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Analyses and projections of economic conditions in WCPO fisheries

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Maggie Skirtun[1] and Chris Reid[1]

[1]Pacific Islands Forum Fisheries Agency, Honiara, Solomon Islands

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, 1998 to 2016. 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 and 2016 improved 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 and 2016 compared to 2014 due to falling costs, they remained below average as low catch rates persisted.
- 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 1998 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.
- Between 2011 and 2014, the fishery has seen persistent but stable below average economic conditions. Conditions improved significantly in 2015 and 2016, albeit still below average, owing to declining fishing costs and increasing fish prices.
- Going forward, economic conditions are projected to remain below average and follow a trend of decline. This is primarily driven by expected increases in fuel costs with fish prices lingering around its long-term average and catch rates persisting at 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 resulted in a sharp fall in economic conditions, low fuel costs and increasing catch rates have led to an improvement in conditions well above the long-term average in 2015 and 2016.
- Conditions are projected to improve considerably over the next 10 years to 2026. This is mainly on the account of higher projected catch rates and above average fish prices.

Overview

In 2016, the 12th Scientific Committee (SC12) recommended that an annual update of "Analyses and projections of economic conditions in WCPO fisheries", in a similar manner to SC12-ST-WP-04, to be provided at future SC meetings[1]. The SC12 working paper provided historical overviews and 10 year projections for economic conditions in the three main tuna fisheries in the Western and Central Pacific Ocean (WCPO)[2]. More specifically, economic conditions were assessed based on relative fish price, fishing cost (excluding license and access fee payments) and catch rates. Together, information from the three components were combined into a single value expressed as an index against the average value over the base period of analysis (1998-2016), set to 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 at SC12, to reflect the conditions in 2016, and to roll the 10 year projections forward to 2026. In the same fashion, projections of prices and catch rates were carried out using Autoregressive Integrated Moving Average (ARIMA) models. 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 2017 Annual Energy Outlook report. For full methodology on how the indicators are calculated, please refer to the 2015 Economic Indicators Report. For the ARIMA models used to projection prices and catch rates, refer to the Appendix.

1 Summary Report, Twelfth Regular Session of the Scientific Committee, WCPFC, para. 177.a), 26 August 2016.

2 The purse seine, tropical longline and southern longline fisheries. The tropical longline fishery is defined as the longline fishery between 10ºN and 10ºS 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 10ºS in the WPCFC-CA.

Southern longline fishery

Historical overview

Economic conditions for the southern longline fishery have followed a declining trend over the period examined, from 1998 to 2016. Conditions 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 (for the period examined) in 2011 and 2012, conditions have continued to remain below long-term average since 2010. Economic conditions improved significantly in 2015 and 2016, compared to 2014, owing to falling fuel costs with the fish price remaining around its long-term average. The economic conditions index reading of 90 in 2016 is the highest since 2008. However, persistent low catch rates continue to impact on economic conditions, and if they continue the likelihood of conditions returning to higher historical average levels remains low.

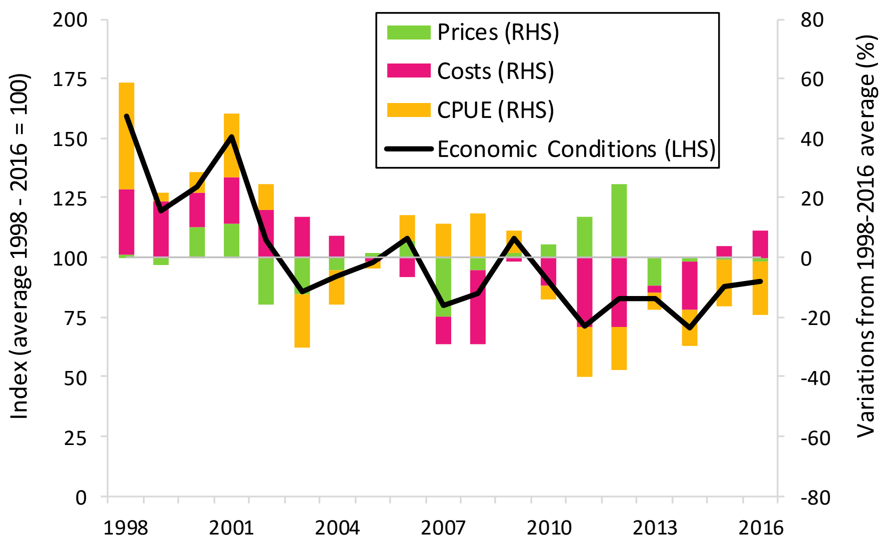

Figure 1: Economic conditions index for the southern longline fishery (LHS) and variance of component indices against average (1998-2016) conditions

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).

While real albacore prices have fluctuated considerably over time (Figure 2), the general trend is relatively stable at around $2,941/mt (in 2016 USD). Real prices were at their highest in 2012 (26% above the 1998-2016 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 (11% below average). In 2016, albacore prices averaged $2,935/mt, 4% lower compared to 2015 but around the long-term average (Figure 5). The 2016 price for albacore projected in the SC12-ST-WP-04 paper, adjusted to real dollars, was very close to the actual average observed – at $2,880/mt. This projected value and the confidence intervals associated are also illustrated in Figure 2.

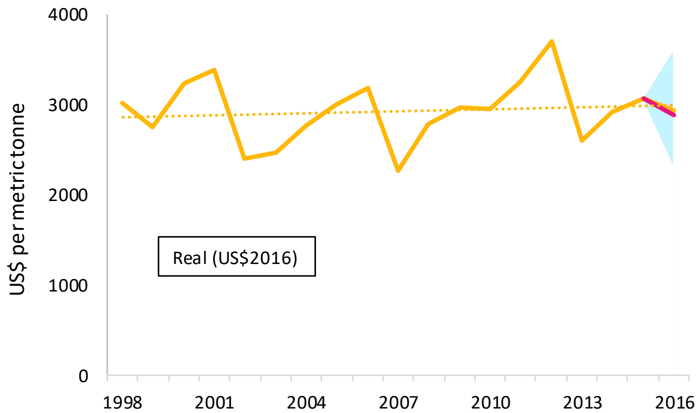

Figure 2: USD real and forecasted prices for imports of albacore into Thailand

Source: Nominal prices [Thai Customs]

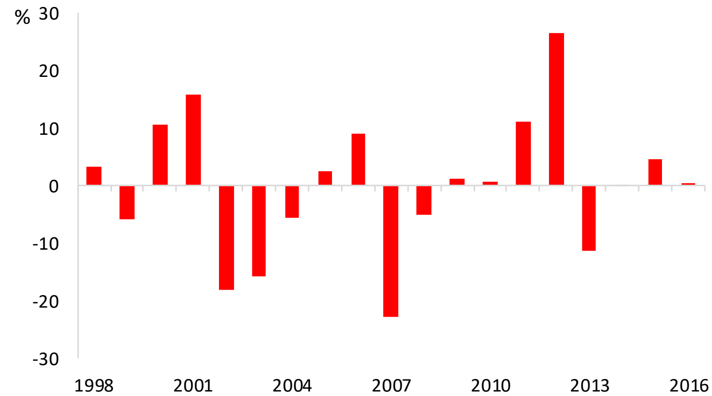

Figure 5: Variations in USD real prices for Thai albacore imports against its long-term average (1998-2016)

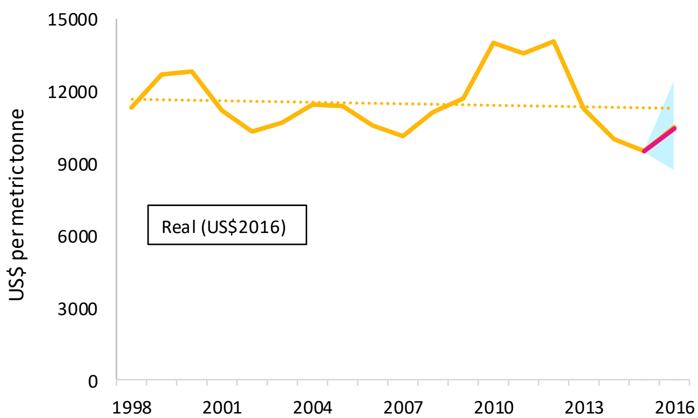

Figure 3: USD real and forecasted prices for Japanese bigeye imports from Oceania

Source: Nominal prices [Japan Customs]

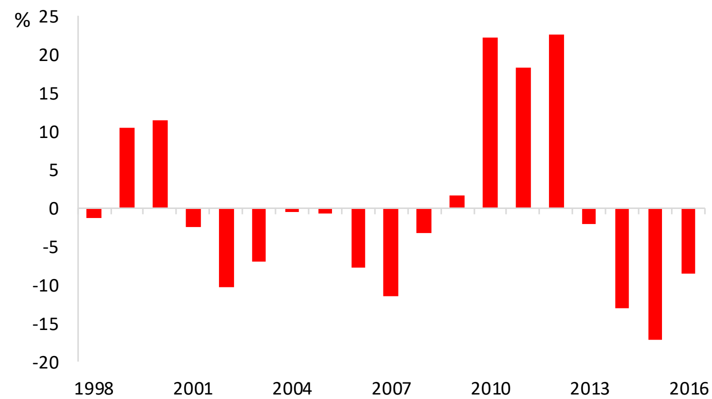

Figure 6: Variations in USD real prices for Japanese bigeye imports from Oceania versus its long-term average (1998-2016)

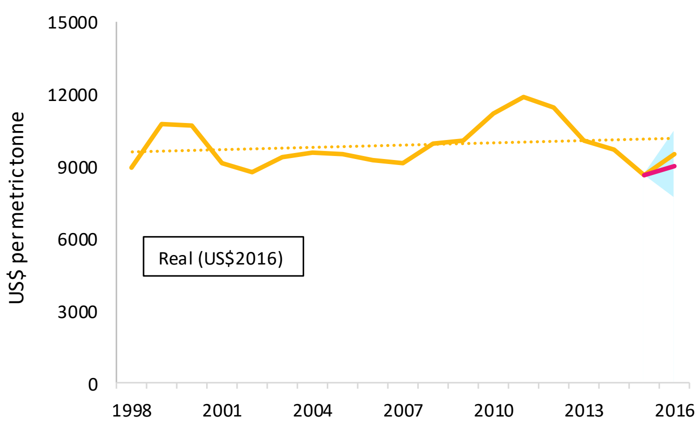

Figure 4: USD real and forecasted prices for Japanese yellowfin imports from Oceania

Source: Nominal prices [Japan Customs]

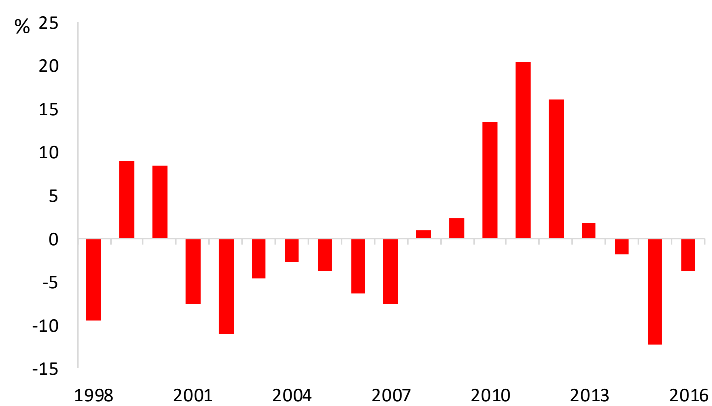

Figure 7: Variations in USD real prices for Japanese yellowfin imports from Oceania versus its long-term average (1998-2016)

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, but recovered slightly in 2016 to $10,521/mt and $9,504/mt (9% and 4% below levels averaged over 1998-2016), respectively. The 2016 projected prices reported in SC12-ST-WP-04 for bigeye and yellowfin imports into Japan were also relatively close to that observed – $10,424/mt and $9,008/mt (Figure 3 and Figure 4).

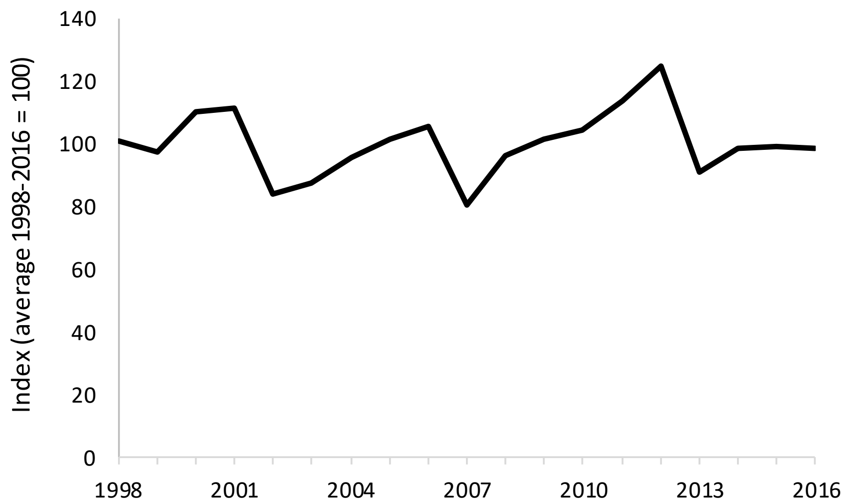

Figure 8: Composite price index for the southern longline fishery

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 FFA's 2015 Economic Indicators Report. Similar to fish prices, the total cost of producing one unit of effort includes all costs incurred up to the point the product enters the market (i.e. includes transhipment and freight costs) in order to reflect the overall conditions of all fleets operating in the fishery.

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 began to decline significantly in the second half of 2014 and continued into 2016. The average of $395/mt in 2016 is the lowest in over a decade, since 2003, and compares to a real price of around $900 and $1000/mt in the period from March 2011 and June 2014.

As a result, the fall in fuel prices have contributed to the significant improvement in economic conditions for the southern longline fishery in 2015 and 2016.

It should be noted that while changes in fuel costs have significant impacts on fishing costs, and in turn economic conditions faced by vessels operating in fishery, it is likely that changes in other non-fuel cost can also affect fishing operations considerably. This is especially true for bait costs in longline fisheries. However, there is limited cost data available in the region for assessing the degree of variation in these non-fuel operating costs, and therefore could not be included in the analysis. As this is an ongoing paper to be presented at future Scientific Committee meetings, it may be possible to incorporate variations in non-fuel operating costs in the estimation of the fishing cost index in the future if the data becomes available.

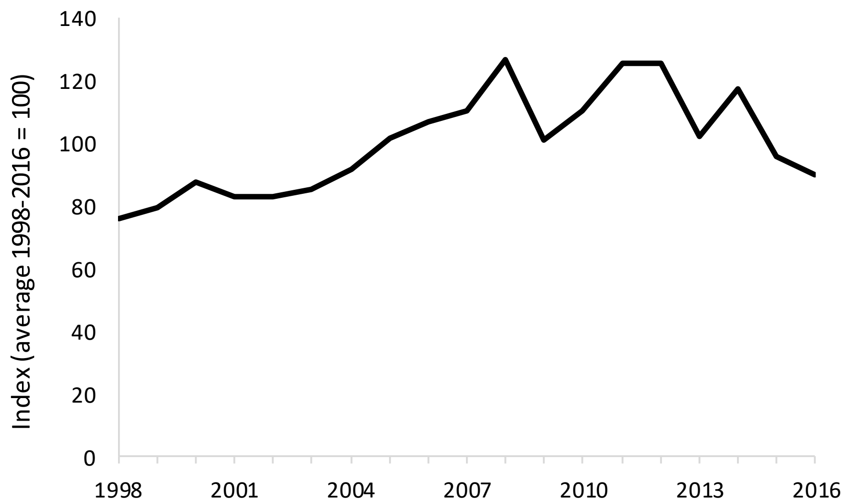

Figure 9: Fishing cost index for WCPO fisheries

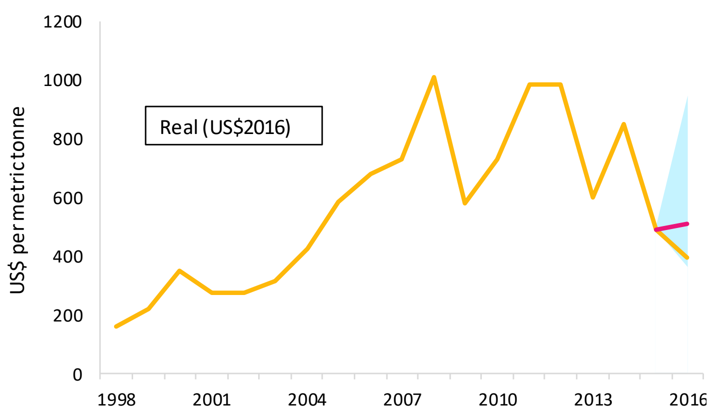

Figure 10: Singapore marine diesel oil (MDO), real and forecasted price series

Source: [Bunker World]

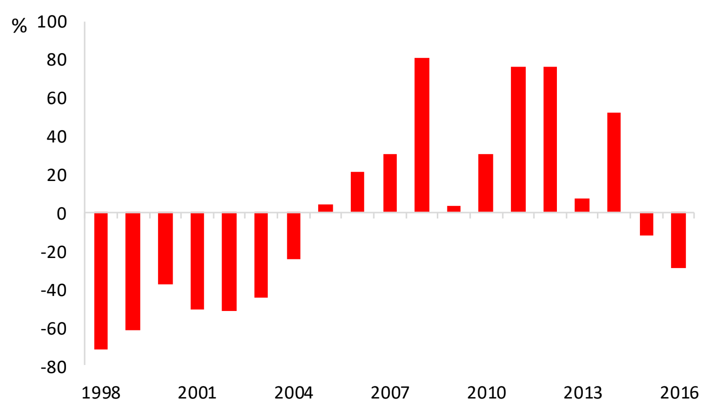

Figure 11: Variations in annual USD real prices for Singapore MDO versus its long-term average (1998-2016)

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 nominal terms of kilograms caught per hundred hooks set (Figure 12)[3]. 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 1998, 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 2012-16 was 36.0 kg per hundred hooks, 11% lower than that over 2002-06 (which was the lowest 5 year average seen prior to 2011), and 20% lower than that over 2005-09.

Figure 12: Catch rate index in the southern longline fishery

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[3] Nominal CPUE is used as it reflects changes in the output (catch) from the fishery per unit of economic input, for which effort (expressed as either hooks set for the longline fisheries or fishing days for the purse seine fishery) is used as a proxy.

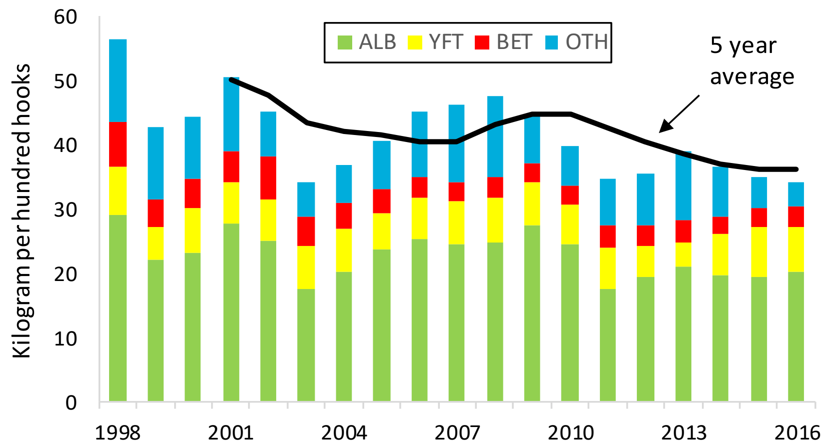

Figure 13: CPUE in the southern longline fishery by species

Source: Pers. com. Peter Williams, SPC July 2017

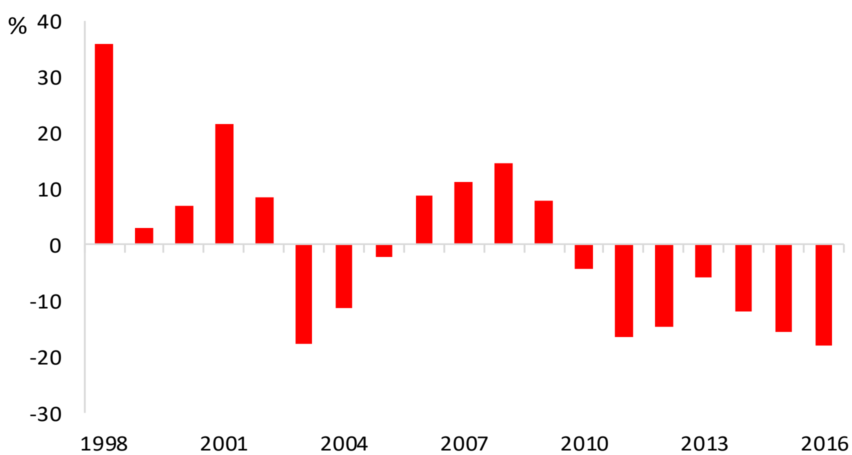

Figure 14: Variations in total CPUE versus its long-term average (1998-2016)

Future projections

Using Autoregressive Integrated Moving Average (ARIMA) models, real prices (in 2016 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 that 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 the historical trends were relatively constant (Figure 2; Figure 3; Figure 4), it is not surprising to see projections of the three price series fluctuate around a somewhat stable mean. In a similar fashion to the composite price index on the historical data, the projected prices are weighted based on average catch composition in the fishery for the period from 1998 to 2016 (Figure 18), and then indexed over the same period. For the southern longline fishery, the composite price index is projected to increase marginally over the next decade to 2026.

Prices

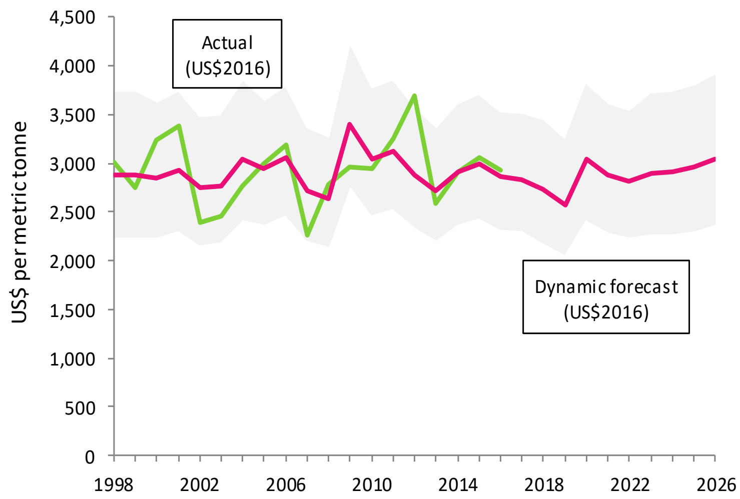

Figure 15: Projections of USD real prices for imports of albacore into Thailand

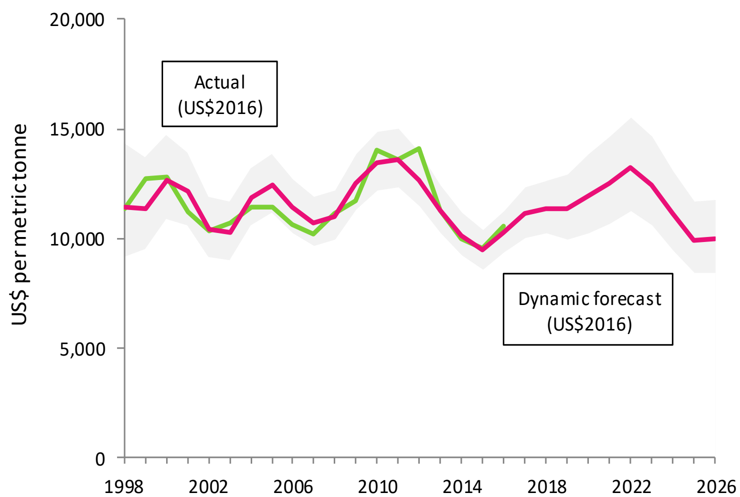

Figure 16: Projections of USD real prices for Japanese bigeye imports from Oceania

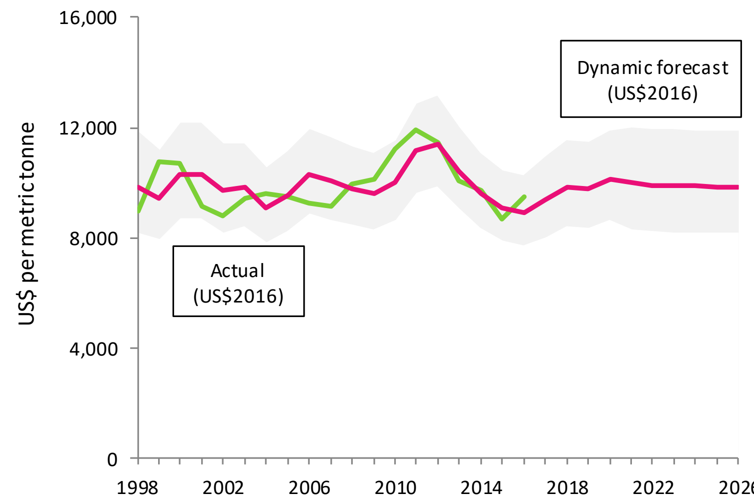

Figure 17: Projections of USD real prices for Japanese yellowfin imports from Oceania

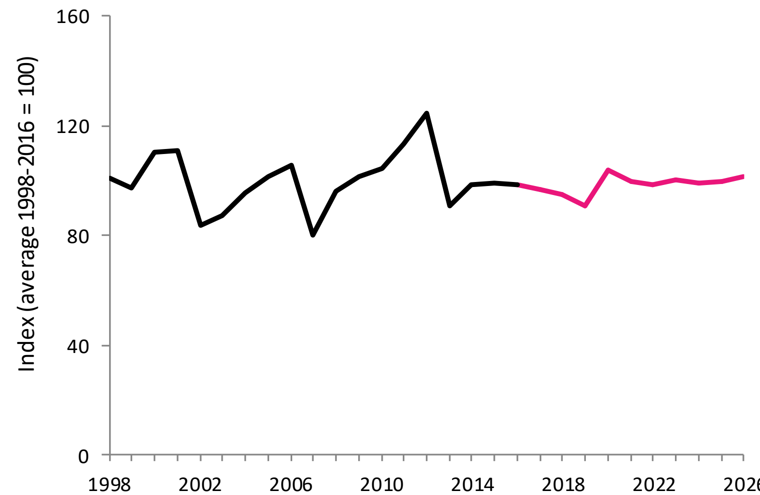

Figure 18: Projections of composite price index for the southern longline fishery

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 non-fuel operating cost component, which is assumed constant in real terms, to create the projection for the fishing cost index (Figure 20). The index shows an increase in fishing costs for the southern longline fishery to above its long-term average from 2018 onwards. This primarily reflects the sturdy 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.

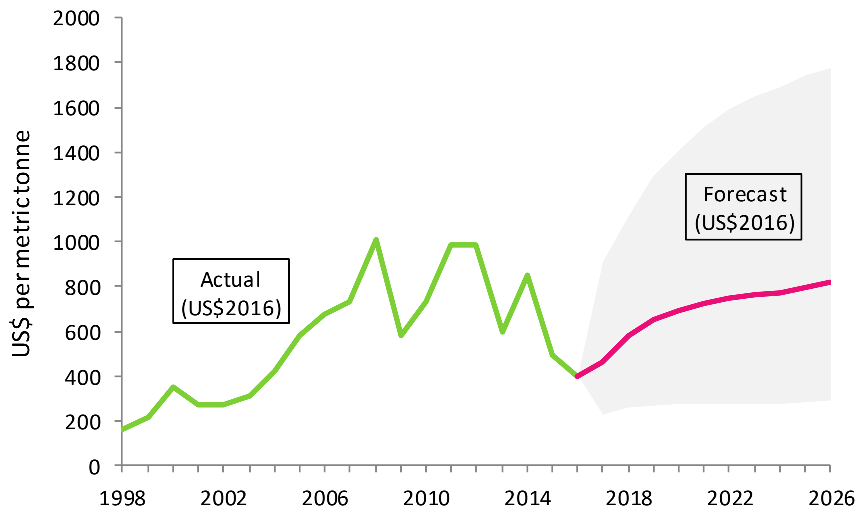

Figure 19: Projections of Singapore marine diesel oil (MDO) in real prices

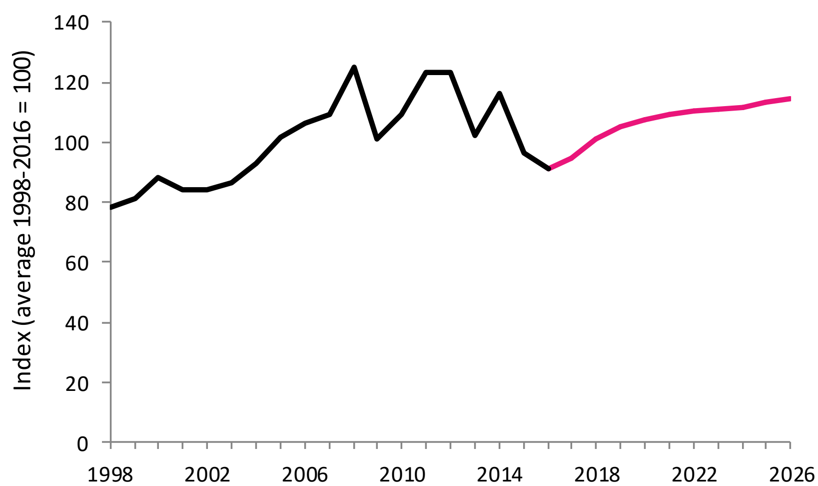

Figure 20: Projections of fishing cost index for WCPO fisheries

Catch rates

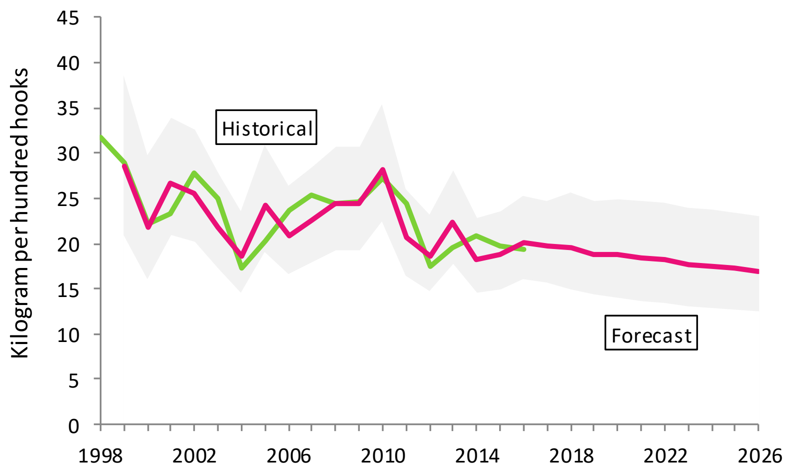

Figure 21: Projections of albacore CPUE in the southern longline fishery

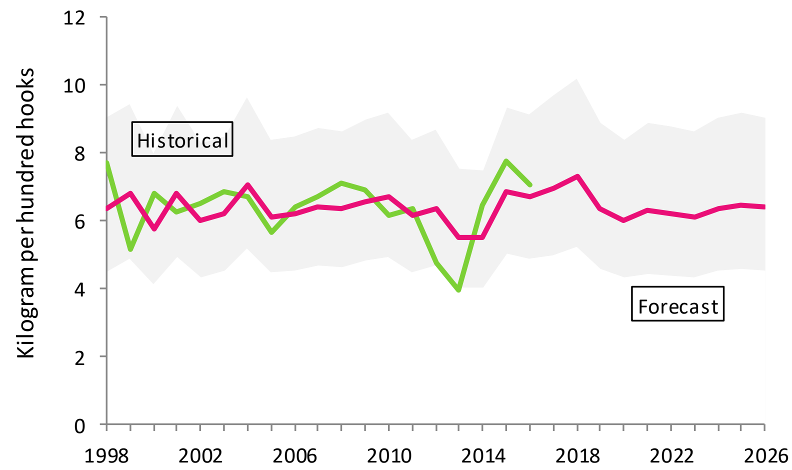

Figure 23: Projections of yellowfin CPUE in the southern longline fishery

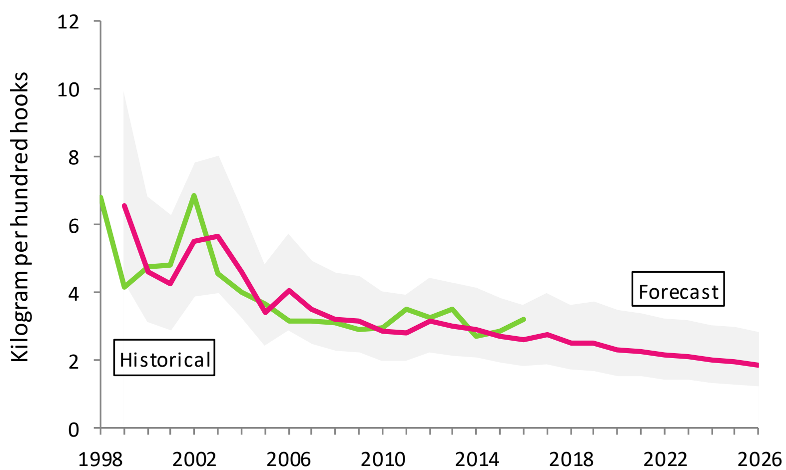

Figure 22: Projections of bigeye CPUE in the southern longline fishery

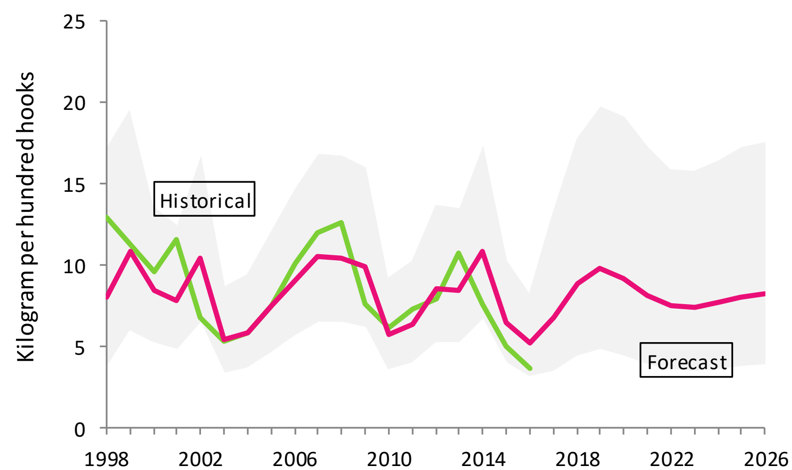

Figure 24: Projections of CPUE of other species in the southern longline fishery

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.

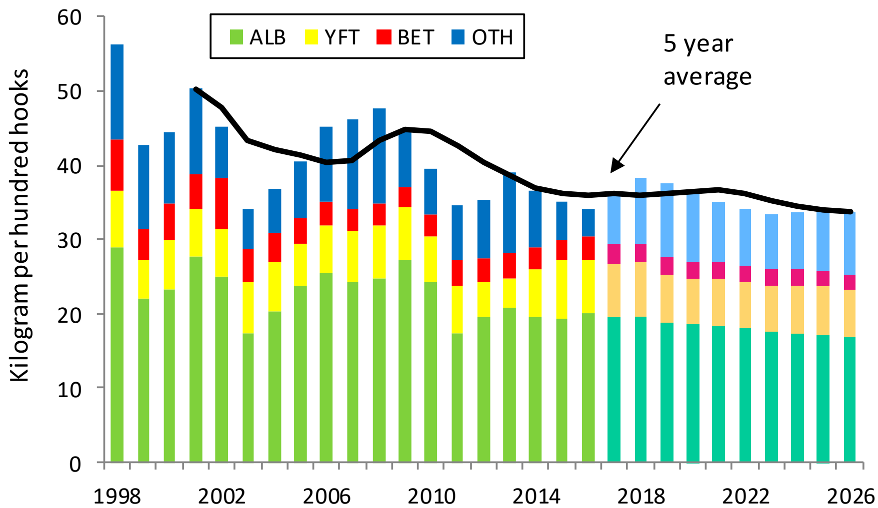

Figure 25: Projections of CPUE in the southern longline fishery by species (2017-2026)

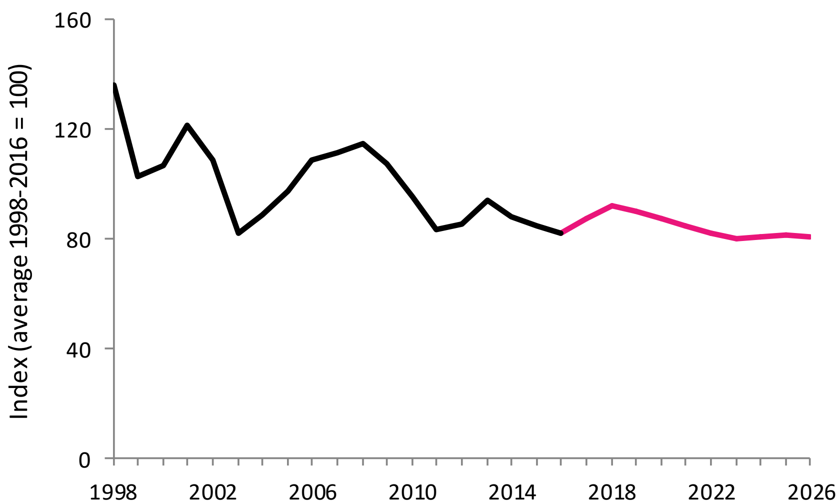

Figure 26: Projections of catch rate index in the southern longline fishery

Economic conditions index

Amalgamating the projections of all three index components, the economic conditions index for the southern longline fishery to 2026 is displayed in Figure 27. Economic conditions in the southern longline fishery are expected to continue to follow the declining trend in the future. This is predominantly driven by the continued falling catch rates and increasing fishing costs. The projected conditions are considerably worse than that reported in last year's SC12-ST-WP-04 paper, owing to the revision in fuel prices by the US Energy Information Administration from a conservative growth forecast to a more studier growth.

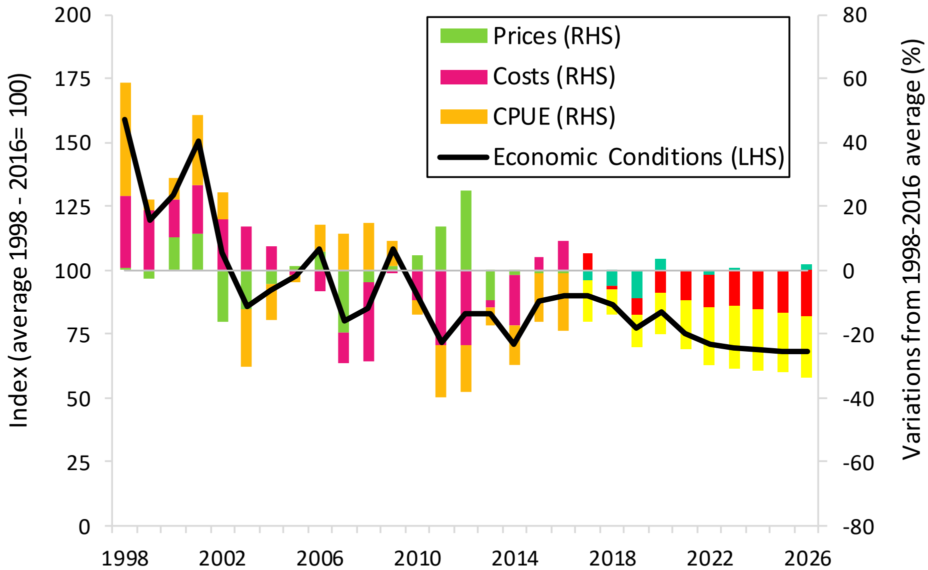

Figure 27: Projections of economic conditions index for the southern longline fishery (LHS) and variance of component indices against average (1998-2016) conditions (RHS)

Tropical longline fishery

Historical overview

Economic conditions in the fishery appear to have gone through two phases since 1998. The first phase between 1998 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 2016. In 2015 and 2016, conditions improved noticeably compared to that experience in the 4 years prior (2011-2014), owing to a significant drop in fuel prices. Nevertheless, economic conditions remained below the long-term average in 2015 and 2016 as the effect of the decline in costs was largely offset by declines in the catch rate and fish price.

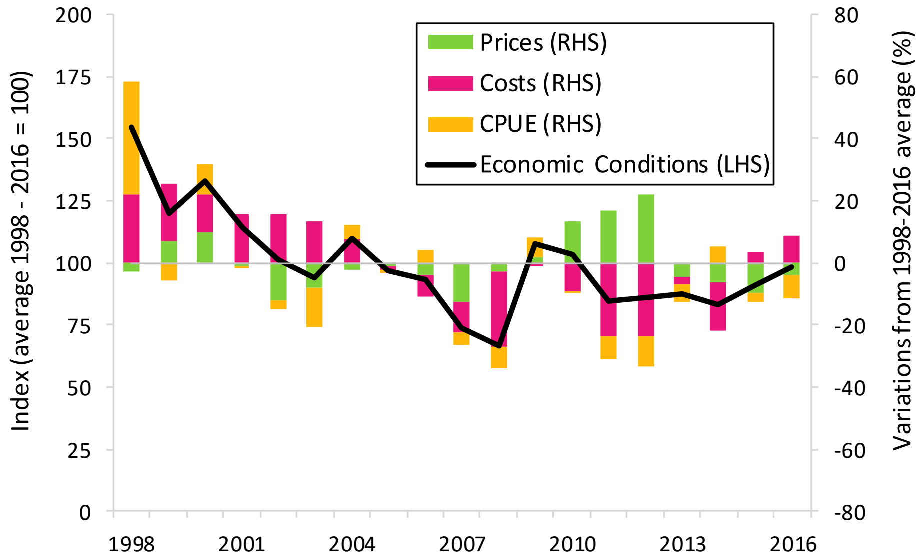

Figure 28: Economic conditions index for the tropical longline fishery (LHS) and variance of component indices against average (1998-2016) conditions

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 31% over the period from 1998-2016, respectively. This compares with only 9% and 16% 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.

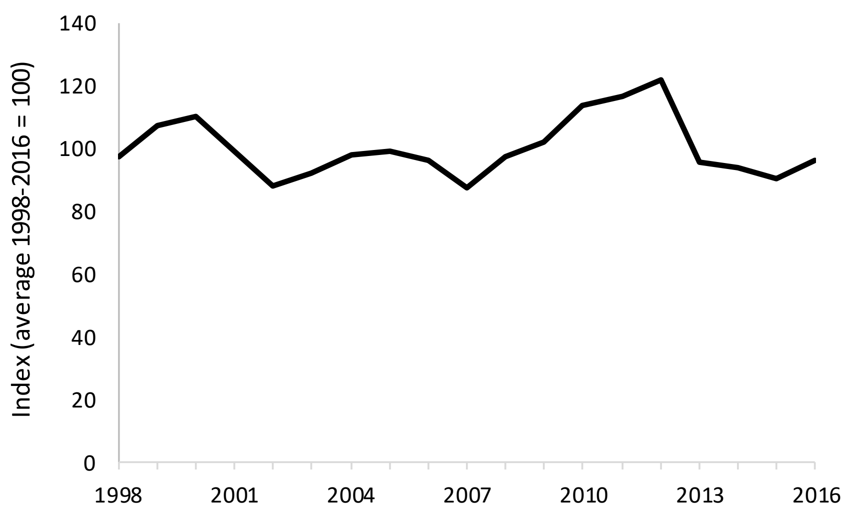

Figure 29: Composite price index for the tropical longline fishery

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 bycatch species (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 1998 and 1999 (Figure 32) was driven by a sharp drop in yellowfin CPUE in the fishery, which fell from 14.7 kilograms per hundred hooks in 1998 to 9.8 kilograms per hundred hooks in 1999.

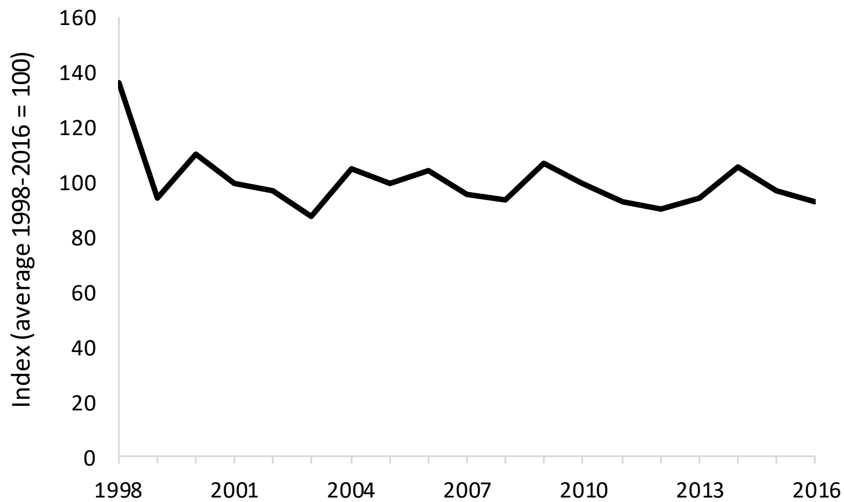

Figure 30: Catch rate index in the tropical longline fishery

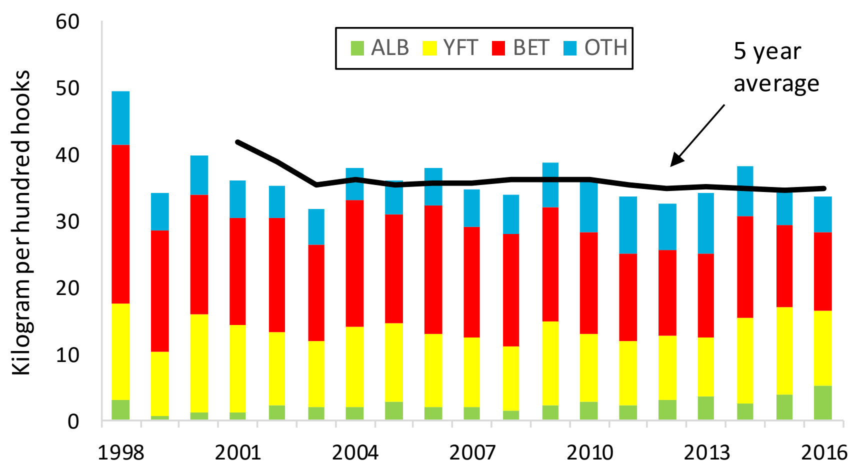

Figure 31: CPUE in the tropical longline fishery by species

Source: Pers. com. Peter Williams, SPC July 2017

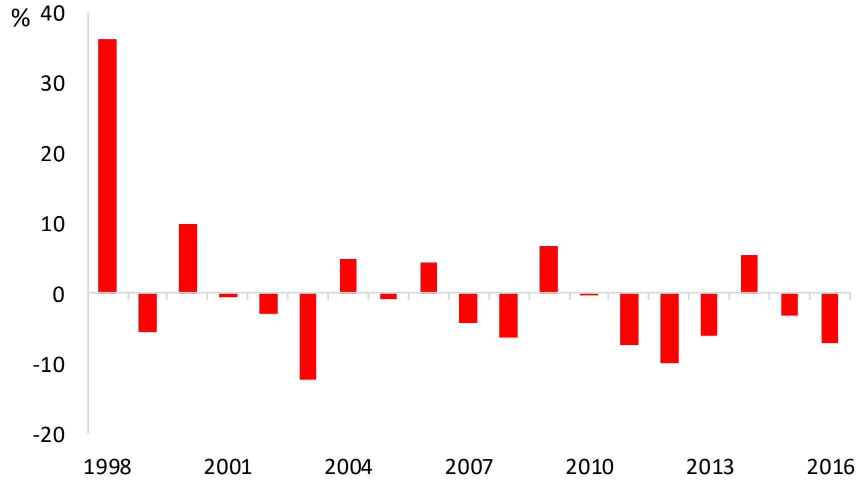

Figure 32: Variations in total CPUE versus its long-term average (1998-2016)

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 1998-2016, 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) from 2017 to around 2023, before declining for the last couple years of the projection as a result of low prices for bigeye which constitutes on average 45% of the catch.

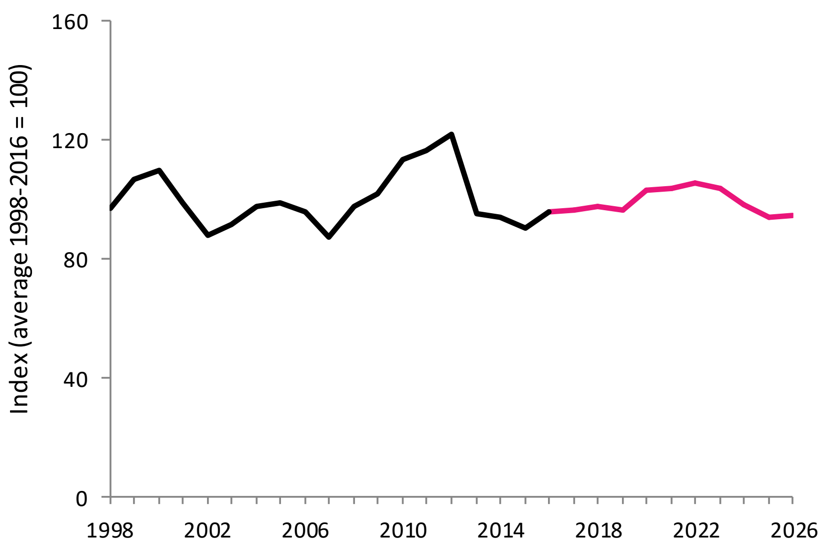

Figure 33: Projections of composite price index for the tropical longline fishery

Catch rates

Similarly, catch rates are projected to stay around 33 kg/hhks, just below its long-term average of 36 kg/hhks for the tropical longline fishery (Figure 34). Improvements in projected catch rates for albacore and other species (Figure 36 and Figure 39) from 2020 onwards are offset by the continual decline in the bigeye CPUE (Figure 37). Yellowfin CPUE is projected to remain relatively constant around its long-term average (Figure 38).

As a result, the catch rates index is expected to remain stable at 91.5 index points on average over the projection period, from 2017 to 2026. Since this represents almost 10 points below long-term conditions in the fishery (100 index points), it is likely that catch rates will put considerable negative pressure on the total economic conditions going into the future.

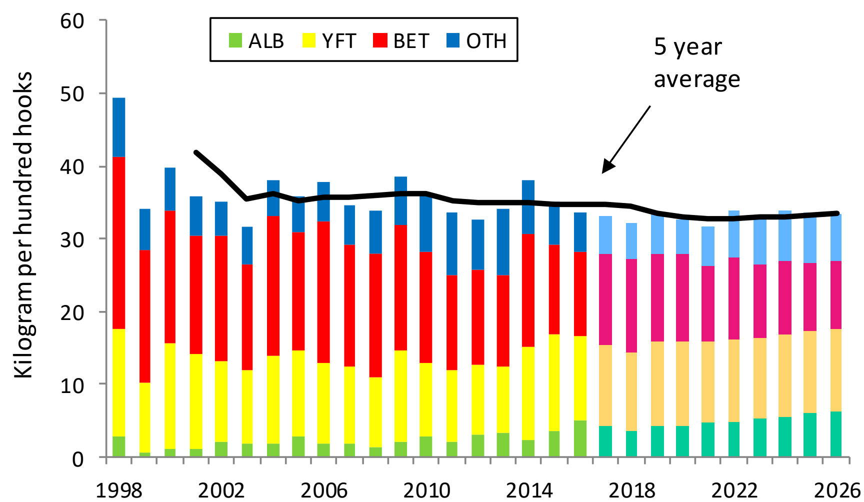

Figure 34: Projections of CPUE in the tropical longline fishery by species (2017-2026)

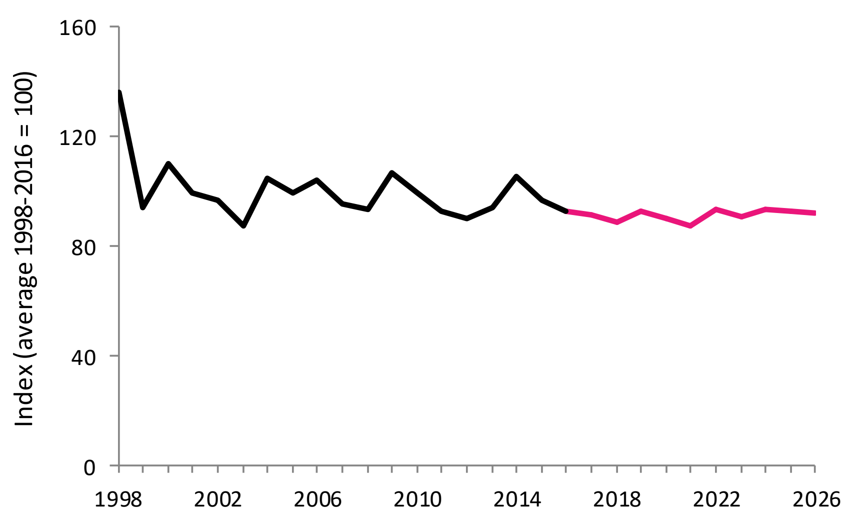

Figure 35: Projections of catch rate index in the tropical longline fishery

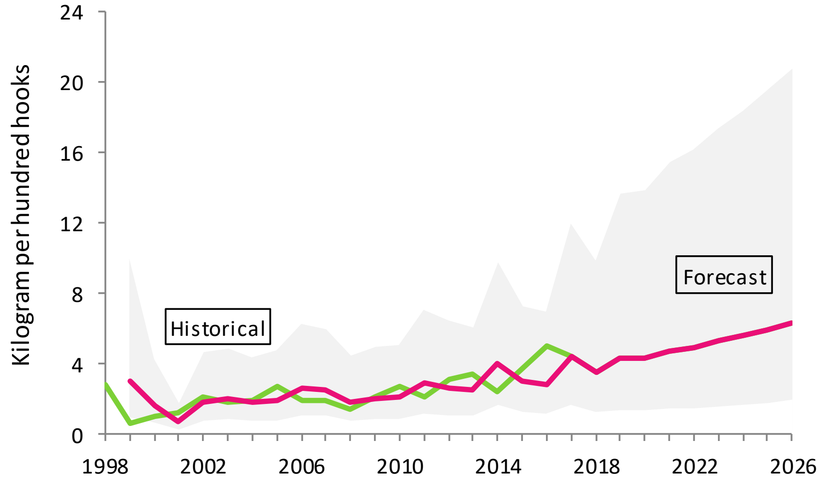

Figure 36: Projections of albacore CPUE in the tropical longline fishery

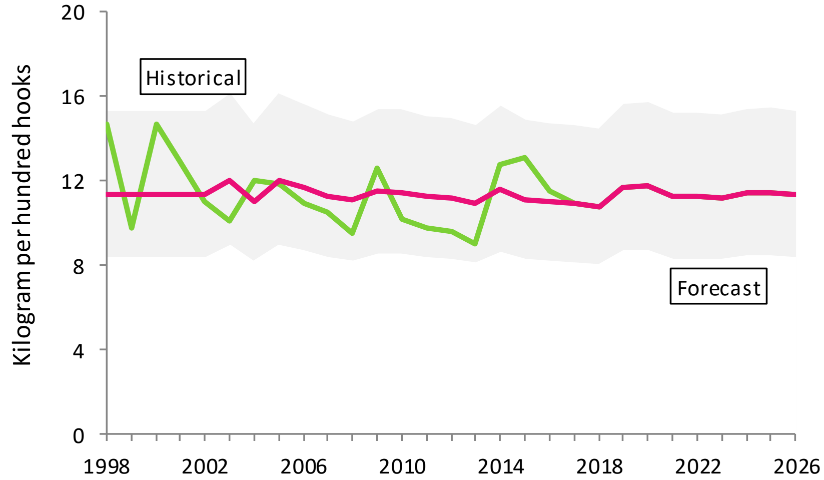

Figure 38: Projections of yellowfin CPUE in the tropical longline fishery

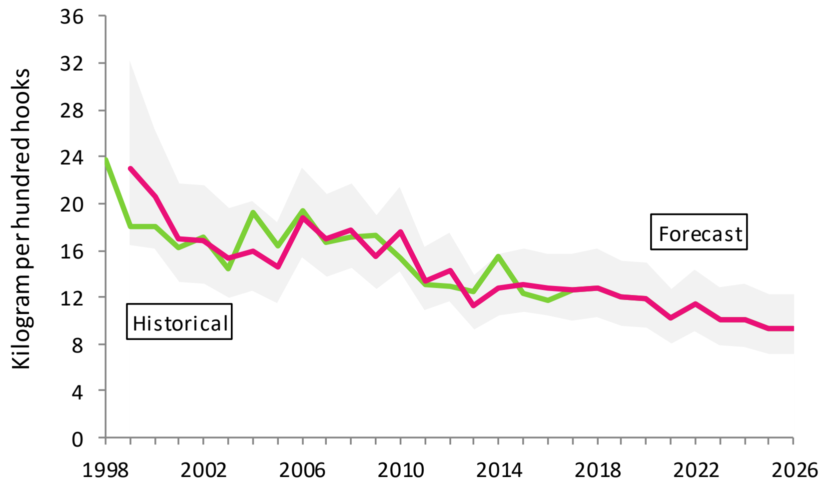

Figure 37: Projections of bigeye CPUE in the tropical longline fishery

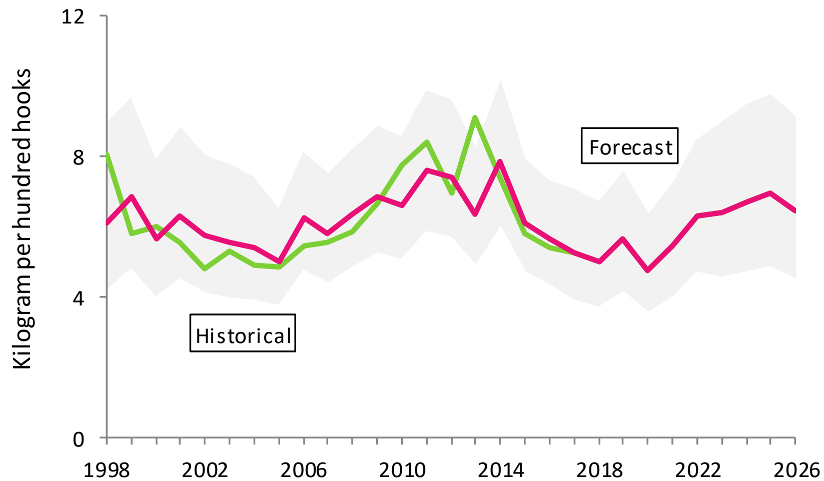

Figure 39: Projections of CPUE of other species in the tropical longline fishery

Economic conditions index

Amalgamating the price and catch rate index for the tropical longline fishery (Figure 33, Figure 35) and the fishing cost index for the WPCO (Figure 20), the economic conditions index for the tropical longline fishery is presented in Figure 40. Economic conditions for the fishery are projected to follow a declining trend from 2017 to 2026, away from long-term average conditions. Most of the decline is driven by the rising fishing cost index, resulting from a revision in fuel cost forecasts by the US Energy Information Administration as discussed in the economic conditions section in the southern longline fishery. Above average fish prices for the period from 2020 to 2023 are unable to offset both the projected rise in fishing cost and the decline in catch rates, primarily bigeye.

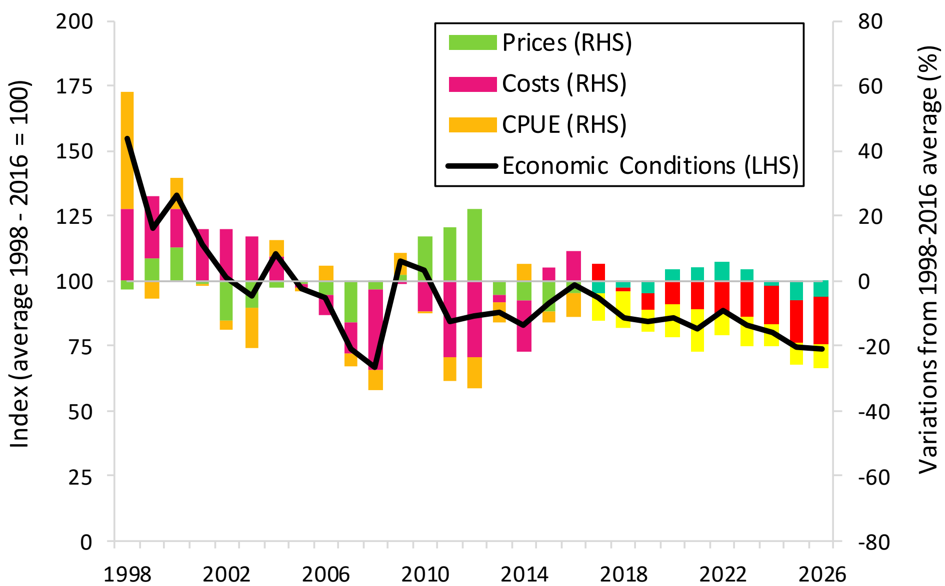

Figure 40: Projections of economic conditions index for the tropical longline fishery (LHS) and variance of component indices against average (1998-2016) conditions (RHS)

Purse seine fishery

Historical overview

The purse seine fishery displays a very different picture to that of the longline fisheries in that it does not display the same general downward trend in economic conditions over time (Figure 41). In addition, the greatest determinant behind changes in economic conditions for the fishery appears to have been movements in fish prices, historically, compared to catch rates in the longline fisheries. In recent years, catch rate changes have had significant positive impacts on conditions, offsetting declines in fish prices from the highs experienced in 2012 to 2013. For the period examined (1998 to 2016), the index shows that economic conditions were also at its peak during the years when the fishery faced the exceptionally good prices, in 2012 and 2013. While the price index fell to a five year low of 90 points in 2015, recovery in fish prices for the fishery have been observed in 2016 and 2017.

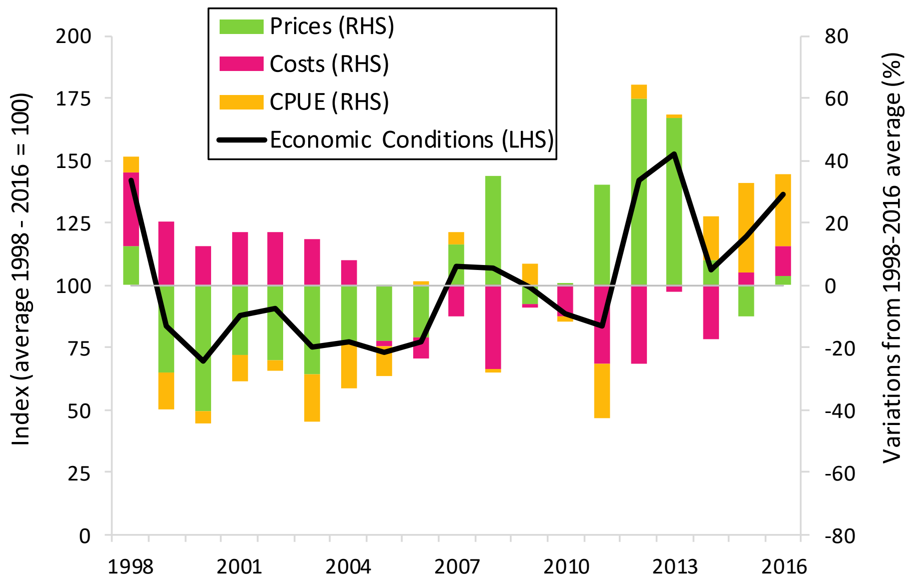

Figure 41: Economic conditions index for the purse seine fishery (LHS) and variance of component indices against average (1998-2016) conditions (RHS)

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 real price series (specified in 2016 USD) have fluctuated over time around a general upward trend. Real skipjack import prices were at their highest in 2012 (63% above the 1998-2016 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 (11% below). For yellowfin, real Thai import prices between 2011 and 2013 (inclusive), were on average 39% above its long-term average. In 2016, real yellowfin price improved slightly compared to 2015, to $1,605/mt, albeit still 7% below its long term average. The 2016 prices for skipjack and yellowfin that were projected in the SC12-ST-WP-04 paper, adjusted to real dollars, were more optimistic than the averages actual observed – at $1,762/mt and $2,240/mt, respectively (Figure 42 and Figure 43). Instead, these projected values are closer to those observed in the first half of 2017.

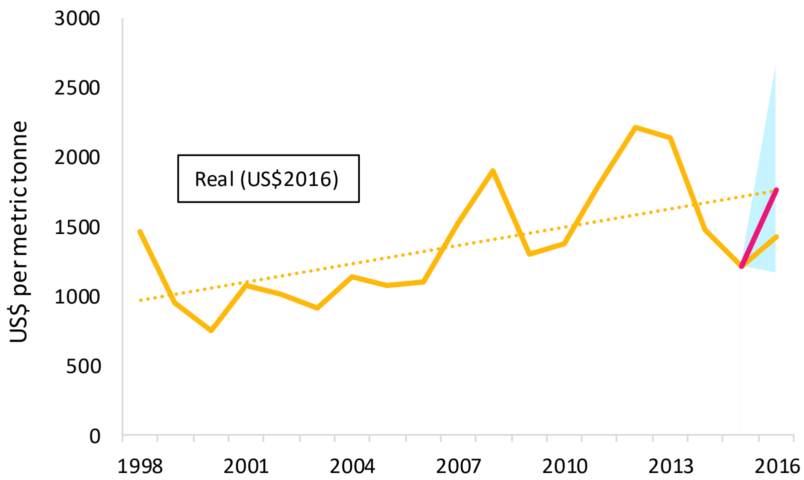

Figure 42: USD real and forecasted prices for imports of skipjack into Thailand

Source: Nominal prices Thai Customs

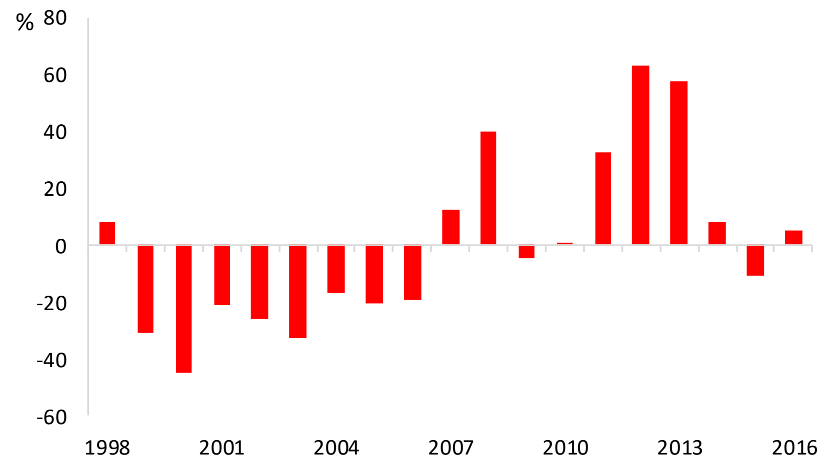

Figure 44: Variations in USD real prices for Thai skipjack imports against its long-term average (1998-2016)

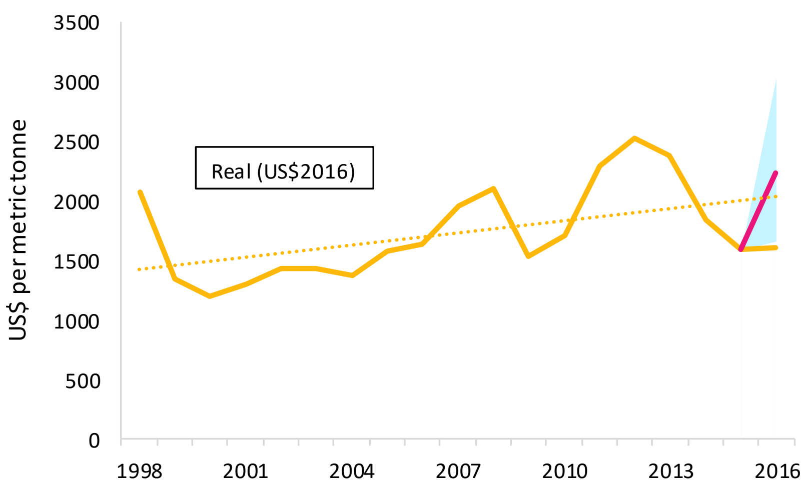

Figure 43: USD real and forecasted prices for imports of yellowfin into Thailand

Source: Nominal prices Thai Customs

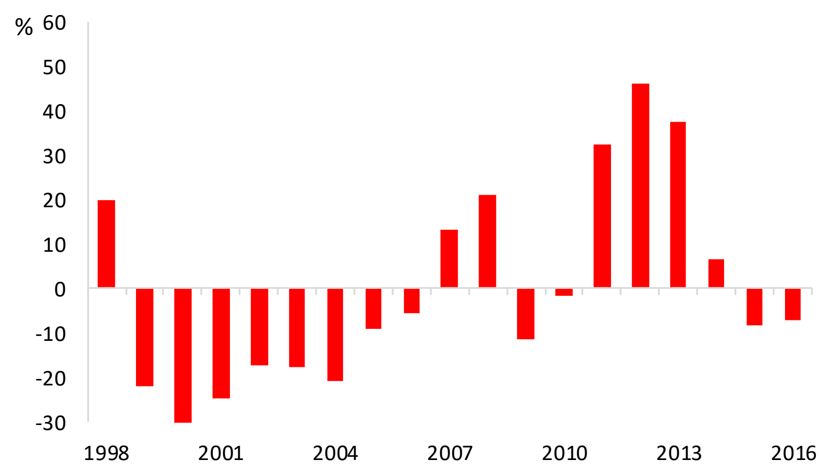

Figure 45: Variations in USD real prices for Thai yellowfin imports against its long term average (1998-2016)

Using the catch composition of the three tuna species and prices displayed in Figure 42 and Figure 43, the composite price index for the purse seine fishery is computed and presented in Figure 46[4]. 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 to 2013.

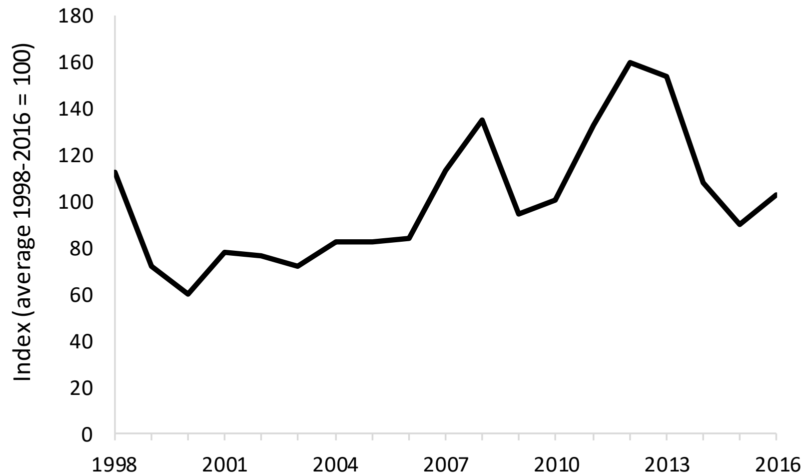

Figure 46: Composite price index for the purse seine fishery

Catch rates

Purse seine catch rates followed a slow and marginal upward trend from 1999 to 2010, before it dipped sharply in 2011. Since then, catch rates in the fishery have increased, with the most significant growths occurring in 2014 and 2015. Catch rates were at the highest in 2015, for the period covered by the index, at 29% above the long-term average (1998 to 2016). This recent increase has been driven primarily by increases in the skipjack catch rate (Figure 48).

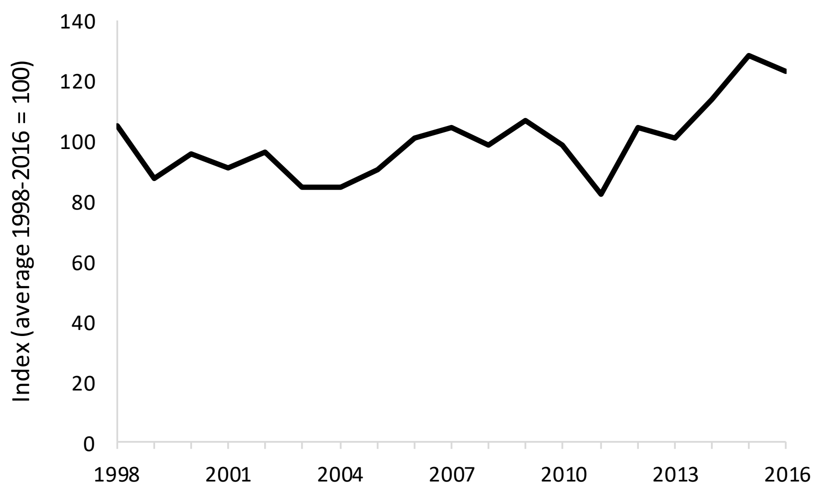

Figure 47: Catch rate index in the purse seine fishery

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

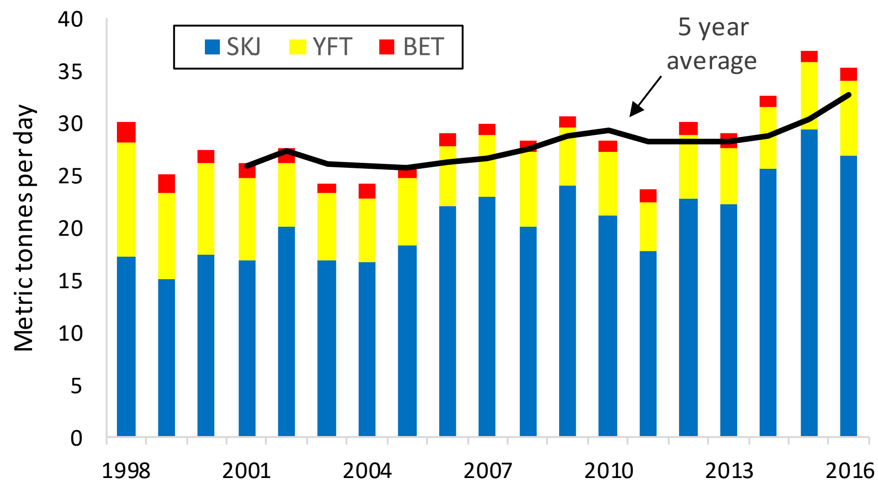

Figure 48: CPUE in the purse seine fishery by species

Source: Pers. com. Peter Williams, SPC July 2017

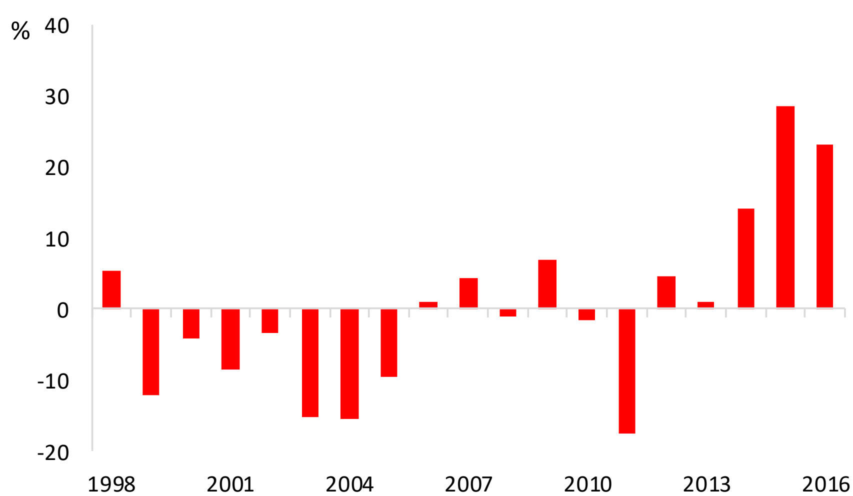

Figure 49: Variations in total CPUE versus its long term average (1998-2016)

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 increase considerably in 2017 before declining in the three years that follow, to 2020. The price for yellowfin imports into Thailand are expected follow a declining trend over the entire projection period, from 2017 to 2026. However, skipjack import price is projected to follow a more favourable, albeit marginal, growth trend. Overall, the composite price index for the purse seine fishery is projected to remain above the long-term 1998-2016 average for the period from 2017 to 2026 (Figure 52).

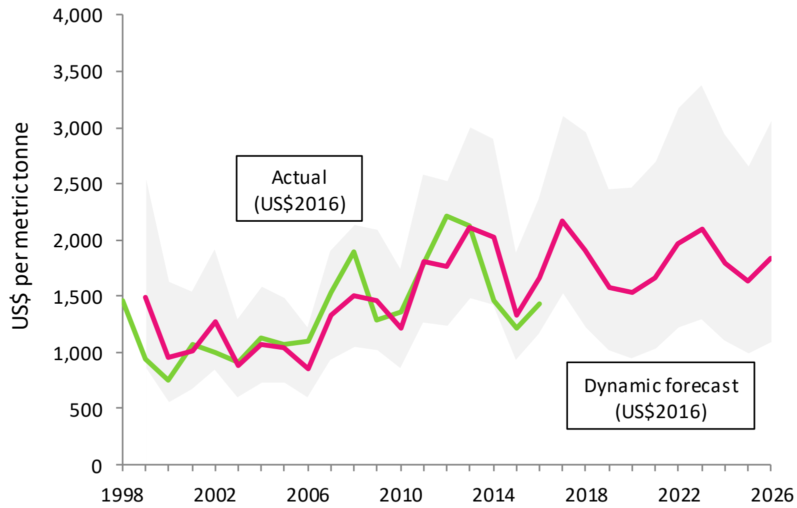

Figure 50: Projections of USD real prices for imports of skipjack into Thailand

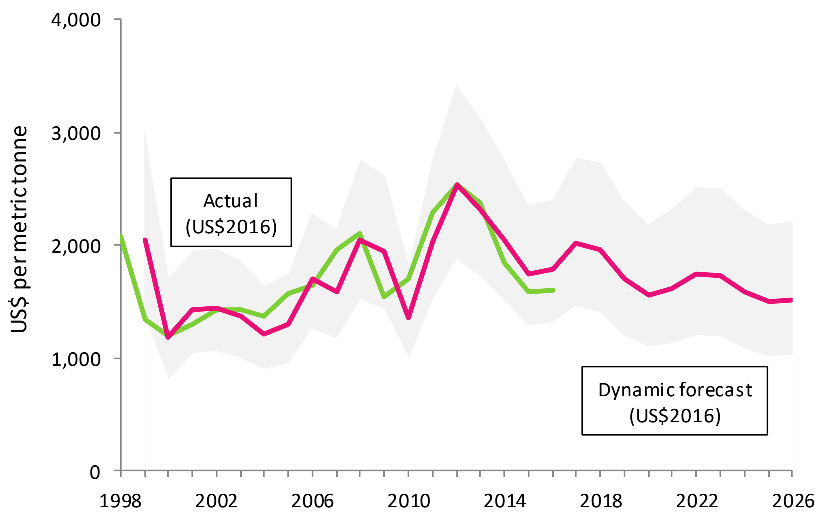

Figure 51: Projections of USD real prices for imports of yellowfin into Thailand

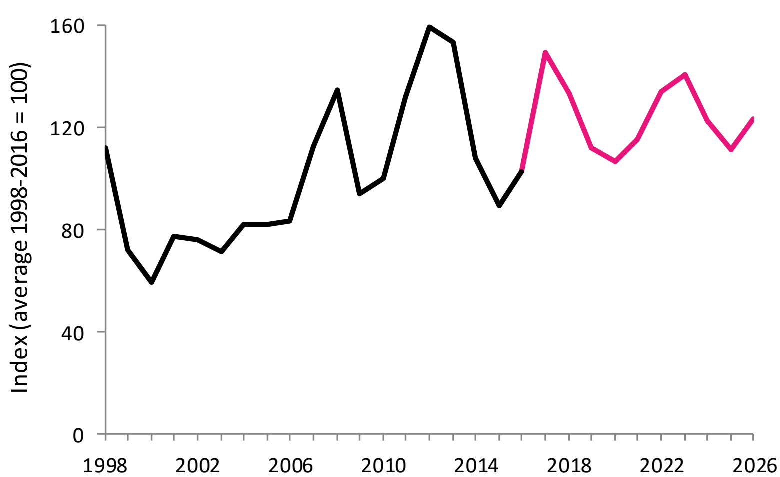

Figure 52: Projections of composite price index for the purse seine fishery

Catch rates

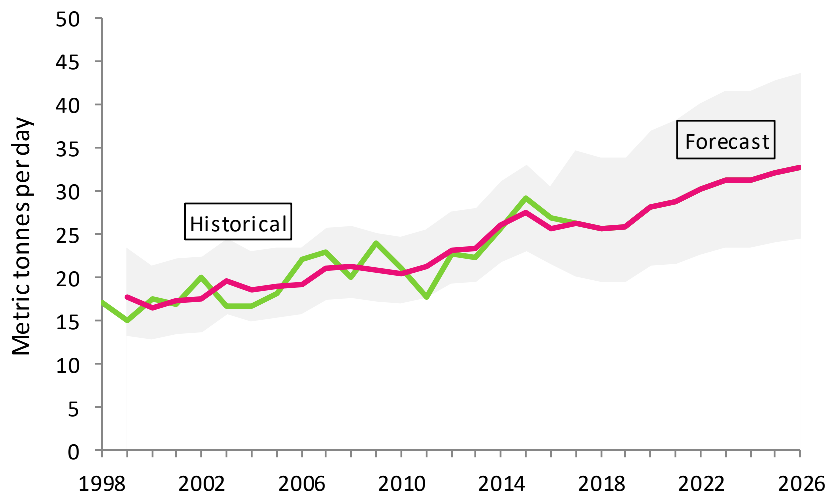

Figure 53: Projections of skipjack CPUE in the purse seine fishery

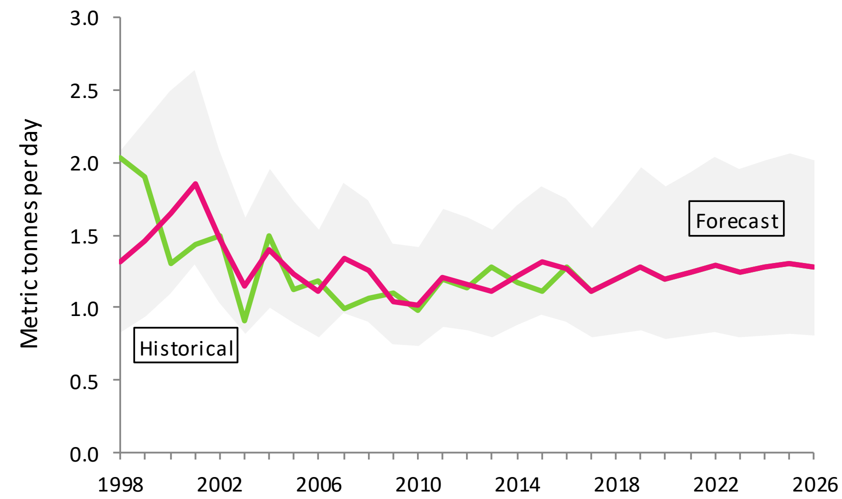

Figure 55: Projections of bigeye CPUE in the purse seine fishery

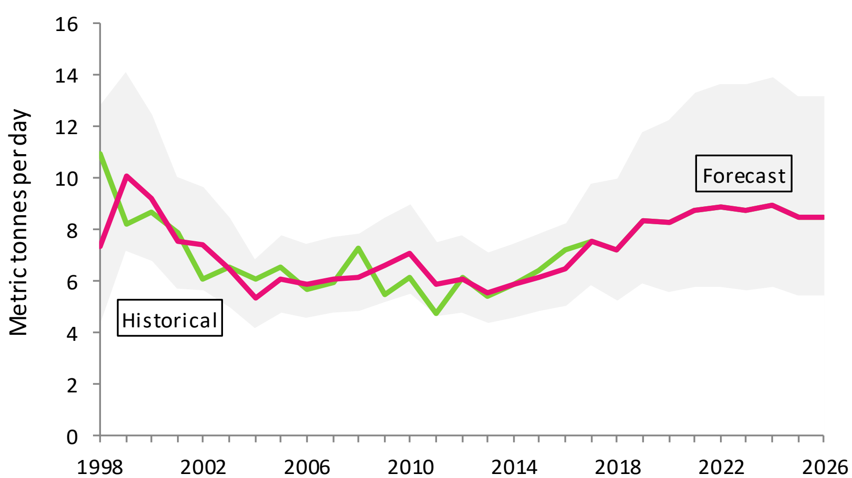

Figure 54: Projections of yellowfin CPUE in the purse seine fishery

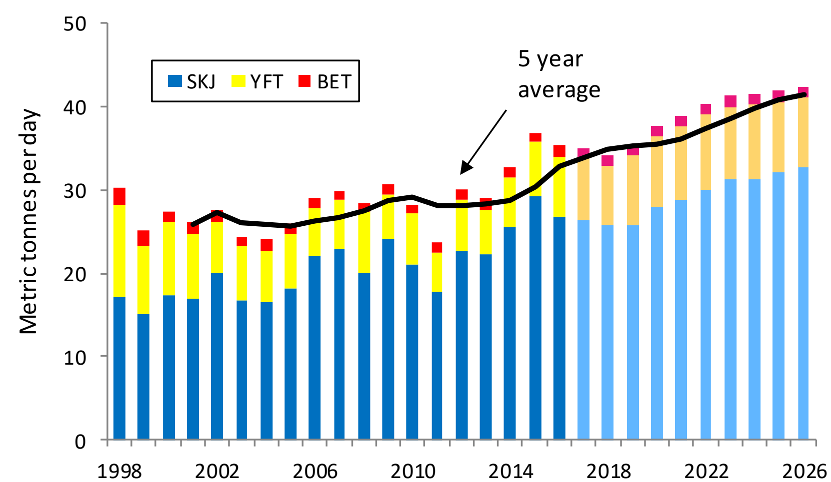

Figure 56: Projections of CPUE in the purse seine fishery by species (2017-2026)

The ARIMA projection of catch rates for skipjack using historical information follows a trend of strong increase over the entire projection period, from 2017 to 2026. 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. While yellowfin catch rates are projected to increase in the immediate future, to 2019, both series are expected to remain relatively constant from 2019 onwards. 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 2017 to 2026 (Figure 57).

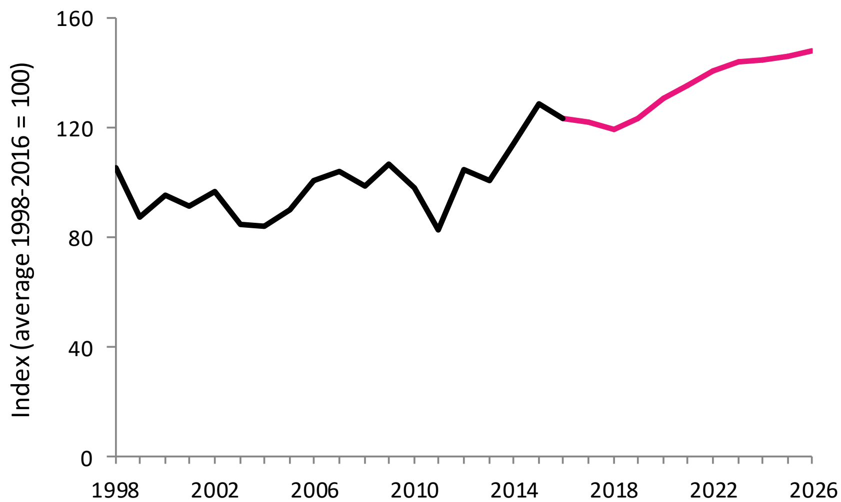

Figure 57: Projections of catch rate index in the purse seine fishery

Economic conditions index

Combining projections of all the three indices, the economic conditions index for the purse seine fishery are estimated in Figure 58. Unlike the projections for the longline fisheries, economic conditions in the purse seine fishery are projected to improve substantially in 2017, and remain well above the 1998-2016 average for the rest of the projection period. The above average conditions are predominantly driven by the strong increasing catch rate index and the above long-term average price index. Similar to the longline fisheries, the increase in fishing cost (as revised by the US Energy Information Administration) does negatively impact on conditions. However, the strong catch rate and fish price index more than offset this effect, keeping the economic conditions index well above long-term average in the projection period for the purse seine fishery.

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.

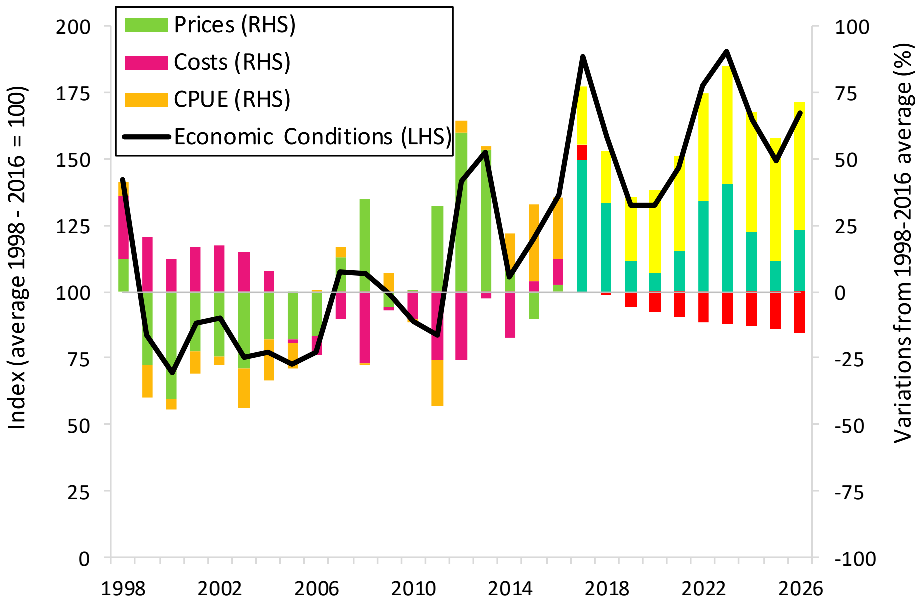

Figure 58: Projections of economic conditions index for the purse seine fishery (LHS) and variance of component indices against average (1998-2016) conditions (RHS)

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 sustained relatively poor catch rates have been impacting negatively on the economic conditions experienced in the fisheries. In recent years fish prices have been around their long term average while costs have been below average, yet economic conditions remain relatively poor. Persistently low catch rates, particularly for the southern longline fishery, continue to undermine vessel profitability and reduce their long term economic viability.

In contrast, projected above average prices and improving catch rates (especially that for skipjack tuna) 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 7	+ve	1, 3 and 7	0	6
Price of Japanese yellowfin import from Oceania	1 and 5	1, 2 and 5	+ve	1	0	5
Thai frozen skipjack price	2	2, 4 and 6	+ve	2 and 6	1	0
Thai frozen yellowfin price	2 and 5	2 and 6	+ve	1, 2 and 5	1	0
Southern longline albacore CPUE	2, 4 and 6	2, 6 and 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	3	2, 4 and 5	+ve	5	0	1
Southern longline other CPUE	1, 3 and 4	1, 2, 5 and 7	+ve	1 and 2	0	0
Tropical longline albacore CPUE	1	1 and 6	-ve	1	1	3
Tropical longline bigeye CPUE	1 to 4, 7	1, 3 and 7	-ve	1 and 7	1	0
Tropical longline yellowfin CPUE	na.	5	+ve	5	0	0
Tropical longline other CPUE	1 to 3, 6 to 7	1, 4 to 6	+ve	7	0	1
Purse seine skipjack CPUE	1	1, 3 to 7	-ve	4	1	1 and 4
Purse seine yellowfin CPUE	1 and 2	1, 2 and 7	+ve	1, 2 and 6	0	0
Purse seine bigeye CPUE	1 to 3	1 to 3	+ve	3	0	2

*Correlation with past value is greater than 0.20 but less than 0.25. Included only for those series that have sub-optimal estimations without it.

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	-2.476	-1.356	0.015	na.	na.	na.
Price of Japanese bigeye import from Oceania	-3.711	-1.356	0.002	na.	na.	na.
Price of Japanese yellowfin import from Oceania	-1.948	-1.356	0.038	na.	na.	na.
Thai frozen skipjack price	-1.279	-1.356	0.113	-2.311	-1.363	0.021
Thai frozen yellowfin price	-1.465	-1.356	0.084	-2.903	-1.363	0.007
Southern longline albacore CPUE	-1.398	-1.356	0.094	-2.815	-1.363	0.008
Southern longline bigeye CPUE	-1.267	-1.356	0.115	-3.503	-1.363	0.003
Southern longline yellowfin CPUE	-2.770	-1.356	0.009	na.	na.	na.
Southern longline other CPUE	-2.183	-1.356	0.025	na.	na.	na.
Tropical longline albacore CPUE	-1.197	-1.356	0.127	-3.379	-1.363	0.003
Tropical longline bigeye CPUE	-0.403	-1.356	0.347	-2.771	-1.363	0.009
Tropical longline yellowfin CPUE	-2.829	-1.356	0.008	na.	na.	na.
Tropical longline other CPUE	-1.437	-1.356	0.088	na.	na.	na.
Purse seine skipjack CPUE	-0.491	-1.356	0.316	-2.705	-1.363	0.010
Purse seine yellowfin CPUE	-2.558	-1.356	0.013	na.	na.	na.
Purse seine bigeye CPUE	-3.088	-1.356	0.005	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	Longline price index[5]			Southern longline composite index	Tropical longline composite index
	Skipjack and bigeye	Yellowfin		Albacore	Bigeye	Yellowfin		
1998	108	120	112	103	99	90	101	97
1999	69	78	72	94	110	109	98	107
2000	55	69	60	110	111	108	110	110
2001	79	75	78	116	97	92	111	99
2002	74	83	76	82	90	89	84	88
2003	67	82	71	84	93	95	88	92
2004	83	79	82	94	99	97	95	98
2005	79	91	82	103	99	96	101	99
2006	81	95	83	109	92	94	106	96
2007	113	113	113	77	88	92	80	87
2008	140	121	135	95	97	101	96	97
2009	95	89	94	101	102	102	101	102
2010	101	98	100	101	122	114	104	113
2011	132	132	132	111	118	120	114	117
2012	163	146	160	126	123	116	125	122
2013	157	138	154	89	98	102	91	96
2014	108	107	108	100	87	98	99	94
2015	89	92	90	105	83	88	99	91
2016	105	93	103	100	91	96	99	96
2017	160	116	149	97	97	95	97	96
2018	141	113	134	94	99	100	95	98
2019	116	98	112	88	99	99	91	96
2020	113	90	107	104	104	103	104	103
2021	123	93	116	98	109	101	100	104
2022	145	101	134	96	115	100	99	106
2023	154	100	141	99	108	100	100	103
2024	133	92	123	100	97	100	99	98
2025	120	86	112	101	86	100	100	94
2026	135	87	124	104	86	100	102	95

[5] Catches of tuna from the tropical and southern longline fisheries are destined for the same key markets. Therefore, prices of individual species received in the tropical longline fishery reflect those in the southern longline fishery, only the composition of catch is different.

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
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	48	248	83	273	84
2003	56	256	85	281	86
2004	76	276	92	301	93
2005	105	305	102	330	101
2006	121	321	107	346	107
2007	130	330	110	355	109
2008	181	381	127	406	125
2009	104	304	101	329	101
2010	130	330	110	355	109
2011	176	376	125	401	123
2012	176	376	125	401	123
2013	107	307	102	332	102
2014	152	352	117	377	116
2015	88	288	96	313	96
2016	71	271	90	296	91
2017	83	283	94	308	95
2018	104	304	101	329	101
2019	116	316	105	341	105
2020	124	324	108	349	107
2021	129	329	110	354	109
2022	134	334	111	359	110
2023	136	336	112	361	111
2024	139	339	113	364	112
2025	143	343	114	368	113
2026	147	347	116	372	114

Table 5: Catch rate index outputs for the purse seine, southern longline and tropical longline fisheries[6]

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
1998	30.2	105.3	56.4	135.9	49.3	136.2
1999	25.2	87.8	42.7	103.0	34.2	94.4
2000	27.4	95.7	44.3	106.9	39.8	110.0
2001	26.2	91.4	50.4	121.5	35.9	99.3
2002	27.7	96.5	45.1	108.6	35.1	96.9
2003	24.3	84.6	34.1	82.3	31.7	87.6
2004	24.2	84.4	36.8	88.7	38.0	105.0
2005	25.9	90.4	40.6	97.8	35.9	99.2
2006	29.0	101.0	45.1	108.7	37.8	104.3
2007	29.9	104.3	46.2	111.3	34.6	95.7
2008	28.4	99.0	47.5	114.6	33.9	93.5
2009	30.6	106.9	44.7	107.8	38.6	106.7
2010	28.2	98.5	39.6	95.5	36.1	99.6
2011	23.7	82.5	34.6	83.5	33.5	92.6
2012	30.0	104.7	35.4	85.4	32.6	90.1
2013	28.9	101.0	39.0	94.1	34.0	94.0
2014	32.7	114.0	36.5	87.9	38.1	105.3
2015	36.8	128.6	35.1	84.5	35.0	96.8
2016	35.3	123.3	34.0	82.0	33.6	92.8
2017	35.0	122.3	36.2	87.3	33.2	91.6
2018	34.2	119.2	38.3	92.3	32.2	88.9
2019	35.4	123.6	37.5	90.3	33.7	93.1
2020	37.6	131.1	36.3	87.4	32.6	90.2
2021	38.8	135.5	35.1	84.6	31.6	87.3
2022	40.3	140.8	34.0	82.0	33.9	93.6
2023	41.2	143.9	33.4	80.4	33.0	91.1
2024	41.5	144.9	33.6	81.0	33.8	93.4
2025	41.9	146.3	33.7	81.3	33.7	93.1
2026	42.5	148.2	33.5	80.7	33.5	92.5

[6] 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
1998	142	159	154
1999	84	119	120
2000	70	129	133
2001	88	151	114
2002	90	107	101
2003	75	86	94
2004	78	92	110
2005	73	98	97
2006	77	108	93
2007	107	80	74
2008	107	85	66
2009	99	108	107
2010	89	90	104
2011	84	71	84
2012	142	83	86
2013	153	83	88
2014	106	71	83
2015	119	87	91
2016	136	90	98
2017	188	90	94
2018	158	86	86
2019	133	77	85
2020	132	83	86
2021	147	75	82
2022	178	71	89
2023	191	69	83
2024	165	69	80
2025	149	68	74
2026	168	68	73