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Twelve Recommendations for Advancing Marine Conservation in European and Contiguous Seas

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Like most ocean regions today, the European and contiguous seas experience cumulative impacts from local human activities and global pressures. They are largely in poor environmental condition with deteriorating trends. Despite several success stories, European policies for marine conservation fall short of being effective. Acknowledging the challenges for marine conservation, a 4-year multi-national network, MarCons, supported collaborative marine conservation efforts to bridge the gap between science, management and policy, aiming to contribute in reversing present negative trends. By consolidating a large network of more than 100 scientists from 26 countries, and conducting a series of workshops over 4 years (2016–2020), MarCons analyzed challenges, opportunities and obstacles for advancing marine conservation in the European and contiguous seas. Here, we synthesize the major issues that emerged from this analysis and make 12 key recommendations for policy makers, marine managers, and researchers. To increase the effectiveness of marine conservation planning, we recommend (1) designing coherent networks of marine protected areas (MPAs) in the framework of marine spatial planning (MSP) and applying systematic conservation planning principles, including re-evaluation of existing management zones, (2) designing MPA networks within a broader transboundary planning framework, and (3) implementing integrated land-freshwater-sea approaches. To address inadequate or poorly informed management, we recommend (4) developing and implementing

adaptive management plans in all sites of the Natura 2000 European conservation network and revising the Natura 2000 framework, (5) embedding and implementing cumulative effects assessments into a risk management process and making them operational, and (6) promoting actions to reach 'good environmental status' in all European waters. To account for global change in conservation planning and management, we further recommend (7) developing conservation strategies to address the impacts of global change, for example identifying climate-change refugia as high priority conservation areas, and (8) incorporating biological invasions in conservation plans and prioritizing management actions to control invasive species. Finally, to improve current practices that may compromise the effectiveness of conservation actions, we recommend (9) reinforcing the collection of high-quality open-access data, (10) improving mechanisms for public participation in MPA planning and management, (11) prioritizing conservation goals in full collaboration with stakeholders, and (12) addressing gender inequality in marine sciences and conservation.

Keywords: Natura 2000, MPAs, transboundary collaboration, global change, invasive species, cumulative impact assessment, conservation planning, risk management

INTRODUCTION

Marine systems are increasingly threatened by cumulative pressures from multiple human activities (Korpinen et al., 2012; Micheli et al., 2013; Mazaris et al., 2019; Jouffray et al., 2020) (**Figure 1**). In addition, the growing impacts of climate change (Philippart et al., 2011; Marbà et al., 2015; IPCC, 2019) interact in complex and context-dependent ways with local anthropogenic drivers (Ramírez et al., 2018). The European and contiguous seas, i.e., the Mediterranean Sea, the Black Sea, the Baltic Sea, the North Sea, and the North-Eastern Atlantic Ocean, provide iconic examples of the human footprint on marine ecosystems (CIESIN, 2020) and are hotspots of cumulative impacts (Emeis et al., 2015; Halpern et al., 2019). Human population density is very high, especially along the coastline, leading to intense marine uses and generating a number of conflicts over marine space (Katsanevakis et al., 2015; Kafas et al., 2018; Mackelworth et al., 2019).

The latest European Environment Agency report provides a grim picture of the status of European seas (European Environment Agency [EEA], 2015). European seas fall below a "healthy" status, their exploitation is unsustainable, and most ecosystem characteristics are in poor condition with deteriorating trends (Dailianis et al., 2018). In a recent assessment of the vulnerability of marine habitats in the European Union (EU) and adjacent regions (Gubbay et al., 2016), 18% of habitats were Critically Endangered, Endangered or Vulnerable. However, if data-deficient habitats are excluded, this figure rises to 38%, and if (under a precautionary approach) data-deficient habitats are considered threatened, the number rises to 71%. European seas, in particular the Mediterranean Sea, are a hotspot of extinction risk for sharks and rays (Dulvy et al., 2014), with no sign of improvement between the Mediterranean IUCN Red List assessments of 2007 and 2016 (Dulvy et al., 2016). For the majority of species assessments, the conservation status of fish stocks, marine turtles, and marine mammals in European seas is unfavorable (European Environment Agency [EEA], 2015). The frequency of population collapses and local extinctions has also increased especially in land-locked basins impacted by global warming. One such case is the Levantine basin in the Mediterranean Sea (Yeruham et al., 2015, 2019; Rilov, 2016; Corrales et al., 2018; Givan et al., 2018), where native biodiversity is gradually being replaced by alien species (Katsanevakis et al., 2018). Moreover, mass mortalities are increasingly occurring in association with strong and recurrent marine heat waves (Garrabou et al., 2019). Such biodiversity shifts can fundamentally alter ecosystem functions (e.g., Peleg et al., 2020) and compromise the flow of ecosystem services (Díaz et al., 2006; Worm et al., 2006).

As part of the United Nations Environment Programme, four Regional Seas Conventions (**Table 1**) have historically contributed to regionally coordinated conservation efforts in European and contiguous seas (Kirkman and Mackelworth, 2016). Within the EU, several legislative acts (**Table 1**) provide the basis for the development of instruments for the protection of marine biodiversity and ecosystem services, and sustainable use of marine resources (Fraschetti et al., 2018). Among them, the Natura 2000 European network of protected areas forms the cornerstone of EU biodiversity conservation strategy, including ca. 4000 sites, which are marine only or both terrestrial and marine, and cover ca. 12% of EU territorial waters (Mazaris et al., 2018).

Despite several success stories (e.g., Pipitone et al., 2014; WWF, 2017), European policies for marine conservation fall short of being effective (Fraschetti et al., 2018). While the objective of an ecosystem-based approach underpins EU environmental legislation, coupled socio-ecological research to advise on integrated ecosystem approaches are lacking (Visbeck, 2018; Lauerburg et al., 2020). Furthermore, the current attitude to reductionism in marine science hinders the implementation of an ecosystem-based approach (Fraschetti et al., 2008). The marine component of the Natura 2000 network fails to represent the

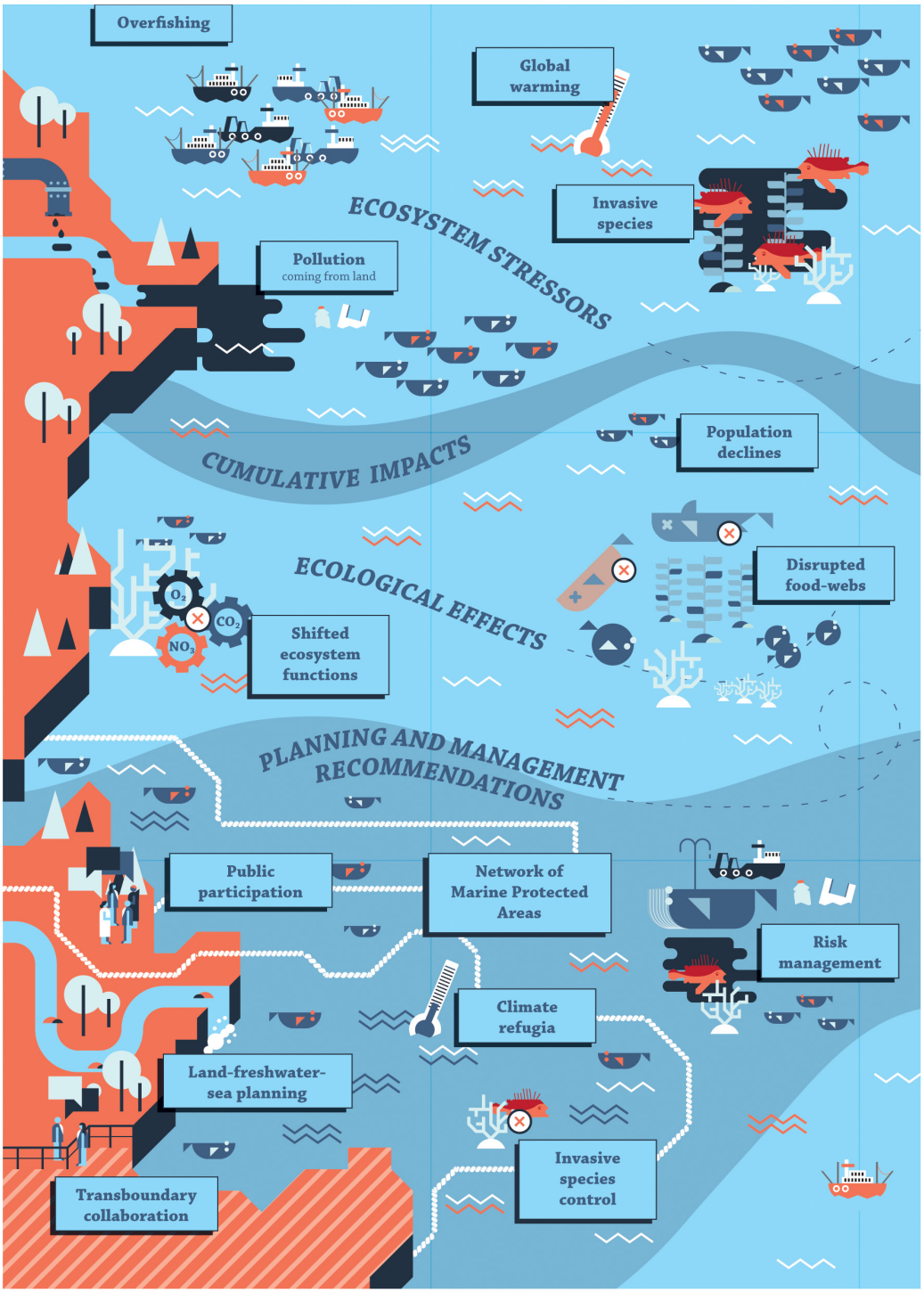

FIGURE 1 | Infographic showing the challenges MarCons aimed to address through planning and management recommendations.

full suite of marine and coastal habitats, largely excluding deep and offshore habitats, and many marine sites are just extensions of terrestrial sites and were not selected on the basis of marine conservation priorities (Mazaris et al., 2018). Indeed, a systematic planning process has not been applied to the design of the Natura 2000 network. Rather, designation has unfolded on a site-by-site basis with spatial configuration and connectivity largely ignored (Giakoumi et al., 2012). Economic interests have often prevailed over conservation objectives in guiding site selection (Olsen et al., 2013; Fraschetti et al., 2018). Furthermore, human activities

TABLE 1 | Conventions and legislative instruments contributing to conservation efforts in Europe and contiguous seas.

Legislative instruments/policies	Short description
OSPAR (https://www.ospar.org/)	Regional Convention for protecting and conserving the North–East Atlantic and its resources.
HELCOM Convention (https://helcom.fi/)	Regional Convention for protecting the Baltic marine environment.
Barcelona Convention (https://web.unep.org/unepmap/)	Regional Convention for the protection of the marine environment and the coastal region of the Mediterranean Sea.
Bucharest Convention (http://www.blacksea-commission.org)	Regional Convention on the protection of the Black Sea against pollution (including protection of biodiversity and marine living resources).
Birds Directive (Directive 79/409/EEC. Amended in 2009 and became Directive 2009/147/EC) (https://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm)	EU Directive aiming to protect all wild bird species naturally occurring in the European Union. It establishes a network of Special Protection Areas (SPAs) including all the most suitable territories for birds. Since 1994, all SPAs are included in the Natura 2000 ecological network, set up under the Habitats Directive 92/43/EEC.
Habitats Directive (Council Directive 92/43/EEC) (https://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm)	EU Directive for the conservation of habitats and a wide range of animal and plant species. It forms the cornerstone of Europe's nature conservation policy with the Birds Directive and establishes the EU-wide Natura 2000 ecological network of protected areas.
Water Framework Directive (Directive 2000/60/EC) (https://ec.europa.eu/environment/water/water-framework/index_en.html)	EU Directive establishing a framework for the Community action in the field of water policy. It sets common EU wide objectives for water (inland surface waters, transitional waters, coastal waters, and groundwater) and introduces an integrated and coordinated approach to water management in Europe.
Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC) (https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm)	The Marine Strategy Framework Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. It promotes the integration of environmental considerations into all relevant policy areas and delivers the environmental pillar of the future maritime policy for the European Union.
Maritime Spatial Planning Framework Directive (Directive 2014/89/EU) (https://ec.europa.eu/maritimeaffairs/policy/maritime_spatial_planning_en)	EU Directive establishing a framework for maritime spatial planning, aiming to ensure that human activities at sea take place in an efficient, safe and sustainable way.
Common Fisheries Policy (https://ec.europa.eu/fisheries/cfp_en)	The CFP is a set of rules for managing European fishing fleets and for conserving fish stocks. It aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens.
EU Biodiversity Strategy for 2030 (https://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm)	This is the EU plan for protecting nature and reversing the degradation of ecosystems. It contains specific commitments and actions to be delivered by 2030, including establishing a larger EU-wide network of protected areas on land and at sea, building upon existing Natura 2000 areas, with strict protection for areas of very high biodiversity and climate value. The EU Biodiversity Strategy aims to protect at least 30% of the land and 30% of the sea, with at least one third of protected areas strictly protected.

continue to jeopardize conservation efforts within protected sites (Yates et al., 2013; Mazaris et al., 2019), and less than 40% of marine sites have management plans, with many Natura 2000 sites considered just 'paper parks' with no actual conservation measures in place (Beal et al., 2017; Claudet et al., 2020).

Climate change mitigation is rarely addressed by EU marine environmental policies (e.g., in member states Programs of Measures under the MSFD) or national marine spatial plans, and the monitoring of marine protected areas (MPAs) commonly does not depict and clearly distinguish between impacts of local and global stressors (Rilov et al., 2020). Often, European and neighboring countries lack a shared vision, exhibiting remarkable heterogeneity in applying regional or European conservation policies, thus limiting transboundary collaboration and large-scale coherent ecological networks (Fraschetti et al., 2018). In practice, clear guidance and political support for transboundary marine conservation is generally lacking (Mackelworth et al., 2019). Even though there has been a global increase of cumulative effects assessments, member states and neighboring countries have not been effective in guiding management or conservation efforts in a multiple impact context (Stelzenmüller et al., 2018, 2020). For instance, despite the recognition that invasive alien species and neonatives (*sensu* Essl et al., 2019) may substantially compromise conservation efforts (Giakoumi et al., 2019a), biological invasions are rarely taken into account in conservation plans (Giakoumi et al., 2016; Mačić et al., 2018). Connections among realms are also commonly overlooked in conservation efforts, despite the need for integrated cross-realm actions for the protection of many threatened multi-realm species (Giakoumi et al., 2019b).

Acknowledging the challenges for marine conservation in the European and contiguous seas, the 4-year multi-national COST ('European Cooperation in Science and Technology') Action MarCons ('Advancing marine conservation in the European and contiguous seas[1]') aimed to bridge the gap between science, management and policy, and increase knowledge required for halting biodiversity loss (Katsanevakis et al., 2017). By consolidating a network of more than 100 marine scientists from 26 countries, in a series of workshops and meetings spanning from 2016 to 2020[2], MarCons analyzed key challenges, opportunities and obstacles, to build a common vision for research priorities and recommendations for advancing marine conservation (**Figures 1**, **2** and **Supplementary Table 1**). In each of these workshops, experts on the topic were invited and provided their expertise to achieve MarCons objectives (for

[1]http://www.marcons-cost.eu/

[2]http://www.marcons-cost.eu/activities/workshops

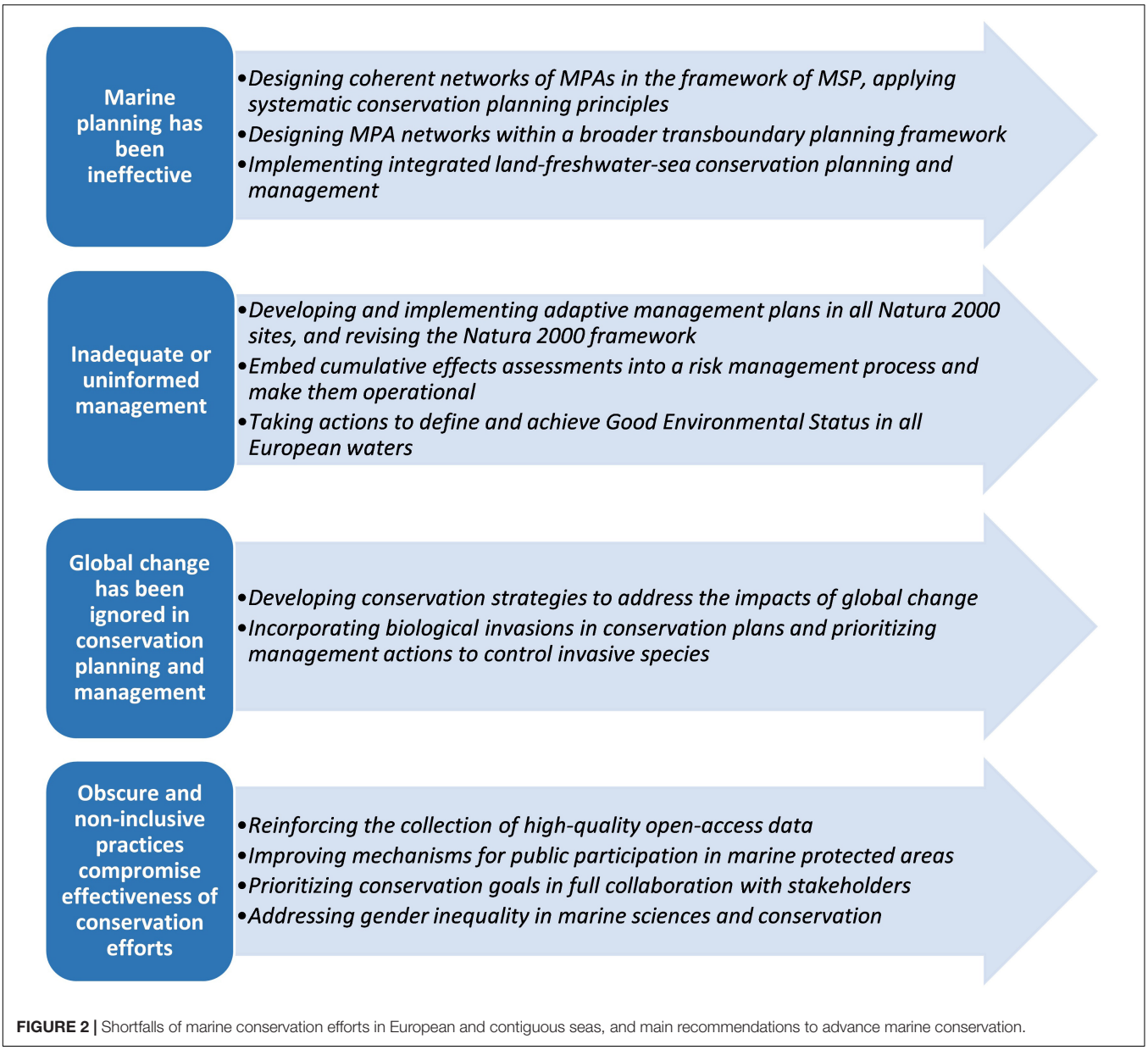

FIGURE 2 | Shortfalls of marine conservation efforts in European and contiguous seas, and main recommendations to advance marine conservation.

details on the working groups and stated MarCons objectives see Katsanevakis et al., 2017). Furthermore, policy makers (e.g., from the European Commission and member states), policy advisors (e.g., members of ICES and IUCN working groups), marine managers (e.g., from MedPAN – Mediterranean association of MPA managers), representatives of transboundary cooperation (e.g., Trilateral Wadden Sea Cooperation), and other stakeholders were invited in MarCons workshops to accommodate their needs and views in MarCons outputs. Various approaches were followed by the MarCons consortium to reach its stated goals. A number of systematic reviews were conducted to critically compile and analyze existing knowledge, current practices, methodological tools, and state-of-the-art in specific topics (e.g., Mačić et al., 2018; Gissi et al., 2019; Corrales et al., 2020). Data from large public databases, such as the Natura 2000 database, the European Red List, and the LIFE program (EU's funding instrument for the environment and climate) database, were retrieved and analyzed to gain insight on conservation outcomes, threats, practices, and efficiency (e.g., Fraschetti et al., 2018; Giakoumi et al., 2019b; Mazaris et al., 2019). Expert knowledge elicitation techniques were applied to evaluate and prioritize management actions (Giakoumi et al., 2019c). Participants offered their knowledge and experience on a national level through a large number of targeted case studies assessing how states have interpreted and utilized different legislative mechanisms over the governance of marine resources or maritime space, evaluating the implementation of conservation tools in Europe and beyond, their effectiveness and regional differences, and testing the operationalization of a risk-based cumulative effects assessment framework (Fraschetti et al., 2018;

Mackelworth et al., 2019; Stelzenmüller et al., 2020). EU Member States Programs of Measures designed for the implementation of EU marine environmental policies and recent European Marine Spatial Plans were critically examined (Rilov et al., 2020). Participating experts offered datasets, whose compilation and analysis provided new insights on the status of the marine environment in European regions (e.g., Bevilacqua et al., 2020). The collective and multi-disciplinary expertise within MarCons, combined with the above-mentioned analyses, was utilized to propose new approaches and tools to advance marine conservation in Europe and beyond (e.g., Bates et al., 2018; Stelzenmüller et al., 2018; Giakoumi et al., 2019b; Rilov et al., 2019). Through all these processes, MarCons working groups provided recommendations to advance marine conservation. These recommendations, published in the peer-reviewed outputs of the working groups, were derived from authors' assessments built upon accumulated knowledge in marine conservation as well as from interactions with different groups of stakeholders and evaluation of their needs.

Here, we synthesize the main findings and key recommendations of MarCons to guide science-based implementation of effective conservation actions in European and contiguous seas beyond 2020, as we step into the UN Decade of Ocean Science for Sustainable Development (Ocean Decade) and for Ecosystem Restoration, and as European research specifically is positioning itself to support the main objectives of the European Green Deal[3]. MarCons results can help to achieve the goals of the new EU Biodiversity Strategy for 2030 (**Table 1**), as setting ambitious targets in biodiversity conservation needs the development of concrete strategies to make their achievement possible. Whilst MarCons focused on European and contiguous seas, the lessons learned apply globally since marine ecosystems are connected and face similar threats.

TWELVE KEY RECOMMENDATIONS

Improved Conservation Planning

Recommendation 1. Designing coherent networks of MPAs in the framework of MSP, applying systematic conservation planning principles.

Decision-making for the management of marine socio-ecological systems is complex, as it must accommodate multiple, often conflicting, objectives/interests. For example, under the Blue Growth initiative the development of economic activities, such as marine tourism and aquaculture, are promoted, which may compromise conservation efforts (Rilov et al., 2020). Disentangling this complex situation requires strategic decision-making that is ideally informed by adequate planning. Marine spatial planning (MSP) initiatives, that explicitly integrate multiple objectives, are expanding worldwide, covering approximately 50% of the Exclusive Economic Zones (Frazao Santos et al., 2019). In European waters, marine spatial plans must be implemented by 2021 (Directive 2014/89/EU). MSP should follow an ecosystem-based approach in allocating maritime uses at sea (Ansong et al., 2017), including priority areas for environmental protection and restoration actions. The way countries will operationalize the ecosystem-based approach in their national MSP initiatives will potentially bring both threats and opportunities to marine conservation and human well-being (Fraschetti et al., 2018; Rilov et al., 2020). Whilst MSP efforts should consider all activities operating in marine space, giving priority to the future allocation of maritime uses that promote blue growth but do not affect ocean health when properly regulated (e.g., diving tourism, ocean energy, and marine biotechnology) will be a win-win strategy.

To ensure that MSP initiatives meet conservation needs and secure the establishment of ecologically coherent networks of MPAs across Europe's seas as requested by EU policies, most notably Article 13(4) of the Marine Strategy Framework Directive (MSFD) and the EU Biodiversity Strategy for 2030 (see **Table 1** for a description of each strategy), the implementation of systematic conservation planning is recommended. The importance of systematic conservation planning for marine spatial prioritization in the European seas has been consistently highlighted by scientists (e.g., Smith et al., 2009; Giakoumi et al., 2012; Metcalfe et al., 2013, 2015; Mazor et al., 2014). Systematic conservation planning provides a transparent, comprehensive framework for guiding the location, configuration, and management of biodiversity conservation areas (Pressey and Bottrill, 2009). The implementation of its core principles – connectivity, adequacy, representativeness, and efficiency – can support the design and management of ecologically coherent networks of MPAs in the European seas (Giakoumi et al., 2012; Fraschetti et al., 2018). For this to happen, systematic conservation planning should be adopted as the selected decision support tool for the future implementation of the key environmental policies, such as the Habitats, Birds, MSFD and MSP directives (see **Table 1**). Beyond species and habitat persistence, to better preserve the functioning of marine ecosystems, networks of MPAs should protect the functionality of marine communities and ecosystems (Bevilacqua and Terlizzi, 2020). To do so, identifying which habitats and species support fundamental ecological roles through space and time is needed. This understanding will provide guidance for the design of coherent networks of MPAs within the framework of MSP.

Marine spatial prioritization approaches with decision support tools, such as Marxan (Ball et al., 2009), have proven to be particularly helpful in integrating systematic conservation planning into MSP, as ecological, economic, and social objectives can be incorporated into the planning process (e.g., Mazor et al., 2014; Yates et al., 2015). Marine spatial prioritization is also useful to make the trade-offs between biodiversity conservation and its influence on economically important sectors more explicit (Gissi et al., 2018a). Given that many MPAs have already been designated within European waters, but so far have little or no conservation actions in place (Beal et al., 2017), systematic conservation planning can be utilized as an effective tool to prioritize actions within existing designations, as well as soliciting the implementation of additional MPAs to achieve

[3]https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

the 30% conservation target set by the new EU Biodiversity Strategy for 2030.

Recommendation 2. Designing MPA networks to function within a broader transboundary planning framework.

All ecosystems straddle national borders. Often two or more countries share access and responsibility for the same habitats, species and ecosystem services, which is especially true in the highly connected marine system (Mackelworth, 2016). Transboundary cooperation can be highly beneficial, as it can allow the exchange of data and knowledge, synergize conservation and monitoring efforts, increase conservation planning efficiency, reduce overall conservation costs, and allow for joint management of transboundary natural resources (Kark et al., 2009; Mackelworth et al., 2019). In marine environments, where borders are not always as clearly marked or strictly upheld as those on land, transboundary cooperation should be easier. However, the same ambiguous characteristics of the border can also lead to disputes and conflicts over food, materials and space (Katsanevakis et al., 2015; Jouffray et al., 2020).

While the Natura 2000 network is considered a European wide network, in many instances its application is significantly different, even in adjacent states protecting the same resource (Mackelworth et al., 2019). One typical example is the application of the Natura 2000 network within the Wadden Sea World Heritage Site. A coherent network was not the output of the consultations between the three states of Denmark, Germany and the Netherlands, but the consequence of the decisions of the European Court of Justice (Enemark, 2016). In the Dogger Bank, there are ongoing management disputes despite the fact the borders are clearly defined and agreed. Of the four states that share the bank (Denmark, Germany, Netherlands, and United Kingdom), three have declared Natura 2000 sites, and the fourth has not. Even within the three sites declared there are serious incompatibilities in the conservation objectives (Mackelworth et al., 2019). The implementation of transboundary MPA networks becomes even more difficult in regions where severe international conflicts hamper any collaboration, such as in the Levantine Basin (south east Mediterranean) (Teff-Seker et al., 2019).

While there are transboundary areas that are recognized and protected, often the management systems in place differ between the states. Developing a coherent network that enables and encourages states to work together to protect common resources would be a major step forward in transboundary conservation. Approaching systematic conservation at a macro-regional level would help to facilitate transboundary cooperation, as shown in the Adriatic and Ionian Macro-region (Gissi et al., 2018a). The development of macro-regional strategies has the potential to facilitate conservation at the border, and even in the area beyond national jurisdiction.

Recommendation 3. Implementing integrated land-freshwater-sea conservation planning and management.

To achieve the EU's conservation target of halting biodiversity loss, the explicit consideration of connectivity and more effective protection of multi-realm species is required (Giakoumi et al., 2019b; Hermoso et al., 2019a). In particular, we recommend that the integration of conservation efforts across realms incorporates the following two steps:

(i) Recognition of the need for integrated management across realms at a policy level. Management policies and strategies will be much more efficient if they consider a broader array of ecosystems and their connections (Giakoumi et al., 2019b). This is needed to address the challenges associated with managing species with complex biological cycles that span across more than one realm. Conservation actions that only cover partially these complexities will often be ineffective (e.g., management of threats affecting just one of the realms the species relies on) (Tallis et al., 2008). Integrated management does not necessarily translate into large increases in area or other resource requirements, if planned adequately (Beger et al., 2010). For this reason, efficient cross-realm management needs to be accompanied by adequate planning (see below).

(ii) Implementation of integrated land-freshwater-sea conservation planning and management. An integrative approach when designating new Natura 2000 sites across realms could increase conservation outcomes and efficiency (Giakoumi et al., 2019b). Integrated conservation planning allows us to meet conservation needs in multiple realms in a more balanced and efficient way, to account for the needs of multi-realm species more by adequately enhancing connectivity across realms for those species that need it, and to explicitly consider the trade-offs between enhancing connectivity across realms and increases in cost (see also recommendation 1). However, further assessments are needed to evaluate the effectiveness of Natura 2000 as a tool for the integrated management of land-freshwater-sea and the species, communities and ecosystems that rely on these connections, and to identify critical areas for conservation outside currently protected areas.

Informed and More Effective Management

Recommendation 4. Developing and implementing adequate and adaptive management plans in all Natura 2000 sites, and revising the Natura 2000 framework.

All Natura 2000 sites were selected on the basis of the same criteria and procedures as defined in the Birds (2009/147/EC) and Habitats (92/43/EEC) Directives, and are subjected to common monitoring schemes and protocols; regular pan-European seminars and meetings aim to ensure a coherent network (Evans, 2012). These top-down processes resulted in a network characterized by a homogenization in the design, establishment and reporting phases. Still, biological features and processes (e.g., population dynamics, species interactions, and community stability), environmental conditions and fluctuations (e.g., ocean weather, frequency of extreme weather events) and socio-economic factors, which drive human activities differently across sites (Mazaris et al., 2019), make every single site a unique entity deserving site-specific, multidimensional efforts toward the understanding of its inherent complexity before being managed and protected. To improve management efficiency, these site-specific needs should be embedded in and fulfilled by flexible management plans that have been adapted to current conditions

and regularly revised based on new knowledge and assessments of the effectiveness of previous decisions (Katsanevakis et al., 2011).

While management plans are vital for effective conservation, in many of the marine sites of the Natura 2000 network neither a management plan nor conservation measures are in place (Buhl-Mortensen et al., 2017; Fraschetti et al., 2018; Mazaris et al., 2018). Even when a management plan exists, there are often substantial time lags between site designation and plan implementation (in some cases of more than a decade), with great delays in their assessment and revision (Álvarez-Fernández et al., 2020), or they are never enforced due to legal challenges or lack of political will (Fraschetti et al., 2018).

As any management plan, the management plans of Natura 2000 sites, to be effective in a dynamic environment, should be periodically reviewed and revised. Adaptive management, as the process that involves the identification and consideration of shortfalls in planning through a monitoring-assessment-revision loop, will be more efficient if embedded within a risk-based framework for the operationalization of cumulative effect assessments (see recommendation 5). Under this context, systematic conservation planning and prioritization of management actions (see recommendation 1) can support in determining priorities and concerns for which plans need adaptive solutions, especially in view of the uncertainties, regime shifts and new challenges imposed by climate change (see recommendation 7) and biological invasions (recommendation 8).

Furthermore, it is time for the entire Natura 2000 framework (28 and 41 years after the adoption of the Habitats Directive and Birds Directive, respectively) to be revised to adapt to new knowledge, state-of-the-art systematic conservation planning approaches, and to better represent threatened biodiversity. It is common knowledge that the Annexes of the Habitats Directive (including species to be protected) inadequately represent marine biodiversity (Fraschetti et al., 2008), and species prioritization for protection is inconsistent with their actual conservation status as reflected by assessments using objective criteria (Maiorano et al., 2015; Habel et al., 2020). These Annexes urgently need revision to improve coverage of threatened species (Hermoso et al., 2019a), and a framework of regular reassessments and revisions of conservation priorities are needed to adapt marine conservation efforts within the Natura 2000 network to the actual changing conservation requirements (see also Cardoso, 2012; Hochkirch et al., 2013). We recommend that species lists in the EU Habitats and Birds Directives that define EU conservation priorities are revised and harmonized with the European Red List. The IUCN Red List Assessment is the most comprehensive global source of information on species extinction risk (Rodrigues et al., 2006) and central to setting conservation priorities (Stuart et al., 2010). Periodic revisions should capture the effectiveness of management actions financed through LIFE-Nature projects or any other funding scheme (Giakoumi et al., 2019b).

Acknowledging the complexities behind revising the Annexes of the Habitats and Birds Directives, alternative strategies should be also reinforced in the future. Among these, opening resource investments to all threatened species through programs like LIFE (Hermoso et al., 2018) or including these threatened species in Prioritized Action Frameworks (i.e., strategic pluriannual tools that review species conservation actions and financing needs across the Natura 2000 network) could provide funding opportunities to high-risk species not adequately covered by current provisions (Hermoso et al., 2019b).

Recommendation 5. Embed cumulative effects assessments (CEA) into a risk management process and make them operational.

Ecosystem-based management requires an assessment of the cumulative effects of human pressures and environmental change. Current decision-making processes do not include operationalization and integration of cumulative effects assessments (CEA), mainly due to their complexity and limitations of knowledge and evidence to allow for the identification of human activities and pressures that should be reduced. To make CEA operational, we suggest applying a comprehensive and transparent framework that embeds CEAs within a risk management process (**Figure 3**; Stelzenmüller et al., 2018). Applying such a risk-based CEA framework can structure the associated complex analyses and facilitate the establishment of direct science-policy links. We recommend a process consisting of the steps of risk identification (finding, recognizing, and describing risks), risk analysis (describing the risk of cumulative effects after accounting for the performance of existing management measures) and risk evaluation (comparing the results of risk analysis with the established risk criteria and benchmarks to determine the significance of the risk) (**Figure 3**). These three steps can help to reveal the likelihood of exceeding accepted risk of ecosystem state changes (Stelzenmüller et al., 2018). Embedding CEA into a management process decreases complexity, allows for the transparent treatment of uncertainty, and streamlines the uptake of scientific outcomes into the science-policy interface. Overall, we propose moving toward standardizing the CEA framework, with common terminology and procedures, and further developing integrative methods.

Cumulative effects assessments need to be well-framed to contribute in integrated planning, and function as tools that bridge different management objectives (Stephenson et al., 2019). Thus, applying the risk-based CEA framework proposed in MarCons (Stelzenmüller et al., 2018) and defining a strategy to communicate uncertainty is key for the operationalization of CEA (Stelzenmüller et al., 2020). This can contribute to overcome imperfect knowledge on the sensitivity of ecosystem components to distinct pressures, and embrace uncertainty around the scientific evidence (Cormier et al., 2017). Differentiating the aim of the CEA to advise policies, marine spatial planning or regulatory processes can facilitate the integration of ecosystem management considerations across multiple sectoral policies. In the process of operationalizing CEAs, and due to the involvement of many stakeholders, describing the roles of scientists and decision-makers well in advance will ensure transparency and clarify expectations. To improve current practices, assessing the effectiveness of management measures and how they can reduce the risk of negative impacts from cumulative effects is essential, but challenging for future research (Borja et al., 2020). It seems difficult to achieve a 'good environmental status' across European seas, without changing governance structures to integrate ecosystem considerations across multiple sectoral

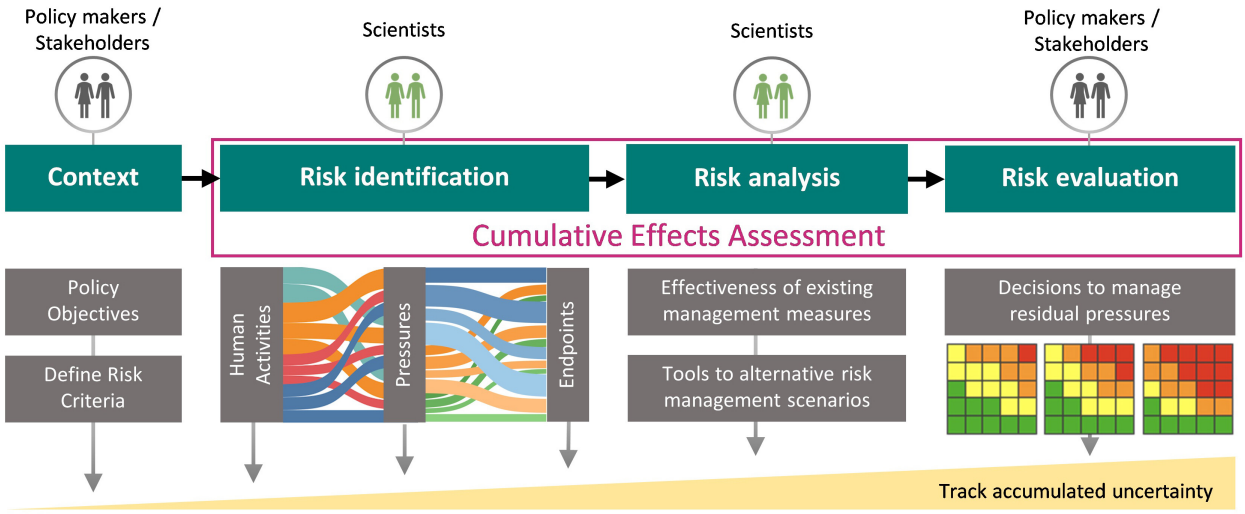

FIGURE 3 | Integrating Cumulative Effects Assessments (CEA) into a risk management process. CEA consists of the three basic steps of risk identification, risk analysis, and risk evaluation. Modified from Stelzenmüller et al. (2020).

policies (Cinnirella et al., 2014; Stelzenmüller et al., 2020). This is a difficult task, but we argue that well-framed and structured CEA can function as a strategic tool in this direction.

Recommendation 6. Taking actions to define and achieve good environmental status in all European waters.

The MSFD has set out a list of descriptors of environmental status. In practice, 'good environmental status' means that the different human activities use marine resources at a sustainable level, ensuring their continuity for future generations. Although MPAs and Natura 2000 sites are focal areas in the Marine Strategy Framework Directive, the condition of 'good environmental status' should be attained across all European waters, not only within areas under conservation regimes. EU seas and oceans are under high levels of human pressures from regional (Coll et al., 2012; Micheli et al., 2013) to local scales (Guarnieri et al., 2016), with inconsistent patterns in the ecological status of systems across entire basins, such as the Mediterranean Sea (Bevilacqua et al., 2020).

A major challenge for broad scale assessments is to define and quantify 'good environmental status.' In this respect, a critical limitation (still to be tackled) is the definition of thresholds to discriminate between different ecological conditions, which requires the knowledge of pressure-state-response relations of marine ecosystems (Borja et al., 2020). A second main problem is that we need spatially continuous data on the ecological condition of different components of marine ecosystems, which is largely unfeasible under current funding.

Cumulative effects assessments could be of crucial help to overcome these hindrances (see recommendation 5), by modeling expected ecological condition over large areas. Reliable predictions, however, should rely on extensive data on the status of ecosystems at varying pressure levels (Bevilacqua et al., 2018). To better define and guide the achievement of 'good environmental status,' future research should (i) capitalize on available spatially explicit data on the ecological status of marine ecosystems and associated pressures, (ii) fill information gaps for poorly studied areas and ecosystems, (iii) provide guidance for applying sound and robust indicators of the ecological status of marine ecosystems across all EU countries, tracking representative pressure-state response relationships to enhance the reliability of CEA, and (iv) define what is ecologically sustainable in a fast-changing ocean when conflicts between protection and the increasing human uses under the growth of the blue economy are rising. By prioritizing these themes, European funding schemes would substantially contribute to the efforts to reach good environmental status in the European seas.

Account for and Be Responsive to Change

Recommendation 7. Developing conservation strategies to address the impacts of global change.

Despite the increasing impact of global climate change on marine biodiversity, Europe and contiguous seas still focus on local and regional anthropogenic pressures. Yet, climate change can cause mass mortalities, reshuffle biodiversity patterns and drive shifts in species distributions, which can strongly affect management efforts. This tendency to consider mostly local and regional human pressures is reflected by the lack of consideration of climate change issues in actual marine management practice, as was exemplified with the implementation plans of the MSFD and MSP European directives by most member states (Rilov et al., 2020). Recently, Johnson and Kenchington (2019) argued that climate-change refugia (areas where climate change impacts are minimal) should become a criterion for the identification of ecologically or biologically significant marine areas as part of the actions proposed by the Convention on Biological Diversity. Under the rapid increase of climate change impacts, it becomes clear that networks of MPAs need to include climate-change refugia as areas of highest priority (Groves et al., 2012),

for example, areas of upwelling of cooler waters from depth (Lourenço et al., 2016). Fine-scale data on ocean conditions will help to identify where potential refugia exist (Bates et al., 2018). Long-term ecological monitoring inside and outside properly managed MPAs should be promoted since it offers one of the strongest tools that can distinguish between local and global stressors (mainly climate change), and identify where signals of resilience exist.

The failure to distinguish and quantify climate change impacts means it is difficult to effectively incorporate climate change dynamics into the MSP process through conservation priorities, and prioritize adaptive management actions (Katsanevakis et al., 2011; Gissi et al., 2019). Toward adaptive management, it is critical that stakeholders acknowledge that marine conservation is a fast-moving target because of climate change. Consequently, management actions and policies will have to be able to cope and respond quickly to strong shifts in biodiversity and marine resources, driven by increasingly intense, and many times unpredictable, impacts of climate change (Rilov et al., 2020).

It is widely acknowledged that shifting from single MPAs into coherent networks will benefit conservation objectives (Olsen et al., 2013). However, climate change poses widespread and pervasive threats that may challenge the goal of MPA networks to fully protect biodiversity. Supporting marine conservation under climate change has been acknowledged as one of the grand challenges for the coming decade (Borja et al., 2020). We therefore suggest that in order to mitigate climate change impacts in European seas, we should focus on: (1) having well designed physical, ecological and socio-economic monitoring programs in MPAs and beyond as requested by the MSFD; (2) effectively including climate change risks into CEA; (3) identifying and considering potential climate refugia areas (where safety margins against extreme weather are large) in conservation plans; (4) setting different targets or criteria for the health of the system in climate hotspots (for example, focus on maintaining ecosystem functions instead of protecting specific species where thermally-sensitive native species rapidly collapse due to warming); (5) counting on safety in numbers and habitat diversity by ensuring that protection networks reflect different environmental conditions to allow for climate adaptation and recovery from extreme climatic events through population connectivity; (6) improving our ability to map climate-driven eco-evolutionary changes and identify vulnerable and resistant populations; (7) implementing adaptation and mitigation strategies iteratively, allowing for their evaluation as our knowledge base improves; and (8) adapting environmental policies by taking into account the above issues. We need to be realistic and well informed when attempting to address the challenge of on-going climate change, and we need to define precisely what is ecologically sustainable in the fast-changing ocean we observe today.

Recommendation 8. Incorporating biological invasions in conservation plans and prioritizing management actions to control invasive species.

The process of conservation planning usually focuses on native biodiversity and almost always overlooks alien species, either as a threat or as a benefit (Giakoumi et al., 2016; Mačić et al., 2018). A global cross-realm systematic review estimated that only 3.2% of conservation planning papers considered alien species in shaping their conservation plans (Mačić et al., 2018), although they often threaten native biodiversity and can cause a complete failure to achieve conservation goals (Simberloff et al., 2013; Katsanevakis et al., 2014). Hence, it is vital to carefully consider the ecological and socio-economic impacts of all alien species in conservation plans, with particular attention to invasive ones that exert the greatest impacts, with the aim to mitigate negative effects through specific conservation actions. Such plans should also recognize that some alien species might contribute to the achievement of conservation goals by securing ecosystem functioning and the flow of ecosystem services (Katsanevakis et al., 2014; Corrales et al., 2018), especially in regions suffering from multiple human stressors and global warming (Katsanevakis et al., 2018; Rilov et al., 2019). Even so, the new ecological state may be profoundly different from the pre-impact one (Peleg et al., 2020).

Furthermore, many species have extended their geographic ranges, without any direct human intervention, tracking human-induced environmental changes (Bates et al., 2014). These "neonatives" (as defined in Essl et al., 2019) may differ from alien species in their features of organismic novelty in the new regions (Essl et al., 2019), and there is evidence that they can become invasive with substantial impacts that are often functionally similar to those caused by alien species (Nackley et al., 2017).

In the marine environment, where most species have dispersal larval stages, eradication is extremely difficult, unless at a very initial stage of invasion (Ojaveer et al., 2015). It is also difficult to prevent geographic range expansions in neonatives, as propagules come from large and nearby source populations. Thus, conservation scientists, managers and decision makers should consider these species at all phases of the conservation planning process. Mačić et al. (2018) proposed 11 steps for the incorporation of alien species into conservation planning, building up on the planning design suggested by Pressey and Bottrill (2009). These steps capitalize on the early inclusion of alien and neonative species in the planning process and conservation goal setting, and in the recognition of a flexible and multi-faceted approach that includes avoiding areas too affected by alien and neonative species, or protecting such areas instead, either with the aim to control aliens and neonatives or include them in the protection plan when recognized useful for achieving conservation goals. We recommend incorporating biological invasions (alien and neonative species) in conservation plans through this stepwise approach (**Figure 4**), as ignoring alien and neonative species can change substantially conservation priorities (Giakoumi et al., 2016) and lead to considerable failures in the achievement of conservation goals (Bax et al., 2003).

Controlling marine invasive species is more likely to succeed when the species are detected early and management responses are rapid. Fast management responses require the early prioritization of actions based on their effectiveness, technical feasibility, social acceptance, impact and cost. In Giakoumi et al. (2019c), management actions were prioritized for groups of invasive species that share similar characteristics (differences in dispersion capacity, distribution in the area to be managed, and taxonomic identity). We recommend this

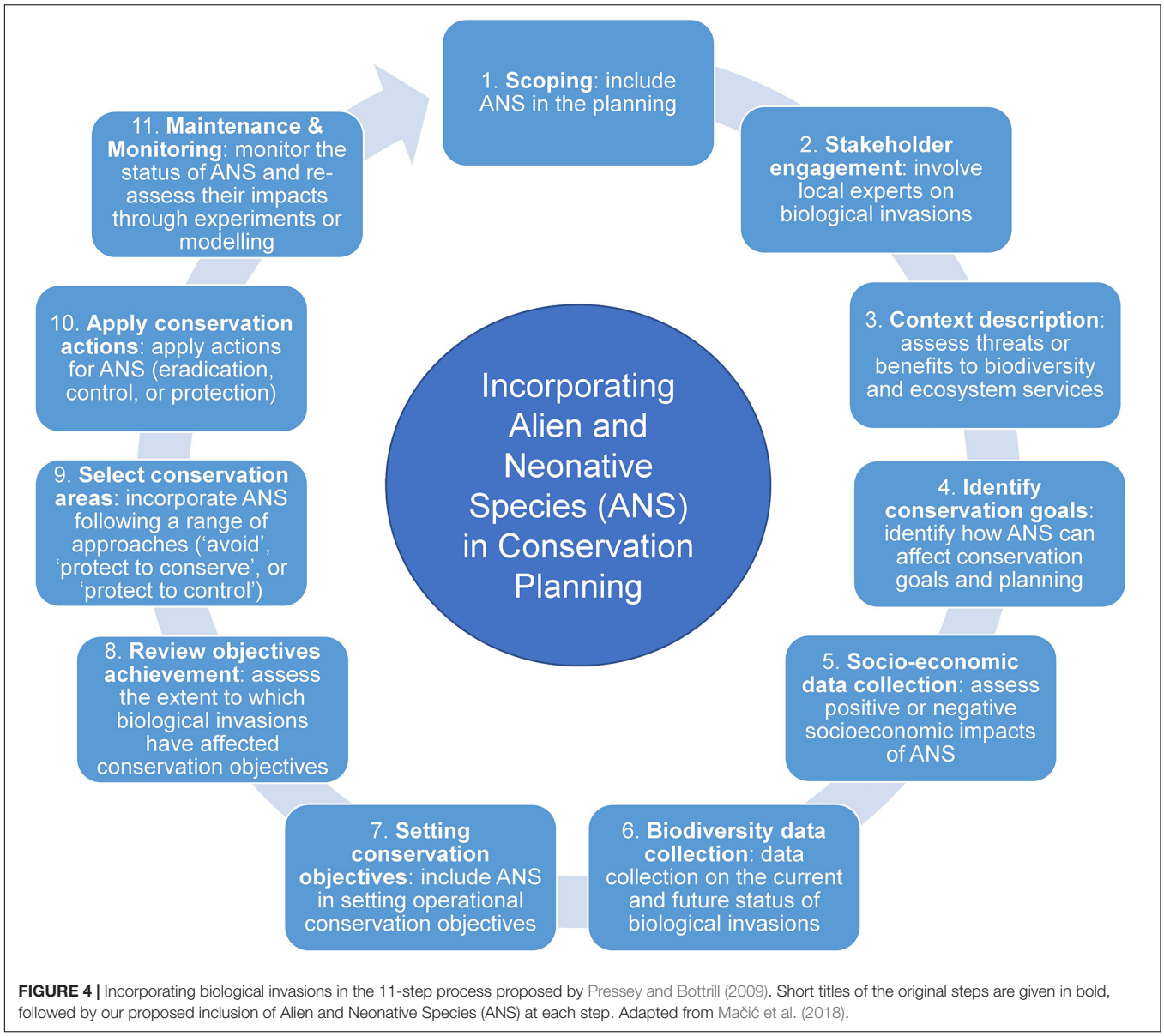

FIGURE 4 | Incorporating biological invasions in the 11-step process proposed by Pressey and Bottrill (2009). Short titles of the original steps are given in bold, followed by our proposed inclusion of Alien and Neonative Species (ANS) at each step. Adapted from Mačić et al. (2018).

approach whereby management actions are prioritized based on species characteristics and current spread, as a way for setting rapid management response priorities, without time-consuming species-specific evaluations. Actions such as raising public awareness and education, and physical removal and encouragement of commercial utilization of marine invaders are fundamental (Giakoumi et al., 2019c) and should be given special attention. Although waiting for invaders to diminish without any action may be considered the easiest and least expensive option, this approach should be discouraged. Spontaneous population decline in invasive species is difficult to predict and may only occur after persistent ecological damage has unfolded.

Transparent and Inclusive Conservation

Recommendation 9. Reinforcing the collection of high-quality open-access data.

Marine ecosystems are subject to a complex interplay of processes acting at different spatial and temporal scales, and are highly dynamic. Long-term monitoring programs are, therefore, essential to understand mechanisms underlying ecological changes and to guide an adaptive management of conservation strategies (see also recommendation 7). Evidence-based feedback through continuous and iterative monitoring, evaluation and reporting is crucial for achieving the objectives of any adaptive management framework (Day, 2008; Katsanevakis et al., 2011). Yet, the extent to which management measures are implemented and their outcomes monitored is poorly known for most European MPAs (Rilov et al., 2020). A limited number of MPAs have a monitoring plan assessing changes in the main species and habitats, and few MPA managers are aware of the current status of their protected areas and the effectiveness of conservation measures (Scianna et al., 2019). Even when monitoring programs

exist, it is often unclear whether measures are effective to reach stated conservation targets. Aligned data across MPAs in terms of taxonomic resolution, sampling methods, habitat coverage, and collection at appropriate spatial and temporal scales are missing.

The setup of observing systems provides the data required to evaluate changes in habitats and species following the implementation of MPAs. More investments are needed to map the distribution and status of ecosystems, habitats and species and set observation platforms to improve our knowledge of biodiversity and ecosystem functioning. A fine-scale mapping of human pressures inside and outside of the MPAs is also fundamental to building measures, priorities, and decisions relevant at local and regional scales. This baseline information is mandatory for reserve siting, planning, and zoning in an MSP perspective and is of fundamental importance to make effective cumulative effect assessments.

New data should complement existing information, which is presently too fragmented in a plethora of repositories and digital archives. Specific investment is required to reinforce an exhaustive and homogeneous data collection of marine data at EU scale within a single, easily accessible platform (Vandepitte et al., 2010; Levin et al., 2014). A major impediment to facilitate open data and integration is the tendency of different disciplines involved in fundamental research, conservation and management of marine systems to act as separate compartments. Initiatives such as the COST Action MarCons, and platforms such as EMODNET (European Marine Observation and Data Network[4]; Calewaert et al., 2016), that increase exchanges and data sharing among experts in different, but complementary, disciplines are a prerequisite for future advances in marine conservation and spatial management. This transdisciplinarity will increase our understanding of pressure-state responses, improve the reliability of cumulative effect assessment models and enhance the effectiveness of conservation strategies in the context of MSP. Promoting and enforcing the obligation to release all standardized datasets produced through public funding under an open access license can maximize their use.

Recommendation 10. Improving mechanisms for public participation in marine protected areas.

Public participation in decision-making is an indelible element of environmental governance intended to foster sustainability of policies, promoting economic efficiency, environmental effectiveness, equity, and political legitimacy (Eden, 1996; Bryson et al., 2012; Pita et al., 2012; Yates and Schoeman, 2013). This governance approach is particularly relevant in the context of nature conservation. Biodiversity is a public resource with benefits that transcend society, and management requires instruments and approaches adequate to address the complex distributive and procedural justice implications of biodiversity loss (Rands et al., 2010). A key instrument for public participation is the United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus Convention). The Convention is a legally binding instrument on environmental democracy that puts Principle 10 of the Rio Declaration in practice and sets legal standards for public participation. The three pillars of public participation are: access to information, participation in decision-making processes and access to judicial and administrative proceedings (United Nations Economic Commission for Europe [UNECE], 1998).

A MarCons study analyzed official websites on MPAs in light of internationally agreed legal standards on public participation provided by the Aarhus Convention to investigate how States deal with public participation in the specific context of MPAs in the EU and contiguous seas (Rossi et al., unpublished data). The study evaluated information on 61 MPAs in 14 countries covering 5 EU regional seas. The results highlighted that access to information was typically limited and that making information available to allow the public to evaluate the "performance of public functions" is a target still far from being achieved. Public participation in decision-making processes is scarce: less than half of the MPAs provide information concerning specific decisions to be adopted that affect or are likely to affect the MPA. This, despite the Aarhus Convention specifying that public participation must be 'informed' and effective. Access to justice also raises serious issues in its implementation. Indeed, information concerning review procedures is very rare, and only 19% of the MPAs studied provide information on available means to challenge unlawful acts and omission that may be prejudicial to the objectives of the MPA. In fact, the implementation of the Aarhus Convention in the specific context of MPAs has been widely unsatisfactory. There is a disconnect between what countries say they are doing regarding the Aarhus Convention in general and what is visible regarding MPAs. The 2017 UNECE country reports on the implementation of the Aarhus Convention often only refer to generic participation platforms and mechanisms, and do not report on specific topics such as biodiversity conservation.

It is crucial to enhance public authority's awareness of their obligations but, most of all, public awareness of 'environmental procedural rights'. This 'right-based approach' to environmental protection is, finally, gaining increasing attention in biodiversity conservation (Knox, 2017). The full implementation of the Aarhus Convention can help ensure that biodiversity is truly managed as a public good. The involvement of the public and stakeholders is usually considered as a means to increase the efficiency of MPAs, guarantee buy-in of resource users to support management decisions, and increase compliance with rules and regulations (Gray, 2005; Berghöfer et al., 2008; Leite and Pita, 2016). There is the need for more meaningful public input than the archaic consultation process, which is really only effective at incorporating views of a very small subset of the public (Yates, 2018). There is also need for more transparency in the MPA designation process and on-going management (Saarman et al., 2013; D'Anna et al., 2016), as well as greater promotion of co-management and community stewardship (Alexander et al., 2017).

Recommendation 11. Prioritizing conservation goals in full collaboration with stakeholders.

Various actors involved in the use and protection of marine space rarely interact, with a substantial lack of involvement of MPA managers in the preparation of national programs of

[4]https://www.emodnet.eu/en

measures and marine spatial plans, and little or no collaboration with different national authorities. Although the MSFD requires the national Programs of Measures to go through a formal consultation process, this is only a consultation with no requirement to act based on stakeholder input. MSP can be seen as an instrument to facilitate the realization of blue growth, i.e., finding space for new human activities in marine areas. Yet, the involvement of stakeholders in MSP processes is very much at the discretion of the competent authorities, and MSP is often driven by top-down processes aiming to fulfill specific policy objectives such as renewable energy targets (Ehler, 2018).

Stakeholder participation has been criticized in the past on the grounds that it is often inefficient, that it often does not achieve genuine participation in planning and decision making (Yates, 2018), and that it seldom improves institutional decision-making (Innes and Booher, 2004). And yet, international organizations that advise and support marine planning processes around the world, such as UNESCO's Intergovernmental Oceanographic Commission, posit that it is a vital part of any such processes (Ehler and Douvere, 2009). Stakeholder participation can reduce conflicts among users of marine space (Ehler, 2008; Yates et al., 2013; Yates, 2018) and is critical for marine planning due to the public nature of marine resources and the need for integration in planning and management, including several dimensions at spatial, temporal and governance levels (Smith et al., 2009; Portman, 2014).

We recommend that early stakeholder involvement, in particular those that can influence or be affected by conservation actions, constitutes an important step in marine conservation planning and management (Pressey and Bottrill, 2009; Smith et al., 2009; Giakoumi et al., 2018; Yates, 2018). Such involvement has important benefits for the effectiveness of conservation, such as: eliciting information and valuable data on biodiversity and human activities that would otherwise be unavailable (Yates and Schoeman, 2013; Yates, 2014); better understanding of concerns of people likely to be affected by conservation actions (Gelcich et al., 2009; Pita et al., 2011; Yates, 2014); engendering trust among environmental managers and other key players; empowering people from all levels and areas of society and providing them a chance to impact their future; producing more sustainable policies; engaging with actors who may facilitate conservation actions financially and politically; helping to identify unexpected opportunities; and gaining important support by governmental and non-governmental organizations and the public (Arnstein, 1969; Pierce et al., 2005; Portman, 2009; Pressey and Bottrill, 2009; Smith et al., 2009; Gopnik et al., 2012).

Recommendation 12. Addressing gender inequality in marine sciences and conservation.

Gender equality has been identified as a key component of the health of marine social-ecological systems (Friedman et al., 2020). Gender equality is also key in defining research interests and priorities regarding ocean health; women have raised important, and often neglected, concerns in marine conservation (Gissi et al., 2018b). Within the framework of MarCons, we explored data from the EU (European Commission, 2019) and three EU research institutes and academia: the Spanish National Research Council (CSIC), the French National Centre for Scientific Research (CNRS), and the Academia in Italy. We found a consistent pattern of gender imbalance across institutions and nations. Whereas a relative gender balance was observed in Ph.D. graduates, a gap was formed between women and men representation in latter career stages, with women being most underrepresented in senior positions. The proportion of women in senior positions varied from 13% in CSIC to 24% in the Academia in Italy (Giakoumi et al., unpublished data). Furthermore, we observed the same pattern in publishing, funding (through European Research Council grants), leadership roles in research institutions, with EU women scientists being more underrepresented in latter stages of their scientific career path. This generalized gender bias can have an impact on setting conservation research priorities and communicating results to policy- and decision-makers (Tallis et al., 2014).

Michalena et al. (2020) showed that inclusive management is critical for the effective creation, use and adoption of environmental governance. We also conducted a global survey to explore the perceptions of marine scientists and practitioners on the role of women in marine sciences and conservation, and found that the vast majority (71%) of respondents (n = 768) believe that gender balance in leading scientific roles influences marine conservation outcomes in a positive way (Giakoumi et al., unpublished data). This perception was related to personal experience and/or scientific evidence demonstrating that gender diversity leads to solving problems more efficiently (Nielsen et al., 2017). There is evidence that women exhibit higher levels of social sensitivity and emotional awareness, and teams with a high proportion of women achieve greater equality in participation, boosting the collective intelligence in scientific team-work (Woolley et al., 2010). As women tend to be more likely to recognize the expertise of fellow team members, gender-integrated teams can also be more productive by fully exploiting team expertise (Joshi, 2014; Nielsen et al., 2017). To bridge the gap between science and policy and achieve biodiversity conservation more effectively, one prerequisite should be to close the gap of gender inequality in marine science and social-ecological systems, and thus harness the potential of gender diversity for collective innovation and increased effectiveness in conservation research and marine management.

CONCLUDING REMARKS

Despite the uptake of important EU conservation initiatives during the last decades, marine conservation in Europe is still challenged by knowledge gaps, inefficiencies, methodological limitations, bad practices, and a substantial gap between science and policy making. Systematic prioritization of economic needs often comes above the needs of the environment, in spite of future costs of short-term economic prioritization and the loss of natural capital. As a consequence, the European and contiguous seas face ineffective conservation policies and measures, and cumulative effects of multiple local and global human pressures, resulting in deteriorating trends and failure to halt biodiversity loss. A holistic vision of the conservation and management of marine space that balances conservation and exploitation of the natural

capital can contribute in reversing these trends. This means that the business-as-usual scenario for marine conservation and current *ad hoc* reactive and segregated approaches need to drastically change. We need to plan for the future by taking proactive steps in revising current conservation policies, acknowledging the dynamic context of marine ecosystems, make explicit the human value systems underpinning management and conservation strategies, secure transparent, inclusive and collaborative decision-making, and bridge the gap between conservation science and policy making.

As the Natura 2000 network constitutes the backbone of conservation efforts in Europe, failing to address its weaknesses compromises the effectiveness of marine conservation in the European seas. Management plans and conservation actions are missing from most Natura marine sites and urgently need development. Unresolved conflicts among economic sectors or among countries hinder the effectiveness of conservation measures. Moreover, many procedures and rules for the governance of the Natura 2000 network are outdated, and insufficiently address the challenges of shifting policies and global change.

MarCons made 12 recommendations aiming to advance marine conservation by making marine planning more effective, improving management, accounting for global change, and improving current practices in marine conservation. Marine conservation needs to escape from inertia by incorporating the following key components: new risk-based approaches for cumulative effects assessments, regional collaboration, strategies for mitigating global change threats, systematic conservation planning approaches across realms instead of *ad hoc* and non-transparent spatial prioritization, adequate monitoring frameworks, adaptation strategies, data accessibility, and stakeholder engagement.

We have provided several examples of how the 12 recommendations can be implemented in existing and future management efforts as short and medium term strategies. For the present recommendations to find their way to European policy making and not remain just a wish list, further actions are needed. The twelve recommendations should be adopted at high levels by European institutions (i.e., the legislative instruments of the EU and regional conventions) to secure their wide implementation. This set of recommendations is a timely intervention, in view of the targets of the new EU Biodiversity Strategy for 2030, and the need to draft new legislation and implementation acts. A pathway to implementation mainly requires extensive lobbying with EU policy makers utilizing all points of intervention (i.e., Directorates General of the European Commission, Members of the European Parliament, parliamentary committees, working parties of the Council of Ministers, Commission expert groups).

Scientists have long expressed their fears that humanity has been pushing Earth's ecosystems beyond carrying capacities and proclaimed that fundamental changes in environmental policies and management are needed (Ripple et al., 2017). Despite the advances in conservation science and numerous past recommendations for better management of the oceans (e.g., Douvere, 2008; Heller and Zavaleta, 2009; Pressey and Bottrill, 2009; Smith et al., 2009), the gap between science and policy remained, representing one of the limits for making substantial progress in effective marine conservation and in halting biodiversity loss (Johnson et al., 2017; Ripple et al., 2017). Setting new targets, as the new ambitious EU Biodiversity Strategy for 2030 has been announced, is of critical importance to plan urgent conservation initiatives. However, without a change in the vision about the importance of developing a sustainable economy in harmony with healthy ecosystems those targets will never be reached. The valuable marine ecosystems in European seas and beyond need adequate protection before it is too late, and here we strongly advocate for substantial advances toward this overarching goal. The launching of the European Green Deal is an important recognition of the need for rapid action for building resilience of human and natural systems against global stressors, and it could be an important vehicle for the implementation of the list of recommendation provided here.

AUTHOR CONTRIBUTIONS

SK coordinated this work. MC, SF, SG, DG, VM, and PM coordinated the six MarCons working groups, and GR coordinated the *ad hoc* climate change focused working group, the work of which led to the recommendations made herein. SG supervised the creation of **Figure 1**. SK created and adapted **Figures 2–4**. All authors co-developed the 12 recommendations, contributed to the drafting of the manuscript, and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2020.565968/full#supplementary-material

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