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Ghoti

Ghoti papers

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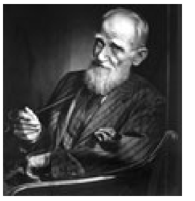

Etymology of Ghoti

George Bernard Shaw (1856-1950), polymath, playwright, Nobel prize winner, and the most prolific letter writer in history, was an advocate of English spelling reform. He was reportedly fond of pointing out its absurdities by proving that 'fish' could be spelt 'ghoti'. That is: 'gh' as in 'rough', 'o' as in 'women' and 'ti' as in palatial.

Reporting and advising on the effects of fishing

Simon Jennings

Centre for Environment, Fisheries and Aquaculture Science, Lowestoft NR33 0HT, UK

Abstract

Scientists hold different views about environmental management. These views may drive their interest in the subject and help them to address a wide range of research issues, but they can also affect the ways in which research results are interpreted and reported. Studies that mix science and perspective can compromise public and scientific understanding of fishing effects, as perceived differences in evidence may actually reflect differences in interpretation. To improve the rigour of 'fishing effects' science, it would help if the benchmarks used to assess whether fishing effects 'matter' were always made explicit. These benchmarks might be the objectives set by the management authorities and/or a series of alternate objectives proposed and stated by the scientist. To demonstrate how the reported significance of fishing effects can depend on objectives, I use a simple model to predict the response of fish populations and communities to fishing. Fishing effects that would be reported as negative in relation to preservation or biodiversity objectives, such as declines in size, abundance and trophic level, occur at lower fishing intensities than those associated with meeting sustainability objectives for target species. When fishing pressure is so high that both conservation and fisheries objectives are not being met, the initial management actions to meet a range of objectives are likely to be compatible (e.g. reduce capacity, support alternate livelihoods).

Keywords advocacy, conservation, ecosystem approach, fisheries, management, objectives

Correspondence:
Simon Jennings, Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory, Lowestoft NR33 0HT, UK
Tel.: +44 1502 524363
Fax: +44 1502 513865
E-mail: simon.jennings@cefas.co.uk.

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Introduction

We all hold opinions about desirable states of the environment and the role of fisheries. These opinions are influenced by our backgrounds, interests, professional responsibilities and political and environmental views. They also influence how we perceive the current state of the environment and the performance of fisheries management, and influence our behaviour and work as professional scientists. As such, it is unavoidable that some scientists see sustainable use when others see a pressing conservation issue.

Political and societal expectations about the state of the environment are formalized as objectives. These range from high-level international commitments in texts such as the Johannesburg Declaration (Anon 2002) to operational objectives that appear in national or regional management plans. The objectives usually reflect the outcome of complex negotiations that take account of short- and long-term economic, social and environmental interests and provide a visible statement of intent against which society can judge the performance of management.

As in farming, where a shift in emphasis from production towards environmental stewardship is reflected in many national and international policies, current fisheries policies emphasize the importance of ensuring the sustainability of fishing impacts on marine ecosystems as well as the sustainable provision of food. Many Governments are working to harmonize environmental and fisheries policy, consistent with an ecosystem approach to fisheries (FAO 2003; Sinclair and Valdimarsson 2003) and driven by processes such as the Rio Convention on Biological Diversity (Anon 1992) and the World Summit on Sustainable Development (Anon 2002), which built on WCED (1987) to articulate 'consensus' views about the expected role of humans in ecosystems. The focus of fisheries science has also changed with policy. For example, from 1926 to 1996, 0.23% of all papers on fisheries ecology and management in the ICES Journal of Marine Science dealt with fishing impacts other than those on target stocks, but this rose to 17.9% in the period 1997–2006 (unpublished analysis, no issues of this journal were published 1940–46). One consequence of the changing objectives and research agenda has been that a one time mathematically-oriented field, where scientists conducted science to advise on a relatively narrow range of objectives relating primarily to economic and biomass yield, now attracts scientists with a wider range of interests (e.g. seabird ecology). Attitudes to fisheries have also been influenced by changing educational, societal and political views about the environment and probably by the educational backgrounds of some ecologists whose experience mixed science and advocacy in a way that was actively avoided in sciences such as mathematics and physics (Johnson and Mappin 2005).

It might have been expected that the broadening of 'fisheries' would have supported the development of the science and the advice needed to integrate environmental and fisheries policy, by increasing the scope of research conducted and the range of organizations involved. In practice, however, research results may seem to be inconsistent and contested to those without specialist expertise in the field, and this can hamper the provision and acceptance of advice. Hilborn *et al.* (2006) for example, report on the New Zealand orange roughy fisheries that meet the objective of providing high and sustainable fishery yield, but which have also been used as an example of the failure of fisheries management. This situation may have arisen because scientists hold different, but usually unspecified, views about the objectives of environmental management (e.g. preservation, restoration and sustainability) and allow these views to influence their interpretation, reporting and promotion of science. Here, I use a simple model to demonstrate incompatibilities among ecological objectives and consider how the results of applied science might be reported to help policy makers and the public make their own assessments about whether fishing effects 'matter' and to safeguard the special role of science in policy development and implementation.

Incompatibilities among objectives

As a simple example, consider four objectives for a management region: (1) preserve the 'natural' ecosystem (minimum possible change from unexploited state), (2) maximize sustainable yield from the largest species, (3) maintain biodiversity of the fish community (no species to be at high risk of extinction) and (4) maximize sustainable yield from the fish community. Any of these objectives could be chosen to support different conservation and/or fisheries management plans.

To describe the impacts of fishing on different components and attributes of the ecosystem, and hence on state in relation to the objectives, I conducted simulations using the size-based multi-species model developed by Pope *et al.* (2006). The model was intended to be illustrative rather than indicative of actual impacts in any known system, but it captures basic interrelationships between population and community dynamics that are supported by empirical analysis and can output abundance and catches of target populations as well as community properties such as mean size, mean maximum size and the trophic level. Such outputs are suitable for relating the impacts associated with different levels of fishing mortality to a range of objectives.

The model uses 15 parameters to describe a 13 'species' fish community, where the properties of species are defined by their maximum body size (expressed as L_∞) and size-related life history parameters. An overall fishing mortality (F) acts on all species and can be modified by defining species and size selectivity. Size selectivity was assumed to follow a logistic exploitation pattern. The parameters used for the model runs followed those applied in the 'key run' by Pope *et al.* (2006), except that all species were deemed to be fished at the same rate of mortality to approximate a mixed fishery.

The Pope *et al.* (2006) model was also extended to output trophic level. This is straightforward given that modelled predation is based on a log-weight size preference ratio (μ). A value of five was assigned to μ (equivalent to a predator-prey weight ratio of 148.5:1). As weight (W) and length (L) are typically related as $W \propto L^3$, the equivalent log-length size preference ratio will be 5/3. To relate changes in size structure of the modelled community to changes in trophic level (λ) I used a relationship of the form $\lambda = b \log_e L + a$, where the slope b is the reciprocal of the log-length size preference ratio μ_L and a is a constant. Assuming that $W \propto L^3$, λ at L is approximated by $\lambda_L = a + \left(\frac{1}{1.66}\right) \log_e L$. Setting $a = 2$ gives the smallest size class a trophic level of three, roughly consistent with a species that feeds on zooplankton. The mean trophic level ($\bar{\lambda}$) of the modelled community was then calculated as:

$$\bar{\lambda} = \frac{\sum_{L_{\min}}^{L_{\max}} W_L N_L \left(\frac{1}{\mu_L} \log_e L + a\right)}{\sum_{L_{\min}}^{L_{\max}} W_L N_L}$$

where $L_{\max}$ and $L_{\min}$ were taken as 30 cm and 130 cm.

The trophic level was calculated in two ways. In the 'fixed' case, the trophic level was assigned based on species identity (L_∞) and in the 'continuous' case, the trophic level was assigned based on the actual body size, so that all individuals of a given size had the same trophic level regardless of species identity. The former approach has been more widely used to report mean trophic level even though there are known to be large ontogenetic changes in trophic level. Both approaches for estimating trophic level focus on the main pathways of energy transmission in the food web and do not account for the fact that some of the largest and rarest species in real food webs feed at lower trophic levels.

The effects of fishing mortality on target populations (Fig. 1) and community attributes (Fig. 2)

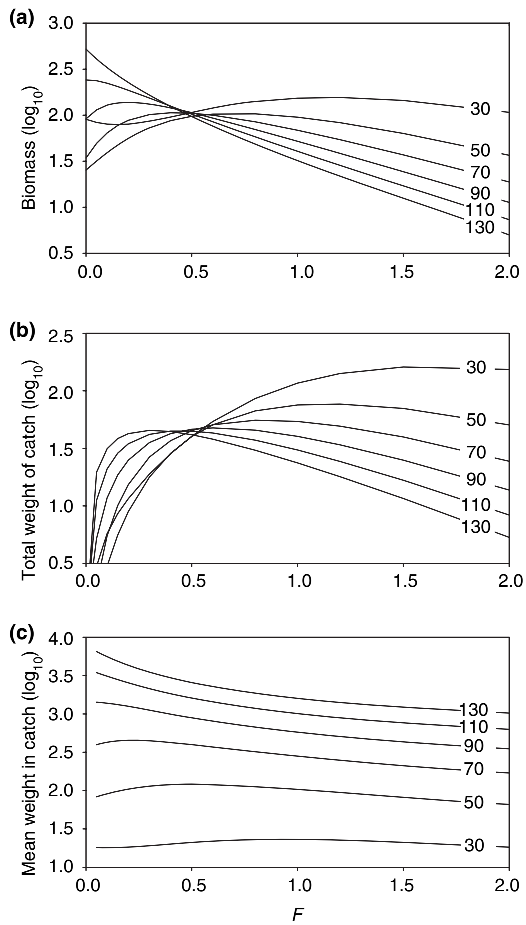

Figure 1 Relationships between (a) biomass, (b) catch weight and (c) mean individual weight in the catch and fishing mortality F for 'species' defined by L_∞ of 30, 50, 70, 90, 110 and 130 cm.

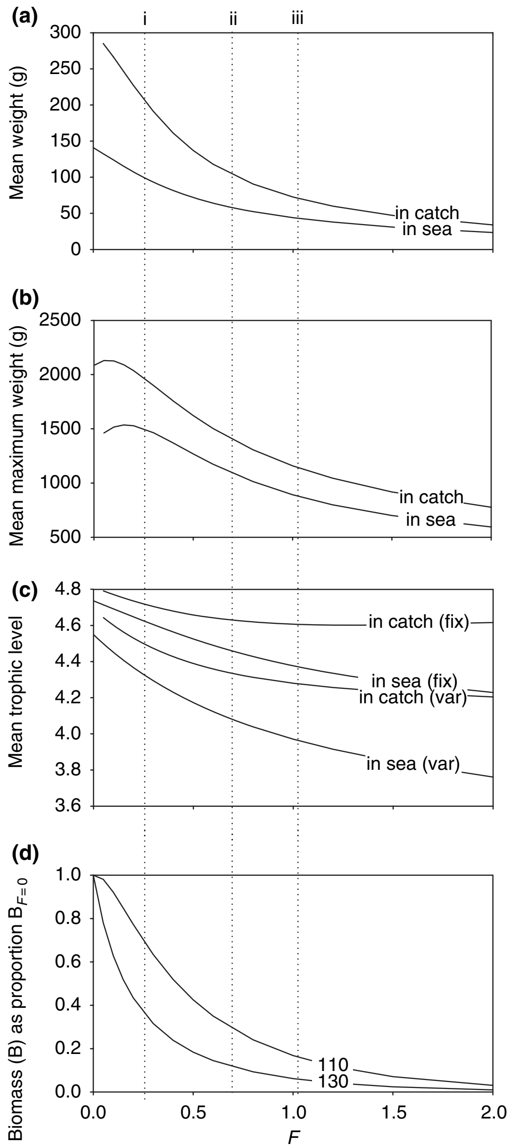

Figure 2 Relationships between (a) mean weight of fish in the community (sea) or catch, (b) mean maximum weight of fish in the community or catch, (c) mean trophic level of fish in the community or sea where trophic level is calculated by assigning fixed trophic levels to 'species' (fix) or variable (var) trophic levels to 'species' and (d) biomass of 'species' with L_∞ of 110 and 130 cm as a proportion of unexploited biomass and fishing mortality *F*. The dotted vertical lines indicate values of *F* associated with (i) obtaining maximum sustainable yield from the largest 'species' with an L_∞ of 130 cm, (ii) listing the largest 'species' as 'critically endangered' according to IUCN A1 criteria if the change in abundance occurred over the greater of 10 years or three generations (Baillie *et al.* 2004) and (iii) obtaining maximum sustainable yield from an assemblage consisting of all 'species' with L_∞ of 30–130 cm.

Table 1 Compatibility among objectives in a fished ecosystem.

Objective	1	2	3	4
1	–	X	X	X
2	X	–	O	X
3	X	O	–	X
4	X	X	X	–

Crosses indicate that objectives cannot be met simultaneously and circles that they can. The codes for the objectives are: (1) preserve the 'natural' ecosystem, (2) maximize sustainable yield from the largest species, (3) maintain biodiversity of the fish community and (4) maximize sustainable yield from the fish community.

show that rates of fishing mortality well below those that would be sustainable for the largest (most vulnerable) species, change the system fundamentally from the unexploited state. Based on the outputs of this analysis, our objectives are almost all incompatible (Table 1), with 2 and 3 being the only objectives that can be met simultaneously.

A community wide mortality rate that achieves the maximum yield from the largest species would be low in relation to rates recorded in many fisheries, but would still reduce the biomass of this species to <40% of unexploited biomass (Fig. 2d) and lead to relatively large reductions in mean size and mean trophic level in the catch and in the sea. By the time the largest species was regarded as critically endangered according to IUCN Red List criteria (90% fall from $B_{F=0}$), the mean size of fish in the community and catch would have more than halved, but *F* would still be too low to obtain the maximum multispecies yield from the community.

As presented here, the trade-offs among objectives are clear. Fishing effects are more commonly observed and reported independently however, and their interpretation is often confused because fishing effects that were once evaluated in relation to objectives like 2 and 4 are now evaluated in relation to objectives like 1 and 3 (and therefore their apparent severity has increased). Effects that compromise objectives like 1–3 were effectively ignored in the 'fisheries' and 'ecology' literature until the early 1980s (Brander 1981). Of course, catch controls, effort controls or technical measures may allow more independent control of mortality rates on component populations than assumed here, but the simulations make the general point that fishing effects such as reductions in trophic level, that have been reported as evidence for the poor state of the global seas, can also occur at levels of fishing mortality regarded as quite benign in terms of the risk they pose to the sustainability of exploited populations.

Shifting baselines or shifting objectives?

The preceding simulations, along with many other theoretical and empirical studies, show that low levels of fishing mortality lead to significant changes in the community. These changes are effectively unavoidable if fishing is allowed, and thus fished and unexploited communities differ fundamentally. Jackson *et al.* (2001) suggested that their analysis of the historical state of parts of the marine environment 'demonstrate(d) achievable goals (objectives) for restoration and management of coastal ecosystems that could not even be contemplated based on the limited perspective of recent observations alone', but many of these objectives could not be met if society also wanted productive fisheries. Thus shifting baselines may not explain why objectives relating to preservation and restoration have not been set and may not have 'arisen because each generation of fisheries scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers, and uses this to evaluate changes' (Pauly 1995). Indeed, while differences between the present and unexploited state may surprise many non-scientists, they are rarely a surprise to fishery scientists because predictions of population or community properties in the absence of fishing are possible, and routinely conducted, using most of the quantitative models that have been developed to assess fishing effects. In reality, the management authorities and parts of society accepted long ago that preservation was not consistent with their other objectives, either stated or unstated, and the environment inevitably changed as a consequence of pursuing them. Current emphasis on shifting baselines thus reflects the concern of scientists that the management authorities and the society have accepted the 'wrong' objectives and/or failed to act on the 'right' ones, as much as providing evidence for an unknowing drift away from unexploited states.

Do fishing effects 'matter'?

Different organizations fund science for different reasons and this will influence the range of issues that scientists address. Thus scientists associated with the FAO Major Programme on Fisheries which 'aims to promote sustainable development of responsible fisheries and contribute to food security' and the Pew Institute for Ocean Science which 'is dedicated to conducting, sponsoring, disseminating and promoting world-class scientific activity aimed at protecting the world's oceans and the species that inhabit them' would be expected to focus on different fishing effects and to relate them to different objectives. The institutional and funding structures that encourage diverse perspectives foster scientific innovation but, from the perspective of non-specialists and recipients of advice, they can also create the impression of contested and divided science. This is only an impression because the perceived differences are largely attributable to differences in the objectives used to assess fishing effects rather than in the scientific evidence used to make the assessment (compare Watling and Norse (1998) with National Research Council (2002) or Roberts (2002) with Hilborn *et al.* (2006)). For example, scientists conducting the same measurements on the fish community shown in Fig. 2 (when $F = 0.7$) could write papers on 'Impending extinction of a vulnerable marine fish', 'Management of a sustainable multispecies fishery' or 'Differential effects of fishing on species with contrasting life histories', all of which convey different messages. A paper that relates a given fishing effect to an objective that increases its apparent significance (the unexploited baseline) as opposed to one that does not (sustainability/reversibility of impact) may help the authors(s) promote a particular objective and attract more press coverage and grant income. Conversely, a paper that relates a given fishing effect to an objective that decreases its apparent significance may reduce the attention paid to other fishing effects.

Assumptions about desirable objectives are reflected in the use of normative language, where terms such as 'failure, 'success', 'degradation' or 'collapse' are used in preference to value-neutral terms such as 'increase' or 'decrease'. Such language implies that there is a preferred state for ecosystem components and attributes, what ought to be rather than what is (Lackey 2004), but the language may not be perceived as normative by other non-specialists or recipients of advice (Lackey 2007). The use of normative language appears to be widespread in the environmental management literature. Thus a recent analysis of the use of normative language in six journals that publish papers on various aspects of environmental management, including the *North American Journal of Fisheries Management*, reported the use of this language in half the paragraphs in the 'conclusion' sections of the 270 papers examined (Scott *et al.* 2007). While the authors comment on the difficulties of unequivocally identifying normative language, it is clear that analyses that mix science and perspective, whether unintentionally or otherwise, are often accepted by the peer review and editorial process.

The role of science?

A lively and unresolved debate about the role of advocacy in science has been running for some years. Such tensions are inevitable when, for example, some conservation biologists contend that the field itself is value driven (Noss 1996). A recent review of a series of perspectives on policy, advocacy and conservation science in the journal *Conservation Biology* led the editor to conclude that the only areas of agreement were that scientists had an ethical obligation to direct their collective expertise and the knowledge base to support important policy decisions and that scientists must do this carefully so as not to erode their individual or collective scientific credibility (Meffe 2007). However, a high-level consensus such as this is not sufficiently specific to guide the day-to-day actions of scientists and to improve the communication of science to policy makers.

The adoption of the ecosystem approach to fisheries and a wider range of management objectives have led to more pressure on management authorities to reduce fishing mortality than when objectives focused largely on the value and productivity of exploited populations (Jennings 2004). The preceding simulations, along with empirical work, have shown that meeting ecosystem objectives, such as those for the conservation of vulnerable species, will require greater reductions in fishing mortality than those needed to maximize the value or productivity of fisheries (Walker and Hislop 1998). As such, it is not surprising that scientists who would like to see greater reductions in the impacts of fishing see the promotion of more conservative objectives as a means of achieving this, and the scientific literature is extensively used to promote such objectives. While scientists may have a good rationale for promoting objectives, I do not consider this a scientific activity. I suggest that the role of science in contributing to work on objectives is, for example, to determine whether objectives are measurable, achievable or compatible and, if so, to assess which combinations of management actions could be used to achieve them.

When mixing science and perspective, scientists use their uniquely valued role as experts in the factual and objective analysis of nature to legitimize their role in making value judgements. This is reasonable given that science can be difficult for non-specialists to interpret and that scientific knowledge may better inform value judgements. However, as the separation between science and perspective may not be transparent to non-specialists, I suggest that scientists always highlight this distinction and make it clear when they are acting as professional scientists and when they are acting as members of society who are expressing an opinion shaped by their knowledge of science. In my view, science will only maintain a special role in the advisory process if it provides evidence that is free from the perspectives that lobby groups bring to the table.

If authors chose to comment on the importance of fishing effects as well as describing or predicting them, then the clarity and consistency of scientific advice and societies' long-term trust in the scientific process would both be improved if we were explicit about the objectives used to assess the importance of fishing effects. For example, the statement 'the results demonstrate that the proposed management objective of halting the decline in fish biodiversity has not been met' would be preferred to 'the results provide more evidence of the ongoing degradation of fish biodiversity'. It would also help if this approach were followed in any media materials that were used to accompany and promote the publication of research papers. While many may consider this use of language too sterile, the explicit separation of science and perspective should ensure that non-specialists and recipients of advice see differences in objectives and not differences in the evidence base. Another more comprehensive option, that also allows incompatibilities among objectives to be assessed, would be to tabulate the observed effects in relation to objectives, as in Table 1.

Based on experience in other fields of research, our profession could also take greater responsibility for helping scientists and society to understand, identify and emphasize the boundaries between science and perspective. Thus, scientific journals and learned societies might play a stronger role in drawing attention to the relationship between science and perspective in fisheries, as they have in other fields (Sorooshian 2006), and scientific journals might provide guidance on how to make the division between science and perspective explicit. Learned societies might review the relative emphasis they place on encouraging and rewarding technical expertise and innovation, as well as newsworthiness, and make explicit their role in policy debate. The recipients of scientific advice should also promulgate the view that they require the best available impartial science and demonstrate that they value the scientists and mechanisms that provide this advice.

Current management issues

Many management regions are now so heavily fished that all conceivable objectives, ranging from preservation to the sustainability of yield from relatively productive populations, are not met. Even when studies of fishing effects are conducted in these regions, and the recommended direction of any initial management action to move towards meeting the objectives would be the same (e.g. reduce capacity, support alternative livelihoods), there is still a significant scope to take different perspectives on the significance of the fishing effects and the magnitude of management action. When this is the case, the role of science in the advisory process would be strengthened if scientists focused on giving the science advice needed to support the objectives of the management authorities (assuming they are stated and transparent), rather than creating apparent divisions in the science based on their own views about objectives. This is a particularly relevant approach today because meeting the ecosystem objectives that have already been agreed by Governments and fishery management agencies will require reductions in the current levels of fishing impact. For example, the abundance and the rate of exploitation of many European fish stocks, as determined in the ICES stock assessments (ICES 2006), does not meet the management objective of sustainable exploitation (EC 2002). Also, when metrics of extinction risks (IUCN A1; Baillie *et al.* 2004) were applied to the same stocks, these warned of potential population collapse, consistent with the outputs of the assessments (Dulvy *et al.* 2005). The two sets of results suggest that scientists with different backgrounds and different views about objectives would legitimately give the same advice on the initial management actions needed (e.g. reductions in effort, recovery plans).

Another factor that may help to reconcile objectives is the increased emphasis on improved profitability of fisheries, to meet objectives for economic efficiency. High profitability is usually achieved at lower levels of fishing mortality and impact than high yield and thus Hilborn (2007) has recently argued that the move towards dedicated access and improving the economic efficiency of fisheries will help to support the achievement of a wider range of ecological objectives.

Conclusions

Science and perspective are poorly distinguished in many contemporary studies of fishing effects. As a result, different conclusions are drawn from the same facts and assumed differences in the evidence base can reflect differences in perspective. Scientists will better serve society and their profession by highlighting when they are doing science and when they are not. In part, this can be achieved by relating the interpretation of fishing effects to explicit objectives that are set by management authorities and/or proposed by the scientist. I will try to improve the rigour of my own work in this way and hope others will consider it too.

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