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Relative abundance of skipjack tuna for the purse seine fishery operating in the Philippines Moro Gulf (Region 12) and High Seas Pocket #1

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Abstract

Port sampling data were used to estimate effort, catch, catch per unit effort (CPUE), standardized CPUE and species composition from the purse seine fishery operating in the southern Philippines (Region 12, SOCCSKSARGEN) and High Seas Pocket #1 from 2005 to 2018. A relative abundance index was produced as a quarterly standardized CPUE index from 2005 to 2018 for use in the 2019 WCPFC skipjack tuna assessment. Standardized CPUE was estimated by Generalized Linear Models (GLMs) by removing effects due to vessel and fishing ground (area). The current index predicted quarterly CPUE with a *YR:QTR, Area* (fishing ground) and *Vessel* effects. A combined *YR:QTR* effect was estimated to be consistent with other fishery CPUE standardization methods used in the assessment. Effort by many vessels consisted of only a few trips and data were filtered for active vessels which had conducted 20 or more trips and resulted in a subset of 54 vessels. There were 18 *Area* designations in the database; however, *Area* was relatively non-informative in the model as fishing trips were dominated by 4 areas.

1 Introduction

Six tuna species dominate Philippine tuna landings, i.e. skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*), eastern little tuna (*Euthynnus affinis*), frigate tuna (*Auxis thazard*) and bullet tuna (*A. rochei*). The most common gears used by the commercial sector for catching these tuna species are purse seines and ring nets while the municipal fishers use hook-and-line or handline. All these gears are operated jointly with fish aggregating devices (FAD), known as *payao* in the Philippines. Skipjack and yellowfin tuna are found throughout the year in all Philippine waters, but are most abundant in Moro Gulf, Sulu Sea, and Sulawesi Sea off Mindanao Island. Large landings of these species occur in General Santos City and Zamboanga City where eight tuna canneries are located.

The objective of this study was to use port sampling data to estimate effort, catch, CPUE, standardized CPUE and species composition from the purse seine fishery operating in the southern Philippines (Region 12, SOCCSKSARGEN) and High Seas Pocket #1 from 2005 to 2018. A ring net fishery also captures skipjack tuna in the southern Philippines (Region 12, SOCCSKSARGEN) and High Seas Pocket #1. A standardized index was developed for skipjack tuna in the ring net fishery; however, the index is not presented in this study as it was decided at the pre-assessment workshop (SPC-OFP 2019a) that the Philippine purse seine index was more informative for the skipjack tuna assessment in the WCPF-Convention Area.

2 Methods

National Stock Assessment Program (NSAP) protocols, sampling coverage rates, raising factors for catch and effort, and quality control

Analyses on fishery performance and relative abundance were based upon NSAP data collected at the Fishport Complex in General Santos City. The Fishport is the major tuna landing site in Mindanao for handline, purse seine and ring net fisheries. The NSAP sampling was initiated in 1997, although sampling was sparse for several years. Analyses considered purse seine from 2005 to 2018. With West Pacific East Asia Oceanic Fisheries Management Project (WPEA-OFMP) funding, sampling has especially improved since 2010. Port sampling data collection prior to 2013 followed a NSAP protocol where sampling was conducted every third day regardless if the sampling day was on the weekend or a holiday. With Philippine purse seiners gaining access to High Seas Pocket #1 in 2013, the sampling protocol was altered to monitor all (100%) of unloadings from vessel activity in High Seas Pocket #1 even if landings occur on a non-sampling day. Therefore, the overall coverage of sampling days per month is ~ 33% prior to 2013 and ranged from 51% to 58% from 2013 to 2018.

Sampling occurred where possible on all fishing boats (e.g. handline, purse seine, ring net, gillnet) that unloaded their catch. Data were recorded on NSAP forms which include the following information based on each fishing trip:

A. Year
B. Month
C. Name of fishing ground
D. Region
E. Landing center
F. Date of sampling
G. Gear
H. Vessel name
I. No. of fishing days (time) of the actual fishing operation
J. Total catch by the vessel (no. of boxes/*bañeras* or weight)
K. Sample weight of the catch
L. Catch composition weight by species (scientific names)
M. Name and signature of the NSAP samplers/enumerators

Collected data are submitted monthly by the Project Leaders or Assistant Project Leaders to the National Fisheries Research and Development Institute (NFRDI) office. Monthly port sampling reports are entered and managed in the NSAP Database System. Two types of data were extracted from the NSAP Database (version 5.1): 1) sampling of each vessel, hereafter referred to as 'trip sample' and 2) raised estimates for each month for trips, effort (days) and catch by species, hereafter referred to a 'raised monthly estimates'.

Raised estimates are based on the sampling coverage which is defined as the coverage of unloaded vessels on days that were sampled (i.e. the proportion of sampled vessels' unloaded catch to the total unloaded catch for days that were sampled) and the coverage of the sampling days in the month.

Vessel name entries in the NSAP database were particularly problematic due to multiple spellings for a unique vessel. Quality control for purse seine vessels consisted of consolidating obvious multiple spellings to a single vessel assignment, which resulted in 389 unique purse seine vessels (3,485 trips). However, effort by many vessels consisted of only a few trips, so data were filtered for vessels which had conducted 20 or more trips. This resulted in a subset of 54 vessels (2,257 trips) for analyses.

Statistical methods to estimate species relative abundance

Trip sample data were used to estimate fishing effort and catch of individual species. Statistical methods were used to estimate 'relative abundance' or 'standardized CPUE' by removing effects due to vessel and fishing area. Generalized Linear Models (GLMs) were used to estimate relative abundance. The GLM predicts mean catch (μ_i) using three categorical variables with a log link as follows:

$$\log(\mu_i) = YR:QTR_i + Area_i + Vessel_i + \log(Effort_i)$$

where *YR:QTR* is the mean local abundance or quarter effect, *Area* is the area effect, *Vessel* is the vessel effect (vessel name) and offset *Effort* is the number of days during the fishing trip. Since a species may have instances of zero catch per quarter, a GLM with a negative binomial distribution was used to accommodate zero observations. The GLMs were fit in R (R Development Core Team, 2016, version 3.3.0 for Linux) with a MASS library. GLMs were initially fit with the *YR:QTR* effect and then with sequential addition of other explanatory variables. Model selection was based on the Bayesian Information Criterion (BIC). Relative abundance of each species was calculated from the GLM results using the 'predict.glm' routine by exponentiating *YR:QTR* while constraining other effects (*Area* and *Vessel*) to a single value. The GLM trends were normalized to facilitate comparison, such that the mean of the entire series is a value of 1.0.

The standardized CPUE for the Philippines purse seine fishery (Bigelow et al. 2014) used in the 2014 assessment (Rice et al. 2014) used a GLM that had separate *YR* and *Month* effects as:

$$\log(\mu_i) = Year_i + Month_i + Area_i + Vessel_i + \log(Effort_i)$$

The *YR* and *Month* effects were predicted and these effects were averaged for each quarter to correspond to the temporal resolution of the 2014 assessment (Rice et al. 2014). The current use of a combined *YR:QTR* effect was estimated to be consistent with other fishery CPUE standardization methods used in the 2016 Philippines standardized CPUE analysis (Bigelow et al. 2016) and 2016 (McKechnie et al. 2016) and 2019 skipjack tuna assessments (Vincent 2019).

3 Results and Conclusions

Purse seine fishery trends – effort, catch and nominal CPUE

Skipjack tuna made up the majority (~ 58.4%) of the purse seine catch from 2005 to 2018. The remainder of the catch was composed of yellowfin tuna (~ 16.7%), mackerel scad (*Decapterus macarellus*, 9.0%), bullet tuna, 7.8%), frigate tuna (4.1%), bigeye tuna (1.7%) and other species representing < 1% of the catch (Table 1). Monthly trends in raised effort and catch and nominal CPUE for the purse seine fleet based in General Santos City are illustrated in Figures 1–3. There are no estimates for months when sampling did not occur; therefore, gaps exist in the time-series.

Purse seine effort averaged ~ 592 boat days per month (Table 2) and generally ranged from 100 to 1,500 days (Figure 1). Effort during 2005 to 2009 was slightly higher than effort in 2010 to 2012. There has been an increase in purse seine effort from 2013 to 2018 due to re-opening of High Seas Pocket #1 for 36 Philippine flagged purse seine vessels.

Purse seine catch of skipjack tuna averaged ~ 2,113 mt per month, and from 2010 to 2012 there was a decline in purse seine catches of skipjack tuna (Figure 2). Skipjack tuna nominal CPUE in the purse seine fishery within a month averaged 4.371 mt per day (Table 1). The decline in skipjack tuna catch from 2010 to 2012 relates to the low CPUE experienced in the fishery (Figure 3).

Purse seine fishery trends – standardized CPUE

Model results of the GLM analysis are provided in Table 3. The lowest Bayesian Information Criteria (BIC) was for a GLM with a subset of vessels and the inclusion of *YR:QTR, Area* and *Vessel* effects. A model based on a subset of vessels and *YR:QTR* and *Vessel* effects was chosen as the model for inclusion in the 2019 skipjack tuna assessment (Vincent 2019). The model based on *YR:QTR, Area* and *Vessel* had a slightly higher explanatory ability (Table 3) and the trend after 2012 was slightly more positive (Figure 4). There were 18 *Area* designations in the database; however, *Area* was relatively non-informative in the model as the trips were dominated by four areas and there is an imbalance in the *Area* covariate as one area (International Waters) wasn't declared in the database prior to 2012 and was fished thereafter.

Standardized CPUE trends for the four models based on a subset of vessels are illustrated in Figure 4. Trends were consistent among the models from 2005 to 2012 and diverged thereafter. The divergence may be related to the larger amount of data from port sampling after 2012.

The standardized CPUE trend from the 2016 and 2019 assessments is illustrated in Figure 5. The trajectory among trends is similar, though the 2016 trend is less from 2006 to 2011 compared to the standardized CPUE indexes in this study.

4 References

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Table 1. Catch and species composition (%) estimated by NSAP for the purse seine fishery (2005–2018) in Region 12 and High Seas Pocket #1 based on BFAR NFRDI monitoring.

Species	**Catch (mt)**	**Percent (%)**
Skipjack tuna (*Katsuwonus pelamis*)	381,362	58.4
Yellowfin tuna (*Thunnus albacares*)	109,085	16.7
Mackerel scad (*Decapterus macarellus*)	58,787	9.0
Bullet tuna (*Auxis rochei*)	50,779	7.8
Frigate tuna (*Auxis thazard*)	26,526	4.1
Bigeye tuna (*Thunnus obesus*)	11,114	1.7
Rainbow runner (*Elagatis bipinnulata*)	6,337	1.0
Eastern little tuna (*Euthynnus affinis*)	5,481	0.8
Mahimahi (*Coryphaena hippurus)*	1,373	0.2
Other	2,444	0.4
Total	653,287	100.0

Table 2. Mean operational and catch characteristics estimated for the purse seine (3,485 trips) fishery operating in Region 12 (SOCCSKSARGEN) and High Seas Pocket #1. Estimates are based on raised data from BFAR NFRDI monitoring.

	Purse seine (2005–2018)
Number of trips per month	115
Number of days per month	592
Days per trip	4.7
Catch (mt) per month	3,959
Skipjack tuna catch (mt) per month	2,113
Catch (mt) per day	7.208
Skipjack tuna catch (mt) per day	4.371

Table 3. Results for Generalized Linear Models (GLMs) applied to skipjack tuna the purse seine fishery (2005–2018) in Region 12 and High Seas Pocket #1. The percent deviance explained is ((null deviance-residual deviance)/null deviance). Model selection was based on the Bayesian Information Criteria (BIC) and the selected model is in bold.

GLM model (vessel subset, 2,257 trips)	**Null deviance**	**Residual deviance**	**AIC**	**BIC**	**% Deviance explained**
YR:QTR	2,919	2,564	50,679	50,385	12.1
YR:QTR+Vessel	**3,566**	**2,520**	**50,537**	**49,969**	**29.3**
YR:QTR+Area	3,207	2,542	50,502	50,152	20.7
YR:QTR+Area+Vessel	3,610	2,517	50,588	49,964	30.2
GLM Model (all vessels, 3,485 trips)					
YR:QTR	4,580	3,991	77,631	77,312	12.8
YR:QTR+Vessel	6,296	3,881	79,737	76,949	38.3
YR:QTR+Area	5,167	3,945	77,246	76,832	23.6
YR:QTR+Area+Vessel	6,398	3,876	79,493	76,921	39.4

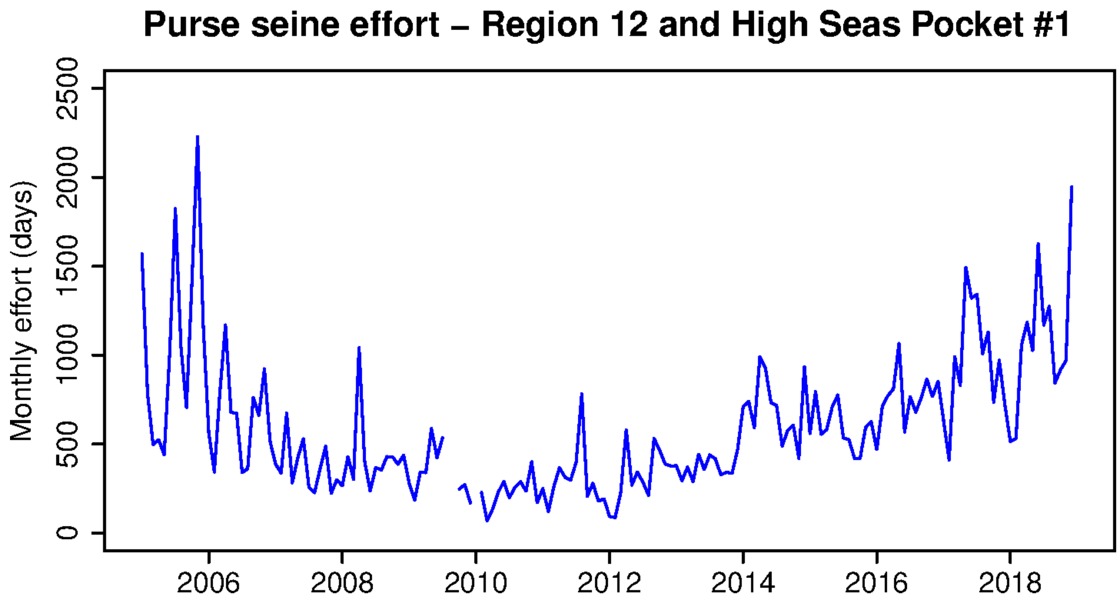

Figure 1. Raised monthly effort in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on BFAR NFRDI monitoring.

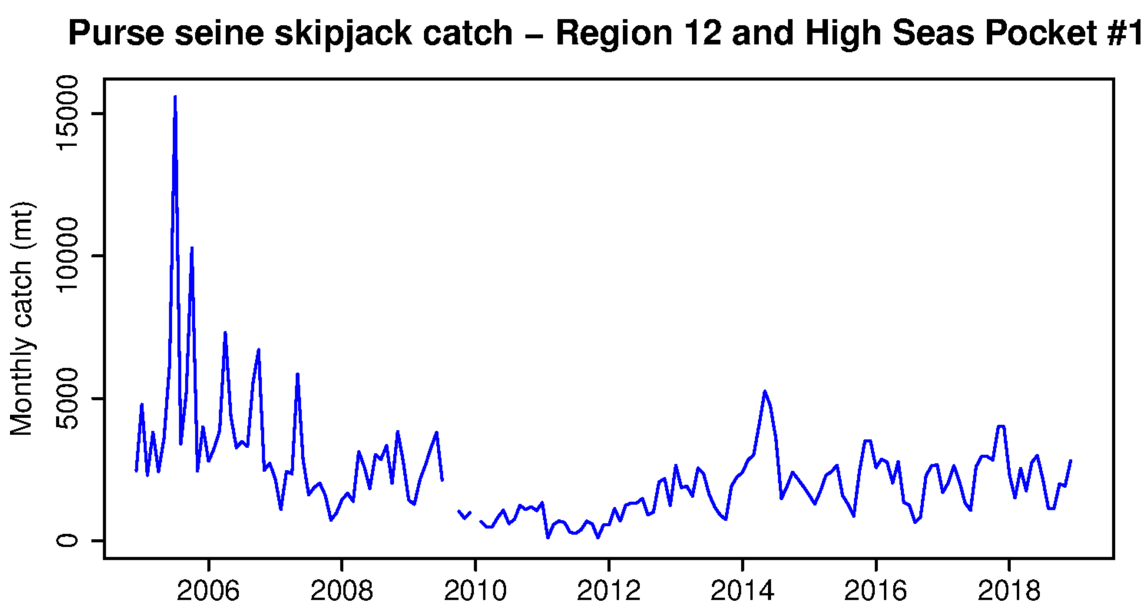

Figure 2. Raised monthly skipjack tuna catch in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on BFAR NFRDI monitoring.

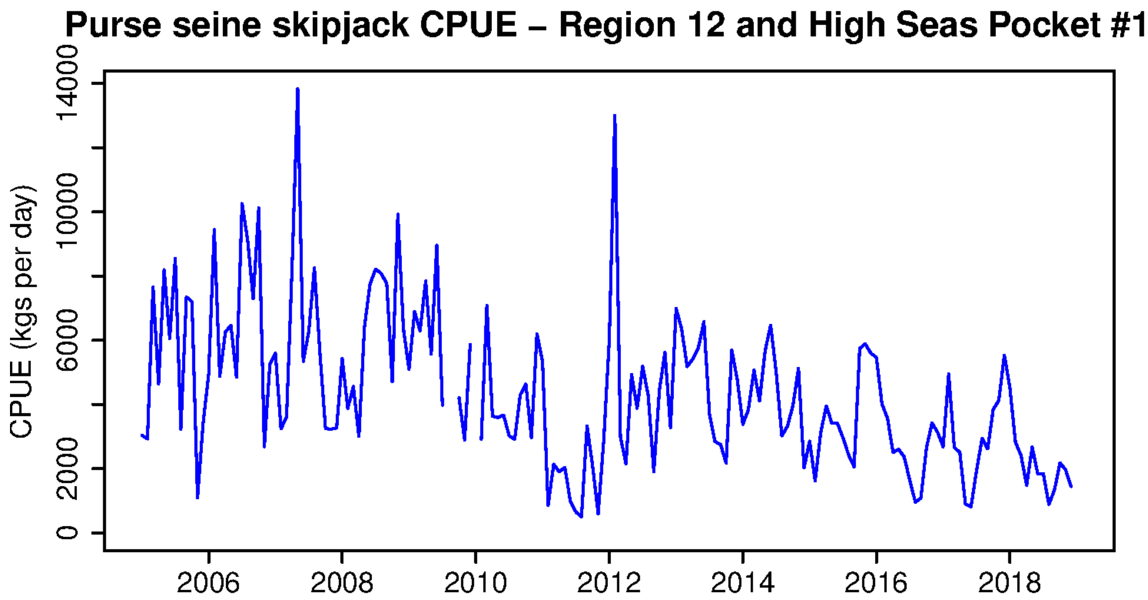

Figure 3. Nominal monthly skipjack tuna CPUE in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on BFAR NFRDI monitoring.

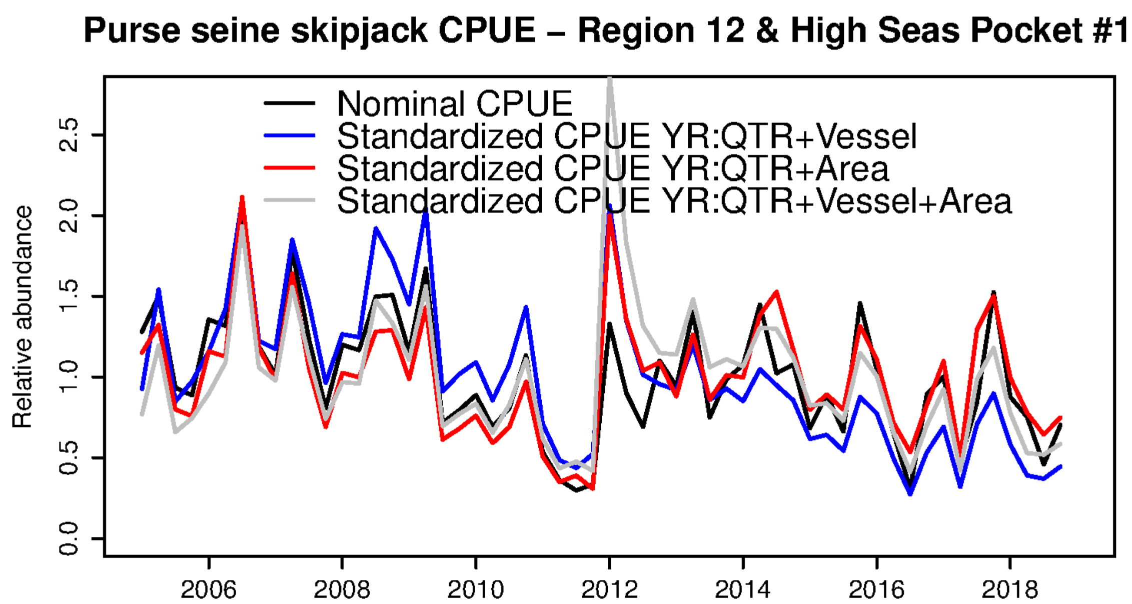

Figure 4. Quarterly relative abundance for skipjack tuna in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.

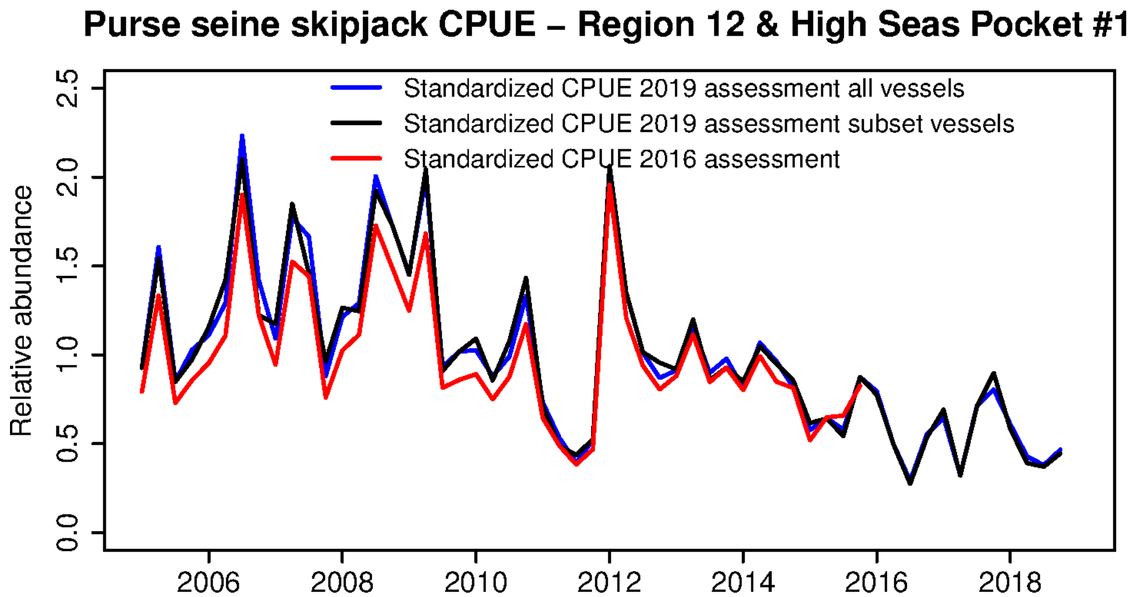

Figure 5. Comparison of Philippine relative abundance indices used in the 2016 and 2019 skipjack tuna assessment for the western and central Pacific Ocean. Indices are for skipjack tuna in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.