Fishing will NOT end in 2048

In November 2006, *Science* magazine featured an article by Professor Boris Worm and thirteen co-authors. That article was extensively reported in the media, though mostly by journalists who reworked press releases and did not read the original. Fisheries management is too important for public perceptions to be built on the media campaigns of special interests and so these notes are offered to aid a deeper understanding of what the Worm *et al*. article said and of the limited evidence for its conclusions. They are a summary of a longer commentary prepared for Seafish.

- The article was **not** about the effects of fisheries on ecosystems. It was about the effects of biodiversity on fishery production and other "ecosystem services".
- It was **not** the outcome of a major research program. Worm *et al*. tried to answer a big question using only existing data and published results. That was a sensible first step but neither could nor did progress far.
- They attempted three separate approaches: First, they considered 32 small-scale experiments, each comparing what happens when one species is present to the results of having 3 to 12 species. None of those experiments involved a fish nor any other fishery resource. They were ecological studies into the effects of biodiversity under abstract conditions. From them, Worm *et al*. extracted information on ecological production, stability, efficiency etc. Greater diversity led to increases across the board. That was not surprising. Indeed, it was only a small contribution to an ongoing academic debate – and one that need not concern the wider community. In ecosystems, what is true at one scale can be the reverse of what is true at others. (The diverse fish faunas of tropical reefs are much **less** productive than the low-diversity sub-arctic fishing grounds, for example.) Thus, small-scale ecological experiments have little direct relevance to public policy.
- Second, Worm *et al*. considered 12 coastal ecosystems previously selected for a different study by Lotze *et al*. Those authors had looked at a range of species from each of their areas and had estimated the abundance of each species over several millennia, comparing those abundances to their "pristine" levels. Unfortunately, how those estimates were produced remains a mystery, since quantitative data from before the mid-20th Century are very rare, while Lotze *et al*. did not explain their methods – as scientists are required to do. In consequence, their results must be set aside. In turn, Worm *et al*.'s further examination of those results must be dismissed as lacking scientific merit. That examination was, in any case, built on factual errors in other data and on misinterpretation of analytical results.
- Third, Worm *et al*. turned to the 64 "Large Marine Ecosystems" (LMEs) – ocean areas mapped for research purposes. They took 1950–2003 catch data from a reliable database but only used those numbers to calculate the percentage of "collapsed" fisheries, meaning those with catches below 10% of the maximum recorded. That is a fair measure of the state of a **fishery** but Worm *et al*., while they wrote of "fisheries", clearly thought of their analysis as saying something about **fishery resources**. It did not. There are many reasons for severe reductions in catches other than resource depletion, including adjustment to sustainable

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fishing following past excessive harvests, tight restrictions to minimize bycatches of other species, loss of markets, rising costs, loss of subsidies and so forth. There were many small fisheries which once recorded catches during brief development projects but which have been abandoned. There are also fisheries for resources which bloom and decline with changes in ocean climate.

Worm *et al*. attempted to relate their percentages of "collapsed" fisheries to the biodiversity of the LMEs – crudely (and very inaccurately) represented as the number of fish species present. They concluded that higher diversity goes with fewer "collapsed" fisheries, greater productivity of the "non-collapsed" and a higher proportion of once-"collapsed" fisheries that have recovered. None of those relationships explained much of the data and they may be no more than artefacts of bad data. Worm *et al*. also confirmed the obvious by showing that the number of exploited species in each LME was related to the number of fish species living there. Higher numbers of exploited species also went with lower year-to-year variation in the overall catch, as expected. Curiously, they concluded that LMEs with more fished species have higher landings, contrary to the usual observation that the largest fisheries are in ecosystems that channel their production into few species. It may be notable that Worm *et al*. claimed a maximum catch of about 3 million tons from a single LME, whereas the data show that the Humboldt Current LME has averaged of over 7 million tons per year. In sum, the catch data themselves are interesting but Worm *et al*.'s naïve interpretations wove a misleading picture from the numbers.

- The central feature of the media coverage was a projection of a global collapse of fished species by 2048 – although that had nothing to do with the declared theme of the article. Quite apart from the error in confusing declining catches with declining species, Worm *et al*. merely graphed the percentage of "collapsed" fisheries against time (starting at zero in 1950, "collapses" reached 29% by 2003) and fitted a simple curve to that trend. They extrapolated that curve to reach 100% "collapsed" in 2048. Professor Worm has stressed that the date was a projection of what would happen if current trends continue. However, management has already responded to fisheries failures and that will intensify until the trend in "collapses" reverses. Continuation of current practices cannot be represented by extrapolating past failures. Moreover, Worm *et al*. arbitrarily chose to represent the trend using an exponential curve that forever accelerates downwards. In reality, some fisheries show no signs of imminent failure and Worm *et al*. should have considered a sigmoid curve that flattens out before reaching "100% collapsed". They should then have tested which curve better matched the data. Since they did not, the projection that the world's fisheries are headed for disaster within decades can be dismissed as an artifact of an assumption. Even had Worm *et al*. chosen another curve, its projection would have been misleading because contrasting reasons can lead to a fishery being "collapsed". Some are because of resource depletion but others are currently "collapsed", in Worm *et al*.'s sense, because of management cuts to address past overfishing. No overall trend composed of such contrary underlying trends can be usefully projected since it contains the seeds of its own demise within itself. **The much-quoted 2048 date was entirely spurious**.
- Following their unsuccessful attempts to answer the question they posed, Worm *et al*. turned to an off-topic issue: whether loss of ecosystem services is reversible by using marine reserves – even though they had not shown that there is any loss of services to be reversed. They based their consideration on 52 previously-published

studies, though without any apparent effort to confirm the validity of the conclusions in those reports. Worm *et al*. claimed to find small increases in biodiversity in reserve areas. However, some of the 52 studies were comparisons between inside and outside reserve areas. Since many reserves were designed to protect high-diversity areas, the elevated biodiversity was partly the cause, not the effect, of closure. Worm *et al*. also reported the well-known increase in catch per unit effort around closed areas, though catches themselves did not increase greatly, if at all – which was also a well-known result. Finally, they looked for an effect of reserves on other ecosystem services but found none, aside from a preference among sport-divers for visiting reserve areas. Despite finding almost nothing from their consideration of reserves, Worm *et al*. used it as a basis for declaring that serious declines in ecosystem services can be reversed. I am confident that such declines as have occurred are reversible but not because of anything in their article.

- Last of all, Worm *et al*. suggested that marine biodiversity can be restored through fisheries management, pollution control, habitat maintenance and the creation of marine reserves. That position (which was not a conclusion of any analysis in their article) seems undisputable. The challenge is to apply those principles in practice.

In summary: Most of the conclusions in the Worm *et al*. article lacked the support of logic and data and must be dismissed as not scientific. That rejection is no denial of problems. Oceans management faces huge challenges which we are struggling to surmount. To succeed, however, we need clear recognition of the real problems and science-based guidance on viable solutions. Peddling ill-founded, sensationalist notions, in the guise of "science", is a dangerous step backwards.

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