers within fisheries and conservation sectors. As a corollary, industrial sectors were not well represented by survey participants, which is a direct reflection of the limited workshop participants. These results are not surprising given the natural resource genesis of EAM, and its development in the management sector (Grumbine, 1994; Yaffee, 1996, 1999), and also highlight the need for a more focused, yet broadly applied engagement strategy for a wider group of ocean researchers, users and managers. Case studies continue to emerge that demonstrate concrete advantages of utilizing and operationalizing EAM, and recommendations for its effective implementation (Österblom *et al.*, 2010; Butler *et al.*, 2013). Continued communication of these successes allows for their increased awareness among sectors, and together with socio-economic impact assessments of practices, can lead to increased application of ecosystem-based, holistic management and marine spatial planning scenarios. As future relevant case studies become available, it would be beneficial to potentially conduct a repeated workshop effort, where improved efforts to facilitate participation of broader sectorial representatives who are applying EAM approaches could occur.

In order to advance EAM, there remains a need for the EAM community to continue educating multiple sectors about the benefits of EAM and applying EAM beyond solely a fisheries management and conservation focus. This is highlighted by the sectoral focus just mentioned, low numbers of survey respondents for EAM practitioner questions, and often unanswered key questions by participants about their perceptions and valuation of an ecosystem approach. Non-responses to several questions may represent a lack of application of key components in a given region or sector, or unfamiliarity with ecosystem approaches within the prescribed categories by respondents. Additionally, continued research into ecosystem function in a given area, and means to assess sociological tradeoffs of ecosystem strategies, including multi-sectoral approaches to EAM, will greatly enhance its practice and evaluation. Example studies that address sectorial costs and benefits of an ecosystem approach include those by Österblom *et al.* (2010) and Butler *et al.* (2013) who specify recommendations for effective implementation of EAM toward nutrient mitigation, fisheries co-management, and coastal zone planning in the Baltic and Great Barrier Reef, Australia regions, respectively. Based upon our survey responses, the roles of sector-level management in EAM appear to be more defined and specified in both Europe and the United States, while less pronounced or responsive for Australia, Canada, South Africa, and South America. It is clear, however, that our findings do show that EAM is being applied within a variety of sectors, and where it is being considered, the participants strongly value an integrated broad-scale approach for management of their respective sectors.

The discipline and practice of EAM has come a long way from some of the earlier descriptions for the marine environment (e.g. Larkin 1996). Certainly there remains much work to be done, and many challenges and caveats persist in the face of increased implementation of EAM. Yet the results of this work show that compared with earlier assessments of the subject, progress is indeed being made, with emerging consensus throughout sectors not only on what EAM entails, and on what is needed to do it, but also on examples of where it is being put into practice.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

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