frontiers in Marine Science

EDITORIAL
published: 14 February 2022
doi: 10.3389/fmars.2021.830225

Editorial: The Approach to Complex Systems in Fisheries

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Keywords: fisheries, complex-systems, sustainability-science, coupled-socioecological-systems, management

Editorial on the Research Topic

The Approach to Complex Systems in Fisheries

A new approach to the management of fishery resources is emerging worldwide: the approach based on the principles of systemic complexity, one that addresses problems whose nature involves social, ecological, and economic spheres. These new ideas have been changing from conventional approaches to natural resource management, to the increasing incorporation of components that integrate highly complex systems with deep uncertainties, Coupled Socio-ecological Systems (CSS), which are characterized by having very close and diverse connections across various scales in the temporal domain mainly but also in the spatial domain. It is possible that, of the primary productive sectors, the most complex are fishing systems, since they involve the use of resources that by their nature are difficult to observe and monitor, and whose local abundance varies -sometimes significantly- due to natural drivers as well as human ones. This has motivated the use of mathematical models as a tool traditional in the management of fishery resources. However, far from seeking the integrative approach initially proposed for its management, the advances have few fundamental changes over time, despite the increasing formal recognition that the drivers of fisheries sustainability are numerous and diverse. A segmented approach has not helped to change the negative trend of many of the world's fisheries, making evident the need to venture into a new paradigm: the incorporation of the SES approach, where issues such as non-linear ecological dynamics and Human decision making are receiving increasing attention for resource management. SES's approach is maturing as a discipline within Sustainability Sciences, incorporating into fisheries management ideas from other interdisciplinary fields such as resilience or complex systems research. This type of approach is maturing as a discipline within Sustainability Sciences, incorporating ideas from other interdisciplinary fields such as resilience or complex systems research into fisheries management. This Frontiers in Marine Science Research Topic includes contributions from different sites with a long fishing tradition, and it is in this context that it is expected to make a compilation, modest yet propositional of the results that have been achieved to date on the management of fisheries under this new approach to CSS.

One of the contributions to this Research Topic is Patanasatienkul et al. It addresses the problem of how to conserve massive fishing resources that are used as bait and how the use of new artificial baits to catch lobster in regions with a great fishing tradition such as Prince Edward Island in Canada, can contribute to its conservation through strategies that are more acceptable for local communities. Their results indicates that alternative bait is a viable replacement to traditional bait, allowing the lobster fishing industry to address the scarcity of bait species and meet the ongoing conservation challenge jointly with the diverse groups that comprise this fishery.

OPEN ACCESS

Edited and reviewed by:
Yngvar Olsen,
Norwegian University of Science and Technology, Norway

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Specialty section:
This article was submitted to Marine Fisheries, Aquaculture and Living Resources, a section of the journal Frontiers in Marine Science

Received: *06 December 2021*
Accepted: *29 December 2021*
Published: *14 February 2022*

Citation:
Salinas-Zavala CA, Morales-Zárate MV, Cisneros-Montemayor AM and Bojórquez-Tapia LA (2022) Editorial: The Approach to Complex Systems in Fisheries. Front. Mar. Sci. 8:830225. doi: 10.3389/fmars.2021.830225

The holistic approach, from the retrospective analysis of published information to the analysis of the variability of the system, details the complexity of a socio-environmental system. A study carried out in Bahía Magdalena (BM, Mexico) Jiménez-Quiroz et al. retrospectively considers the relationship of commercial bivalves and the possible impact of environmental variability in these populations, as a contribution to this Research Topic. This comprehensive approach allows us to tell a story of decades of fishing development that shows the socio-environmental complexity of a region with a strong fishing vacation, emphasizing the importance of analyzing fluctuations in the abundance of commercial species and their relationship with oscillations in the oceanic environment and longer-term climate trends.

In most small-scale fisheries (SSF), due to the lack of explicit spatial and temporal data, there is limited or no information on the distribution and spatial extent of the sites where the fleets operate. This information is key when addressing spatial planning and management programs for fisheries and forces one to consider aspects of shared use together with users themselves. Using a correlative modeling approach and employing spatially explicit variables in their contribution to this Research Topic, Torres-Irineo et al. propose that this approach seems appropriate to learn more about the factors that define the spatial distribution of small fleets scale and its potential fishing sites, thereby determining emerging behaviors of the fishing system.

In addition to the spatial analysis above, there is also an interesting analysis focuses on fishermen's responses to the question: What will fishermen do about the new distribution of the target fish? Will they follow the new distribution of them or, will they prefer to stay in the traditional fishing site and catch other fish? Papaioannou et al. combined qualitative interviews with quantitative analysis of fishing records and ecological studies and concluded that following fish is rare, while the most common response was a change in the target species and therefore a change in the composition of the catches; understanding the cultural and regulatory factors behind these emergent adaptive responses will be key for many fisheries facing similar challenges due to climate change.

The complexity of fishery systems of course includes the fishery-megafauna interactions. This aspect was addressed in the contribution that describes the case of loggerhead turtle bycatch in the Gulf of Ulloa, Mexico (Bojórquez-Tapia et al.). This contribution presents the implementation of exploratory modeling to address this type of complex socio-ecological problem. The results identified the level of bycatch that indicated a possible critical transition to a state of low resilience of the loggerhead turtle population and the appropriate multiple-use management scheme. Their results were used to formulate regulations aimed at establishing an incidental catch limit and a refuge area for the loggerhead turtle population in the region and represent a key initial step to establish holistic co-management strategies.

The allocation of fishing effort is a key feature in planning the spatial management of fisheries, especially in small-scale fisheries, due to its multispecies context. The analysis of the movement of the vessels has allowed in recent years a better evaluation and management of artisanal fishing. Using a Random Walk (RW) modeling approach, the routes of the fishing trips of small-scale fishing vessels were characterized, concluding that the Composite Correlated Model (CCRW) was the most suitable for this fleet. This allows the spatial domain to be included in the analysis of complex systems of artisanal fisheries (Quijano-Quiñonez et al.).

This geospatial analysis approach was also used in Morales-Bojórquez et al., when analyzing the effects of catch of small pelagic fish in the Gulf of California ecosystem. This study estimates the latitudinal differences of endangered and threatened marine species attracted by purse seines in a Mexican fishery for small pelagics, incorporating the spatial patterns of fishing effort in the Gulf of California. In this study, the number of individuals of various species sighted and counted per fishing set was used for each area of the Gulf of California, and a conservative baseline was calculated based on the Pennington estimator. This estimator is recommended by the authors due to the precision of the confidence intervals and the nature of the uncertainty in data collection based on sightings. Within complex systems the interaction of fisheries with species under a protected status is considered a wicked problem, but one that needs to be addressed in the transition toward sustainability.

Finally, this Research Topic presents a work that systematically documents the current understanding of the social sciences of the multiple human dimensions that must be incorporated into ecosystem assessments and the general approach of each of them within of Comprehensive Ecosystem Assessments (CEA) and other ecosystem-based fisheries management efforts (Szymkowiak). It is important to again highlight the fact that addressing these social dynamics—which includes their description as well as the active support for social equity within fisheries and management itself—is at least as important as better understanding the biology and ecology of fisheries.

There is an evident need to address at a global scale, without reductionism, the objects of fisheries research as an increasingly complex system; constituted by human societies and the natural systems with which they interact and of which, ultimately, they are part. That is the reason of the new paradigm of the Sustainability Science, whose explicit objective is to contribute to a Transition to Sustainability—that is, to point the way toward sustainable societies—and whose characteristics must permeate both the different scientific disciplines and social activities as a whole, of course including fisheries.

AUTHOR CONTRIBUTIONS

CS-Z, MM-Z, AC-M, and LB-T contributed to conception and design of the study. AC-M, MM-Z, and CS-Z edited contributions. CS-Z wrote the first draft of the manuscript. MM-Z and AC-M wrote final version of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

ACKNOWLEDGMENTS

We thank the editors of Frontiers in Marine Science for the invitation, particularly Thimedi Hetti for guidance and follow-up to integrate this Research Topic. This special issue was carried out within the project CONACYT-CIENCIA BASICA A1-S-43455: Modeling based on agents as a tool for the evaluation of resilience in a socio-environmental system of fishing use.

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