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Innovation and Capacity in Fisheries: Value-Adding and the Emergence of the Live Reef Fish Trade as part of the Great Barrier Reef Reef Line Fishery

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for the degree of Doctor of Philosophy
in the School of Environmental and Earth Sciences
James Cook University
STATEMENT OF SOURCES

DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived and published or unpublished work of others has been acknowledged in the text and a list of references given.

_____________________________  _______________________  
Geoffrey Muldoon  Date
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Date
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The word that epitomises the journey that has been this thesis is patience. It has been doled out in droves by all persons who have played a role in its completion. In the course of its production, I have moved between part-time and full-time employment and lived a life. All the while those individuals most crucial in the process have remained steadfast in their determination to see me achieve this milestone. To coin a well used phrase; *they have acted above and beyond the call of duty.*

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ABSTRACT

According to the Food and Agriculture Organisation approximately 70% of the world’s fisheries are fully or overfished. One approach posited to address economic and biological sustainability goals is to value-add existing target species. The emergence of new ‘high value-added’ products in expanding markets, however, can have unique implications for the management of fisheries resources. Understanding the relationship between investment and effort, and investment and profits is regarded as essential to effective fisheries management, as most fishery problems are partially the result of over-investment in excess fishing capacity. Moreover, economic incentives for increasing capital investment in such industries are compounded by the presence of a) latent effort and b) under-utilisation of existing capacity. Lastly, participation in the value-adding process may require the take-up of new technology. Most research into technological change and innovation adoption in fisheries is confined to innovations that enhance productive capacity of the fishing vessel, not product form or quality.

The Great Barrier Reef reef-line fishery (RLF) is a multi-species fishery that has traditionally marketed its catch as either frozen fillets, frozen whole or whole chilled fish. Since 1994, some species of coral reef fish have been kept alive for export, with the expectation of increased returns per unit of effort. The development of this live reef fish fishery (LRFF) has coincided with reported increases in catch and effort and a recognition that considerable latent effort exists within the fishery that may mobilise.

This research is an attempt to draw together related but previously unconnected themes of value-adding, innovation and adoption, investment, capacity and latent effort into a coherent framework to explore; the link between value-adding opportunities and profit maximising behaviour; constraints to adoption of and investment in value-adding innovations; profitability, efficiency and capacity comparisons between users and non-users of value-adding innovations and capacity implications of value-adding innovations where latent effort exists. This thesis has three primary research objectives:

1) To examine the financial and economic motivations for participating in the LRFF as a component of the commercial RLF and for the re-allocation of fishing effort on a spatial and temporal scale;
2) To identify the economic and non-economic factors dictating the adoption of requisite technology for participating in the LRFF; and

3) To analyse fishing capacity outcomes for the live and frozen commercial RLF sectors and explore the implications arising from the emergent LRFF for the management of a commercial RLF with a heterogeneous fleet structure.

A survey of fishers endorsed to remove reef fish by line was conducted and a response rate of 60% was achieved. The operation and profitability profiles and investment behaviour of both live and non-live operations was compared across spatial scales.

The data showed high take up of live fishing technology by the existing ‘active’ fleet with more than 80% of all vessels in the sample converting to live operations between 1994 and 2000. Live catch as a proportion of total catch increased in all sections of the Great Barrier Reef Marine Park over the period of this study. The average cost of entry into the LRFF ranged from $24,440 for those converting existing vessels to $438,875 for those with no history in the RLF for whom entry necessitated the purchase of a vessel and license suggesting considerable barriers to entry for some intending participants. In general, fishers responded positively to economic incentives as evidenced by their switching between marketing frozen/fresh and live fish, with a slight time lag. Moreover, fishers with a longer history in the LRFF responded with less alacrity to downward movement in prices, suggesting a better understanding of comparative costs and revenue structure of their fishing firm over time.

In terms of financial and operational characteristics, live operations differed significantly from frozen operations. Live operations were more highly capitalised than frozen operations and while incurring per unit higher costs, live operations generated higher gross and net revenues and were more economically efficient than frozen operations. Lastly live operations differed significantly from frozen operations at a micro-operational level (trip length, number of trips) but not in terms of aggregate annual days fished. The superior financial and economic returns offered from marketing product alive as opposed to frozen, provides the necessary incentive to take-up of live technology although barriers to entry faced by those wishing to enter the LRFF vary according to existing capital and their history of participation in the RLF.
Comparatively high returns to capital, relative to other smaller-scale Australian fisheries, suggest incentives do exist for the entry of first time fishing operations.

Determinants of adoption or non-adoption of live technology were separated into personal and attitudinal characteristics, and perceived attributes of the innovation. The adoption sequence was examined in two parts; firstly, what influenced the decision to proceed and subsequently what determined the investment decision, or the scale to which live technology was incorporated into the vessel. For non-adopters, their decision was examined using the same conventional investment determinants; expected income, expected costs and existing capital. Firm size (i.e. vessel length) and expected income are the principal determinants in the decision of operators to convert to live or remain as frozen operators during both the decision-making stage and, in the case of adopters, following the commitment to innovate. Moreover, expected income and existing capital were more important determinants of the adopter’s decision to undertake investment than it was for non-adopters to reject it. Expected costs exerted a minimal influence for both adopters’ and non-adopters’. For adopters it is speculated that anticipated higher incomes prevailed over the influence of costs while for non-adopters this low importance reflects recognition of the financial barriers to adoption posed by limited capital stocks. Over time, as uncertainty declines in respect of technological capability, observable benefits become more obvious and the gap between expected income and investment risk closes, adoption of live technology may be may become more endemic, thereby accelerating the mobilisation of latent effort. This will have implications for managing the fishery to counter against over-capacity in the fishing fleet.

Data Envelopment Analysis (DEA) was used to compare the efficiency and capacity of live and frozen operations within the RLF fleet. Two efficiency measures calculated using DEA; technical (TE) and revenue efficiency (RE); showed interesting contrasts. Frozen operations were overall more technically efficient than live operations; but these positions were reversed in terms of revenue efficiency. Only 28% of frozen operations had a TE score of less than 0.95 as compared to 63% of live operations. In contrast, 78% of frozen operations had an RE score of less than 0.5 as compared with only 13% of live operations. In terms of capacity measures, frozen operations exhibited a higher degree of capacity utilisation than live operations while a greater number of live operations could increase their variable inputs in order to operate closer to full capacity.
Both efficiency and capacity results highlight that frozen operations have lesser capital endowments and that live operations are poorly utilising their combined freezer and live capacity to increase overall catches. Based on the entire licensed fleet mobilising into the live fishery over time, and irrespective of catch constraints from additional effort, the estimated harvesting capacity of the fleet for coral trout is approximately 2,400 tons higher than current catch levels.

For fisheries where latent effort exists, emerging pecuniary incentives can result in that fishery exhibiting common property characteristics. Any potential rent gains from value-adding of existing target species may be eroded by an influx of effort, leading to overcapacity. In fisheries characterised heterogeneity in effort, capacity reduction programs will need to not only target removal of ‘effective’ (active) effort but also of latent or less active licences that may, in the space created by fewer active vessels’, increase their individual effort. Economic efficiency measures are deemed more appropriate to guide capacity reduction in heterogeneous fleets, such as the RLF.
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<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AE</td>
<td>Allocative Efficiency</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>AQIS</td>
<td>Australian Quarantine Inspection Service</td>
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<tr>
<td>CRS</td>
<td>Constant Returns to Scale</td>
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<tr>
<td>CU</td>
<td>Capacity Utilisation</td>
</tr>
<tr>
<td>DEA</td>
<td>Data Envelopment Analysis</td>
</tr>
<tr>
<td>DPI &amp; F</td>
<td>Department of Primary Industries and Fisheries</td>
</tr>
<tr>
<td>ELF</td>
<td>Effects of Line Fishing</td>
</tr>
<tr>
<td>GBR</td>
<td>Great Barrier Reef</td>
</tr>
<tr>
<td>GBRMP</td>
<td>Great Barrier Reef Marine Park</td>
</tr>
<tr>
<td>GBRMPA</td>
<td>Great Barrier Reef Marine Park Authority</td>
</tr>
<tr>
<td>GFI</td>
<td>Goodness of Fit Indices</td>
</tr>
<tr>
<td>HKCSD / CSD</td>
<td>Hong Kong Census and Statistics Department</td>
</tr>
<tr>
<td>HKAFCD / AFCD</td>
<td>Hong Kong Agricultural, Fisheries and Conservation Department</td>
</tr>
<tr>
<td>IMA</td>
<td>International Marinelife Alliance</td>
</tr>
<tr>
<td>ITQ</td>
<td>Individual Transferable Quota</td>
</tr>
<tr>
<td>LRFF</td>
<td>Live Reef Fish Fishery</td>
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<tr>
<td>LRFF</td>
<td>Live Reef Food Fish Trade</td>
</tr>
<tr>
<td>LTV</td>
<td>Live Transport Vessel</td>
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<tr>
<td>LWE</td>
<td>Live Weight Equivalent</td>
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<tr>
<td>CPUE</td>
<td>Catch Per Unit Effort</td>
</tr>
<tr>
<td>MPA</td>
<td>Marine protected areas</td>
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<tr>
<td>MEY</td>
<td>Maximum Economic Yield</td>
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<td>DPI&amp;F</td>
<td>Department of Primary Industries and Fisheries (Queensland)</td>
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<td>QFMA</td>
<td>Queensland Fisheries Management Authority</td>
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<tr>
<td>QFS</td>
<td>Queensland Fisheries Service</td>
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<tr>
<td>RE</td>
<td>Revenue Efficiency</td>
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<tr>
<td>RLF</td>
<td>Reef Line Fishery</td>
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<td>PCP</td>
<td>Price Conversion-for-Product</td>
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<td>RTE</td>
<td>Red-throat Emperor</td>
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<tr>
<td>RMSR</td>
<td>Root Mean Square Residual</td>
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<tr>
<td>TACC</td>
<td>Total Allowable Commercial Catch</td>
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<tr>
<td>TE</td>
<td>Technical Efficiency</td>
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<tr>
<td>TNC</td>
<td>The Nature Conservancy</td>
</tr>
<tr>
<td>VRS</td>
<td>Variable Returns to Scale</td>
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