Opportunities and challenges for Australian wild fishing and aquaculture businesses in the carbon economy.

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Non-technical summary

The research involved financial modelling to gain a better understanding of the impact of Australian carbon policy on fishing and aquaculture businesses, and an exploration of options that might be available to reduce the negative impact of carbon policies, or to generate revenue from projects that reduce greenhouse emissions.

The specific objectives of the research project were as follows;

1. To utilise case studies to project the financial implications of Australian greenhouse emission policies on businesses involved in the fishing and aquaculture sector in Australia

2. To develop, through case studies, a range of feasible response strategies in order to assist the fishing and aquaculture industry to best manage the impact of greenhouse emission policies on their businesses.

3. To identify further issues for research by the fishing and aquaculture industry in order for the sector to successfully respond to the implementation of greenhouse emission policies in Australia.

Given the diversity of Australian fishing and aquaculture businesses and the difficulty associated with defining an 'average' business, a case study approach was taken for the research. The case study models were;

- Eastern king prawns and scallop fishery.
- Western Rock lobster fishery.
- Northern prawn fishery.
- Commonwealth trawl fishery.
- Queensland prawn farm.
- Abalone farm.

In each instance, a financial model of the business was developed, identifying input costs and sources of revenue. Where appropriate, energy and energy-related inputs used by input suppliers were detailed, as were energy and energy-related inputs used by participants in the post-business supply chain.

In the case of the Northern prawn fishery and Commonwealth trawl fishery, the financial models developed were based on published ABARES data from fishery surveys. In the case of the Eastern king prawns and scallop fishery and the Western rock lobster fishery, detailed financial information was obtained for two businesses that agreed to participate in the research. In the case of the Queensland prawn farm and the Abalone farm, data was obtained for a number of different businesses and averaged in order to develop a case-study model.

The implications of Australia's greenhouse emission policies was then modeled over future years, under a number of different carbon price scenarios, and for two different scenarios for the

future treatment of fuel emissions (“Core policy” and “Fuel in”). Importantly, the modelling makes no assumptions about responses by these businesses to adjust inputs in response to changes in costs. A summary of the results is shown in Table S.1.

Table S.1 Annual change in business input costs for fishery and aquaculture businesses, arising from carbon policies. (Medium carbon price scenario).

	‘Core policy’ scenario			‘Fuel-in’ scenario	
Case study	**Year 1**	**Year 3**	**Year 5**	**Year 3**	**Year 5**
Eastern King Prawn	0.03%	0.15%	0.16%	2.13%	2.35%
Western Rock Lobster	0.24%	0.26%	0.29%	0.46%	0.50%
Northern King Prawn	0.02%	0.08%	0.09%	1.25%	1.37%
Southern Trawl Fishery	0.00%	0.09%	0.10%	1.49%	1.64%
Queensland Prawn Farm	2.05%	2.27%	2.50%	2.32%	2.56%
Abalone Farm	1.75%	1.94%	2.14%	2.19%	2.41%

The research also examined options that may be available for Australian fishery and aquaculture businesses to reduce input costs or to generate additional revenue from emission offset projects.

Some energy efficiency options may be available, although wild fishery businesses operate within a web of regulation that severely limit efficiency options. Aquaculture businesses may have alternative energy options available, although these are marginally competitive at present and, given relatively high energy use, would require significant capital investment to implement.

The nature of the fishery and aquaculture businesses means there does not appear to be many opportunities to take advantage of the Carbon Farming Initiative (CFI). The case study businesses had only limited areas of land, and therefore do not have an opportunity to participate in the CFI by planting trees. They also produce very limited amounts of direct emissions, meaning that CFI mitigation projects are unlikely to be feasible.

Proposals at the international level to provide incentives for the sequestration of additional carbon in vegetated marine areas such as sea-grass beds and mangrove forests (“blue carbon”), may result in opportunities for some fishery and aquaculture businesses, if adopted at the national level.

Issues that would require resolution would include ownership of carbon sequestration rights on lease-holdings over marine vegetated areas, and actions that could be recognised as sequestering additional carbon in these areas. The permanence requirements for sequestration activities would also create some limitations for blue carbon sequestration projects.

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Acronyms

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ACCU	Australian Carbon Credit Unit
CFI	Carbon Farming Initiative
CO2-e	Carbon dioxide equivalents
DOIC	Domestic Offsets Integrity Committee
DCCEE	Department of Climate Change and Energy Efficiency
DEEDI	Department of Employment, Economic Development and Innovation (Queensland)
DPI	Department of Primary Industries (Victoria)
ETS	Emissions Trading Scheme
FRDC	Fisheries Research and Development Corporation
NCOS	National Carbon Offset Standard
QPFA	Queensland Prawn Farmers Association
RIRDC	Rural Industries Research and Development Corporation.

1. Background

The Australian Government has introduced legislation that will impose a cost on some activities producing greenhouse emissions, through the introduction of an emissions trading scheme (ETS). The legislation (The Clean Energy Act 2011) specifies that the ETS is to start on 1 July 2012, commencing with fixed-price emission permits for the first three years, before being converted into a market-based emissions trading scheme, albeit with some continuing constraints on carbon prices.

The implementation of significant greenhouse emission mitigation policies will usher in a new era for many sectors of the Australian economy. It will mean that organisations carrying out activities that generate greenhouse gas emissions will progressively be required to pay the cost that those emissions are estimated to impose on the environment. This will create an economic incentive for those organisations to either (1) reduce the volume of emissions they create, or (2) to pay others to take actions to reduce emissions or to sequester additional greenhouse gas from the atmosphere.

The legislation specifies which businesses are required to account for their greenhouse emissions and participate in the ETS; which emissions are 'counted' for the purposes of the scheme; which businesses receive concessional treatment to reduce the additional costs that will be encountered; and also includes a staged implementation of the ETS for some businesses.

The legislation requires that businesses that meet certain criteria become participants in the ETS, and report the amount of greenhouse emissions they produce each year, utilising standard calculation methodologies. From 2012 onwards, those businesses will need to purchase one emission permit (an Australian Carbon Credit Unit or ACCU) for each tonne of greenhouse emissions they produce and surrender those to the government when they file their annual greenhouse emission return.

Those businesses will be able to buy ACCUs from the government (at an initial price of $23) or from those businesses or individuals who have implemented 'offset' projects that are recognized as reducing greenhouse gas concentrations in the atmosphere. The prospect that the price of the emission permits to be released by the Government will increase each year creates a growing incentive for participating businesses to either switch to low-emission technologies, or to invest in research to find ways to reduce the amount of emissions they produce.

Several aspects of the policies are important to understand.

First, greenhouse emissions are not measured using meters. In most instances, the greenhouse emissions generated by a particular activity are calculated using standard calculation methodologies. For example, the combustion of one litre of petrol, according to official methodologies, produces 2.3 kilograms of carbon dioxide equivalent (CO_2-e) greenhouse gas emissions. Therefore to calculate the emissions associated with fuel combustion, the activity (litres of fuel combusted) is measured and then multiplied by the relevant emission factor.

The greenhouse emission estimation methodologies utilised in Australia are specified in the "*National Greenhouse Accounts Factors*" and the associated "*National Greenhouse and Energy Reporting (Measurement) Technical Guidelines*" published by the Department of Climate Change and Energy. For those businesses required to participate in the ETS either immediately or in the future (which may include food processing businesses), these standards and calculation methodologies are important to understand. Of particular significance is the fact that some emission accounting methodologies (especially associated with the land sector) have seemingly arbitrary date rules, and some activities (for example soil carbon sequestration) are not included in those methodologies.

Second, there are a number of exemptions and concessions associated with the legislation that have implications for certain businesses. Perhaps of most significance is the treatment of emissions associated with liquid fuels such as petrol and diesel.

Liquid fuels used for rail and air transport will incur an emission cost from 2012, meaning that both rail and air transport costs are anticipated to increase as a consequence of the ETS.

The legislation exempts fuel used in passenger vehicles and light commercial vehicles (less than 4.5 tonnes) used on-road. In addition, the Government has stated that there will be no emission cost imposed on fuel used off-road in the agriculture, forestry and fishery industries.

However, from 2014 onwards the Government has proposed that fuel used by heavy vehicles on-road will incur an emission cost (through adjustments to current fuel tax credit arrangements). There is some uncertainty about this measure, as it is yet to be agreed by independent members of parliament, who currently hold the balance of power in the House of Representatives.

Third, the focus of the ETS is on large energy producers and energy-dependent businesses. The minimum threshold for businesses to be included in the scheme is the production of 25,000 tonnes CO_2-e emissions per annum, which based on available published emission information, excludes most businesses involved in the seafood industry with the possible exception of some of the major food processing organisations. However, the ETS will include most coal-fired electricity generators and gas producers, as well as some of the suppliers of products such as fertilisers and processed grain products (used in aquaculture). This will mean that the main impact of the ETS on businesses in the seafood industry is likely to be an indirect impact – through increases in the cost of energy and energy-related inputs within specific supply chains.

The Australian Government has also enacted the "Carbon Farming Initiative" (CFI), a legislative framework for the recognition of projects that either sequester additional greenhouse emissions from the atmosphere, or mitigate emissions from existing sources. Once accredited and audited, CFI projects will earn one emission permit (an Australian Carbon Credit Unit (ACCU)) for each tonne of greenhouse emission abatement achieved. These will be able to be sold to Australian emitters who are required to participate in the ETS, and who will require one ACCU for each tonne of emission they produce.

There are a range of activities in livestock, crop and forestry production where the opportunity exists for farmers to take action that will either sequester greenhouse gases from the atmosphere (forestry development or soil carbon sequestration) or will mitigate the amount of greenhouse gases that would normally be produced (through changed livestock and crop production systems and land management practices).

A technical panel, the Domestic Offsets Integrity Committee (DOIC), has been established to assess proposed methodologies to ensure that they meet the requirements of the National Carbon Offset Standard. The NCOS specifies that for actions to be recognised as an offset, the scheme under which they are produced needs to meet the following criteria;

- **Additional:** A project must result in carbon sequestration or abatement that would not have occurred in the absence of the scheme.
- **Permanence:** The scheme must be able to demonstrate that the sequestration will be maintained for 100 years.
- **Leakage:** The scheme must not result in additional emissions being produced elsewhere as a result.
- **Measurable and verifiable:** Systems must be in place to accurately measure or estimate the abatement or sequestration, and must be verified by an independent third party.
- **Conservative:** The scheme must result in conservative estimates of sequestration or abatement.
- **Internationally consistent:** Estimation systems must be consistent with international estimation standards and reporting practices adopted under the United Nations Framework Convention on Climate Change.
- **Peer-reviewed science:** Supporting evidence must be peer-reviewed science that has been published in a reputable journal.

The extent to which any proposed methodology meets these criteria will be decided by the DOIC, which will be guided by policy and documentation already made available by the Government. Once approved, a methodology is then available for adoption by a landholder seeking to participate in the CFI.

Farmers participating in the CFI to generate ACCUs will be required to adopt and implement a methodology, will be subject to a regular audit, and will have to complete periodical returns that will be submitted to the scheme administrator. If these returns confirm that the landholder has met the requirements of the methodology, the landholder will receive ACCUs equivalent in number (less a risk management buffer) to the calculated tonnes of emission reduction achieved as a result of adopting the approved methodology.

The demand side of the market for these CFI credits will consist of those companies that are required to participate in the ETS (mandatory market) or companies and individuals that voluntarily decide to take action to reduce the net greenhouse emissions attributable to, or associated with their activities (voluntary market).

As mentioned above, it is the Australian Government’s intention that during the initial stages of the carbon policy (a period of 3 years) the price of an ACCU will be fixed annually by the government, with an initial price of $23. During the fixed-price phase, ETS participants will be able to use ACCUs from CFI projects to meet up to 5% of their emission obligations.

From the perspective of the seafood industries, it is difficult to foresee significant opportunities for the sector to benefit from the CFI initiative, given the CFI focus on land-sector sequestration and mitigation. One exception may be the case of land-based aquaculture operations, where either the opportunity exists to plant trees on some of the land owned by the business, or the business involves wastewater evaporation ponds which, if modified, would enable methane emissions to be trapped and either flared or utilised as a source of energy. A further option may be the creation of offsets through the restoration of native vegetation in areas that were previously vegetated (for example under mangroves) but have since been cleared. Based on a current understanding of the rules, this would only be recognised on land held as private land, and not on crown land.

2. Need.

Australian carbon policies are complex, and have the potential to impact on the operations of businesses in a number of different ways. While the Australian Treasury has carried out some long-term economic modelling at the sectorial level, there has not been any modelling of the shorter or longer-term implications of these policies that is specific to fishery and aquaculture businesses.

This research meets the needs of fishery and aquaculture business owners, who need to better understand the implications of Australian carbon policies for their specific businesses, in order that they can plan and implement appropriate responses where necessary, or take advantage of new business opportunities.

3. Objectives.

The project involved financial modelling to better understand the impact of carbon policy on fishing and aquaculture businesses and related supply chain participants, and also an exploration of options that might be available to reduce the negative impact, or to generate revenue from projects that reduce greenhouse emissions.

The specific objectives of the research project were as follows;

1. To utilise case studies to project the financial implications of Australian greenhouse emission policies on businesses involved in the fishing and aquaculture sector in Australia

2. To develop, through case studies and workshop processes, a range of feasible response strategies in order to assist the fishing and aquaculture industry to best manage the impact of greenhouse emission policies on their businesses.

3. To identify further issues for research by the fishing and aquaculture industry in order for the sector to successfully respond to the implementation of greenhouse emission policies in Australia.

4. Methodology

A number of case study models were developed of different businesses and supply chains in the industry. The case studies were businesses involved in;

- the eastern king prawns and scallop fishery.
- the western Rock lobster fishery.
- the northern prawn fishery.
- the commonwealth trawl fishery.
- the queensland farm prawn industry, and
- the farmed abalone industry.

Itemised business input costs and other production and financial data were obtained for each case study. In four case studies (Eastern king prawn, Western Rock lobster, Queensland prawn farm and Abalone farm) the business input and financial data was obtained from industry sources – either businesses, or industry organisations that had appropriate survey data available. In the two other cases, available ABARES survey data was utilised.

The impacts of carbon policies for these case study businesses was estimated by identifying energy and energy-dependent inputs of either the business or its associated supply chain, and using computer spreadsheet models to calculate the impact of different carbon prices on the cost of energy, and the resulting change in the cost of energy-dependent goods or services utilised by these businesses.

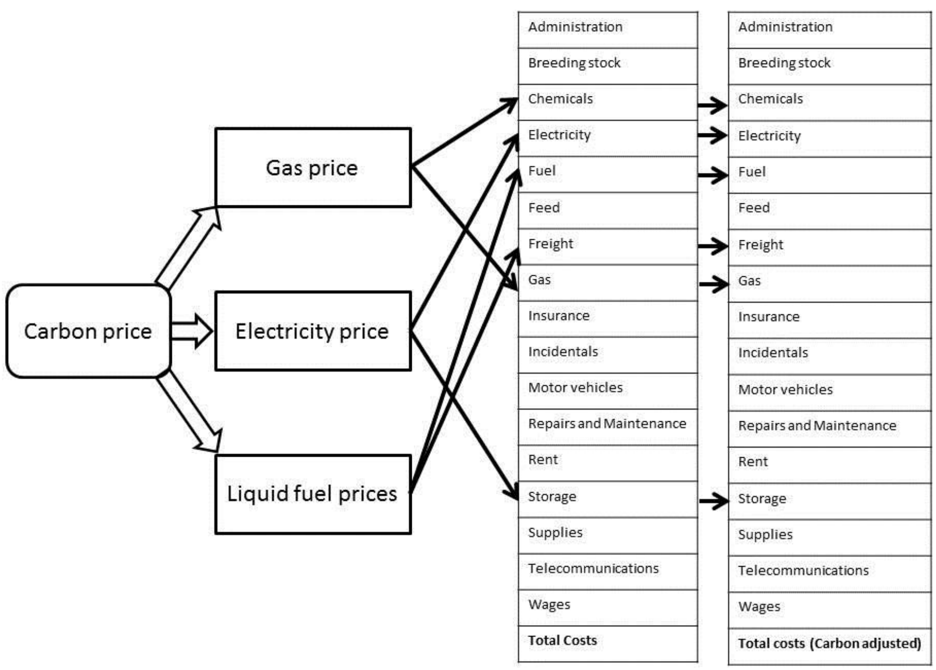

Figure 1: Model utilised to project impacts of carbon policy on case study businesses.

Once developed, the computer models were used to calculate a projection of future 'business-as-usual' results for the case study business, in the absence of the carbon policy. Business outcomes under several different carbon policy scenarios were then calculated, and the results compared with the 'business-as-usual' scenario. The results arising from the modelling project changes in business outcomes relative to what would otherwise have been the case, in the absence of the carbon policy.

Different businesses have different structural arrangements for the various elements of their production system. For example, a trawl fishing business may include ownership of a coolroom and a truck to transport fish to market, or alternatively the owner of a fishing business may contract these functions out to separate storage or transport companies. In order to accommodate these structural differences and ensure that carbon policy impact estimates for each case study were calculated on a comparable basis, the 'boundary' for each case study was the delivery of the product to the point whereby it was available for sale to a consumer. This meant delivery to a wholesale fish market, to a retail outlet, or landed in an overseas location. On occasions, this meant that some costs such as road transport might be identified as 'business costs' in one case study and 'supply chain costs' in another, however the calculated overall cost changes identified for the each of the case-study supply chains are comparable.

An important aspect of research was the need to also develop detailed understanding of the upstream and downstream supply chains relevant to each case-study. This required the collection of information about the inputs of businesses involved in the supply chain. Once obtained, the implications of greenhouse policies were also modeled for participants in the supply chain. Some assumptions needed to be made about the extent to which increases in supply chain costs will be passed on to fishery businesses, as either higher costs or lower prices. The extent of any 'pass-on' of additional costs will be determined by factors such as the competitive nature of the supply chain and market (including the potential for international competition), and the timeframe over which impacts are being considered. In the very short term, it could be anticipated that additional costs will largely be passed on to fishery businesses, but in the longer term it could be expected that cost adjustments will occur throughout the entire supply chain.

A range of different scenarios was modeled for each case study, and from these projections were generated of impacts and implications for the industry over a period of up to ten years.

Much of the analysis was necessarily based on assumptions, recognising there can be considerable variability in input costs and price received for fishery and aquaculture products. The explicit assumptions associated with each modelling exercise are provided in more detail for each case study, and in the following section which provides details of some assumptions that were common to all case studies. It is also important to recognise that in the absence of comprehensive industry survey data, it is not possible to model potential impacts on an 'average' business in any of the fisheries under consideration, therefore the results are applicable only to the specific case study.

Further, it is recognised that emissions from diesel fuel used off-road or for passenger transport will initially be exempt from carbon tax. However there will be a review of implementation of carbon pricing by the Productivity Commission in 2013-14. One of the scenarios that was examined therefore was the extent of changes to case-study business costs and profitability should emissions from off-road diesel use cease to be exempt from a carbon cost following that 2013-14 Review.

4.1 General assumptions.

For each the case studies, a number of assumptions that are important in the modelling are common. These include emission factors for different energy and fuel sources, and assumptions about the significance of changes in the cost of fuel and other energy sources for the cost of different business inputs. The common assumptions associated with the case studies included in the modelling are detailed below.

Energy emission factors.

In order to estimate the impact of emission costs on the cost of energy inputs throughout the supply chain (in the case where it is proposed those emissions will have a cost imposed under the Clean Energy Futures legislation) the standard emission factors used in calculating the Australian national greenhouse gas inventory (DCCEE, 2011) were used.

Table 1 displays those emission factors for each of the relevant energy sources. Emission factors associated with electricity vary depending on the energy used to generate that electricity. For the purposes of the analysis, the emission factors published by the DCCEE for each state were used and it was assumed that all supply chain electricity costs would be incurred in the State in which the fishing or aquaculture business was located.

Table 4.1 Emission factors associated with various energy sources.

Energy source	Unit	CO_2-e per unit.
Natural gas	m^3	2.017 kg
LPG	1 litre	1.539 kg
Diesel	1 litre	2.7 kg
Petrol	1 litre	2.3 kg
Coal (Black)	1 kilogram	2.39 kg
Aviation fuel (jet)	1 litre	2.56 kg
Electricity (NSW)	kWh	0.89 kg
Electricity (Victoria)	kWh	1.21 kg
Electricity (Qld)	kWh	0.88 kg
Electricity (SA)	kWh	0.68 kg
Electricity (SW of WA)	kWh	0.80 kg
Electricity (Tasmania)	kWh	0.30 kg
Electricity (NT)	kWh	0.67 kg

Energy costs.

Energy costs used for the following analysis were those reported from a range of different sources for the relevant period (2010-11). The source of the cost information and the relevant data are shown in the following table. It should be noted that there is a high degree of variation in costs both for a specific energy source and between energy sources, and these costs at best represent an approximation of the unit costs that fishing and aquaculture businesses and related processors may have experienced for the relevant period. It is also relevant to note that large industrial users are generally able to negotiate lower energy unit costs based on higher volumes of usage.

In the case of gas, there is considerable cost variation between different states, and cost relativities are changing as pipelines and export terminals are established in the eastern states. For this reason, a national average cost was assumed, based on published prices for NSW. For the period under consideration, this is probably a significant under-estimation of gas costs in WA, although eastern and western unit costs are converging as new market outlets develop.

In the case of diesel, there is a $0.38c/litre fuel rebate paid by the government to users of off-road fuel – including fuel used in farming, fishery and forestry businesses. In calculations associated with off-road fuel costs used in the fishing business, the cost was assumed to be the published annual average fuel price, less the fuel rebate. In cases where available financial data records all fuel use as a single cost item – “fuel” – it is assumed this is a reference to the use of diesel for fuel, rather than petrol.

The government has announced that fuel used in agriculture, forestry and fishery businesses will not have an emission cost applied for the foreseeable future. This assumption has been used in the following modelling. In addition, a scenario has been added to each case-study which assumes that such fuel use will be subject to an emission cost from 2014, in the same manner as is proposed for on-road fuel used by heavy transport. The results of these scenarios provide some information about the likely impact of such a policy on case study businesses.

Table 4.2 Energy costs used in the modelling.

Energy source	Unit	Source of cost data	Average unit cost
Electricity (NSW)	kWh	Australian Energy Markets Commission: Retail electricity prices.	22.75c
Electricity (Victoria)	kWh		22.86c
Electricity (Qld)	kWh		20.69c
Electricity (SA)	kWh		23.99c
Electricity (SW of WA)	kWh		23.99c
Electricity (Tasmania)	kWh		20.75c
Electricity (NT)	kWh		23.76c
Natural gas	m^3	IPART NSW, 2010	58.95c
LPG	1 litre	ACCC, 2010	59.3c
Diesel (NSW)	1 litre	Australian Institute of Petroleum – Annual Price Data (2010-11). (Note: Net off-road cost for fishing businesses is the published cost less a 38c/litre fuel rebate.)	$1.48/$1.10
Diesel (Vic)	1 litre		$1.44/$1.06
Diesel (Qld)	1 litre		$1.47/$1.09
Diesel (SA)	1 litre		$1.47/$1.09
Diesel (WA)	1 litre		$1.50/$1.12
Diesel (Tas)	1 litre		$1.51/$1.13
Diesel (NT)	1 litre		$1.57/$1.19
Petrol (NSW)	1 litre	Australian Institute of Petroleum – Annual Price Data (2010-11)	$1.40
Petrol (Vic)	1 litre		$1.39
Petrol (Qld)	1 litre		$1.41
Petrol (SA)	1 litre		$1.39
Petrol (WA)	1 litre		$1.41
Petrol (Tas)	1 litre		$1.45
Petrol (NT)	1 litre		$1.49
Aviation fuel (jet)	1 litre	Shell Australia	$1.60

The above costs are those assumed to apply in the business-as-usual case study analysis for the 2010-11 year. In subsequent years, these costs were assumed to increase in response to changes in the carbon price as applicable for each form of energy. An exception was applied to liquid fuel costs, where it was assumed that the cost of fuel used for heavy-vehicle road transport will not be affected by the carbon price until 2014.

Electricity use.

Most of the fishery and aquaculture supply chains included in the analyses have participants involved which rely on electricity and gas use for cooling, or for heating water that is used in processing and cleaning. From discussions with those directly involved in fishery businesses, it is apparent that cool stores and processing facilities can either be part of the fishing business itself; be a service provided as part of a transport business that is utilised by the business, or may also be part of fish wholesale and retail businesses utilized by the case study business.

In the case of aquaculture businesses, electricity is a major input used for pumping and aeration of ponds, as well as an input used in packing, processing and storage facilities. The significance of electricity inputs varies from business to business, dependent on how the business is structured, and the types of energy utilised by different parts of the supply chain.

Because of the variability in business structures, it is often the case that those involved in the fishery or aquaculture business are not aware of the extent of electricity or other energy use in other parts of the supply chain they are involved in. To the extent that it was possible, those participants involved in supply chains downstream from the fishery or aquaculture business were canvassed about their energy use, especially in relation to processing facilities and cool stores.

Some detailed information has been made available by several of these facilities, sufficient to identify that a reasonable estimate of electricity use in a cool store and processing facility that uses electricity for both heating water and cooling produce is 1.25 kilowatts of electricity use per kilogram of throughput.

There is undoubtedly considerable variation around this figure depending on the nature of any processing that is carried out, the amount of time product is held in cool storage, and whether the storage is specific to the fishery products or also utilised for other products. Nevertheless, this figure has sufficient robustness to enable it to be used in the following case studies, but only in the event that it has not otherwise been possible to directly ascertain the electricity use associated with those activities within a specific supply chain. In each case, whether or not this estimate has been used is included in the description of the supply chain.

Transport costs.

An important cost item for all the case study businesses was transport costs. These may be either road or air transport costs, with some businesses incurring both these. Air and rail transport costs will be immediately affected by the ETS due to the emission cost that will be applied to their fuel from July, 2012. Road-transport costs will not be affected by a carbon price during the first two years, but the government currently proposes that fuel used by heavy vehicles will be subject to an emission cost from 2014. As noted earlier, this measure is subject to some political uncertainty, but given the announced intentions of the government, has been modeled from 2014 onwards.

Estimating the impact of the ETS on air transport costs is not a straightforward matter. Much air freight is carried on commercial passenger aircraft, and industry personnel advise that there is a degree of cross subsidization between passenger and freight revenue, depending on the route, the demand for freight space on aircraft on that route, and the nature of competition on that route. Whether or not the aircraft involved in providing air freight services is a passenger aircraft, or purely a freight aircraft affects the significance of fuel as part of total operating costs. For passenger aircraft, fuel costs are generally considered to be approximately 40% of total operating costs (Standard and Poors, 2011), while for long-haul freighter aircraft, fuel is estimated to constitute between 50 and 70% of total operating costs (Morrell, 2011). For the purposes of the modelling reported here, it has been assumed that fuel constitutes and average of 50% of aircraft operating costs.

For road transport, industry estimates are that fuel costs constitute between 20% and 30% of total road transport operating costs in Australia, depending on prevailing fuel prices, distances travelled and waiting times, and the type of truck involved. (Freightmetrics, 2011). It was assumed that on average fuel costs make up 25% of the costs of road transport. The majority of long-distance road freight of chilled seafood is by semi-trailers, typically carrying approximately 22 pallets of product weighing 600 kilograms, or a net weight of 13.2 tonnes per load. Based on averaged road freight quotes from a number of industry sources, a road freight cost of 29.2 cents per net tonne-kilometre was used. This is considered to be a representative cost during 2010-11 and is relevant for use in particular in situations where road freight is not a direct cost of the business, but is managed by a co-operative or wholesaler who deducts this cost from the net proceeds received by the case study business.

Other business costs.

While a cost of a range of other business inputs may potentially be indirectly impacted by carbon policy, the only other cost assumed to be impacted in this analysis was the cost of packaging. Paper and packaging manufacturers have identified that, due to the significance of electricity costs in manufacturing these products, there will be flow-on cost impacts for these products. Because these products are also subject to import competition, it has been assumed that cost increases for these products will be limited. For the purposes of the modelling, it has been assumed that the flow-on cost increases will be 10% of the calculated change in electricity costs. That is, if electricity prices are projected to increase by 10%, packaging costs were assumed to increase by 1%.

Carbon price.

Three different carbon price scenarios were used in the analysis, to provide a better understanding of the sensitivity of the case study models to different carbon prices. In each case the carbon price scenario commenced at the governments announced fixed price of $23.00/t CO_2-e for 2012 (adjusted to 2010-11 dollars). The scenarios were;

- **LOW** – a carbon price scenario that increased by 3% per annum.
- **MEDIUM** – a carbon price scenario using Australian Government Treasury modelling of a price that would be required to reduce national emissions by 5% by 2020.
- **HIGH** - a carbon price scenario that increased at an annual rate of 7% per annum.

The Medium carbon price scenario is that which was modeled by the Treasury and published as part of the Clean Energy Futures legislation information package (Treasury, 2011). This price series commences with the Government's announced fixed carbon price ($23 in 2012-13), but has been adjusted to 2010-11 dollars, so that all financial data used in the analysis has a common year basis.

There has been some discussion about likely carbon prices after 2015, when the ETS converts from a fixed-price to a market-based scheme. The government has stated that a $15 minimum price will apply, although this appears to be the subject of ongoing discussions. Current international carbon prices are closer to $10 per tonne CO_2-e. Given the uncertainty and the potential for these prices to change due to changes in government rules (especially in relation to the EU carbon market) no analyses was carried out of the implications of a lower carbon price. The implications of such a scenario can, however, be inferred from the results.

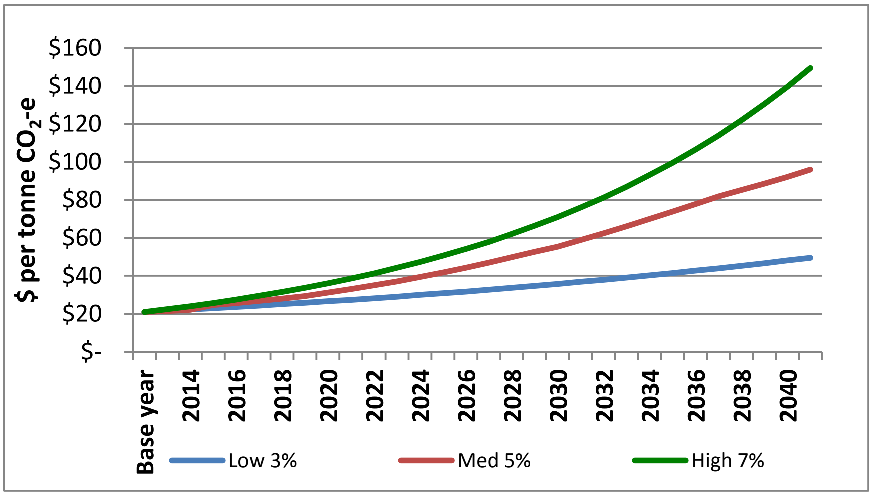

Figure 2: Carbon price scenarios used in case study financial modelling.

Fishery and aquaculture business productivity growth.

In most economic sectors, productivity gains over time provide businesses with the opportunity to remain profitable in the face of increasing costs. Productivity growth implies either improving the rate of growth in outputs relative to growth in inputs, or maintaining output while reducing inputs. Productivity gains over time will be important for Australian businesses seeking to remain profitable in the face of the higher energy and energy-related costs that will arise as a consequence of policies imposing a cost on greenhouse emissions.

For the Australian fisheries and aquaculture sectors, productivity gains are not necessarily able to be achieved in a predictable way. Businesses involved in wildcatch fisheries, in particular, are subject to a high degree of regulation, and utilise a resource that has biological constraints and legislative restrictions that are beyond the control of the businesses involved in the sector. Regulations such as restrictions on the nature of technology used, the hours which a fishing vessel can be used, and arbitrary closures of fisheries depending on catch levels or other indicators make it very difficult to secure productivity gains as they would be conventionally measured, especially at the sector level. The high cost of fixed capital such as fishing vessels also means it is not feasible over the short-term to upgrade to a more efficient vessel in response, for example, to higher fuel costs.

Australian fishery and aquaculture businesses are also fully exposed to international competition. Many of these businesses export to international markets, and have to compete against seafood sourced from other nations. Others compete in domestic markets against imports, with many imports sourced from developing nations that have considerably lower labour and other costs than is the case in Australia.

Given the export exposure of fishing and aquaculture businesses, profitability can be directly impacted through Australian dollar exchange rate fluctuations. The relative appreciation of the value of the Australian dollar against overseas currencies over recent years has had a significant impact of business profitability in the sector (ABARES, 2011)

The Australian fishing and aquaculture sector has experienced a 4-5% decline in production volumes over the past decade, with 2009-10 production being 241,000 tonnes (ABARES, 2011). However, over this period the composition of fisheries production has changed considerably. Wildcatch production has declined while aquaculture production has increased, the result being that the share of aquaculture in volume terms has increased from 17% in 2004-05 to 30% in 2009-10.

Different fishery sub-sectors have experienced different trend in terms of their gross value. There have been significant declines in the value of rock lobsters, prawns, abalone and tuna, while at the same time there has been a significant increase in the value of salmon production and exports.

There has been a significant decline in the export value of fisheries products over this period. Australia became a net importer (value basis) of fish products in 2007-08, and this situation has persisted since that time. In 2009-10, exports were approximately $1.2 billion, while imports were approximately $1.5 billion.

Given this data, the changing trends in different production sub-sectors and the longer-term trend of a net real decline in the value of fisheries production of around 2% per annum, it is not realistic to make broad assumptions about an underlying rate of productivity growth in fisheries business over time. That is not to suggest that individual business managers will not be able to achieve efficiency gains (all others things being equal), but rather that such changes will depend on individual business managers and cannot be assumed to occur at an industry-wide level.

Rather than using an assumed rate of productivity growth for the case studies included in the research, an alternative approach has been used. This involves modelling the impact of the proposed policy on the individual business, assuming that no growth occurs in productivity over time, and then testing a series of productivity growth scenarios to determine what rate would be required in order to maintain profitability, given the projected impact of the carbon policy.

4.2 Policy scenarios.

Two different scenarios were modelled for each of the case study businesses, to gain a better perspective of the range of potential carbon policy impacts under different policy assumptions. The scenarios modelled for each case study were as follows;

"Core policy" scenario.

Under this scenario, the current policy that has been outlined in a number of Government announcements has been assumed to apply. Emissions associated with fuel used in air and rail transport are assumed to effectively be subject to a carbon price from June 2012. Emissions associated with fuel used in heavy (more than 4.5 tonne) on-road transport was assumed to be effectively subject to a carbon price from 2014, but fuel used for off-road purposes in agriculture, forestry and fishery businesses was assumed to not be subject to an effective carbon cost.

"Fuel in" scenario.

Under this scenario, it was assumed that emissions associated with the off-road use of fuel in forestry, fisheries and agriculture were effectively subject to a carbon price from 2014, at the same time that it is proposed that emissions associated with on-road heavy vehicle fuel use will also be subject to a carbon cost. Emissions associated with fuel used in rail and air transport were assumed to be subject to a carbon cost from July 2012.

As noted, in each cased a core assumption of the modelling was that the business manager made no change to production systems or inputs in order to moderate the financial impact of carbon policy. The modelling results therefore project the scale of the challenge faced by the relevant case study businesses, rather than forecasting what the future outcome for the business might be. This modelling is appropriate in order to project short-term policy impacts, but is less realistic over the longer-term when technology and enterprise changes will undoubtedly be implemented if possible to moderate any impacts.

The modelling involves, firstly, a projection of likely future business costs and revenue for a 'business as usual' scenario, under which no carbon policy is implemented in 2012. Modelling was then carried out for each of the scenarios outlined.

To the greatest extent possible, the modelling incorporates both direct business costs and supply-chain costs, with these identified separately in the tabulated results. The reported percentage changes in total costs include both direct business and supply chain costs, given the likelihood that most additional costs will be transferred to fishing and aquaculture businesses in the form of higher charges or reduced returns, at least in the shorter-term.

5. Results

5.1 Case study: Eastern king prawns and scallop fishery.

This case study business is located on the central coast of Queensland, and is involved in the eastern king prawn and scallop fishery. The business is an integrated fishing and processing business which involves multiple fishing trawlers, as well as a cool store and a processing centre. The boats operate approximately fifty weeks of the year, trawling for prawns and scallops at depths of 120 to 320 metres, at distances of between 80 and 160 kilometres off the Queensland coast.

Prawns and scallops are snap frozen on the boats, then processed on shore and packaged before being consigned to seafood wholesalers in the major capital cities. Frozen product is shipped in 5 kilogram boxes, which are stacked on pallets and transported by refrigerated road transport to the major east coast markets. In recent times, approximately 50% of the annual catch has been sent to Sydney, 30% to Melbourne and 20% to Brisbane. Those wholesalers then distribute the product to a range of different retail and food service outlets for sale to consumers.

Of total business costs in 2010-11, 44% was wages, 33% was boat fuel, 3% were packaging costs and electricity and road freight both comprised 2% . A range of other costs make up the balance of total business costs (16%). Income is entirely derived from prawn and scallop sales, the vast bulk of which are domestic sales. On occasions, product is exported by air to Asian markets, although this amounted to less than 3% of the total annual catch.

The boats all operate on an input quota basis, which effectively determines the number of hours each can operate per year. Import competition exists for the medium to smaller size prawns, and there is also competition from domestically farmed prawns (aquaculture). The business owner observed that the extent of import pressure from Asia fluctuates with exchange rates, and has been greater over recent years due to the appreciation of the Australian dollar.

Based on the available details of the case study business and on the assumptions outlined above, the impacts of the different policy scenarios were modeled. Projected changes in financial results for the business as a result of announced carbon policies are shown in Table 5.1, below. Under the 'Core policy' scenario, there are expected to be only minor cost impacts on the business in year one arising from electricity and air freight cost increases.

The inclusion of an effective carbon price for on-road heavy vehicle fuel emissions in year three results in increases in freight costs, but these are relatively minor and overall business costs are projected to increase by approximately 0.20% by year ten under the Medium carbon price scenario, assuming no action is taken to moderate these cost increases.

The picture is somewhat different under the 'Fuel in' scenario as shown in Table 5.2. Business cost increases are more significant in year three due to the emission cost assumed to apply to off-road fuel use. Under the Medium carbon price scenario, the result is projected to be a 3.0% increase in overall business costs by year ten, meaning a projected 4.5% decrease in business annual net cash income, compared to what would be the case under the business-as-usual scenario.

Table 5.1 Change in business costs and business cash income for Eastern King prawn case study under the core policy scenario.

Carbon Price	Item	Year 1		Year 3		Year 5		Year 10	
		2013		2015		2017		2022	
Low 3%	Carbon Price	$	21.85	$	23.18	$	24.59	$	28.51
	Business cost change	$	1,115	$	6,130	$	6,494	$	7,504
	Supply-chain cost change	$	175	$	185	$	197	$	228
	Total cost change ($)	**$**	**1,289**	**$**	**6,315**	**$**	**6,691**	**$**	**7,732**
	Total cost change (%)		0.03%		0.14%		0.15%		0.17%
	Income change (%)		-0.04%		-0.21%		-0.22%		-0.26%
Med 5%	Carbon Price	$	21.85	$	24.09	$	26.56	$	33.90
	Business cost change	$	1,115	$	6,367	$	7,004	$	8,890
	Supply-chain cost change	$	175	$	193	$	212	$	271
	Total cost change ($)	**$**	**1,289**	**$**	**6,559**	**$**	**7,216**	**$**	**9,161**
	Cost change (%)		0.03%		0.15%		0.16%		0.20%
	Income change (%)		-0.04%		-0.22%		-0.24%		-0.31%
High 7%	Carbon Price	$	21.85	$	25.02	$	28.64	$	40.17
	Business cost change	$	1,115	$	6,608	$	7,543	$	10,496
	Supply-chain cost change	$	175	$	200	$	229	$	321
	Total cost change ($)	**$**	**1,289**	**$**	**6,808**	**$**	**7,772**	**$**	**10,818**
	Cost change (%)		0.03%		0.15%		0.17%		0.24%
	Income change (%)		-0.04%		-0.23%		-0.26%		-0.36%

As noted, these projections are based on the assumption that the business operator does not change the nature of inputs used in the business, or fined more efficient ways to utilise existing inputs. Over time, this assumption becomes progressively less realistic, although it does provide a projection of the scale of the future challenge presented by carbon policy for the business.

Table 5.2 Change in business costs and business cash income for Eastern King prawn case study under the 'Fuel-in' policy scenario.

Carbon Price	Item	Year 1 2013	Year 3 2015	Year 5 2017	Year 10 2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 1,115	$ 92,260	$ 97,870	$ 113,433
	Supply-chain cost change	$ 175	$ 185	$ 197	$ 228
	Total cost change($)	**$ 1,289**	**$ 92,445**	**$ 98,066**	**$ 113,661**
	Total cost change (%)	0.03%	2.05%	2.17%	2.52%
	Income change (%)	-0.04%	-3.08%	-3.27%	-3.79%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 1,115	$ 95,874	$ 105,686	$ 134,836
	Supply-chain cost change	$ 175	$ 193	$ 212	$ 271
	Total cost change ($)	**$ 1,289**	**$ 96,067**	**$ 105,898**	**$ 135,107**
	Cost change (%)	0.03%	2.13%	2.35%	3.00%
	Income change (%)	-0.04%	-3.20%	-3.53%	-4.50%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 1,115	$ 99,558	$ 113,961	$ 159,753
	Supply-chain cost change	$ 175	$ 200	$ 229	$ 321
	Total cost change ($)	**$ 1,289**	**$ 99,758**	**$ 114,190**	**$ 160,074**
	Cost change (%)	0.03%	2.21%	2.53%	3.55%
	Income change (%)	-0.04%	-3.33%	-3.81%	-5.34%

As anticipated, the "High' carbon price scenario results in projections of a greater impact on business costs, more particularly over longer timeframes. In percentage terms, however, the impact of a relatively higher rate of increase in the price of carbon is not substantial under the 'Core policy' scenario over ten years, although becomes more significant under the 'Fuel in' scenario.

While the potential impacts of the carbon policy on the case-study business are relatively small, they will, if realized, require business managers to increase productivity (either by increased revenue or reduced costs or both) over time in order to maintain business profitability.

Modelling was carried out assuming a range of different rates of increase in business revenue in order to assess the rate of productivity growth that might be required in order to prevent net business income declining as the carbon price increases.

Table 5.3 displays the results of modelling using the 'Core policy' scenario and the Medium carbon price series, assuming different rates of annual growth in revenue are able to be achieved.

Table 5.3 Effect of different rates of average annual revenue growth on net business income under the Medium carbon price scenario.

Annual productivity growth (%)	Net business income change, year 5	Net business income change, year 10
0.0	-0.24%	-0.31%
0.5	-0.23%	-0.27%
1.0	-0.21%	-0.24%
1.5	-0.20%	-0.22%
2.0	-0.19%	-0.20%
2.5	-0.18%	-0.18%
3.0	-0.17%	-0.16%
3.5	-0.16%	-0.15%
4.0	-0.16%	-0.14%

The critical question for the business is the rate of annual productivity growth that would need to be achieved into the future to ensure increasing carbon costs do not progressively erode business profitability. One way of answering this question is to identify the rate of productivity growth that needs to be achieved so that the projected net change in business income in year ten is less than the projected net change in year five.

The results in the table show that while changes in net business income as a consequence of the carbon policy are relatively modest, average annual revenue growth of approximately 2.5% per annum needs to be achieved by the business over ten years in order to prevent the additional costs associated with the carbon policy continuing to erode business profitability, as the price of carbon increases.

At lower rates of revenue growth the net reduction in business continues to grow between year five and year ten, whereas if revenue growth rates of greater than 2.5% per annum can be achieved, the impact of the carbon price on the business declines over time.

5.2 Case study: Western Rock lobster fishery.

This case study business is based in Western Australia, and exclusively involved in fishing for Western Rock Lobster. The business operates a single fishing boat used for lobster fishing, and is based approximately 120 kilometres by road from Perth. Lobsters are caught live and transferred to a facility onshore that is part of the fishing business. The boat used by the business operates an average of slightly more 1,000 hours per year. Total fuel use by the business is approximately 500 litres of diesel used on-road, and approximately 40,000 litres of diesel used for boat running.

There are no other major uses of energy by the business. Major costs of the business include labour costs, licence fees and quota/lobster pot leasehold costs.

From the shed, the lobsters are regularly transported by road to Perth by a processor/wholesaler, where they are placed in tanks before being packed live and air-freighted to China. Because the road transport part of the supply chain operates throughout the entire season and is therefore not likely to be able to carry complete loads, and because the road transport is likely to complete one leg of the trip empty, road freight costs have been calculated on the basis of a two-way trip (ie 240 kilometres for each journey, at the tonne/kilometre rate identified earlier).

The processing and refrigeration costs associated with the processor/wholesaler business were not able to be separately ascertained, so it was assumed that the default electricity use identified for such facilities (1.25 kilowatts of electricity per kilogram of product throughput) was applicable to the processing and storage facility associated with this supply chain. This would mean there was approximately 51,250 kilowatt hours of electricity use associated with the processing and storage of the product from this fishery.

Air freight costs to China range from $2.75 to $3.50 per kilogram, (Average $3.25) depending on fuel costs and freight space availability on major airlines. All costs ex the business shed are account of the processor – hence all road transport, storage and air freight costs are netted out of the proceeds of the fishing business, before payment is received for lobsters.

Total production for the business was 41,000 kilograms, with gross revenue of $1,500,000 and gross business costs (before debt repayment, owner drawings or capital costs) of $1,200,000.

Modelling was carried out to determine the potential impacts of carbon policy on the business, and the results under the “Core policy” and “Fuel-in” scenarios are displayed in Tables 5.4 and 5.5.

Table 5.4 Change in business costs and business cash income for Western Rock Lobster case study under the "Core policy" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ -	$ -	$ -	$ -
	Supply-chain cost change	$ 3,168	$ 3,391	$ 3,597	$ 4,170
	Total cost change ($)	**$ 3,168**	**$ 3,391**	**$ 3,597**	**$ 4,170**
	Total cost change (%)	0.24%	0.25%	0.27%	0.31%
	Income change (%)	-1.06%	-1.13%	-1.20%	-1.39%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ -	$ -	$ -	$ -
	Supply-chain cost change	$ 3,168	$ 3,524	$ 3,885	$ 4,958
	Total cost change ($)	**$ 3,168**	**$ 3,524**	**$ 3,885**	**$ 4,958**
	Cost change (%)	0.24%	0.26%	0.29%	0.37%
	Income change (%)	-1.06%	-1.17%	-1.29%	-1.65%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ -	$ -	$ -	$ -
	Supply-chain cost change	$ 3,168	$ 3,659	$ 4,189	$ 5,876
	Total cost change ($)	**$ 3,168**	**$ 3,659**	**$ 4,189**	**$ 5,876**
	Cost change (%)	0.24%	0.27%	0.31%	0.44%
	Income change (%)	-1.06%	-1.22%	-1.40%	-1.96%

The fishing business in isolation does not utilise any energy or energy-related inputs which will change in price as a consequence of the implementation of Australian carbon policy, and hence there are not projected to be any changes in business costs.

Under the core policy scenario and medium carbon price assumptions, the implementation of carbon policy adds 0.24% to supply chain costs in year one, with all of that additional cost arising due to increased electricity costs for the processing/storage component of the supply chain, and from the additional fuel costs associated with air freight.

Fuel used by airlines will be subject to an additional cost from the commencement of the carbon policy in June 2012. By year three, (when it is assumed on-road fuel use will be subject to additional costs), the cost impact on the supply chain is projected to total 0.26% under the medium carbon price scenario, with the small increase reflecting the fact that road freight is only a relatively small cost for the business, given its location.

This increase in business costs implies a 1.17% reduction in net cash income for the business, under the assumption that the extra costs are passed back to the fishing business, and the business manager has no options available to respond to the added costs.

Table 5.5 shows the results of modelling the impacts of the carbon policy on the Western Rock Lobster business under the "Fuel-in" policy scenario.

Table 5.5 Change in business costs and business cash income for Western Rock Lobster case study under the "Fuel in" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ -	$ 2,504	$ 2,656	$ 3,079
	Supply-chain cost change	$ 3,168	$ 3,391	$ 3,597	$ 4,170
	Total cost change ($)	**$ 3,168**	**$ 5,894**	**$ 6,253**	**$ 7,249**
	Total cost change (%)	0.24%	0.44%	0.46%	0.54%
	Income change (%)	-1.06%	-1.96%	-2.08%	-2.42%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ -	$ 2,602	$ 2,868	$ 3,661
	Supply-chain cost change	$ 3,168	$ 3,524	$ 3,885	$ 4,958
	Total cost change ($)	**$ 3,168**	**$ 6,125**	**$ 6,753**	**$ 8,619**
	Cost change (%)	0.24%	0.46%	0.50%	0.64%
	Income change (%)	-1.06%	-2.04%	-2.25%	-2.87%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ -	$ 2,702	$ 3,093	$ 4,338
	Supply-chain cost change	$ 3,168	$ 3,659	$ 4,189	$ 5,876
	Total cost change ($)	**$ 3,168**	**$ 6,361**	**$ 7,282**	**$ 10,214**
	Cost change (%)	0.24%	0.47%	0.54%	0.76%
	Income change (%)	-1.06%	-2.12%	-2.43%	-3.40%

The projected impact of the carbon policy under the "Fuel in" scenario is higher, given the relative importance of fuel used in vessel operations as a proportion of total business costs. The projected cost impact in year three (when it is assumed the additional costs will first be incurred) is an increase of 0.46% in total business costs, almost double the cost impact projected under the Core Policy scenario.

The impact of the carbon policy on the case study business is relatively modest in the early years, although will become more significant over time and may become more significant due to future policy decisions relating to fuel emissions. In order to retain profitability levels, the business manager will need to find ways to reduce costs or increase revenue, or both.

Table 5.6 displays the results of modelling runs carried out using the 'Core policy' scenario and the Medium carbon price series, assuming different rates of annual growth in revenue are able to be achieved by the business.

Table 5.6 Effect of different rates of average annual revenue growth on net business income under the Medium carbon price scenario.

Annual productivity growth (%)	Net business income change, year 5	Net business income change, year 10
0.0	-1.29%	-1.65%
0.5	-1.15%	-1.32%
1.0	-1.02%	-1.03%
1.5	-0.96%	-0.93%
2.0	-0.90%	-0.85%
2.5	-0.78%	-0.69%
3.0	-0.72%	-0.61%
3.5	-0.67%	-0.54%
4.0	-0.62%	-0.49%

It shows that while changes in net business income as a consequence of the carbon policy are relatively modest, average annual revenue growth of approximately 1.5% per annum needs to be achieved by the business over ten years in order to prevent the additional costs associated with the carbon policy continuing to erode business profitability. At lower rates of growth in business revenue, the impact of the carbon policy increases over time as the price of carbon increases. Achieving annual revenue growth in excess of 1.5% per annum ensures the business is able to ‘keep up’ with increasing costs associated with the carbon policy.

5.3 Case study: Northern prawn fishery.

The Northern Prawn fishery case study is based on data reported by ABARES (ABARES, 2012) arising from a survey of fishing businesses involved in the Northern Prawn fishery, which involves trawlers operating in the Timor Sea, Arafura Sea and Gulf of Carpentaria between Cape York (Queensland) and Cape Londonderry (W.A).

Trawlers fish for two species of prawns (tiger prawns and banana) each of which has a distinct season. Tiger prawns are generally marketed at much higher prices than banana prawns, and a large proportion of the Tiger prawns caught are exported by air to Japan. Banana prawns are predominantly sold into the Australian domestic market.

Both species have limited and specific seasons based on average catch rates. For tiger prawns the season typically extends from early August to late November, while for banana prawns the season extends from late March to mid-late June.

The ABARES survey data utilised for this case study was for the 2009-10 year, and has been adjusted to 2010-11 dollars in order to be reported on the same basis as other case studies. The ABARES data has been supplemented with information obtained from international air freight agents involved in negotiating air freight consignments to Japan, and with data obtained from road transport operators specialising in the transport of seafood products from northern Australia to the major domestic markets in southern Australia.

Once caught, prawns are typically snap-frozen on the boat, which returns to port periodically to offload and re-provision. From the port, prawns are typically moved to a freight warehouse/coolroom for a short period, before being loaded onto an aeroplane or a road transport. In the case of consignments being sent by road, these are typically loaded from either Karumba, on the eastern side of the Cape York peninsula, or Darwin, Northern Territory. Air freight consignments typically depart from Darwin.

Consignments for Australian domestic markets are currently sent entirely by road, with the main destinations being the southern capital cities. According to road transport operators, an approximate break-up of domestic market destinations may be 40% to Sydney, 30% to Melbourne, with the balance split between Brisbane and Adelaide (15% each). This varies by season and depending on the availability of competing products from other locations, including from overseas.

Based on the ABARES survey data, the average catch per boat for 55 boats operating the fishery in 2009-10 was 23 tonnes of tiger prawns and 105 tonnes of banana prawns. Average gross revenue per boat for 2009-10 was $1.546 million (in $2010-11), and average cash costs (before debt repayment, owners' drawings and depreciation) was $1.289 million ($2010-11). The three major cost items for each boat on average were labour (32%), fuel (26%) and repairs and maintenance (17%). Freight and marketing costs were approximately 5% of total business costs, and it was assumed that the majority of these costs are freight costs. For this case-study, it was assumed that all freight costs were for road freight. It was also assumed that the fishing business continues to contract all freight, meaning that additional freight costs will be reflected within farm expenses, rather than as additional post-business costs.

The impacts of the range of different carbon price scenarios on the case study business were modelled, and the results for the "Core policy" scenario are displayed in Table 5.7. The projected impact of the carbon price under the core policy scenario is relatively minor, and largely confined to additional freight costs. Even under the highest carbon price scenario, costs are projected to increase by approximately 0.1% by year 10.

Table 5.7 Change in business costs and business cash income for Northern Prawn case study under the "Core policy" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 304	$ 984	$ 1,042	$ 1,202
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 304**	**$ 984**	**$ 1,042**	**$ 1,202**
	Total cost change (%)	0.02%	0.08%	0.08%	0.09%
	Income change (%)	-0.09%	-0.31%	-0.33%	-0.38%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 304	$ 1,022	$ 1,123	$ 1,420
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 304**	**$ 1,022**	**$ 1,123**	**$ 1,420**
	Cost change (%)	0.02%	0.08%	0.09%	0.11%
	Income change (%)	-0.09%	-0.32%	-0.35%	-0.44%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 304	$ 1,061	$ 1,209	$ 1,673
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 304**	**$ 1,061**	**$ 1,209**	**$ 1,673**
	Cost change (%)	0.02%	0.08%	0.10%	0.13%
	Income change (%)	-0.09%	-0.33%	-0.38%	-0.52%

The results of modelling assuming the "Fuel in" policy scenario is adopted are shown in Table 5.8. Under that scenario, total business costs are projected to increase by substantially more, as would be anticipated given that the case study business is based on the operation of a trawl boat, which uses large amounts of fuel.

Under this scenario, the modelling projects that total business input costs would increase by 1.37% by year five, and 1.75% by year ten, compared to the business-as-usual scenario.

Table 5.8 Change in business costs and business cash income for Northern Prawn case study under the "Fuel in" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 304	$ 15,191	$ 16,114	$ 18,674
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 304**	**$ 15,191**	**$ 16,114**	**$ 18,674**
	Total cost change (%)	0.02%	1.20%	1.27%	1.47%
	Income change (%)	-0.09%	-4.74%	-5.03%	-5.83%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 304	$ 15,786	$ 17,400	$ 22,195
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 304**	**$ 15,786**	**$ 17,400**	**$ 22,195**
	Cost change (%)	0.02%	1.25%	1.37%	1.75%
	Income change (%)	-0.09%	-4.93%	-5.43%	-6.93%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 304	$ 16,393	$ 18,762	$ 26,292
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 304**	**$ 16,393**	**$ 18,762**	**$ 26,292**
	Cost change (%)	0.02%	1.29%	1.48%	2.08%
	Income change (%)	-0.09%	-5.12%	-5.86%	-8.21%

In order to maintain profitability in a period of increased costs, businesses involved in this fishery will need to increase revenue at a faster rate than cost increases over future periods.

Table 5.9 displays the rates of productivity growth required to maintain profitability under the Medium carbon price scenario over five and ten years. It highlights that annual revenue growth of 1.5 - 2% per annum on average will be required to stabilize net business income over a ten year period in the face of a rising carbon price.

Table 5.9 Effect of different rates of average annual revenue growth on net business income under the Medium carbon price scenario.

Annual productivity growth (%)	Net business income change, year 5	Net business income change, year 10
0.0	-0.35%	-0.44%
0.5	-0.31%	-0.35%
1.0	-0.28%	-0.29%
1.5	-0.25%	-0.25%
2.0	-0.23%	-0.21%
2.5	-0.21%	-0.19%
3.0	-0.20%	-0.16%
3.5	-0.18%	-0.15%
4.0	-0.17%	-0.13%

5.4 Case study: Commonwealth (southern) trawl fishery.

The Commonwealth trawl fishery is comprised of trawler fishing boats operating in the waters off south eastern Australia, extending from Sydney in the north, around the east and southern coasts of Australia (including Bass Strait and south of Tasmania) to Adelaide, and encompassing all of Australia's two hundred mile fishing zone in this region. The main fish species caught in this fisheries include blue grenadier, tiger flathead and silver warehou, although species such as orange roughy have been important species in the past. The fishery is managed through a system of quotas and total allowable catch (TACs) limits on key species, with up to thirty different fish species included in the management system. (ABARES, 2010).

Total annual catch for the fishery has exceeded 30,000 tonnes, but since 2002-03 the volume of production from the fishery has declined considerably due to reduced catches and subsequent lower quota limits, and a reduction in the number of trawlers operating in this fishery as a consequence of quota buybacks. In 2010-11, the total production from the fishery was 15,000 tonnes of fish, valued at approximately $55 million. (ABARES, 2011).

This fishery is the main source of fresh fish for the Sydney and Melbourne markets, and involves 50 trawler boats and 24 scalefish hook vessels, with the main landing ports being Ulladulla (NSW), Eden (NSW), Lakes Entrance (Victoria), Hobart (Tasmania) and Portland (Victoria). Some of the catch is occasionally exported in frozen form to international markets, but the bulk is transported by road from landing ports to the main Melbourne and Sydney markets.

The most recent ABARES survey data for boats involved in this fishery was obtained for the 2008-09 year, and this data has been adjusted to 2010-11 dollars using relevant conversion factors published by the Reserve Bank (RBA, 2012). The ABARES boat survey data segments the boats involved in the fishery into two groups – those using otter trawl systems, and those using Danish seine trawl systems. While there are differences in the financial results of these two types of boats, the sample numbers of boats included in the surveys are quite small, therefore the data used for the case study is the "All boat" average for the fishery.

The 'average' total revenue per boat for all boats included in the fishery survey was $1,141,109, and the average total costs were $944,688 (all expressed as $2010-11). Major cost categories were labour (31%), fuel (23%) and freight and marketing (16%). All other cost categories were less than 10%.

The relatively high level of freight and marketing costs (16%) compared to other fishery case studies raises questions about how much of this cost is freight, and how much is marketing costs. Information available from the Sydney Fish Market indicates that commission rates charged on fresh fish sales range from 7 – 12%, and it can be assumed that similar commission rates would apply in other major metropolitan markets. The majority of the catch from this fishery is sold to the Sydney and Melbourne metropolitan markets, and therefore presumably incurs these marketing costs. If this cost is included with freight costs, it may be the reason the freight and marketing costs per boat for this fishery are substantially higher than for other fisheries.

Further clarification was sought about the breakup of these costs, but the advice was that such information is not available.

Given the uncertainty in relation to the data, two different options were analysed. The first assumed that virtually 100% of these costs were for freight, and the second assumed that 50% of these costs were for freight, and 50% were for marketing. These assumptions are significant, as freight costs will be impacted by a carbon price through its impact on fuel costs post 2014, but marketing costs are likely to be largely unaffected, perhaps except for a minor impact associated with additional electricity costs.

The projected impacts of different carbon price scenarios on the performance of the businesses involved in this fishery were modelled, and the results are displayed in the following tables.

Table 5.10 Change in business costs and business cash income for Commonwealth trawl case study under the "Core policy" scenario. (100% of freight and marketing costs allocated to freight).

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ -	$ 1,628	$ 1,724	$ 1,989
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 1,628**	**$ 1,724**	**$ 1,989**
	Total cost change (%)	0.00%	0.17%	0.18%	0.21%
	Income change (%)	0.00%	-0.83%	-0.88%	-1.01%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ -	$ 1,692	$ 1,859	$ 2,355
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 1,692**	**$ 1,859**	**$ 2,355**
	Cost change (%)	0.00%	0.18%	0.20%	0.25%
	Income change (%)	0.00%	-0.86%	-0.95%	-1.20%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ -	$ 1,757	$ 2,003	$ 2,777
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 1,757**	**$ 2,003**	**$ 2,777**
	Cost change (%)	0.00%	0.19%	0.21%	0.29%
	Income change (%)	0.00%	-0.89%	-1.02%	-1.41%

The results show no change to business or supply chain costs in year one, due to the minimal amount of electricity associated with either the business or the supply chain. Note that freight costs associated with moving fish to metropolitan markets are included as part of the business costs, rather than as supply-chain costs.

Table 5.11 Change in business costs and business cash income for Commonwealth trawl case study under the "Fuel-in" scenario. (100% of freight and marketing costs allocated to freight).

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ -	$ 14,373	$ 15,245	$ 17,664
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 14,373**	**$ 5,245**	**$ 7,664**
	Total cost change (%)	0.00%	1.52%	1.61%	1.87%
	Income change (%)	0.00%	-7.32%	-7.76%	-8.99%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ -	$ 14,936	$ 16,462	$ 20,991
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 14,936**	**$ 16,462**	**$ 20,991**
	Cost change (%)	0.00%	1.58%	1.74%	2.22%
	Income change (%)	0.00%	-7.60%	-8.38%	-10.69%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ -	$ 15,511	$ 17,750	$ 24,863
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 15,511**	**$ 17,750**	**$ 24,863**
	Cost change (%)	0.00%	1.64%	1.88%	2.63%
	Income change (%)	0.00%	-7.90%	-9.04%	-12.66%

Table 5.12 Change in business costs and business cash income for Commonwealth trawl case study under the "Core policy" scenario. (50% of freight and marketing costs allocated to freight).

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ -	$ 814	$ 862	$ 995
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 814**	**$ 862**	**$ 995**
	Total cost change (%)	0.00%	0.09%	0.09%	0.11%
	Income change (%)	0.00%	-0.41%	-0.44%	-0.51%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ -	$ 846	$ 930	$ 1,177
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 846**	**$ 930**	**$ 1,177**
	Cost change (%)	0.00%	0.09%	0.10%	0.12%
	Income change (%)	0.00%	-0.43%	-0.47%	-0.60%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ -	$ 878	$ 1,001	$ 1,388
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ -**	**$ 878**	**$ 1,001**	**$ 1,388**
	Cost change (%)	0.00%	0.09%	0.11%	0.15%
	Income change (%)	0.00%	-0.45%	-0.51%	-0.71%

Table 5.13 Change in business costs and business cash income for Commonwealth trawl case study under the "Fuel-in" scenario. (50% of freight and marketing costs allocated to freight).

Carbon price	Item	Year 1		Year 3		Year 5		Year 10	
		2013		2015		2017		2022	
Low 3%	Carbon Price	$	21.85	$	23.18	$	24.59	$	28.51
	Business cost change	$	-	$	13,559	$	14,383	$	16,669
	Supply-chain cost change	$	-	$	-	$	-	$	-
	Total cost change ($)	**$**	**-**	**$**	**13,559**	**$**	**14,383**	**$**	**16,669**
	Total cost change (%)		0.00%		1.44%		1.52%		1.76%
	Income change (%)		0.00%		-6.90%		-7.32%		-8.49%
Med 5%	Carbon Price	$	21.85	$	24.09	$	26.56	$	33.90
	Business cost change	$	-	$	14,091	$	15,532	$	19,814
	Supply-chain cost change	$	-	$	-	$	-	$	-
	Total cost change ($)	**$**	**-**	**$**	**14,091**	**$**	**15,532**	**$**	**19,814**
	Cost change (%)		0.00%		1.49%		1.64%		2.10%
	Income change (%)		0.00%		-7.17%		-7.91%		-10.09%
High 7%	Carbon Price	$	21.85	$	25.02	$	28.64	$	40.17
	Business cost change	$	-	$	14,632	$	16,748	$	23,475
	Supply chain cost change	$	-	$	-	$	-	$	-
	Total cost change ($)	**$**	**-**	**$**	**14,632**	**$**	**16,748**	**$**	**23,475**
	Cost change (%)		0.00%		1.55%		1.77%		2.48%
	Income change (%)		0.00%		-7.45%		-8.53%		-11.95%

The results displayed in the above tables highlight that under the scenario where 100% of freight and marketing costs are attributed to freight, the projected impact of the carbon policy on these fishery businesses in year one is minimal, and is not projected to increase greatly over time, with projections indicating a 0.25% increase in business costs by year 10. This increase is largely as a result of projected increases in freight costs associated with higher fuel costs for road transport.

Under the scenario where 50% of freight and marketing costs are assumed to be associated with marketing Table 5.12), the projected increased cost impact is approximately halved.

The results displayed in the above tables highlight that, under a scenario where both on-road and vessel fuel use is subject to an emission cost, the projected impact of the carbon price on business profitability is substantially greater, ranging from a 7% projected reduction in net business cash income in year three to a 10% reduction by year ten.

Table 5.14 displays the results of modelling to identify the extent to which annual increases in business income will mitigate the impact of projected cost increases for the case study businesses. The results are displayed for both the "50% freight cost" and the "100% freight cost" business case studies, and for the medium carbon price scenario.

The results indicate that in both cases, achieving annual business income growth of approximately 1.0 to 1.5% per annum over ten years enables the business to retain profitability despite increasing business input costs associated with the carbon policy. If revenue growth is slower than this, profitability declines over time as carbon costs increase.

Table 5.14 Effect of different rates of average annual revenue growth on net business income under the Medium carbon price.

	50% freight cost model		100% freight cost model	
Annual productivity growth (%)	**Net business income change, year 5**	**Net business income change, year 10**	**Net business income change, year 5**	**Net business income change, year 10**
0.0	-0.47%	-0.60%	-0.95%	-1.20%
0.5	-0.41%	-0.46%	-0.83%	-0.92%
1.0	-0.37%	-0.37%	-0.73%	-0.75%
1.5	-0.33%	-0.31%	-0.65%	-0.62%
2.0	-0.29%	-0.26%	-0.59%	-0.53%
2.5	-0.27%	-0.23%	-0.54%	-0.46%
3.0	-0.25%	-0.20%	-0.49%	-0.40%
3.5	-0.23%	-0.18%	-0.45%	-0.35%
4.0	-0.21%	-0.16%	-0.42%	-0.32%

5.5 Aquaculture case study – Queensland prawn farm.

As wild fishery stocks decline and additional restrictions are placed on fisheries, there has been an increase in the relative importance of aquaculture as a means of meeting consumer demand for fish products. According to the most recent fisheries statistics published by ABARES (ABARES 2011), aquaculture accounted for 40% of the gross value of Australian fisheries in 2009-10, and 30% of the volume of production. In 2009-10, total Australian aquaculture production was valued at $870 million, with the most important products by value being salmon ($370 million), pearl oysters ($104 million), tuna ($102 million), oysters ($100 million) and prawns ($77.5 million). Virtually all Australian farmed prawns are produced in Queensland.

The growth in prawn farming in Queensland has been quite dramatic, with year-on-year production increases of almost 30%, and the total value of production growing from $47.9 million in 2005-06 to $74.3 million in 2009-10. (DEEDI, 2011).

In 2009-10 there were 23 operating prawn farms in Queensland, with total production of 5,115 tonnes of prawns, as well as an associated prawn hatchery business with estimated output of $1.3 million. Most of the hatchery businesses were part of an integrated hatchery/growout business, and also involved in marketing hatchlings to other growout businesses. Queensland prawn farms involved a total ponded area of 669 hectares, and the average yield was 6.2 tonnes of prawns per hectare per crop, with each pond on average growing 1.24 crops per year. The average price received for prawns was $14.27 per kilogram, and in excess of 98% of production is marketed in the Australian domestic market.

Based on available date for the Queensland farmed prawn industry, (DEEDI, 2011) major inputs for prawn farm businesses include feed, electricity and labour. Total feed use in Queensland was estimated to be 11,578 tonnes in 2009-10, and prawn farms achieved an average feed conversion ratio (kilograms of feed per kilogram of prawn) of 2.0:1. Of the feed used, 44% was sourced from Australia, and 56% was imported.

Financial and other details of a case-study prawn farm were supplied by the Queensland Prawn Farmers Association (QPFA 2012) for use in the analysis reported here. The QPFA advised that the case-study farm details could be considered to be typical of prawn farming businesses in Queensland, but should not be assumed to be an average for the industry. This is reinforced by survey data (DEEDI, 2011) which highlights that prawn farm size distribution is skewed towards larger-scale producers, with 20% of farms producing in excess of 70% of total production.

The case study farm costs data were for the 2008 year, and these were adjusted to 2010-11 dollars using the appropriate Reserve Bank of Australia inflation rates.

Based on industry survey data and the case study information, the case study farm was assumed to be operating a pond area of 37.6 hectares and produced 222 tonnes of prawns, at an average yield of 5.9 tonnes per hectare. Gross revenue from the sale of prawns was $3.83 million (2010-11 dollars) while total cash operating cost (excluding owners drawings, debt repayments and depreciation) was $2.704 million. A breakdown of operating costs is provided in Table 5.15.

Table 5.15 Itemised operating costs for case-study Queensland prawn farm.

Item	Cost ($)	Proportion of total operating costs (%)
Administration	$137,383	5.1
Total staff costs	$ 424,576	15.7
Electricity	$429,737	15.9
Chemicals	$10,112	0.4
Maintenance	$90,030	3.3
Feed	$937,644	34.7
Processing	$212,828	7.9
Freight	$137,694	5.1
Storage	$42,568	1.6
Post-larvae hatchlings	$281,616	10.4
Total operating costs	**$2,704,189**	**100**

The data highlights the relatively high proportion of total costs which are electricity costs for this case-study business. Prawn farming is virtually unique in this regard, because other wild catch fishery businesses and indeed most primary industry businesses have a much smaller proportion of total operating costs that are due to electricity inputs. The relatively high electricity costs arise due to the need to constantly operate pond aerators, and also due to electricity costs associated with water pumping and refrigeration for cool-room and storage facilities.

It is likely that such a large user of electricity would have access to a cheaper per unit electricity tariff than domestic or small-scale industrial users. This will have some impact on estimated cost increases for electricity arising from Australian carbon policy. Based on available information on electricity prices incurred by Queensland prawn farms (QPFA, 2011), it appears that a 'normal' electricity tariff for 2011 was approximately 15c per kilowatt hour, rather that the 20.69c reported by the Australian Energy Markets Commission (see earlier table). For the analysis reported here, this lower tariff rate was used.

A second noteworthy feature of the costs associated with a prawn farm business is the cost of feed inputs. The feed used is typically pelletised or extruded fish meal, either produced in Australia by major stock feed manufacturers or imported from Indonesia, Thailand or Taiwan. Of particular interest is the significance of energy inputs in feed manufacturing, because this may mean that future feed costs may be impacted by carbon costs.

No specific details of the input costs associated with the feed used in prawn farming is available, although a recent study carried out into similar issues for the Australian pig industry (Wiedemann, 2010) provided relevant input information for feed used in the pig industry.

That research involved the estimation of energy use and emissions production in the pig industry using Life Cycle Analysis (LCA), part of which involved an LCA analysis of manufactured pig feeds.
The energy use associated with the manufacture of pig feeds is displayed in Table 5.16.

Table 5.16. Energy and energy-related inputs for one tonne of pig feed.*

Energy type	Average input
Electricity (Kwh)	31.8
LPG (Litres)	2.3
Diesel (Litres)	6.0

Source: Wiedemann et al.

This information was used as a proxy for the energy inputs associated with prawn feed, and used to model a scenario under which it was assumed that all the feed inputs used on the prawn farm were sourced from Australian manufacturers, rather than imported. Based on available data, the approximate cost of prawn feed was $1,800/tonne. Utilising the above figures and earlier data on energy costs, the cost of energy per tonne of feed used would equate to approximately $15, or 0.83% of the total cost.

The assumption that all feed is sourced within Australia is not a realistic scenario, and it has been identified that approximately half the feed used in the Queensland prawn industry is imported at present, and from locations that do not have carbon policies in place. This means it is likely that feed costs will not necessarily increase, but rather that there will be an increased use of imported, rather than locally manufactured prawn feed. The scenario has been modelled however, in order to gain an understanding of the likely cost impacts of the carbon policy on livestock feed manufacturers in Australia.

There is still likely to be some cost increases associated with feed inputs if, as proposed, heavy vehicle road transport operators have an effective carbon cost imposed on their fuel use post-2014. This will be due to increased freight costs associated with shipment and road transport of feed to prawn farms.

The post-farm supply chain for prawns principally involves transportation to domestic markets, as only approximately 2% of total production was exported in 2009-10. (DEEDI, 2011). This is the likely explanation for the relatively high freight costs associated with the above case study. It is assumed that all of this cost item would be associated with road freight to major capital city markets. This cost item will be affected by carbon policy in the event that a cost is imposed on carbon emissions associated with heavy vehicle fuel use post 2014.

The above data was used in combination with the more general assumptions detailed earlier to model the likely impacts of Australian carbon policy on a case-study prawn farming business in Queensland. The results of that modelling are displayed in the table 5.17.

The data in the Table identifies that, in the absence of any changes to business inputs and under the assumption that electricity retailers and generators pass on all the effects of the carbon policy to consumers, the case-study business would experience a 2.05% increase in costs ($55,548) in year one under the core policy scenario, increasing to be equivalent to a 2.68% cost increase by year ten. In the event that on-road fuel emissions are costed under the policy from 2014, costs are projected to increase by 2.75% by year ten. As a consequence of these cost increases (and assuming the business manager is not able to increase prices), the impact on the net cash income of the business is projected to be a 4.93% reduction in year one, rising to a 7.7% reduction in year ten.

Table 5.17 Change in business costs and business cash income for Queensland Prawn farm case study under the "Core policy" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	**2015**	**2017**	**2022**
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 55,087	$ 58,441	$ 62,000	$ 71,875
	Supply-chain cost change	$ 462	$ 577	$ 612	$ 710
	Total cost change ($)	**$ 55,548**	**$ 59,019**	**$ 62,613**	**$ 72,585**
	Total cost change (%)	2.05%	2.18%	2.32%	2.68%
	Income change (%)	-4.93%	-5.24%	-5.56%	-6.45%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 55,087	$ 60,733	$ 66,958	$ 85,457
	Supply-chain cost change	$ 462	$ 600	$ 661	$ 844
	Total cost change ($)	**$ 55,548**	**$ 61,333**	**$ 67,619**	**$ 86,301**
	Cost change (%)	2.05%	2.27%	2.50%	3.19%
	Income change (%)	-4.93%	-5.45%	-6.01%	-7.67%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 55,087	$ 63,069	$ 72,207	$ 101,274
	Supply chain cost change	$ 462	$ 623	$ 713	$ 1,000
	Total cost change ($)	**$ 55,548**	**$ 63,691**	**$ 72,920**	**$ 102,275**
	Cost change (%)	2.05%	2.36%	2.70%	3.78%
	Income change (%)	-4.93%	-5.66%	-6.48%	-9.08%

Table 5.18 Change in business costs and business cash income for Queensland Prawn farm case study under the "Fuel-in" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 55,087	$ 58,441	$ 62,000	$ 71,875
	Supply-chain cost change	$ 462	$ 577	$ 612	$ 710
	Total cost change ($)	**$ 55,548**	**$ 59,019**	**$ 62,613**	**$ 72,585**
	Total cost change (%)	2.05%	2.18%	2.32%	2.68%
	Income change (%)	-4.93%	-5.24%	-5.56%	-6.45%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 55,087	$ 60,733	$ 66,958	$ 85,457
	Supply-chain cost change	$ 462	$ 600	$ 661	$ 844
	Total cost change ($)	**$ 55,548**	**$ 61,333**	**$ 67,619**	**$ 86,301**
	Cost change (%)	2.05%	2.27%	2.50%	3.19%
	Income change (%)	-4.93%	-5.45%	-6.01%	-7.67%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 55,087	$ 63,069	$ 72,207	$ 101,274
	Supply chain cost change	$ 462	$ 623	$ 713	$ 1,000
	Total cost change ($)	**$ 55,548**	**$ 63,691**	**$ 72,920**	**$ 102,275**
	Cost change (%)	2.05%	2.36%	2.70%	3.78%
	Income change (%)	-4.93%	-5.66%	-6.48%	-9.08%

Included in the above calculations (labeled as post-farm costs) are the projected cost increases for the Australian-based stockfeed manufacturer as a consequence of increases in electricity, gas and fuel costs. Given the relatively high unit value of the feed uses and the small proportion of total costs associated with energy inputs into stockfeed manufacturing, these cost increases are projected to be relatively minor and do not appear likely to have a large impact on the projected prawn farm business results.

In contrast to other fishery businesses, the inclusion of fuel emissions in the carbon policy post 2014 does not have a major impact on total farm costs. This is because the businesses is not a direct user of liquid fuel.

Unlike wildcatch fisheries, prawn farms have some options to increase productivity, and have been doing so over recent years through improved management and the application of new technologies. Annual industry surveys (DEEDI, 2011) have recorded progressive increases in pond stocking rates, number of harvests per year, and decreases in the kilograms of feed required to produce a kilogram of prawn (for the leading farms). Increasing rates of productivity growth will be an important way for prawn farm businesses to respond to the additional costs associated with Australian carbon policy.

This is highlighted in Table 5.19, which shows projected changes in net business income under the medium carbon price scenario for the case study farm business under a range of different productivity growth rate scenarios. The results in the table project that if the case study farm business is able to achieve annual productivity growth rates in excess of 2% then the impacts of the carbon policy can be managed over time and gradually decline. At lower rates of annual productivity growth, the increasing price of carbon adds additional costs faster than productivity growth adds net revenue, and the net effect of the carbon policy increases over time.

Table 5.19 Effect of different rates of average annual revenue growth on net business income for the Queensland Prawn farm case study under the Medium carbon price scenario.

Annual productivity growth (%)	Net business income change, year 5	Net business income change, year 10
0.0	-6.01%	-7.67%
0.5	-5.53%	-6.53%
1.0	-5.12%	-5.65%
1.5	-4.76%	-4.96%
2.0	-4.44%	-4.39%
2.5	-4.15%	-3.93%
3.0	-3.90%	-3.53%
3.5	-3.67%	-3.20%
4.0	-3.46%	-2.91%

5.6 Aquaculture case study – Abalone farm.

Abalone farming has been carried out in both land-based and sea-based operations in Victoria, Tasmania, Western Australia and South Australia, although in recent years the high Australian dollar and production problems have led to some businesses ceasing production. Statistics detailing the total value of farmed abalone production in Australia are somewhat uncertain, because the small number of businesses – in particular in Victoria – means that confidentiality provisions limit reporting for that state, and therefore distort national totals. According to ABARES (ABARES 2011) and based on earlier reported data for Victoria (DPI, 2010), farmed abalone production nationally was valued at approximately $22 million in 2009-10, with almost half of the total production value attributed to South Australia.

The steady decline in Australian wildcatch abalone production has led to speculation that farmed abalone production might increase quickly and substitute for the losses, but these expectations are yet to be realised. A particular challenge is the fact that almost all abalone production is exported to Asian markets, and hence prices are sensitive to changes in Australian exchange rates and supply in those markets. Of particular impact have been dramatic increases in farmed abalone production in China and Chile, (Cook, 2010).

For the purposes of the case study reported here, farm energy and financial data was obtained for a total of seven abalone farms, one of which was located in Tasmania, one of which was located in Western Australia, three of which were located in Victoria, and two of which were located in South Australia. While there was some variation between the different farms which made combining the data problematical, there were data gaps and confidentiality issues that made this necessary. There were sufficient similarities across all farms to ensure that an 'average' model provided useful information, and the variations evident in the data also provided the opportunity to model a range of different scenarios in order to better understand potential impacts.

On average, each of the farms used 84 tonnes of feed to produce 53.7 tonnes of abalone, with a 2011 average farmgate price of $30 per kilogram. This resulted in average gross revenue of $1.61 million per farm. Farm operating costs (not including depreciation or debt repayment) averaged $1.24 million, meaning a gross operating margin of around $370,000, or 23% of gross revenue. The average breakup of farm operating costs for all seven farms is shown in Table 5.20

Table 5.20 Itemised operating costs for Abalone farm case study.

Item	Cost ($)	Proportion of total operating costs (%)
Administration/overheads	$372,562	30.0
Staff costs	$347,725	28.0
Electricity	$198,509	16.0
Feed	$248,375	20.0
Off-road fuel	$70,818	5.7
On-road fuel	$3,885	0.3
Total operating costs	**$1,241,874**	**100**

The feed used for abalone production is sourced both domestically and internationally. Abalone produced on the farms is generally processed on site, and then transported to market as fresh, bottled or frozen product. For the farms included in this research, an average of 37% of product was sent to domestic markets and 63% was exported, principally to Asian markets but also to the USA and the EU.

In the case of abalone production, it is notable that relatively small volumes of high value product are involved. As a result, freight costs associated with movement of feed to abalone farms is a relatively small proportion of total feed costs, and the cost of freight associated with the transport of abalone products to markets (both domestic and international) is also relatively small compared to the product value. For this reason, in the main scenario analysed, post-farm freight costs were not included in the analysis and nor were freight costs associated with moving feed products to the farms. Given that the farms included in the analysis were located in four states, for the purposes of the carbon price impact projections electricity and fuel prices were averaged across the four states, and the resulting average figure was used in the analysis.

The above data was used in combination with the more general assumptions detailed earlier to model the likely impacts of Australian carbon policy on a case-study abalone farming business. The results of that modelling are displayed in the table 5.21.

Table 5.21 Change in business costs and business cash income for the Abalone farm case study under the "Core policy" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	**2015**	**2017**	**2022**
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 21,687	$ 23,172	$ 24,583	$ 28,499
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 21,687**	**$ 23,172**	**$ 24,583**	**$ 28,499**
	Total cost change (%)	1.75%	1.87%	1.98%	2.29%
	Income change (%)	-5.89%	-6.29%	-6.68%	-7.74%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 21,687	$ 24,081	$ 26,549	$ 33,884
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 21,687**	**$ 24,081**	**$ 26,549**	**$ 33,884**
	Cost change (%)	1.75%	1.94%	2.14%	2.73%
	Income change (%)	-5.89%	-6.54%	-7.21%	-9.20%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 21,687	$ 25,007	$ 28,630	$ 40,156
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 21,687**	**$ 25,007**	**$ 28,630**	**$ 40,156**
	Cost change (%)	1.75%	2.01%	2.31%	3.23%
	Income change (%)	-5.89%	-6.79%	-7.78%	-10.91%

Table 5.22 Change in business costs and business cash income for the Abalone farm case study under the "Fuel-in" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	**2015**	**2017**	**2022**
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business costs	$ 21,687	$ 26,167	$ 27,761	$ 32,182
	Supply-chain costs	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 21,687**	**$ 26,167**	**$ 27,761**	**$ 32,182**
	Total cost change (%)	1.75%	2.11%	2.24%	2.59%
	Income change (%)	-5.89%	-7.11%	-7.54%	-8.74%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business costs	$ 21,687	$ 27,193	$ 29,980	$ 38,263
	Supply-chain costs	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 21,687**	**$ 27,193**	**$ 29,980**	**$ 38,263**
	Cost change (%)	1.75%	2.19%	2.41%	3.08%
	Income change (%)	-5.89%	-7.39%	-8.14%	-10.39%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business costs	$ 21,687	$ 28,239	$ 32,331	$ 45,345
	Supply chain costs	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 21,687**	**$ 28,239**	**$ 32,331**	**$ 45,345**
	Cost change (%)	1.75%	2.27%	2.60%	3.65%
	Income change (%)	-5.89%	-7.67%	-8.78%	-12.32%

The modelling identifies that there are projected to be no changes in supply-chain costs as a result of carbon policy. This result arises because all processing (and associated costs) are included as part of the business, and the only post-business costs are likely to be those associated with transport fuel, which are minimal given the relatively small volume of product arising from the business.

The results project that in year 1, the average abalone farm will experience cost increases of 1.75%, rising to 1.94% in year 3 and 2.14% in year five under the medium carbon price, assuming the core policy scenario, and assuming no changes are made to farm inputs. Cost increases of 2.19% will arise in year 3, rising to 2.4% by year 5 if off-road fuel use became subject to a carbon price in 2014 (the "Fuel in" scenario).

The data obtained for the seven abalone farms revealed a range of different business models – especially in relation to energy dependence. In one particular case, the business relied more heavily on off-road fuel use (8% of total input costs) and less heavily on electricity (14% of total input costs) than the average for the case study farms. This provided an opportunity to examine a slightly different energy-mix scenario, and to examine the potential impacts of the carbon price under this scenario.

Tables 5.23 and 5.24 shows the results of this modelling, which utilised the same total input costs and revenue of the first case-study, but adjusted the energy-mix of the business to reflect that detailed above.

Table 5.23 Change in business costs and business cash income for the Abalone farm case study with modified energy inputs under the "Core policy" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business costs	$ 19,082	$ 20,408	$ 21,651	$ 25,100
	Supply-chain costs	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 19,082**	**$ 20,408**	**$ 21,651**	**$ 25,100**
	Total cost change (%)	1.54%	1.64%	1.74%	2.02%
	Income change (%)	-5.18%	-5.54%	-5.88%	-6.82%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business costs	$ 19,082	$ 21,209	$ 23,382	$ 29,843
	Supply-chain costs	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 19,082**	**$ 21,209**	**$ 23,382**	**$ 29,843**
	Cost change (%)	1.54%	1.71%	1.88%	2.40%
	Income change (%)	-5.18%	-5.76%	-6.35%	-8.11%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business costs	$ 19,082	$ 22,024	$ 25,216	$ 35,366
	Supply chain costs	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 19,082**	**$ 22,024**	**$ 25,216**	**$ 35,366**
	Cost change (%)	1.54%	1.77%	2.03%	2.85%
	Income change (%)	-5.18%	-5.98%	-6.85%	-9.61%

Table 5.23 Change in business costs and business cash income for the Abalone farm case study with modified energy inputs under the "Fuel-in" scenario.

Carbon price	Item	Year 1	Year 3	Year 5	Year 10
		2013	2015	2017	2022
Low 3%	Carbon Price	$ 21.85	$ 23.18	$ 24.59	$ 28.51
	Business cost change	$ 19,082	$ 24,412	$ 25,898	$ 30,023
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 19,082**	**$ 24,412**	**$ 25,898**	**$ 30,023**
	Total cost change (%)	1.54%	1.97%	2.09%	2.42%
	Income change (%)	-5.18%	-6.63%	-7.04%	-8.16%
Med 5%	Carbon Price	$ 21.85	$ 24.09	$ 26.56	$ 33.90
	Business cost change	$ 19,082	$ 25,369	$ 27,969	$ 35,696
	Supply-chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 19,082**	**$ 25,369**	**$ 27,969**	**$ 35,696**
	Cost change (%)	1.54%	2.04%	2.25%	2.87%
	Income change (%)	-5.18%	-6.89%	-7.60%	-9.70%
High 7%	Carbon Price	$ 21.85	$ 25.02	$ 28.64	$ 40.17
	Business cost change	$ 19,082	$ 26,344	$ 30,162	$ 42,303
	Supply chain cost change	$ -	$ -	$ -	$ -
	Total cost change ($)	**$ 19,082**	**$ 26,344**	**$ 30,162**	**$ 42,303**
	Cost change (%)	1.54%	2.12%	2.43%	3.41%
	Income change (%)	-5.18%	-7.16%	-8.19%	-11.49%

The results highlight that a reduced reliance on electricity as a business input results in a smaller projected impact from the carbon policy under the "Core policy" scenario, and also under the 'Fuel-in' scenario despite the assumption that off-road fuel would be subject to a carbon price after 2014. This result may have arisen due to the nature of the specific farm and where it is located, and suggests that the use of diesel for localized electricity generation at that location may in fact be more cost-effective that purchasing electricity from the grid.

Abalone farm businesses potentially have more opportunities than wild-catch fishing businesses to increase productivity, even though abalone farms are perhaps even more exposed to international market fluctuations than businesses supplying fresh fish to the domestic seafood market.

A number of different productivity growth scenarios were modelled, to gain some understanding of the rates of productivity growth likely to be required in order to retain business profitability subsequent to the implementation of a carbon price. The results of this analysis are displayed in Table 5.24.

In order to offset the additional business input costs over time, abalone farm businesses will need to achieve productivity growth rates of approximately 2% per annum over ten years, under the carbon price scenario examined here. Achieving a 2% or greater productivity growth rate would enable the farm business to accommodate additional carbon-related input costs increases over time, although this only considers additional carbon-related input cost increases, and assumes that other costs and prices received by the business will remain relatively constant over time.

Table 5.24 Effect of different rates of average annual revenue growth on net business income for the Abalone case study under a Medium carbon price.

Annual productivity growth (%)	Net business income change, year 5	Net business income change, year 10
0.0	-7.21%	-9.20%
0.5	-6.49%	-7.52%
1.0	-5.90%	-6.31%
1.5	-5.39%	-5.41%
2.0	-4.96%	-4.70%
2.5	-4.58%	-4.14%
3.0	-4.25%	-3.68%
3.5	-3.96%	-3.29%
4.0	-3.70%	-2.97%

Perhaps more than other fishery businesses modelled in this research, abalone businesses are heavily reliant on export markets, and are therefore vulnerable to loss of competitiveness due to relatively high Australian dollar exchange rates. As noted earlier, abalone farm businesses have also been under pressure in recent times due to the growth of abalone farming in low labor cost Asian locations including China, and also in Chile.

6. Discussion and conclusions.

The impacts of Australian carbon policy on a number of Australian fishery and aquaculture case study businesses are summarized in Table 6.1.

Table 6.1 Change in business input costs arising from the impacts of carbon policy on case study fishery and aquaculture businesses. (Medium carbon price scenario).

	'Core policy' scenario			'Fuel-in' scenario	
Case study	**Year 1**	**Year 3**	**Year 5**	**Year 3**	**Year 5**
Eastern King Prawn	0.03%	0.15%	0.16%	2.13%	2.35%
Western Rock Lobster	0.24%	0.26%	0.29%	0.46%	0.50%
Northern King Prawn	0.02%	0.08%	0.09%	1.25%	1.37%
Southern Trawl Fishery*	0.00%	0.09%	0.10%	1.49%	1.64%
Queensland Prawn Farm	2.05%	2.27%	2.50%	2.32%	2.56%
Abalone Farm	1.75%	1.94%	2.14%	2.19%	2.41%

* Assumes approximately half of reported post-business costs are selling commissions.

The results indicate that, based on the case study businesses used in the analysis, the impacts of the carbon price as currently proposed will be relatively small on most fishery businesses. This applies in particular to trawl fishing businesses supplying the domestic market. These businesses essentially land fresh fish for transport to domestic fish markets in the mainland capital cities. Little if any processing or storage is involved, and the only post-business costs that may potentially be affected by a carbon price is the cost of fuel associated with road transport, if the carbon price is extended to heavy-vehicle on-road fuel use in 2014, as has been proposed by the Government.

In the case of the Western Rock Lobster case study, the cost impacts are projected to be greater than for other boat-based fishery businesses, principally because in the case study example, virtually all the catch was exported by air to markets in Asia. As the Government has stated that the carbon price will be applied to fuel use by airlines from 2012, this business is projected to experience increases in air-freight costs (assuming airlines operate on full cost-recovery for air freight) as a consequence of the carbon price from that time onwards.

The Western Rock Lobster fishing business only has a relatively minor reliance on road transport and relatively low levels of fuel use for the boat (because the lobster grounds are located close to shore), and is therefore less impacted under the 'fuel-in' scenario than the other fishery businesses that have been included in the analysis.

The Eastern King Prawn and the Northern King Prawn fishery businesses experience only relatively minor impacts from the carbon policy under the ‘core-policy’ scenario, although the Eastern King Prawn business includes on-shore processing and storage facilities which use electricity and therefore experience a greater impact than the Northern Prawn business, which is almost entirely boat based. Both these businesses would experience more substantial impacts under a ‘fuel-in’ scenario, as the trawl boats used in these fisheries cover large ocean distances, and hence are relatively more reliant on fuel as an input for the business.

In comparison to the trawl based fishery businesses, the two aquaculture case study businesses experience greater impacts from the carbon policy than do the other case study businesses. Both prawn and abalone farm businesses rely on relatively high levels of electricity inputs. Both businesses involve pumping large amounts of water through ponds, and the prawn business involves the operation of paddle aerators in ponds, to ensure the water has the appropriate level of dissolved oxygen for optimum prawn growth. Both businesses also involve considerable processing of the product prior to shipment, which again involves the use of electricity for hot water and refrigeration.

In contrast with a number of the other case studies included in this research, the inclusion of a carbon cost for off-road fuel emissions makes little difference to the profitability of these businesses, because they use relatively small amounts of liquid fuel, other than for road transport. In the case of abalone farms, the relatively small volume of product arising from the farm means that post-farm freight costs are a proportionally small component of total business costs, and the impact of additional fuel costs is therefore relatively minor.

The difference observed between the impact of the carbon policy on fishing and aquaculture businesses highlights a particular challenge for industry and policymakers with the advent of the carbon policy. The aquaculture industry arguably has commenced becoming a replacement source of seafood products as the Australian wildcatch fishing industry has come under increased constraints due to sustainability concerns and the creation of marine reserves. However, the aquaculture industry case studies included this research rely on relatively high levels of energy inputs – in particular electricity, and will be the businesses that are most immediately impacted by energy cost increases associated with the carbon policy. This has the potential to make these businesses less competitive in comparison with imported seafood and fishery products, with much of the imported product sourced from developing Asian and South American nations which do not have a carbon policy, and which arguably have less stringent sustainability standards associated with their growing aquaculture sectors.

This will create a considerable challenge for the Australian aquaculture sector and the seafood sector more generally. It is apparent that there is some degree of consumer loyalty to Australian seafood products amongst consumers (Australian prawns typically sell at a $5 - $8/kg premium to equivalent imported product), but this loyalty obviously has limits, and will need to be maintained by superior industry food safety and quality performance, as well as strong marketing support at both the ‘brand’ and the industry level.

7. Benefits and Adoption.

Australian fishery and aquaculture businesses will benefit from this research because the results provide industry participants with a clear picture of the implications of carbon policy for their businesses.

In the case of fishery businesses, the results show that the impact of carbon policy will be small, but also highlight that forthcoming decisions about the future treatment of emissions from off-road fuel use could be of considerable importance.

For the owners of aquaculture businesses, the results indicate that the initial impact of the carbon policy on their businesses is manageable, but the heavy reliance of these businesses on electricity as a major input means that changes will be required in the medium term, in order for those businesses to remain viable. This may include greater reliance on renewable energy sources such as solar hot water systems and photo-voltaic cells for electricity generation, and also indicates that research into alternative pond aeration systems (such as the use of compressed air) should be accelerated.

For providers of services and research and development investment to these businesses, the research provides some strong pointers towards the sorts of technologies that will be required by these businesses to remain competitive in the future.

8. Opportunities and areas for further research.

The preceding case study analysis has identified a number of different issues that will arise for fishery businesses as a consequence of the implementation of carbon pricing policy in Australia from July, 2012.

Depending on future policies associated with the imposition of carbon costs on fuel emissions, the impact of the carbon policy on fishery businesses is generally fairly small, with cost impacts by year five of the policy projected to amount to less than a 0.5% increase in total business input costs for fishing businesses. In the case of aquaculture businesses, the projected cost impacts are somewhat greater, projected to result in business cost increases in the range of 2.5 to 3% by year five, depending on the future policy decisions.

These projected cost increases will present a challenge for Australian fishery and aquaculture businesses, because both types of businesses operate in business environments that are fully exposed to international competition. Both types of businesses are also subject to a relatively high level of regulatory control in comparison with some of the major international sources of competitor products, many of which are developing nations. International competitors typically also operate businesses that face lower wage costs than apply in Australia, which is a particular challenge for those businesses that rely on relatively high levels of labour input into supply chains – typically due to processing requirements.

There are two broad areas of possible response for the Australian fishing and aquaculture industries. The first involves increased research and a focus on increasing operating efficiency, so that the overall reliance on energy inputs is reduced in the future, or changed to those sources of energy that will be less likely to experience future cost increases. The second involves the identification of potential opportunities for owners of fishing industry businesses to participate in the Carbon Farming Initiative (CFI) thereby generating revenue from carbon permits.

Energy efficiency and alternative fuel use.

Energy costs are a significant part of the total input costs of most fishing and aquaculture businesses, although as the case study data has highlighted, the significance of energy inputs varies by business, and depending on the nature of the associated supply chain. In the case of trawler boats, fuel costs typically make up between 20 and 30% of total business input costs. In the case of aquaculture businesses, electricity costs make up15 to 20% of total input costs. Increases in the costs associated with either of these energy sources will obviously be of significance to the viability of these businesses.

It is relevant to note that a number of major research initiatives have been implemented both in Australia and internationally in an attempt to find opportunities to increase the energy efficiency of fishery businesses. These efforts have arisen in response to energy price increases over recent years, and not specifically in response to energy cost increases associated with carbon policies.

Most recently, the second international symposium on fishing vessel energy efficiency has been held in Spain (E-fishing.eu, 2012), which involved the presentation of thirty papers on a wide range of issues associated with improvements in the energy efficiency of fishing vessels and fishery businesses. Improved energy efficiency has been a major focus of most fishery business managers over recent decades, and research efforts in pursuit of that outcome are completely relevant to the challenges associated with carbon-related energy cost increases.

There have been a number of recent Australian research studies carried out to identify system efficiencies or new technologies that may be useful to fishery and aquaculture businesses as a means of responding to potential energy cost increases. These include work by the Fisheries Research and Development Corporation (Sterling and Goldsworthy, 2006), the National Centre for Engineering in Australia (NCEA, 2008), and work by the CSIRO (Miller, 2011).

The research has resulted in a comprehensive list of issues that, given successful research, may yield beneficial results for fisheries businesses facing higher energy costs. There seems little merit in detailing those issues in the context of this report, as they are comprehensively analysed in the above references. The list of potential research areas includes alternative fuels, modified or different engines, changed hull design, changed boat operating speeds, changed fishing nets or trawling practices, energy audit processes, changed lubrication systems, and the adoption of alternative or supplementary means of propulsion.

These research topics have a focus on the efficiency of operation of fishing boats. As noted earlier, each of the case-study fishing supply chains considered in the research reported here also involves land-based operations, and there are obviously opportunities to also make changes to increase efficiency in this part of the supply chain. These may include the use of more efficient road or air transport, the development of more efficient logistics systems, and the development of more energy-efficient heating, cooling and refrigeration systems.

It should be noted that these issues are not unique to the fishing industry, and that a large number of food processing and manufacturing sub-sectors also face the need to improve the energy-efficiency of this part of the supply chain. Businesses have been facing efficiency pressures in relation to these issues for some time as fuel and electricity prices have increased, independently of the cost increases anticipated as a consequence of carbon policy.

The use of alternative fuels – such as biodiesel – has often been proposed as a means of reducing greenhouse emissions and avoiding higher fuel costs. However, these fuels are not cost-competitive with conventional fuels, given current fuel excise arrangements. In order for such fuels to become cost-competitive, there would need to be a substantial increase in the projected carbon price, a change in policy settings such that the carbon price is applied to both on-road and off-road fuel users, and possibly a change to current fuel excise arrangements. At this stage it seems extremely unlikely that any of these changes will occur (let alone all of them), meaning that there appears little likelihood that alternative fuels such as biodiesel will become cost-competitive with conventional fuels for the foreseeable future.

The situation faced by Australian aquaculture businesses, and hence the likely research needs of that section of the industry, are distinctly different. As identified in the two case studies analysed in this research, electricity in particular is a very significant business input, amounting to around 15% of total business input costs. While these are case studies and therefore do not provide information about the industry average, the fact that all the aquaculture businesses included in the case study analysis (approximately eight) had similarly high reliance on electricity as a business input suggests the 15% figure may be a reasonable indicator of the reliance of the sector on electricity.

Many (but not all) aquaculture businesses are land-based, meaning that the options available to utilise alternative technologies and energy sources are considerably greater than is the case for ocean-based fisheries businesses. Non-conventional sources of electricity generation are unlikely to be sufficient to meet all the electricity needs of an aquaculture business on a continual basis, but may be able to be utilised to reduce net energy costs utilising revenue generated under renewable energy credit schemes.

An analysis of the options available for the Queensland prawn farm industry (Miller, 2011) concluded that it was not possible to reach specific conclusions about the viability of any particular alternative energy options, because there were a large number of site-specific and location-specific factors involved. However, options such as solar hot water systems appeared to be promising even at current energy prices for some businesses. Other possible options to reduce energy use (and costs) included the use of alternative pond aeration technologies utilising compressed air rather than paddle systems, and the use of biomass combustion for heating or electricity generation (in situations where a reliable biomass supply is available).

In each case, the specific technologies under discussion (with the exception of the pond aerators) are not unique to the aquaculture industry, and it is therefore a case of industry participants needing to become aware of the opportunities and adapting them to specific business situations, rather than a need for dedicated research efforts by the industry.

Potential opportunities arising from the carbon market.
The Carbon Farming Initiative has established the framework by which the Australian Government aims to create opportunities for landholders to earn income from the sale of emission permits generated by accredited greenhouse emission abatement projects. It creates the framework for two broad categories of offset projects – those involving a reduction in emissions from current recognised sources (mitigation), and those involving the removal of additional greenhouse gases from the atmosphere, and the storage of those gases in non-atmospheric forms such as trees or soil (sequestration).

Mitigation projects typically involve actions that reduce emissions from known sources, which are recognised in Australia's national emission inventory. For example, adding up to 3% of oil to the feed ration of dairy cattle is known to reduce methane emissions from the cows by up to 10% per annum. Similarly, placing a cover over the effluent ponds of a piggery and capturing the methane gas released, and then combusting that methane results in a large change in the calculated emissions associated with the effluent pond.

There are already several CFI methodologies that detail the requirements of specific mitigation projects.

For fishery businesses operating trawler boats, there are no obvious current sources of emissions that seem likely to be able to be utilised to create mitigation projects. The most obvious source of emissions would be those associated with fuel combustion, but the Government has foreshadowed that fuel emissions will be addressed by imposing additional costs on some fuel through changes in fuel tax arrangements, so it is unlikely that a methodology for mitigating fuel emissions would be adopted.

If it was possible to have a mitigation project accepted which reduced fuel emissions, the technology would need to reduce the emissions associated with each litre of fuel used, and not just improve fuel efficiency. There is no known technology available to achieve that at the scale of a trawler boat, at present.

For aquaculture businesses, there are no major sources of greenhouse emissions that would appear to have the potential to become the subject of a CFI mitigation project. Aquaculture businesses have few if any known emission sources, apart from the emissions associated with relatively minor use of liquid fuel. Even if technology were available, it is doubtful that the small volume of fuel used would be sufficient to result in a financially viable CFI project, given project administration costs.

Aquaculture businesses that produce large volumes of biological waste may consider the implementation of a biodigestion system for the disposal of that waste, which could be used to generate a combustible gas for use in electricity generation or water heating, and organic fertilisers. This would not be a CFI project that generates ACCUs, but may be a potential means of reducing electricity usage and costs, which may advantage the business. Anecdotal discussion about these systems with consultants and experts indicates that there needs to be a relatively large biological waste stream available in order to make them viable.

The installation of solar power cells or solar hot water systems may also be a viable option for aquaculture businesses which have large roof areas or available land.

Sequestration projects such as planting carbon sink forests may be feasible for land-based aquaculture businesses, especially if those tree plantings also bring associated benefits such as wind protection, shade, or screening from neighbours. To be feasible, carbon sink forestry projects are likely to require sufficient scale – somewhere in the vicinity of 50 hectares – which is likely to be greater than the amount of land available for most land-based aquaculture businesses.

One form of sequestration project that has been discussed that may be of relevance to fisheries and aquaculture businesses is what has been termed "blue carbon" sequestration (UN Interagency report, 2011).

"Blue carbon" refers to carbon sequestration in marine environments, such as in sea-grass beds or mangrove forests. It is estimated that of all the biological carbon captured in the world, 55% is taken up at sea by marine living organisms, and that at least half of this is taken up by the ocean's vegetated habitats – mangroves, salt marshes, sea-grasses and seaweed, despite these areas covering less than 0.5% of the sea bed. (UN Interagency report, op.cit).

Projects to restore degraded areas of such vegetation are thought to have considerable potential to sequester large amounts of carbon, but also to deliver substantial other environmental benefits. A proposal ("A Blueprint for Ocean and Coastal Sustainability") has been prepared by UN agencies for consideration at the forthcoming UN Conference on Sustainable Development which proposes the development of a global Blue Carbon market, and which if adopted would create economic incentives for projects which result in the sequestration of carbon through the restoration of vegetated marine habitats.

This proposal would seem to be of some interest to the Australian government, given Australia's extensive coastline and significant areas of vegetated marine habitat. Some caution is required, however, noting that international negotiations on terrestrial carbon sequestration programs have been underway since the early 1990s and remain unresolved at present.

If 'blue carbon' projects gained international support and were also acknowledged under Australian greenhouse emission policies, a number of issues would need to be resolved before individuals could generate a commercial benefit from these projects. The first relates to the ownership of carbon sequestration rights over the areas in question. As a general rule, most of the areas where the marine vegetation exists are in tidal zones, and would almost certainly be considered to be areas of crown land, controlled by the relevant State Government Crown Lands Minister. In order for a project to be initiated in these areas, agreement would be needed from the Crown Lands Minister that ownership rights to sequestered carbon arising from a project would vest with a person holding some form of lease over this area.

The next two issues that would need to be resolved would relate to the requirements under the National Carbon Offset Standards for projects to meet additionality and permanence requirements. The 'additionality' requirement would mean that a project proponent would need to be able to identify the actions that would be taken in addition to 'business as usual' activities in order to sequester additional carbon. This might involve replanting areas of mangroves, excluding livestock or other persons from these areas, or taking some other action to increase carbon sequestration by vegetation in the identified area.

The second issue that would need to be considered is the requirement for 'permanence'. This has been interpreted in current legislation to mean that the additional carbon sequestered as a consequence of the project needs to be retained for 100 years. That would mean the leasee would need to be able to identify how the sequestered carbon could be retained for that period of time. This implies that there would need to be a perpetual leasehold agreement arranged over the area in question, and the leasee (and descendants) would face an obligation to continue to retain the carbon in the project area for 100 years, or be required to pay back the ACCUs earned during the life of the project.

Further issues that would need to be considered include methodologies to measure the rate of sequestration of carbon resulting from the project, and to monitor the sequestered carbon for 100 years. As is the case for soil carbon, there is likely to be both temporal and spatial variation in sequestration rates over a project area, and scientifically acceptable methodologies would be required to first obtain representative samples, and then to measure the change in the amount of carbon sequestered in the project area over time.

A brief search of available literature on this topic indicates that the required science is still at a very early stage, and would require a long-term investment in order to come up with workable and scientifically acceptable systems.

In conclusion, the opportunities for fishery or aquaculture businesses arising from Australian Government greenhouse emission policies appear to be quite limited, and would require research and development investment over an extended period of time in order to be successful. An important first step could be for the Australian Government to consider, and potentially support the Global Blue Carbon Initiative.

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