Modeling catch-quota management in a multi-species fishery

Olivier Thébaud[1]*, *Sophie Gourguet*[1], *Pierre Lelong*[2], *Luc Doyen*[3], *Rich Little*[4], *Tony Smith*[4], *and Sean Pascoe*[5]

[1]*Ifremer, UMR M101, AMURE, Unité d'Économie Maritime, Brest, France,*
[2]*ENEA Consulting, Paris,*
[3]*CNRS, GREThA, Bordeaux, France,*
[4]*CSIRO, Hobart, Australia,*
[5]*CSIRO, Brisbane, Australia*
**Corresponding author: olivier.thebaud@ifremer.fr*

Summary
Individual transferable catch quotas (ITQs) are an increasingly popular tool used for fisheries management. How these management systems can be implemented in multispecies fisheries however remains a difficult question. The aim of this paper is to propose a modeling framework that addresses some of the key management issues that must be faced in ITQ regulated multispecies fisheries. We apply this model to a stylized representation of the Australian South-East Trawl fishery, and illustrate how it can be used to explore the bio-economic implications of a ban on discards.

Introduction
By providing fishing operators with harvesting rights, Individual transferable catch quotas (ITQs) have the potential to reduce excess competition and foster economic efficiency (Grafton *et al.*, 2006). Implementing these management systems in multispecies fisheries however remains a challenge (Squires *et al.*, 1998), due to joint production leading to by-catch and discards of non-targeted species. Here, we propose a modeling framework that addresses some of the key management issues faced in ITQ regulated multispecies fisheries. The framework captures the main characteristics of a mixed fishery composed of multiple fleets with different species targeting patterns, and multiple species with different biological characteristics. The fishery is assumed to be regulated via TACs and individual quotas that can be traded on a lease market, the operation of which is also modeled. The model is applied to a stylized representation of the Australian South East Trawl Fishery, and is used to explore the potential influence of discards management on the bio-economic status of the fishery.

Materials and methods
We use the modeling approach developed by (Pereau *et al.*, 2012) for an ITQ managed single species and single fleet fishery, and expand this to the case where several biologically independent species are caught simultaneously by multiple fleets with differing fishing techniques. The model is applied to a stylized representation of the Australian South-East Trawl Fishery with two fleets (Danish Seiners and Trawlers), and three species (Tiger flathead, *Neoplatycephalus richardsoni*; Jackass morwong, *Nemadactylus macropterus*; John dory, *Zeus faber*). Calibration of this highly simplified representation of the fishery is based on published data for both the biological characteristics of the species and the cost and earnings of the fleets. Using this model, we compare the outcomes of a fixed TAC policy schedule with or without a discard ban.

Results and discussion
Results show that a ban on discards radically changes the outcomes of catch-quota management, in terms of quota prices, fleet profile and rent distribution across the two fleets (Figure 1). Given the catchability and abundance of Flathead, there is a strong incentive to catch this species, particularly for Danish seiners. The Flathead catch however entails a bycatch of Morwong which leads to an increase in the demand for quota of this species. With discards allowed, the fleet purchases Morwong

quota up to a point where its price is equal to the market price for the species, but discards any catch beyond this level (with no obligation to hold quota for the discarded fish). The activity of both sub-fleets stabilizes at a slightly reduced effort level, and at comparable levels of rent. Significant discards of Morwong catch are then observed. With discards banned, any increase in the catch of Morwong must be met with a purchase of quota on the lease market. This entails an increase in the quota price over and above the market price for this species, and a degraded economic performance of the trawlers that are less effective at catching Flathead than Danish Seiners, and have more difficulties avoiding Morwong. The fleet thus evolves towards a progressive eviction of Trawl, in favor of Danish Seine. In this case, heterogeneity within the two fleets in terms of economic performance is also much greater than with discards.

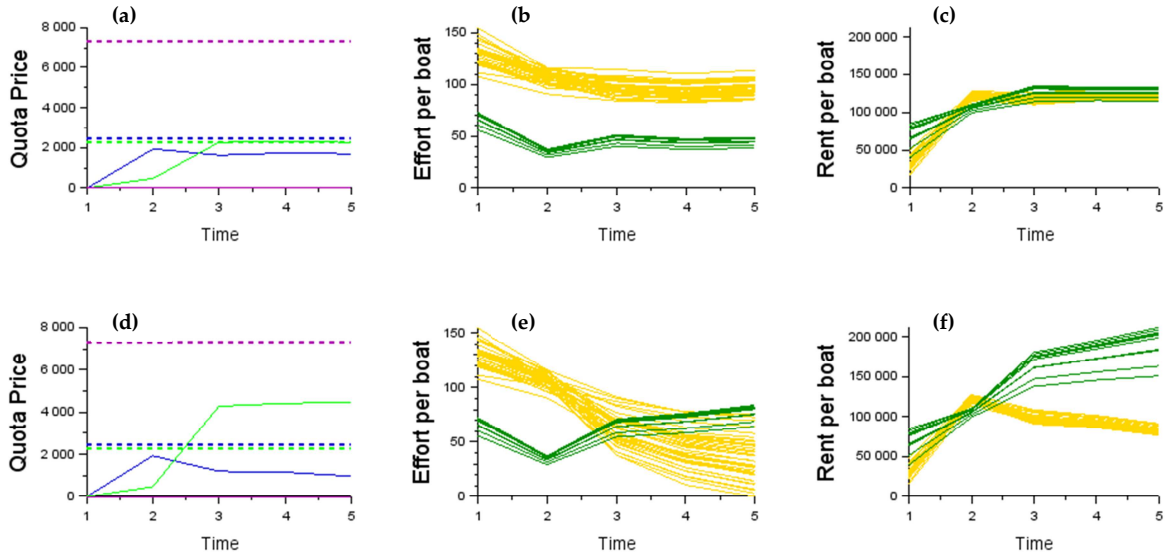

Figure 1. Top (a, b and c): discards allowed. Bottom (d, e and f) : discards banned. Quota price per species (AUD$/ton, plain line) and fish landing price (AUD$/ton; dashed line) per species (blue: Tiger Flathead, green: Morwong, purple: John Dory) in (a) and (d), fishing effort per boat (days at sea) in (b) and (e) and rent per boat (AUD$) in (c) and (f) (yellow: Trawlers; green: Danish Seiners). Total Allowable Catches set at the 2011-12 values: Tiger Flathead 2750 tons, Morwong 450 tons, John Dory 221 tons.

The model thus enables the comparison of alternative approaches to setting TACs and managing bycatch and discards in a mixed fishery. According to the results, the imposition of a discard ban on the fishery (provided it can effectively be implemented) entails significantly different fishery responses, with more variability in economic returns than without a ban. These results are of particular interest in the context of a move towards more comprehensive catch-quota management systems under the ecosystem approach to fisheries management. Further research with the model involves identifying TAC schedules across species that meet multiple sustainability criteria by which a fishery may be managed, and the inclusion of uncertainty in key economic and ecological processes.

References

Grafton, R., Arnason, R., Bjorndal, T., Campbell, D., Campbell, H., Clark, C., Connor, R., Dupont, D., Hannesson, R., Hilborn, R., Kirkley, J., Kompas, T., Lane, D., Munro, G., Pascoe, S., Squires, D., Steinshamn, S., Turris, B., Weninger, Q., 2006. Incentive-based approaches to sustainable fisheries. Can J Fish Aquat Sci 63, 699-710.

Pereau, J.-C., Doyen, L., Little, L.R., Thebaud, O., 2012. The triple bottom line: Meeting ecological, economic and social goals with individual transferable quotas. Journal of Environmental Economics and Management 63, 419-434.

Squires, D., Campbell, H., Cunningham, S., Dewees, C., Grafton, R., Herrick, S., Kirkley, J., Pascoe, S., Salvanes, K., Shallard, B., Turris, B., Vestergaard, N., 1998. Individual transferable quotas in multispecies fisheries. Marine Policy 22, 135-159.