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Climate change risks and adaptation options across Australian seafood supply chains – A preliminary assessment

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ABSTRACT

Climate change is already impacting the biology of the oceans and some dependent industries are in turn responding to these impacts. The development of response options for users of marine resources, such as fishers, is important in guiding adaptation efforts. However, harvesting fish is only the first step in a supply chain that delivers seafood to consumers. Impacts higher up the chain have seldom been considered in fisheries-climate research yet an understanding of these impacts and how climate risks and adaptation information are interpreted and used by stakeholders across the chain is vital for developing viable and sustainable adaptation options. We examined stakeholder perceptions of points where climate change impacts and adaptations currently occur, or may occur in the future, across the supply chains of several Australian fisheries (southern rock lobster, tropical rock lobster, prawn) and aquaculture sectors (oyster, aquaculture prawn). We found that climate change impacts are well understood at the harvest stage and there is evidence of potential impacts and disruption to supply chains. Yet, there currently is no strong driver for change higher up the chain. Holistic adaptation planning along the supply chain, underpinned by targeted information and policy for the catch, processing and distribution, and marketing phases is needed. This effort is needed now, as some adaptation options have long lead times, and a delay in adaptation planning may limit future options. Given potential lead times and associated uncertainty, a risk-based approach is recommended with regard to adaptation planning for Australia's seafood sector.

Introduction

Anthropogenic climate change drivers such as global warming and ocean acidification are modifying the oceans and seas around the world. In Australia, the marine climate is already changing substantially (Poloczanska et al., 2007; Lough and Hobday, 2011), and these trends are projected to continue (Hobday and Lough, 2011). Significant warming of ocean temperatures has been documented on both the east and west coasts (Ridgway, 2007; Pearce and Feng, 2007; Lough and Hobday, 2011). Such changes are in turn impacting coastal marine ecosystems (Ling et al., 2009; Last et al., 2011; Wernberg et al., 2011), by altering the distribution, growth, recruitment, and catch of exploited marine species, and/or their prey and

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predators (Poloczanska et al., 2007; Doney et al., 2012; Poloczanska et al., 2013). As a result, marine resource-based industries, such as fishing and aquaculture, are expected to see both opportunities and losses (Hobday and Poloczanska, 2010) and may need to adjust practices in order to maintain or enhance production. This adjustment is important in Australia and elsewhere as seafood plays an important role in food and economic security (Allison et al., 2009; ABARES, 2011) and supplies about 10% of world human calorific intake (Nellemann et al., 2009; FAO, 2011).

The response of regionally important marine industries such as fisheries to climate change is an area of active investigation. Even though the bio-physical elements of these industries have so far received the most attention (e.g., Hobday, 2010; Cheung et al., 2012), long-term shifts in target species and related changes in fisher activity have been reported from around the world (e.g., Nye et al., 2009; Last et al., 2011; Pinsky and Fogarty, 2012; Hamon et al., 2013) while climate-related extreme events also impact fisheries and aquaculture in the short term (Caputi et al., 2010; Wernberg et al., 2011; Marshall et al., 2013). Planning responses to climate change at all time scales is built on a solid biophysical understanding, yet this alone is not sufficient as the full range of opportunities and threats that will confront fisheries and aquaculture as a result of climate change are not just at the production phase. Consideration of the impacts of climate change along seafood supply chains, the steps a product takes from capture to consumer (Peterson et al., 2000) is vital to safeguard the ongoing supply of seafood.

Supply chains represent a useful construct for examining industries in their entirety, because the success of a chain relies more on the way components are assembled to provide effective delivery than on the components themselves (Peterson et al., 2000). A holistic perspective allows examination of barriers and opportunities that would not be apparent from a focus on a single element, such as the wild fish capture phase. Supply chains can range from complex representations that include all of the scientific, production, commercial, technical, structural, policy and related activities involved in the matching of the product to a consumer need, its production, storage, packaging, marketing, sale and transport, including in-chain and in-store quality management, to simpler, fisher-processor-distributor representations (Peterson et al., 2000; Spencer and Kneebone, 2012).

Formally, adaptation is the process of developing local responses to climate change and a deliberate change in anticipation of, or in reaction to, external stimuli and stress (Adger et al., 2005; Nelson et al., 2007). Adaptation can include both biological (e.g., changing distribution) and social adaptation (e.g., human responses such as fishers moving target locations or switching species) (Marshall et al., 2013). An understanding of how adaptation could occur along the catch and post-harvest elements of the supply chain will complement existing bio-physical knowledge, and inform future planning.

To this end, documenting the potential impacts along the chain and the potential adaptation responses, coupled with integration of the social values or priorities showing which adaptations are favored or limited should improve the effectiveness of response actions. As an example, public perceptions of seafood industries vary in terms of their sustainability, traceability, freshness, cost, and ease of preparation (Sparks, 2011). While current perceptions of sustainability in seafood are primarily focused on proximate ecological concerns (e.g., eco-certification processes such as Marine Stewardship Council, Kaiser and Edward-Jones, 2006), impacts stemming from the material and energetic demands of industrial fisheries can also be substantial (Pelletier and Tyedmers, 2008), and may be of increasing importance to consumers. For example, the capture and landing phase of wild marine fisheries account for about 1.2% of global oil consumption and directly emit more than 130 million tonnes of CO_2 into the atmosphere each year (Tyedmers et al., 2005). Each step along the supply chain adds to the environmental burden with some products travelling thousands of kilometres before final consumption (Grescoe, 2008; Merino et al., 2012). As a result of these factors, improved energy efficiency and mitigation of emissions are therefore likely to be important considerations for fisheries responding to climate change (Hobday and Poloczanska, 2010), In this case, reducing emissions may also improve public perception and result in improved sales at the end of the supply chain.

An integrated assessment of adaptation options that also includes an investigation on social decision making, such as stakeholder perceptions about the changes *per se*, or perceptions about the positive and negative social consequences of changes, is currently lacking in marine adaptation research (but see Marshall et al., 2013 for an exception). There is also a need to understand any cascading effects of climate change mitigation and adaptation strategies along the chain. For example, distributions of harvested fish species have been reported to move poleward as a result of climate change (Last et al., 2011), which can result in reduced abundance at a location. One potential adaptation response to this local change in abundance is a management change to the individual tradable quota (Frusher et al., 2013). This may lead to two seemingly unrelated effects that are likely to have cascading effects: a shrinking in the size of the fleet (Hamon et al., 2009) and fishers taking increasing risks to fish while the price is high (Emery et al., in press). Beyond the capture phase these effects may lead to the need for a change in processing locations or increased supply of new products that need to be marketed in new ways.

For successful adaptation planning and appropriate risk management it is also important to understand if change typically occurs at isolated links in supply chains, propagates, or is integrated. Different motivations and values can drive decision-making at different points in the chain. Thus, responses to climate change that do not consider all aspects of the supply chain may not achieve expected outcomes – continued seafood sustainability – and result in unforeseen risks. Here we address these challenges by examining seafood stakeholder perceptions regarding impacts and risks from climate change and potential adaptation options and barriers along the supply chain of five Australian fisheries and aquaculture industries. This research represents the first step toward more holistic adaptation planning and management of climate risk for this sector in Australia.