

limit the overall catch rate — that is, to conserve fish stocks. But it would make little sense to ignore issues of efficiency when considering issues of conservation. Applied without regard to efficiency, conservative strategies tend to create fisheries that — even if sustainable — generate few benefits. The need to be cautious with regard to fish stocks is not at odds with the aim of providing fisheries that actually generate benefits.

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The live fish trade on Queensland's Great Barrier Reef: changes to historical fishing practices

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Introduction

Up until 1993, all catch from the Great Barrier Reef (GBR) commercial reef line fishery was sold as frozen fillet or whole fish, or as fresh chilled whole fish; and fish caught in Australia was sold on the domestic market, with limited amounts being exported. In 1993, the first live reef food fish were exported from Australia (McDonald and Jones 1998; Mapstone et al. 1996; Squire 1994). The practice developed slowly through 1994 and 1995 — with relatively small quantities of fish being supplied by only a few vessels — then grew rapidly in 1996 and in more recent years. For the most part, this growth has involved traditional participants in the fishery changing their holding and marketing practices, rather than the growth of a 'new' fishery.

'Live fishing' in Australia predominantly targets coral trout, particularly *Plectropomus leopardus*, with 90–95% of all live food fish exports from Australia being coral trout. Small quantities of barramundi cod (*Cromileptes altivelis*), humphead Maori wrasse (*Cheilinus undulatus*) and a number of small groupers are also exported from Australia. Selling live fish represents considerable value adding for the reef line fishery compared with selling the same product frozen. Prices for live fish have been between 40–300% greater than for the same fish dead, although prices for live fish have been unpredictable and can fluctuate on a daily basis.

The prospect of high returns for reef fish is seen as a strong incentive for Queensland fishers to enter into the live fish industry. Anecdotal information

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suggests that the high value of live reef fish already has resulted in increased numbers of people entering the industry and has raised concerns that increased fishing pressure may have detrimental effects on the GBR. These concerns were flagged with CRC Reef ELF (effects of line fishing) researchers as early as 1995, mainly from recreational fishers and conservationists, but also from some commercial fishers. Specific concerns were about the potential for increases in commercial fishing effort and resultant over fishing, with detrimental effects to the fishery and the ecosystem in the GBR World Heritage Area. Concern was also raised that live fishing effort was concentrated on reefs close to large ports with international airports, which are required for freight of the live product, resulting in potential localised depletion of fish stocks. The issue of localised concentration of effort may be complicated further because the reefs close to major population centres are the preferred fishing locations for recreational fishers, thus providing the environment for greater visibility of commercial operations and conflict between the two fishing sectors.

This controversy prompted researchers from the CRC Reef, based in Townsville, Australia to investigate this new industry. The aim of the research was to provide managers and stakeholders with information on how the change in fishing practice (from selling frozen to live fish) impacted catch rates, effort and fishing behaviour in the reef line fishery in Queensland. This research was carried out over two years (1996–1998) in the early development of the trade. The research was based on four sources of information: 1) Direct observations of fishing activities by on-board observers; 2) Analysis of research logbooks filled out voluntarily by skippers of commercial fishing operations; 3) Analysis of compulsory logbook data provided to the Queensland Fisheries Service (formerly the Queensland Fisheries Management Authority); and 4) interviews with skippers. This article highlights some of the main findings from this research project.

Background

Commercial fishing for demersal reef fish on Australia's Great Barrier Reef has been established since at least the early 1940s. The fishery harvests a wide variety of fish species, with three main target species groups: coral trout (mainly *Plectropomus leopardus*, *P. laevis* and *P. maculatus*), red throat emperor (*Lethrinus miniatus*) and spanish mackerel (*Scomberomorus commersons*) (Mapstone et al. 1996). Similar species are also the target of a large recreational fleet with access to the same reef areas. Commercial fishers fish from 3.5–6 m boats (dories)

tendered to larger primary vessels, with each fishing operation having between 0 and 6 dories, depending on the fishing license held. Fishing is done by hook and line, using 50–130 lb breaking strain hand lines with a single 7/0–9/0 hook. Fishers generally only use one line per person when fishing commercially.

Management arrangements for the fishery are complex because the fishery operates within the GBR Marine Park and World Heritage Area. As a result, it is subject to direct and indirect regulation by both state and commonwealth acts. Minimum size limits apply to a number of important target species, including coral trout, and are set to protect spawning stocks. Other regulations restrict areas where fishing can occur, and currently around 16–23% of coral reef habitats within the GBR Marine Park are protected from fishing. Destructive fishing practices such as cyanide poisoning and explosives are strictly prohibited. Commercial fishers must hold an endorsement to sell coral reef fish in Queensland. The number of these endorsements has been capped at around 1800 licenses since 1993. Fisheries regulations are strictly enforced by surveillance agencies, and despite the considerable size of the area, surveillance is reasonably efficient, using planes, boat patrols and voluntary reporting facilities.

Effort in the Queensland commercial reef line fishery has increased in recent years from around 16,800 primary vessel days in 1989 to over 27,000 vessel days in 1998. Effort specifically targeting live fish has also increased from less than 100 vessel days in 1993 to nearly 7400 vessel days in 1999. The extent to which the live fish industry has contributed to the overall increase in fishing effort is unclear, partly because of inconsistent reporting of live fishing in the early days of the industry and partly because a number of other management adjustments in related fisheries may have led to increased participation in the reef line fishery. Nevertheless, it is expected that the high price paid for live fish has provided at least part of the incentive for real increases in total commercial effort in the fishery since 1994, whether through increased effort by already active fishers or through the activation of inactive licenses.

Consequences of growth in the trade in live reef fish

Historically, line fishing effort was uneven along the tropical Queensland coast with the majority of catch and effort recorded in the Central GBR region (Townsville, Mackay and Swains regions; Mapstone et al. 1996). Live fish were first landed in the Mackay and Swains regions in 1993. Since 1996–1997, the distribution of live fishing has

spread substantially to the north and south, with a concentration of effort in the vicinity of Cairns, the location of the main international airport suitable for export of live fish. This concentration of effort may be responsible for much of the controversy about the live fish trade as Cairns also has a large recreational fishing fleet. The prospect of encounters between recreational and commercial fishers with resultant conflicts would have been high. In recent years, however, this concentration of effort has diminished with live fish now being taken from most areas of the GBR and live operations tending to fish in more remote locations.

Research on trip lengths and the distance traveled by live fishing operations on normal fishing trips provided some information on the notion that live fishers were targeting inshore reefs close to major ports. Anecdotal information provided to the research team indicated that especially in the early days of the live fish industry, poorly refined handling and holding techniques resulted in primary vessels being unable to hold live fish on board for more than five to six days. This, in addition to the fact that holding capacity for live operations is considerably lower than a similar operation keeping frozen product, meant that live operations made shorter trips than 'dead operations' and stayed closer to port. The research corroborated this commentary from fishers, showing that live operations tended to make shorter trips, remain closer to ports during trips, and spend shorter periods at fishing sites than those targeting fish for the frozen/fresh market. However, this trend may now be diminishing with better husbandry and holding techniques on fishing vessels.

Catch rates of most species of reef fish in this study tended to be less when fish were being kept alive for market than when they were being killed. This was most conspicuous for by-product species but also was true for live target species at times of maximum catch rates, indicating that keeping fish alive tended to impose lower maximum catch rates than if fishers were killing their catch. This may be due to increased handling times in the dory and other factors. Fishers targeting live fish tended to fish for shorter periods per fishing session, make more returns to the primary boat, move more often between 'hangs' (fishing sites), and spend more time searching for each fishing site than did fishers who were killing their catch. Further, fishers selling live fish were more selective about where they fished in order to maximise their catches of prime market fish, especially coral trout, rather than less valuable species that could not be sold live. Indeed, on some live fishing vessels, most species that could not be sold alive were simply not kept. Overall, operations selling their catch

alive generally landed up to half as much demersal by-product as operations killing their catch.

The size of coral trout taken also varied between live and dead fishing practices. The results, however, did not support the notion that live operations harvest significantly more small coral trout than did dead operations, despite small trout (38–45 cm total length) being preferred for the live market and fetching higher prices than larger individuals. Relatively higher rates of capture and subsequent release of coral trout under the 38-cm minimum size restriction that applies in Queensland, were observed on live trips than on trips where the fish were killed, which may be a concern if post-release mortality is significant.

Spawning aggregations

The research also found little evidence of the consistent targeting of spawning aggregations of coral trout by commercial fishers. The targeting of fish spawning aggregations has been suggested to have major detrimental impacts on fish stocks overseas due to large increases in catch rates, and disruption of spawning behaviour. Earlier studies have shown that *P. leopardus* form relatively small spawning aggregations (Samoilys 1997; Samoilys and Squire 1994; Zeller 1998) on the GBR and only about 6–10% of coral trout individuals attend such aggregations sites at any one time (Fulton et al. 2000). This would make spawning aggregations difficult to find, and the benefits from searching for them minimal. This research indicated that either deliberate targeting of spawning aggregations of *P. leopardus* is a relatively minor factor in the success of fishers on the GBR or that spawning aggregations cannot be found consistently. Hence, it appears unlikely that *P. leopardus* is at great risk from the targeted harvesting of spawning aggregations by Queensland commercial fishers, although other species that are believed to form larger, more predictable aggregations may be more vulnerable to harvest when spawning.

Conclusion

The potential exists on the GBR for the trade in live reef fish for food to be a success story, largely because of a strong regulatory environment, the absence of destructive fishing practices, and a range of management strategies that protect spawning stocks while also allowing regulation of their harvest. The trade in live fish on the GBR has not resulted in increased per capita catch rates or fishing practices that are intrinsically worse than those that have been in place in the fishery for decades. Indeed, given the significantly reduced catches of by-product species, no increase in catch rates of live target species, and added value to the

industry, the transition from frozen to live markets for GBR reef fish might be seen as positive development in both economic and ecological terms. On the other hand, the increased prices paid for live fish are likely to have provided at least part of the incentive for real increases in effort seen in the fishery since 1994. Any potential benefits of the live fish industry, such as reduced catch rates, especially of by-product species, that can be sustained by individual fishers due to value adding on the live product, may be offset by overall increases in effort. Prudent management action is advisable, therefore, to control effort adequately and avoid real or perceived stock depletions, either locally in areas close to ports and population centres or more widely, and economic hardship in the fishery.

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An economic analysis of the spawning aggregation function in Komodo National Park, Indonesia

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Abstract

This study provides an economic valuation of the demersal fishery spawning aggregation function in Komodo National Park. A parametric generalised single-period model is developed to assist in modeling and estimating the value of the fishery linkages. For a linear function, the maximum value of the spawning aggregation function is calculated to be USD 629,000 annually at 100% protection of the spawning sites. This is of a similar order of magnitude to the direct recreational values associated with the park.

Introduction

Komodo National Park (KNP) is widely recognised as an exceptional storehouse of both terrestrial and marine biodiversity with global significance.

Established in 1980, it is listed as a World Heritage Site and a Man and the Biosphere Reserve. Located between Sumbawa and Flores Islands in eastern Indonesia, the park consists of three main islands, Komodo, Rinca, and Padar and several smaller