Incorporating social objectives in evaluating sustainable fisheries harvest strategy

Wu, Jiafeng, Wang, Na, Hu, Zhi-Hua, Hong, Zhenjie and Wang, You-Gan

Incorporating social objectives in evaluating sustainable fisheries harvest strategy

Jiafeng Wu[1], Na Wang[2], Zhi-Hua Hu[3] , Zhenjie Hong[4*] and You-Gan Wang[2*]

[1] *School of Applied Mathematics, Nanjing University of Finance and Economics, Nanjing, China*

[2]*School of Mathematical Sciences, Queensland University of Technology, Queensland 4000, Australia.*

[3] *Logistics Research Center, Shanghai Maritime University, Shanghai 201306, China*

[4*] *College of Mathematics and Physics, Wenzhou University, China*

You-Gan Wang, D.Phil (Oxford)
Professor in Data Science
School of Mathematical Sciences
Science and Engineering Faculty
Queensland University of Technology (QUT), Australia
http://www.researcherid.com/rid/A-6059-2008
Tel: +61 7 3138 5224

Abstract Fisheries management must take account of environmental sustainability, economic profitability and social benefits generated by the public resources. The traditional approach of maximum economic yield (MEY), however, is yet to consider social objectives in deriving quantitative quotes. Current MEY evaluation framework would be appropriate if the economic rent were distributed back to the public. If public resources are privatized as corporations, the rent largely flows to the owners of large capital in the fishing industry. This is in stark contrast to the aims of benefiting the community as a whole. In this short paper, we promote a socially responsible framework in decision-making of fisheries management. This approach is beyond the fleet-based MEY approach, for it incorporates fleet profitability, chain profitability, employment, environmental concerns and broad social benefits, in strict accordance with stock sustainability. Recognising the needs of fishers, as well as the interests of chain sectors and the broader community is a vital part of ensuring responsible fishery management and a viable future for Australian fisheries. The established framework will provide open view scenarios and enrich the MEY approaches in fisheries management.

Key words**:** fisheries, value chain, maximum economic yield, social responsibility, social benefits and impacts

Introduction

Making society better off

In Australia, the general policy is to ensure the commercial fishing industry contributes to Australia's economy, society and environment. Maximum economic yield (MEY), which is deemed as the most efficient harvest reference point, is highly promoted and adopted. Where possible, the Australian Fisheries Management Authority (AFMA) applies MEY harvest strategy targets to key fish stocks in Commonwealth managed fisheries. However, the current MEY approach is based on fishing fleet, which considers only total revenues and the total costs of fishing.

The Australian Commonwealth Fisheries Harvest Strategy Policy and Guidelines (DAFF, 2007) clearly stated that the proclaimed management objective is “maximising net economic returns to the community, within the context of ecological sustainability”. This policy has required consideration of social impacts when managing fisheries. In fact, the importance of social objectives in fisheries management has been more and more recognized by fisheries researchers, economists, and policy makers in recent years. And many published works (Pascoe et al., 2013; Pascoe et al., 2014; Brooks et al., 2015) has discussed social objectives for either state or Commonwealth fisheries of Australia. Yet, there has been a lack of framework and challenges in quantifying the whole chain-based MEY for all sectors incorporating social objectives to derive harvest strategies, especially for the MEY approach.

Australia's oceans are some of the richest in species and most diverse on our planet (https://www.australiangeographic.com.au/news/2010/08/australian-oceans-are-most-biodiverse/). However, the oceans do not seem rich at least in terms of harvested stock per unit area, which may due to over-cautious approaches. A catch of more than 8 million tonnes has been reported for 1950-2010 to the United Nations Food and Agriculture Organisation.

Fleet-based MEY

MEY has been identified as a primary management objective for Australian fisheries

and is under consideration elsewhere (Dichmont et al., 2015). The existing approach of MEY, is fleet-based and used to authorize the profit-making of the fishing industry being a priority. One example is the Northern Prawn Fishery (NPF) in Australia, which is a multi-species tropical prawn fishery. Before 2000, the fishery had approximately 250 vessels in 1980s and 120 vessels in 1990s. The sustainable catch for the tiger prawns alone was estimated as 4,000 tonnes (Wang and Die, 1996). A bio-economic study framework based on yield per recruit was also established to determine the fishing effort and season closure dates by Somers and Wang (1997). However, due to a number of reasons its value is halved since the fleet-based MEY approach was implemented. Apart from the falling prawn prices, another key contributing factor is the total catch has been drastically reduced (as the total number of vessels is only 52). This makes people wonder if the fleet-based MEY approach should be modified towards MSY so that more catches are allowed to benefit public instead of just the income for the fishing industry (Wang and Wang, 2013).

While Australia targets maximum MEY, our next door neighbor country New Zealand targets maximum sustainable yield (MSY). The MEY approach is to consider the fishing efficiency for the benefit of the fishing industry while the MSY approach is from biological perspective that determines the limit amount we can remove each year. For an excellent review on this topic, see Bromley (2009), Christensen (2010) and Sumaila and Hannesson (2010). Bromley (2009) has provided rigorous justification for why fleet-based MEY is not the same as “making society better off”. Pascoe et al. (2016) recently shared their experience in Australian fisheries and compared with New Zealand fisheries managed by a counterpart approach.

When applying fleet-based MEY, government resource was devoted to increase the profit of a few companies which have a de-facto monopoly on the resource. This approach is appropriate if the resource rent is fully collected by the government and redistributed to the society. This is partly achieved by collecting license fees of the fleet, but not going far enough. There is an urgent need to develop a framework, to

fundamentally answer a key question: which side we stand for and whose benefit we are maximizing for. The fundamental problem here is the disconnection between objectives at the policy level (e.g. the Commonwealth Fisheries Harvest Strategy Policy, HSP) and the actual management at operational level. In the HSP, MEY means "maximising net economic returns to the community, within the context of ecological sustainability", which appears to be socially responsible. However, at operational level, MEY is estimated purely based on fleet profitability ignoring the HSP objective. As to how the benefit should be distributed among the public that consists of different cohorts with different interests in different sectors, how the benefit flows should be modeled and the total benefit for the whole society should be maximized, not just the gain for a particular sector. This is the focus of our discussion. The established society-based MEY would provide an open view on fisheries management that subject to more discussions among fisheries modelers, economists, and policy makers. The essential characteristic of this approach is to have the community's interests clearly defined and incorporated.

Conflicts in the objectives

There has long been a debate over the issue of maximizing economic efficiency (for fishing companies) versus community benefit in fisheries. Currently, the social concerns have been overwhelmed by arguments and criticisms from fisheries economists, who set social responsibilities (such as job creation and other happiness impacts) against "efficiency". The current fleet-based MEY approach stops the benefit flow to other sectors, and does not account for the benefit drained from the community either. This might be the worst welfare-economic deal possible for the community, who does not benefit from the use of their public resources (i.e. the fish stocks), but also

pay a higher prices for seafood because supply is maintained artificially low.

Including social objectives in management decisions is not necessarily conflicting with managing for healthy stocks and good economic returns. The framework we established here makes it possible to balance environmental, social and economic goals.

Methods

Fleet-based MEY versus value chain-based MEY

Applying social responsibility in fisheries management requires accounting for all interests in our community, when determining the optimal harvest level. The cost or gain must be dealt with carefully; one person's cost can be another person's gain (cf. Table 1). In fisheries, the income for the fishing industry is (Grafton et al., 2008),

$$R(Y) = PY - C(Y, E),$$

where Y is the yield, P is the average fish price, E is the fishing effort, C is the total cost including labour, processing, fuel, license and whatever the fixed or variable costs are. Here the sustainable yield Y is generally calculated from the stock assessment models (i.e. MSY analysis) and as an input in the model. The fleet-based approach only considers cost in the fishing industry (Table 1).

Suppose n_v is the number of vessels. Under fleet-based approach, the income for the government is $n_v \times c_L$, where c_L is the license fee. Company tax paid on the resource rent gifted to companies by the Commonwealth is also taxed by the Commonwealth. So the same jurisdiction receives the tax. But note that this tax doesn't occur in Australian state fisheries.

Now let us expand the domain. We define a multiplier effect γ, which is the market price of fish. The total value of processed fish products increases from one sector to the next in the value chain, ending with consumers who bear the final cost for their consumption. γ consists of $\gamma_1, \gamma_2, \ldots, \gamma_n$, depending on how many sectors (n) involved in the chain, from dock-side to dinner table. The net revenue in each sector

149 starting from fleet is,

150 $$R_0 = P_f Y - C_0,$$

151 $$R_1 = \gamma_1 P_f Y - P_f Y - C_1,$$

152 $$R_2 = \gamma_1 \gamma_2 P_f Y - \gamma_1 P_f Y - C_2,$$

153 $$\vdots$$

154 $$R_n = \gamma_1 \gamma_2 \dots \gamma_n P_f Y - \gamma_1 \gamma_2 \dots \gamma_{n-1} P_f Y - C_n.$$

155 Here P_f is the dock-side fish price, and C_0 is the cost in the fishing industry.

156 In intermediate sectors, besides the large cost of buying fish stocks, other costs
157 includes labor costs, the price of buying other goods and services, and taxes. If, we
158 simply assume the average cost proportion in each intermediate sector to be p, we
159 have,

160 $$R = R_0 + R_1 + \cdots + R_n = [(1-p)(\ \gamma - 1) + 1] P_f Y - C_0,$$

161 where $\gamma = \gamma_1 \gamma_2 \dots \gamma_n$ and p is always between 0 and 1. When $\gamma \gg C_0 / P_f Y$, the MEY
162 becomes almost the same as the MSY level. In the case of $\gamma = 1$, it becomes the
163 fleet-based approach.

164 The parameter γ extends the scope beyond fishing sector; the gross revenue from
165 the community perspective is γPY. As there is always value added through the
166 processing and marketing chain (i.e., a profit for each sector) for the sectors to remain
167 viable (Bromley, 2009), this results in $\gamma > 1$. The economic (multiplier) effect of
168 fisheries in Australia was 5.79 (Sumaila and Hannesson, 2010).

169 Sumaila and Hannesson (2010) argued that one has to take into account the
170 productive resources necessary to obtain a product for some end use. Obviously
171 more fish needs more handling and processing, which means more cost. Normally,
172 the additional cost will be covered by next sector who buy fish from the fish wharf. If
173 fishing industry pay for the cost, it means they earn less economic rent. At an extreme
174 case, $P_f Y = C_0$, the fishing industry will earn no economic rent; and $p = 1$, all chain
175 sectors make no extra profit. Bromley (2009) pointed out, even under that situation; all

sectors still make normal profit (including salaries and all operating cost). Note that collecting economic data and conducting bioeconomic modelling also incur substantial additional costs.

The benefits of applying social objectives

People

Employment is a shadow profit but is often treated as a cost. But it is not a cost to the society. Actually, the social performance of fisheries has been measured mainly through the use of income and employment figures. The fishers' income, which is clearly a labor cost for the fishing industry, is also a source of income for the fishers. From the society viewpoint, the crew cost is like moving money from the left hand pocket and putting it back in the right hand pocket. Applying the society-based MEY approach also maintain/create jobs in fish chain sectors. Some may worry that additional catch would result in drop in dock-side price (P_f). In that case, the broader community consumers would be benefited.

Government

Let us look at the economic rent collected by the government. Under fleet-based approach, the income is from license fee and taxes. Commercial fishers pay a license fee to access a particular marine resource and pay for the right to own quota units of a particular species. These fees are often substantial as they support management, compliance, and research in that fishery. That license fee is even not a real 'cost' to the fishing industry – the money has been put back into fisheries and benefit fisheries. When society-based MEY is applied, part of the rest economic rent (not collected by the government) flow into other sectors. Especially for the fisheries dependent sectors such as processing, distribution, and retail. Because the fleet-based MEY approach does not adhere to the objective described in the high level policy, we recommend to incorporate societal benefits to better achieve the management objective at operational level. For example, if MEY is close to MSY, the simple approach may be to

adopt MSY as a limit rather than as a target. Setting MSY as a limit has been widely recognized outside Australia.

Discussion

The fleet-based MEY approach has kept the fishing effort at a low lever and stopped "rent drain" to the society, with the consequence of low economic effect in the board economy. It is true that when the fisheries collapse, the fishing sector would perish and fishermen would have to find alternative employment. However, fishermen, and particularly those with vertically integrated businesses, place a lot of value on certain skilled employees, who play various roles within the company. In reality, businesses often continue to operate long into overdraft situations in an attempt to retain staff and keep their businesses operating. That is not what we promote. We argue for extra caution when lowering fisheries employment, when the fish stocks are considered healthy.

Some may argue that the fish caught by the fishing industry in Australia is sold to international consumers thus it makes no sense to increase the captures of fish to benefit the other sectors. Even for fish stocks which would export, benefits are not at maximum from the social perspective. Fleet-based MEY is a suitable reference point only when the resource rent is fully collected by the government and is used to benefit the society. However, under current situation where large resource rent is collected by private companies, extending fleet-based MEY to a broad MEY would help re-distribute the resource rent in the economy. Fleet-based MEY is benefiting the fishing companies by exploiting public resources. Controls and regulations by government are needed on commercial exploitation of fish resources - as a government function. Employment costs are absorbed in a sense when using a social benefits model, while the employers will argue against the social benefits model because their benefit will partially flow to the society due to more employment. In Australia, the total allowable catches (TAC) are obtained from fleet-based MEY and then individual transferable quotas (ITQs) are allocated. A TAC management strategy

231 imposes an extra risk of overfishing due to natural and fishing induced variability in
232 stocks (Hsieh et al., 2006). For this reason, input controls are more sensible. Stock
233 assessment should be modified to account for the great natural variability in
234 abundance, high reproductive potential, and resilience of marine fishes, relative to
235 other taxa (Beddington and May, 1977; May et al., 1978; Hutchings, 2000).

236 Globally, many fish stocks have been depleted due to overexploitation, pollution, and
237 habitat loss (Ye et al., 2012). In open access fisheries, fishing often reaches or even
238 goes far beyond a cost neutral position before it stops. Government subsidies are
239 often granted to fisheries when the margin is low or negative, especially in developing
240 countries. Thus, the precautionary approach was introduced to limit lost yield to
241 overexploitation. It can be criticized that government assistance to unprofitable
242 fisheries would result in government funds being diverted to inefficient uses
243 (unprofitable fisheries) and away from other uses (e.g. roads, hospitals and others).
244 However, a broad MEY is far from being unprofitable even in the fishing sector
245 (Bromley, 2009).

246 By-catch problems and the ecological stress on the environment and the targeted fish
247 stocks due to the increased fishing pressure also need careful consideration and
248 evaluation. However, the indicators of human caused impacts are controversial and
249 often difficult to collect. Nonetheless, fishing generates benefits, apart from food,
250 employment, and income, and all of these benefits need to be factored into “economic”
251 models to maximize benefit from replenishable natural resources.

252 The United Nations Convention on the Law of the Sea (UNCLOS) states that the goal
253 for harvesting fish species is to achieve MSY. There is a broad range of parameter
254 values exist for determining MEY beyond the scope of fishing fleet. And there is a
255 need to bridge the gap in objectives between fisheries management and social
256 benefits. While it is acceptable to have low fishing effort in order to protect fish stocks,
257 there is much to consider before shrinking to fleet-based MEY. The rent ‘drain’ from
258 the fishing sector should be accepted, as it drains to the society, causing people to
259 benefit from our precious resources.

Concluding remarks

While we agree that the MEY theory is valid, we argue that determination of MEY is dynamic. Another disadvantage of MEY-based management involves large uncertainty. The estimated MSY is already highly uncertain for most fisheries. Adding economic variables on top of the uncertain biological parameters makes the estimated MEY very unreliable. Furthermore, collecting economic data and doing bioeconomic modelling incur additional costs. The fleet-based approach is not applicable to natural resources, with the reasons,

1) The resource rent is not fully collected by the government and re-distribute to the broad community.
2) Maximising economic rent for private companies should not be obfuscated with the fishery efficiency.
3) The benefit drained from the broad community is not accounted for, which leads to lower optimal fishing effort and catch levels.
4) The large cost of buyback scheme is not factored in when moving MSY to feet-based MEY. The cost is large to the government.
5) Within fleet, the fishing crew incomes and employment are also set at a minimum, when maximizing the fleet profit (fleet-based MEY).
6) From the perspective of the ‘best interests of the community’ (Bromley, 2009), a fishery managed to achieve fleet-based MEY is unlikely to perform at full economic efficiency.

The society-based MEY approach that we are promoting simply factors in other benefits generated by the fishery - it may be beyond the traditional fleet-centric economic theory (which is largely confined to maximize profit of the harvesting firms or fishing industry itself) and requires multidisciplinary research (social science, decision theory and biological science, in particular).

The resource rent extracted via license fees is only a small proportion of the MEY

287 value – possibly just as a proportion of cost recovery with an overall neutral effect.
288 The absence of license fees would imply subsidy. Collection of the resource rent by
289 the government or the broader community will result in greater catch and effort levels
290 in fisheries compared to fisheries that operate at MEY. It balances a greater benefit to
291 the society against the cost of reducing profitability of fishing fleets.
292

References

1. DAFF. 2007. Commonwealth fisheries harvest strategy: policy and guidelines. Canberra: Department of Agriculture, Fisheries and Forestry.

2. Pascoe, S., C.M. Dichmont, K. Brooks, R. Pears, and E. Jebreen. 2013. Management objectives of Queensland fisheries: putting the horse before the cart. Mar. Policy. 37:115-122.

3. Pascoe, S., K. Brooks, T. Cannard, C. M. Dichmont, E. Jebreen, J. Schirmer, and L. Triantafillos. 2014. Social objectives of fisheries management: What are managers' priorities?. Ocean. Coast. Manag. 98:1-10.

4. Brooks, K., J. Schirmer, S. Pascoe, L. Triantafillos, E. Jebreen, T. Cannard, and C.M. Dichmont. 2015. Selecting and assessing social objectives for Australian fisheries management. Mar. Policy. 53:111-122.

5. Dichmont, C. M., S. Pascoe, T. Kompas, A. E. Punt, and R. Deng. 2010. On implementing maximum economic yield in commercial fisheries. Proc. Natl. Acad. Sci. U.S.A. 107(1):16-21.

6. Wang, Y.G., and D. Die. 1996. Stock-recruitment relationships of the tiger prawns (Penaeus esculentus and Penaeus semisulcatus) in the Australian northern prawn fishery. Mar. Freshwater. Res. 47(1):87-95.

7. Somers, I., and Y. G. Wang. 1997. A simulation model for evaluating seasonal closures in Australia's multispecies northern prawn fishery. N. Am. J. Fish. Manage. 17(1):114-130.

8. Wang, Y. G., and N. Wang. 2013. Rejoinder to Pascoe et al.'s (2013) Comment Paper. Fish. 38(11):509-509.

9. Bromley, D.W. 2009. Abdicating responsibility: the deceits of fisheries policy. Fish. 34:280-290.

10. Christensen, V. 2010. MEY = MSY. Fish. Fish. 11:105-110.
11. Sumaila, U.R., and R. Hannesson. 2010. Maximum economic yield in crisis? Fish. Fish. 11:461-465.
12. Pascoe, S., V. Kahui, T. Hutton, and C. Dichmont. 2016. Experiences with the use of bioeconomic models in the management of Australian and New Zealand fisheries. Fish. Res. 183:539-548.
13. Grafton, Q., W. Adamowicz, D. Dupont, H. Nelson, R. J. Hill, and S. Renzetti. 2008. The economics of the environment and natural resources. John Wiley & Sons.
14. Hsieh, C., C.H. Reiss, et al. 2006. Fishing elevates variability in the abundance of exploited species. Nature. 443:859-862.
15. Beddington, J.R., and R.M. May. 1977. Harvesting natural populations in a randomly fluctuating environment. Science. 197:463-465.
16. May, R., J.R. Beddington, et al. 1978. Exploiting natural populations in an uncertain world. Math. Biosci. 42:219-252.
17. Hutchings, J.A. 2000. Collapse and recovery of marine fishes. Nature. 406:882-885.
18. Ye, Y., K. Cochrane, et al. 2012. Rebuilding global fisheries: the World Summit Goal, costs and benefits. Fish. Fish. 14(2):174-185.

339 **Table 1** Cost (-) and gain (+) parameters for implementing socially responsible
340 management. Some cost/gain items that may be canceled out are matched by
341 superscript numbers.

Parameter	MEY	
	Fleet-based	Society-based
Fishing industry		
Crew cost	-	[-][1]
Packing cost (A$ per kg)	-	-
Repairs and maintenance (A$ per day)	-	-
Fuel (A$ per day)	-	-
Licence fee (A$ per vessel)	-	[-][2]
Opportunity cost of capital	-	[-][3]
Depreciation rate of capital	-	-
Crew income	0	[+][1]
Company Tax & personal income tax	0	[-][4]
Gross value of fish products	0	[+][6]
Government		
Licence fee (A$ per vessel)	0	[+][2]
Tax		
Gross Production Tax	0	[+][4]
Company Tax	0	[+][4]
Personal income tax	0	[+][4]
Export duties	0	[+][4]
Sales tax	0	[+][4]
Subsidies to fishing industry		
Compensation to fishing operations	0	[-][5]
Fuel subsidies	0	[-][5]
Unemployment benefits saved	0	[+][5]
Ecological and environmental impacts	0	-
Processors and distributors		
Salary and wages	0	[-][7]
Processing cost related to product	0	-
Labour income	0	[+][7]
Company Tax, sales tax & personal income tax	0	[-][4]
Consumers		
Purchase cost (> dockside price)	0	[-][6]
Life quality	0	+
Resource rent	Benefit fishing industry	Shared by the community

342