## REPLY TO SZUWALSKI:

# Recognizing ecological income inequality in the ocean 

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Szuwalski (1) suggests that our meta-analysis of global changes in fish stock recruitment capacity (2) should be weighted according to the biomass or catch of individual stocks, instead of weighting each stock equally. Although informative, it is important to recognize that such a perspective heavily biases any global trends in favor of a few large stocks. This bias occurs because a small number of fish stocks contribute disproportionately to global fisheries, with less than $5 \%$ of stocks contributing well over $50 \%$ of the assessed global catch (Fig. 1). Just as economists have established income inequality as a problem for the global economy (3), ecologists have also recognized that such a focus on "top earners" misses the point about what makes the "natural economy" work. For marine ecosystems, it has been repeatedly shown that ecological diversity at all levels maintains production in the face of climate
variation (4), stabilizes communities (5), and provides valuable ecosystem services (6). The question facing fisheries' managers is whether ecosystems should continue being managed for the top $5 \%$, or if native diversity and functional food webs are recognized as important measures of fisheries' prosperity.

We do agree with Szuwalski (1) that managers must ask both questions: (i) How do changes in productivity affect total biomass and total catch, and (ii) how has productivity changed in the community, and how is the environment influencing that change? We asked the second question in our paper, and Szuwalski (1) has highlighted the first. Szuwalski (1) also raises an important issue: Why are the big stocks doing relatively well, whereas the average stock shows a decline? Our first inclination is that fishing plays a role. If the smallest stocks are those stocks that


Fig. 1. Rank-log(abundance) curves for global fish stocks in terms of total stock biomass ( $A$ ) and annual catch (B) with $50 \%$ of the total indicated on each plot. The data represent 262 fish stocks analyzed in our previous study (2), with biomass and catch values taken here as the most recent available estimate for each stock. Note that catch data were not reported for all 262 fish stocks for which biomass time series were available, resulting in fewer stocks in $B$. We restricted the analysis to total catch (as opposed to landings, which are reported for some species). KG, kilogram; NAFO 4T, Northwest Atlantic Fisheries Organization, Southern Gulf of St. Lawrence.

[^0]have been fished down, they are more likely to have experienced the adverse biological effects of overfishing, such as reduced size (7) or Allee affects (8), both of which are known to affect recruitment capacity. However, without more detail on Szuwalski's meta-analysis (1) (e.g., whether uncertainty was taken into account, as in our paper), it is difficult to determine how comparable the two sets of results are.

Szuwalski (1) also raises a second, more technical issue regarding the methods to quantify long-term productivity trends in the context of regime-like behavior. Here, we agree and welcome the development of tailored methods that incorporate potential mechanisms of rapid and nonlinear ecological change. We also caution that purely
statistical methods of regime-shift detection often overinterpret time series and mistake autocorrelated errors for significant ecological shifts (ref. 9 and references therein), which may be particularly dangerous in the context of fisheries management. Although we agree that the linear trends presented in our study are likely conservative, they provide the most unbiased view of productivity change in the absence of additional information on nonlinear patterns.

We thank Szuwalski for his thoughtful opinions, and we hope further data-focused analysis of individual stocks in key regions (e.g., 10) will provide the necessary information to inform ecosystembased fisheries management and promote food security at a time of ongoing environmental and biological change.

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