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Productivity analysis of key Commonwealth fisheries

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Summary

Total factor productivity (TFP) analysis of a fishery can provide a useful indicator of how well fishers use inputs to produce outputs. A fisher's ability to convert inputs into outputs changes over time, reflecting changes in the fishery's operating environment. When viewed over time, productivity trends can assist in the evaluation of a fishery's economic performance. For example, structural adjustment of a fishery's fleet or changes in management settings that regulate fishers' technology choice can affect fishery-level productivity, and in turn influence the economic performance of a fishery.

In recent years, the economic performance of Commonwealth fisheries has been affected by a number of factors that are likely to have also altered TFP trends. These changes include:

- the *Securing our fishing future* (SOFF) structural adjustment package for Commonwealth fisheries that concluded in 2006–07
- implementation of the Commonwealth Fisheries Harvest Strategy Policy (HSP) in 2007
- management changes by the Australian Fisheries Management Authority (AFMA) required to ensure sustainable and profitable fisheries.

Fisheries have also faced adverse changes in market conditions, including adapting to high fuel prices and a high Australian dollar exchange rate.

The SOFF package included a $149 million fishing concession buyback that enabled fishing businesses to exit the industry voluntarily. The competitive tender buyback process is likely to have encouraged the exit of the least profitable and/or least productive vessels from the fishery, making the remaining fleet more profitable and productive on average.

The Commonwealth Harvest Strategy Policy, implemented in 2007, is also likely to have had a positive impact. This policy focused on restricting catches and allowing stocks to rebuild to levels that are sustainable and that maximise economic yields, to ensure that the benefits of the SOFF package are maintained.

Consistent with the HSP, AFMA's management decisions have been focused on achieving sustainable maximum economic yields from Commonwealth fisheries. There has also been an increased focus on creating effective market-based rights for access to fisheries through the increased use of output controls. Those fisheries managed with a market-based rights system are likely to have greater levels of autonomous adjustment, where fishing rights flow to the most profitable vessels.

Productivity improvements can also result from changing market conditions. Market conditions that have negatively affected profitability of fishers in recent years include increased input costs, in particular fuel and business overhead costs, increased competition in the seafood-export market, and the appreciation of the Australian dollar, which has increased competition in the domestic market from imported seafood. These are likely to have provided fishers with incentives to pursue vessel-level productivity improvements to offset some of these negative effects on profitability. This may have been achieved by modifying business operations, such as making changes to input–output combinations used in production or adopting new technology. These adverse market conditions may also have helped to drive autonomous structural adjustment within the industry, with fishing rights moving to the most profitable fishers and the

least efficient and least profitable vessels exiting the industry. Autonomous adjustment generally results in the remaining fleet being more productive.

In this report, recent total factor productivity trends for key Commonwealth fisheries are estimated and discussed. The Commonwealth fisheries analysed are:

- the Eastern Tuna and Billfish Fishery (ETBF)
- the Commonwealth Trawl Sector (CTS)
- the Gillnet, Hook and Trap Sector (GHTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF)
- the Northern Prawn Fishery (NPF)
- the Torres Strait Prawn Fishery (TSPF).

A Fisher index method is used to combine the multiple inputs used and the outputs (catch) produced from these fisheries into separate indexes. These indexes are then used to derive a TFP measure for an individual vessel, which is then aggregated across vessels to derive aggregate fishery-level TFP measures for each of these Commonwealth fisheries and sectors.

Where stock biomass data are available, the TFP index is adjusted to account for changes in stock biomass. The adjustment of TFP for stock changes corrects for the impact of fish-stock changes on the ability of fishers to produce output. Stock-adjusted productivity trends were estimated for the otter-trawl vessels of the Commonwealth Trawl Sector and the Gillnet, Hook and Trap Sector (excluding automatic longliners) of the Southern and Eastern Scalefish and Shark Fishery. Stock-adjusted productivity estimates for the Gillnet, Hook and Trap Sector are undertaken for the period between 1998–99 and 2008–09, the years in which stock data are available. Stock-adjusted productivity trends were also estimated for the tiger prawn component of the Northern Prawn Fishery.

Key results

Productivity across all the Commonwealth fisheries analysed in this report generally follows an increasing trend over the periods analysed, but most noticeably in the period post 2006–07, following the conclusion of the SOFF buyback.

Productivity in the **Eastern Tuna and Billfish Fishery** grew by an annual average of 6.7 per cent between 1995–96 and 2010–11. Productivity growth is most noticeable between 2003–04 and 2010–11; this occurred at the same time as a reduction in fleet size, driven primarily by changes in market conditions but also by the SOFF buyback. It is likely that the least efficient vessels left the fishery during this period, which may be the principal driver for increasing productivity. However, as the fishery targets a range of low-value to high-value species, annual productivity changes in the fishery are also strongly influenced by changes in the availability of these different species over time.

Stock-adjusted productivity of the otter-trawl vessels in the **Commonwealth Trawl Sector** followed an increasing trend between 1996–97 and 2010–11, growing by an annual average of 10 per cent. The productivity increase is fastest between 2004–05 and 2010–11. As the stock levels and vessel numbers decreased (by 52 per cent) during this period, it is likely that the improvement in productivity was driven mainly by improvements in the remaining operators' ability to use inputs to produce outputs.

Over the analysis period (1998–99 to 2010–11), vessels in the **Gillnet, Hook and Trap Sector** (excluding automatic longliners) achieved an annual average productivity growth of approximately 2 per cent. The stock-adjusted productivity index increased by an annual average of 0.9 per cent. Productivity followed a generally declining trend between 1998–99 and 2003–04, then an increasing trend between 2003–04 and 2010–11. The latter productivity increases can be attributed to changes in the fleet structure. Over this period the number of vessels in the fishery decreased by 34 per cent, making it likely that the least efficient vessels exited the sector. Productivity increased due to fewer, more efficient vessels operating, and less competition within the sector. In 2010–11 productivity trends may have been influenced by spatial closures in the fishery to protect Australian sea lion populations. These closures are likely to have affected the availability of gummy shark to some operators in the fishery. However, it is unclear whether an increase in productivity in 2010–11 is a result of autonomous adjustment to the closures or a result of other factors.

The **Northern Prawn Fishery** has two main seasons: the banana prawn season early in the calendar year, and the tiger prawn season in the latter part of the year. Fishers apply different methods to catch prawns in these seasons. The productivity analysis for this fishery was undertaken across both seasons and for the tiger prawn season and the banana prawn season separately. Across both seasons productivity increased by an annual average of 7 per cent between 1992–93 and 2009–10. The productivity increase is most prominent between 2004–05 and 2009–10. For the tiger prawn season, productivity increased by an annual average of 7 per cent between1990–2000 and 2009–10, reduced to 3 per cent after stock adjustment. Productivity increased most noticeably between 2004–05 and 2009–10, likely reflecting the impact of the SOFF buyback and AFMA's setting of fishery-effort levels to target maximum economic yield. Productivity in the banana prawn season increased by an annual average of 15 per cent between 1998–99 and 2009–10, but increased more noticeably between 2004–05 and 2009–10. Although stock estimates are not available for the banana prawn season, assessments have linked a large increase in catch rates during that period to favourable environmental conditions supporting high banana prawn biomass (Woodhams et al. 2011b). The productivity increase is likely a result of favourable stock condition.

Between 1993–94 and 2007–08, productivity in the **Torres Strait Prawn Fishery** increased by an annual average of 4.8 per cent. The increase in productivity is most noticeable between 2000–01 and 2007–08. During this period, the number of operating vessels declined. This corresponds to declines in profitability and the 2005–06 voluntary licence surrender process. Also, assessments indicate that tiger prawn biomass had been steadily increasing since 2000. Therefore, the productivity increase can be attributed to a combination of factors: less competition among a smaller fleet, the exit of less productive vessels, and a larger stock allowing for easier catch.

1 Introduction

In recent years the economic performance of Commonwealth fisheries has been affected by a range of factors. These factors include policy decisions such as the *Securing our fishing future* buyback scheme and the Commonwealth Fisheries Harvest Strategy Policy, and also fishery-management decisions by the Australian Fisheries Management Authority. Market influences—such as increased fuel costs, increased competition for skilled labour, increased competition in the seafood-export market and the appreciation of the Australian dollar—have also affected the economic performance of Commonwealth fisheries (Mazur et al. 2010).

A key recent change in the regulatory environment for Commonwealth fisheries has been the introduction of the Harvest Strategy Policy in 2007. The HSP requires that AFMA manages all Commonwealth fisheries to target stock-biomass levels associated with maximum economic yield, which is generally consistent with maximising net economic returns from fisheries to the Australian community (AFMA 2010). In the lead up to implementing this policy, the Australian Government put in place the $220 million SOFF structural adjustment package for Commonwealth fisheries; this was announced by the Australian Government in November 2005 and concluded in December 2006. The package included a $149 million fishing concession buyback to enable fishing businesses to exit the industry voluntarily. By facilitating business exit and reducing the number of fishing vessels, the SOFF buyback aimed to assist remaining operators to adjust to the new management environment under the HSP (AFMA 2005).

The analysis of productivity trends for a fishery helps to provide an understanding of the fishery's ability to convert inputs into outputs. It is also a useful tool for assessing a fishery's overall economic performance (Box 1). The ability to convert inputs into output tends to change over time in response to changes in the fishery's operating environment. An increase in a vessel's productivity over a period of time implies that a vessel has done one of the following:

- increased its output while using the same or lower inputs
- increased its output by an amount greater than its increased input use
- decreased its output by a lower amount relative to input use
- produced the same level of output with fewer inputs.

The rates of change in input use and output production are important in determining productivity trends. The availability of productivity estimates over a number of years enables trend analysis to determine the key drivers of vessel-level productivity growth—for example, changes in the fishing technology mix, seasonal conditions, and any changes in the regulatory environment over the analysis period.

The SOFF buyback is expected to have impacted industry-level productivity of Commonwealth fisheries in a number of ways. First, the voluntary tender process used for the buyback is likely to have resulted in the least profitable (and therefore, least efficient) vessels exiting the fishery. This is because operators that value their participation in the fishery least are more willing to accept compensation for exiting the fishery (Metzner & Rawlinson 1998). Such operators are likely to be the least efficient and to have lower expectations of the future profits they can earn from remaining in the fishery. In removing the least profitable and least productive vessels, the remaining fleet is likely to have become more productive on average. Secondly, the SOFF buyback resulted in fewer vessels sharing a similar sized resource, with decreased crowding and competition among vessels. This generally allows vessels to operate more efficiently and results in increased fishery productivity. Similarly, the use of individual transferrable quotas and the targeting of maximum economic yield by AFMA in line with the Commonwealth HSP may increase autonomous adjustment in some fisheries. This can further promote the movement of fishing rights to the most efficient vessels which improves fishery-level productivity.

The external market-based factors affecting the economic performance of Australia's fishing industry are well documented. There is, however, little in the literature that assesses how well Australia's fishing industry has improved its productivity performance in response to these factors. These external factors may, for example, provide incentives for fishers to pursue vessel-level productivity improvements by changing how their inputs—for example, gear, boat size, fuel, labour and so on—are used to produce the fishing output. Improvement in vessel-level productivity can help to offset some of the negative effects that external factors can have on long-run profitability. Autonomous adjustment may also have occurred, with the least efficient operators exiting the industry, thereby increasing average productivity of the remaining fleet.

This report provides an analysis of productivity trends for key Commonwealth fisheries and discusses the likely impact of policy changes and other fishery-specific changes on these trends.

The Commonwealth fisheries analysed are:

- the Eastern Tuna and Billfish Fishery (ETBF)
- the Commonwealth Trawl Sector (CTS)
- the Gillnet, Hook and Trap Sector (GHTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF)
- the Northern Prawn Fishery (NPF)
- the Torres Strait Prawn Fishery (TSPF).

As the latter fishery is not managed solely by the Commonwealth, it has not been subject to the policies outlined above. It has, however, seen significant management changes over the same period that are likely to have affected productivity, including a one-off substantial reduction in effort and a voluntary licence-surrender process.

The total factor productivity analyses presented in this report are a first step towards a greater understanding of the underlying drivers of productivity growth for Commonwealth fisheries. Further research could improve methods of analysis, such as better capturing the impact of fish stocks on productivity. More detailed analysis of the drivers of productivity trends at the vessel level, particularly operating decisions, could provide additional insights for increasing fishery-level productivity of Commonwealth fisheries.

Box 1 Productivity as an indicator of fishery economic performance

ABARES undertakes a range of research focused on maximising net economic returns to the Australian community from the management of Commonwealth fisheries. The Commonwealth Fisheries Harvest Strategy Policy's (2007) recommended harvest strategy target of 'maximum economic yield' has created a greater need for such research. This research can be divided into two streams.

1. Informing management decisions against the economic objective: this area of research is focused on providing advice on the management settings that should be implemented in a fishery to achieve maximum economic yield. Studies using bioeconomic models serve this purpose and have been developed for a number of fisheries (Kompas & Che 2004; Kompas & Che 2006). Other management-strategy, evaluation-based approaches that include an economic component can also serve this role and are a potential future research focus.

2. Monitoring management performance against the economic objective: this area of research is focused on assessing previous management decisions and their impact on economic performance. For the fisheries analysed in the current report, such research has included survey-based estimation of net economic return (George et al. 2012; Perks & Vieira 2010), index number profit decomposition (Skirtun & Vieira 2012) and the examination of economic efficiency (Kompas & Che 2002; Elliston et al. 2004; New 2012).

The productivity analysis presented in this report can assist in evaluating a Commonwealth fishery's economic performance, complementing work done under stream two above. The analysis shows the fishery's past ability to convert inputs into output given policy and market changes. For given levels of input and output prices, an increase in productivity indicates an increase in profitability. An increase in productivity is driven by an increase in output and/or a decline in input use. This suggests profitability improvements, which are influenced by either an increase in revenues or a decline in costs.

Productivity analysis is a first step towards better understanding the underlying drivers of productivity growth for Commonwealth fisheries. Future research can provide information to assist vessel operators and policy makers to promote greater productivity and profitability in fisheries.

Productivity can be measured in a number of ways. The measure of productivity used here is a complete measure. That is, it includes all inputs and outputs. This differs from the partial measure developed by Skirtun and Vieira (2012) in their profit-decomposition analysis. Their analysis evaluates the contribution of productivity to profit relative to other contributions. This means that the productivity results for the same fisheries may differ between the two research reports. However, the total factor productivity results presented here are best used to observe the fishery's ability to use inputs to produce outputs over time. The profit-decomposition productivity results are best suited to evaluating the relative impact of productivity on profit.

2 Productivity in the fisheries context

Two types of productivity measures are commonly used to assess industry performance: total factor productivity (TFP) and partial factor productivity (PFP).

- Total factor productivity measures (sometimes referred to as multi-factor productivity) are a ratio of total outputs and total inputs. TFP growth measures change in total output relative to the change in total inputs used through time.
- Partial factor productivity measures a ratio of total outputs and a single input. It is therefore less accurate in assessing overall productivity for a fishery. PFP measures result in a misleading assessment of a fishery's productivity performance because the effects of efficiency changes, input substitution and technological improvements embodied in other inputs are incorrectly attributed to a particular input (Sheng 2011).

For these reasons, a TFP measure is preferred for obtaining overall productivity trends in a fishery in order to assess improvements in fishing practices and efficiency.

Productivity growth in a fishery can generally be attributed to four sources (Wood & Newton 2007):

1) A major source will often be **improvements in technology** that allow operators to produce greater amounts of output for their inputs.
2) A related driver occurs with **increased adoption of existing technology** by operators.
3) **Structural adjustment of a fishery's fleet** (through exit and entry) will positively impact productivity. The change to more productive vessels can occur both through autonomous adjustment (as a result of market forces) or through government-funded adjustment assistance (for example, vessel buyback programs).
4) A final source, unique to fisheries, is **changes in the resource stock**. An increase in the abundance of fish stock leads to an increase in estimated productivity as fish can more easily be caught with relatively fewer inputs.

Changes in a fishery's stock biomass should be taken into consideration when assessing productivity sources. If not, productivity improvements may be overestimated, as some of the observed increase in productivity may be attributed to increased stocks. One solution is to adjust productivity for stock levels; however, estimates of stock biomass are often not available for a fishery. Alternatively, productivity trends can be interpreted with reference to information about a fishery's stock biomass and its fluctuations. This allows for the distinction between productivity changes due to stock fluctuations and productivity changes due to improved economic performance (Grafton 2006).

Some government management arrangements directly determine the technology used and adopted in a fishery. Under input controls, a fisher's technology choices are substantially influenced by regulation on what fishing gear can be used, vessel size, or when and where a vessel can operate. These can indirectly limit harvests by limiting input use. Therefore, a one-off change in an input control (for example, allowing more efficient nets to be used) will shift productivity, holding all else constant. Output controls, normally through a total allowable catch, allow vessels to adopt inputs and technologies that maximise efficiency. However, where output controls are complemented by input controls, productivity improvements are likely to reflect both changes in input-management restrictions and profit-maximising behaviour (subject to prevailing input restrictions).

Market-based rights also affect productivity. A market-based right implies that the right to operate in a fishery can be traded. Such rights can be applied to input controls (for example, tradable effort units) and output controls (for example, individual transferrable quota). Under trading, these rights will naturally gravitate to the most efficient operators in a fishery, as such operators will be more willing to pay for those rights. This process of autonomous structural adjustment tends to increase productivity, holding all else constant. However, Elliston and et al. (2004) note that, under individual transferable quotas, if total allowable catches are not set at binding levels that lead to positive economic returns, trade in quota entitlements will be impeded. This is because quota entitlements will have little economic value and autonomous adjustment is likely to be compromised.

The economic impacts of fishery buybacks have been covered widely (Vieira et al. 2010; Pascoe et al. 2012; Fox et al. 2006; Holland et al. 1999). In most cases, buybacks aim to remove excess capacity, allow stocks to recover and improve profitability. An improvement in efficiency can occur through two mechanisms: having fewer vessels competing for a resource, and exit of the least efficient and least profitable vessels. The main effect of a buyback is an increase in efficiency and profitability, holding all else constant. These can be captured as an increase in productivity.

Commonwealth fisheries management focuses on setting catch levels to achieve stock biomass levels that maximise the net economic return (the difference between fishery revenues and costs). The point at which this generally occurs is referred to as 'maximum economic yield'. The biomass level associated with maximum economic yield may differ from that which results in maximum productivity. This is because changes in relative input and output prices affect total costs and revenues, and can prompt vessel operators to maximise profits at the expense of productivity.

The relationship between productivity changes and industry profitability should be interpreted in the context of the fishers' terms of trade. The terms of trade is a ratio of prices received for outputs to the prices paid for inputs. For example, favourable terms of trade lead to profitability increases; however, this does not always correspond to increasing productivity. Commonwealth fishery management has a legislated objective of maximising net economic returns to the Australian community from the management of Australian fisheries (AFMA 2010). The evaluation of productivity improvement within Commonwealth-managed fisheries is a way of assisting AFMA to meet this objective, as AFMA management actions can indirectly affect productivity outcomes. The productivity analyses presented here can therefore be used to assess the performance of Commonwealth fisheries and evaluate impacts of one-off changes in fishery management.

Box 2 Productivity, efficiency and profitability

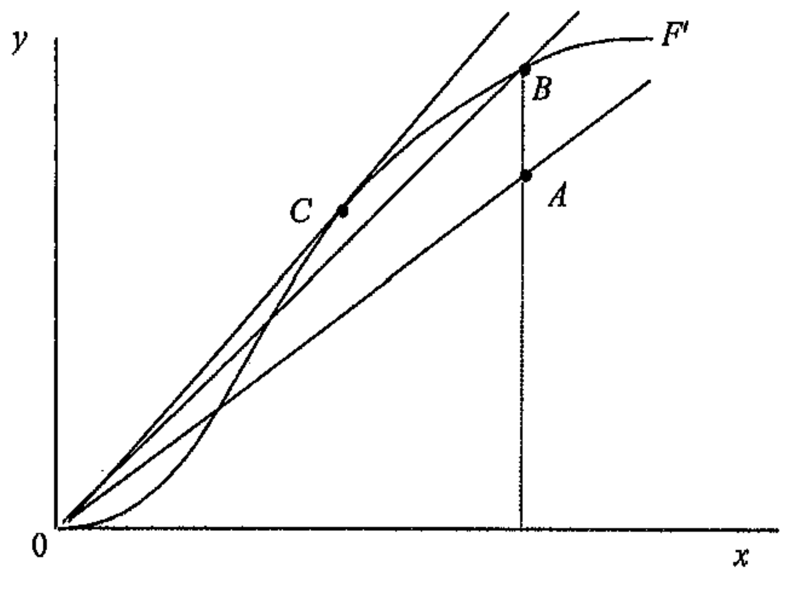
Economic efficiency can be split into two categories: technical efficiency and allocative efficiency. The production possibility frontier (F') represents the maximum output attainable from each input level. Technical efficiency is a measure of a firm's ability to maximise outputs with a given set of inputs—that is, operate on its production possibility frontier. Allocative efficiency measures a firm's ability to achieve a set of outputs with the least costly mix of inputs (Coelli et al. 2005).

Profitability is the difference between total revenues earned and total economic costs incurred.

If a firm achieves allocative efficiency, it is maximising outputs while choosing inputs that minimise costs. Therefore, it is maximising profits. In turn, this firm will also be technically efficient and have high productivity.

The least efficient vessels are those that are not using their inputs to maximise outputs and/or are not selecting the set of inputs that minimise costs. Therefore, these vessels are also the least profitable. Following a policy change such as the SOFF, the least efficient vessels are likely to exit the industry as these vessels value their participation in the fishery least and hence are more willing to accept compensation for exiting. In turn, this will result in the more efficient vessels continuing to operate in the fishery, increasing average fishery productivity.

In the figure below, a line through the origin is used to measure productivity at a particular data point. The slope of this line (y/x) provides a measure of productivity. If the firm operating at point *A* moves to the technically efficient point *B*, the slope of the line would be greater. This implies a higher productivity point. Movement from point *A* to point *B* shows the firm increasing outputs for a given input level. By moving to point *C*, the line becomes a tangent to the production frontier and defines the point of maximum productivity. At this point, the firm is exploiting allocative efficiency, where it is selecting the least costly input mix to produce output. Operating at any other point of the production frontier will result in lower productivity. A technically efficient firm can improve its production by exploiting allocative efficiency.



3 Method

Productivity measurement

Productivity is defined as the quantity of output produced with a given quantity of inputs. For example, a partial measure of productivity for a fishing vessel would be kilos of a particular species of fish produced per hook used. A more complete measure of productivity is the total catch per unit of all the inputs used. This latter approach is preferred as a measure of productivity, and is usually referred to as total factor productivity—TFP.

There are various methods developed to assess quantitatively TFP trends for industries, and for individual enterprises within industries (see Coelli et al. 2005 for discussion). A common approach uses index number theory. In this report, a Fisher quantity index is used to measure TFP trends for key Commonwealth fisheries (see Box 2). Fishery-level input, output and TFP indexes were estimated for each of the Commonwealth fisheries analysed and for each year where data were available. The Fisher quantity index is well suited to handling the range of inputs and outputs recorded in ABARES fisheries economic survey data—for example, these ABARES data contain many zero entries, which are well handled by the Fisher quantity index approach.

As with other index number approaches that measure productivity, the Fisher quantity index enables measurement of productivity trends with multiple inputs and outputs. The prices paid for inputs and received for outputs are used as weights to derive aggregations of outputs and inputs, which are expressed in index form. Output and input indexes are estimated using both a Laspeyres and a Paasche index approach. A geometric mean of these indexes is derived to determine the Fisher output and input indexes. TFP is measured as the ratio of the Fisher output and Fisher input indexes.

Box 3 Fisher index

Using price and quantity data for a set of outputs (inputs), the Laspeyres quantity index Q_{0t}^{L} can be defined as:

$$Q_{0t}^{L} = \frac{\sum_{i=1}^{N} p_{i0} q_{it}}{\sum_{i=1}^{N} p_{i0} q_{i0}} = \sum_{i=1}^{N} W_{i0} \frac{q_{it}}{q_{i0}}$$

where

$$W_{i0} = \frac{p_{i0} q_{i0}}{\sum_{i=1}^{N} p_{i0} q_{i0}}$$

is the share of ith item in the total value of outputs (inputs) in the base period (denoted by 0) . The Laspeyres index compares a total quantity in time period (t) to a base period.

The Paasche index (Q_{0t}^{P}) is defined as:

$$Q_{0t}^{P} = \frac{\sum_{i=1}^{N} p_{it} q_{it}}{\sum_{i=1}^{N} p_{it} q_{i0}} = \left\{ \sum_{i=1}^{N} W_{it} \left(\frac{q_{i0}}{q_{it}} \right) \right\}^{-1}$$

where

$$W_{it} = \frac{p_{it} q_{it}}{\sum_{i=1}^{N} p_{it} q_{it}}$$

is the share of ith item in the total value of outputs or inputs in the current period (denoted by t). Like the Laspeyres index, the Paasche index compares a total quantity in time (t) to a base period (0).

The Fisher index (Q_{0t}^{F}) is the geometric mean of Laspeyres and Paasche indexes, defined as:

$$Q_{0t}^{F} = \sqrt{Q_{0t}^{L} Q_{0t}^{P}}$$

The TFP index can be calculated as the ratio of the Fisher output (Q_{0t}^{FO})and input (Q_{0t}^{FI}) indexes:

$$TFP_{0t} = \frac{Q_{0t}^{FO}}{Q_{0t}^{FI}}$$

Adjusting productivity for stock changes

To better reflect the efficiency of vessel owners in using inputs to produce outputs, changes in fishery stock biomass levels must be considered. By not accounting for an increase (decrease) in stock, fishery productivity will appear to improve (decrease) if harvest increases (decreases) relative to input use. Adjusting for changes in the stock allows for a distinction between productivity changes due to fluctuations in the stock, and productivity changes influenced by changes in economic performance (Grafton 2006).

Where stock biomass data were available, stock-adjusted productivity was estimated. The stock-adjusted total factor productivity index (TFP_{0t}^A) is defined by:

$$TFP_{0t}^A = TFP_{0t} / \frac{B_t}{B_0} \quad \text{where} \quad B_t = \sum_{j=1}^{n} j \; R_{jt} B_{jt}$$

Where B_0 and B_t are measures of the stock biomass available to fishers in the fishery in time period (0) and time period (t), respectively, and where period (0) is defined as the period of earliest available stock biomass data used in the analysis. The contribution of the stock biomass of species j in period t (B_{jt}) to the aggregated biomass index (B_t) is weighted by its corresponding revenue share (R_{jt}) which is defined by that species' price and output quantity in period t. The final result is an aggregated stock index (B_t) in which the biomass of a higher valued species receives a greater weight (holding all else constant) and, similarly, the biomass of a species that has been caught in greater quantity receives a greater weight (holding all else constant).

A stock biomass index (B) is estimated for each fishery to combine multiple species' biomass into a single measure of biomass. This is complicated by factors that include (but are not limited to) understanding stock abundance variability across species and through time; capturing different species contribution to output (and productivity); and accounting for stock distribution issues and how this impacts on productivity across different vessels.

Given that each output used to estimate the TFP index is determined by its quantity and its price, a conceptually consistent approach is to use each species' price and harvest to weight its contribution to a fishery's aggregated biomass. This multi-species stock biomass calculation is consistent with the approach outlined by Jin et al. (2002) and Squires (1992).

Stock adjustment is rarely undertaken in fisheries literature. The above stock-adjustment method was undertaken due to its compatibility with the Fisher index. Similar stock-adjustment approaches have been applied in productivity studies using index number profit-decomposition approaches such as by Fox et al. (2006), Kompas et al. (2009), Vieira (2011), and Skirtun and Vieira (2012). Alternative stock-adjustment methods are discussed by Jin et al. (2002) and Hughes (2011).

It is important to note that the inclusion of a stock index in a multi-species fishery may be problematic. In particular, the contribution of specific stocks to changes in the productivity index will vary across species and this variation may not be well captured. Such variations will also occur across vessels. Despite this, the stock-adjusted TFP suggests changes in those stocks caught by the vessels in a given year. Therefore, the stock biomass index will reflect aggregate changes in the stock biomass and the catch composition of the vessels.

Data

The data used for this TFP analysis are sourced from the ABARES Australian fisheries surveys dataset. The surveys dataset comprises physical and financial survey data for a sample of vessels operating in key Commonwealth fisheries. The inputs incorporated in the input indexes for each fishery are labour, fuel, repairs and capital (Appendix A). The output indexes for each fishery are described in the results section for each individual fishery. Population estimates are derived using sample vessel data from this database, and are calculated for each of the fisheries analysed in this report. A weight is calculated for each boat in the sample, to represent its importance in the total unobserved population. The weight is generally based on the vessel's catch representation. Weighted vessel-level information is used to derive fishery-level input and output indexes.

Stock biomass data were only available for the Commonwealth Trawl Sector, the Gillnet, Hook and Trap Sector (calculated by CSIRO and sourced from Day 2012) and the tiger prawn season of the Northern Prawn Fishery (calculated by CSIRO and sourced from Pascoe 2012).

Interpretation of results

The input, output and TFP indexes are presented graphically for each fishery. Where stock biomass data are available, a stock biomass index and a stock-adjusted TFP index are also presented. Where possible, observed trends in productivity are linked to recent changes in the fishery's operating environment such as management decisions. Although such linkages are drawn in this report, further research is required to understand better the principal drivers of productivity trends observed over the analysis period for each of the fisheries assessed.

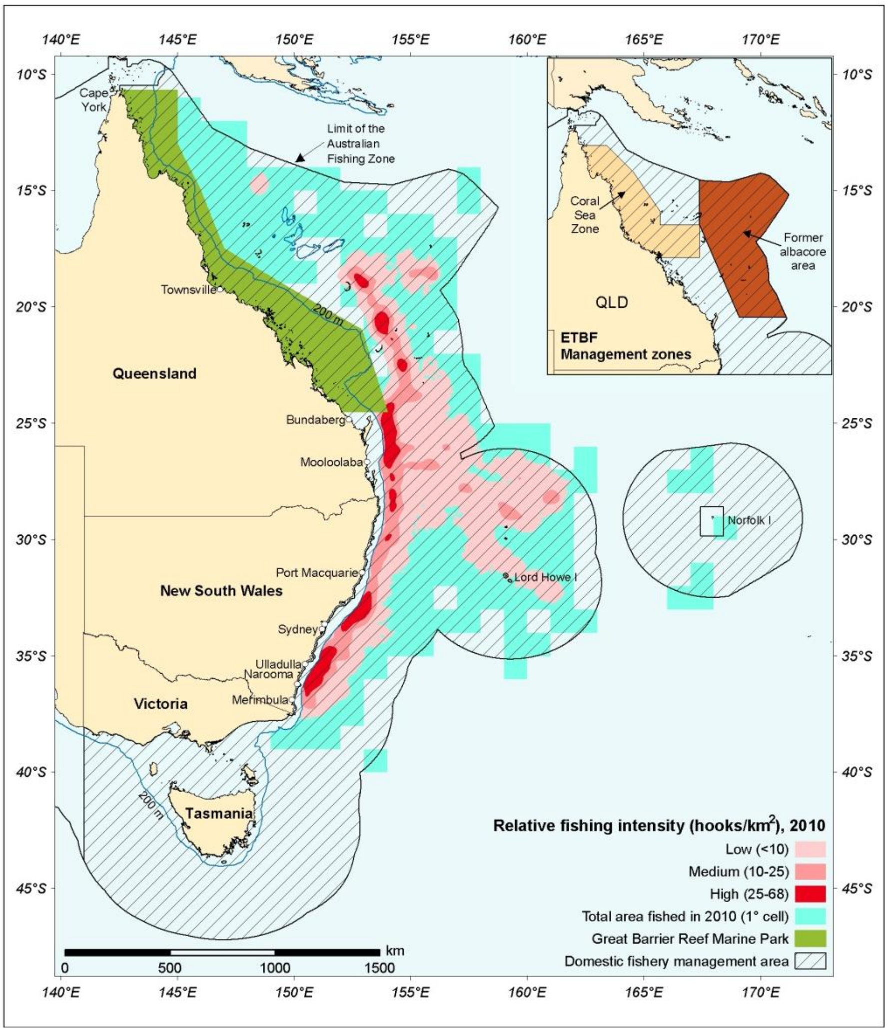
Establishing productivity trends for fisheries is best done using datasets that extend over relatively long periods. Short-term influences, such as the effect of stock changes on fishery production and the deferral of input expenditure in low-income years, have an impact on annual productivity estimates produced using index number approaches. The interpretation of data from year to year can also be affected by sampling issues. For example, outlier vessels may have greater weights due to data unavailability. Therefore, analysis and observation of productivity trends for each fishery are best undertaken over a longer period.

4 Eastern Tuna and Billfish Fishery

Background

The Eastern Tuna and Billfish Fishery (ETBF) is a multi-species fishery. It stretches from the tip of Cape York to the South Australian – Victorian border and includes the waters around Lord Howe Island and Norfolk Island (Map 1). Key target species caught are yellowfin tuna, bigeye tuna, albacore tuna, broadbill swordfish and striped marlin. The species targeted are highly migratory and occur throughout the Pacific.

Map 1 Location and relative fishing intensity, Eastern Tuna and Billfish Fishery, 2009



The Western and Central Pacific Fisheries Commission is the regional fisheries management organisation which manages these stocks jointly with other countries. Domestic management arrangements take account of Australia's obligations to the commission and its management decisions.

Stocks in the ETBF support both commercial and recreational fishing activities. Commercial fishing occurs in a longline sector—using longline fishing methods—and a minor line sector in which rod-and-reel, handline and trolling methods are used. The longline sector accounts for most of the fishery's catch (Wilson et al. 2010), and this is the focus sector in the ETBF productivity analysis.

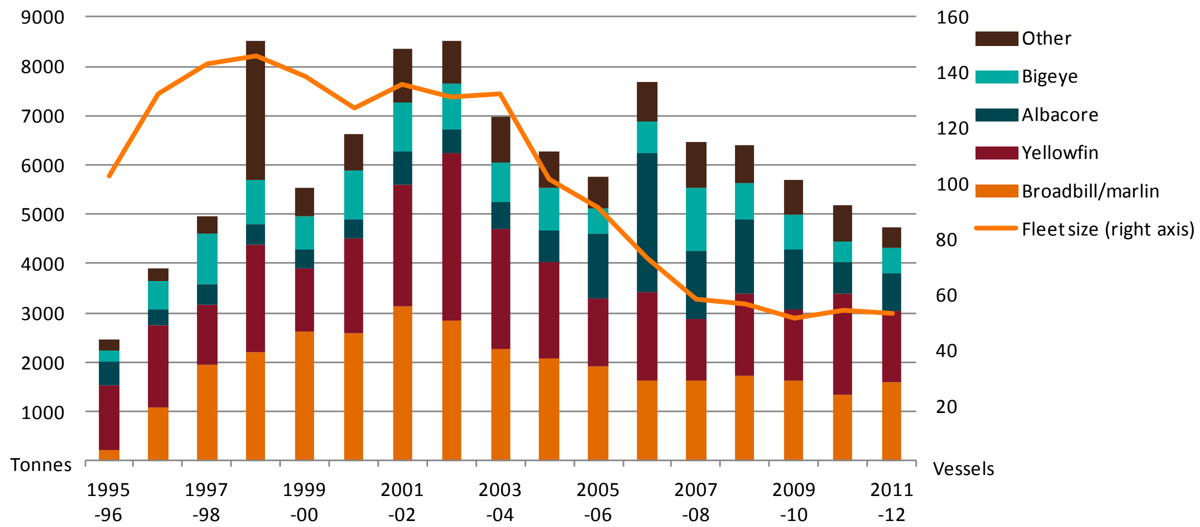
The fishery has been managed with various forms of input controls such as gear restrictions, spatial management and fishing permits. In November 2009 AFMA set a total allowable effort limit (in terms of hooks) allocated via tradable statutory fishing rights. This replaced the use of annual fishing permits and applied for 16 months, ending in February 2011. In March 2011, output controls were introduced in the form of total allowable catches allocated as individual transferable quotas.

The ETBF was targeted in the 2006 Australian Government SOFF structural adjustment package (Abetz 2006). This package resulted in the surrender of 99 longline and 112 minor line permits, leaving 119 longline and 118 minor line permits in the fishery.

Fishery trends

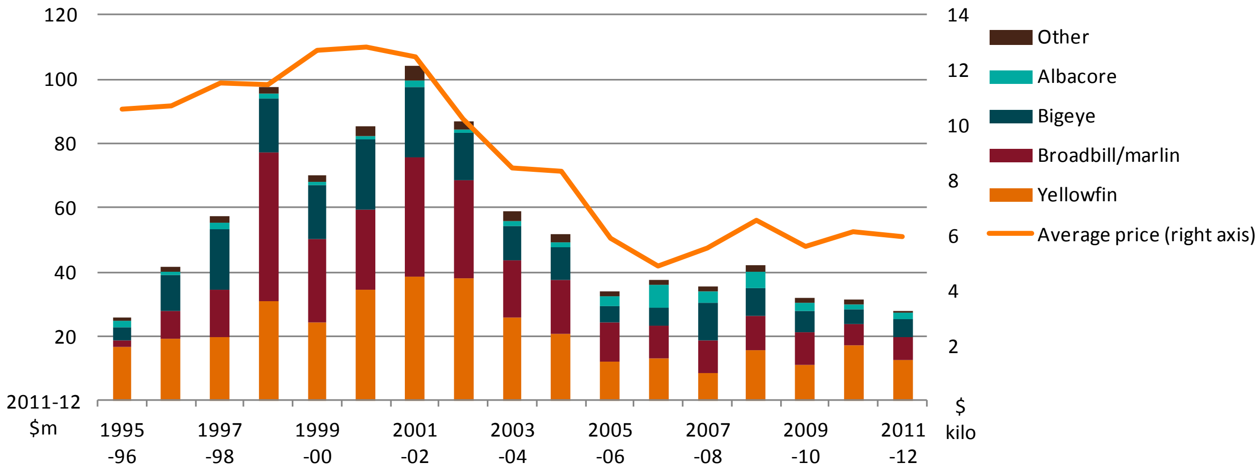
From 1995–96, production in the ETBF followed an increasing trend (Figure 1), peaking in 1998–99 (at 8524 tonnes) and 2002–03 (at 8523 tonnes). The main driver of these peaks was yellowfin tuna catches, accounting for 26 per cent and 30 per cent in 1998–99 and 2002–03 respectively. Following 2002–03, production in the fishery decreased each year for three years, reaching a low of 5758 tonnes in 2005–06. In 2006–07, production in the fishery increased by 1937 tonnes (34 per cent) to 7695 tonnes. This was largely driven by a doubling in catch of low-value albacore to 2814 tonnes. Since 2006–07, the fishery's production has continued to decline and was 4733 tonnes in 2011–12.

Figure 1 Production by species and fleet size in the Eastern Tuna and Billfish Fishery, total longline and minor line, 1995–96 to 2011–12



Between 1995–96 and 2001–02, the fishery's real gross value of production (GVP) followed an increasing trend, peaking in 2001–02 at $104.3 million (2010–11 dollars) (Figure). During this period, the catch composition changed from being predominantly yellowfin tuna to broadbill swordfish. Following 2001–02, the GVP continued to decrease steadily to $34 million in 2005–06. Since then, GVP has followed a flat trend. It decreased in 2009–10 by 24 per cent to $32 million (in 2011–12 dollars) due to declines in both production and real output prices.

Figure 2 Real gross value of production by species and total average catch price in the Eastern Tuna and Billfish Fishery, longline and minor line, 1995–96 to 2011–12



Productivity analysis and results

The TFP analysis for the ETBF is undertaken for the financial years 1995–96 to 2010–11. The species included in the output index are yellowfin tuna, skipjack tuna, albacore tuna, bigeye tuna, billfish (including broadbill swordfish, striped marlin and other billfish) and other species caught. Productivity is not adjusted for stock changes as relevant stock biomass data are not available for this fishery.

The tuna and billfish species targeted in the fishery are migratory and occur across the Pacific beyond ETBF waters. Stock availability in the ETBF (that is, the fish that can be accessed by fishers for harvest) is believed to be influenced by total abundance of stock and oceanographic factors, making interpretation of productivity trends more difficult (Kompas at al. 2009).

Productivity in the ETBF increased by an average of 6.7 per cent each year between 1995–96 and 2010–11. Between 1995–96 and 2002–03, the TFP index remained relatively constant because the input and output indexes followed a similar increasing then a decreasing trend (Figure). During this period, the fleet size increased in line with the positive net economic returns evident in the late 1990s (Perks & Vieira 2010). These positive net economic returns and increased capacity were largely associated with increased targeting of high-value broadbill swordfish. As the fleet size increased, input use doubled, with the build up in capacity appearing to be largely unconstrained by management settings.

The TFP index increased between 2003–04 and 2010–11. The input and output indexes both followed decreasing trends with inputs decreasing at a faster rate. Vessel numbers declined by almost 60 per cent, likely influenced by the negative net economic returns prevailing post 2002–03 (Perks & Vieira 2010). The increase in productivity during this period could have been driven by the exit of less efficient vessels.

Productivity followed a generally increasing trend following the conclusion of the SOFF buyback (2006–07) as the input index declined faster than the output index. Fleet size decreased as a result of the SOFF buyback, which is likely to have left the more efficient vessels continuing to operate in the fishery. This may be the principal driver for the increasing productivity trend during the latter part of the last decade.

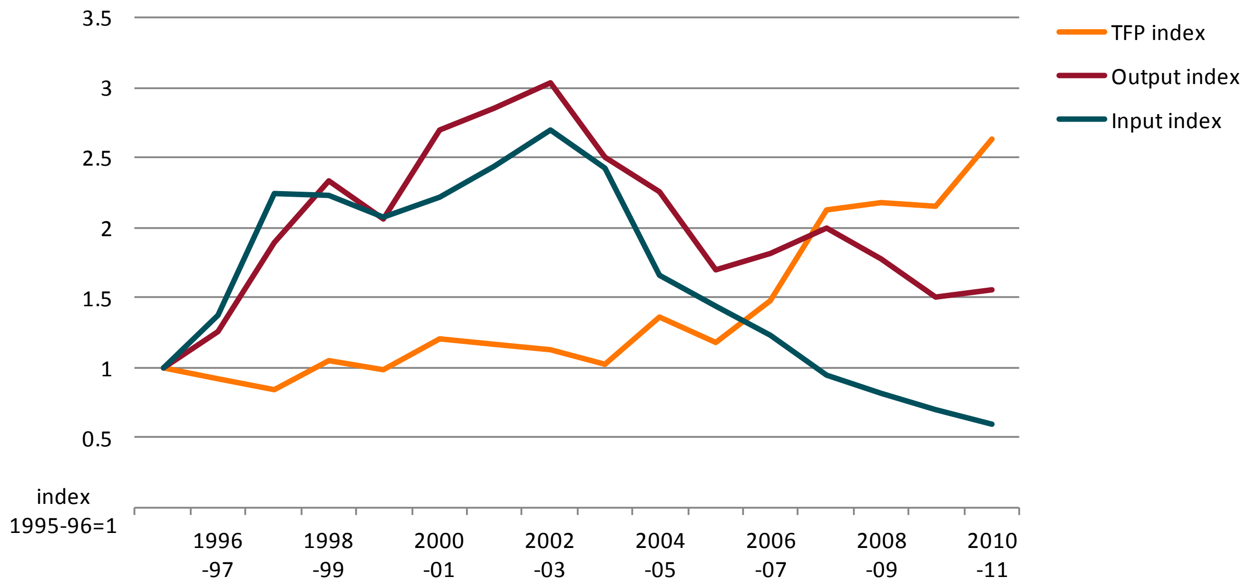
The TFP index has followed a generally increasing trend since 1999–2000, although the rate of increase post 2003–04 was faster. This occurred at the same time as the reduction in fleet size, driven primarily by market forces in the early 2000s, but also by the SOFF buyback which concluded in 2006–07.

It is difficult to identify specific management changes that have influenced these productivity trends. The exclusion of Japanese longliners from the ETBF in 1997 occurred at the same time as the build up in domestic capacity. Sharing available stocks with fewer vessels would be expected to have a positive impact on those remaining vessels; however, this productivity impact was not observed as Japanese vessels were replaced with domestic vessels. Management of bycatch issues such as wire leader bans in 2005, requirements to use bird scaring tori lines and weighted swivels in 2006, and the voluntary uptake of circle hooks in 2007 (AFMA 2009) may have hampered productivity growth, but this cannot be quantified here. Similarly, operational and quota holding requirements for fishers operating in New South Wales waters where southern bluefin tuna occur could have affected the productivity of some operators in that state. However, despite all these changes, an overall positive productivity trend was maintained.

As the fishery targets a range of low-value to high-value species, annual productivity changes in the fishery are strongly influenced by changes in the availability of these different species over time. For example, the build up in capacity in the late nineties was a response to the targeting of high-valued broadbilled swordfish. Evidence of localised depletion of this species following this build up would have impacted profitability and productivity. Similarly, in 2006 some operators began to target albacore (a lower-valued species) in response to reduced swordfish availability. This would also have affected productivity growth.

In November 2009, AFMA set a total allowable effort limit, with tradeable statutory fishing rights, adjusted by a sub-area factor (Wilcox et al. 2011). This arrangement was in effect for 16 months, ending in February 2011. In March 2011, this system of input controls was replaced by output controls comprising the setting of total allowable commercial catch with a system of individual transferrable quotas. Although these policy changes are outside the period of analysis, it is expected that the move to quota may promote greater efficiency in the fishery and, as operators adjust to the new management arrangement, there will be greater trade in quota towards the most efficient operators. These factors combined should increase future productivity growth in the fishery.

Figure 3 Productivity, input and output indexes for the Eastern Tuna and Billfish Fishery, 1995–96 to 2010–11



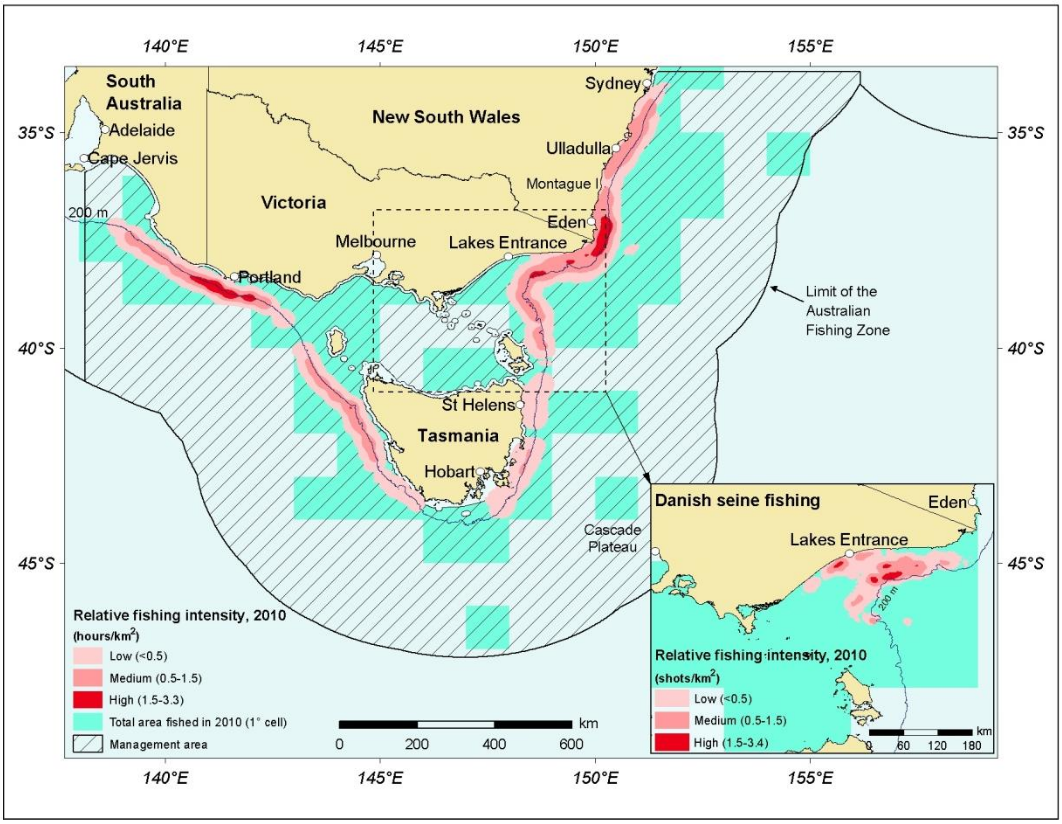
5 Commonwealth Trawl Sector

Background

The Commonwealth Trawl Sector (CTS) is one of four sectors in the Southern and Eastern Scalefish and Shark Fishery (SESSF). It is the largest SESSF sector in catch and value terms and one of Australia's oldest commercial fishing sectors, commencing operation off the coast of Sydney in the early 1900s (DEH 2003).

Fishing in the CTS occurs in waters extending south from Barrenjoey Point (north of Sydney) around the New South Wales, Victorian and Tasmanian coastlines to Cape Jervis in South Australia (Map 2).

Map 2 Location and relative fishing intensity, Commonwealth Trawl Sector, 2009



The primary harvesting method used is otter trawling, although a number of Danish seine boats operate out of Lakes Entrance in Victoria. Some species and stocks extend beyond the fishery's boundaries and are managed by other jurisdictions. Under offshore constitutional settlement arrangements, the Australian Government manages the SESSF quota-managed species. Therefore, in most instances, the catches in state waters are taken into account in setting the SESSF total allowable catch.

The CTS is largely managed with output controls on key species in the form of individual transferable quotas (ITQs) and total allowable catches (TACs). Under this system, there are 16 individual quota species and 29 species that are covered under basket or multi-species TACs (Stobutzki et al. 2010). However, more than 100 species are routinely caught in the sector.

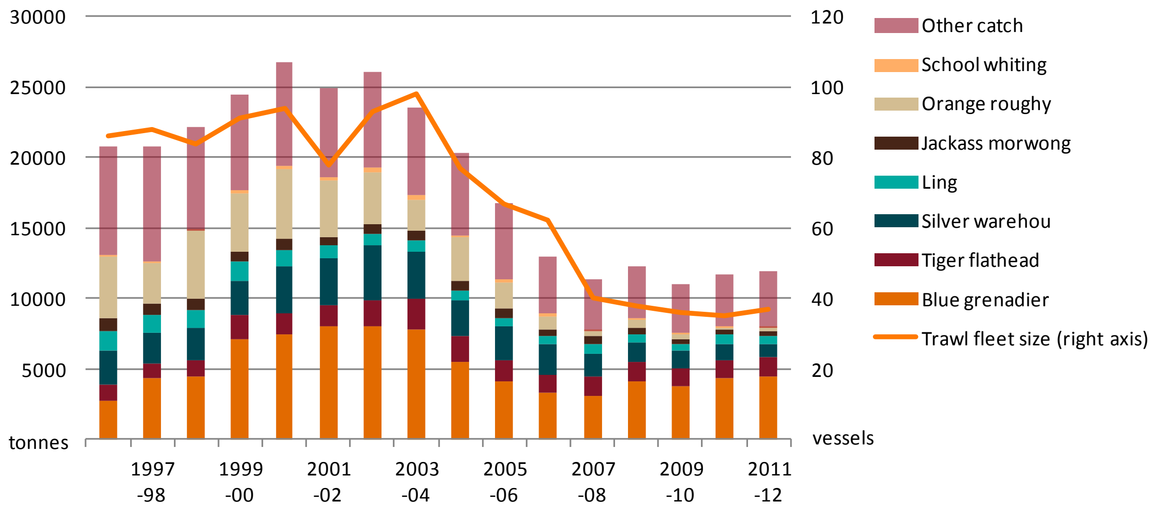
Over the last decade, the TACs for some key species have been reduced. Since 2005, these TAC decisions have conformed with the SESSF harvest strategy framework, implemented to provide a more strategic approach to TAC determination. The decisions are also consistent with the HSP, implemented in 2007. The framework requires that TACs be set to manage stocks at target biomass levels. The rules that guide catch setting have been designed to incorporate a higher level of precaution when there is increased uncertainty about stock status. The framework also improves the transparency of the TAC-setting process (Larcombe & McLoughlin 2007).

The CTS was a sector targeted in the 2006 Australian Government SOFF structural adjustment package. The adjustment package resulted in the purchase of 59 boats' statutory fishing rights (SFRs), 50 per cent of the total SFRs in this sector.

Fishery trends

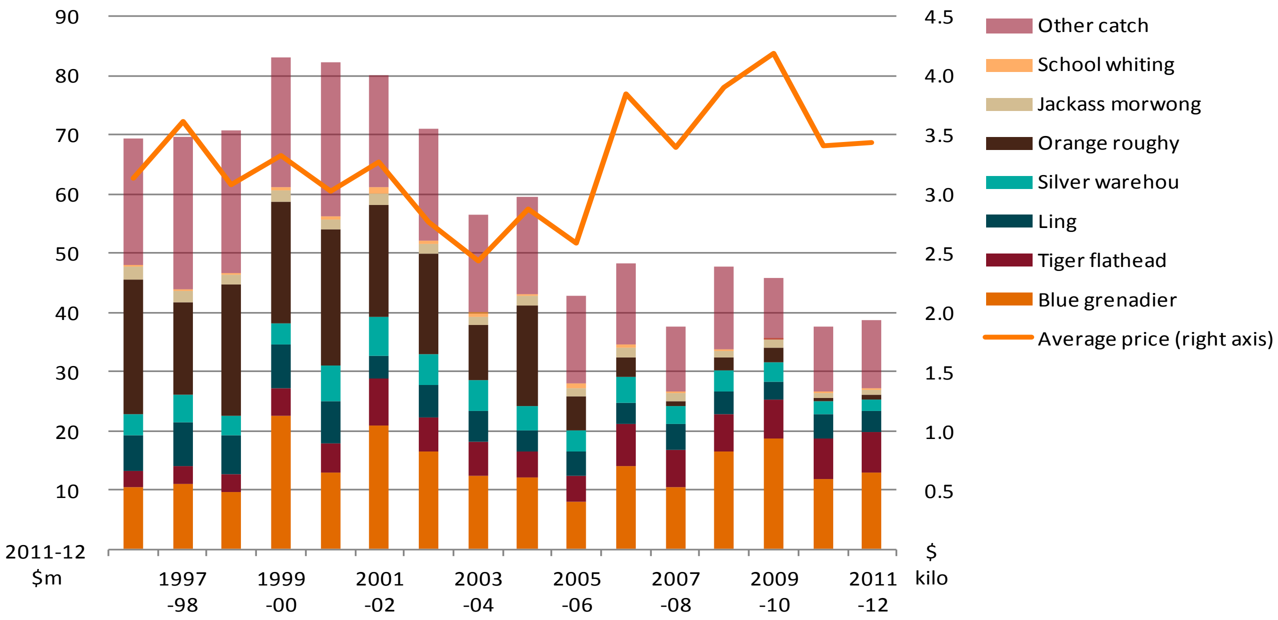
The otter-trawl boats that operate in the CTS account for approximately 90 per cent of the catch, with the remaining 10 per cent being caught by Danish seine boats. The analysis in this chapter therefore focuses on the performance of otter-trawl boats. In 2000–01, production of otter-trawl boats peaked at 26 784 tonnes (Figure). In this year, orange roughy and blue grenadier catches were higher relative to the years that followed (2001–02 to 2009–10). With the exception of 2002–03, catches decreased in every year following 2000–01, dropping to 11 879 tonnes in 2011–12, almost half the 2000–01 peak catch. This decreasing trend partly reflects more conservative TAC settings for key species. The three key species, blue grenadier (4447 tonnes), tiger flathead (1340 tonnes) and silver warehou (917 tonnes), constituted more than 50 per cent of the 2011–12 otter-trawl production.

Figure 4 Production by species and fleet size of the otter-trawl vessels in the Commonwealth Trawl Sector, 1996–97 to 2011–12



In 1990–2000, the real gross value of production (GVP) peaked at $83 million (2011–12 dollars) (Figure). Following this peak, the GVP followed a generally decreasing trend over the next decade. In 2011–12, GVP was $38.8 million, 47 per cent lower than the 1999–2000 peak. This decline is mainly attributed to a 90 per cent decrease in orange roughy catches. Orange roughy is currently classified as overfished and managed under much lower TACs.

Figure 5 Real gross value of production by species and total average catch price of the otter-trawl vessels in the Commonwealth Trawl Sector, 1996–97 to 2011–12



Productivity analysis and results

The TFP index for the otter-trawl boats in the CTS is presented as stock adjusted and non–stock adjusted. Both the indexes cover the period between 1996–97 and 2010–11.

The species included in the output index are blue grenadier, flathead, silver warehou, pink ling, orange roughy, whiting, jackass morwong and other species caught. The species included in the stock index are blue warehou (east and west), gemfish (east), jackass morwong (east and west), orange roughy (cascade and east), pink ling (east and west), warehou, whiting and flathead.

During the analysis period (1996–97 to 2011–12), the productivity of the otter-trawl vessels increased by an annual average of around 6 per cent while stock-adjusted productivity increased by an annual average of 10 per cent. The analysis can be split into three periods.

Between 1996–97 and 2003–04, the input and output indexes declined at similar rates, so productivity remained relatively constant. During this period, the stock index decreased slightly causing an increase in stock-adjusted productivity.

Between 2003–04 and 2006–07, the productivity of otter-trawl boats increased as the input index declined at a faster rate than the output index. Stock levels continued to decline causing a further increase in the stock-adjusted productivity index. These observations were likely influenced by a 37 per cent reduction in the otter-trawl fleet size and AFMA's tightening of TAC restrictions over the same period. Large TAC reductions for species such as orange roughy, blue warehou and eastern gemfish contributed to the observed decline in the output index. If such restrictions can promote the rebuilding of these stocks, they will allow fishers to take catches using fewer inputs in the future.

Between 2006–07 and 2010–11, the productivity of the otter-trawl boats in the CTS continued to increase as the input index declined faster than the output index (Figure). As the stock levels remained relatively constant during this period, the stock-adjusted productivity increased (Figure). Vessel numbers declined by 35 per cent between 2006–07 and 2007–08, but have remained relatively constant since 2007–08. These trends indicate that increased productivity during this period was driven mainly by improvements in the remaining operators' ability to use inputs to produce outputs, highlighting the impacts on productivity of the SOFF buyback.

Figure 6 Productivity, input and output indexes for the otter-trawl vessels of the Commonwealth Trawl Sector, 1996–97 to 2010–11

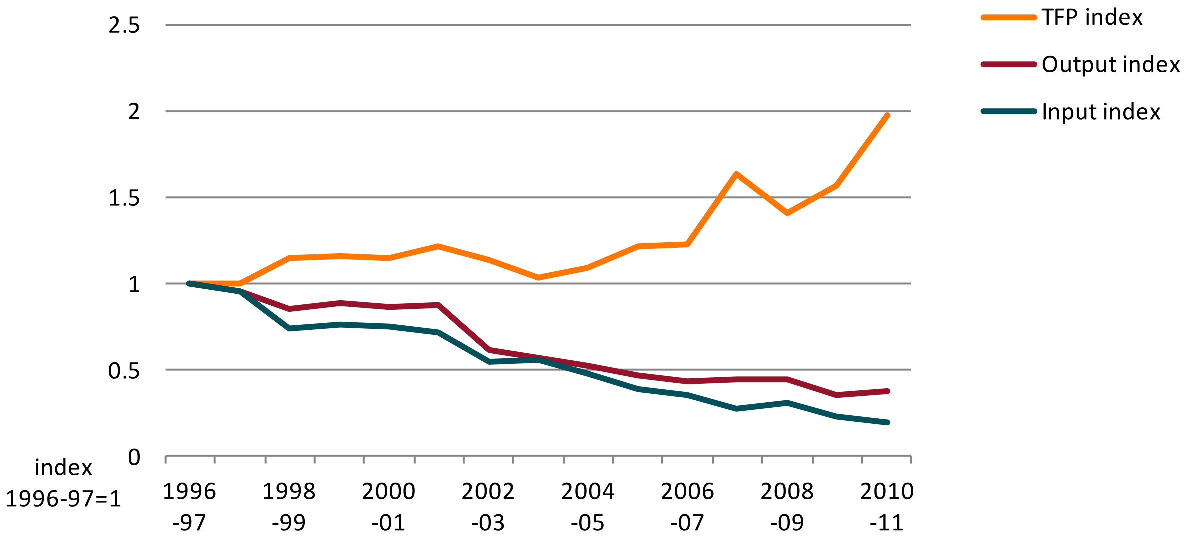
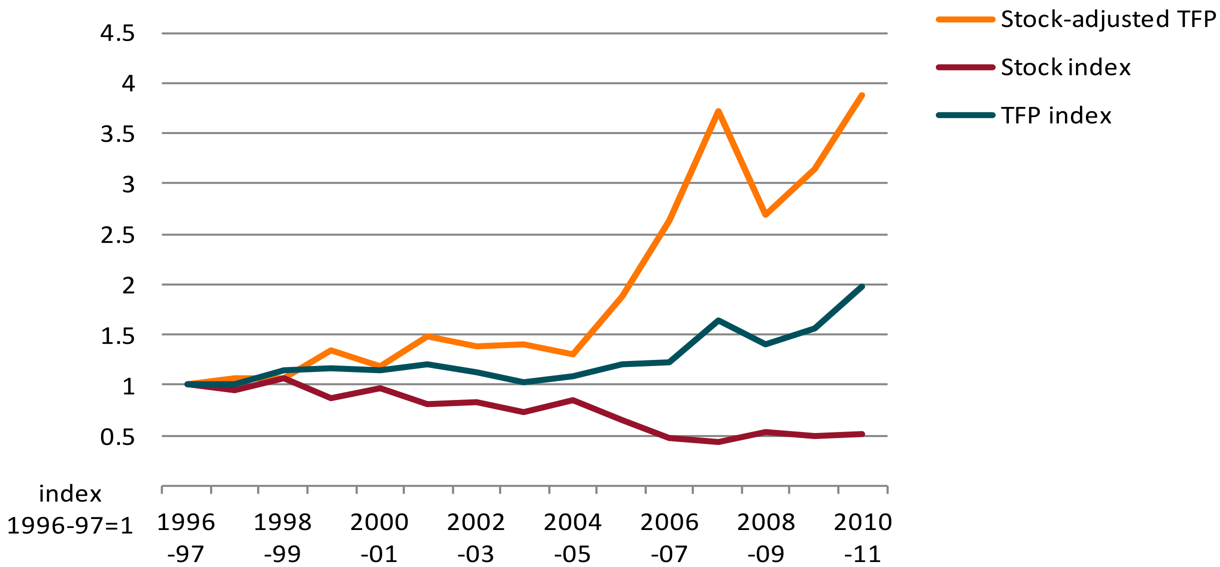


Figure 7 Productivity, stock indexes and stock-adjusted productivity of the otter-trawl vessels of the Commonwealth Trawl Sector, 1996–97 to 2010–11



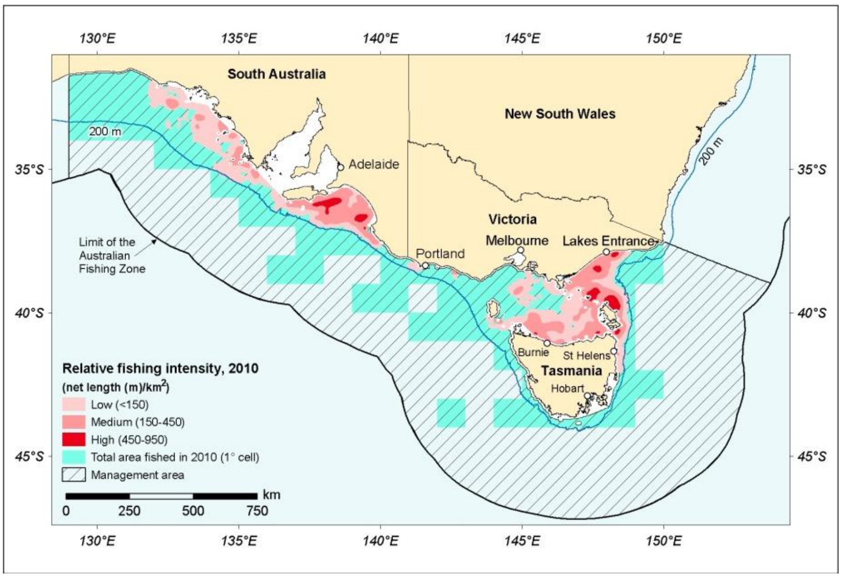
6 Gillnet, Hook and Trap Sector

Background

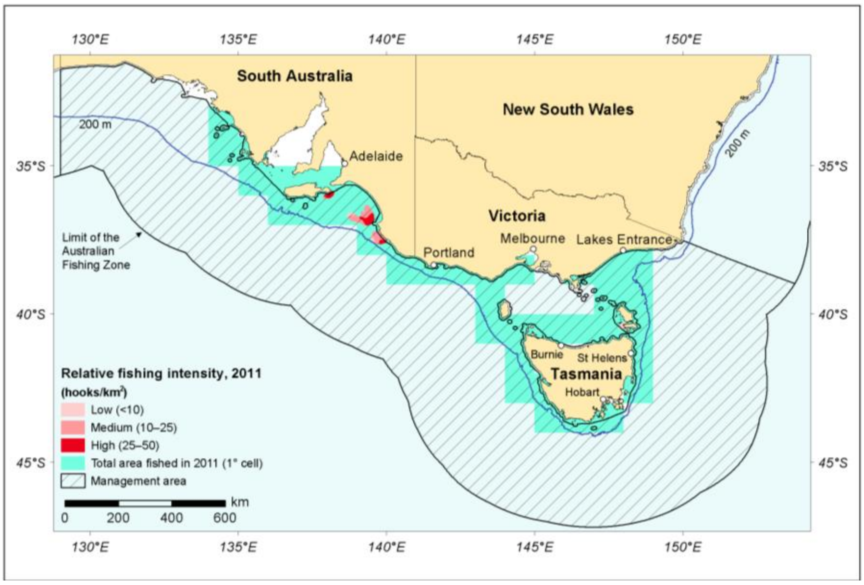
The Gillnet, Hook and Trap Sector (GHTS) is a combination of the previous South East Non-Trawl Fishery and the Southern Shark Fishery. Like the Commonwealth Trawl Sector, the GHTS is a sector of the Southern and Eastern Scalefish and Shark Fishery. Fishing in the sector extends from southern Queensland south to the western border of South Australia and the waters to the south of Tasmania (Map 3).

Map 3 Location and relative fishing intensity for a) the Shark Gillnet Sector and b) the Scalefish Hook Sector, of the Gillnet, Hook and Trap Sector

a) Shark Gillnet Sector, 2010



b) Scalefish Hook Sector, 2011



Gear types that can be used in the sector include gillnets, droplines, demersal longlines, automatic longlines and traps. Gillnets are used to target shark species (mainly gummy shark), while all other methods are used mainly to target finfish species, with some targeting of shark species using line methods. Operators are permitted to use only the gear types specified on their boats' statutory fishing right or fishing permit. Automatic longlining is a relatively new fishing method used in the GHTS, introduced in 2002–03. It is a form of demersal longlining in which some of the functions (baiting and dehooking) are automated, allowing operators to set and haul more hooks. This method has been excluded from the productivity analysis in this chapter to ensure the sector's productivity is not overestimated.

Like the Commonwealth Trawl Sector, the management of the GHTS is also based on output controls in the form of species-based total allowable catches and individual transferable quotas. ITQ management was implemented in the GHTS in 1998. In 2001 ITQ management of all quota-managed species in the South East Trawl Fishery was expanded to the non-trawl sector, when global TACs were set across both the Commonwealth Trawl Sector and the GHTS (Wilson et al. 2010). Also in 2001 ITQs were introduced for school and gummy shark species targeted in the GHTS. ITQs for saw shark and elephant fish were introduced in 2002 (Vieira et al. 2009). In May 2010, the use of quota statutory fishing rights (as opposed to quota permits) was introduced for these shark species, following the resolution of legal challenges to the quota-allocation formula (Woodhams et al. 2011a).

The harvest strategy framework adopted for the SESSF in 2005 also applies to the GHTS and provides a more strategic approach for determining TACs. The framework identifies TAC-setting rules for different species based on whether a stock (or an indicator of its biomass) declines or rises relative to predetermined levels (Larcombe & McLoughlin 2007). With the exception of gummy shark, TACs for all key species in the GHTS were reduced in the last decade. Like the Commonwealth Trawl Sector, a range of input controls are also used to manage the GHTS, including area and seasonal closures, limited entry, catch-size restrictions and a variety of gear restrictions.

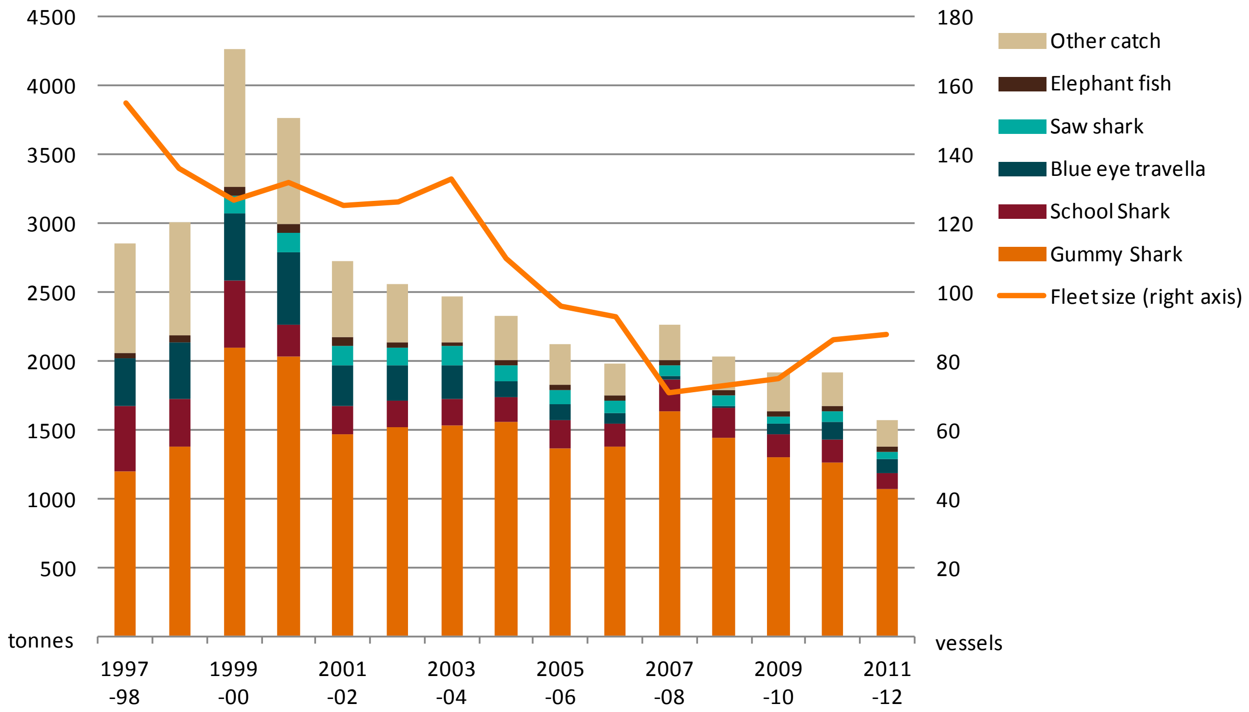
The GHTS was targeted in the Australian Government SOFF structural adjustment package which concluded in November 2006. The scheme resulted in the purchase of the statutory fishing rights of 26 gillnet boats, 63 scalefish hook boats and 17 shark boats. Eight of the 20 existing trap or automatic longline permits were also purchased (Vieira et al. 2010). Many GHTS operators hold multiple-boat SFRs or permits; of the 19 operators that tendered SFRs or permits in the SOFF buyback, four continued to fish in the sector in 2007–08 (Vieira et al. 2010).

Spatial closures to protect Australian sea lion populations were implemented on a voluntary basis in 2009–10 and became mandatory in 2010–11(AFMA 2010). These restricted fishers using gillnets from some areas that were fished for gummy shark.

Fishery trends

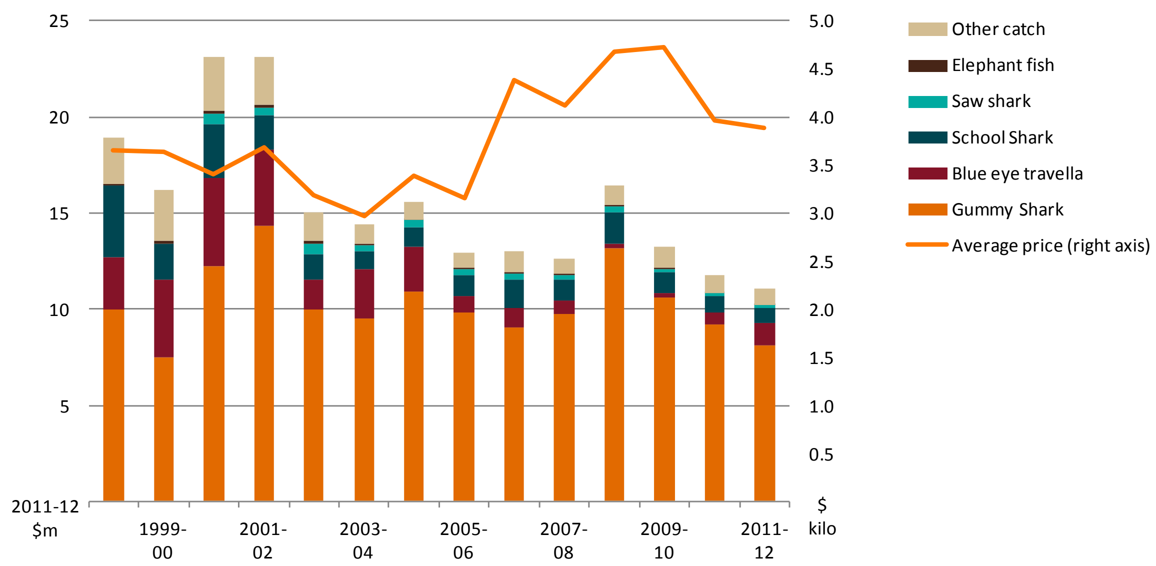
The species typically caught by boats in this sector (excluding automatic longliners) are gummy shark, school shark, saw shark and elephant fish. In 2011–12, gummy shark catches accounted for 68 per cent of production and school shark accounted for 8 per cent. The other key species caught in 2011–12 were blue eye trevalla (7 per cent), saw shark (3 per cent) and elephant fish (2 per cent). Over the past decade, catches have been relatively stable. Catches peaked in 1999–2000 at 4269 tonnes (Figure 8) as gummy shark catches reached a peak of 2096 tonnes. After this peak, total catches dropped to 2720 tonnes in 2001–02 and have remained relatively stable. As gummy shark accounts for a large proportion of catch, the changes in total catch are primarily determined by changes in gummy shark catch.

Figure 8 Production by species and fleet size of the Gillnet, Hook and Trap Sector (excluding automatic longliners), 1998–99 to 2011–12



In 2000–01, the real gross value of production (GVP) in the GHTS (excluding automatic longlining boats) peaked at $23.1 million (in 2011–12 dollars) (Figure). In 2011–12, the boats' GVP dropped to $11 million (52 per cent decline). This was mainly driven by a $4.1 million (34 per cent) decline in the value of gummy shark, due to falls in both production and price. In the same year, the value of school shark also decreased by 73 per cent to $2 million.

Figure 9 Real gross value of production by species and total average catch price of the Gillnet, Hook and Trap Sector (exluding automatic longliners), 1998–99 to 2011–12



Productivity analysis and results

The TFP index for the GHTS (excluding automatic longliners) is presented as stock adjusted and non–stock adjusted. The non–stock-adjusted analysis covers the period from 1998–99 to 2010–11, while the stock-adjusted analysis covers 1998–99 to 2008–09 as updated stock data are not yet available. The output index incorporates the following species: blue eye, pink ling, gummy shark, school shark, elephant fish and other species caught. The species included in the stock index are gummy shark and school shark.

Over the analysis period (between 1998–99 and 2010–11), productivity increased by an annual average of 2 per cent. The stock-adjusted productivity index increased by an annual average of 0.9 per cent between 1998–99 and 2008–09. Productivity results for the GHTS can be split into two periods.

Between 1998–99 and 2003–04, the TFP index followed a decreasing trend, reflecting a decline in output while input use remained relatively constant (Figure). Stock-adjusted productivity followed a similarly decreasing trend when the slight increase in stock during this period was taken into consideration (Figure). This was a period during which vessel numbers declined by 14 per cent. ITQs were also introduced during this period: for scalefish species in 1998, gummy shark and school shark in 2001, and elephant fish and saw shark in 2002. For the latter four shark species groups, ITQs were initially allocated as annually renewable permits due to legal challenges against the ITQ-allocation process (AFMA 2006). During this period the delay in allocating permanent SFRs may have hampered ITQ trade and its benefits for productivity growth in the sector.

During the second period, between 2003–04 and 2010–11, productivity increased as the input index declined faster than the output index. This suggests an improvement in vessels' ability to convert inputs into outputs. The stock-adjusted TFP index also increased during this period as stocks remained relatively constant.

This productivity increase can be attributed to a number of drivers. Vessel numbers declined by 34 per cent during this period, driven mainly by the SOFF buyback. It is likely that the least efficient vessels exited the sector and that productivity increased due to fewer, more efficient vessels and less competition among vessels. Greater amounts of quota trade may also have occurred during this period as operators became more familiar with quota management. To et al. (2009) showed that, for the period September 2005 to June 2008, gillnet, hook and trap species dominated postings to AFMA's *Quotaboard* website, an online quota trading site for Commonwealth fishery quota. Increasing trade in quota generally indicates an increase in autonomous structural adjustment with quota moving to more profitable operators.

Spatial closures to protect Australian sea lion populations were implemented on a voluntary basis in 2009–10 and became mandatory in 2010–11. The introduction of these closures coincided with a period in which net economic returns became negative (George & New 2013). George & New (2013) partly attribute the lower net economic returns in the fishery during this period to lower availability of gummy shark. A decline in productivity in the sector in 2009–10 is also likely to have contributed to low economic returns in 2009–10. The productivity increase in 2010–11 acts to moderate and offset some of the negative impact on net economic returns in the fishery from lower availability of gummy shark. However, it is unclear whether the productivity increase in 2010–11 was a result of autonomous adjustment to the closures or a result of other factors.

Figure 10 Productivity, input and output indexes for the Gillnet, Hook and Trap Sector (excluding automatic longliners), 1998–99 to 2010–11

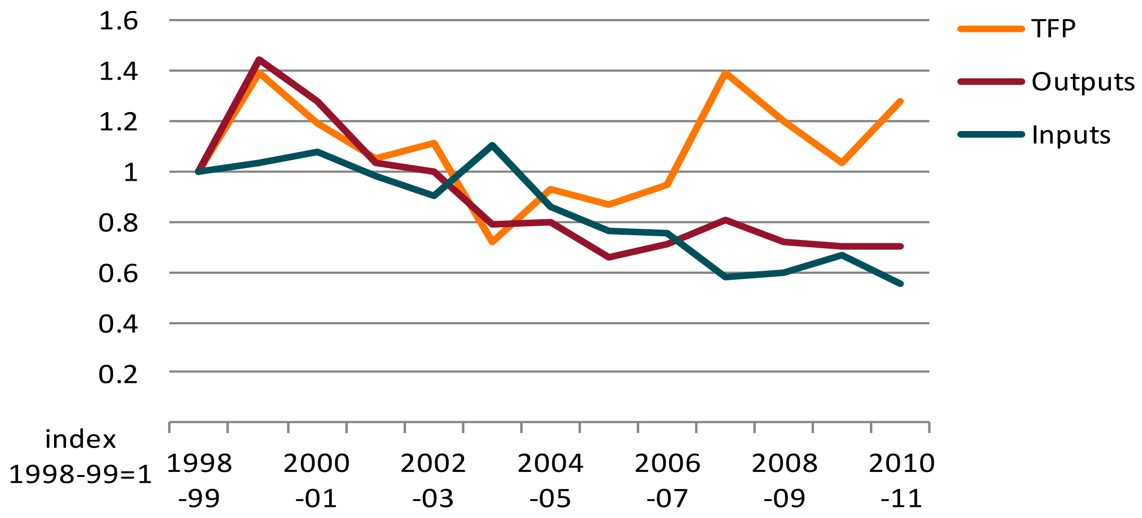
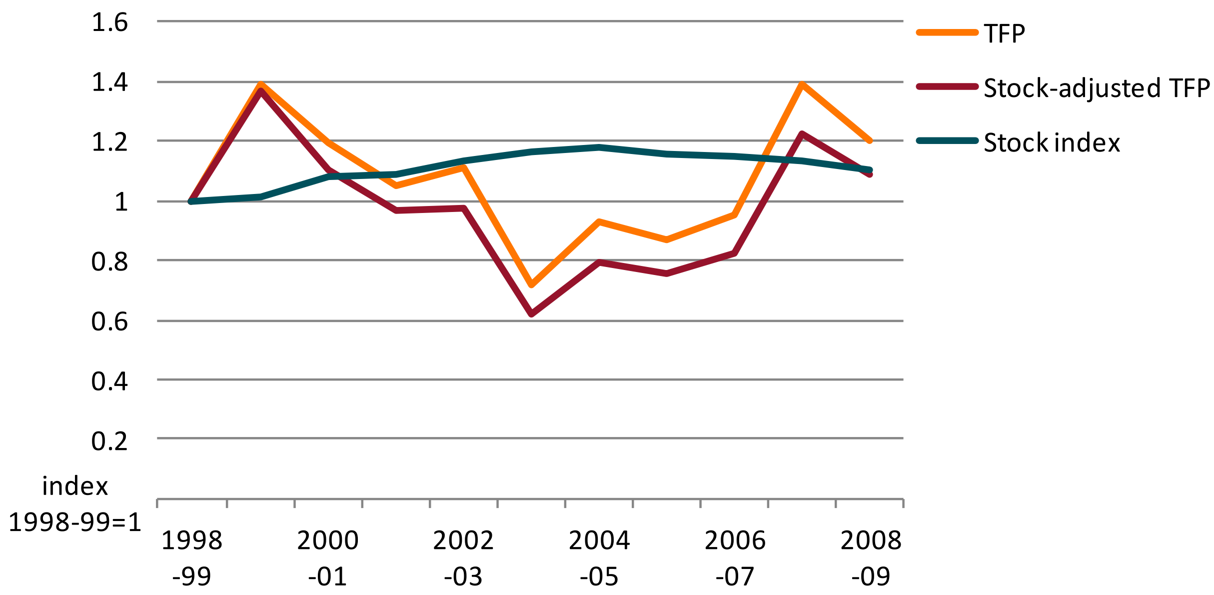


Figure 11 Productivity, stock index and stock-adjusted productivity for the Gillnet, Hook and Trap Sector (excluding automatic longliners), 1998–99 to 2008–09

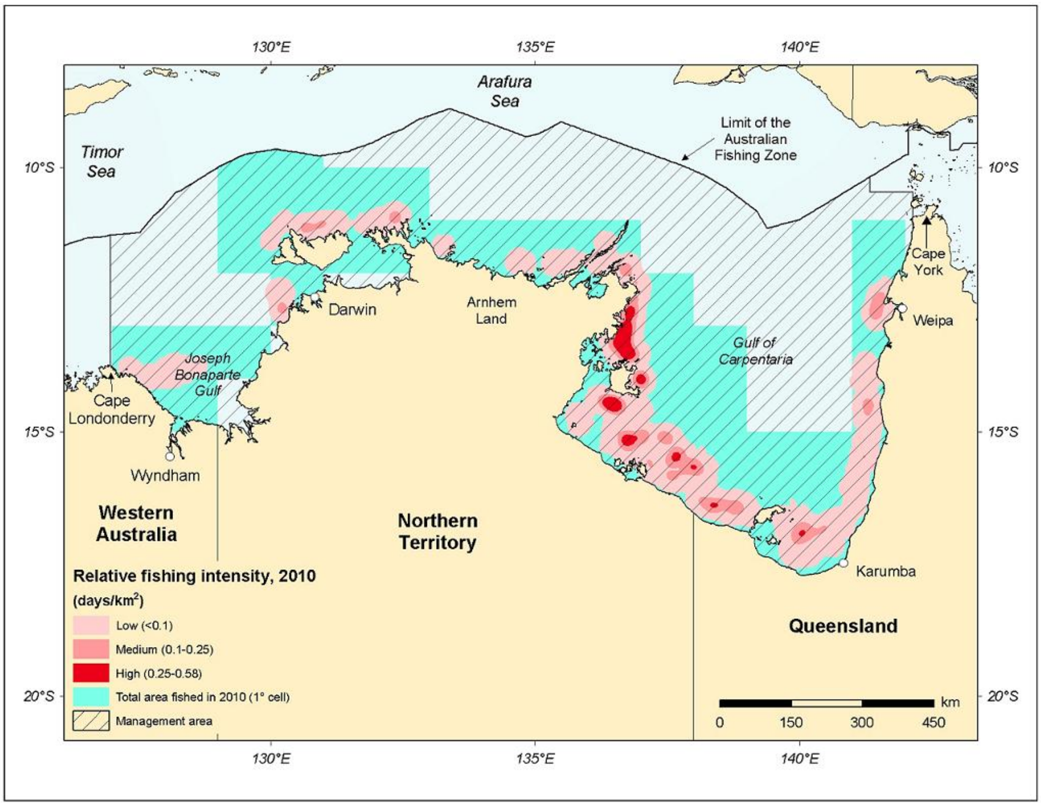


7 Northern Prawn Fishery

Background

The Northern Prawn Fishery (NPF) is a multi-species fishery located in Australia's northern waters between Cape York in Queensland and Cape Londonderry in Western Australia (Map 4). Two key species groups are targeted in the fishery: tiger prawns and banana prawns.

Map 4 Location and relative fishing intensity in the Northern Prawn Fishery, 2010



The main management tool for the NPF is input controls that restrict the length of trawl-net headrope allowed in the fishery and the length of the fishing season. Gear units allocated to each operator specify the length of headrope allowed and operators are able to buy, sell or lease these gear units. Seasonal closures split fishery operations into two distinct seasons: a banana prawn season and a tiger prawn season. AFMA's adaptive management approach to the NPF means that each season's length can vary from year to year depending on catch rates. Other input controls used to manage the fishery include other gear restrictions, vessel restrictions, limited entry, area closures and seasonal closures. In 2006, operators were allowed to use quad-gear-configured trawl nets in the tiger prawn season. Also in 2006, the definition of headrope unit was changed. In 2008, the headrope length allowance was increased by 33 per cent.

During the banana prawn season, targeting of banana prawn aggregations (referred to as 'boils') allows large catches to be taken with relatively low levels of trawling time. Aggregation is less common in tiger prawn species, requiring greater trawling time. Tiger prawns receive substantially higher market prices and a large part of the catch is exported (predominantly to Japan). The catches sold on the domestic market compete with imports of lower valued prawns. As a result, prices are subject to external factors including demand in foreign markets, competition from other prawn supplying countries and the exchange rate.

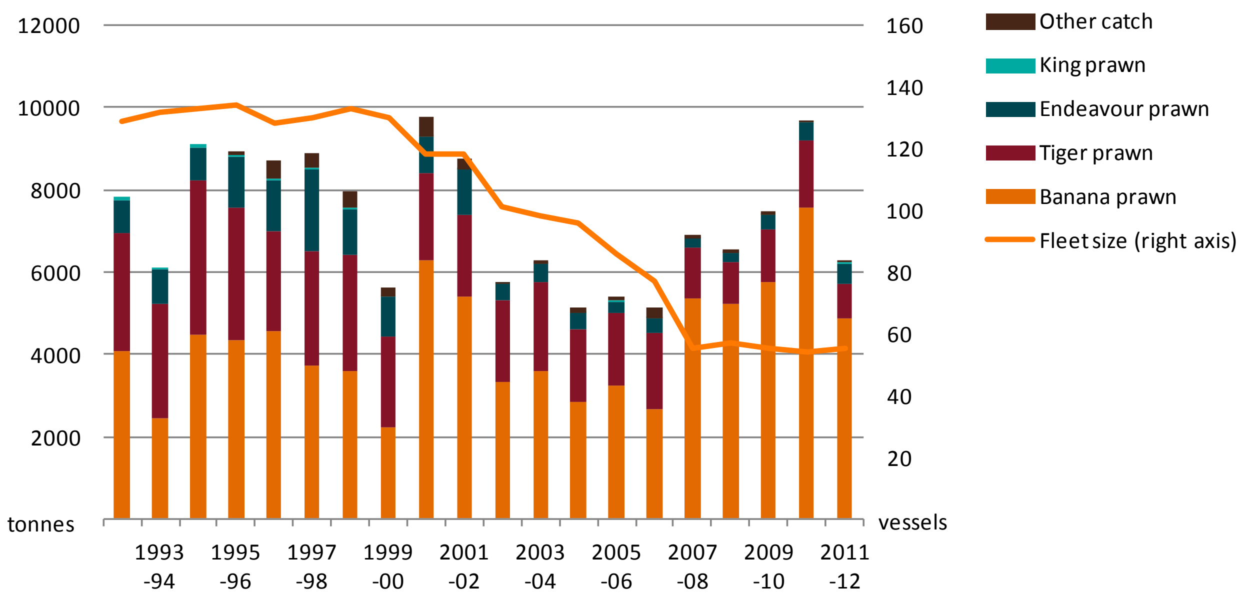
The NPF was a fishery targeted in the 2006 Australian Government SOFF structural adjustment package. The Australian Government purchased 43 Class B statutory fishing rights and 18 365 gear SFRs, representing a 45 per cent and 34 per cent reduction in each SFR type respectively (Abetz 2006).

In 2007, a harvest strategy consistent with the HSP was introduced for the fishery. It specifies a long-term maximum economic yield target for tiger prawns and endeavour prawn byproduct, with effort levels determined according to a bioeconomic model of these species.

Fishery trends

Banana and tiger prawns account for around 90 per cent of the total NPF catch (Figure). The remainder is composed of endeavour prawns, king prawns and other non-prawn species. Total catch peaked in 2000–01 at 9752 tonnes, with banana prawn contributing 6286 tonnes (64 per cent) and tiger prawn contributing 2116 tonnes (22 per cent). Between 2000–01 and 2006–07, catches followed a declining trend, largely driven by falls in banana prawn catches. In 2007–08 the trend reversed with a doubling in banana prawn catch (from 2674 tonnes in 2006–07 to 5380 tonnes in 2007–08). Since 2007–08, banana prawn catches have been high relative to previous years. In 2011–12, banana prawn catches were 4855 tonnes while tiger prawn catches were 864 tonnes, accounting for 77 per cent and 14 per cent of total catch respectively.

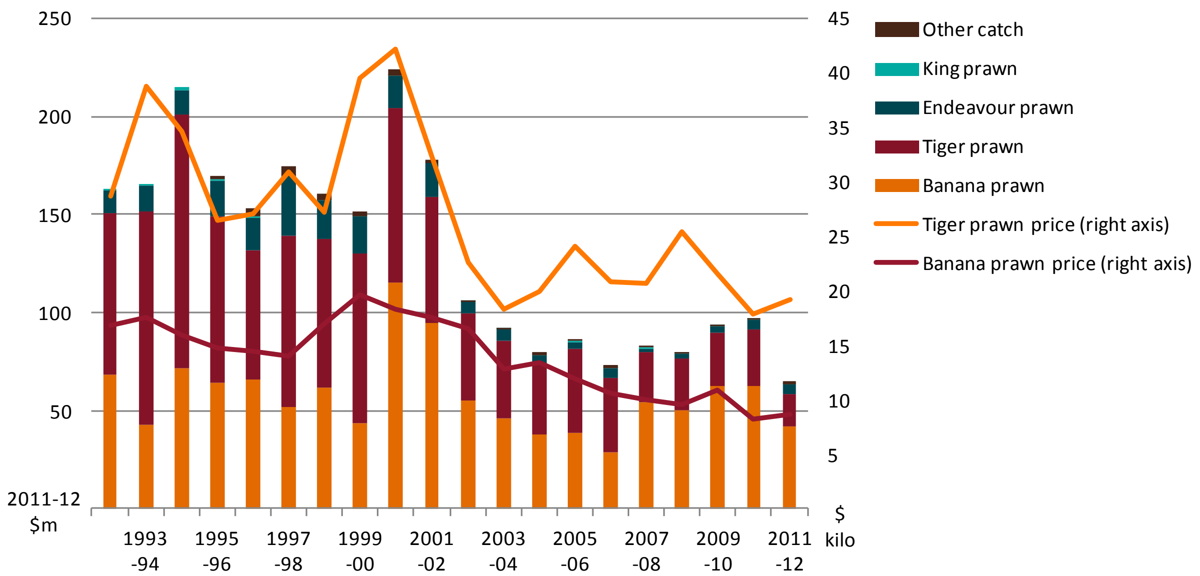
Figure 12Production by species and fleet size in the Northern Prawn Fishery, 1992–93 to 2011–12



In 2000–01, the gross value of production (GVP) for the NPF peaked at $224 million (2011–12 dollars) (

Figure). This reflected high prices for tiger and banana prawn species. Between 2000–01 and 2006–07, GVP followed a declining trend and reached a low of $73 million in 2006–07. This was mainly driven by decreases in banana prawn catch and tiger prawn prices. Since then, GVP followed a slightly increasing trend due to the large banana prawn catches. In 2011–12, total fishery GVP was $65 million, with banana prawn catch accounting for $42 million (65 per cent of the total) and tiger prawn accounting for $17 million (26 per cent).

Figure 13 Real gross value of production by species and total average catch price in the Northern Prawn Fishery, 1992–93 to 2011–12



Productivity analysis and results

TFP analyses were undertaken for the total NPF, the tiger prawn season and the banana prawn season. TFP analysis for the total NPF covers 1992–93 to 2008–09 and the species incorporated in the analysis include banana, tiger, endeavour and king prawns, and other catch. The TFP index for the total NPF is not adjusted for stock levels as estimates for changes in stock biomass are not available.

As a result of data availability, the tiger and banana prawn indexes cover the period from 1999–2000 to 2008–09, and only the tiger prawn season TFP index is adjusted for stock levels.

Total Northern Prawn Fishery

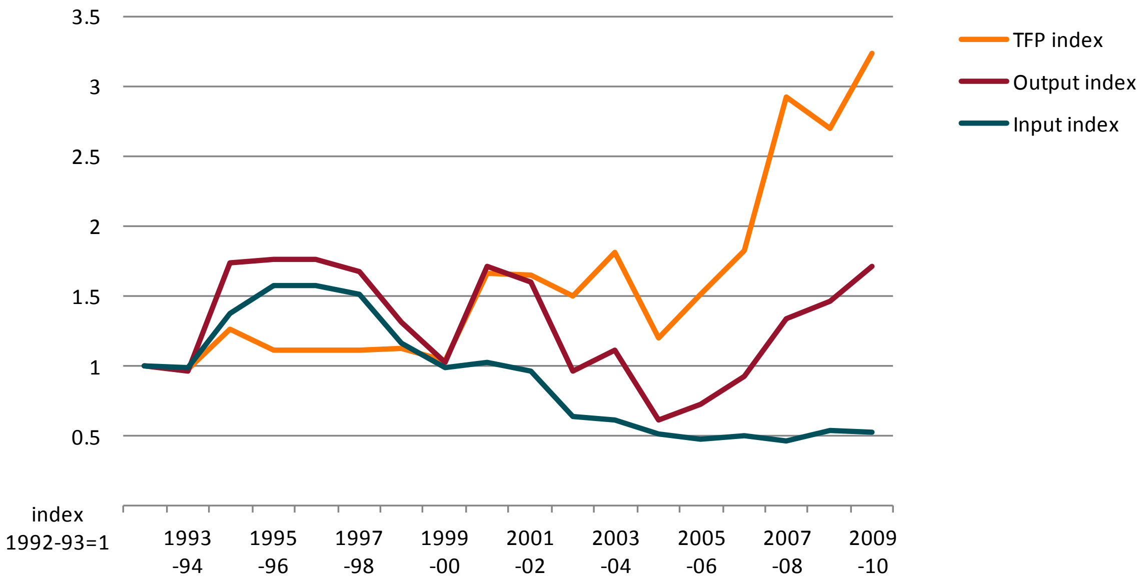
During the analysis period (1992–96 and 2009–10), annual average productivity increased by an average of 7 per cent. Between 1992–93 and 1999–2000, the TFP index remained relatively close to one as the input and output indexes moved similarly (Figure). From 1999–2000 to 2004–05, the input index declined at a faster rate than the output index and productivity increased as a result. This was likely influenced by a 52 per cent decline in vessel numbers during this period in response to declines in profitability. It is assumed that the least efficient vessels exited the fishery.

A number of significant management changes also occurred over this period. In 2000, the fishery moved from management based on vessel and engine-size restrictions to gear-based management (tradeable entitlements for headrope length). The aim was to provide the fleet with greater flexibility to match capacity to determined sustainable catches (Cartwright 2005), given that operators can more easily vary the size of trawl nets than vessel and engine size. This greater flexibility meant that industry would be better able to improve productivity to maintain profitability in the face of more restrictive management settings. This would have been particularly important for the large-effort reductions that followed shortly after to ensure tiger-prawn sustainability, including a 40 per cent effort reduction in 2002 (Woodhams et al. 2011b).

Between 2004–05 and 2009–10, productivity increased rapidly as input use decreased while output increased. During this period, the number of operating vessels declined, with the SOFF buyback being a major driver of this decline. The productivity increase therefore reflects the exit of the least efficient vessels. With fewer, more productive vessels and reduced competition and crowding among vessels, the fishery has improved its ability to convert inputs into outputs. Results presented by Pascoe et al. (2012) confirm that these effects occurred. They show that the least efficient vessels did exit the fishery via the buyback, and, further, that the average efficiency of remaining vessels increased due to reduced crowding and higher catch rates.

Given the reduced number of vessels in the fishery and revised bioeconomic model outputs, AFMA allowed for a 33 per cent increase in headrope length in 2008. This combined with the allowance of quad-gear in 2006 is likely to have contributed to the observed growth in productivity between 2004–05 and 2009–10. Analysis of productivity trends for each of the fishery's two seasons below allows for improved interpretation of these fishery-wide trends.

Figure 14 Productivity indexes for the Northern Prawn Fishery, 1992–93 to 2009–10



Tiger prawn season

The TFP index for the tiger prawn season of the NPF is adjusted for changes in stock levels for the period of 1999–2000 and 2009–10. The species incorporated in the output and the stock indexes are tiger and endeavour prawns.

The productivity of vessels fishing in the tiger prawn season increased by an average of 7 per cent each year between 1990–91 and 2009–10. Between 1999–2000 and 2003–04, productivity increased as the input index decreased faster than the output index (Figure). The stock index increased during this period; as a result, the stock-adjusted TFP index remained constant (Figure). These trends indicate constant productivity as the operating vessels used fewer inputs to produce relatively fewer outputs while stock biomass increased.

Productivity dropped dramatically in 2004–05 as a result of a decline in the output index. This decline was driven by the 52 per cent decline in tiger prawn catches in that year, while input use remained relatively constant. In the same year, stock levels declined, causing a further decrease in the stock-adjusted productivity.

Between 2004–05 and 2009–10, productivity followed a generally increasing trend because input use declined faster than output. As stock levels increased over this period, the stock-adjusted TFP index grew at a slower rate. These trends indicate that the operating vessels were better able to convert inputs into outputs during this period. Following the SOFF buyback, vessel numbers declined by 43 per cent. Given the increasing productivity trends during this period, it is likely that a more efficient fleet continued to operate as the least efficient vessels exited the fishery.

Management changes introduced by AFMA that may have contributed to this productivity growth include an increase to the length of the tiger prawn season in 2005, the allowance of quad gear in 2006, and a 33 per cent increase in allowable headrope length in 2008. Management of the tiger prawn sector to a maximum economic yield target is also likely to have been a contributing factor. Species biomass levels have been moving towards maximum economic yield levels and are likely to have made a favourable contribution to profits as a result.

However, the growth in stock-adjusted productivity suggests that the improvements in productivity have not just been driven by this stock effect. Targeting maximum economic yield also has an indirect positive impact on efficiency as higher profitability promotes greater trade in fishing rights, with rights gravitating to the most efficient fishers.

Figure 15 Productivity indexes for the tiger prawn season of the Northern Prawn Fishery, 1999–2000 to 2009–10

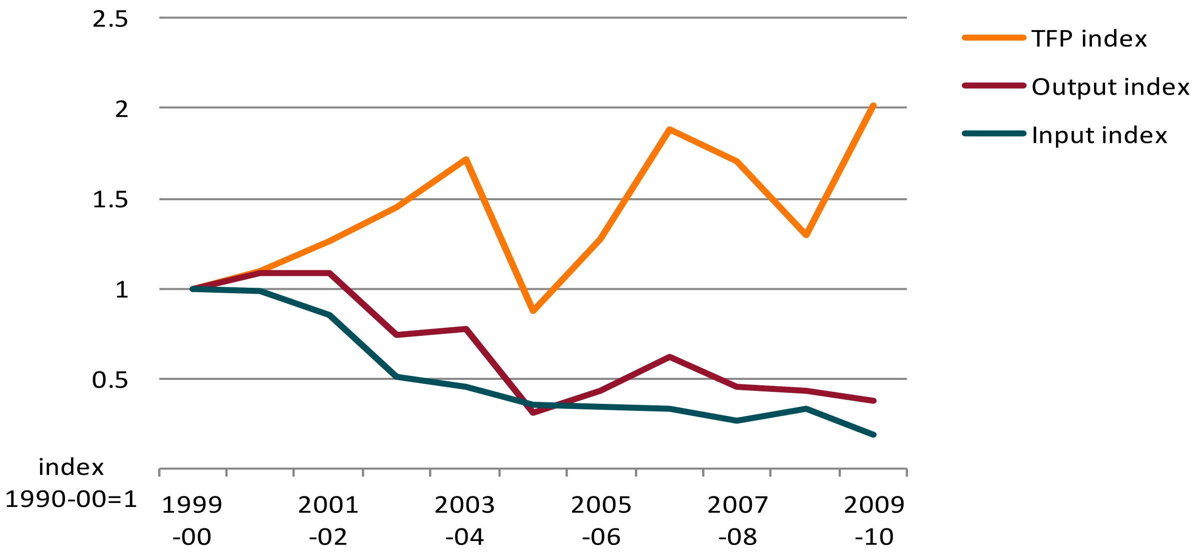
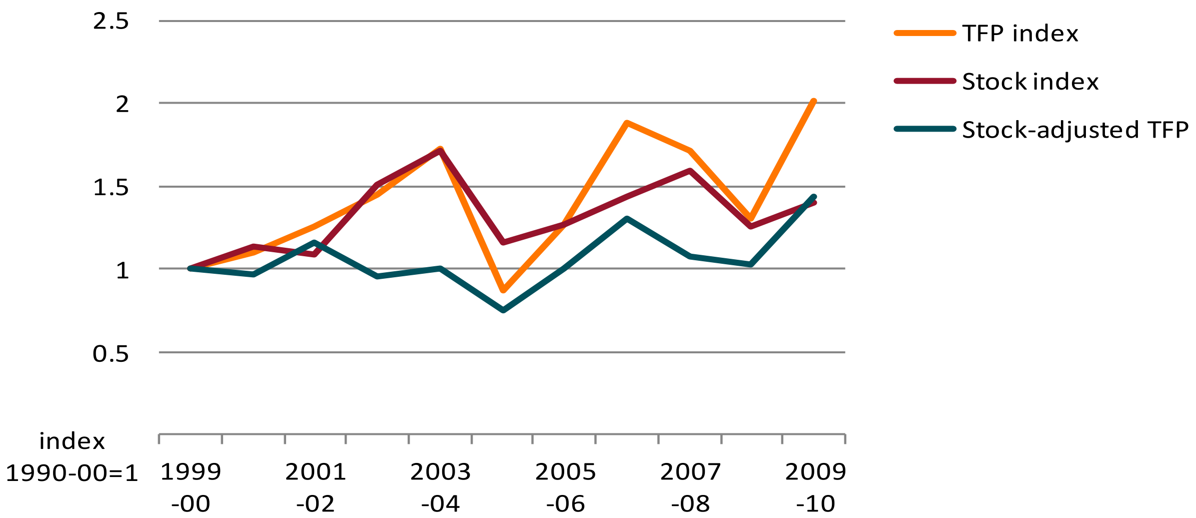


Figure 16 Productivity, stock indexes and stock-adjusted productivity for the tiger prawn season of the Northern Prawn Fishery, 1999–2000 to 2009–10



Banana prawn season

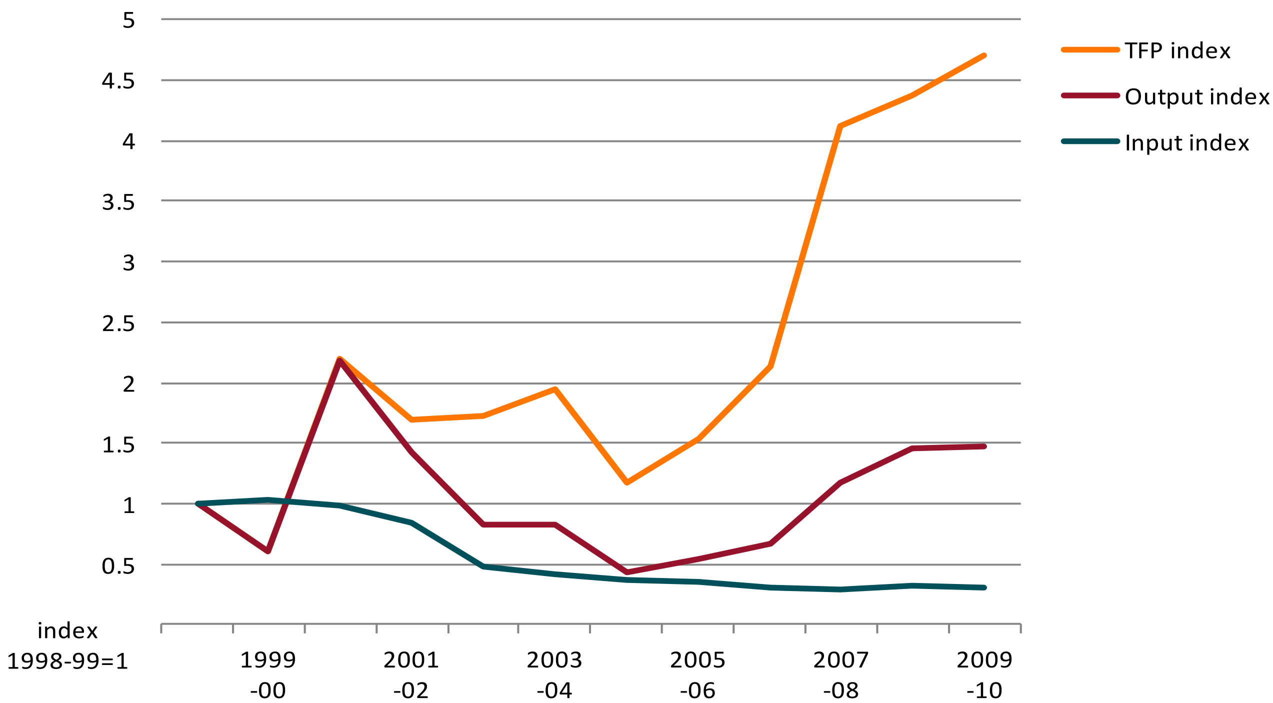
Analysis of the banana prawn season covers the period 1998–99 to 2009–10. The output index includes banana prawn catch as minimal amounts of other species are caught in the banana prawn season. The TFP index is not adjusted for stock as estimates of stock biomass for this species are not available.

The annual average productivity growth of vessels fishing in the banana prawn season was 15 per cent between 1998 –99 and 2009–10. The interpretation of results can be split into two periods.

Between 1998–99 and 2004–05, productivity increased as the output and input indexes decreased at a similar rate (Figure). This coincided with a decrease in fleet size (by 28 per cent). As vessel numbers declined, the productivity increase reflects the positive impacts of less competition in the fishery and/or exit of the least efficient vessels.

In the second period, between 2004–05 and 2009–10, productivity increased noticeably. This was primarily influenced by the increase in output. This reflects the large increases in banana prawn catch rates linked to the favourable environmental conditions supporting high banana prawn biomass (Woodhams et al. 2011b). Hence, the large productivity increase in this period is likely a result of favourable stock conditions.

Figure 17 Productivity indexes for the banana prawn season of the Northern Prawn Fishery, 1998–99 to 2009–10

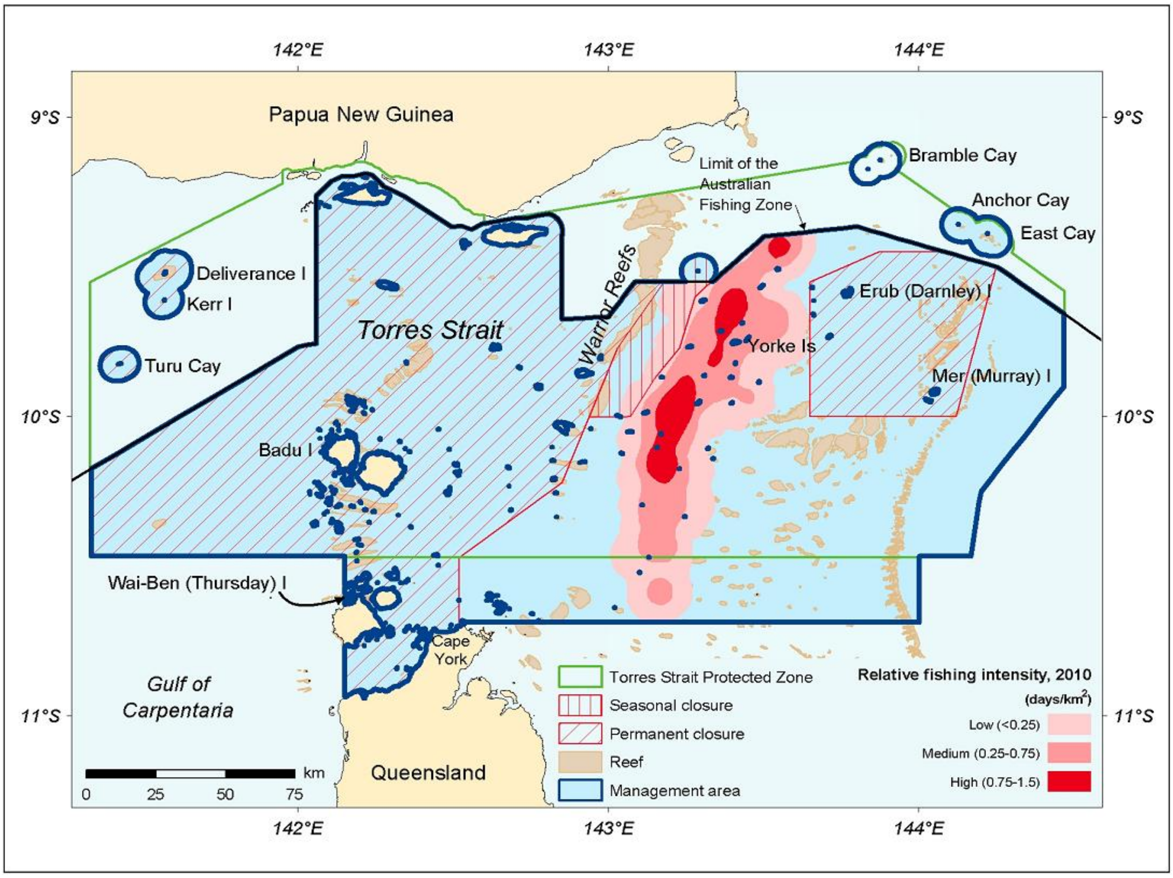


8 Torres Strait Prawn Fishery

Background

The Torres Strait Prawn Fishery (TSPF) operates in an area of water shared by Australia and Papua New Guinea that is referred to as the Torres Strait Protected Zone. The zone is bordered by Papua New Guinea in the north, Cape York Peninsula in the south, the Coral Sea to the east and the Arafura Sea to the west (Map 5). Since the fishery operates in the waters of two countries, the Torres Strait Treaty (ratified in 1985) dictates resource sharing arrangements within the zone (Taylor et al. 2007). The Torres Strait Protected Zone Joint Authority (PZJA) is responsible for management of the fishery. The PZJA comprises the Commonwealth and Queensland ministers responsible for fisheries and the chair of the Torres Strait Regional Authority (PZJA 2006).

Map 5 Location and relative fishing intensity in the Torres Strait Prawn Fishery, 2009



The two target species in the fishery are brown tiger prawn and blue endeavour prawn. Boats in the fishery use otter-trawl gear with all fishing undertaken at night. The fishery is managed with a variety of input controls. The main effort control is a cap on the number of nights that can be fished in a given season. The current management plan allows for nights in the fishery to be permanently traded and seasonally leased. Seasonal and area closures are also in place, with the season running from 1 March to 1 December each year. Other key input controls include a restriction on boat size to 20 metres and restrictions on trawl-net dimensions in terms of combined headrope and footrope length and mesh size.

In November 2005, the Torres Strait PZJA introduced a total cap of 9197 days (equivalent to an estimate of maximum sustainable yield) via a 31.8 per cent pro-rata effort reduction. In December 2005, the Australian Government released a request for tender to Australian operators in the TSPF for the voluntary surrender of licences and fishing days in order to fully meet its obligations to Papua New Guinea under the Torres Strait Treaty. In February 2006, it was announced that the tender process resulted in the removal of 16 licenses from the fishery and the surrender of 2333 allocated fishing days (25 per cent of total fishing effort).

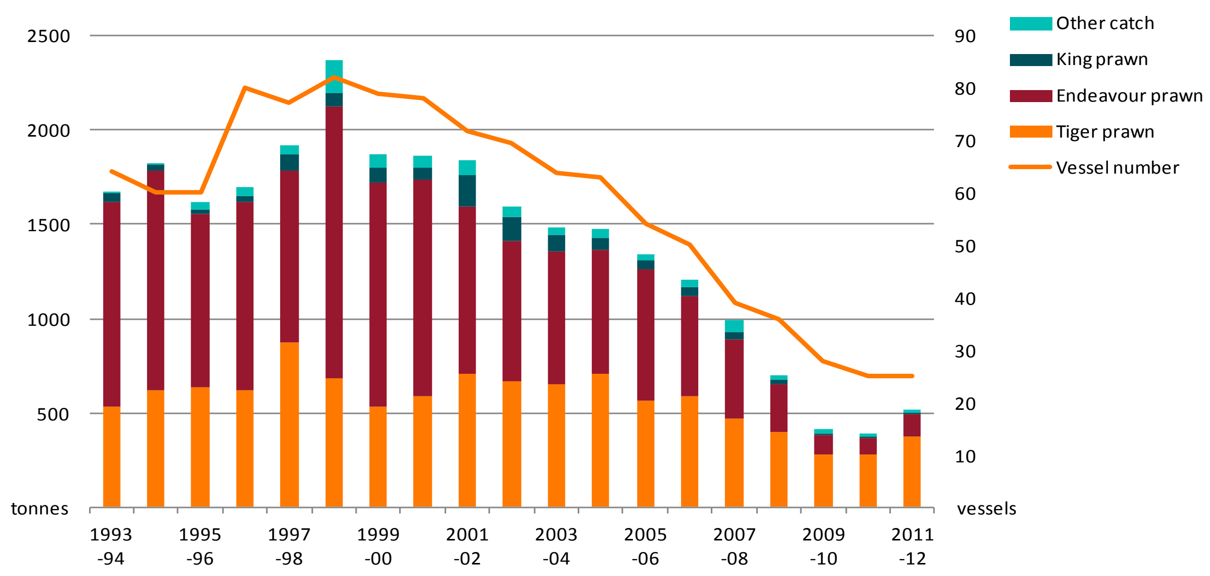
For the 2006 season, the PZJA set the overall effort cap at 9200 fishing days. Of these fishing days, 6867 were available to Australian operators and 2070 to Papua New Guinea operators, with 263 days held in trust by the Australian Government. Despite these changes, large amounts of unused or latent effort remained in the fishery due to unfavourable economic conditions in the form of high costs and historically low prawn prices.

In 2007, Papua New Guinea made its effort entitlements available to Australian licence holders in the Australian fisheries jurisdiction of the TSPF. This arrangement was rolled over for the 2008 season. The Torres Strait Prawn Fishery Management Plan was implemented in 2009, which formalised a number of arrangements for the fishery including internal leasing of Australian effort units (Flood et al. 2011).

Fishery trends

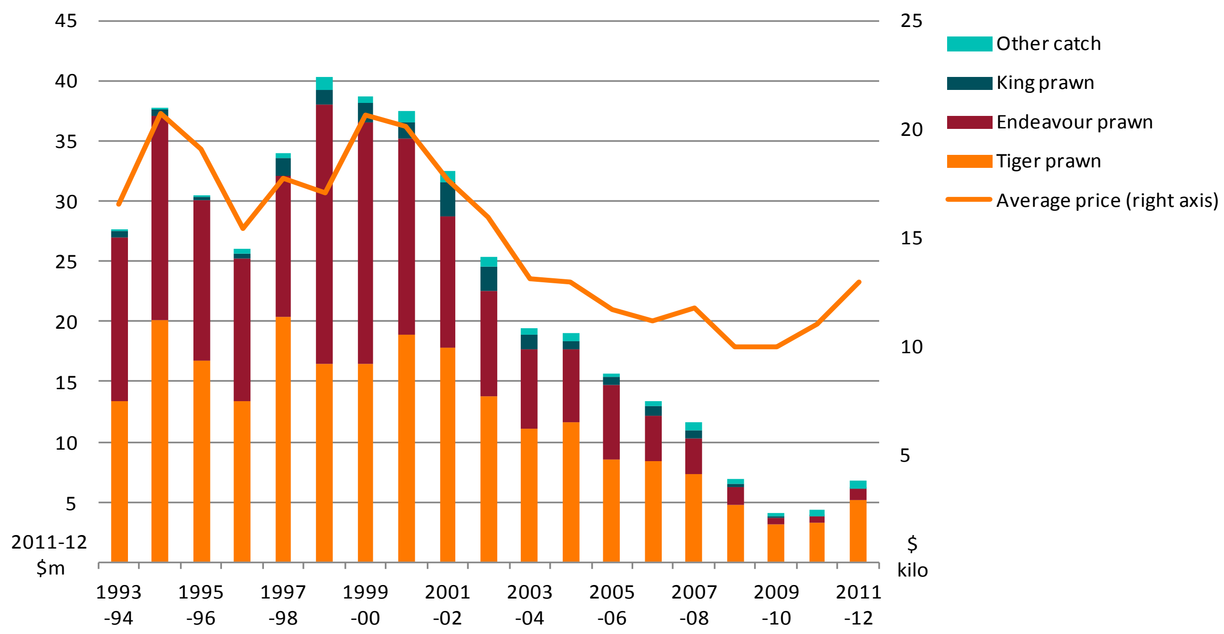
Between 1993–94 and 2009–10, the catch quantities and composition in the TSPF have changed substantially (Figure). In 1998–99, catches peaked at 2367 tonnes, mainly driven by the peak in endeavour prawn catches of 1446 tonnes. Since then, catches in the fishery have followed a declining trend, reaching 520 tonnes in 2011–12 (78 per cent lower than 1998–99). Historically, endeavour prawns accounted for two-thirds of the catch and tiger prawns accounted for the remaining third. However, since 2006–07, tiger prawns have been the major contributor to the total catch.

Figure 18 Production by species and fleet size in the Torres Strait Prawn Fishery, 1993–94 to 2011–12



The gross value of production (GVP) for the TSPF followed a similarly declining trend to production (Figure). GVP peaked in 1998–99 at $40.3 million with endeavour prawn accounting for $21.6 million (54 per cent). Since 1998–99, GVP followed a decreasing trend reaching $6.7 million in 2011–12. During this decline, the contribution of endeavour prawn to GVP decreased, reaching $0.9 million (14 per cent) in 2011–12. The decline in the fishery's GVP since 1998–99 was driven by a decrease in both catches and average unit price, although the average unit price has started to increase since 2009–10.

Figure 19 Real gross value of production by species and average catch price in the Torres Strait Prawn Fishery, 1993–94 to 2011–12



Productivity analysis and results

The TFP analysis for the TSPF is undertaken between 1994–95 and 2007–08, the period for which survey data were available. The output index incorporates tiger, endeavour and king prawns and other species caught. Productivity for this fishery is not adjusted for stock changes as relevant stock biomass data are not available.

The annual average productivity growth for the TSPF was 4.8 per cent between 1993–94 and 2007–08. Between 1993–94 and 2001–02, productivity fluctuated slightly (

Figure). The input and output indexes moved together during this period, with the change in productivity being mainly influenced by changes in the output index.

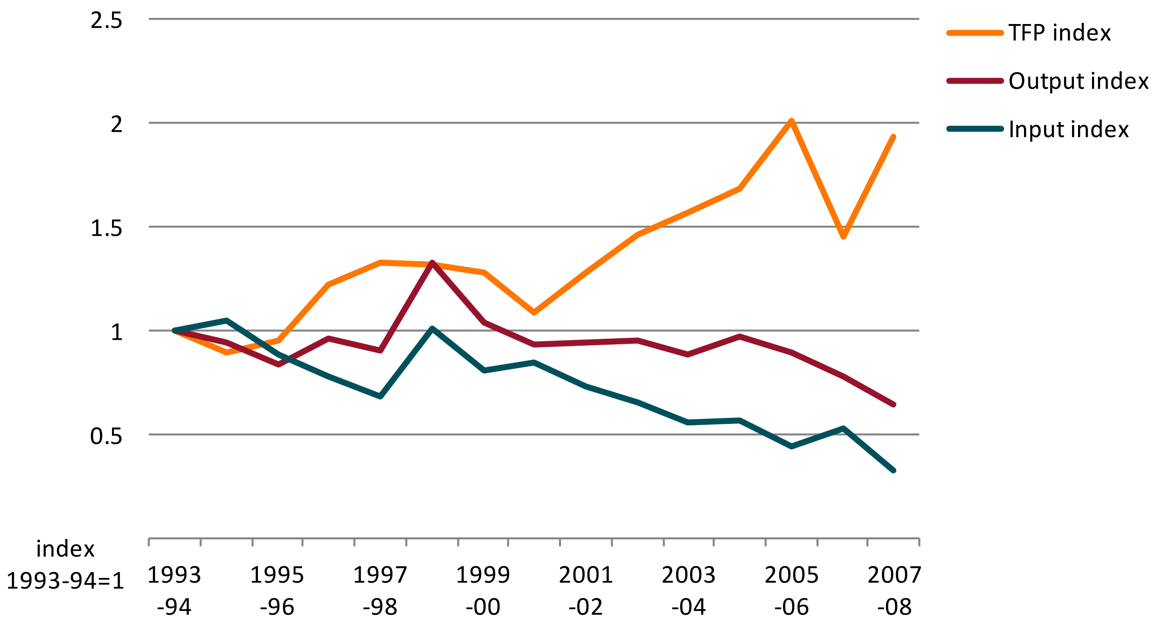
From 2001–02 to 2007–08, productivity increased as the input index decreased faster than the output index. This productivity increase was influenced by the fleet size and stock biomass. The number of operating vessels decreased from 75 in 2001–02 to 28 in 2009–10 (61 per cent) (Figure). The decline in vessel numbers corresponds to declines in profitability and the 2005–06 voluntary licence surrender process. This decline indicates that the least efficient vessels exited the fishery. Although stock biomass data were not available for the analysis, assessments indicate that tiger prawn biomass has steadily increased since 2000 (Taylor et al. 2007). Therefore, the productivity increase can be attributed to a combination of factors: less competition among the smaller fleet, the exit of less productive vessels, and a larger stock allowing for easier catch.

Vessel numbers declined following the 2005–06 voluntary licence surrender process. The direct impacts of this process on productivity are difficult to assess due to the year-on-year fluctuations (a large decrease in 2006–07, and an increase in 2007–08). This could reflect a number of factors including variations in the survey sample.

Between 2005 and 2009, the TSPF has undergone numerous management changes aimed at decreasing effort levels. As noted by Skirtun and Vieira (2012), despite the reduction in total effort cap amounts, unused (or latent) effort remained in the fishery. This latent effort is due to unfavourable economic conditions largely reflecting historically low prawn prices and high costs (particularly for fuel).

Skirtun and Vieira (2012) also noted the distinction between the economic performance of the TSPF and the Northern Prawn Fishery, a fishery that has faced the same deterioration in economic conditions. While the TSPF has exhibited productivity growth, this has not been enough to allow the fishery to maintain positive net economic returns (Vieira & Perks 2009). Participation in the fishery has declined considerably as a result. Productivity growth in the Northern Prawn Fishery on the other hand has allowed it to move from achieving negative to positive net economic returns. The authors suggest that differing management approaches to the two fisheries may be a factor. In particular, recent restrictions on trade in TSPF fishing entitlements and a limit on vessel size are suggested to have hampered productivity growth and profitability in the TSPF.

Figure 20 Productivity, input and output indexes for the Torres Strait Prawn Fishery, 1993–94 to 2007–08



9 Discussion of results

Productivity increased across the Commonwealth fisheries analysed. Productivity trends have largely reflected government-induced structural adjustments and management changes as well as autonomous adjustment responses to market conditions. These findings are consistent with previous productivity findings presented by Skirtun and Vieira (2012) and Vieira et al. (2010).

The TFP trends presented here capture two key effects associated with changing policy and market conditions. The first is structural adjustment at the fishery level with the least profitable and efficient vessels first to exit the fishery. The second effect is improvement in the efficiency of remaining vessels as the operators innovate to adapt to changes in the operating environment largely driven by external economic factors, environmental factors and fishery management.

Government-induced structural adjustment has predominantly affected productivity changes via the SOFF structural adjustment package. Focusing on maximum economic yield and, for most fisheries, moving to individual transferrable quotas means that management settings are better aligned with achieving positive net economic returns and promoting fishery-level efficiency. Maintaining this focus is likely to go on providing incentives for productivity improvements through vessels adopting new technology and operating methods.

Autonomous adjustment responses to market conditions result in operators adjusting the scale and scope of their activities but can also result in the exit of the least efficient vessels from the fishery. Fisheries that rely on export markets such as the Eastern Tuna and Billfish Fishery, the Northern Prawn Fishery and the Torres Strait Prawn Fishery are exposed to exchange rate movements and increased competition on international markets. These factors have put downward pressure on output prices. Fuel-intensive fisheries such as trawl-based fisheries (for example, the Northern Prawn Fishery, Torres Strait Prawn Fishery and Commonwealth Trawl Sector) have been exposed to higher input cost pressures over recent years. These pressures could have reduced the potential economic returns that can be earned from harvests.

The TFP analyses presented in this report are a first step towards a greater understanding of productivity trends in Commonwealth fisheries. Further research could improve methods of analysis, such as better capturing the impact of stocks on productivity. More detailed analysis of the drivers of productivity trends at the vessel level, particularly operating decisions, could provide additional insights for understanding trends in productivity and increasing fisheries productivity and performance in Australia.

Appendix A: Variable definitions

Total factor productivity inputs

Total inputs comprise 13 items that can be split into four major groups:

Capital – Capital costs account for all capital items associated with the fishing business. These include the boat, hull, engine, onboard equipment, vehicles and sheds. The estimate of capital is based on the depreciated replacement value. The quantity variable used for all capital is the average value of capital stock deflated by the respective prices paid indexes for each.

Fuel – Fuel costs include the costs of all fuel, oil and grease. The quantity variable used for all fuel is the average of fuel use deflated by the fuel price paid.

Labour – Labour includes the number of crew employed in boat-related aspects of the fishing business, such as crew or onshore administration costs, but does not cover the cost of onshore labour involved in processing fisheries products. It covers owner/partner, family and unpaid labour.

Repairs – Repairs costs include boat and motor-vehicle repairs, gear costs and other repairs expenditure. The quantity variable is the value of all repairs deflated by the price of repairs.

Total factor productivity outputs

Outputs are the species caught by vessels in each fishery. Vessels operating in different fisheries will catch different species (discussed in the fishery chapters). The price variable is the price received for the species caught. The quantity variable is the kilograms of each species caught by individual vessels.

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