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Comparison of Estimated Biomass of CSNA from Different Methods

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In the May 2016 coastal pelagic species (CPS) data-limited workshop sponsored by the Pacific Fishery Management Council at the Southwest Fisheries Science Center (SWFSC), the workshop panel recommended comparison of spawning biomass estimates of the central subpopulation of northern anchovy (CSNA) from the CalCOFI ichthyoplankton-based model (i.e., MacCall et al. 2016) with an estimate of total biomass from recent Acoustic Trawl Method (ATM) surveys (Zwolinski et al. 2016, 2017). More recently in January 2018, a workshop was held at the SWFSC to review the ATM survey, with the review panel finding that ATM results could be interpreted as a relative biomass index but not absolute biomass.

Here, we provide a comparison of results from these two very different approaches for two years when both estimates are available, 2015 and 2016, and a recommendation for utilizing this comparison to ground-truth each source of biomass estimates for CSNA. We clarify definitions and highlight *consistency of results* from these different sources. We demonstrate that there are no conflicting interpretations of biomass estimates for the CSNA in 2015 and 2016. However, were estimates to diverge in the future, that would signal the need to more closely examine the potential biases of each to determine the source of discrepancy.

Definitions

Estimates have been developed for CSNA **spawning biomass** (MacCall et al. 2016) and **total biomass (**Zwolinski et al. (2016, 2017**)**. Spawning biomass represents only the mature portion of the population that is spawning. Total biomass includes the spawning biomass plus any non-spawners (e.g., age-0).

Estimates from MacCall et al. (2016), with follow up in Thayer et al. (2017), are of spawning biomass based on geo-spatially weighted abundances from eggs and larvae caught in net trawls on the CalCOFI winter and spring surveys. Estimates in Zwolinski et al. (2016, 2017) are of total biomass, estimated in summer from acoustic signals and fish caught in net trawls using the acoustic-trawl method (ATM).

Spatially, the core CalCOFI survey covers primarily the Southern California Bight, the population center of the central anchovy stock, and accounts for the upper water column but does not sample extensively inshore. The inner-most standard CalCOFI stations, however, are used to scale all the way to shore. This is done given that catch at the inner CalCOFI stations was not significantly different from additional inshore stations sampled in 2005-2015 (i.e., SCCOOS stations, including years of both extremely high and low biomass; Davison et al. 2017). These CalCOFI-derived spawning biomass estimates also utilize a correction factor to scale from the core CalCOFI area to the greater CSNA subpopulation area (from Bahia del Rosario, Baja California Norte, up to Point Reyes, CA).

The ATM survey spans from San Diego to north of Pt. Arena, covering much of the CSNA subpopulation area within the U.S., but does not sample in Mexico, nor does the ATM survey account for the upper-most part of the water column, nor the nearshore regions.

Comments

If anchovy have spawned recently in the nearshore California region unobserved by CalCOFI ichthyoplankton sampling and the ATM survey, nor observed by the Continuous Underway Fish Egg Sampler (CUFES), Rockfish Recruitment and Ecosystem Assessment Survey (RREAS), or Spring CPS NMFS rope trawls (see Davison et al. 2017), such spawning activity must have been confined to a very narrow strip along the shore. Aerial surveys can observe inshore shoals of anchovy, and up to 1,700 km^2 inshore of the ATM survey lines along the coast of the Southern California Bight were surveyed aerially in recent years by the California Department of Fish and Wildlife (Lynn et al.

2017). In 2013–2016, visually-estimated anchovy biomass from aerial surveys ranged from 0 - 15,199 metric tons (mt), with a mean of 3,230 mt and median of 568 mt. The maximum was observed in 2013, while no anchovy were observed in 2015. In summer 2016 similar to the timing of the ATM survey, only 29 mt was aerially observed; 1,052-4,224 mt was aerially observed in spring 2016, similar to the timing of the CalCOFI survey. Thus, it is clear that even though a dense population of anchovy could occur nearshore, it does not amount to a large biomass due to the restricted spatial distribution.

Relative to the ATM surveys, non-breeding migration of other anchovy stocks into the survey area may inflate estimates of the local CSNA stock size (Parrish et al. 1985). This bias is not present for CalCOFI-based estimates, which stem from eggs/larvae.

Finally, in addition to methodological differences, inherent differences include the fact that the ATM survey includes older fish transitioning from age-0 to age 1+ between spring when the CalCOFI data were collected and summer when the ATM survey was conducted (so precluding any mortality, biomass is augmented by growth of individuals from spring to summer).

Comparison 2015

CalCOFI-based spawning biomass in spring 2015 was estimated at 5,300 mt , but with low precision (CV=1.23; Thayer et al. 2017). Consequently, the mean spawning biomass over the previous 4-7 years was also reported, roughly 20,000 mt (2009-2015) or 25,000 mt (2012-2015) (Thayer et al. 2017).

The preliminary ATM-based total biomass estimate in summer 2015 was 31,427 mt (CV=0.25; Zwolinski et al. 2016). To compare this with the spawning stock biomass, one needs to estimate and remove the juvenile (age-0) proportion of the population. We assume that anchovy > 100 mm standard length are age 1+ and part of the spawning population (Parrish et al. 1986). Anchovy > 100 mm were caught in the 2015 ATM survey in spatial clusters 2, 5, 6, 7 and 15 (see Zwolinski et al. 2016, Fig. 3). Converting length distribution data (Zwolinski et al. 2016, Table 2) to mean weights, 26% of the biomass of the population was > 100 mm and thus assumed age 1+, resulting in an estimate of 8,300 mt of spawning biomass from the ATM survey. This estimate has a minimum CV=0.25 given survey results from the total biomass estimate (pers. comm. J. Zwolinski/SWFSC).

Comparison 2016

In 2016, CalCOFI-based spawning biomass in spring was estimated at 153,200 mt (CV= 0.95; Thayer et al. 2017). ATM-based total biomass in summer of 2016 was 151,588 mt (CV=0.41; Zwolinski et al. 2017), of which roughly 144,900 mt was estimated to represent individuals > 100 mm standard length and thus likely comprising the spawning population.

Summary

These comparisons demonstrate coherence between the CalCOFI-based and ATM-based abundance estimates, with both approaches pointing to an extremely low spawning abundance in 2015. In 2016, while the spawning abundance from both methods increased to roughly 150,000 mt, this is still very low relative to a long-term mean of 500,000 mt (MacCall et al. 2016). Given the uncertainty of the estimates from the different methods, *we are unable to tell them apart in each year*. Therefore, since there are no conflicting biomass data from these surveys utilizing very different methodology and thus containing different biases (see Summary Table, below), it is prudent to say that the actual biomass of CSNA is likely close to this amount.

In the quest to realize the best available data on CSNA biomass, a comparison of CalCOFI and ATM results can be used to **ground-truth** biomass estimates of each. If solely the ATM method were to be used moving forward to estimate CSNA biomass, there is risk that one of the biases of this method may over or underestimate the stock. However, if the CalCOFI-based estimate is used to corroborate the ATM estimate, this risk is lessened considerably. If divergence of future estimates from these two methods were to occur, this would signal the need to examine from which potential bias the discrepency originated, and thus better understand whether estimates in that particular instance may be biased high or low.

	CSNA biomass estimate derived from:	
Estimate includes:	**CalCOFI**	**ATM**
Total biomass?	No	Yes, includes juveniles
Spawning biomass?	Yes	Yes, can be estimated using length or age data
Southern CA?	Yes, directly surveyed	Yes, directly surveyed
Central CA?	Yes, scaled up using DEPM	Yes, directly surveyed
N. Baja, Mexico?	Yes, scaled up using DEPM	No
Upper water column?	Yes, directly surveyed	No, acoustics miss upper ~10m
Nearshore?	Yes, tesselated from inner-most stations to shore	No, but estimates could be derived from aerial survey?
Other stocks?	No	Maybe, southern or northern stocks may overlap with central stock after spawning; no way to distinguish acoustically
Sample type:	*Eggs/larvae*	*Adults/juveniles*
Survey timing:	*Spring*	*Summer*
2015 spawning biomass estimate:	**5,300 mt**	**8,300 mt**
2016 spawning biomass estimate:	**153,200 mt**	**144,900 mt**

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