Marine Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Delivering sustainable fisheries through adoption of a risk-based framework as part of an ecosystem approach to fisheries management

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ABSTRACT

Recently, the role which fisheries play in the provision of marine ecosystem services has been more widely acknowledged, largely as a result in recent years of fisheries management organisations developing and adopting more ecosystem-based approaches to fisheries management (EAFM). Accordingly, several important management and science challenges have been identified. We argue that these challenges represent a number of important steps which underpin effective science based fisheries management, and when taken together and integrated, offer a logical framework by which to best achieve an EAFM. The challenges, or steps of the framework, identified and described are, i. defining appropriate spatial management units based upon significant and coherent ecosystem production processes, ii. assessing multi-species stock dynamics, iii. developing mixed fisheries management approaches, and iv. assessing the impacts of fisheries on non-target species and ecosystem components. The paper considers how the knowledge gained from research on these challenges can be applied to a risk-based management framework as an essential step towards the achievement of the Sustainable Development Goal (SDG) 14 with respect to the conservation and sustainable use of marine resources for sustainable development.

1. Implementing an ecosystem approach to fisheries management

Fisheries, as a provisioning ecosystem service, represent vital components of developed and developing economies, providing income and employment in addition to food and nutrition. The continued benefits derived from sustainable fisheries are dependent upon the achievement of United Nations Sustainability Development Goal (SDG) 14.4 (science-based fisheries management) and SDG 14.2 (productive and resilient ecosystems). The achievement of these sub-targets can also contribute to the achievement of SDG 2 (on ending hunger, achieving food security and improved nutrition), SDG 1 (on ending poverty), and SDG 8 (on sustained, inclusive and sustainable economic growth, full and productive and decent employment). The greater part of world fish supply comes from marine fisheries, currently yielding around 80 million tonnes per annum, with a value of around US$148 billion (FAO, 2016). At the same time, the negative impacts which poorly regulated fishing activities can have on the wider marine ecosystem are increasingly being recognised [72]. While “single-state single-species” fisheries have allowed the implementation of some innovative management systems (e.g. [24]), the interaction between traditional concepts of national sovereignty, marine ecosystems and international relations raises particular problems in managing common fishery resources and the ecosystems of which they are part. Since the early-1980s, various international instruments have been developed with the aim of promoting the sustainable use and rational management of shared marine resources.

Many of the world's most productive fisheries take place on transboundary or high seas stocks, where the “globalised” nature of fisheries has often led to conflict between coastal fishers and those operating in international waters. As a result, formal institutions, typically regional fisheries management organisations (RFMOs), have developed as fora for transparent decision-making and conflict resolution, informed by relevant and responsive scientific advice, supporting the international management and cooperation essential for assessment and regulation of fisheries in areas beyond national jurisdiction (ABNJ), as stipulated by the UN Convention on the Law of the Sea (UNCLOS) and supplemented

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http://dx.doi.org/10.1016/j.marpol.2017.05.018
Received 20 October 2016; Received in revised form 2 May 2017; Accepted 11 May 2017

by the Fish Stocks Agreement.[1] Transfer of knowledge and scientific findings within and between these organisations, from areas where fish stocks, the marine environment and associated human factors have been studied, has been facilitated through sharing of practice and experience, for example, via the Food and Agriculture Organization (FAO) of the United Nations.

In line with the understanding of sustainable development as a development "which meets the needs of the present generation without compromising the ability of future generations to meet their needs" [7], managing fisheries sustainably requires protection of ecosystem structure and function while also considering the current and future needs of people as part of marine ecosystems. Sustainable fisheries can also directly contribute to the maintenance or restoration of a wide range of ecosystem services beyond provisioning. For instance, poorly managed by catches of protected, endangered or threatened species can represent an economic cost to fisheries, particularly in developing countries, both through a loss of amenity value of charismatic species, and through the generation of negative perceptions of the products of the fishery. Furthermore, key ecosystem functions and services can be disrupted by the collapse of certain species within their respective functional groups. For instance, top predators have an important regulatory role in the food chain, and large-bodied species play key roles in nutrient cycling and sediment bioturbation [49]. Many other barriers to sustainable fisheries exist, including data deficiencies, particularly with regard to catch data, fleet overcapacity, ecosystem effects of fishing, such as habitat loss, and the frequent disconnect between social and ecological goals [32].

Link and Browman [45] proposed that single species fisheries management (SSFM) and Ecosystem-Based Management (EBM) represent bounding philosophies along a management continuum. At one end, SSFM focuses on a single species or stock. Ecosystem considerations such as habitat, environmental drivers, and predator–prey dynamics can be integrated into the management of a single stock, but management is solely fishery focused. At the other end of the spectrum, EBM represents a holistic approach to management which can go beyond fisheries to include exploration of goals and trade-offs across multiple fleets, sectors, and competing interests (e.g., harvest maximization, economic performance, biological diversity) [22,23]. EBM is expected to lead to more holistic management recommendations by explicitly considering species interactions and environmental processes, quantifying the value of marine ecosystems beyond fishery harvest, and allowing the discussion of trade-offs [16]. Adopting the ecosystem approach provides a means of achieving both fishery and ecosystem-level goals [44].

The Ecological Society of America Committee on the Scientific Basis for Ecosystem Management [12] provided one of the first widely used definitions of Ecosystem Management. They defined it as "*management driven by explicit goals, executed by policies, protocols and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem structure and function*". In its fifth meeting, the Conference of the Parties to the U.N. Convention on Biological Diversity defined the Ecosystem Approach as "*a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*" and indicates that is "…*based upon the application of appropriate methodologies focused on levels of biological organization which encompass the essential processes and interactions among organisms including humans and their environment*". Guidance for the implementation of the ecosystem approach was further developed and adopted by CBD COP 7 (CBD Decision VII/11, 2004).

When applied to fisheries, Ecosystem Approaches to Fisheries (EAF) are intended to ensure that the planning, development, and management of fisheries will meet social and economic needs, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems Garcia et al. [73]. Achieving this purpose requires addressing components of ecosystems within a geographic area in a more holistic manner than is used in classical target resource oriented management approaches. It requires identifying [geographically] exploited ecosystems together with explicit recognition of the many, and often competing, human interests in fisheries and marine ecosystems [73]. Therefore, following Garcia et al. [73] "…*an ecosystem approach to fisheries strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries*".

Similarly, the U.S. Commission on Ocean Policy noted that "U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including human and nonhuman species and the environments in which they live. Applying this principle will require defining relevant geographic management areas based on ecosystem, rather than political, boundaries." As the recognition for the need for ecosystem approaches grow (The Future We Want, paragraph 158; SDG 14c; CBD Aichi Biodiversity Target 6), political commitments to ecosystem-based fisheries management are increasing worldwide. Overall, these (and many other) definitions of EAF embody the recurring themes of the need to understand and account for interactions among the parts of the system, the recognition that humans are an integral part of the ecosystem and that potential conflict among human activities can exist (and hence, achieving trade-offs is required), and that EAF is fundamentally a place-based management framework.

There are very few, if any, examples of such EAF frameworks being fully implemented in fisheries at present. However, there are many examples where at least a number of important steps are being addressed. Most of these are in relation to establishing MPAs and undertaking some form of fisheries spatial management, e.g. by way of establishing fishery closures to protect VME and or defining active fishing areas.

The United Nations Conference on Sustainable Development (Rio +20), which took place in 2012, launched a process to develop a suite of Sustainable Development Goals (SDGs). Member states agreed that the SDGs would build upon the Millennium Development Goals (MDGs) and form part of the Post-2015 development agenda. The 2030 Agenda for Sustainable Development, adopted by the UN General Assembly in September 2015, promotes a set of 17 SDGs, encompassing 169 specific targets, covering areas such as poverty, equality, environment and climate, which represent a framework for achieving efficient policies and governance for global sustainable development. Of these, SDG 14 concerns the conservation and sustainable use of oceans, seas and marine resources for sustainable development. Within this goal, target 14.4 aims for states, by 2020, to *effectively regulate harvesting and end overfishing, illegal, unreported and unregulated (IUU) fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics*. The broad scope of this target covers the specific areas of compliance with regulation, protection of vulnerable marine ecosystems, and the assessment of exploited fish stocks. The balance between these objectives will require decision makers to agree trade-offs among alternative management goals.

Seen in the context of wider marine ecosystems and the management of fisheries upon them, there are clear overlaps in scope between this goal, which seeks an end to unsustainable fishing practices, and several others, such as SDG 14.2, which seeks the sustainable management and protection of marine and coastal ecosystems from significant adverse impacts, and 14.5 which mandates the conservation of at least 10 per cent of coastal and marine areas, based on the best available

[1] However, in practice, many challenges still remain in the implementation of these obligations as observed in the recent UN Fish Stocks Agreement Resumed Review Conference [67].