

FISHERY-DEPENDENT STAKEHOLDERS - IMPACTS AND RESPONSES TO AN
ANNUAL CLOSED FISHING SEASON IN TAMIL NADU & PUDUCHERRY, INDIA

By

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ABSTRACT

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Global fisheries are in crisis, threatening millions of fisher livelihoods worldwide. The way in which we manage these resources has the potential to greatly impact not only fishery health, but livelihood viability. This research aims to understand the socio-economic and resultant livelihood implications of resource management regulations, and how those impacts feedback to influence an individual's resource use. I hypothesize that impacts are not uniform amongst stakeholder groups and only in identifying the varied impacts and adaptation responses can we begin to move towards developing more effective and legitimate regulations. I use the case of an annual closed fishing season in Tamil Nadu and Puducherry, India, to investigate the consequences of this resources use regulation. Using a longitudinal sampling frame, I employ interview, survey techniques and seasonal activities calendars over the course of three seasons to understand how the seasonal ban impacts different stakeholder groups, how individuals adapt or cope with the impacts and how individuals modify their resources use to deal with restrictions. This dissertation is divided into three empirical chapters. The first chapter examines the distributional equity issues that have arisen as a result of the fishing ban. I find that not only is the harvest sector (as anticipated) heavily impacted, but it is also individuals from the non-harvest sectors who lose significantly during this time despite being largely left out of the decision making process. In some cases, those who lose the most are overlooked in government aid provisions. The second chapter examines the ways in which impacted individuals have adapted or coped with significant fluxes in their incomes and expenditures. Using the

framework of intersectionality in feminist research I uncover that power, class and sex intersect to influence an individual's likelihood of employing coping strategies that may threaten their long-term livelihood sustainability. Chapter three investigates how harvest sector individuals adapt their resource-use practices to accommodate the closed fishing season. I find that fishers adapt by shifting effort to unregulated time frames or to boat-types that are allowed to fish during the closed fishing season. These adaptations threaten the efficacy of the fishing ban but highlight the adaptability and ingenuity of resource users. This dissertation contributes to multiple areas of scholarship on natural resource management, refining existing literature by more clearly specifying how policy impacts vary depending on individual resource user characteristics. Response to the marine fisheries crisis is necessary. This research shows that the way in which we respond to this crisis may have both short and long-term consequences not only for fishery health, but for the millions of people world-wide that depend on fish resources for their livelihoods. Without a thorough examination of resource use history, socio-cultural aspects and local innovation and adaptation, the likelihood of unintended consequences arising from a management decision are high. These findings can therefore be used by managers to anticipate the potential consequences of management decisions in order to mitigate for the harms and maximize the benefits.

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1 Introduction

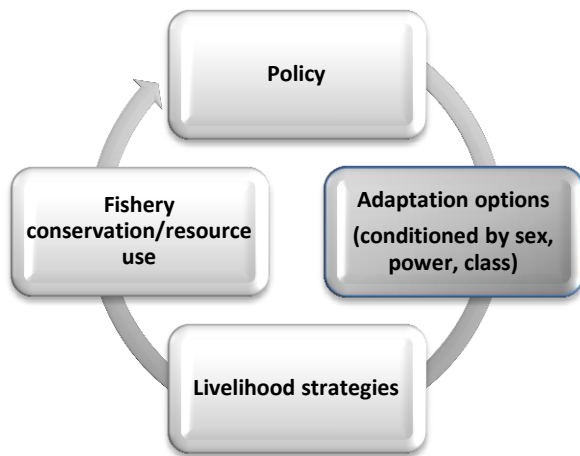
1.1 Crisis in marine fisheries

The global fisheries crisis threatens millions of fisher livelihoods worldwide. The crisis manifests not only through depleted resources and ecosystem degradation but through increased competition for scarce resources (Stephen, 2014), increased user to user conflict (Menon, Bavinck, Stephen, & Manimohan, 2015), greater income disparities and threats to food security (Allison, 2001; Bhathal & Pauly, 2008). Managing global fisheries is not only an ecosystem issue, but a human security issue (Mcclanahan, Allison, & Cinner, 2015) with often the most marginalized individuals at highest risk. However, despite the recognition of the fisheries crisis, successfully managing global fisheries has remained somewhat untenable. Efforts to devise regulations to address the fisheries crisis have been met with varying degrees of success, as measured through ecosystem benefits, but the unintended human consequences of these regulations is ripe for study.

Devising legitimate rules in the eyes of resource users is a major barrier to successful management (Agarwal, 2001). Legitimate rules enhance the probability of successful enforcement and are often achieved through iterative processes of stakeholder engagement (Dietz, Ostrom, & Stern, 2003). However, an individual's involvement in the process of developing regulations is often contingent on their power and visibility within the system. Many times it is those individuals who are not included in decision making processes, for various reasons, who are most impacted by a regulation. How these individuals adapt to the impacts may have either negative or positive long term livelihood implications.

This research aims to understand the potential socio-economic and resultant livelihood implications of resource management regulations, and how those impacts feedback to influence an individual's resource use (Figure 1-1).

Figure 1-1: Conceptual framework



By examining the case of a closed fishing season in India, I highlight the cascade of effects stemming from the decision to close the mechanized fishery for forty-five days each year. I incorporate not only those individuals consulted in the original stakeholder engagement process towards ban development, but also those – particularly from fishing allied sectors – who have been historically left out of management discussions. Additionally, with over 70% of the allied sector comprised of women in India (CMFRI, 2015), this research aims to include these previously underrepresented groups. The research is guided by three interrelated research questions aimed at investigating the full impacts, both human and ecological, of the ban period:

- 1) How are different occupational stakeholder groups impacted by the ban period?
- 2) How do members of these impacted groups adapt and cope during the ban period?
- 3) How do fishers modify their effort during and after the closed fishing season in response to these rules?

These findings can then be used by managers to anticipate the potential consequences of management decisions in order to mitigate for the harms and maximize the benefits. This information may be particularly timely given that a current management decision by the central government has mandated a gradual increase in ban duration from 45 to 60 days by 2020.

1.2 Indian marine fisheries: A case for study

The current trend in Indian fisheries is a mirror image of what is happening in much of the rest of the world: overfishing has led to increased depletion of marine fish stocks. There are many explanations for this crisis, one of the most called upon being that increased fishing technology has increased fishers' geographic range, which at one time had a natural limit (Bhathal & Pauly, 2008). This increase in range has been partly enabled by the provision of harmful subsidies, to different extents worldwide that lead to overcapitalization. In India, these harmful subsidies come in the form of subsidies for enhanced fishing technologies, such as the state-sponsored promotion of trawling or more recently the subsidy to convert trawlers to deep sea tuna longliners. They also include a range of other subsidies, one of the most prevalent being fuel subsidies or tax free diesel. The provision of tax free diesel not only increases the geographical range of fishermen, but artificially lowers the price of searching for fish. Without subsidies, this cost-benefit curve has a clearly defined natural limit, where operating costs exceed profit (Sumaila et al., 2010). In India, the government provides over US\$221,000 in fuel subsidies to fishermen (Salagrama, 2004).

Additionally, the fisheries phenomenon, "fishing down the food chain" is evident in Indian waters as well. The term is coined for the theory that fleets gradually "fish down" the Marine Trophic Index (MTI): as the more desirable, high MTI fish become depleted, they move

down the MTI hierarchy to less and less desirable fish at lower MTI levels (Bhathal & Pauly, 2008). Some scholars argue that this should not be alarming because it is usually due to a shift in commercial fishing pressure to lower trophic level species like prawns (Essington et. al. 2006). This explanation would be believable, particularly in India where prawns are a major portion of the marine fisheries' export basket. However, a study done by Bathal & Pauly (2008) shows that even after excluding species with less than 3.25 MTI (such as penaeid shrimp and Indian oil sardine), the MTI is still declining at close to the world average, at 0.058 trophic levels per decade. Fishermen themselves widely report decreasing catches, as well as changes in species composition, particularly after the 2004 Indian Ocean tsunami.

1.2.1 The fishing ban in India – An abbreviated account

To help combat this reality of overfishing in India, the governments of coastal states have implemented a ban on certain types of fishing during certain times of the year. There are a number of countries around the world that implement seasonal moratoria on specific types of fishing or harvest of specific stocks. For example, there are over a dozen countries imposing seasonal bans on shrimp trawling. These bans range in duration from 45 days to 9 months (in the case of New Zealand) (Vivekanandan, Narayanakumar, Najmudeen, Jayasankar, & Ramachandran, 2010). The 45-day closed fishing season (or seasonal ban) in India was implemented largely to sustain the capture fisheries, and applies mainly to near shore trawling fleets (Bavinck et.al., 2008). In Goa, Gujarat and Maharashtra, the ban is extended to include all fishing vessels: mechanized, motorized and non-motorized. In Tamil Nadu, Andhra Pradesh, Orissa, Kerala and Karnataka, the ban covers only mechanized boats, and also extends in some areas to motorized boats with engines over 25 horse power (Vivekanandan et al., 2010).

The original ban was “seen as part of a larger anti-trawler struggle to protect small-scale fishermen” from competition with higher capacity vessels (V. Vivekanandan, personal communication, 2015). The anti-trawler struggle began in the 1970s in many Indian states when mechanized fishing was first introduced as part of the Indo-Norwegian Project, and promoted with gusto by the state governments. At that time, there were no fisheries management regulations at the state level, only an antiquated set of laws from the British era, the Indian Fisheries Act of the British Crown founded in the late 1890s. This Act is still in effect but focuses mainly on inland fishing. The conflict between big (mechanized) and small (artisanal) fishers was particularly heated in Kerala, Goa and Tamil Nadu where there was a significant tradition of fishing, putting artisanal fishers at odds with the new mechanized contingent. Trawlers frequently destroyed artisanal gears and the disparity in landings (in terms of quantity) was seen by fishing community members and some fisheries professionals as a problem from the beginning.

The idea of the ban originated in Kerala in the early 1980s, and it was put into effect, albeit experimentally, in 1987. Conflict over the ban itself (duration, inclusion, etc.) continued into the early 1990s before a middle ground was reached between the artisanal and mechanized fisher contingents. This middle ground was a ban of 45 days in duration (pared down from the originally proposed 90 day ban) and included mechanized trawlers only (but not other mechanized boat types such as purse seine). The timing of the ban was negotiated (but not without conflict) to be implemented during the Southwest monsoon during June and July. During this time (June, July & August), there was a long-standing traditional ban on fishing along the coast. Not only does this time coincide with the monsoon season and increased safety risk to fishers, but a large number of species also breed during this time, providing additional

ecological benefits of harvest restrictions. However, as only Kerala had adopted the ban, concerns soon arose due to bordering states' fishermen (i.e. Tamil Nadu & Karnataka) encroaching on Keralan waters during the ban period. These encroachments were viewed by Kerala fishermen as unfair, and they also diminished the ecological benefits of the fishing restrictions. Keralan fishermen and the state government then agitated to the central government to expand the ban period to other states as well. In the mid-1990s, a full west coast ban came into effect.

The east coast of India adopted a trawl ban later. Andhra Pradesh (AP) was the first to adopt a ban in 2000 on the East coast of India and timed it to coincide with the local lean fishing season. There was little objection to the ban because of this timing. However, since Andhra was the first to adopt a ban on the east coast, a similar encroachment problem soon emerged, with Tamil Nadu and Orissa fishermen entering AP's waters during the AP ban period. AP fishermen and the state government then followed Kerala's lead, pushing the central government to expand the ban period to other east coast states. In 2001, Tamil Nadu adopted the ban and the resultant east coast ban is in effect from 15 April to 29 May annually.

Above is summarized from an interview with V.Vivekanandan, corroborated with interview data from E. Vivekanandan & Vijayakumaran of CMFRI

The evolution of the ban and experiences stemming from it may provide lessons for the development of other policies both in and outside India. Understanding the history of the ban's evolution provides valuable learnings for why a regulation may succeed in the first place. Pairing this with other research on fisher conflicts, movements and policy change (Sinha, 2012; Subramanian, 2009) gives credence for the merit of examining the historical context of policy

development. Examining the cascade of effects on different segments of resource-dependent populations gives insight into who the most impacted individuals may be and how human impacts contribute to ecosystem impacts. Policies and regulations can then be crafted in a more effective way to not only maximize ecosystem benefits but human benefits as well.

1.3 Examining the fishing ban in India: Geographical case selection

The marine fisheries sector in India supports a wide range of livelihoods and also makes significant contribution to India's GDP. This sector employs around 3,200,000 people and makes up around 0.83% of India's total GDP. There are nine coastal states in India and two coastal Union Territories. Tamil Nadu (TN) was chosen as the primary study state due to its importance in India's overall marine fish production. Tamil Nadu, Gujarat and Kerala are the top three coastal states in terms of marine fish production (CMFRI, 2015). Out of 3.59 million tons of marine fish landed at the all-India level, 660,000 tons came from TN in 2014 and 65,933 tons came from the nearby Union Territory of Puducherry. Tamil Nadu also ranks third in terms of value, landing about 13% of the total valued catch, just behind Kerala and Gujarat (CMFRI, 2015).

Tamil Nadu and Puducherry territory are the only two territories in India to distribute relief money to fisherfolk during the ban period. A noteworthy difference between the two areas is that in Tamil Nadu, that stipend is Rs.2000 and in Puducherry the stipend is Rs.4000. In both areas the relief is distributed per fishing family ration card. However, in Tamil Nadu, only families with a registered fisherman are eligible (i.e., female-headed households, are not eligible). In contrast, all Puducherry fishing-caste household ration card holders are eligible for the relief. We do not expect this difference to affect results because the majority of individuals

report not receiving relief until about a month after the ban period. So in practicality, since most fisherfolk report limited to no savings ability, this money is not useful in aiding people during the ban time.

Additionally, the total relief given by both Fisheries Departments throughout the year (i.e. rainy season relief, Deepavali allocation, etc.) is comparable between the areas. Nonetheless, we control for geographic differences in all analyses to ensure this difference is not influential. Boat owners in Puducherry territory are not eligible for the ban relief. However, in Karaikal during the ban season, there is a Rs.20,000 idle boat maintenance allowance for mechanized boats and Rs.10,000 for motorized boats. This allowance is provided on a reimbursement basis and is allocated according to the registration number/owner of each participating boat. Owners must provide proof of expenditures to claim this allowance (Department of Fisheries & Fishermen Welfare, Karaikal 2015).

Nagappattinam and Karaikal districts were chosen as the study sites because of their historically prominent role in marine fishing in the area. Karaikal, Union Territory of Puducherry, is couched within Tamil Nadu's Nagappattinam territory, making the physical characteristics of the coastal fishery similar in both districts. There are 68 villages within Nagappattinam and Karaikal territory which have historically worked together to solve fishery issues (Swamy, 2011). Nambiyar Nagar, in Nagappattinam, has traditionally been the head village within this 68 village cluster, dating back to the time of the Chola kings. Although Nagappattinam is governed by the Tamil Nadu state government and Karaikal by the central government as part of the Union Territory of Puducherry, fishery decisions in Karaikal largely follow Nagappattinam decisions due to the historical legacy of fishing in the area and the geographical location of Karaikal itself.

One village in each territory was chosen because previous research outlined that the seasonal ban was implemented differently within each territory. In particular, those studies indicated that Tamil Nadu banned only mechanized boats, but Puducherry also included motorized boats with engines above a certain horsepower (Bavinck et al., 2008). However, local observations demonstrated that the Karaikal region of Puducherry has adopted rules employed in surrounding Tamil Nadu areas.

1.3.1 Village selection

Two villages were chosen based on 2010 Marine Fisheries Census data for Tamil Nadu (CMFRI, 2010b) and Puducherry territory (CMFRI, 2010a). Villages were selected based on similarities in demographic profiles (prevalence of below poverty line (BPL) residents, education level, caste and religion) and boat distribution patterns (i.e. mechanized owners/laborers represent the majority in each village, though motorized boat fishing is prevalent in both). To determine villages without significant differences in the above categories, Chi Square tests were performed using the relevant CMFRI 2010 Census data. Additionally, the coastline between Nagappattinam and Karaikal was heaviest hit by the 2004 Indian Ocean tsunami. As a result, it was also important to take into consideration the relative impact of the tsunami on villages under consideration.

Based on the above criteria, I selected Nambiyar Nagar village in Nagappattinam, Tamil Nadu and Kottucherry Medu in Karaikal, Puducherry. Each village was heavily impacted by the 2004 tsunami and both have separate tsunami nagar and old nagar areas. The tsunami nagar in each village is a cement block housing colony built nearby to the original (old) area of the village by an NGO. However, in Nambiyar Nagar, this colony was built opposite the main road in

Nagappattinam, which is roughly 2.5km from the sea. In Kottucherry Medu, the tsunami nagar was also built opposite the main road but within 0.5km from the sea.

1.3.2 Sample selection

I met with the panchayats (local village councils) of each village to explain the project, and they each granted permission to work in their village. I also notified the local district Fisheries Departments of the project's purpose, as well as which villages we were surveying. We then began the process of village mapping and sample generation.

I followed a random sampling strategy in each village. The process used to arrive at the random sample was different in each village. Individuals were included in the sample if they were a member of the fishing community and had a job either directly or indirectly related to fishing, or a job that may be impacted by fishing, given their customer base. An example of a directly related job would be harvesting or fish trading, indirectly related would be a tempo driver (transferring fishers and their catch back and forth to the harbor), and potentially impacted may be a shop keeper or auto driver in the village. Every participant was above the age of 18. If there were multiple individuals in a household that qualified, we¹ attempted to interview individuals with different occupations and treated them as discreet observations.

The unit of analysis was the individual, though household data was also collected in all cases. The individual was chosen as the unit of analysis because we assumed that all resources were not shared equally within the household. Furthermore, given the distinct gender division of labor within fishing communities and various occupational constraints for different individuals,

¹ "we" refers to the team of research assistants and myself

allowing individual level responses increased the likelihood of capturing the ban's full effects on individuals within different occupational groups.

In Kotucherry Medu, since the village was smaller in size, we mapped both the tsunami and old parts of the village and assigned unique numeric IDs to each house (Figure 1-2). Then, I entered the IDs into Excel and generated a random sample.

Figure 1-2: Village map of Kotucherry Medu



In Nambiyar Nagar, it was not possible to map the village (either tsunami nagar or the old area) because the old nagar contains many areas that are not clearly defined and palm huts that are built on the beach. In the tsunami nagar, there are now a significant portion of rentals to other caste and occupational groups that were not relevant for our study. Therefore, in Old Nambiyar Nagar, we did a census of the village by area (divided into North, South, Middle and Colony)

and took the father's name from each house where someone was working as part of the fishing industry. Using father's name does not exclude households headed by women or other individuals as these houses are still identified by the absentee father's name. With village consultation, this method was considered the most relevant to find and identify houses because numeric addresses are not common. In the tsunami nagar, which is built in a grid with clearly defined house numbers, we removed from the potential sample list the houses that were rented by individuals engaging in occupations unrelated to, and not impacted by, fishing (e.g., those working in concrete laying outside of the village). In the case of Old Nambiyar Nagar, I entered fathers' names into Excel and in the case of New Nambiyar Nagar, I entered house numbers into Excel. I then generated a random sample (equally spread across New and Old) for participation.

Between Nambiyar Nagar and Kottucherry Medu (based on CMFRI 2010 census data) there were 1851 adults over the age of 18. I weighted the sample towards Nambiyar Nagar due to its larger size. There were three sampling time frames: before, during and after the 2015 seasonal ban. Our initial sample was comprised of 300 individuals. However, our final sample at round three included 282 of the original 300 individuals. The discrepancy between rounds was due to the fact that we were sampling humans: a small number of people either decided they were no longer interested in the survey and/or they were consistently drunk and/or unavailable. Nonetheless, the high rate of participation (>90%) at subsequent stages provides important data about changes over different time periods. The response rate for the final sample at round three in Kotucherry Medu was 75% (i.e. out of a total of 170 individuals contacted, 127 participated in the survey). In Nambiyar Nagar, our response rate was also 75% (out of a total of 208 individuals contacted in the original random sample, 155 responded). There is no reason to

believe the sample is biased as those who declined to participate or dropped out of the survey were spread across occupational groups, not centered in any particular group.

One of the primary goals of the research was to give a voice to female fishworkers and other individuals not involved in fish harvesting. Therefore, after the original random sample was generated and collected, we purposefully contacted additional women fisherfolk, as well as other individuals in potentially impacted occupational groups (such as shop keepers and auto drivers). All fisherwomen in Kottucherry Medu were targeted and interviewed. The village of Nambiyar Nagar runs its own fish vending stall in the middle of Nagappattinam town. Women vendor's names and addresses were collected from the vending hall on three separate occasions. Collecting names on separate days was important as local demand is directly dependent on day of the week, with most Hindus abstaining from fish on temple days such as Fridays. Therefore, all fisherwomen do not vend every day of the week due to low demand certain days and an associated increase in the risk of loss to their business if they cannot sell the fish. These Nambiyar Nagar women fish vendors were then surveyed in their homes at a time that was convenient for them. To ensure we also incorporated headloaders, not just stationary vendors, into the sample, we used key informants to identify women headloaders. We attempted to sample all shop keepers who had a shop within each village. We also used key informants to identify auto drivers that live in the village to include them as well. These purposeful sampling characteristics do not bias results because we control for these factors in all statistical analyses.

1.4 Data collection methods (i.e. qualitative and quantitative)

I utilized a mixed methods approach for this study. Quantitative tools were useful because impacts to stakeholder groups, outside the harvest sector and to some extent within the

harvest sector, have not been quantified to date. Qualitative tools allowed me to gather rich, descriptive data on all groups. My aim was to show how significantly, in terms of changes to an individual's income, expenditure, stresses and adaptations, the ban impacts different segments of the fishery-dependent population. Survey data allows correlational findings, a valuable method for identifying patterns of response across different groups (Reinharz, 1992). However, such correlational research does not address why the impacts occur and potentially why they differ by individual or by stakeholder group. As a result, qualitative, semi-structured interviews were also used to unpack the process behind the impacts. The development of the interview questionnaires was an iterative process through the different phases of data collection. During the first phase of data collection, all individuals surveyed were also interviewed. During the second phase of data collection, all individuals surveyed were also interviewed in Kottucherry Medu. However, once theoretical saturation was achieved in Nambiyar Nagar, we randomly surveyed individuals within the larger sample ($n=54$). We chose this method in Nambiyar Nagar due to the shorter sampling timeframe (2 weeks at round two) and the larger sample size. There were no additional interview questions in phase three.

The survey questionnaire was developed in consultation with the Office of Survey Research at MSU. It was approved by MSU IRB as project #x14-1145. Survey questions focused on demographic information and sustainable livelihood indicators. Information collected included a household roster, migration information, social capital indicators, income and expenditure, household and productive assets and skills trainings. Included in the survey were seasonal activities calendars and resource use calendars. These tools were used to understand seasonal fluctuations in stresses, adaptation strategies, income sources and resource use (Slocum, 1995).

Once in India, the full survey was reviewed with experts from the Central Marine Fisheries Research Institute (CMFRI), International Collective in Support of Fishworkers (ICSF) and M.S. Swaminathan Research Foundation (MSSRF). The survey was translated into Tamil and translations were checked by the Director of MSSRF Nagappattinam as well as the primary translator for Bedroc Foundation, Nagappattinam. Four research assistants (two from Nagappattinam and two from Karaikal) were trained on the survey and the survey was piloted with a small group of fisherfolk. Delivery was also practiced within the group of research assistants. During each phase of revision, MSSRF, ICSF and CMFRI staff were consulted on relevant local measures for variables such as wealth and appropriate time frame to measure income, as well as appropriate time of day for interviews, and other logistical matters. There was some turnover of research assistants during the data collection period. However, each new research assistant was trained through the same process as the original group, and overlap with the exiting assistant ensured minimum differences in survey delivery. Additionally, because assistants interviewed in teams and never alone, the consistent team members were always present to ensure quality.

Survey and interview instruments are available as Appendices

I determined time frames for the data collection in consultation with CMFRI. The first phase of data collection began on 15Feb and continued up until about two weeks before the start of the ban period. During this time, the full survey questionnaire was asked as well as a brief semi-structured interview questionnaire (found in the Appendix). During those two weeks before the ban period started, a semi-structured questionnaire was developed for women fish vendors and administered to a purposefully selected group of women in Nambiyar Nagar and all women fish vendors in Kottucherry Medu (Questionnaire to be found in Appendix).

The second phase of data collection was planned for weeks 4 and 5 of the ban period (6 May – 20 May). The third phase was planned for weeks 4 & 5 post-ban. However, the day the ban came into effect (15 April), the government announced that the ban would be extended to 60 days for the current year. At that point, I reconfigured our plan to include an additional during ban sample: sampling individuals at weeks 4 & 5 and then again during weeks 7 & 8. At that time, I also developed a secondary questionnaire to understand how people were coping with the last minute notification of the ban extension. We employed this along with an additional semi-structured interview questionnaire focused on people's participation in village and fisheries-related decisions, as well as details about their experience with the ban and trainings that may be helpful for them to generate alternative income during the ban period. We employed these questionnaires during the second phase of sampling, along with seasonal calendars and resource use calendars. On May 29th, the government of Tamil Nadu and the Fisheries Department of Karaikal announced they would not be following the central government's order for a ban extension to 60 days. I therefore reverted to the original plan of having the third sampling phase post-ban at weeks 4 & 5 after the ban was lifted (22 June – 6 July).

During the third phase of data collection, we again employed the seasonal activities calendars and resource use calendars. After data collection was complete, we met with the panchayats of each village to notify them of the project's completion and thank them for their hospitality and help.

The survey and interview data was entered every night during the data collection period; this allowed for real-time analysis and the development of the follow up questionnaires based on the previously collected data. Immediate data entry also allowed for constant accuracy checks of the data collected. If I had any doubts about the accuracy of the recorded information, I would

highlight it, return it to the research assistant responsible for that survey and either discuss the doubt or we would return to the participant's home to clear the doubt. Additionally, since there were three time periods of data collection with each respondent, there were multiple possible opportunities to check the reported data. Both qualitative and quantitative data were entered into an Access database organized by unique identifiers associated with each respondent.

Each empirical chapter explains the rationale and descriptive statistics for specific items used in each analysis. As each chapter is written to be a stand-alone article for journal submission, there is some overlap in discussion of methods and study site justification in each chapter.

1.5 Organization of dissertation

1.5.1 First empirical chapter: Socio-economic impacts of a closed fishing season on resource-dependent stakeholders: An analysis of differences in income and expenditure by occupational group over two seasons

This chapter examines the economic implications of the closed fishing season for different occupational groups within fishing-dependent communities. Previous research has shown that mechanized fishers exhibit a total loss of income, while motorized fishers do quite well during the ban time (Bavinck et al., 2008). However, impacts to other segments of the fishing community have not been well studied or documented. I disaggregate mechanized fishers into owners and laborers, examining the differential effects within this group. I also examine income and expenditure effects on fishers utilizing a local gear type, *surukku valai*, as well as motorized fishers, individuals in the transport, resupply and maintenance sector, female and male fish traders, and those in fishing unrelated occupations that rely on fishers as their client base (such as petty shop owners within fishing villages). I find that while mechanized

fishers lose a significant amount of their income during the ban, it is actually the laborers on mechanized boats, rather than the boat owners, who lose more. Both female and male fish traders are also significantly, negatively impacted. Additionally, according to the results, motorized fishers do not gain significantly during the ban period as previously shown.

Since many individuals lose a significant portion, if not all, of their income during the ban period, we followed up by asking fisherfolk what livelihood enhancement options they would be interested in to generate temporary extra income. Here we find that male fishers are generally unwilling to take on fishing unrelated work, whereas women are more likely to do any work that offers minimum wage. These findings provide valuable information regarding the socio-cultural constraints of developing livelihood enhancement opportunities within fishing communities. Our results highlight the cascade of effects stemming from a single resource management initiative, indicating that not only resource harvesters, but also those in allied professions, are heavily impacted by a regulation that limits resource extraction. Environmental justice requires attention to these disadvantaged groups. This information can be used to develop preventative schemes that mitigate the unintended human consequences of resource regulations.

1.5.2 Second empirical chapter: A gendered analysis of fisherfolk's livelihood adaptation and coping responses in the face of a seasonal fishing ban in Tamil Nadu & Puducherry, India

This chapter examines how individuals adapt and cope to the economic stresses incurred as a result of the ban period. Previous research has demonstrated that in some cases, men and women tend to adapt differently to stresses and shocks to their livelihoods (Kiewisch, 2015). However, I argue that looking only at an individual's sex is insufficient in understanding why they adapt (or cope) the way they do. Instead, using the framework of intersectionality, I

examine individuals' adaptation strategies and coping responses as influenced not only by their sex but also their power and class within the fishing communities. Using locally relevant measures of these variables, I show that if we consider only sex, then indeed women are more likely to resort to reactive coping than men in times of stress. However, this relationship is contingent on various configurations of power and class. In some cases, when power and class are equal between men and women, there is no sex divide in the likelihood of resorting to reactive coping. Furthermore, we find that power and class lead to different outcomes for men and women. Data indicate that while men only derive the benefits of power if they are also of medium to high class, power benefits women regardless of their class. This chapter highlights the necessity of examining gender and livelihood adaptations beyond the male versus female dichotomy: considering intersecting and locally relevant measures of power, class and sex are pivotal in understanding why people adapt and cope the way they do. This information may be useful for practitioners in designing interventions that decrease the necessity of individuals to jeopardize their long term livelihood resiliency to deal with present situations.

1.5.3 Third empirical chapter: Unintended consequences of a seasonal ban on fishing pressure

This chapter examines how fishers of various gear types respond to the fishing ban. I look at mechanized, motorized and *surukku valai* fishing effort (measured in hours/month spent fishing) over the course of three seasons: before the ban period, during the ban period and after the ban period. Previous research has suggested that post-ban, there is about a 10% increase in fishing effort (Vivekanandan et al., 2010). However, I aimed to understand the source of that increase in effort, and its likely effects on marine fisheries. While I do find an approximate increase of 10% in total effort post-ban, results indicate that the majority of this extra effort

stems from the *surukku valai* gear type, a gear type that is illegal under state regulations though still very much in use within certain regions. I also find that motorized effort during the ban period actually decreases, instead of increasing as previously suggested. However, much of this decreased effort by motorized fishers is replaced by *surukku valai* fishers employing motorized vessels during the ban period. I use the findings from the changes in effort, paired with data on the average kg/hr of fish caught by various vessels, to simulate what impact these fishing effort changes have on fish stocks. I show that additional 10,318.65 kg are likely harvested by mechanized vessels alone post-ban, at the district level, while a single *surukku valai* operation is estimated to harvest an additional 19,543 kg of fish post-ban (as compared to pre-ban).

While the data does suggest that effort is significantly reduced during the ban, it is not reduced all the way to zero. I then use qualitative data to understand whether this change in fishing effort leads to a re-appropriation of effort to different ecosystems (i.e. whether fishers just migrate and fish somewhere else), as previous research has suggested. I find that the majority of fishers do not migrate nor fish smaller boats during the ban period. Individuals who have access to non-motorized *kattumarams* may fish for household sustenance.

The final part of the chapter examines fishers' perception of any proposed change in ban period, whether that be a ban extension or the establishment of an additional ban period at a different time of year. The ban currently works because of its widespread acceptance within the fishing communities and the joint enforcement between fishing communities and Fisheries Departments. I find that although the ban was originally widely supported, within our sample at least, the difficulties that have stemmed from the ban period far outweigh the benefits for fishing community members. As a result, the majority of individuals oppose any addition to the ban period. Given this opposition, I assert that the implementation of any change in ban period may

lead to a de-legitimization of the current ban period as well. Using the data on fishing effort paired with mean catch data for various gear types, I simulate the potential impact to fish stocks if this opposition emerges. This chapter demonstrates that strict fishing ban policies may have unintended consequences if they ignore resource users' likely responses. This result offers important information to government entities responsible for fisheries policy formulation, highlighting the need for community consultation prior to any change in regulation.

1.6 Literature contribution

Response to the marine fisheries crisis is necessary. This research shows that the way in which we respond to this crisis may have both short and long-term consequences not only for fishery health, but for the millions of people world-wide that depend on fish resources for their livelihoods. Without a thorough examination of resource use history, socio-cultural aspects and local innovation and adaptation, the likelihood of unintended consequences arising from a management decision are high. This dissertation contributes to multiple areas of scholarship on natural resource management, refining existing literature by more clearly specifying how policy impacts vary depending on individual resource user characteristics. First, my research contributes to the literature on natural resource management and participation. The World Resources Institute asserts that those with more power have more opportunity to capture the benefits derived from a conservation policy (World Resources Institute, 2005). I show that: 1) historically marginalized segments of populations continue to be significantly impacted by resource management decisions about which they are not consulted, and 2) marginalized segments within otherwise represented groups may get overlooked. Individuals therefore from both unrepresented and represented segments derive unequal benefits from conservation policy, regardless of their membership within powerful groups. Second, the research also contributes to

the literature on unintended consequences of resource management decisions, showing that the idea of roving bandits, as presented by Berkes and colleagues (Berkes, 2010; Berkes et al., 2006) applies not only spatially but temporally. That is, resource users may shift effort by replacing seasonally-banned resource harvesting with increased use in subsequent periods. Third, this research contributes to an enhanced understanding of relationships between gender and livelihood choices through the application of the intersectionality framework. In utilizing this framework I highlight that the sex divide identified in livelihood capabilities and options (Ellis, 2000) may not be so clear as men vs. women, but rather reflects intersecting relationships of sex, power and class that combine to influence possibilities and outcomes. Finally, this research presents the first data set of *surukku valai* effort over three seasons, while also providing the first quantification (to the author's knowledge) of motorized fishing effort exerted during the ban period. This empirical contribution is necessary for better assessment of the policy's effectiveness.

APPENDICES



Livelihood effects of a closed fishing season and their impact on resource use in Tamil Nadu, India

You have been randomly chosen to participate in a research project examining the social, economic and resource use impacts of the government fishing ban. The research will be used to make policy recommendations to the Fishery Department and Government of Tamil Nadu.

Name:

Reference #:

Date:

Location:

Interviewer name:

Informed consent

My name is Julia Novak Colwell and I am from Michigan State University in the United States. I am doing PhD research on how fishers and fishworkers adapt to different circumstances. Is it alright if I ask you questions about this?

Answering these questions will take about 30 minutes and we will return in April and June to ask similar questions. Answering the questions in April and June should take no more than 20 minutes. If you decide to participate in the study we will ask you about 30 questions from the survey form. If I ask a question you do not want to answer, just let me know and we can move on to the next question.

At any time, if you do not want to answer any question, we can stop. Participation is voluntary. Information you give will be kept confidential. If you have any questions, please feel free to ask me at any time. If you would like to contact me, my mobile number is +9578563944 and my email is novakju2@msu.edu.

Verbal consent received?

YES ☒

NO ☐

DATE

1. HOUSEHOLD ROSTER (adapted from Nicaragua, 2012)

Aim: ID household members, ID dependency ratio, education level, caste, wealth

1a. How many years have you lived in this village?

1b. Do you own your house?

YES...1

NO...2

1.b.1 Is this a tsunami house?

YES...1

NO...2

1.b.2 If this is a tsunami house, have you made any changes to the basic structure provided?

YES...1

NO...2

1.b.3 If yes, were those changes for

Maintenance...1

Additions...2

Renovations..3

1.b.4 What were those changes?

1c. What are the walls of the house primarily made of?

THATCH...1

BRICK OR MUD...2

CONCRETE...3

OTHER...88

1d. What is the floor of the house primarily made of?

MUD...1

TILE...2

CONCRETE...3

OTHER...88

2a. Who lives in this house for at least part of the year?	Mark 'X' for respondent	2b. Sex?	2c. In what viillage was she/he born?	2d. Age?	2e. Marital status?	2f. Years of schooling completed?	2g. Religion?	2h. Caste?	2i. Primary occupation?
Head...1 Spouse...2 Son/daughter...3 Father/mother...4 Brother/sister...5 Nephew/niece...6 Father/mother in-law...7 Other family...8 Not family...9		Male...1 Female...2			Single...1 Married...2 Widowed...3		Hindu...1 Muslim...2 Catholic...3 Other...88		Fisher/laborer...1 Fisher/boat owner...2 Allied fishworker...3 Other...88

MIGRATION (adapted from Nicaragua, 2012)

In the past 12 months, how many members of your household have left the community either for temporary work or permanently?

Who is the household member that left?	Sex	Did he/she leave seasonally or permanently?	If seasonally, during which months of the year are they gone?	For what reason did he/she leave the household?	Where did he/she go?	Does he/she send money to your household?	If yes, how much per month?
Head...1	Male...1	Seasonally...1		To work...1		YES...1	Rs.
Spouse...2	Female...2	Permanently...2		To study...2		NO...2	
Son/daughter...3				To join other family members...3			
Father/mother...4				Health...4			
Brother/sister...5				Other...88			
Nephew/niece...6							
Father/mother in-law...7							
Other family...8							
Not family...9							

SOCIAL CAPITAL (adapted from Nicaragua, 2012)

Aim: Assess both formal and informal exchange networks and group membership

Do you have contacts in the following places that would help you in case you needed to travel or find work in any of the below places?

Location	Type of contact	If other (88), please specify
	Family...1 Friend...2 Business acquaintance...3 Other...88	
Nearby community		
Your district capital		
Chennai		
Southern Tamil Nadu (Jagathapattinam, Mallipattinam, etc.)		
Kerala		
Mumbai, Delhi, Kolkata, Hyderabad, Bangalore		
UAE		
United States		
Other countries		

I am now going to ask you about your participation in various activities

Activity	In the last year, did you participate in any of the following?	What did you expect from them in return?
	YES...1 NO...2	Return the favor...1 Money...2 Thanks...3 Nothing...4 Other...88
Give food to a person outside your household?		
Offer your labor to another person without asking for a wage?		
Lend money to another person?		
Share your knowledge or expertise?		
Raise funds for the community?		
Participate in the collective construction of community projects?		
Take care of another person's children?		
Vote for a candidate in an election?		
Participate in a political campaign?		
Participate in a village panchayat meeting?		
Participate in a gram panchayat meeting?		
Notify the panchayat of problems?		

If you suffered an important economic loss (for example loss of harvest or unemployment, a serious illness, etc.), who would help you?	
DO NOT PROVIDE CATEGORIES	No one...1 Family...2 Neighbors...3 Friends...4 Religious group...5 Community leaders...6 Self-help group...7 Government institution...8 Other...88

7. I will now ask you about the various organization in which you participate

Organization	In the last year, how many of each of the following groups did you or someone in your household belong to?	Is the group a local group, NGO sponsored or a government sponsored group?	What were the benefits of membership? SELECT ALL THAT APPLY	What was the primary reason you joined?	For how many years have you been a member?
	Number of groups	Local...1 NGO...2 Government...3	Savings...1 Access to government aid...2 Access to better markets...3 Social support...4 Access to credit...5 Other...88	Savings...1 Access to government aid...2 Access to better markets...3 Social support...4 Access to credit...5 Other...88	
Fisherman cooperative					
Fisherwoman cooperative					
Self-help group					
Religious organization					
Panchayat					
Boat Owners Association					
Other (please specify)					

INCOME (adapted from Nicaragua, 2012; Kruks-Wsier, 2011; Shields & Thomas-Slayer, 1993; CMFRI, 2010)

Aim: Sources of income, seasonality differences in income streams, diversification, wealth

How many meals do you eat per day?

2 or more REGULARLY...1

2 or more SOMETIMES...2

2 or more NEVER...3

I am going to ask you about your bought or acquired possessions

Item	Which of the following items do you own? And how many?	Did you purchase them or did you receive them from the government?	Which of the following items do you have access to through someone else?
	Please check all that apply		
Refrigerator			
Freezer/icebox			
TV			
Mobile phone			
Electric fan			
Air conditioner			
Gas stove			
Radio			
Mixer/grinder			
Cycle			
Motorcycle			
Land			
Goats			
Cow			
Chickens			

11. Do you or someone in your house receive aid from the government?

YES...1

NO...2

DON'T KNOW...3

12. I will now ask you about the aid your household has received

Aid type	Please check all that apply	Amount received	Date received
Government savings-cum relief scheme for fishermen during lean period			
Government savings-cum relief scheme for fisherwomen during lean period			
Government stipend for fishermen during ban period			
Government stipend for fishermen during lean period			
NGO aid			
Other:			

13. Have you or someone in this house received a loan in the past year?

YES...1

NO...2

DON'T KNOW...3

14. Now I will ask you some questions about the loans you have taken out in the past year

Why was the loan obtained?	Which household member obtained the loan?	When did he/she obtain the loan?	From whom did he/she obtain the loan?	How much money did he/she borrow? (Rs.)	What was the interest rate of the loan?
Fishing equipment purchase...1 Fishing equipment repair...2 Special event...3 Education...4 Personal use...5 Home improvement...6 Land...7 Other...88	Head...1 Spouse...2 Son/daughter...3 Father/mother...4 Brother/sister...5 Nephew/niece...6 Father/mother in-law...7 Other family...8 Not family...9	Month/year	Relatives/friends/neighbors...1 Employer...2 Village money lender...3 Pawn broker...4 Self-help group...5 Microcredit bank...6 Commercial bank...7 NGO...8 Shopkeeper...9 Other...88	Under 500...1 500-1,000...2 1,000-5,000...3 5,000-10,000...4 Over 10,000...5	Percentage or "T" for don't know

MONTH			
SEASON	Pre-Ban	Ban period	High season
Is this a normal month for you in this season in terms of activities and expenses?			
<u>Please indicate which stresses you are currently facing and how stressful they are on a scale of 1-3 (1= not very stressful, 2=somewhat stressful, 3=very stressful)</u>			
STRESS PERIODS			
Many expenses			
Lower income			
Hunger			
Disease			
Other:			
<u>COPING STRATEGIES: Please indicate any strategy you are currently employing to cope with the above stresses</u>			
Cut back to less than 2 meals/day			
Cut back on amount of food consumed at each meal			
Took out a loan			
Sold jewelry or other asset			
Asked relatives or friends for help			
Migration:			
Access savings:			
Other:			
INCOME/EXPENDITURE			
Please indicate your approximate income during this month			
Please indicate your approximate expenditure this month			
This month, what types of major expenses were there for you (i.e. school fees, etc.)?			

<u>For the following activities, please indicate the percentage of your income that is derived from the below sources in this season</u>	<u>Pre-Ban</u>	<u>Ban period</u>	<u>High season</u>
FISHERIES			
Active fishing - mechnaized			
Active fishing - vallam			
Active fishing - kattumaram			
Fish marketing			
Fish vending			
Fish drying/ selling			
Fish curing			
Fish processing			
Fish seed collection			
Net making/mending			
Seaweed collection			
Sea grass collection			
Reef gleaning			
Bivalve collection			
Shell collection			
Crab/shrimp collecting			
Crab/shrimp farming			
NON-FISHING			
Wild edible collection			
Raising/ grazing livestock			
Collecting fuel material			
Paid farm labor			
Paid non-farm labor (i.e. construction, etc.)			
Professional salary			
Remittance (from migrated relatives)			
Selling home-made products			
100 day government employment scheme (MNREGA)			

FISHING (adapted from Nicaragua, 2012)

Aims: To understand level of investment in fishing assets and for how long the family has been a fishing family

Does anyone in your household fish?

YES...

NO...

If yes, for how many years has that individual fished?

For how many generations has your household fished?

If you fish, do you fish in the sea adjacent to other districts in Tamil Nadu at any time during the year?

YES...1

NO...2

If yes, what area do you go for fishing in?

During what months do you fish in the above areas?

If you fish, do you fish in the sea adjacent to other states outside of Tamil Nadu at any time during the year?

YES...1

NO...2

If yes, what state do you go for fishing in?

During what months do you fish in the above areas?

Does your household own any fishing assets? If NO->Skip to next section

YES...

NO...

DON'T KNOW...

I will now ask you about your household's fishing equipment

Gear type	How many of each of the following gears do you own?
Fishing baskets	
Weigh scale	
Mechanized boat	
FRP or Woodplank boat with motor	
Kattumaram with motor	
Kattumaram without motor	
Trawl net	
Gill net	
Long lines	
Cast nets	
Shore seine	
Crab trap	
Other:	
Other:	
Other:	

SKILLS TRAINING (adapted from Nicaragua, 2012)

Aim: To understand the individual's level of specialization in a particular field

I will now ask you about the informal and formal training you have received

Activity	Please check all of the following in which you have receive informal or formal training	From whom did you receive this training
		Relatives/friends/neighbors...1 Employer...2 Self-help group...3 NGO...4 Government...5 Other...88
Fishing – mechanized		
Fishing – motorized		
Fishing – kattumaram		
Agriculture		
Livestock rearing		
Construction		
Fish marketing		
Fish processing		
Crab fattening		
Seaweed cultivation		
Household maintenance activities		
Small business/entrepreneurship		
Health care		
Other:		
Other:		
Other:		
Other:		
Other:		

RESOURCE USE (adapted from Shields and Thomas-Slayer, 1993)

<u>Please indicate the hours per day you spend performing the following activities during this season:</u>	<u>Lean season</u> <u>Feb-Mar</u>		<u>Ban period</u> <u>Apr-may</u>	<u>High</u> <u>season</u> <u>Jun-Jul</u>
	Hrs/day	Days/week		
Active fishing - mechanized				
Active fishing - vallam				
Active fishing - kattumaram				
Fish marketing				
Fish vending				
Fish auctioneering				
Fish drying/ selling				
Fish curing				
Fish processing				
Fish seed collection				
Net making/mending				
Seaweed collection				
Sea grass collection				
Reef gleaning				
Bivalve collection				
Shell collection				
Other:				
Other:				
NON-FISHING				
Wild edible collection				
Raising/ grazing livestock				
Collecting fuel material				
Paid farm labor				

Paid non-farm labor (i.e. construction, etc.)				
Professional salary				
Selling home-made products				
Household reproduction (child care, household tasks, etc.)				
Community management work				
100 day government employment scheme (MNREGA)				

24. How do you prepare for the fishing ban, if at all?

25. Is your income during the ban comparable to your income during the pre-monsoon, monsoon, post-monsoon or summer season or is it different?

- a. If it is the same as one of the aforementioned seasons, in what way is it the same?
- b. If it is different than one of the aforementioned seasons, in what way is it different?

26. Would you support an additional government ban at an alternate time of year?

- c. If yes, why would you support it?
- d. If no, why would you oppose it?

APPENDIX B: Ban time interview

Fishing ban and livelihood effects

Flip back to seasonal activities calendar in survey

1. FB1: Have you always done these activities at these times (even before the implementation of the ban period in 2001)?
 - e. Why/how did you decide on this activity schedule?

2. FB2: Is there any income earning activity, training, etc. that you feel would be particularly helpful during the ban time other than fishing?

3. FB3: Do you support the extension of the ban? Why/Why not?

4. FB4: If you would have received notification in advance, would you have done anything differently to prepare for a 61 day ban vs. a 45 day ban?

Rules, regulations and governance

1. RRG1: Do you participate in making village rules? Why or why not?
 - a. RRG1a: Who participates in making village level rules?
 - b. RRG1b: Do you or any other village members or organizations participate in making rules or regulations with the government?
2. RRG2: Which local, village level organization makes rules regarding fishing?
 - a. RRG2a: Who is able to participate in creating those rules?
 - b. RRG2b: How do they enforce those rules?
3. RRG3: Are there civic groups or other community groups that are active in your community?
 - a. What role do they play?

4. Is there any support, either social or monetary that you receive in the village or from the government that helps you get through the fishing ban?
 - a. RRG4a: From the government? Yes/No
 - b. RRG4b: From the village? Yes/No
 - c. RRG4c: From an SHG? Yes/No
 - d. RRG4d: From a civic organization? Yes/No
 - e. RRG4e: From your neighbors? Yes/No
5. RRG5: Who enforces the government fishing ban?
 - a. How do they enforce the government fishing ban? (i.e. how do they monitor fishing activity AND what punishment is given if someone is caught?)

APPENDIX C: Additional interview questions for women fish traders

Name:

Date:

Location:

Additional questions for women fish vendors:

TYPE OF VENDOR

(circle one): FRESH/ DRY/ POULTRY FEED

1. Where do you buy your fish before the fishing ban? (i.e. harbor location, beach location, specify)
 - a. Whom do you buy your fish from (i.e middle man, directly from steel boat, fiber boat, kattumaram, etc.)
2. Will you vend during the fishing ban?
 - a. If not, why not?
3. If yes, where do you buy your fish from during the fishing ban? (i.e. harbor location, beach location, specify)
 - a. From who do you buy your fish (i.e middle man, directly from fiber boat, kattumaram, etc.)
 - b. How does your access to fish differ between before the ban, during the ban and after the ban?
 - c. How does the price you have to pay differ between before the ban, during the ban, and after the ban?

- d. How does the price you sell your fish for before the ban, during the ban, and after the ban differ?
 - i. How does this impact your income?
 - e. Is the demand different before, during and after the ban?
4. Where do you vend your fish?
- a. Do you vend in the same location during and after the ban?
5. What do you do with fish that you do not sell?
6. Do you and the other vendors fix the price of fish you sell at the market?
- a. If so, how do you fix the price?
7. Are there any rules that affect how you vend (i.e. village rules, government rules, or rules imposed by other fish vendors)?
- a. Did you participate in making those rules?

8. Do you have to pay a tax to sell the fish in the market (if yes, to who and how much?)

9. How do you negotiate with the other vendors for your place in the market?

10. How does a new person enter into the market to sell fish?

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2 Socio-economic impacts of a closed fishing season on resource-dependent stakeholders: An analysis of differences in income and expenditure by occupational group over two seasons

2.1 Introduction

2.1.1 Livelihood impacts of environmental regulations

It has been increasingly accepted within the conservation community that conservation policies will not be successful unless they simultaneously speak to local development needs (Wunder, 2005). The way in which policies address these needs has important implications for environmental justice and the related distributional impacts of environmental policies.

Policies can have both limiting and additive impacts on the livelihoods of individuals. For instance, policies that promote overspecialization can undermine livelihood diversification and limit adaptive strategy options (Allison & Ellis 2001). Policies that make aid available to only a certain subset of a population can positively impact the options of the recipients. However, these same policies negatively impact other non-recipients as their lack of access to funds may limit their livelihood options. Policies that promote education, on the other hand, can increase livelihood diversity options in the long term (Niehof, 2004).

Some policies (whether aimed at resource conservation, poverty alleviation, etc.) can exacerbate or alleviate intra-communal inequities. For example, policies that focus on the promotion of production sectors have been found to marginalize women and create gender specific opportunities that can intensify gender inequities (Rubinoff, 1999). Bias towards the production sector has also been found, in some cases, to lead to an undervaluation of resources, where important users and their associated resource-dependent livelihood activities get overlooked (Cleaver, 1998).

Institutions that govern resource use can raise equity concerns (Mitchell, 2008). For example, conservation policies may decrease poorer users' resource endowment (Baland & Platteau, 1999). Research on the economically and culturally significant Hilsa fishery in Bangladesh has shown an undervaluation of the importance of Hilsa to local communities' food and economic security (Hasan, Rahman, Hasen, & Mahmud, 2010). There, the poorer segments of the fishery dependent population have been disproportionately impacted by a government decision to close fishing grounds and seasons. Unequal access to aid among fisher households has exacerbated the problem (Islam, Mohammed, & Ali, 2016).

The goal of this research is to understand the implications of conservation policy on different segments of resource-dependent populations. By understanding who is impacted by environmental regulations in any situation, we can begin to work towards developing strategies to proactively mitigate the negative consequences of a resource management decision while maximizing the overall benefits. Some scholars have asserted that short term losses from ecosystem restrictions impact the poor most and that these losses can be mitigated by providing training programs, alternative income streams, and by establishing savings or credit groups (World Resources Institute, 2005). I argue that while indeed the poor may be most impacted by restrictions, these impacts may manifest in different ways for different stakeholder groups. Based on these differential impacts, mitigation measures must be contextualized. Finally, it may be that the most important mitigation measure of all in stymying the inequitable impact of conservation policy is policy adaptability.

2.1.2 Causes of unequal impacts

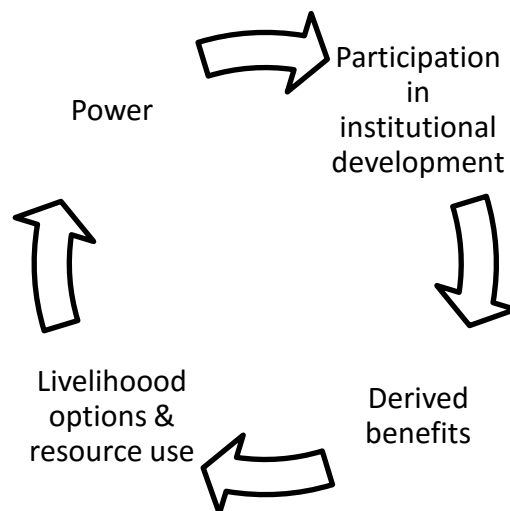
Unequal access to resources and, in turn, inequitable impacts of policies may be fueled by a number of socio-economic factors. Some scholars assert that even if individuals have equal

access to a resource, it does not mean they have equal resources to be able to take equal advantage of that access (Adhikari & Lovett, 2006). Therefore, when examining resource use, there are certain factors that may enable one group to access a range of resource options while inhibiting another group from doing so. These factors are important to identify for management or development initiatives (Allison & Horemans, 2006). Putnam (1993), for instance, asserts that low levels of certain types of social capital limit livelihood options that are accessible to individuals: individuals who have limited networks may have a hard time accessing certain opportunities. In research regarding the seasonality of rural livelihoods, opportunities to diversify during different times of the year are shown to vary by gender, education level and skill set (Ellis, 1998). In South Asia there are a range of cultural constraints that may prohibit women from accessing certain resources and livelihoods options. The practice of purdah, for example, prohibits some women from leaving the home, making livelihood opportunities that rely on outside-the-home movement untenable (Agarwal, 1994). In traditional fishing areas in India, women's responsibility for shore-based activities versus men's responsibility for harvest clearly prohibits women's access to fishing as a livelihood option (Rubinoff, 1999). Additionally, in some cases, local rules against non-caste fishermen harvesting fish restricts these individuals to jobs associated with stocking boats, transporting supplies and boat maintenance duties (Swamy, 2011). Others are constrained from non-fishing professions due to fishing caste identity (Coulthard, 2008). If socio-cultural factors limit the opportunities individuals have to employ other options when circumstances change, this again threatens to fuel uneven and unequitable policy impacts as adaptation options are limited.

Whether an individual has the ability to employ multiple livelihood strategies or is confined to certain options, their role in resource exploitation and utilization makes it important

to include all stakeholders in decision making. Those that have fewer options to diversify often have higher stakes in a management decision (Baland & Platteau, 1999) and may require targeted inclusion in the decision making process. However, those with more power (and wealth) tend to have more opportunity to capture the benefits derived from a conservation policy (World Resources Institute 2005). Even if certain stakeholder groups are included in decision making processes, power relationships within a group can play an important role regarding which individuals obtain maximum benefits from a decision. For example, the wealthy have been shown to have more incentive to work towards collectively creating conservation policies (Baland & Platteau, 1999), possibly because of expected derived benefits. Figure 2-1 outlines the conceptual relationship between power, inclusion, derived benefits and livelihood options.

Figure 2-1: Conceptual framework of feedback loop where livelihood strategies and resource use influence an individual's power and their inclusion in policy making, thereby impacting the derived benefits received from policy



2.1.3 Case selection

In order to investigate this relationship and understand the unequal impacts of resource use policies and viable mitigation measures, I examine the case of a closed fishing season (i.e.

seasonal ban) in India. This management decision was taken by individuals from the production sector (i.e. fish harvest sector) while other members of allied sectors² were not consulted. I examine the case of Nagappattinam, Tamil Nadu and neighboring Karaikal, Puducherry (Figure 2-2), traditional fishing areas along the Eastern coast of India where a 45 day seasonal, mechanized³ fishing ban is enacted each year from April-May. This is a particularly good case study for understanding the unequal effects of policies given the diverse stakeholder groups in the area coupled with the narrow consultation process undertaken to establish the ban in Tamil Nadu. Using both survey and interview techniques, I investigate socio-economic and resultant livelihood implications of a closed fishing season on different segments of the fishery dependent population and use this case to study the unequal impacts of a policy that was created by a few but impacts many.

2.1.4 Ban background

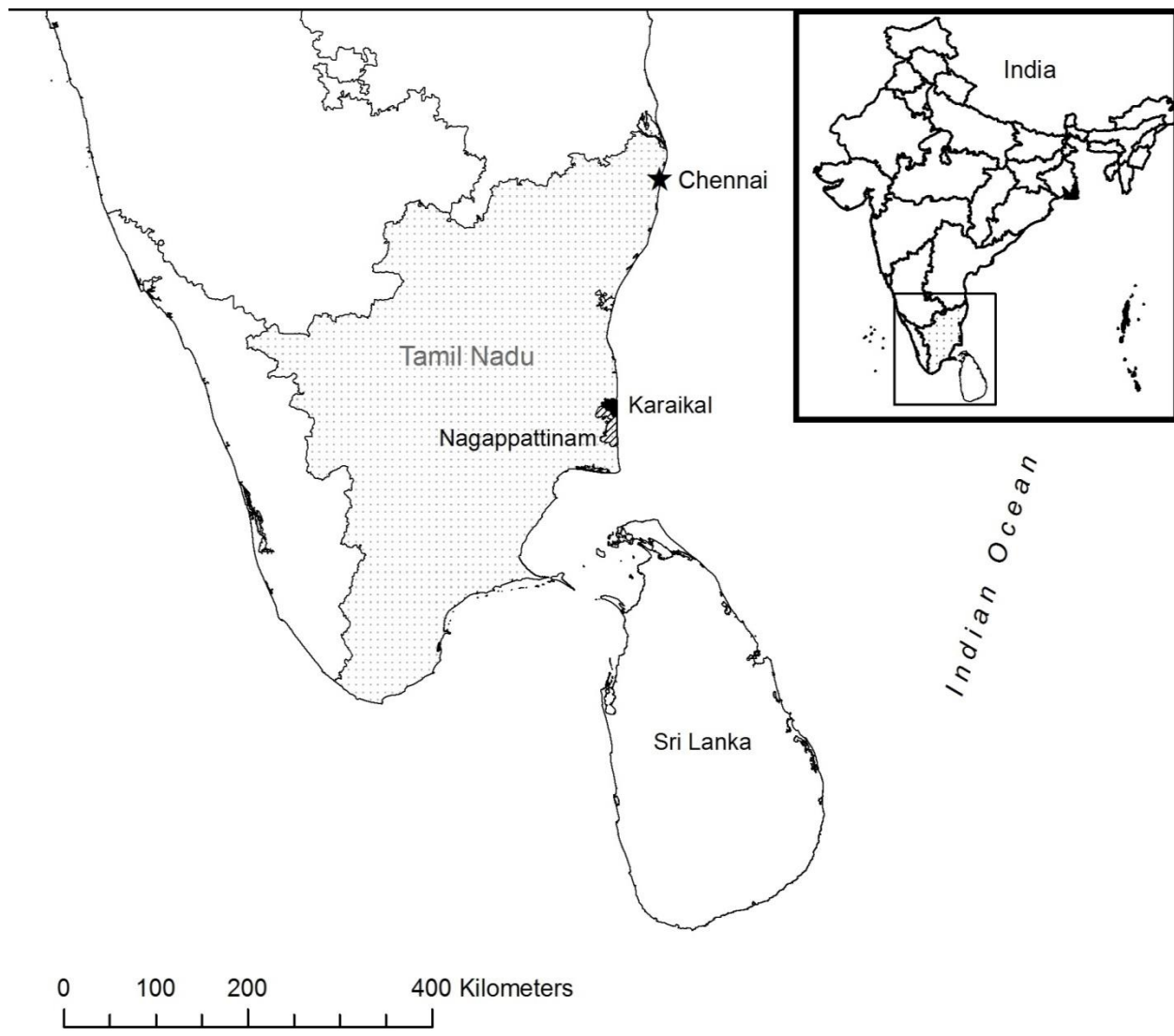
The ban itself is India-wide and implemented at the state level. It was originally instituted on the Western coast of India (Kerala) as a mechanism to resolve conflict between artisanal and mechanized fishers. This conflict between large (mechanized) and small-scale (artisanal) fishing was particularly heated in Kerala, Goa and Tamil Nadu where there was a significant tradition of fishing, pitting artisanal fishers and the new mechanized contingent at odds with each other. Trawlers frequently destroyed artisanal gears and the larger quantity of fish landed by trawlers was seen as a problem from the beginning. The timing of the original ban was negotiated to coincide with the Southwest monsoon season. During this time on the West coast,

² Members of the allied sectors are defined as “adult members...engaged in marketing of fish, making/repairing net, laborer, etc. (laborer includes head load workers, helpers, etc. at the landing centers) and other fishing associated activities such as auctioneers, ice breakers, members involved in collection of bivalves, other shells, seaweed, ornamental fish, etc.” (CMFRI, 2010:13).

³ Mechanized boats are characterized by having engines over 25hp and a net hauled in by machine rather than man power.

there is an increased safety risk to fishers – particularly those using smaller vessels – and a large number of species are breeding, which maximizes the conservation and safety benefits of a closed season. However, on the East coast of India, the ban was timed to coincide with the lean season, resulting in little objection from mechanized fishers but potentially fewer conservation benefits. In 2001, Tamil Nadu (Figure 2-2) adopted an annual East coast ban from 15 April to 29 May (V.Vivekanandan, *personal communication*, May 7, 2015).

Figure 2-2: Tamil Nadu, along with the rest of India's East coast, follows the seasonal ban from 15-April to 29-May annually (map created by Amanda Tickner, MSU Map Library, 2016)



The ban is upheld as one of the only successful state-sponsored fisheries management regulations in India (Vivekanandan, Narayanakumar, Najmudeen, Jayasankar, & Ramachandran, 2010), due to the history of its joint evolution between fishing communities and the government. This is evident from multiple unsuccessful regulations in place under the Tamil Nadu Marine Fisheries Regulation Act of 1983, such as net and mesh size restrictions as well as spatial restrictions on fishing (Bavinck, 2001). Tamil Nadu adopted the seasonal ban in 2001, after it had already been implemented on the West coast and in other Eastern states. The decision to implement the initial ban was taken as a joint exercise between fisheries professionals and scientists, as well as mechanized boat owners: to arrive at the initial ban period duration and timing, a number of technical committees were formed, comprised of fisheries professionals and scientists to discuss the ban's benefits with mechanized fishermen. Mechanized boat fishers were consulted in the late 1990s during the first technical committee's meeting for the Tamil Nadu ban. During this time, the season and duration were agreed upon between these stakeholders, and implementation followed shortly. More recently (2013), in the national level discussions of modifying ban length and inclusion (i.e. whether the ban should be extended to other boat types, if any, beyond the mechanized sector), traditional motorized and non-motorized fishers were also consulted in a series of stakeholder meetings held at CMFRI⁴ regional centers along the coast of Tamil Nadu (E. Vivekanadan, 2015). This narrow consultation process makes the Tamil Nadu ban a good case for examining unequal impacts of fisheries policies.

As a fisheries management regulation, the ban aims not only to temper conflict, but also to protect India's dwindling marine resources, where overfishing has led to an alarming decline in marine fish stocks. However, despite this trend, a huge amount of people still rely on marine fishing and associated employment opportunities for their livelihoods. In India alone, the total

⁴ India's Central Marine Fisheries Research Institute

marine fisherfolk population is roughly 4 million. While roughly 1.5 million are actively engaged in marine fishing harvest, the other 2.5 million of these individuals are members of fishing allied sectors (CMFRI 2010).

2.1.5 Previous research on the fishing ban

Previous research has investigated ecosystem effects of the closed season: research by Vivekanandan and colleagues (2010) found that there is no evidence that the ban is effective in terms of sustaining fish populations in coastal India (using fishery-dependent data). However, the presence of the ban has helped prevent the projected annual increase of fishing effort that would be expected without a ban in place.

Other fisher-focused research has investigated the economic effects for fishermen (Bavinck et.al, 2008), i.e. 45 days of their primary employment (mechanized) per year is eliminated. In contrast, previous research suggests that those individuals allowed to fish during the ban period (non-mechanized⁵ fishers) end up doing quite well during this time due to low competition and lower quantity landings, allowing them to charge inflated prices. However, evidence of these benefits is mixed (see chapter 4), with non-mechanized fishing also decreasing during the ban period.

However, this project addresses a gap in the literature on the impact to the pre- and post-harvest sectors (i.e. allied sectors), with a focus on women fisherfolk who dominate these sectors. Preliminary research has shown that these sectors may face heavy impacts because they are dominated by lower-class workers and traders who have limited alternative livelihood opportunities (Bavinck et.al., 2008).

⁵ Non-mechanized fishers are comprised of both motorized fishers (usually fishing a wooden or FRP (fiberglass-reinforced plastic) boat with an outboard engine of around 10hp, as well as *kattumaram* fishers (traditional wood plank boats that may or may not have an outboard engine affixed to them).

This research disaggregates mechanized “fishers” by ownership status, as there is reason to believe that owners and laborers have different experiences due to differences in capital investment, savings potential, etc. I also include non-harvest sector stakeholders in the analysis. Despite their collective numbers, these groups have been largely left out of previous analyses, and there are a limited number of studies on how fisheries management regulations impact this allied population.

2.1.6 Hypotheses

In the case of India, occupation and sex are indicators of marginalization, as socio-cultural factors limit certain individuals to certain livelihoods. Based on this, I hypothesize that the impacts to resource dependent stakeholder groups of this resource use regulation are not uniform. I expect that fish traders and other post-harvest sector workers – like their harvest sector counterparts - are significantly, negatively impacted by the ban period in terms of income. I also expect that non-mechanized harvest sectors will experience a significant increase in income during the ban period due to low competition. However, although previous research has indicated that mechanized fishers suffer significantly during the ban period, I expect that the less politically powerful mechanized laborers lose out more than their boat owner counterparts during the ban period. Finally, I posit that individuals with limited ability to diversify to other income earning activities (i.e. high resource dependence) will be most negatively impacted by the ban period.

2.2 Methods

2.2.1 Study area

The marine fisheries sector in India employs approximately 3,200,000 people and makes up around 0.83% of India's total GDP. There are nine coastal states in India and two coastal Union Territories. Tamil Nadu (TN) was chosen as the primary study state due to its importance in India's overall marine fish production. Tamil Nadu, Gujarat and Kerala are the top three coastal states in terms of marine fish production (CMFRI, 2015). Out of 3.59 million tons of marine fish landed nation-wide in 2014, 660,000 tons came from TN and 65,933 tons came from the Union Territory of Puducherry, which is surrounded by Tamil Nadu. Tamil Nadu also ranks third in terms of value, landing about 13% of the total valued catch, just behind Kerala and Gujarat (CMFRI, 2015).

Nagappattinam (TN) and Karaikal (Puducherry) were chosen as the study districts because of their historically prominent role in marine fishing in the area. Karaikal, Union Territory of Puducherry, is couched within Nagappattinam territory, making the physical characteristics of the coastal fishery similar between the two districts. There are 68 villages within Nagappattinam and Karaikal territory that have historically worked together to solve fishery issues. Nambiyar Nagar, in Nagappattinam, has traditionally been the head village within this 68-village cluster, dating back to the time of the *Chola* kings (who ruled the area until the 13th century C.E.). Nagappattinam is governed by the Tamil Nadu state government, and Karaikal is governed by the Indian central government as part of the Union Territory of Puducherry. However, fishery policies in Karaikal largely follow Nagappattinam decisions due to the historical legacy of fishing in the area and the geographical location of Karaikal (Swamy, 2011).

Two villages were chosen based on 2010 Marine Fisheries Census data for Tamil Nadu (CMFRI, 2010b) and Puducherry territory (CMFRI, 2010a). One village in each territory was chosen because existing research outlined that the seasonal ban was implemented differently within each territory (Bavinck et al., 2008). In Tamil Nadu, research indicated that the ban included only mechanized boats, but in Puducherry territory the ban was also said to include motorized boats with engines above a certain horsepower.⁶ Villages within these territories were selected based on similarities in demographic profiles (prevalence of below poverty line (BPL) residents, education level, caste and religion) as well as similarities in boat distribution patterns (i.e. mechanized owners/laborers are in the majority in each village, though motorized boat fishing is still prevalent in both). To determine villages without significant differences in the above characteristics, Chi Square tests were performed using the relevant CMFRI 2010 Census data. Additionally, because of the geographical location of these areas, it was also important to take into consideration the relative impact of the 2004 tsunami on villages under consideration.

Based on the above criteria, the villages chosen were Nambiyar Nagar in Nagappattinam, Tamil Nadu and Kottucherry Medu in Karaikal, Puducherry.⁷ Each village was heavily impacted by the 2004 tsunami and both have a tsunami nagar and old nagar. The tsunami nagar in each village is a cement block housing colony built nearby to the original (old) area of the village by an NGO. However, in Nambiyar Nagar, this colony was built opposite the main road

⁶ However, since that research was conducted, there were policy shifts, as was evident after preliminary field interviews. At the time of research, the ban applied only to all mechanized boats in both territories.

⁷ The two villages selected for this study were traditional, caste-fishing villages. Future research should also consider non-traditional fishing areas, as individuals from non-fishing castes may be more willing and able to take on additional types of work during the ban period, particularly agriculture. Also, in some cases, fishers from non-fishing castes do not have access to the same government relief provided to caste fishermen. This difference in aid may also influence the effects of the ban period on certain individuals. However, our data provide a starting place for comparing the substantive effects of the ban within traditional fishing caste communities, without confounding results due to other demographic differences.

in Nagappattinam, which is roughly 2.5km from the sea; whereas in Kottucherry Medu, the tsunami nagar was also built opposite the main road but within 0.5km from the sea.

2.2.2 Data collection

This study was designed using a mixed-methods approach. Longitudinal data was collected at three time points: before, during and after the 2015 seasonal fishing ban. Individual and household level data were collected through a survey instrument. In this survey, information was collected on each individual's education level, occupation, skill set, organizational membership, etc. Seasonal activities calendars (Slocum 1995) were the primary instrument employed at the three time points. In these calendars, individuals were asked to indicate the sources (and associated value) of their monthly income and expenditure.

Semi-structured interviews were administered to every individual surveyed to understand the variation over the years in an individual's seasonal activities calendar, as well as details on participation in decision making and opinions on viable livelihood enhancement options. We asked whether individuals were involved in fisheries management decisions at any level (from local village level up to state government level). We also asked participants to indicate what types of livelihood enhancement opportunities they thought would be useful for them during the ban period, as local NGOs were having difficulty identifying what proactive trainings they could offer within the communities that would help people manage the stress of the ban in the short-term.

Open-ended interviews were conducted with fisheries and NGO professionals, SHG presidents, *panchayat*ars and municipality officers. These interviews focused on the ban development process and enforcement, loan procurement, and community level mechanisms that may ease difficulties incurred as a result of the ban period. Participant observation was also

conducted at local fish markets and landing sites to understand the fluctuation in fish availability, cost and customer demand and how that impacted the availability of work for vendors.

2.2.3 Sampling strategy

Since the fishing ban in Tamil Nadu and Puducherry is from 15 April-29 May, I used a longitudinal sampling frame. The first phase of data collection began on 15 February and continued up until about two weeks before the start of the 2015 ban period. The second phase of data collection was conducted during weeks four and five of the ban period (6 May – 20 May 2015). The third phase was conducted during weeks four and five post-ban (22 June – 6 July 2015).⁸

In Kotucherry Medu, since the village is smaller in size, we mapped both the tsunami and old parts of the village and assigned unique numeric IDs to each house. Then, I entered the IDs into Excel and generated a random sample. In Nambiyar Nagar, it was not possible to map the village (either tsunami nagar or old neighborhoods). In the old nagar, there are many areas that are not clearly defined and palm huts that are built on the beach. In the tsunami nagar, there are now a significant portion of rentals to other caste and occupational groups that were not relevant for our study. Therefore, in Old Nambiyar Nagar, we did a census of the village by area (divided into North, South, Middle and Colony) and took the father's name from each house where someone was working as part of the fishing industry. Identifying houses by father's name does not exclude female-headed households because they are still identified within the community by absentee father's name. With village consultation, this method was considered the most relevant

⁸ Our results indicate changes to income and expenditure over three seasons. However, fishers reported that catches and income vary not only by season but also by year. Therefore, future research should incorporate a multi-year study to validate our findings.

to find and identify houses, as numeric addresses are not common. In the tsunami nagar, which is built in a grid with clearly defined house numbers, we went through house by house and removed houses from the potential sample population if they were rented by individuals engaging in occupations unrelated to and not impacted by fishing (such as those working in concrete laying outside of the village). In the case of Old Nambiyar Nagar, I entered fathers' names into Excel and in the case of New Nambiyar Nagar, I entered house numbers into Excel. I then generated a random sample (equally spread across New and Old) for participation.

We used a random sampling strategy in both villages. The process used to arrive at the random sample was different in each village. Individuals were included in the sampling frame if they were a member of the fishing community and had a job either directly or indirectly related to fishing, or a job that may be impacted by fishing, given their customer base. An example of a directly related job would be harvesting or fish trading, indirectly related would be a tempo driver, and potentially impacted may be a shop keeper or auto driver in the village. Every participant was above the age of 18. If multiple individuals in a household qualified, we attempted to interview individuals with different occupations and treated them as discreet observations. Since one of the project objectives was to ensure adequate representation of all members of the fishing community, particularly those that have been historically overlooked, once our random sample was completed, we continued to sample women fish vendors through purposeful sampling techniques. As a result, women fish workers are oversampled in comparison to other stakeholder groups to ensure sufficient data for comparison with other groups.

Between Nambiyar Nagar and Kottucherry Medu (based on CMFRI 2010 census data) there were 1851 adults over the age of 18. I weighted the sample towards Nambiyar Nagar due

to its larger size. Our initial sample was comprised of 300 individuals. However, our final sample at round three comprised 282 individuals. The discrepancy between rounds is based on the fact we were sampling humans: a small number of people either decided they were no longer interested in the survey and/or they were consistently drunk and/or unavailable. Nonetheless, the high rate of participation (>90%) at subsequent stages provides important data about changes over different time periods. Our final response rate at time three in Kotucherry Medu was 75% (i.e. out of a total of 170 individuals initially contacted, 127 participated in all three stages of the survey). In Nambiyar Nagar, our response rate was also 75% (out of a total of 208 individuals contacted in the original random sample, 155 responded). There is no reason to believe the sample is biased, as those that declined to participate or dropped out of the survey were spread across occupational groups, not centered in any particular group or income level.

The unit of analysis was the individual, though in all cases household data was also collected. The individual was chosen as the unit of analysis because I assumed that resources were not necessarily shared equally within the household (Kevane & Gray, 1999). Additionally, given the distinct gender division of labor within fishing communities and various occupational roles available to different individuals (Novak Colwell, 2016; Rubinoff, 1999) it was important to allow response at the individual level. This increased the likelihood of capturing the full effects of the ban on individuals within different occupational groups.

Individuals were divided into eight stakeholder groups for analysis:

- 1) Mechanized boat owners are individuals who have full ownership of a mechanized trawl boat and may or may not fish on that boat as well. Mechanized boats are characterized by having engines over 25hp and a net hauled in by machine rather than man power.

- 2) Mechanized laborers are individuals who provide labor (i.e. fishers) on the mechanized trawl boats.
- 3) Non-mechanized fishers are those individuals who either own or provide labor (or both) on non-mechanized craft such as fiberglass motorized boats or *kattumaram*. This group is comprised of both motorized and non-motorized fishers. I do not distinguish between owners and laborers within these groups as non-mechanized fishers are permitted to fish year round and the ban does not apply to them. Additionally, *kattumaram* is a single-person enterprise (owner and laborer are one in the same).
- 4) The *surukku valai* (purse seine⁹) category is comprised of those fishers involved in the joint ownership venture of this gear type. *Surukku valai* is a banned gear that is nevertheless operated in between the areas of Nagappattinam, Kodiakarai and the Sri Lankan border. It involves 8-10 fiberglass motorized boats and one mechanized boat to operate. The mechanized boat sets the net and the fiber boats circle the set net to minimize the number of fish that escape. There are usually 52 people employed through joint ownership of one set of gear. Each fisher in this venture owns the same share of the gear and there is no wage system: they share completely evenly in gain or loss. Individuals employed in this stakeholder group were treated as a distinct occupational group because the gear is not usable without the mechanized boat, meaning it cannot be operated during the ban period. However, the 8-10 fiber boats can operate other gears (i.e. gill nets) during the ban period. Having said this, because of the excess of fishermen employed in one *surukku valai* venture, not all fishermen are able to fish these fiber boats completely at their will during the ban period.

⁹ The purse seine is a type of circular net that cinches at the bottom to prevent fish from escaping. This net type is used for catching small pelagic fish species such as oil sardine.

- 5) Transport, resupply and boat maintenance workers (TRM) are grouped into one occupational category. These are individuals involved in the net repair business or transport of supplies, fishermen or catch to and from harbor.
- 6) Fish traders as an occupational group are those individuals who take part in post-harvest activities including fish marketing and auctioneering, fish drying, export agents, middle men, and ice factory owners. Fish traders were partitioned by sex, given that the scale of traders' work is very different: men tend to work for export agencies and move throughout the state and country to source fish, while women traders operate only within their district (and mostly within the villages directly adjacent to their own village).
- 7) The final occupational category includes those individuals who have jobs wholly unrelated to fish harvesting or pre/post harvest activities, but still have occupations focused within the fishing village, such as village shop owners, milk sellers and flour makers. Even though their occupational category is unrelated to fishing, their customer base is largely fishing-dependent. Therefore, it was deemed worthwhile to include them in the analysis to show the potential spinoff effects of a fishery-policy decision on other groups of people.

2.2.4 Analysis

2.2.4.1 Quantitative analysis

Generalized linear mixed-models (GLMM) were used to understand the difference in income and expenditure within each group of stakeholders at the three time points (before, during and after ban). A GLMM is the most appropriate approach because it allows for the incorporation of random effects into the model. This is important as we have longitudinal data

where the impact of the individual on their answers varies. A GLMM also allows for dependent variable distributions other than normal distributions. Since our dependent variable is an estimation of monthly income or expenditure, values are often clustered together, sometimes around zero (as is the case with incomes during the ban period). Since the data was over-dispersed towards zero in many cases, a negative binomial distribution was used.

After running the full model, it was apparent that income at time period one and time period three (before and after ban sampling timeframes) were not significantly different from each other. Therefore, post-ban observations were dropped to streamline the analysis. Both fixed and random effects were incorporated in the final model. Fixed effects variables were occupation, education level, skill set, organizational membership and village. The random effect variable was an individual's unique ID number, given that there may be other individual factors affecting income shifts.

Income or Expenditure

$$\begin{aligned}
 &= \text{constant} \\
 &+ [(fixed\ effects)\text{ Occupation} + Ban\ Period + Yrs\ School + Skills \\
 &+ Org\ Member + Village] + [(random\ effects)ID] + \varepsilon
 \end{aligned}$$

A GLMM was run for each occupational group separately to assess the ban's impact on the income and expenditure of each group. This partition was preferable to including all the occupations together in one model because it allows for clear interpretation of the ban's differential impacts without numerous interaction variables (Braumoeller, 2004). I analyzed GLMM models for both income (Table 2-2) and expenditure (Table 2-3) as the dependent variable.

I also employed logistic regression (Table 2-4) to understand whether there were certain occupational groups that were more or less likely to lose their entire (100%) income during the ban period. The response variable was a dichotomous variable with 1 equating to total loss of income during the ban period, and all other values being zero. *Surukku valai* was chosen as the occupational reference group because this group is least impacted by the ban period (i.e. they exhibit no significant change in income between seasons). Since the results for the GLMM are heavily influenced by an occupational group's earning potential, by converting income into either total loss or incomplete loss, we are able to look past this effect. The logistic regression results are presented in Table 2-4 below. I also plot the mean income (Figure 2-3) and mean expenditure (Figure 2-4) of each group before and during the ban period to help contextualize the results of both the GLMM and logistic regression.

2.2.4.2 Qualitative Analysis

Qualitative analysis of the semi-structured interview data was performed based on a corpus based coding system: emergent themes and concepts were identified within each occupational group regarding their participation in decision making and suggested viable livelihood enhancement opportunities. Analysis of the open-ended interview data from fisheries professionals focused on the stakeholder engagement process in working towards the ban's implementation in Tamil Nadu. The qualitative data is then paired with the quantitative data on income and expenditure impacts to understand how the ban's substantive effect varies by occupational group.

2.2.5 Variables

2.2.5.1 *Dependent Variables*

Income is a continuous response variable. The value for each income observation is the participant's monthly income during the month we inquired. Monthly income was chosen instead of daily or weekly income because many fishermen do not get paid on a weekly schedule, and many boats have 7-10 day trips. Fishermen of the *surukku valai* gear type get paid only monthly or even every couple of months. Local collaborators suggested that monthly income was the most reliable measurement for the above reasons.

Expenditure is a continuous response variable. The value for each expenditure observation is the participant's family expenditure. This measure is at the family level because it was unrealistic to ask the participants to separate out their personal expenditure. Expenditure can be used as a proxy measure for financial capital (Buvinić & Gupta, 1997) and also a measure of welfare (Hentschel & Lanjouw, 1996). However, the ban period is not the only push factor leading to changes in expenditure. Expenditure is heavily influenced by the academic calendar year (i.e., school fees) as well. Therefore, in reporting impacts of the ban on expenditure, we have to be careful in indicating that while indeed the ban may increase expenditure (as reported by most respondents) due to fishermen being home, there are also extraneous impacts on expenditure unrelated to the ban period.

2.2.5.2 *Explanatory Variables*

Occupation is a set of eight, dichotomous categorical variables. The fishing ban prohibits mechanized boats from fishing and as a result from large (in relative quantity) fish landings being made. Therefore, each occupational stakeholder group that either is included in the ban, or

interacts with individuals included in the ban, has the potential to be impacted, either positively or negatively. Therefore, an individual's occupation may impact their income and expenses during the ban period.

2.2.5.3 Control Variables

Education level is an ordered categorical variable. Its value ranges from 0-4 (with 0 being equal to no school and 4 equal to college or higher education). Research has shown that education level can affect an individual's income and adaptation opportunities (Ellis, 1998). I therefore control for an individual's education level in this analysis.

Skills is another ordered categorical variable. Individuals reported anywhere from 1-6 skills. They were given a list of fishery-related and unrelated skills as well as the option to indicate additional skills not on the list. Participants were then asked which skills they had. Every individual reported at least one skill: the skill associated with their primary occupation.

However, it is expected that the more skills an individual has, the more opportunity they have to potentially diversify their income earning strategies.

Organizational membership is a dichotomous variable, coded 0 for "no membership" and 1 for "membership" within a community group or other local society. Organizational membership as a measure of social capital has been shown by some scholars to affect an individual's income/financial capital (Putnam, 1993).

Village is a dichotomous variable. It is necessary to include village fixed effects in the model because while demographic qualities and boat ownership/labor patterns do not vary by village, village size is significantly different and each village is located in a different state with slightly different welfare measures. For example, in Karaikal the ban assistance offered by the government is Rs. 4000 but fishers do not receive assistance during the rainy season. This is

compared to Tamil Nadu where fishermen receive a ban assistance of Rs. 2000 but also receive assistance during the rainy season. Therefore, it is worthwhile to control for village-level

differences. In the analysis, Nambiyar Nagar is coded as 0 and Kotucherry Medu as 1.

ID number is a unique number assigned to each individual participant. For example, Selvi¹⁰, a

fisherwoman in the tsunami nagar of Nambiyar Nagar has an ID number of 10256. An

individual's ID number does not change over interviews/timeframes; it is constant. ID number is

included in the model as a random effects predictor variable.

Table 2-1: Descriptive statistics for the dependent variables of monthly income and expenditure as well as the primary explanatory variable: Occupation

Variable	Mech. boat owners	Mech. laborers	Non-mech.	Surukku valai	TRM	Male fish traders	Female fish traders	Fishing unrelated
# of Observations	39	73	16	30	10	7	81	14
Pre ban income min-max	0-800000	0-50000	0-30000	0-20000	0-20000	10000-85000	0-15000	0-100000
Pre-ban expenditure min-max	4000-700000	1200-115000	4000-30000	3000-50000	3500-40000	8000-35000	25-60000	3000-200000
Pre-ban income mean	57567 (22785)	11190 (1114)	10894 (1902)	4779 (826)	12488 (1888)	30000 (9819)	3532 (326)	15060 (6464)
Pre-ban expenditure mean	55229 (19738)	11606 (1724)	12526 (1639)	12029 (1571)	17277 (4636)	20642 (3864)	7796 (865)	22133 (12808)
Ban time income min-max	0-35000	0-15000	0-27000	0-30000	0-15000	0-42000	0-6500	0-150000
Ban time income mean	1237 (900)	613 (246)	10000 (2432)	4790 (1329)	5900 (1852)	6000 (6000)	654 (168)	13507 (10615)
Ban time expenditure Mean	119000 (60633)	9986 (835)	14250 (2736)	15250 (2248)	7070 (1108)	24714 (9920)	10598 (963)	10785 (1664)
Ban time expenditure min-max	4500-1700000	1000-40000	1000-45000	4000-60000	700-12000	3000-80000	1000-50000	3000-20000

¹⁰ Name and house number are changed for confidentiality purposes.

Table 2-2: Frequency distributions of control variables

Variable	Mech. boat owners	Mech. laborers	Non-mech.	Surukku valai	TRM	Male fish traders	Female fish traders	Fishing unrelated
Yrs. School								
0	1	6	3	2	0	0	49	6
1	13	31	5	17	5	1	26	4
2	24	31	7	11	5	6	6	2
3	1	3	0	0	0	0	0	0
4	0	2	1	0	0	0	0	2
Skills								
1	2	1	0	0	0	2	16	2
2	5	11	0	1	2	1	49	9
3	25	30	1	2	4	2	14	2
4	5	19	10	19	3	1	2	1
5	2	12	5	7	1	1	0	0
6	0	0	0	1	0	0	0	0
OrgMember	4	5	1	0	1	2	34	9
Village								
Nambiyar	7	23	13	29	4	3	52	12
Kotucherry	32	50	3	1	6	4	29	2

Figure 2-3: Mean income by group before and during the ban period

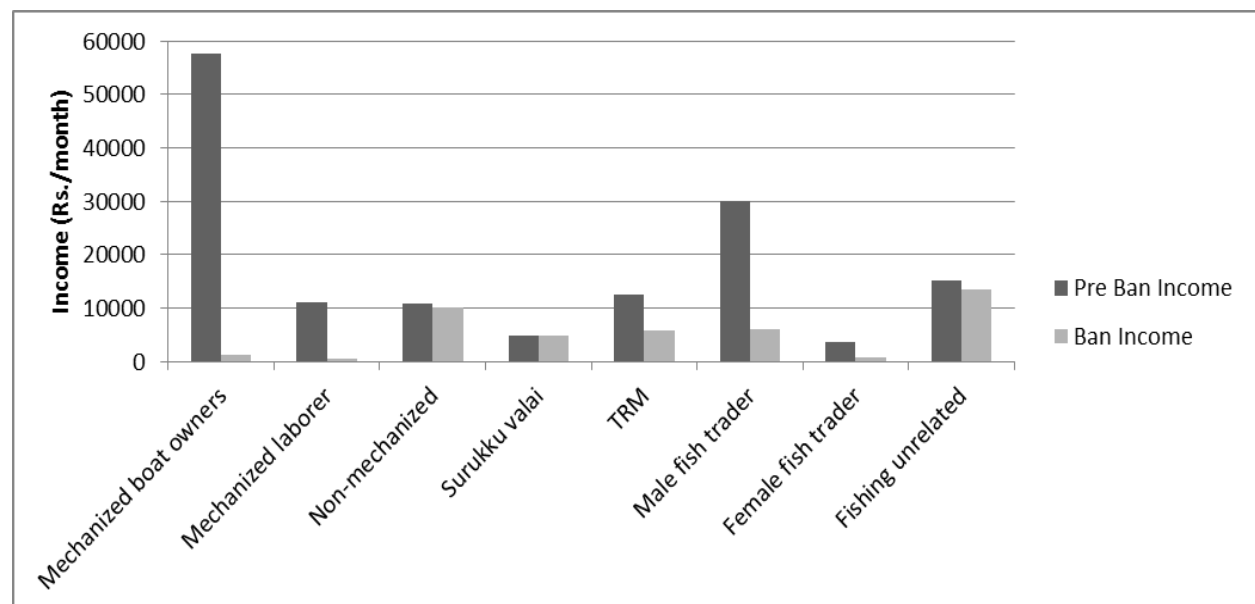
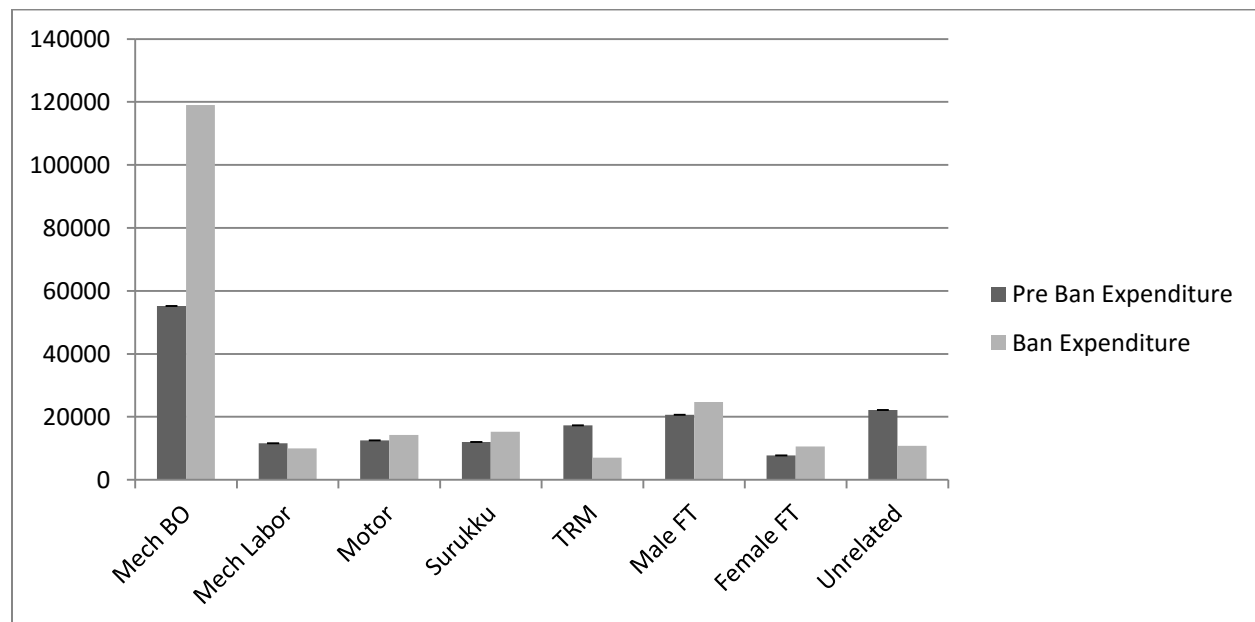


Figure 2-4: Mean expenditure by group before and during the ban period



2.3 Results

2.3.1 Are fish traders and other post-harvest sector workers – like their harvest sector counterparts - significantly, negatively impacted by the ban period in terms of income? Expenditure?

While post-harvest sector Transport, Resupply & Maintenance workers' income is not significantly impacted by the ban period ($b=-0.85$, $p=0.29$), their expenditure is. TRM workers spend significantly less during the ban period ($b=-0.82$, $p=0.00$). Since there is low demand for this business during the ban period, there is also little need to buy diesel, supplies, etc.

Fish traders' income (both male ($b=-12.89$, $p=0.00$) and female ($b=-1.96$, $p=0.00$)) are significantly, negatively impacted by the ban period. The coefficient for impact is strongly tied to earning potential in the first place. Therefore since male fish traders have higher earning potential, they exhibit larger absolute losses. For instance, during all times, women fish traders have a significantly lower mean income (Figure 2-2: pre-ban $M=3532$, ban $M=654$) than men (pre-ban $M=30000$, ban $M=6000$). A possible explanation for this difference is that men in the

fish trade business are exporters or middle men, generating larger profits. Men in these businesses also exhibit increased mobility and stability of non-ban income as they may work for companies and have a larger geographical range they move within to source fish. While both female and male traders lose income during the ban, male traders experience greater absolute declines, though the impact may be greater on women due to their low starting point. We can see the range of incomes clearly in Table 2-1 and Figure 2-3 with women fish traders having the lowest pre-ban income of all groups.

Although insignificant, the regression results for the likelihood of having complete loss (100%) of non-ban time income during the ban period (Table 2-5) suggests that female fish traders are less likely to lose their entire income during the ban period ($b=-0.46$, $p=0.49$) (as compared to the reference group *surukku valai*). Qualitative interview data shows that, especially in Nambiyar Nagar, many women attempt to vend *kola meen* (flying fish), which is in season during the ban period and caught by motorized boats. Women buy this fish when possible, though high prices frequently leave them with large losses if the customer base is unwilling to pay higher prices. As a result, female traders may not suffer total loss, but still face substantial hardships during the ban. In fact, their willingness to accept suboptimal alternative employment may indicate increased need.

Although women traders' income is significantly, negatively impacted by the ban period, their expenditure actually increases during this time (Table 2-4: $b=0.35$, $p=0.00$). Qualitative data suggests that the reason for this increased expenditure is that women are responsible for family expenses. Women and panchayat leadership suggested that expenditure is higher during the ban period because fishermen are home. As opposed to taking 5 days' worth of meals on a trawl boat, they are now eating all meals at home and many are buying drinks. Also, women

report increased food expenditure during this time, not only to make regular meals, but also to make special meals for their husbands during the time they are home. Additionally, children are on school break, requesting money for snacks and they too are taking all meals at home as they are not getting the noon-meal scheme (free lunch at school) during this time. Anecdotal reports indicate medical expenses and drink expenses (not necessarily related) are higher during this time due to fishermen inactivity.

Within the sample, the majority of individuals in fishing unrelated occupations were those who run local petty shops. Their mean expenditure during the ban is lower than before the ban (Figure 2-4). Although the results of the statistical analysis show that this group's income ($b=-2.15$, $p=0.17$) and expenditure ($b=-0.08$, $p=0.93$) are not significantly impacted by the ban period), qualitative interviews suggested a need to further disaggregate groups within this category. In interviews, shop owners suggested that if possible, they stock up on materials before the ban period. During the ban period, many individuals within the village do not have sufficient funds to buy with cash at their stores and they resort to selling on credit, on the understanding that they will be paid back after the ban is lifted and the government ban compensation is distributed. Some shopkeepers are in a position to offer goods on credit, but others are not. Those that are not in a position to offer credit are forced to close their shops during the ban period. Based on field observations, the shops owned by female headed households were more likely to close during the ban period. Shopkeepers also stated that although women cook more and spend more on food, they are also more likely to go down into the central bazaar to buy fruits and vegetables in larger quantities during the ban time, leaving small petty shops lacking in business.

2.3.2 Does the non-mechanized harvest sector experience a significant increase in income during the ban period?

Non-mechanized fishers experience no significant difference in income during the ban period as compared to their pre-ban income levels ($b=-0.50$, $p=0.47$).

2.3.3 Do mechanized fishers lose significant income during the ban period, and do the laborers lose more than the boat owners?

Mechanized laborers are much more likely to lose their entire income during the ban period ($b=1.15$, $p=0.04$). This loss is notable because – compared to their boat owner counterparts – they have less prior income to cushion this loss (Figure 2-3).

2.3.4 Are those individuals with limited ability to diversify to other income earning activities (i.e. high resource dependence) most negatively impacted by the ban period?

Using education level as a proxy for ability to diversify, those individuals with higher education levels are less likely to experience total loss of income during the ban period (i.e. increases in education level are associated with a significantly lower likelihood of total income loss during the ban period ($b=-0.42$, $p=0.04$)). Certain groups with low education are particularly vulnerable to ban-time income loss¹¹. There is a discrepancy in educational levels between groups, particularly in comparing the women fish trader group with others (Table 2-2). The majority of women fish traders have no education whatsoever. The remainder of women fish traders have only a primary education. This reality makes women fish traders particularly vulnerable to ban-time income loss. Additionally, education level (rather than skills) may also be a better proxy for an individual's ability to diversify away from fishing, as most skills

¹¹ Further research is necessary to unpack the mechanism between education and decreased likelihood of total income loss.

individuals reported were fishing-related and therefore may not provide alternative options during the ban time.

Table 2-3: GLMM for each occupational group run separately for factors predicting income

Variable	Mech. boat owners	Mech. laborers	Non- mech.	<i>Surukku valai</i>	TRM	Male fish traders	Female fish traders	Fishing un- related
N	76	150	35	64	19	14	169	29
Prob> Chi2	0.0	0.0	.55	.96	.88	0.0	.00	.40
Ban time	-4.34*** (.93)	-3.20*** (.48)	-.50 (.70)	.12 (.73)	-.85 (.80)	-12.89*** (3.08)	-1.96*** (.45)	-2.15 (1.55)
Yrs. School	-1.61 (.73)	.42 (.27)*	.94* (.51)	.12 (.20)	-.49 (1.02)	-15.05*** (5.11)	.56* (.38)	1.19 (.92)
Skills	-.33 (.52)	-.01 (.26)	.01 (.48)	.27 (.73)	.68 (.76)	-4.45*** (1.13)	-.09 (.30)	.30 (1.14)
OrgMem	-1.34 (1.46)	-.89 (1.02)	-3.65* (2.27)	---	-.69 (1.58)	-.25 (3.14)	.27 (.45)	2.11 (2.43)
Kotu- Medu	-1.08 (1.24)	-.82 (.59)	-.11 (1.05)	-.51 (2.26)	.48 (1.16)	9.32*** (3.69)	-.30 (.52)	4.74 (3.73)
Constant	16.50*** (3.15)	10.13*** (1.72)	8.22*** (2.67)	7.59* (4.60)	7.22* * (3.69)	38.12*** (8.44)	8.41*** (.90)	.90 (.26)

P<0.01***, p<.05**, p<.1*, standard error in parentheses

Table 2-4: GLMM for each occupational group run separately for factors predicting expenditure

Variable	Mech. boat owners	Mech. laborers	Non- mech.	<i>Surukku valai</i>	TRM	Male fish traders	Female fish traders	Fishing un- related
N	76	150	35	64	19	14	169	29
Prob> Chi2	0.0	0.0	.20	.06	0.0	0.86	0.0	0.0
Ban time	-.13 (.21)	.05 (.09)	.12 (.19)	.21* (.11)	-.82*** (.25)	-.10 (.25)	.35*** (.10)	-.08 (.31)
Yrs. School	-.40 (.30)	.15** (.07)	.24* (.15)	.01 (.03)	-.93*** (.28)	-1.46 (1.48)	.02 (.10)	.35*** (.13)
Skills	-.10 (.22)	-.14 ** (.06)	.04 (.13)	.29** (.14)	.42* (.23)	-.11 (.31)	-.26*** (.10)	.01 (.23)
OrgMem	-.05 (.58)	.03 (.24)	-1.07* (.66)	---	.25 (.52)	.51 (.63)	.16 (.13)	-.32 (.38)
Kotu- Medu	-2.91*** (.49)	-1.03*** (.14)	-.46 (.34)	-.28 (.59)	-.19 (.34)	.71 (.75)	-.43*** (.15)	-.48 (.53)
Constant	16.56*** (1.48)	11.07*** (.41)	9.46*** (.70)	8.33*** (.94)	9.87** * (1.14)	11.62** * (2.70)	9.81*** (.26)	9.85** * (.75)

P<0.01***, p<.05**, p<.1*, standard error in parentheses

Table 2-5: Logistic regression results for factors predicting the likelihood of total loss in income during ban period

Variable	Coefficient
Mechanized boat owners	.87 (.68)
Mechanized laborers	1.15** (.56)
Motorized fishers	-.87 (.68)
TRM	-1.47* (.89)
Male fish traders	1.23 (1.20)
Female fish traders	-.46 (.66)
Fishing unrelated	-.45 (.86)
Yrs. School	-.42** (.20)
Skills	-.29 (.19)
OrgMember	.11 (.44)
Kotucherry Medu	.73** (.37)
Constant	1.74* (1.74)

P<0.01***, p<.05**, p<.1*, () standard error
n=248¹², *Prob>chi*²=0.00, *Pseudo R*²=0.14

2.3.5 Livelihood Enhancement

Finally, all participants were asked what types of livelihood enhancement options they felt would be useful to them to get through the ban period. Many participants indicated more than one enhancement option. The results are found in Table 2-6 below, partitioned by sex.

Table 2-6: Livelihood enhancement options as indicated by men vs. women during ban period¹³

Option	% of male respondents indicating option (n=173)	% of female respondents indicating options (n=96)
Fishing-related	68%	44%
Fishing unrelated	3%	12%
Anything with a good salary	26%	0%
Anything that gives minimum wage	0%	9%
No idea	26%	35%

¹² Individuals were removed from the sample if they did not answer questions regarding organizational membership or skills

¹³ Not all individuals surveyed chose to answer the question on livelihood enhancement recommendations

A number of men within the fishing communities suggested that the provision of subsidy to purchase *kattumaram* with or without motor, or fiber glass boat under joint ownership, for subsistence use during the ban period would be useful. Some suggested a desire for high technology fishing training, engine repair, net maintenance, and GPS usage training. Men emphasized the provision of trainings WITH remuneration. Others suggested that using the ban time to run awareness programs about government schemes would be useful. There was a general unwillingness to partake in fishing-unrelated activities, especially agriculture. Most men interviewed indicated that if an income-earning activity is offered other than fishing, the training for it or activity itself must be outside the fishing villages, as men within the village are embarrassed to take part in fishing-unrelated activities.

Women, on the other hand, had different specifications than men in regards to livelihood enhancement options deemed useful and feasible during the ban period. Women were far less likely to oppose fishing-unrelated work. A number of women indicated that they would be interested in taking advantage of the 100 Days Work Scheme (n=10) under the Mahatma Gandhi National Rural Employment Guarantee Act (NREGA). One member of each family that falls Below the Poverty Line (BPL) and whose village lies under the jurisdiction of a *gram panchayat* is eligible to take advantage of this scheme. This is an important note because Nambiyar Nagar falls under a municipality, not a *gram panchayat*, meaning that families currently do not qualify for the 100 Day Work Scheme. Extending this work scheme to all Below the Poverty Line (BPL) families (no matter the location of their village) may be worthwhile. Many women also emphasized that they will do any work that keeps their family going during the ban time. Some individuals who requested fishing-related training indicated that learning how to make fish pickle, dry fish or fish masala would be useful.

2.4 Discussion

2.4.1 The individuals that are losing most: Distributional equity and ban period impacts – The “poor” as a heterogeneous group

Previous research has indicated that the powerful and wealthy tend to derive more benefits from conservation policy (Baland & Platteau, 1999; World Resources Institute, 2005) and that short term restrictions on ecosystem use affect the poor most (World Resources Institute, 2005). While I find that mechanized fishers are losing significantly during the ban period, a finding that confirms previous research (Bavinck et al., 2008), I also find that mechanized laborers are more likely to lose 100% of their income during the ban period than their boat-owning counterparts. Figure 2-4, on mean expenditure before and during the ban period suggests that this group is unable to smooth their expenditures during this time. In contrast, their mechanized owner counterparts spend, on average, almost double their pre-ban levels. This finding highlights that even within a stakeholder group, such as mechanized fishers, policy impacts are different.

Research also suggests that there is unequal benefits sharing from resource conservation policies (World Resources Institute, 2005) such that those that have more capital investment are able to capture more of the benefits from a policy (i.e. the bigger the boat, the more fish). While previous research on the fishing ban has suggested that non-mechanized fishers do quite well during the ban due to lack of competition (Bavinck et al., 2008), I find that during the ban period, non-mechanized fishers experience no significant change to their income or expenditure, indicating that the ban neither makes them any better or worse off on average. Non-mechanized fishers therefore have limited ability to capture benefits derived from the ban.

Previous research in rural South Indian agricultural villages suggests that although seasonal income may vary, smoothing mechanisms, like interfamilial borrowing and loan arrangements help individuals smooth expenditure over times of low income (Townsend, 1994). These mechanisms allow necessary expenditures to continue throughout the year regardless of season and as such, fluxes in expenditure are not evident where sufficient smoothing mechanisms exist. This communal support tends to emerge in areas where people have similar livelihoods and therefore may expect to eventually face similar shortages to those currently experienced by neighbors (Scott, 1976). However, it is possible that even within areas where individuals face similar stresses, socio-cultural factors may make certain groups less likely to be able to access smoothing mechanisms from other livelihood groups. In our data set, while TRM workers' income was not affected by the ban period, they do not maintain consistent expenditure across the time frames. This could mean that they are unable to smooth their consumption during the period when they are not earning money. However, business expenses for this group also decline during the ban time: since there is low demand for this business during the ban period, there is also little need to buy diesel, supplies, etc. Further research is necessary to separate business and household related expenses to understand if there is a real poverty threat to this group as a result of the ban period.

While fish traders' incomes (both male and female) are significantly, negatively impacted by the ban period, female fish traders' expenditure actually significantly increases during the ban period. As outlined above, there a number of reasons for this, coinciding with both fishermen and children being at home. There are two community mechanisms of note that may enable increased expenditure during this time: the extensive, small scale (Rs. 100-200) borrowing networks between family and friends that are utilized sometimes on a daily basis, as well as the

fact that village shop owners may allow purchase on credit, often without interest. This latter option does not extend to shops outside the village, where the majority of household goods are usually purchased (as village shops are not able to stock extensive fresh food stocks needed by families daily). As female traders' earning potential is lowest of all occupational groups in the first place, both before and during the ban period (Figure 2-3), this increased spending during the ban period comes with high risk post-ban if traders are unable to earn sufficient funds for debt repayment (village store credit is not interest free forever). Additionally, since female-headed households, without a registered fishermen, are not eligible for the government's ban subsidy of Rs. 2000, the funds distributed by the government post-ban offer no relief to them. Although this group increases their expenditure during the ban, I would argue based on field experience that this group is still at high poverty risk. Female fish traders especially are a politically weak group and considered marginalized and underrepresented in decision making in general. As evident from qualitative data and literature on the ban decision making process (Vivekanandan et al., 2010), there was a bias towards the production (i.e. harvest) sector which appears to have led to this stakeholder group's resource use needs being overlooked, as anticipated by other scholars (Cleaver, 1998).

While the expenditure of the fishing unrelated group is not significantly impacted by the ban period, there is a decline in mean expenditure (Figure 2-4) for this group during the ban period indicating that, on average, they are unable to maintain smooth expenditure over the two time frames. The lack of statistical significance may reflect adaptation responses by certain petty shop owners who close their businesses during this time to maintain necessary family expenditure.¹⁴ If individuals within this group belong to families without a registered fisherman,

¹⁴ Closing a petty shop reduces expenditure on shop related necessities, thereby opening up funds usually spent on shop maintenance for family expenditure.

they do not qualify for the government ban stipend of Rs. 2000. They therefore do not have access to this smoothing mechanism.

Scholars have indicated that indirect and unequal impacts to resource users may arise from conservation policies, regardless of the success of the policy itself (Mitchell, 2008). The findings presented here have serious implications for understanding the cascade of impacts that follow from a management decision, showing not only that individuals who actively harvest the resource are impacted (mechanized fishers), but so are those in post-harvest (fish traders and TRM) and seemingly unrelated occupations (petty shop owners). Tamil Nadu, in its provision of relief stipend only to fisher-households, disregards a significant portion of the impacted population. The World Resources Institute (2005) asserts that unless specific provisions are made for the poor, ecosystem benefits generated from successful conservation policy do not necessarily translate into their benefits. Since the purpose of the ban stipend is to help relieve financial difficulty for fisherfolk during the ban period, it should also be extended to households in the fishing community (many female-headed) that do not have an active fisher, but are either fish-traders or have businesses within the community that rely on fishers as their client base. Based on the evidence, they too are significantly impacted by the ban and without targeted provisions, inequitable impacts will continue to compound on these resource users that can afford it least.

2.4.2 Mitigation measures for increasing equitability in derived benefits: Informal and formal support mechanisms

The establishment of savings and credit groups have been touted as one possible way to mitigate for the short term losses incurred from ecosystem use restrictions (World Resources Institute, 2005). However, I find that while they can be helpful, if the group's savings and loan

provisions are not structured specifically around the ecosystem use restriction, the efficacy in mitigating short term losses is limited. Within the fishing villages, self-help groups (which are mainly comprised of women) as a formal support mechanism may provide members with an increased ability to smooth consumption (and even increase it) during the ban period: One primary focus of the SHGs is savings schemes, where women contribute small amounts monthly to an account. SHGs also offer rotating loan availability, but there are eligibility criteria that prevent these loans from being easily accessed when needed during the ban period. During field interviews, one SHG president in Kottucherry Medu was trying to initiate a “ban-time savings account” where members (in addition to their monthly contributions) would also contribute an additional Rs. 500 per month specifically for use during the ban period. However, she was having trouble getting member buy-in for this initiative as the monthly, mandatory savings contribution was considered quite high.

Another mitigation measure frequently promoted is the provision of training programs and alternative income streams (World Resources Institute, 2005). However, I find that it is only properly conceptualized, short-term livelihood enhancement opportunities that are viable in this case. These opportunities could be useful as a smoothing mechanism for individuals that are not able to maintain their expenditure during the ban period. Previous research in other areas of the world has indicated that alternative livelihood opportunities that are not perceived by participants to speak to locally important cultural identities are not successful (Katikiro, 2016). I find that unless enhancement opportunities are cognizant and respectful of the strong caste-identity associated with fishing, they will not be viewed by potential participants as viable.

2.5 Conclusions

Previous research has demonstrated how India's seasonal trawl ban impacts the mechanized fishing sector as well as fish stocks. This study not only delves deeper into the mechanized sector impacts by disaggregating individuals by occupation (boat owners and laborers), but also expands the analysis to include a variety of other directly and indirectly dependent fishery stakeholders. I hypothesized in the beginning of the chapter that the impacts of a regulation on resource dependent stakeholder groups are not uniform. I find that both female and male fish traders are heavily impacted by the ban in terms of income, though this impact appears to have more dire consequences for female traders. While I do find that mechanized fishermen are heavily, negatively impacted by the ban period in terms of income, I disaggregate this group to show that the less well-off mechanized laborers are more likely than their boat-owning counterparts to lose 100% of their income during this time. Based on this data, I conclude that some of the populations most impacted by the ban are also some of the most marginalized populations. Many of these individuals were excluded from the decision making process. Furthermore, in certain cases these individuals were further disadvantaged by decisions to provide aid only to represented groups (i.e. fishers). These results demonstrate the importance for fisheries officials to consider the range of likely policy impacts, rather than only aggregate outcomes.

Second, this data gives further evidence for existing theories of representation in decision making in natural resource management. However, I also highlight the complications of representation for diverse groups. Individuals from marginalized segments within represented groups (e.g., mechanized laborers within the broader context of mechanized fishers) may get

overlooked despite facing heavy policy impacts. Therefore, effective participation requires identification of appropriate representatives for the full range of stakeholder concerns.

Finally, I hypothesized that individuals with limited ability to diversify to other income earning activities (i.e. high resource dependence) would be most negatively impacted by the ban period. There is support for this hypothesis in the regression results. By taking education level as a proxy for ability to diversify, I show that those individuals with higher education levels are less likely to lose their entire income during the ban period. This suggests that indeed those individuals with little opportunity to diversify are often the most negatively impacted by conservation policies. As Niehoff (2004) suggests, policies that promote education can increase livelihood diversity options in the long term. In addition to adaptation constraints, stakeholder involvement tends to decrease with lower literacy (Gupta, 1998), thus leading to the potential for important groups to be left out of the decision making process. Women fish traders, who have low education levels across the board in this dataset, do indeed lack representation in the development of policies that heavily impact them. Education support as a mitigation measure may therefore offer further opportunities for both adaptation and participation by marginalized groups.

I started this paper by highlighting that the conservation community increasingly accepts that conservation policies will not be successful unless they simultaneously speak to local development needs (Wunder, 2005). The data presented here suggest a distributional equity issue resulting from a resource management decision. It is clear that the reach of a fisheries management decision extends beyond the harvest sectors. Mechanized boat owners are heavily impacted by the ban, a result that may not be consequential for resource managers depending on

their intentions. However, other sectors are also significantly impacted, something that was not taken into account in deciding on the ban nor the associated government compensation.

Based on these results, it is worthwhile to step outside the box in resource management to look at the cascade of effects on both direct and indirect dependence stakeholders. This consideration is pivotal in understanding the true costs and benefits of a management decision. Once the costs and benefits are thoroughly understood, it will be important to develop livelihood enhancement programs for individuals who are expected to lose a lot during the period under consideration, particularly those who start in disadvantaged positions. As we have seen from the data above, it is extremely important to take into consideration the cultural context in developing strategies. For instance, a strategy that would open agricultural jobs to fishers during the ban period would not be a useful program due to social stigmas. Well thought out management initiatives have the potential to have long lasting, positive impacts. However, without considering the possible unintended consequences of a decision, the likelihood of leaving a legacy of negative impacts is high.

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3 A gendered analysis of fisherfolk's livelihood adaptation and coping responses in the face of a seasonal fishing ban in Tamil Nadu & Puducherry, India

3.1 Introduction

It is well documented in the sustainable livelihoods literature that men and women often respond differently to stresses and shocks to their livelihoods. Certain adaptation and coping strategies may jeopardize one's longer term ability to respond to stresses or bounce back from other shocks. An individual's choices, therefore, may have a legacy effect on their long term livelihood resiliency.

Livelihoods and resiliency research has addressed the so-called "gender gap" in adaptations: i.e. men and women tend to adapt differently to stresses. For example, women are more likely to cut back on the amount of food they eat to conserve funds and/or ensure their family members have sufficient nutrition (Kiewisch, 2015). This is an example of a reactive coping strategy that may have long term consequences for their own human capital (health).

There has been a great deal of feminist research on gender and the environment which has focused on women's relationship with nature. Some of this research has suggested that women are naturally closer to nature and therefore more impacted by environmental degradation and policies (Shiva, 1988). Other feminist scholars argue that – while women are in fact more impacted by declining resource health – the adaptation gap is driven primarily by the roles women take on in everyday life (like subsistence food production) (Agarwal, 2001; Jackson, 1993). Still other scholars assert that the disproportional impact on women is caused by the ways in which they have been involved, historically, in the production sector. These historical roles women have played in relation to the production sector condition their access to resources

or distribution of the resource itself (Carney, 1994; Rocheleau, Thomas-Slayter, & Wangari, 1996).

I argue that none of these ways of incorporating gender into research on natural resource management is sufficient for understanding how and why people make the choices they do about their livelihoods. Outside of natural resources, there is a rich literature on the intersectionality between sex, class, and power in conditioning experiences of gender (McCall, 2001; Weber, 2010). However, in the natural resources literature, relatively little attention has been paid to how these aspects may influence adaptation choices. This study operationalizes gender as the intersection between sex, class and power and in the context of natural resource management, assessing these factors' interactive impact on adaptation choices.

I argue that if we really want to understand why people respond to stresses the way they do, we need to consider one's power, class and sex as factors conditioning gendered livelihood adaptation choices. Without doing so, we risk oversimplifying relationships between livelihood adaptations and gender (if only considering gender as male vs. female) and maintaining superficial levels of understanding (Arora-Jonsson, 2011). In summary, sex by itself does not fully explain adaptation options employed as part of one's livelihood strategy; power and class condition the impact of sex on one's adaptation choices.

This research aims to understand how sex, power and class relations influence an individual's adaptation choices in the face of economic hardship caused by resource use restrictions. I approach this problem using the framework of intersectionality as theorized in feminist literature. Intersectionality is "the interaction of multiple identities and experiences of exclusion and subordination" (Davis, 2008: 67). Studying the issue of livelihood adaptation choices through the intersectionality framework provides insights into people's behavior that

other traditional models of gender and the environment do not. If we understand the factors that intersect to make an individual more likely to employ a reactive response to crisis, we may be able to design interventions that decrease individuals' need to jeopardize their long term livelihood resiliency when dealing with the present situation. These reactive responses are otherwise known as coping (Niehof, 2004) or *ex post* risk management (de Haan & Zoomers, 2005), rather than proactive adaptation strategies (or *ex ante* risk management strategies).

In this chapter, I first outline why it is important to investigate natural resource management issues through a gendered lens. I summarize the relevant literatures on power, class and intersectionality and demonstrate how this study contributes to existing scholarship before presenting the hypotheses and research methods. In summary, I find that sex alone does not explain an individual's adaptation or coping choices; instead various configurations of sex, power and class intersect to significantly impact responses.

3.1.1 Adaptation to stresses vs. coping with shocks

Adaptation strategies are strategies used to adapt to stresses by becoming better suited to new conditions. These strategies could involve diversification of assets, pursuing new livelihoods, etc. These stresses are often anticipated and individuals therefore may take proactive measures to ensure their wellbeing. Some scholars have referred to these strategies as intentional, *ex ante* risk management decisions (de Haan & Zoomers, 2005). These proactive strategies may include arranging for or identifying possible avenues for loan procurement or building up savings.

Coping, in contrast, is a response characterized by short-term survival choices that limit future options. These *ex post* risk management strategies are reactive strategies employed many times as an "after the fact" decision, like reducing meals (de Haan & Zoomers, 2005). How a

family or individual responds to stresses throughout the year can influence how they are able to handle subsequent shocks. If they continue to successfully adapt to stresses they will be less vulnerable to the potential negative effects of shocks (Ellis, 2000). However, there may be cases where adaptations fail or stresses are so acute and long-lasting that individuals are forced to employ reactive coping, or *ex post* risk management strategies.

The key difference between *ex ante* risk management (or what I will continue to refer to as adaptation) and coping is in the anticipation of the event. In theory, an anticipated stress allows for planning. However, as mentioned above, not all individuals have the same capacity to plan ahead and sometimes the gravity of a stress may be unanticipated. As an example, I would argue that an annual closed fishing season is an anticipated annual stress to an individual's livelihood requiring adaptation. However, some individuals are unable or unwilling to prepare in advance, leading them to choose coping strategies that diminish future capacity.

3.1.1.1 Why is the issue of adaptation and coping important to explore through a gendered lens?

In various contexts, a basic sex divide has been uncovered between men's and women's abilities and options when responding to livelihood stresses or shocks. For example, in periods of prolonged stress leading to food insecurity, it is often women who are first to reduce their food consumption in order to cope with insufficient income (Kiewisch, 2015). This is an example of reactive coping, or an *ex-post* risk management strategy, that may jeopardize long-term adaptive capacity and livelihood resiliency. In the fisheries sector specifically, men and women may have different adaptation opportunities due to differential access to credit or capital, or cultural constraints. For example, Bennett (2005) argues that men typically have less access to credit than women. However, women's enhanced access to credit may not be accompanied by

autonomy over how they use credit. This lack of power then narrows the adaptation options open to them and increases their relative vulnerability.

Some feminist scholarship (Cornwall, 2003) has suggested that research and policies that focus only on women, particularly token women chosen to represent the interests of their sex, can further marginalize other women and also large segments of the male population. This practice in research can lead to the production of institutions that exacerbate existing inequitable power structures. For example, in some cases the advocacy of women's inclusion in local decision-making may reify the power of upper class/caste individuals over other marginalized groups (Cornwall 2003). Conceptualizing gender as more than just women is important. This includes incorporating men into the gender discourse, as well as acknowledging that not all women or all men have the same experience or opportunities. Ray (2007) argues that this more nuanced understanding of gender impacts could be essential in a natural resource management context. We need to examine how socially constructed attributes such as power and class intersect to condition the impact of biological sex differences. Only then can we begin to understand how gender influences adaptation choices.

3.1.2 Power

Raik et. al. (2008) examines different views of power and their associated roles in the success/failure of natural resource management (NRM) decentralization. They assert that understanding power relationships is vital in forecasting the success of natural resource management. Other scholars suggest that thus far, power has really only been analyzed in NRM (specifically fisheries development) as a binary: powerful vs. marginalized (e.g., men have power and women do not) and as a descriptor of societal spheres (e.g. men dominate the production sector and women the informal economy) (Bennett, 2005).

In feminist literature, however, power has been defined in multiple ways. By domination theorists, power has been defined as the ability of an individual to get someone else to do what they want, even if it is not in the interest of the dominated individual (MacKinnon, 1987). Empowerment theorists have argued that power is the ability of an individual to resist domination (Wartenburg, 1990). However, other scholars suggest that there are multiple manifestations of power that may play out in any single situation. Only in dissecting these multiple manifestations of power can we really understand why a situation plays out the way it does. Therefore, I adopt the definition outlined by Allen (1998), which suggests that power is the ability of an actor or set of actors to act. This definition is purposefully broad because she goes on to specify modalities of this power. To this end, she argues that in each situation different forms of power may play important roles.

The first manifestation of power is the *power to*, exhibited by the ability to get something done or to achieve an end. The second manifestation is *power over*, also known as domination or the ability to have power over someone else's choices and actions. The third manifestation of power is *power with*, or the power that is derived from a collective working together (i.e., group agency).

Power derived from networks can heavily influence an individual's adaptation options. For example, individuals without social networks beyond their communities [or with weak networks inside their communities] may be limited in alternative employment options (Putnam, 1993). In India, self-help groups (SHGs) are a type of collective that has been a popular tool for rural development. SHG membership is usually comprised largely of women. Although SHGs have had mixed success in the Indian context, their underlying premise of increasing savings and access to credit for members, as well as social empowerment, has maintained their popularity

within development circles and with the government of India (*Self-help groups: India*, 2005).

There is some evidence that women have used their collective power attained through SHGs to bypass local, male-dominated governance structures, to access state mechanisms for their community's benefit (Kruks-Wisner, 2011). This increased access to state and local decision making bodies has the potential to influence an individual's adaptation options.

Other research has highlighted women's increased use of networks to overcome unequal natural resource access arrangements. For example, to secure access to water, women use informal social networks in the absence of formal rights (Ray, 2007). Along similar lines, other research has suggested that women are more likely to invest their time and energy into strengthening social networks at the expense of building productive capital, with the aim of securing access to resources especially during times of scarcity (Berry, 1989). Finally, in research highlighting women's unequal access to market information, Young (1993) suggests that women tend to rely more on social networks, in contrast with men who rely on more formal networks. The above scholarship highlights the importance of social networks, whether it be inter or intra community networks or group membership for women, especially in gaining the power necessary to successfully adapt to changes in their livelihoods.

3.1.3 Class

Class and power have been considered by some scholars to be tightly linked (Nightingale, 2011). In line with this concept, the basic Marxian notion of class is reflective of one's role within the production sector (Marx, 1957), or class as social grouping.¹⁵ The Marxian notion of class is based on control of the means of production, which includes power over, or position

¹⁵ Other scholars view class as a social process (Resnick & Wolff, 1987). While I recognize the simplicity of the Marxian model, for the purposes of operationalizing class in an NRM context, this simplicity provides a good starting point from which other scholars may diverge.

within, the labor force. I adopt a slightly elaborated view of this concept, considering that an individual may have control/ownership of productive assets without control over others' labor. Class therefore is more than just owner vs. worker; it includes ownership of different property types, both productive and not. To this end, an individual's role within the workforce might be less a determinant of class than one's financial power (as measured through asset ownership, productive or otherwise).

I argue that there are significant differences in what kind of assets an individual owns and their ability to exploit others' labor. For example, owning multiple fishing boats is significantly different than owning one in terms of an individual's power to exploit labor in the Marxian sense. Additionally, owning land does not by itself indicate an individual's ability to exploit others' labor but it may be a definite marker of class in scenarios where the majority of individuals do not have land ownership.

Therefore, while upper class individuals may fall under the Marxian notion of class aligned with ownership of productive assets and power over the labor pool, other markers may be equally important in distinguishing classes. Middle class individuals may also have ownership over productive assets (but not necessarily control over the labor of others). The types of assets a middle class individual has may enable their own productivity but not necessarily that of others. In this way, the assets middle class individuals have are distinctly different than those of upper class individuals. Finally, lower class individuals are those who provide their labor to be exploited by others and have no productive assets of their own (Wright, 1978).

An individual's class can impact their ability to diversify to different income streams (Haque, Idrobo, Berkes, & Giesbrecht, 2015). For example, a lack of financial assets may

prohibit an individual from buying other assets that would increase their ability to diversify. This inability to diversify may then constrain an individual's other adaptation options. On the other hand, while productive asset ownership may indicate upper class, overspecialization within a particular industry, like a fishery, can limit one's adaptation options (Allison & Ellis, 2001). Financial capital is the most versatile form of capital (Kollmair & St. Gamper, 2002), and a lack of financial capital can be the primary limiting factor for diversification and adaptation (Haque et al., 2015).

An individual's sex can also impact their ability to diversify (Niehof, 2004). For example, Niehof (2004) discusses a case in Indonesia where sex and class intersect to determine the livelihood diversification options open for men and women. In this case, work for lower-class men is prevalent in their home villages whereas women of lower class households, expected to contribute to household earning, must migrate out to cities where work as petty traders and vendors is viable. Therefore, being of lower class and being a woman intersect to influence the need and social acceptance of female migration and associated ability of these women to diversify their livelihoods.

Finally, women may have less access to productive assets than men (Buvinić & Gupta, 1997). This lesser access to productive assets may lead to livelihood options that are less capital intensive. In many cases, these options may be less profitable (i.e. headloading versus mechanized fishing) but in others the lower investment costs may lead to higher relative profits. Hence, the type of productive assets owned by women and men may be quite different in certain cases, as would an individual's associated ability to exploit others' labor in the Marxian sense.

3.1.4 Intersectionality of sex, power and class

Both power and class are important factors that condition how one experiences gender. Feminist scholars argue that to understand gender, it is insufficient to look at a single piece of the puzzle, like sex or class. Instead they argue that it is actually the intersection between an individual's variable experiences with sex, power, class, and other forms of social difference that need to be examined when attempting to understand the influence of a person's gender on adaptation behaviors (Weber, 2010).¹⁶

An example of intersectionality and its impact on adaptation can be seen through gendered restrictions on movement, which limit learning opportunities that may in turn limit an individual's adaptation choices (Barrig, 2006; Ram, 1991). To this end, an individual's ability to access education or plan for certain livelihoods or professions may be influenced not only by their sex, but their power within their family, their household responsibilities, and cultural constraints on acceptable livelihoods or professions. Their ability to attend school and make choices about their future may be influenced not only by their financial ability, but class expectations of gendered behavior by individuals within their class group, among a variety of other factors. For example, Agarwal (2001) asserts that lower caste¹⁷ women in India have less strict socially dictated rules on movement and speech than upper caste women. Caste, class and power therefore intersect to condition the impact of sex differences on other outcomes.

¹⁶ Other scholars identify gender as a process, i.e. "the process through which differences based on presumed biological sex are defined, imagined and become significant in specific contexts" (Nightingale 2006: 171). In this model, an individual's gendered experience is constantly evolving, giving rise to new manifestations of gender. Given my data set (which includes one year of data), I cannot employ this process approach, though future studies may build on that understanding of gender.

¹⁷ Caste may correlate with class but in a very different way from the Marxian purely economic class.

3.1.5 Hypotheses

Based on the above literature, I hypothesize that an individual's sex, conditioned by power and class, influences adaptation and coping. As previous studies show (Kiewisch, 2015), women may be more likely than men to resort to reactive coping. I refer to this difference as the "sex divide" in coping. However, when power and class are taken into account, I expect the relationship to be further specified. For example, women with power and/or from an upper class may be less likely to resort to reactive coping that compromises their long term livelihood resilience (i.e., their ability to bounce back from shocks). Conversely, I hypothesize that women with no observable measure of power and from a lower class will be more likely to resort to reactive coping. Furthermore, males of low power and class may also pursue reactive strategies. However, I hypothesize that power and class may lead to different outcomes for men vs. women.

H1: There is a sex divide in likelihood of employing a reactive strategy, but this divide is contingent on various configurations of power and class

H1a: The sex divide is insignificant at upper class and high power levels

Null hypothesis: The sex divide is consistent at all levels of power or class

H2: Power and class have different impacts for men and women

H2a: The impact of power on the likelihood of employing a reactive strategy changes with different configurations of sex and class

H2b: The impact of class on the likelihood of employing a reactive strategy changes with different configurations of sex and power

Null hypothesis: Power and class have the same impact for men and women

3.2 The Indian Fisheries Context: A Case for analysis

The fisheries sector in Tamil Nadu and neighboring Puducherry, India was chosen as the case for analysis as it is characterized by a deeply entrenched gender division of labor (Rubinoff, 1999). The gender division of labor is not manifested simply by different jobs allocated to men versus women; it is manifested through differences in power relationships, access to resources and culturally constructed notions of an individual's capabilities (Jackson, 1993). Women are responsible for much of the pre and post-harvest activities, as are individuals of Scheduled Castes and Tribes (ICSF, 2005), who are often among the lowest class (in economic terms) as well. Within Tamil Nadu, women make up over 70% of the post-harvest workforce (CMFRI, 2010b), responsible for jobs such as headloading (selling fish house to house via baskets on their head), market vending, and fish processing, among others. Only men may work in the harvest sector, though there is also a significant male presence in more export-oriented post-harvest work, as well as transport, resupply and maintenance activities that ensure boats and crew are prepared for their next trip.

Other research has shown that the seasonal fishing ban, which halts mechanized fishing for 45 days each year in all coastal states in India, significantly impacts the income of many fishery-dependent stakeholders beyond the harvest sector (Novak Colwell, 2016). Both male and female fish traders lose a significant amount of income during this time. I therefore present the ban as an expected annual event that poses a stress to people in coastal communities. The ban may be representative of other stresses, especially stresses incurred as the result of policy decisions that limit resource access. People anticipate the ban each year, just as one may anticipate the rainy season or another policy that places yearly constraints on their livelihoods.

Despite being heavily impacted by the ban in terms of income, post-harvest sector workers, specifically women, were left out of the decision making and negotiation process of the ban's formation in Tamil Nadu. Where post-harvest traders were included, those individuals were prominent male fish traders who also owned boats (E. Vivekanandan, personal communication, May 2015). Panchayats, local traditional village governance bodies, play a leading role in rule formation at the village level. This body also plays an active role in ban enforcement within traditional fishing communities. However, over the course of data collection, it was evident that women have very limited access to this group though they may access it through SHG membership in some cases.

Original data suggest that most women, with the exception of SHG members and presidents, consider the *panchayat* as male-only, reporting they have never been involved in panchayat meetings that discuss proposed village rules. Many stated that only men participate in making the rules. This indicates that women are usually not included in village decision-making processes. Many indicated that women are not allowed in the meetings unless specifically invited. One woman indicated that one individual from every family is expected to participate, and as long as there is a male of age, that responsibility transfers to him. Therefore, there may be a representative for a woman at the meetings; however, this representation does not guarantee that the representative's interests align with those of female family members, nor does it guarantee distribution of information, either from family to panchayat or the other way around. However, when asked whether they were willing to bring up issues to the panchayat (i.e. issues that affect the whole village, like standing water), most women answered in the affirmative. So while their actual participation in decisions regarding what to do about village problems seems minimal, most feel they are able to raise issues and potentially be heard.

The majority of men, on the other hand, answered that they participate in meetings and village rule-making with the panchayat. Non-participating men often had specific reasons why they did not participate. One stated that he used to participate, but a few years ago his boat was damaged at sea and the panchayat would not help him get the insurance amount, so he therefore stopped attending meetings. Another stated that he did not participate because the panchayat is partial towards richer men in the village, so poor and middle class people do not participate because when they do the rich people do not take their opinions seriously.

When asked about panchayat participation, one boat owner stated that *Yes, I participate as they give importance to the boat owners.*¹⁸ A previous panchayatar (member of the village panchayat) indicated, when asked who participates in the meetings, that *educated people, important people, people from big families, and the panchayatars are those that participate.*¹⁹ This indicates that class also might play a significant part in an individual's relative power, as measured through participation in village decision-making. I explore these relationships in the analysis below.

3.3 Methods

3.3.1 Data collection

I collected new data to investigate these hypotheses. Data collection took place over three time periods (before, during and after the 2015 seasonal fishing ban). However, data for this paper's analysis is drawn from the second sampling frame (during the ban period) which occurred from 6-20 May 2015. This time frame was chosen because the seasonal fishing ban

¹⁸ Translations by bilingual research assistants and first author

¹⁹ The information on panchayat participation comes from original material and is important because it shows the variation in power and class among men and women.

takes place yearly in Tamil Nadu from 15 April - 29 May, meaning that responses represent behavior during the fourth and fifth weeks of the ban period.

Two villages were chosen based on 2010 Marine Fisheries Census data for Tamil Nadu (CMFRI, 2010b) and Puducherry territory (CMFRI, 2010a). One village in each territory was chosen because existing research outlined that the seasonal ban was implemented differently within each territory. In particular, this research indicated that the ban included only mechanized boats in Tamil Nadu but was expanded to include motorized boats with engines above a certain horsepower in Puducherry territory (Bavinck et al., 2008).²⁰ Villages within these territories were selected based on similarities in demographic profiles (prevalence of below poverty line (BPL) residents, education level, caste and religion), as well as similarities in boat distribution patterns (i.e. mechanized owners/laborers are in the majority in each village, though motorized boat fishing is also prevalent in both). To determine villages without significant differences in the above categories, I performed Chi Squared tests using the relevant 2010 Marine Fisheries Census data. Additionally, because of the geographical location of these areas, it was also important to select villages that experienced similar impacts from the 2004 Indian Ocean tsunami.

Based on the above criteria, the villages chosen were Nambiyar Nagar in Nagappatinam, Tamil Nadu and Kottucherry Medu in Karaikal, Puducherry. Each village was heavily impacted by the 2004 tsunami. Both areas experienced heavy loss of human life and extensive destruction of infrastructure and fishing assets. The majority of the original housing structures in each village were destroyed. As a result, both have a tsunami nagar and old nagar (Figure 3-1). The tsunami nagar in each village is a cement block housing colony built nearby to the original (old)

²⁰ However, by the time this research was conducted, field validation indicated that the ban was implemented similarly in both Tamil Nadu and Karaikal territories.

area of the village by an NGO. However, in Nambiyar Nagar, this colony was built opposite the main road in Nagappatinam, which is roughly 2.5km from the sea; whereas in Kottucherry Medu, the tsunami nagar was also built opposite the main road but within 0.5km from the sea.

Figure 3-1: Post-tsunami colony houses on left (some individuals have upgraded their basic tsunami houses as they are able to afford it) and tsunami-destroyed house on right) [photos by author]



3.3.2 Sampling methods

A random sampling strategy was used in both villages. The process used to arrive at the random sample was different in each village. Individuals were included in the sampling frame if they were a member of the fishing community and had a job either directly or indirectly related to fishing, or a job that may be impacted by fishing, given their customer base. An example of a directly related job would be harvesting or fish trading; indirectly related would be a tempo driver (transports boat supplies and catch to and from harbor); and potentially impacted may be a shop keeper or auto driver (three-wheelers) in the village. Every participant was above the age of 18. If there were multiple individuals in a household that qualified, we attempted to interview individuals with different occupations and treated them as discreet observations.

The individual was chosen as the unit of analysis because I assumed that all resources were not necessarily shared equally within the household. Given the distinct gender division of

labor within fishing communities and various occupational roles available to different individuals, allowing response at the individual level increased the likelihood of capturing the full effects of the ban on different individuals.

In Kotucherry Medu, since the village was smaller in size, we mapped both the tsunami-rehabilitated and old parts of the village and assigned unique numeric IDs to each house (Figure 3-2). Then the IDs were entered into Excel to generate a random sample.

Figure 3-2: Village map of Kotucherry Medu



In Nambiyar Nagar, it was not possible to map the village (either tsunami nagar or old neighborhoods) because the old nagar has many areas that are not clearly defined and palm huts that are built on the beach. In the tsunami nagar, there are now a significant portion of rentals to other caste and occupational groups that were not relevant for our study. Therefore, in Old Nambiyar Nagar, we did a census of the village by area (divided into North, South, Middle and

Colony) and took the father's name from each house where someone was working as part of the fishing industry. Identifying houses by father's name does not exclude female-headed households because they are still identified within the community by absentee father's name. With village consultation, this method was considered the most relevant to find and ID houses, as numeric addresses are not common. In the tsunami nagar, which is built in a grid with clearly defined house numbers, we went through house by house and removed from the potential sample list the houses that were rented by individuals engaging in occupations unrelated to fishing. In the case of Old Nambiyar Nagar, I entered fathers' names into Excel and in the case of New Nambiyar Nagar (the tsunami nagar), I entered house numbers into Excel. I then generated a random sample (equally spread across New and Old) for participation.

Between Nambiyar Nagar and Kottucherry Medu (based on CMFRI 2010 census data), there were 1851 adults over the age of 18. I weighted the sample towards Nambiyar Nagar due to its larger size. Our initial sample was comprised of 300 individuals. However, our final sample at round three included 282 individuals. The reason for the discrepancy between rounds is based on the fact we were sampling humans: a small number of people either decided they were no longer interested in the survey and/or they were consistently drunk and/or unavailable. Nonetheless, the high rate of participation (>90%) at subsequent stages provides important data about changes over different time periods. The response rate in Kottucherry Medu was 75% (i.e. out of a total of 170 individuals contacted, 127 participated in the survey). In Nambiyar Nagar, our response rate was also 75% (out of a total of 208 individuals contacted in the original random sample, 155 responded). There is no reason to believe the sample is biased as those that declined to participate or dropped out of the survey were spread across occupational groups, not centered in any particular group.

A structured survey questionnaire administered at the individual level was used to gather demographic information, community and group participation, household and productive asset ownership. A seasonal activities calendar was used to solicit information on the stresses an individual faced during this time frame and how they adapted to those stresses (Slocum, 1995). In the seasonal activities calendar, we asked individuals if they were experiencing any stress during the current month. Individuals indicated stresses such as high expenses, lower income, health problems, etc. We then asked participants to indicate how they dealt with those stresses. Individuals were given five options: Took out a loan, ask friends and relatives for help, drew on savings, cut back on food, and/or sold assets.²¹ They were asked to indicate all options they had pursued. Participants were also given the option to fill in any other way they were dealing with their current stresses. This chapter analyzes all respondents who indicated dealing with a stress during May 2015 (94% of the overall sample).

The survey questions were translated into Tamil and delivered face to face (in Tamil) with the help of two teams of two local research assistants, who I switched off accompanying daily. Additional data was collected through participant observation. I lived nearby and worked in the fishing community for the period of data collection, interacting with community members, frequenting fish markets and landing sites, attending a village panchayat meeting and local temple festivals.

3.3.3 Data

The dependent variable, *reactive strategies*, is a dichotomous variable with value=0 for those individuals employing only proactive adaptation strategies, such as asking friends and

²¹ In all cases, those individuals who chose “sold assets” indicated that they sold or pledged (as collateral to a bank) their gold.

relatives for help, drawing on savings or taking a loan, versus those employing reactive coping (value=1) such as selling assets or cutting back on food. The delineation between adaptive vs. reactive is drawn from Corbett's (Corbett, 1988) work on famine in sub-Saharan Africa where modifying food intake and selling assets are considered reactive responses to crisis. While in Corbett's analysis, taking a loan is considered reactive coping, I argue that in the context of TN fishing villages, taking a loan is a very common occurrence and not a last-ditch strategy. Taking a loan from an institution indicates you have sufficient assets for collateral while taking a loan from neighbors is a form of social network building. Additionally, many individuals report planning to take loans during the ban period because they can repay the loan post-ban with the help of government ban compensation (usually received in late June or early July). This indicates an adaptation or *ex ante* risk management strategy. Many individuals do employ multiple strategies. I coded responses as reactive if they employ any reactive coping, even if they also pursue *ex ante* adaptations.

Power relationships and class differences between individuals play an important part in producing varied experiences of gender (Jackson, 1993). I therefore operationalize sex, power and class by looking at the following measurable indicators as outlined in Table 3-1 below.²² First, sex is operationalized as male vs. female based on respondent self-identification.²³

There are a number of different ways to operationalize power in line with Allen's facets of power. The first facet is Power Over, which is operationalized by one variable: *Power1* is Panchayat membership or prior membership, of which there are very few observations ($n=7$), all of whom are male. I do not expect this measure to play a significant role in explaining an

²² Caste has been argued to be an important conditioning factor of sex as well (Nightingale, 2011). As caste does not vary in our sample (our entire sample was from the same caste: *Pattinavar*) we are able to focus on other factors such as class and power.

²³ Although there is a significant literature on how to define gender, and in particular, sex, our entire sample self-identified as either male or female.

individual's likelihood of turning toward a reactive strategy. However, panchayatars have significant sway over village happenings at every level from the personal (marriage disputes) to higher level inter-village negotiations on fishing rules.

The second facet is Power With as measured by variable *Power2*: participation in an SHG, political party or panchayat meeting. This is a measure of the power derived from group agency. This measure is relevant because some women report SHG members being involved in panchayat meetings, indicating that in some cases women may use this avenue as a means of access to village decision-making powers (i.e. an individual has a network that enables power to achieve certain goals). Women may also use SHGs to access large group loans, something unachievable as an individual. Men also either indicated that they participate in panchayat meetings or political parties to make the village better and contribute to positive change.

The third facet is Power To which is measured by two variables. The first variable is *Power3*: report of notifying the panchayat of a village problem. This type of power is derived from an individual's willingness to bring an issue to the attention of village authorities and be confident that their voice will be heard and taken seriously (i.e. the power to act). The second variable is *Power4*: whether an individual has a network outside of their village or villages within their direct vicinity. The logic behind the P4 variable is that individuals with contacts in major cities or other countries may have enhanced ability (i.e. power) to adapt by finding alternative work.²⁴

There are two explanatory variables for class, both of which are based on financial capital measurements and one's status in the labor process. *Class 1* is a measure of fishing asset

²⁴ I acknowledge the possibility there may be omitted variable bias concerning the way in which an individual obtains these measures of power. The perceived ways in which individuals achieve the various measures of power are controlled for in the analysis except for the measure *panchayatar* which is achieved through processes not indicated in the data.

ownership spanning from no assets (value=0) to those owning multiple boats (value=4). One drawback of this measure is that it artificially deflates class representation for the small sample of individuals working in fishing-unrelated work, such as auto drivers or shop owners. However, I still include this variable for analysis as relationship to production within the fish-related sectors is an explanatory variable of interest that may be relevant in some cases. The second measure of class is *Class 2*, which indicates ownership of household assets. Those with high levels of wealth are indicated by ownership of land or an air conditioning unit. Those with middle wealth are indicated by ownership of at least two of the following three assets: refrigerator, gas stove and mixy-grinder. Finally, the lowest class is indicated by possession of a government TV. TVs are given by the government but are of poor quality and very small. All individuals who can afford to upgrade to a bigger TV do so. These divisions are based on extensive local consultation regarding the bundle of assets that divide social classes. This measure of class is our operationalization of class as a manifestation of financial power (Nightingale, 2011) while fishing asset ownership is our operationalization of role within the production sector.

Table 3-1: Dependent and independent variable matrix

Variable	Type	Male <i>n</i>	Female <i>n</i>	Values
Dependent: Reactive coping	Dichotomous	132 adaptive only 37 reactive	61 adaptive only 34 reactive	0=adaptive strategy only 1=reactive strategy
Independent: Sex	Dichotomous	169	95	0=Male 1=Female
Power1: Panchayat member	Dichotomous	7/169 are members	0/84 ²⁵ are members	0=Not a member 1=Panchayat member
Power2: Participation (in SHG, political party or panchayat meetings)	Dichotomous	141/169 participate	51/84 participate	0=No group participation 1=Group participation
Power3: Report of problem to panchayat	Dichotomous	122/169 report	35/84 report	0=Would not report problem 1=Reports problems
Power4: Outside village network	Dichotomous	146/169 have networks	55/95 have networks	0=No outside local villages network 1=Outside local villages network
Class1: Asset ownership-Fishing	Ordinal	0=88 1=1 2=2 3=32 4=5	0=58 1=19 2=1 3=15 4=2	0(none)-4(multiple boats) 1. fishing baskets/boxes 2. fishing nets only 3. boat 4. multiple boats
Class2: Asset ownership-Household	Ordinal	1=48 2=95 3=26	1=52 2=39 3=4	1(low)-3(high) 1. low: Gov't tv 2. mid: Refrigerator+gas stove+Mixy-grinder 3. high: Land/AC
Control variable: Education	Ordinal	0=13 1=72 2=28 3=6	0=55 1=30 2=9 3=1	0-3 0. No education 1. Primary school 2. High school 3. College +

²⁵ Please note that some women were not presented the full survey due to time constraints. Therefore, analyses including these variables have a smaller total number of observations.

3.3.4

3.3.5 Analysis

Chi-squared Test of Independence was used to assess whether adaptation strategy (partitioned into the five possible adaptive/coping choices) differed by sex. Logistic regressions were run in Stata with each independent variable separately to determine main effect significance. These results indicated that, of the predictor variables, only sex and C2-Household assets are significant (at the $p < 0.1$ level) in predicting an individual's likelihood of resorting to reactive coping. Due to the large number of combined variable possibilities, Minitab software was utilized to perform stepwise linear regression for variable selection. Stepwise linear regression converges on main effect and interaction effect predictors that best explain the model outcome (i.e. an individual's likelihood of resorting to reactive coping). All predictor variables were included in Minitab for variable selection. Variable selection indicated that the main effects variables sex, P1-Panchayat and C2-Household assets explained the outcome of the model best. Additionally, the variable selection process indicated the interactions between C2-Household assets and P4-Network, as well as sex and P3-Notify as interactions that best explain model outcome. After variable selection, STATA was used to model the relationships among selected variables and the outcome variable (reactive coping) using logistic regression (example equation below).

$$\text{logit}[P(\text{reactive coping} = 1)] = \alpha + \beta_1 \text{Sex} + \beta_2 \text{P4Network} + \beta_3 \text{C2HouseholdAssets}$$

This method was chosen because the dependent variable is dichotomous (indicating whether or not an individual resorted to reactive coping).

3.4 Results and discussion

3.4.1 Is there always a sex divide regardless of power and class?

The literature suggests that there is a relationship between sex and the deployment of reactive coping. Results from the chi squared test of independence (Table 3-2) indicate that this relationship holds within our data set as well ($X^2(4, N=264) = 27.73, p<.01$).

Table 3-2: Chi-squared test of independence indicating relationship between sex and adaptation/coping strategy utilized

Strategy	Male	Female
Savings	54	13
Ask relatives for help	28	7
Took loan	98	72
Pledged jewels	27	24
Cut back on food	6	15

df=4, $X^2 = 27.73, p<.01$

However, the regression results for the likelihood of resorting to a reactive coping strategy as predicted by sex, power and class measures are presented in Table 3-3. As hypothesized, women are more likely than men to pursue reactive coping strategies (Table 3-3, model 1) ($b=0.69, p=0.02$), though this effect does not hold when controlling for both main effect variables and interaction effect variables, possibly due to substantial correlation with these other variables (Table 3-3, model 2 & 3). In other words, the sex divide is driven by other factors that are correlated with sex, such as power and class.

Additionally, although the sample of *panchayatars* is small ($n=7$) and completely male dominated, when controlling for sex and class effects, being a *panchayatar* actually increases the likelihood of reactive coping (Table 3-3, models 2 & 3; $b=1.36, p=0.10$). This is an unexpected

result given that *panchayatars* generally are of higher power (due to their position) within the village and therefore not expected to need to resort to reactive coping. In examining the data, individuals in this group who resorted to reactive coping do so solely by selling assets (i.e. pledging gold to the bank) and not cutting back on food. Two of the three individuals in this group who resorted to reactive coping have ownership of one or multiple boats, making ban time maintenance costs quite high. This may suggest that being in an upper class category and owning inflexible assets necessitates high spending. This gives additional evidence in line with current scholarship indicating that overspecialization in a particular industry can limit adaptive options (Allison & Ellis, 2001). If an individual cannot meet their expenses, it forces them to react. However, the implications of upper class/higher power individuals pledging gold may be vastly different than those individuals of lower class/power doing the same. Within the fishing village, pledging gold and taking a loan are considered two different things. There are two scenarios: an individual pledges gold (i.e. sells it to the bank²⁶) knowing they will be able to buy it back with interest OR an individual pledges gold to the bank (i.e. sells it to the bank) knowing that they will not be able to buy it back (with the compounded interest). Given the earning potential of mechanized boat owners, scenario one may be more likely here, though future research can disaggregate this category with additional survey questions. Upper class/ higher power individuals may use gold as collateral in times of short-term need, under the assumption that post-ban profits will allow them to recoup their gold for the next time, similar to other loan arrangements. It is also of note that these individuals have assets to sell and do not have to resort to cutting back on food to reduce expenses. Nonetheless, the reliance on interest to recover pledged gold still reduces these individuals' available capital for future efforts. This finding

²⁶ A brief account of gold bank loans is included in Sinha's (2005) account of informal credit sources and microfinance in India (Sinha, 2005).

highlights the importance for future analysis of disaggregating adaptation and coping responses into their component parts (i.e. taking a loan, cutting back on food, etc.) to understand more nuanced patterns in individuals' options. Also, a further exploration of the meaning and use of gold by different segments of the population is warranted.

Lastly, an individual's likelihood of resorting to reactive coping strategies decreases with increasing levels of household assets (Table 3-3, model 2, $b=-0.50$, $p=0.04$). Selling productive household assets has been shown by some scholars to be a primary coping strategy of individuals and families in times of need (Allison & Seeley, 2004). Our results indicate that having ownership over additional productive household assets decreases your likelihood of resorting to reactive coping (i.e. selling those assets), though this result loses significance when some additional controls are included in the model (Table 3-3, model 3).

Table 3-3: Logistic regression results for factors impacting an individual's turn toward reactive coping using sex first, then including main effects variables, followed by two-way interactions in Stata

Variable	(1) Bivariate logistic regression for overall sex divide	(2) Regression with main effects variables	(3) Regression with main effects & 2-way interactions selected by step-wise regression
Sex (female)	0.69** (0.28)	0.50* (0.31)	0.41 (0.48)
P1-Panchayatar		1.36* (0.81)	1.31* (0.82)
P3-Notify			0.17 (0.43)
P4-Network			-0.12 (0.98)
C2-Household Assets		-0.50** (0.25)	-0.47 (0.52)
C2*P4			-0.06 (0.59)
Sex*P3			0.24 (0.64)
Constant	-1.96*** (0.43)	-0.43 (0.47)	-0.28 (0.94)
N	264	253	253
Pseudo R ²	0.02	0.03	0.04

P<0.1*, p<0.05**, p<0.01***

3.4.2 Is there a sex divide in the likelihood of reacting at all class and power levels?

I hypothesized that the sex divide is contingent on levels of power and class, such that the sex divide in reactive coping would not exist at upper class and high power levels. The data suggests that the sex divide is only significant when individuals have no external network (i.e.

have low power) (Table 3-4) ($b=1.46$, $p=0.02$). The sex divide is insignificant ($b=0.25$, $p=0.49$) when people have a network (i.e. higher power). Additionally, the sex divide is only significant at low class levels (0.73 , $p=0.08$). Based on this evidence, we can reject the null hypothesis in support of the first alternative hypothesis: there is a sex divide in likelihood of employing a reactive strategy, but this divide is contingent on various configurations of power and class.

Table 3-4: Impact of sex on reactive coping for various configurations of power and class

Variable	No Network	Network	Class1	Class2	Class 3
Sex	1.46**(0.63)	0.25 (0.36)	0.73*(0.42)	0.32 (0.46)	0.11 (1.24)
Constant	-1.56 (0.55)	-1.23*** (0.20)	-0.89*** (0.32)	-1.52*** (0.27)	-1.20*** (0.47)
N	63	201	100	134	30
Pseudo R2	0.07	0.00	0.02	0.00	0.00

$p<.1^*$, $p<.05^{**}$, $p<.01^{***}$

3.4.3 Do power and class have different impacts for men and women?

I then hypothesized that power and class have different impacts for men and women. The data support this hypothesis. For women, being connected to an external network significantly decreases their likelihood of resorting to reactive coping strategies ($b=-1.03$, $p=0.02$). In contrast, neither connection to an external network nor household asset ownership significantly impacts men's likelihood of reacting.

Table 3-5: Impact of power and class on reactive coping for men and women

Variable	Women	Men
P4-Network	-1.03**(0.45)	0.36 (0.59)
C2-Household	-0.17 (0.39)	-0.28 (0.29)
Constant	0.32 (0.61)	-1.08 (0.74)
N	95	169
Pseudo R2	0.05	0.00

p<.1*, p<.05**, p<.01***

This indicates that the outside village network may play an even greater role for women than men in enabling them to draw on extra resources during times of hardship. These extra resources may give them the power to adapt and successfully employ *ex ante* risk management strategies versus *ex post* coping reactions.

Additionally, the data suggests that class matters for women with an external network (Table 3-6) (b=-1.04, p=0.08), but not for other groups. Partitioning by class level (Table 3-7), men who are networked are no less likely to react than if they were not connected. However, middle to upper class networked women significantly benefit from being networked (b=-1.69, p=0.04).

Overall, these results suggest that women, unlike men, require some additional support – networked power and/or household assets – in order to avoid reactive responses to seasonal livelihood stress. However, in line with Arora-Jonsson’s (2011) warning, this outcome also highlights disparities among women, demonstrating the need for decision makers to confront more nuanced gender differences rather than the simplistic sex divide.

Table 3-6: Impact of C2-Household assets on reactive coping for non-networked and networked women and men

Variable	Women without a network	Men without a network	Men with network	Women with network
C2-Household	-0.38 (0.58)	0.05 (1.04)	-0.31 (0.30)	-1.04* (0.59)
Constant	0.40 (0.82)	-1.64 (1.90)	-0.67 (0.59)	0.62 (0.93)
N	40	23	146	55
Pseudo R ²	0.01	0.00	0.01	0.05

p<.1*, p<.05**, p<.01***

Table 3-7: Impact of P4-Network on reactive coping for women and men of low and med/upper class

Variable	Low class women	Med-upper class women	Low class men	Med-upper class men
P4-Network	-0.19 (0.56)	-1.69** (0.81)	1.02 (1.31)	-0.08 (0.70)
Constant	-0.07 (0.37)	-0.18 (0.61)	-1.79* (1.08)	-1.47** (0.64)
N	52	41	48	96
Pseudo R ²	0.00	0.10	0.02	0.00

p<.1*, p<.05**, p<.01***

3.5 Conclusion

In the beginning of this chapter, I asserted that looking at NRM issues through a lens of intersectionality provides valuable insight into people's livelihood choices that traditional models of gender and the environment do not. By examining gender as intersecting arrangements of sex, power and class, I demonstrated that sex by itself does not explain differences in livelihood adaptation and coping choices. The relationships previously identified by scholars regarding

gender and the environment, and the sex divide in reactive coping, may not be driven by sex alone, but rather by configurations of power and class within each sex.

In particular, this research confirms the importance of networks, particularly for women, in adapting to livelihood stresses. However, this research also suggests that networks do not have the same significance to all individuals, whether male or female. When examining the importance of networks to individuals, an enhanced understanding of their utility may be derived from an understanding not only of an individual's sex but also of their class.

In this study, by incorporating these components and how they interact with each other, I showed characteristics of individuals that are more likely to resort to reactive coping. This information can be used to design relevant and effective interventions that build individuals' livelihood resiliency. The findings indicate the utility of initiatives that help individuals build the tools necessary to ensure sustainable livelihoods. Based on the data, it may be worthwhile to focus interventions on building certain high-risk groups' networks to decrease an individual's need to resort to strategies that have negative livelihood implications. However, this strategy may not work for those who may need additional assets first in order to benefit from networks.

I expect these results to be generalizable to other caste-homogenous areas. However, because caste is such an important facet of an individual's identity in India, future research should incorporate other caste groups into the sample. Additionally, our sample was drawn from two villages that were heavily impacted by the 2004 Indian Ocean Tsunami. This event had a huge impact on social networks and community cohesiveness: large segments of the surviving population in each village moved to newly constructed housing colonies of varying distances from the old areas of each village. Research on displaced individuals in other contexts has suggested that the displacement faced by individuals after a major disaster severs social

networks, greatly impacting an individual's ability to adapt or cope with livelihood fluctuations (Berry, 1989). Additionally, the aid that arrived post-tsunami was so extensive that it was termed "the second tsunami" (Kruks-Wisner, 2011). For these reasons, it is probable that indicators of power and class within tsunami affected areas are different than in other areas, particularly due to the widespread distribution of aid post-tsunami. For this reason, when conducting NRM research that incorporates intersectionality, it is important to assess locally relevant measures of power and class. Blanket measurements that are not contextualized, such as household asset ownership, may have different impacts in other settings.

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4 Unintended consequences of a seasonal ban on fishing pressure

4.1 Introduction

One goal of regulating resource-use activity is to extend the life and health of the resource in order to maximize long-term economic gain or employment. Social and ecological contexts therefore moderate the impact of any regulation. As a result, in the absence of complementary regulations or social initiatives, there is the potential for adverse and unintended consequences to occur.

There are a wide range of examples in the literature on the unintended consequences and tradeoffs of resource management regulations. For example, Berkes and colleagues (Berkes, 2010; Berkes et al., 2006) describe the effects of “roving bandits”. In this situation, spatial harvest regulations may be enforced in one area, but individuals adapt to these restrictions by shifting their effort to the next unregulated option. The successful implementation of one regulation may then unintentionally induce widespread overharvest over a large geographic range. Due to fishers’ extensive range, and rapid adaptations by resource users, problems with overexploitation may go unnoticed in the local context until it is too late.

Other research suggests a phenomenon called the “race to fish”: when there are limited seasons, there is a build-up of capital such that fishers rush out and capture fish as soon as the season opens. This race to fish may actually cause a reduction in the number of fishable days, as seen in the Peruvian anchoveta fishery (Tveteras, Paredes, & Peña-Torres, 2011). Additionally, a number of scholars have outlined a similar race to fish driven by higher catch rates. In this case, fishers race to catch fish during times of abundance and taper effort during periods of low catch (Emery, Hartmann, Green, Gardner, & Tisdell, 2014; Novak & Axelrod, 2016). These

times of abundance may be related to seasonal variability or any number of fisheries management regulations such as ITQs or seasonal closures.

Fisheries scientists and resource governance scholars are concerned with both roving bandits and the “race to fish”. Both raise concerns that managers overlook indirect effects when they regulate behavior at a given time and place. They may fail to consider a host of possible human adaptations when implementing a certain policy (for instance, one species is banned, thereby instigating overfishing of another species). These outcomes are unintended consequences of resource management regulations. For example, a seasonal closure on Hilsa shad (*Tenuulosa ilisha*) fishing in Bangladesh actually caused some fishermen to switch from targeting other species to targeting Hilsa so that they could become eligible for government relief schemes (Islam, Mohammed, & Ali, 2016). In this case, an increase in Hilsa shad fishers was an unintended policy outcome and this human adaptation in turn threatened the resiliency of the ecological system under the new rules.

In order to study unintended consequences, I examine the case of a closed fishing season (or seasonal ban) in India. I argue that resource regulations do not work unless accompanied by additional measures that mitigate their social impacts. Scholars have demonstrated that modularity and redundancy help achieve a robust and resilient system (Adger, Hughes, Folke, Carpenter, & Rockström, 2005; Huitema et al., 2009). This means that there should be more than one regulation with the same goal. Other scholars argue that it would actually be worthwhile to get rid of institutional redundancy, as building institutions involves high start-up costs (Mitchell, 2008). Still others have demonstrated that having multiple rules or regulations pertaining to the same system (i.e. legal pluralism) may enable resource users to choose one regulation at the expense of implementing others if they are not carefully coordinated (Novak &

Axelrod, 2016). This study addresses these conflicting arguments by demonstrating how unintended consequences may emerge in the absence of complementary measures. I hypothesize that in the absence of complementary regulations, resource users adapt by innovating different ways to exploit resources, and that these innovations potentially threaten the resiliency of the system.

4.1.1 Fisheries regulation: A seasonal ban on fishing

The seasonal fishing ban is one resource management tool that has been widely implemented and appears to have had a positive impact both in India and elsewhere (Vivekanandan, Narayanakumar, Najmudeen, Jayasankar, & Ramachandran, 2010). However, the possibility of unintended consequences is ripe for exploration to determine whether the benefits are as substantial as expected. Many countries around the world implement seasonal moratoria on specific types of fishing or harvest of specific stocks. For example, over a dozen countries impose seasonal bans on shrimp trawling. These bans range in duration from 45 days to 9 months (in the case of New Zealand) (Vivekanandan et al., 2010). Shrimp trawling bans are intended to prevent destruction of benthic habitat and associated consequences on trawled ecosystems (Stilles, Stockbridge, Lande, & Hirshfield, 2010; Watling & Norse, 1998). Conversely, management efforts such as bans may lead to increased fishing effort of other types.

4.1.2 The seasonal fishing ban in India: The case for analysis

In India, the seasonal fishing ban is a fisheries management mechanism whose dual aim is protection of spawning species as well as conflict resolution. It is a closed season for all mechanized boats, and not species-specific. Indian marine fish stocks have become seriously depleted, threatening millions of fisherfolk livelihoods. The depletion of fish stocks also

enhances the risk of conflict between fishers of various boat types, particularly mechanized vs. non-mechanized. The ban aims to mitigate this risk (Bavinck et al., 2008).

One of the main criticisms of the fishing ban by fisheries professionals in India is that it is the only state-administered, effectively enforced regulation so its full potential is not realized due to the lack of complementary rules (E. Vivekanandan, personal communication May 2015; Vijayakumaran, personal communication, April 2015). There are many regulations on the books, such as net and gear restrictions that are specifically recorded in the Tamil Nadu Marine Fisheries Act of 1987. However, they are mainly paper policies in practice, meaning that despite the presence of these complementary regulations, enforcement is lacking.

The ban is enforceable because it was jointly created with fishing communities and Fisheries Departments. Due to this joint creation, it has a high degree of legitimacy, therefore allowing it to be enforced at many levels (Novak & Axelrod, 2016). In contrast, fishers continue to use a state-level banned gear (purse seine or *surukku valai*) where the gear was banned without the mutual support of fishing communities. At the district Fisheries Department level, the seasonal ban is enforceable because it limits trawlers from leaving the harbor. Fisheries scientists in Tamil Nadu suggested that once you let boats leave the harbor, enforcement of regulations such as mesh size restrictions or spatial restrictions on fishing are nearly impossible to enforce (E.Vivekanandan, personal communication, May 2015). During the ban time, the harbor is closed and tax free diesel (normally provided by the Fisheries Department) is unavailable. If there is an emergency at sea during this time involving a banned boat, the Fisheries Department will not send help (Nagappatinam Fisheries Department, personal communication, 2015).

At the grassroots level, local village governance bodies (*panchayats*) also support ban enforcement by administering penalties on those who break the regulation, including heavy fines, boat impoundment, and catch confiscation (Panchayatar, Nambiyar Nagar, 2015). These disincentives are perceived as a type of social ostracization and in many cases are the real deterrent against prohibited ban-time fishing. All of these disincentives, both at the Fisheries Department and local level, and the clear enforcement/monitoring process make the ban easily enforced in Tamil Nadu.

However, because the ban includes mechanized boats only²⁷, there is growing dissatisfaction within fishing communities and the Fisheries Department regarding fairness of expanding the ban to other vessels. Mechanized fishers claim that motorized fishers exert significant pressure on the fishery during the ban period, innovate new gears to catch more fish, and consequently should be included in the ban. Some fisheries professionals in India suggest the ban could be effective in sustaining fish stocks if it is more widely extended to include smaller motorized boats, coupled with gear restrictions (Vivekanandan et al., 2010). During field interviews, many mechanized fishers advocated for motorized boats above a certain horsepower to be included in the ban. However, this expansion would be difficult to monitor.

Additionally, a gear type that is illegal at the state level, locally termed *surukku valai* or purse seine, requires one mechanized and eight to ten motorized boats for operation. Despite failure to enforce restrictions on *surukku valai* throughout the year, these operations stop during the ban due to mechanized vessel restrictions. However, individual motorized boats that are a part of this operation continue to fish independently during the ban period. As a result, the ban does not eliminate this substantial portion of fishing effort.

²⁷ All boats with engines over 25 hp

Due to the range of options still available for fishermen during the ban period, it is worthwhile to quantify the actual impact of the ban in terms of fishing effort. While mechanized boats account for around 37% of the craft and 75% of the catch in the Indian coastal fishery, motorized boats still account for roughly the same percentage of craft and land approximately 23% of the total yearly catch (CMFRI, 2015a). Previous research has suggested that the motorized segment of the fleet does quite well during the ban time (Bavinck et al., 2008), implying that they exert some level of fishing pressure over the course of the closed season.

Other research has shown that the fishing ban effectively curbs a projected annual increase in total effort, though post-ban (June-July) mechanized effort increases by 10% on average in comparison to pre-ban²⁸ effort (Vivekanandan et al., 2010). However, there is no evidence that the ban is effective in terms of sustaining fish populations (Vivekanandan et al. 2010). Additionally, there is a dearth of information on what fishers actually do during the ban period. Research by Bavinck and colleagues (Bavinck et al., 2008) outlines that mechanized fishers have difficulty finding alternative jobs. They indicate that many from traditional fishing communities continue fishing but with smaller vessels, while others migrate to the West coast where they fish on mechanized boats (the closed season is at a different time on that coast). Non-traditional fishers find alternative employment in agriculture, construction or other odd jobs.

Based on the above literature and background information, I expect motorized fishers to exert significantly more effort during the ban period than they do before or after the ban period due to low competition and high price received upon landing. I also expect that mechanized boats and *surukku valai* operations will exert significantly more fishing effort post ban than

²⁸ Pre-ban is considered a middle season in terms of catch and associated effort (which is correlated with fish abundance) along the Tamil Nadu coast. The ban period is scheduled during what is considered a low season for the Tamil Nadu fishery, while post-ban is considered a high season.

before the ban as they race to fish in order to adapt to lost income during ban time. Finally, based on reported post-ban benefits, I expect that fishers will support an additional ban period or ban extension.

4.2 Materials & Methods

To address these expectations I first quantify the differences in fishing effort over different seasons.²⁹ I do this for all boats together and then partition by boat type, with special emphasis on mechanized boats and *surukku valai* before vs. after the ban. I also quantify the effort of motorized boats before, during, and after the ban. Although previous research has shown that the ban does limit the otherwise predicted annual increase in mechanized effort if there were no ban, there has not been a quantification of *surukku valai* effort during any season nor motorized effort during the ban period.

Quantifying these effort types is important to understand overall changes in effort that result from the seasonal ban policy. More specifically, I want to understand whether mechanized and *surukku valai* effort intensifies post-ban as fishermen “race for fish”, an indication of a temporal rather than spatial roving bandits scenario. This information could help inform as to what follow-up measures (i.e. complementary regulations) would be necessary to ensure the continued benefits of the fishing ban, as fishermen currently report an increased catch per effort for 1-2 weeks post ban. Additionally, I explore whether people adapt to the ban by putting pressure on other resources.

²⁹ Fishermen recount that seasonality is an inherent part of fishing. Seasonality in catches occurs not only by season but by year. In this study, I was able to account for three seasonal variations in effort. This three-season account offers a jumping-off point for future research or other scholars to conduct a multi-year study to account for yearly differences in catch and effort.

Pairing the catch per effort post ban with landing data collected by the Central Marine Fisheries Research Institute, I then project how much fish is caught (by weight) post-ban by boat type, as an indicator of ecosystem impacts. Finally, I use the quantitative data on fishing effort with qualitative data on fisher support of ban changes to project how fishing effort may change if the ban is expanded to motorized vessels, extended temporally, or repeated during another season.

4.2.1 Study location

Two villages were chosen based on 2010 Marine Fisheries Census data for Tamil Nadu (CMFRI, 2010b) and Puducherry territory (CMFRI, 2010a). I chose one village in each territory because existing research outlined that the seasonal ban was implemented differently within each territory. In particular, this research indicated that the ban included only mechanized boats in Tamil Nadu but was expanded to include motorized boats with engines above a certain horsepower in Puducherry territory (Bavinck et al., 2008).³⁰ Villages within these territories were selected based on similarities in demographic profiles (prevalence of below poverty line (BPL) residents, education level, caste and religion) as well as similarities in boat distribution patterns (i.e. mechanized owners/laborers are in the majority in each village, though motorized boat fishing is still prevalent in both). To determine villages without significant differences in the above categories, I performed Chi-Square tests using the relevant 2010 Marine Fisheries Census data. Additionally, because of the geographical location of these areas, it was also important to select villages that experienced similar impacts from the 2004 Indian Ocean tsunami.

³⁰ However, by the time this research was conducted, field validation indicated that the ban was implemented similarly in both territories.

Based on the above criteria, the villages chosen were Nambiyar Nagar in Nagappatinam, Tamil Nadu and Kottucherry Medu in Karaikal, Puducherry. Each village was heavily impacted by the 2004 tsunami. Both areas experienced heavy loss of human life and extensive destruction of infrastructure and fishing assets. The majority of the original housing structures in each village were destroyed. As a result, both have a tsunami nagar and old nagar (Figure 4-1). The tsunami nagar in each village is a cement block housing colony built nearby to the original (old) area of the village by an NGO. However, in Nambiyar Nagar, this colony was built opposite the main road in Nagappatinam, which is roughly 2.5km from the sea; whereas in Kottucherry Medu, the tsunami nagar was also built opposite the main road but within .5km from the sea.

4.2.2 Research permits and ethics

Permission to conduct research was first provided by local NGOs engaged in each village. The village *panchayats* (local, informal village governance bodies) then provided permission to work within their village. The relevant Fisheries Departments were then notified in each district. Every participant was above the age of 18. Clearance for Human Subjects Research was provided by Michigan State University's Institutional Review Board case x14-1145.

Figure 4-1: Post-tsunami colony houses on left (some individuals have upgraded their basic tsunami houses as they are able to afford it) and tsunami-destroyed house on right.



4.2.3 Sampling methods

We used a random sampling strategy in both villages. The process used to arrive at the random sample was different in each village. Individuals were included in the sampling frame if they were a member of the fishing community and had a job either directly or indirectly related to fishing, or a job that may be impacted by fishing, given their customer base. If there were multiple individuals in a household that qualified, we attempted to interview individuals with different occupations and treated them as discreet observations. For this chapter, only fishers' responses are included in the analysis.

In Kotucherry Medu, since the village was smaller in size, we mapped both the tsunami and old parts of the village and assigned unique numeric IDs to each house (Figure 4-2). Then, the IDs were entered into Excel to generate a random sample.

Figure 4-2: Village map of Kotucherry Medu



In Nambiyar Nagar, it was not possible to map the village (either tsunami nagar or old neighborhoods) because the old nagar has many areas that are not clearly defined and palm huts that are built on the beach. In the tsunami nagar, there are now a significant portion of rentals to other caste and occupational groups that were not relevant for our study. Therefore, in Old Nambiyar Nagar, we did a census of the village by area (divided into North, South, Middle and Colony) and took the father's name from each house where someone was working as part of the fishing industry. Identifying houses by father's name does not exclude female-headed households because they are still identified within the community by absentee father's name. With village consultation, this method was considered the most relevant to find and ID houses, as numeric addresses are not common. In the tsunami nagar, which is built in a grid with clearly defined house numbers, we went through house by house and removed from the potential sample

list the houses that were rented by individuals engaging in occupations unrelated to fishing. In the case of Old Nambiyar Nagar, I entered fathers' names into Excel and in the case of New Nambiyar Nagar (the tsunami nagar), I entered house numbers into Excel. I then generated a random sample (equally spread across New and Old) for participation.

Between Nambiyar Nagar and Kottucherry Medu (based on CMFRI 2010 census data) there were 1851 adults over the age of 18. I weighted the sample towards Nambiyar Nagar due to its larger size. Our initial sample was comprised of 300 individuals. However, our final sample at round three comprised 282 individuals, of which 171 individuals actually fished. The reason for the discrepancy between rounds is based on the fact we were sampling humans: a small number of people either decided they were no longer interested in the survey and/or they were consistently drunk and/or unavailable. Nonetheless, the high rate of participation (>90%) at subsequent stages provides important data about changes over different time periods. The response rate in Kotucherry Medu was 75% (i.e. out of a total of 170 individuals contacted, 127 participated in all stages of the survey). In Nambiyar Nagar, our response rate was also 75% (out of a total of 208 individuals contacted in the original random sample, 155 responded at all stages).³¹

4.2.4 Data collection methods

All data collection, both survey and interview, was conducted in Tamil. Data was translated on the spot by bilingual research assistants and the author. When in doubt of a particular translation, the issue would be brought to weekly team meetings and discussed between all research assistants and myself to come to a final translation.

³¹ There is no reason to believe that the sample of fishermen contains a systematic bias as we returned to the randomly selected houses multiple times to allow for response if fishers were not available. However, the possibility exists.

Individual-level surveys were administered to each respondent. Seasonal activities calendars were used as part of this larger, individual-level survey (delivered in Tamil) to quantify fishing effort over the three time periods. All fishers ($n=171$) were asked to specify the hours per day, days per week and weeks per month they spent fishing their particular boat type. They were also asked to specify their fishing grounds during different seasons and fishing asset ownership.

Semi-structured interviews were administered to each fisher surveyed. Interview questions asked fishermen how they prepare for the ban period, what work they do during the ban period (if any), what they did prior to ban implementation during April/May, and if they would support a ban extension or additional ban. This data was then used to assess the legitimacy of, and likely compliance with, ban changes.

4.2.5 Statistical analysis

4.2.5.1 *Relevant variables for analysis*

The variables included in the statistical analysis of fishing effort can be found in Table 4-1. The primary variable of interest is *total fishing hours/month*. As outlined above, during each time frame, individuals were asked to specify how many hours/month they fished. This variable measures the total time out of harbor (i.e. from departure to landing).³² We then examined whether effort hours differed across *timeframes*, defined as pre-ban (the month of February or March), during ban (the month of May) and post ban (the month of June) for each *boat type*, defined as mechanized (which is banned during the ban), motorized, and *surukku valai*.

³² Time out of harbor does not directly reflect time actively spent fishing. Mechanized trawl boats actively trawl for four to five hours at a time and they travel anywhere from two to ten hours to reach a fishing ground. Motorized boats travel anywhere between one to ten hours to a fishing site, and the nets are set for four to five hours before being hauled in. *Surukku valai* operations have an average land to sea travel time of three hours to reach suitable fishing grounds. After the net is set, it is left in place for roughly three hours. They may set the net up to four times (i.e. hauls) in one trip if catch is high.

Table 4-1: Variable matrix

Variable	Type	Response value
Dependent: Total fishing hours/month ($n=489$)	Continuous	0-672
Indpenedent1: Timeframe	Categorical	Pre-ban, Ban, Post-ban
Independent2: Boat type	Categorical	Mechanized, motorized, <i>surukku valai</i>

4.2.5.2 Analysis of fishing effort data

Fishing effort data over three seasons was analyzed using ANOVA methods. If significant differences are found between means, associated post-hoc tests determine the source of those differences. First, all effort from each boat type (mechanized, motorized and *surukku valai*) was taken together as total effort in time frame one (pre-ban), timeframe two (ban) and timeframe three (post-ban). The means were then compared, to understand whether there are significant differences in mean effort across time periods. If there is evidence for a “race for fish”, I would expect to see increased effort post-ban as compared to pre-ban. Since effort was collected in hours/day, days/week and weeks/month spent fishing, I used total monthly hours of fishing as the measure at each sampling period.

After running the ANOVA with combined effort of all boat types, I segmented effort by boat type: mechanized, motorized and *surukku valai* to understand which gears exhibit significantly different effort over the time periods (descriptive data in Table 4-2).

4.2.5.3 *Catch and landing statistics*

To demonstrate how effort changes affect fish catch, I draw on landing estimates for different boat types from CMFRI landings data. *Surukku valai* kg/hr effort comes from data compiled on average yearly catch over five years (from 1994-1998) by CMFRI on the coast of Karnataka (Bhat & Bhatta, 2001). This number reflects average catch of mechanized purse seine. No data is available on actual *surukku valai* landings in Tamil Nadu due to the illegal nature of this activity. However, after validation with local sources in Nagapattinam, I used the average catch of a mechanized purse seine operation as a proxy for post-ban *surukku valai* landings. Based on local informants, the data for the *surukku valai* estimate reflects high season catch only for the *surukku valai* gear (as we would see post-ban) and cannot be assumed to reflect the catch of this gear type during other seasons.

Mechanized and motorized kg/hr effort estimates come from yearly catch during 2011 (the most recent publically available) in Nagapattinam as collected by CMFRI. Since this number reflects the year's average for each vessel type, utilizing these statistics to project post-ban time catch (high season) is likely an underestimation of the quantity of additional fish caught in the post-ban month by these boat types. Data on catch per hour of effort is paired with the data on fishing hours/month to project the quantity of additional fish caught per fishing operation after the ban is lifted compared to pre-ban levels. While these numbers fluctuate by state and fishery characteristics, as well as by season, it offers a rough snapshot to the potential population dynamics implications of increased post-ban effort. Finally, using CMFRI 2010 census data on the number of mechanized and motorized boats in Nagapattinam (CMFRI, 2010b) and Karaikal (CMFRI, 2010a), I estimated the increase in fish caught post-ban district-wide. There is no official data on number of *surukku valai* operations in Nagapattinam or Cuddalore. However,

based on the proportion of fishers in Nambiyar Nagar who operate this gear type (roughly 1 in 5), I calculate an average number of *surukku valai* operations if the same proportion of fishers that reside along the coast of Nagapattinam and Cuddalore (n=58,834) (CMFRI, 2015b) were to adopt this gear type. At that ratio, roughly 11,766 fishers would participate in *surukku valai* operations. With 52 fishers per operation, I estimate 226 operations would be active in this area.

4.2.6 Analysis of adaptation and/or effort shift and ban support

Qualitative analysis of interview data was conducted to assess what fishers do during the ban period, as well as whether they would support an additional ban or ban extension to a longer period. Ban support data was qualitatively analyzed first by count (yes or no). After yes and no answers were categorized, a corpus-based coding system was used to identify emergent themes and concepts that explained the viewpoints. This information was then used to predict whether an additional ban could be effectively enforced (i.e. how effective could an additional ban be if X% of people oppose it?) and if fishers reappoint their effort to other resources during the ban period. If this is the case, it again limits some of the ecosystem benefits of the ban period.

4.3 Results

Table 4-2 shows the total sample distribution of fishers by boat type and the associated mean hours of fishing per month they undertake per operation. The total sample (n=489) is reflective of the number of data points over time (i.e. fishers were asked to recount during each season, how many hours/month they spent fishing a particular boat type) used in analysis. During ban, mean mechanized fishing (M=56.08 hours/month) reflects those mechanized fishers

who switch to fish *kattumaram*³³ only for subsistence purposes during the ban time. During ban, mean *surukku valai* fishing (M=133.9 hours/month) shows the number of hours that individual motorized boats (that in other seasons operate the *surukku valai* gear) fish when their mechanized component is sidelined by the ban. These boats use other gears (e.g., gill nets) during this time.

Table 4-2: Descriptive data of total average fishing hours per month by boat type and time frame (standard deviation in parentheses)

Boat type	Pre-ban	Ban	Post-ban	<i>n</i>
Mechanized	444.09 (13.89)	56.08 (11.13)	467.35 (13.32)	117
Motorized	289.35 (43.2)	144.82 (28.98)	288.75 (57.23)	19
<i>Surukku valai</i>	210.65 (25.81)	133.90 (28.71)	329.29 (29.52)	35
Total Average	377.51 (181.74)	80.44 (131.9)	422.27 (169.29)	489

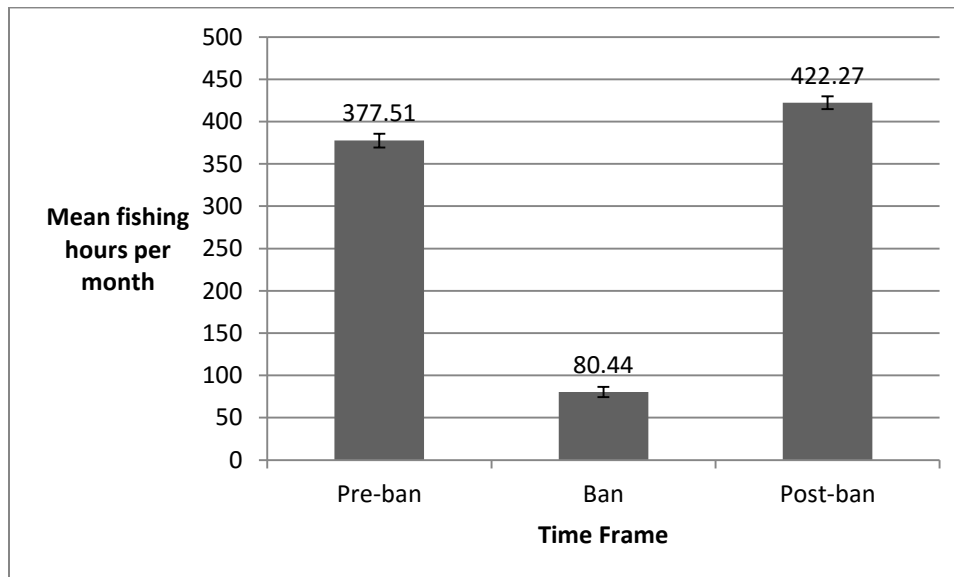
4.3.1 Does the ban significantly impact fishing effort?

Figure 4-3 shows the mean fishing hrs/month. Results indicate that there was a significant effect of time period on total monthly hours fished [$F(2, 486)=211.91, p=0.00$]. Post hoc comparisons using the Bonferroni test indicated that the mean total monthly fishing hours during the pre-ban timeframe (M=377.51, SD=181.74) was significantly lower than the post-ban time frame (M=422.27, SD=169.29). Additionally, the mean total monthly fishing hours during pre and post ban time frames differ significantly from the mean monthly fishing hours during the ban timeframe (M=80.44, SD=131.90). Taken together, these results suggest that there is significantly more effort overall post-ban than pre-ban ($p<.05$). However, the effort during the

³³ Kattumaram is a traditional, wood plank boat usually without an engine. This type of boat is manned by one person and has a typical fishing trip duration of 3-4 hrs/day and operates within 2km of the shore.

ban, while significantly lower than at other time periods, is not reduced to zero. This is reflective of the motorized and non-motorized fishing that occurs during this time.

Figure 4-3: Mean fishing hours per month during the three sampling time frames +/- 1 standard error



4.3.2 Do mechanized and *surukku valai* significantly increase their post-ban effort?

Figure 4-4 shows the mean effort by boat type over the three time periods. Post hoc comparisons using the Bonferroni test indicated that the mean mechanized monthly fishing hours during the post-ban timeframe (M=467.35, SD=13.32) were not significantly different than the pre-ban time frame (M=444.09, SD=13.89). These results suggest that the significant increase in fishing effort that is seen post-ban when all boats are combined does not stem from a significant increase in effort by mechanized boats.

I hypothesized at the start of this chapter that mechanized boats would exert significantly more pressure post-ban than pre-ban. The results indicate that while this group does exert more pressure, it is not significantly more pressure than their pre-ban levels. Many fishers stated that post-ban catch per effort is high for about one to two weeks. During this time of high catch,

exporters stock their freezers. As such, after one to two weeks, exporters' freezers are at capacity and they are no longer buying. This drives down the price of fish received upon landing. This low price makes it pointless to fish intensively, as any catch landed may not even recoup the cost of a trip. This is one potential explanation for why we do not see a significant difference in effort for mechanized boats between pre and post ban time frames.³⁴

However, this explanation would seem to be contradicted by the effort of other fishers. For the *surukku valai* gear type, post hoc comparisons using the Bonferroni test indicated that the mean total monthly fishing hours during the post-ban timeframe (M=329.29, SD=29.52) was significantly higher than the pre-ban time frame (M=210.65, SD=25.81). These results suggest that the increase in total fishing effort we see post-ban period is largely the result of the significant increase in *surukku valai* effort at this time. Like motorized effort, there is also substantial effort by *surukku valai* fishermen during the ban (reflective of these fishers fishing the motorized boats utilized normally in the *surukku valai* operation), and a full accounting of ban time effort should include this effort as well.

I hypothesized that *surukku valai* would exert significantly more pressure post-ban than pre-ban. The data supports this hypothesis. One potential explanation for why we see an increase in *surukku valai* effort while not mechanized effort is the difference in catch composition between the two gear types as well as the wage structure. *Surukku valai* catch is comprised mostly of small pelagic species like sardine (*Sardinella longiceps*), which have a substantial domestic market (E. Vivekanandan, Personal Communication, May 2015). The over-capacity export market likely does not apply as much to these fishes, though follow up research is necessary to confirm this hypothesis. Additionally, *surukku valai* is completely joint

³⁴ Since the survey was at week 4-5 post-ban period, the insignificant increase in monthly fishing effort by mechanized boats may be reflective of decreased fishing effort after the initial post-ban period rush.

ownership. There is no distinction between boat owners and crew: All fishers in this enterprise, whether assigned to the mechanized boat or motorized boats, own equal shares and share evenly in gain or loss. Each of the *surukku valai* co-owners has taken out a loan of around 70,000 rupees to jointly fund the operation. This means that they have a large incentive to fish intensively. Therefore, after a month and a half of relatively low catch given gear restrictions, the push to fish heavily post ban is motivated by the need to make loan repayments plus the collective incentive of joint ownership.

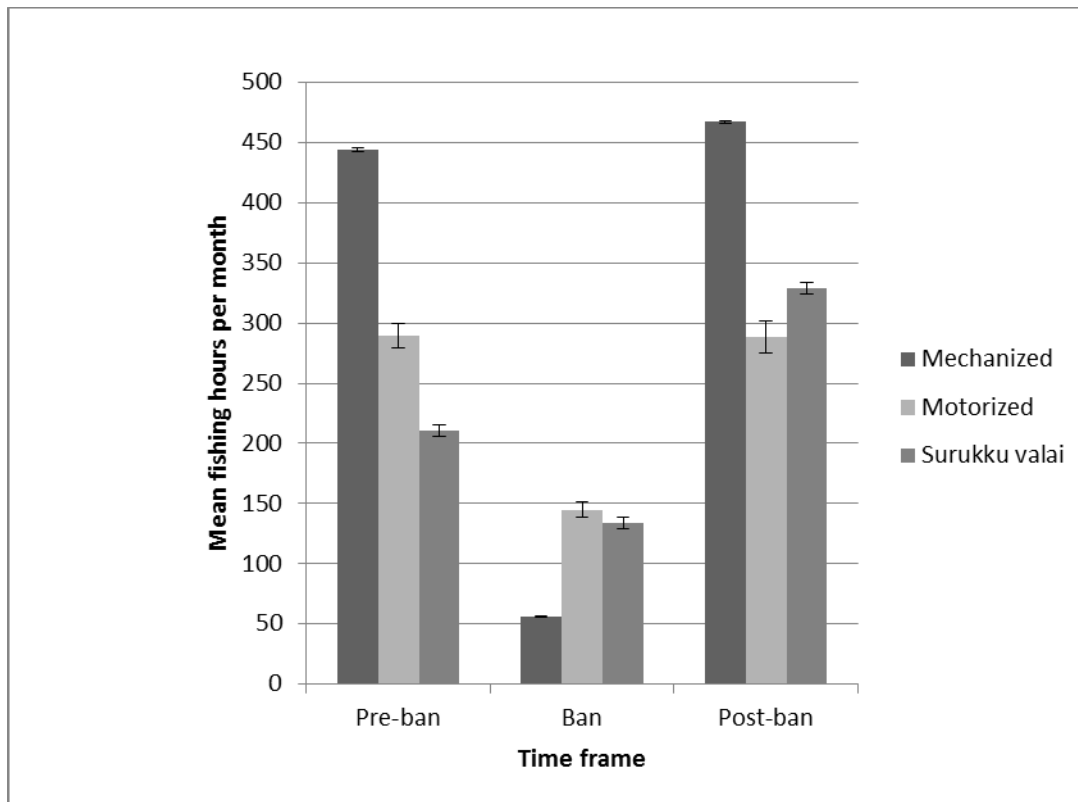
4.3.3 Do motorized fishers significantly increase their ban time effort?

For motorized boats, post hoc comparisons using the Bonferroni test indicated that the mean total monthly fishing hours during the ban timeframe ($M=144.82$, $SD=28.98$) was significantly lower than the pre-ban time frame ($M=289.35$, $SD=43.2$). These results suggest that instead of increasing their effort during the ban period to take advantage of lack of competition from mechanized boats, motorized fishers actually exert significantly less effort during the ban period than they do before the ban begins. Nonetheless, motorized fishing during the ban remains substantial and should be considered in any calculation of the ban's impact. Additionally, there is no significant difference in motorized effort before and after the ban-period, again indicating that the significant increase in total post-ban fishing effort does not stem from this group.

I initially hypothesized – in line with previous studies – that motorized boats would exert significantly more effort during the ban period, as compared with pre or post ban time frames, due to lack of competition from mechanized boats and high price received upon landing. Instead, motorized fishers actually exert significantly less pressure during the ban period than other time frames. This may be because fishermen of this group, given the lack of competition,

are able to meet their quotas and recoup their costs faster due to increased price received upon landing, leading them to “need” to fish less.

Figure 4-4: Mean fishing hours per month disaggregated by boat type +/- 1 standard error



4.3.4 What are the projected impacts to fish of this fishing behavior?

Pairing the above calculated increase in average monthly fishing post ban with catch and landing statistics from CMFRI, Table 4-3 highlights the projected impact of the above increases in post-ban effort on fish stocks.

Table 4-3: Estimate of additional fish caught (kg) per fishing operation after the ban period as compared to pre-ban catch levels based on increased fishing effort (hrs)

Boat Type	Average kg/hr fish caught³⁵	Additional post-ban effort (hrs)	Additional fish caught (kg)/boat or operation
Mechanized trawl	23	23	529
Motorized boat	11	-0.6	-7
<i>Surukku valai</i>	241 ³⁶	119	28,680

Whereas the increase in mechanized and slight decrease in motorized effort amounts to roughly an additional 529 and -7 kilograms/boat respectively during the month post-ban (compared to pre-ban levels) of fish caught, the increased *surukku valai* pressure may account for over 28,500 kilograms/operation of fish caught in the post ban month per operation. This removal of fish from populations not only contributes to overexploitation but is also largely unaccounted for in management decisions. Thereby, these large landings may impact not only the population dynamics of these exploited stocks, but also the long term food security of fishery-dependent communities. Additionally, regular and *surukku valai* motorized fishing continues to have an impact – albeit smaller than usual – during the ban that must be deducted from any calculation of ban success. Both types continue to exert approximately half of their pre-ban fishing time during the ban.

As *surukku valai* operations during the ban period do not operate *surukku valai* gear, but rather resort to similar fishing methods as other motorized boats, I clump together their effort with motorized boats to project the total average motorized catch during the ban period. Given

³⁵ Proxy measures are explained in the methods section.

³⁶ This estimate of kg/hr effort comes from data compiled on average yearly catch over five years (from 1994-1998) by CMFRI on the coast of Karnataka (Bhat & Bhatta, 2001).

the total during ban effort of approximately 277 motorized fishing hours (Table 4-2), based on an average of 11 kg per hour of effort (Table 4-3), this equates with roughly 3,050 kg/boat of fish caught during the ban period. This draws attention to the need for complementary regulations, such as further restrictions on vessel hours during and post-ban or constraints on motorized components of *surukku valai* operations, to allow ban benefits to be fully realized.

4.3.5 Projection of district-wide fishery impacts

There are a total of 927 mechanized and 4016 motorized boats in Nagappatinam and a total of 15 mechanized and 154 motorized boats in Karaikal. However, this number likely includes the individually registered boats that comprise the *surukku valai* operations (*surukku valai* estimated at 226 operations). Therefore, I subtract these boats from the above mechanized and motorized figures (taking half of *surukku valai* operations (as the other half will be reflective of Cuddalore fishing). In terms of total additional fish caught, mechanized boats in Karaikal and Nagappatinam land, on average, an additional 438,541 kg (i.e. $(927 \text{ Nagai boats} + 15 \text{ Karaikal boats} - 113 \text{ surukku valai}) * 529 \text{ kg fish/boat}$) of fish post-ban as compared to pre-ban. Using the estimated number of *surukku valai* operations in Tamil Nadu, this gear type may land on average an additional 6,590,386 kgs of fish post ban. These figures highlight the implications of the temporal effort adaptations exhibited by fishers as a result of the ban period.

Finally, I quantify the average amount of fish landed by motorized boats in Nagappatinam and Karaikal. Motorized boats may land on average an additional 520,245 kg (i.e. $(4016 \text{ Nagai boats} + 154 \text{ Karaikal boats} - 1017 \text{ motorized boats used for surukku valai}) * 165 \text{ kg fish/boat}$) of fish post-ban as compared to pre-ban. Taken together, during the post-ban month, mechanized and motorized boats in Nagappattinam and Karaikal plus TN *surukku valai* operations land an additional 7,549,622 kgs of fish over pre-ban levels. Although this estimate is

not precise and uses yearly average catch (kg)/hour data it offers a ballpark figure of the consequences of this case of race to the fish. Finally, during the ban period, when motorized boats are fishing (as are the motorized *surukku valai* boats), these fishing operation on average are responsible for a total of 6,638,640 kg of fish caught (i.e. (4016 Nagai boats + 154 Karaikal boats)*((144 hrs/month)*(11 kg/hr)).

4.3.6 Are fishers adapting by exploiting other resources during the ban period?

While mechanized fishing is reduced to zero during the ban period, some individuals that undertake mechanized fishing during other seasons resort to *kattumaram* fishing during this time. Individuals who fish on *kattumaram* during the ban period usually do so to fulfill subsistence needs. Many families during the ban period instead become vegetarian and must purchase much of their needed food items. Many families have stocks of dry fish to use as well. However, due to handling and drying techniques, this fish only lasts for approximately one week into the ban period. *Kattumaram* fishing allows many families to continue consuming some quantity of fresh fish throughout the ban period.

There seems to be a widespread assumption by non-fishers, and even a number of fisheries professionals, that fishers are able to find alternative work during the ban period. However, the majority of individuals I interviewed indicate high levels of unemployment during the ban period. They do not reappoint their effort to other gears nor seek alternative employment. The general tone in discussions with non-fishers is that agricultural labor provides a short-term alternative for fishermen during the ban period. However, according to fishers themselves, this is not the case. Not only are fishers averse to agricultural work, the seasons where there is work available do not coincide with the ban period. Coinciding with the lack of desire for agricultural work, there was a general lack of interest and resentment towards taking

on jobs that are unrelated to fishing. Individuals explained this resentment as a result of the pride associated with the fishing profession by traditional fishing community members. Their cultural heritage is strictly tied to fishing and it would be embarrassing to take another type of job. I would stress that this is specific to traditional, caste fishermen and may not translate to non-traditional fishers who have historically worked the land or taken part in other professions, only recently coming to fishing.

In the sample there were only two people who migrated or took on alternative work. One individual migrated to Kerala to find work in construction but did not return post-ban for fishing. A number of fishermen indicated that it was too risky to migrate to Kerala to attempt to fish on mechanized boats there. They indicated that the trip and associated lodging is expensive and there is no guarantee of work. One individual was trained as a tailor and did tailoring work during the ban period to earn money to fulfill his family's basic needs. Fishers and boat owners may do boat maintenance and repair but report that this type of work is available only 10 days before the start of the next fishing season.

4.3.7 Would fishers support an additional ban or ban extension? (n=141)

People supported the current ban because they suggested it was good for fish spawning, and income after the ban was good for a week or two. However, only 17% of fishermen supported an additional ban. Seventy-seven percent of respondents stated they could not accept an additional ban period at all, while 6% of respondents said they would accept an additional ban if other people accepted it. There was some distinction of support between mechanized laborers and boat owners with 11 out of 37 mechanized boat owners (i.e. 29%) and 11 out of 73 mechanized laborers (i.e. 15%) in support of an additional ban. Of note is the lack of support for additional ban among motorized boat fishers, despite the ban rules not applying to them and

allowing them to fish without mechanized competition. Only 4 out of 19 non-mechanized fishers (i.e. 21%) would support an additional ban, possibly because they fear additional ban time would eventually apply to their efforts as well.

Some individuals stated that they do not agree with the first ban and only follow it because it is mandatory. The majority of respondents suggested that the problem with the ban is that their income is eliminated and it is difficult to manage their families. Although many respondents take loans during the loan period, this response increases debt that is already prevalent. The government of Tamil Nadu does provide a ban relief stipend (Rs.2000) to all registered fisher families. However, the ban compensation is not received during the ban period and only reaches families in late June to early July, making the relief useless during the ban period. Some stated they use the ban period money to pay loan interest incurred during the ban. Loans from money lenders and formal institutions require monthly payments, which are untenable during the ban period. During the rainy season, some formal institutions waive this requirement for fishing community members, though it is not waived during the ban period. A number of people acknowledge that the ban period may be good for fish and that income is higher post ban, but not high enough to offset the difficulties incurred during the ban period. This is clearly evident in the results where families without access to a *kattumaram* eliminate fish from their diet. However, if money is not available to buy vegetables either, the ban instigates a serious food security issue for many individuals. Studies elsewhere indicate that food security needs may lead to noncompliance with resource harvest rules (Groff & Axelrod, 2013).

Additionally, over the course of data collection, it was announced by the government that this year (2015) the ban would be 60 days instead of 45 days. This was announced on the local

news on the opening day of the ban period. No fishers had any forewarning that this was coming. This lack of consultation with the fishing communities on a ban extension led most community members to be angry and defiant of the upcoming ban extension. Fisher groups advocated to the Fisheries Departments, which in turn advocated to the government that the ban extension would not be followed. This not only happened in Tamil Nadu but Kerala as well, leading the central government to revise its stance, indicating the coastal states should instead phase in a 60-day ban over the course of five years.

Karaikal, part of the Union Territory of Puducherry, initially accepted the ban extension. However, because their territory is couched within Tamil Nadu, the fishers refused to follow the ban extension unless Tamil Nadu fishers agreed to follow it. Based on the backlash, on day 45 of the ban, the Tamil Nadu and Karaikal Fisheries Departments announced the ban would be lifted the next day. This shows the power of community support (or dissent) towards a regulation. This level of dissent, coupled with lack of support demonstrated in these interviews, further suggests a likely backlash if the ban is extended or expanded in future years. Without that support, communities are unlikely to enforce the policy.

4.4 Discussion

Policy may affect behavior and resource use in one given place and time. However, there are often unintended consequences not taken into account. I asserted in the beginning of the chapter that despite the presence of a regulation, resource users are adaptive and innovative, and in many cases will find ways to continue their livelihoods within restricted time frames. While the adaptations exhibited in the roving bandits phenomena involve exploiting resources outside of regulated geographical areas (Berkes et al., 2006), I find that resource users will also manifest similar behaviors by increasing their resource use in unrestricted time frames and adapt to

restrictions by utilizing un-restricted fishing gears. This behavior does suggest a race for fish, which I show has the potential to have serious ecosystem impacts. It also highlights the significant pressure exerted on the resource with alternative gears during the ban. This adaptation in effort is rarely calculated into a management approach, including in the development of India's seasonal trawl ban.

In implementing the ban period regulation, the reality that individuals may (and have) shifted their fishing effort from regulated options to unregulated options slipped through the cracks. This gives further evidence to the call for institutional modularity and redundancy by some scholars (Adger et al., 2005; Huitema et al., 2009). I find that in the absence of complementary regulations, many fishers increase their fishing pressure outside of restricted gears and timeframes. Again, this phenomenon, akin to what we see with the idea of “roving bandits”, is produced by gear and temporal – rather than spatial – restrictions on fishing. Although the ban may be effective in curbing a yearly increase in overall effort, substantial effort remains during the ban, and the current management structure also incentivizes a post-ban race for fish.

In developing complementary regulations, resource users' likely adaptations should be addressed, perhaps through support for livelihood alternatives that would alleviate the need for shifting harvest (Lewis et al., 2011). In addition, legitimacy is a key quality leading to rule enforceability (Hoefnagel, de Vos, & Buisman, 2013; Novak & Axelrod, 2015). Other scholars have found that fishers break rules and regulations for two primary reasons: they deem the regulation illegitimate, or they break the rule or regulation out of economic hardship (Daw & Gray, 2005). Additionally, a key element in good resource governance is stakeholder involvement (Gupta, 2008), which tends to increase the legitimacy of decisions made. Drawing

on the primary reasons for the ban's enforceability: the history of the ban's joint development between fishing communities and government, I find that the economic hardship incurred by the ban is decreasing support for the ban by resource users. This suggests that not only is a successful and enforceable regulation achieved through legitimacy, it also must be adaptable to the unintended consequences that arise out of it. Therefore, legitimacy may initially enhance enforceability, but adaptability will ensure its long-term success.

I also find that regulations asserted without stakeholder involvement (i.e. the ban extension) may be immediately termed illegitimate. Some scholars highlight the need to build coalitions of diverse stakeholders in working towards effective conservation (Chhatre & Saberwal, 2005). I find that indeed, the stakeholder engagement process is key in building support and legitimacy of a regulation, as well as understanding resource users' needs and likely responses. Without this support and legitimacy, resource users may find loopholes or refuse to follow a regulation, and this opposition may spread to other communities that are otherwise more inclined to follow the new policy.

4.5 Conclusion

4.5.1 Implications of ban modifications for compliance and fishing behavior

While other research has calculated the overall effort changes due to the ban period (Vivekanandan et al., 2010), my findings contribute a more nuanced understanding of those effort changes by gear type and how they may impact the fishery, thus highlighting the unintended consequences of a resource management decision. This research also contributes valuable empirical information regarding the impact of the *surukku valai* gear type. As discussions on India's National Marine Policy, as well as ban modifications, are underway, the

data presented here may be useful in deciding how to move forward in improving marine fisheries policy.

In any discussion of working towards modular and redundant regulations, it is important to remember why the seasonal ban is enforceable in the first place. Lessons from the ban's enforcement can then be used to craft feasible, enforceable solutions. The current ban has been successfully implemented because of its widespread acceptance by fishing communities and collaborative effort between the communities and Fisheries Departments to develop and implement the ban. As such, if an additional ban was introduced and over 75% percent of the active fishing population opposed it, as is suggested by our sample, it begs the question of how effective an additional ban could be. Indeed, Tamil Nadu communities have a history of overriding government fishing regulations perceived as illegitimate (Novak & Axelrod, 2016). Implementing an additional ban without the support of the people may also jeopardize the legitimacy of the first ban, thereby decreasing the minimal benefits currently derived from it.

Additionally, the merits of including motorized boats in the ban period need to be considered in concert with an associated acknowledgement that inclusion of this boat type may also delegitimize the current ban. Decision-makers would need to consider the possible elimination of community support derived from the ban's conflict resolution mechanism, as well as potentially increased economic hardship incurred as a result of the ban. Although banning motorized boats during the same period would help decrease total allowable monthly fishing effort during ban time to near zero (given the extremely small amount of pressure exhibited by non-motorized *kattumaram*), one of the ban's original purposes was to support smaller, artisanal vessels versus the mechanized industry. By including all boats except non-motorized country craft, the original underpinnings of the ban and some of its legitimacy may be diminished.

However, mechanized fishers may be more willing to accept a ban extension if it is applied to motorized boats as well, a possibility requiring further analysis.

Any discussion of amendments to the current fishing ban needs to include comprehensive discussions with fishing community stakeholders. Only through the joint collaboration of district Fisheries Departments and communities can they realize a package of locally relevant controls and community support that could be paired with the fishing ban. At present, the ban is the only state sponsored fishing regulation that is effectively enforced. The fishery is in crisis and all participating fishers acknowledged continuously declining overall catch levels. Mobilizing this knowledge and collaborating with different fisher factions is important. In this way, management proposals may be jointly developed for greater legitimacy.

4.5.2 Policy recommendations

Locally relevant solutions to this problem are necessary. As stated above, understanding the reasons for successful compliance with the fishing ban is important in constructing a modular and redundant regulatory system. Three specific policy recommendations stem from this research. First, efforts should continue to focus on initiatives that are easily monitored and enforced. One of the main reasons the fishing ban is enforceable is because it essentially limits boats from leaving the harbor. When implementing complementary regulations to the seasonal ban, this stipulation needs to be remembered. For example, another regulation that has been successful in certain districts in Tamil Nadu has been a 3:4 day share rule, where mechanized boats are permitted to fish for three days of the week and the other four days are reserved for motorized boats (Jentoft, Bavinck, Johnson, & Thomson, 2009). Enforcement of this regulation employs a similar mechanism to the ban and may be considered for implementation in other

areas. This year-long temporal constraint on effort could limit unchecked fishing post-ban, which may help continue ban benefits throughout the year.

Second, building a two-tier system of enforcement is key, involving both district-level Fisheries Departments and local community governance structures. Successful monitoring and enforcement of the ban period relies on community support. Local social ostracization is perceived as deterring violations as much as the lack of government response to accidents at sea during the ban time. Any top-down regulation uncoordinated with the community is bound to fail, as seen by responses to the surprise 2015 ban extension announcement or the state-level *surukku valai* gear ban. Therefore, stakeholder involvement and meaningful community outreach are crucial in developing regulations that will complement the ban period.

Third, if motorized boats are to be banned during the ban period as well, the government might consider subsidizing the purchase of non-motorized *kattumarams* to enable fishers to fish for household and subsistence purposes. Food security issues are a major concern during the ban period, and ensuring basic needs are met is the first step in building an environment where new regulations may be negotiated and successfully implemented.

In conclusion, there are often confounding factors to successful fisheries management. I have shown that restricting fishing temporally leads to increased effort outside restricted time frames and by unrestricted gears. Fishers continue to adapt to regulations through gear innovations and flexibility during unregulated fishing seasons. These unintended consequences are often unanticipated in fisheries policy development and have the potential to derail even the most well intentioned initiative. While fishers rove for fish not only spatially but temporally, other resource users may also adapt in similar ways to prohibitions on resource harvest.

Anticipating and mitigating these adaptations is important in developing robust management strategies.

4.5.3 Study limitations

I expect these results to be generalizable to many other geographic locations in Tamil Nadu where there is a long tradition of fishing and a diversity of boat types, as in our study villages. However, two key differences are important to consider beyond the Nagapattinam and Karaikal context.

First, given that the *surukku valai* gear type is only used in fishing communities in Nagapattinam and Cuddalore district, I expect the findings regarding the sources of increased post-ban effort to be generalizable to these areas only. Additionally worth discussion is the possible difference in fishing patterns and incentives to fish between traditional fishing caste communities and non-traditional fishers. Individuals fishing in the study area are strictly from caste-fishing communities. Examining fishing effort over time in areas like Ramanathapuram, where the majority of fishers are non-traditional fishermen with a different wage structure, would be worthwhile to understand whether fishing effort in these places also increases post-ban. This information would be important in understanding how big a role the share system plays in the incentive to overfish.

The second exception is specific to Kanyakumari district. This area, at the Southern tip of India, is where Tamil Nadu spills over onto the western coast. Historically, fishermen in this area have considered themselves brothers at sea with Keralan fishermen (Subramanian, 2009). Despite this geographical cultural link, the East coast ban schedule still applies to them because the district is within Tamil Nadu jurisdiction. Due to their proximity and relationships with Keralan fishermen, this group of mechanized fishers may have an easier time finding work on

Keralan fishing vessels during the ban period. Additionally, the cost of migration is relatively lower for this group compared with individuals along the rest of the eastern coast. Nonetheless, Keralan mechanized boats, like boats in Tamil Nadu, already have full crews. As such, Kanyakumari fishers face similar limitations for finding work as temporary employees. Future research should compare responses from other parts of the state and country to determine whether adaptation behaviors are affected by these characteristics.

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