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Targets and Fisheries Management in the Asia and Pacific Region

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Abstract

Marine fisheries in the Asia and the Pacific region play an important role in global, regional and national economies. Many of the fisheries in the region are over-exploited, both biologically and economically. We focus on the use of appropriate fishery targets, and the importance of tying those targets to management objectives to overcome the usual and unwanted negative externalities that occur in ocean fisheries, the ones that result in substantial over-fishing. Of particular importance is the use of a maximum economic yield target for both short- and long-lived species. Maximum economic yield, when combined with appropriately designed marine protected areas, or marine reserves, not only provides maximum profitability and generally larger and more 'conservationist' stocks of fish, but it also ensures a measure of resilience from stochastic shocks that may negatively impact the fishery. It remains the preferred target for most fisheries in the Asia and Pacific region.

Key words: fisheries targets, maximum economic yield, maximum sustainable yield, Asia and the Pacific, fisheries management

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1. Introduction

Marine fisheries are an important part of the world's economy, with a total catch of 80 million tons of fish in 2009, and providing 34 million jobs and nutrition to at least three billion people in 2008 (FAO 2010). Forty per cent of the world's marine fisheries are located in the Asia and the Pacific region, covering three main fishing zones—the Northwest Pacific, the Western Central Pacific and the Southwest Pacific—with a combined total surface area of 80.6 million km^2 and a catch of 31.8 million tons in 2009 (Bianchi & Fletcher 2011; Yatsu & Ye 2011; Ye 2011). Marine fishing activities contribute a sizeable share of income to the gross domestic product (GDP) of many countries, especially small Pacific island countries, where fish production accounts for as much as 60 per cent of GDP.

Recognising the importance of these marine resources and the 'tragedy of the commons' associated with them—without regulation, the tendency for overexploitation and dissipated rents or returns to the fishery—has resulted in a significant desire to manage these fisheries more properly. Unfortunately, success has been limited. For example, in the Northwest Pacific zone, with three management agreements among Japan, China and the Republic of Korean in place, 3 out of the 17 species (or groups of species) have been classified as overfished (FAO 2011). In the Western Central Pacific zone, where many countries have established fishing 'management areas', many of the key species remain overexploited, especially high-value species like big eye and yellowfin tuna (Kompas et al. 2010). In the South, where Australia and New Zealand are key participants, three key species are overfished. The failings of fisheries management in these cases are generally due to complicated transnational governance arrangements, poorly performing catch targets, and the loose connection between management targets and the instruments used to obtain them (Grafton et al. 2006a; Kompas & Che 2006; Kompas et al. 2010; Yatsu & Ye 2011).

In order to obtain more effective management outcomes, some management authorities have imposed a maximum sustainable yield (MSY) target. MSY is defined as the maximum sustainable catch of a species, essentially drawing off net additions to the stock of fish, guaranteeing that the resource is not depleted over time. This concept is appealing, so much so it is explicitly stipulated as the appropriate target in existing global treaties on fishing (for example, United Nations Convention on the Law of the Sea, Food and Agricultural Organization (FAO) Code of Conduct for Responsible Fisheries) and at the regional level by the largest fisheries management authority, the Western and Central Pacific Fisheries Commission (FAO 2013), as well as being supported by some notable marine researchers (for example, Christensen 2010).

While MSY is clearly a target that can guarantee the sustainability of a resource, it is also clear that this target does not maximise the economic benefits from fishing. MSY is a parameter intrinsic to the biology of a species. It is not connected to the fundamental economic incentives that result in fishing activity, for example, how much it costs to have fish landed and how much we value the fish when caught. This lack of economic fundamentals in the MSY target not only diminishes its appeal but also results in an economically inefficient allocation of resources. In terms of the economics, at given fish prices, the target would only be correct when and if the cost of fishing is zero or constant as fishing effort increases, both of which are a practical impossibility.

When it comes to the sustainability objective itself, MSY is also not the best among the many targets that guarantee sustainable outcomes. In fact, any target that maximises the long-term economic benefits from fishing will have to meet a sustainability objective, simply because the economic incentives for fishing vanish when the stock of fish becomes too low and cost of fishing rises considerably (Grafton et al. 2007, 2010). Moreover, it has been shown that the stock that generates the maximum economic yield (MEY)—a target that creates the largest difference between discounted revenues and costs over time—is usually well above the stock of fish consistent with MSY (Grafton et al. 2011). MEY, in other words, results in larger stocks of fish and is thus a better target than MSY in terms of both the economics and the goals of marine conservation.

In the following sections, we will address some key points with regard to targets for marine fisheries in the Asia and the Pacific region. We will first summarise four of the aspects associated with a ‘tragedy of the commons’ in fisheries (often referred to as ‘externalities’), and then analyse how an appropriate target needs to respond to these externalities. Our objective is not to make light of the technical and practical complications needed to determine a proper target from an optimal fishing model (Dichmont et al. 2010), but rather to confirm that an appropriate target for fisheries management should provide a more direct and clear connection between management objectives and the associated management target. This will always involve connecting the biology of the fishery to its economics.

2. Externalities in Fisheries Exploitation

Externalities in fisheries occur when the harvesting activity of a single fisher has negative impacts on the rest of the fishing community (and even the society as a whole), and where these impacts are not fully taken into account in the individual decision to fish. There are four types of externalities, and each of them, if present, must be taken into account when determining the best fisheries target.

2.1 Stock Effects

The stock externality is the one most often mentioned in fisheries research and present in all fisheries, at least at some point in their evolution. It arises when the catch of any fisher reduces the stock of fish and thus lowers the current catch rate for the remaining fishers. In other words, an increase in the catch by one fisher will, under these circumstances, make fishing harder and more costly for others. This effect occurs especially at low or already 'fished-down' stock levels.

2.2 Congestion Effects

In some fisheries, fishing activity is especially concentrated in small or restricted areas and times of the year. In these cases, it is common for congestion effects to occur, with obstructions in fishing lines and increased costs associated with proximate fishing activities resulting in delays and added costs. Salmon fisheries in the Pacific coastal fisheries in North America and long-liners in the North Atlantic, where fishing activity can be intense and often concentrated in a very few days, often experience this effect.

2.3 Dynamic Effects

Another externality, also commonly mentioned in fisheries research, is the dynamic effect of an individual catch. This externality occurs when the catch in 1 year affects the stock available in the following years, principally through altering the recruitment process or by reduced amounts of spawning stock. Unlike the stock effect, the dynamic externality does not always exist in every fishery. For species with a short lifespan, for example, it is often the case that a catch in any given year does not affect the stock in subsequent years. Shrimps and prawns in the Western Central and Southwest Pacific fishing zones are practical examples of this kind of short-lived species.

2.4 Price Effects

The third externality that an individual fisher imposes on the fishing community as a whole is through changes in the price of fish. Fish, like many other consumption goods, is subject to a law of demand that stipulates that consumers are only willing to pay less for any additional fish supplied or brought to market. The law of demand, thus, implies that an increase in the catch by any one fisher will reduce the average price paid to others. This price externality depends on how responsive the price of fish is to catch. A so-called elastic price elasticity of demand will result in a large price effect, where a moderate increase in the catch will result in a substantial reduction in the price. On the other hand, if the price of fish is relatively insensitive to the catch, the effect will be small.

2.5 Technology Effects

Technological progress in the harvesting sector will likely increase catchability, making fishing costs comparatively cheaper and often increasing the incentive to expand fishing effort, as other vessels race to use the new technology (Squires & Vestergaard 2013). The extent of this externality depends on the regulatory instrument in place. In fisheries managed by effort controls, in particular, technological change results in increases in fishing power, 'effort creep' and decreases in the stock of fish. In systems regulated by individual transferrable quotas, or ITQs, on the other hand, the effect is simply to lower costs and increase profitability (Grafton et al. 2006a). The catch target maintains stocks.

2.6 Uncertainty Effects

The fourth externality is that which results from the uncertain effects from harvest that impact the fishery. Fish stocks are always subject to uncertainties, both positive and negative. Weather effects are a good example. But harvesting activities may also increase the probability and magnitude of negative shocks to the fishery. The negative shocks can originate not only from directly harmful activities, such as trawling near the ocean floor, discarding of fish or the spread of disease, but also from accidental occurrences in the fishery. Evidence for such effects can be found in Goni (1998), Turner et al. (1999) and Jennings et al. (2001).

3. Dealing with Externalities with the Right Target

Externalities, if not appropriately managed or regulated, will result in an inefficient expansion of fishing effort and a drain of economic rent from the marine resource. What is the best management target to effectively deal with these externalities? Specific calculation of the optimal target often requires technical bioeconomic models, but it can also sometimes be as simple as calculating a breakeven point to maximise profitability (for example, Kompas & Chu 2013). Nevertheless, the fundamental principles in determining the best target for fisheries management are clear.

3.1 MSY and MEY

There is an ongoing debate about whether MSY is the most economically efficient target not only for the fishery, but for the society as a whole. For example, Christensen (2010) claims that, given the importance of the offshore processing of fish in the value chain, MSY will maximise the social benefit. But both Grafton et al. (2011) and Sumaila and Hannesson (2010) provide clear counterexamples. Grafton et al. (2011), in particular, using an MEY model that both incorporates offshore processing and accounts for consumer surplus from the sale of fish, emphasise that the stock of fish at MSY is generally too small to ensure that fishing costs are at the socially optimal level. The cost of fishing at MEY compared with MSY is lower, put simply, since fish stocks are larger. A similar conclusion is drawn from Sumaila and Hannesson (2010), who show that in an economy where all resources are fully utilised, further value added in the value chain for fish is an additional cost and has the effect of reducing fishing effort and optimum yield, rather than increasing it.

All practical bioeconomic models have, thus far, drawn the conclusion that the fishing effort that maximises the total benefit at MEY is usually smaller than the effort required to maintain the resource at MSY (Kompas et al. 2010; Grafton et al. 2011). This is a result of the stock externality, or the stock effect, that implies that the catch rate deteriorates when the stock of fish falls. For long-lived species, in particular, with dynamic effects, sustainable outcomes can be obtained only if catch is sustainable (at intrinsic growth rates), and the economic surplus associated with each sustainable outcome depends not only on the catch (revenue) but also on fishing effort (cost). Without effective management to guarantee this outcome, externalities would induce an effort expansion until all economic profit is either gone or at least smaller than at MEY. If price effects are present, this is doubly important, since harvests larger than MEY can, in this case, lower price and thus revenues.

This too is why targeting fisheries at MSY does not maximise the surplus from a marine resource, unless fishing costs are zero or constant with increases in effort, and the price of fish is fixed. While generating the highest sustainable catch (and hence revenue), MSY fails to take into account how much cost must be incurred to land the expected level of catch, as well as the effect of potential changes in the price of fish with changes in catch. Furthermore, starting from MSY, a reduction in the effort will cause both revenue and costs to fall, but the cost of fishing generally falls faster due to the stock and dynamic externalities. The exact position for optimal and sustainable harvest depends on specific parameters, but a 'win–win' outcome where both net surplus and fish stocks are larger than those at MSY is common in practice.

The only factor that can possibly reverse this effect is the interest rate (Grafton et al. 2007; Chu et al. 2013). In a fishery with an existing small stock, a relatively large interest rate discourages fishers from waiting until stocks are rebuilt before fishing. Likewise, in a fishery with an existing abundant stock and low rates of biological growth, a high interest rate creates an incentive for fishers to quickly fish down a stock of fish, especially in cases where the interest earned in the 'bank' exceeds the biological growth rate of fish. However, the influence of the interest rate is limited. Low growth rate fish stocks are expensive to find and harvest when stocks are low, and the interest rate rarely overcomes the effect of falling stocks on the cost of fishing; the cost of fishing and the stock effect always dominate. Grafton et al. (2010, 2011) nicely show this effect, demonstrating that under reasonable conditions, optimal fishing effort is always smaller than that at MSY, regardless of the interest rate. These exact conditions are met in many fisheries, including those for the most valuable tuna species in the Asia and the Pacific region (Kompas et al. 2010).

3.2 Targeting Long-Lived versus Short-Lived Species

The difference in the dynamic effects between a long-lived and a short-lived species should be considered when determining a management target. The stock of a long-lived species, with significant dynamic effects in place, will be very much subject to a catch history, along with environmental factors. Therefore, the right target for a long-lived species must take into account the dynamic effects of fishing. This requires the construction of a dynamic bioeconomic model (for example, Kompas et al. 2010, 2011).

A short-lived species, on the other hand, is free from dynamic effects, but that does not imply that determining a target for short-lived species is easy. Stock levels for most short-lived species are often affected by such things as the weather and other environmental factors, and the catch target must reflect this. The challenge here is that while it is relatively straightforward to qualitatively evaluate what are good and bad 'weather states', quantitative forecasts on how these states will influence the exploitable biomass or stock of fish are much harder to calculate.

Recent studies suggest ways to overcome this challenge. Statistical models (for example, Zhou et al. 2008; Venables et al. 2011; Buckworth et al. 2014) and mathematical models (for example, Kompas & Chu 2013) have been developed to determine the quantitative relationship between maximum available catch and factors such as rainfall, river flows and other environmental conditions. This work can help predict the optimal catch given how the weather and environmental factors unfold overtime, thus providing an accurate prediction of optimal catch for a short-lived species contingent on weather data. The techniques are complicated here, but of good use to fisheries managers in Asia and the Pacific. In terms of the catch target, this is straightforward: with an absence of stock and dynamic externalities, MEY is preferred. It simply and clearly maximises profit.

3.3 The Role of Marine Protected Areas (MPAs) in Fisheries Targeting

MPAs have been a valued conservation measure for some time. These reserves act as an important tourist destination and facilitate research into ocean effects and ecosystem design. It was first thought that MPAs would lower the economic benefit or profit from fishing, simply because they restrict the fishing opportunities that would otherwise be available without the reserves. However, a recent strand of research has found that no-fishing zones can instead improve economic profitability in environments where fish stocks are subject to the externalities that stem from the effects of uncertainty.

MPAs, when appropriately enforced, provide two economic benefits. First, they reduce the vulnerability of the fish stock to harmful shocks, directly or indirectly caused by fishing activities, since the stock of fish inside the protected areas is largely exempt from the fishing-related activity. Second, and perhaps more importantly, fish stocks inside MPAs act as an important buffer to negative shocks in the fishery, allowing for a transfer of fish from the reserve to the fishing area. Fish stocks inside MPAs, in other words, where population density is higher, will migrate to fishing areas and help the exploitable stock and catch recover more quickly after a shock (Grafton et al. 2005, 2006b). This buffer effect is precisely why profits are higher with MPAs, even though some parts of available fishing grounds are closed. Evidence for these kinds of benefits is already available, and highlighted, for example, by effects of weather-induced shocks for some species in the Northwest Pacific zone (Yatsu & Ye 2011), and from the concerns over the damages from longer term climatic effects on surface temperatures and ocean acidification (Bahri & Cochrane 2011). A recent study (Chu et al. 2013) suggests that the flexible management of MPAs (that is, changing their location and the temporary opening of an MPA) may make profitability even larger with reserves.

4. Conclusion

The important role of marine fisheries in the Asia and the Pacific region makes it essential to effectively manage them and to clearly connect catch targets to management objectives. While acknowledging the technical complexities in determining a perfect target, we emphasise that effective management must be able to reflect the true costs and benefits obtained from the use of the fishery. Approaches to determining an effective target in practice vary enormously, contingent on the kinds of negative externalities existing in each specific situation. But one of the fundamental principles we find is that conservation measures are most often (and should be) consistent with economic objectives.

In this sense, MEY is a crucial choice for most fisheries in the region. First, a MEY target maximises profits (or resource rents) regardless of changes in the price of fish or the cost of fishing. Profits may be low when the price of fish is low and costs high, but they will still be maximised under this target. With the right instrument in place, a MEY target will also ensure that the costs of harvesting are minimised at the MEY target level, improving the international competitiveness of regional fisheries. Second, a MEY target is a sustainable harvest, and as such is preferable to a MSY. If sustainability is the goal, as it should be, it makes sense to select a sustainable yield that guarantees the largest resource rents or profitability regardless of market conditions. Depending on prices and costs, profits can be zero or even negative at MSY. Third, at most biological growth rates, as well as practical discount rates and costs of harvesting, a MEY target will imply a stock of fish larger than that consistent with MSY. In this sense, MEY is more 'conservationist' than MSY, and provides additional environmental benefits and added resilience to unforeseen environmental and harvest-related shocks to the fishery.

All that is required is sufficient data to determine an MEY target. For short-lived species, this may simply involve data on prices and the costs of fishing. In more complicated fisheries, estimates of the stock–recruitment relationship are also needed. If unavailable, harvest-control rules, such as stock values that are a given percentage larger than MSY, or rules that establish fishing limits as some maximum fraction of estimated 'virgin biomass', may also be sufficient.

Of course, an effective fishing target must also be holistic and adaptive. It must take into account stochastic effects from weather and the unintended harmful effects and uncertainties that go with fishing activity. This is why MPAs are so important to any management plan. When properly designed, they also, with MEY, help achieve the maximum sustainable benefit from our marine resources.

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References

Bahri T, Cochrane K (2011) *Climate Change Impacts on World Fisheries Resources*. Review of the State of World Marine Fishery Resources, FAO, Rome.

Buckworth R, Venables W, Lawrence E, et al. (2014) *Incorporation of Predictive Models of Banana Prawn Catch for MEY-based Harvest Strategy Development for the*

Northern Prawn Fishery. Fisheries Research and Development Corporation, Project 2011/239, CSIRO Marine and Atmospheric Research, Brisbane.

Christensen V (2010) MEY = MSY. *Fish and Fisheries* 11, 105–10.

Chu L, Kompas T, Grafton RQ (2013) *Impulsive Controls: Method and Application in Economics*. Working Paper, Australian Centre for Biosecurity and Environmental Economics, The Australian National University, Canberra.

Dichmont C, Pascoe S, Kompas T, Punt A, Deng R (2010) On Implementing Maximum Economic Yield in Commercial Fisheries. *Proceedings of the National Academy of Sciences* 107, 16–21.

FAO (2010) *The State of World Fisheries and Aquaculture 2010*, Rome.

FAO (2011) *Review of the State of World Marine Fishery Resources*, Rome.

FAO (2013) *Western and Central Pacific Fisheries Commission (WCPFC)*, viewed July 2013 <http://www.fao.org/fishery/rfb/wcpfc/en>.

Goni R (1998) Ecosystem Effects of Marine Fisheries: An Overview. *Ocean and Coastal Management* 40, 37–64.

Grafton RQ, Arnason R, Bjorndal T, et al. (2006a) Incentive-Based Approaches to Sustainable Fisheries. *Canadian Journal of Fisheries and Aquatic Sciences* 63, 699–710.

Grafton RQ, Kompas T, Che TN, Chu L, Hilborn R (2011) B_{MEY} as a Fisheries Management Target. *Fish and Fisheries* 13, 303–12.

Grafton RQ, Kompas T, Chu L, Che N (2010) Maximum Economic Yield. *Australian Journal of Agricultural and Resource Economics* 54, 273–80.

Grafton RQ, Kompas T, Ha PV (2006b) The Economic Payoff from Marine Reserves: Resource Rents in a Stochastic Environment. *Economic Record* 82, 469–80.

Grafton RQ, Kompas T, Hilborn R (2007) Economics of Overexploitation Revisited. *Science* 318, 1601.

Grafton RQ, Kompas T, Lindenmayer D (2005) Marine Reserves with Ecological Uncertainty. *Bulletin of Mathematical Biology* 67, 957–71.

Jennings S, Dinmore T, Duplisea D, Warr K, Lancaster J (2001) Trawling Disturbances Can Modify Benthic Production Process. *Journal of Animal Ecology* 70, 459–75.

Kompas T, Che TN (2006) Economic Profit and Optimal Effort in the Western and Central Pacific Tuna Fishery. *Pacific Economic Bulletin* 21, 46–62.

Kompas T, Chu L (2013) *MEY for Short-Lived Species: A Neural Network Approach*. Working Paper, Australian Centre for Biosecurity and Environmental Economics, The Australian National University, Canberra.

Kompas T, Che TN, Chu L, Klaer N (2011) *Transition to MEY Goals for the Great Australian Bight Trawl Fishery*. Report to Fisheries Research and Development Corporation, Project Report, Australian Centre for Biosecurity and Environmental Economics, Crawford School of Economics and Government, The Australian National University, Canberra.

Kompas T, Grafton RQ, Che TN (2010) Bioeconomic Losses from Overharvesting Tuna. *Conservation Letters* 3, 177–83.

Squires D, Vestergaard N (2013) Technical Change in Fisheries. *Marine Policy* 42, 286–92.

Sumaila U, Hannesson R (2010) MEY in Crisis? *Fish and Fisheries* 11, 461–5.

Turner S, Thrush S, Hewitt J, Cummings V, Funnel G (1999) Fishing Impacts and the Degradation or Loss of Habitat Structure. *Fisheries Management and Ecology* 6, 401–20.

Venables W, Hutton T, Lawrence E, et al. (2011) *Prediction of Common Banana Prawn Potential Catch in Australia's Northern Prawn Fishery*. Final Report. Prepared for Australian Fisheries Management Authority, CSIRO, Brisbane.

Yatsu A, Ye Y (2011) *Northwest Pacific in Review of the State of World Marine Fishery Resources*. FAO, Rome.

Ye Y (2011) *Southwest Pacific in Review of the State of World Marine Fishery Resources*. FAO, Rome.

Zhou S, Vance D, Dichmont C, Burridge C, Toscas P (2008) Estimating Prawn Abundance and Catchability from Catch-Effort Data: Comparison of Fixed and Random Effects Models Using Maximum Likelihood and Hierarchical Bayesian Methods. *Marine and Freshwater Research* 59, 1–9.

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