Are Current Research Evaluation Metrics Causing a Tragedy of the Scientific Commons and the Extinction of University-Based Fisheries Programs?

Robert Arlinghaus

Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 310, 12587 Berlin, Germany, and Chair of Integrative Fisheries Management, Faculty of Life Sciences & Integrative Research Institute for the Transformation of Human–Environment Systems, Humboldt-Universität zu Berlin, Invalidenstrasse 42, 10115 Berlin, Germany. E-mail: arlinghaus@igb-berlin.de

Most academics and, by the same token, departments and whole organizations, are today explicitly ranked, or implicitly valued, according to quantitative measures of research output, such as number of publications in journals with an impact factor, citation rates, and cumulative grant income. A prominent example is the British Research Assessment Exercise (www.rae.ac.uk). Similarly, all search processes to fill tenure-track research positions will follow, or be influenced by, some metric of research productivity. There are obvious downsides to such procedures (Lawrence 2007; Alberts 2013), yet current practice continues to promote the ranking of people or research units based on ill-defined performance metrics that are often only modestly and sometimes even completely uncorrelated with scientific quality (Brembs et al. 2013; Eyre-Walker and Stoletzki 2013; Macilwain 2013). I contend here that nontrivial social costs are emerging from the perverse focus of many presidents, deans, hiring committees, and researchers on quantity-based output metrics. In fact, I suggest that the orientation of the research community to meet these powerful metrics collectively undermines, slowly but steadily, the scientific and higher education systems (Weingart 2005; Adler and Harzing 2009). These developments bear an analogy to the open-access exploitation of natural resources (Hardin 1998) and financial markets (Ségalat 2010). In both cases, individual rational behavior designed to maximize individual payoff causes system destruction if it remains self-organized and unmanaged. To manage undesirable changes, leaders of the game have to rapidly modify its rules. Otherwise, our science and higher education systems are doomed to produce suboptimal outcomes at best or to become dysfunctional at worst. The consequences for university-based fisheries science might be particularly severe as will be outlined below.

At least four reasons contribute to academia's contemporary "obsession with quantity" (Fischer et al. 2012a), for simplicity defined here as a tendency to focus on the production of long lists of papers in journals with a high impact factor. First, papers are needed to disseminate science and hence more of them supposedly signals a more successful and productive scientist or research group. Second, paper-based productivity promotes one's career by safeguarding tenure and promotion. Third, producing many papers elevates one's visibility, which in turns affects the acquisition of research funds, networks, and reputation. Fourth, papers and the impact factors of journals in which they are published have become extremely important in the evaluation of grant proposals, individuals, groups, departments, and entire organizations. Consequently, most academic administrations have created strong incentives to their academic staff to publish more and "better." Despite recent calls to focus on "influence" rather than quantity (Donaldson and Cooke 2013), better often implies larger numbers of papers printed in journals with a high impact factor—the latter essentially being a metric of the average citation frequency of recent articles published in a given journal. But there is a fundamental issue that has gone unnoticed by many: the impact factor of a journal is useful to rank journals, but it is entirely unsuitable to judge the scientific quality of an individual article or the scientist in charge (e.g., Alberts 2013; Brembs et al. 2013; Eyre-Walker and Stoletzki 2013). Similarly, I am doubtful that the cumulative grant income acquired is a suitable correlate of scientific quality, and the same doubts can be cast toward other popular metrics of research performance such as citation rates.

To be clear: I am not arguing against the need to be productive as a researcher; I am also not against publication in high impact factor journals per se—I certainly understand the role and importance of publications in high-profile (i.e., high impact factor) journals such as *Nature* or *Science*, and I value competition for jobs. What I criticize, however, is the *exclusive focus* on a few highly biased productivity metrics, the associated overproduction of research papers to the detriment of other research output, and the disproportionate importance of a few journals to justify status, tenure, and promotion, all of which are also sources of concern to others (Weingart 2005; Lawrence 2007; Alberts 2013; Macilwain 2013; Schekman 2013). Moreover, some of the now popular research metrics have an infinite scale (e.g., number of papers produced, grant money acquired). Hence, there is in principle no end to the publish-or-perish race, which is problematic for young scholars, who often respond with unhealthy work loads (Schäfer et al. 2011). Individual-level downsides of the obsession with quantity have been identified and encompass disrupted work–life balance, loss of creativity, and reduced time for reflection and exchange (Fischer et al. 2012a, 2012b). Socially, we are beginning to see more downsides, such as the reduced attractiveness of the science profession to female researchers (Lockwood et al. 2013), a tendency to avoid risky and groundbreaking research (Lawrence 2007), reduced scientific integrity (Hayer et al. 2013), and

erosion of collegiality when it comes to investing time into supporting others without expecting an immediate payoff through coauthorship (Kaushal and Jeschke 2013). In this essay, I list further social costs associated with the current focus on quantity-based research products. I structure these in four dimensions that I feel are highly relevant to the fisheries profession. The list is by no means complete and reflects my experiences in European countries such as Germany, the United Kingdom, France, and Spain. I will end with a call for action to reverse (Europe) or avoid (United States) the negative trend we are seeing for the science system as well as more specifically for the role of university-based fisheries research.

THE SOCIAL COSTS OF BOGUS RESEARCH PERFORMANCE MEASURES

The first social cost associated with a focus on productivity-based research metrics is the danger of erosion of the quality of scientific publications and of peer review. In fact, due to the pressure to publish in the most prestigious journals, most high-demand journals are swamped with submissions. Many of these submissions include flashy novelty claims matched to rigorous word limits (Schekman 2013). As a result, many papers in highly ranked journals, for the sake of brevity, readability, and clarity, tend to fall short on important methodological information, critical contextual information, and citations. In particular, for the sake of readability, alternative views and results are often "cleaned" away in the preparation of the manuscript to produce a more coherent story that appears more convincing to reviewers. In addition, it seems that the articles that are preferred by the high-profile journals offer the potential to generate news headlines, which are not necessarily the ones of highest scientific quality in a given discipline (for an example in fisheries, see Hilborn 2006). Needless to say, most submissions to highly ranked journals are rejected due to space limitations.

A plethora of new journals—many of which are open access journals of dubious quality (Bohannon 2013)—have appeared on the horizon to absorb the many inevitable rejections. There is a fair chance element in academic publishing (Neff and Olden 2006). Hence, one can now publish anything somewhere, even with questionable quality (Bohannon 2013). One just needs to be persistent enough and resubmit previously rejected papers, usually climbing down the impact factor ladder. For the individual, the strategy will normally pay off, because it is often the total paper count that guarantees survival in the academic system (Haslam and Laham 2010). But there are unaccounted social externalities, because we can no longer guarantee the quality control mechanism of peer review. In fact, as associate editor of several journals, I have realized that it is nowadays increasingly difficult to secure timely reviews of good quality, probably because far too many articles are circulating (and recirculating after initial rejection) in the system—a number that can no longer be absorbed and assessed by the peer-review system. Hence, the backbone of the scientific enterprise is at risk of dilution due to a mixture of loss of scientific integrity (Hayer et al. 2013) and overburdening of the peer-review system.

A second relevant social downside of contemporary publication pressure relates to the erosion of incentives to invest into teaching, mentoring, and education outside one's own lab (Adler and Harzing 2009). In fact, because of the now global market for students and postdocs, a professor (and indeed many research-heavy high-rank universities) are better off free-riding on the educational investments by others and instead invest scarce time into generating grant income, publishing, and polishing marketing products to attract the most talented graduate students. Moreover, the best research professors can today buy out of teaching duties and, in fact, in many hiring processes I have followed, teaching and mentoring quality are of minor importance and sometimes not even assessed by the hiring committee. In addition, "high-impact" researchers often manage to secure reduced teaching loads during hiring negotiations, many of whom are so specialized in their research that they might be neither able nor willing to produce a basic lecture for undergraduates. It is acknowledged that not everybody can and will do both research and teaching with equal quality. Yet, for all researchers, mentoring of a new generation of scientists should be a key endeavor, which will often involve some form of high-quality teaching. Displaying the educational efforts elsewhere to be able to focus strongly on the production of grants and papers undermines von Humboldt's (1986) principle of the unity of research and education, which has potentially far-reaching societal consequences by affecting the future generations who leave our higher education system. In this context, as one reviewer of this manuscript noted, even the most high-ranking and research-intensive universities typically generate most of their funds from teaching. Therefore, the reduction of interest and competency in university-level undergraduate and graduate teaching by selected professors might ultimately also damage the financial stability of its employer.

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Third, the wider scholarship and societal impact associated with tax-funded research activities is declining as output-oriented researchers rationally reorient their behaviors to the production of papers. Unfortunately, many of the now unattractive other activities of our profession are key to maintaining the functionality of the scientific system and improving our society, such as engaging in outreach, advising fisheries management agencies, or reviewing organizations, programs, grants, and manuscripts. Almost ironically, many tax-funded environmental and ecological scientists in universities whose task is, broadly speaking, to help society overcome fundamental ecological and environmental challenges through knowledge-based innovation and good citizenship seem to engage less and less in activities that safeguard our future. Instead, preoccupation with the number of technical papers produced and the marketing of oneself has become an end in itself, which severely reduces the impact science can have in society.

Finally, "bogus measures of scientific quality" (Macilwain 2013, p. 255), such as the cumulative impact factor acquired by a candidate through publications, disqualify academics who study applied questions related to natural resource use and may lead to their extinction in universities. This is for two main reasons. First, the maximum and the average impact factor of applied journals (e.g., in the field of fisheries, *Canadian Journal of Fisheries and Aquatic Sciences*, *Transactions of the American Fisheries Society*, *Fisheries Management and Ecology*) is usually lower than the maximum and average impact factor of basic molecular, ecological, or evolutionary journals (e.g., *American Naturalist*, *Ecology*, *Ecology Letters*, *Molecular Ecology*; Schäfer et al. 2011). Therefore, even if fisheries researchers publish in, say, the top five fisheries journals, they will not earn the same credit as a basic ecologist or evolutionary biologist publishing identically in their disciplinary outlets. Second, applied scholars are disfavored due to the lower ranking of the source of grant money. Money generated, for example, from an applied source such as fisheries agencies is often seen as inferior compared to money attracted from funding sources that support basic research (e.g., National Science Foundation) because basic funds are perceived as more competitive. As a result, fisheries researchers that do not manage to reach out to more basic journals (compare Jensen et al. 2012) and that do not secure basic research funding will suffer selective disadvantages compared to more basic natural scientists and may consequently not reach a tenure-track position in a prestigious school.

A focus on publications in high-impact-factor journals and on basic funding is particularly problematic where there is no tradition of university-based fisheries and wildlife or natural resources departments or programs. This is, for example, the case in much of Europe, where fisheries research is traditionally structurally related to agriculture, biology, ecology, evolutionary biology or life sciences, or similar organizational units. Hence, "low-impact" fisheries science is forced to directly compete with "high-impact" basic ecological or evolutionary science. Similar developments are underway in the United States where many traditional fish and wildlife departments and colleges are being restructured to form more general biodiversity, conservation, or sustainability science schools. Consequently, fisheries scientists in Europe and elsewhere have been slowly but steadily out-selected by more basic ecological and molecular biological researchers in many departments at universities. I contend that university-based fisheries programs are in fact facing the risk of extinction. This has already happened at once-prominent European fisheries schools, such as the Imperial College in London or at Kiel University in Germany, where life scientists or evolutionary biologists have largely taken the role of traditional fisheries professors. The latter are increasingly forced to either move to foreign countries or to find a (much less independent) home in research organizations outside universities, such as in governmental fisheries laboratories. In some countries, joint ventures among university departments and nonuniversity fisheries institutes have developed that serve the dual purpose of high-quality academic research and providing science-based fisheries management and policy advice (e.g., Institute for Marine Resources and Ecosystem Studies associated with Wageningen University in The Netherlands). It is as yet not clear how stable such joint ventures will be.

Any substantial loss of fisheries professors from universities will inevitably affect the curricula of ongoing master's programs. This comes at a time where many of the traditional fisheries and wildlife programs are developing into biodiversity and conservation programs that no longer focus on fisheries or aquaculture. Master's programs in natural resources are currently transforming because their broader scope promises to generate more basic funding, more "important" publications (i.e., higher impact factor), and greater numbers of students, all aspects on which the financial backbone of most universities depend. Unfortunately, many new professor hires for these programs are no longer trained in traditional fisheries methods, such as quantitative fish stock assessment. Correspondingly, many natural resource students in universities are no longer taught the key toolbox of methods needed to advance the fisheries profession (Berkson et al. 2010). It is unlikely that the new generation of "biodiversity scientists" will be able to contribute meaningfully to sustainable fisheries other than by publishing papers on the bad state of the world's fisheries (Hilborn 2006).

POTENTIAL SOLUTIONS TO REVERT THE TRACK

For economic reasons of rational choice, loss of investments in the collective good, other than by publications, is unavoidable in the current climate of quantity-oriented research metrics. The positive message is that a rising "tragedy of the scientific commons" can be avoided by incentivizing prosocial behavior (Fischer et al. 2012b). Four changes seem crucial to me.

First, we as a scientific community would benefit from a reorientation toward the key goal of our endeavor, which is to create and disseminate relevant knowledge that matters to society rather than maximizing paper counts or citation rates as ends in themselves. Publishing is a means to an end, but not more. Within the fisheries profession, and in fact environmental science in general, we need to focus on influential work (Donaldson and Cooke 2013) that helps solving the pressing environmental challenges humanity is facing.

Second, each of us needs to work toward rebirth of a healthy academic culture. Put simply: salary, funding, and status should no longer be achieved by having a paper published in the equivalent of *Nature* or *Science* or maybe PNAS (= Post *Nature* and *Science*) or by having long lists of papers, but through the actual discussion and evaluation of factual content that an individual or project has made. We should particularly value achievements, products, and results that make a difference in the real world—in our case, contribute to sustainable fisheries. Critics will say that this is not easily quantifiable, and that is exactly right (Eyre-Walker and Stoletzki 2013). The quality of individual scholarship can probably best be judged through rigorous peer review, and this includes taking the time to read a candidate's work. I like the German Science Foundation's

regulation that prohibits the mentioning of publication numbers or listing papers in curriculum vitae in grant proposals and instead demands that each individual only mentions their five most important articles. This is a very laudable development because it forces reviewers to check content rather than numbers.

Third, leaders of the scientific community need to alter the rules of the game, deliberately and permanently. This mainly involves altering the payoff structures that drive individual behavior by fostering a culture of appreciation of alternative forms of research impact (Winfield 2010). Impactful prosocial activities include quality publications, quality teaching and student supervision, quality review activities, committee work, outreach, and very important, engagement with civil society through transdisciplinary research or other means to help solving pressing societal issues such as those presented by overfishing. These contributions should not be valued as ancillary to technical papers but on equal footing. Put simply: research organizations and funding agencies need to sustain and value the many scholarly efforts that are needed for long-term maintenance of cutting-edge research programs, even if those efforts (e.g., reviewing, advising an agency) currently do not confer the same status as the technical papers that emerge from such cutting-edge research.

Finally, deans and hiring committees are well advised to seek a diversity of research staff in terms of gender and complementary competencies rather than hiring paper-based rock stars only. Similar to the portfolio effect in finance and natural ecosystems (Schindler et al. 2010), diverse teams produce better decisions and are likely to complement each other optimally to allow less steep but sustainable growth of a research organization. Key in this context is the promotion of researchers who unselfishly excel by helping others solving science-related issues, which has been found to elevate the research quality of entire research units (Oettl 2012).

Without purposeful intervention in the four areas just mentioned, I contend that individually rational behavior that does not pay attention to wider societal effects is bound to produce many irrelevant papers that are published for the sake of publishing but do not advance the knowledge base, while at the same time producing important costs to the scientific system and society at large that are no longer trivial. Erosion of scientific integrity (Hayer et al. 2013), decline of university-based fisheries programs, and unsustainable fisheries will be among them.

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