SCIENTIFIC COMMITTEE
TWELTH REGULAR SESSION

Bali, Indonesia
3-11 August 2015

Analyses and projections of economic conditions in WCPO fisheries

WCPFC-SC12-2016/ST-WP-04
Rev 1 (11 July 2016)

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Executive summary

Ex-vessel fish prices, fishing costs and catch rates are the three key determinants of economic conditions prevailing in a fishery. Changes in each can have significant impacts on the financial viability of vessels operating in a fishery and the returns generated from the exploitation of fish stocks. This paper provides an historical overview of relative economic conditions and simplistic projections over the next 10 years for the southern longline, tropical longline and purse seine fisheries of the Western and Central Pacific Ocean.

Southern longline fishery

- Economic conditions have fluctuated significantly in the fishery over the reference period, 1997 to 2015. However, the general trend is one of decline.
- Declines in catch rates and increases in fishing costs have driven the decline in economic conditions although fishing costs in 2015 declined significantly.
- Economic conditions were relatively poor throughout the period 2011 to 2014 despite real composite fish prices in 2012 being at record levels.
- While conditions improved significantly in 2015 they remained below average as below average catch rates persist although costs and fish prices were around their long term average.
- Projections based on past trends suggest persistent below average catch rates will be the key driver behind the continuation of relatively poor economic conditions for the fishery.

Tropical longline fishery

- Between 1997 and 2008 economic condition rapidly declined as costs increased and prices and catch rates fell. This was followed by a significant improvement in economic conditions in 2009 as costs fell as a result of falls in the global fuel price and an increase in catch rates.
- Since 2011, and continuing in 2015, the fishery has seen persistent but stable below average economic conditions. While overall conditions have been relatively stable since 2011 the components of the index have seen significant annual variations.
- Going forward, economic conditions are projected to improve slightly in first few years of the projection period as fuel costs are expected to remain relatively low and catch rates are projected to improve. However, declines in the catch rate and prices from around 2022 are expected to drive economic conditions back below average levels.

Purse seine fishery

- In contrast with the longline fisheries, economic conditions in the purse seine fishery have been on an upward trend since 2006 after a sustained period (1999-2006) of relatively poor conditions.
- The key driver behind the trend over the period 2006-2013 was the upward trend for fish prices which more than offset increases in fuel costs.
- While declines in fish prices in 2014 and 2015 resulted in declines in economic conditions compared with 2012 and 2013 declining fuel costs and increasing catch rates have resulted in conditions remaining above the long term average.
- Conditions are projected to improve significantly over the next 10 years to 2025. This is mainly on the account of higher projected catch rates and above average fish prices.

Overview

In the second half of 2015, FFA developed a series of *Economic Conditions Indices* for the three main tuna fisheries in the Western and Central Pacific Ocean (WCPO)[1]. These indices are constructed based on relative fish prices, fishing costs (excluding license and access fee payments) and catch rates. Fish prices and fishing costs are specified in real terms (2015 USD), that is, adjusted to account for inflation. Together, information from the three components are combined into a single value expressed as an index where the average values for the period of data series (1997-2015 inclusive) is set at 100, and provide a relative measure of changes in economic conditions over time. Values below 100 suggest that the fishery is experiencing below average economic conditions, while values of over 100 show periods in which economic conditions in the fishery the fishery are relatively favourable and the ability of operators to generate profits and pay license and access fees is relatively higher.

The purpose of this paper is to update economic conditions for the southern longline, tropical longline and purse seine fisheries of the WCPO presented in the 2015 Economic Indicators Report, but also to provide projections of conditions going forward, to 2025. Projections of prices and catch rates using Autoregressive Integrated Moving Average (ARIMA) models for individual species in each fishery are also included. The intention of the projections is to sketch out the likely trend for prices and catch rates using only historical information of the time series themselves. The projections are not aimed to give an accurate year by year prediction as there are various uncertainties and drivers behind prices and catch rates not accounted for, such as performance of international economies and markets, advancement in technology, and biological characteristics of the tuna species. All projections are also bound by 95% confidence intervals for this reason. Fuel price projections are derived using information from the US Energy Information Administration Annual Energy Outlook report. For full methodology on how the indicators are calculated, please refer to the 2015 Economic Indicators Report. For ARIMA models used to projection prices and catch rates, refer to the Appendix.

[1] The purse seine, tropical longline and southern longline fisheries. The tropical longline fishery is defined as the longline fishery between 10°N and 10°S in the WPCFC-CA excluding the waters of Indonesia, Philippines and Vietnam, and the southern longline fishery is defined as the longline fishery south of 10°S in the WPCFC-CA.

Southern longline fishery

Historical overview

Economic conditions for the southern longline fishery were particularly poor in the period from 2010 to 2014, as a result of low catch rates and high real fuel prices (Figure 1). Despite the fact that real fish prices were at its second highest and highest levels over the period in 2011 and 2012, respectively, conditions have continued the declining trend that is evident from the beginning of the assessment period, 1997. Economic conditions improved significantly in 2015, with the index at 89 compared with 65 in 2014. This improvement was primarily driven by falling fuel costs with the fish price remaining around its 2014 level, which was also about the same as its long term average. The index reading of 89 in 2015 is the highest since 2009. However, persistent low catch rates continue to impact on economic conditions and if they continue the likelihood of economic conditions returning to higher historical average levels remains low.

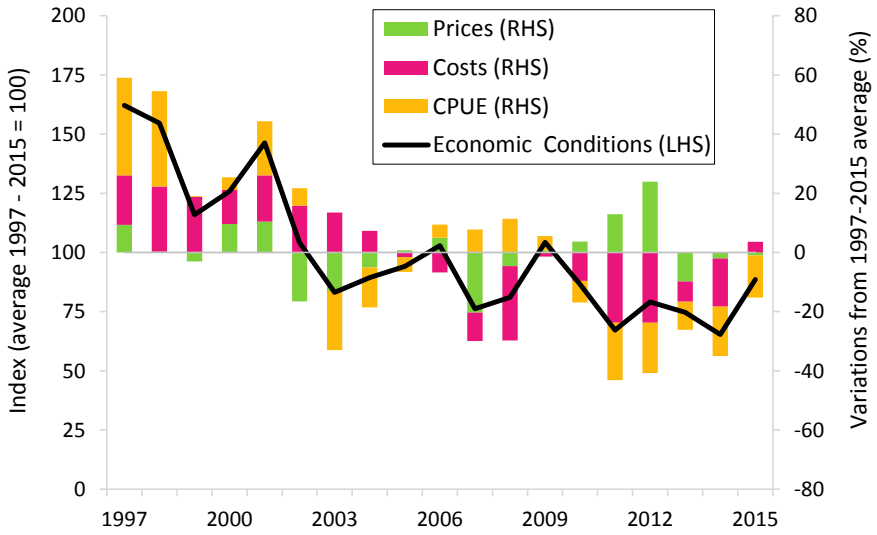

Figure 1: Economic conditions index for the southern longline fishery (LHS) and variance of component indices against average (1997-2015) conditions

Prices

The fish price component of the economics index (Figure 8) is a weighted composite of the annual real (that is, inflation adjusted) USD price of Thai imports of albacore and Japanese imports from Oceania of fresh bigeye and yellowfin (Figure 2; Figure 3; Figure 4).

Nominal albacore prices have fluctuated considerably over time (Figure 2) with a generally upward trend. In contrast, prices in real terms (specified in 2015 USD) have remained relatively stable over time at around $2,904/mt, with significant fluctuations around it. Real prices were at their highest in 2012 (26% above the 1997-2015 average) and lowest in 2007 (23% below average). Since 2008, the only time the real albacore price was significantly lower than the long term average was in 2013 (12% below average). In 2015 prices averaged $3,020/mt, 4% above the long term average (Figure 5).

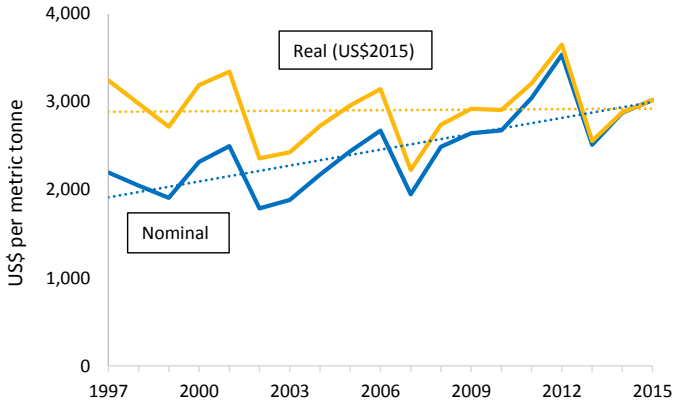

Figure 2: USD real and nominal prices for imports of albacore into Thailand

Source: Nominal prices Thai Customs

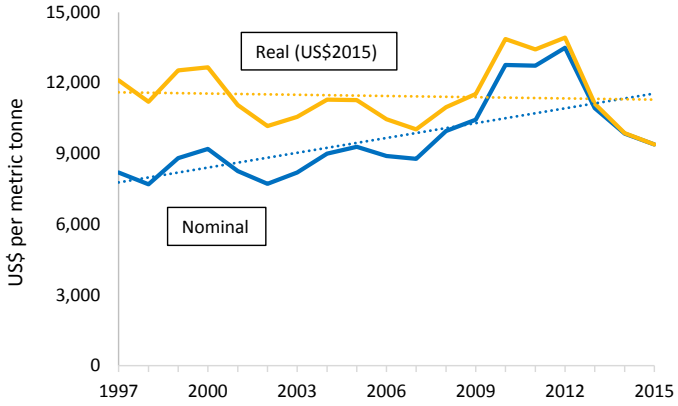

Figure 3: USD real and nominal prices for Japanese bigeye imports from Oceania

Source: Nominal prices Japan Customs

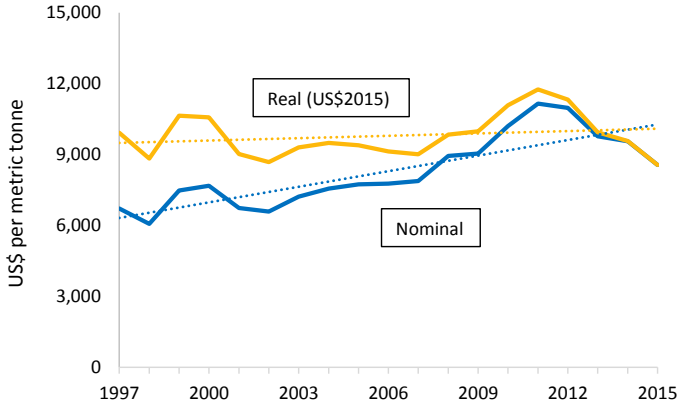

Figure 4: USD real and nominal prices for Japanese yellowfin imports from Oceania

Source: Nominal prices Japan Customs

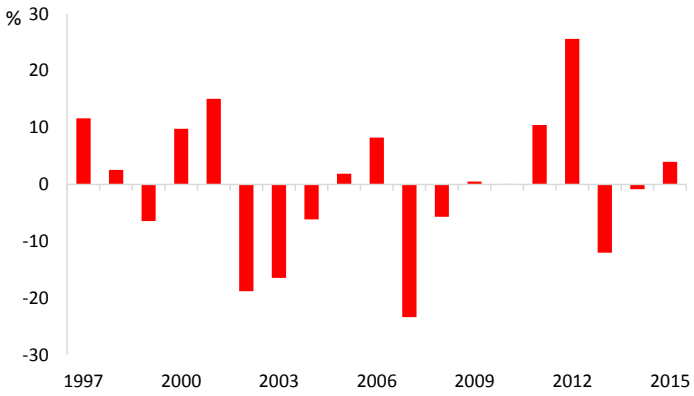

Figure 5: Variations in USD real prices for Thai albacore imports against its long term average (1997-2015)

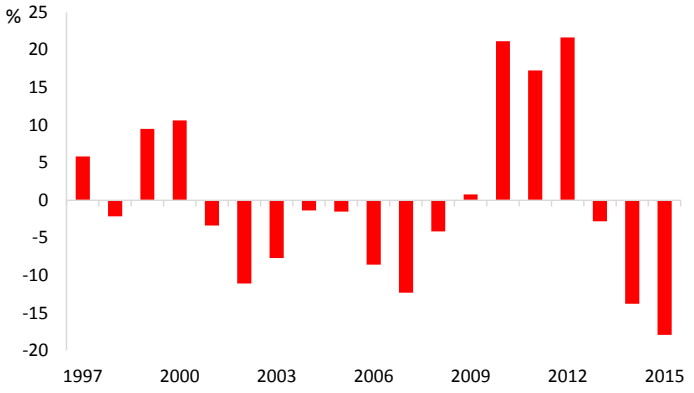

Figure 6: Variations in USD real prices for Japanese bigeye imports from Oceania versus its long term average (1997-2015)

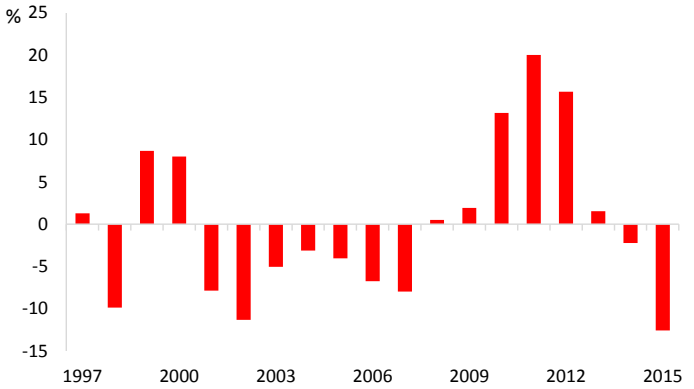

Figure 7: Variations in USD real prices for Japanese yellowfin imports from Oceania versus its long term average (1997-2015)

As can be seen from Figure 3 and Figure 4, real USD prices for fresh bigeye and yellowfin imports into Japan followed a similarly steady trend over time. While the trends were similar to that for albacore, the pattern of variation from the average price over the period differed in that real USD yellowfin and bigeye prices spent longer periods at lower and higher than average levels while albacore prices appeared more volatile (Figure 5; Figure 6; Figure 7). Average fresh bigeye and yellowfin import prices into Japan fell in USD terms during 2015 as a result of the appreciation of the Dollar against the Yen, and were respectively 18% and 13% below levels averaged over 1997-2015.

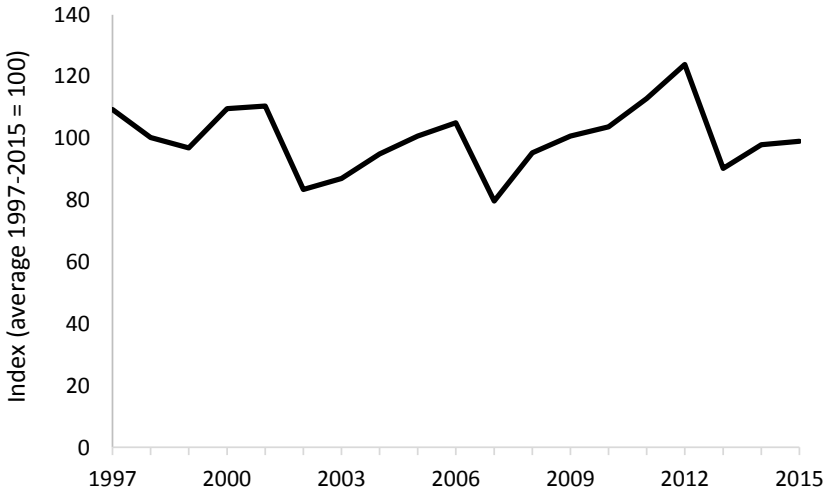

Figure 8: Composite price index for the southern longline fishery

Costs

The fishing cost component of the economic conditions index (Figure 9) is based on changes to real fuel prices, as reflected by the Singapore marine diesel oil (MDO) price (Figure 10). Other costs were assumed to remain constant in real terms (i.e. non-fuel costs are assumed to increase at the same rate as US CPI). The proportion of total costs related to fuel costs was estimated by fitting the data to historical estimates as detailed in in FFA's 2015 Economic Indicators Report.

While constant real non-fuel operating costs were slightly different between the longline fisheries (southern and tropical) and the purse seine fishery, the fishing cost index between all three fisheries remained more or less the same when combined with the Singapore MDO price series (Figure 9). The detailed data outputs are displayed in the Appendix.

As can be seen in Figure 10, the Singapore MDO price declined significantly in the second half of 2014 and into 2015, to an average of US$485/mt. This compares to a real price of around $900 and $1000/mt in the period from March 2011 and June 2014. Recent (June 2016) prices are around $530/mt. As mentioned previously, the fall in fuel prices contributed to the significant improvement in economic conditions for the southern longline fishery in 2015.

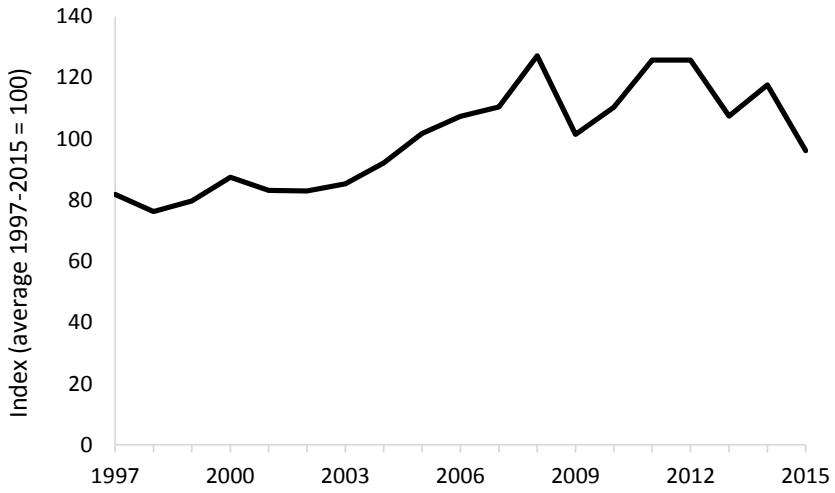

Figure 9: Fishing cost index for WCPO fisheries

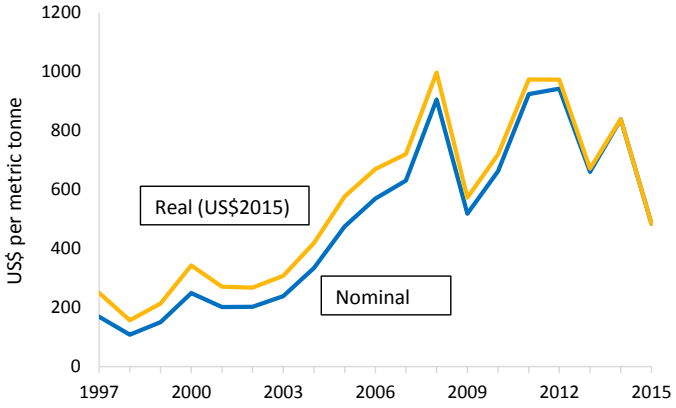

Figure 10: Singapore marine diesel oil (MDO) nominal and real price series

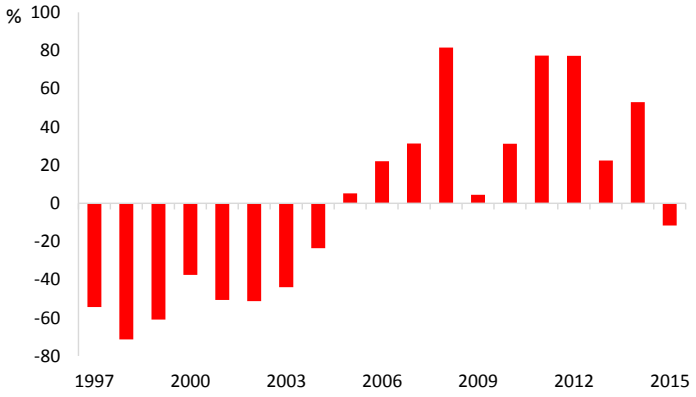

Figure 11: Variations in annual USD real prices for Singapore MDO versus its long term average (1997-2015)

Source: Bunker World

Catch rates

The catch rate component of the economic conditions index is for the southern longline fishery is based on the catch per unit of effort (CPUE) across all species in the fishery, measured in terms of kilograms caught per hundred hooks set (Figure 12). The full breakdown of contribution to the catch rate index by species is shown in Figure 13.

While catch rates appear to exhibit cyclical behaviour since 1997, the trend has been one of decline. The rate at which catch rates recover after a trough has slowed significantly. This phenomenon of lower peaks and troughs, and slower recovery from troughs has resulted in average catch rates declining over time. This is reflected by the 5 year running average, which is on a downward trend (Figure 13). The 5 year average over 2011-15 was 34.8 kg per hundred hooks, 16% lower than that over 2002-06 (which was the lowest 5 year average seen prior to 2011), and 28% lower than that over 2005-09.

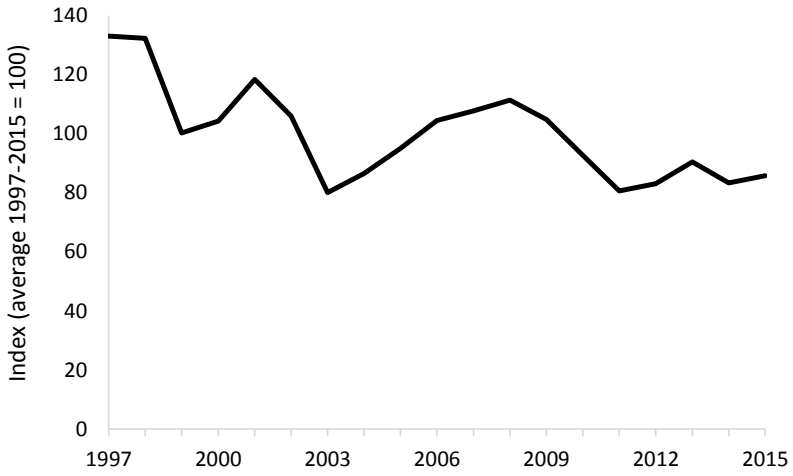

Figure 12: Catch rate index in the southern longline fishery

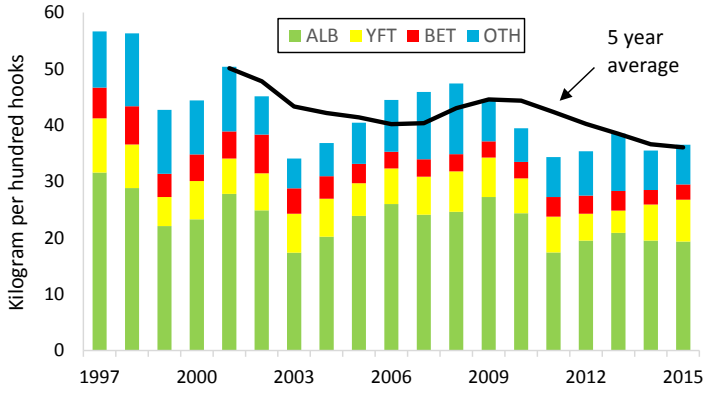

Figure 13: CPUE in the southern longline fishery by species

Source: *Pers. com. Peter Williams, SPC June 2016*

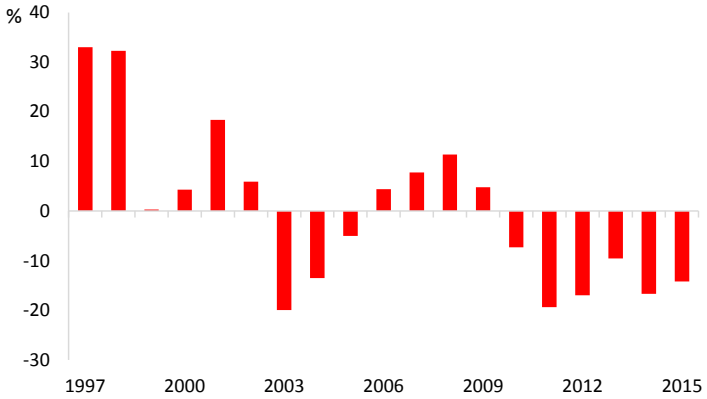

Figure 14: Variations in total CPUE versus its long term average (1997-2015)

Future projections

Using Autoregressive Integrated Moving Average (ARIMA) models, real prices (in 2015 USD) of Thai imports of albacore and Japanese imports from Oceania of fresh bigeye and yellowfin are projected to 2025 in Figure 15, Figure 16 and Figure 17. The 95% confidence intervals for the projections are shaded in grey. The models utilises the relationship the each time series has with its past values only to extrapolate future predictions of the series. Therefore, potential movements in international markets, exchange rates (especially for bigeye and yellowfin prices which are normally determined by the Japanese markets in Yen) and financial shocks are not considered. As prices are expressed in real dollars, where little historical trends were evident (Figure 2; Figure 3; Figure 4), it is not surprising to see fluctuations around a somewhat constant mean. The projected prices are then combined into the composite price index in Figure 18, indexed over the same average period of 1997-2015. For the southern longline fishery, the composite price index is projected to increase marginally over the next decade to 2025.

Prices

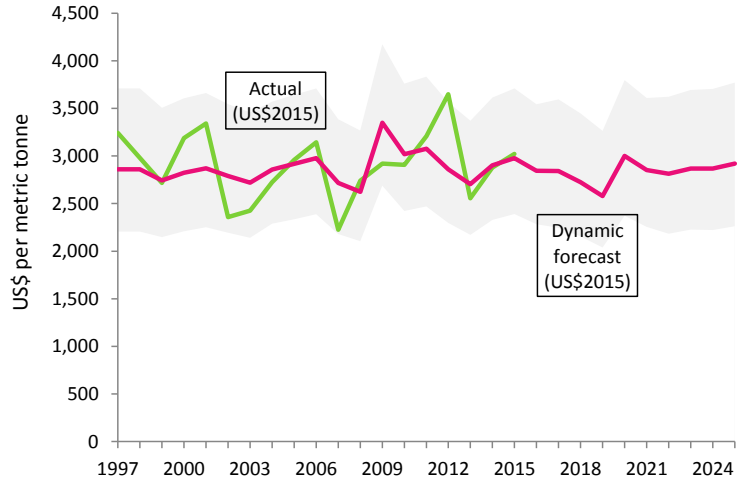

Figure 15: Projections of USD real prices for imports of albacore into Thailand

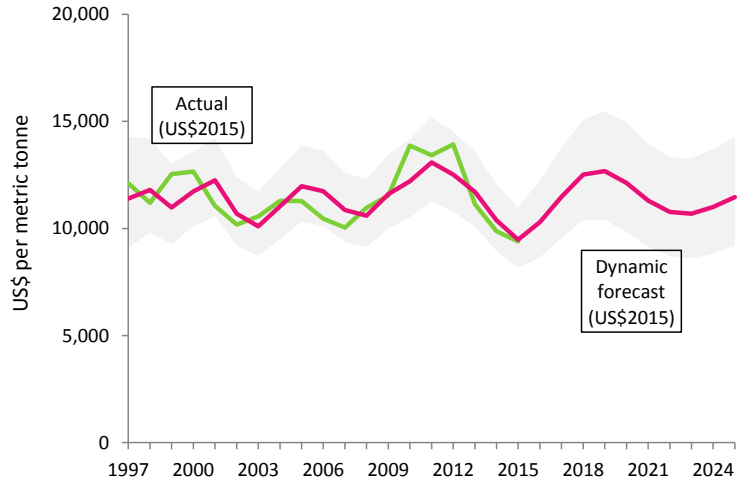

Figure 16: Projections of USD real prices for Japanese bigeye imports from Oceania

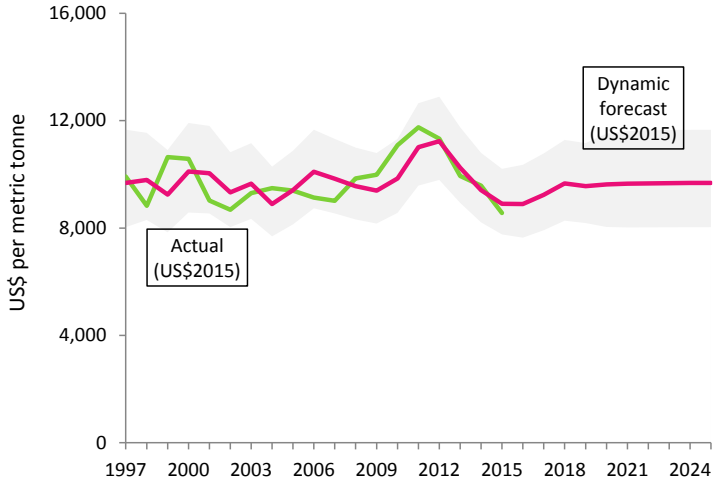

Figure 17: Projections of USD real prices for Japanese yellowfin imports from Oceania

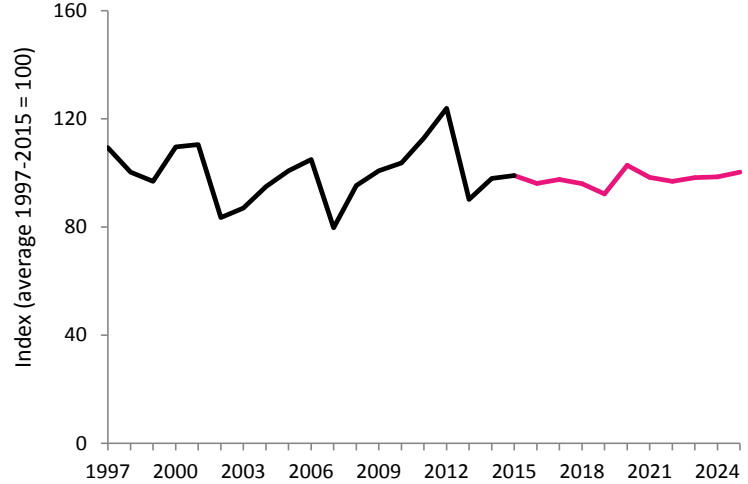

Figure 18: Projections of composite price index for the southern longline fishery

Using Autoregressive Integrated Moving Average (ARIMA) models, real prices (in 2015 USD) of Thai imports of albacore and Japanese imports from Oceania of fresh bigeye and yellowfin are projected to 2025 in Figure 15, Figure 16 and Figure 17. The 95% confidence intervals for the projections are shaded in grey. The models utilises the relationship the each time series has with its past values only to extrapolate future predictions of the series. Therefore, potential movements in international markets, exchange rates (especially for bigeye and yellowfin prices which are normally determined by the Japanese markets in Yen) and financial shocks are not considered. As prices are expressed in real dollars, where little historical trends were evident (Figure 2; Figure 3; Figure 4), it is not surprising to see fluctuations around a somewhat constant mean. The projected prices are then combined into the composite price index in Figure 18, indexed over the same average period of 1997-2015. For the southern longline fishery, the composite price index is projected to increase marginally over the next decade to 2025.

Costs

The real price of Singapore MDO is projected by applying the growth rate of North Sea Brent crude oil forecasts from the US Energy Information Administration Annual Energy Outlook report (Figure 19). Unlike the ARIMA projections, the confidence intervals for the MDO price projection reflect the other two scenarios to the reference case examined by the US Energy Information Administration, of high and low oil prices.

This is then combined with the other operating cost component, constant in real terms, to create the projection for the fishing cost index (Figure 20). The index shows a gradual increase in fishing costs for the southern longline fishery, and this primarily reflects the conservative growth forecast of the US Energy Information Administration for the volatile commodity. As mentioned earlier, the index is more or less the same for all three fisheries examined in the WCPO. Individual values are displayed in the Appendix.

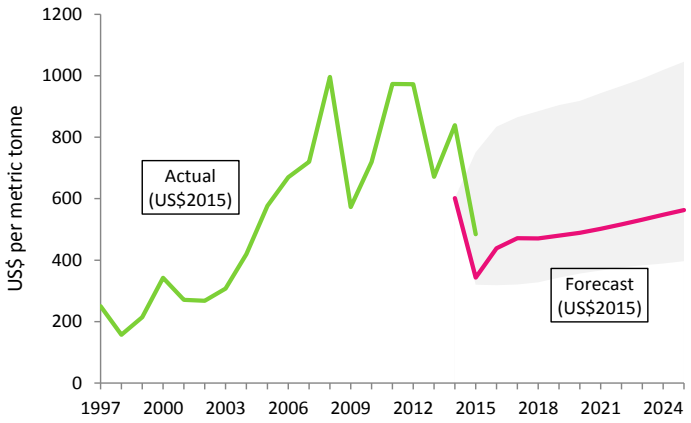

Figure 19: Projections of Singapore marine diesel oil (MDO) in real prices

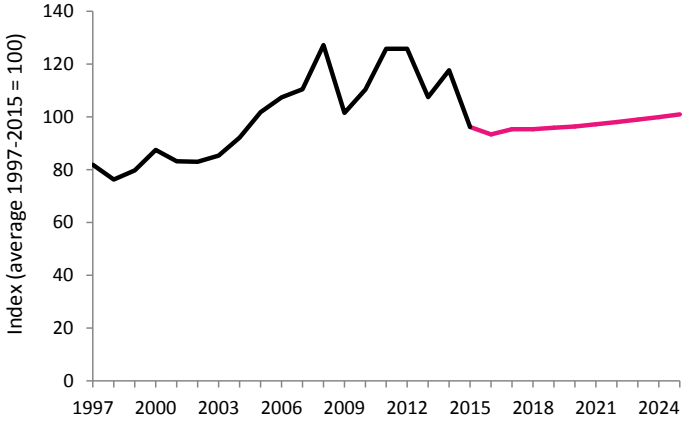

Figure 20: Projections of fishing cost index for WCPO fisheries

Catch rates

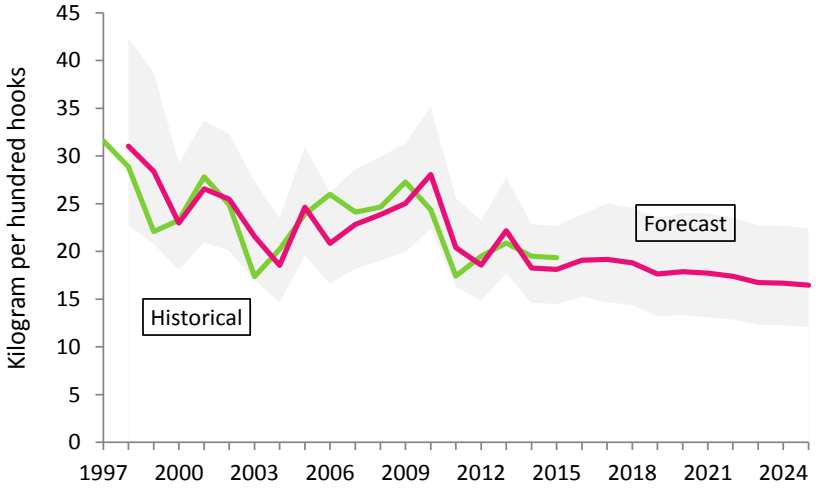

Figure 21: Projections of albacore CPUE in the southern longline fishery

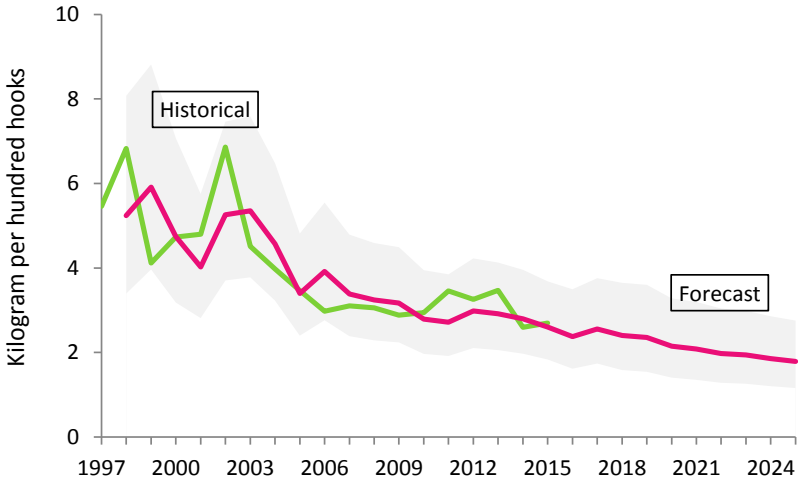

Figure 22: Projections of bigeye CPUE in the southern longline fishery

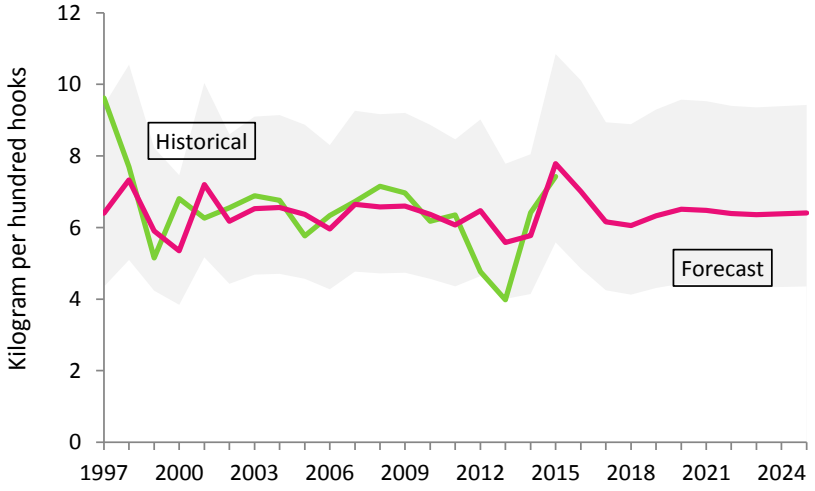

Figure 23: Projections of yellowfin CPUE in the southern longline fishery

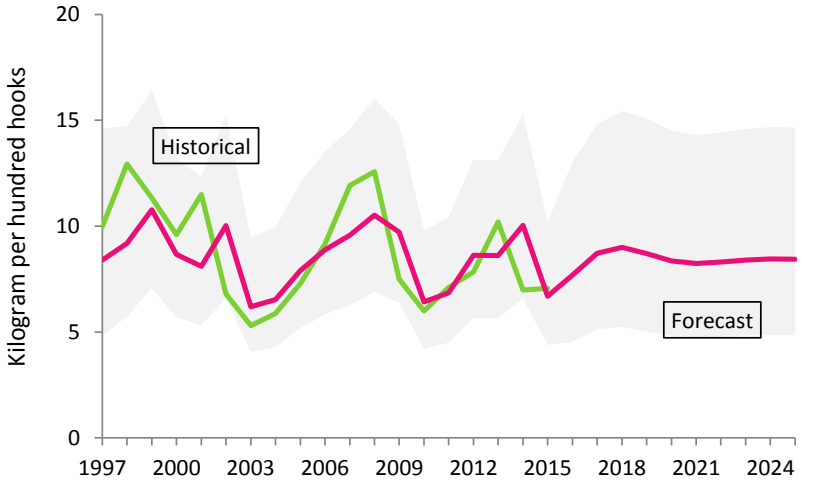

Figure 24: Projections of CPUE of other species in the southern longline fishery

Catch rates for the three key tuna species landed in the southern longline fishery along with an others category are projected in Figure 21, Figure 22, Figure 23 and Figure 24. The dynamic ARIMA projections are again bound by 95% confidence intervals. Using the relationship each series has with its past values, the models suggest declines in catch rates for both albacore and bigeye landed in the southern longline fishery. Catch rates for yellowfin and other species on the other hand, are projected to remain relatively constant from 2018 onwards.

Combining the four catch rate series, the 5 year moving average for catch rates and the catch rate index in the southern longline fishery are illustrated in Figure 25 and Figure 26, respectively. The general projected trend is one of decline, driven primarily by the fall in albacore catch rates. While these projections are not based on biological characteristics or interactions of the stock, they do appear to be representative of the overall experience in the fishery over the last decade.

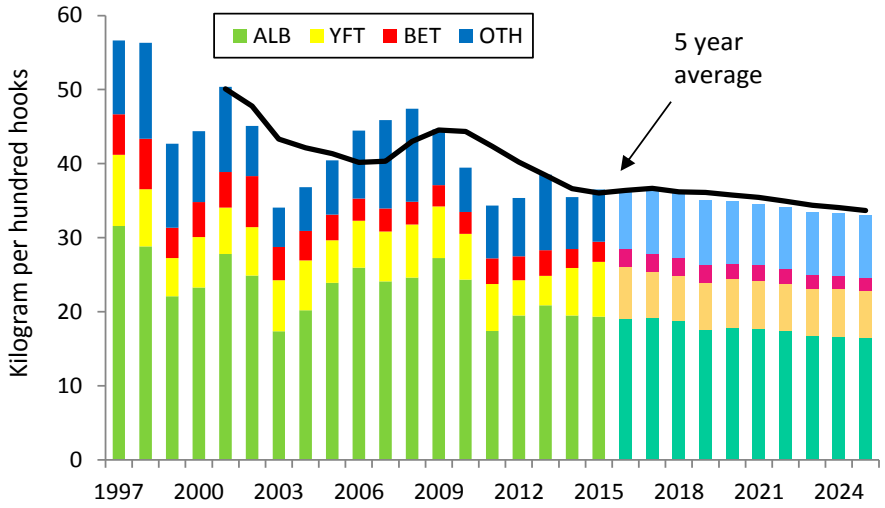

Figure 25: Projections of CPUE in the southern longline fishery by species (2016-2025)

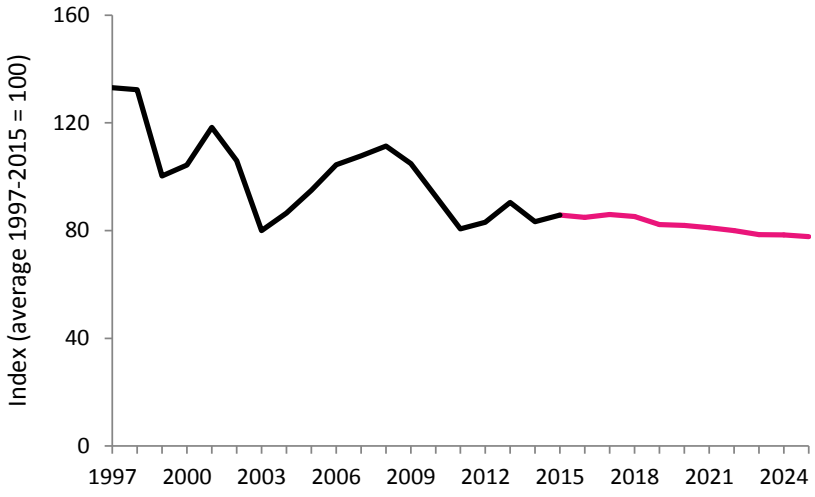

Figure 26: Projections of catch rate index in the southern longline fishery

Economic conditions index

Amalgamating the projections of all three index components, the economic conditions index for the southern longline fishery to 2025 is displayed in Figure 27. Economic conditions are expected to deteriorate for the southern longline fishery, predominantly driven by the continued decline in catch rates.

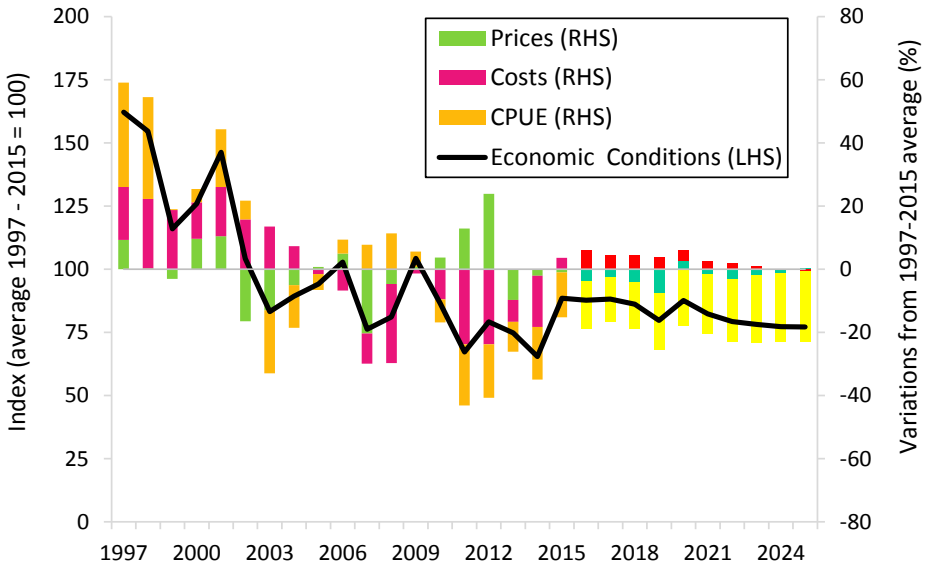

Figure 27: Projections of economic conditions index for the southern longline fishery (LHS) and variance of component indices against average (1997-2015) conditions (RHS)

Tropical longline fishery

Historical overview

Economic conditions in the fishery appear to have gone through two phases since 1997. The first phase between 1997 and 2008 saw a continuous and rapid decline as costs increased and prices and catch rates fell. This was followed by a significant improvement in economic conditions in 2009 as costs fell as a result of falls in the global fuel price and catch rates rose. The second phase, of persistent but stable below average conditions, commenced in 2011 and continued in 2015. While overall conditions have been relatively stable since 2011 the components of the index have seen significant annual variations. For example, in 2015 conditions improved marginally compared with 2014 despite a significant fall in fuel prices as the effect of the resulting decline in costs was largely offset by declines in the catch rate and fish price.

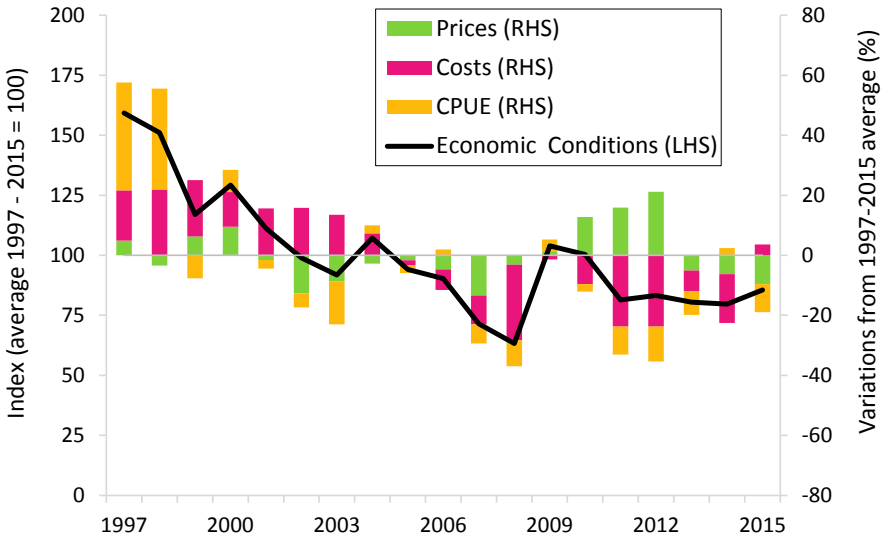

Figure 28: Economic conditions index for the tropical longline fishery (LHS) and variance of component indices against average (1997-2015) conditions

Prices

The same individual species prices used in the southern longline fishery are used for the tropical longline fishery price index (Figure 2; Figure 3; Figure 4). However, the composition of catch is significantly different, which in turn, yields a different composite price index (Figure 29). That is, for the tropical longline fishery bigeye and yellowfin catches make up on average 45% and 32% over the period from 1997-2015, respectively. This compares with only 9% and 15% of bigeye and yellowfin catches in the southern longline fishery. Therefore, while the fluctuations in the composite price index are similar between the two longline fisheries, the fluctuations appear to be dampened in the tropical longline fishery as real prices of bigeye and yellowfin are comparatively less volatile than albacore.

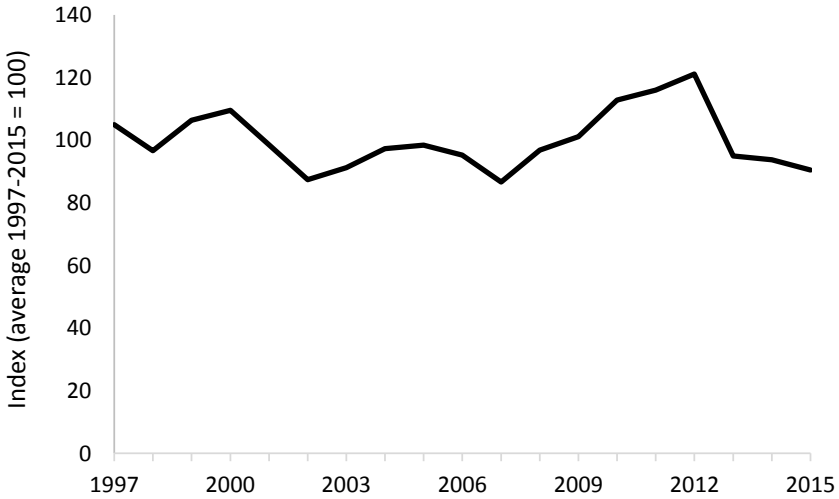

Figure 29: Composite price index for the tropical longline fishery

Catch rates

In contrast, the catch rate index for the tropical longline fishery is considerably different to that of the southern longline fishery (Figure 30). While the southern longline fishery experienced continual decline in catch rates (Figure 12), mainly albacore and bigeye (Figure 13), the tropical longline fishery maintained a relatively stable catch rate index between 1999 and 2015. This is largely the result of constant or increasing CPUE for all species except bigeye over the same period (Figure 31). The sizeable variation in catch rates between 1997 and 1999 (Figure 32) was driven by a sharp drop in yellowfin CPUE in the fishery, which fell from 9.6 kilograms per hundred hooks in 1997 to 5.1 kilograms per hundred hooks in 1999.

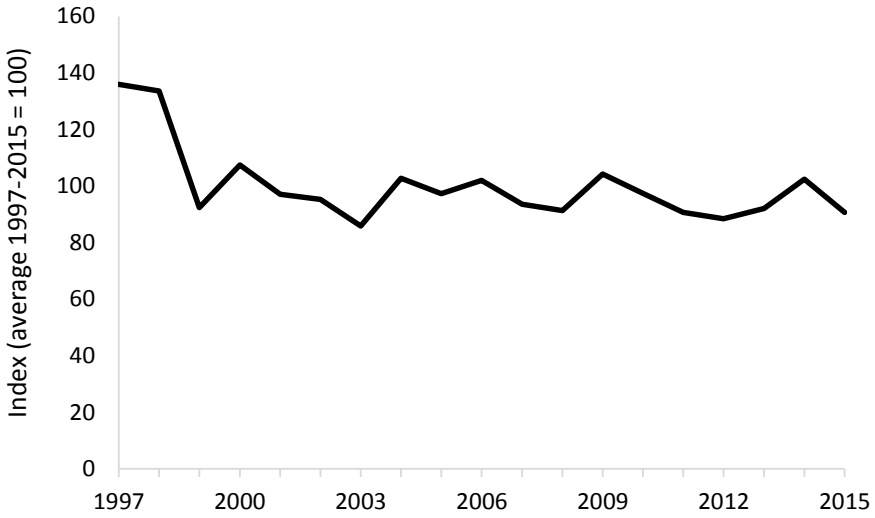

Figure 30: Catch rate index in the tropical longline fishery

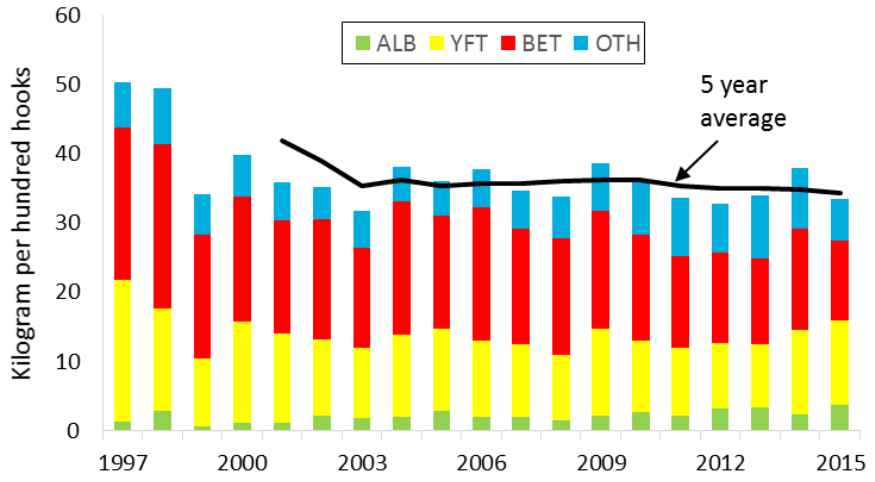

Figure 31: CPUE in the tropical longline fishery by species

Source: *Pers. com. Peter Williams, SPC June 2016*

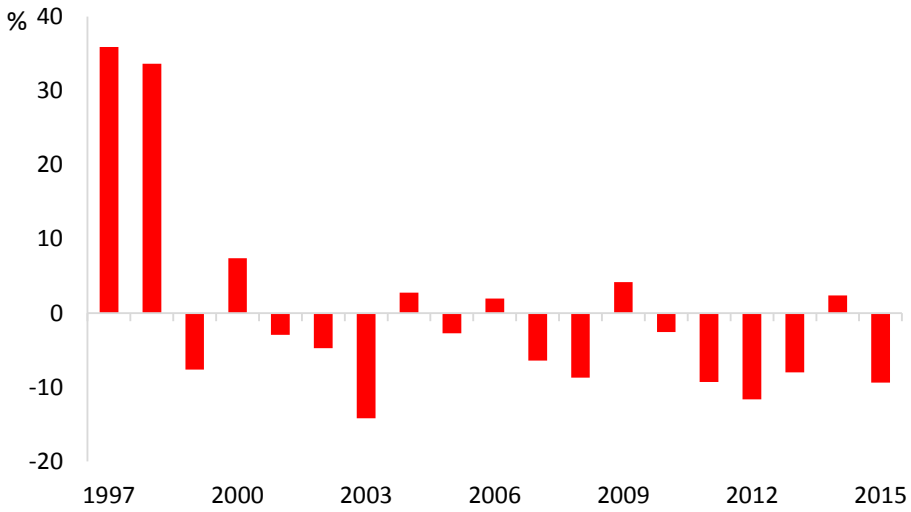

Figure 32: Variations in total CPUE versus its long term average (1997-2015)

Future projections

Prices

Using the same ARIMA price projections of that in Figure 15, Figure 16 and Figure 17, and average catch composition over the period from 1997-2015, the composite price index for the tropical longline fishery is composed in Figure 33. It follows a moderate upward trend similar to that of the southern longline fishery (Figure 18) for the period from 2016 to 2025.

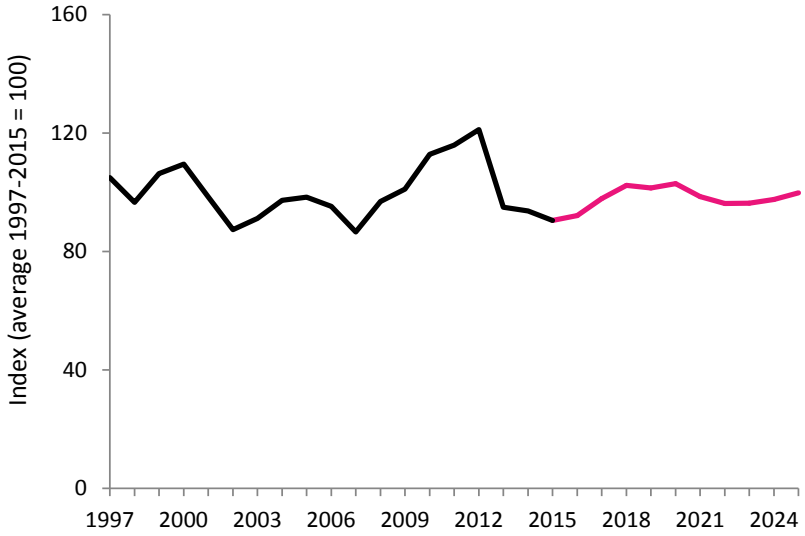

Figure 33: Projections of composite price index for the tropical longline fishery

Catch rates

Catch rates on the other hand, are projected to stay around its long term average for the tropical longline fishery, with marginal improvements in 2017 and 2019 (Figure 34). This occurs despite continual

decline in the bigeye CPUE (Figure 36), primarily offset by marginal improvements in the CPUE for yellowfin (Figure 37) and albacore (Figure 35) in the projection period from 2016 to 2025.

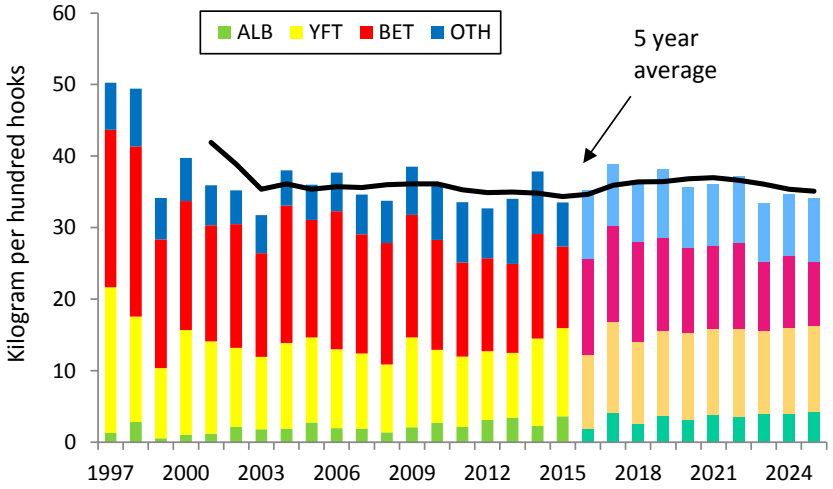

Figure 34: Projections of CPUE in the tropical longline fishery by species (2016-2025)

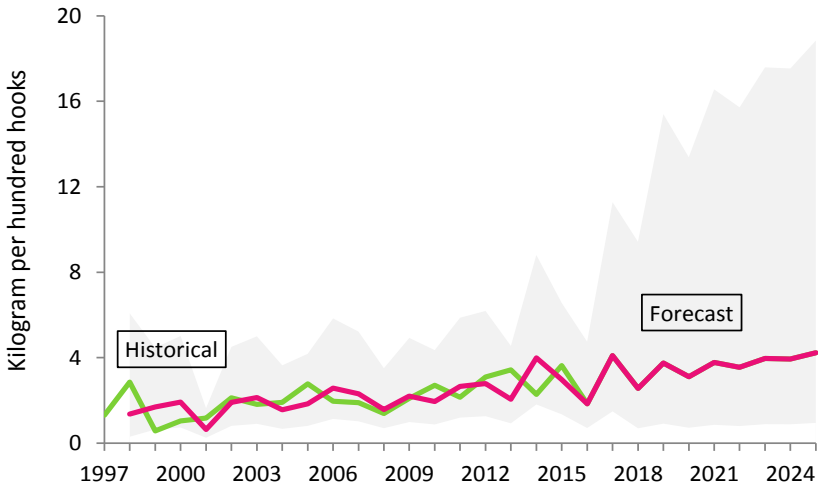

Figure 35: Projections of albacore CPUE in the tropical longline fishery

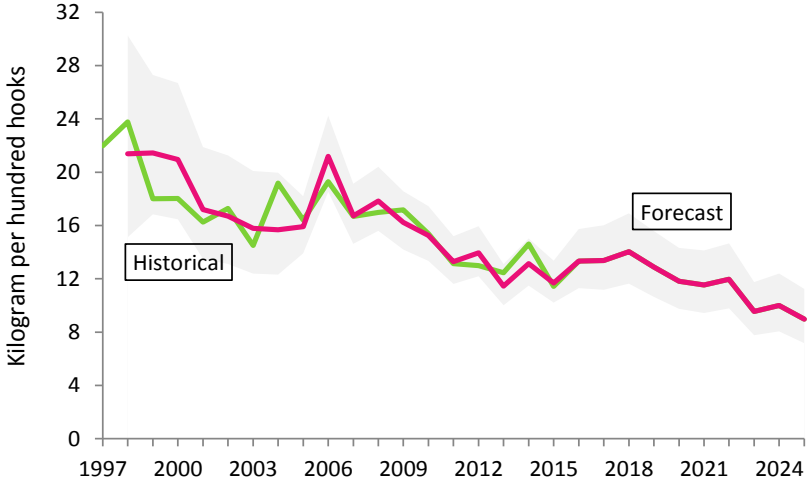

Figure 36: Projections of bigeye CPUE in the tropical longline fishery

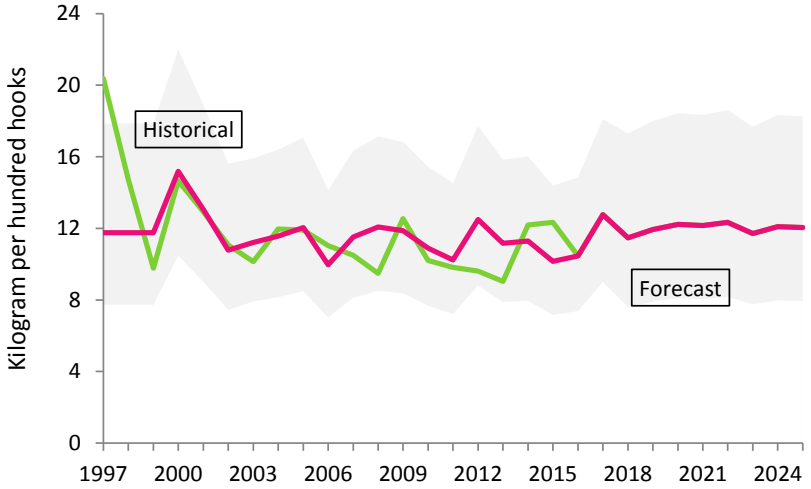

Figure 37: Projections of yellowfin CPUE in the tropical longline fishery

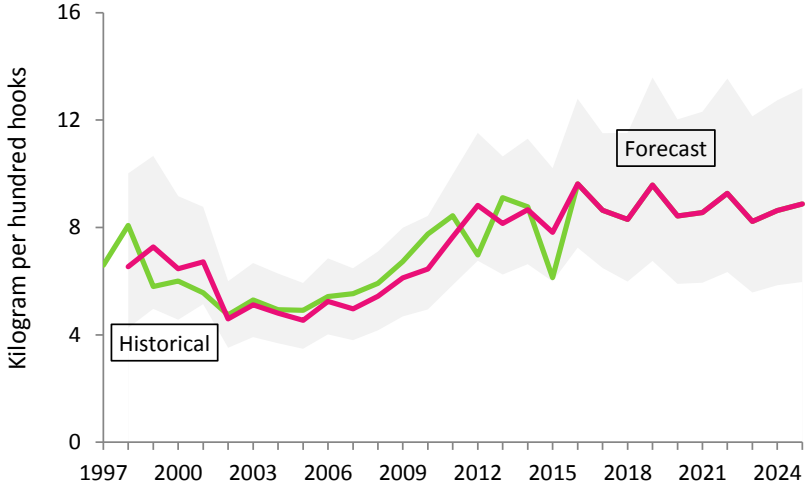

Figure 38: Projections of CPUE of other species in the tropical longline fishery

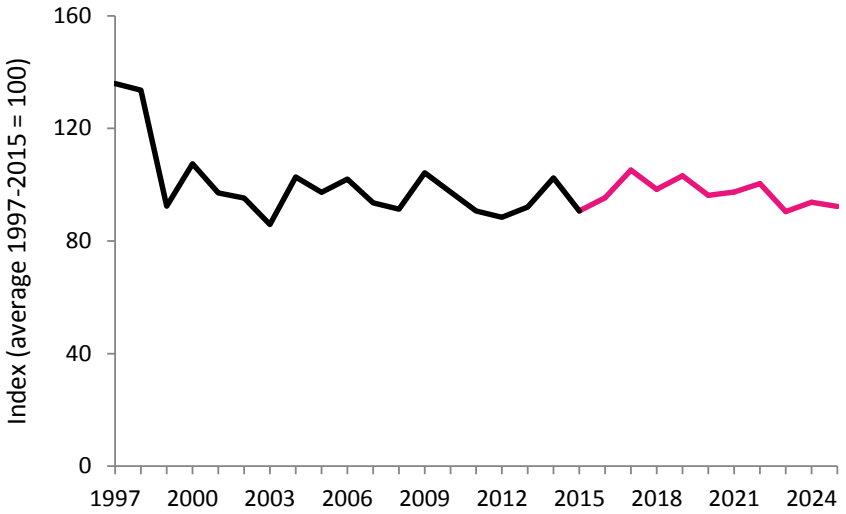

Figure 39: Projections of catch rate index in the tropical longline fishery

Economic conditions index

Amalgamating the price and catch rate index for the tropical longline fishery (Figure 33, Figure 39) and the fishing cost index for the WPCO (Figure 20), the economics conditions index for the tropical longline fishery is presented in Figure 40. While economic conditions are projected to follow a declining trend from 2017 onwards, it is falling from above average conditions to slightly long term average conditions by 2025. This juxtaposes those projected for the southern longline fishery, which suggests further declines from current economic conditions which are already below their long term average.

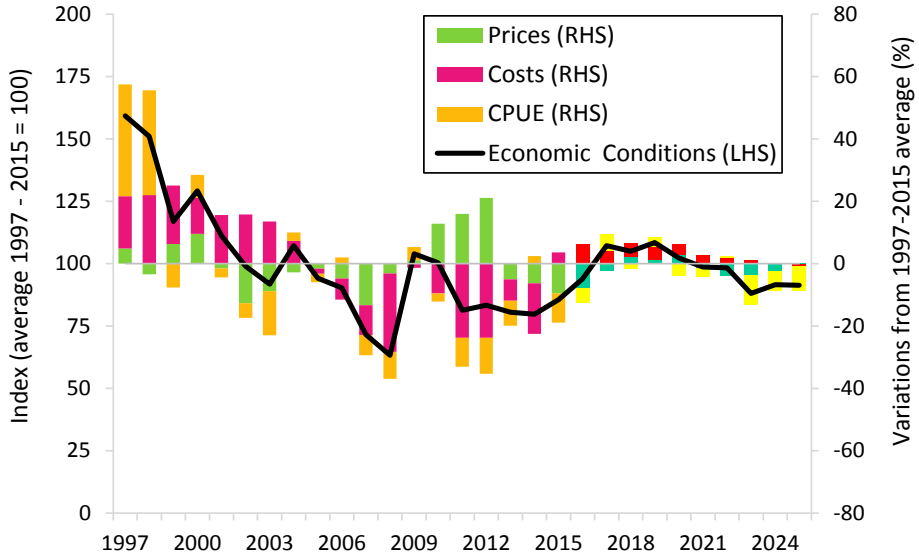

Figure 40: Projections of economic conditions index for the tropical longline fishery (LHS) and variance of component indices against average (1997-2015) conditions (RHS)

Purse seine fishery

Historical overview

The purse seine fishery displays a very different picture to that of the longline fisheries with movement in fish prices appearing to be the greatest determinant of changes to economic conditions in the fishery and catch rate changes having the least impact. Unlike the longline fisheries, this fishery does not display a general downward trend in economic conditions over time (Figure 41). The purse seine index shows the exceptionally good economic conditions that existed in the fishery between 2012 and 2013 which was driven by high tuna prices which more than offset the high price of fuel. The index also shows the return to average conditions in 2014 as fish prices declined. While prices continued to decline in 2015 with falls in fuel costs and above average catch rates, economic conditions in 2015 appear to have been better than in 2014 and well above the long term average.

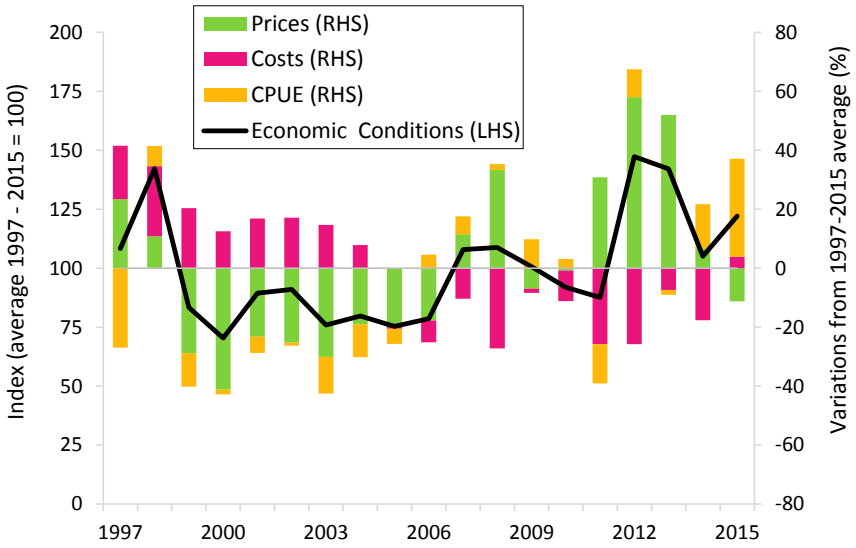

Figure 41: Economic conditions index for the purse seine fishery (LHS) and variance of component indices against average (1997-2015) conditions (RHS)

Prices

For the purse seine fishery, the fish price component of the index (Figure 46) is a weighted composite of the annual real USD price of Thai imports of frozen skipjack (Figure 42) and yellowfin (Figure 43). Both nominal and real skipjack price (specified in 2015 USD) have fluctuated over time around a general upward trend. This contrasts against stable or declining real prices in the longline fisheries, with the exception of Japanese yellowfin imports from Oceania, which followed a marginal increasing trend over the period from 1997 to 2015. Real skipjack import prices were at their highest in 2012 (62% above the 1997-2015 average) and lowest in 2000 (45% below). Since 2009, the only time the real skipjack price was below its long term average was in 2015 (12% below). Similarly, real and nominal price of Thai yellow imports also followed a general increasing trend over the same period. Between 2011 and 2013 (inclusive), real Thai yellowfin import price was on average 36% above its long term average. In 2015, yellowfin price fell to US$1,568/mt, 10% below the long term average.

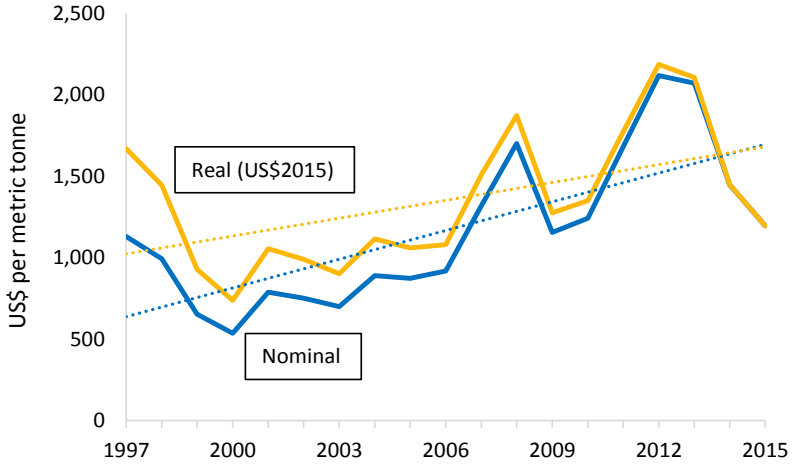

Figure 42: USD real and nominal prices for imports of skipjack into Thailand

***Source*:** Nominal prices Thai Customs

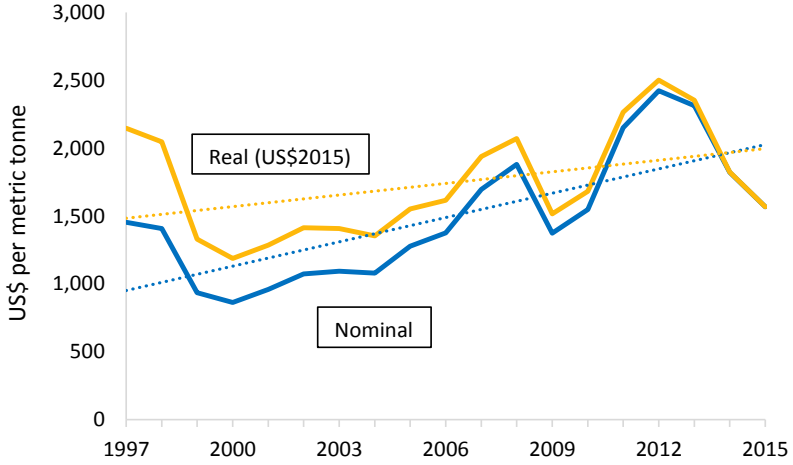

Figure 43: USD real and nominal prices for imports of yellowfin into Thailand

***Source*:** Nominal prices Thai Customs

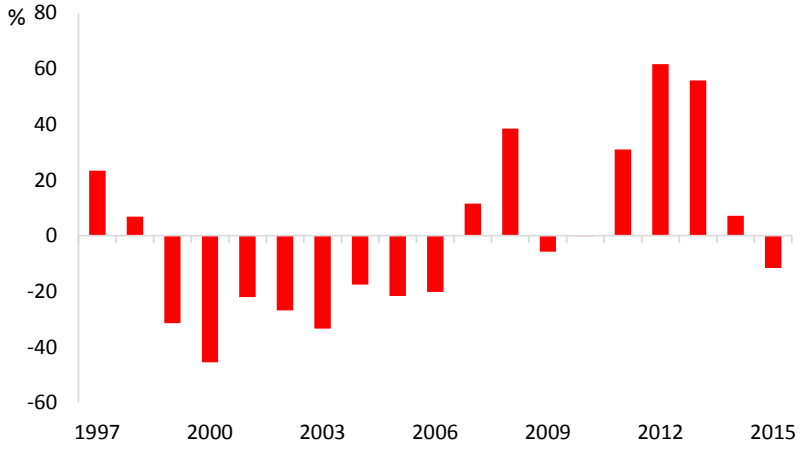

Figure 44: Variations in USD real prices for Thai skipjack imports against its long term average (1997-2015)

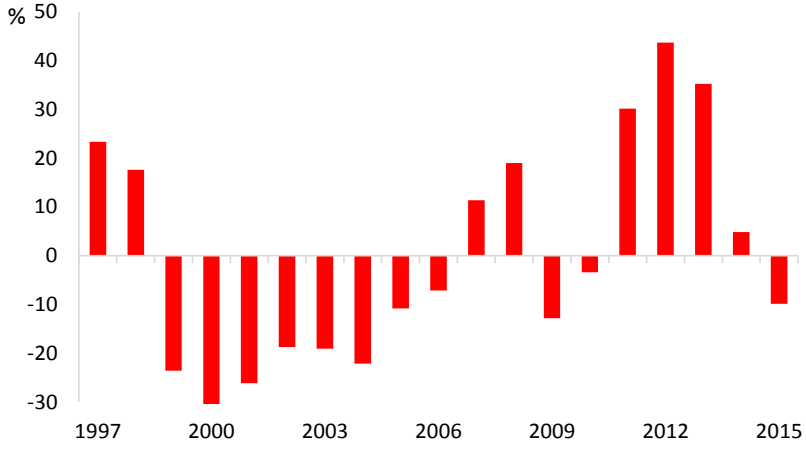

Figure 45: Variations in USD real prices for Thai yellowfin imports against its long term average (1997-2015)

Using the catch composition of the three tuna species and prices displayed in Figure 42 and Figure 43,[2] the composite price index for the purse seine fishery is computed and presented in Figure 46. Reflecting real individual species prices, the composite price index for the purse seine fishery exhibits a general increasing trend in the period from 2000 to 2013, with significant peaks in the composite price index in 2008 and 2012.

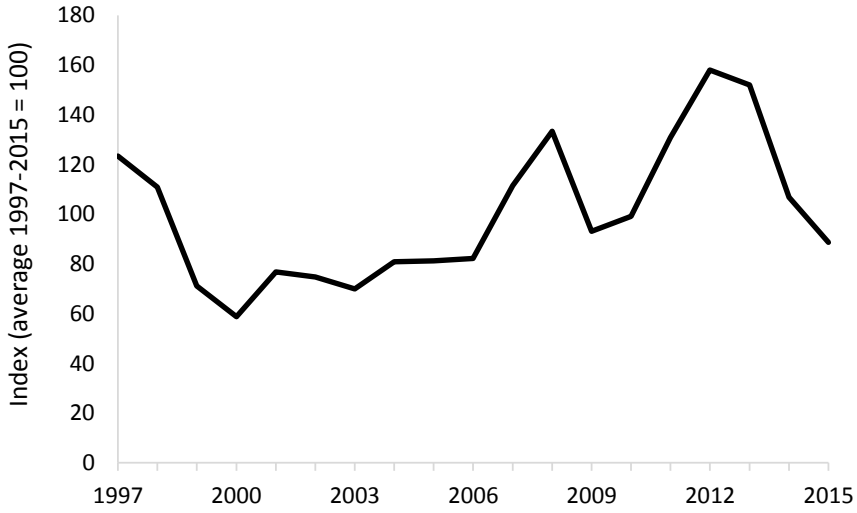

Figure 46: Composite price index for the purse seine fishery

Catch rates

Purse seine catch rates were on a slow upward trend from 1999 to 2010 before flatten off through to 2013 and then increases significantly in both 2014 and 2015. 2015 catch rates are the highest seen over the period covered by the index. This recent increase has been driven primarily by increases in the skipjack catch rate (Figure 48).

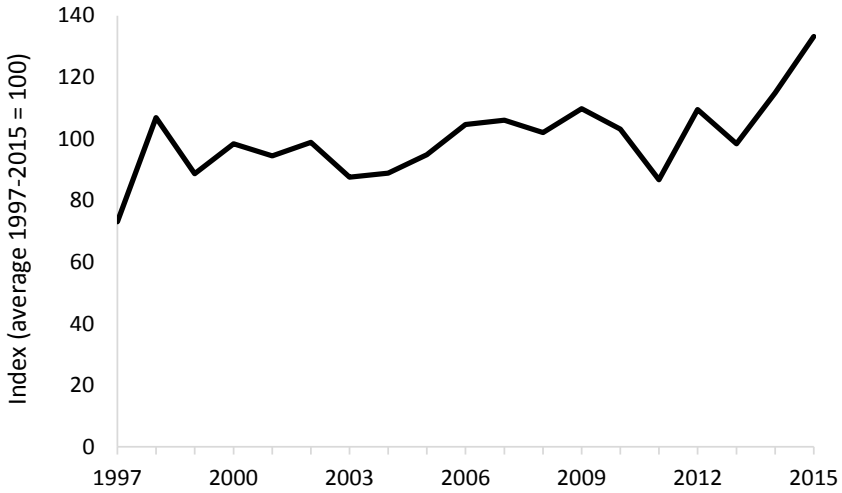

Figure 47: Catch rate index in the purse seine fishery

[2] Bigeye prices are set at the same level as for skipjack.

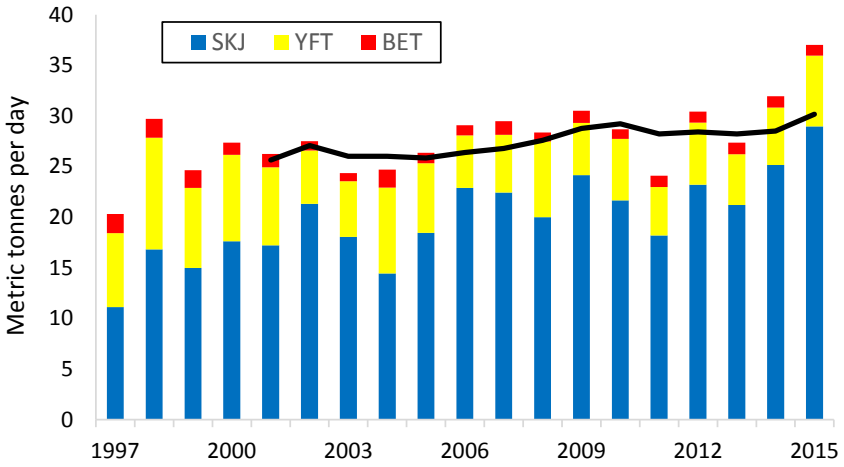

Figure 48: CPUE in the purse seine fishery by species

***Source*:** Pers. com. Peter Williams, SPC June 2016

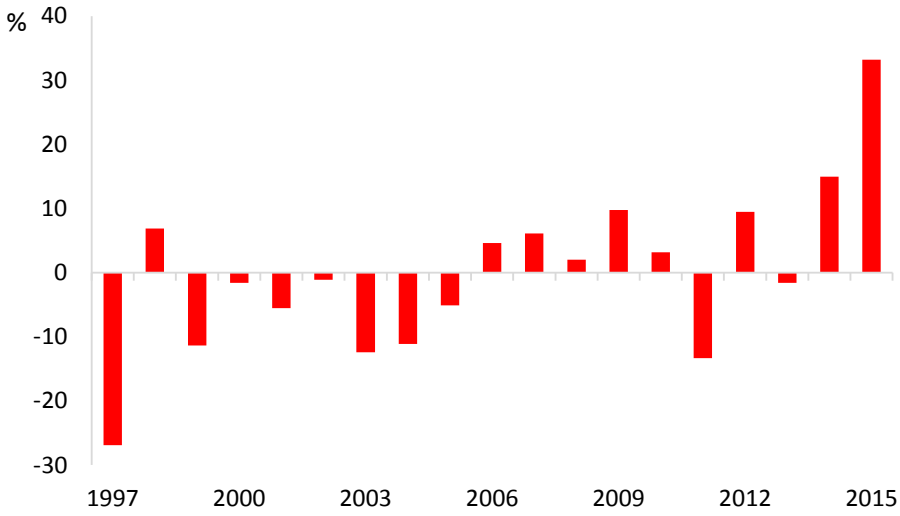

Figure 49: Variations in total CPUE versus its long term average (1997-2015)

Future projections

Prices

Projections of skipjack and yellowfin prices into Thailand using ARIMA models are displayed in Figure 50 and Figure 51. While both price series are projected to follow a trend of marginal decline in the period from 2016 and 2025, prices for skipjack and yellowfin imports into Thailand are expected to improve significantly in 2017-18. Overall, the composite price index for the purse seine fishery is projected to remain above the long term 1997-2015 average for the period from 2016 to 2025 (Figure 52).

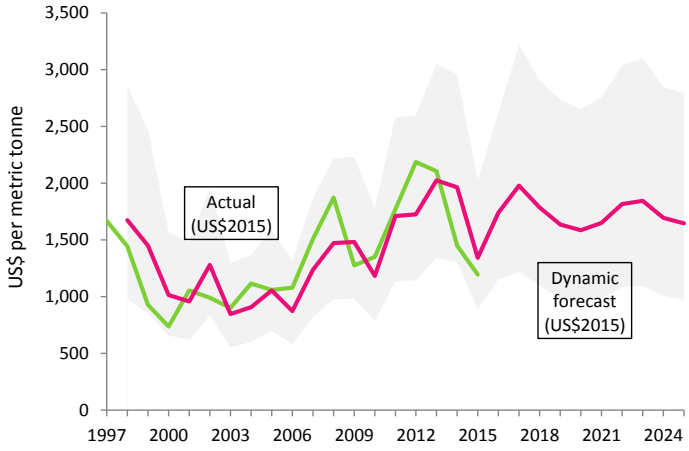

Figure 50: Projections of USD real prices for imports of skipjack into Thailand

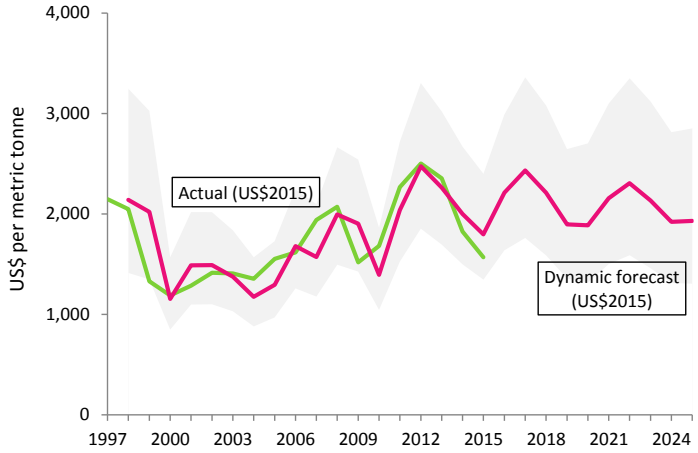

Figure 51: Projections of USD real prices for imports of yellowfin into Thailand

Figure 52: Projections of composite price index for the purse seine fishery

Catch rates

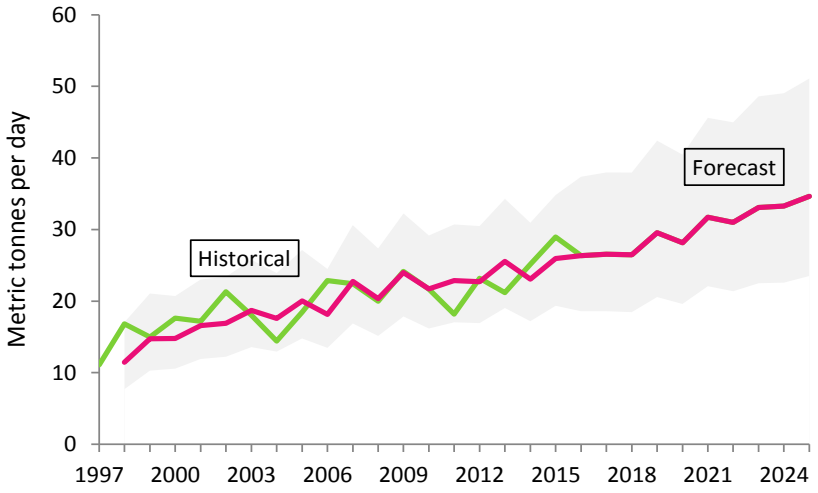

Figure 53: Projections of skipjack CPUE in the purse seine fishery

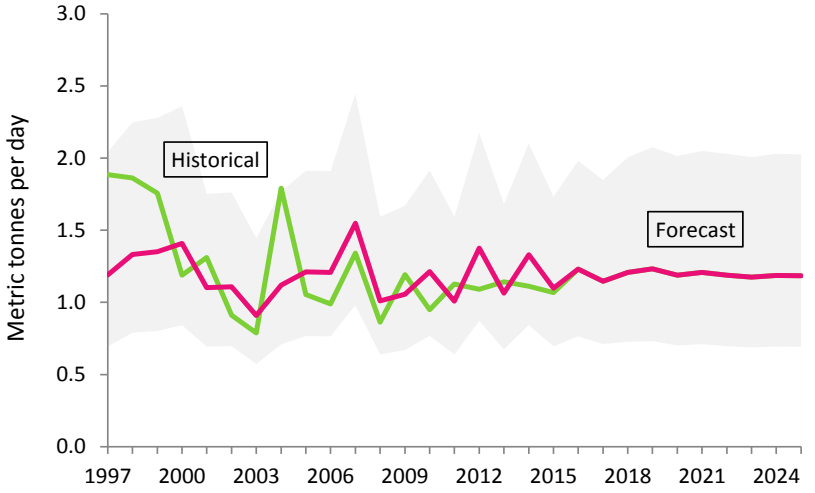

Figure 55: Projections of bigeye CPUE in the purse seine fishery

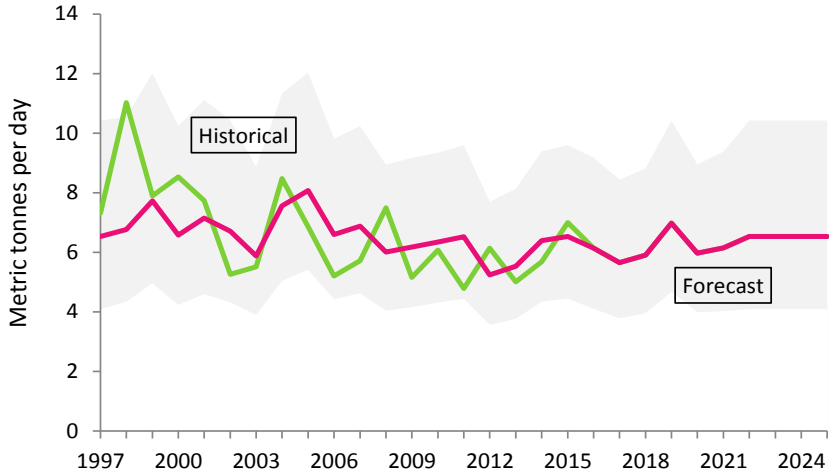

Figure 54: Projections of yellowfin CPUE in the purse seine fishery

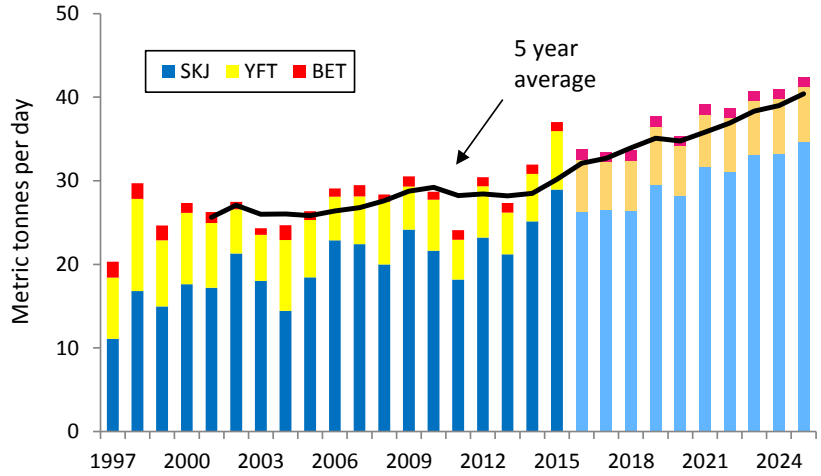

Figure 56: Projections of CPUE in the purse seine fishery by species (2016-2025)

The ARIMA projection of catch rates for skipjack using historical information follows a trend of strong increase. It is important to note that past values of the series is likely to encompass technological progress and the dynamic ARIMA model inherently projects these past improvements in technology into the future.

Projections of yellowfin and bigeye CPUE reveals a different story. Both series are projected to remain relatively constant. However, as the CPUE for skipjack constitutes the bulk of the catch rate index the index is projected to increase considerably over the period from 2016 to 2025 (Figure 57).

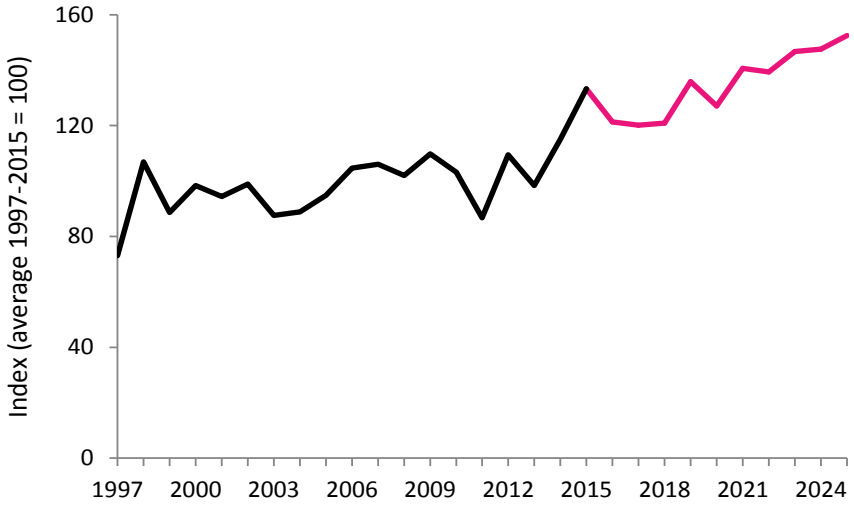

Figure 57: Projections of catch rate index in the purse seine fishery

Economic conditions index

Combining projections of all the three indices for the economic conditions index for the purse seine fishery is estimated in Figure 58. Unlike the projections for the longline fisheries, economic conditions in the purse seine fishery are projected to improve and remain well above the 1997-2015 average. The above average conditions are predominantly driven by the strong increasing catch rate index and the above long term average price index. The steady fishing cost index derived from conservative fuel cost forecasts by the US Energy Information Administration has little impact on the projection of the economic conditions index.

However, it is important to note again that the projection of each element of the different component indices are based purely on the relationship each time series has with itself and do not take into account any biological considerations or changes in international markets or economic performances.

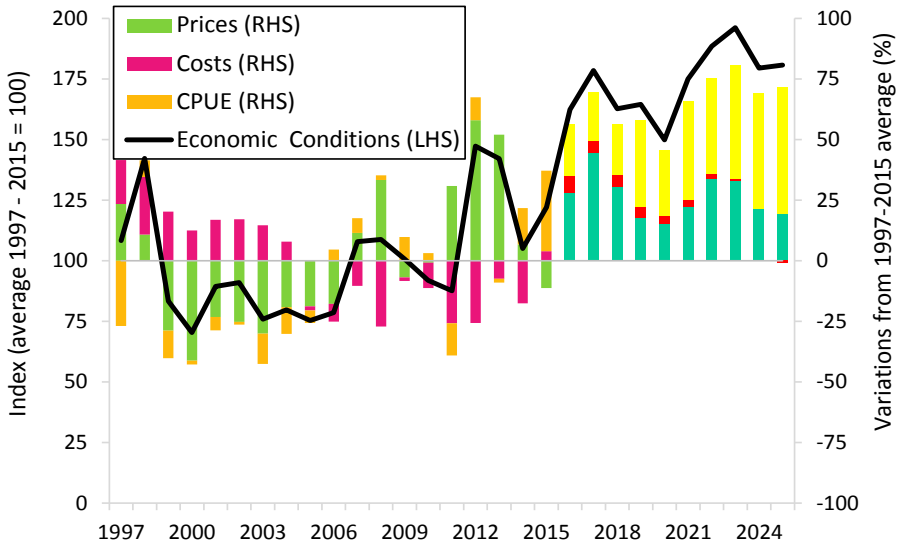

Figure 58: Projections of economic conditions index for the purse seine fishery (LHS) and variance of component indices against average (1997-2015) conditions (RHS)

Conclusion

Fish prices, fishing costs and catch rates are key drivers behind economic conditions of a fishery. For the southern and tropical longline fisheries of the WCPO, it is evident that relatively poor catch rates and high costs have been impacting negatively on the economic conditions experience in the fisheries. Persistently low and declining catch rates, particularly for the southern longline fishery, is likely to continue to undermine vessel profitability and may force some operators to exit the fishery.

In contrast, projected above average prices and improving catch rates are expected to maintain a strong increasing trend in economic conditions for the purse seine fishery. It is important to note that projections of catch rates do not reflect biological characteristics of stocks in the purse seine fishery, but the past trend experienced. Therefore, it is likely that the projected catch rates for the purse seine fishery also embody the technological progress that drove the observed previous increasing trend in catch rates.

To conclude, the aim of this paper is to provide some context and outlook on the economic conditions for the three key fisheries of the WPCO. Fishery managers should consider the information provided in conjunction with scientific information on the biological health and sustainability of fish stocks in these fisheries in making management decisions. The information provided in this paper can also be used to support other fishery management tools such harvest strategies and management strategy evaluations.

Appendix

Autoregressive Integrated Moving Average models

Autoregressive Integrated Moving Average (ARIMA) model is a generalisation of the autoregressive moving average (ARMA) model applied to data that show evidence of non-stationarity. It is a simple and parsimonious forecasting technique that projects future values of a data series by exploiting the relationship it has with its past values and/or past forecast errors. Lags of the stationarized series included in the forecasting equation are called "autoregressive" terms while lags of forecast errors are called "moving average" terms, and the number of times the series is required to be differenced in order to become stationary is captured in the "integrated" component. Random-walk, autoregressive models, and exponential smoothing models are all special cases of ARIMA models. In general the ARIMA(p,d,q) model can be expressed as the following:

$$(1-L)^d\left(1-\sum_{i=1}^{p}\varphi_i L^i\right)Y_t = \theta_0 + \varepsilon_t\left(1-\sum_{j=1}^{q}\theta_j L^j\right) \quad (3)$$

where Y_t is the data series, ε_t is the forecast error and L represents the lag operator.

The number and order of autoregressive and moving average terms included in the model are typically determined by the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots of the differenced/stationary series. The cut off of the PACF is normally dictate the autoregressive terms to include, while the ACF reveals information about moving average terms. Of course there are a range of other factors to consider, including the sign of the first autocorrelation lag, the number of iterations it takes for the model to converge, the size of the coefficient in front each term, the p-value or significance of the individual terms and of the model in general, the degree of integration, and the overall model fit (i.e. Akaike information criterion, Bayesian information criterion, correlation of residuals, forecast errors and graphical fit).

Dynamic ARIMA predicts in-sample estimates using observed historical values up to the last year the data is available, but continues to forecast out-of-sample using model projected values. The in-sample predictions tend to be slightly lagged owing to the nature of ARIMA models using relationship with its past values. Similarly, out-of-sample ARIMA projections are also likely to be lagged, and therefore should be only used to provide an indication of the likely direction a time series will take in the future rather than exact year on year predictions. In addition, as the projection period extends further into the future, more uncertainty is anticipated. This is especially true for series that have a less predictable relationship with its past values or errors. Therefore, the 95% confidence interval generally widens for projections further in the future.

Based on all the factors mentioned above, the details of the ACF and PACF, and the final ARIMA model selected for each time series are displayed in Table 1. Model fit and confidence intervals are illustrated in the ARIMA projection figures in the main texts of this document. Supporting outputs of unit root tests are listed in Table 2.

Table 1: autocorrelation and partial autocorrelation functions, and final ARIMA model selected

Time series	Correlations of the stationarized series greater than absolute(0.25)			Final model selected		
	AC	PAC	Sign of the 1st AC lag	AR	D	MA
Thai frozen albacore price	2	2 and 7	+ve	7	0	2
Price of Japanese bigeye import from Oceania	1, 3 to 5	1 to 3, and 5	+ve	1 and 3	0	0
Price of Japanese yellowfin import from Oceania	1	1, 2, 4, 5 and 7	+ve	1	0	5
Thai frozen skipjack price	2	2 and 6	+ve	2 and 6	1	0
Thai frozen yellowfin price	2	1, 2, 4 and 5	+ve	1, 2 and 5	1	0
Southern longline albacore CPUE	2, 4 and 6	2, 5 to 7	-ve	4	1	2 and 5
Southern longline bigeye CPUE	1 and 3	1 and 3	-ve	3	1	1
Southern longline yellowfin CPUE	1	1, 2 and 4	+ve	1 and 2	0	0
Southern longline other CPUE	1, 3 to 5	1, 2, 4, 6 and 7	+ve	1 and 2	0	0
Tropical longline albacore CPUE	1	1, 6 and 7	-ve	1	1	3
Tropical longline bigeye CPUE	1 to 5, 7	1, 6 and 7	-ve	1, 6 and 7	1	0
Tropical longline yellowfin CPUE	na.	3, 5 and 7	+ve	3 and 6	0	0
Tropical longline other CPUE	3	1, 3, 6 and 7	-ve	1 and 3	1	0
Purse seine skipjack CPUE	1 and 7	1, 2, 5 to 7	-ve	1 and 7	1	2
Purse seine yellowfin CPUE	1	1, 6 and 7	+ve	0	0	6 and 7
Purse seine bigeye CPUE	4	3	+ve	1 and 4	0	3

Table 2: Augmented Dickey-Fuller test for unit root with a drift and 2 included lags

Time series	Log level			Log difference		
	Test statistic	10% crit value	p-value	Test statistic	10% crit value	p-value
Thai frozen albacore import	-2.286	-1.356	0.021	na.	na.	na.
Price of Japanese bigeye import from Oceania	-3.240	-1.356	0.004	na.	na.	na.
Price of Japanese yellowfin import from Oceania	-1.860	-1.356	0.044	na.	na.	na.
Thai frozen skipjack price	-1.055	-1.356	0.156	-3.041	-1.363	0.006
Thai frozen yellowfin price	-1.375	-1.356	0.097	-2.817	-1.363	0.008
Southern longline albacore CPUE	-1.239	-1.356	0.120	-2.943	-1.363	0.007
Southern longline bigeye CPUE	-0.894	-1.356	0.194	-3.592	-1.363	0.002
Southern longline yellowfin CPUE	-1.923	-1.356	0.039	na.	na.	na.
Southern longline other CPUE	-2.910	-1.356	0.007	na.	na.	na.
Tropical longline albacore CPUE	-0.505	-1.440	0.316	-2.525	-1.476	0.026
Tropical longline bigeye CPUE	-0.975	-1.356	0.175	-2.660	-1.363	0.011
Tropical longline yellowfin CPUE	-1.739	-1.356	0.054	na.	na.	na.
Tropical longline other CPUE	-1.008	-1.356	0.167	-1.247	-1.363	0.119
Purse seine skipjack CPUE	-1.349	-1.356	0.101	-3.403	-1.363	0.003
Purse seine yellowfin CPUE	-2.068	-1.356	0.030	na.	na.	na.
Purse seine bigeye CPUE	-3.742	-1.356	0.001	na.	na.	na.

Model outputs

Table 3: Price index outputs for the purse seine, southern longline and tropical longline fisheries

Year	Purse seine price index			Purse seine composite index	Southern longline price index			Southern longline composite index	Tropical longline composite index[3]
	Skipjack	Yellowfin	Bigeye		Albacore	Bigeye	Yellowfin		
1997	123	123	123	123	112	106	101	109	105
1998	107	118	107	111	103	98	90	100	97
1999	69	76	69	71	94	109	109	97	106
2000	55	68	55	59	110	111	108	110	109
2001	78	74	78	77	115	97	92	110	98
2002	73	81	73	75	81	89	89	83	87
2003	67	81	67	70	84	92	95	87	91
2004	82	78	82	81	94	99	97	95	97
2005	78	89	78	81	102	98	96	101	98
2006	80	93	80	82	108	91	93	105	95
2007	112	111	112	111	77	88	92	80	87
2008	138	119	138	133	94	96	101	95	97
2009	94	87	94	93	101	101	102	101	101
2010	100	97	100	99	100	121	113	104	113
2011	131	130	131	131	110	117	120	113	116
2012	162	144	162	158	126	122	116	124	121
2013	156	135	156	152	88	97	102	90	95
2014	107	105	107	107	99	86	98	98	94
2015	88	90	88	89	104	82	87	99	90
2016	129	127	129	128	98	90	91	96	92
2017	146	140	146	145	98	100	94	98	98
2018	132	127	132	131	94	109	99	96	102
2019	121	109	121	118	89	111	98	92	101
2020	117	108	117	115	103	106	98	103	103
2021	122	124	122	122	98	99	99	98	99
2022	134	133	134	134	97	94	99	97	96
2023	136	123	136	133	99	93	99	98	96
2024	125	110	125	122	99	96	99	99	98
2025	122	111	122	119	101	100	99	100	100

[3] Catches of tuna from the tropical longline fishery are destined for the same key markets as the southern longline fishery. Therefore, prices of individual species received in the tropical longline fishery reflect those in the southern longline fishery.

Table 4: Fishing cost index outputs for the purse seine, southern longline and tropical longline fisheries

Year	Purse seine cost index			Southern and tropical longline cost index	
	MDO price index	Raw fishing cost index	Composite cost index	Raw fishing cost index	Composite cost index
1997	46	246	82	271	83
1998	29	229	76	254	78
1999	39	239	80	264	81
2000	62	262	87	287	88
2001	49	249	83	274	84
2002	49	249	83	274	84
2003	56	256	85	281	86
2004	76	276	92	301	93
2005	105	305	102	330	102
2006	122	322	107	347	107
2007	131	331	110	356	110
2008	182	382	127	407	125
2009	104	304	101	329	101
2010	131	331	110	356	110
2011	177	377	126	402	124
2012	177	377	126	402	124
2013	122	322	107	347	107
2014	153	353	118	378	116
2015	88	288	96	313	96
2016	80	280	93	305	94
2017	86	286	95	311	96
2018	86	286	95	311	96
2019	87	287	96	312	96
2020	89	289	96	314	97
2021	92	292	97	317	97
2022	94	294	98	319	98
2023	97	297	99	322	99
2024	100	300	100	325	100
2025	103	303	101	328	101

Table 5: Catch rate index outputs for the purse seine, southern longline and tropical longline fisheries[4]

Year	Purse seine		Southern longline		Tropical longline	
	Total catch rates	Catch rate index	Total catch rates	Catch rate index	Total catch rates	Catch rate index
1997	20.3	73.1	56.6	133.0	50.3	135.9
1998	29.7	106.9	56.3	132.3	49.4	133.6
1999	24.6	88.6	42.7	100.3	34.2	92.4
2000	27.3	98.4	44.4	104.3	39.7	107.4
2001	26.2	94.4	50.4	118.3	35.9	97.1
2002	27.5	98.9	45.1	105.9	35.2	95.3
2003	24.3	87.6	34.1	80.0	31.7	85.8
2004	24.7	88.9	36.8	86.5	38.0	102.7
2005	26.4	94.9	40.4	95.0	36.0	97.3
2006	29.1	104.6	44.5	104.4	37.7	101.9
2007	29.5	106.1	45.9	107.8	34.6	93.6
2008	28.3	102.0	47.4	111.4	33.8	91.3
2009	30.5	109.8	44.6	104.8	38.5	104.2
2010	28.7	103.2	39.5	92.7	36.0	97.4
2011	24.1	86.7	34.3	80.6	33.5	90.7
2012	30.4	109.5	35.4	83.0	32.7	88.4
2013	27.3	98.4	38.5	90.5	34.0	92.0
2014	31.9	115.0	35.5	83.3	37.9	102.4
2015	37.0	133.2	36.5	85.8	33.5	90.6
2016	33.7	121.3	36.2	84.9	35.3	95.3
2017	33.4	120.1	36.6	86.0	38.9	105.1
2018	33.6	120.8	36.3	85.2	36.4	98.3
2019	37.7	135.8	35.0	82.3	38.1	103.1
2020	35.3	127.1	34.9	82.0	35.6	96.2
2021	39.1	140.6	34.5	81.1	36.0	97.4
2022	38.7	139.4	34.1	80.0	37.1	100.4
2023	40.8	146.7	33.4	78.5	33.5	90.5
2024	41.0	147.5	33.4	78.4	34.7	93.7
2025	42.4	152.5	33.1	77.7	34.1	92.3

[4] Individual CPUE projections are not shown. Please contact authors directly.

Table 6: Economic conditions index outputs for the purse seine, southern longline and tropical longline fisheries

Year	Purse seine	Southern longline	Tropical longline
1997	108	162	159
1998	142	155	151
1999	83	116	117
2000	70	126	129
2001	89	146	111
2002	91	104	99
2003	76	83	92
2004	80	89	107
2005	75	94	94
2006	79	103	90
2007	108	76	71
2008	109	81	63
2009	101	104	104
2010	92	87	100
2011	88	67	81
2012	147	79	83
2013	142	75	80
2014	105	65	80
2015	122	89	86
2016	162	88	94
2017	178	88	107
2018	163	86	105
2019	164	80	108
2020	150	88	102
2021	175	82	99
2022	189	79	98
2023	196	78	88
2024	180	77	92
2025	181	77	91