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Preliminary kawakawa (*Euthynnus affinis*) stock assessment by ASPIC using standardized CPUE of drift gillnet fisheries in Sultanate of Oman

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1. Introduction

Neritic tuna stock assessments in the Indian Ocean has been difficult to conduct due to their data (information) poor situation regarding (a) stock structure, (b) nominal catch, (c) CPUE and (d) biological information. We reduce these difficulties to some extent by setting the hypothetical stock structures, using available (best) nominal catch in IOTC and newly available standardized CPUE (STD_CPUE). Then we attempt the simple stock assessment without biological information for kawakawa (*Euthynnus affinis*) by A Stock Production Model Incorporating Covariates (ASPIC) (ver. 5) (Prager, 2004). This is a preliminary work before the IOTC/WPNT03 (July 2-5, Bali, Indonesia) using newly available STD_CPUE of Omani drift gillnet fisheries (IOTC-WPNT03-___) during the meeting, we may explore ASPIC runs further by incorporating other available STD_CPUEs.

2. Stock structure

IOTC WPNT02 (2012) suggests considering the stock structure of kawakawa as one stock. We conduct the ASPIC stock assessment by following this hypothesis.

3. Input data

Global catch data

We extract the nominal kawakawa catch (1950-2011) from the IOTC nominal catch data set. Fig. 2 shows the trends of the catch by fleet.

STD_CPUE

We used estimated kawakawa STD_CPUE of gillnet fisheries by launch boat (see IOTC-2013-WPNT03-___). Fig. 1 shows the STD_CPUE.

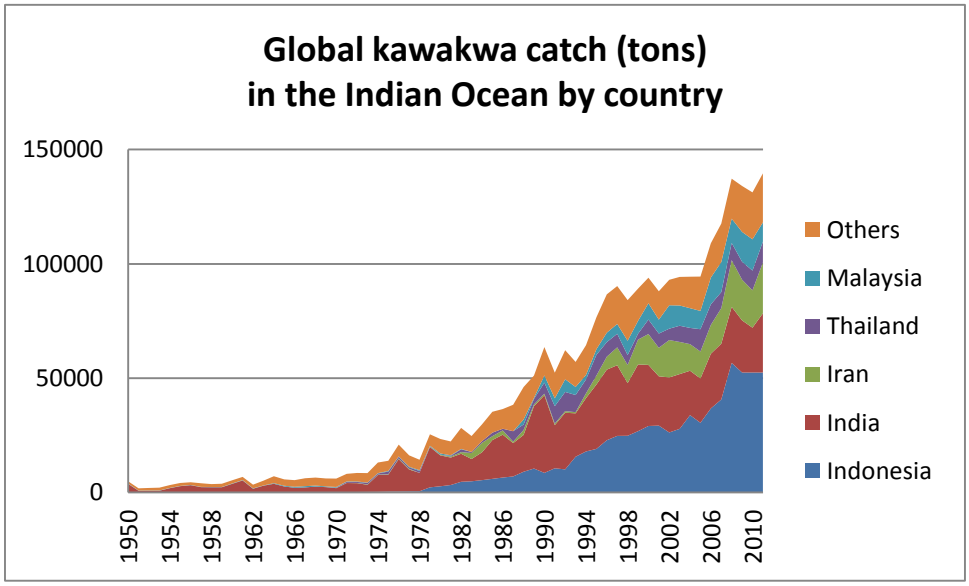


Fig. 1 Trends of kawakawa catch (tons) by fleet in the Indian Ocean (1950-2011) (Source: IOTC).

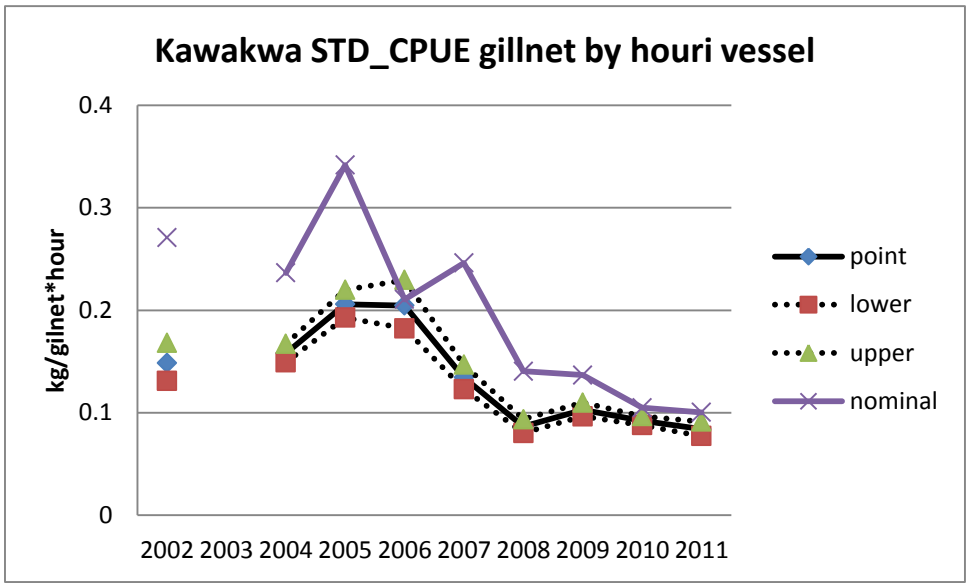


Fig. 2 STD_CPUE and its 95% confidence intervals with nominal CPUE of drift gillnet fisheries (houri type boat) in Oman

4. ASPIC

4.1 Base (initial) run

As the base (initial) run, We attempted to run ASPIC using the global catch in the Indian Ocean and Omani STD_CPUE by assuming B0 (1950) =K, but could not get convergence.

4.2 Alternative (second) run

Alternative stock structure hypothesis

We consider that one stock structure hypothesis may not be realistic because of long distances among countries, i.e., kawakawa cannot move from Oman to Indonesia as an extreme example (Box 1). Thus, STD_CPUE may not able to reflect well to the global catch in the Indian Ocean which might cause the convergence problem in the initial ASPIC run.

Then we set up the alternative hypothesis of stock structure. The first IOTC-WPNT01 (2011) report considered some stock structure hypotheses for neritic tuna. For kawakawa, it indicated 4 stock structures (Box 1). Assuming this 4 stock hypothesis, we re-attempted the ASPIC run. As the STD_CPUE (Oman) belong to the NW region, we run ASPIC for the NW (hypothetical) stock. We assume B0 (1950) =K.

Global catch in the NE region

We again extracted the kawakawa nominal catch in the northwest region (1950-2012) from the IOTC catch data set, i.e., Oman, Iran, UAE, Pakistan, Somalia, Saudi Arabia and Yemen. Fig. 3 shows the trends of the nominal catch by fleet.

Results

For this time we could get the convergence and could get the reasonable results. Figs. 4-9 show the results.

Box 1 Hypothesis of 4 kawakawa stock structure

IOTC-2011-WPN01-report (p.18)

Table 1. Neritic tunas (and tuna-like species) under the IOTC mandate with potential sub-regions/stock identified

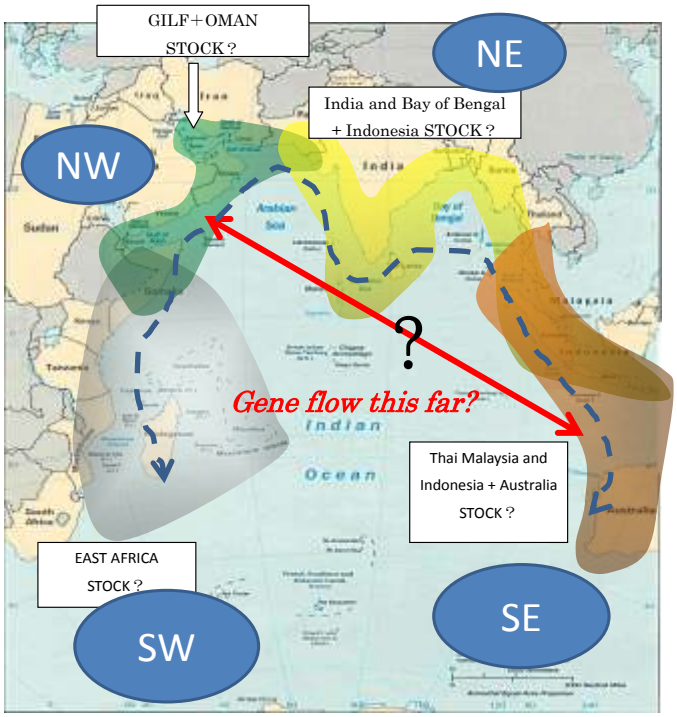
Species	East Africa (Kenya, Tanzania, Mozambique, Madagascar, Seychelles, Mauritius, La Réunion, Comoros, Somalia)	Gulf, Oman Sea (I.R. Iran, Oman, Pakistan, U.A.E., Yemen, Somalia, Qatar)	West India (India, Pakistan, Sri Lanka, Maldives)	East India/Bay of Bengal (India, Sri Lanka, Malaysia, Indonesia, Thailand, Myanmar, Bangladesh)	Indonesia and Australia (Australia, Indonesia, Thailand)
	Possible sub-regions and countries				
Longtail tuna (*Thunnus tonggol*)	▬	▬		▬	▬
Narrow-barred Spanish mackerel (*Scomberomorus commerson*)	▬	▬			▬
Bullet tuna (*Auxis rochei*)	–	–	▬		▬
Frigate tuna (*Auxis thazard*)	▬	▬	▬	▬	▬
Kawakawa (*Euthynnus affinis*)	▬	▬	▬	▬	▬
Indo-Pacific king mackerel (*Scomberomorus guttatus*)	▬	▬	▬	▬	▬

Black bars refer to potential management units for further examination/research, by species. Countries in red text are not yet Members of the IOTC, however collaborative research is encouraged.

Kawakawa

4 stocks hypothesis based on the Table 1 above

Northwestern Stock **[Oman+Gulf]** Oman, Iran, Pakistan, UAE, Yemen, Somalia, Qatar



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Schematic diagram of 4 stock structure hypothesis

Red line with? Implies if kawakawa moves such a long distance to support the one stock hypothesis.

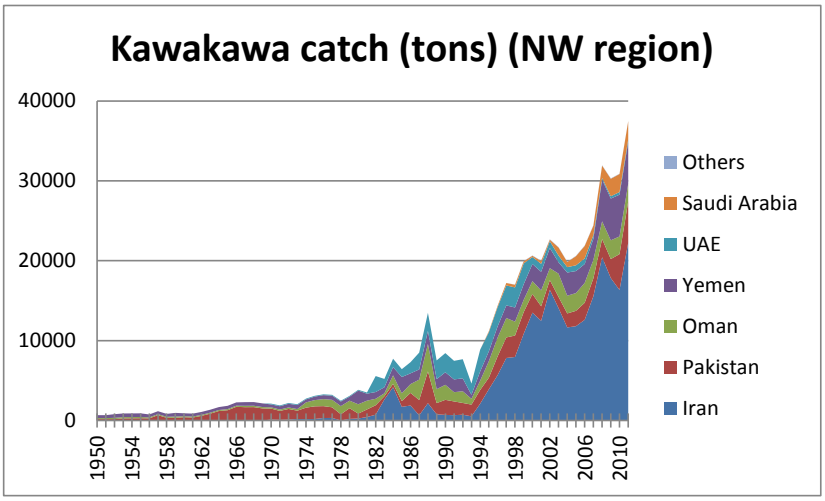

Fig. 3 Trends of kawakawa catch (tons) by fleet in the NW region of the Indian Ocean (1950-2011) (Source: IOTC).

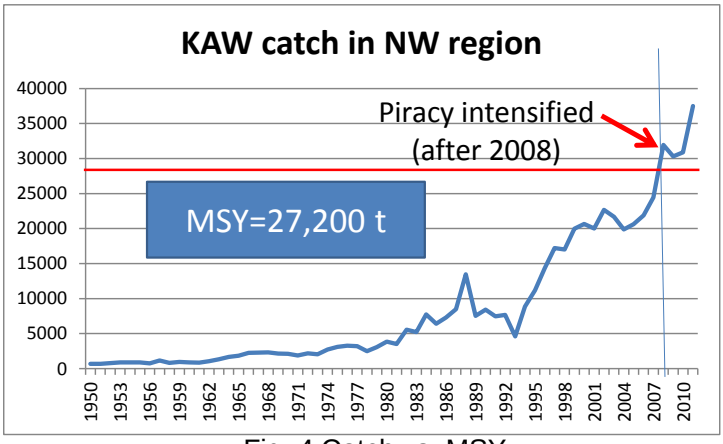

Fig. 4 Catch vs. MSY

(After the piracy started intensified in 2008, catch increased. For details see the discussion)

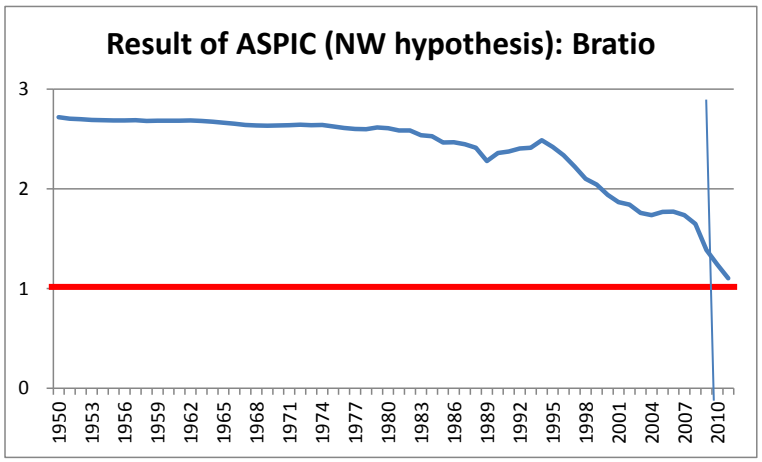

Fig. 5 TB (total biomass) ratio (TB/TBmsy) (after the piracy started intensified in 2008, TB (ratio) decreased. For details see the discussion). Red line: MSY level (TB ratio=1)

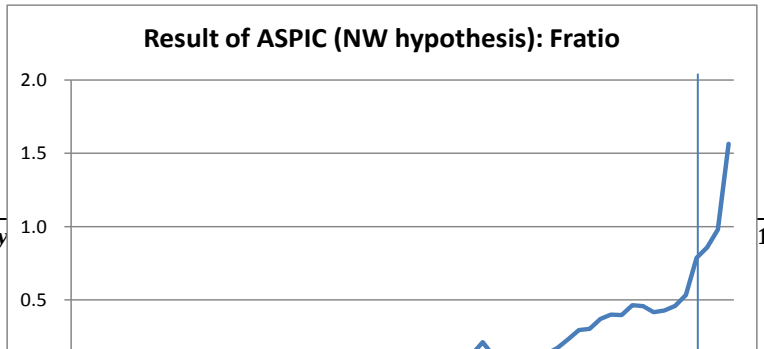

Fig. 6 Fratio (F/Fmsy) (after the piracy started intensified in 2008, F (ratio) increased sharply. For details see the discussion) Red line: MSY level (TB ratio=1)

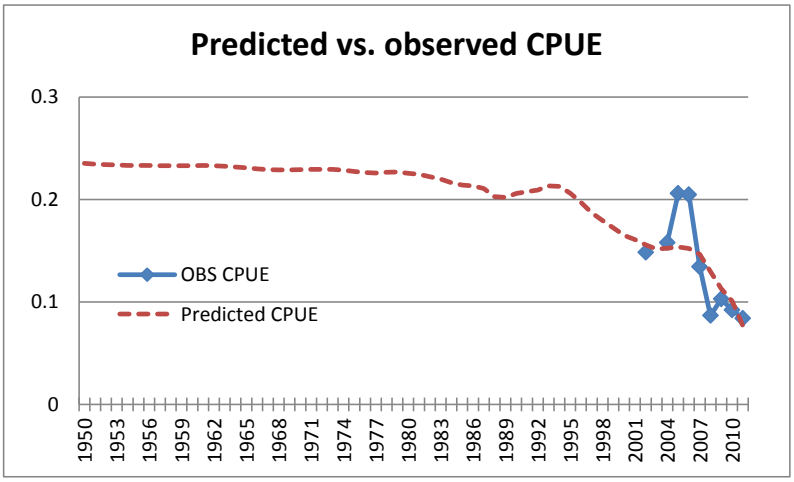

Fig. 7 Predicted vs. observed CPUE

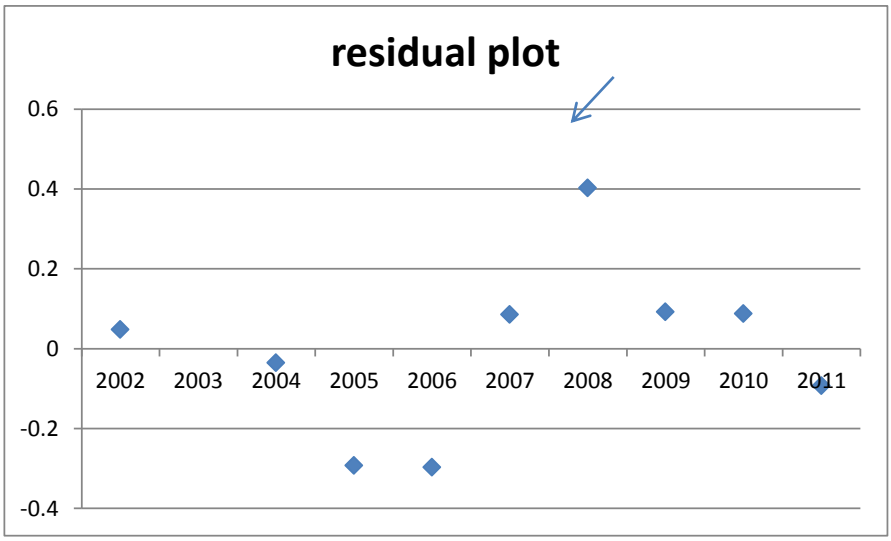

Fig. 8 Residual plot of CPUE (except 2008 point, residual levels are small)

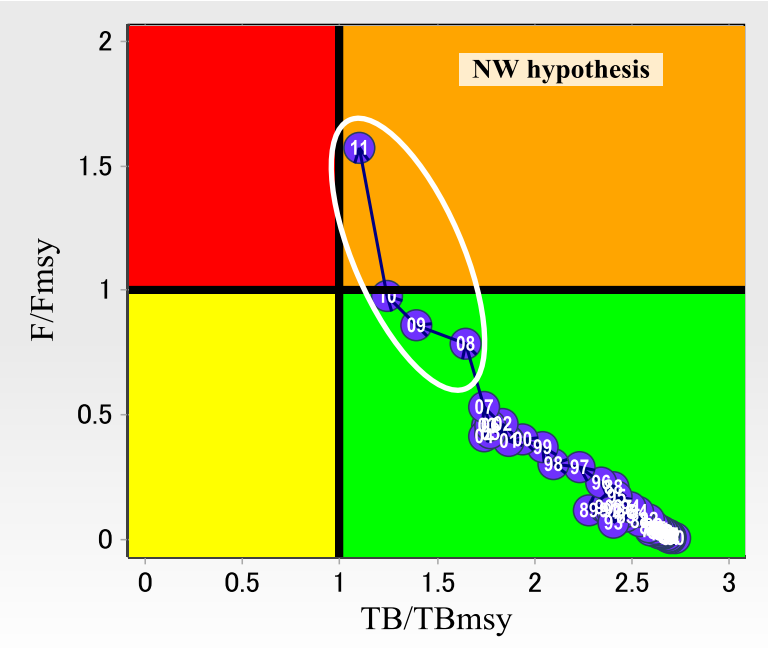

Fig. 9 Kobe plot (stock trajectory) (after 2008, fishing pressure sharply increased due to intensified piracy activities. For details see Discussion)

5. Discussion

For this time, we did preliminary attempt of the kawakawa stock assessment by ASPIC using the Omani drift-gillnet STD_CPUE. As mentioned in Introduction, we may need to explore ASPIC runs further during the IOTC-2013-WPNT03 meeting using additional available STD_CPUE.

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. 10). Numbers of active tuna longliners and purse seiners have been decreasing after 2008 (Figs. 11-12). Some vessels moved to Pacific or Atlantic Ocean.

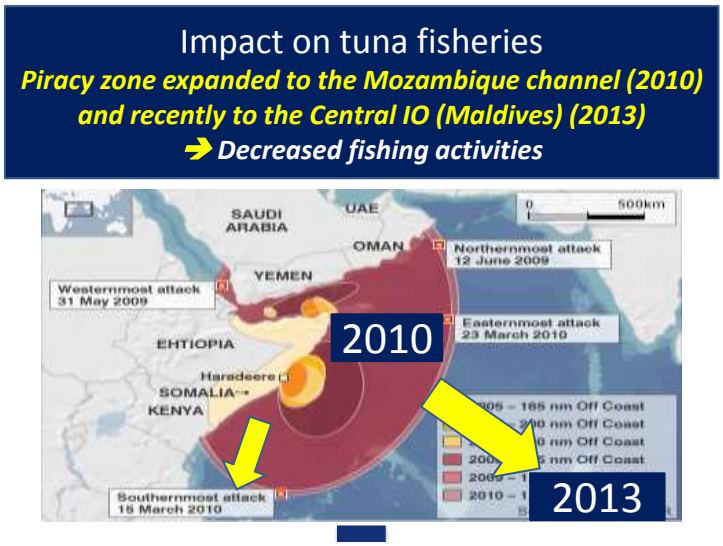

Fig. 10 Affected waters by piracy activities

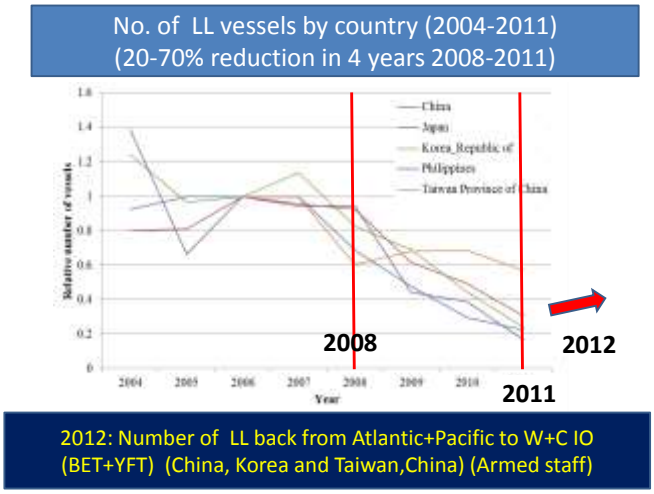

Fig. 11 Change of number of tuna longliners in the Indian Ocean

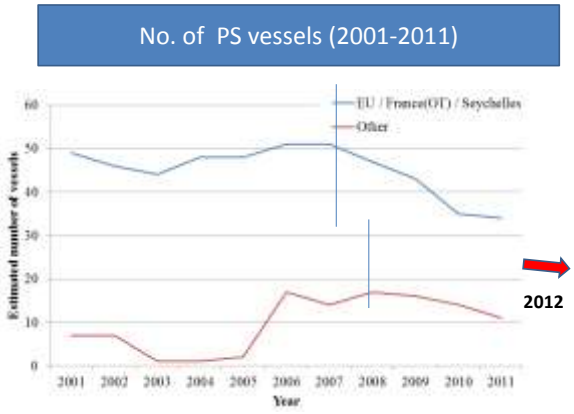

Fig. 12 Change of number of purse seiners in the Indian Ocean

Thus, fishing intensities for tropical tuna (yellowfin, bigeye tuna and skipjack) and also swordfish had greatly reduced after 2008. Consequently their catch sharply decreased (Fig. 13). However, a number of tuna longliners remained in the Indian Ocean moved to the southern ocean where there are the albacore fishing grounds and they have been targeting albacore. Hence, only albacore catch has been increased (Fig. 13). This situation is well reflected in the Kobe plots for 5 commercially important species in the IOTC, i.e., the stock status of yellowfin, bigeye, skipjack and swordfish have been recovering after 2008, while for albacore, it has been worsening after 2008 (Fig. 14).

As for the small scale fishing operating in the high seas, especially drift gillnet fisheries in the NW Indian Ocean, they 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 attached 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 (for example, kawakawa in Fig 3). This situation is very similar to the one in albacore.

Stock structure

There may be some possibilities of gene flows in the entire region and one stock hypothesis may be true (Box 1). But as we could net get the convergence in the first ASPIC run assuming the one stock, while we could get the convergence in the 2nd ASPC run using the NW hypothetical stock under the 4 stocks scenario. We wonder if gene flows are possibly occurred and genes can be mixed well in the entre Indian Ocean region, which has large geographical distances for some countries (e.g. between Kenya and Australia). Although convergence does not imply that 4 stock hypothesis is true, it might suggest it indirectly to some extent.

Exploring other STD_CPUEs

During the WPNT03 meeting, we may need to compare available kawakawa STD_CPUE (or nominal CPUE: N_CPUE) from different fleet operating different waters, so that we may be able to learn geographically homogenous groups that have similar trends. Then we may be able to discuss further about the stock structure.

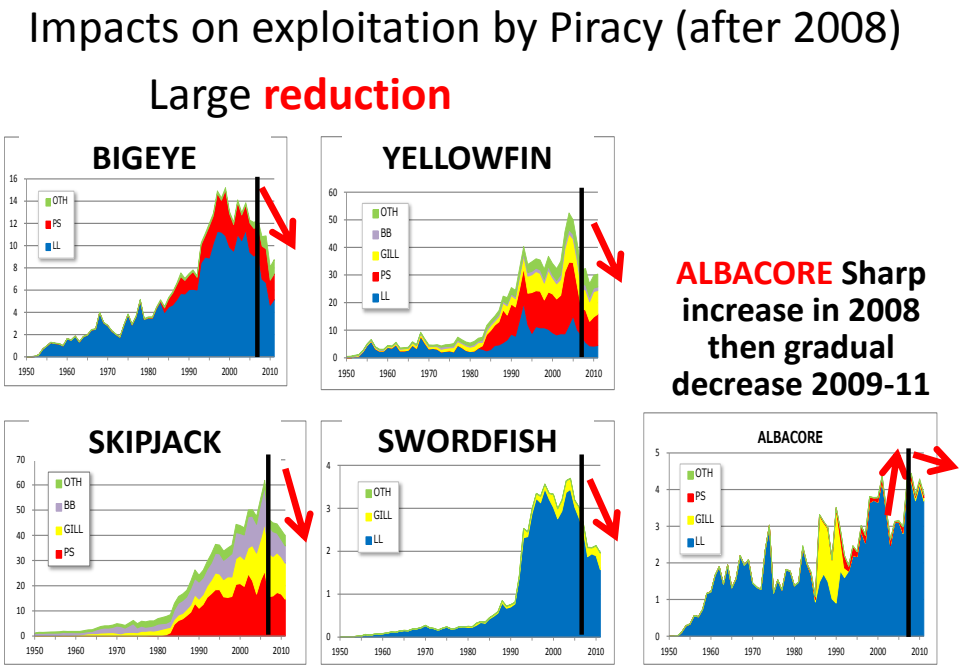

Fig. 13 Catch trends of 5 commercially important species in the IOTC. Catch[13] except albacore sharply decreased after 2008.

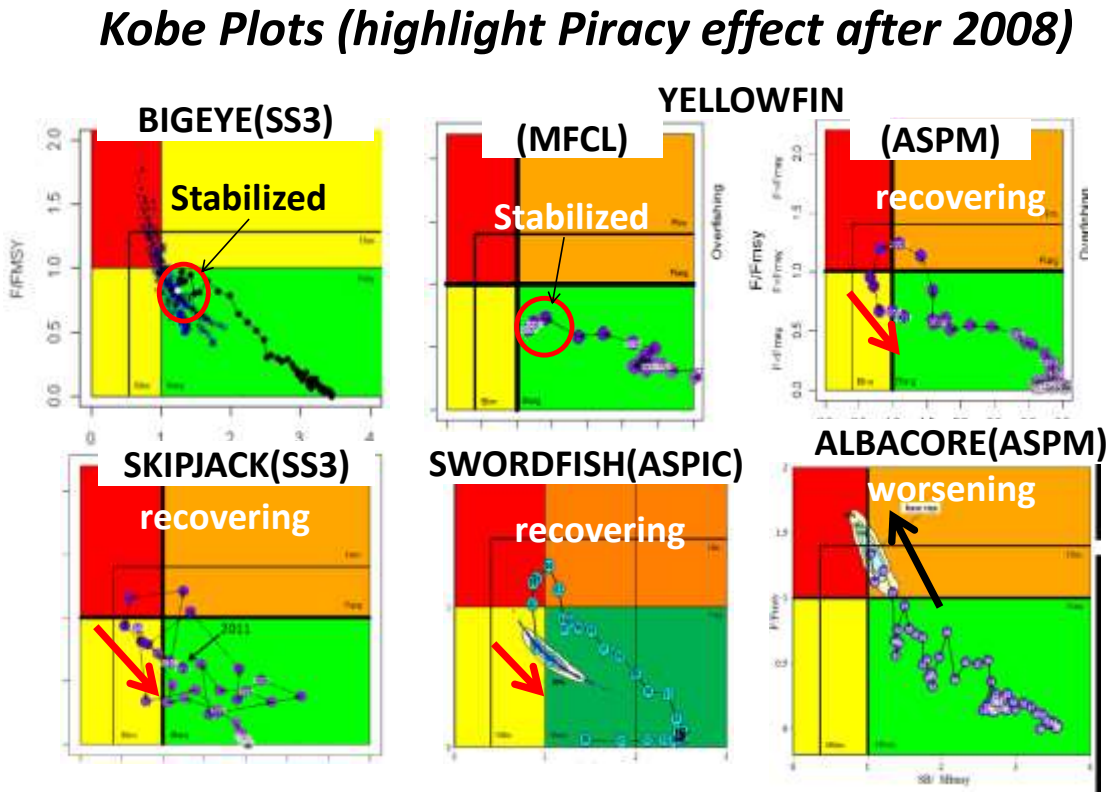

Fig. 14 Status of the stock (Kobe plots) of 5 commercially important species. All species except albacore have been recovering after 2008 when piracy activities intensified.

Stock status

Assuming that there is the NW Indian Ocean stock, we will discuss the kawakawa stock status. Based on the Kobe plot (Fig. 9), we understand that the kawakawa stock in the NE Indian Ocean region is now about entering to the overfished status due to high fishing pressure after 2008 when piracy activities intensified.

As discussed previously, major drift gillnet fisheries in this region moved back to their EEZ waters and targeted more neritic tunas. That is the major reason why catch (F) has been sharply increased in recent years after 2008 (Figs. 4, 6 and 9). This caused the sharp decrease in its biomass (population) size and the status of the stock has been worsening (Figs. 5 and 9). This situation is very similar to the one in albacore, i.e., more Asian tuna longline fisheries started targeting albacore in the pricy free zone in the southern Indian Ocean which worsen its stock status.

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