

Proposed SEDAR Methods and Procedures Workshop: Index Development Using Fishery Independent Survey Data that Varies Across Space and Time

Workshop Objective: To improve the quality of fishery-independent data inputs and streamline future stock assessments by defining best practices for generating indices of relative abundance and size composition that incorporate data from multiple surveys and/or account for survey changes through time.

Problem Description: Fishery-independent indices of relative abundance and size/age composition are critical inputs to stock assessment models ranging from data-limited models to statistical catch-at-length or catch-at-age models. These indices are also often used to provide interim management advice in between more robust and time-intensive assessments. A fundamental assumption of indices of relative abundance is that they accurately reflect population-level trends of the stock being assessed. For this assumption to be met, indices are ideally constructed using data from a single survey that encompasses the full spatial extent of the population of interest and that has been conducted using consistent methodology through time. However, in the southeastern U.S., these criteria are often not met. Many surveys have been altered in some way through time; these changes include spatial expansion or contraction of survey efforts as the level of available funding fluctuates (Buble and Smart 2019; Pollack et al. 2019; Thompson et al. 2020), expansion of survey efforts into previously-unsampled habitats (Campbell et al. 2017; Thompson et al. 2020), or in some instances, the implementation of completely new survey designs (Pollack and Ingram 2010; Gulf Reef Fish Video Survey beginning in 2020). Additionally, for some stocks (e.g., reef fishes, sharks and other highly migratory fishes), it is often necessary to integrate data from multiple sympatric (SEDAR 2020) or spatially disjunct surveys or sampling programs (SEDAR 2011; SEDAR 2013; SEDAR 2017; Latour and Peterson 2020; Thompson et al. 2020) to best estimate population-level trends. These issues are common to many species currently assessed through the SouthEast Data, Assessment, and Review (SEDAR) process; however, there is little consistency to the analytical approaches recommended by Data Workshop panelists, even when analyzing the same survey data for different stocks (SEDAR 15; SEDAR 18a; SEDAR 18b). Because of these inconsistencies, considerable time is spent at each Data Workshop revisiting past decisions and exploring multiple analytical approaches for each assessment as well as discussing the relative advantages and limitations of each approach tested. More importantly, it is presently unknown how sensitive final analytical products (time series of relative abundance and size/age composition) may be to the choice of analytical approach applied to survey data. Since many of these data challenges are inherent to many data collection programs and therefore similar from stock to stock, decisions and approaches for dealing with common challenges could be standardized, and lessons learned from one survey or stock may be applicable to other assessments. Such efforts would provide data providers with the guidance they need to better prepare for workshops, allow workshop participants to focus on unique or more pressing issues of the stock under consideration, and improve consistency in the treatment of common uncertainties and data collection issues. Accordingly, we propose to convene a SEDAR Methods

and Procedures workshop to explore and evaluate various analytical approaches for generating indices of relative abundance and size/age composition from fishery independent survey data that varies across space and time. Although several interrelated issues would be discussed in the proposed workshop, discussions will be organized around two fundamental themes: combining data from multiple surveys and accounting for survey changes through time.

Issue #1. Combining Data from Multiple Surveys:

For stocks distributed across a broad geographic range, there are often multiple sources of fishery independent survey data, each of which cover a fraction of the full range of the stock. For reef fish stocks in the Gulf of Mexico, data have been provided from multiple stereo-baited remote underwater video (S-BRUV) surveys that have been conducted over the past two decades. Beginning as a shelf-break survey, regional survey efforts have subsequently expanded to include the northeastern Gulf of Mexico, the West Florida Shelf, and offshore waters throughout the Florida Gulf coast including artificial reef habitats (Keenan et al. 2018; Thompson et al. 2020). Similarly, multiple bottom longline and gillnet surveys have been conducted throughout the Gulf of Mexico and South Atlantic that provide data for sharks and other highly migratory fishes (SEDAR 2011; SEDAR 2013; SEDAR 2017; Latour and Peterson 2020). While assessment models are capable of incorporating multiple indices of abundance, complications arise when indices show conflicting trends through time. Although originally covered during the first SEDAR Methods and Procedures workshop (SEDAR 2009), SEDAR data providers have increasingly applied novel statistical approaches to integrate data from multiple data sources into a single population-wide index (Conn 2010; Latour and Peterson 2020; SEDAR 2020; Thompson et al. 2020). However, it remains unclear when a particular analytical approach may be most appropriate, or whether combining indices is even valid. During this workshop, participants would first identify important criteria to consider when determining whether it is appropriate to combine indices. Most commonly, concerns have been raised regarding combining indices that exhibit different selectivity patterns due either to gear-specific differences in selectivity (Paperno et al. 2018) or to differences in the size composition of the underlying population that may arise due to spatial differences in survey coverage (SEDAR 2018b), although other potential issues (e.g., highly restricted spatial coverage of a candidate survey or significant inconsistencies among candidate surveys; Campbell et al. 2017) will also be considered. Participants would then evaluate the appropriateness of various analytical approaches used to combine abundance or size/age composition data among surveys, especially when surveys may differ markedly in respect to the proportion of the stock covered due to differences in spatial extent or the quality and quantity of critical habitat included within the sampling domain of each survey (Latour and Peterson 2020; SEDAR 2020; Thompson et al. 2020). At a minimum, several previously-applied approaches to combine data for abundance determination would be evaluated, including traditional model-based standardization (SEDAR 2009), hierarchical modeling (SEDAR 2009; Conn 2010; SEDAR 2020), dynamic factor analysis (Latour and Peterson 2020), and approaches that incorporate some design-based processes (Thompson et al. 2020); the potential utility of other novel approaches, including the vector

autoregressive spatio-temporal (VAST) package (Thorson 2019) or other approaches identified by workshop participants, would also be explored. A variety of analytical approaches to combine size/age composition data from multiple surveys will also be evaluated, including weighted averaging (Thompson et al. 2020), multinomial regression models (Walter et al. 2017) with and without the application of survey-specific weighting factors, and other approaches (e.g., overdispersed multinomial, dirichlet-multinomial; *cf.* Kim and Margolin 1992) that account for non-independence of size/age composition data at each sampling site.

Issue #2. Accounting for Changes in Survey Design Through Time:

Inevitably, most long-term fishery independent surveys will experience some degree of change through time. Most commonly, either overall sampling intensity or the area encompassed by a particular survey may expand or contract in relation to changes in overall funding availability (Bubley and Smart 2019; Pollack et al. 2019; Thompson et al. 2020). Less frequently, the design of long-term surveys may be modified through the addition of entirely new sampling methods (Bacheler et al. 2013), inclusion of previously-unsampled strata (Campbell et al. 2017; Thompson et al. 2020), or the transition to an entirely new survey design to improve survey efficiency or statistical power (Pollack and Ingram 2010; Gulf Reef Fish Video Survey beginning in 2020). Data providers generally will utilize one of a suite of model-based standardization protocols to account for survey changes through time (SEDAR 2009; Cheshire and Bacheler 2018; Bubley and Smart 2019; Pollack et al. 2019), although design-based elements are incorporated in some instances (Thompson et al. 2020). Regardless, analysts rarely assess whether models used are appropriate (e.g., whether or not there is evidence of a significant interaction between time and space). If temporal changes cannot adequately be accounted for through the standardization process, it may be more appropriate to truncate or split an index, as is often the case with fishery dependent indices. During this workshop, participants would begin by identifying what criteria may preclude attempts to extend time series through data standardization in favor of generating truncated or split indices. If appropriate, participants would then evaluate the utility of various data standardization approaches for accounting for significant temporal changes through time, including generalized linear models (including zero-inflated models and various underlying distributional assumptions), generalized additive models, design-based inferential methods, and VAST among others identified by workshop participants. As part of the evaluation process, appropriate diagnostics would be identified to aid in assessing whether models are adequately and appropriately accounting for changes through time.

Workshop Structure and Outcomes:

Although this workshop has a substantial library of published literature and SEDAR working papers to draw from, proper evaluation of the salient issues will require a significant amount of new and revised analyses. Accordingly, a lead panel or steering committee would need to be assembled well prior to the in-person workshop to draft workshop Terms of Reference and identify a preliminary suite of analytical approaches and representative case studies to be

explored during the workshop. Based on the initial decisions of the steering committee, workshop participants would be identified that would likely include a mix of statisticians and quantitative ecologists, assessment scientists, and survey scientists most familiar with the surveys, stocks, and analytical issues that will be the focus of this workshop (Table 1).

The outcome of this workshop will be a report documenting recommendations of the workshop participants as to when complex index-development analyses are warranted and, if so, which analyses are most appropriate. It is unlikely that a single best approach will be identified; instead, the report will identify key index issues that need to be accounted for along with advantages and disadvantages of various analytical approaches to address those issues. Potentially the workshop report could be structured as some form of flow chart or decision tree that would lead future data providers through the most common issues than arise when analyzing data that varies across space or time, leading to a ranking of best approaches to apply depending on whether key criteria are met. Ultimately, results from this workshop will streamline the index development and review process for multiple surveys and stocks during future assessments.

Table 1. A summary of the key surveys, stocks, and analytical issues in the Southeastern U.S. that will be the focus of the proposed SEDAR Methods and Procedures Workshop.

Survey	Stocks	Analytical Issues Encountered
Bottom Longline and other gear (non-NMFS surveys)	HMS	Combining data from multiple surveys
South East Reef Fish Survey (SERFS)	Reef Fishes	Combining data from multiple surveys Survey expansion
Gulf Groundfish Trawl Survey	Reef Fishes / Shrimp	Survey expansion Change in survey design
Gulf Reef Fish Video Survey	Reef Fishes	Combining data from multiple surveys Survey expansion Inclusion of new strata Change in survey design

Workshop Format and Participants:

To best accomplish workshop objectives, we propose convening a three-day in-person workshop to review and evaluate potential approaches to addressing defined analytical issues. At least two pre-workshop webinars will likely be required to identify potential analytical approaches and develop a list of analytical tasks and responsible parties; due to the complexities of some of the analyses being evaluated, these webinars will likely need to occur well in advance (3 – 6 months) of the in-person workshop. Following the in-person workshop, at least one post-workshop webinar will be required to tie up any loose ends from the in-person workshop and continue remaining work on the final workshop report. Overall format and

content of the webinars and the in-person workshop will be determined by the workshop planning or steering committee, which will consist of a subset of necessary workshop attendees:

- SEFSC – Gulf survey and analytical representatives (~ 3 attendees)
- FL – Gulf survey and analytical representatives (~ 2 attendees)
- SEFSC – South Atlantic survey and analytical representatives (~ 2 attendees)
- SC – South Atlantic survey and analytical representatives (~ 2 attendees)
- SEFS – HMS survey and analytical representatives (~ 3 attendees)
- SEFSC – Assessment scientists (~ 1 each from the Gulf, South Atlantic, HMS)
- Academic faculty (~ 3 attendees)
- SSC representatives (~ 1 each from the Gulf and South Atlantic)
- SEDAR coordinators and facilitators (~ 3 attendees)
- Total of ~ 23 attendees

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