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Transboundary research in fisheries

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ABSTRACT

Spatial boundaries have become an indispensable part of regimes and tools for regulating fisheries, with examples including marine protected areas, regional fisheries management organizations and Exclusive Economic Zones. Yet, it is also widely acknowledged that boundaries are a social construct, which may be resisted by both fishers and fish ecology. The ensuing spatial and institutional mismatches have been shown to frustrate management efforts, exacerbating issues of non-compliance and ultimately leading to conflicts and overfishing. Interestingly, the often static and rigid nature of these boundaries has also led to a concomitant research interest in 'transboundary'. This paradoxical situation of more boundary-setting entailing more transboundary thinking warrants a deeper understanding about boundaries and the role of transboundary research in fisheries. The aims of this review article are twofold: (1) a theoretical clarification on the meanings and uses of spatial boundaries drawing on geographical "boundary studies" literature; and (2) a construction of a typology that outlines how transboundary research is being articulated and envisioned. Together, the study reveals that transboundary scholarship in fisheries are mostly related to resources, fleets, trade and governance aspects and that dealing with the "boundary paradox" encompasses re-incorporating, re-scaling and re-imagining of boundaries. This article provides a conceptual basis for reflecting upon boundaries in world's fisheries and opens up discussions for a more nuanced boundary application that can better cope with multi-level interactions and dynamicity.

1. Introduction

Spatial boundaries are an indispensable part of the fisheries management system. Numerous legal and administrative schemes exist to define how fisheries are to be partitioned and organized in the world's oceans. Exclusive Economic Zones (EEZs), high-seas designation represented by regional fisheries management organizations (RFMOs), Large Marine Ecosystems (LMEs) and Marine Protected Areas (MPAs) are some of the most prominent examples. The widespread application of spatial boundaries in the oceans and inland waters would not take many people by surprise, however. In fact, the use of boundaries might be largely assumed and even taken for granted. Lidskog et al. [1] argue that spatial boundaries have been instrumental in making complex and fluid environmental problems more governable, as they help draw attention to important management issues, anchor those issues to particular administrative-geographical jurisdictions, and ascribe legitimacy and responsibility to relevant actors. States, arguably the most dominant actor in resource management, have been keen proponents of inscribing spatial boundaries, as the boundaries help make intricate local resource patterns and decentralized social practices legible for state functions of taxation, policing and provision of services [2]. What is more, at the sub-state or the community level, the importance of well-defined and enforced bounded space around a group of users and a resource system has been extensively argued for by common-pool resource scholars and fishery economists alike as a precondition for the successful management of fishery resources (see [3–6]). Thus, boundary delimitation has been proliferated in many fields, including fisheries, to enhance the effectiveness of management tasks.

At the same time, it is widely acknowledged that boundaries are

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inescapably a social construct, which may be neither aligned with nor respected by ecological and human components essential to fishing. The ensuing spatial mismatches between legal-politico-management boundaries on the one hand and ecological or socio-cultural ones generated by fish and fishers on the other have been identified as a significant institutional pitfall and a governability challenge [7–11], frustrating management efforts and posing threats to the health of fish stocks as well as fisher wellbeing. Real-life repercussions include erosion of communities' adaptive capacity and fishing livelihoods due to a reduction or restriction of traditional fishing spaces [12,13], and exacerbation of non-compliance by fishers who are suddenly labeled as poachers or unwanted migrants [14,15]. Other harmful consequences could involve human rights violations such as abduction, arrests or physical assaults in addition to being hostages or "pawns" in larger geopolitical struggles [16,17]. Ecologically, because of the magnified intractability of the enforcement problem, boundary mismatches have been shown to create an added pressure on fish stocks, giving rise to serial overfishing at the regional-global scale as well as localized depletions in border areas [18,19].

The realization that the static spatial boundaries deployed to manage fisheries can be ill-equipped for the fluctuating patterns of the natural and social order has given rise to a set of research efforts focused on dealing with their unintended, but critical, side-effects. For instance, a research tradition of investigating optimal/cooperative arrangements for managing transboundary resources in a multilateral setting (see [20]; also theme 1.2 in Fig. 2) was precipitated by the episode of delineating Extended Fisheries Jurisdiction (EFJ) in the 1970s (and later EEZs). As the term implies, an interest in 'transboundary' represents an approach that aims to carefully assess the effects of boundary-setting and provide ways to reconcile or transcend the limitations of static and rigid spatial demarcation for fisheries management. Practical solutions for alleviating the inadvertent shortcomings of spatial boundaries are being sought on several fronts including joint fishing zones or transboundary conservation areas [21], more flexible harvest plans for shared or migratory fish stocks [22], MPA networks linking fragmented small reserves [23] and 'dynamic ocean management' based on the integration of real-time data [24]. What this research trend implies is that with installation of spatial boundaries, we are also propelled to engage with *transboundary* flows, connections and cooperation.

The situation of more boundary delineation entailing more transboundary approaches in managing world's fisheries, which we term "boundary paradox", warrants attention to deeper questions about boundary and transboundary – a topic that has so far eluded academic attention. This article proposes that coming to terms with spatial boundaries and their inherent shortcomings could start from reflecting on the basic notions of what boundaries mean, how they have been used and in what alternative ways they can be conceptualized. What is the broad historical and intellectual current with which to understand the proliferation of boundaries in the ocean and inland waters? What are the varied ways in which spatial boundaries can be envisioned? What are the transboundary responses to the boundary paradox, and more specifically, what is the scope of transboundary fisheries research? In addressing these questions, this article engages in two review activities; it offers (1) a theoretical clarification drawing on a wider "boundary studies" literature, followed by (2) a typology of transboundary scholarship developed through a review of a fisheries literature. The aim is to organize wide-ranging perspectives that exist on transboundary fisheries through a typology, as they pertain to resources, fleets, trade and governance; it thus presents a collective viewpoint on the topic.[1]

In what follows, Section 2.1, first, deconstructs the general concept of a boundary, drawing on pertinent geographical literature. This then guides our narrative on spatial boundaries used in fisheries management (Section 2.2). We subsequently provide a review of relevant fisheries literature in order to outline the thematic extent of transboundary scholarship (Section 3). This was facilitated through an initial brainstorming discussion (Section 3.1) and a construction of an interdisciplinary typology (Sections 3.2–3.5). Section 4 moves on to further conceptualize this body of work as comprising three idealized transboundary responses – re-incorporating, re-scaling and re-imagining. In Section 5, the article concludes with a proposition that gaining insights into the underlying meanings and the wider trend in boundary application could enable alternative discussions for spatially-based fisheries management that are better able to cope with dynamic and multi-scalar interactions.

2. Understanding boundary and transboundary

2.1. Studying boundaries

Boundaries in geography have long been understood as a firm, monolithic feature that helps secure sovereignty and control [25]. This view stems in part from the Westphalian system,[2] which shifted focus from city states towards governments of larger territorial units. Nation-states became the primary institutional agents asserting territorial integrity and self-determination in a system of inter-state relations [26,27]. In line with this, boundary studies were mainly concerned with international borders that divide the world into a (supposedly) neat mosaic of politico-jurisdictional units. In the early 1960s Minghi [28] assembled eight categories of boundary research: boundaries in disputed areas, effects of boundary change, evolution of boundaries, delimitation process, boundaries involving tiny states, offshore areas and internal division and, finally, boundaries in disputes over natural resources. Although Minghi's categorization, the first of its kind, hinted at the evolution of what is possible of boundary studies, Jones [29] submits that the meaning of boundary in much of the 20th century was still limited to line-in-Cartesian-space founded on a relatively static understanding of political borders.

The early 1990s marked the end of the cold war and the hastening of globalization, which brought with it an infusion of new concepts such as mobility, de/re-territorialization, hybridity, post-modernity and neo-liberalism [25,29]. These developments provided an impetus that began to challenge the apparent fixity that had characterized the boundary discourse. Moving away from the realist position of international relations, nation-states were no longer to be immediately privileged as the unit of analysis. A more critical stance and alternative visions of boundaries were sought to expand the scope of discussion and curb state-centric limitations. Concepts such as "territorial trap", i.e., the tendency to assume states as rigid containers of societies with uniform spatial identities of internal members [30], and "seeing like a state", i.e., states' wholesale reliance on abstract and universal geometric boundaries for depicting society with little concern for what lies inside the parcel [2], were made influential to warn about the risky impression of centralized boundary-drawing. Contingent on historical-geographical context, boundaries were increasingly seen as processes, practices, symbols, institutions or networks through which power and control is negotiated rather than simply imposed [25,31,32].

Against this backdrop, the idea of boundaries in boundary studies gained several new dimensions. One of the major shifts was that

[1] It must be noted, however, that in attempting these reviews, we leave aside the issues arising from contradictory boundary settings, as in situations of legal pluralism [142]. In such situations, people adhere to different socio-legal perceptions of boundaries and boundary behaviour, creating normative confusion and possibly conflict [53].

[2] Stemming from the Peace of Westphalia, signed in 1648 to end the European Thirty Years' War, the Westphalian system refers to the Western-originated, "realist"-based international system of states, where each nation state is seen to have sovereignty over its territory and domestic affairs. Subsequently, it champions the principle of legal equality between states as well as the principle of non-intervention in the internal affairs of other states.

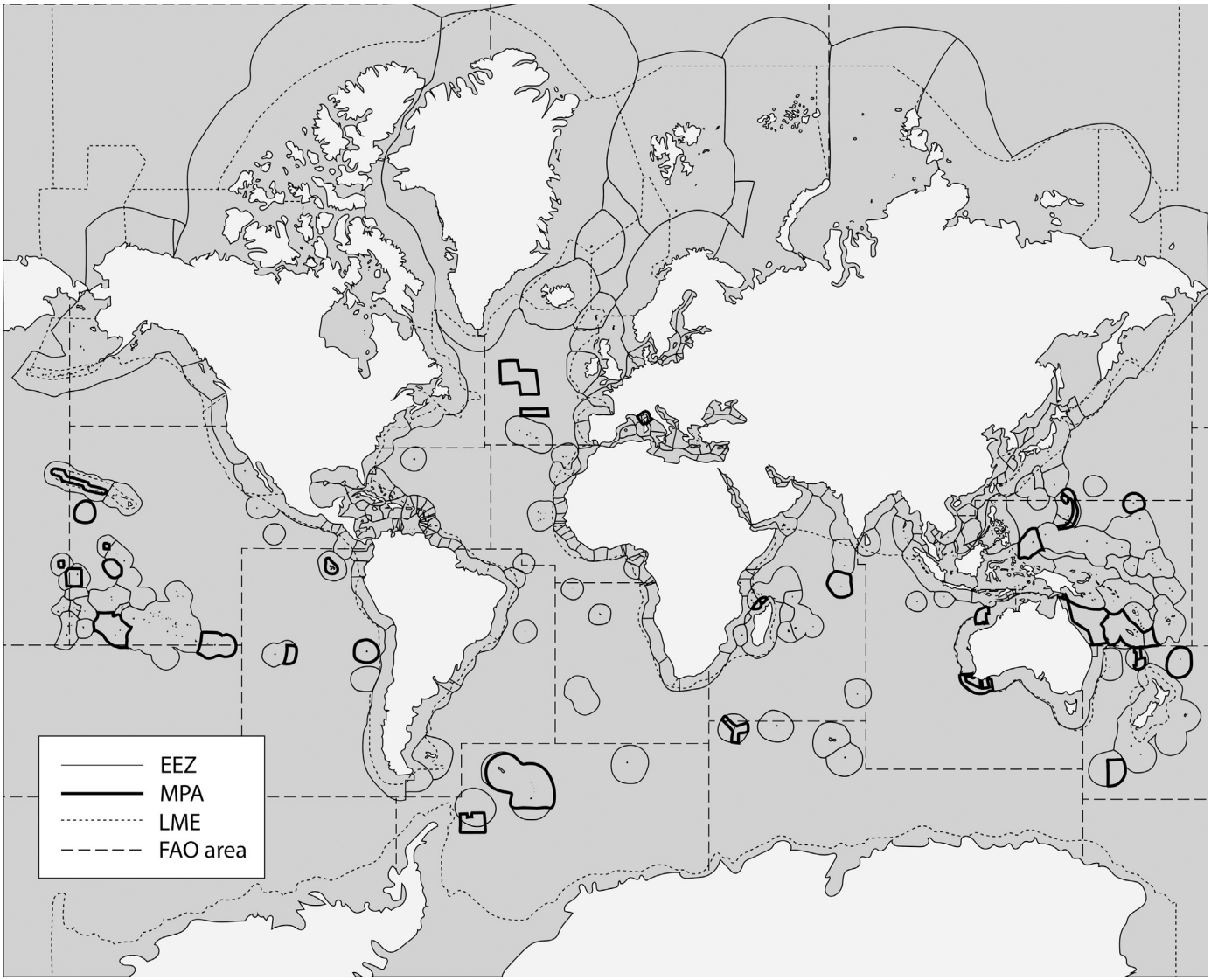

Fig. 1. An overlay of four existing boundary regimes used for fisheries management. Together, they hint at the complex and 'tangled' nature of their designation (EEZ – Exclusive Economic Zone; MPA – marine protected area, only those over 75,000 km^2 in size are shown; LME – Large Marine Ecosystem; and FAO major fishing areas) (Note: this is not in scale and for illustration purpose only).

boundaries are not merely conferred and assumed but they are enacted by the performance of multiple actors including both state and non-state agents. This represents a remarkable expansion from the earlier view of boundaries as a prerogative of only the geographical elite such as diplomats, lawyers, cartographers and engineers [29]. For instance, Rumford [33] has highlighted the idea of 'borderwork' to denote the process in which political boundaries on land are created and maintained by the labor of real people through the mundane activities of border-crossing, cross-border shipment or trade, border security or even loitering (see also [34]). People are not just subject to the official directive of boundary-drawing and enforcement, but they can also take part in the envisioning, constructing and resisting of boundaries as part of their daily lives, exerting influence both discursively and physically. According to this perspective, the symbolic and material value of the boundary, as well as its purpose and legitimacy, is in fact something that can be questioned and evaluated.

Similarly, a broader inclusion of non-state actors in the study of boundaries has also led to the unveiling of multiple possible meanings of boundaries. For instance, Bauder [35] writes that an international border signifies a visual, sometimes physical and often conspicuous, line on the ground that delineates people's status as migrants or returning citizens. Depending on which side of the border you are from, the experiences could be vastly different. For government, it can serve as an instrument to manage economic trades and labor markets by controlling movement of goods, people, capital and ideas. It can also stir up nation-building rhetoric for consolidating domestic power [36], and be employed as a marker that highlights cultural differences in people [37]. Hence, boundaries and borders "do not have the same meanings for everyone" [38, p. 81]. The multiple meanings can also clash with each other and accentuate the intrinsic function of a boundary as an exclusion device separating 'Our' perspectives from 'Theirs' and distinguishing what is relevant 'Here' from 'There'. The ability of boundaries to make neat divisions has been, however, challenged by poststructural critiques questioning the plausibility of the precise categories on which systems of knowledge is based and problematizing uneven power relationships almost always associated with creating distinctions [29]. Accordingly, power lies in the ability to institute division and order the world in particular ways. For those seeking to gain advantage in society, becoming a proactive participant in boundary-making is, thus, a crucial means of asserting one's claims and prolonging the meanings s/he finds worth protecting.

Beyond the conventional assumption of boundaries as being divisive and restricting mobility, they are also being conceptualized as the "engines of connectivity" [25, p. 67]. This view is evidenced by

the observation that there are often intense interactions that happen at border regions as the boundaries attract flows of people and goods, including specific gateway locations such as airports and maritime ports. Boundaries can thus be drawn with the purpose of facilitating communication and connection with others. For instance, cross-border regions are shown to exhibit a greater tendency to transform into 'spaces of flow' where more polycentric and networked integration of public, private and non-profit sectors are expected [39,40]. There one finds 'border culture' that "sustains linkages, assures continuity and maintains prosperity between bounded states" [41, p. 70]. Seeing boundaries in terms of openness and inclusion has been further exemplified by the typical convergence of humanitarian assistance for refugees and migrants (e.g., refugee camps) in international border areas [25].

As such, the thinking on spatial boundaries has evolved to embody a rich set of possibilities. This development implies a shift away from the overly restrictive worldview that privileges political demarcations of a nation-state framework. It also means that there are numerous shapes and meanings of boundaries that are relevant to our world. Together, the prevailing conception of boundary as fixed, divisive, exclusive, binary and universal has begun to share a conceptual space with a set of alternative imaginations that hinge on context, praxis, diversity, connectivity and inchoateness. The application of this to aquatic realm, particularly fisheries, is explored below.

2.2. Spatial boundaries in fisheries management

Spatial regulation is a widely-applied instrument in fisheries management, whose visibility has markedly grown in recent decades with large-scale, multilateral zoning of the oceans. At the national level, the parceling of EEZs by coastal states has marked a major development in ocean governance that fundamentally changed how fisheries are organized [42]. At the supra-national level, the oceans have been delineated into a number of geographic areas represented by RFMOs for managing highly migratory or straddling fish species in the high seas. Additionally, the locally-popular schemes of MPAs, "catch shares" and territorial use rights for fishing (TURF) are all predicated on spatial zoning of the sea in order to administer particular fisheries and community groups (see [43–45]). Customary law in fishing too often makes use of territorial zonation [46]. As shown in Fig. 1, other contemporary zonation includes LMEs which divide the seaward perimeters of the continents into distinct regions to promote large-scale ecosystem approaches (see [47]) and 27 'major fishing areas' maintained by the Food and Agriculture Organizations (FAO) which partition inland and marine waterbodies for statistical purposes as well as regional/national initiatives such as spatially managed areas in the European Union (see [48]) and the Large Ocean Management Area (LOMAs) in Canada (see [49]).

Arguably, the most far-reaching spatial boundary regime influencing contemporary fisheries management is the EEZ. By the mid-1970s, a number of coastal states had already extended their fisheries jurisdiction to 200 nautical miles offshore. Formalized by the Law of the Sea Convention (UNCLOS) in the following decade, the ensuing division of the sea into the EEZs has effectively granted coastal states an exclusive authority to exploit and manage fisheries resources contained within respective EEZs, further consolidating state-based, centralized management ethos. Since then, several influential narratives arose to challenge the state-driven focus, however. The decline of fish stocks in many EEZs gave rise to the possibility of fisheries crises near the turn of the century and put pressure on government agencies [50–52]. In addition, lessons from the legal pluralism literature [53], a growing acceptance of co- and community-based management initiatives [54,55] as well as the rise of neoliberal-kind, market-based approaches [56,57] have all contributed to placing the state-centric mode under increasing criticism for mishandling fisheries development. While the shortcomings of the state-controlled fisheries management in both inshore and offshore fisheries have thus been confronted from several angles, none of these arguments have led to the serious questioning of the logic and operation of the EEZ, which have sustained and undergirded state-centric operation, let alone suggesting any substantial revision.[3] Differently put, despite many varied calls for paradigmatic changes in the way fisheries are governed (e.g. [58–62],), the near irrefutability and permanence of EEZ (and the boundaries that define them) has been maintained, constituting somewhat of a curious trend. What can explain its persistence?

EEZs arguably provide a leading example of the idea of boundaries that are fixed and stable as reflected in the early geographical thinking. While the UNCLOS provisions guiding EEZ delineation are specific to the oceanic circumstances (e.g., in consideration of the unique features such as the location of islands and continental shelves and innocent passage of civilian vessels), EEZs are still very much approached as if they are rigid containers with visible and physical dividers. The same rationale applies to inland waters, where though without an overarching international regime like the UNCLOS, each country sharing a waterbody has been extending its national or sub-national jurisdiction out to Cartesian lines-on-the-water agreed to serve an international boundary. On this point, Norman [27, p. 28] states that "it is only in relatively recent history that territorial power and sovereignty has been conflated into distinct territorial units that can be determined by abstract concepts such as latitudinal lines (e.g., the 49th parallel) that have little or no reference to major water sources." Going further, Roszko [36], drawing from Vandergeest and Peluso [63], has claimed the sea has become subject to the territoriality of the modern state, transformed into an abstract space which is homogeneous and linear for partitioning and comparing and placed in a national and global territorial grid defined by latitudes and longitudes. The implication is that spatial boundaries are seen as a fixed given, which creates mechanisms of control over territory and any resources within by a sovereign politico-administrative entity (e.g., a nation-state). We reason that EEZs are artifacts of this particular conception of boundaries.

Similarly, another critical view is that boundaries that create TURFs, MPAs, quota-based management and now marine spatial planning all draw their basis on terrestrial management [24,64]. According to Siriwardane and Hornidge [65, p. 12], this view starts from questioning "how traditionally earth-bound, 'land-locked' disciplines such as human geography and sociology, together with their very 'grounded' methodologies could be put out to sea". It follows that the traditional terrestrial land use planning model has been incrementally extended from the land to the coast and then to the marine environment and the open seas. Practical challenges are amplified when a model based on the land-based static notion of boundaries is brought to account for highly dynamic, multi-scale oceanographic features and patterns. This risks making inappropriate claims about the precise spatiotemporal definition of fish habitats and property rights, especially relating to fine-scales [24,64].

Conceptually, there is room for the fisheries management discourse to embrace ocean and aquatic boundaries to signify lines of connection, that is, "lines of connection with far-flung terrestrial territories, production sites and markets… [or with] something more material, such as fish and minerals" [66, p. 254]. If we acknowledge that connections and divisions are both necessary outcomes of boundary-drawing and that the zonation of the ocean is inherently dynamic (see [67] for two contemporary real-world examples in which seeing the ocean as a stable set of well-defined areas ordered for specific uses would prove to be a fallacy), then, boundaries used for fisheries management may also represent a site of connection. This possibility is hinted by the novel aims of MPAs – the argument that the design of

[3] Although a single EU EEZ has consolidated individual member states' EEZs, the basic tenet and the structure of the EEZ remain intact.

an MPA system is fundamentally about improving networked connectivity between individually-drawn reserves to ensure sufficient larval dispersal [68–70]. Seen in this light, MPA boundaries, though still producing a distinction between inside and outside, can clearly hold an outward orientation.

The connective appeal of boundaries is further bolstered by their relations to the acts of movement that occur within, across and outside the boundaries, as Steinberg [71, p. 467] states, "boundaries also regulate and are reproduced by acts of movement". His argument (and those of many scholars of critical borderland and migration studies) is that understanding and managing bounded space requires not only the construction of the "inside" with preoccupation with maintaining spatial fixity, but also simultaneously understanding the construction of the "outside" as an arena of mobility. He further explains this by quoting de Certeau [72, p. 117], "space is composed of intersections of mobile elements. It is in a sense actuated by the ensemble of movements deployed within it". According to the insular portrayal of spatial boundaries, mobility, and in fact transboundariness, would be a disruption and even a frustration to the project of enclosure. Yet, being open to the perspective that sees movement and mobility as constitutive of boundary-making could permit asking different questions about the meaning of the boundary, its varied effectiveness and the possibilities for its renewal and adaptation. The movement of fish across the many spatial aquatic boundaries such as MPAs and EEZs is already widely acknowledged (see next section for more). Likewise, we can begin to more deeply engage with the spatial movements of fishing activities occurring across or near certain boundaries drawn on water. What are different fisher groups' relationships with a certain spatial boundary? Does their fishing activity amount to support or resistance to the existing boundary? What do their spatial tendencies reveal in terms of the legitimacy of the boundary? There already exist several useful inquiries aimed at exploring ways in which the performance of non-state actors, and even the movement of non-human actors, such as fish, cetaceans and oceanic currents, co-determine the progress of a maritime boundary through refusal, revision or re-creation (for example, see [15,17,27,73,74]).

In short, boundaries are equipped with more varied trajectories and plural meanings than conventional understanding would depict it. We submit that the effect of this conceptual expansion would be most pronounced in the boundaries set on water, an already dynamic and fluid medium on its own. Research that alleviates the static view of spatial boundaries or that attempts to accommodate the associated limitations (e.g., scale mismatch or overfishing of shared stocks) are already underway in fisheries – a field exhibiting considerable reliance on spatial management strategies. We compile, classify and interpret the existing work on transboundary fisheries to create a typology, which is presented in the next section.

3. Depicting transboundary scholarship

3.1. Methods

Numerous work has engaged with the topic of transboundary fisheries so far. Yet, given the increasingly interconnecting world together with a continuing need for spatial enclosure, a coherent platform constructed through a typology is expected to help generate more focused research impetus to this otherwise scattered body of scholarship. An open discussion was first organized to obtain a preliminary impression of the scope of transboundary fisheries research. Fifteen researchers from academia, non-governmental and inter-governmental sectors were part of the brainstorming session held at the University of Amsterdam in June 2015.[4] In view of the wide-ranging perspectives raised in the discussion concerning this topic, the authors proceeded to develop a typology of contents of transboundary fisheries research. The typology was constructed through a review of fisheries literature. Over 90 peer-reviewed articles returned from online searches, using Scopus and Google Scholar conducted in September 2015 with search words "transboundary" AND "fish or fishing or fishery", formed the basis of the review. The authors' personal libraries were also scanned for relevant work including book chapters and online reports. An inductive approach was employed in the development of a typology [75]. Papers were reviewed without an *a priori* set of criteria allowing for the emergence of key themes. Key research questions were first extracted from each paper, which were then grouped into research themes. As more papers were scanned, the themes were revised to accommodate any new topics and to reduce overlap among them. The process continued until the typology was deemed comprehensive enough to account for all major threads in transboundary fisheries research while still striving for conciseness. Lastly, a meta-level categorization of the themes produced four dimensions of transboundary scholarship – (1) transboundary resources; (2) transboundary fishing; (3) transboundary trade; and (4) transboundary governance.[5] Fig. 2 displays the typology, which contains four research dimensions and 11 research themes. A full table with sample research questions and article references for each theme can be accessed online in Supplementary material.

3.2. Transboundary resources

The transboundary resources dimension comprises articles that belong to three research themes. Although having somewhat distinct foci, the three themes share the same underlying concern for transboundary fish stocks. Together, as shown in Fig. 2, they are about the scientific understanding of resource dynamics, management and conservation in light of the installment of spatial boundaries, namely, (1.1) monitoring and studying the characteristics of the shared resource such as stock structure and migration patterns; (1.2) determining harvest management strategies including allocation of catch quotas and fishing rights; and (1.3) improving resource and ecosystem conservation through integrated planning and other technical measures.

This research dimension has arguably been the point of departure for much transboundary scholarship in fisheries. With the onset of EEZ implementation in the 1970s transboundary resources such as tuna, Alaska pollock, oceanic squids and jack mackerel were suddenly established as a salient fisheries category. Munro et al. [76], for example, estimated that transboundary fish stocks represent roughly a third of global marine capture fishery harvests. Due to the mobility of these species, issues of jurisdictional overlap and of the divided "ownership" became pertinent. There arose an acute need to ascertain the spatial distribution of these resources as well as to coordinate harvest strategies in order to avoid overfishing. Hence, a substantial share of the articles in this dimension focuses on understanding relative abundance, fish assemblages, and migration patterns of transboundary resources (e.g., [77–80]). Secondly, beyond merely studying stock characteristics, a number of papers have relied on bioeconomic principles and modelling techniques to predict the optimal level of total allowable catch (TAC) and allocation of quotas among the involved countries (e.g. [81–84]). Similarly, game theoretic scenarios were used to calculate the optimal harvesting solutions under cooperative and non-cooperative management strategies (e.g. [20,85,86]). We also observed that the emerging effect of climate variability has been recently incorporated into the analysis thereby offering a more realistic and sensitive diagnosis (e.g., [87,88]). Thirdly,

[4] The session was organized as part of the People and the Sea VIII conference with the support of Too Big To Ignore network.

[5] The last three of the four dimensions in the transboundary typology broadly resembles Thorpe and Bennett [112]'s distinction of globalization of fish production, trade and regulatory control, respectively. Also see Bavinck and Salagrama [10, Section 2.2].

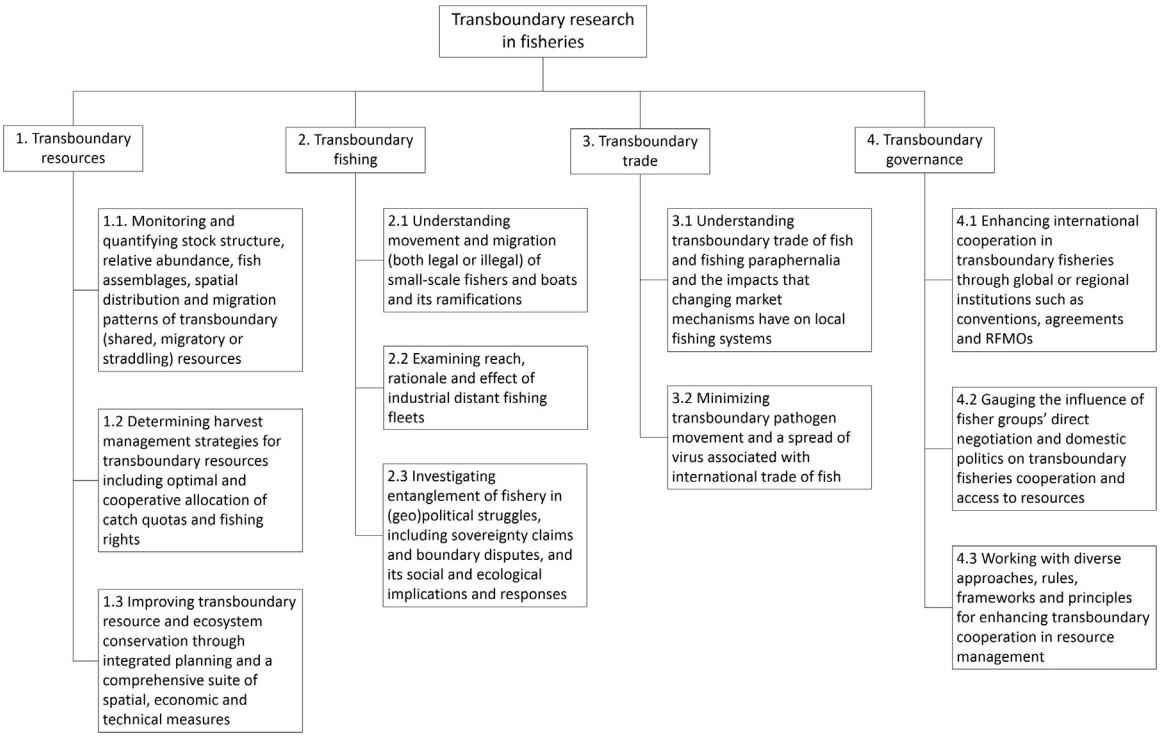

Fig. 2. A typology cataloguing transboundary research in fisheries.

the articles with explicit conservation aims are shown to feature three sub-areas of inquiry. One thread concerns the design of management tools for the protection of transboundary species such as MPAs and Payment for Ecosystem Services (e.g., [89–91]). Another is focused on monitoring and understanding multi-sectoral and basin-wide issues affecting transboundary fisheries (e.g., land-based industries, hydro-electricity and hydrocarbon energy production, and transportation) drawing on integrated and ecosystem-based management approaches (e.g., [92–95]). Finally, transboundary resources need not be only about fish stocks. Estimating impacts that fisheries bycatch as well as abandoned, lost and discarded fishing gear have on aquatic diversity and long-ranging species such as turtles, sharks and seabirds has formed another visible sub-group of the resource-driven transboundary inquiry (e.g., [96–98]).

3.3. Transboundary fishing

Distinction between resources that move across boundaries and fishers who do has been recently articulated by Scholtens and Bavinck [99], who also added that much of the literature on transboundary fisheries has so far favoured the resource dimension. Nevertheless, transboundary fishing amounts to a significant area of research, as this review confirms. Here, it is organized into three main themes – (2.1) understanding boundary-related movement of small-scale fishers and the legal and socioeconomic ramifications; (2.2) tracing the reach, rationale and effect of industrial distant-water fleets as they traverse potentially several jurisdictional boundaries; and (2.3) examining complication that arises from transboundary fishing's entanglement in (geo)political boundary issues.

Transboundary fishing can occur when customary fishing habits precedes an installment of a boundary, as is the case of trawling in the Palk Bay between India and Sri Lanka [100], and sea cucumber harvesting in the "MOU Box" between Indonesia and Australia [101]. Alternatively, it could be driven by economic motives as distant-water fleets or small-scale fishers devise strategies to pursue external fishing grounds, although a combination of several motivations is likely at work. On the one hand, research on small-scale fishers' movement in coastal or inland waters has looked at the extent, causes and outcomes of fishing across fixed boundaries, whether a village fishing ground, a protected area or an inter-state border (e.g., [102,103]). Furthermore, this line of inquiry has explored the illicit and controversial facets of transboundary fishing, namely illegal, unreported and unregulated (IUU) fishing as well as arrests and detainment of fishers by authorities (e.g., [16]). On the other hand, the research on distant-water fleets has taken a somewhat critical stance to problematize the negative fallouts of fishing operation in overseas EEZs or the high seas. Swartz et al. [104] estimated that approximately 30 out of 80 million metric tons of marine catches are occurring outside the domestic EEZs of the fleets. Also, China's distant water fleets alone operate in 93 EEZs and its transboundary operations are responsible for 5 per cent of global marine landings [105]. The concern has been their tendency to erode ecological surplus and marginalize the welfare of the coastal developing states. Hence, estimating the catch capacity of the fleets and probing into their modus operandi appear to be the mainstay of this research theme so far (e.g., [106,107]). The third theme centres on the recognition that fishing is often embroiled in the geopolitical processes that occur beyond the typical domain of a 'fisheries system'. Transboundary fishing is often not just a fisheries issue, but becomes a part of bigger struggles towards territorialization and nation-building manifested through events such as maritime boundary disputes or sovereignty claims of islands and reefs. For instance, the way fishers and fishing boats have been drawn into the conflict as victims at the whims of more powerful governing bodies, or as an active agent in co-constructing the fate of the boundary struggle through resistance or support has formed an emerging, but lively, research agenda (e.g., [17,100,108,109]). In doing so, nuanced meanings and diverse values of boundaries and transboundary fishing have also been sought.

3.4. Transboundary trade

This review has also revealed a market or trade dimension that revolves around a transboundary movement of landed fish and seafood products. Global and regional fish trade is inherently transboundary. In 2012, export of fish encompassed 37% of total fish production by

weight [110], and major seafood consuming countries are increasingly sourcing their seafood from foreign sources [104]. Characteristic of the resource, too, "its fugitive nature, its propensity to straddle territorial waters, and the potential for irreversible overexploitation" make fish stocks easily susceptible to the vagaries of market forces [111, p. 144]. Reflecting the high tradability of the seafood as well as its significant potential for contributing to food security, seafood trade has been on the rise and is now considered the largest traded food commodity internationally [112]. Despite increasing attention for the global flow of fish, this review indicates that research that explores the issue from the perspective of boundary spanning has been comparatively lacking, albeit with some exceptions. We identify two research themes that engage with the transboundary notion – (3.1) understanding the geographical pattern of fish exploitation and trade and the impacts that changing market mechanisms have on local fishing systems; and (3.2) minimizing transboundary pathogen movement and the spread of virus associated with fish trade.

Fish trade can be limited to a small area but can still cross an international border (as in the case of Malaysia-Philippines maritime frontier zone, see [113]). Or it could involve distant markets exhibiting a large-scale pattern of serial expansion over time across the globe [18,114–116]. International trade and accessing foreign markets necessarily implies transcending national boundaries where there could exist differences in politico-institutional setup, environmental conditions as well as socio-economic status of consumers (e.g., the developed-developing world binary). This is a crucial topic for research as the intensifying international trade (inexorably a capitalistic mode of exchange) has been identified as one of the culprits of the accelerated depletion of wild fish stocks [117–119]. Fluctuation in market conditions, including a sudden ban of fish exports, can also negatively impact the livelihood situation of local small-scale actors, for instance, through reduced employment and income loss [14,120]. In the second theme, scholars have raised biosecurity concerns associated with international trade of fish (e.g., live broodstock, frozen uncooked shrimp as well as farmed and ornamental fish), as it is known to increase the risk of transboundary spread of disease and movement of pathogens to the detriment of aquaculture industries and domestic biodiversity protection (e.g. [121,122],). In sum, understanding the enlarging spatial reach of fish trade and the shifting circumstances in the global market appears an important agenda for transboundary fisheries research with a view to devising less disruptive outcomes for stock health, consumer food security, and fisher wellbeing.

3.5. Transboundary governance

Intricately connected to all transboundary dimensions is the governance aspect. Given the involvement of more than one party in a transboundary setting, what appears essential to transboundary governance is the question of *cooperation*, that is, engendering a process where autonomous parties with similar interests work together to achieve mutual goals. In this review, three inter-related research themes are outlined – (4.1) enhancing multi-lateral cooperation via the work of supranational institutions such as conventions, agreements and RFMOs; (4.2) exploring multi-scalar interactions including the influence of domestic interests and politics on shaping international cooperation and access to resources; and (4.3) working with diverse approaches, rules, frameworks and principles for facilitating cooperation.

Research effort in understanding and improving transboundary governance has occurred at various scales. On the one hand, the efficacy of global institutions has been questioned through an in-depth analysis of existing treaties, such as the 1995 Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and by making suggestions for a revamped global agreement aimed at mending the gaps in high seas fisheries regime (e.g., [123,124]). On the other hand, some have focused on the regional setting by investigating RFMO's effectiveness in coordinating multi-lateral action (e.g., [125,126]). Secondly, there are studies that focus on multi-scalar interactions as a way to seek innovative and synergistic governance outcomes for a transboundary fishery. For instance, Miller et al. [127] examined an intricate interplay between a RFMO and a sub-regional institution for the West and Central Pacific Ocean tuna fisheries. In another instance, transboundary cooperation at the international level might also be influenced by the demands of domestic interest groups (e.g., fisher organizations) who may apply political pressure to intervene in the negotiation of TAC allocation or modify an internationally-agreed fishing boundary regime (e.g., [128–130]). The third and final theme categorizes researches that engage with various novel approaches, frameworks and principles for improving cooperation among involved partners. Notable conceptual attempts include merging ecosystem-based management with a community-based model [131], mainstreaming gender considerations in transboundary resource governance [132], highlighting the usefulness of informal arrangements (i.e., scientific and post-bureaucratic cooperation without high costs of administration and formalized structures) [133,134], and elucidating transboundary fishing challenges from a legal pluralism perspective [99]. The effort also extends to pragmatic and methodologically-driven inquiries. For example, development of a transparent, equitable and politically admissible rule framework for assessing and allocating 'conservation burdens' has been initiated [135]. Finally, the suitability of catch shares or other rights-based tools for managing a transboundary fishery has also recently been evaluated (e.g., [136]).

4. Discussions: approaches in transboundary research

Seen through the typology, transboundary scholarship indeed spans a rich variety of perspectives and methodologies, which can cover the range of scales from *de facto* community tenure lines all the way to highly-codified supranational management boundaries. The subject of boundary-crossing varies, too, producing different foci that involve fish stocks, fishers, fish products or governance arrangements. Amid this diversity, three main approaches to understanding and responding to the inherent (albeit inadvertent) shortcomings of fixed spatial boundaries can be identified, as shown in Fig. 3. They are described in the increasing degree of the progressiveness of the engagement, in line with the broadening scope of what boundary can mean and do.

4.1. Re-incorporating

Research that falls into this response type works with the existing spatial fisheries regime. While recognizing the static and rigid nature of the boundaries and the ensuing inconsistency with the mobile aspects of fisheries, it does not tend to directly challenge the present boundary configuration. Instead, this response type is aimed at re-working the science and the terms of boundary-traversing. It thus signifies an attempt to make things work given the constraints. It also represents an attempt to build on the successful examples of boundary schemes in promoting conservation and fishery cooperation aims (e.g., see [21,137]). Relevant research includes improving the knowledge of the spatial behaviour of: fish stocks (studies in research theme 1.1), small-scale fishers (2.1), industrial fishing fleets (2.2), fish trade (3.1), spread of fish pathogen (3.2), as well as devising optimal quota allocation among the parties involved (1.2). Though being the most passive approach, it is still a crucial one that often sets the baseline knowledge for making more substantial claims about the boundary uses in fisheries management.

4.2. Re-scaling

Transboundary reactions to rigid boundaries can represent a more active undertaking, as this response type is directed at re-drawing of

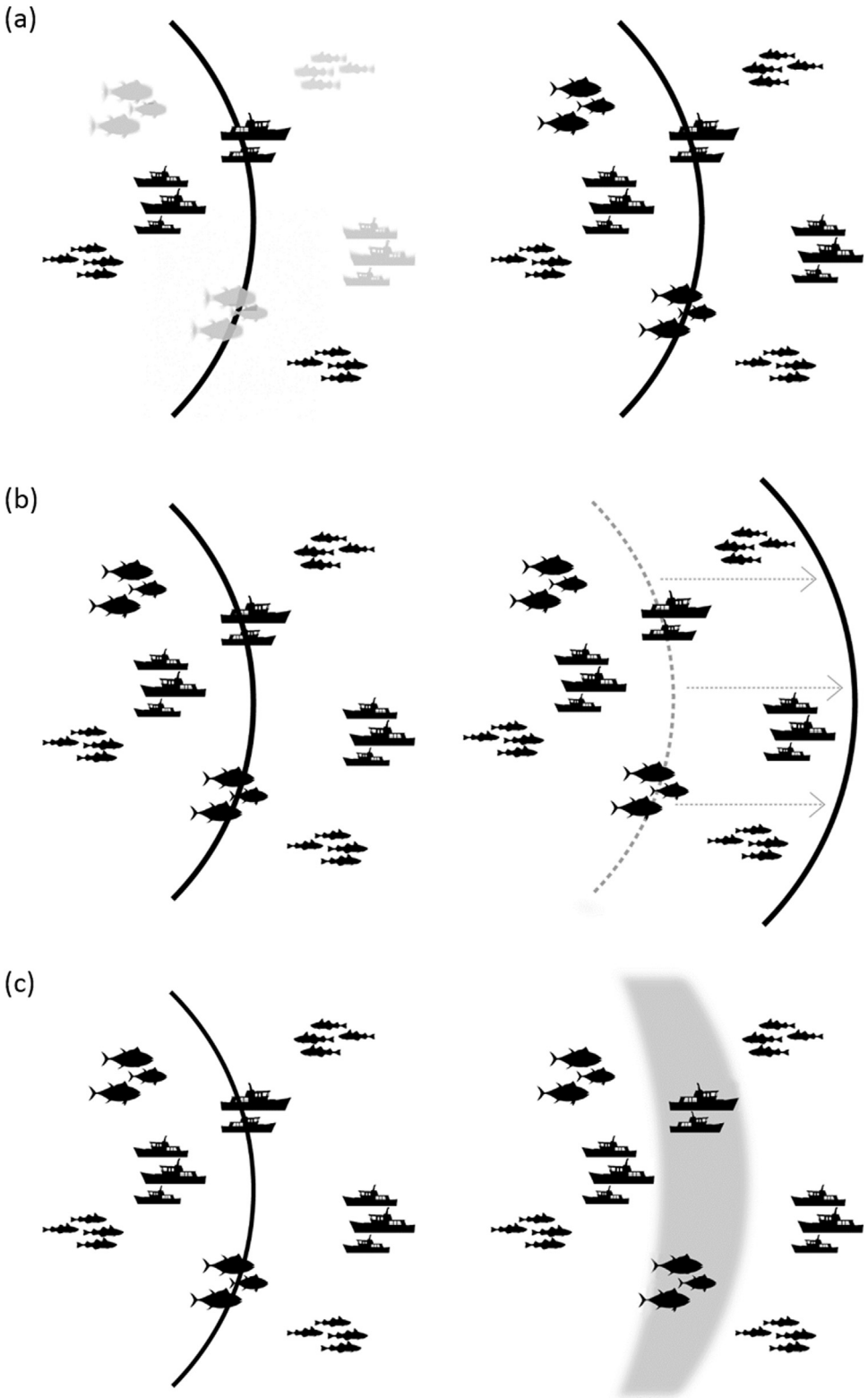

Fig. 3. Idealized 'before and after' depiction of three types of transboundary responses – (a) re-incorporating of an existing boundary by improving the science and the terms of boundary-crossing (e.g., previously little-known fish and boat movement is now better ascertained); (b) re-scaling of a boundary by more appropriately matching the spatial range of fish and fishers, (e.g., a re-drawn boundary now more accurately encompasses the 'natural' range of fish and boat movement); and (c) re-imagining of a boundary by being attentive to its relative and provisional interpretations, (e.g., a flexibly-managed joint fishing area can be shown to replace a fixed boundary).

boundaries. It proposes a revision of a boundary scheme in closer accordance with the (often dynamic) spatial extent of ecological processes and the (often unpredictable) sphere of socio-economic influences. Identification of conservation "hotspots", ecosystem-based approaches and integrated cross-sector planning has served a useful guidance for the re-scaling initiatives, as identified by the studies in research theme 1.3. Boundary is an institution. It constrains and regulates human behaviour, as it relates to fishing strategies, compli-

ance and tendencies to cooperate [138]. The re-scaling effort thus encompasses striving for congruence between the confines of fishing activities and the reaches of an institution, such that institutions are appropriately scaled to generate desired incentives for sustainability and collective action. The question of the appropriate scale of institutions for the governing of regional/high seas fisheries has received ongoing attention (4.1). Similarly, the need to ensure a match between the multiple kinds of boundaries (i.e., social, ecological and institutional) has been a conscious theme in the fisheries governance literature, as Berkes [139, p. 236] emphasized "part of the challenge is that we cannot expect a perfect fit between the scales, but we can achieve some degree of matching" (see also [7,140,141]). The central recommendation of this transboundary approach is that the project of boundary re-scaling should be a continual, adaptive and collective endeavour that takes into account the perpetually shifting and the socially-ecologically linked nature of a fisheries system [24,62,139].

4.3. Re-imagining

Finally, the third response type is based on confronting the very idea of a boundary as an entity that is fixed and given. It transcends the limitations of a rigid boundary because it conceives of boundaries as something different altogether. Fisheries research offering this response sees instead that boundaries are always relative and provisional. Consistent with the social constructionist outlook, this response type posits that boundaries can hold varied meanings and utility to different parties, and thus it works to deconstruct their taken-for-granted meaning and inherent power-based orientation. This re-imagining of spatial boundaries has been used to highlight the often concealed impact of the conventional boundary-drawing and enforcement on small-scale fishers (studies in research theme 2.3), expose the way fishers themselves become an influential force in boundary-production (4.2), or elaborate on new approaches for eliciting transboundary cooperation (4.3). According to this perspective, transboundariness is not a diversion but a norm, and more possibilities for management innovation are expected to open up through the shedding of the narrower conceptions of a boundary.

Although the three approaches depicted above are sufficiently distinct from each other, they are not always bound by this heuristic division. In other words, the boundaries of the conceptualization are not themselves stable and impermeable. As the scholarship grows, the organization and characterization of transboundary research would require a routine update. Research themes and dimensions in the typology could merge, morph into a new format or branch out. Nevertheless, this is an important first step towards an improved collective understanding of boundary issues in fishery management; a more basic and nuanced reflection on their origin, uses and impacts has been long overdue.

5. Conclusion

Despite the world being a rapidly integrating place, the significance of spatial boundaries has persisted [26], and, in the ocean realm, expanded. Their roles as dividers and containers of management authority, cultural identity and territorial power are crucially relevant for fisheries. They are, however, increasingly important in a different sense, too, that is, boundaries are inherently equipped with the tendency to create transboundary implications. This paper has critically examined the widespread phenomenon of boundary-drawing in fisheries management. Many contemporary management schemes, including MPAs, TURFs, ITQs, RFMOs, LMEs, and EEZs, are all grounded in the delineation of bounded space for exclusive control and governability of specifically designated resources and fisher groups. The conventional view of boundary as a firm and impermeable "wall" has, however, faced considerable, though not entirely unforeseen, limitations in coping with the fluid and dynamic makeup of fisheries environment. Research that engages with this issue has emerged simultaneously with the drawing of boundaries, raising a paradoxical situation of more boundary application necessitating more transboundary interventions. Thus, this paper had two aims that bring the boundary and transboundary ideas together – first, deconstructing the notion of spatial boundary by drawing on "boundary studies" in geography; and second, defining the contours of the so-called transboundary scholarship by categorizing its contents and developing a typology. Four dimensions of the scholarship emerged as they revolve around resources, fishers/fleets and trades as well as the governance question of enhancing multilateral cooperation. These research bodies were also conceptualized as idealized responses that represent an infusion of the transboundary thinking into the spatial management milieu. According to the degree of progressiveness embedded in the approaches, they formed three response types from re-incorporating and re-scaling to re-imagining of boundaries.

In sum, although this paper does not reject the usefulness of, and the ongoing need for, spatial boundaries, it is argued that the systematic and holistic categorization presented in this review forms a useful initial step for re-calibrating the ways in which we approach and think about spatial boundaries in the ocean and inland waters. Re-incorporating, re-scaling and re-imagining of boundaries can invite varied and context-driven configurations of organizing fishery interactions. We can also begin to make sense of a (trans-)boundary problem according to the four dimensions identified in the typology. With this recognition, there may arise more creative ways that fisheries policy, and more broadly marine spatial planning, can adapt to on the basis of enhanced cooperation, connectivity and informality, triggering practical innovations in the governance of these watery subjects. More research and debate based on the transboundary understanding of the world's fisheries is therefore encouraged and anticipated.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2016.10.023.

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