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Environmental and economic dimensions of fuel use in Australian fisheries

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ABSTRACT

Fisheries globally are facing multiple sustainability challenges, including low fish stocks, overcapacity, unintended bycatch and habitat alteration. Recently, fuel consumption has joined this list of challenges, with increasing consumer demand for low-carbon food production and the implementation of carbon pricing mechanisms. The environmental impetus for improving fishery fuel performance is coupled with economic benefits of decreasing fuel expenditures as oil prices rise. Management options to improve the fuel performance of fisheries could satisfy multiple objectives by providing low-carbon fish products, improving economic viability of the industry, and alleviating pressure on overfished stocks. We explored the association of fuel consumption and fuel costs in a wide range of Australian fisheries, tracking trends in consumption and expenditure over two decades, to determine if there is an economic impetus for improving the fuel efficiency – and therefore carbon footprint – of the industry. In the years studied, Australian fisheries, particularly energy-intensive crustacean fisheries, consumed large quantities of fuel per kilogram of seafood product relative to global fisheries. Many fisheries improved their fuel consumption, particularly in response to increases in biomass and decreases in overcapacity. Those fisheries that improved their fuel consumption also saw a decrease in their relative fuel expenditure, partially counteracted by rising oil prices. Reduction in fuel use in some Australian fisheries has been substantial and this has resulted not from technological or operational changes but indirectly through fisheries management. These changes have mainly resulted from management decisions targeting ecological and economic objectives, so more explicit consideration of fuel use may help in extending these improvements.

1. Introduction

1.1. Fuel use and carbon emissions in fisheries

Fossil fuel consumption is the primary source of energy for modern marine fishing fleets and plays a central role in both the environmental and economic performance of fisheries. Interest in measuring, comparing and improving the energy performance of food production systems, including fisheries, first arose after the oil price shocks of the 1970s (Rawitscher, 1978; Tyedmers, 2004). The issue is of increasing pertinence in recent years as a result of rapidly increasing oil prices, concern over greenhouse gas (GHG) emissions and climate change, and implications for fishing communities and food security (Abernethy et al., 2010; Pelletier et al., 2014).

In the decade from 2002 to 2011, the price of Brent crude oil rose more than 300%, increasing by an average of US$0.70 per month (EIA, 2012). After peaking in 2008, global oil prices dropped during the Global Financial Crisis, but have since increased to be consistently above US$100 per barrel. This increase in oil prices and the resulting burden placed upon diesel-consuming fisheries has easily outpaced any increase in seafood prices, resulting in an overall decrease in profitability (Tveteras et al., 2012). The different trajectories of fuel and seafood prices have sparked concerns over the impact of such energy costs on seafood consumers and fishing communities (Abernethy et al., 2010).

Tracking and improving energy performance is critical in ensuring the long-term sustainability of food production, both economically and environmentally. Changes to fishery-sourced food supply and seafood prices can have drastic socio-economic impacts, particularly in poorer countries that rely heavily on fisheries as a source of food and income (Pelletier et al., 2014). These

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potential impacts will likely become more apparent as oil prices rise and as emissions-based regulations are put in place.

Wild harvest fisheries are unique in that the industrial energy inputs and GHG emissions of their operations, ranging from propulsion and fishing to powering cooling systems and other ancillary activities, are typically from direct fossil fuel consumption (Tyedmers, 2004). In contrast, the energy inputs and GHG emissions of land-based food production systems are largely via inputs to production of fertilizers and pesticides, soil nutrient loss and methane emissions from ruminant livestock. Likewise, energy inputs and emissions in carnivorous aquaculture systems are often dominated by upstream production of fish feeds (Pelletier et al., 2011; Pimentel and Pimentel, 2003; Troell et al., 2004). Tyedmers et al. (2005) estimated that, in the year 2000, the global fishing fleet consumed 42.4 million tonnes of fuel and released over 130 million tonnes of carbon dioxide (CO_2). Emissions from the burning of fuel by fishing vessels typically outweigh the combined emissions associated with processing, packaging and transporting seafood products (Parker, 2012; Sonesson et al., 2010). Exceptions to this include instances where fishery products are transported via airfreight, for example, with live lobster exports (Boyd, 2008; Farmery et al., 2014). In addition to carbon emissions, contributions of fisheries to a wide range of airborne emissions can, in large part, be directly attributed to fuel, including sulphur dioxide (SO_2), photochemical smog particulates, and ozone-depleting substances (CFCs) (Pelletier et al., 2007; Avadí and Fréon, 2013; Parker and Tyedmers, 2013).

In many fishing operations throughout the world, fuel is the second highest cost after wages to crew (Lam et al., 2011). Fuel accounts for a rising portion of fisheries operating costs (Parker and Tyedmers, in press), and is a leading source of concern for the economic viability of fishing operations and fishery-dependent communities (Abernethy et al., 2010). This varies by region, with the role of fuel generally greater in developing countries (FAO, 2007). Abernethy et al. (2010) surveyed UK fishermen on their observations and opinions related to the cost of fuel, and found 100% of respondents expected a “significant reduction in fishing fleet as a result of increasing fuel prices”, while 94% expressed uncertainty about the future of the industry as a result. Many of the world's fisheries are already facing economic pressure from fleet overcapacity, declining fish stocks and highly variable ex-vessel prices; rising fuel prices will serve to exacerbate these challenges.

Analyses over the past decade have measured the fuel use intensity (FUI) of fishing fleets, expressed in litres of fuel burned per tonne of round weight landings (L/t). The FUI of many commercial fishing fleets increased throughout the 1980s and 1990s (Tyedmers, 2001). Fuel prices during those years were low enough to allow for production to occur that would not have been viable with higher prices (*e.g.* use of intensive gear types), and modest increases in costs could more easily be compensated for by technological and operational changes. This trend may have reversed since the beginning of the 21st century; European fleets, for example, have decreased their FUI since 2002 (Cheilari et al., 2013). In addition to fishery-specific assessments, broad analyses of fisheries fuel consumption exist for North Atlantic fisheries (Tyedmers, 2001), Norway (Schau et al., 2009), Denmark (Thrane, 2004), the European Union (Cheilari et al., 2013), Japan (Watanabe and Okubo, 1989), Taiwan (Hua and Wu, 2011) and global fisheries targeting tunas (Parker et al., in press). These analyses identified a number of consistent patterns in fuel consumption. On a macro level, FUI varied by species (related to biological measures such as biomass levels and schooling behaviour), fishing gear and location (Parker and Tyedmers, in press). This variation is on a scale of several orders of magnitude, with some fisheries for small pelagic species requiring less than 50 L/t, while those for crustaceans such as lobsters may require several thousand L/t (Schau et al., 2009; Tyedmers, 2001; Ziegler and Valentinsson, 2008). Similarly, fisheries targeting related species but using different gears also varied markedly in their fuel consumption; tuna fisheries fishing with purse seine required far less fuel than those fishing with longline and pole-and-line gears (Parker et al., in press). On a micro level, FUI was influenced by size of vessel, skipper behaviour, management rules and fishing technique, such as the use of fish aggregating devices or the choice of how far to travel to fishing grounds and whether to fish on days of poor weather (Farmery et al., 2014; Parker et al., in press; Thrane, 2004; Vázquez-Rowe and Tyedmers, 2013).

1.2. Australian fisheries

Australia has the third largest fishing zone in the world, owing to its geographic size, island status and territorial claims over Antarctic waters. Despite this, the relatively low productivity of its surrounding waters results in a contribution of only 0.2% to global fisheries landings. The high value of some of the main species targeted makes Australian fisheries some of the most valuable, accounting for a disproportionately high 2% of global landing value (Ridge Partners, 2010). The low-volume, high-price fisheries that drive the value of Australia's fishing industry include those targeting rock lobsters (*e.g.*, *Jasus edwardsii*, *Panulirus cygnus*), prawns (*e.g.*, *Penaeus esculentus*, *Melicertus plebejus*), tunas (*e.g.*, *Thunnus maccoyii*, *Thunnus albacares*), crabs (*e.g.*, *Portunus pelagicus*) and abalone (*e.g.*, *Haliotis laevigata*, *Haliotis rubra*) (Fig. 1).

Total volume of Australian wild fisheries production in 2010–11 was 163,000 tonnes, while the gross value of production (GVP) was AUD$1.3 billion (Skirtun et al., 2012). Value of production has decreased steadily since 2001 as the result of declining ex-vessel prices in many of the most valuable fisheries. Federally managed fisheries, generally located beyond the three nautical mile coastal zone, make up 29% of landings and 24% of fisheries value, while the majority of catch is taken by state-managed fisheries (Fig. 2). Within three nautical miles of the coast, each state manages the fisheries within its jurisdiction, including those where a stock is shared with other states (*e.g.* rock lobster fisheries in South Australia and Tasmania). Western Australia (22%) and South Australia (15%) contribute most to national fisheries GVP (Skirtun et al., 2012). Australian fisheries are heavily export-oriented: 20% of production volume and 50% of production value is typically exported, primarily to East Asian markets of Japan and China; increased demand for live exports to Asia has shifted production and marketing effort to these high-value fisheries since the 1990s. Fisheries export value, however, has also declined steadily over the past decade as prices have dropped (Ridge Partners, 2010).

The effect of fuel costs on fishing is of special interest for Australian fisheries and Oceania more widely because this region of the world has the highest overall costs of fishing, with fuel representing an estimated 20% of total costs on average (Lam et al., 2011). In addition, the operating environment for fisheries is changing with concerns regarding the potential effects of carbon pricing policies, if they are enacted by the federal government. Fisheries and transport were exempt from the recent Australian carbon tax. The fishing industry remains concerned over the increased role fuel plays in the economic performance of fisheries, the effect of potential carbon management options, and the limited capacity of fisheries to respond to fuel costs through efficiency measures and technological improvements (Madon, 2011; NSW Fishing Fleet., 2009).

Understanding the fuel consumption and carbon footprint of fisheries is necessary for assessing the current and future environmental and economic performance of the industry. Energy analyses contribute to economic assessments of fishing sectors, help