Thesis Abstract

Qualitative modelling to aid ecosystem analyses for fisheries management in a data-limited situation

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The need for ecosystem-level analyses is becoming widely recognised following the failure of single-species management in many systems around the world. In order to include multispecies and environmental interactions, ecosystem based fisheries management (EBFM) (known as ecosystem approach to fisheries (EAF) in Europe), has been put forward as a necessary next step for the management of fisheries. Policy regarding EBFM has been produced in Australia, the North Sea and the North Pacific yet the practical application of the approach has not been undertaken in any region. The implementation of EBFM has been slow due to the complexity of ecosystems and the large data needs usually required for ecosystem-level analyses. This study investigates a process of ecosystem analyses with the aim of aiding the swift implementation of EBFM.

The banded morwong (*Cheilodactylus spectabilis*) fishery was investigated in this case study due to the large number of non-target species captured in addition to the target species. The area in which this fishery operates is also important as it is subject to a number of other fisheries, increasing sea surface temperature (SST) and the influx of a number of warm-water invasive species.

Ecosystem analyses were undertaken in a number of steps. Firstly, step the definition of the spatial scale of the ecosystem and its constituents was undertaken using biodiversity survey and commercial catch sampling data. Multivariate statistics were used to identify spatial differences in fish, invertebrate and macroalgal communities between and within the area in which the majority of banded morwong fishing occurs. Significant differences in community composition suggested the spatial bounds of the inshore reef ecosystem should occur at Eddystone Point (Lat. 40.99, Long. 148.35) and south Bruny Island (Lat. 43.27, Long 146.99). Commonly captured species were identified using commercial catch sampling data. The species with the highest catch were identified as banded morwong, blue throat wrasse, purple wrasse, draughtboard shark, marblefish, bastard trumpeter and long-snouted boarfish. Commonly sighted fish, invertebrate and algal species were identified using biodiversity surveys. Correlations with environmental data were investigated for invertebrate and algal species and identified a significant positive trend between sea surface temperature and the invasive urchin *Centrostephanus rodgersii*. A number of data gaps, such as the need for trophic information, and trends for further analysis were also highlighted.

The second step undertaken in these analyses was the production of qualitative models to examine the dynamics of the banded morwong fishery and the formation of urchin barrens on the inshore reef ecosystem. Profit was found to destabilise the fishery, while a total allowable catch (TAC) had a stabilising impact on the fishery, profit and stock biomass. Rock lobster were predicted to be able to control urchin abundance and limit barren formation. Qualitative predictions were generated from each model to guide and focus further research using quantitative models.

A survival experiment focussing on the target and non-target species captured in the banded morwong fishery was undertaken as the third step in the ecosystem analyses. This survival experiment was used to relate fish condition at capture to overall fishery mortality (including retained and discarded individuals) and discard survival rates. The majority of banded morwong (97.8%) were found to survive for the period of study (seven days). The species with the highest fishery-induced mortality and the highest discard mortality were the commercially valuable non-target species, blue throat wrasse (86.21% fishing-induced mortality) and long-snouted boarfish (34.67% discard mortality). This result suggests the banded morwong fishery may have a negative impact on the commercial wrasse fishery, which also operates in the inshore reef ecosystem of eastern Tasmania. Fish condition at capture was suggested as a proxy for mortality in banded morwong and may be used to reduce waste and increase profits in the commercial fishery.

The fourth step in the process was the collection of ecosystem-specific dietary information for six commercially important fish species. Banded morwong, bastard trumpeter and wrasse (*Notolabrus* spp.) were found to feed primarily on benthic invertebrates (>53% IRI). In contrast, marblefish were found to be herbivorous (91% IRI) while long-snouted boarfish fed almost exclusively on ophiuroids (97.3% IRI). This information was used to create a detailed qualitative trophic model of the ecosystem and to examine the impact of model simplification and aggregation error on model results. Three methods of aggregation (Bray Curtis similarity, Euclidean distance and Regular Equivalence) were used to simplify the detailed trophic model. The aggregation of variables may create error as information may be lost between detailed and simplified models. The level of aggregation error produced by each method was therefore calculated and assessed with regard to the simplification of future ecosystem models. The use of regular equivalence was found to produce the least amount of error (14%) between the simplified and detailed models.
The production of an Ecopath with Ecosim model and the comparison of results between quantitative and qualitative models was the final step in the process of ecosystem analysis. The model was produced using the trophic and survival information from the previous chapters. The impact of a TAC on the banded morwong fishery, decreased macroalgal biomass and an increased biomass of urchins were investigated. The proposed TAC was found to be too large to allow banded morwong stocks to increase. Similar to the qualitative models (Chapter 3), rock lobster controlled urchin abundance and allowed foliose algal biomass to increase. The majority of results were found to be robust to the uncertainties and assumptions of the models. Inconsistencies were found to be due to differences in model building or the calculation of predictions.

There is a need for an efficient process of ecosystem analysis that increases the understanding of ecosystem dynamics and can be used in relatively data-poor situations. The method of analysis undertaken in this thesis, from ecosystem definition to qualitative modelling, data collection and quantitative modelling, can be of particular use in the implementation of EBFM in data-poor situations.