SCIENTIFIC COMMITTEE
SIXTEENTH REGULAR SESSION

ELECTRONIC MEETING
12–20 August 2020

Relative abundance of yellowfin tuna for the purse seine and handline fisheries operating in the Philippines Moro Gulf (Region 12) and High Seas Pocket #1[1]

WCPFC-SC16-2020/ SA-IP-19

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1 Working Paper WP-20-004. Issued 26 August 2020.

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https://doi.org/10.25923/p0j9-3v54

Abstract

Port sampling data from the National Stock Assessment Program (NSAP) in Region 12 were used 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 and the handline fishery operating in Region 12. A quarterly standardized CPUE index was produced for the purse seine (2005 to 2019) and handline (2004 to 2019) fishery for use in the 2020 WCPFC yellowfin tuna assessment. Standardized CPUE was estimated using Generalized Linear Models (GLMs) and removing effects due to vessel and area (fishing ground). 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. There were 28 *Area* designations in the database; however, *Area* was relatively non-informative in the model as fishing trips were dominated by a few 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 ringnets, 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 are found throughout the year in all Philippine waters but are abundant in Moro Gulf, Sulu Sea, and Sulawesi Sea off Mindanao Island. Large landings of these species occur in General Santos City where seven out of nine tuna canneries are located.

The objective of this study was to use port sampling data from the National Stock Assessment Program (NSAP) in Region 12 to estimate effort, catch, CPUE, standardized CPUE for yellowfin tuna in the purse seine fishery operating in the southern Philippines (Region 12, SOCCSKSARGEN) and High Seas Pocket #1 and handline fishery operating in Region 12.

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 General Santos City Fishport Complex (GSCFPC). The GSCFPC is the major tuna landing site in Mindanao for handline, purse seine, and ringnet fisheries. The NSAP sampling was initiated in 1997, though sampling was sparse for several years. Analyses considered purse seine from 2005 to 2016 and handline from 2004 to 2016. With Western Pacific East Asia – Oceanic Fisheries Management Project funding, the sampling ratio of unloaded vessels to total vessels 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 2012, the sampling protocol was altered to monitor up to 100% unloadings from vessel activity in High Seas Pocket #1 even if landings occur on a non-sampling day.

Sampling occurred where possible on all fishing boats (e.g. handline, purse seine, ringnet, 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 Projects 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 as '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. Annual coverage prior to 2009 was 10% for the handline fishery and improved to 31% from 2008 to 2019. Annual coverage was 8% for the purse seine fishery from 2005 to 2012. Coverage improved to 50% in the purse seine fishery during 2013 to 2019 because more unloadings were monitored. 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 the 419 purse seine vessels.

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 year and quarter effect, *Area* is the area effect, *Vessel* is the vessel effect (vessel name), and offset *Effort* is the number of days of 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 3.6.2) 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 Akaike Information Criterion (AIC). 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 are normalized to facilitate comparison, such that the mean of the entire series is a value of 1.0. Canonical standard deviations were estimated with library canonical variances.r.

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

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

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 (Davies 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 2017 (Tremblay-Boyer et al. 2017) and 2020 assessments (Vincent et al. 2020).

3 Results and Conclusions

Handline fishery trends – effort and catch

Yellowfin tuna comprised ~83.1% of the handline catch during 2004 to 2019 (Table 1) and typically varies between 80 to 90% annually (NFRDI/BFAR 2012). The remainder of the catch is composed of blue marlin (*Makaira mazara,* ~10.7%), bigeye tuna (~3.9%), albacore (*Thunnus alalunga,* ~1.2%) and other species of <1% (Table 1). Monthly trends in effort, catch, nominal CPUE, and relative abundance for the handline 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 effort, catch, nominal CPUE, and relative abundance time-series. Handline effort averaged ~8,200 boat days per month and generally ranged from 5,000 to 15,000 days (Figure 1). Effort during 2006 to mid-2009 was higher than from mid-2009 until the end of 2019. Handline effort averaged 21 boat days per trip, although there has been an increase over time due to vessels traveling farther away from port in an attempt to obtain higher catch rates and/or the use of larger vessels that can remain at sea for longer durations. Handline catch of yellowfin tuna averaged ~728 mt per month during 2004–2019 with low catches in years 2012 and 2015 (Figure 2).

Handline species trends – nominal CPUE and relative abundance

Monthly yellowfin tuna nominal CPUE for the handline fleet averaged 91 kg per boat day and fluctuated from 40 to 170 kg per boat day (Figure 3). The CPUE increased from 2004 to 2007, declined precipitously from 2008 until the end of 2009, rebounded strongly in 2010, and was relatively stable from 2011 to 2019, though there is high seasonal variability.

The GLM analysis considered four models based on effects of: 1) *YR:QTR* (Figure 3 black line), 2) *YR:QTR* and *Vessel* (Figure 3 blue line), 3) *YR:QTR* and *Area* (Figure 3 red line), and 4) *YR:QTR*, *Vessel*, and *Area* (Figure 3 grey line). Results and diagnostics indicated that models based on *YR:QTR* and *Vessel* and *YR:QTR, Vessel,* and *Area* were statistically preferred. Relative trends were similar for all models, with *YR:QTR* and *Area* having the most optimistic trend. Inspection of the *Area* declaration indicated that Moro Gulf was declared for ~53% of the fishing areas from 2004 to 2019; therefore, the area effect is not very informative as an explanatory effect in the model. The trend based on *YR:QTR* and *Vessel* is considered the most representative to illustrate relative abundance of yellowfin tuna for the handline.

In the comparison between nominal yellowfin CPUE and relative abundance, the relative abundance trend has less variability and generally follows the trend in nominal CPUE. While the GLMs included a *Vessel* effect, in reality the relative abundance trend may be biased because the analysis does not adequately quantify efficiency for each handline vessel. The nominal increase in CPUE for yellowfin tuna (Figure 3) from 2004 to the end of 2008 may be related to increased vessel efficiency, such as handline vessels having an increasing number of *pakura* or small boats with engines that were introduced in 2005. Thus, the increasing CPUE and relative abundance in reality may relate to vessels with more *pakura* catching more fish per boat day, i.e. an increase in catchability.

The standardized CPUE trend from the 2017 assessment is illustrated in Figure 5. The trajectory among trends is similar as the 2017 and 2020 indices were based on the same explanatory variables by the GLMs.

Purse seine fishery trends – effort, catch and nominal CPUE

Yellowfin tuna comprised 16.7% of the purse seine catch from 2005 to 2019. The remainder of the catch was composed of skipjack tuna (59.0%), mackerel scad (*Decapterus macarellus*, 8.9%), bullet tuna (*Auxis rochei*, 7.4%), frigate tuna (*Auxis thazard*, 4.0%), bigeye tuna (1.8%), and other species representing less than ~2% of the catch (Table 4). Monthly trends in raised effort and catch and nominal CPUE for the purse seine fleet based in General Santos City are illustrated in Figures 6–8.

Purse seine effort averaged ~648 boat days per month (Table 2) and generally ranged from 100 to 1,500 days (Figure 6). 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 2019 due in part to the re-opening of High Seas Pocket #1 for a limited number of Philippine flagged purse seine vessels.

Purse seine catch of yellowfin tuna averaged ~526 mt per month, and from 2010 to 2012, there was a decline in purse seine catches of yellowfin tuna (Figure 7). Yellowfin nominal CPUE in the purse seine fishery averaged 0.91 mt per day and was low during 2010 and 2011 (Figure 8).

Purse seine fishery trends – standardized CPUE

Model results of the GLM analysis are provided in Table 5. The highest explanatory ability and lowest AIC were for GLMs with the inclusion of *YR:QTR, Area,* and *Vessel* effects. There were 18 *Area* designations in the database; however, *Area* was relatively non-informative in the model as the trips were dominated by three areas. Standardized CPUE trends for the four models are illustrated in Figure 9. Trends were consistent among the models from 2005 to 2014, and nominal CPUE diverged from the other three models in 2014 and was more optimistic.

A model based on *YR:QTR* and *Vessel* effects was chosen as the model for inclusion in the 2017 yellowfin tuna assessment (Vincent et al. 2020). The model based on *YR:QTR, Area,* and *Vessel* had a slightly higher explanatory ability; however, there is an imbalance in the *Area* covariate as one area (International Waters) was not declared in the database prior to 2012, but was fished thereafter.

The standardized CPUE trend from the 2017 and 2020 assessments is illustrated in Figure 10 and the trajectories among trends is similar.

4 References

Bigelow, K., E. Garvilles, and N. Barut. 2014. Relative abundance of skipjack and yellowfin in the Moro Gulf (Philippine Region 12). WCPFC- SC10-2014/SA-WP-09, Majuro, Republic of the Marshall Islands, 6–14 August 2014.

Davies, N., S. Harley, J. Hampton, and S. McKechnie. 2014. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. WCPFC-SC10-2014/SA-WP-04, Majuro, Republic of the Marshall Islands, 6–14 August 2014.

NFRDI and BFAR. 2012. Philippines tuna fisheries profile. Bureau of Fisheries and Aquatic Resources National Fisheries Research and Development Institute Republic of the Philippines and Western and Central Pacific Fisheries Commission. 84p.

Tremblay-Boyer, L, S. McKechnie, G. Pilling, and J. Hampton. 2017. Stock assessment of yellowfin tuna in the Western and Central Pacific Ocean. WCPFC-SC13-2017/SA-WP- XX, Rarotonga, Cook Islands 9-17 August 2017.

Vincent, M., N. Ducharme Barth, J. Hampton, P. Hamer, P. Williams, G. Pilling. 2020. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. WCPFC-SC16-2020/SA-04, 12-20 August 2020.

Table 1. Catch and species composition (%) estimated by NSAP for the handline fishery (2004 to 2019) in Region 12 (SOCCSKSARGEN) based on NSAP monitoring.

Species	**Catch (mt)**	**Percent (%)**
Yellowfin tuna (*Thunnus albacares*)	138,892.9	83.12%
Blue marlin (*Makaira mazara*)	17,839.8	10.68%
Bigeye tuna (*Thunnus obesus*)	6,501.0	3.89%
Albacore (*Thunnus alalunga*)	1,915.1	1.15%
Sailfish (*Istiophorus platypterus*)	791.0	0.47%
Black marlin (*Makaira indica*)	682.9	0.41%
Swordfish (*Xiphias gladius*)	370.0	0.22%
Moonfish (*Lampris guttatus*)	62.8	0.04%
Other	39.3	0.02%
Total	167,094.7	100%

Table 2. Mean operational and catch characteristics for handline (11,890 trips) and purse seine (3,197 trips) fisheries operating in Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 based on NSAP monitoring.

	Handline (2004–2019)	**Purse seine (2005–2019)**
Number of trips per month	386	114
Number of days per month	8,048	648
Days per trip	21.2	5.2
Catch (mt) per month	888	3,991
Catch (kgs) per day per vessel	109.4	6,893

Table 3. Results for Generalized Linear Models (GLMs) applied to yellowfin tuna in the handline fishery (2004 to 2019) in Region 12 (SOCCSKSARGEN). The percent deviance explained is ((null deviance-residual deviance)/null deviance). Model selection was based on the Akaike Information Criteria (AIC).

GLM Model	Null deviance	Residual deviance	AIC	% deviance explained
YR:QTR	14,896	13,779	202,817	7.5
YR:QTR+ Vessel	28,558	13,198	238,462	53.7
YR:QTR+ Area	15,329	13,748	202,032	10.3
YR:QTR+ Area+Vessel	28,993	13,194	238,469	54.4

Table 4. Catch and species composition (%) estimated by NSAP for the purse seine fishery (2005 to 2016) in Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 based on NSAP monitoring.

Species	**Catch (mt)**	**Percent (%)**
Skipjack tuna (*Katsuwonus pelamis*)	410,805.1	59.0
Yellowfin tuna (*Thunnus albacares*)	116,251.3	16.7
Mackerel scad (*Decapterus macarellus*)	61,719.2	8.9
Bullet tuna (*Auxis rochei*)	51,277.8	7.4
Frigate tuna (*Auxis thazard*)	27,986.6	4.0
Bigeye tuna (*Thunnus obesus*)	12,419.4	1.8
Eastern little tuna (*Euthynnus affinis*)	5,557.6	0.8
Rainbow runner (*Elagatis bipinnulata*)	6,491.5	0.9
Mahimahi (*Coryphaena hippurus)*	1,438.4	0.2
Other	2,553.1	0.4
Total	696,500.0	100.0

Table 5. Results for Generalized Linear Models (GLMs) applied to yellowfin tuna in the purse seine fishery (2005 to 2019) in Region 12 (SOCCSKSARGEN) and High Seas Pocket #1. The percent deviance explained is ((null deviance-residual deviance)/null deviance). Model selection was based on the Akaike Information Criteria (AIC).

GLM Model	Null deviance	Residual deviance	AIC	% deviance explained
YR:QTR	5,067	4,677	77,471	7.7
YR:QTR+ Vessel	7,081	4,509	79,232	36.3
YR:QTR+ Area	5,849	4,608	76,879	21.2
YR:QTR+ Area+Vessel	7,253	4,500	79,240	37.9

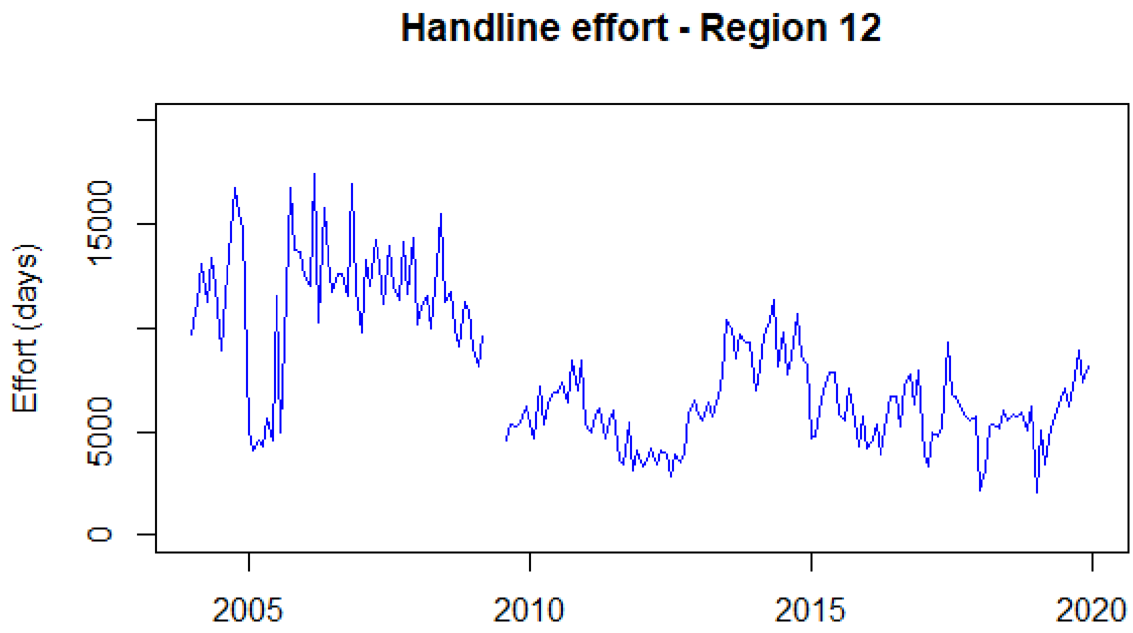

Figure 1. Raised monthly effort in the Philippine Region 12 (SOCCSKSARGEN) handline fishery based on NSAP monitoring.

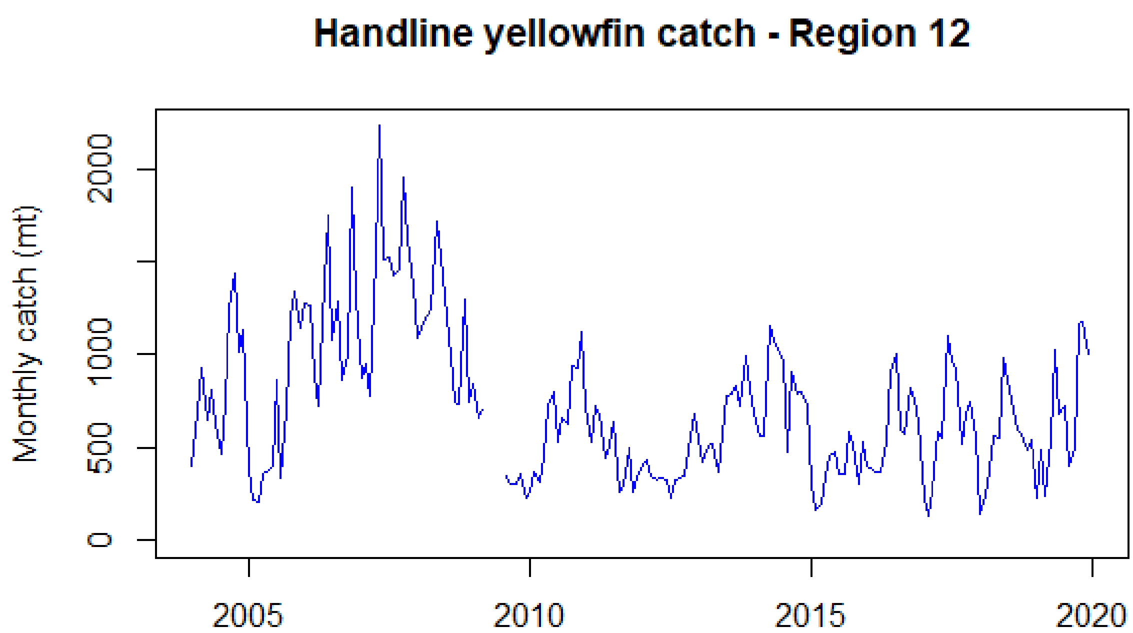

Figure 2. Raised monthly yellowfin tuna catch in the Philippine Region 12 (SOCCSKSARGEN) handline fishery based on NSAP monitoring.

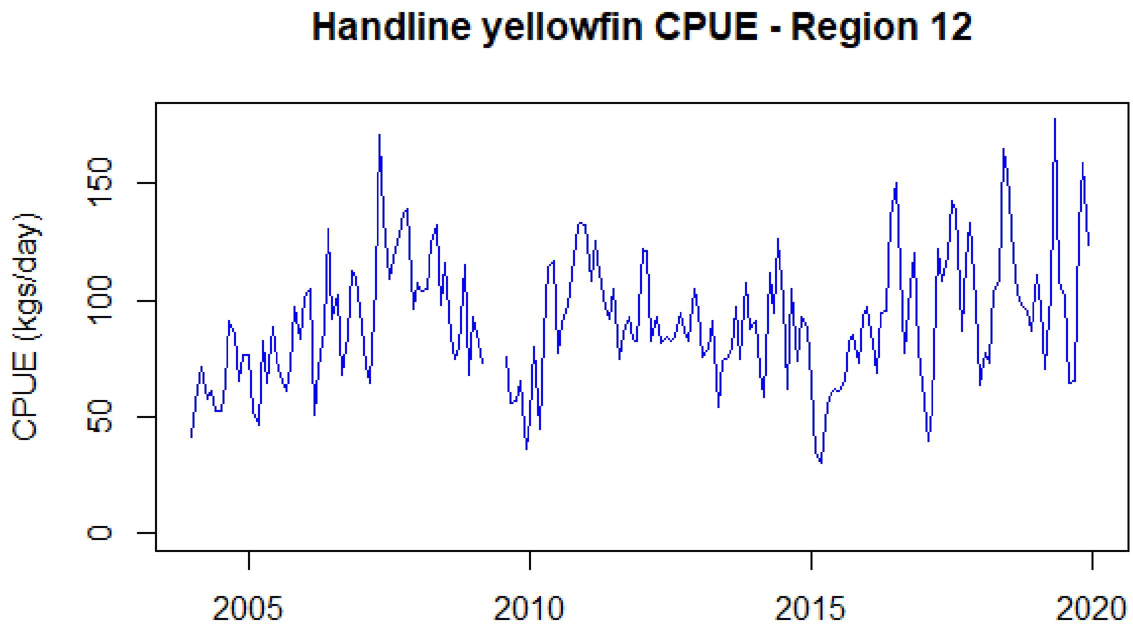

Figure 3. Nominal monthly yellowfin tuna CPUE in the Philippine Region 12 (SOCCSKSARGEN) handline fishery based on NSAP monitoring.

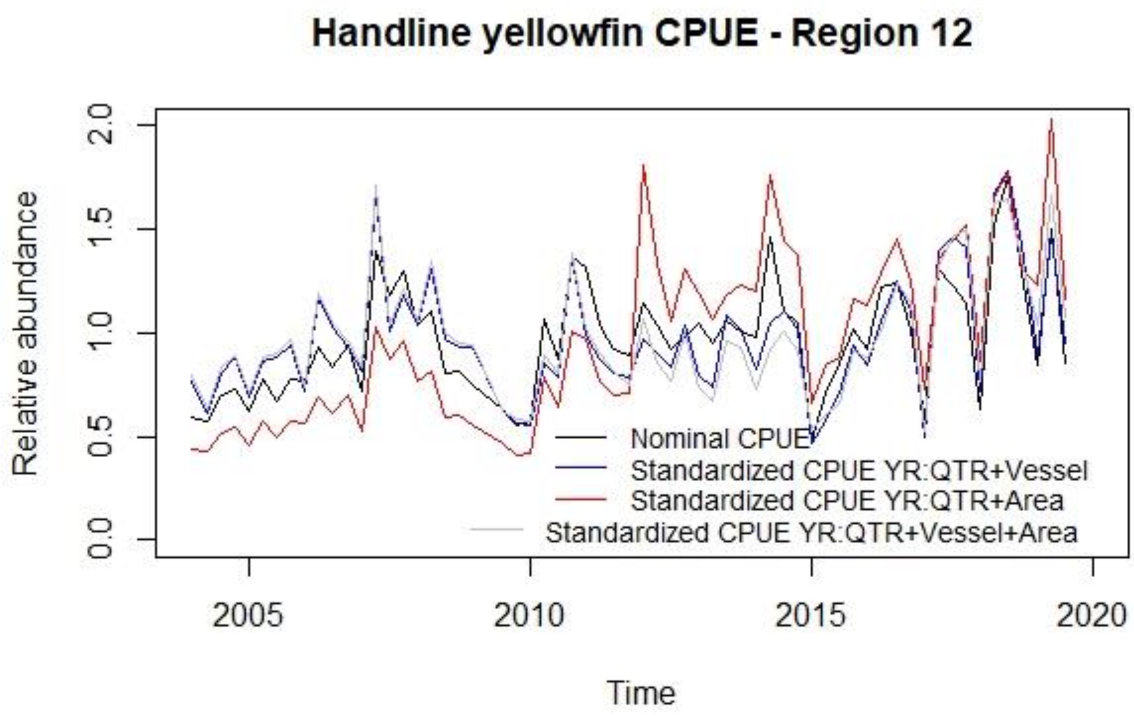

Figure 4. Quarterly relative abundance for yellowfin tuna in the Philippine Region 12 (SOCCSKSARGEN) handline fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.

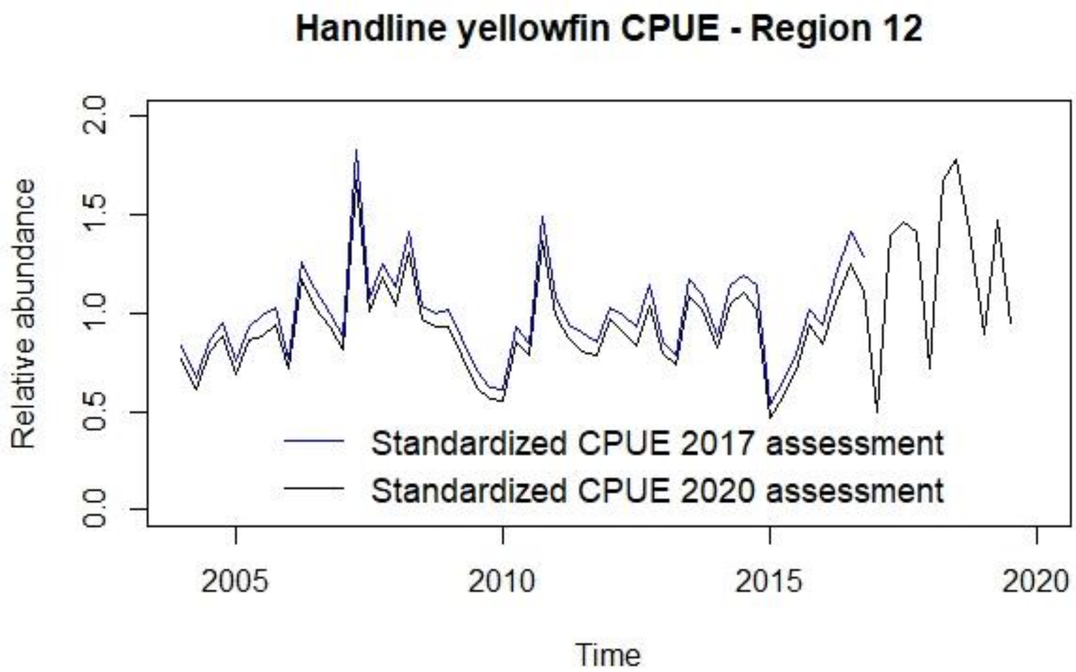

Figure 5. Comparison of Philippine relative abundance indices used in the 2017 and 2020 yellowfin tuna assessments for the western and central Pacific Ocean. Indices are for yellowfin tuna in the Philippine Region 12 (SOCCSKSARGEN) handline fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.

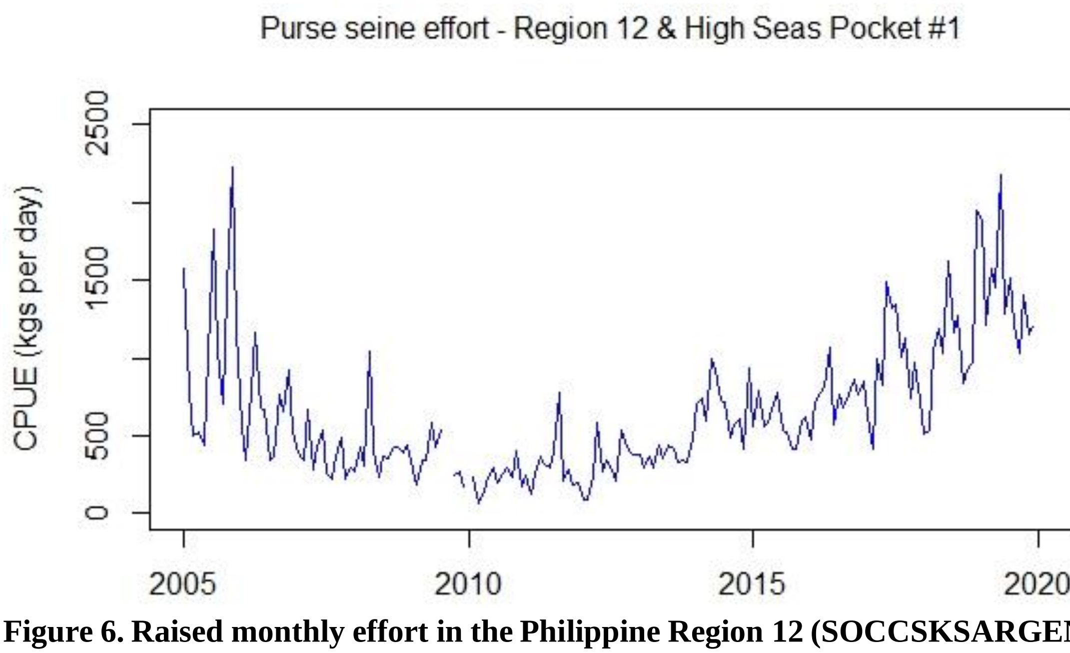

Figure 6. Raised monthly effort in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on NSAP monitoring.

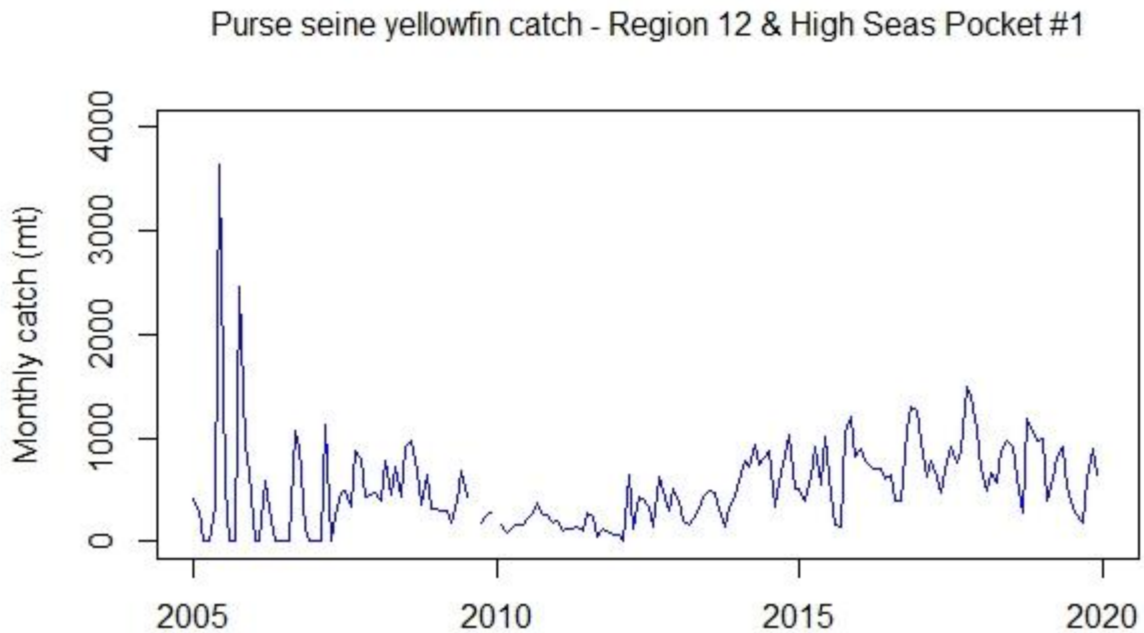

Figure 7. Raised monthly yellowfin tuna catch in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on NSAP monitoring.

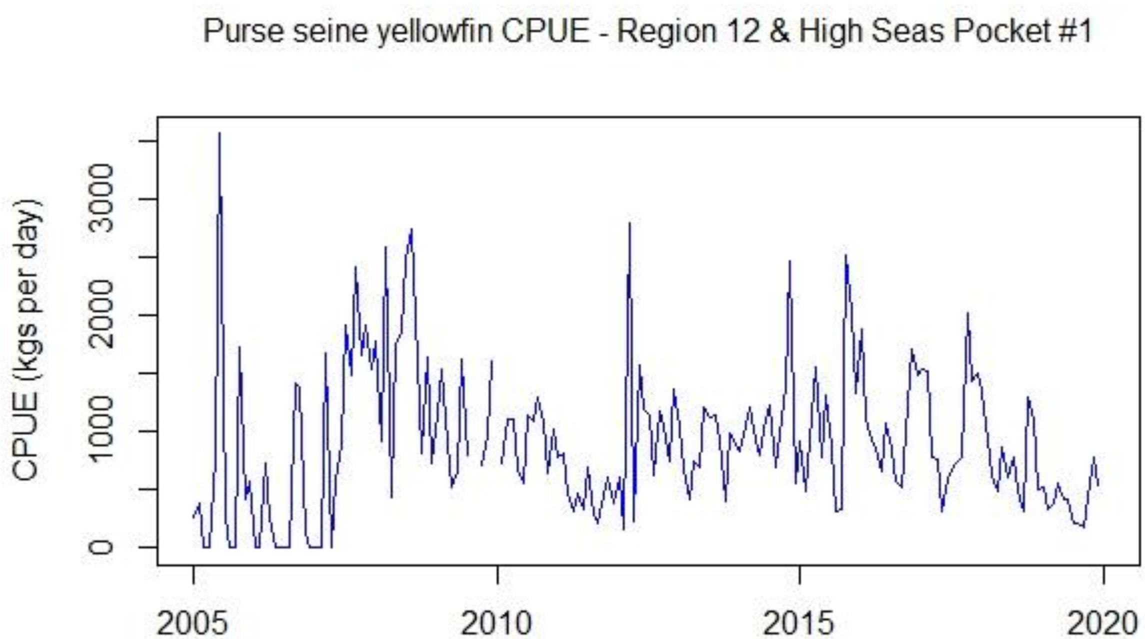

Figure 8. Nominal monthly yellowfin tuna CPUE in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on NSAP monitoring.

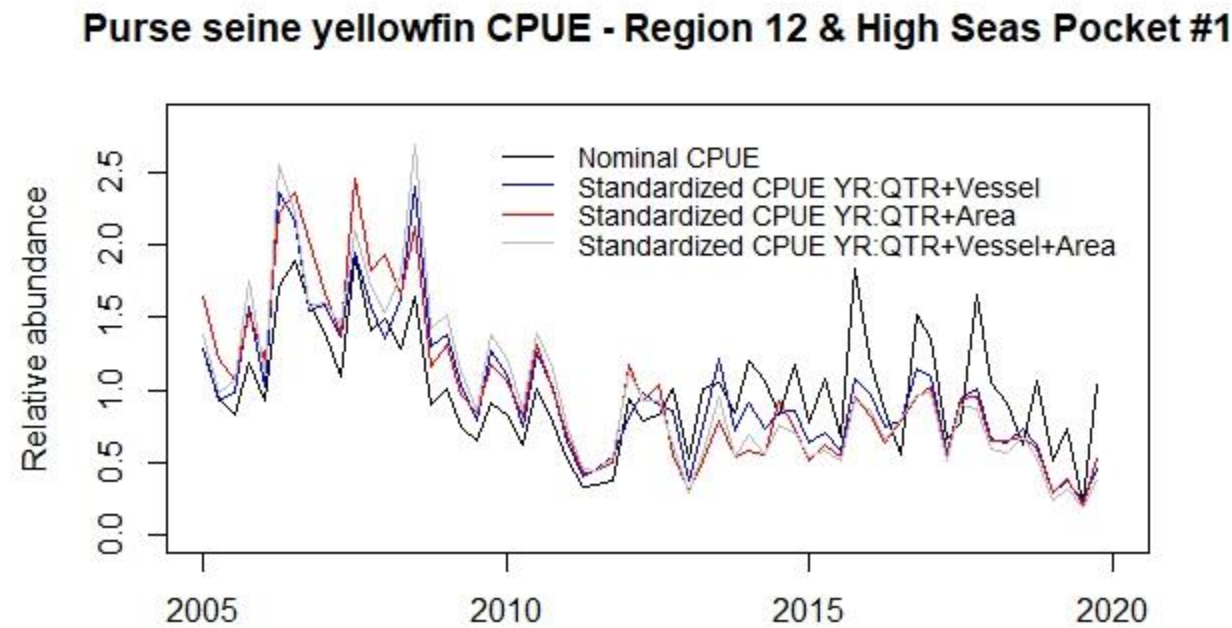

Figure 9. Quarterly relative abundance for yellowfin tuna in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.

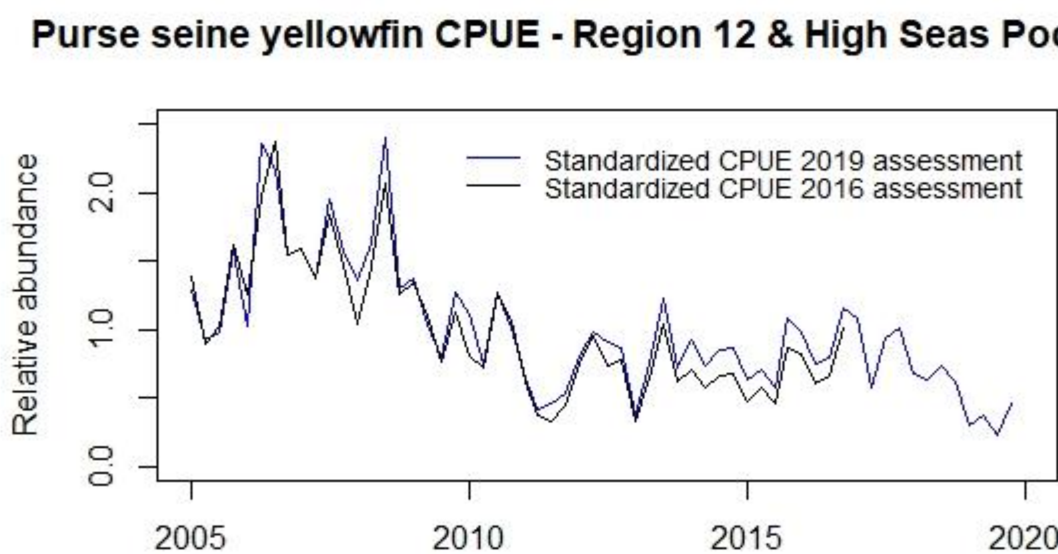

Figure 10. Comparison of Philippine relative abundance indices used in the 2014 and 2017 yellowfin tuna assessments for the western and central Pacific Ocean. Indices are for yellowfin tuna in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.