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

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Abstract

Port sampling data 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. A quarterly standardized CPUE index from 2005 to 2015 was produced for use in the 2016 WCPFC skipjack assessment. Standardized CPUE was estimated by Generalized Linear Models (GLMs) by removing effects due to vessel and fishing ground (area). The index for the 2014 assessment used a GLM that predicted monthly CPUE with year, month and vessel effects. 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 12 *Area* designations in the database; however, *Area* was relatively non-informative in the model as fishing trips were dominated by 3 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 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.
A ringnet fishery also captures skipjack tuna in the southern Philippines (Region 12, SOCCSKSARGEN) and High Seas Pocket #1. A standardized index was developed for skipjack in the ringnet fishery; however, the index is not presented in this study as it was decided at the pre-assessment workshop (SPC-OFP 2016a) that the Philippine purse seine index was more informative for the skipjack 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 ringnet fisheries. 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%) 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 increased to 48%, 58% and 51% during 2013, 2014 and 2015, respectively.

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 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.

The NSAP sampling was initiated in 1997, though sampling was sparse for several years. Analyses considered purse seine from 2005–2015. With WPEA-OFMP funding, sampling of unloaded vessels to total vessels has especially improved since 2010. Overall coverage was 6.5% during 2005–2009, 11.9% during 2010–2012 and 42.4% during 2013–2015.

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 consequently reduced the number of purse seine vessels in the database from 301 to 250.

Statistical methods to estimate species relative abundance

Trip sample data were used to estimate fishing effort and catch of individual species. Statistical methods are 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 are 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 assessment (SPC-OFP 2016b).

3 Results and Conclusions

Purse seine fishery trends – effort, catch and nominal CPUE

Skipjack tuna (*Katsuwonus pelamis*) comprised the majority (~ 58.2%) of the purse seine catch from 2005 to 2012. The remainder of the catch was composed of yellowfin tuna (~ 15.3%), bullet tuna (*Auxis rochei*, 9.0%), mackerel scad (*Decapterus macarellus*, 8.9%) frigate tuna (*Auxis thazard*, 4.5%), 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 ~ 410 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 2015 due to re-opening of High Seas Pocket #1 for a limited number of Philippine flagged purse seine vessels.

Purse seine catch of skipjack averaged ~ 2,093 mt per month, and from 2010 to 2012 there was a decline in purse seine catches of skipjack (Figure 2). Skipjack nominal CPUE in the purse seine fishery within a month averaged 4.849 mt per day and (Table 1). The decline in skipjack 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 highest explanatory ability and lowest BIC were for GLMs with the inclusion of *YR:QTR, Area* and *Vessel* effects. There were 12 *Area* designations in the database; however, *Area* was relatively non-informative in the model as the trips were dominated by 3 areas. A recommendation from the pre-assessment workshop (SPC-OFP 2016a) was to spatially aggregate some of the sparsely fished areas into 3 main areas: Moro Gulf, International Waters and Mati. The corresponding GLM results with 3 main areas (not illustrated) were similar to results with all areas.

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

A model based on *YR:QTR* and *Vessel* effects was chosen as the model for inclusion in the 2016 skipjack assessment (ref TBD). The model based on *YR:QTR, Area* and *Vessel* had a slightly higher explanatory ability and the trend after 2012 was slightly more positive; however, 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.

The standardized CPUE trend from the 2014 and 2016 assessment is illustrated in Figure 5. The trajectory among trends is similar, though the 2014 trend is smoother and has less variability than the standardized CPUE index in this study because of the different covariates related to time (*Year* and *Month*; *YR:QTR*) estimate by the GLMs.

4 References

Bigelow, K., Garvilles, E. 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.

Rice, J., Harley, S., Davies, N. and J. Hampton 2014. . Stock assessment of skipjack tuna in the western and central Pacific Ocean. WCPFC- SC10-2014/SA-WP-05, Majuro, Republic of the Marshall Islands, 6–14 August 2014.

SPC-OFP. 2016a. Report from the 2016 pre-assessment workshop. WCPFC-SC12-SA-IP-01, Bali, Indonesia, 3–11 August 2016.

SPC-OFP. 2016b. SPC Assessment of skipjack tuna in the WCPO. WCPFC-SC12-SA-WP-04, Bali, Indonesia, 3–11 August 2016.

Table 1. Catch and species composition (%) estimated by NSAP for the purse seine fishery (2005–2015) in Region 12 and High Seas Pocket #1 based on BFAR NFRDI monitoring.

Species	**Catch (mt)**	**Percent (%)**
Skipjack tuna (*Katsuwonus pelamis*)	301,445.7	58.2
Yellowfin tuna (*Thunnus albacares*)	79,481.9	15.3
Bullet tuna (*Auxis rochei*)	46,854.8	9.0
Mackerel scad (*Decapterus macarellus*)	46,022.6	8.9
Frigate tuna (*Auxis thazard*)	23,544.4	4.5
Bigeye tuna (*Thunnus obesus*)	8,557.2	1.7
Eastern little tuna (*Euthynnus affinis*)	4,900.2	0.9
Rainbow runner (*Elagatis bipinnulata*)	4,246.1	0.8
Mahimahi (*Coryphaena hippurus)*	1,129.0	0.2
Other	1,646.0	0.3
Total	517,827.8	100.0

Table 2. Mean operational and catch characteristics estimated for the purse seine (1,779 trips) fishery operating in Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 Estimates are based on raised data from BFAR NFRDI monitoring.

	Purse seine (2005–2015)
Number of trips per month	111
Number of days per month	496
Days per trip	4.1
Catch (mt) per month	4,014
Skipjack catch (mt) per month	2,093
Catch (kgs) per day	7,984
Skipjack catch (kgs) per day	4,859

Table 3. Results for Generalized Linear Models (GLMs) applied to skipjack tuna the purse seine fishery (2005–2015) 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).

GLM Model	Null deviance	Residual deviance	AIC	BIC	% deviance explained
YR:QTR	2,221	1,968	39,328	39,107	11.4
YR:QTR+ Vessel	3,057	1,925	40,526	38,082	37.0
YR:QTR+ Area	2,436	1,954	39,215	38,940	19.8
YR:QTR+ Area+Vessel	3,088	1,924	40,588	38,090	37.7

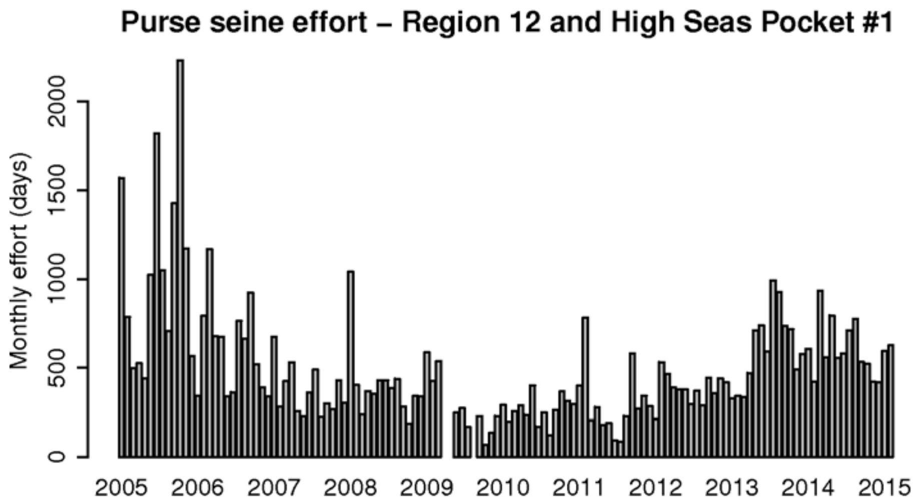

Figure 1. Raised monthly effort in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on BFAR NFRDI monitoring.

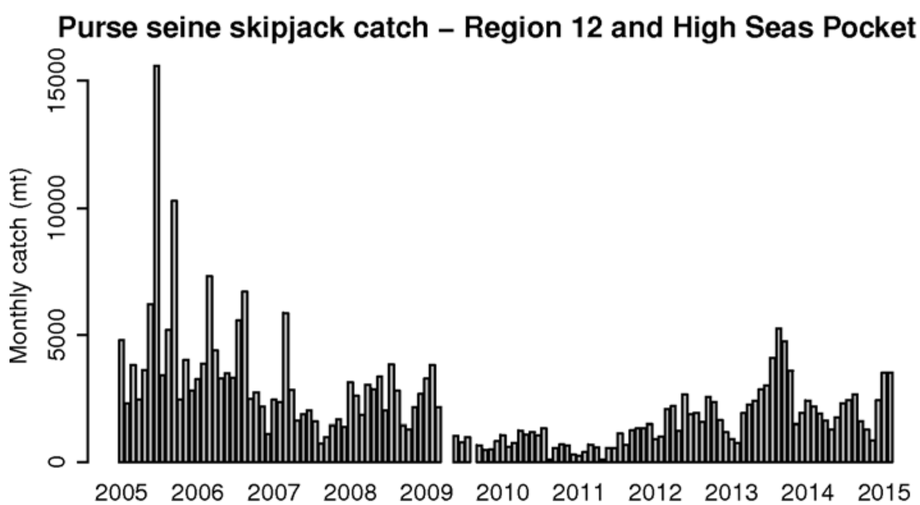

Figure 2. Raised monthly skipjack tuna catch in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on BFAR NFRDI monitoring.

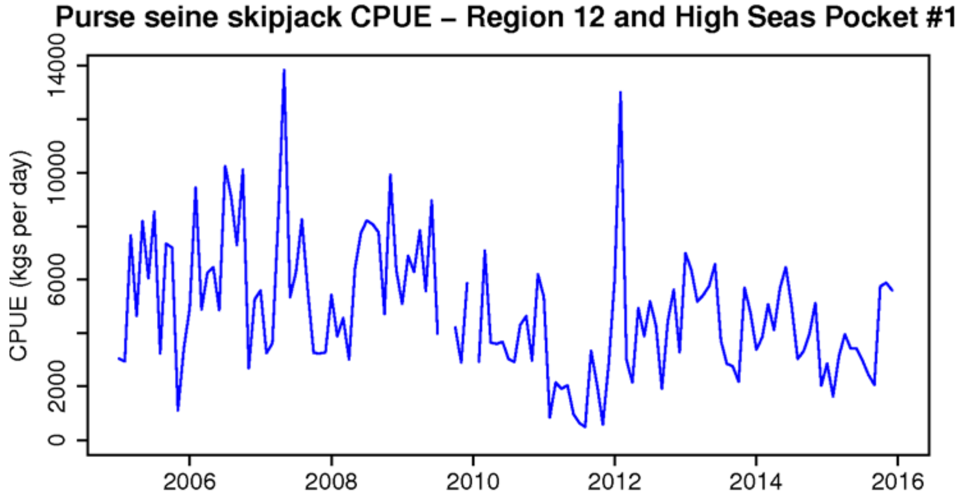

Figure 3. Nominal monthly skipjack tuna CPUE in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery based on BFAR NFRDI monitoring.

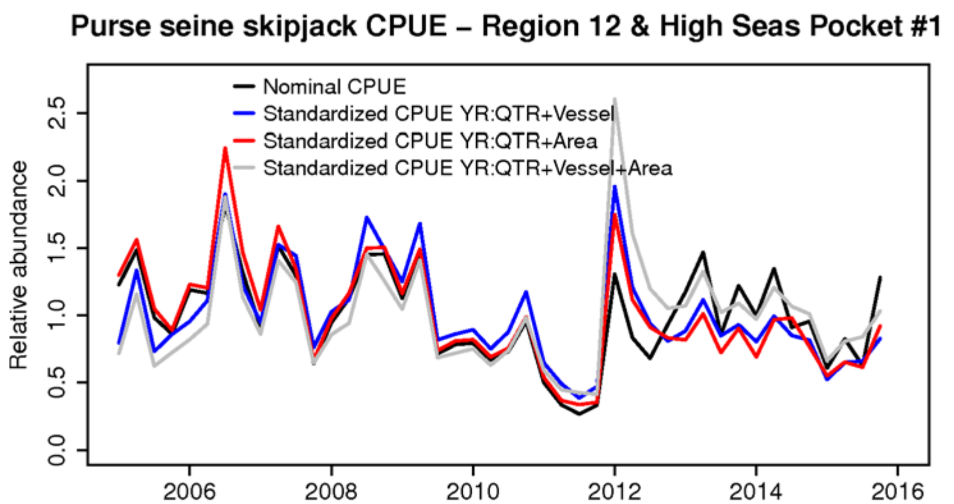

Figure 4. Quarterly relative abundance for skipjack tuna in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.

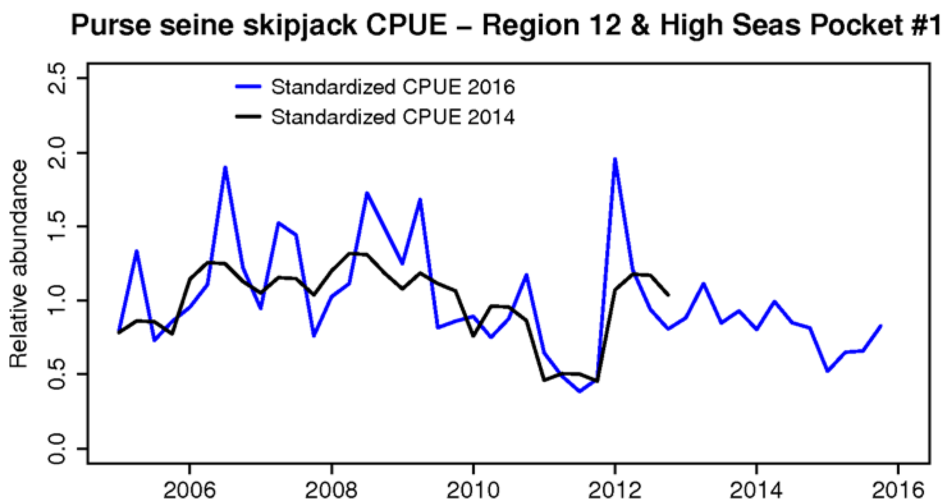

Figure 5. Comparison of Philippine relative abundance indices used in the 2014 and 2016 skipjack assessment for the western and central Pacific Ocean. Indices are for skipjack tuna in the Philippine Region 12 (SOCCSKSARGEN) and High Seas Pocket #1 purse seine fishery as determined by Generalized Linear Models (GLMs). Each series is normalized to a mean value of 1.0.