Ecological and Socioeconomic Tradeoffs in Implementing Fair Trade USA in Small-Scale Fisheries

A Case Study of Costa Rican Snapper

A Group Project submitted in partial satisfaction of the requirements for the degree of
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The Group Project is required of all students in the Masters of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

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Table of Contents

Abstract

Small-scale fisheries in developing countries often face barriers in obtaining seafood certifications. Existing certification programs, such as the Marine Stewardship Council (MSC), can offer ecological and economic benefits, but have effort-intensive and costly requirements. Since developing country fisheries contribute over 50% of seafood products entering global markets, there is a need for novel solutions to address the challenges of certifying these fisheries. Fair Trade USA (FTUSA), a program known for certifying land-based products from developing countries, launched a capture fisheries certification in 2014, but the ecological and economic effects are currently unknown. We used a small-scale Costa Rican snapper fishery, which abandoned the MSC certification process in 2015, as a case study to examine the effects of implementing the FTUSA standards on the supply chain, snapper stock, and economic profits of the fishery. After establishing that FTUSA was a good fit for small-scale fisheries, we mapped the supply chain of the Costa Rican snapper fishery using a systems mapping approach. We found that implementing FTUSA would restructure the supply chain by redirecting the domestic sale of snapper to export markets. We then developed a bio-economic model to predict the impact of FTUSA certification on the snapper stock and profits generated for the community. We found that if FTUSA and corresponding fishing mortality controls were adopted by our study system, the communities in the Guanacaste region of Costa Rica, the program would have economic benefits but an insignificant effect on the depleted snapper stock. A greater proportion of the region's snapper fisheries would have to operate under FTUSA to help the fish stock recover. However, the generation of community funds and the emphasis on social criteria make FTUSA a beneficial certification program for the Costa Rican snapper fishery case study, and more generally for small-scale fisheries in developing countries.

Figures & Tables

Acronyms and Abbreviations

	English	*Español*
ARCAE	The Costa Rican Environmental and Educational Network	Asociación Red Costarricense para el Ambiente y la Educación
ASOBEJUCO	Association of Fishers of Bejuco	Asociación de Pescadores de Bejuco
ASPEPUCO	Association of Fishers of Point Coyote	Asociación de Pescadores de Punta Coyote
EEZ	Exclusive Economic Zone	Zona Económica Exclusiva
FTUSA	Fair Trade United States of America	
FAO	Food and Agriculture Organization of the United Nations	Organización de las Naciones Unidas para la Alimentación y la Agricultura
FECOP	Costa Rican Fisheries Federation	Federación Costarricense de Pesca
FIPs	Fishery Improvement Projects	
INCOPESCA	Costa Rican Institute of Fisheries and Aquaculture	Instituto Costarricense de Pesca y Acuicultura
MPA	Marine Protected Area	Área Marina Protegida
MSC	Marine Stewardship Council	
NGO	Non-governmental Organization	Organización no Gubernamental
PD	Sport/tourism fishing	Pesca deportiva
PRETOMA	Marine Turtles Restoration Program	Programa Restauración de Tortugas Marinas
RBF	Risk-based Framework	
SSF	Small-Scale Fishery	Pesca Pequeña Escala
SFP	Sustainable Fisheries Partnership	
WWF	World Wildlife Fund	

Executive Summary

Global demand for sustainable seafood is increasing, driven by consumer awareness and seafood sustainability pledges by large retailers. For example, Wal-Mart (U.S.) pledged to source all seafood from sustainable sources by 2015. To guarantee sustainability and secure healthy fish stocks for the future, companies commonly source their seafood from fisheries bearing a third party certification label, including the Marine Stewardship Council (MSC). However, the MSC certification process and standards are extremely rigorous and costly. Small-scale fisheries in developing countries face barriers to certification, including a lack of data collection systems and effective fishery management programs. These developing country fisheries account for over 50% of seafood products by value entering global markets (FAO 2014). For companies to meet their sustainability goals and incentivize fishers to continually utilize responsible practices there is an increasing need to incorporate small-scale fisheries in developing countries into seafood certification programs.

The two Costa Rican coastal fishing communities of San Francisco de Coyote and Bejuco, located on the Pacific coast of the Nicoya Peninsula, exemplify the struggle faced by small-scale fisheries when attempting to obtain seafood certification. Our client, Conservation International Costa Rica, and two other Costa Rican non-government organizations (NGOs), Programa Restauración de Tortugas Marinas (PRETOMA) and the Costa Rican Environmental and Educational Network (ARCAE), have worked extensively with San Francisco de Coyote and Bejuco to assist in seafood certification preparation. In 2011, the fisheries underwent a Marine Stewardship Council pre-assessment, which resulted in a series of necessary improvements including extensive data collection systems and collaboration with the Costa Rican Institute of Fishing and Aquaculture (INCOPESCA), Costa Rica's primary fisheries regulatory agency, which allowed them to enter the full assessment process in January 2015. However, in late 2015, it was decided that the fishery would no longer pursue MSC certification, largely due to lack of requisite stock information. A fishery improvement project (FIP), a partnership between NGOs, retailers, and fishers that uses a process of continual improvement to eventually achieve the MSC certification was considered but rejected. The barriers to MSC certification could not be overcome in a timely, cost-effective manner, even through a step-wise process.

After deciding not to pursue the MSC certification or a fishery improvement project, the fishing communities decided to explore the Fair Trade USA Capture Fisheries Program (FTUSA), a newly established seafood certification launched in 2014. FTUSA is fundamentally different from the MSC because it utilizes a system-wide approach to certification, uniquely addressing social criteria, while also including the biological and ecosystem-based considerations mandated by the MSC. Given the novelty of FTUSA, there was a clear need to understand whether FTUSA was an

appropriate seafood certification for small-scale fisheries generally and the Costa Rican snapper fishery in particular. In addition, it was not known how or whether FTUSA would affect the stock status of the target species and the economics of the fishery both via changes to the supply chain and fishery related profits.

Our approach was divided into three components: (1) a comparison of three existing seafood programs (MSC, FIP, and FTUSA), (2) supply chain and systems mapping of the fishery, and (3) a bio-economic model to quantify specific effects of FTUSA. First, we compared the suitability of MSC, FIP, and FTUSA for small-scale fisheries using a peer-reviewed framework of recommended criteria for seafood certifications. From this evaluation, it was clear that the inclusion of social criteria in FTUSA's standard makes this certification most appropriate for small-scale fisheries in developing countries. Next, in order to understand the effect that FTUSA may have on all aspects of a target fishery from landings to sale for consumption, we mapped the Costa Rican snapper fishery's current supply chain using information gathered during a series of in-person and phone conversations conducted in August - December 2015. This information was used to create causal loop diagrams (CLDs) to understand the complexity of the snapper fishery supply chain system. We then qualitatively examined the effects of the Resource Management section of the FTUSA certification on the fishery to understand how the certification could change the biological and socioeconomic components of the supply chain. We found that domestic sale of snapper would significantly decrease as FTUSA guarantees a USA-based buyer. We also determined that the communities of San Francisco de Coyote and Bejuco would need to take numerous organizational steps in order to comply with the FTUSA model, such as the creation of a local Fair Trade Committee to democratically manage the price premium earned through certification.

Finally, we developed a bio-economic model to quantify and project biological and economic effects of FTUSA certification on the snapper fishery. A unique attribute of FTUSA is that the premium price of certified seafood paid by consumers is transferred directly to the producers, accumulating in a Community Development Premium fund managed by the local Fair Trade Committee. This Community Development Premium is the primary economic incentive promised by FTUSA, and understanding its potential value is therefore critical to assessing the benefit of FTUSA certification. The Community Development Premium fund depends on two main aspects: (1) the FTUSA premium percent, a fixed percent of dock price that is allocated to the community and, (2) volume of landings, which under FTUSA certification, must be managed to ensure that overfishing is not occurring. FTUSA requires that appropriate control rules must be implemented to promote stock recovery and prevent overfishing by certified fishers. We decided that the most feasible control for the overfished snapper fishery would be in the form of effort reduction as defined by the number of fishing trips. Thus, we were interested in both how changes in effort could influence the biology of the fish stock and how changes in the FTUSA price premium percent combined with landings could influence community profits.

To predict the revenue that could be generated in the Community Development Premium fund, we used landings and price data from INCOPESCA and sample catch per unit effort (CPUE) data collected by PRETOMA and ARCAE, two marine conservation NGOs working to promote sustainable fisheries policies in Costa Rica and throughout Central America. We examined the effects of multiple FTUSA certification implementation scenarios on economic and biological components of the fishery by varying fishing effort reduction and price premium percent. In all scenarios of FTUSA implementation, we found that San Francisco de Coyote and Bejuco would obtain some economic benefit from certification; the communities, which together represent 10% of regional fishing effort, would generate an average annual amount of $540 - $868 in the Community Development Premium at a 6% FTUSA price premium percent. The effects of FTUSA certification on biological features of the target stock were more variable and largely depended on estimates of movement patterns of the snapper stock. In particular, if the snapper stock in Guanacaste is well-mixed through the entire region, and only San Francisco de Coyote and Bejuco implement controls on fishing mortality through certification (10% of the effort in the region), the effect on the snapper biomass will be negligible, regardless of the degree of effort reduction by the communities. A positive stock trajectory was seen when the entire region committed to reducing effort by at least 20%, at which point the snapper biomass began to stabilize.

Our results provide critical insight into the potential economic and biological tradeoffs that could be obtained from adopting the FTUSA certification in small-scale fishing communities around the globe. Overall, as demand for sustainable seafood continues to increase worldwide, it is imperative that small-scale fisheries in developing countries are able to participate in the sustainable seafood market via certification programs. By examining the Costa Rican snapper fishery as a case study, we are able to show that FTUSA may fill the gaps that MSC struggles to address in small-scale fisheries by utilizing a system-wide approach and incorporating social criteria. Remaining challenges to FTUSA include defining the role of middlemen and predicting the consequences of the void left when FTUSA product is exported to the USA. Looking forward, FTUSA certified seafood is poised to experience additional demand as retailers and suppliers react to current problems of inequity in seafood trade and pursue a guarantee of both environmental and social sustainability.

Resumen Ejecutivo

La demanda global de productos pesqueros continúa incrementando gracias a la creciente concientización de los consumidores, y los compromisos de sostenibilidad iniciados por grandes cadenas de supermercados. Por ejemplo, Wal-Mart (USA) se comprometió en abastecerse exclusivamente de fuentes sostenibles para el 2015. Con el fin de garantizar poblaciones pesqueras saludables y productos pesqueros sostenibles, muchas compañías compran productos con certificaciones expedidas por terceras partes, incluyendo las de 'Marine Stewardship Council (MSC)'. Sin embargo, el proceso y valor de obtener una certificación MSC es extremadamente estricto y costoso. En el caso de los pescadores de pequeña escala en países en vías de desarrollo, existen grandes barreras para obtener certificaciones. La deficiencia de recolección de datos y programas de manejo efectivos, dificultan la obtención de estas etiquetas de sostenibilidad. Las pesquerías de países en vías de desarrollo, representan un 50% de los productos pesqueros que entran a los mercados globales (FAO 2014). Con el fin de lograr que las grandes cadenas de supermercados cumplan sus metas de sostenibilidad, y continuar incentivando a los pescadores para seguir prácticas responsables, existe la necesidad de incorporar a estos pescadores de pequeña escala en países en vías de desarrollo dentro de los programas de certificación.

Las comunidades pesqueras de San Francisco de San Francisco de Coyote y Bejuco, ubicadas en la Península de Nicoya, Pacífico norte de Costa Rica, ejemplifican la lucha que enfrentan muchos pescadores de pequeña escala al intentar obtener certificaciones de sostenibilidad. Con el apoyo de Conservación Internacional Costa Rica, dos Organizaciones no Gubernamentales (ONGs), la Asociación Red Costarricense para el Ambiente y la Educación (ARCAE) y el Programa Restauración de Tortugas Marinas (PRETOMA), han trabajado durante un largo tiempo con las comunidades de San Francisco de Coyote y Bejuco para obtener una certificación. En el 2011, la pesquería de pargo manchado se sometió a una pre-evaluación de Marine Stewardship Council. Durante este proceso, se identificaron una serie de mejoras necesarias, incluyendo recolección de datos y colaboración con el Instituto Costarricense de Pesca y Acuicultura (INCOPESCA), la agencia regulatoria de pesca en Costa Rica, sin embargo, las comunidades pudieron empezar el proceso de evaluación completo en enero 2015. A finales del mismo año, se tomó la decisión de no continuar con el proceso de certificación MSC, en gran parte por la falta de información sobre la población del pargo manchado. Ante este esto, las comunidades de San Francisco de Coyote y Bejuco consideraron adoptar un Proyecto de Mejoramiento Pesquero (FIPs), una asociación entre ONGs, distribuidores y pescadores, que usa un proceso de mejoramiento continuo para eventualmente obtener la certificación MSC. Este proceso fue abandonado, ya que por este medio, tampoco era posible superar las barreras para obtener una certificación MSC a un bajo costo.

Después de eliminar la certificación MSC y un FIP como opciones, las comunidades de San Francisco de Coyote y Bejuco decidieron explorar el programa Fair Trade USA Capture Fisheries (FTUSA), una nueva certificación lanzada al mercado en 2014. La mayor diferencia entre FTUSA y MSC es la utilización de un programa integral para otorgar certificaciones. Esto implica que FTUSA incluye criterios sociales, al igual que criterios ambientales (biológicos y ecosistémicos), incluidos por MSC. Dado lo novedoso del programa FTUSA, es importante entender el alcance de esta certificación, al igual que determinar si es un programa apropiado para pescadores de pequeña escala en general y particularmente para la pesquería de pargo manchado en Costa Rica. Adicionalmente, es incierto si la certificación FTUSA tendría efectos y de qué índole sobre la población de pargo manchado, al igual que impactos económicos sobre la cadena de valor y los posibles beneficios obtenidos por los pescadores.

El presente estudio se dividió en tres componentes: (1) comparación entre tres programas para productos pesqueros (MSC, FIP y FTUSA), (2) mapeo de la cadena de valor de la pesquería de pargo manchado, y (3) desarrollo de un modelo bio-económico para predecir el efecto de FTUSA en términos de biomasa y beneficios económicos. Primero, se hizo una comparación de la aplicabilidad de MSC, FIP y FTUSA para pescadores de pequeña escala, utilizando un protocolo publicado por expertos en programas de certificación y sostenibilidad de comercialización de productos pesqueros. A partir de esta evaluación, se encontró que FTUSA es el programa más apropiado para pescadores de pequeña escala, puesto que incluye criterios sociales esenciales para comunidades pesqueras en países en vías de desarrollo. Seguidamente, con el fin de entender el alcance de FTUSA sobre los diferentes pasos a lo largo del proceso de captura, comercialización y venta de pescado, se mapeó la actual cadena de valor del pargo manchado capturado por las comunidades de San Francisco de Coyote y Bejuco. Este componente se llevó a cabo utilizando información recopilada entre agosto y diciembre 2015, por medio de entrevistas informales en campo, y conversaciones telefónicas con diferentes usuarios a lo largo de la cadena de valor. Con la información obtenida se creó un Diagrama de Circuitos Causales (CLDs) para comprender la complejidad del sistema. Seguidamente, con el fin de entender los impactos de obtener la certificación FTUSA sobre el recurso y los beneficios económicos a lo largo de la cadena de valor, se hizo un análisis cuantitativo de los efectos de la sección de “Manejo de Recursos” dentro de los criterios de certificación FTUSA. Se encontró que las ventas de pargo manchado hacia el mercado local disminuirían significativamente, puesto que FTUSA garantiza un comprador en Estados Unidos. De igual manera, se determinó que las comunidades de San Francisco de Coyote y Bejuco, necesitarían hacer varios cambios en su organización para cumplir con el modelo de FTUSA. Por ejemplo, la creación de un Comité Local de Fair Trade que administre el *precio premium* obtenido por medio de la certificación.

Finalmente, se desarrolló un modelo bio-económico que cuantificara y proyectara los efectos ecológicos y económicos de la certificación FTUSA sobre la pesquería de pargo manchado. Un atributo único de FTUSA es el *precio premium*, valor pagado por los consumidores para obtener un producto certificado. Esta diferencia de precio es transferida directamente a los pescadores, y se acumula en el Fondo de Desarrollo para la Comunidad, el cual depende de dos factores: (1) el porcentaje de *precio premium* establecido por FTUSA. Este valor es un porcentaje fijo del precio del pescado a la hora de la descarga, adjudicado a la comunidad; y (2) el volumen de descarga, el cual bajo la certificación FTUSA, debe ser inspeccionado para evitar sobrepesca. El programa de FTUSA requiere controles de esfuerzo pesquero, dadas las políticas pesqueras en Costa Rica, se optó por una reducción del número de viajes de pesca al año como reducción de esfuerzo pesquero. El modelo bio-económico busca entender de qué manera los cambios en esfuerzo pesquero traen cambios ecológicos, y cómo el *precio premium* de FTUSA, en combinación con las descargas, influencian los beneficios para la comunidad.

Con el fin de predecir los beneficios totales generados en el Fondo de Desarrollo para la Comunidad, se utilizaron dos fuentes de datos. Primero, información colectada por INCOPESCA sobre descargas y precios entre 1990 y 2013. Segundo, datos sobre Capturas Por Unidad de Esfuerzo (CPUE) PRETOMA y ARCAE, dos organizaciones no-gubernamentales locales, enfocadas en conservación marina y promoción de políticas pesqueras sostenibles en Costa Rica. Se examinaron los efectos de multiples escenarios de implementación de la certificación FTUSA, sobre los componentes ecológicos y económicos de la pesquería, modificando esfuerzo pesquero y el *precio premium*. En todos los escenarios donde FTUSA fue implementado, se encontró que San Francisco de Coyote y Bejuco obtendrían beneficios económicos gracias a la certificación. Estas dos comunidades, que representan 10% del esfuerzo pesquero de la región, generarían en promedio entre $270 y $434 anualmente por comunidad para el Fondo de Desarrollo para la Comunidad, con un porcentaje de *precio premium* FTUSA de 6%. Los efectos ecológicos de la certificación FTUSA fueron mas variables, mostrando fuerte dependencia de estimaciones de patrones de movimiento de la población de pargo manchado. Si la población de pargo manchado esta bien mezclada en toda la región de Guanacaste, y San Francisco de Coyote y Bejuco implementan controles de mortalidad por medio de la certificación FTUSA (10% de la región certificada), los incrementos de biomasa de pargo manchado serían insignificantes, independientemente del nivel de reducción de esfuerzo pesquero de las comunidades certificadas. Se encontró que la población de pargo manchado presenta una trayectoria positiva, cuando toda de la región de Guanacaste reduce el esfuerzo en un 20%, mostrando una recuperación de biomasa a niveles mayores al estado actual.

Los resultados presentan información crítica sobre el potencial económico y ecológico que existe si comunidades de pescadores de pequeña escala alrededor del mundo, adoptaran una certificación FTUSA. Conforme la demanda mundial por productos pesqueros sostenibles continua creciendo, es claro que por medio de programas de certificación, los pescadores de pequeña escala de países en vías de desarrollo tienen la posibilidad de participar en el mercado de productos pesqueros sostenibles. Por medio del caso de estudio del pargo manchado en Costa Rica, el presente estudio demuestra que el programa de FTUSA, con su sistema inclusivo que incorpora criterios sociales, tiene el potencial de llenar vacíos que MSC tiene para abordar pesquerías de pequeña escala. Existen desafíos para el programa FTUSA, primero, definir el papel que juegan los intermediarios, y segundo, entender las consecuencias sobre el mercado local, al exportar el producto certificado a Estados Unidos. Mirando hacia adelante, con la actual inequidad en la comercialización de productos pesqueros, las grandes cadenas de supermercados y proveedores, continúan incrementando su demanda de productos pesqueros con certificaciones como la de FTUSA, que garantizan bienestar social y sostenibilidad ambiental.

1. Introduction

Seafood programs are market-based initiatives that encourage sustainable fishing practices through economic incentives. Once implemented, these programs can provide social, biological, and economic benefits to fishers, supply chain partners, and consumers (Ward & Phillips 2008). However, the success of seafood programs in small-scale fisheries in developing countries (referred to from this point forward as small-scale fisheries (SSFs)) is constrained by limitations in data collection, finances, and national governance (Jacquet & Pauly 2008). The two communities of San Francisco de Coyote and Bejuco, part of the Nicoya Peninsula snapper fishery in the Guanacaste region of Costa Rica, exemplify the challenges that SSFs have faced when trying to obtain a certification that would ultimately allow producers to access larger markets and receive higher prices for their responsible practices. The significance and motivation for our project is discussed below, followed by our objectives.

1.1. Project Significance

Fisheries in developing countries play a crucial role in the global fish trade and are responsible for more than half of total fishery exports by value (FAO 2014). Much of this volume is sold in markets in developed countries that have begun to demand seafood products that do not contribute to degradation of marine environments (Perez-Ramirez et al. 2012). There is a need for further research and case studies regarding the applicability of existing seafood certification programs to SSFs. The problem is twofold: (1) many SSFs are poorly managed and lack an incentive to utilize sustainable practices to improve the health of the target fish stock; (2) SSFs lack access to the existing certification programs that have been successful in large-scale fisheries due to barriers in data collection, finances, and governance. Additionally, because certification programs have only recently begun in SSFs in developing countries (the first was the red rock lobster in Baja California, Mexico in 2004), there is limited information of the effects of these programs on the supply chain, traceability effectiveness, stock status and recovery, and associated fisher profits.

In 2011, the communities of San Francisco de Coyote and Bejuco on the Nicoya Peninsula in the Guanacaste region of Costa Rica, which target spotted rose snapper (*Lutjanus guttatus*), began a pre-assessment for the dominant global seafood certification, the Marine Stewardship Council (MSC). After working on recommended improvements with the support of Programa de Restoracion de Tortugas Marinas (PRETOMA), the Costa Rican Environmental and Educational Network (ARCAE), and Conservation International Costa Rica (CI), the fishery entered the full certification assessment process in January 2015. However, in late 2015 it was decided that the fishery would not move forward with the full assessment process, largely due to barriers in completing criteria in MSC Principle 1, which addresses the ecological status of the target stock. Limited by a lack of scientific information about the snapper stock and a lack of effective fishery management, but still willing to pursue a certification to promote sustainable fishing practices and gain larger market access, the fishery decided to pursue the recently established Fair Trade USA (FTUSA) capture fisheries certification.

Our client, Conservation International, has been supporting the communities of San Francisco de Coyote and Bejuco through fisheries-based scientific data collection since 2005 and is interested in improving traceability of snapper while simultaneously increasing market access and profits for fishers in the communities of San Francisco de Coyote and Bejuco. The knowledge gaps about seafood certifications in SSFs globally, our client's desire to improve traceability and fisher profits in San Francisco de Coyote and Bejuco specifically, and the history of attempted seafood certification on the Nicoya Peninsula that exemplify the challenges associated with certifying seafood in developing country SSFs were the primary motivators for our project.

1.2. Project Objectives

We sought to assess the applicability and biological and economic tradeoffs of existing seafood certification programs for small-scale fisheries (SSFs) in developing countries. We used the Nicoya Peninsula snapper fishery in Costa Rica as a case study and model system. Our project objectives were achieved via a three-prong approach:

1. Determine which of the three seafood programs – the Marine Stewardship Council, fishery improvement projects with the goal of MSC certification, and Fair Trade USA Capture Fisheries -- is most appropriate for the complexities of SSFs, we compared each program against a framework of established governance, socioeconomic, and ecological criteria recommended for inclusion in seafood certification for SSFs.
2. Assess the effect of the Fair Trade USA Capture Fisheries seafood certification on a SSF supply chain, we used the Costa Rican snapper fishery as a case study and assembled a

detailed systems map of the biological and economic components of the fishery's supply chain.

3. Understand the potential long-term biological and economic consequences of implementing the Fair Trade USA Capture Fisheries seafood certification program on a SSF, we developed a bio-economic model that incorporated controls on fishing mortality and seafood price premiums for the San Francisco de Coyote and Bejuco snapper fishery.

To accomplish these objectives within our study system in Costa Rica, we qualitatively assessed the suitability of the three programs that have been considered by the San Francisco de Coyote and Bejuco snapper fishery using a framework of system-wide criteria for seafood assessments (Micheli et al 2014). Next, we mapped the snapper supply chain based off a series of conversations and phone calls conducted in August - December 2015. We then employed systems mapping to understand complex linkages and influences in the snapper supply chain. After understanding the snapper supply chain and seafood certifications in SSF, we modeled the effect that the FTUSA capture fisheries certification would have on the fishery and existing supply chain using catch and price data from INCOPESCA and sample catch per unit effort data collected by the Costa Rican NGOs ARCAE and PRETOMA. We employed bio-economic modeling to predict the amount of revenue generated by the fishing community if FTUSA were to be successfully adopted.

2. Case Study: Costa Rican Snapper

2.1. Small-Scale Fisheries in Costa Rica

With more than 1200 km of coastline on both the Pacific Ocean and Caribbean Sea (Figure 1), marine resources play a vital role in Costa Rica for food and livelihoods (Herrera-Ulloa et al. 2011; Villalobos 1982; MINAE 2002). It is estimated that more than 14,000 fishers live on the coasts and islands of Costa Rica, many of whom are living in impoverished conditions due to deterioration of the fisheries, poor monetary compensation and labor conditions, weak infrastructure of the artisanal fishing sector, and the presence of international industrial fishing fleets (FECOP 2013). About 95% of Costa Rica's fishing fleet operates in the Pacific Ocean, which can be divided into four regions (Palacios 2007): Guanacaste, Gulf of Nicoya, Central Pacific, and South Pacific (Figure 1). Between 75% and 80% of all landings in Costa Rica come from artisanal fleets. Fisheries management and planning is the responsibility of the Costa Rican Institute of Fishing and Aquaculture (INCOPESCA) (Herrera-Ulloa et al. 2011), through the Costa Rican Fishing and Aquaculture Law No. 8436 (2005).

As in many other small-scale fishing communities around the world, many fishers in Costa Rica are organized as part of fishing associations, cooperatives, committees, and unions, commonly supported by NGOs. Nevertheless, many of these fishers' organizations are not legally registered or recognized with INCOPESCA (Herrera-Ulloa et al. 2011). Studies investigating the socio-economic aspects of these small-scale fishing communities in Costa Rica have found that most fishers fall within the category of poverty, but not extreme poverty (Charles & Herrera 1994). Some studies suggest that the booming tourism industry in Costa Rica has led to improved economic conditions for fishers in many regions as local tourism demand can lead to higher prices for fish (Gónzalez & Villalobos 1999). Additionally, many small-scale fishing communities in Costa Rica have embraced alternative forms of employment related to sport fishing, tourism and ecotourism.

Figure 1. Map of Costa Rica showing the major fishing regions on the Pacific and Caribbean coasts.

2.2. Study Locations: San Francisco de Coyote and Bejuco

In order to address our project objectives, we focused on a case study area in Costa Rica that shares many characteristics of small-scale fisheries in developing countries around the world. The two communities, San Francisco de Coyote and Bejuco, are located at the southern end of the Nicoya Peninsula on the north Pacific coast of Costa Rica (Figure 2). Since 2007, the Programa Restauración de Tortugas Marinas (PRETOMA), a Costa Rican NGO, has been working with the fishers' associations in these communities to monitor fishing effort and catch rates and to ultimately gather sufficient data to assess the ecological status of the target species, spotted rose snapper *(Lutjanus guttatus)* as well as common bycatch species associated with the fishery (Mongeon et al. 2013).

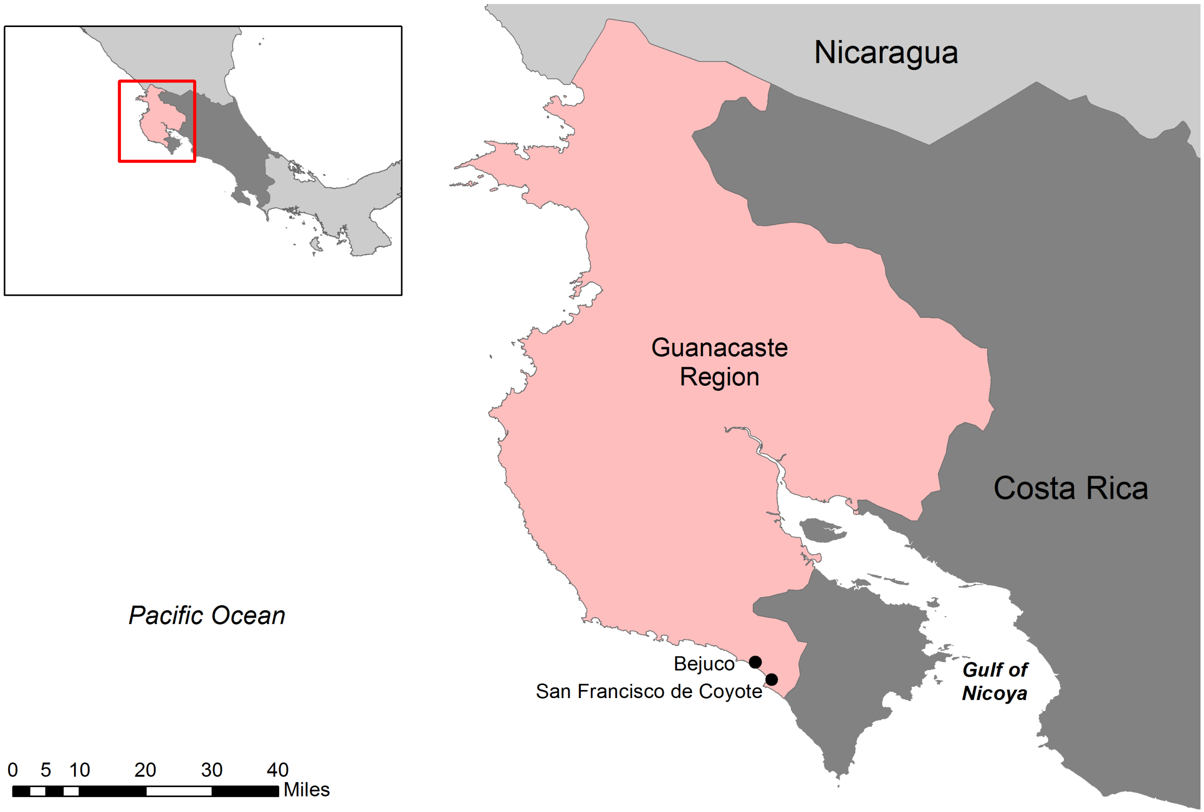

Figure 2. Map of study location. The fishing communities of San Francisco de Coyote and Bejuco are located on the south Pacific side of the Nicoya Peninsula in the Guanacaste region.

2.2.1. Community Characteristics

Between the two small-scale fishing (SSF) communities of San Francisco de Coyote and Bejuco, there are 25 to 30 families that depend on the snapper fishery for their livelihoods out of the approximately 3,000 total residents. Around 45% of the fishers in the two communities work independently, while the rest are members of a fisher association (ASPEPUCO in San Francisco de Coyote or ASOBEJUCO in Bejuco). The fishing grounds used by the two communities extend from the southern boundary near Manzanillo to Punta Islita in the north. Within the fishing region are two marine protected areas (MPAs): Camaronal National Wildlife Refuge and Caletas-Ario National Wildlife Refuge. In these MPAs, artisanal bottom longline fishing is permitted, but shrimp trawling, compressor lobster fishing, and gillnetting are prohibited (Mongeon et al. 2013).

Fishing activity is primarily carried out with bottom longlines (poly-filament main line with J-hooks) though some fishers also use gillnets (mesh size between 3.5 and 4.5 inches). The number of hooks on each longline ranges between 500 and 3000 with spacing of approximately 2 meters between each hook. Lines are baited by hand before every fishing trip, usually with sardines, squid, or bycatch species (e.g. eel) that have a low commercial value. Most fishing activity is carried out at night and lines are left in the water for 6 to 8 hours. Fishers use small fiberglass skiffs, or pangas, which are approximately 6 m in total length powered by 25 horsepower engines (Mongeon et al. 2013; SCS 2011). Fish are gutted at sea and stored on ice before being landed and sold to the buyer at the dock. The buyer, who provides many of the fishers with coolers and fishing equipment, compiles fish tickets, or receipts, which include the total weight of snapper landed, size classes, the monetary value of the fish minus costs of materials, date sold, and general fishing location (SCS 2011).

The community size and structure, fishing activity range, and non-industrial gear types of San Francisco de Coyote and Bejuco are shared with many SSFs around the world and validate this case study as an appropriate representation of SSFs in developing countries. Additionally, as in San Francisco de Coyote and Bejuco, many SSFs in developing countries have extensive involvement with NGOs and multiple stakeholders who have sponsored the establishment of scientific data collection systems and financially supported the fisher associations.

2.2.2. History with Seafood Certifications

San Francisco de Coyote and Bejuco have been working to obtain a seafood certification for over five years. The challenges encountered are representative of the struggle faced by small-scale, developing country fisheries when seeking certification. Critical to the initial conversation about seafood certification was the strong relationship with two Costa Rican NGOs, PRETOMA and ARCAE, which provided scientific and financial support. Additionally, these NGO partnerships were valuable to our case study by facilitating data availability and access to community members.

PRETOMA was founded in 1997 with the mission to protect and restore sea turtles, sharks, and other endangered marine species. PRETOMA's scope, influence, and mission has evolved over the past 18 years to include campaigns on sustainable fisheries, MPA development, and other marine conservation projects at regional, national, and international levels. PRETOMA, which has a field station in San Francisco de Coyote, began working with the fisher association in San Francisco de Coyote in 2007 and then that in Bejuco in 2010. Collaborative efforts included enforcement of the two MPAs and extensive data collection on snapper weight, length, and location and duration of fishing trips.

In 2011, the snapper fisheries underwent a MSC pre-assessment. The pre-assessment, which depended heavily on the data collection efforts of PRETOMA and was funded by Resource Legacy Fund and conducted by Scientific Certification Systems (SCS) Global Services, resulted in a series of recommendations that would need to be implemented before the fishery could enter the full assessment process. Significant barriers to certification identified included making necessary improvements to government fishery management, creation of uniform data collection practices, and assemblage of credible science regarding the fish stock. During pre-assessment, the Costa Rican Environmental and Educational Network (ARCAE) was established to facilitate progress on the pre-assessment recommendations, to assist SCS Global Services, and to fill a necessary gap in coordinating the certification process. A $60,000 grant from Resource Legacy Fund was not sufficient to cover all of SCS's expenses, so ARCAE collected and organized information that would have been done by billable auditors. In January 2015, the full assessment process began and was officially announced by the MSC in March 2015. However, despite these efforts, it became apparent that there was insufficient information to meet the requirements of MSC's Principle 1 (Sustainable Fish Stocks) due to lack of stock information available and limited data collection by INCOPESCA. In May 2015, three options were discussed: 1) turn the assessment into a fishery improvement project (FIP) which would establish a timeline of improvements; 2) conduct a Fair Trade audit which SCS believed would greatly benefit the small-scale fishing communities; 3) continue with the originally planned full MSC assessment.

In September 2015, it was decided by ARCAE and the fishing communities that the fishery would no longer pursue MSC full assessment and certification because of the difficulty in fulfilling the rigorous MSC standards related to stock information and criteria for government enforcement. A FIP was also decided against because similar barriers would be experienced in reaching the ultimate goal, MSC certification. Additionally, the process of securing a Costa Rican or international retail partner in the FIP stakeholder process was uncertain. Instead, the fishing communities are in the process of pursuing the Fair Trade USA (FTUSA) capture fisheries certification. FTUSA includes biological and stock requirements like MSC, but operates on a process of continual improvement, with increasing stringency required in Years 1, 3, and 6. Also, FTUSA addresses social criteria that MSC lacks. As of October 2015, the communities are working towards eliminating barriers that may prevent FTUSA certification and actively making progress towards a FTUSA assessment. However, there is a lack of understanding of the predicted effects that the certification would have on community profits and snapper stock and our project seeks to fill these gaps.

Before moving to our analysis of seafood certifications and the predicted effects of FTUSA on the snapper stock and community profits, it is first necessary to understand the target species, spotted rose snapper (*Lutjanus guttatus).*

2.3. Spotted Rose Snapper (Lutjanus guttatus)

Spotted rose snapper (*Lutjanus guttatus*) is an important species for artisanal fisheries in Central America (Rojas 1997a; Vargas 1999; Rojas et al. 2004) and is the primary target species of small-scale fishing communities on Costa Rica's Pacific coast (Mongeon et al. 2013). Most of these communities use bottom longlines to catch snapper from small boats (FECOP 2013).

2.3.1. Geographic Distribution and Biology

The spotted rose snapper (*L. guttatus*) (Steindachner 1869) inhabits coral reefs and rocky reefs in nearshore regions along the Pacific coast of the Americas from the Gulf of California to Peru (Boza-Abarca et al. 2008; Rojas et al. 2004). The maximum size for *L. guttatus* is approximately 66 cm and longevity is estimated at 13 - 23 years (Correa-Herrera & Jiménez-Segura 2012). Many studies have described the growth characteristics of *L. guttatus* in Central and South America using the von Bertalanffy equation (Table 1).

Table 1. Reported von Bertalanffy growth function parameters for spotted rose snapper (*Lutjanus guttatus*). Method is classified as "length/frequency" if the study used monthly length frequency distributions to estimate growth, and "otolith" if ages were determined from bands on the otoliths. From the von Bertalanffy growth function, L_∞ is the theoretical maximum length (cm) for an individual if it lived indefinitely, K is the growth coefficient or curvature parameter which represents the rate at which maximum size is reached.

Source	Location	Method	Sex	L_∞ (cm)	K
Bystrom 2015 (Excel)	Bejuco, Costa Rica	Length/Frequency	Both	63.2	0.37
Bystrom 2015 (Elefan)	Bejuco, Costa Rica	Length/Frequency	Both	64.6	0.21
González-Ochoa et al. 2009	Gulf of California, Mexico	Length/Frequency	Both	51.5 (SL)	0.13
Rojas 2007	Gulf of Nicoya, Costa Rica	Otolith & Length/Frequency	Both	65.9	0.13
Fishbase 2007	-	-	-	64.2	0.19
Amezcua et al. 2006	Gulf of California, Mexico	Otolith	Both	66.2	0.13
Andrade 2003	-	-	-	66.4	0.13
Rojas 2001	Central Pacific Coast, Mexico	Otolith	Both	68.4	0.14
Vargas 1999	-	-	-	67	0.3
Rojas 1997	-	-	-	60	-
Fisher et al. 1995	-	-	-	80	-
Siefke 1995	Gulf of Nicoya, Costa Rica	Otolith	Both	83	0.15
Cruz & Chaves 1993	-	-	-	64	0.19

Like many other tropical reef fishes, spotted rose snapper have a bi-phasic lifestyle with a planktonic larval phase and a benthic adult phase (Leis 1987; Leis 1991). During the planktonic phase, currents may help to distribute fish larvae, but many studies suggest that this passive larval transport only plays a minor role in determining the geographic distribution of reef fishes (Jones et al. 1999; Swearer et al. 1999; Cowen et al. 2000). *L. guttatus* from the Pacific coast of Colombia was found to have a pelagic larval duration of 24.4 days, which is longer than other snapper species from the same region (Zapata & Herrón 2002). The MSC pre-assessment conducted by SCS Global Services in 2011 raised concerns about the number of snapper stocks in the Guanacaste region (SCS 2011). Due to the small scale and range of the fishery, the auditors hypothesized the snapper caught in Coyote and Bejuco are likely part of the same stock as the rest of the region (SCS 2011).

The average length at maturity for *L. guttatus* is approximately 30 cm (Anderson 2005; Correa-Herrera & Jiménez-Segura 2012), which corresponds to an age of 2-3 years. In Mexico and Costa Rica, *L. guttatus* is reproductively active yearlong, though there are two periods with the greatest spawning activity: March to April and August to November (Rojas 1997b).

After understanding the case study communities and their target species, *Lutjanus guttatus,* it was clear that San Francisco de Coyote and Bejuco exemplify the struggle faced by small-scale fisheries in developing countries when seeking seafood certification. To explore this problem, we used a three-pronged approach, detailed in the following sections as three sub-projects:

- Certification Comparison
- Systems Mapping
- Bio-economic Model

3. Certification Comparison

3.1. Introduction to Seafood Certification Comparisons via Frameworks

People consume more fish products and depend more heavily on the fishing sector for their livelihoods and food security than ever before (FAO 2014). An increasing global human population, coupled with a projected increase in per capita protein consumption, is predicted to increase pressure on fish stocks, which currently provide protein to over 3 billion people worldwide (Tilman et al. 2011; FAO 2014). However, the lack of stock status information on the fish species targeted by small-scale fisheries (SSFs), which contribute greater than 80% of global catch, indicates that most of the world's fisheries may be poorly prepared to handle increased exploitation (Costello et al. 2012). As estimated by the Food and Agriculture Organization of the United Nations, 61% of marine fish stocks are fully fished at their maximum sustainable yield and over 29% are overexploited (FAO 2014). Overfishing not only has consequences for the target stock and people that depend on it, but can also drastically alter the entire marine food web, with negative, system-wide ramifications (Pauly et al. 1998).

In response to the crisis of overexploited global fish stocks and degraded marine ecosystems, there has been a growing demand for sustainable seafood (Jacquet & Pauly 2007). In other words, people and industries are increasingly demanding an assurance that seafood products have been harvested in a manner that does not contribute to the degradation of marine ecosystems and fisheries. Demand for sustainable seafood is growing in North America and Europe through a rise of consumer awareness programs about the harmful effects of many fishing practices on the environment and marine species (Jacquet & Pauly 2007). This demand for sustainability often manifests through an increase in seafood products bearing a certification.

Seafood certifications, or programs with rigorous scientific standards, are increasingly used to guarantee that seafood products are harvested without negatively impacting the environment or target stock. However, because these certifications necessitate extensive data collection and appropriate government enforcement, the fisheries to first become certified have been in developed countries. It is apparent that the “low hanging fruit” fisheries have been certified and the current challenge remains to certify small-scale fisheries in developing countries, which are often data poor and lack the capital necessary to complete costly audits required by the third party certifying agencies, or conformity assessment bodies.

In this section, we detailed the rise of seafood certification programs and focused on three, prominent programs and their specific application in small-scale, developing country fisheries: the Marine Stewardship Council (MSC), fishery improvement projects (FIPs), and Fair Trade USA capture fisheries (FTUSA). We then compared the suitability of the MSC, FIP with an end goal of MSC certification, and FTUSA for small-scale fisheries using a peer-reviewed framework of recommended criteria for seafood certifications.

3.1.1. The Rise of Seafood Certifications Programs

Seafood certification and eco-labelling programs are “system(s) used to create market-based incentives to encourage products that can demonstrate they are produced in an ecologically sustainable manner” (Ward & Phillips 2008). The overarching goal of seafood certifications and eco-labels is to influence consumer or retailer purchasing decisions in order to gain a higher, premium price for fisheries products, thereby incentivizing environmentally friendly and sustainable fishing practices.

There are two major categories of seafood certifications: single-attribute and multi-attribute (Chaffee et al. 2004). Single-attribute programs catalyzed the seafood certification movement and developed from advocacy campaigns targeting single species (Thrane et al. 2009; Gulbrandson 2009). For example, the dolphin-tuna controversy, driven by the U.S.-based Earth Island Institute in the 1980s, highlighted dolphins incidentally captured by tuna fisheries in the Eastern Tropical Pacific (Teisl et al. 2002). As a result of public outrage, the United States government passed the Dolphin Protection Consumer Information Act of 1990 with international support, and the “dolphin-safe” label was created to support tuna fisheries that did not extensively harm dolphins.

In the past two decades, there has been a transition from single-attribute certifications to multi-attribute certifications paralleling the transition in fishery science and management from a single-species focus to ecosystem based management. Multi-attribute certifications focus on protecting multiple fish stocks and the broader marine ecosystem in addition to a target stock (Thrane et al. 2009). The Marine Stewardship Council (MSC), the dominant global seafood certification standard, exemplifies a multi-attribute program with standards that assess the biology of the target stock, the impact of fishing gear on the marine environment, and enforcement of fishery laws. Other multi-attribute seafood certification programs include: KRAV, developed in Sweden and prominent in Europe; Friend of the Sea (FOS), born out of the single-attribute dolphin-safe eco-label started by the Earth Island Institute; Aquaculture Stewardship Council, the aquaculture equivalent to MSC; and ranking systems such as SeaChoice and Seafood Watch, which advise consumers on the degree of sustainability of seafood products.

As seafood certification programs have proliferated worldwide, there has been criticism about the credibility of the myriad standards and potentially overwhelming number of choices facing consumers and retailers. Even conscious consumers may not be able to distinguish between standards and confusion could lead to retailer mistrust. Additionally, retailers have been increasingly pressured to market themselves as “green” while balancing higher costs of certified seafood products (Czarnezki 2014). As a reaction to the seafood eco-label growth, there has been an increasing need to compare or unite the many certifications present in the market. The Global Sustainable Seafood Initiative (GSSI), a benchmarking initiative for seafood certifications launched at the 20th Anniversary of the FAO Code of Conduct of Responsible Fisheries in October 2015, is the first global step in establishing a set of standards to systematically evaluate and benchmark existing certification programs (GSSI 2016). GSSI also seeks to unite sustainability standards and has partnered with the International Social and Environmental Accreditation and Labeling (ISEAL) to promote credibility across standards (ISEAL 2015).

3.1.2. Seafood Certifications Programs and their Application in Small-Scale Fisheries

Many characteristics of SSFs in developing countries make traditional management and data collection strategies difficult to implement and consequently, certifications difficult to obtain. Contrary to large, industrial fisheries, SSFs are often multi-gear, multi-species, low capital, or labor intensive, and may have remote landing sites, migrant workers, a lack of post-harvest infrastructure, and weak market power (FAO 2015). As a result, these fisheries are more likely to suffer from a potential resource overexploitation scenario due to lack of stock information. Additionally, a substantial portion of catches in countries with SSFs are not reported or grossly under-reported in the form of bycatch, subsistence catches, and illegal catches (Trujillo et al. 2015). These issues in governance, data collection, and infrastructure create significant barriers for obtaining certifications that were developed for large-scale, industrial fisheries in developed countries.

Even though SSFs struggle to meet rigorous requirements of existing certifications programs, they often operate or can potentially operate in a more sustainable manner than large, industrial fisheries. For example, many SSFs do not use the indiscriminate, energy-intensive fishing gear characteristic of industrial fisheries (Chuenpagdee et al. 2012). By utilizing smaller or artisanal gear types, bycatch and the corresponding habitat and ecosystem impacts may be significantly lessened. These examples illustrate that SSFs often employ sustainable methods and that there is an urgent need to adapt existing certification programs or develop alternatives in order to address the complexities of SSFs to encourage continued use of sustainable practices at all fishing scales.

To determine which existing program best addresses the above complexities of SSFs, we assessed three prominent seafood programs (MSC, FIP, FTUSA) against a framework developed to promote environmental sustainability and social and economically responsible practices in SSFs. The MSC holds a dominant position in the seafood certification industry and has set the global standard for seafood sustainability. FIPs allow these fisheries to utilize a stepwise process of improvement which can result in achievement of the MSC standard. Finally, the FTUSA capture fisheries certification seeks to fill a significant seafood certification gap by including socioeconomic standards, such as wages and working conditions. The FTUSA program works with SSFs to encourage responsible fishing and labor practices through the incentive of a premium price, which is used to support community improvement projects.

3.1.3. Marine Stewardship Council (MSC) & Fishery Improvement Projects (FIPS)

The Marine Stewardship Council (MSC) is an international non-profit organization, created through a partnership between World Wildlife Fund and Unilever, that sets sustainability standards for wild-caught fisheries and seafood products. The MSC seeks to incentivize sustainable fishing practices by providing fishers with access to markets that demand sustainability. The MSC organization was established in 1997 in London, its fisheries standards were created in 1998, and the program became fully operational in 1999. The first fishery to be certified was the Western Australian rock lobster in 2001 and the first developing country fishery to gain certification was the Mexican Baja California red rock lobster fishery in 2004.

The MSC's central critique stems from its lack of accessibility and applicability in SSFs in developing countries (Duggan & Kochen 2016). In 2015, out of the 256 globally certified fisheries, only 8% were located in developing countries and only and 2% considered small-scale (Duggan et al. 2016; MSC 2015b). Because the MSC certification process requires a high degree of scientific information, stable infrastructure, and established governance and management systems, SSFs often struggle to meet the rigorous criteria (Gulbrandsen 2009). Additionally, the cost of certification is extremely high, ranging from a few thousand dollars to over $20,000 for the pre-assessment, and the full assessment may reach over $100,000 (Peacey 2001; Jacquet & Pauly 2008). Furthermore, the necessary improvements required to obtain certification in SSFs are rarely affordable for local fishery management programs without support or donations (Ramirez et al. 2015).

In order to address these criticisms, the MSC created a Developing World Program that “seeks to ensure that developing country fisheries can access the environmental and economic benefits of MSC certification, and help to safeguard fisheries as a reliable, long term source of food security” (MSC 2013). Additionally, a risk-based framework (RBF) was developed for data poor fisheries seeking certification and includes a consequence analysis and productivity susceptibility analysis. Besides the RBF, the MSC allows SSFs to count different management strategies towards fulfilling Principle 3, Effective Management. The Developing World Program and RBF demonstrate the adjustments that the MSC has undertaken to incorporate a wider range of global fisheries. These branches of the MSC were created to work with fisheries that may not have proper infrastructure or government support and assist in overcoming barriers to establish sustainable fishing practices (MSC 2011).

However, despite these efforts, the MSC faces a fundamental challenge in SSF certification: the target unit of certification, a small fleet, often fishes a small proportion of a larger fish stock. Analogous to problems faced in transboundary stock management, it is difficult to fulfill the rigorous MSC stock criteria when other fisheries not seeking certification, and consequently not similarly effort controlled, are harvesting the same resource. In 2015, of the 18 MSC certified fisheries in developing countries, only five were considered small-scale (Blackmore et al. 2015). The fisheries are: red rock lobster in Baja California, Mexico; spiny lobster in Sian Ka’an and Banco Chinchorro, Mexico; hard clam in Ben Tre, Vietnam; short-neck clam in the Ashtamudi Estuary, India; and rock lobster in the Juan Fernandez Islands, Chile (Appendix I). These fisheries were able to obtain certification because they target benthic species and consequently, the scale and impact of each SSF is well-defined. Continuing, as a reaction to criticism that the “Pass/Fail” MSC certification system eliminated fisheries that could benefit from a step-wise process of improvement, the fishery improvement project (FIP) model was created.

As defined by the Conservation Alliance for Seafood Solutions, FIPs are multi-stakeholder efforts to improve a fishery by involving partners in the private sector, NGOs, government, and fishing communities (Deighan & Jenkins 2015). This process of improvement with set deliverables to better fisheries management and foster sustainable harvest was established to ultimately assist fisheries in reaching MSC certification, but other end goals are common, such as general fishery improvement or other seafood certifications. The World Wildlife Fund (WWF) was a critical partner in FIP establishment and offers support through working with financial institutions to garner funding, communicating sustainability efforts to the public, and endorsing responsible fishing through the WWF media channels (WWF 2014). In order to ensure that FIPs are delivering proposed improvements and implementing responsible fishing practices, the Sustainable Fisheries Partnership (SFP) created a five-stage FIP Improvement Tracker: 1) FIP is launched; 2) FIP is formed; 3) Encouraging improvements; 4) Delivering improvements in policies and/or fishing practices; 5) Delivering improvements in the water; the optional 6^{th} step is to become MSC certified (SFP 2012). As of 2015, there are 29 FIPs in Latin America (Appendix II; SFP 2015).

Caution has been raised in regards to FIPs potentially contributing to a "race to the bottom" in seafood sustainability standards (Sampson et al. 2015). Because some retailers, including Wal-Mart (U.S), may fulfill sustainability pledges by sourcing from fisheries in the *process* of improvement, a potentially premature eco-label may undermine motivation to reach MSC certification. Additionally, a significant limitation of FIPs is the strong selection bias for fisheries with adequate data (Deighan & Jenkins 2015). Therefore, fisheries that are "easier" to certify are targeted first. However, Deighan and Jenkins (2015) found that the greatest *potential* for fishery improvement lies in fisheries that are furthest from certification. In addition, fishing communities often associate FIPs with the high cost of MSC certification (Deighan & Jenkins 2015). Due to the barriers to entry presented by the MSC and certain FIPs, the FTUSA capture fisheries program may be a more viable option for SSFs.

3.1.4. Fair Trade Labels and Fair Trade USA Capture Fisheries

The Fair Trade USA capture fisheries program (FTUSA) is the first prominent eco-label to offer seafood products that address economic, environmental, and social criteria. The program is a six-year process of continual improvement with standards set in six areas (Appendix III). Across these six standard areas, FTUSA established three main parties -- the Certificate Holder (CH), the Fisher Association (FA), and the Fair Trade Committee (FTC) -- with roles and responsibilities in each area (FTUSA 2015).

FTUSA is focused on social criteria and the guarantee of fair labor and working conditions for producers. Additionally, the strong environmental commitments are evident in the resource management section, which details scientific standards and management of the target fish stock. The process of continual improvement in FTUSA capture fisheries makes this program comparable to a FIP. After initial certification in year 0, fishers and supply chain partners are required to meet increasingly rigorous criteria in years 1, 3, and 6. To connect FTUSA and the MSC, the FTUSA compliance criteria states that fisheries holding a valid certification from the MSC will be considered compliant with the FTUSA resource management section requirements (FTUSA 2014c). Additionally, there has been discussion about facilitating the MSC certification process after the fishery has completed FTUSA year 6 criteria requirements (FTUSA 2014d).

The FTUSA model is fundamentally different from the MSC because producers benefit directly via the accumulation of a premium price, a percentage of the established FTUSA price, in a Community Development Premium fund. FTUSA strives to establish a premium percentage that will allow fishers to obtain significant added value, but not price the product out of the market. However, there is a high degree of variability in the premium price in existing FTUSA seafood products. For example, the premium is currently set at 10% for Moluccan yellowfin tuna in Indonesia, 6% for shrimp in Sinaloa, Mexico, and 3% for Maldivian skipjack (FTUSA 2016).

A potential problem with distributing benefits of FTUSA is that the Community Development Premium fund accumulates in a defined geographic area, but the nomadic nature of some fishers may prevent them from accessing benefits. For example, in the first FTUSA certified fishery, Moluccan yellowfin tuna in Indonesia, the fishers follow the tuna migration and it is difficult to coordinate community funded projects to allow benefits to reach all the members of the fisher associations (Duggan & Kochen 2016). Due to this constraint and the nature of the fishery, small-scale fishers may become disincentivized and prioritize daily income over community development (Duggan & Kochen 2016). Another critique is that fishing pressure may become transferred to other marine areas, increasing pressure on other fish stocks (Duggan & Kochen 2016). For example, by decreasing fishing pressure for the certified species, through fishing mortality controls, fishers may feel the need to make up for the amount of fish caught by fishing for other species in different locations.

As the FTUSA capture fisheries certification expands to new fisheries, there is a need for case studies that examine the potential impacts of the certification on the fishing community, fisher profits, and the fish stock. As the Costa Rican snapper fishery on the Nicoya Peninsula is a good representative of global SSFs and is interested in pursuing FTUSA, our project seeks to provide further information on the potential effects of the program.

To compare these fundamentally different programs, we needed a set of established criteria to use as an evaluative framework. Frameworks have been widely used in certification comparison and evaluation, from forestry to seafood (Tikina & Innes 2008, WWF & Accenture 2009). We were interested in how the three target certification programs addressed components that would allow them to be successful in SSFs. Thus, we chose a set of 30 performance indicators for a conceptual, system-wide fisheries and aquaculture certification program developed by Micheli et al. (2014) that addressed governance, socioeconomic, and ecological factors. The framework was created to address the fact that existing certification programs do not comprehensively examine coupled socio-ecological systems, which may lead to ineffectiveness and difficulties in implementing change (Micheli et al. 2014). Specifically, the lack of social criteria was considered a fundamental reason why SSFs were unable to implement successful certification programs. Thus, this system-wide approach would allow for greater participation and support of SSF in developing countries. Additionally, an urgent need to apply and utilize these 30 performance indicators was expressed by expert working groups at the SeaWeb Seafood Summit in New Orleans, Louisiana in February 2015 (Short 2015). Thus, we accepted these criteria as the considerations necessary for inclusion in a successful SSF certification program and evaluated the MSC, FIP with an end goal of MSC, and FTUSA against these criteria.

3.2. Methods

3.2.1. Data Sources

To assess the suitability of the three target programs, MSC, FIP, and FTUSA, for SSFs, we qualitatively examined their criteria against performance indicators developed by Micheli et al (2014) that promote environmental sustainability and social and economically responsible practices in SSFs. The certification criteria used were: the MSC Fisheries Certification Requirements and Guidance, Version 2.0, released October 2014 (MSC 2015a); the Guidelines for Supporting Fishery Improvement Projects (Conservation Alliance for Seafood Solutions 2015); and the FTUSA Compliance Criteria for the capture fisheries standard (FTUSA 2014b) and FTUSA capture fisheries standard released December 2014, Version 1.0 (FTUSA 2014c).

The proposed criteria for system-wide assessments in seafood certification programs developed by Micheli et al. (2014) was used to qualitatively assess the suitability of seafood certification programs for SSFs (Table 2). The 30 indicators are divided and weighed equally between three components: governance, socioeconomic and ecological factors (Table 2).

3.2.2. Approach

We analyzed the frameworks of the MSC, FIP, and FTUSA and examined how their standards addressed each of the 30 system-wide performance indicators points using a stoplight scale (red, yellow, green). If the certification did not address or include the key words in the performance indicator, then it was ranked “red” and if it explicitly addressed the indicator, it was ranked “green”. If the certification moderately addressed the indicator (such as a management option), then it was ranked “yellow”. It is important to note that the analysis did not rank or address the degree of stringency of the performance indicator in the standard. Rather, the standard was evaluated solely on the inclusion or exclusion of the performance indicator.

Table 2. Proposed criteria for system-wide assessments in seafood certification programs. Performance indicators developed by Micheli et al. (2014). We used these criteria as a framework to evaluate the three target programs: MSC, FIP, and FTUSA.

Governance	Socioeconomic	Ecological
1. Leadership. *Existence of a decision-making and management body.*	**11. Equity.** *No discriminatory practices.*	**21. Water quality.** *Water-quality parameters are within acceptable bounds.*
2. Legislation. *Existence of effective legal and/or customary framework.*	**12. Free labor.** *No forced labor.*	**22. Native biodiversity.** *Strategies in place to minimize impacts of fisheries on natural diversity.*
3. Enforcement of regulation. *Existence/effectiveness of a regulation and sanction system.*	**13. Compliance with child labor laws.** *No child labor.*	**23. Habitat integrity.** *Strategies in place to minimize impacts of fisheries on habitat structure and function.*
4. Governance structure and function. *Governance has a nested structure, partial autonomy of different levels of authority.*	**14. Socioeconomic development.** *High investment in community infrastructure and human capital.*	**24. Food-web integrity.** *Strategies in place to minimize impacts of fisheries on food-web structure and dynamics.*
5. Incentives. *Existence/effectiveness of incentives for following the rules and promoting sustainable use.*	**15. Education** *High investment in younger generation, eg. presence of adequate schooling.*	**25. Resilience.** *Resilience is maintained by conserving key species, functional groups, and functional redundancy.*
6. Management plan. *Long-term management plans in place.*	**16. Fair wages and benefits.** *Meet or exceed minimum wage and benefit requirements*	**26. Stock abundance.** *Target stocks are at a level that maintains high productivity and has a low probability of recruitment overfishing.*
7. Harvest control. *Well-defined and effective harvest control rules are in place.*	**17. Occupational health and safety.** *Written risk assessment, policies, and procedures for safe and healthy working conditions.*	**27. Interaction with endangered species.** *Fishery does not pose a risk of serious or irreversible harm to endangered, threatened, or protected species and does not hinder their recovery.*
8. User involvement mechanism. *High level of stakeholder involvement, information dissemination to the community, mechanisms in place for conflict resolution.*	**18. Fair conditions of employment.** *Employers are up to date on labor regulations and comply with legal regulations and collective bargaining agreements.*	**28. Connectivity.** *Connectivity maintained by avoiding extreme habitat and population reduction and fragmentation.*
9. Defined boundaries and access rights. *Long-term tenure, use rights, and boundaries are clearly defined, documented, and legally established.*	**19. Traceability.** *Products traceable from harvest to sale.*	**29. Bycatch.** *Fishery does not pose a risk of serious or irreversible harm to bycatch species and does not hinder the recovery of depleted bycatch species.*
10. Presence of MPAs. *Representative samples of existing ecosystems are protected.*	**20. Diversification.** *Diversification of fisheries and non-extractive activities (communities do not engage in and depend on a single activity.*	**30. Chemical/drugs/pesticides.** *Acceptable drug and chemical management, microbial sanitation, minimized and safe use of agrochemicals.*

3.3. Results

The MSC and FIPs scored identically across all 30 performance indicators because we chose to analyze a FIP that used the MSC criteria in the process of continual improvement, with the ultimate goal of MSC certification. Overall, FTUSA definitively addressed 21 out of the 30 system-wide indicators, whereas the MSC and FIP addressed only 17 out of 30.

In the *Governance* section, all three target certification programs addressed 7 of the 10 performance indicators (Figure 3). However, not all indicators were explicitly addressed; for example, under indicator (5) *Incentives*, FTUSA was ranked "yellow" because the FTUSA compliance criteria includes language to discuss incentives that contribute to problematic fishing patterns and ways to reduce these behaviors, but does not explicitly address a plan for incorporating incentives to follow the rules. For this same indicator, the MSC and FIP standards do not include clear, direct language regarding the incorporation of incentives to following the rules and promoting sustainable use and were assigned a rank of "red". Neither of the three programs explicitly addressed or necessitated the presence of Marine Protected Areas (MPAs), leading to a rank of "red". The MSC standard does not have an explicit requirement for MPAs or other spatial management approaches, but it does state that MPAs may contribute to effective management. MSC notes that an MPA may or may not contribute to the overall sustainability of a fishery. FTUSA does not explicitly address MPAs as tools to protect representative samples of existing ecosystems, but includes a guidance point that the FTUSA Fishery Management Plan may be part of another framework, such as a Marine Protected Area Management Plan (FTUSA 2014c).

The MSC and FIP standards addressed 2 out of the 10 *Socioeconomic* indicators, whereas FTUSA addressed 9 out of 10 (Figure 3). The two indicators addressed by MSC and FIP were (12) *Free labor* and (19) *Traceability,* leading to a rank of "green" in these areas. Free labor was addressed by MSC and FIPs only recently in the 2014 revision of the standards. The new language states that an entity cannot be certified if it "has been successfully prosecuted for a forced labor violation in the last 2 years" (MSC 2015a). The only indicator that FTUSA did not explicitly address was (15) *Education.* There is no specific language for investment in the younger generation; however, the Community Development Premium fund developed under FTUSA may be used for education projects such as schools, leading to a rank of "yellow".

For *Ecological* criteria, the MSC and FIP addressed 8 indicators, as opposed to 6 indicators addressed by FTUSA (Figure 3). Neither of the three programs addressed indicator (21) *Water Quality,* leading to a rank of "red"*.* Regarding indicator (30) *Chemicals/drugs/pesticides,* the MSC and FIP standards do not address these issues whereas FTUSA includes language to ensure that fishing methods do not use "explosives, cyanide, bleach and/or all other poisons" (FTUSA 2014b). FTUSA also includes language to eliminate harm to workers by toxic chemical use. FTUSA does not explicitly address the language in indicators (24) *Food-web integrity* and (25) *Resilience* as required components of the certification.

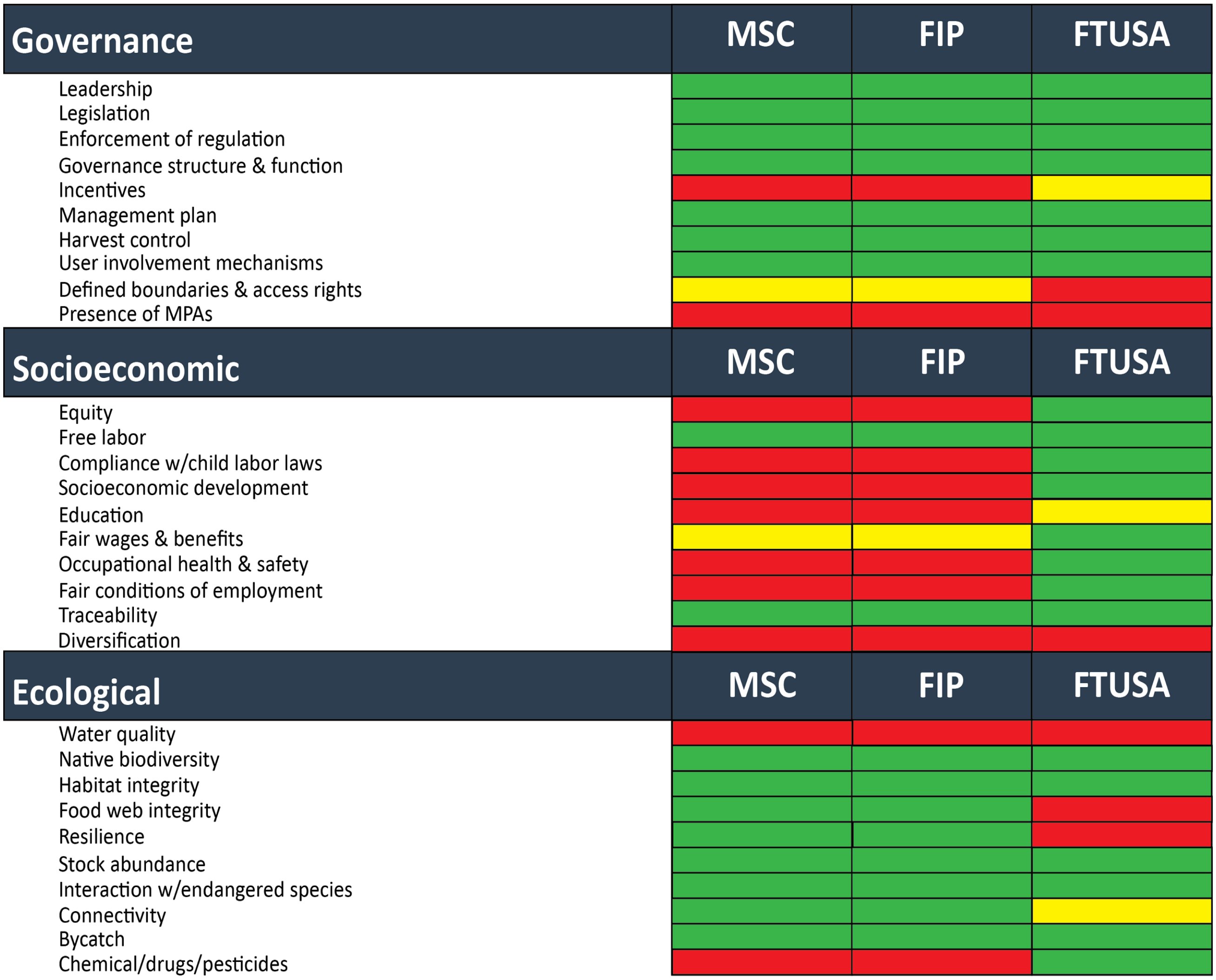

Figure 3. Seafood certification suitability for SSFs using performance indicators established by Micheli et al. (2014). Three programs (MSC, FIP with an end goal of MSC, and FTUSA) were assessed according to how they addressed each governance, socioeconomic, and ecological indicator (red = not addressed, green = explicitly addressed, yellow = moderately addressed).

3.4. Main Findings

A framework approach allowed us to compare three, fundamentally different programs across a set of uniform criteria. We accepted the 30 system-wide performance indicators as the ideal seafood program for small-scale, developing country fisheries and then assessed the extent to which the indicators are addressed by existing programs. Based on the assumption that a successful seafood program for SSFs in developing countries must take a system-wide approach with inclusion of governance, socioeconomic, and ecological criteria, FTUSA is the most applicable when compared with MSC and FIPs with an end goal of MSC certification. According to Micheli et al. (2014), the system-wide approach may translate into greater success for small-scale fishing communities. This conclusion should not be interpreted to mean that only FTUSA is appropriate for these fisheries. Rather, the goal of the fishery (market access, stock recovery, and/or socioeconomic reform) must be evaluated before choosing which seafood program to pursue. Although FTUSA is well suited for SSFs, its impact on the fishery supply chain, as well as the biology and economics of a certified fishery are not yet well understood. In the next sections, we use a supply chain analysis and bio-economic model to examine the impact that FTUSA would have on SSFs using the Costa Rican snapper fishery as a case study.

4. Systems Mapping

4.1. Introduction to Systems Mapping

Fisheries are characterized by dynamic interactions between social, biological, economic, and ecological systems, each with multiple subsystems. The complexity and high level of uncertainty involved in these processes present challenges for conservation and management (Cochrane 1999; Garcia & Charles 2007). The broader marine ecosystem, social-ecological systems, and economic influences must be comprehensively understood in order to ensure appropriate management interventions.

Small-scale fisheries in developing countries (SSFs) present arguably higher levels of intricacy, uncertainty, complexity, and even chaos when compared with large-scale fisheries in developed countries (Mahon et al. 2008; Wilson et al. 1994). Thus, successful problem-solving in fisheries management is dependent on the degree of understanding of the complex linkages, interactions, and feedbacks present in the system. There is a need for tools that can accurately depict complex fisheries, convey interacting systems, and simulate the dynamic interactions between them.

Systems thinking, also referred to as systems mapping, is a method of communicating issues as systemic wholes and facilitating visual communication of the dynamic complexities and interdependencies between variables (Kunc 2008). This tool has been used to explore key linkages and identify potential points of intervention (Garrity 2011). Causal loop diagrams (CLDs) are graphical notations used in systems thinking that represent system structure and influences. CLDs help demonstrate interactions that are difficult to explain by traditional linear models (Kirkwood 1998). CLDs are valuable in simplifying and visualizing complex relationships. As well as providing scientists and managers with visual tools, multiple stakeholders have found value in CLDs, specifically for raising awareness of bigger picture processes and understanding interactions (Inam et al. 2015).

Systems thinking and the use of CLDs as management tools have been increasingly applied to understanding fisheries. Caillaux et al. (2013) employed systems mapping to explore the dynamics of the Peruvian anchoveta fishery and Badjeck et al. (2009) used causal loop diagrams to integrate ecological and social components in a dynamic model of the Peruvian scallop fishery. Both of these analyses relied almost exclusively on qualitative interview data to understand the variables and direction of influences between variables (Caillaux et al. 2013; Badjeck et al. 2009). As we used systems thinking to map the supply chain of the Costa Rican snapper fishery, it is important to understand the role that large retailers, significant supply chain players, play in seafood supply chains and their importance in driving sustainability.

4.1.1. Retailers as Drivers of Sustainable Seafood

Large retailers have enormous potential for driving sustainable seafood supply chains. "As large buyers of seafood, the rules they put in place through sustainable seafood policies and sourcing commitments translate into action through the supply chain back to the fisheries," stated Geoff Bolan, Commercial Director of the Americas for the MSC, via Triple Pundit (Zanolli 2014). The current challenge facing large retailers is that more than half of seafood products entering global markets come from developing countries. These fisheries face barriers to certification that must be overcome if large retailers continue to purchase seafood products that are in compliance with their sustainability pledges.

The dominant approach to sustainable consumption in the past was focused on creating markets for products aimed at "green consumers" (Iles 2007). Nevertheless, this approach depends on consumers' preferences, and studies have shown that campaigns to raise consumer awareness and create more green consumers, have resulted in minimal changes to consumer preferences or sustainable seafood purchases (Gunn 2011; Iles 2007). Consumers respond to product availability when purchasing, making retailers important keystones for sustainability. Large retailers have the capacity to require compliance with sustainability standards from their suppliers (Iles 2007), thus facilitating the decision-making process for consumers. "Choice editing" (Gunn 2011) for sustainability is the progressive strategy taken by retailers that does not rely on consumers' behavior change, but instead eliminates the option of poor environmental or social products, offering sustainable products as the default. Through this strategy, retailers decide product availability, supplying products that cut out environmentally damaging goods by offering sustainable choices on their shelves (SDC 2009). Through purchasing products that are MSC or FTUSA certified, retailers can offer consumers an assurance of sustainability.

4.1.2. Local and International Markets for Spotted Rose Snapper

In Costa Rica, exports are an important component of the fishing industry. In the 1990s, Costa Rica had the highest total fishery landings in Central America (179,000 tons, contributing $616 million) (Herrera-Ulloa et al. 2011). Costa Rica has seen a decrease in catches of many species since the beginning of the 1980s. Domestic seafood markets have been supported by snappers and groupers (Herrera-Ulloa et al. 2011), and since fish is not a product considered by the government to be a basic daily good, the prices have no governmental subsidies, and are dictated by markets, resulting in large fluctuations. According to the U.S. National Marine Fisheries Service, Fisheries Statistics and Economics Division, the U.S. imported an average of 393 tons of snapper from Costa Rica valued at $1,717,474.08 between 1990 and 2013 (NOAA 2016).

4.2. Methods

4.2.1. Data Sources

In order to create causal loop diagrams of the Costa Rica small-scale snapper fishery and its supply chain, we conducted in-person and phone interviews with the directors of PRETOMA and ARCAE. Their field experience in data collection as well as their relationship with the communities and the different stakeholders of the fishery and supply chain gave us the information necessary to understand nodes and interactions within the system. Additional informal conversations with fishers, distributors, retailers, and NGOs were held during site visits to Costa Rica in August and December 2015. Based on these sources of information, we constructed the supply chain of snapper, including economic (e.g. price fluctuation, price increase in each step of the supply chain), social (e.g. fishers and middlemen), and ecological (e.g. biomass, CPUE) factors influencing the fishery and supply chain. Once the business as usual snapper CLD was created, we then hypothetically introduced the Fair Trade USA capture fisheries certification program and examined how its adoption would change the system.

4.2.2. Constructing Causal Loop Diagrams

We created two causal loop diagrams of the snapper fishery, one of the system as it is now (business as usual), and a second of the system under FTUSA in order to highlight the factors, processes, and supply chain nodes that would be directly affected by the adoption of the FTUSA certification. In CLDs, causal relationships between variables are represented by arrows with an influence sign (+ or -). If a change in one variable causes a change of the same direction in the linked variable, a positive sign (+) is present between the two variables. Contrastingly, a negative sign (-) means that a change will cause opposite directional change in the second variable (Inam et al. 2015). Our CLD mapping process corresponded to steps in the supply chain, starting with the biological fish stock, moving to the fishers, then to the landing sites, and all the way to point of sale either domestically in Costa Rica or internationally.

Finally, we analyzed the effect that a FTUSA certification would have on the snapper fishery by interpreting the standards and requirements of the certification. Our knowledge of Fair Trade USA certification stemmed from three main sources: 1) literature; 2) Fair Trade USA documents including the FTUSA capture fisheries standard and FTUSA Compliance Criteria (FTUSA 2014b; FTUSA 2014c); 3) conversations with representatives of FTUSA, SCS Global Services, and the Sustainable Fisheries Partnership.

Unique to the Fair Trade USA certification model is the assurance of a buyer in the United States. Given that there is not currently an existing USA-based buyer for snapper from San Francisco de Coyote and Bejuco, we assumed that an importer in the USA would pay the FTUSA premium and transfer this amount annually to the Community Development Premium fund. At the time of our report's preparation, ARCAE had been attempting to contact Industrias Martec, a major Costa Rican processor, to discuss participation in the FTUSA certification. We assumed that Industrias Martec would be the processor and exporter for FTUSA certified snapper. Industrias Martec is the largest fish processor and exporter in the country. Their primary receiving plant is in Puntarenas and their only processing plant is in Quepos. In 2011, more than 50% (775 tons) of Industrias Martec's shipments went to their primary importer in the U.S., Ore Cal Corporation, also known as Harvest of the Sea, located in Los Angeles, CA (Olsen 2012).

4.3. Results

<u>4.3.1. Causal Loop Diagrams of the Costa Rican Snapper Fishery</u>

After identifying all the steps and actors involved in the Costa Rican snapper fishery and the direction of their influences on the system, we created a complex causal loop diagram (Figure 4). Beginning with the snapper biomass, San Francisco de Coyote and Bejuco fishers share what is thought to be a regional stock with other small-scale fishing communities in the Guanacaste region. The enforcement of responsible fishing practices is carried out mainly by the Coast Guard and INCOPESCA in the region; however, the San Francisco de Coyote and Bejuco associations conduct local enforcement to ensure that bottom longlines with the correct hook size are used. Our results show that both San Francisco de Coyote and Bejuco have separate landing sites and they have one common intermediary, Caco, who is part of the community association. Caco picks up fish from all the associated fishers and provides them with bait and ice. Additionally, fishers in Bejuco work with another intermediary, referred to as "unknown" in the CLD (Figure 4 and 5). This intermediary received fish from Coyote and Bejuco as well as from vicinity communities around the area. The fish is then transferred to a second intermediary step, Sandoval, who receives fish not only from the communities of our case study, but also from other fishers in the

Guanacaste region and then sells the product to buyers from Puntarenas. From here onwards, the product embarks on multiple, split routes. A proportion goes to Industrias Martec, a processing plant and exporter. Another proportion is sold to local Puntarenas buyers, fish markets, hotels and restaurants. The remainder is sold to the Central Valley (San Jose, Cartago and Alajuela) where it is distributed to retailers, markets, hotels and restaurants (Figure 4).

4.3.2. Implementing Fair Trade USA Certification

The following changes would occur if Fair Trade USA were to be implemented (Figure 5):

- Two existing fisher associations (ASPEPUCO and ASOBEJUCO) would merge into one, singular association if the two communities are certified as one unit.
- Fair Trade Committee established with representatives from the two fisher associations, middlemen, and ideally the processor, Industrias Martec.
- Fair Trade Community Development Fund established and managed by a democratically elected Fair Trade Committee.
- All boats obtain valid licenses through INCOPESCA
- All fishers obtain government-issued fisher identification cards
- A Certificate Holder is established (We assume a new entity is created to fill this role or the existing processor, Industrias Martec, holds the certificate)
- Industrias Martec becomes the FTUSA exporter
- A USA importer “fronts” the bill (an importer has not yet been secured)
- Ratio of product exported increases to 80%. Approximately 20% remains in the country due to quality issues.

These changes result in minimal changes in the structure of the first several nodes of the supply chain (Figure 5). However, effort reduction may be a necessary component of the certification process if it is determined that overfishing has occurred. Once a fish is landed, FTUSA implementation would lead to a series of supply chain alterations. First, the Fair Trade Premium Price, the percentage of ex-vessel price paid by the importer directly to the communities will be established. This percentage is fixed and set early in the process of certification. The premium accumulates in the Community Development Premium fund, which will be democratically managed by the Fair Trade Committee (Figure 5). Other factors influencing the Community Development Premium fund include volume of landed fish and market ex-vessel price. Finally, the Fair Trade Certificate Holder will be in charge of managing the FTUSA certificate and ensuring compliance along the supply chain. Given that the Fair Trade USA model guarantees a USA-based buyer, the majority of the product will be exported, nearly eliminating the within-country stages of the supply chain. Only fish that do not fulfill the USA buyer’s requirements will stay in the Costa Rican market.

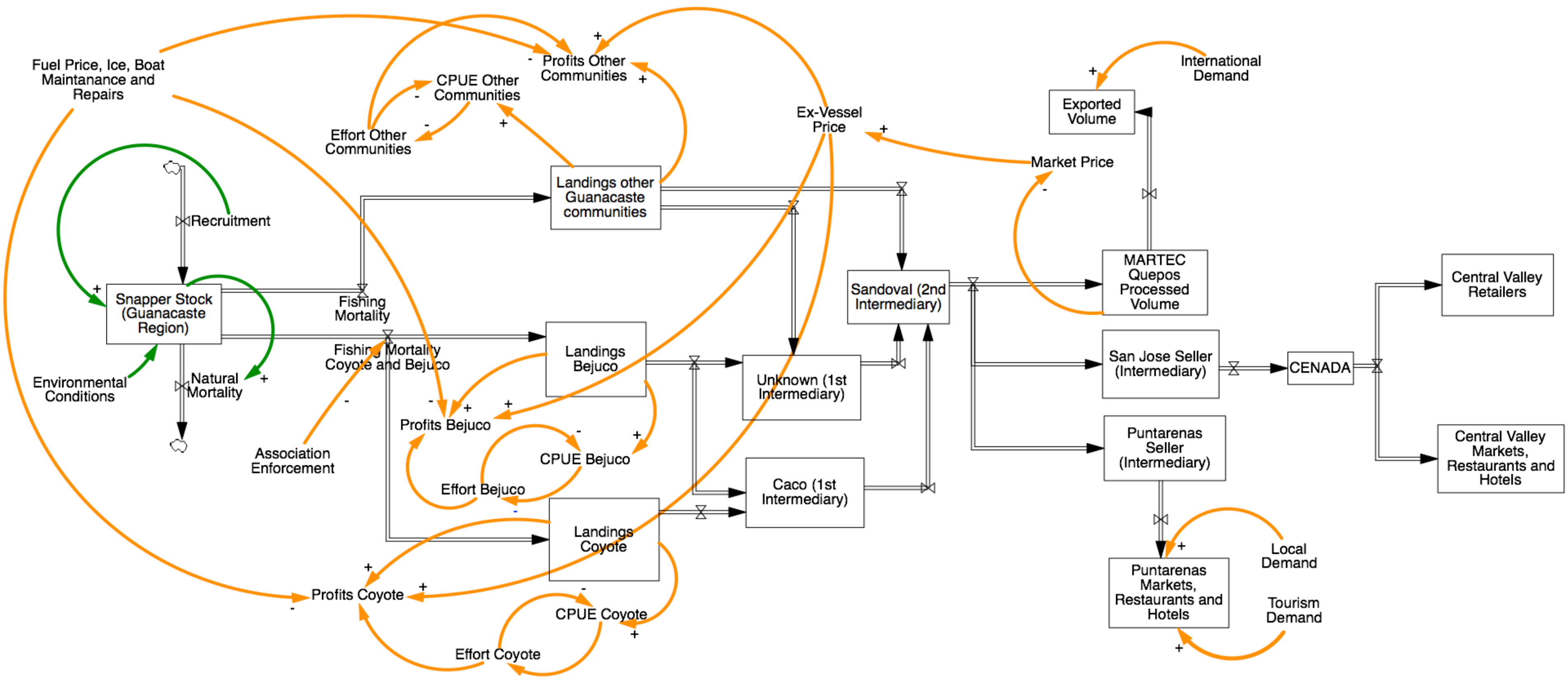

Figure 4. Causal loop diagram of the small-scale snapper fishery in San Francisco de Coyote and Bejuco. Boxes represent volumes of snapper, black arrows represent flow of snapper, and colored arrows indicate effect on fish biomass and flow through the supply chain (green= biological components, orange=economic components).

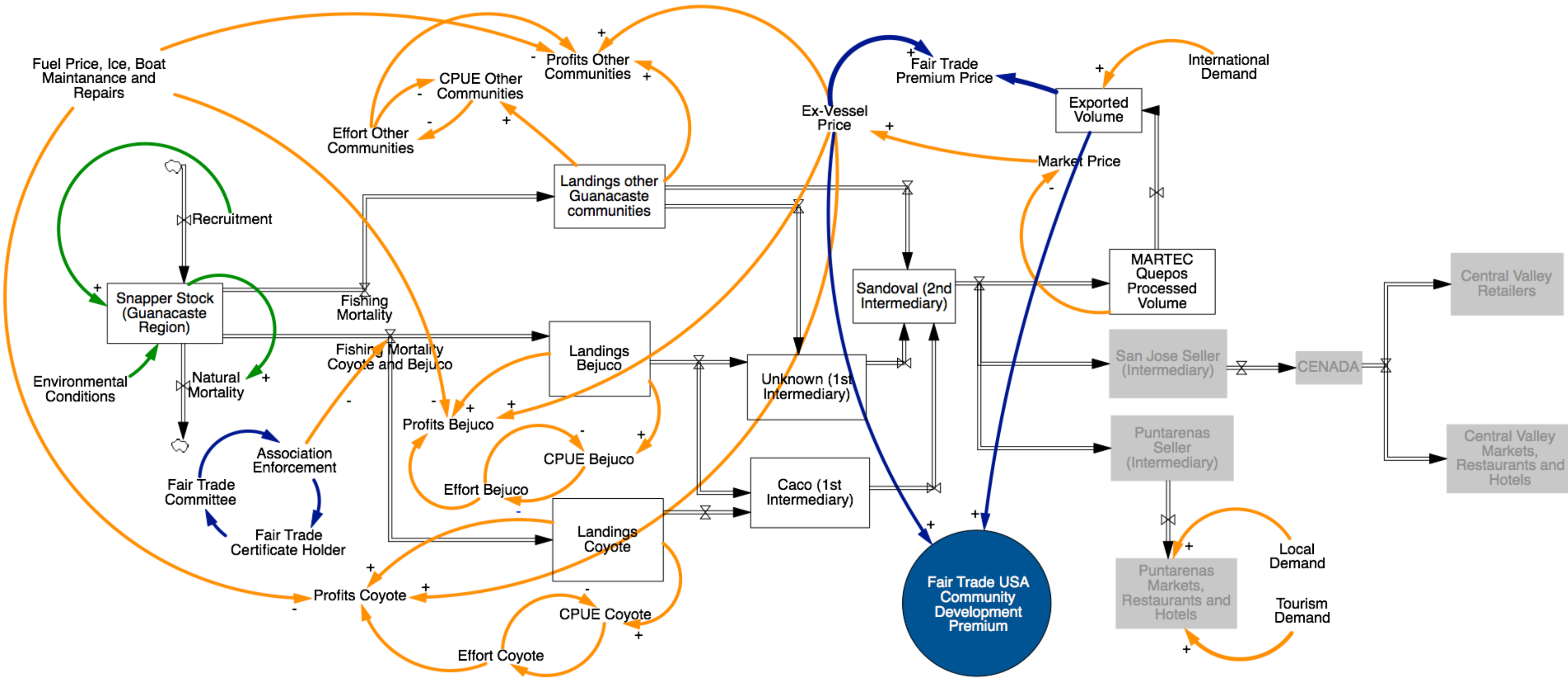

Figure 5. Causal loop diagram showing the supply chain post Fair Trade USA implementation on the small-scale snapper fishery of San Francisco de Coyote and Bejuco (green= biological components, orange=economic components; blue= Fair Trade USA). Grey boxes show the decrease in sells of snapper towards local markets.

4.4. Main Findings

The implementation of the FTUSA certification would change the snapper system by introducing a Community Development Premium fund managed by the Fair Trade Committee and also reduce the domestic market for snapper. First, while the MSC has been widely criticized for its failure to link the economic benefits of certification to fishery producers, the FTUSA model directly addresses this critique through the creation of the Community Development Premium fund. Under FTUSA, the importer fronts the bill and pays the premium sustainable seafood price directly to the producers via the Community Development Premium fund. San Francisco de Coyote and Bejuco would directly benefit because the premium price is not dispersed along the supply chain and instead directly reaches fishers and their communities. Additionally, we found that FTUSA will greatly reduce the amount of fish that remains in Costa Rica, leading to significant gaps that may contribute to a decrease in food security if substitutes are not found. Additionally, if snapper fishing effort is re-targeted towards shark or any endangered species, FTUSA must be adopted with caution.

5. Bio-Economic Model

5.1. Introduction to Fisheries Modeling for Small-Scale Fisheries

Stock assessments are useful tools that allow fishery managers to determine the health of a fish stock, how the stock may be affected by potential management actions, and what future conditions may look like. The term “stock” is used to refer to any group of fish that are lumped together for management purposes, and many include one or more populations, which are groups of individuals of the same species living in the same area capable of reproducing with one another. Determining the status of a stock involves estimating biological characteristics such as abundance (total number of fish) or biomass (total mass of fish), and then comparing these estimated values to reference values that represent desired conditions for the fishery. Comprehensive monitoring strategies such as long term fishery independent surveys offer the best information to perform stock assessments, but these programs are generally too expensive for SSFs in developing countries, such as our case study fishery. Additional difficulties occur in isolating the impact of a small-scale fishing operation on a stock if the fishery is targeting a small portion of a larger stock. Since many seafood certification programs will only certify a fishery once the health of the fishery is determined via a stock assessment, this is a major barrier to certification for SSFs. Our case study fishery in Costa Rica decided to abandon the MSC assessment process in 2015 when it became clear that MSC would not certify the fishery without more information about the biological health of the target stock, which is largely unknown.

Surplus production models (e.g. Schaefer, Fox, and Pella-Tomlinson) offer simple solutions to gain a basic understanding of the state of a fishery if catch and effort data is available. The utility of surplus production models for fishery management purposes is heavily debated (Wang et al. 2014; Maunder 2003; Hilborn & Walters 1992; Zhang 2013), but remains one of the only viable options to assess the biological health of fish stocks in developing countries (Pauley et al. 2013). The concept of surplus production is essential to fisheries, as fishing pressure would quickly deplete the supply of available fish in any geographic area without it. Surplus production is the ability of a fish population to produce more offspring in each generation than are needed for the population to replace itself as long as there are enough resources available to support these excess individuals. The relationship between the total biomass of a stock and surplus production (equilibrium yield) is given by the production function. The production function of a stock depends on the rates of many biological processes such as growth, natural mortality, recruitment, and density dependence. Surplus production models do not incorporate the age or size structure of fish populations, and are designed to characterize the dynamics of a stock simply in terms of changes in total biomass. Surplus production models are frequently used to derive estimates of historical abundance based on catch and effort data (e.g. catch per unit effort, CPUE), but since factors like recruitment, mortality, and growth are examined collectively, they cannot explicitly provide explanations for observed changes in abundance.

To understand possible long-term biological and economic consequences of implementing FTUSA in SSFs, we developed a bio-economic surplus production model incorporating catch, effort, and price data using the Costa Rican snapper fishery as a representative case study. There is intrinsically some uncertainty involved in using surplus production models to estimate the condition of a fishery due to the simplicity of the model, and we explicitly explored additional areas of uncertainty specific to our case study but common in SSFs.

First, there are uncertainties regarding the catch and effort data that is available for the Costa Rican snapper fishery. The MSC pre-assessment raised concerns about the amount of un- and under-reported catches and illegal fishing in Costa Rica (SCS 2011). Trujillo et al. (2015) attempted to reconstruct the country's total catch history between 1950 and 2010 in order to account for un- and under-reported catches, subsistence catches, and post-release mortality from sport fishing, and estimated that the actual total fisheries catch in Costa Rica was likely 2.6 times the amount reported by INCOPESCA (Figure 6). This discrepancy was primarily driven by bycatch from shrimp trawlers, which is either discarded or retained and sold in Costa Rica, but is not required to be reported as landings in either case. This unreported catch was thought to make up more than 50% of the total reconstructed catch in Costa Rica. The reported landings from INCOPESCA show total fisheries landings almost doubling from approximately 18,000 tons per year to more than 34,000 tons per year between 1990 and 2005, but actual fisheries landings could have been well above 88,000 tons per year if the Trujillo et al. (2015) estimation is correct. Though PRETOMA has been working with the fishers' associations in San Francisco de Coyote and Bejuco to monitor the snapper fishery in San Francisco de Coyote and Bejuco since 2007, the available data depicts catch per unit of effort (CPUE), and effort data alone is not available for this fishery.

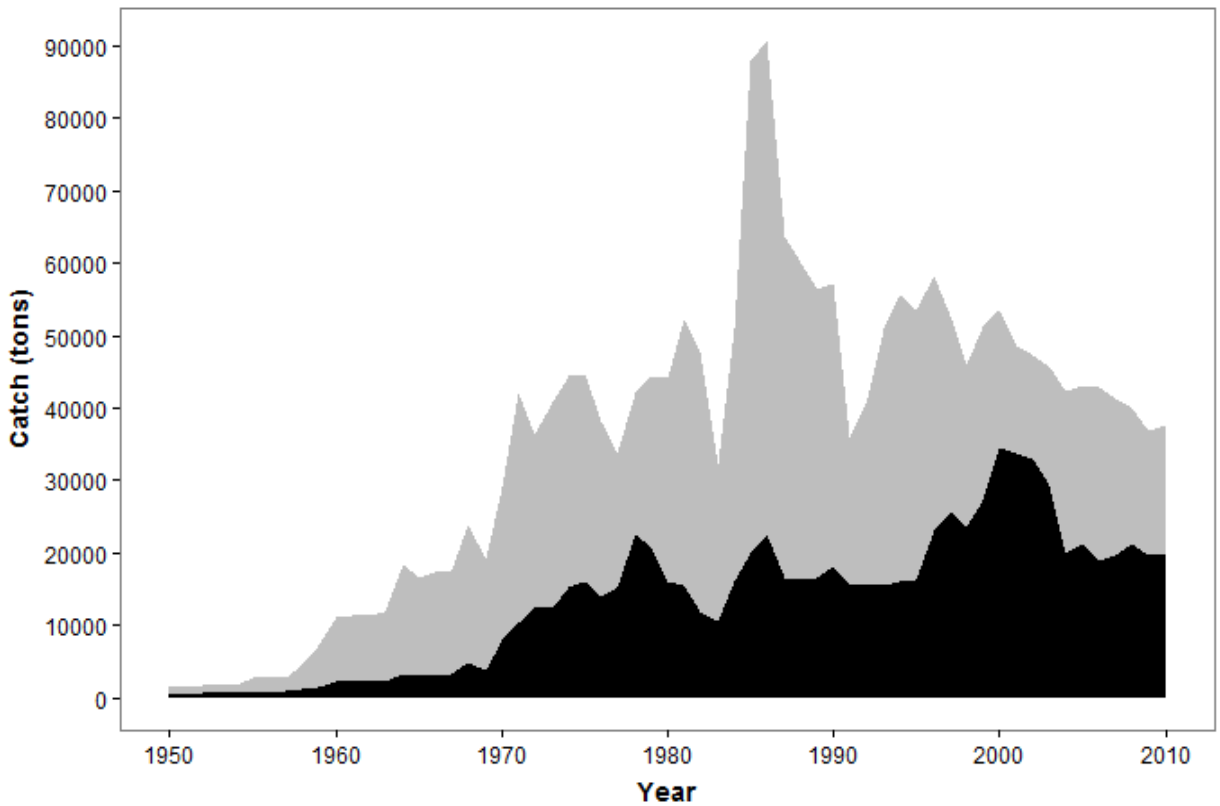

Figure 6. Reported total landings and possible catch history reconstruction for Costa Rica between 1950 and 2010. Actual reported landings provided to FAO by INCOPESCA (black) are shown with a likely reconstruction of the actual catch history (grey) that takes into account unreported and under-reported catches, subsistence fishing, and post-release mortality from sport fishing (Trujillo et al. 2015).

Second, FTUSA mandates the implementation of controls on fishing mortality, but does not explicitly define what such a mechanism must look like for a SSF like our case study. Possible control strategies could include effort restrictions such as gear, size, sex, and season limits, or a total allowable catch limit (FTUSA 2014c). Since the majority of fishers in San Francisco de Coyote and Bejuco already use the same gear type (bottom longlines) and the MSC pre-assessment conducted in 2011 did not raise any concerns about the use of this gear type, we determined that it is unlikely these communities would switch to a different fishing gear. Additionally, implementation of a total allowable catch limit would be difficult to monitor and enforce without better regulatory infrastructure on a region-wide or nationwide scale. The most appropriate and feasible fishing mortality control would be in the form of effort reduction in number of fishing trips.

5.2. Methods

5.2.1. Data Sources

Two datasets publically available through INCOPESCA's website were used to parameterize the bio-economic model (INCOPESCA 2014): 1) annual dock prices by species between 1990 and 2013 (Figure 7) and 2) annual landings by species between 1990 and 2013. Only data for snapper ("Pargo" and "Pargo Seda") were used (Figure 8). The official reported landings data is separated by geographic region: Guanacaste, Gulf of Nicoya, Golfito, Quepos, and the Caribbean Sea. Total annual landings of snapper were multiplied by a correction factor of 2.6 to account for illegal, unreported, and under-reported catches (Trujillo et al. 2015).

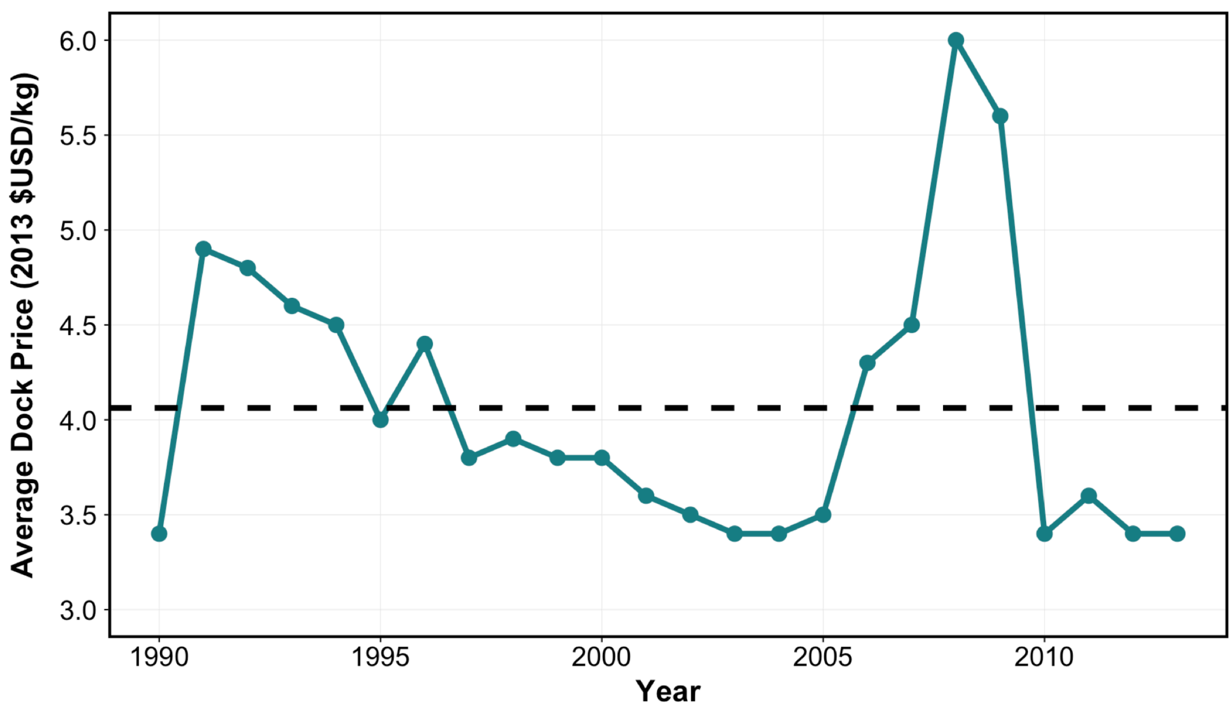

Figure 7. Average dock price for snapper in Costa Rica (1990 - 2013). Values corrected for inflation using the Consumer Price Index, setting 2013 as the reference year. The dashed line represents the average price between 1990 and 2013.

Average catch per unit effort (CPUE) data for fishers in the communities of San Francisco de Coyote and Bejuco were also used to parameterize the model. ARCAE and PRETOMA have been working with fishers in the communities of San Francisco de Coyote and Bejuco extensively since July 2007 to establish a fisheries monitoring protocol and landings data collection effort by members of the community. These data are collected by both onboard and dockside observers and includes information about the type of fishing gear used (bottom longlines or gillnets), duration of fishing activity for each trip, number of fish caught by species per trip, and size and weight measurements for selected fish. This dataset is the property of Andy Bystrom of ARCAE and we obtained permission to use the data as part of a collaboration between the Bren School of Environmental Science & Management, Conservation International Costa Rica, ARCAE, and PRETOMA.

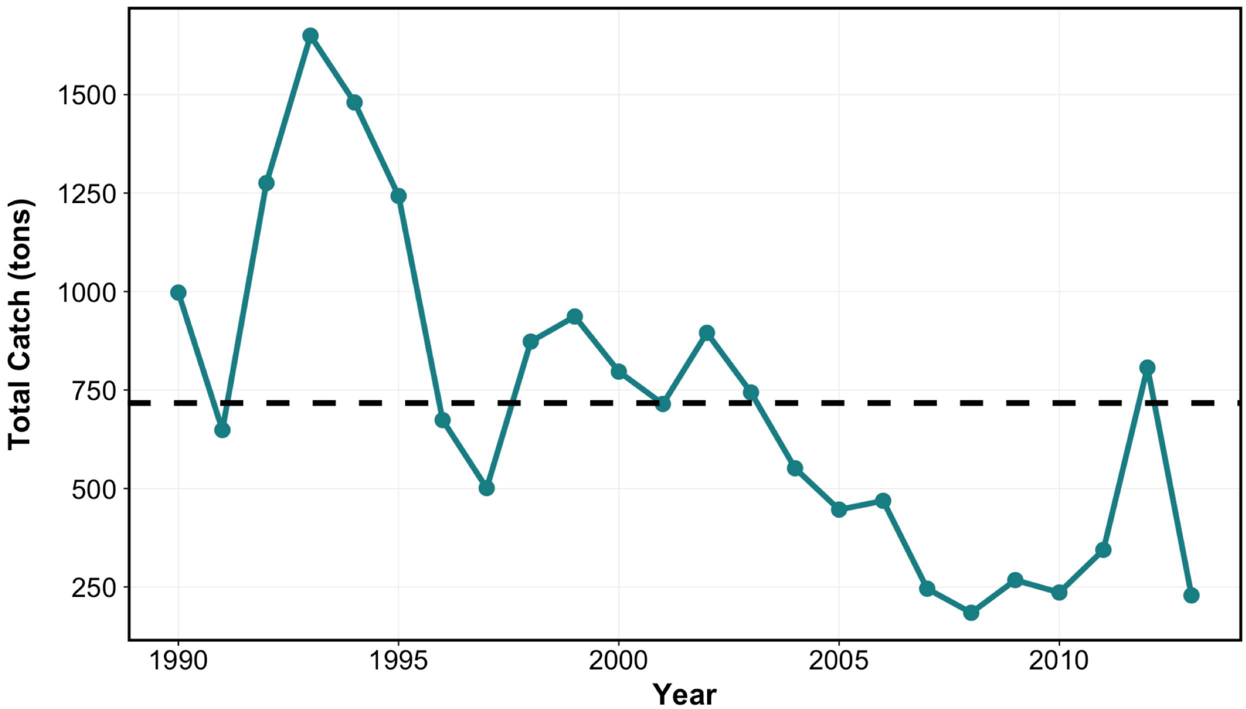

Figure 8. Total landings of snapper (tons) in the Guanacaste region in Costa Rica (1990 - 2013). Values multiplied by a factor of 2.6 to correct for illegal fishing and un- and under-reported catches as reported by Trujillo et al. (2015). The dashed line represents the average catch between 1990 and 2013.

5.2.2. Schaefer Surplus Production Model

To estimate snapper biomass, we used two different forms of the basic surplus production model

$$B_{t+1} = B_t + f(B_t) - C_t$$

where B_{t+1} is the biomass at the start of year *t*+1, B_t is the biomass at the start of the previous year (*t*), surplus production is a function of the biomass in time *t*, and C_t is the amount of the biomass that was removed from the population as catch during year *t.* Recruitment, population growth and natural mortality are all combined into a single term that defines the amount of surplus production produced in each year. The first model we parameterized, a Schaefer (logistic) model, is the most general manifestation of the surplus production model (Lotka 1924; Schaefer 1957; Pella 1967).

For the Schaefer surplus production model, the population biomass (B) that should yield the greatest amount of surplus production ("maximum sustainable yield", MSY) is

$$B_{MSY} = \frac{K}{2}$$

where K is the carrying capacity. Maximum sustainable yield is equal to

$$MSY = \frac{rK}{4}$$

where r is the intrinsic population growth rate that combines recruitment, population growth, and natural mortality. The amount of fishing effort that should result in the maximum sustainable yield is defined as

$$f_{MSY} = \frac{r}{2q}$$

where q is the catchability coefficient, which is the fraction of the population fished per unit of effort, and r is the intrinsic population growth rate.

We used a Schaefer logistic growth model to estimate snapper population dynamics using the observed catch (kg) data for Guanacaste between 1990 and 2013, and the observed CPUE (snapper/trip) data for Coyote and Bejuco between 2007 and 2013. We fit a logistic model to predict biomass of the whole snapper stock in the Guanacaste region for each year between 1990 and 2013 with the initial biomass in 1990 (B_{1990}) defined as

$$B_{1990} = K(1 - Depletion)$$

where *K* is the carrying capacity (kg) and some depletion of the stock relative to the carrying capacity has already occurred by 1990 as a result of previous fishing pressure. The model was fit for a range of initial depletions (0 – 0.9), but an initial depletion of 20% of the carrying capacity was chosen as a conservative starting point for the *L. guttatus* fishery in 1990 due to the fishery's short history prior to that point. Total biomass (B_{t+1}) in the Guanacaste region each subsequent year (1991 - 2013) was then defined using a Schaefer model as

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{K}\right) - C_t$$

Total catch in each year (C_t) is defined as

$$C_t = qf_t^{\alpha}B_t$$

where f_t is the fishing effort (number of trips) that year and α governs how quickly diminishing returns to effort can take effect. Although we did not include spatial information in the model, α

can also be thought of as a biological mixing parameter, where a value closer to 1 indicates almost perfect mixing within the stock. Under a near perfect mixing scenario, decreases in effort by one portion of the region will lead to increases in effort in the rest of the region as a result of a compensatory response. As α decreases, reductions in effort are less proportionally compensated by others in the region, as if each community is harvesting from its own separate stock instead of from as shared stock.

Schaefer model parameters were estimated by fitting observed landings data from Coyote and Bejuco (2007-2013), where catch per unit effort (CPUE) was used as a proxy for biomass. The parameters *r*, *K*, and *q* were assumed to remain constant through time. A log-normal error assumption was made, and the best set of parameters (*r, K*, and *q*) was determined by minimizing the negative log likelihood (NLL) using the box-constrained optimization function **nlminb** in R (R Core Team 2015).

A Kobe plot was used to visualize desired reference points for the fishery by displaying the estimated biomass in each year relative to the predicted biomass that would provide the maximum sustainable yield (B_{MSY}) in each year.

5.2.3. Bio-Economic Model Summary: Business as Usual

For our business as usual projection, biomass was estimated using the Schaefer model described above. The economic portion of our model defined total fishery profit π as a function of biomass and effort

$$\pi_t = pqf_t^{\alpha}B_t - cf_t$$

where *p* is the dock price of snapper, *q* is catchability, f_t is the total fishing effort in a given year, B_t is the total snapper biomass in the region, and *c* is the cost of each unit of effort (each fishing trip). For our business as usual projection, fishing effort in each year was assumed to change based on a simple fleet dynamics model where the fishing effort changes each year proportionally to the profits in the previous year

$$f_{t+1} - f_t = \varphi(pqf_t^{\alpha}B_t - cf_t)$$

where φ is a dampening parameter that determines how much effort can increase or decrease relative to changes in profit, constrained between 0-1, or from not changing at all to being perfectly proportional. Under this model, fishing effort will continue to increase as long as profits are positive. Our model operates under the assumption that it would be more difficult for fishers in this fishery to increase effort than to stop fishing, and therefore we chose to use a non-symmetric dampening parameter. If profits were greater than 0 in a given year, a dampening parameter of 0.0004 was used, which allowed fishing effort to increase by approximately 400 trips per year. If profits were less than 0 in a given year, a dampening parameter of -0.0006 was used, which allowed fishing effort to decrease by 600 trips per year. These dampening parameters were chosen based on the changes in model predicted fishing effort between 1990 and 2013, which rarely changed by more than 500 trips between consecutive years.

Using the best set of parameters from our surplus production model with an initial depletion of 0.2 of the carrying capacity, biomass was projected until 2050 under two assumptions: 1) fishery is in open access, and 2) effort will change via a fleet dynamics model in response to profits. The regulations stated by INCOPESCA limit the type of gear, fishing areas and assign fishing licenses. Nevertheless, there are no limits on catches, therefore, any fisher can increase their effort as desired. Additionally, INCOPESCA is understaffed, making enforcement of any regulatory measures difficult. This facilitates illegal fishing as well as entry to the fishery.

5.2.4. Bio-Economic Model Summary: Implementing Fair Trade USA

We assumed that the most feasible control on fishing mortality for this fishery would be fishing effort restriction by the certified communities by limiting the number of allowable fishing trips. The effects of FTUSA certification on biological and economic components of the snapper stock divides the Guanacaste region into two groups: certified and uncertified.

We assume that there is one snapper stock distributed throughout the whole Guanacaste region, which is fished by both the certified and uncertified communities. Thus, snapper in this region share the same growth rate (r), carrying capacity (K), and catchability (q). Under all scenarios of Fair Trade USA implementation, the effort in certified communities was capped at a maximum value, f_c. The proportion of the total fishing effort γ put by the certified communities was therefore

$$\gamma = \frac{f_c}{f_c + f_u}$$

where f_c is the restricted effort in the certified communities, and f_u is the unrestricted effort in the uncertified communities. Profit is still defined as a function of biomass and fishing effort in a given year, but the total profits for all certified fishers with restricted effort can now be separately defined from those of all uncertified fishers using γ as

$$\pi_{c,t} = \gamma(pqf_{c,t}^{\alpha}B_t - cf_{c,t})$$

where $f_{c,t}$ is the effort in a given year by certified fishers. The total profits for all uncertified (unrestricted) fishers is similarly defined by replacing $f_{c,t}$ with $f_{u,t}$. Since effort is not restricted in the uncertified communities, they are still assumed to be operating under open access dynamics, and will therefore continue to respond to changing profits via a fleet dynamics model just like in the business as usual scenario. Total catch for the Guanacaste region is then defined as a function of both certified and uncertified effort, scaled by γ

$$C_t = \gamma q f_{c,t}^{\alpha} B_t + (1-\gamma) q f_{u,t}^{\alpha} B_t$$

To address economic changes to the fishery post FTUSA implementation, we predicted potential Community Development Premium revenue as

$$CDP_t = \lambda p \delta q f_{c,t}^{\alpha} B_t$$

where λ is the FTUSA premium price percentage, p is the ex-vessel price, δ is the proportion of the catch going to export, $f_{c,t}$ is the fishing effort in the certified communities, and B_t is the total biomass of snapper in the Guanacaste region. Based on conversations with exporters in Costa Rica, we assumed that 80% of the fish caught by the certified communities would be exported, and 20% would not meet the standards and requirements of the importer, thus remaining in-country. Given the relatively small variation in ex-vessel price for snapper in Costa Rica between 1990 and 2013 (after correcting for inflation), the average price between 1990 and 2013 was used to project profits into the future for all FTUSA scenarios.

Biomass projections were then run using the Schaefer model for 418 scenarios of possible FTUSA implementation determined by varying four parameters (Table 3):

1. γ: Proportion of total effort by certified communities
2. α: Diminishing returns on effort
3. f_c: Maximum allowable effort in certified communities
4. λ: FTUSA premium price percentage

Table 3. Parameter values for scenarios of Fair Trade USA implementation. The parameters f_c and γ ranged between 3-10% by increments of 5%, and λ between 3-10% by increments of 1%.

f_c	γ	α	λ
50 – 100%	10 – 100%	0.8 0.99	3 – 10%

Our most conservative scenarios of FTUSA implementation assume a diminishing return on effort (α) of 0.99, since this indicates that reductions in effort in one portion of the region can be easily counteracted by others. In other words, any increase in snapper stock due to effort reductions in San Francisco de Coyote and Bejuco would be fished by fishers without effort control. In order to simulate the possibility that spotted rose snapper in the Guanacaste region are not an extremely well mixed stock, we also ran scenarios with a diminishing return on effort of 0.8. When the level of mixing is lower, any effort reduction by the certified communities will not have the same compensation from the uncertified, open access fishers working in the region.

5.3. Results

5.3.1. Parameter Estimations and Model Fit

Using the Schaefer surplus production model, estimates of *MSY* ranged from 667 tons if the fish stock was at carrying capacity in 1990 (initial depletion = 0) to 2,713 tons if the fishery was only at 10% of carrying capacity in 1990 (Table 4).

Table 4. Parameter estimates for the *L. guttatus* fishery in Costa Rica with different initial depletions using a Schaefer surplus production model with box-constrained optimization. *K* represents carrying capacity (tons), *q* catchability coefficient, r intrinsic growth rate, σ variation between observed and predicted CPUE values, *MSY* maximum sustainable yield (tons), B_{MSY} biomass producing *MSY* (tons).

Initial Depletion	*R*	*K* (tons)	*q*	σ	*MSY* (tons)	B_{MSY} (tons)
0	0.351	7595	4.15e-5	0.2049	667	3797
0.1	0.322	8185	3.87e-5	0.2051	659	4092
0.2	0.339	8219	4.07e-5	0.2049	697	4110
0.3	0.340	8219	4.07e-5	0.2049	697	4106
0.4	0.256	11031	3.27e-5	0.2103	706	5515
0.5	0.276	11564	3.51e-5	0.2081	799	5782
0.6	0.320	11877	4e-5	0.2056	950	5938
0.7	0.248	17539	3.35e-5	0.2091	1089	8769
0.8	0.195	29147	2.85e-5	0.2121	1419	14573
0.9	0.225	48142	3.18e-5	0.2094	2713	24071

B_{MSY} ranged from 3,797 tons to 24,071 tons depending on the initial depletion of the fishery. The average intrinsic growth rate *r* for the snapper population was 0.29, and estimated carrying capacity ranged from 7,595 to 48,142 depending on the initial depletion. For an initial depletion of 20%, intrinsic growth rate was 0.34, carrying capacity was 8,219, and *MSY* was 697 (Table 5). The amount of optimal effort was estimated to be just over 4,000 trips per year (Table 5). Given this set of parameters, we found a decreasing trend of catch per unit effort between 1990 and 2013 (Figure 9).

Table 5. Estimated parameters for the *L. guttatus* fishery in Costa Rica using a Schaefer surplus production model with box-constrained optimization. Initial biomass was estimated to be 0.8 of the carrying capacity based on fishing history prior to 1990. K represents carrying capacity (tons), q catchability coefficient, r intrinsic growth rate, σ variation between observed and predicted CPUE values, MSY maximum sustainable yield (tons), f_{MSY} optimal fishing effort (# of fishing trips).

r	K	q	σ	MSY	f_{MSY}
0.339	8,219	0.0000407	0.205	697	4,165

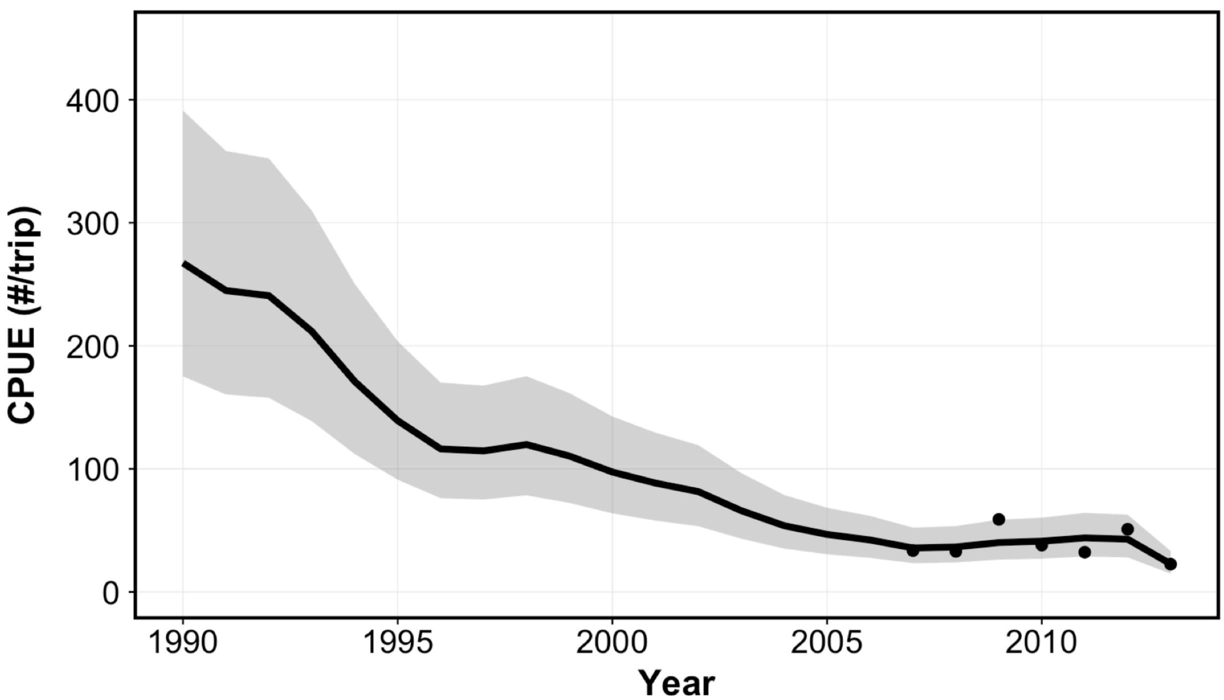

Figure 9. Observed and predicted catch per unit effort (CPUE) for spotted rose snapper in Guanacaste (1990 - 2013) using a Schaefer surplus production model. Best fit was determined by minimizing the NLL between observed (black points) and predicted CPUE (black line) for different combinations of r, K, and q with box-constrained optimization. The shaded region indicates 95% confidence intervals for the model fit generated from the likelihood profiles of each parameter.

Total annual catches of snapper for the region were above *MSY* for most years between 1990 and 2003 (Figure 10). The snapper stock has been depleted below B_{MSY} since 1995 ($B/B_{MSY} < 1$) and the level of fishing effort has been above the optimal level since 1992 ($F/F_{MSY} > 1$) (Figure 11).

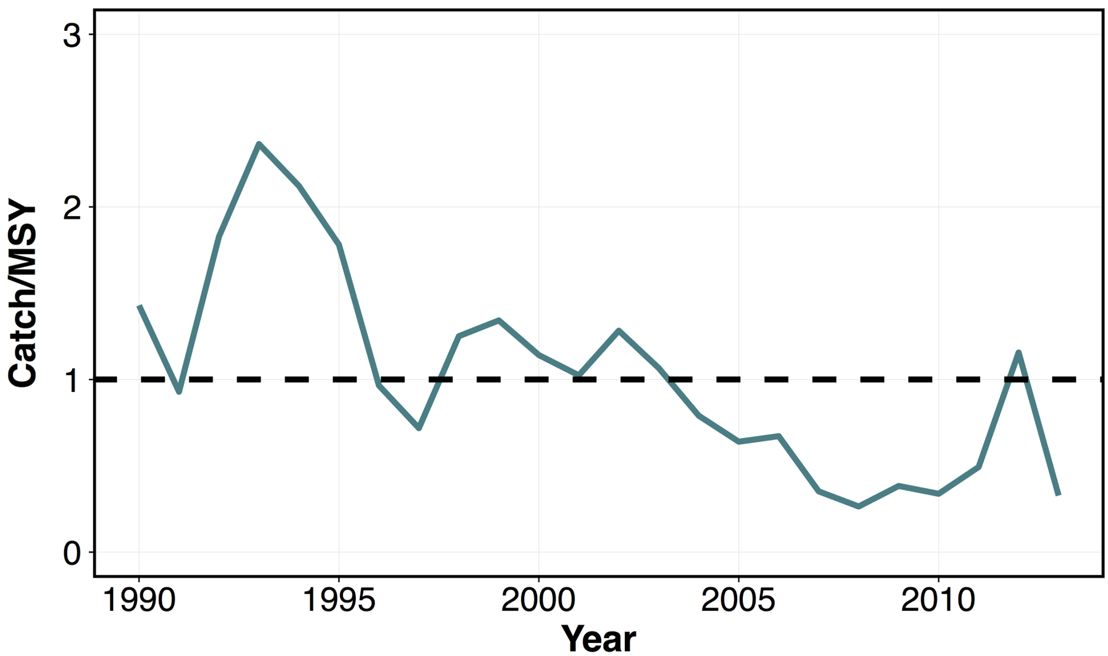

Figure 10. Catches from the Guanacaste snapper fishery relative to predicted MSY (1990 - 2013). MSY was calculated as $\frac{rK}{4}$, using the estimated model parameters. The dashed horizontal line indicates the point at which catch = MSY; the fishery is considered overexploited above this line.

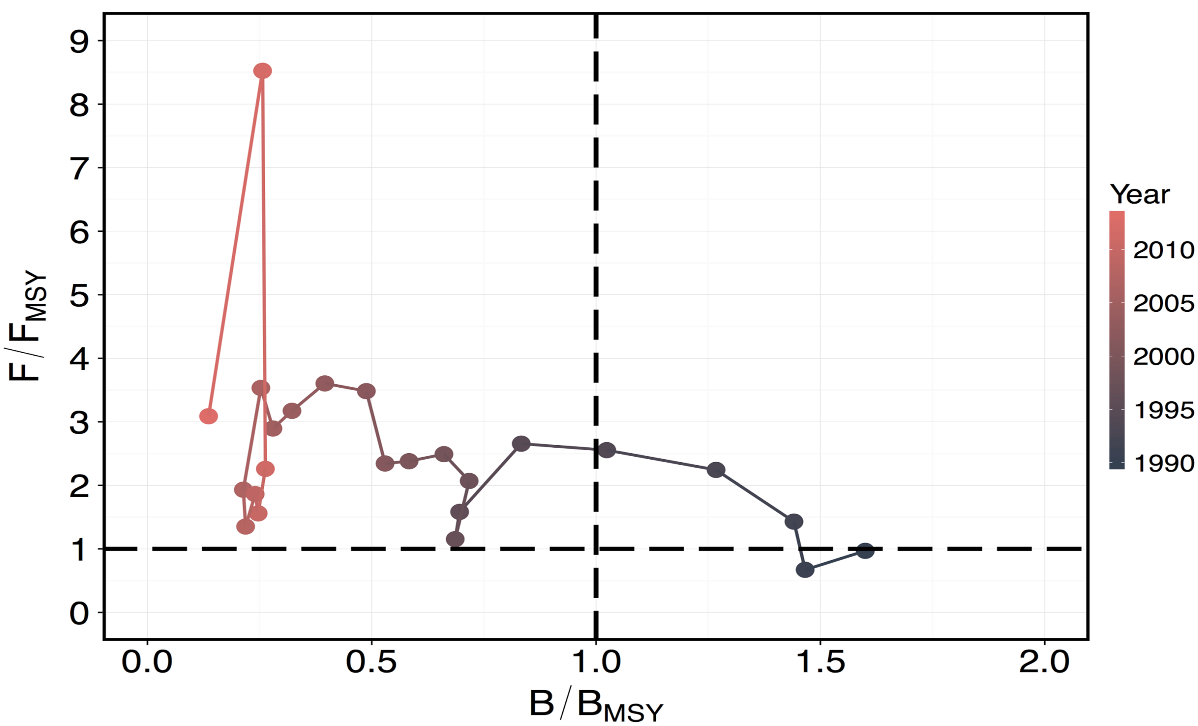

Figure 11. Kobe plot for the Guanacaste snapper fishery (1990 - 2013). The relationship between fishing effort relative to the predicted optimal fishing effort (F/F_{msy}) and biomass relative to the predicted biomass that gives maximum sustainable yield (B/B_{msy}) is shown between 1990-2010 (dark to light colors). The dashed horizontal line indicates the point at which fishing effort = F_{MSY} and the dashed vertical line indicates the point at which biomass = B_{MSY}.

5.3.2. Business as Usual Projection

Projecting to 2050 under a business as usual scenario (BAU), we found that snapper biomass in the Guanacaste region will precipitously decline, with the fishery becoming unprofitable in 2018 (Figure 12). Fishing effort will similarly decline from the point at which fishery profits drop below 0, and biomass eventually starts to recover slightly in 2039 due to decreased fishing effort. The amount of snapper biomass in 2050 is predicted to be only 25% of that in 2013 (Figure 12).

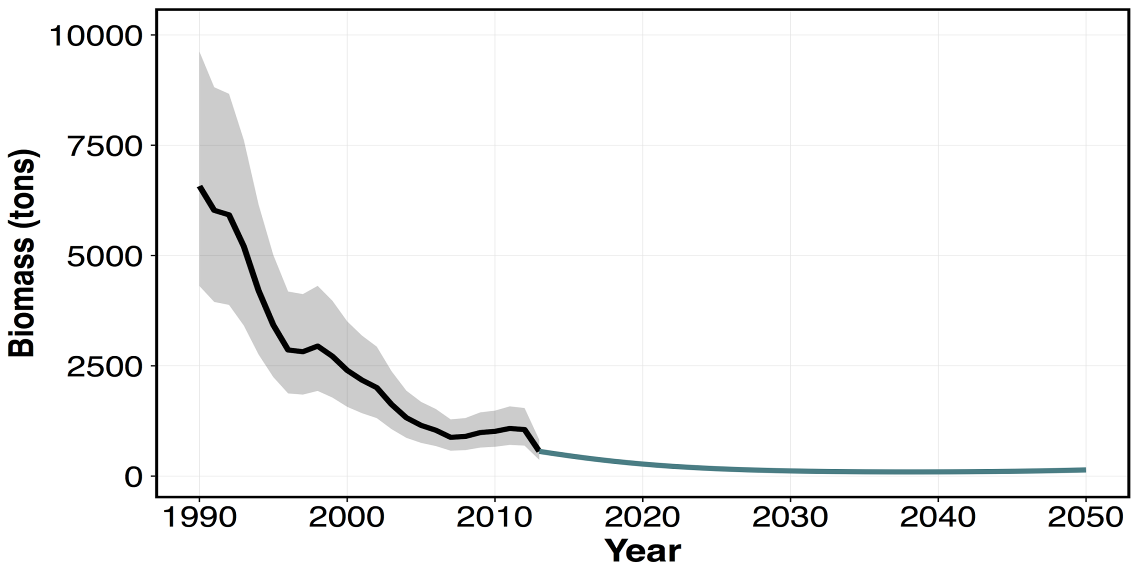

Figure 12. Business as usual biomass projection for the Guanacaste snapper fishery using a Schaefer surplus production model (2013 - 2050). The fishery is assumed to be open access and fishing effort responds to profits via a fleet dynamics model.

5.3.3. Scenarios of Fair Trade USA Implementation

With a very highly mixed stock (α = 0.99) and only 10% of the region under a FTUSA effort control strategy (as if the communities of Coyote and Bejuco became certified), there was little difference from the BAU scenario regardless of the level of effort control implemented (Figure 13, A). With 50% of the Guanacaste region certified, slight positive increases in biomass from the BAU scenario with 30% and 50% reductions in effort (Figure 13, B). Under the 50% reduction in effort scenario, biomass increased during the first decade, but, due to corresponding changes in fishing effort by non-certified fisheries, ultimately ended up decreasing to a level similar to the BAU scenario. (Figure 13, B). With 100% of the region under an effort control strategy biomass increases until leveling off at or above the current biomass in 2013 with even a 20% reduction in fishing effort (Figure 13, C). A 50% reduction in fishing effort resulted in snapper biomass recovering (Figure 13, C).

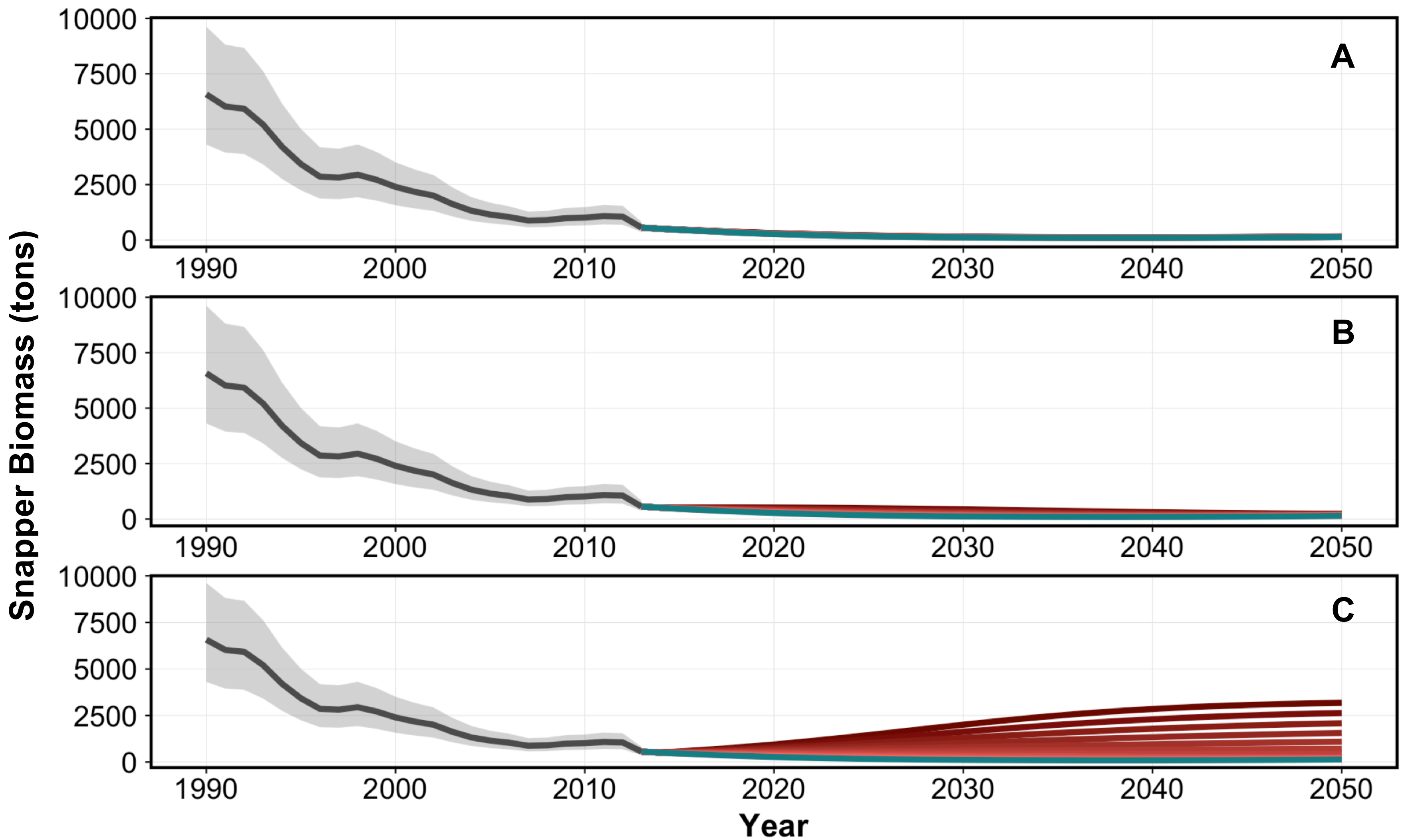

Figure 13. The effect of FTUSA implementation on biomass for the Guanacaste snapper fishery projected using a Schaefer surplus production model with a return on effort of 0.99 (2013 - 2050). Scenarios were run for different percentages of the region being certified (effort controlled): (A)10%, (B) 50%, and (C) 100%. Fishing effort was also capped at different levels (no effort reduction - 50%) of the current effort for the proportion of the region that would be certified (lowest to highest percent effort reduction indicated by light to dark red, respectively). Predicted biomass under a business as usual model is also shown (teal).

For a very well mixed stock (α = 0.99), the average Community Development Premium generated each year with a 6% premium price would be between $270 - $434 per community if 10% of the region was under an effort control strategy depending on the level of effort reduction (Figure 14). With 50% of the region under an effort control strategy, the average Community Development Premium (6% premium price) increased to $439 - $465 per community per year, and if the entire region was certified, $473 - $1,432 per community per year could be generated (Figure 14).

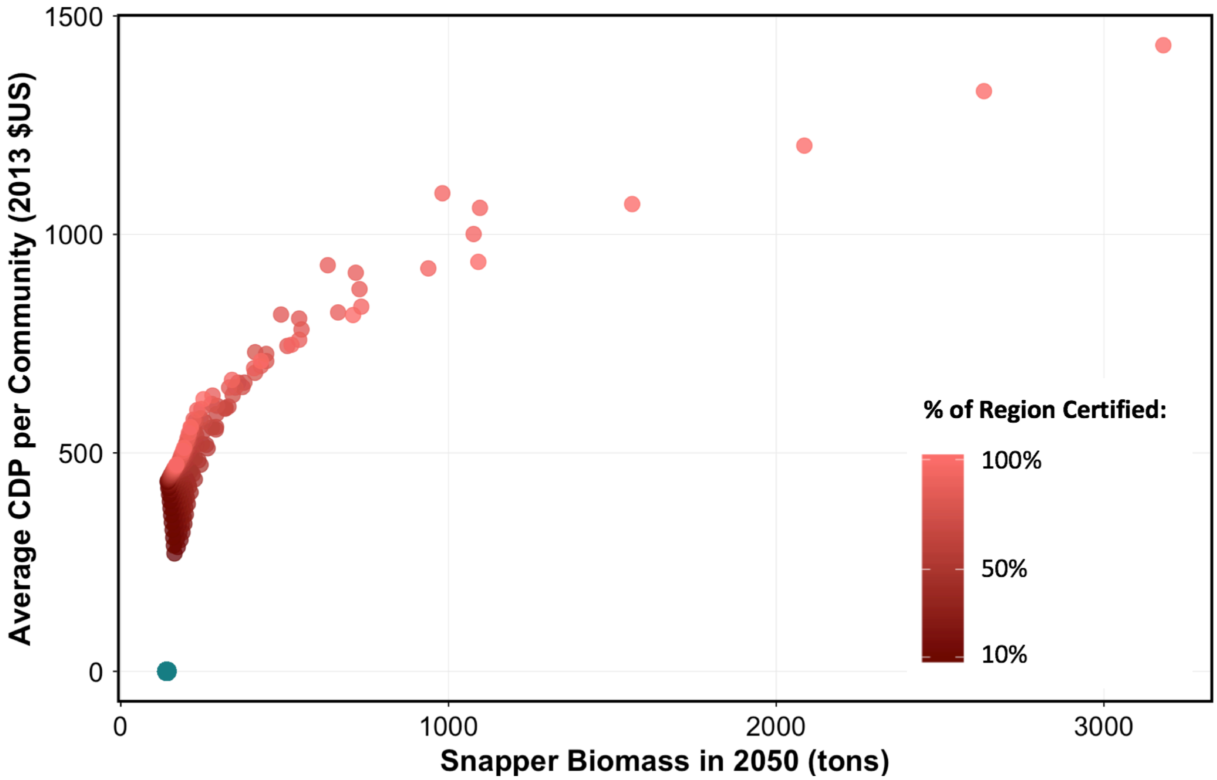

Figure 14. Snapper biomass in 2050 from different scenarios of Fair Trade USA implementation and average Community Development Premium fund per community with a return on effort of 0.99. Scenarios were run for 0 – 50% effort reduction where effort was capped at that level of the current effort for the proportion of the region that would be certified. Different proportions of the region were also certified: 100% (pink), 50% (red), and 10% (dark red). The business as usual scenario where Fair Trade USA is not implemented is also shown (teal).

With a less well-mixed stock (α = 0.8) and only 10% of the region under an effort control strategy, snapper biomass increased through time under FTUSA as compared to the BAU scenario regardless of the level of effort control implemented (Figure 15, A). With 50% of the Guanacaste region certified, biomass began to level out well above the current level in 2013 under all levels of effort control (Figure 15, B). Under a scenario where 100% of the region is under an effort control strategy, snapper biomass increased above the level in 2013 and leveled off (Figure 15, C).

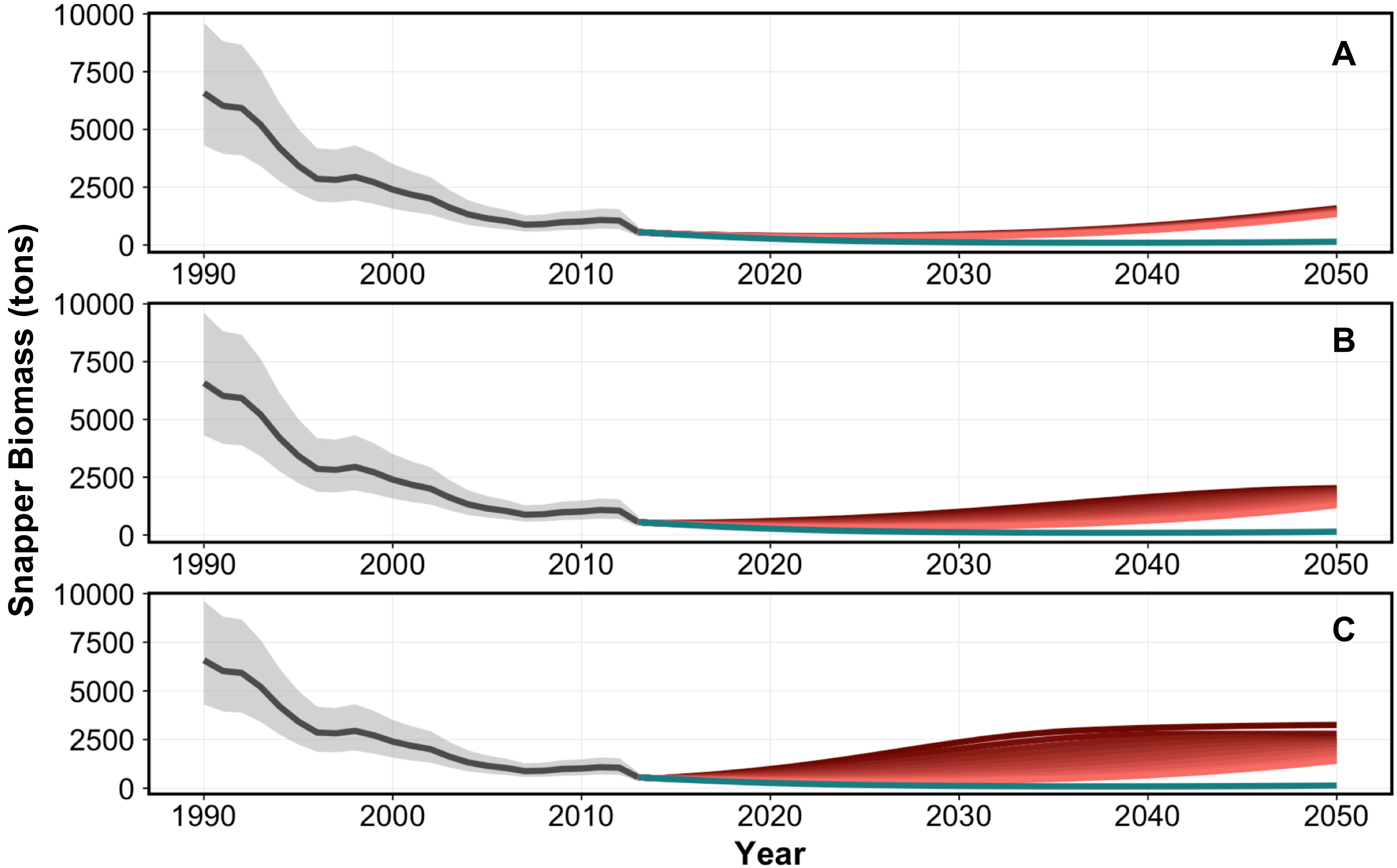

Figure 15. The effect of FTUSA implementation on snapper biomass in the Guanacaste snapper fishery projected using a Schaefer surplus production model with a return on effort of 0.8 (2013 - 2050). Scenarios were run for different percentages of the region being certified (effort controlled): 10% (A), 50% (B), and 100% (C). Effort was also capped at different levels of the current effort for the proportion of the region that would be certified from no effort reduction (pink) to 50% reduction (dark red). The business as usual biomass projection is also shown (teal).

Under this stock mixing scenario, the average Community Development Premium generated per community each year with a 6% premium price would be between $452 - $690 if 10% of the region was under an effort control strategy depending on the level of effort reduction (Figure 16). With 50% of the region under an effort control strategy, the average Community Development Premium (6% premium price) per community increased to $652 - $758 per year, and if the entire region was certified, $664 - $1,496 per community per year could be generated (Figure 16).

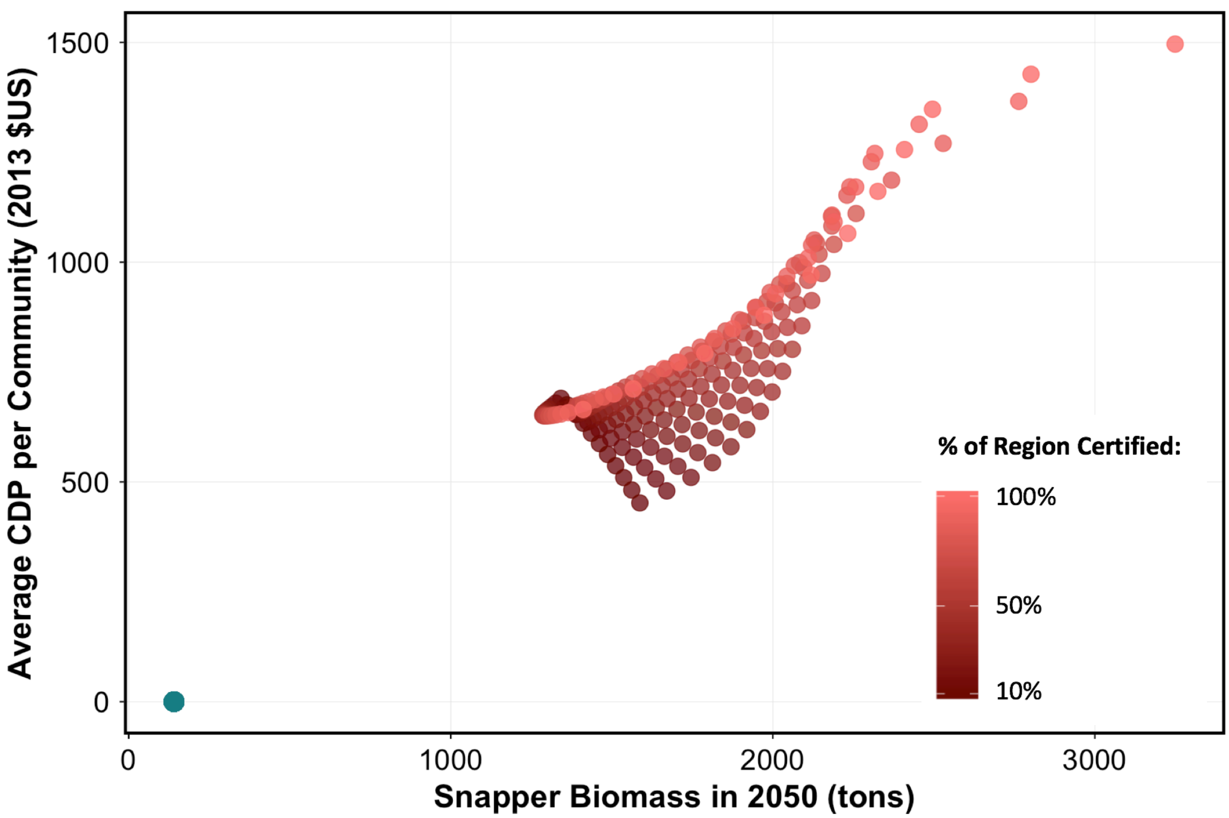

Figure 16. Snapper biomass in 2050 from different scenarios of Fair Trade USA implementation and average Community Development Premium fund per community with a return on effort of 0.8. Scenarios were run for 0 – 50% effort reduction where effort was capped at that level of the current effort for the proportion of the region that would be certified. Different proportions of the region were also certified: 100% (pink), 50% (red), and 10% (dark red). The business as usual scenario where Fair Trade USA is not implemented is also shown (teal).

5.4. Main Findings

With a very well mixed stock and less than half of the region under a control on fishing mortality in the form of effort reduction, the biological effects of implementing Fair Trade USA are negligible regardless of the level of effort reduction. A positive impact on the stock was only seen if the entire region committed to reducing effort by at least 30%, at which point the snapper biomass could recover. Notably, under all of these scenarios a Community Development

Premium is generated even if the fishery is not profitable. This occurs because the Community Development Premium fund is an accumulation of the fixed percentage of the ex-vessel market price. However, if only San Francisco de Coyote and Bejuco become certified, the Community Development Premium may be an insignificant amount that does not justify the effort of the process of certification. The FTUSA premium price percent, which remains to be established by working with buyers and fishermen, would determine the incentive of certification.

With a less well mixed stock, the biomass trajectories show much better results, with any level of effort reduction by 10% of the region showing positive impacts on the snapper biomass. Even though these biomass trajectories shown better results than those with a higher alpha, they are much less conservative projections and should be treated with caution. Further research on the mixing of snapper in the region must be conducted in order to support the theory that such localized effects would be seen within this stock.

6. Discussion

We explored the biological and social tradeoff in seafood certification programs through the case study of the small-scale snapper fishing communities of San Francisco de Coyote and Bejuco. We found that Fair Trade USA presents the best seafood certification scheme to address the social needs of SSFs in developing countries, while still addressing important ecological and governance considerations. Through systems mapping, we understood the high complexity of the supply chain and that the adoption of FTUSA certification will have two main effects: 1) create social benefits even when biomass benefits are negligible; and 2) increase the exports of sustainable, certified fish. Finally, our projections of social benefits and biomass supported the finding that the certification will always bring economic benefits for the community through the Community Development Premium fund, independent from a biomass increases.

Based on our seafood program comparison of the MSC, FIP with the end goal of the MSC certification, and FTUSA, and the assumption that a successful seafood program for SSFs in developing countries must take a system-wide approach with inclusion of both socioeconomic and ecological criteria, FTUSA is the most applicable when compared with the MSC and a FIP targeted at the MSC certification. Unique to FTUSA is that it incorporates a process of improvement, with the fishery needing to meet increasingly stringent criteria in Years 1, 3, and 6. In this way, FTUSA has incorporated an improvement model within its standards, allowing and demanding the fishery to progress after initial certification. While the objectives and structure of FTUSA seem more appropriate than the MSC for SSFs, the successes and challenges faced by FTUSA in practice remain to be seen. Additionally, if a fishery seeks to solely improve its biological status, data collection systems, and sustainable management, the MSC may be the most appropriate choice. However, if social concerns are prioritized, FTUSA may be best. It is important to critically evaluate the goals of the fishery before embarking on the lengthy process of certification.

After mapping the effect that FTUSA could have on the supply chain of a small-scale fishery, it became clear that the unique model of this certification program could offer unique benefits to fishers though the Community Development Premium fund. We found a significant, potential increase in benefits for fishers at the community level. Other certifications have been criticized for not adding value to the product, or adding it in a manner that never reaches producers. Under FTUSA, the premium price paid by consumers skips multiple intermediate supply chain steps and benefits the community directly. Another critique of existing certifications is that a higher ex-vessel price for certified fish may encourage increased fishing effort. Profits are a key motivation for fishing, and holding other factors constant, if fishing becomes more profitable, fishing effort will generally increase (Sumaila et al. 2008). However, under the FTUSA model, FTUSA certified fishers do not receive a higher ex-vessel price and the benefits accumulate in the community instead of to individuals. Thus, there is no direct incentive for non-community residents to overfish. The Community Development Premium model may also provide a unique, community-based sentiment of resource stewardship. Nevertheless, it is worth mentioning that the money generate, presents restrictions in how it can be invested. These restrictions are stated by Fair Trade USA.

The long-term incentive for middlemen to participate in the FTUSA capture fisheries supply chain should be further investigated. Middlemen perform a range of necessary functions, from providing fishing equipment to transporting products, that allow fishers to access markets. Under a scenario where FTUSA is implemented, middlemen must take effort-intensive, additional measures to ensure traceability and the separation of FTUSA certified product, without seeing a direct, guaranteed price increase. As the financial gain of FTUSA accumulates in the form of a Community Development Premium fund, middlemen will not directly benefit unless they live in or near the community. Bailey et al. (2016) argue that the successes and challenges of FTUSA capture fisheries depend heavily on the consideration of these fisher-middlemen dynamics and our case study in Costa Rica supports this claim. Additionally, the impact of the FTUSA certification on the domestic markets in developing countries should be further investigated. Asche et al. (2015) found that the international trade of seafood between developing and developed countries may foster a quality exchange in which developing countries export their high-quality seafood in exchange for lower quality seafood. Income generated by developing countries is sufficient to compensate for exported seafood, but questions are raised about food security, adequate nutrition, and the types of substitute goods that may fill domestic marketplaces. If FTUSA continues to expand globally to certify developing country fisheries, this potential deficit of sustainable fish must be closely monitored.

Our model of the biological and social effects of Fair Trade USA in a small-scale fishery demonstrates a wide range of possible outcomes if effort restriction is used as a control on fishing mortality. We found that the magnitude of the impact from effort reduction is largely dependent on the diminishing return on effort (mixing or movement of the stock). The level of snapper stock regional isolation most significantly altered predicted snapper biomass under different certification scenarios. Additionally, gaining a better understanding of the mixing or movement of the stock is difficult in many small-scale fisheries without the appropriate data to conduct a full stock assessment. The problem with certifying small-scale fisheries in developing countries that fish a small portion of a larger stock can be seen in practice through the fact that the only SSFs in developing countries certified by the MSC are benthic species with small ranges (Blackmore et al. 2015; Appendix II).

Additionally, part of the success of the FTUSA capture fisheries program in the future will be dependent on the demand for socially responsible seafood in the United States. As evidenced by current media attention to the issues of slavery in the seafood industry, we predict that retailers and companies will respond by increasingly demanding equity in their supply chains, a concern that the MSC and FIP do not address as comprehensively as FTUSA. We believe that FTUSA seafood is poised to experience high demand and that the resulting benefits to small-scale fishing communities in developing countries can be significant. However, FTUSA has introduced an additional seafood certification to the market, which may add to increasing consumer confusion when purchasing seafood (Stokke et al. 2004). The competing claims or conflicting labels may confuse consumers, and lead to a loss in credibility and confidence in the sustainability claims, depriving the approach of its value (Wessells 2001). It is important that FTUSA continue its collaborative work with the MSC, as these certified products will be demanded by US retailers seeking to fulfill sustainability pledges.

Finally, the power of a committed NGO or supply chain partner in assisting with certification implementation in small-scale fisheries cannot be underestimated. Moving forward, linking fisheries seeking certification to a NGO or another on-the-ground group that can assist with data collection, document organization, and annual audits is critical to the success of the program. Specifically regarding the FTUSA capture fisheries program, NGO involvement catalyzed and facilitated the certification process in the currently certified fisheries. From the involvement of Yayasan Masyarakat dan Perikanan Indonesia (MDPI) with the Moluccan yellowfin tuna fishery in Indonesia (Duggan & Kochen 2016; Bailey et al. 2016) and the Sustainable Fisheries Partnership's assistance with the shrimp certification in Sinaloa, Mexico, it can be seen that NGO partners were instrumental in certification. Fishers often do not have the capacity or time to compile certification requirements and NGO partnerships fill these gaps. Regarding our case study in

7. Conclusion

"There are no more fisheries that can be 'easily' certified. Smaller fisheries in developing countries have a lack of pre-existing conditions including management, science, and money. We need to work on those fisheries based on the reality they face." Juan Manuel Garcia Caudillo (2015), the Director of Sustainable Fisheries Partnership Mexico, exemplified the challenge we are currently facing in the sustainable seafood industry—that all of the "low-hanging fruit" fisheries have been certified. Moving forward, as the global demand for sustainable seafood continues to increase, certification programs must find innovative ways to accommodate the complexities of small-scale fisheries and the people which depend on them. The Fair Trade USA capture fisheries certification offers a novel, system-wide approach to seafood certification which operates along a process of continual improvement. By examining the Costa Rican snapper fishery as a case study, we demonstrated that FTUSA may fill the gaps where other prominent seafood certification programs struggle by utilizing a system-wide approach, incorporating social criteria, and operating over a 6-year process of improvement. We provided critical insight into the potential economic and biological tradeoffs that could be obtained from adopting the FTUSA certification in small-scale fishing communities around the globe.

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Appendix I – MSC Certified Small-Scale Fisheries in Developing Countries.

Table 6. MSC certified small-scale fisheries in developing countries (adapted from Blackmore 2015, MSC 2015c). Note: Blackmore (2015) consider the MSC certified Suriname Atlantic seabob shrimp as small-scale, though MSC does not, leading to its exclusion from this table.

Fishery	Country	Gear/Vessel	Fishing Grounds	Markets
Baja California: Red rock lobster	Mexico	Baited wire traps and fiberglass boats <10m	Low intertidal zone to 100 m depth	Asia, France, USA
Sian Ka'an and Banco Chinchorro biosphere reserves: Spiny lobster	Mexico	Free diving with Cuban "casitas" and fiberglass boats 6-8m	Nearshore waters	Yucatan Peninsula and USA
Ben Tre province: Lyrate hard clam	Vietnam	Hand gathered or meal rakes with net pockets	Coastal waters	EU, Japan, China, Taiwan, USA
Ashtamudi estuary: Short-neck clam	India	Free diving and hand dredge	Estuary	Vietnam, Thailand, Malasia, & Indonesia
Juan Fernandez Islands: Juan Fernandez rock lobster	Chile	Baited wooden/plastic traps	Subtidal zone to 180 m depth	China

Appendix II – Fishery Improvement Projects (FIPs) in Latin America.

Table 7. Current fishery improvement projects (FIPs) in Latin America. Projects are arranged alphabetically by country. The common name of the target species is given in English, and the specific scope or locale of the project within each country (if applicable) is the stock (SFP 2015).

Country	Common Name(s)	Scientific Name(s)	Stock	Year Started	Gear Type(s)
Argentina	Argentine hake	*Merluccius hubbsi*	Southern	2009	bottom trawls
Argentina	red shrimp	*Pleoticus muelleri*	off-shore	2014	bottom trawls
Argentina	red shrimp	*Pleoticus muelleri*	on-shore	2015	bottom trawls
Argentina, Chile	Southern hake	*Merluccius australis*	Chilean regions VII-XII, Southern coast of Cape Horn	2010	bottom trawls, longlines, midwater trawls
Argentina, Uruguay	Argentine hake	*Merluccius hubbsi*	North of 41°S	2011	bottom trawls
Brazil	Caribbean spiny lobster, green lobster	*Panulirus argus, Panulirus laevicauda*	Northern and Northeastern	2011	pots
Brazil	Caribbean red snapper	*Lutjanus purpureus*	Northern Brazil	2014	hook and line, traps
Chile	anchoveta, araucanian herring	*Engraulis ringens, Strangomera bentincki*	regions V-X	2008	seine nets
Chile	South Pacific hake	*Merluccius gayi gayi*	regions IV-X	2012	bottom trawls, hook and line, midwater trawls, gillnets, longlines
Chile	Chilean jack mackerel	*Trachurus murphyi*	Southeast Pacific	2010	trawls, purse seines
Ecuador	mahi-mahi	*Coryphaena hippurus*	EEZ, international	2009	longlines
Guatemala	mahi-mahi	*Coryphaena hippurus*	Pacific Ocean	2014	longlines
Guyana	Atlantic seabob	*Xiphopenaeus kroyeri*	Western central Atlantic	2012	trawls, canoe dip-nets
Honduras	Caribbean spiny lobster	*Panulirus argus*	Caribbean Sea	2011	diving, traps
Mexico	Pacific blue shrimp, whiteleg shrimp, yellowleg shrimp	*Farfantepenaeus californiensis, Litopenaeus stylirostris, Litopenaeus vannamei*	Gulf of California	2009	bottom trawls (industrial)
Mexico	Pacific blue shrimp	*Farfantepenaeus californiensis*	Gulf of California, Sinaloa State coast	2010	cast nets
Mexico	Pacific blue shrimp	*Farfantepenaeus californiensis*	Gulf of California, Sonora State coast	2010	driftnets
Mexico	swimming crab, warrior swimming crab	*Callinectes arcuatus, Callinectes bellicosus*	Gulf of California	2008	lift nets, pots

Mexico	Pacific blue shrimp, Yellowleg shrimp	*Farfantepenaeus californiensis, Litopenaeus vannamei*	Magdalena Bay, Western Baja	2008	cast nets, otter trawls
Mexico	black grouper, red grouper	Epinephelus morio, Mycteroperca bonaci	Campeche Bank, Yucatan Peninsula	2013	bottom longlines
Mexico	blue swimming crab	*Callinectes rathbunae, Callinectes sapidus*	Campeche Bank, Yucatan Peninsula	2013	traps
Mexico	red snapper	*Lutjanus campechanus*	Campeche Bank, Yucatan Peninsula	2013	hook and line
Nicaragua	Caribbean spiny lobster	*Panulirus argus*	Caribbean Sea	2011	traps
Panama	mahi-mahi	*Coryphaena hippurus*	Pacific Ocean	2011	longlines
Panama	yellowfin tuna	*Thunnus albacares*	Pacific Ocean	2011	longlines
Panama	Pacific anchoveta Pacific bumper, Pacific thread herring	*Cetengraulis mysticetus, Chloroscombrus orqueta, Opisthonema libertate*	Gulf of Panama	2011	cast nets, purse seines
Peru	mahi-mahi	*Coryphaena hippurus*	EEZ, international	2012	longlines
Peru	Peruvian hake	*Merluccius gayi peruanus*	North of 6°S		bottom trawls, longlines, midwater trawls
Suriname	Southern red snapper	*Lutjanus purpureus*	EEZ	2013	hook and line

Appendix III – Fair Trade USA Capture Fisheries Standard Components.