Final Report on

Bioeconomic Analysis of the Red Snapper Rebuilding Plan and Transferable Rights Policies in the Gulf of Mexico.

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I. Abstract

In this project we studied implications of typical policies on the red snapper rebuilding plan and the use of transferable rights for the red snapper recreational and commercial fisheries. The project made use of econometric analysis and a simulation model. This summary report provides a summary of the findings, which are developed in detail in a supplement technical document. The data used in this project was provided by the National Marine Fisheries Service (NMFS). Chapter one provides an analysis of the typical policies used in managing a fishery. This uses the General Bioeconomic Fisheries Simulation Model (GBFSM) and evaluates bag limits, minimum size limit, and total allowable catch (TAC). In Chapters 2 we discuss the potential to use a transferable rights (TR) approach to regulate recreational fishing effort in the Gulf of Mexico. Chapter 2 discusses the many practical issues that must be addressed if such a program is to be established. In Chapters 3 and 4 we develop and implement a simulation model for a TR program using GBFSM. Chapter 3 presents the recreation demand modeling exercise that we carry out in order to parameterize the simulation model. In chapter 4 we simulate how such a market might play out if implemented. Two main policy options are modeled, one in which trading among recreational fishermen is allowed, and another in which trading between the recreational and commercial sectors is also permitted.

II. Purpose

Red snapper stock in the Gulf of Mexico has been assessed as overfished and undergoing overfishing. In an effort to rebuild the red snapper fishery, the Gulf of Mexico Fishery Management Council (Council) with the National Marine Fisheries Service (NMFS) have enacted several regulations including: a prohibition on the use of long lines within the 50-fathom depth, a maximum total allowable catch (TAC) split between the commercial and recreational fishermen, closures when the TAC is reached, size limits for both commercial and recreational fishermen, bag limits for recreational fishermen, trip limits for commercial fishermen, individual fishing quota (IFQ), and the mandatory use of bycatch reduction devices (BRDs) by shrimp vessels. In previous economic analyses as well as the stock assessments of red snapper, consideration has not been given to the impact of red snapper policies on other reef fish fisheries. In addition, while restrictions on entry with permits can be effective in reducing fishing pressure, they do not foster an efficient allocation of effort; those who have the right to fish may not be the fishermen that value that right the most. As an alternative to strict efforts moratoriums, transferable quotas are being increasingly considered in fisheries across the globe.

The principal objective of this project is to improve upon existing bioeconomic analyses of the proposed red snapper rebuilding plan through 2032 by including three important issues that have not received adequate attention to date:

1. Include in the bioeconomic model the for-hire recreational red snapper fishery.
2. Explore the impact of red snapper policies on other reef fish fisheries, particularly vermilion snapper.
3. Study the possible use of transferable rights in the red snapper recreational and commercial fisheries.

III. Approach

The project proceeded in a number of steps.

1. The first phase of the project was to obtain data to be used in the project. Shrimp data has been obtained from the NMFS at Galveston, TX and transformed in landings and effort data that can be used in GBFSM. Shrimp stock assessment reports were obtained from Galveston and from other sources. Commercial reef fish data has been obtained from Beaufort, NC. Recreational MRFSS, head boat and Texas data has been received from Miami, FL.

2. The second phase of the project was to make changes in the Bioeconomic Fishery Simulation Model (GBFSM). The GBFSM is a multiple species, multiple length-based model using cohort analysis and instantaneous mortality. A description of the model can be found in Griffin (2003). Several modifications were made to GBFSM. The main change for this project was to allow fishing effort to be re-directed to other fisheries thereby allowing a given vessel class to continue to fish for other fish. For example, when the TAC is filled commercial red snapper could no longer land red snapper but they could re-direct their fishing effort toward other species, such a vermilion snapper or other reef fish. The other major change was not to GBFSM itself, but rather we created user friendly Excel model to manage the large amount of data and to run GBFSM. We also developed Excel out put models that allow quick analysis of the simulation results. We call this the bioeconomic simulation system or BESS (GBFSM). Modifications to BESS (GBFSM) through the life of this project proceeded as needed.

3. The third phase was to calibrate the GBFSM for shrimp, red snapper, vermilion snapper, and other reef fish. We treat each species east and west of the Mississippi River as separate stocks. We define the period of 1985 to 2002 as our "historical" era, and use the generated data for this period to set up BESS (GBFSM). The maximum age of red snappers was set at 35 years; therefore we also adopt a "prehistoric" period (1935-1984) to get the old fishes in the model. Our data base is sufficient to generate a quasi prehistoric data set of the 1935-1984 period, which we used as a burn in to scale the model results. This prehistoric period allows us to "get the appropriate number of old fish in the model at the appropriate length and weight. After tuning the prehistoric period (1935-1984), we calibrate the model to predict the historic period (1985-2002), which facilitates realistic policy analysis beyond 2002. After calibrating the biological model of GBFSM, we run the model through 1992 and store the biological information into files. This allows us to begin the model in 1993 by reading in the biological information that was stored and the end of 1992, cutting down computer simulation time by a significant amount. We then run the model from 1993 to 2005 to calibrate the cost and revenue data. After being satisfied that the model is working properly we store the biological information at the end of the simulation, 2005. Our policy analysis will begin in 2006 and we will use the actual yearly policies for 2006, 2007 and 2008. Differences in policies proposed will be for the period 2009 through 2032. Prices and unit cost are in 2005 dollars.

4. The fourth phase was to consider a more economically efficient policy, a system of transferable rights (TRs). We provide an overview of some of the problems of the suite of traditional management tools, and then discuss in general terms the advantages of a TR approach to management. The introduction of a TR for recreational fisheries, although not completely new, has not been widely applied. We discuss the experience that we have found documented, and also draw some lessons from hunting programs and applications of TRs in addressing pollution. Although relatively simple in principle, the success of a TR approach to recreational fisheries would depend upon a number of institutional details, any one of which can be critical to the success of the program. We list and discuss nine critical questions that must be addressed in the design of such a program. We develop a proposal for a TR program for the red snapper recreational fishery in the Gulf of Mexico.

5. The fifth phase was to empirically estimate recreation demand that incorporates TR permit demand. Because the model uses travel cost as an approximate variable of the price, it is often called Travel Cost model (TCM). We expect that when TR program is implemented, the price (cost) of fishing will increase because anglers are required to buy TR permits to do additional fishing. Our focus was on estimating an effect of price changes on the fishing trip demand. Suppose the price of taking a fishing trip increases simply by paying a daily access fee. A daily fee will be directly compatible with day-based TRs discussed in the previous two chapters. The difference is that a fee is fixed by the government, but the price of day-based TRs can vary by market demand. We examine a daily access fee policy as an approximate price instrument of TR program.

6. The sixth phase was to develop a simulation model that will be used to conduct an economic analysis of transferable rights (TR) program aimed at reducing over-use of the Gulf of Mexico red snapper (GRS) fishery and rationalizing fishing effort. A TR program can play a role in restricting the harvest of recreational red snapper fisheries, thereby increasing the red snapper stock to a level which will ensure its sustainability. It also could allow for recreational fishermen to fish when they want, rather than during the increasingly restricted times when the fishery is currently open. We also explore the possibility of allowing a TR

program in which the recreational sector is allowed to purchase rights from the commercial sector or vice versa. A simulation approach was adopted to evaluate both biological and economic effects of the TR policy on the fishery. We will use the GBFSM as a simulation tool. We consider feasible a program in which rights to fish are based on the right to a day of fishing. This is the program that will be simulated. The demand for recreational fishing is based on the econometric analysis presented in phase four.

7. The seventh phase was to analyze policies typically used by the Gulf of Mexico Fishery management Council (GOMFMC) and NMFS. These policies included bag limits, minimum size limit, and total allowable catch (TAC). All policies analyzed are changes for red snapper. We look at the how the changes in red snapper policies affect the red snapper stock and consumer and producer surplus to vermilion and other reef fish.

IV. Findings

A. Actual accomplishments and findings

In Chapter 1 we have analyzed three major policy tools used by fisheries managers for the red snapper fishery. We have looked at the impact of alternative red snapper management policies on the present value of producer surplus and consumer surplus not only for the red snapper fishery but also for the vermilion snapper and other reef fish fisheries. The policies considered included the bag limit, minimum size limit, and the TAC. We also looked at the stock effects to red snapper for each of the policies.

The PV of TS of the shrimp and reef fish fisheries in PV (7% discount rate) for the period 2009 to 2032 is $11.8 billion dollars. The recreational anglers contribute $9.1 billion followed by the shrimp fishery at $1.6 billion, the recreational for-hire fishery at $0.83 billion and the commercial reef at $0.27 billion.

An increase in red snapper bag limits from the current two-fish limit was found to have a negative influence on the red snapper recreational angler present value of consumer surplus in the east Gulf but a positive effect on vermilion and other reef fish recreational angler present value of consumer surplus. In the west Gulf it had a positive effect on both red and vermilion snapper recreational angler present value of consumer surplus. A change to a 1-fish bag limit could not be filled by the end of December, and therefore was costly to both the east and west Gulf. This policy led to a decline in the present value of total surplus by as much as $40.0 million for the period 2009 to 2032. An increase in the bag limit basically had no effect on the stock of red snapper in the east and west Gulf with the exception of a 1-fish bag limit which increased the stock in the Gulf because anglers, beginning the open season June 1, were unable to harvest enough fish to fill the TAC.

A decrease in red snapper minimum size limit from the current 16 inches was found to have a negative influence on the red snapper recreational angler present value of consumer surplus in the east Gulf but a positive effect on other reef fish recreational angler present value of consumer surplus, which more than offset the decrease in red snapper present value of consumer surplus. Therefore the effect on present value of total surplus was always positive for decreases in the minimum size limit. The minimum size limit did have an effect on the red snapper stock of fish in the east Gulf but none in the west Gulf. In the east Gulf the 13 inch minimum size limit allowed the recreational fishermen to harvest more age 1 fish and reduce the number of red snapper that were recruited to the age 2 fish. This caused the number of effective spawners to remain fairly

constant in the east Gulf from 2009 to 2032. A minimum size limit of 14 inches and higher causes the effective numbers of spawners to increase in the east Gulf.

An increase in TAC always increased the present value of total surplus because in the east Gulf an increase in the red snapper recreational angler present value of consumer surplus was greater the loss in the other reef recreational angler present value of consumer surplus. Effective number of spawners increased in the east and west Gulf for all levels of TAC; although they increased at a slower rate at higher TACs and the recreational red snapper anglers could not fill the higher TACs by the end of December.

All previous stock assessments have concluded that red snapper in the Gulf are overfished and undergoing overfishing. Their results were the same when the two stocks (east and west stock) were managed independently or managed as a single unit. They did note that the east stock could recover in the time period allowed under certain conditions (SEDAR 7 SARI Section 1). However, recent published studies have shown that red snapper are density dependent and that age 0 and age 1 fish have a much higher natural mortality rate than was used in previous stock assessments. By using a density dependent model and a higher natural mortality for age 0 and age 1 fish, it appears to us that red snapper stock are neither overfished nor undergoing overfishing. It should be remembered however that in setting up the biological model we calibrated the simulation as two separate stocks with no movement back and forth between to two stocks. Also, because the natural mortality for age 0 and age 1 fish are much higher than originally assumed, shrimp trawls have less effect on red snapper reaching age 2+ than previously modeled.

Efficiency frontiers were estimated for the east and west Gulf along which there are always trade-offs between the change in surplus and S/S_0. It was shown that improvements could be made in the total surplus and still increase the stock of red snapper in both the east and west Gulf. It was also shown that the stock of red snapper in the east Gulf was the constraining factor when using a single policy for the whole Gulf.

Finally, over 70% of the commercial red snapper landings are from the west Gulf. Approximately 83% of the recreational harvest in the Gulf come from east of the Mississippi river. So the major portion of the commercial harvest is west of the Mississippi river and the major portion of the recreational harvest is east of the Mississippi river. The stock of red snapper on the east Gulf is only approximately 60% as large as the stock of red snapper in the west Gulf. A single total TAC for the red snapper in the Gulf which always has a 51%-49% split between commercial and recreational fishermen can more readily cause more overfishing in the east than in the west Gulf. Future research and stock assessments need to look at separate management policies for the east and west Gulf red snapper fishery.

In Chapters 2-4 we discuss the potential to use a transferable rights (TR) approach to regulate recreational fishing effort in the Gulf of Mexico. Chapter 2 discusses the many practical issues that must be addressed if such a program is to be established. TRs are increasingly being sought by policy makers as a way to limit use of the environment and natural resources. They are now common in fisheries and the control of air pollutants. They hold promise to rationalize resource use in a way that is most economically efficient. However, their use for the control of recreational use of natural resources has been quite limited, in part because of the many practical challenges that must be overcome in order to use this policy instrument. In Chapter 2 we discuss the questions that policy makers must answer before a TR approach can be applied to a recreational fishery. Drawing on economic theory and experience in other areas, we propose that one feasible approach would be to use day-based rights to recreational fishing for the control of red snapper effort in the Gulf of Mexico. This would be a second-best policy since actual harvests would not be controlled. But given the limited ability to monitor deep-sea fishing, it may be the only practical alternative.

In Chapters 3 and 4 we develop and implement a simulation model for a TR program using GBFSM. Chapter 3 presents the recreation demand modeling exercise that we carry out in order to parameterize the simulation model. Our model is new in that it estimates demand for each of three modes of fishing in the Gulf of Mexico that are included in the 1997 Marine Recreational Fishery Statistics Survey (MRFSS). We estimate separate demand coefficients for each mode and for three levels of income. The mode-specific coefficients are used in the simulation model so that we can predict how a TR program, which would raise the price of participation, would change not only the overall level of angler days, but also the distribution of those days among the various modes of fishing.

Using the parameter estimates from Chapter 3, in Chapter 4 we simulate how such a market might play out if implemented. Two main policy options are modeled, one in which trading among recreational fishermen is allowed, and another in which trading between the recreational and commercial sectors is also permitted. In the recreation-only scenarios, we predict that the prices that would be paid for the right to a day of fish would be over $25 per day at the current Total Allowable Catch (TAC) of 2.45 million pounds for the recreational sector. The exact value should be treated as a rough estimate, but given that currently the TAC is being harvested in only two months, it is reasonable to believe that anglers would be willing to pay a fair amount for the right to harvest this fish throughout the year. When we simulate an increase in the TAC to 7 and 10 million pounds, the equilibrium price falls sharply. When we model a market in which trading between the recreational and commercial sectors is allowed, we predict that the recreational sector will tend to purchase a majority of the rights to red snapper in the gulf unless the TAC is expanded substantially. This is not terribly surprising given that recreational fishermen seem to currently have unmet demand and commercial fishermen are only earning a profit of about $1 per pound. Although we did not carry out sensitivity analysis on all of the parameters in the model, we did carry out sensitivity analysis on the commercial demand parameter and found that our results were qualitatively robust. In evaluating the surplus of the fisheries, as theory would predict, the complete market yields the greatest total level of estimated surplus. As simulated, the commercial sector ends up losing in the complete market unless they receive grandfathered shares of the TRs. In that case the revenues that they can earn from selling their rights to fish are more than they would have earned by actually participating in the commercial red snapper fishery.

B. Significant problems

The project was delayed for a variety of reasons.

- We had expected to use a recreational demand model from a previous MARFIN project. However, getting into the research we found the previous model was inadequate and we had to empirically estimate recreation demand that incorporates TR permit demand.
- We had great difficulty calibrating GBFSM for red snapper due to the data reported in the last red snapper stock assessment plan (SEDAR 7) for number of fish at age and size of fish. Finally we abandoned this and calibrated the model with respect number at size of fish.
- Many changes were made in the GBFSM such that the user friendly interface, EFESUS, was becoming outdated. We developed a system which we now refer to is as a **B**io**E**conomic **S**imulating **S**ystem, BESS.

- Considerable effort was put into remodeling the optimization procedure for calibrating the biological model in GBFSM. The reason for doing this was to make calibrating the model easier and more accurate. This optimization proved to be very useful in calibrating shrimp.

C. Description of need, if any, for additional work.

- Over 70% of the commercial red snapper landings are from the west Gulf of Mexico. Approximately 83% of the recreational harvest in the Gulf of Mexico come from east of the Mississippi river. So the major portion of the commercial harvest is west of the Mississippi river and the major portion of the recreational harvest is east of the Mississippi river. The stock of red snapper on the east Gulf of Mexico is only approximately 60% as large as the stock of red snapper in the west Gulf of Mexico. A single total TAC for the red snapper in the Gulf of Mexico which always has a 51%-49% split between commercial and recreational fishermen can more readily cause more overfishing in the east then in the west Gulf of Mexico. Research is needed to look at separate TACs for the east and west Gulf of Mexico red snapper fishery.
- All previous stock assessments have concluded that red snapper in the Gulf of Mexico are overfished and undergoing overfishing. However, recent published studies have shown that red snapper are density dependent and that age 0 and age 1 fish have a much higher natural mortality rate than was used in previous stock assessments. By using a density dependent model and a higher natural mortality for age 0 and age 1 fish, it appears to us that red snapper stock are neither overfished nor undergoing overfishing. Also, because the natural mortality for age 0 and age 1 fish are much higher than originally assumed, shrimp trawls have less effect on red snapper reaching age 2+ than previously thought. Future stock assessments need to consider density dependent models and higher natural mortality rates for age 0 and age 1 red snapper.
- Our initial question in this research was, Can a TR program work for the GRS recreational fishery? We believe it could. There are numerous practical decisions that need to be made, and we offer possible answers to some of these above. Our answers are proposed not as the final solution, but as a starting point from which managers, analysts and stakeholders can start and look for alternatives that might be preferred.

V. Evaluation

A. Achievement of project goals

Basically the goals of the project have been achieved, although it took considerably longer to accomplish than we anticipated when we wrote the proposal. However, by taking a longer period of time, additional data became available which we feel has greatly improved the result of the analysis and its usefulness.

B. Dissemination of Project results.

The project's findings will be distributed primarily through academic conference presentations, papers to be published in peer-reviewed publications and is part of one Ph.D. thesis at Texas A&M. Output from this work includes:

- Transferable Rights in Recreational Fisheries: An Application to the red Snapper Fishery in the Gulf of Mexico, Ph.D. Dissertation by Hwa Nyeon Kim, May 2007

- Hwa Nyeon Kim, Richard T. Woodward, Wade L Griffin and W. Douglass Shaw. “Transferable rights for a more efficient allocation of Recreational Red Snapper Fishing in the Gulf of Mexico.” Paper presented at the 2007 Meetings of the Southern Economics Association, New Orleans, LA, November 19-21. Rich Woodward was the presenter.

- Kim, Nyeon, Richard T. Woodward and Wade L. Griffin. “Can Transferable Rights Work in Recreational Fisheries?” Sponsored by the Property and Environment Research Center and Environmental Defense. Emigrant, Montana, October 5-8, 2006.

- Kim, Hwa Nyeon, Richard T. Woodward and Wade L. Griffin. 2009. "Can Transferable Rights Work in Recreational Fisheries?" in D.R. Leal and V. Majaraj (eds.). Evolving approaches to managing marine recreational fisheries. Lexington Books: Lanham, MD.

- Kim, Hwa Nyeon, Richard T. Woodward, and W. Douglass Shaw “Distributional Consequences of Fees in a Discrete Choice Model of Recreation Demand with Incomplete Data: An Application to Mode-Specific Fishing," Land Economics, 83(4): 539-560.