

14. Ravier, C. & Fromentin, J.-M. *Fish. Oceanogr.* **13**, 145–160 (2004).
 15. Chavez, F. P., Ryan, J., Lluch-Cota, S. E. & Niqun, C. *Science* **299**, 217–221 (2003).

Myers and Worm reply — Hampton and colleagues¹ challenge one aspect of our report on global declines in predatory fish communities². They posit that Japanese longline catch per unit effort (CPUE) may be a biased abundance estimator for albacore, bigeye and yellowfin tuna (*Thunnus alalunga*, *T. obesus* and *T. albacares*) in the tropical Pacific, one of the 13 regions we considered. The appropriate use of CPUE data is an important technical issue with substantial policy implications. We have therefore made every effort to check and correct the data for potential bias and to validate them against independent survey data. The results of our analyses^{3–7} indicate that our main conclusions are still justified. We note that Hampton *et al.* also use uncorrected CPUE data, assuming that CPUE is proportional to abundance (see ref. 8, for example). As yet, they have not demonstrated a mechanism that could explain why the assumption of proportionality should break down.

We agree that changes in targeting, particularly the increase in the depth of hooks, have altered catchability; however, when the effects of depth are estimated³, the combined CPUE shows declines greater than those we estimated originally². Other recent analyses of gear changes suggest that newer gear is twice as effective as older gear⁹, potentially obscuring continuing declines in stock abundance from CPUE data.

Hampton *et al.* discuss two cases. First,

they note that Taiwanese longline CPUE for albacore does not match the Japanese data (decline of about 50% compared with about 90%). However, the Taiwanese data may be misleading as they commenced a decade after the Japanese data and so fail to capture the start of industrialized fishing. Intense albacore fisheries were well developed in this region before the Taiwanese data were collected and had large effects on this species¹⁰. Thus, less of the decline is seen in the later data (the ‘shifting baseline’ syndrome¹¹). The same issue applies to the tropical Pacific, where populations were exploited previously — those areas were therefore excluded from our analysis.

Second, the authors observe that for Pacific yellowfin and bigeye the initial decline in longline CPUE occurred under moderate fishing effort, whereas CPUE remained low and stable under later regimes of high fishing effort. We explained this pattern by an increase in fish productivity, caused by the decline of large predators. Both ecosystem models^{12,13} and survey data⁵ support this mechanism.

We note further that CPUE is measured in units of numbers of fish large enough to be harvested by longline hooks, which are very size-selective. Initially, there was an accumulated biomass of large fish. Thus, CPUE was very high, but dropped rapidly as those susceptible individuals were removed. CPUE declined as the fishery became completely dependent upon new fish recruiting to the population. Thus, related shifts in size distribution, CPUE and fishing effort may lead to rapid depletion of large individuals, even at relatively low initial fishing effort.

This simple mechanism is consistent with

the large (2–4-fold) reduction in the average size of large predatory fish, as seen from research survey data⁵. The same surveys revealed an 89% decline of large pelagic biomass in the tropical Pacific⁵ that precisely matched our global estimate². Hampton *et al.* imply that environmental effects are partly to blame for these changes. Although environmental factors can drive year-to-year variation^{8,14}, they cannot explain long-term, worldwide declines, particularly as these coincide with the onset of industrialized fishing^{5,15}.

We welcome the incentive from Hampton *et al.* to refine and critically evaluate abundance estimates derived from CPUE data. However, in following their call, either by correcting for potential biases or by analysing independent data sets, we find that our estimates of decline remain conservative.

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1. Hampton, J., Sibert, J. R., Kleiber, P., Maunder, M. N. & Harley, S. J. *Nature* **434**, doi:10.1038/nature03581 (2005).
2. Myers, R. A. & Worm, B. *Nature* **423**, 280–283 (2003).
3. Ward, P. & Myers, R. A. *Can. J. Fish. Aquat. Sci.* (in the press).
4. Ward, P., Myers, R. A. & Blanchard, W. *Fish. Bull.* **102**, 179–195 (2004).
5. Ward, P. & Myers, R. A. *Ecology* **86**, 835–847 (2005).
6. Ward, P. & Myers, R. A. *Fish. Oceanogr.* (in the press).
7. Myers, R. A. & Worm, B. *Phil. Trans. R. Soc. Lond. B* doi:10.1098/rstb.2004.1573 (2005).
8. Lehodey, P., Bertignac, M., Hampton, J., Lewis, A. & Picaut, J. *Nature* **389**, 715–718 (1997).
9. Stone, H. H. & Dixon, K. L. *Fish. Bull.* **99**, 210–216 (2001).
10. Otsu, T. & Sumida, R. F. *Fish. Bull.* **67**, 47–67 (1968).
11. Pauly, D. *Trends Ecol. Evol.* **10**, 430 (1995).
12. Cox, S. P. *et al. Can. J. Fish. Aquat. Sci.* **59**, 1736–1747 (2002).
13. Cox, S. P. *et al. Can. J. Fish. Aquat. Sci.* **59**, 1724–1735 (2002).
14. Myers, R. A. *Rev. Fish Biol. Fish.* **8**, 285–305 (1998).
15. Worm, B. & Myers, R. A. *Nature* **429**, 15 (2004).