**Training materials (09)**

Training course on stock assessments of Longtail tuna and Kawakawa in the SE Asia

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# Longtail tuna (*Thunnus tonggol*) stock assessment in the Indian Ocean by ASPIC (A Stock–Production model Incorporating Covariates) using available CPUE information

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Abstract

We attempted the stock assessment for longtail tuna in the Indian Ocean by ASPIC using nominal catch and four available CPUE (1950-2013). We assume that longtail tuna in the Indian Ocean is a single stock. Results of the ASPIC analysis suggested that longtail tuna stock status (2013) is in the overfishing phase (orange zone in the Kobe plot) (F/Fmsy=1.43 and TB/TBmsy=1.01), i.e., high F (high fishing pressure, 43% above the Fmsy level), while the TB is about in the TBmsy level. Uncertainty around the 2013 point estimate in the Kobe plot is covered by 54% in the red zone, 25% in orange and 21% in green. In addition, the direction of the stock status trajectory vector is toward the red zone. These facts suggest that the 2013 stock status has the high probability in the red (overfished) zone. The risk assessment (Kobe II) suggests that if the current catch continues (159,313 t), there are high risks (100%) for both TB and F to violate their MSY levels. If the current catch level is reduced by 30%, then risk probabilities for both TB and F will be reduced by 50% in three years later (2016).

Contents

# 1. Introduction

We attempted the stock assessment of longtail tuna (*Thunnus tonggol*) in the Indian Ocean by ASPIC (A Stock–Production model Incorporating Covariates) (ver. 5) (Prager, 2004) using available nominal catch and CPUE data. As the WPNT has been suggesting the single stock hypothesis until the stock structure is elucidated, we also apply this hypothesis.

# 2. Data

## 2.1 Global catch data

Fig. 1 shows the longtail tuna nominal catch for 64 years (1950-2013) in the whole Indian Ocean by gear type based on the IOTC database (as of April, 2015). Catch has been increasing steadily since 1950 until 2012 (170,000 tons) and slightly decreased in 2013 (169,000 tons) as the first time. There are very sharp increases in recent years (2008-2012), which is caused by the intensified piracy activities from 2008. This is because that gillnets fisheries especially in the NW Indian Ocean moved into their EEZ and target more neritic tuna (Nishida et al, 2014)

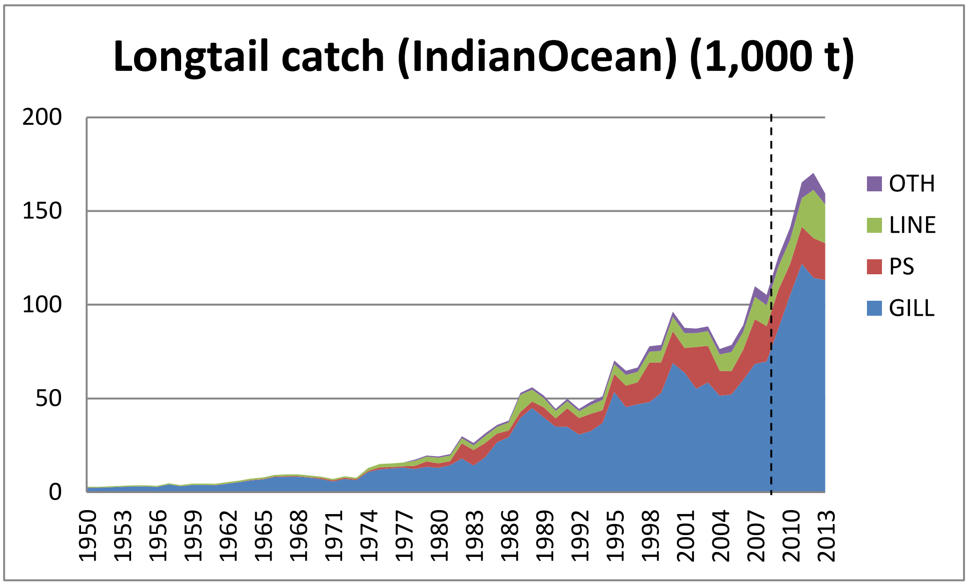



Fig. 1 Nominal longtail catch (1950-2013) by gear type (IOTC database) (April, 2015)

*(Note) Others include longline, bait boat and all other gear types. The broken vertical line shows 2008.*

2.2 **Available CPUE**

We use four available CPUE series in the IOTC database and previous WPNT documents. We search the CPUE data series minimum 10 years to conduct reliable stock assessment.

(1) - (2) Nominal PS and GILL CPUE in the Andaman Sea, Thailand (1998-2010) (IOTC–2013–WPNT03–33 Rev_2).

Two nominal CPUE series are available in "Analyses of catch, fishing efforts and nominal CPUE of neritic tuna and king mackerel exploited by purse seine and king mackerel drift gillnet fisheries in the Andaman Sea (Sa-nga-ngam et al, 2013) (IOTC–2013–WPNT03–33 Rev_2). Fig. 2 shows these nominal CPUE series including landing places and fishing grounds in the Andaman Sea and the Gulf of Thailand. These two CPUE series are from the statistical areas 6 and 7.

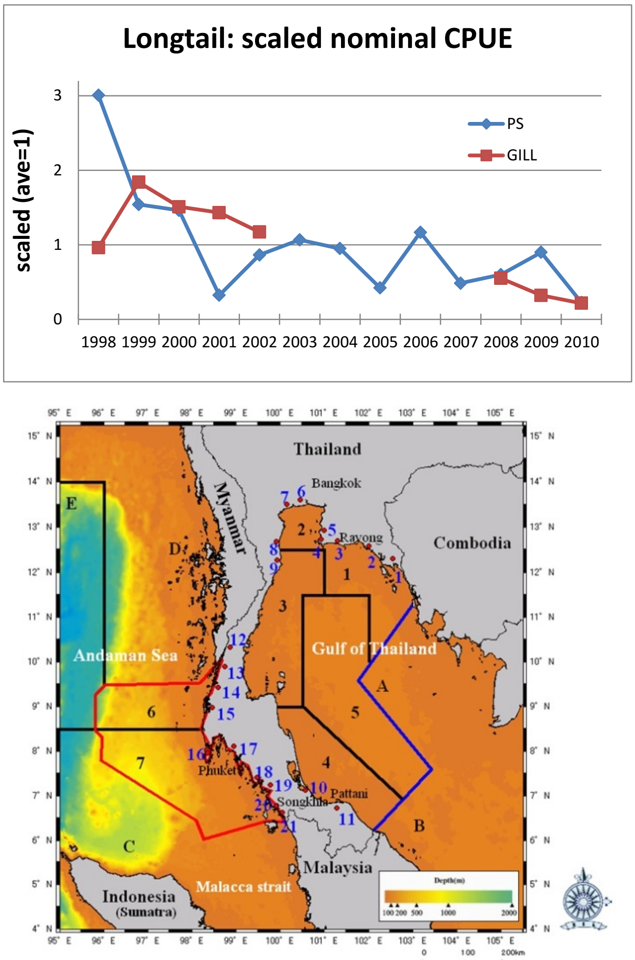
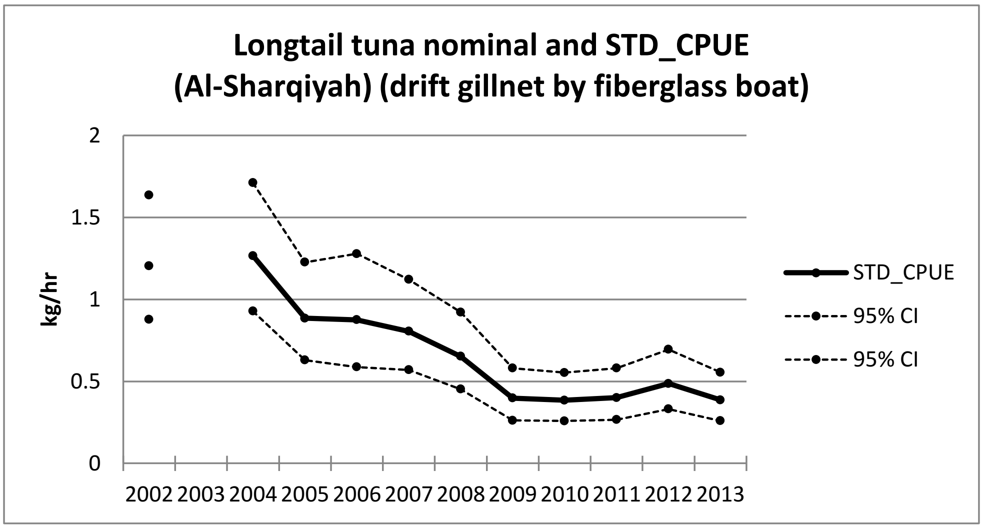



Fig. 2 (*above*) Nominal CPUE of GILL and PS fisheries from fishing areas 6 and 7 (Sa-nga-ngam et al, 2013) (IOTC–2013–WPNT03–33 Rev_2)
(*below*) Locations of fishing grounds (1-7 and A-E) and landing places (1-21) in the Andaman Sea and the Gulf of Thailand

(3) Standardized CPUE of drift-gillnet in Oman (2002-2013) (IOTC-2014-WPNT04-28)

The standardized CPUE of drift-gillnet fisheries in Oman (2002-2013) by Al-Kiyumi et al (2014) are available in IOTC-2014-WPNT04-28 (Fig. 3).



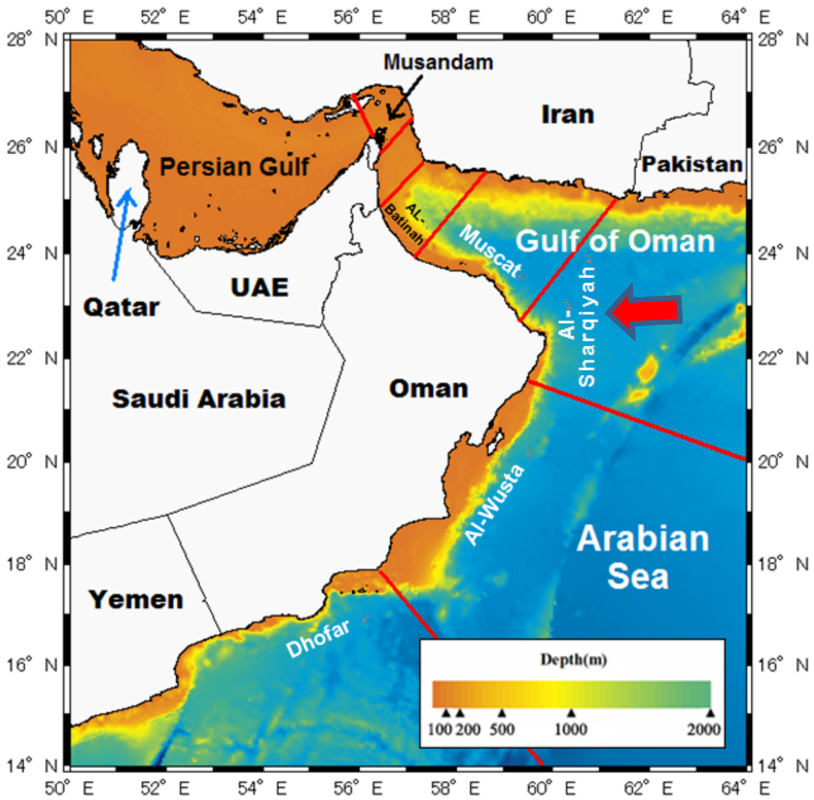
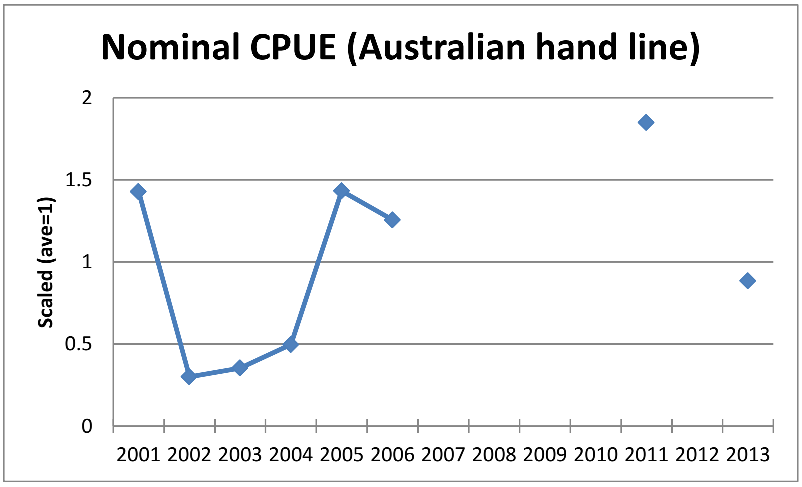




Fig. 3 *(above)* STD_CPUE and its 95% confidence intervals with nominal longtail tuna CPUE of drift gillnet fisheries by fiberglass boat in Al-Sharqiyah (one of six fishing grounds) (below) Six fishing areas in Oman

(4) Nominal CPUE of Australian handline fisheries (2001-2013) (IOTC database)

In the IOTC catch-effort dataset (as of April, 2015), there is one nominal CPUE dataset containing a longer time series, i.e., Australian handline catch and effort data set. Fig. 4 shows the trend of the nominal CPUE.



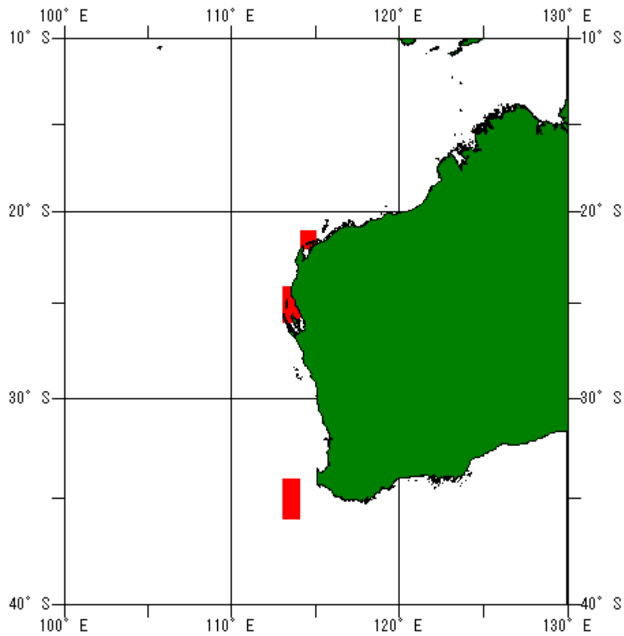




Fig. 4 (*above*) Australian nominal CPUE data set by handline
(*below*) Locations of fishing grounds of the CPUE data

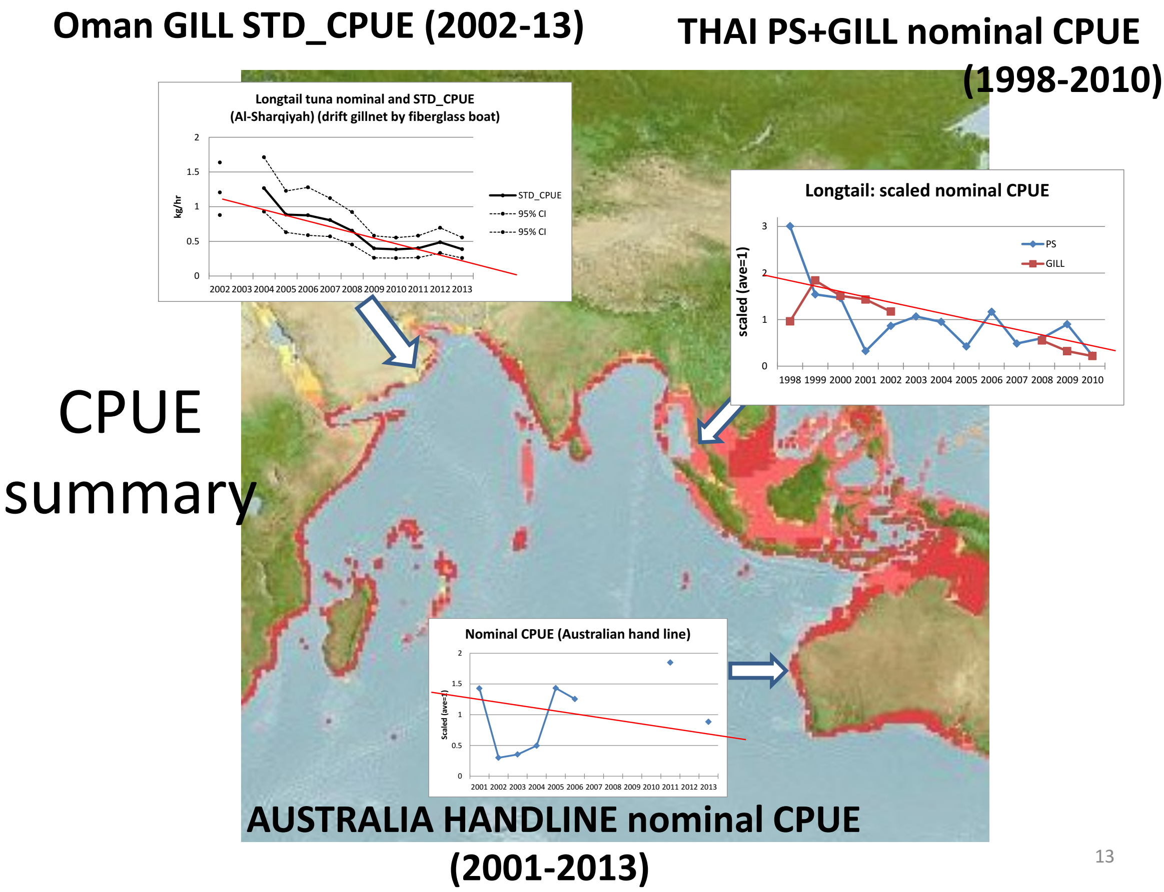
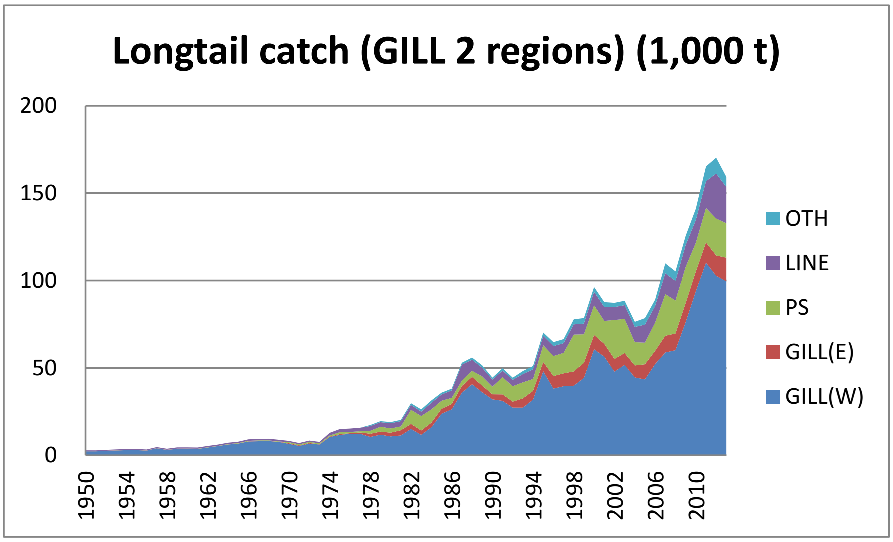



Fig. 5 Distribution of longtail tuna in the Indian Ocean and four available CPUEs in three regions. All CPUE show the declining trends.

## 3. ASPIC

### 3.1 Gear types

Using four available CPUE series, we conduct stock assessment by ASPIC. In ASPIC, we use 5 gear types, (a) GILL (W), (b) GILL (E), (c) PS, (d) (HAND) LINE and (e) OTHERS. The reason that we have GLL by 2 regions (W: Western IO for F51 and E: Eastern IO for F57) is as follow: we have 2 CPUE from Oman (West) and Thailand (West) and we assume that CPUE in the western region reflect to catch in the same region and vice versa. Fig. 6 shows the restructured nominal catch corresponding to 5 fleet types used in ASPIC assessment.




| Nominal catch by gear | | Corresponding CPUE | Average composition of catch (%) of CPUE fleet |
|---|---|---|---|
| GILL (W) | Gillnet (Western IO) | Standardized CPUE (Oman) | 16.9 |
| GILL (E) | Gillnet (Eastern IO) | Nominal CPUE (Thailand) | 5.8 |
| PS | Purse seine | Nominal CPUE (Thailand) | 34.0 |
| LINE | Line type gears | Nominal Handline (Australia) | 0.2 |
| OTH | Other gears | Not available | |

Fig.6 (*above*) Nominal catch corresponding to 5 gear types used in the ASPIC assessment

(*below*) List of nominal catch and corresponding CPUE used in the ASPIC stock assessment

### 3.2 ASPIC runs

In ASPIC for our dataset, we need to estimate 8 parameters (K: carrying capacity, B0/K where B0 is the total biomass in 1950, q: catchability for 5 gear types and MSY). We assume that B0=K and attempt to estimate 7 parameters (K, MSY and 5 q's).

(1) Initial ASPIC runs

Using 64 years data and assuming K=B0, we attempted the initial ASPIC runs using the Fox model. However we could not get any convergences nor plausible estimates in the initial run.

(2) Final ASPIC runs

Then, we fixed K and attempted to explore seven K values within plausible ranges, i.e., 300, 400, 500, 600, 700, 800, 900,000 tons. Table 1 shows the ASPIC results by K values. Fig. 7 shows locations of seven TB/TBmsy and F/Fmsy in the Kobe plot, which indicate ranges of uncertainties among K values.

We considered that TBmsy=110,000 and 147,000 tons (when K=300,000 and K=400,000 tons respectively) are too low comparing MSY. In addition, MSY=107,000 tons and 100,000 tons are also too low considering the current catch levels (142,000 tons in 5 years average). Thus, we selected the median case (K=600,000 tons) (among K=500, 600 and 700,000 tons) as the representative ASPIC result.

Table 1 Summary of ASPIC runs within seven plausible K values

## Optimum K=600,000 tons (median)

| K | MSY | TBmsy | TB2013 | Fmsy | TB2013/TBmsy | F2013/Fmsy | B2013/B1950 (depression) |
|---|---|---|---|---|---|---|---|
| (1,000 tons) | | | | | | | |
| 300 | 152 | 110 (too low) | 128 | 1.38 | 1.16 | 0.94 | 0.43 |
| 400 | 142 | 147 (too low) | 165 | 0.97 | 1.12 | 1.07 | 0.41 |
| 500 | 132 | 184 | 196 | 0.72 | 1.07 | 1.23 | 0.39 |
| 600 | 122 | 221 | 223 | 0.55 | 1.01 | 1.43 | 0.41 |
| 700 | 114 | 258 | 243 | 0.44 | 0.96 | 1.63 | 0.39 |
| 800 | 107 (too low) | 294 | 274 | 0.36 | 0.93 | 1.80 | 0.34 |
| 900 | 100 (too low) | 331 | 296 | 0.30 | 0.89 | 2.02 | 0.33 |

Too high

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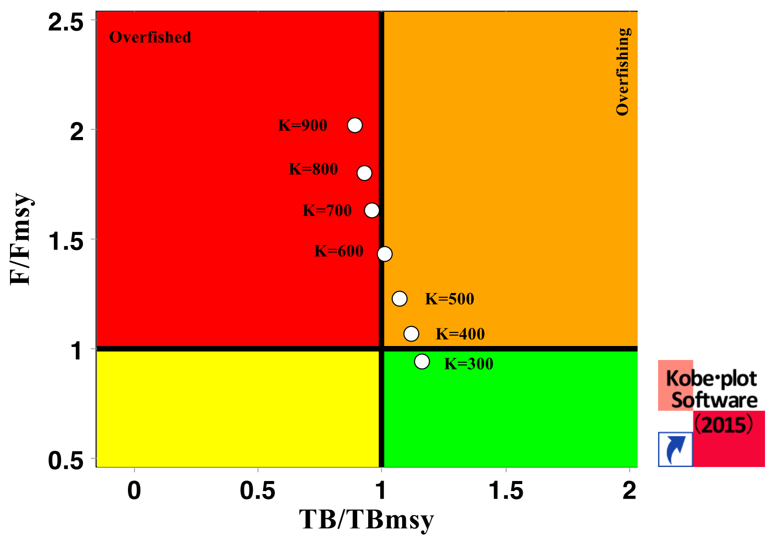


Fig. 7 Locations of the 2013 stock status points by K value (1,000 tons), which also shows uncertainties among seven plausible K values

(3) Results

Table 2 shows the summary of the ASPIC stock assessments. Box 1 shows results including graphs for catch vs. MSY, TB (total biomass) vs. TBmsy, F vs. Fmsy, observed vs. predicted CPUE for GILL (W), Gill (E), PS, LINE and OTHER and estimated q (catchability) by gear type.

Table 2 Longtail tuna stock status summary in the Indian Ocean based on ASPIC

| **Management Quantity** | **Whole Indian Ocean** |
|---|---|
| Most recent catch estimate (1,000 t)(2013) | 159 |
| Mean catch over last 5 years (1,000 t) (2009-2013) | 142 |
| MSY (1,000 t) | 122 (106-173) |
| Current Data Period (catch) | 1950-2013 |
| CPUE | GILL (Andaman Sea, Thailand) (1998-2010)<br>GILL (Oman) (2001-2012) (2002-2013)<br>PS (Andaman Sea, Thailand) (1998-2010)<br>HANDLINE (Australia) (2001-2013) |
| Fmsy (80%CI) | 0.55 (0.48-0.78) |
| TBmsy (1,000 t) (80%CI) | 221 (189-323) |
| F(2013)/F(MSY) (80% CI) | 1.43 (0.58-3.12) |
| TB(2013)/TB(MSY) (80% CI) | 1.01 (0.53-1.71) |
| TB(2013)/TB(1950) (80%CI) | 0.41(n.a.) |
| K (tons) (fixed) | 600,000 |
| r | 0.81 |

**Box 1 Results of ASPIC (longtail tuna in the Indian Ocean)**

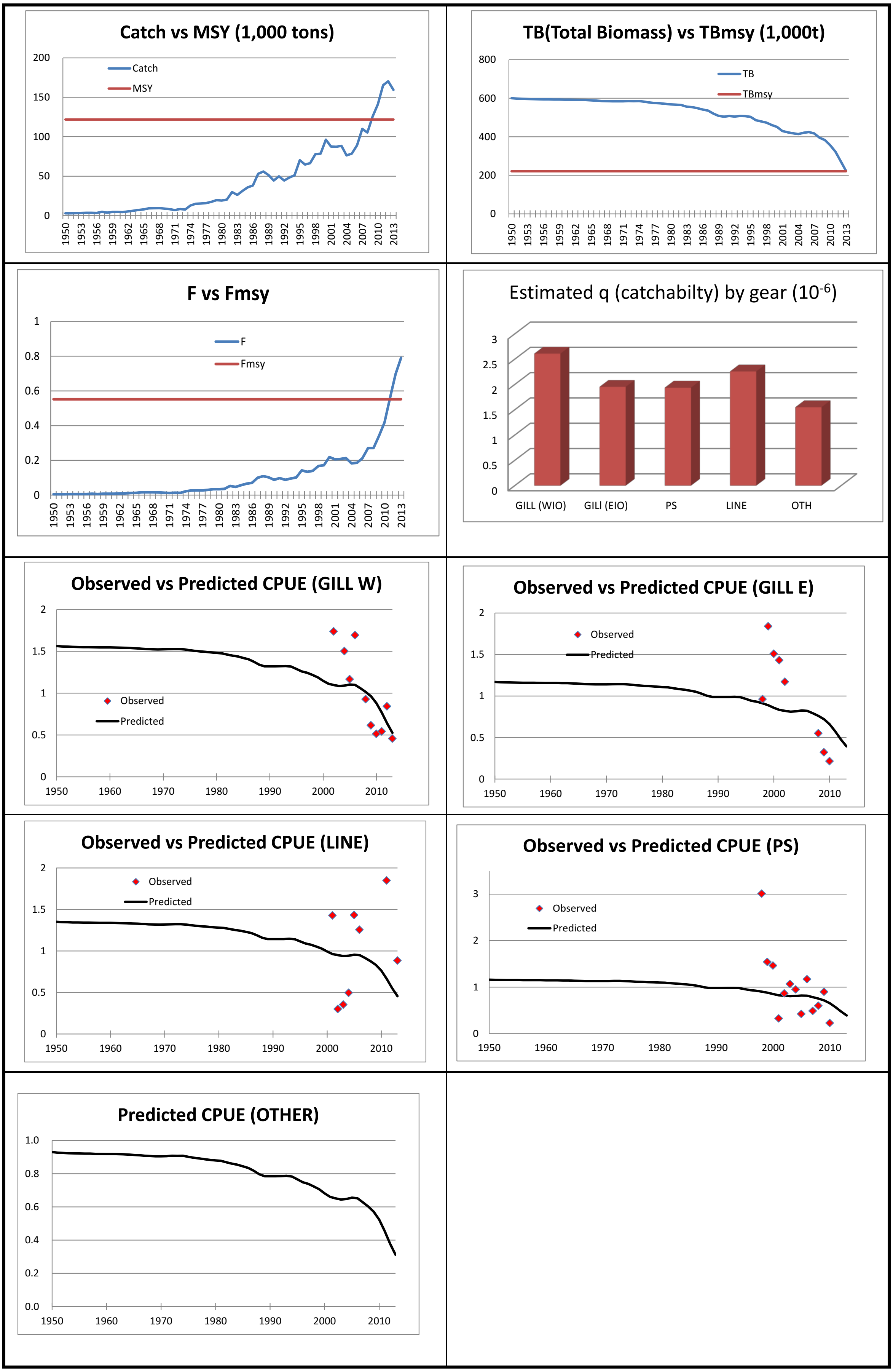

Fig. 8 shows the Kobe plot suggesting that the current stock status is in the overfishing (orange) zone (F/Fmsy=1.44 and TB/TBmsy=1.01), i.e., high F (high fishing pressure, 44% above the Fmsy level), while the TB is about in the TBmsy level.

The Confidence surface around the 2013 point in the Kobe plot (Fig. 8) was estimated by 500 times of the bootstrap using the Kobe plot software (Nishida, et al, 2015). Uncertainty around the 2013 point estimate is covered by 54% in the red zone, 25% in orange and 21% in green. In addition, the direction of the stock status trajectory vector is toward the red zone. These facts suggest that the 2013 stock status has the high probability in the red (overfished) zone.

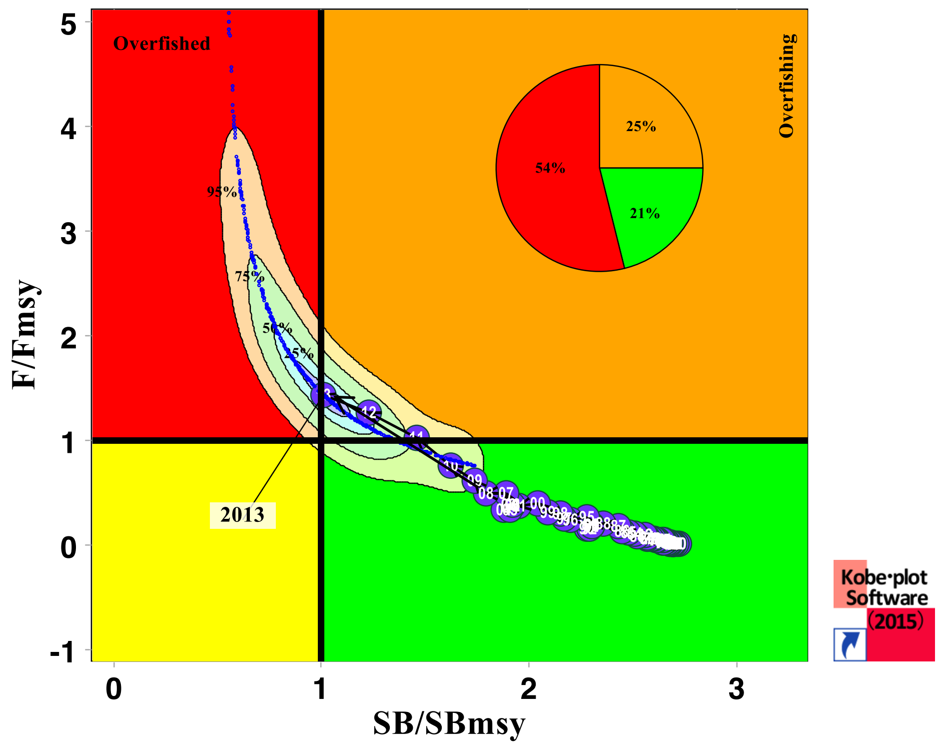


Fig. 8 Kobe plot of the longtain tuna in the Indian Ocena (1950-2013) with uncertinty around the 2013 point and compostions of uncertainties in terms of 4 phases (colors) of the Kobe plots (pie chart)

### 3.3 Risk assessment (Kobe II)

The risk assessment (Kobe II) was conducted using the bootstrap results (Table 3), which suggests that if the current catch continues (159,313 t), there are high risks (100%) for both TB and F to violate their MSY levels. If the current catch level is reduced by 30%, then risk probabilities for both TB and F will be reduced by 50% in three years later (2016).

Table 3 Longtail tuna ASPIC aggregated Indian Ocean assessment Kobe II Strategy Matrix. Probability (percentage) of violating the MSY-based target for nine constant catch projections (2013 catch = 159,313 t, ± 10%, ± 20%, ± 30% ± 40%) projected for 3 and 10 years.

| Reference point and projection timeframe | Alternative catch projections (relative to the current catch level in 2013) and probability (%) of violating MSY-based target reference points ($SB_{targ} = SB_{MSY}$; $F_{targ} = F_{MSY}$) MSY=122,000 t | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| % of status quo | 60% | 70% | 80% | 90% | 100% | 110% | 120% | 130% | 140% |
| tons | 95,588 | 111,519 | 127,450 | 143,382 | 159,313 | 175,244 | 191,176 | 207,107 | 223,038 |
| 3 years later | | | | | | | | | |
| $TB_{2016} < TB_{MSY}$ | 48 | 56 | 66 | 100 | 100 | 100 | 100 | 100 | 100 |
| $F_{2016} > F_{MSY}$ | 13 | 53 | 71 | 87 | 100 | 100 | 100 | 100 | 100 |
| 10 yers later | | | | | | | | | |
| $TB_{2023} < TB_{MSY}$ | 52 | 76 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| $F_{2023} > F_{MSY}$ | 65 | 82 | 89 | 96 | 100 | 100 | 100 | 100 | 100 |

# 4. Discussion

**Piracy effects**

To interpret the ASPIC results, the piracy effect is very important factor to understand the situation. Thus, firstly, we will discuss this issue then will discuss the ASPIC results incorporating the piracy effect.

The piracy activities started in the middle of 2000's off Somalia and became intensified in 2008 afterwards. Areas of their activities have been expanding to the entire north and central western Indian Ocean by 2013 (Fig. 9). Numbers of active tuna longliners and purse seiners have been decreasing after 2008. Some industrial tuna longline vessels moved to Pacific or Atlantic Ocean. However, from the later 2013, the piracy activities have been weakened and then longline vessels have been back to the Indian Ocean. Now more purse seine and longline vessels operate off Somali with armed security staff.

Small scale fishing operating in the high seas, especially drift gillnet fisheries in the NW Indian Ocean, have been exploiting yellowfin tuna in the waters beyond their EEZs. But after 2008 when the piracy activities were intensified and some fishing vessels have attacked by pirates, they go back to their EEZs and they are now exploiting more neritic tuna. This situation resulted sharp increase in the neritic tuna catch (Figs. 1 and 10).

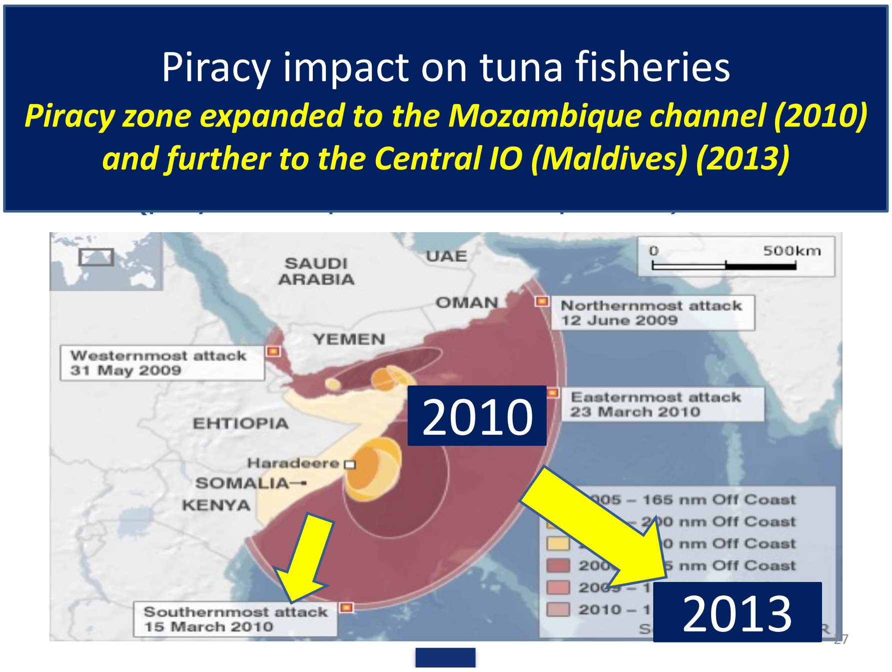


Fig. 9 Expansion of the piracy activities in the western Indian Ocean

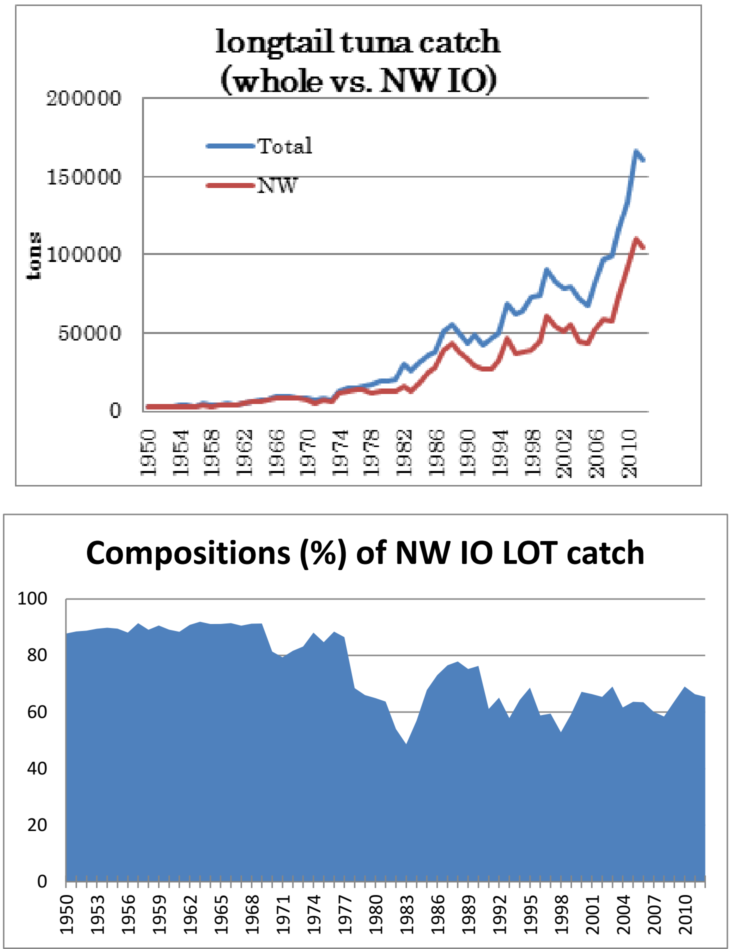


Fig. 10 Longtail tuna catch (Whole vs NW Indian Ocean)
(above) Nominal catch (t) and (below) Compositions (%)

**Stock assessments**

ASPIC stock assessments suggests that the current stock status of the Indian Ocean is overfishing stage (TB/TBmsy=1.01 and F/Fmsy=1.43). This is due to the sharp increase of the catch in the NE region by the piracy effects as discussed. The risk assessment suggests that if the current catch level continues, then there is 100% of chance violating MSY levels for both TB and F. If the catch is reduced by 30%, then risk probabilities for both TB and F will be reduced by 50% in three years later (2016).

In the stock assessments, nominal CPUE are used for Thailand PS and Australian handline as the original data are not available. However, the trends of 4 CPUE are similar (decreasing trend). It is suggested that these nominal CPUE need to be standardized in the future.

In addition, the catch compositions of 4 CPUEs are 17% for GILL in WIO (Oman CPUE), 6% GILL (Thailand) for EIO, 34% PS (Thailand) and 0.2% LINE (Australia). As coverages by GILL for EIO (6%) and LINE (0.2%) are low, the results should be interpreted carefully. However, the catch compositions of these two fleets are low (11% and 8% respectively) (Fig. 11), hence it is considered that effects of low coverages of these two fleets may be not too serious.

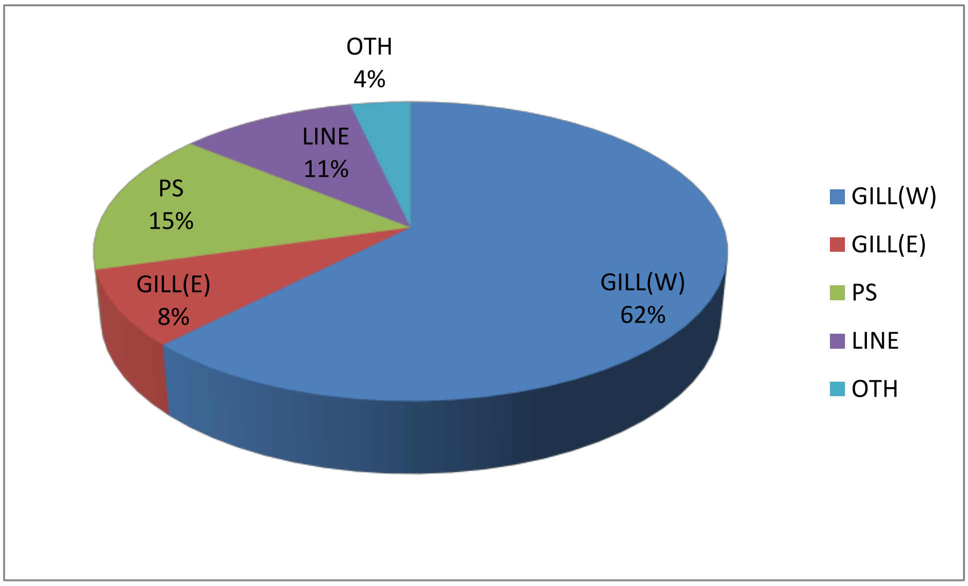


Fig. 11 Average catch compositions of 5 fleets

Longtail stock assessments in the whole Indian Ocean (IOTC, 2015) and this study (Nishida and Iwasaki, 2015) shows very similar and consistent results suggesting the stock is the overfishing status (Orange zone in the Kobe plot) (Fig. 12).

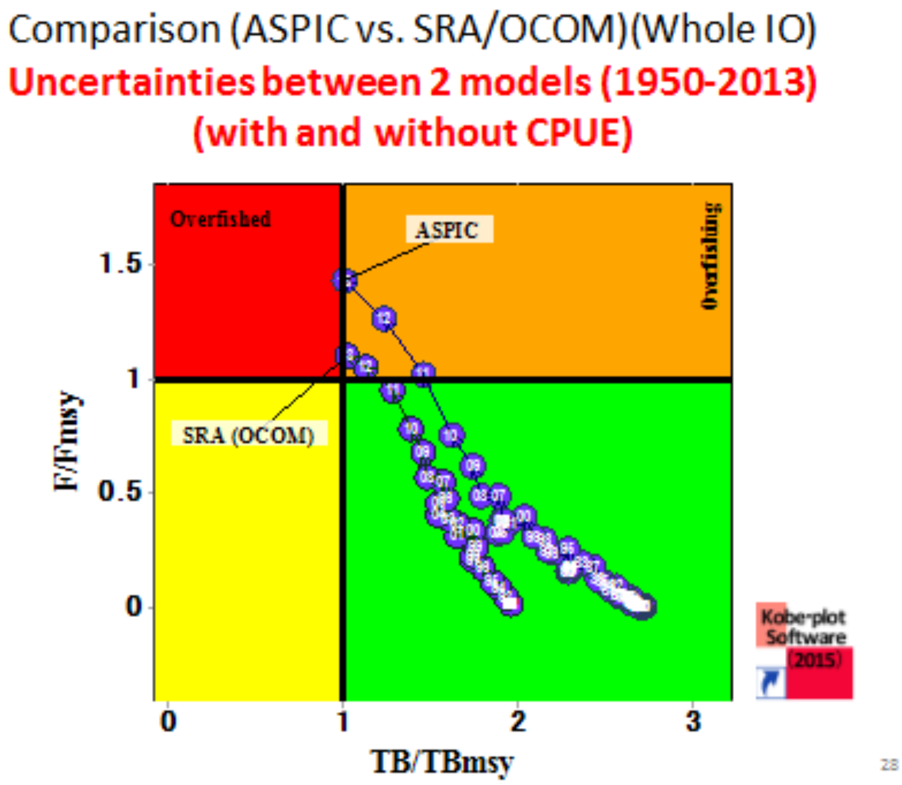


Fig. 12 Comparisons of longtail tuna stock assessments results between ASPIC and SRA (OCOM)

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