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Standardization of kawakawa (*Euthynnus affinis*) catch rates of drift gillnet fisheries in Sultanate of Oman

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Abstract

Using available kawakawa nominal catch and effort data from gillnet fisheries in Oman (2002-2011), we standardized nominal CPUE (N_CPUE) by GLM. Standardized CPUE (STD_CPUE) suggested that it increased from 2002 to 2005 then decreased afterwards to 2011.

Contents

1. Introduction

CPUE is the important information to learn the rough trends the stock abundance and also to conduct the stock assessment. But quality of CPUE should be good, otherwise we cannot use. In Oman, to now we have not yet explored any nominal CPUE for neritic tuna. In the occasion of the on-going project, *"Management of the exploited coastal tuna fisheries resources of the Sultanate of Oman"*, we explored available nominal CPUE in the catch and effort data set available in the statistical section, Ministry of Agriculture & Fisheries, Sultanate of Oman. As a first trial, we attempted to standardize kawakawa nominal_CPUE.

2. Kawakawa: biology, ecology and fisheries in Oman

Biology and ecology

Oman has 3,165 km coastline and its location is unique as it comprises of Oman Sea and Arabia Sea. Both Seas have different oceanographic and marine ecosystem features and have rich fisheries resources. Many pelagic species were recoded and kawakawa, *Euthynnus affinis* (Cantor, 1849) is one of them. This species is widely distributed in the world. In the Indian Ocean, kawakawa is distributed in its rim from Africa, middle-east, S & SE Asia to Australia. In Oman, this species is found along the entire coastline including the Arabian Gulf (Al-Abdessalaam, 1995).

Generally kawakawa forms small schools and sometimes move with other scombrids. Kawakawa is often seen in coastal area (Randall, 1995). Sexual maturity is reached when the fish is about 52 centimeters in length (Johnson and Tamatamah, 2013). Although sexually mature kawakawas may be encountered throughout the year, there are seasonal spawning peaks. In Oman, distribution of kawakawa is associated with summer months, which is related with the southwest monsoon (Abdessalaam, 1995).

Fisheries

Fisheries in Oman are conducted mainly by 4 types of small-scale traditional fishing vessels, i.e., skiff (fiber glass) (LOA: 8-10m), launch (15-25m), houri and shasha (Plate 1) (Stengel and Al Harthy, 2002). Kawakawa is mainly exploited by launch and houri using gillnets or hand lines.

Plate 1 Four types of fishing vessels in Oman

Catch is highly seasonal. Most of the kawakawa fisheries occur between October and May. Kawakawa catch are largely fluctuated during 1988-2012. Fig. 1 shows the kawakawa annual catch (1988-2012). The 2012 catch in Fig. 1, indicates that the catch sharply increased to 4,608 tons (48% increase from the 2011 catch) (GoSO, 2013). Kawakawa exports in 2011 were 715 tons (GoSO, 2011).

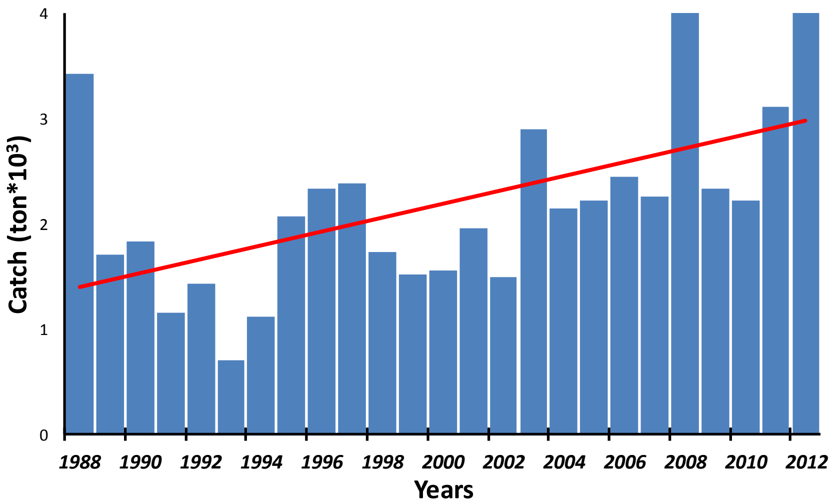


Fig. 1 Kawakawa annual catch in Oman (1988-2012)

Landing sites and fishing grounds

In Oman, there are some 60 landing sites and 6 six coastal fishing grounds, i.e., *Musandam, AL-Batinah, Muscat, AL-Shargyia, AL-Wusta and Dhofar* (Fig. 2). The Sharqiyah region always records the highest kawakawa catch (38% of the total catch in average during 2007-2011). The 2nd and 3rd highest catches are recorded in AL Batinah (18%) and Muscat (17%) region respectively (Table 1).

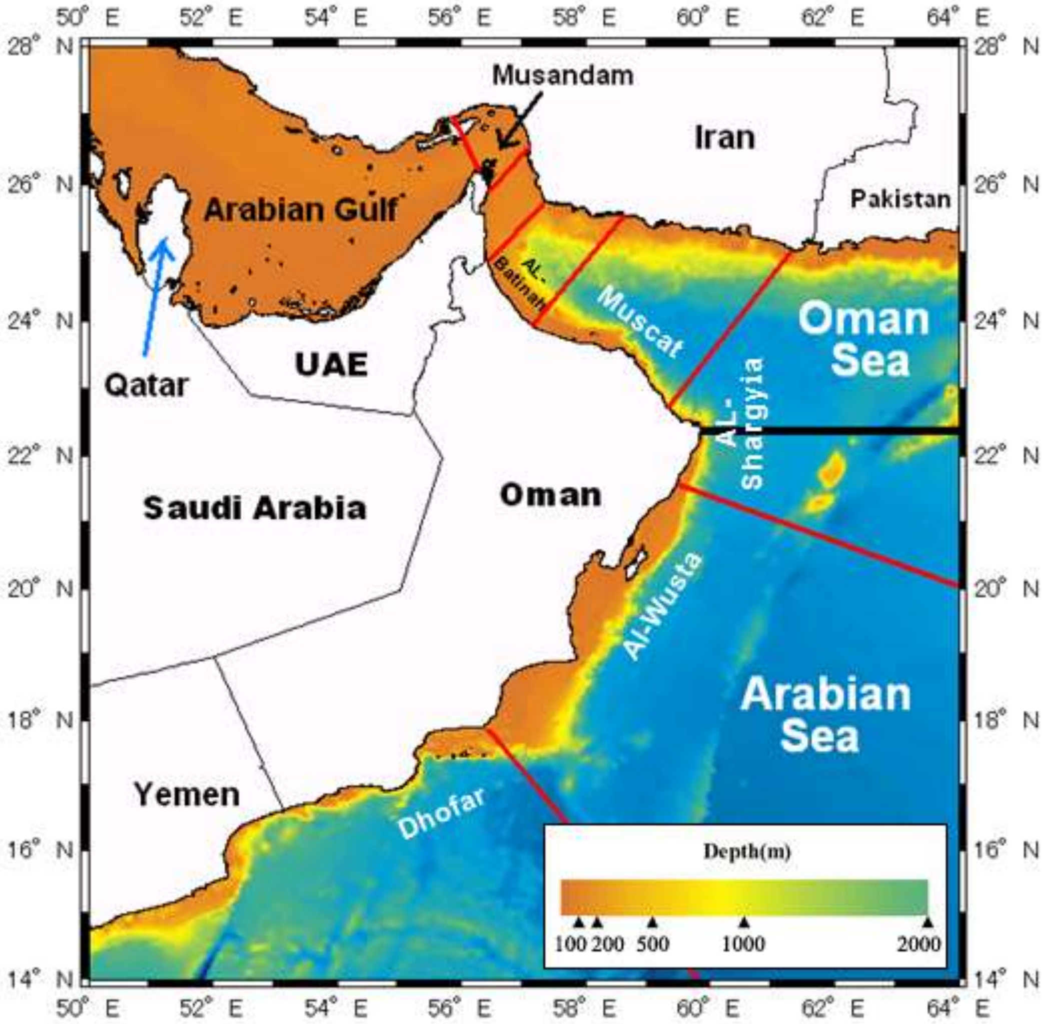


Fig. 2 Six coastal fishing grounds in Oman

Musandam, AL-Batinah, Muscat, AL-Shargyia, AL-Wusta and Dhofar

Regarding area used in the GLM (Oman Sea and Arabian Sea), refer to page 8

Table 1 annual kawakawa catch (tons) by region

Year	Musandam	AL-Batinah	Muscat	AL-Shargyia	AL-Wusta	Dhofar	Total
2007	443	284	474	940	28	93	**2,262**
2008	321	451	360	2,427	129	389	**4,077**
2009	216	766	329	516	59	450	**2,336**
2010	347	426	447	317	81	596	**2,214**
2011	180	615	826	1,059	19	415	**3,114**
Total	**1,507**	**2,542**	**2,436**	**5,259**	**316**	**1,943**	**14,001**
Percentage	11%	18%	17%	38%	2%	14%	100%

3. Data

The catch and effort data set was prepared by the statistical section in the Ministry of Agriculture & Fisheries, Sultanate of Oman. Data are available from 2002-2011 except the 2003 data, which was accidentally deleted during the data processing. The total number of the data set is n=33,238. We extracted kawakawa catch and effort data (n=13,656) from the data set to standardize its nominal CPUE.

First, we examined the number of observation by gear type and boat type. Table 2 shows the result. In the small scale fisheries in Oman, there are 4 types of boats (Plate 1) and 11 types of gears as shown in Table 2. Kawakawa has been targeted by the drift gillnet fisheries using the fiber glass and launch fishing vessels, while kawakawa has been caught as bycatch by hand line fisheries with fiber glass boats.

Table 2 Number of observations by gear and boat type used in the small scale fisheries in Oman

Number of the observation (n=)				
Gear type	**Boat type**			
	Beach seine	Fiber glass	Launch	Houri
beach seine net	4	446	14	0
drift gillnet	2	5701	1864	2
Fish trap	0	42	2	0
Hand line	0	4147	2	0
Linear Fixed Gillnet	0	458	84	0
Pen-Type Fixed Gillnet	0	258	43	0
Longline	0	9	0	0
Surrounding net	0	93	0	0
Troll line	0	479	2	0
Cast net	0	3	0	0
Lobster trap	0	1	0	0

1. Nominal CPUE

Using three types of nominal CPUE (gillnet with fiber glass and launch and hand line with fiber glass) we investigated their annual trends.

Gillnet

The gear expert, Captain Al-Harthy, Marine Science and Fisheries Center suggested to use the number of gillnet units as the effort unit (Table 3). As we have also the fishing hours in the data set, we define the nominal CPUE per boat as below:

Nominal CPUE = [Kg]/[(number of gillnet unit)(fishing hours)]*

Table 3 Number of gillnet unit by boat type and period suggested by Captain Al-Harthy

Type of boats	suggested number of gillnet units
Fiber glass	unit=7.5
Launch	unit=33 before 2007 and unit=50 after 2008

Hand line

In the data set, there are the effort information (number of line used). But the data range from 0 to 30. Realistic unit of hand line is 1-10 depending on the number of crews. Thus we decided not to use this unit as the fishing effort because of large uncertainty and/or errors in the number of lines in the data set. To solve this problem, Captain Al-Harthy further suggested using the number of crew as the proxy of number of hand lines as the effort unit. The number of crew information is available, which are considered to be realistic because the number ranges from 1-6. As we have also the fishing hours in the data set, we define the nominal CPUE per boat as:

Nominal CPUE = [Kg]/[(number of crew)(fishing hours)]*

Trends of the nominal CPUE

Using the efforts defined, we computed three different types of N_CPUE (nominal CPUE). Fig. 3 shows scaled trends as average N_CPUE=1. In this way, we can compare N_CPUE trends objectively. Their trends are similar, i.e., from 2002-2005 the N_CPUE trends are increasing, but after 2005 they show the decreasing trends. As three types of N_CPUE are computed independently, it is suggested that these trends are likely robust.

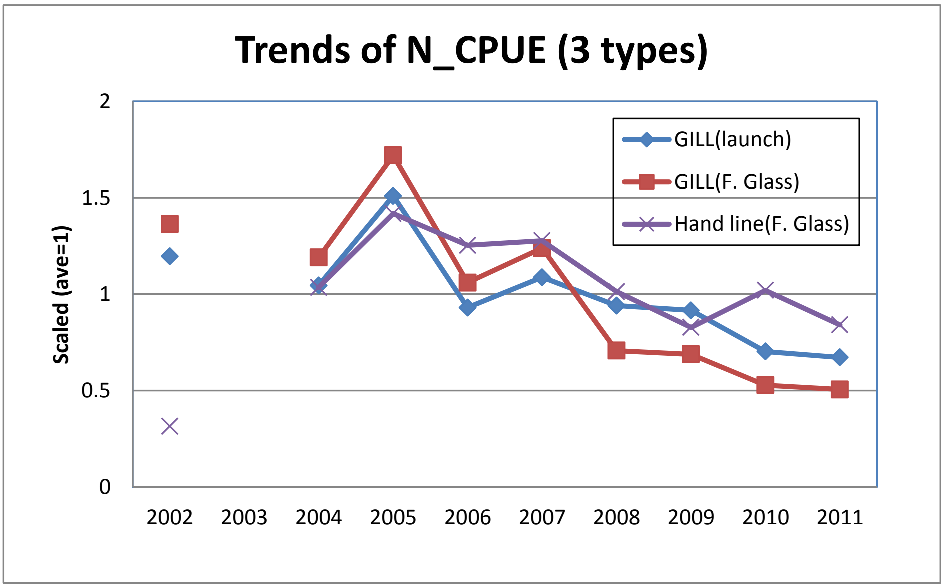


Fig.3 Annual trends of 3 types of nominal CPUE (Drift gillnet by launch + fiber glass boat and also hand line by fiber glass boat).

2. CPUE standardization

As an initial attempt, we standardize the nominal CPUE of drift gillnet data from launch boat as they target kawakawa and it also represents three N_CPUE, i.e., it is situated in the middle of three N_CPUE trends (Fig. 3). We applied the simple GLM to standardize N_CPUE.

Initial GLM

We set the flowing GLM:

Log (CPUE+c) = (mean) + [Y] + [Q] + [A] + [Y][A] + [Q]*[A] + (error) ---- [1]*

where, *CPUE (per boat): kg/(number of gillnet unit)*(fishing hours)*

c: 10% of average overall nominal CPUE(0.0174)

Y : effect of year

Q : effect of quarter(season)

A : effect of area (see Fig. 2 and note below)

Y×A: interaction term between year and area

Q×A: interaction term between quarter and area

Note on area (Fig. 2)

There are not enough number of the data to run GLM if we use the data for 5 fishing areas, i.e., we will face the missing data problem. Hence we define two aggregated fishing areas for the GLM, i.e., Oman Sea and Arabia Sea. In Oman Sea, 4 fishing areas are included (Musandam, Al-Batinah, Muscat and Al-Sharqyia), while in the Arabian Sea 2 included (Al-Wusta and Dhofar). In the Al-Sharqyia, its fishing area includes both Oman Sea and Arabian Sea, but majority of kawakawa are from Oman Sea. Thus we include it in Oman Sea.

Results of the initial GLM run and the 2nd Run without interaction terms

As we had missing data with the interaction terms, we could not get least mean values for 2002. Thus we removed the interaction terms and re-run the reduced GLM model [2] as below:

Log (CPUE+c) = (mean) + [Y] + [Q] + [A] + (error) -------------------------- [2]

Then we could get the least mean values for all the years. Table 3 shows the results (ANOVA) and it is clearly understood that there is a high statistical significance in area effect, i.e., N_CPUE between 2 areas (Oman Sea vs. Arabian Sea) is highly significant. This is true as the oceanographic conditions and marine ecosystem are highly heterogeneous between two these two Seas (Lan *et al,* 2010). Thus the GLM results reflect the situation well. In addition, residual box plot and QQ plot (Box 1) show the goodness of fitness of the data to GLM well.

Box 1 Results of the 2nd GLM run

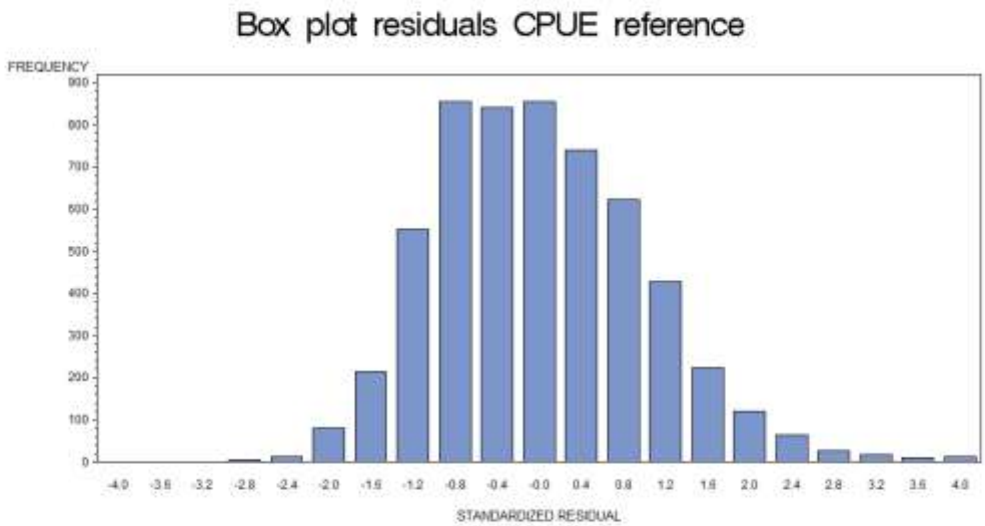
The GLM Procedure

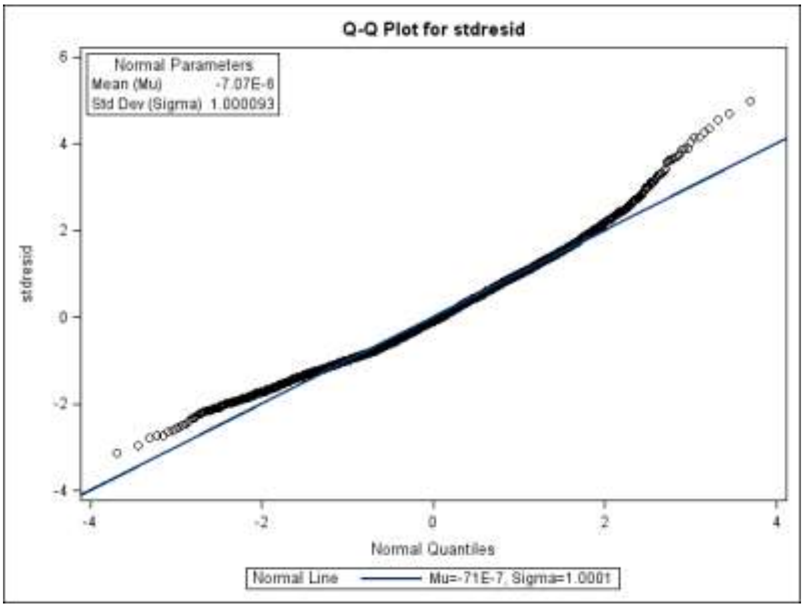
Dependent Variable: L_CPUE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	1699.163046	141.596921	185.68	<.0001
Error	5663	4318.503604	0.762582		
Corrected Total	5675	6017.666650			

R-Square	Coeff Var	Root MSE	L_CPUE Mean
0.282362	-38.50637	0.873260	-2.267832

Source	DF	Type III SS	Mean Square	F Value	Pr > F
yr	8	563.4076665	70.4259583	92.35	<.0001
q	3	43.3429878	14.4476626	18.95	<.0001
a	1	766.1985558	766.1985558	1004.74	<.0001



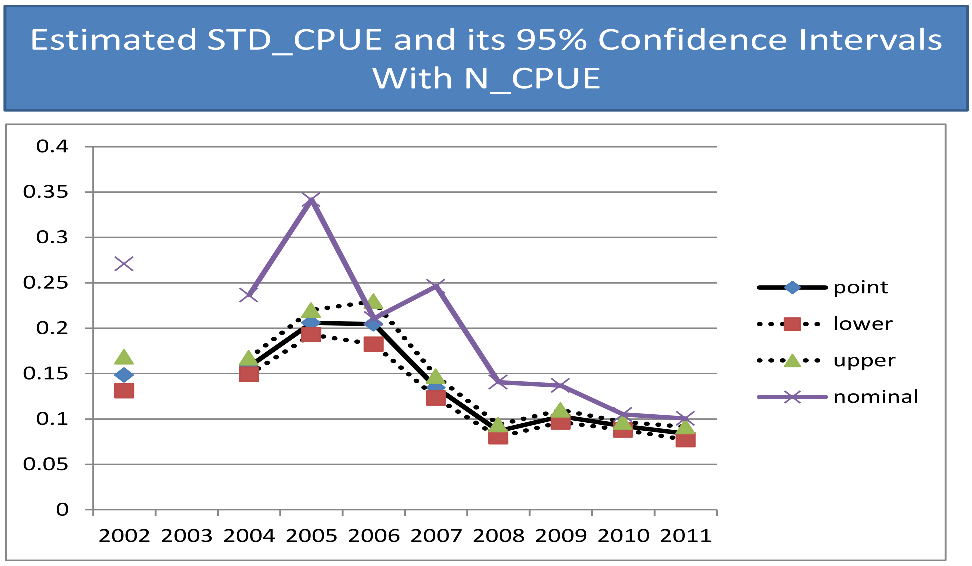


Then using the estimated least squares in the SAS output, we back calculated to evaluate annual STD_CPUE (point estimate and its 95% confidence intervals) from GLM [2]. Fig 4 depicts these trends along with N_CPUE.

STD_CPUE (lower) *=exp (lsmean-1.96*SE-0.0174)*

STD_CPUE (point) *=exp (lsmean-0.0174)*

STD_CPUE (upper) *=exp (lsmean+1.96*SE-0.0174)*



	point	lower	upper	nominal
2002	0.148	0.131	0.168	0.271
2003				
2004	0.158	0.149	0.167	0.237
2005	0.206	0.193	0.220	0.342
2006	0.205	0.182	0.230	0.211
2007	0.134	0.123	0.147	0.246
2008	0.087	0.080	0.094	0.141
2009	0.103	0.096	0.110	0.137
2010	0.092	0.088	0.097	0.105
2011	0.084	0.077	0.091	0.100

Fig. 4 Trends of STD_CPUE, its 95% confidence intervals and N_CPUE (2002-2011)

3. Discussion

Trends of 3 independent nominal CPUEs computed separately, are very similar (Fig. 3), although normally neritic tuna N_CPUE and/or STD_CPUE are very bumpy (IOTC, 2011 and 2012). Under such situation, we consider that the definition of kawakawa CPUE and quality of N_CPUE of drift gillnet fisheries by houri boat in Oman are likely realistic and satisfactory. Hence estimated STD_CPUE is considered roughly representing the kawakawa abundance. i.e., kawakawa STD_CPUE (abundance) increased from 2002 to 2005 then decreased afterwards to 2011.

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