Bren School of Environmental Science & Management, UC Santa Barbara

Group Project proposal
Portfolio Analysis for Fishery Management in the South China Sea

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Project Clients[1]**:**
Environmental Defense Fund (EDF)
Global Aquaculture Alliance (GAA)

Suggested Faculty Advisors:
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I. Objective

The objective of this project is to evaluate stock management through fishery portfolio theory by comparing the differences in catch, revenue and risk (revenue and biomass variability) with the historical values of the South China Sea under a summer fishing moratorium.

Specifically, the analysis will explore the combinations of fisheries that bring the best economic return, considering management questions like: how fishermen will decide how to allocate the fishing efforts across species? What are the stock trade-offs and feedbacks if portfolio theory is applied? Will portfolio management improve the stock composition enough to shorten the moratorium? What are the rates of fishing that prove to be profitable over the long term? And, would the catch composition in the South China Sea transition to fewer but more profitable species?

II. Significance

China's summer fishing moratorium is one of the most significant and strongest fishery management actions in the country, which bans all fishing activities in most of China's marine areas for the summer. Although the summer fishing moratorium is a great step toward fishery sustainability for China, it lacks flexibility and consideration of the complexity of the marine ecosystems and diverse resources. As China moves forward in its fishery supervision, a more sophisticated fishery management system should be involved. The *portfolio theory* will help to understand how fisheries can be better managed in the South China Sea in terms of biomass, revenue and economic regulation.

In the case of biomass, a resource management the consider the trophic relationships between all the species will allow to identify if their populations and diversity are sustainable (Roughgarden & Smith, 1996). The lack of specific regulation and fishing gear provokes bycatch problems in the South China Sea. In this context, around two thirds of the landings belong to unidentified species while 40% of the fish stocks are overexploited (One Shared Ocean, 2020). The improvement of this situation is not encouraging if we consider that the fishing effort has grown almost 500% since 1950 (One Shared Ocean, 2020).

[1] We are still in negotiations with EDF and GAA, but they manifested their interest in the project. These negotiations are separated.

The implementation of a portfolio analysis can be costly according to the number of species and stakeholders to regulate. However, its recommendations can be implemented gradually in the stocks with the most significant impact in aspects of population availability, stable and attractive profits, and social welfare (Sethi, Reimer, & Knapp, 2014). This approach contributes to measure policy implementation costs (monitoring, compensation and report), to identify winners and losers, and if it is possible to shorten the summer ban or establish multiple fishing seasons. The last benefit is attractive for decision-makers because an increase a continuous fishing activity (distributed across multiple species) will reduce the revenue variability along the year and increase the effectiveness of the subsidies in the activity. In consequence, the Government will be able to prioritize the sustainable use and regulation of their most strategic marine resources towards challenges like climate change.

III. Background

Since 1995, China imposed a summer fishing ban in East China sea, Bohai Sea, and Yellow Sea, and expanded the jurisdiction to South China Sea since 1999. Each year, the summer fishing moratorium spans from May 1st to August 16th in South China Sea (including Beibu Gulf), which bans all fishing gears except for fishing line and hook (MOA, 2018). The moratorium is meant to alleviate overfishing by protecting spawning activities and allowing more time for species maturation, which increases the resilience of the marine ecosystem and the continuation of the fishery activity (State Council of China, 2006).

However, recent research has found that the summer fishing moratorium could be enhanced for improved fishery management. For example, fisheries biomass compositions are shown to change following the implementation of the moratorium, which does not result in improved population composition in East China Sea (Jiang, Cheng, & Li, 2009). The moratorium provides a short-term benefit for the ecosystem, yet it does enough to allow the long-term improvement in harvest quality (Yan, Liu, Jin, & Cheng, 2016). The prohibition of all fishing activities during the moratorium has little effect on fish stocks recovery in South China Sea (Wang, Duan, Li, Zeng, & Failler, 2015), and it is estimated that lower fishing effort policy will have a better performance than the summer ban throughout the year (Wang, Hu, Pan, Li, & Failler, 2016).

In this context, using portfolio theory in evaluation of fisheries management in the South China Sea can contribute to figure out how to maximize fisheries revenue within a certain range of risk. We cover two types risk: extreme variations of the revenue across time (within the year and throughout years) and biomass instability

IV. Data availability

The National Aquatic Product Wholesale Market Data Sharing Platform records China's aquatic product market prices and transaction status since 2009. This database contains over 7 million data points, including information for over 200 species from more than 80 major aquatic wholesale product markets in China.

The China's Fishery Statistical Yearbook[2] and the National Scientific Big Data Sharing Platform will provide the catch data for each species from each province since 1978. Additionally, MSY estimates for 11 of the most important commercial species in the South China Sea is given by Zhang (Zhang, Liao, & Xu, 2017), which are the species that will be the focus of this project.

[2] This publication is only available in Chinese.

Furthermore, fisheries export data can be found in the Statistical Yearbook of Import and Export Trade of Aquatic Products in China. This yearbook records detailed information about the economic value and transaction volume associated with the export of each aquatic species since 2002. To include export data allows to identify if the pressure on the resources is motivated by the local or international market. If the pressure comes from international trade, then is relevant to know China's position in influencing the international price, which might affect the maximization of revenues.

V. Possible approaches

- The portfolio theory was first developed by Markowitz (Markowitz, 1952) to compare different portfolios and select those that maximize expected returns and minimize risk. In marine management, a combination of assets (fish stocks) is selected to reach highest expected revenue with a relative low variation.
- There are many optimization techniques like minimizing the tail-risk by Value at Risk (Morgan/Reuters, 1996) or Conditional Value at Risk (Rockafellar & Uryasev, 2000), incorporate the asymmetric dependence by copula and modelling the variance through ARCH and GARCH methods (Opare, Ofosu-Hene, & Evans, 2017; Collado & Yong, 2009).
- The ecological interactions among commercial species imply the correlations among yields. In addition, it is necessary to model the fisheries considering their maximum sustainable yield (MSY) and maximum economic yield (MEY) as revenue constraints. There are many modelling alternatives like traditional single species optimization (Quirk & Smith, 1970), adaptive management framework or ecological analysis framework (Dame & Christian, 2006) but we will explore the approach of Sanchirico and Smith (2003). and Sanchirico, Smith and Litpton (2008).
- The comparison between estimated and historical revenues of revenues and stocks will allow to analyze aspects like exploitation, profitability and investment status of the fishery. For example, the opportunity to recover a fishery may arise if the species is collapsed and the profits are low. In addition, the portfolio analysis may indicate that summer ban may not be beneficial for all species.
- Lastly, first-hand interview recordings with fishermen about summer fishing moratorium from multiple fishing villages in South China Sea, which are critical to understand social dimensions of fisheries management enhancements in the South China Sea.

VI. Deliverables

The final deliverables for the Bren School will include a final presentation, poster, policy brief, and written report.

Our potential clients, EDF and GAA, manifested that they are interested in the following deliverables:

- Generate evidence about the potential benefits of implementing the portfolio theory as an alternative of the summer ban.
- Estimate the total costs of implementing the portfolio management of fisheries in South China Sea.
- Propose policy recommendations about how the Chinese Government may implement this approach. The implementation must consider graduality and which stakeholders are affected.

VII. Internships

EDF and GAA are evaluating the possibility of offering one internship. The details about the funding amount are still under discussion. We expect the internship may include a trip to China to conduct expert's interviews.

Supporting materials

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Budget

Item	Cost (USD)	Justification
Printing	$ 300	BREN School
Presentation materials	$ 300	BREN School
Access to National Aquatic Product Wholesale Market Data	$ 200	BREN School
Internship	$ 5,000	EDF*

*EDF is still evaluating their available funding resources.

Schedule

This project will last for one year, starting at the spring quarter of 2020. By the end of summer 2020, the database construction will be complete (including data collection and data extrapolation). We will also conduct interviews and summarize opinions on the summer fishing moratorium from different stakeholders from South China Sea: fishermen, captains, NGOs (ChinaBlue, GAA), media (Sina, FishFirst), and the government (Marine Fishery Department). The portfolio modeling will start during Fall Quarter 2020, and we will present the preliminary results to gain feedback from the mentioned experts.

Table 1: Project schedule

Activities	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21
Literature research											
Data collection											
Expert interviews											
MSY and trophic analysis											
Portfolio modelling											
Expert feedback											
Final report											
Project presentation											

Own elaboration

The project team will finalize the portfolio analysis by January of 2021 and develop policy recommendations based on results by March. The final project presentation will be in April of 2021.

Client letter of support

We are still in negotiations with EDF and GAA, but they manifested their interest in the project.