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A Risk Based Approach for Promoting Management Regimes for Trawl Fisheries in South East Asia

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Abstract

Risk based fishery assessment systems have become more widely developed since their introduction about 5 years ago. Interest has been expressed in applying them in data poor fisheries to help inform management decisions. In the multispecies trawl fisheries in South East Asia, risk based systems may be of great benefit in facilitating the development of management regimes which are urgently needed to improve sustainability. This paper proposes a novel application of an existing risk assessment method for enabling rapid evaluation of different management options. It enables managers and stakeholders to explore options and evaluate which are the most suitable.The risk based system used is the Productivity Susceptibility Analysis (PSA). The trial focuses on the susceptibility axis and explores 12 options for changing the susceptibility of 9 species to benthic trawl gear. The potential for such a system to support management tools such as risk based reference points and harvest control rules is also canvassed.

Introduction

In many parts of Asia, fish catches continue to grow despite widespread evidence of resource depletion and overfishing (Chuenpagdee and Pauly 2003; Kongprom et al. 2003; Stobuzki et al. 2006; Ahmed 2011;Ye et al. 2011; Funge-Smith et al. 2012). Serial depletion in geographic and species terms as well as on a trophic basis (i.e 'fishing down the foodchain')(Christensen 1998; Vibunpant et al. 2003; Chen et al.2011) has taken place as fisheries have expanded both in terms of spatial distribution and capacity. Factors contributing to the depletions include habitat destruction (Anon 2002) and the lack of adequate controls on fishing activities. Overcapacity (Long 2003; FAO 2010), inadequate gear controls such as the lack of minimum mesh sizes (e.g. Thailand – Supongpan and Boonchuwong 2010) and illegal fishing and enforcement issues (Anon 2008; Boonstra and Dang 2010; Nguyen et al. 2011) are all symptomatic of inadequate management. Multispecies fisheries present some major challenges for fishery managers wherever they occur in the world. They are especially problematic in countries where species diversity is very high (such as in the tropics), where management capacity is low and where fisheries policy and law continues to be focused on development rather than long term sustainable use (Williams 2007).

Very few Southeast Asian countries have management plans for their fisheries. Generally, clear management objectives and management measures are not explicitly linked, beyond measures to separate some user groups (e.g. small boats inshore, large boats offshore) and, in some cases, the protection of juvenile fish (via mesh size limits). Gathering data for a

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large number of species, identifying the cause of the problem and building support for change may take years. Thus many management tools potentially useful for convincing stakeholders that resources are being overexploited or fishing is having other unacceptable impacts are commonly not in place. Depending on the country, management has commonly failed to lock in the benefits of fishery development, resulting in transient and inequitably distributed benefits, and missed opportunities for long term poverty alleviation.

In the face of the above trends, a number of regional forums have highlighted the need for an enhanced approach to trawl fisheries management (SEAFDEC 2012). In 2012 the Asia Pacific Fisheries Commission focused its attention on trawl fisheries and agreed to progress work on the development of a trawl fishery risk based assessment method, the creation of best practice advice for trawl management and the reduction of trawl bycatch (http://www.apfic.org/modules/news/article.php?storyid=199).

This paper puts forward the view that a risk based approach to evaluating management options in data poor fisheries can assist managers and stakeholders to engage in the management process in a productive way. Risk based approaches help implement a precautionary approach to fisheries in that justifiable decisions can be made in the absence of complete information. The need for timely decision making has been highlighted frequently by those with an interest in fisheries sustainability – including government, industry and NGOs, amongst others. This has created a demand for tools that can provide defensible information for decision makers even in the absence of rigorous, detailed scientific data.

The Regional Guidelines For Responsible Fishing Operations In Southeast Asia (SEAFDEC 2003) set out the rationale for managing fisheries in Southeast Asia that takes heed of the cultural, ecosystem and fisheries structural attributes which, it argues, differ from developed countries in cooler climates. For example, management frameworks that focus on 'target species' and minimising 'bycatch' do not generate the understanding and support needed of stakeholders because the concept of bycatch is not well recognised as most, if not all, species taken in most fisheries have a use. As a result discarding is not as prevalent as it is in many temperate countries. In addition, the high diversity of species that comprise the majority of the catch in a fishing operation means that the cost of conducting formal stock assessments for all species is prohibitive (Stobutzki et al. 2001; Patrick et al. 2010).

For these, and other reasons, a large number of fisheries are data poor, with formal assessments either not being undertaken or being undertaken at long time intervals (e.g. decades). Assessments are not coordinated across international boundaries due to lack of formal fishery agreements and most national agencies do not have formal processes for performing assessments and formulating advice for management based on the assessments, as is the ideal in several OECD countries.

The development of risk based approaches in fisheries parallels the rise in the adoption of the precautionary principle (FAO 1995) which has sought the adoption of more risk-averse decision making although there is abundant evidence that its global application has been patchy at best. According to Sethi (2010), risk has three components, namely: the variable state of the world, imperfect knowledge on the state of the world, including in the future, and a desired state of the world. Most fisheries operate in a variable world of less than optimum knowledge and this is particularly the case for multispecies fisheries for the reasons outlined above. The third component implies the establishment of management objectives and will be addressed below.

Risk based decision making is increasingly common in data rich fisheries where tools such as Management Strategy Evaluation (MSE) (Rademeyer et al. 2007) are used. In the case of data poor fisheries, risk assessment approaches have gained significant interest from managers, policy makers and industry. Although there are a number of approaches to dealing with data poor situations (Smith and Punt 2009; Starr et al. 2010), tools such as the Productivity Susceptibility Analysis (PSA, see below) particularly have enabled fisheries that take a large number of species to be evaluated in away that is rigorous and defensible even though formal stock assessments are not undertaken.

An early approach to risk assessment for a complex tropical trawl fishery was put forward by Stobutzki et al. (2001) as a mechanism for evaluating the sustainability of bycatch species and addressing management priorities for the Northern Prawn Fishery in the Gulf of Carpentaria, Australia. In this fishery over 400 species are taken and for the vast majority, little information is available beyond basic biological parameters. The costs of conducting stock assessments for every species to ensure sustainability are simply prohibitive and the authors postulated that some species are less vulnerable to trawling than others and may thus not need immediate management attention. Identifying which species were more vulnerable than others would help managers, scientists and industry focus their research and management efforts.

A key component of this risk based approach that has been developed (Stobutzki et al. 2001; Hobday et al. 2011) is Productivity Susceptibility Analysis (PSA) which generates an index of the vulnerability of a species to overfishing. This index is based on comparisons of parameters that describe the productivity of a given species with other parameters which describe its susceptibility to capture by the fishery of interest (gear type and areas fished). Patrick et al. (2010) define vulnerability as a measurement of a stock's productivity and its susceptibility to a fishery. Productivity refers to the capacity of the stock to recover rapidly when depleted, whereas susceptibility is the potential for the stock to be impacted by the fishery.

The Productivity axis comprises attributes that are inherent to the species involved. Whilst changes in some of these parameters may be driven by fishing (e.g. age at first maturity can be affected by heavy fishing pressure) these biological attributes are generally less amenable to management intervention than attributes that comprise the Susceptibility axis. Thus, opportunities to reduce risk would be driven more by changes in susceptibility than by changes in productivity.

Materials and Methods

In the present study, the potential for using the PSA to evaluate management options is explored using 12 hypothetical management scenarios for a number of species found in tropical trawl fisheries from Vietnam, Thailand and Australia. The PSA method developed by Hobday et al. (2011) was chosen as an Excel workbook is available from the website of the Marine Stewardship Council. The same technique could, conceivably, also be applied to the methods published by Patrick et al. (2010) and Vivekanandan et al. (2009) should such workbooks be easily available. Susceptibility is defined and scored in accordance with Table 1 which is based on Hobday et al. (2011).

Table 1. Categorisation of risks of capture.

Attribute	Low susceptibility (low risk, score = 1)	Medium Susceptibility (medium risk, score = 2)	High susceptibility (high risk, score = 3)
Availability (overlap of species range)	<10% overlap	10-30% overlap	>30% overlap
Vertical overlap (position in water column)	Low overlap with gear (e.g. species in upper water column, gear on seabed	Medium overlap with fishing gear (e.g. fish position in water column may vary)	High overlap with gear (e.g. both species and gear on seabed)
Selectivity	Species<meshsize or >5m in length	Species 1 to 2 times meshsize or 4-5m in length	Species > 2 times meshsize up to 4m in length
Post capture mortality	Evidence of post capture release and survival	Released alive	Retained species or majority dead when released.

Source: modified from Hobday et al. (2011) – note that areal overlap is termed "encounterability" in the Hobday et al paper.

Vertical overlap was deemed to be related to whether the fish were on the seabed at the time the trawl was deployed noting that the position of some species in the water column varies with time of day or whether high opening nets are used. Selectivity relates to whether all or some of juveniles, sub adults or adults are caught.The greater the size range caught, the higher the risk. Undoubtedly many alternatives could be explored and the options chosen for the present study are simply to illustrate how the system could operate. Scenarios 1 and 12 represent the extremes of minimum and maximum susceptibility, respectively.

The hypothetical management scenarios involved several different management interventions designed to alter the degree of susceptibility to capture (availability, vertical overlap and selectivity) and response to discarding (Table 2). For each of the parameters a low, medium and high risk option was created to represent increasing degrees of risk.

Table 2. Scenarios and management measures used as their basis for risk assessment.

Scenario	Availability	Vertical overlap	Selectivity	Post harvest
1	Green	Green	Green	Green
2	Green	Green	Green	Yellow
3	Green	Green	Yellow	Yellow
4	Green	Green	Green	Red
5	Green	Yellow	Yellow	Yellow
6	Yellow	Yellow	Yellow	Yellow
7	Red	Red	Green	Green
8	Yellow	Yellow	Yellow	Red
9	Red	Red	Yellow	Yellow
10	Red	Red	Red	Green
11	Yellow	Red	Red	Red
12	Red	Red	Red	Red

Green - low susceptibility rating (score 1) as per Table 1.
Yellow – medium susceptibility rating (score 2) as per Table 1
Red – high susceptibility rating (score 3) as per Table 1

Whilst, in Asia, few species are discarded (see Kungsawan 1996 in Clucas 1997 for discussion about Thailand) and thus questions of post-harvest survival are generally not applicable, no parameters were dropped at this stage. This is because the algorithms used in the workbook rely on multiplication and rescaling, and removing one of the parameters may affect the rescaling. Substituting a parameter more suited to Southeast Asian trawl fisheries may be an option if the system is further developed.

Two trials were conducted using the 12 scenarios. The first evaluated the response of one common species in the region (the Malabar grouper – *Epinephelus malabaricus* (Bloch & Schneider 1801 -Leadbitter and Banks 2010) and the second evaluated the responses of nine species found in trawl fisheries in Vietnam, Thailand and Australia. These species were chosen to demonstrate a range of PSA scores based on life history attributes from those that are highly productive (e.g. *Penaeus monodon* Fabricius 1798) to those with low productivity (*Pristis zijsron* Bleeker 1851). The productivity attributes are removed for clarity.

The full list of species used in Table 4 is as follows:

Species	**Latin name**	**Source of productivity parameters**
Shrimp	*P.monodon*	Griffith et al.2007
Goatfish	*Upeneus sulphureus* Cuvier 1829	Griffith et al.2007
Bigeye	*Priacanthus macracanthus* Cuvier 1829	Fishbase and Liu et al. 2001
Grouper1	*Epinephelus coioides* (Hamilton 1822)	Griffith et al.2007
Snapper	*Lutjanus malabaricus* (Bloch & Schneider 1801)	Griffith et al.2007
Grouper2	*E.malabaricus*	Leadbitter and Banks 2010
Squid	*Loligo chinensis* Gray 1849	Griffith et al.2007
Shark	*Glyphis glyphis* (Müller & Henle 1839)	Griffith et al.2007
Sawfish	*P.zijsron*	Griffith et al. 2007

Results

Table 3 demonstrates that the Malabar grouper is relatively robust to exploitation if some controls are in place but where management controls are negligible then it may be placed at risk. Its current IUCN listing as ‘near threatened’ is based on the observations that it is targeted at all stages of its life cycle and is probably overfished in some countries (http://www.iucnredlist.org/details/61338/0 - last accessed 27 March 2013). This listing may be considered comparable with scenarios 11 and 12 in Table 1, thus reflecting the overall inadequacy of management.

Table 3. Example of the response of trawl caught *E. malabaricus* to the scenarios identified in Table 2.

Scenario	Productivity Scores: Average age at maturity	Average max age	Fecundity	Average max size	Average size at Maturity	Reproductive strategy	Trophic level (fishbase)	Total Productivity (average)	Susceptibility Scores: Availability	Encounterability	Selectivity	Post-capture mortality	Total (multiplicative)	PSA scores (automatic): PSA Score	Risk Category Name
1	2	2	1	2	2	1	3	1.86	1	1	1	1	1.00	2.11	Low
2	2	2	1	2	2	1	3	1.86	1	1	1	2	1.03	2.12	Low
3	2	2	1	2	2	1	3	1.86	1	1	2	2	1.08	2.15	Low
4	2	2	1	2	2	1	3	1.86	1	1	1	3	1.05	2.13	Low
5	2	2	1	2	2	1	3	1.86	1	2	2	2	1.18	2.20	Low
6	2	2	1	2	2	1	3	1.86	2	2	2	2	1.38	2.31	Low
7	2	2	1	2	2	1	3	1.86	3	3	1	1	1.20	2.21	Low
8	2	2	1	2	2	1	3	1.86	2	2	2	3	1.58	2.44	Low
9	2	2	1	2	2	1	3	1.86	3	3	2	2	1.88	2.64	Low
10	2	2	1	2	2	1	3	1.86	3	3	3	1	1.65	2.48	Low
11	2	2	1	2	2	1	3	1.86	2	3	3	3	2.33	2.98	Med
12	2	2	1	2	2	1	3	1.86	3	3	3	3	3.00	3.53	High

Scenario 12 is the worst case where the full distribution of the species' range is fished, most life history stages are caught, refuges are few and any discards do not survive. Taking modest management action (i.e. action to reduce the scores from 3 to 2 in any of the susceptibility parameters) is sufficient to reduce the risk to a low level. Such actions could include, for example, larger time/area closures and technical measures to reduce mortality of juveniles such as bycatch reduction devices.

For a wider range of species, Table 4 demonstrates the combined effect of low natural productivity and high susceptibility due to the absence of effective management controls.

Table 4. Species of varying productivity (P) scores versus management scenario (S).

Species	P	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Shrimp	1.00	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Med
Goatfish	1.14	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	High
Bigeye	1.29	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Med	High
Grouper 1	1.43	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Med	High
Snapper	1.71	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Med	High
Grouper2	1.86	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Med	High
Squid	2.29	Low	Low	Low	Low	Low	Med	Low	Med	Med	Med	High	High
Shark	2.43	Low	Low	Med	Med	Med	Med	Med	Med	Med	Med	High	High
Sawfish	2.86	Med	Med	Med	Med	Med	Med	Med	High	High	High	High	High

Trawl fisheries that have access to a large proportion of the range of a species, employ mesh sizes that catch a wide range of sizes and have high post-harvest mortalities (by retaining all the catch, for example) (Scenario 12) pose high risks to even those species that, under relatively modest management regimes, could otherwise be quite tolerant of fishing pressure. This has important implications for species commonly used for surimi (Mullidae and Priacanthidae for example) and fish meal (wide variety of species known as trashfish) especially in areas where management controls are inadequate or ineffective. Thus Scenarios 11 and 12 may correspond to the widespread evidence of decline in species which are relatively productive (Lymer et al. 2010).

The modelling results (Table 4) demonstrate how it would be possible to generate a comparison of the consequences of agreed management options for a large number of species taken in a fishery so as to recommend measures that are generally risk averse. Depending on the objectives adopted (e.g. no high risk species or low risk species comprise greater than 80% of the catch, as two examples) stakeholders could explore scenarios and what the consequences could be for fishing activities. This would help focus management attention on those species that stand out as being at an unacceptable risk under a number of management scenarios.

Some caution is needed in considering the results from these tables. For example, the PSA approach is designed to be used in data poor situations and, in line with the precautionary principle, is conservative in that it likely overestimates risk. Another consideration is that reducing the risk of overfishing is but one fisheries management objective. A species can persist at population levels that are well below those needed to support an economically viable fishery, i.e. a species may have a viable population even if it is below B_{msy} or B_{mey}. Finally, the judgements made about the interactions with the fishing gear are based on informed opinion. In any fishery the degree of gear interaction with a particular species would differ, possibly in subtle ways. For example, the time of day that trawling is permitted could substantially change the species composition as could changes to the way that the gear is rigged, irrespective of mesh size (Suuronen 2005).

Discussion

The case for better management of trawl fisheries in Asia has been well recognised by researchers and agencies, so too have the differences between Asian fisheries and those in many developed countries upon which current approaches to management are based. High species diversity and a wide range of seafood products and user groups coupled with historical open access policies have made progress on management extremely difficult. Management approaches based on concepts such as target species and bycatch, formal stock assessments and biomass based reference points have probably exacerbated the management planning impasse being experienced in some countries. Given the diversity it is probable that there is no single, optimum solution and management will depend on objectives agreed by a variety of stakeholders. Table 5 demonstrates the differences between a tropical trawl fishery from Australia and Thailand thus illustrating how management approaches will need to differ in order to accommodate the differing expectations about the benefits of fishery exploitation.

Table 5. Differences in objectives, products and management between selected tropical trawl fisheries.

Fishery attributes	**Northern prawn fishery, Australia**	**Gulf of Thailand or Vietnam trawl**
Target species	Several species of penaeid shrimps	Non
Retained species	Cephalopods, crustaceans	All retained
Discards	Wide variety of small fish and invertebrates	Probably nil
Products	Frozen molluscs and crustaceans	Fresh/frozen fish, molluscs and crustaceans, surimi and other processed seafoods, fish meal
Number of participants and beneficiaries	Low	High
Management objectives	Maximum economic yield for target species Minimisation of bycatch and discards	Maximum participation, maximum biomass removal
Management measures	Output controls for target species Closed areas and seasons Limited entry Minimum mesh size	Closed areas and seasons Limited entry (for Thailand) Minimum mesh size (Vietnam)

Productivity Susceptibility Analysis does not provide estimates of sustainable yield but it does provide a mechanism for seeking to minimise harm (as one aspect of overfishing) and this would enable a step forward for many fisheries which are experiencing resource declines. Whereas the large data requirements would make it almost impossible to fish every species in these tropical trawl fisheries at a known maximum sustainable yield (MSY) (or equivalent such as maximum economic yield (MEY) in the Northern Prawn Fishery) the adoption of a 'no unacceptable risk of overfishing' objective could provide a lower threshold to enable a discussion about management options to be conducted. In the Northern Prawn Fishery only a small number of species are subject to formal stock assessments whereas the majority are subject to risk assessment (of which the PSA is one tool). From this perspective the primary difference between the Australian fishery and the Thailand/Vietnam fisheries is that species discarded in the Australian fishery are retained for use in the Thailand/Vietnam fisheries in order to increase the number of products and employment the fishery can produce. This maximisation of production and beneficiaries approach does not absolve the managers from having mechanisms for protecting resources and future livelihoods but it will demand a different suite of management objectives and tools.

Whilst a 'no unacceptable risk' approach to designing a management system may be construed as being a very low level of performance, it would ensure that all the current users of the fisheries are brought into the management process while still permitting a discussion that explores mechanisms for taking management action. Recently the concept of ‘balanced harvest’ was advanced (Garcia et al. 2012) to provide a framework for managing fisheries that is an alternative to the current push towards increasing selectivity. The balanced harvest concept builds on the premise put forward by several authors including Zhou et al. (2010) who argued that selective fishing may hinder rather than help an ecosystem approach to fisheries, and cited a number of cases where the disproportionate removal of target species has caused undesirable ecosystem changes. Garcia et al. (2012) present modelling to support a view that spreading modest fishing mortality across a wider range of species (and sizes) results in lower risks of problematic ecosystem outcomes. For tropical trawl fisheries, which take a wide variety of species from many trophic levels the balanced harvest approach may provide a more suitable framework for exploring management options. If Scenario 6, as a midpoint between low and high risk management approaches, is viewed as a ‘balanced’ approach then the benefits for all species are apparent in Table 3, at least in comparison to the approaches common in Asia today.

If a risk based approach is adopted (using PSA as a key tool) further investigation would be required to address some of the known issues such as the possibility of excessive subjectivity (which could lead to interpretations of available information that are either too lenient or too strict), the need to ensure that interactions with other fisheries are taken into account, the need to incorporate non fishery influences on vulnerability (Morales – Yokoboria et al. 2011) and the need to incorporate other objectives for the fishery beyond risk minimisation. Balanced against these issues are the advantages which include cost effectiveness (many of the parameters required are available via websites), inbuilt precaution, all the known species are explicitly covered, habitat (Williams et al. 2011) and Protected/Endangered/Threatened species (Waugh et al.2008; Kiszka 2012) risk assessments are available, and the overall approach encourages stakeholder engagement, which would progress the co-management approach.

The approach proposed needs to be established within a framework that sets clear objectives for the fisheries, implements workable reference points and harvest strategies and addresses economic and social needs. Given the pressure on many fish resources in the region, timely attention to the resolutions of SEAFDEC/ASEAN will prevent further decline and help rebuild resources where needed.

Conclusion

Asia’s fisheries are at a crossroads (again). After a long period of expansion, the consequences of not controlling this within a robust management framework are increasingly being expressed via growing evidence of overexploitation and serial depletion. Although the trawl fisheries are not the only ones to demonstrate this, the widespread nature of this fishing method, the large number of species taken and the ability to take most life history stages for some species means that managing trawling warrants the high priority status accorded by the Asia Pacific Fisheries Commission.

In such species rich fisheries the high costs of gathering sufficient data to generate detailed management advice can be an impediment to decision making. If decisions regarding the implementation of capacity controls, technical measures such as mesh sizes and time/area closures are delayed, overexploitation continues and the benefits of fishery utilisation increasingly forgone. More cost effective tools are needed to support justifiable decision making if sustainability is to be achieved.

Risk based tools, such as PSA, provide a mechanism for supporting decision making in complex trawl fisheries. This paper demonstrates how management measures can be altered to reduce the risk of overfishing in Asia's trawl fisheries in a cost effective way. Whilst there are a number of limitations to this method, its primary value is shifting the balance from an approach that requires decisions supported by large amounts of data to one that provides the rationale for the implementation of measures known to be effective in a variety of circumstances.

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