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Hidden in plain sight: Using optimum yield as a policy framework to operationalize ecosystem-based fisheries management

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ABSTRACT

An often-cited impediment to the operationalization of ecosystem-based fisheries management is the lack of a governance structure that explicitly provides the authority and framework for implementing this holistic approach to fisheries management. However within the United States and elsewhere in the world, the concept of optimum yield appears to be an explicit mandate and framework that can and should be used to operationalize ecosystem-based fisheries management. This optimum yield policy has been hidden in plain sight for close to 40 years, largely due to happenstance, as other factors facing society-at-large have masked the original intent behind this concept. This paper describes the similarities between optimum yield and ecosystem-based fisheries management, how it has been overlooked in the past, and how the concept can be used to operationalize ecosystem-based fisheries management.

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1. Introduction

The ability to operationalize ecosystem-based fisheries management (EBFM) remains a challenging process [21,89], even though the concept was first adopted by several nations as a more holistic approach to fisheries management over 20 years ago [2,33,44]. There have been several impediments to implementing EBFM [21,37,77], one of which is whether there is a governance structure that can effectively implement EBFM [6,18,43].

From an EBFM perspective, governance involves both the legal authority and the regulatory framework of how fisheries could be managed. In general, discussions over governance and EBFM usually include such things as:

- Whether existing mandates provide the legal authority to manage fisheries using an ecosystem approach to management (e.g., [77,56,71]).
- The stakeholder and jurisdictional challenges of managing within a large marine ecosystem (e.g., [77,3,21]).
- The ability to incorporate social and economic dimensions into the decision making process (e.g., [88,3]).
- The ability to identify long-term goals and prioritize among conflicting goals (e.g., [88,93,21]).

Although several authors have described how many of the past governance impediments to EBFM are no longer an issue (e.g., [77,71,21]), the debate on governance is far from over. This is especially true in the United States (U.S.), where many scientists and managers still regularly state they lack governance structures to implement EBFM because there are no explicit mandates or frameworks to operationalize the concept (e.g., [56,88,48,3]).

This paper describes why the U.S., and likely other countries, does have a clear mandate and robust framework to implement EBFM. In the U.S., this governance structure was developed by the Magnuson-Steven Fishery Conservation and Management Act (MSA) almost 40 years ago (16 USC 1801, etc.), which among other things mandated the use of optimum yield (OY). Below, the paper describes the similarities between OY and EBFM, why OY was possibly overlooked during the early implementation phases of EBFM, and how to use OY to implement EBFM.

2. Similarities between OY and EBFM

The concept of OY was formalized as a guiding principle in fisheries management in the U.S. and Canada in 1976 [47]. Although the U.S. and Canada define OY differently, in general the definitions imply that OY is an amount of fish that is derived from maximum sustainable yield and balances the ecological, economic, and social goals of the Nation [47]. Other countries that use similar concepts such as maximum economic yield and optimum sustainable yield [26,68,69,72], and face similar governance challenges would be able

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to use this framework to implement EBFM too. For example, countries like Australia, United Kingdom, New Zealand, and South Africa use or are exploring OY concepts and could benefit from this approach. In the U.S., the definition of OY has essentially been the same since 1976 (see the section below on overlooking OY), which is currently defined as:

> *the amount of fish which will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems; is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery* (16 United States Code (USC) §1802(33)).

In contrast with the fairly consistent North American definitions of OY, there are several derivatives of EBFM defined in the scientific literature (e.g., [55,1,59]). They have all mostly coalesced to substantively mean the same thing, just with different subtle points of emphasis. One of the more prominent definitions, produced by the Food and Agriculture Organization (FAO) – an intergovernmental organization with representatives from 194 nations, defines EBFM[1] as an approach to fisheries management that:

> *strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries* [33].

To compare the similarities between the OY and EBFM concepts, a matrix of the key phrases from each of the definitions was constructed (see Table 1). The degree of overlap was rated as high, moderate or low, based on expert opinion of the authors. Both concepts share the common objective of providing the greatest benefits to the Nation or Society. However, the OY definition is explicit in the types of objectives (e.g., food production, recreational opportunities, ecological factors, etc.) that are important to consider when determining the OY; whereas the EBFM definition is explicit about acknowledging the different components of the ecosystem (i.e., biotic, abiotic, and human dimensions), and the uncertainty surrounding these variables. The EBFM key phrase "strives to balance diverse societal objectives" aligns with several of the key phrases used in the OY definition, and the OY key phrases "particularly accounts for the protection of the marine ecosystem" and "based on relevant ecological factors" aligns with several of the keywords used in the EBFM definition (see Table 1).

There are, however, several key phrases (or portions thereof) that do not directly align with the OY or EBFM definitions (see Table 1). In these cases, similarities are discussed elsewhere in the FAO guidelines for EBFM [33], MSA (16 USC Section 1801 etc.), or National Standard 1 (NS1) Guidelines [35]. For example, the EBFM definition does not include a reference to "an amount of fish" that is taken from the fishery. The FAO guidelines for EBFM do, however, recognize that quotas for target and bycatch species are needed to protect more vulnerable species and the marine ecosystem as a whole ([33], see Section 3.2.2.2). Another example is that the OY definition does not include a reference to "use ecologically meaningful boundaries." Within the U.S., boundary issues have largely been resolved by the MSA, which created eight Regional Fishery Management Councils that manage fisheries within their marine ecosystems [21,77]. The point being, the supporting context of each framework indeed often aligns with the main tenets of the other.

While this key phrase comparison is helpful, overarching questions remain. In the U.S., OY is commonly specified at the stock or stock complex level, whereas EBFM is performed at the fishery or ecosystem level (i.e., multiple stocks and/or fisheries). The MSA actually notes that OY should be specified for the fishery, and defines fishery as one or more stocks which can be treated as a unit for purposes of conservation and management (16 USC Section 1802(15) and (33)). To operationalize this concept for traditional single-species approaches to fisheries management, NOAA Fisheries has generally recommended that OY be specified at the stock or stock complex level [109]; however, fishery-wide OY can also be specified for mixed-stock fisheries [109]. Currently, only the Bering Sea/Aleutian Island and Gulf of Alaska groundfish fisheries specifies a fishery-wide OY [106]. The concept of specifying OY at the larger fishery or ecosystem level to prevent ecosystem level overfishing is also encouraged in the scientific literature (e.g., [76,58,17]), and by existing guidance for developing Fishery Ecosystem Plans (1999). Currently, 4 out of 8 U.S. Regional Fishery Management Councils have Fishery Ecosystem Plans for at least a portion of the regions over which they have responsibility [100,80].

Another overarching issue related to OY and EBFM is that OY is often considered a reference point or specified amount of catch, rather than an integrated approach (as described in the EBFM definition). However, the NS1 guidelines explicitly layout an integrated approach by which OY is assessed and specified. OY should be reduced from MSY based on tradeoffs that are of ecological, economic, or social importance to the fishery and the Nation [35]. The process is also adaptive, where OY is expected to change on a regular basis due to changing circumstances in the fishery. For example, profit margins on specific species may change due to increases in harvesting cost, the demographics of the fishing fleet and fishing communities could change over time, ocean productivity may alter the production potential of fish stocks, or technological advancements in gear could reduce bycatch and increase OY.

Overall, the comparison shows that OY and EBFM are essentially identical in concept: (1) each suggests there is an integrated process whereby (2) the ecological, economic, and social objectives of fisheries can be balanced to (3) provide the greatest benefit to the nation or society. The only difference between the two concepts is that the definitions emphasize different aspects, where OY emphasizes the type of objectives that should be considered while EBFM emphasizes the various components of an ecosystem. Where differences did occur from a definitional standpoint, supporting FAO and U.S. guidelines further elucidate their similarities.

3. Overlooking optimum yield

The history of U.S. fisheries management provides some clues as to why OY was not seen as an explicit framework whereby EBFM could be implemented. In the U.S., the definition of OY has essentially been the same since 1976 [73]; however, the manner in which it has been interpreted has changed dramatically over the last 38 years. The OY concept evolved over time as the MSA was revised and as NOAA Fisheries revised the NS1 guidelines pertaining to OY. The result was an OY that reflected the fisheries management concept du jour.

Prior to 1976, the prevailing fishery management concept was MSY, which attempted to maximize the yield of fisheries without considering other management objectives. Healey [47] notes that "by 1975 it had become abundantly clear that, in most cases, stock

[1] The FAO guidelines use the term ecosystem approaches to fisheries management (EAFM), which is sometimes used interchangeably with the term EBFM and appears to be the case here.