LETTER

Weak evidence for sardine collapse

Zwolinski and Demer (1) described indicators suggesting imminent collapse of Pacific sardines (*Sardinops sagax*) in the California Current. Those indicators are lacking in explanatory or predictive power, and the paper does not recognize fundamental differences between conservative sardine fishery management today and *Sardinops* fisheries that were virtually unregulated previously in the California Current and in other regions of the world.

Zwolinski and Demer's assertion of a concordance in fishery collapses in Japan and South America and collapse in the California Current continues to be a subject of debate (2). Furthermore, their own figure 2A in ref. 1 showed that California now lags the others by at least 20 y—contradicting the idea of concordance. Rather than the lag being associated with mackerel (*Scomber japonicus*), we believe that the lag is due to an unusually low harvest rate, which is less than one-third that of any comparable historical sardine fishery (figure 9.3a in ref. 3). The annual exploitation rates during the Japanese and South American collapses exceeded 50% (3) so that the unregulated fisheries were unable to tolerate even a brief decline in reproductive rate. Exploitation rates in the California Current have been 10–20%, and US management requires programmed decreases if abundance decreases.

Zwolinski and Demer (1) also reported a sudden increase in mackerels (*S. japonicus* and *Trachurus symmetricus*) and school mixing in their 2011 trawl survey. They neglected to mention that this increase is relative to the lowest observed historical abundances of both mackerels (their figure 2B). Although a pattern of historical species alternations has been documented, that pattern exists at the decadal scale and there is no evidence that a single year's fluctuation is meaningful. Trawls do not catch single schools and cannot reliably reveal mixing patterns.

The stock assessment (4) is a peer-reviewed demographic model incorporating catches, age structure, and survey data. It agrees that sardine abundance has declined from peak values ~10 y ago, but the regulated catches have also decreased by half. Multiyear trends of sardine population increase and decrease are expected (2). However, figure 3 in ref. 1 overstated the decline by omitting contrary available data showing that the 2011 Daily Egg Production Method estimate of population abundance increased (4). The authors stated that, by itself, their acoustic-trawl survey provided unique insight. This position is not generally supported by the community of fishery scientists, who consider survey results to be just one of several inputs to a stock assessment. Moreover, Zwolinski and Demer's assertion of a "critical biomass" of 0.74 million tons is ad hoc and is based on a single historical observation with no analysis or documentation.

We do agree that maintenance of the northern portion of the stock (shared by the United States and Canada) may be important to resource health. That portion has also declined recently, but is at similar abundances to those in other years in the past decade. It would be worthwhile for the United States, Canada, and Mexico to work toward a management agreement for this and other transboundary species.

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