Not Fish, Not Meat: Some Guidance on How to Study Fisheries from an Interdisciplinary Perspective

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Key Points

When designing an interdisciplinary project,

- Develop a solid disciplinary foundation before becoming an interdisciplinary scientist.
- Choose the right project leader as knowledge broker.
- Employ the right mix of people.
- Conceptualize the problem to be addressed with the whole interdisciplinary team.
- Plan the integration at the onset of the project.

Introduction

Fisheries can best be viewed and understood from a systems perspective, which is defined as a web of interrelated and interacting ecological, biophysical, social, economic, and cultural components. Unfortunately, reductionist approaches focused on single-species fisheries biology as a discipline have long dominated fisheries science. Consequently, many well-

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intended fisheries-management actions have failed to meet their objectives, either because of unexpected human responses or because of complex ecological dynamics. To address the resulting implementation uncertainty, scholars have increasingly asked for research programs that study the implications of management actions throughout the whole coupled social-ecological system. To achieve this aim, interdisciplinary science and the integration of disparate knowledge sources is needed, something that few graduate programs in fisheries specifically focus on.

A key assumption of this essay is that the simplification of key feedback processes and a general lack of integration of the natural and social components of fisheries may lead to system responses that are often characterized by high social and economic costs. To avoid such costs, we need a better understanding of the type and function of cross-scale and nonlinear feedbacks among the human and environmental subsystems because these feedbacks determine how fisheries as systems respond to disturbances and management interventions. We are convinced that the greatest breakthroughs in capture fisheries science wait at the interface of the social and ecological components of fisheries. Here, we offer some advice for the aspiring fisheries professional on how to develop a successful interdisciplinary agenda (see Box 1 for terminological clarification).

Before listing our advice, a disclaimer is in order: interdisciplinary projects in fisheries are no panacea, and in many cases it is just fine to work from single disciplines. For example, if the task is to estimate the current stock size for a purely scientific, or a theoretical, purpose, a quantitative stock assessment project that analyses abundance and catch-at-age data works well and is appropriate. Or, if the task is to learn how the broader angling public in a region feels about an existing fisheries regulation, a survey-based project based on probabilistic sampling conducted by a social scientist knowledgeable with the particular fishery system is a perfectly suitable approach. However, we can also think of many situations where an interdisciplinary research approach would be superior. Think about situations of marine spatial planning where multiple stakeholders, coastal zones, and transboundary fish stocks are involved. Or consider developing a holistic analysis of the impact of harvest regulations or other policies on ecosystems and fishing communities in a landscape of freshwater fisheries. Surely, integrating the ecological, evolutionary, and human dimensions of fisheries may be fruitful to solve these and related complex situations where ecological and social systems strongly interact though cross-scale interactions and feedbacks. Here is our (entirely subjective) list of recommendations that should help researchers enjoy the many advantages and mitigate any potential disadvantages of an interdisciplinary research path in fisheries.

Develop a Solid Disciplinary Foundation before Becoming an Interdisciplinary Scientist

Deeply entrenched disciplinarity is thought to be a barrier to interdisciplinary collaboration. However, some level of specialization in a given subject is needed to develop the foundation for basing future interdisciplinary projects. Hence, preparing oneself for interdisciplinary work involves attaining specialized depth in a given subject through a dedicated M.S. or Ph.D. program. Often, in the fisheries profession, such programs will be fisheries or applied ecology programs. However, as one specializes, one must maintain a broad interest, read widely (e.g., human dimension of fisheries, natural resource economics), and possibly also take some interdisciplinary courses to receive an appreciation for the multitude of approaches that exist to tackle a given problem. Recommending additional classes to a student enrolled in a busy graduate program is no trivial matter and may even mean extending the studies by one or

Box 1. Some Semantics on the "…disciplinarities"

There is wide variation in what is understood as interdisciplinary and transdisciplinary research, which should be separated from multidisciplinary research approaches. *Multidisciplinarity* refers to the study of an object such as a fishery through the lenses of multiple isolated scientific disciplines. For example, when a fisheries biologist and a human dimension researcher work side by side in the same management agency on the same fishery, each with his or her own research question, conceptual framing, and methodological toolbox, and with little attempt to integrate findings to solve a common research objective, one would talk about multidisciplinarity. *Interdisciplinarity* differs from multidisciplinarity in some important ways. Most importantly, research problems and questions are answered using methods, frameworks, and concepts from at least two separate schools of thought. In a prototypical interdisciplinary project, scholars from at least two disciplines would work together in an integrated fashion to answer common research objectives. For example, a bioeconomic model to help identify an economically suitable management action would demand the integration of a behavioral model of the fisher, a fish population model, and associated evaluation criteria, and hence be forced to use theories, variables, concepts, and models from different disciplines, such as economics, fisheries ecology, and operation research, to answer the research questions. Finally, *transdisciplinarity* is interdisciplinary research that substantially integrates the world of action into the knowledge generation and integration process. Here, stakeholders and practitioners are part of the scientific knowledge generation process and may be involved in framing the problem, collecting data and interpreting results, or in all of this; hence, the suffix "trans." A special form of transdisciplinary research is action research where the research process is conducted in sites and areas used and managed by communities and in close collaboration by researchers and practitioners. Transdisciplinary research of all variants aims at democratizing research through deliberate involvement of stakeholders to increase capacity building, ownership of results, and knowledge transfer to solve local and regional sustainability issues. One example of inter- and transdisciplinary fisheries research is a German research project called Stocked Fish (www.besatz-fisch.de) led by the first author of this article. In this project, principles of sustainable fish stocking in German angling clubs were derived using jointly conducted fish stocking experiments that took place in the club's waters and that were planned, conducted, and evaluated by researchers and angling club heads in joint teams.

two semesters. However, for interested students, this investment will usually pay off. Assisted by an appropriate interdisciplinary mentor, it is important to identify what classes outside the own narrow discipline would be worth taking and what literature to consult. We recommend that a motivated student carefully choose mentors and advisors that are themselves broadly interested and that have a proven record (grants, papers) of successful interdisciplinary work. Also, some fisheries programs have produced more interdisciplinary output than others, and

hence, the M.S. or Ph.D. fisheries program to pursue may also constitute a decisive choice. Any resulting foundation of depth and breadth can then provide the raw material for facilitating the branching into interdisciplinary endeavors.

There are three reasons for why one needs both depth and breath before engaging in interdisciplinary work. First, any interdisciplinary project needs methods developed in a specific field, hence methodological depth. Second, to foster interdisciplinary projects and to build teams one needs a basic knowledge of jargon and methods used in alternative relevant disciplines (i.e., scientific breath). Finally, on a more practical level, many of the more traditional faculties emphasize specialized knowledge of some sort in their hiring processes despite the appreciation and increasing value attached to interdisciplinary interest and expertise. Therefore, there are real risks to a traditional career path for those who become interdisciplinary researchers too early on (e.g., at the masters level). Hiring committees at very traditional disciplinary departments, and even in multidisciplinary ones where you apply to a position demanding a specific methodological toolbox (e.g., fisheries stock assessment within a natural resource management unit), might disfavor your application with the simple argument "this person is neither fish nor meat." This statement means that she or he has no deep understanding in any school of thought and cannot bring any specialized knowledge into the program. This assumption might actually be false, but often the perception of the committee members matters. Hence, scientific depth might be important to safeguard tenure and promotion.

Such critical assessment was levelled on some authors of the present essay, even when applying at prestigious interdisciplinary schools. Even there, the question was asked "What approaches and methods do you bring to the table that no one else currently does in our unit? What in-depth disciplinary course can you teach?" The first author was even given "friendly" career advice to start conducting "true" fisheries research (meaning population dynamics of exploited fish), after finishing a Ph.D. in the human dimensions of fisheries. Apparently, fisheries biology was perceived as the only valid fisheries science discipline by some leading fisheries professionals in Germany. However, the first author had completed an aquatic ecology-based fisheries degree before branching out into the then unfamiliar domain of the human dimensions of fisheries. It is, of course, possible to learn the foundation of other disciplines in the period of a Ph.D., such as the human dimensions of fisheries, and then return to fisheries biology or to branch out. However, not every hiring committee is prepared to think that way. Therefore, interdisciplinary fisheries researchers have to be prepared to compete with disciplinary scholars during the chase of tenure.

Choose the Right Project Leader as Knowledge Broker

To facilitate true integration, rhetorically strong knowledge brokers as facilitators and integrators are needed. These brokers are people who are well read in multiple disciplines; they can help translate disciplinary jargon and provide the necessary kit for interdisciplinary teams. These peoples have the expertise for problem conceptualization, are able to run effective meetings, and are good motivators of team members. Although the leaders of most projects often involve tenured senior scientists, this might not be the case. Catalysts of interdisciplinary work usually have other qualities that are not contingent on age or experience in the science community. Basically, the leader of interdisciplinary teams has to think outside (all of) the narrow specialized boxes and be able to conceptualize in a holistic systems perspective. Leaders of interdisciplinary projects must feel excitement when they open a social science journal and find a paper about angler behavior, yet the same person must equally feel excitement when reading a paper about the genetic impacts of stocking or any

other fisheries ecological theme. The key innovation is bringing thoughts together that have been developed in isolation. Often, the same general concepts are developed and applied in different disciplines. The problem is that these same concepts often have different labels. Careful reading can afford opportunities to see the similarities in concepts across disciplines. For example, ideal free distribution theory from behavioral ecology offers the same predictions in behavioral economics when the fitness function of the (human) predator is replaced by the utility function from economics. In such cases, theory developed in ecology and in economics can be merged and predictions tested once the homology of thought is identified among disciplines. The leader would then have the role of helping the disciplinary team members appreciate the complementarity of the various approaches (i.e. facilitating cooperation among economists and biologists leading to the formulation of frameworks, research questions, hypotheses, and methodological approaches that can only be solved from an interdisciplinary perspective and that help solving the sustainability issue). The very same team leader must over time also accept that she or he might sometimes feel bereft of a true disciplinary home. Symptoms of success include subscription to listservs of seemingly nonoverlapping research domains, membership in unrelated scientific communities, and travel to conferences that do not share a single common attendee other than oneself! This success usually involves abandoning the security of a true disciplinary home and choosing instead to feel excitement through the enrichment of intellectual lives from the experience of multiple homes.

Employ the Right Mix of People

Interdisciplinary projects usually involve a range of expertise and competencies. It hugely pays off to choose the right mix of people. Often, scientists are brought into interdisciplinary teams for the particular expertise they know best. However, this overlooks the importance of interpersonal skills, intellectual openness, and curiosity, which is equally or even more important if interdisciplinarity is to succeed because the best expertise might be unavailable to the interdisciplinary project if the person is not willing to sit down with others from other disciplines and develop a joint problem conceptualization. Usually, you do not want to include principal investigators who are known to only enjoy disciplinary research outputs, however excellent these people are, unless they promise to contribute a very particular method and expertise that nobody else is able to bring to the table. Members of interdisciplinary teams must also be patient when training young scholars in novel, unfamiliar theories and methods and be willing to integrate findings to solve the sustainability issue at hand. Otherwise, one risks interdisciplinary projects developing into multidisciplinary ones where the integration of knowledge bases is not achieved at the end. The first author of this paper has had this experience in the first interdisciplinary project that he guided. In the so-called Adaptfish program (www.adaptfish.igb-berlin.de), the goal was to study the adaptive dynamics of recreational fisheries from local to regional scales by linking local-level angler decision making to broad-scale governance and institutional dynamics. Although the project was intended to develop an interdisciplinary endeavor, it ended as a multidisciplinary project in which team members (usually Ph.D. students) developed their own disciplinary research approaches, publishing in disciplinary journals and receiving their Ph.Ds. in disciplinary fields. It was only after the official end of the four-year project that the first truly interdisciplinary research products were developed, but these products were only achieved with a small subset of team members who had developed integrative research questions and had invented novel modelling techniques to reap the benefits of integration and cross-disciplinary cooperation.

Take Your Time and Conceptualize the Problem with the Whole Interdisciplinary Team

Expect interdisciplinary work to take substantially more time than discipline-specific projects to develop common grounds and terminology among team members. It is important to be prepared in order to avoid frustration with some unavoidable time lags. You need the time and resources to invest in team building, problem conceptualization, and reading diverse literatures. One should plan at least a year of interactions, including a couple of excellent meeting (whose organization is the task of the above-mentioned knowledge broker), to reach common ground in interdisciplinary teams. If multiple disciplines are involved, make sure the team agrees, understands, and commits to common research questions. It is our experience that it helps to develop concepts that serve as bridges among disciplines and to develop a glossary of terms and definitions. Concept mapping exercises can help to conceptualize the system under study and to reveal the hidden perceptions and assumptions of all team members. For example, studying the issue of fish stocking from interdisciplinary lenses involves identifying critical components (concepts), feedback, and interactions within the ecological system (e.g., genes, phenotypes, and species) and among the ecological, social, governance, and policy systems. Developing maps of relevant concepts, relations, and interactions using mapping exercises will expose the team to the complexity of the interaction web and help nail down the most important feedbacks for the project to address. All team members, even those with the most diverse backgrounds, must ultimately agree with the small set of joint research questions and the general methodological approach to be taken that emerge from these exercises. Such consensus is not easy, but an early focus on this it will pay dividends as the project unfolds. Communication must regularly occur throughout the project to keep all involved in the research results and to maintain mutual understanding. This communication can best be achieved by agreeing on a research framework in which all commonly agreed specific research questions are embedded and all contribute to the overarching research goal. Regular meetings about preliminary research findings keep the subteams informed, involved, and motivated, and this helps the final integration of research results. For example, if the overall research goal is to understand the sustainability of fish stocking, subquestions may deal with how stocked fish interact with wild fish or how anglers respond to stocking. Answering these subquestions, using disciplinary or interdisciplinary approaches, is needed as intermediate steps before the final integration and answering of the overarching research problem can take place. It is important to keep the whole team engaged in enjoying the intermediate successes, which in some cases might embark changes to research directions.

Plan the Integration at the Onset of the Project

Successful interdisciplinary projects (i.e., those that help solving the chosen sustainability problem) are based on a joint problem conceptualization by all team members that are then decomposed into smaller research questions, whose answers help to solve the overarching sustainability issue. The approach to integration of the smaller-scale research results must be planned a priori. Questions to be answered are as follows: Which social and ecological data could be easily integrated and which cannot? What collection methods and models will best facilitate data integration? When and which data are needed for integrated model building? Who in the team is willing and able to integrate and synthesize? Will joint products such as publications, reports, and presentations be generated that provide evidence of the integra-

tion? Who will be the authors and who should be the audience for the products? It is our experience that while many people are broadly interested in integrating social and natural science information, often people develop disciplinary interests as projects unfold and have difficulty in (or even deeply rooted resentment towards) integrating the disparate knowledge in the end. Part of this dilemma is caused by specific reward systems in various disciplines. For example, economists often are rewarded for sole-authored papers, whereas such papers will be the exception in interdisciplinary projects. Hence, it makes sense to think through the research products from the onset and to agree on deliverables and strategies to fulfil the integrative demand and manage expectations.

Closing Thoughts

As in other areas of natural resource use, substantial institutional, organizational, and academic hurdles have to be overcome when one attempts to integrate the natural and social sciences in fisheries. When these hurdles have finally been cleared, however, huge payoffs await. Well-executed interdisciplinary projects offer many rewards such as a more holistic system understanding that supports management recommendations, which are robust to irreducible uncertainties. Academically, interdisciplinary science is also lots of fun. There are also various downsides to these complex projects, such as the need for considerable time investments into capacity building for learning new specialized terminology and for managing teams of diverse expertise and competencies. Moreover, interdisciplinary research is not always appreciated in hiring processes and, hence, may turn into a disadvantage for the young scholar when applying for tenure in strictly disciplinary schools and faculties. Also, interdisciplinary journals sometimes suffer lower status in more traditional scientific subcommunities, although this evaluation is changing. In fact, some well-respected multidisciplinary journals such as *Proceedings of the National Academy of Sciences of the United States of America* have special sections that are specifically tailored towards high-quality interdisciplinary research output in relation to natural resource use problems (the section called "Sustainability Science"). Nevertheless, in many organizations there remain important disincentives to collaboration across disciplines and faculties. Despite these challenges, we predict that the need for interdisciplinary studies will increase, rather than decrease, particularly in applied research fields such as capture fisheries, simply because sustainability problems are very difficult to be solved by other modes of research. Many challenges lie ahead of us, and, as senior scientists, we are looking at the training of a new generation of fisheries scholars to join us in our quest for integrated discoveries in capture fisheries. Welcome!

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Biographies

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Len Hunt is a human dimensions of natural resource management research scientist with the Ontario Ministry of Natural Resources. He is most interested in human dimensions studies that help to address the uncertainty associated with implementing different management actions. He has increasingly worked and published on the development and application of integrated recreational fisheries (and other resource management) models that explicitly connect changing resource, managerial, and other social conditions to human behavior and connect human behavior to changes in ecological and social conditions.

John Post is professor of ecology and evolution in the Department of Biological Sciences, University of Calgary, Canada. He is interested in growth, survival, and population dynamics of freshwater fishes and sustainable harvest of recreational fisheries. He and his students use experiments, models, and landscape-scale adaptive management approaches to assess sustainable management approaches. Ongoing research focuses on effective integration of fisheries biology, human dimensions, and management using adaptive experimental management approaches in freshwater recreational fisheries.

Micheal Allen is a professor at the University of Florida whose work has focused on population dynamics and ecology of fishes. Allen has evaluated fisheries management strategies for recreational fisheries in lakes, reservoirs, and marine environments. His research uses a combination of field studies, experiments, and computer models to explore how management strategies (e.g., harvest regulations, habitat restoration, and stock enhancement) can improve recreational fisheries. Allen joined the faculty at the University of Florida in 1997 and is currently investigating fisheries ecology and management problems in the USA and around the world.