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Reply to Hilborn: Role of marine reserves depends on assumptions

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REPLY TO HILBORN:

# Role of marine reserves depends on assumptions

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We appreciate the points made by Hilborn (1) that changing the assumptions we made could lead to different conclusions. In fact, our overall goal in developing the model in ref. 2 was similar to the goal in developing the model in ref. 3 to indicate how a model with clear assumptions would shed light on the role played by marine protected areas in spatial fishery management. Here we make three simple points:

- The main result in ref. 2 is that under the assumptions of our model higher strong-stock yield can be achieved with marine reserves as part of the management mix. Hilborn's own model accords with this result. Hilborn's main critique seems to be that the cost of fishing would rise, because fishing would be concentrated in the areas outside the reserve. We agree with this point (and mentioned it in our paper), though the empirical magnitude is a matter of much debate and likely depends on where the reserve is located relative to ports, among other features. This raises an important area for empirical research about the extent to which costs would rise for reserves of different size and location.
- Naturally, we agree that changing assumptions of the model could lead to changes in results. Hilborn points to changing those assumptions that, if changed,

could favor traditional fisheries management. Of course, changing other assumptions would instead favor marine reserves. For example, spatial heterogeneity in the composition of stocks could favor marine reserves (this is, in part, the justification for the current reserves on the West Coast). Also, because our model suggests that monitoring of weak-stock catch becomes far less important (or perhaps completely unnecessary) outside reserves, including policy implementation cost could advantage a policy that includes marine reserves.

- Our model shows that there typically exists a continuum of policies that all achieve the same weak-stock protection and strong-stock catch: from small reserves with tight regulations and oversight on weak-stock catch to large reserves with essentially no oversight on weak-stock catch. If fishermen could eliminate all weak-stock-catch monitoring, in exchange for a reserve that was the same, or perhaps smaller, than that which already exists, we posit that they might show interest in this policy.

We view our model not as the final word in developing an approach to spatial management of stocks but as a first step that provides a platform to develop insights on the costs and benefits of alternative spatial uses of the ocean.

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- 1 Hilborn R (2017) Traditional fisheries management is the best way to manage weak stocks. *Proc Natl Acad Sci USA* 114:E10610.
  - 2 Hastings A, Gaines SD, Costello C (2017) Marine reserves solve an important bycatch problem in fisheries. *Proc Natl Acad Sci USA* 114:8927–8934.
  - 3 Hastings A, Botsford LW (1999) Equivalence in yield from marine reserves and traditional fisheries management. *Science* 284:1537–1538.

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The authors declare no conflict of interest.

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