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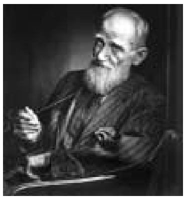
Ghoti

Ghoti papers



Ghoti aims to serve as a forum for stimulating and pertinent ideas. Ghoti publishes succinct commentary and opinion that addresses important areas in fish and fisheries science. Ghoti contributions will be innovative and have a perspective that may lead to fresh and productive insight of concepts, issues and research agendas. All Ghoti contributions will be selected by the editors and peer reviewed.

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.

Keep it simple: three indicators to deal with overfishing

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Abstract

Three simple fisheries indicators are presented: (i) percentage of mature fish in catch, with 100% as target; (ii) percent of specimens with optimum length in catch, with 100% as target; and (iii) percentage of 'mega-spawners' in catch, with 0% as target, and 30–40% as representative of reasonable stock structure if no upper size limit exists. Application of these indicators to stocks of *Gadus morhua*, *Sardinella aurita* and *Epinephelus aeneus* demonstrate their usefulness. It is argued that such simple indicators have the potential to allow more stakeholders such as fishers, fish dealers, supermarket managers, consumers and politicians to participate in fisheries management and eventually hold and reverse the global pattern of convenience overfishing, which is defined here as deliberate overfishing sanctioned by official bodies who find it more convenient to risk eventual collapse of fish stocks than to risk social and political conflicts.

Keywords fisheries indicators, length at first maturity, longevity, optimum length, overfishing, sustainable fishing

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Introduction

There is increasing evidence that global fisheries are depleting natural resources much faster than these can replenish themselves (Sadovy 2001; Pauly *et al.* 1998; Christensen *et al.* 2003; Myers and Worm 2003). This process is called overfishing and usually consists of two components: (i) diminishing the ability of fish to reproduce, called recruitment-overfishing, and (ii) catching them before they can fully realize their growth potential, called growth-overfishing. In response to the problem, fisheries research over the past 100 years has developed increasingly complex stock assessment models that are incomprehensible to but a few experts. For example, the report of the International Council for the Exploration of the Sea (ICES) Advisory Committee on Fishery Management for eight fish species of the Southern Shelf (Celtic Sea, Western Channel, Bay of Biscay) in 2002 covers about 1000 pages. This level of detail is requested by the regulatory body (the Directorate General of Fisheries of the European Commission, which makes proposals for decisions on this basis to the Fisheries Council composed of the Fisheries Ministers of the currently 15 EU Member States). However, fishing quotas are decided on the basis of political considerations, largely ignoring the scientific advice, and typically legalizing catches beyond safe levels. Other than 'Malthusian overfishing' (Pauly 1990) which is driven by extreme poverty and lack of alternatives, this deliberate overfishing is administered by official bodies who find it more convenient to risk the eventual collapse of fish stocks than to risk generating social or political conflict. I therefore suggest the label 'convenience overfishing.' As a result of such convenience overfishing, most stocks in the ICES area, and global stocks in general, are at historically low levels and continue to decline.

One precondition of convenience overfishing is the apparent lack of public involvement in fisheries issues. The complexity of fishery models has made it impossible for citizens outside the traditional institutions to bring their influence to bear on how humanity shall deal with responsible usage of aquatic natural resources. I propose three simple and easily understood indicators that allow an effective assessment of status and trends in most fisheries by all concerned stakeholders including the general public.

Description of indicators

Indicator 1 can be described as 'Let them spawn!' and is measured as percentage of mature specimens in the catch. The target would be to let all (100%) fish spawn at least once before they are caught to rebuild and maintain healthy spawning stocks. This may seem obvious, but for example an analysis of ICES (2002) data for the cod stock (*Gadus morhua*, Gadidae) of the western Channel area for 1994–2001 (referred to below as 'Western cod') shows that only 20–54% (mean 37%) fish in the annual catch were mature, or in other words: every year about two-thirds of Western Cod were excluded from reproduction.

Indicator 2 can be described as 'Let them grow!' and is measured as the percentage of fish caught at optimum length, i.e. the length where the number of fish in a given unfished year class multiplied with their mean individual weight is maximum and where thus the maximum yield and revenue can be obtained. Optimum length is typically a bit larger than length at first maturity and can be easily obtained from growth and mortality parameters or empirical equations (Froese and Binohlan 2000). The target would be to catch all fish (100%) within, for example, ±10% of optimum length (see Fig. 1). An analysis of the Western Cod data shows that only 6–27% (mean 18%) of the fish caught were of that size.

Indicator 3 can be described as 'Let the mega-spawners live!' and is measured as percentage of

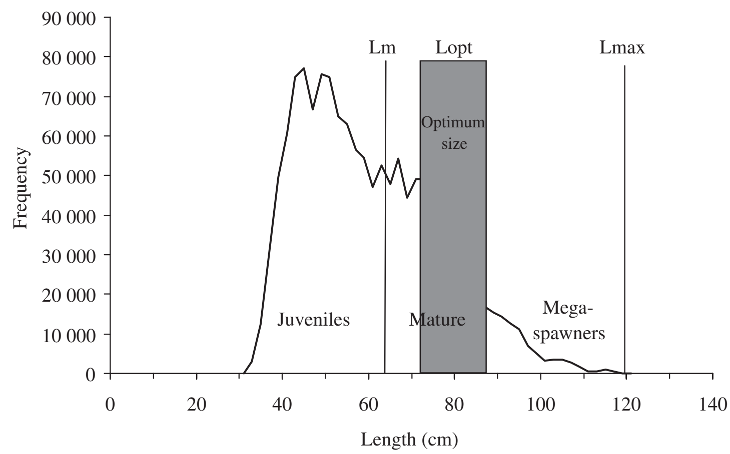

Figure 1 Length–frequency data of Western Cod landings from 1994 to 2001 in the Western Channel area, where L_m indicates length at first maturity, L_{opt} indicates the length range where maximum yield could be obtained and L_{max} is the maximum size reached during that time.

old, large fish in the catch, i.e. fish of a size larger than optimum length plus 10%. Here the target depends on the management regime: the aim is to implement a fishing strategy that results in no (0%) mega-spawners being caught. If no such strategy is in place and thus the catch reflects the age and size structure of the stock, values of 30–40% mega-spawners represent a healthy age structure and are desirable, whereas less than 20% will be a matter of concern. This attention to large specimens draws on the increasing evidence that old fish play several important roles in the long-term survival of a population: (i) large females are much more fecund because the number of eggs increases exponentially with length in most species; their eggs also tend to be larger, thus giving a greater chance of survival to larvae (Solemdal 1997; Trippel 1998); (ii) reaching old age is usually a sign of overall individual fitness and thus these mega-spawners are reservoirs and distributors of desirable genes; and (iii) extending longevity and prolonging the reproductive phase can be viewed as a natural safeguard against subsequent recruitment failure (Craig 1985; Beverton 1987). Such events are visible in respective long-term time series and are a common cause of collapse in heavily fished stocks (Murphy 1967; Longhurst 2002a,b). In other words, the percentage of mega-spawners in a stock can be viewed as a simple proxy for resilience against random events. An analysis of the Western Cod data shows that 2–7% (mean 5%) of the fish caught were mega-spawners. As no upper size limit exists for any commercial species in the ICES area, this very low value is a reflection of the dire state of the stock and the prevalent practice of fisheries to remove large specimens first and foremost. According to this analysis, the Western Cod has very little resilience against natural events such as recruitment failures because of unfavourable combinations of environmental parameters.

Two examples where the indicators have been applied to real world scenarios are given below. In Senegal, yields from pelagic resources were considered satisfactory, whereas yields from demersal species had declined in recent years (B. Samb, personal communication). Preliminary application of our simple indicators to time series of length–frequency data for the pelagic Round sardinella (*Sardinella aurita*, Clupeidae) and the demersal White grouper (*Epinephelus aeneus*, Serranidae) resulted in Figs 2 and 3 (B. Samb and M.D. Barry, personal communication). For Round sardinella the percentage of mature specimens in the catch was above 90% since 1992, and the percentage of specimens with optimum length has increased from about 50% in 1990 to about 80% in 2002. This would suggest a healthy stock and reasonable fishing regime, confirming the traditional assessment based on catch per effort (B. Samb, personal communication). However, the percentage of mega-spawners in the catch is decreasing from 20–30% in the early nineties to around 10% from 1999 to 2002, which is a matter of concern as this is not the result of an upper size limit and the erosion of the age-structure will reduce the resilience of the stock.

For White grouper, the percentage of mature specimens has decreased from close to 80% in the early nineties to about 38% in 1999. In the same

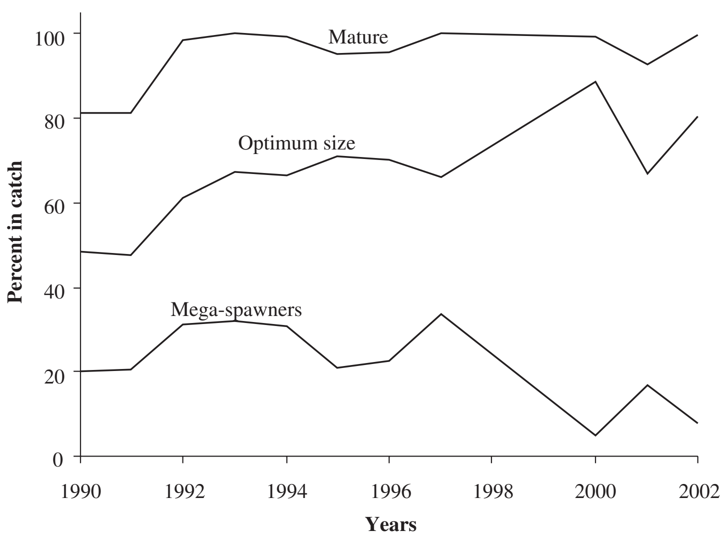

Figure 2 Time series of percentages of mature, optimum size and mega-spawner specimens in the Senegalese catch of Round sardinella. Note that mature and optimum size percentages are close to or approaching the target of 100%. However, percentage of mega-spawners is below 30–40% and declining since 1997.

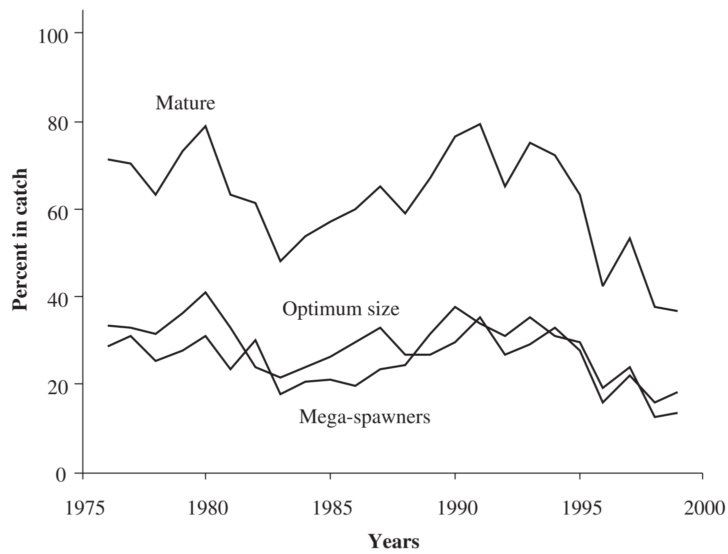

Figure 3 Time series of percentages of mature, optimum size and mega-spawner specimens in the Senegalese catch of White grouper. Note that percentages of mature and optimum-size specimens are relatively low compared with the target of 100%; all indicators are declining since 1991.

period, the percentages of specimens at optimum size and of mega-spawners have decreased from about 35% to less than 20%. The indicators suggest that the stock is overfished, again confirming the traditional assessment.

Discussion

In the early days of modern fisheries science Beverton and Holt (1956) used length–frequency data in combination with biological information (growth parameters K and L_∞ and smallest length in catch L_c) to show that a simple indicator (mean length in catch) was inversely correlated with fishing mortality. One year later, Beverton and Holt (1957) presented their yield-per-recruit model which allowed optimizing yield by balancing fishing mortality with age or length (L_c) at first capture. Indicators 1 and 2 return to these themes with clear targets by suggesting that length at first capture shall be beyond length at first maturity, and mean length shall be close to the length where maximum potential yield can be obtained (Beverton 1992).

Myers and Mertz (1998) have submitted the ‘Let them spawn’ strategy to rigorous modelling. They conclude that if fish in their first year are not harvested until the completion of the spawning season, and if every spawner produces at least one replacement spawner – which is true for most bony fish, but not for most sharks and rays (Myers et al. 1999) – then the stock will not collapse at any fishing mortality, no matter how high. Note that this rests on the assumption of successful recruitment at all times. In reality, however, recruitment failures are common and therefore unlimited fishing mortality is not an option. Myers and Mertz (1998) also show that the larger the difference between age at first capture and age at first maturity the more vulnerable the stock is to overfishing, thus confirming the relevance of indicator one.

Had the Western Cod been managed according to these simple indicators, i.e. all undersized fish allowed to spawn and to grow to optimum length and all mega-spawners excluded from the catch, then that fishery would have increased its landings and revenue by about 26–71% (mean 46%), despite the fact that some juveniles would have died from natural mortality before reaching optimum length (see below for methods). Annual yield would have been lower in the first years because there were so few specimens at optimum length, but would reach and surpass observed yields after a few years. Yields may be much higher in later years as the rebuilt spawning stock is likely to lead to better recruitment. In reality, nominal landings of Cod in the area dropped by 32% from 1994 to 2000 (ICES 2002).

It has been argued that it is not possible to catch only fish of a certain, narrow size class. But this cannot be agreed upon. Most commercial fish show clear patterns of spatial and temporal distribution by size group. Many traditional gears are highly size-selective, and standard electronic equipment on industrial fishing boats combined with modern gear technology and relevant information – and with appropriate incentives – can achieve the desired results. Hawaii (K. Lowe, personal communication) and Senegal (B. Samb, personal communication) are currently implementing regulations setting the minimum landing size beyond size at first maturity, and Hawaii is also contemplating maximum size limits for some species.

The proposed indicators are based upon the observation that overfishing changes the length frequency of populations. They shift focuses away from regulation of fishing effort, the area where fisheries management has failed for 100 years and continues to fail. These indicators are not a panacea for all the woes of fisheries. For example, the fishing effort that is appropriate in a given year still involves assessment of the current status of each stock, its interactions with other stocks and overall ecosystem management goals. However, it should be noted that assessment of year class strength of recruits before they reach size of first capture under the proposed regime is much easier and more precise than current attempts to predict recruitment from egg and larvae surveys or from environmental variables (Mertz and Myers 1995).

The indicators are not a replacement for large no-take zones or marine protected areas as proposed by Beattie *et al.* (2001). These measures will assist in the rebuilding of stocks and are especially needed for the many non-commercial species that are affected by fishing, habitat loss and other threats to aquatic biodiversity. If such areas are established and if these simple indicators can be enforced then yields can be expected to increase and overfishing may become exceptional rather than being the rule.

Methods and general remarks

The indicator estimates for the Western Cod were based on length–frequency time series of FR-LORIENT gadoid trawlers (ICES 2002), using the following biological parameters: maximum total length 120 cm, length at first maturity 62.9 cm, length with optimium yield $L_{opt} = 80.2$ cm. Every year was analysed individually, i.e. no connection between years was made and there is no assumption about recruitment; results were averaged over the available samples. Actual yield was calculated by transforming length into weight with the relationship $W = 0.00683L^{3.094}$, multiplying these weight classes with the respective frequencies, and summing it up over all classes. For the estimation of potential yield, L_{opt} was derived from growth parameters as $L_{opt} = L_\infty \times [3/(3 + M/K)] = 91.1$ cm (Beverton 1992), with $L_\infty = 123$ cm TL, $K = 0.19$, and $M = 0.2$. Note that M was taken from ICES (2002), L_∞ corresponds to the largest fish in the samples (Froese and Binohlan 2000), and K was chosen to result in an age at first maturity of about 3 years, as given in ICES (2000). Frequencies in lower length classes were reduced by natural mortality and then added to the length class containing L_{opt}. Multiplying the frequency of the L_{opt} class with the corresponding weight gave the potential yield. Specimens in length classes above L_{opt} were not included. The length–frequency data as well as a 'Length–Frequency Wizard' to perform these calculations are available in FishBase (http://www.fishbase.org).

The above indicators are based upon length compositions that can be derived from commercial catches and compared against biological properties that are usually known or easily established. Selection of parameter values used for length at maturity, growth and natural mortality affects the absolute percentages of the indicators, but not their trends. Thus, preliminary estimates for the respective parameters can be taken from studies compiled in FishBase (Froese and Pauly 2000; http://www.fishbase.org) or empirical equations in Froese and Binohlan (2000).

Figures 2 and 3 can be used to monitor the development of stocks. Because of the simplicity of the indicators and their resemblance to, e.g. financial indicators, one can imagine these graphs to be used in public debates, enabling informed participation of stakeholders in resource management.

The indicators also work at the level of individual fish which can be evaluated as being juvenile, mature, of optimum length, or a mega-spawner by simply measuring their length and comparing it with respective information, which can be given, for example, in the form of posters depicting commercial fishes at the respective sizes. This enables other stakeholders such as supermarket managers, consumers, anglers and politicians to participate in fisheries management. For example, the German Agency for Technical Cooperation (GTZ) has started using such posters in its training courses (M. Waltemath, personal communication). Similarly, the Department of Agriculture – Bureau of Fisheries and Aquaculture Research (DA-BFAR) of the Philippines has just produced a 'fish ruler' with pictures and lengths at maturity, which is distributed widely and encourages consumers 'to assess how mature/immature the fishes being sold are' (DA-BFAR 2003). Thus, the process of involving other stakeholders and bringing common sense to fisheries management has already begun.

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