Abstract

Fisheries regulations can have a host of implications for both fishers and the fishery they aim to protect. Oftentimes there are unanticipated adaptations employed by resource users in the face of restrictions. Unintended consequences of fisheries regulations are examined through the case of an annual 45-day closed fishing season in India. Using a longitudinal study design over the course of three seasons: before, during and after the 2015 seasonal fishing ban, seasonal activities calendars and semi structured interviews are employed to randomly selected participants (n=171) within two fishing villages in Tamil Nadu and Puducherry, India. Data suggests that some fishers shift their fishing effort to unrestricted gears during the ban and that post-ban race for fish is exemplified by all gear types, though an illegal, unregulated gear type, locally termed *surukku valai* exhibits the largest increase in effort. Lack of fishing-related employment options during the ban period leads to high levels of unemployment and food security concerns. Using data on average landings for each gear type post-ban fish catch is estimated and impacts to local fish populations is projected.

Keywords: regulatory impacts; India; fishing effort; fishing ban; IUU Fishing

Unintended consequences of a seasonal ban on fishing effort in Tamil Nadu & Puducherry, India

1 Introduction

A seasonal closure is one intervention managers use to mitigate the overuse of open access fisheries. However, used in isolation, there is a threat of a race to fish after the fishery is reopened (Cinner, Marnane, Mcclanahan, & Almany, 2006; Philippa J Cohen, Cinner, & Foale, 2013). Much of the research to date on seasonal closure comes from the Indo-Pacific where it has been widely used as co-management strategy with varying degrees of success (Cinner et al., 2006). This research has asserted conditions for the success of seasonal closures, including low human population density, low fishing dependency and associated high ability for livelihood diversification, and that the community has exclusive tenure over the resources. The opposite conditions lead to likely failure of seasonal closures in terms of achieving policy goals (Cinner et al., 2006). This study examines the response to seasonal closure in the challenging context of a reliant population that has limited alternatives to fishing. We trace how fishers respond in this context and the resulting limitations to management success.

While many countries in the Indo-Pacific employ periodic closures, they are most frequently associated with prohibiting harvest of a single species (Oliver et al., 2015) or the closure of a relatively small area of coral reef to fishing and gleaning activities (Cohen & Foale, 2013). Many countries outside the Indo-Pacific implement seasonal moratoria on specific fishing gear or harvest of specific stocks (Vivekanandan, Narayanakumar, Najmudeen, Jayasankar, & Ramachandran, 2010). For example, over a dozen countries impose seasonal bans on shrimp trawling (Vivekanandan et al., 2010) to prevent destruction of benthic habitat and associated consequences on trawled ecosystems (Stilles, Stockbridge, Lande, & Hirshfield, 2010;

Watling & Norse, 1998). However, fewer and far between are full seasonal closures applying to all species and all gear. China for example, enacted a 2-3 month annual closure in the northwestern South China Sea in 1999. Its success is widely contested in many parts due to the fact that the ban prohibits fishing in contested territory. Therefore, it is not followed by many Vietnamese fishers who do not recognize Chinese sovereignty over the area. As a result, this ban has led to arrests, beatings, gear and catch confiscations, and a race for fish following the annual ban (Vu, 2013).

A race to fish is one example of an unintended consequence of seasonal closures (Cohen et al., 2013; Sys, Van Meensel, Polet, & Buysse, 2017). A "race to fish" is a fisheries commons problem that can occur when fishing seasons are limited and fishers rush to capture fish when the season opens (Birkenbach, Kaczan, & Smith, 2017). This race to fish may actually cause a reduction in the number of fishable days (Tveteras, Paredes, & Peña-Torres, 2011) and is often attributed to the open access nature of many fisheries (Emery, Hartmann, Green, Gardner, & Tisdell, 2014). A race to fish can also be driven by variation in catch rates, where fishers increase effort during times of abundance and taper effort during periods of low catch (Emery et al., 2014; Novak & Axelrod, 2016). As the opening of a fishery closure usually coincides with larger catches, the short term benefits of a seasonal ban to fishermen include increased harvesting efficiency (Cohen & Alexander, 2013) and higher prices at opening (Sys et al., 2017). It is assumed that if fishermen are rational and profit maximizing, the most sensible strategy with the highest payoff to fishers is to intensively fish as soon as a ban is lifted (Sys et al., 2017), thus leading to the race for fish.

Another example of an unintended consequence of a seasonal ban is fishers' adaptations and innovations which may include switching gears or target species to exploit unregulated

options (Islam et al., 2016) or a reallocation of effort during the ban to other fishing grounds (Beare et al., 2013; Poos & Rijnsdorp, 2007; Tidd, Hutton, Kell, & Padda, 2011). Along similar lines, Berkes and colleagues (Berkes, 2010; Berkes et al., 2006) describe the effects of "roving bandits" where spatial harvest regulations are enforced in one area, but individuals adapt to restrictions by shifting effort to unregulated locations. The successful implementation of one regulation may unintentionally induce widespread overharvest across a large geographic range. Due to fishers' extensive range and their rapid adaptations, problems with overexploitation may go unnoticed until negative consequences become apparent. When fishers have few livelihood alternatives, these effort shifts may be the only option during a seasonal closure.

This study examines the case of a full, seasonal closure in India by integrating an analysis of fishing effort and livelihood outcomes. Due to the tropical nature of the Indian coastline, the associated fisheries are multi-species, multi-gear. As a result, the ban in India is somewhat unique in that it focuses on effort rather than catch constraints. We build upon the literature regarding the impacts of seasonal closures, particularly when used as a stand-alone management strategy in an area where fishing populations that have few livelihood alternatives. In this paper, we examine both fishing effort changes in response to the seasonal ban and fishers' livelihood adaptations during the ban period.

We find that fishers adapt to the seasonal closure by increasing their effort in unrestricted time frames, lending evidence to the argument for a closure-induced race to fish. We also find that some fishers adapt by switching to unrestricted gear types during the ban, to allow for continued harvest. Despite having few livelihood alternatives, high compliance rates with the ban period point to the ban as an effective fisheries governance innovation for an open access

fishery. However, serious concerns remain about the impact to fishers' livelihoods and basic subsistence needs.

1.1 A seasonal fishing ban in India

In India, the 45 day seasonal fishing ban is a fisheries management mechanism whose dual aim is protection of spawning species and conflict resolution[1]. It is a closed season for all mechanized[2] boats, and not species-specific. The Indian coastal fishery is a multi-species, multi-gear fishery characteristic of most tropical marine fisheries. Catch is comprised primarily of pelagic finfish species such as Indian oil sardine (*Sardinella longiceps*) and Indian mackerel (*Rastrelliger kanagurta*) (57%) and to a lesser extent demersal finfishes like threadfin breams (Nemipteridae) and croakers (Sciaenidae) (27%), crustaceans such as penaeid prawns (Penaeidae) (13%) and mollusks (5%) where different cephalopod species comprise the majority (CMFRI, 2015). The majority of catch is landed by mechanized trawl boats, but other gears and boat types are also commonly used, particularly in the non-mechanized sector, such as gill nets and hook and line (CMFRI, 2015) Indian marine fish stocks have become heavily depleted as indicated through declining overall catch levels (CMFRI, 2015), threatening millions of fisherfolk livelihoods, introducing food security concerns, and increasing the risk of conflict between fishers of various boat types. The seasonal ban aims to mitigate these ecological and social risks (Bavinck et al., 2008).

The seasonal ban is the only state-administered, effectively enforced nationwide Indian fishing regulation, but fisheries scientists and managers are concerned that its full potential is not realized (E. Vivekanandan, personal communication, May 2015). The ban is enforceable

[1] While this paper does not investigate the conflict mediation mechanism of the ban period, the authors acknowledge that this could be an avenue for future research.
[2] All boats with engines over 25hp

because fishing interest groups participated in its creation with state and district-level Fisheries Departments. Due to this participatory process, it has a high degree of legitimacy, 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*) that was banned without fishing community support. The seasonal ban is also followed because – unlike the gear restriction – it can be enforced by preventing all trawlers from leaving the harbor. Fisheries scientists in Tamil Nadu suggested that once boats leave the harbor, 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 season, the harbor is closed and tax free diesel (provided by the Fisheries Department) is unavailable. If there is an emergency at sea during this time involving a banned boat, the district Fisheries Department will not send help (Nagappatinam Fisheries Department, personal communication, 2015).

At the grassroots level, local village governance bodies (*panchayats*) further support ban enforcement by administering penalties on those who break the regulation, including heavy fines, boat impoundment, and catch confiscation (*Panchayat leader)*, Nambiyar Nagar, 2015). These disincentives are perceived as a type of social ostracization, which is often a stronger deterrent of ban-time fishing.

However, food security and income needs persist during the ban (Novak Colwell & Axelrod, 2017). Because the ban is directed only at mechanized boats, other vessels may continue to fish during this season. For instance, *surukku valai* requires one mechanized and eight to ten smaller motorized boats for operation. Despite failure to enforce restrictions on *surukku valai* during other seasons, these operations stop during the ban due to mechanized vessel restrictions. However, individual motorized boats that are part of these operations

continue to fish independently while the mechanized vessel components remain in port. Some legal fishing options are therefore still available to fishermen during the ban period. As a result, the ban does not completely eliminate fishing effort. We therefore explore the extent to which the ban's success is constrained by effort shifts.

Previous research has suggested that the motorized segment of the fleet does quite well during the ban season (Bavinck et al., 2008), implying that they exert some level of fishing pressure over the course of the closed season. Other research demonstrates that the fishing ban effectively curbs a projected annual increase in total effort, though post-ban[3] (June-July) mechanized effort increases by 10% on average in comparison to effort in years prior to the ban's implementation (Vivekanandan et al., 2010). However, there is no evidence that the ban is effective in terms of sustaining fish populations (Vivekanandan et.al. 2010) and there is a dearth of information on fisher livelihoods during the ban period. Research suggests that mechanized fishers have difficulty finding alternative jobs. Many from traditional fishing communities may be constrained by cultural expectations of caste behavior (Coulthard, 2008), many continue fishing but with smaller vessels, while others migrate to the West coast to fish on mechanized boats (where the closed season is at a different time) (Bavinck et al., 2008).

1.2 Hypotheses

Based on the wider literature regarding seasonal closures as well as previous research on the Indian fishing ban, we anticipate that effort reductions may be limited in the context of fishing populations with few livelihood alternatives. Our study therefore examines particular pathways by which fishers may adapt to the seasonal fishing ban. In particular, we hypothesize:

[3] 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. In other areas of India, the ban timing is associated with the monsoon, however in Tamil Nadu & Puducherry this is not the case and the ban does coincide with a leaner season in terms of fish catch and subsequent income.

1) The lifting of ban instigates a race for fish post-ban amongst all gear types
    a. Mechanized boats and *surukku valai* operations exert significantly more fishing effort post-ban than pre-ban as they race to fish to adapt to lost income during ban time
    b. Motorized boats exert significantly more fishing effort post-ban as they race to fish in competition with mechanized and *surukku valai* operations.
2) Fishing effort during the ban is reduced but not for all gear types
    a. Motorized fishers exert more effort during the ban period than before or after the ban due to low competition and high price received upon landing
3) Fishers shift effort to other techniques or resources (e.g. land-based) during the ban period. In particular, *suruku valai* fishers employ their motorized components in order to maintain effort during the seasonal ban.

We assess these pathways by examining fisher behavior during the 2015[4] ban season in Southeast India. In the remainder of this paper, we first outline study location characteristics, as well as village and participant selection criteria, before addressing the data collection methods and analyses. The Results section addresses changes in fishing effort before, during and after the ban, followed by a discussion of the projected impacts to fish populations and a qualitative analysis of livelihood adaptations. The paper finishes with a discussion of management implications and policy recommendations.

[4] The day before the start of 2015 seasonal ban, the government announced that the ban would be extended from 45 days to 60 days (without fishers' knowledge or previous consult). It was not determined then at the start of the ban period, whether fishers would choose to follow the extension or boycott it. Fishers rallied to boycott the extension and the 45-day ban was followed, with the government deciding to phase in the 60-day ban over a course of five years. This ban extension proposal should not affect the post-ban effort allocations that we have documented, but we do acknowledge that the proposed extension could impact some fishers' decisions about effort during the ban prior to the government's final decision.

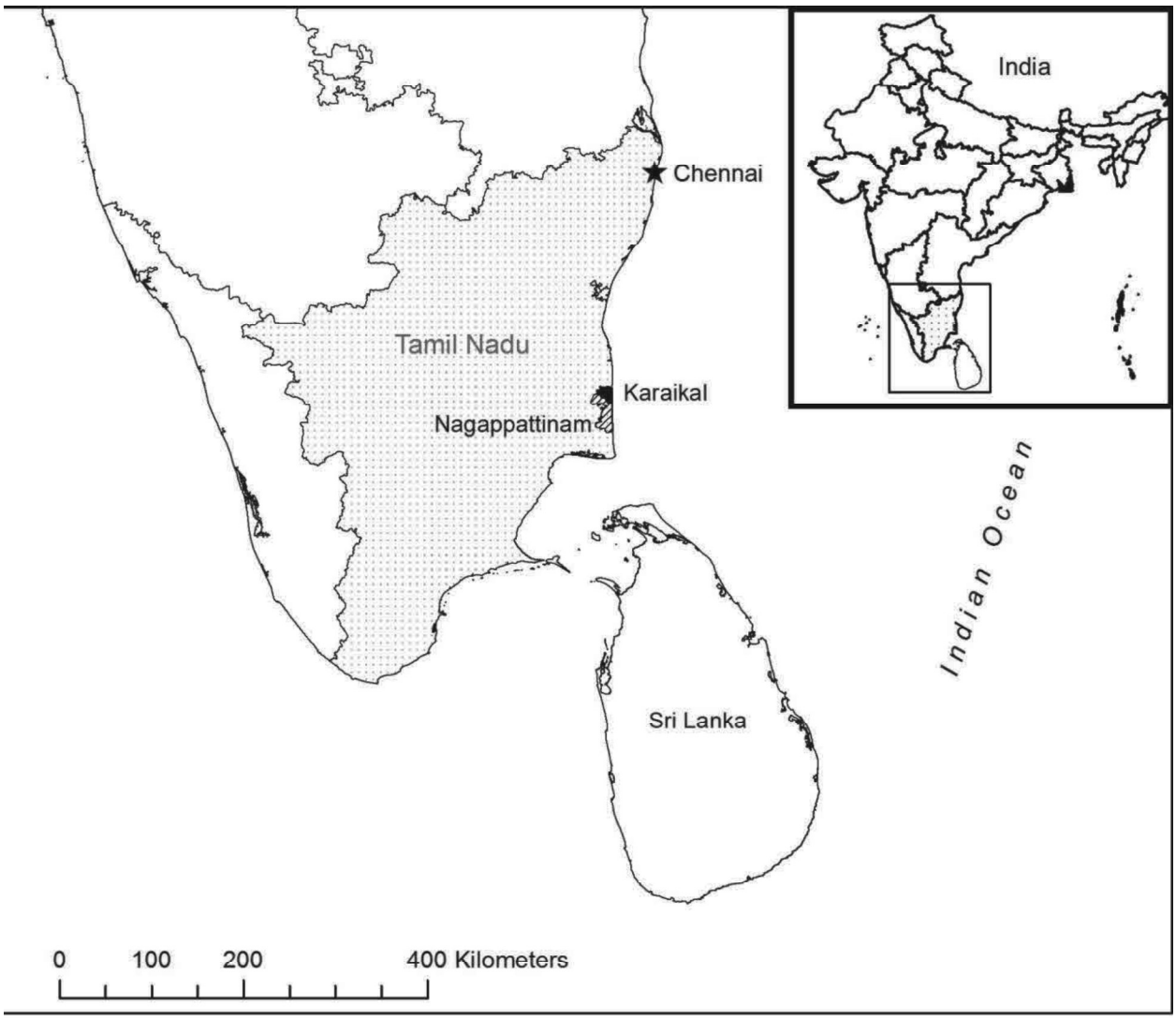
2 Materials & Methods

2.1 Study location

In order to test the above hypotheses, two villages were chosen based on the 2010 Marine Fisheries Census data for Tamil Nadu (CMFRI, 2010b) and Puducherry (CMFRI, 2010a). Villages within these territories were selected based on similarities in demographic profiles (prevalence of below poverty line residents, education level, caste and religion) as well as similarities in boat distribution patterns (i.e. mechanized owners/laborers are the majority in each village, though motorized boat fishing is still prevalent in both). The villages chosen were Nambiyar Nagar (hereafter NN) in Nagappatinam District, Tamil Nadu and Kottucherry Medu (hereafter KM) in Karaikal, Puducherry (Figure 1).[5]

Figure 1: Map of Nagappattinam & Karaikal within Tamil Nadu, India territory (map credit: Amanda Tickner, MSU Map Library, 2016)

[5] For more details on village and participant selection, please see online appendix at [website redacted to maintain anonymity]



.

2.2 Research permits and ethics

The village *panchayats* (local, informal village governance bodies) provided permission to work within their villages. Clearance for Human Subjects Research was provided by X (Removed for anonymity) University's Institutional Review Board, permit #x14-1145e.

2.3 Sampling methods

A random sampling strategy was used in both villages (see online appendix). Individuals were included in the sampling frame if they were a member of the fishing community and had a job related to fishing either directly (i.e. fishers) or indirectly (i.e. fish trading). Individuals were interviewed three times: before, during and after the 2015 seasonal ban. Our study and recommendations are therefore based on one year of data collected during these time frames. Out of the 282 individuals surveyed at all three stages, 171 individuals actually fished. The responses from fishers only are used in this paper. The overall response rate in Kottucherry Medu and Nambiyar Nagar was 75% (i.e. 127/170 from KM and 155/208 from NN respectively participated in all stages of the survey).[6]

2.4 Data collection

All data collection was conducted in Tamil. Data was translated by bilingual research assistants[7] and the first author. Individual-level surveys were administered to each respondent. Seasonal activities calendars (Slocum, 1995) 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.

[6] 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.

[7] Research assistants were hired from within the fishing communities and as a result were familiar and trusted by the fishing community members. Participants were generally willing to share information and did not view the questions regarding their fishing activity as threatening, as evidenced by willingness of many fishers to share information about illegal behavior. Additionally, all responses were kept anonymous.

Semi-structured interviews were administered to each fisher surveyed. Interview questions asked fishermen how they prepare for the ban period and what work they do during the ban period (if any).

2.5 Statistical analysis

2.5.1 Relevant variables for analysis

Total fishing hours/month measures the total time out of harbor (i.e. from departure to landing).[8] Effort hours were examined across *timeframes*, defined as pre-ban (February-March), during ban (May) and post ban (June) for each *boat type*: mechanized, motorized, and *surukku valai*.

2.5.2 Analysis of fishing effort data

Fishing effort data over three seasons was analyzed using repeated measures ANOVA with a Greenhouse-Geisser correction (descriptive data in Table 2). Repeated measures ANOVA allows for the comparison and detection of significant difference between the means at three measurement points (in our case fishing effort during three different seasons) in which the observations at each time point are not independent of each other, as is the case with panel data (Acock, 2016).

2.5.3 Catch and landing statistics

[8] 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. These trip components are used in our effort model below.

To estimate how effort changes may affect fish catch, landing estimates for different boat types were drawn from CMFRI landings data. Mechanized and motorized kg/hr effort estimates come from yearly catch during 2011 (the most recent publically available) in Nagappattinam as collected by CMFRI.[9] Due to the lack of official data on local illegal *Surukku valai* fishing, we draw from data on kg/day effort for *surukku valai* collected by Lawrence & Bhalla (2018) for the Coromandel coast from June 2012-June 2013.

Using this secondary data on kg/hr effort, paired with original survey data on fishing hours/month, we estimate how much additional fish is caught by each boat type during and after the ban period (as compared to pre-ban levels). While these numbers fluctuate by state and fishery characteristics, as well as by season, they offer a rough snapshot of possible impacts to fish populations from increased post-ban effort. We employed conservative estimates in order to demonstrate likely minimum impacts. Finally, we used CMFRI 2010 Marine Fisheries Census data on the number of mechanized and motorized boats in the two villages (CMFRI, 2010b; 2010a) to estimate the aggregate increase in fish caught post-ban in these two villages. There is no official data on number of *surukku valai* operations in Nagappattinam. However, other researchers have shown there are a total of seven *surukku valai* operations within Nambiyar Nagar village (Bavinck, Imara Hoefsloot, & Wastiaux, 2017) (there are no *surukku valai* fishers in KM).

2.5.4 Analysis of adaptation and/or effort shift

Qualitative analysis of interview data was conducted to assess if fishers are employed during the ban period and what they do during that time. Fishers were asked the location (state)

[9] 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.

of their fishing trips and during what months they fished in those locations. They were also asked whether they migrate seasonally for fishing or other work. Finally, fishers were asked about their income earning activities before, during and after the ban period. This information was used to determine whether fishers shift their effort to other vessels or states unregulated during the Tamil Nadu ban, or target other resources, during the ban period. If this shift occurs, it would limit some of the ecosystem benefits of the ban period.

3 Results

As policy makers intended, total fishing effort during the ban time is substantially less than before or after. However, effort is not reduced to zero, and it is therefore important to more precisely measure the impact of this policy. Before the ban period, mechanized, motorized and *surukku valai* boats operate as usual. However, during the ban (Table 1), some mechanized fishers (M=56.08 hours/month) switch to *kattumaram* vessels[10] for subsistence purposes (i.e. mechanized and *surukku valai* effort reported in Table 1 during the ban period does not reflect illegal fishing, it reflects the effort of those fishers that identify as mechanized and *surukku valai* during non-ban times). Additionally, some *surukku valai* owners (M=130.56 hours/month) fish in individual motorized boats (that in other seasons operate the *surukku valai* gear) when their mechanized component is sidelined by the ban. These boats use other gears (e.g., gill nets) during this time.

Table 1: Descriptive data of total sample distribution of fishers by boat type and the associated mean hours of fishing per month they undertake per fishing operation (standard error in parentheses)

Boat type	**Pre-ban**	**Ban**	**Post-ban**	***N***

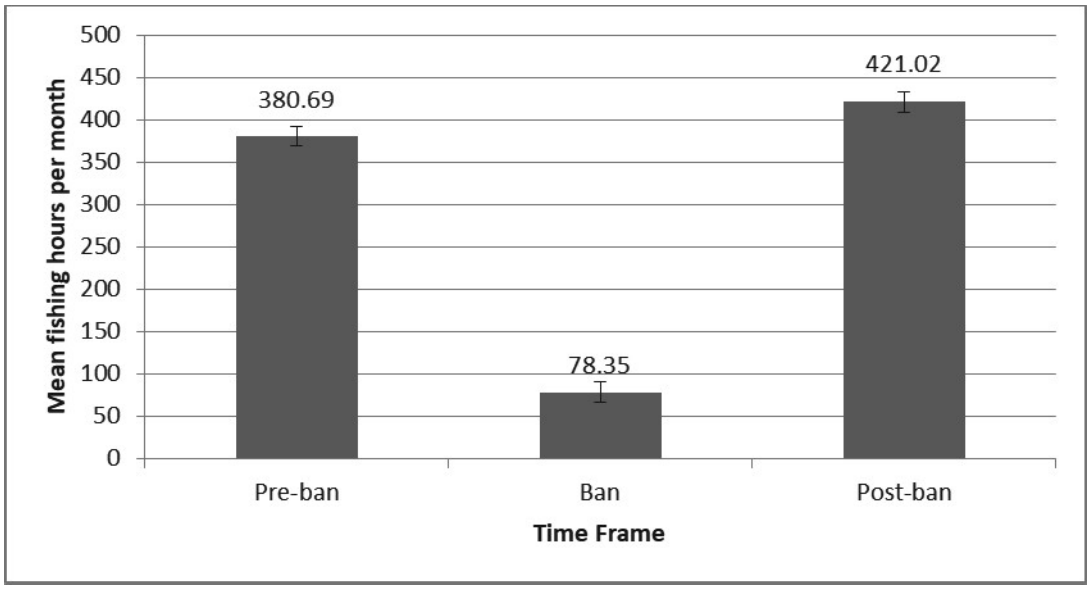
[10] *Kattumaram* is a traditional, wood plank boat usually without an engine. This type of boat is manned by one person and has a typical fishing trip duration of 3-4 hrs/day and operates within 2km of the shore.

Mechanized	443.72 (11.83)	56.65 (11.84)	468.90 (12.15)	117
Motorized	270.60 (35.99)	149.98 (36.73)	286.35 (37.45)	19
Surukku valai	213.98 (25.69)	130.56 (26.79)	325.95 (26.79)	35
Total Average	380.69 (11.74)	78.35 (11.87)	421.02 (12.11)	171

3.1 Does the ban significantly impact fishing effort and instigate a race for fish post-ban?

The ban significantly decreases the overall effort exerted within the fishery but when the ban is lifted, there is significantly more effort than both before and during the ban. ANOVA analysis indicates a significant difference between total monthly hours fished across time periods [$F(2,316)=247.12$, $p<0.01$]. Mean total fishing hours during the pre-ban timeframe ($M=380.69$, $SE=11.74$) were significantly lower than the post-ban time frame ($M=421.02$, $SE=12.11$, $p<0.05$). 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 ($M=78.35$, $SE=11.87$, $p<0.01$). These results suggest that there is significantly more effort overall post-ban than pre-ban. However, effort during the ban, while significantly lower than at other time periods, is not reduced to zero. This is reflective of the motorized and *kattumaram* fishing that occurs during this time.

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



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

In order to understand *how* the seasonal ban influences a possible race to fish, it is important to identify which vessels are responsible for this post-ban increase. This increase does not stem from motorized or standard mechanized boats. Mean mechanized monthly fishing hours during the post-ban timeframe (M=468.90, SE=12.15) are not significantly different than the pre-ban time frame (M=443.72, SE=12.15, $p>0.1$) (Fig. 3). Motorized fishers – who are allowed to fish during the ban – also do not fish significantly more in the month after the ban than they did before the ban ($p>0.1$)

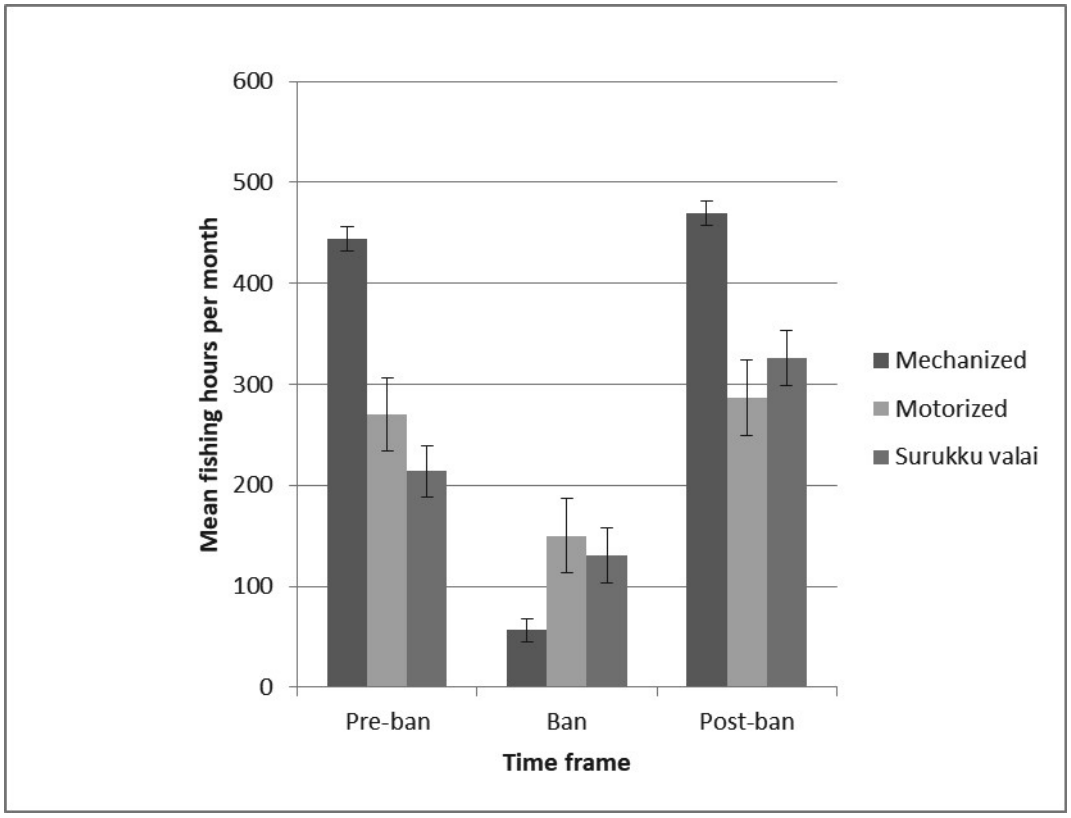
Surukku valai operations significantly decrease their effort during the ban time (as compared to pre ban effort) ($p<0.05$). However, their total monthly fishing hours during the post-ban timeframe (M=325.95, SE=26.79) are significantly higher than pre-ban (M=213.98, SE=25.68, $p<0.01$), suggesting that the significant increase in total post-ban fishing effort is

largely the result of the significant increase in *surukku valai* effort at this time (Figure 2). As discussed below, similar to 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).

3.3 Do motorized fishers significantly increase their ban time effort?

Motorized boats significantly decrease their effort during the ban timeframe (M=149.98, SE=36.73) compared to pre-ban (M=270.60, SE=35.99, $p<0.05$) and post-ban (M=286.35, SE=37.45, p=0.01) timeframes. 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 expend less effort during the ban period than they do before the ban begins.

Figure 2: Mean fishing hours per month disaggregated by boat type +/- 1 standard error



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 2 highlights the projected impact of the above increases in post-ban effort on fish catch, simply multiplying effort by catch efficiency.

Table 2: 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 caught**[11]	**Additional post-ban effort (hrs)/boat or operation,**	**Additional fish caught (kg)/boat or operation, compared**	**Number of operations in NN & KM**	**Total projected additional fish caught**

[11] Estimates for each type of operation are explained in the methods section above.

		compared with pre-ban	**with pre-ban**		**(kg) in NN & KM**
Mechanized trawl	23	25	575	131	75,325
Motorized boat	11	16	176	34	5,984
Surukku valai	95[12]	112	10,640	7[13]	74,480

The increase in mechanized and motorized effort may amount to roughly an additional 575 and 176 kilograms/boat respectively during the month post-ban (compared to pre-ban levels) of fish caught, and the increased *surukku valai* pressure may account for over 10,500 additional kilograms/operation of fish caught in the post ban month, as compared with pre ban. Within Nambiyar Nagar and Kottucherry Medu there are a total of 133 mechanized and 52 motorized boats registered. These numbers likely include the individual boats (both mechanized and motorized, that comprise the *surukku valai* operations (mechanized~2, motorized~18)[14]. Separating the *surukku valai*–bound boats from the mechanized and motorized totals, the final column in Table 2 projects a conservative estimate of catch based on increased post-ban fishing in these villages. Therefore, the total additional fish landed post-ban by all operations in these

[12] *Surukku valai* operations have an average land to sea travel time of three hours to reach suitable fishing grounds. After they set the net, they leave it in place for about three hours. They may set the net up to four times (i.e. hauls) in one trip if they are catching a good quantity of fish. Therefore, there may be an average active fishing time of 12 hrs within one fishing day for the surukku valai gear type. Lawrence & Bhalla, 2018 provide an estimate of 1135.57 kg/day caught by surukku valai which, when translated into active time spent fishing equates to roughly 95kg/hr effort.

[13] Drawn from (Bavinck et al., 2017).

[14] While Bavinck et al., 2017 estimate seven surukku valai share-holding operations in Nambiyar Nagar, data derived from our random sample suggests that some of those operations must include boats registered in other villages, as the total number of motorized boats registered in Nambiyar Nagar would not support seven surukku valai operations. Using the proportion of fishers from our random sample in Nambiyar Nagar that operate this gear type (roughly 1 in 5), the average number of *surukku valai* operations is calculated for this village (total fishers in NN = 594) (there are no *surukku valai* fishers in KM).We estimate that there are likely two surukku valai share holder operations of which all boats within the share are registered under Nambiyar Nagar village. We subtract these numbers (2 mechanized and 18 motorized) in our calculation of mechanized and motorized boats and the subsequent impact of their post-ban effort.

two villages may be upwards of 155,000 kilograms. Although this estimate is not precise and uses yearly average catch per hour effort (kg/hour), it offers a ballpark figure of the consequences of racing to fish in this fishery. Given that post-ban catch per unit effort is high compared to other times of year, an estimate derived from yearly average catch is likely conservative. Additionally, regular and *surukku valai* motorized fishing continues to have an impact – albeit smaller than usual – during the ban that must be accounted for in any calculation of ban-time fishing reduction. Both types continue to exert approximately half of their pre-ban fishing effort during the ban. From the 52 motorized boats (which catch an average of 11 kg/hr and fish for an average of 140 hours during the ban) registered between the two villages, there may be roughly 80,000 kilograms of fish landed during the ban period.

3.5 Are fishers adapting by using other gear or exploiting other resources during the ban period?

While mechanized fishing is reduced to zero during the ban period, some individuals (*n*=23) report resorting to *kattumaram* fishing during this time. Individuals who fish on *kattumaram* during the ban period usually do so to fulfill subsistence needs. Some families during the ban period become vegetarian and must purchase many of their food items. Many families have stocks of dry fish to use as well (NGO leader, personal communication, May 2015). 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.

The majority (98%) of individuals interviewed indicate no additional employment during the ban period. Fishers do not shift their effort to other gears besides *kattumaram*, nor seek alternative employment. Agricultural labor has been proposed by the government and some

NGOs as a short-term alternative for fishermen during the ban period. However, according to fishers themselves, agricultural work is not a viable option in this situation. As noted in interviews, in addition to fishers' aversion to agricultural work due to caste associations, the timing of demand for such labor does not coincide with the ban period. There was also a general lack of interest and resentment towards taking on jobs unrelated to fishing. For example, one fisherman stated that "*we are not interested in doing other work except fishing related*" which was a sentiment among many participants. Another stated that "*the people feel embarrassed to do non-fishing work at the village so if the training/employment is related to non-fishing that should be held somewhere outside*". 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. This is most likely specific to traditional, caste fishermen (Scales et al., 2015) 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 during the ban. One individual migrated to Kerala to find work in construction, but did not return post-ban for fishing. Two 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. In conclusion, while some

fishermen report adapting by using other gear (*kattumaram* or motorized boats) during the ban period, the majority of fishermen do not adapt by exploiting other resources during this time.

4 Discussion

Resource management policies may affect behavior and resource use. However, there are often unintended consequences not taken into account. Previous research has shown that roving bandits tend to occur in the context of relatively unprotected fisheries that have not anticipated targeted exploitation: the so-called "new frontiers" (Ellison, 2008). This has been exemplified in the Live Reef Fish Trade, where serial depletion has occurred in one, relatively healthy unprotected fishery after the other (Blasiak, 2015). Roving banditry also materializes under conditions where wild harvest of broodstock is still necessary, as is the case of prawn and crab aquaculture (Berkes et al., 2006). Problems stemming from roving banditry arise because people adapt faster than institutions. After depleting one species, fishers may adapt by shifting their exploitation to another species or by deploying more advanced fishing technologies (Berkes et al., 2006).

Surukku valai fishers increase their effort after the ban, providing other evidence of people adapting faster than institutions. In this way, our data indicates that adaptations occur through temporal, rather than spatial, shifts in response to the Tamil Nadu seasonal trawl ban. While the adaptations exhibited in the roving bandits phenomena involve exploiting resources outside of regulated geographical areas (Wilen, 2006), we find that certain resource users will also adapt to rules by increasing their resource use in unrestricted time frames. Both are examples of adaptations to rules that, rather than purely eliminating resource use, exemplify shifts in resource exploitation.

Mechanized and *surukku valai* fishers also switch to unregulated gear types during the fishing ban in order to adapt to the ban period. This indicates that equipment shifts are an additional adaptation that needs to be accounted for in the development of any management initiative. Both the adaptation to restrictions by switching to un-restricted fishing gears and the temporal effort shifts seen post-ban are examples of adaptations in effort that are rarely incorporated into management regulations, including in the development of India's seasonal trawl ban.

Some scholars have found that a fishing ban can lead to a post-ban race to fish and associated negative ecosystem outcomes (Sys et al., 2017). Our data also indicate that the ban promotes a race for fish – particularly by *surukku valai* operations – when the fishery is reopened after the annual closed season. Fishers heavily fish within their own territorial waters, taking advantage of weak governance and relatively high post-ban fish catch. Here the open access expectation of overexploitation persists post-ban after being stymied by the ban restriction. While mechanized boats do not show a significant difference in pre vs. post ban effort, this may be due to the timing of the survey (at week 4-5 post-ban), reflecting the decrease in fishing effort after an initial post-ban rush, explained below.

Reduced market value is one outcome of the race for fish (Tveteras et al., 2011). Many mechanized fishers stated that post-ban catch per effort is high for one to two weeks. During this time of high catch, exporters fill their freezers, after which they stop buying. This drives down the price of fish received upon landing, making it pointless to fish intensively, as any catch landed may not even recoup the cost of a trip. This high price at fishery opening followed by a price drop has been observed by other researchers as well (Bavinck et al., 2008) and in other cases has been exacerbated by overcapitalization and rent dissipation (Ostrom, 1990). In our

case, this low market price effectively stymies a continued race for fish for this gear type.[15]

However, the race to fish continues for the *surukku valai* gear type. This may be because the catch composition of *surukku valai* is different than mechanized trawl, as is their 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 and therefore this type of operation, though additional research is necessary to confirm this explanation. Additionally, *surukku valai* involves completely joint 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 (USD$1,100) to jointly fund the operation. This means they have significant incentive to fish intensively. After a month and a half of relatively low catch given gear restrictions, the push to fish heavily post ban may be motivated by the need to make loan repayments, along with the collective incentive of joint ownership. Again, future research could further assess the causes of this difference across gear types.

Our findings confirm previous research that non-mechanized fishers do well during the ban period (Ostrom, 1990). By closing the fishery to certain gear types (i.e. mechanized) the fishing ban effectively curbs one of the major pitfalls of an open access fishery that leads to the race to fish: conflicts between gears (Vivekanandan et al., 2010). Non-mechanized fishermen, 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 achieve income goals with less fishing.

[15] While fishermen specifically referenced their fishing effort choices in relation to decreased price and demand, they also referenced that CPUE also declines after about 1-2 weeks after the ban period is lifted.

One motorized fisher stated that "*We prepare to go for fishing during the ban time as the trawler will not come to sea. We get a good amount of fish also. Due to the ban, we also get good price for the fish*". Instead of increasing effort during the ban period, most non-mechanized fishers decrease their effort, though not as drastically as the mechanized fishers who are restricted from using their gear during this period. This decrease in motorized effort during the ban may be evidence of differences in future discount rates placed on fisheries resources between mechanized and motorized fishers (Bavinck, 1998; Novak & Axelrod, 2016) or it could simply be a result of the ban being positioned during the low season. Further research is necessary to ascertain the motivations for decreased motorized effort.

As hypothesized in the beginning of this paper, the presence of – and compliance with – a regulation did not prevent resource users from being adaptive and innovative. In many cases, users found ways to continue their livelihoods within restricted time frames. Our results indicate that fishers adapt to restrictions by using un-restricted fishing gears or increasing catch after the ban. These behaviors highlight substantial pressures exerted on the resource despite compliance with the ban. While the seasonal ban does appear to reduce total pressure on fisheries, its impact may not be as comprehensive as hoped. This adaptation in effort is rarely incorporated into management regulations, including in the development of India's seasonal trawl ban, and the current management structure also incentivizes a post-ban race to fish for certain gears. As Cinner et al. (2006) note, and our findings also confirm, seasonal fishing constraints may be less effective in areas where fishers are heavily dependent on the resource and unable to pursue alternative livelihoods.

5 Conclusion

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 (Jentoft, Bavinck, Johnson, & Thomson, 2009), this research contributes 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. Such fishing adaptation may continue to increase over time, as fishers experiment with alternative responses to the policy. This study demonstrates that the limitations of seasonal bans may be particularly acute for particular gear types, such as *surukku valai*, that are inherently adaptable due to their multiple components.

This research also contributes 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 to improve marine fisheries policy.

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. Tamil Nadu communities have a history of overriding government fishing regulations perceived as illegitimate (Bavinck et al., 2013). Therefore, at present, the ban is the only state sponsored fishing regulation that is effectively enforced. When asked about support for the current ban, all participating fishers acknowledged continuously declining overall catch levels and the resulting need for a policy of this nature. However, the policy's effectiveness requires a clear understanding of differentiated responses. Mobilizing this

knowledge and collaborating with different fisher factions is important. In this way, future management proposals may be jointly developed for greater legitimacy and impact.

5.2 Policy recommendations

Locally relevant solutions to this problem are necessary. As stated above, a robust regulatory system requires understanding the reasons for successful compliance with the fishing ban, as well as ongoing challenges. Three specific policy recommendations stem from this research. We make these recommendations with the caveat that policy changes are best informed by multiple years of data and simultaneous monitoring for their environmental and socioeconomic impacts.

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 (Vivekanandan et al., 2010). 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. A solution may emerge akin to what Bavinck et al. (2017) call for in their work on the importance of legal pluralism in governing small-scale fisheries in India. They highlight the need for coordination between state

and non-state actors, which could address some of the unexpected responses we have identified. 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 without community participation is bound to fail, as seen by disregard for the state-level *surukku valai* gear ban and district-level net restrictions that were not supported by local *panchayats* (Novak and Axelrod 2016). Therefore, stakeholder involvement and meaningful community outreach are crucial in developing regulations that will complement the ban period.

Third, to mitigate food security threats, the government might consider subsidizing the purchase of non-motorized *kattumarams* to enable fishers to fish for household and subsistence purposes during the ban period. Additionally, there is an obvious opportunity for intervention to improve fish drying techniques to improve preservation.[16] 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, supported, and successfully implemented. Addressing these concerns as part of a longer term process of adaptive management may increase the overall effectiveness of the seasonal ban as a successful fisheries governance innovation. Additionally, any future changes to the seasonal ban itself should be carefully considered in light of what stands to be lost if fishermen buy in for the original 45 day ban is compromised.

In conclusion, there are often confounding factors to successful fisheries management. This research has shown that restricting fishing temporally may lead 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

[16] It is acknowledged within both the non-governmental and governmental sectors that this is an area of need.

consequences are often unanticipated in fisheries policy development and have the potential to impact the efficacy of the most well intentioned initiative. There is therefore a need for further governance interventions to respond and account for fishers' adaptation to this regulation. 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.

Acknowledgements

This work was supported by the United States-India Educational Foundation, Fulbright-Nehru Student Research Program (grant number 2014/ST/20). Previous versions of this work were presented at the MARE 2015 & 2017 Conferences at the University of Amsterdam, The Netherlands and International Studies Association Annual Convention (2016) in Atlanta, GA. The authors thank Dr. S. Velvizhi of M.S. Swaminathan Research Foundation, Dr. A. Gopalakrishnan and Dr. Shyam S. Salim of the Central Marine Fisheries Research Institute for their help in facilitating the research process and Dr. Maarten Bavinck for his helpful insight. We also thank Monalisha Sundar for her language expertise.

6 References

Acock, A. C. (2016). *A gentle introduction to STATA* (5th ed.). College Station, TX: STATA Press.

Bavinck, M. (1998). “A matter of maintaining peace” State accomodation to subordinatelegal systems: The case of fisheries along the Coromandel coast of Tamil Nadu, India. *Journal of Legal Pluralism & Unofficial Law*, *151*(40).

Bavinck, M., de Klerk, L., van Dijk, D., Rothuizen, J. V., Blok, A. N., Bokhorst, J. R., … Scholtens, J. (2008). Time-zoning for the safe-guarding of capture fisheries: A closed season in Tamil Nadu, India. *Marine Policy*, *32*(3), 369–378. http://doi.org/10.1016/j.marpol.2007.08.007

Bavinck, M., Imara Hoefsloot, F., & Wastiaux Maarten Bavinck, M. (2017). Responsible Fisheries? A Response to the “New Path” of Co-governance. *Economic & Political Weekly EPW SEPTEMBER*, *30*, 83–86. Retrieved from http://www.epw.in/system/files/pdf/2017_52/39/DI_LII_39_300917_Maarten_Bavinck.pdf

Bavinck, M., Johnson, D., Amarasinghe, O., Rubinoff, J., Southwold, S., & Thomson, K. T. (2013). From indifference to mutual support: A comparative analysis of legal pluralism in the governing of South Asian Fisheries. *European Journal of Development Research*, *25*(4), 621–640. http://doi.org/10.1057/ejdr.2012.52

Beare, D., Rijnsdorp, A. D., Blaesberg, M., Damm, U., Egekvist, J., Fock, H., … Verweij, M. (2013). Evaluating the effect of fishery closures: Lessons learnt from the Plaice Box. *Journal of Sea Research*, *84*, 49–60. http://doi.org/10.1016/j.seares.2013.04.002

Berkes, F. (2010). Linkages and Multilevel Systems for Matching Governance and Ecology : Lessons From Roving Bandits. *Bulletin of Marine Science*, *86*(2), 235–250.

Berkes, F., Hughes, T. P., Steneck, R. S., Wilson, J. A., Bellwood, D. R., Crona, B., … Worm, B. (2006). Globalization, Roving Bandits, and Marine Resources. *Science*, *311*(5767), 1557–1558. http://doi.org/10.2307/3845652

Bhat, M., & Bhatta, R. (2001). *An economic analysis of sustainability of marine fish production in Karnataka*. *Marine Ecosystems & Sustainability EERC Working Paper Series: MES-1*. Mangalore, India. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:An+Economic+Analysis+of+the+Sustainability+of+Marine+Fish+Production+in+Karnataka#3%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:An+Economic+Analysis+of+the+Sustainability+of+

Birkenbach, A. M., Kaczan, D. J., & Smith, M. D. (2017). Catch shares slow the race to fish. *Nature*, *544*(7649), 223–226. http://doi.org/10.1038/nature21728

Blasiak, R. (2015). Balloon effects reshaping global fisheries. *Marine Policy*, *57*, 18–20. http://doi.org/10.1016/j.marpol.2015.03.013

Cinner, J., Marnane, M. J., Mcclanahan, T. R., & Almany, G. R. (2006). Periodic Closures as Adaptive Coral Reef Management in the Indo- Pacific, *11*(1).

CMFRI. (2010a). *Marine Fisheries Census 2010 - Puducherry*. Kochi.

CMFRI. (2010b). *Marine Fisheries Census 2010 - Tamil Nadu*. Kochi.

CMFRI. (2015). *2014-2015 Annual Report*. Kochi.

Cohen, P. J., & Alexander, T. J. (2013). Catch Rates , Composition and Fish Size from Reefs Managed with Periodically-Harvested Closures. *PLoS ONE*, *8*(9). http://doi.org/10.1371/journal.pone.0073383

Cohen, P. J., Cinner, J. E., & Foale, S. (2013). Fishing dynamics associated with periodically harvested marine closures. *Global Environmental Change*, *23*(6), 1702–1713. http://doi.org/10.1016/j.gloenvcha.2013.08.010

Cohen, P. J., & Foale, S. J. (2013). Sustaining small-scale fisheries with periodically harvested marine reserves. *Marine Policy*, *37*, 278–287. http://doi.org/10.1016/j.marpol.2012.05.010

Coulthard, S. (2008). Adapting to environmental change in artisanal fisheries—Insights from a South Indian Lagoon. *Global Environmental Change*, *18*(3), 479–489. http://doi.org/10.1016/j.gloenvcha.2008.04.003

Ellison, A. M. (2008). Managing mangroves with benthic biodiversity in mind: Moving beyond roving banditry. *Journal of Sea Research*, *59*(1–2), 2–15. http://doi.org/10.1016/j.seares.2007.05.003

Emery, T. J., Hartmann, K., Green, B. S., Gardner, C., & Tisdell, J. (2014). Does "race to fish" behaviour emerge in an individual transferable quota fishery when the total allowable catch becomes non-binding? *Fish and Fisheries*, *15*(1), 151–169. http://doi.org/10.1111/faf.12015

Islam, M. M., Islam, N., Sunny, A. R., Jentoft, S., Ullah, M. H., & Sharifuzzaman, S. M. (2016). Fishers' perceptions of the performance of hilsa shad (Tenualosa ilisha) sanctuaries in Bangladesh. *Ocean & Coastal Management*, *130*, 309–316. http://doi.org/10.1016/j.ocecoaman.2016.07.003

Jentoft, S., Bavinck, M., Johnson, D. S., & Thomson, K. T. (2009). Fisheries Co-Management and Legal Pluralism: How an Analytical Problem Becomes an Institutional One. *Human Organization*, *68*(1).

Lawrence, T. N., & Bhalla, R. S. (2018). Spatially Explicit Action Research for Coastal Fisheries Management. *PlosOne*, *13*(7), 1–26.

Novak, J. M., & Axelrod, M. (2016). Patterns of Multi-Level Fisheries Governance and Their Impact on Fishermen's Adaptation Strategies in Tamil Nadu, India. *Environmental Policy and Governance*, *26*(1), 45–58. http://doi.org/10.1002/eet.1694

Novak Colwell, J. M., & Axelrod, M. (2017). Socio-economic impacts of a closed fishing season on resource-dependent stakeholders in Tamil Nadu, India: Differences in income and

expenditure effects by occupational group. *Marine Policy*, *77*, 182–190. http://doi.org/10.1016/j.marpol.2016.10.026

Oliver, T. A., Oleson, K. L. L., Ratsimbazafy, H., Raberinary, D., Benbow, S., & Harris, A. (2015). Positive catch & economic benefits of periodic octopus fishery closures: Do effective, narrowly targeted actions "catalyze" broader management? *PLoS ONE*, *10*(6), 1–25. http://doi.org/10.1371/journal.pone.0129075

Ostrom, E. (1990). *Governing the commons: The evolution of Institutions for collective action*. Cambridge, United Kingdom: Cambridge University Press.

Poos, J.-J., & Rijnsdorp, A. D. (2007). An "experiment" on effort allocation of fishing vessels: the role of interference competition and area specialization. *Canadian Journal of Fisheries and Aquatic Sciences*, *64*(2), 304–313. http://doi.org/10.1139/f06-177

Scales, H., Balmford, A., Liu, M., Sadovy, Y., Manica, A., Hughes, T., … Worm, B. (2015). Keeping bandits at bay? *Science*, *313*(5787), 612–614.

Slocum, R. (1995). Seasonal activities calendar. In R. Slocum, W. L, R. D, & T.-S. B (Eds.), *Power and Participation: Tools for change* (pp. 181–185). London: Intermediate Technology Publications.

Stilles, M. L., Stockbridge, J., Lande, M., & Hirshfield, M. F. (2010). *Impacts of bottom trawling on fisheries, tourism and the marine environment*.

Sys, K., Van Meensel, J., Polet, H., & Buysse, J. (2017). A temporal race-for-fish: The interplay between local hotspots of flatfish and exploitation competition between beam trawlers after a seasonal spawning closure. *Fisheries Research*, *193*, 21–32. http://doi.org/10.1016/j.fishres.2017.03.018

Tidd, A., Hutton, T., Kell, L., & Padda, G. (2011). Exit and entry of fishing vessels: an evaluation of factors affecting investment decisions in the North Sea English beam trawl fleet. *ICES Journal of Marine Science*, *68*(5), 961–971.

Tveteras, S., Paredes, C. E., & Peña-Torres, J. (2011). Individual Vessel Quotas in Peru: Stopping the Race for Anchovies. *Marine Resource Economics*, *26*(580), 225–232. http://doi.org/10.5950/0738-1360-26.3.225

Vivekanandan, E., Narayanakumar, R., Najmudeen, T. M., Jayasankar, J., & Ramachandran, C. (2010). *Seasonal Fishing Ban* (Marine Fisheries Policy Brief No. 2). Kochi.

Vu, H. D. (2013). A Bilateral Network of Marine Protected Areas Between Vietnam and China: An Alternative to the Chinese Unilateral Fishing Ban in the South China Sea? *Ocean Development & International Law*, *44*(2), 145–169. http://doi.org/10.1080/00908320.2013.750984

Watling, L., & Norse, E. A. (1998). Disturbance of the Seabed by Mobile Fishing Gear: A Comparison to Forest Clearcutting. *Conservation Biology*, *12*(6), 1180–1197. http://doi.org/10.1046/j.1523-1739.1998.0120061180.x

Wilen, J. E. (2006). Why Fisheries Management Fails: Treating Symptons Rather Than The Cause. *Bulletin of Marine Science*, *78*(3), 529–546.