Catalyzing sustainable fisheries management though behavior change interventions

Gavin McDonald – Marine Science Institute, Bren School of Environmental Science & Management, University of California, Santa Barbara – Bren Hall, 2400 University of California, Santa Barbara, CA 93106, USA – gmcdonald@bren.ucsb.edu

Molly Wilson – Bren School of Environmental Science & Management, University of California, Santa Barbara - Bren Hall, 2400 University of California, Santa Barbara, CA 93106, USA - mwwilson@ucsb.edu

Diogo Veríssimo - Department of Zoology, Oxford Martin School, University of Oxford – 34 Broad St, Oxford OX1 3BD, UK - diogo.gasparverissimo@zoo.ox.ac.uk

Rebecca Twohey – Coral Reef Alliance – 1330 Broadway #600, Oakland, CA 94612 - becky@twohey.org

Michaela Clemence – Marine Science Institute, Bren School of Environmental Science & Management, University of California, Santa Barbara – Bren Hall, 2400 University of California, Santa Barbara, CA 93106, USA - mclemence@bren.ucsb.edu

Dean Apistar – Rare Philippines – 91-104 F. Ramos St, Cebu City, 6000 Cebu, Philippines - dapistar@rare.org

Stephen Box – Rare – 1310 N Courthouse Rd Suite 110, Arlington, VA 22201, USA - sbox@rare.org

Paul Butler – Rare – 1310 N Courthouse Rd Suite 110, Arlington, VA 22201, USA - pbutler@rare.org

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Fel Cesar Cadiz – Rare Philippines – 91-104 F. Ramos St, Cebu City, 6000 Cebu, Philippines - fcadiz@rare.org

Stuart J. Campbell – Rare Indonesia – Jl. Gunung Gede I No.6, RT.3/RW.4, Bantarjati, Bogor Utara, Kota Bogor, Jawa Barat 16153, Indonesia - scampbell@rare.org

Courtney Cox – Rare – 1310 N Courthouse Rd Suite 110, Arlington, VA 22201, USA - ccox@rare.org

Micah Effron –Previously at Rare – 1310 N Courthouse Rd Suite 110, Arlington, VA 22201, USA - Not currently affiliated – micah.effron@gmail.com

Steve Gaines – Bren School of Environmental Science & Management, University of California, Santa Barbara – Bren Hall, 2400 University of California, Santa Barbara, CA 93106, USA - gaines@bren.ucsb.edu

Raymond Jakub – Rare Indonesia – Jl. Gunung Gede I No.6, RT.3/RW.4, Bantarjati, Bogor Utara, Kota Bogor, Jawa Barat 16153, Indonesia - RJakub@rare.org

Roquelito H. Mancao – Rare Philippines – 91-104 F. Ramos St, Cebu City, 6000 Cebu, Philippines - lito@rare.org

Pablo T. Rojas – Rare Philippines – 91-104 F. Ramos St, Cebu City, 6000 Cebu, Philippines - jong@rare.org

Rocky Sanchez Tirona – Rare Philippines – 91-104 F. Ramos St, Cebu City, 6000 Cebu, Philippines - rtirona@rare.org

Gabriel Vianna – Previously at Rare - Rua Visconde de Pirajá, 177-sala 801, Ipanema, Rio de Janeiro, RJ, Brazil – Currently at University of Western Australia - 35 Stirling Hwy, Crawley WA 6009, Australia - gabe.vianna@gmail.com

**Corresponding author mailing address and contact information:**

Gavin McDonald

Bren School of Environmental Science & Management

2400 Bren Hall

University of California, Santa Barbara

Santa Barbara, CA 93106

USA

gmcdonald@bren.ucsb.edu

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**Article impact statement**

Moving from overfishing to sustainability, fisheries can use behavior-change campaigns to bridge from near-term losses to long-term gains.

**Abstract:**

Small-scale fisheries are an important livelihood and primary protein source for coastal communities in many of the poorest regions in the world, yet many suffer from overfishing, requiring effective and scalable management solutions. Positive ecological and socioeconomic responses to management typically lag behind immediate costs borne by fishers from fishing pressure reductions

necessary for fisheries recovery. These short-term costs challenge the long-term success of these interventions. However, social marketing may increase perceptions of management benefits before ecological and socioeconomic benefits are fully realized, driving new social norms and ultimately long-term sustainable behavior change. Using ecological surveys and community-perceived measures of management support and socioeconomic conditions, we assess the impact of a standardized small-scale fisheries management intervention that was implemented across 41 sites in Brazil, Indonesia, and the Philippines. The intervention combines TURF-reserves (community-based Territorial Use Rights for Fishing coupled with no-take marine reserves) with locally-tailored social marketing behavior change campaigns. Leveraging data across diverse indicators, our results suggest that communities were developing new social norms and fishing more sustainably, even before long-term ecological and socioeconomic benefits of fisheries management had materialized.

**Introduction**

Small-scale fisheries provide livelihoods for more than 90% of the planet's fishers (Franz & Stamoulis 2015). However, overfishing has driven many fisheries to unsustainable conditions (Costello et al., 2012). Territorial Use Rights for Fishing coupled with no-take marine reserves (TURF-reserves) have been touted as one solution for improving biological and socioeconomic conditions of small-scale near-shore fisheries (Afflerbach et al., 2014). There is theoretical support that TURF-reserves can increase harvest and conservation when they are designed to encompass the species home range and when fishing pressure is otherwise poorly controlled (Lester et al., 2017). However, empirical evidence usually focuses separately on either TURFs (Quynh et al., 2017) or no-take marine protected areas, also known as marine reserves or no-take zones (NTZs) (Lester et al. 2009). Moreover, there have been no studies that empirically investigate the effectiveness of TURF-

reserves when coupled with social marketing campaigns. Social marketing aims to influence specific behavior change associated with sustainability and social good by using marketing techniques, and has been described as an important tool for successful adoption of conservation interventions (Salazar et al. 2018).

TURF-reserves aim to reduce fishing pressure by restricting access to the fishery and establishing management controls for those who retain rights to fish. While theory predicts they will produce long-term benefits when properly designed, ecological responses may be inherently slow due to life history traits of target species (Russ & Alcala 2004). Socioeconomic benefits may also be slow to materialize and fishers may even incur short-term costs, especially when catches must be reduced to allow stocks to recover (Ovando et. al 2016). This temporary period presents a behavioral challenge since communities may slip back to overfishing when they fail to see dividends. Social norm-based interventions could be uniquely situated to address this problem. Social sanctions for deviation which accompany social norms may create enabling conditions for compliance with that norm, even if that outcome is temporarily inferior to overfishing (Boyd & Richerson 1992). This stability could help a community comply until fish stocks are restored. Community support of the intervention is therefore critical for long-term behavior change (Bennett 2016), and may build more quickly if the intervention includes a behavior change social marketing component (Veríssimo & McKinley 2016). A meta-analysis of 84 conservation-oriented social marketing campaigns found that on average, all social norm and behavior change indicators experienced positive changes following the intervention (Green et al., 2019). This suggests that behavior change campaigns may help address a ubiquitous small-scale fisheries management challenge.

A recent initiative provided an opportunity for examining the efficacy of TURF-reserves coupled with behavior change campaigns across a wide range of small-scale fisheries contexts. Fish Forever is a global program aimed at improving the ecological, economic, and social conditions of small-scale

fishing communities. To do so, the program: 1) implemented local "Pride campaigns", a unique style of social marketing campaign pioneered by Rare (Jenks et al. 2010); and 2) provided decision-support tools to guide technical TURF-reserve fisheries management. Implementation of the intervention was guided through a common Theory of Change (ToC) across all sites. Fundamentally, the intervention works through the creation of a new social norm of sustainable fishing, where fishers moderate their fishing because of the beliefs and behavior of those in their community (Bicchieri, 2016).

Here we evaluate the effects of the program across 41 sites in Brazil, Indonesia, and the Philippines implemented from 2014 to 2017. First, we assess biological and socioeconomic responses to the intervention across a diverse suite of indicators including community support of the intervention, behavior change, and ecological and socioeconomic impact. Second, we supplement a subset of these findings using three Philippines control sites to provide limited counterfactual evidence on what would have happened without the intervention at these three sites. Third, we use structural equation modeling to explore linkages between indicators across the ToC. This study offers new evidence on the effectiveness of TURF-reserves coupled with behavior change campaigns, providing insights into how behavior change campaigns can be a tool for solving a fundamental challenge to fisheries management reform.

## Methods

### Study areas

Figure 1 shows the location of the intervention and control sites in this study. Sites are located across most of the major island groups in Indonesia and the Philippines, and spread along the length of the Brazilian coastline. Figure S1 shows summary statistics of the intervention sites including the

size of the TURF and NTZ, the percentage of the TURF covered by NTZ, and the number of affected fishers.

**Theory of Change**

Through a ToC, Fish Forever aimed to achieve sustainable ecosystem, fisheries, and livelihood outcomes via a series of intervention and process goals (Figure 2). While more nuanced ToCs might be relevant at site- or country-level scales, the following overarching Fish Forever ToC was kept as simple as possible to maintain relevance in different contexts while still reflecting key behavior change dynamics. Literature suggests that seeing a situation as competitive versus cooperative influences one's behavior (Engel & Rand, 2014). Many fishers implicitly see fishing as a competitive interaction, where a fish taken by one person is a fish unavailable to everyone else. The intervention supplanted this belief with the knowledge that fisheries are in fact a cooperative dilemma: individuals have a selfish incentive to overfish, but everyone can do better by fishing sustainably. The intervention did so by using social marketing to promote knowledge, attitudes, and interpersonal communication related to sustainable fishing, which are keys to facilitating shifts in cooperation (Ostrom et al., 1992). This was done through the use of "Pride" campaigns, a type of social marketing led by a local campaign manager who is embedded within the community and a local implementing partner organization. Pride campaigns aim to drive behavior change around specific conservation actions, and leverage audience research and segmented marketing through platforms including parades, banners, and radio (Jenks et al., 2010).

The intervention also provided essential technical knowledge needed to fish more sustainably through two decision-support toolkits that help communities: 1) delineate TURF-reserve boundaries (Oyanedel et al., 2017); and 2) establish new fishery management controls, such as gear restrictions or size limits, as part of an adaptive management framework (McDonald et al., 2018). These toolkits

were provided to intervention sites but not control sites, and were used by local campaign managers who facilitated participatory processes involving fishers, government, and other local stakeholders.

Once new regulations are established, the decision to comply is more complex than a simple monetary decision that weighs expected costs and benefits – it also involves non-monetary factors including social influence and moral values (Hatcher et al. 2000). Social marketing has been shown to influence pro-environmental social norms, even during campaigns that last three years or less (Green et al., 2019). New norms can be established rapidly via a tipping point once a critical mass of individuals is reached (Centola et al. 2018). Further, along with the social norm that people are wrong to overfish comes a willingness to socially sanction those who do through self-enforcement (Ovando et al., 2013).

By building shared community and government support and empowering fishers, we hypothesize the intervention may directly increase social and political trust, equity, collective efficacy, and subjective well-being. As fish stocks increase through increased sustainable fishing practices, catches may also stabilize or increase. Ultimately, more stable catch levels may also have positive impacts on livelihood stability, food security, and household assets. However, theory predicts that benefits will not be realized if there is significant species movement outside of the TURF-reserve into heavily fished open-access areas, and that adding reserves to TURFs may have a neutral or even negative impact on harvest and income if the fishery is otherwise well-managed (Lester et al., 2017). Social marketing alone cannot compensate for biological constraints or insufficient management design, which could eventually result in a loss of community support and ultimately intervention failure. Therefore, adaptive management and capacity building are important aspects of the program so that the community is equipped for long-term sustainability (McDonald et al., 2018).

**Data description and survey design**

The ToC provided the framework for a global monitoring and evaluation plan to assess impact across a diversity of indicators (Table 1). Three socioeconomic household surveys assessing community support, sustainable fishing practices, and sustainable livelihoods were conducted across all sites in all countries and collected indicators via direct questioning to elicit self-reported perceptions (Table 2). Meanwhile, a sustainable ecosystem survey was conducted at sites in Indonesia and the Philippines. Unlike the coral reefs at Indonesia and Philippines sites, Brazil sites feature mangrove and estuarine systems and thus a comparable ecosystem survey could not be conducted in Brazil. All surveys at each site were conducted before and after the intervention. Additionally, sustainable ecosystem and sustainable livelihoods surveys were conducted in the Philippines at three matched control sites, both before and after the intervention time period. In contrast to Philippines and Indonesia, access rights for Brazil TURFs were not finalized by 2017. Therefore, observed changes in Brazil would only be related to Pride campaigns and capacity building of existing fisheries management regimes. Table 2 summarizes representative socioeconomic survey questions, spreadsheet S2 contains complete lists of the exact socioeconomic survey questions asked at each site, Table S3 summarizes how many sites collected each indicator, Tables S3-S8 summarize sample sizes for each site and indicator, and all original socioeconomic survey instruments are provided in S4 – S20.

To measure progress towards community support and the sustainable fishing practices which community support is hypothesized to drive, we leveraged the framework used by Green et. al (Green et al., 2019), which integrates a transtheoretical behavior change model (Prochaska & Norcross, 2018), a diffusion of innovation model (Rogers, 2010), and a planned behavior model (Ajzen, 1991). Respondents were asked about six behavior change components of the intervention, and were asked whether they know what the behavior change is (“Knowledge”), if they believe the

behavior change will benefit themselves and the fishery ("Attitude"), if they discuss the behavior change with other members of the community ("Communication"), and if they personally changed their behavior ("BC") (Table 2).

To measure progress towards achieving sustainable livelihoods goals, we selected a suite of indicators by using the Sustainable Livelihoods Framework (SLF) from the Department for International Development (DFID, 1999). The SLF is based on the concept that people require certain capitals to achieve sustainable livelihoods: human, social, physical, financial, natural, and political. We therefore selected indicators from across these capitals that we hypothesized would be affected by the intervention, according to our ToC (Tables 1 and 2).

Household survey questions were kept as consistent as possible across sites and countries while still allowing for differences in local social context, language, and institutions. Question framing was highly related to the objectives and specific interventions implemented at each site and were defined in community-based discussions during the pre-implementation phase of each intervention. A global monitoring and evaluation team trained campaign managers in sampling protocols and worked with them to tailor survey questions to local context while maintaining global consistency. Households were selected randomly from households actively engaged in the intervention target fisheries, geographically stratified across the community. Surveys were performed with heads of these households, with the vast majority of these individuals being males. However, given the broader dependence of these communities on fisheries, socioeconomic changes perceived by these households were also likely noticed to some extent by other community members.

For household surveys, we calculated a normalized response score for each indicator that is scaled from between 0 and 100 (where 0 is the worst possible score and 100 is the best possible score). For binary questions, a positive response became a 100 and a negative response became a 0. For

questions with multiple Likert-type response options along a gradient (for example, from “Strongly agree” to “strongly disagree”), the most positive response became a 100, the most negative response became a 0, and responses in between were given a score scaled between 0 and 100 and proportional to the number of response options. Some sites asked multiple questions relating to the same indicator, in which case we averaged values across the normalized indicator scores (S3 provides a summary of these sites and indicators, along with which questions were combined). Combining or comparing normalized scores from binary and Likert-type questions may introduce bias, since respondents to Likert-type responses may chose extreme options less frequently than more central options (Guilford, 1954). In future studies, we recommend asking all survey questions on the same scale.

While direct questioning is known to result in biased responses, deliberate survey design and interview training can reduce some biases (Catania, 1999), and direct questioning remains a predominant technique for eliciting community support and socioeconomic indicators where objective techniques are not possible (Steg & Vlek, 2009). The on-site campaign manager conducted most community support, sustainable fishing practices, and sustainable livelihoods surveys due to logistical and financial constraints, while third-party contractors conducted the Philippines and Indonesia sustainable livelihood surveys. Use of impartial third-party interviewers may reduce social desirability bias, which is a systematic self-reporting error that may occur when survey respondents try to project a positive image of themselves (Krumpal, 2013). However, we acknowledge that this bias may still result in inflated estimates of positive change. Objective measures of socioeconomic indicators (for example from government economic data or enforcement reports) could not be obtained for this study, but these could triangulate self-reported data in future impact evaluations. Additionally, while household surveys of individuals cannot directly measure changes in social norms

that occur at the community level, they can measure individual behavior changes that require social buy-in to happen.

The sustainable ecosystem survey in Indonesia and the Philippines is a standard coral reef monitoring underwater visual survey that measures biomass of target fished families within the TURF, both inside and outside the NTZ (English et al. 1997). Monitored target families include snappers, groupers, and parrotfish (see Table S10 for a complete list).

**Ethics statement**

The participation of a community in Fish Forever is a voluntary process that requires a democratic representative of a community to complete an application, followed by a selection process. This was the case for both intervention sites and control sites. Fish Forever is implemented at the local level by a representative of the local government or of a local NGO, and local institutions were active in the co-design and the implementation of the intervention design. The data collection for this study was conducted under permission of the national and local governments. Free prior informed consent was obtained verbally from village leaders and participants before conducting household surveys. Participants were informed about the survey, its purpose, and how the data would be used prior to consenting. Personal identifiers were anonymized. All data remained strictly confidential throughout the data analysis process and reporting.

**Before-after analysis**

For each indicator and intervention site, we performed a separate linear regression to determine changes from before to after the intervention for that indicator and site. Each separate linear regression leverages survey respondents as the unit of observation for community support, sustainable fishing practices, and sustainable livelihoods surveys and underwater visual survey

location as the unit of observation for sustainable ecosystem surveys. The before-after estimator $\beta_1$is the standardized effect size. Standard errors are robust to heteroscedasticity.

$$Outcome_i = \beta_0 + \beta_1 BeforeAfter_i + u_i$$

For each indicator and country, we also calculated the precision-weighted average effect size across all sites. This uses the inverse variance weight of each individual model result to give higher weighting to site-level models with lower standard errors (Hartung et al., 2008). Since the before-after analysis does not include a counterfactual, results from this approach cannot imply causality but simply establish whether changes occurred.

**Difference-in-difference impact analysis**

Impact evaluation aims to compare real-world observations to an inferred counterfactual scenario, with the objective being to rule out alternative explanations for the observed outcomes (Ferraro 2009). Control sites should therefore be as similar as possible to the intervention sites regarding the characteristics that are expected to influence the intervention outcomes. For the Philippines sustainable ecosystems and sustainable livelihoods surveys, a formal process was used to select three matched control sites where no Fish Forever interventions were implemented. First, several communities voluntarily self-selected by expressing interest in becoming a Fish Forever site. For each community, 30 ecological, socioeconomic, and governance baseline attributes were scored on a scale of 1 to 5. These included species richness, extent of illegal fishing, and social capacity for conservation efforts (see S21 for a complete list of attributes). Next, an aggregate coarse matching score was calculated for each site by summing the individual attribute scores (see Table S1 for a summary of these scores). After intervention sites were selected following a multi-round process that considered matching scores, strength of candidate campaign manager and implementing partner, and logistical constraints, control sites were selected from the pool of sites which made it to

the final round of this process. Self-selection biases were therefore avoided because all control and intervention sites had applied to participate in Fish Forever and had already made it through initial screenings. Control sites were selected that were within 10 points of the intervention site based on the aggregate matching score, and within 3 points of the intervention site based on each individual baseline attribute score. To assess how well the control and intervention sites were matched, we calculated the standardized mean difference between the intervention site and control site aggregate matching scores, with a maximum cutoff of 0.25 representing reasonably similar sites (Stuart et al. 2013). Intervention and control sites were well matched, with a standardized mean difference of 0.225.

We performed a difference-in-difference analysis using linear regression for the three intervention sites and matched control sites. For each indicator and intervention site, we performed a separate linear regression as follows, where "$MatchingScore$" is the coarse aggregate matching score, therefore addressing selection bias. The difference-in-difference estimator $\beta_3$is the standardized effect size. Standard errors are robust to heteroscedasticity.

$$Outcome_i = \beta_0 + \beta_1 BeforeAfter_i + \beta_2 ControlImpact_i + \beta_3 BeforeAfter * ControlImpact_i + \beta_4 MatchingScore + u_i$$

For each indicator, we again present the precision-weighted average effect size across all sites.

**Structural equation model**

To examine relationships among our ToC indicators and to better understand the potential causal pathways between intervention and outcomes, we developed a structural equation model (SEM). Structural equation modeling integrates several multivariate analyses to test hypothesized relationships among both manifest indicators (i.e., directly observed) and latent indicators (i.e., hypothesized constructs to explain behavior) (Grace, 2006). Because the interventions were three

years or less in duration, we did not include hypothesized future sustainable livelihood benefits indicators in our main SEM. We instead limited our main SEM to relationships between community support and sustainable fishing practices, and tested an additional iteration that includes sustainable ecosystem benefits which is presented in the Supplementary Information. Because of its high degree of hypothesized links to sustainable fishing practices, we defined "community support" as a latent indicator predicted by the manifest indicators of "knowledge", "attitude", and "communication".

We ran the model using the *lavaan* package in *R* (Rosseel, 2012) with a pooled dataset from intervention sites across all three countries and using before-after differences in site level means. Sample sizes for some indicators precluded country-specific SEM analyses at this point, although each indicator is represented by comparable survey questions across countries. We evaluated performance of model iterations using comparative fit index (CFI) values. CFI compares $\chi^2$ values of the model to a null model in which all indicators are uncorrelated.

**Results**

**Before-after analysis**

While there is heterogeneity across sites, some patterns emerge when looking at the precision-weighted estimates at the country level (Figure 3). All community support indicators describing knowledge, attitudes, and interpersonal communication related to the intervention showed statistically significant increases in all countries from before to after the intervention, with precision-weighted estimates ranging from 0.27 to 1.32. Additionally, most sustainable fishing practice indicators showed statistically significant positive changes, with the exception of three indicators in Brazil that showed no change (TURF compliance, NTZ compliance, and catch reporting). In Indonesia, targeted fish biomass increased outside the NTZ and saw no change inside the NTZ, while Philippines biomass decreased outside the NTZ and increased inside the NTZ. Many sustainable livelihood

indicators showed increases, although there is variability across countries regarding which indicators increased. While livelihood stability increased across all three countries, social trust decreased in the Philippines and the perceived 5 year catch trend decreased in Indonesia.

**Difference-in-difference impact analysis**

There is again variability across individual sites, but certain patterns emerge when looking at country-level precision-weighted estimates (Figure 4). Biomass increased both inside and outside the NTZ relative to the control sites. Political trust also increased relative to the control sites, while social equity, food security, and collective efficacy decreased relative to control sites.

**Structural equation model**

Figure 5 shows the final SEM depicting relationships among community support and sustainable fishing practices. Overall model performance (CFI=0.908) meets the desired threshold of 0.9. The model suggests that community support is a strong predictor of management participation, enforcement, and catch reporting, but not of NTZ compliance or TURF compliance. Enforcement strongly predicts NTZ compliance but not TURF compliance. Management participation predicts neither NTZ nor TURF compliance. Measured ecological outcomes are not significantly predicted and their inclusion greatly reduces the performance of the model (Figure S2, CFI= 0.570).

**Discussion**

For all three countries, positive impacts on all community support indicators suggest that the Fish Forever intervention is creating the social conditions needed for shifting behavior toward more sustainable fishing practices. We see this result despite neutral or negative trends in several sustainable ecosystem and livelihood indicators, suggesting that behavior change interventions can build community support and social norms even while communities incur short-term costs and

before tangible results materialize. Before and after impact trends of the intervention were generally positive or neutral for ecosystem and sustainable livelihoods indicators, with the exception of social trust in the Philippines and perceived 5 year catch trends in Indonesia which both decreased. Limited counterfactual analyses in the Philippines showed that biomass improved both inside and outside the NTZ relative to the control sites, while political trust was the only sustainable livelihoods indicator that improved relative to control sites. The intervention sites in the Philippines did not perform as well as the control sites in terms of food security, collective efficacy, and social equity. This provides complementary information to the results of the before-after analysis which showed positive or neutral responses for these indicators. These negative results may be partially driven by near-term socioeconomic costs and disruptions from marine reserves and more restrictive fisheries management at intervention sites (Christie 2004). Continued long-term socioeconomic and ecological monitoring is needed to address temporal lags and to better understand the long-term relationships between behavior changes, ecological responses, and livelihoods responses. While our difference-in-difference conclusions are limited by the small number of control sites, the analysis provide a valuable complement to our before-after results.

**Community support**

Positive changes were seen across knowledge, attitudes, and interpersonal communication indicators. Changes across this spectrum are illuminating and point towards changing social norms, since knowledge alone is not enough to drive behavior change (Steg & Vlek 2009). There may also be heterogeneity in changes in attitudes based on resource dependency and livelihood diversification (Gelcich et al. 2005). Therefore, behavior change campaigns that aim to increase knowledge while also increasing interpersonal communication can positively influences attitudes, which in turn leads to positive behavior change (Green et al. 2019).

**Sustainable fishing practices**

The structural equation model indicates the importance of community support in driving TURF-reserve self-enforcement, management participation, and catch reporting. We further found that self-enforcement and reserve compliance were strongly associated. While management participation increased across all countries and TURF and reserve compliance increased in Indonesia and Philippines, Brazil did not see increases in catch reporting or TURF or reserve compliance. These neutral results in Brazil could reflect the shorter intervention duration in Brazil, which was two years instead of three, during which time TURF access rights had not yet been finalized. These results are reflected in the SEM which shows that self-enforcement does not significantly correlate with TURF compliance, and that neither community support nor management participation significantly correlate with TURF compliance or reserve compliance. This contradicts previous findings that stakeholders who participate in the decision-making process are more likely to comply and self-enforce (Epstein, 2017). Follow-up monitoring should be conducted to determine if sustainable fishing practices materialized and if they were maintained over time.

**Sustainable Ecosystems**

Some positive before-after trends in target species biomass in Indonesia and Philippines suggest that compliance with reserves and adoption of new fisheries management controls may have led to biomass gains, as has been shown elsewhere (Campbell et al. 2018). Fish biomass in the Philippines increased relative to control sites both inside and outside the NTZ. Increases in fish biomass within a three-year time frame may be driven by species that are fast growing and spawn frequently, such as herbivorous fishes including parrotfishes and rabbitfishes that are primary targets in many of the Indonesian and Philippines sites. It is unsurprising that in several sites no change in fish biomass was detected, most likely due to slower growing species and temporal lags that occur between behavior

change, management adoption, and ecological response (Russ & Alcala 2004). SEM results reflect these mixed ecological impacts since significant links from sustainable fishing practices to ecological indicators could not be established (Figure S1).

**Sustainable livelihoods**

Across all three countries, the before-after improvement in most of the sustainable livelihoods indicators is consistent with findings that well-being, social equity, and trust are indicative of successful co-management approaches (Cinner et al. 2012). Political trust showed positive trends across all three countries, most likely because the strengthening of community institutions was well supported by fishing communities and not hindered by a lack of local government interest (Christie 2004). Political trust in the Philippines intervention sites also showed an increase relative to the control sites. However, we did observe several indicators with negative changes, perhaps indicative of the short-term costs that fishers may incur when moving to more restrictive sustainable management. While data limitations prevented us from including livelihoods impacts in our SEM, increased data availability across sites and time would allow us to more fully investigate predicted links within Fish Forever's ToC.

**Impact evaluation: Opportunities, challenges, and enabling conditions**

Effective impact evaluation is crucial to evidence-based decision making, and has been called for to improve conservation interventions and outcomes (Ferraro 2009). This is especially important when resources are limited, implementation costs are high, and intervention efficacy is uncertain (Pullin & Knight 2001). Fortunately, the field of monitoring and evaluation in marine conservation and small-scale fisheries management is growing, and researchers are adopting innovative approaches to assess performance (Ahmadia et al., 2015).

From a practical perspective, impact evaluation has both challenges and opportunities. Data collection is expensive, and there may not be budget for collecting data at control sites or for continued long-term monitoring. Whenever possible, objective measures of social change should be used to complement direct questioning methods in order to mitigate social desirability bias. When assessing social impact across a wide range of contexts, a global monitoring and evaluation team can work with local survey administrators across sites to ensure that question intention is consistent while allowing for contextualized framing. Finally, certain data types are useful not only for impact evaluation but also for adaptive fisheries management, a positive benefit exchange for stakeholders.

Behavior change campaigns can play a critical role in building and sustaining positive perceptions and behavior change in small-scale fisheries management interventions. While theory predicts that managed access interventions such as TURF-reserves may eventually lead to long-term benefits, they may also necessitate short-term reductions in catch due to sustainable yet more restrictive management. Despite our results that intervention sites sometimes experienced short-term neutral or negative changes across several sustainable livelihoods indicators, these same communities experienced increases in intervention support and shifts toward sustainable fishing behaviors. This highlights the role of social marketing behavior change campaigns as tools that can help managers overcome the short-term challenges faced when implementing new management regimes.

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**Tables**

**Table 1: Summary of surveys conducted at sites, including the indicators from each survey, which Department for International Development (DFID) capital type each indicator corresponds to, survey type, who administered the survey, the indicator units, the countries that conducted each survey, and the before and after years they were administered.**

| Survey | Indicators | DFID capital type | Type | Administrator | Units | Countries and administration years |
|---|---|---|---|---|---|---|
| Community Support (CS) | Attitude; Communication; Knowledge relating to Catch Reporting; Enforcement; NTZ Compliance; TURF Compliance; Management Participation | Human | Household | Site campaign manager | 0-100 (normalized using either binary responses or Likert-type scale) | Brazil (2015 and 2017), Indonesia (2014 and 2017), and Philippines (2014 and 2017) |
| Sustainable fishing practices (SFP) | BC relating to Catch Reporting; Enforcement; NTZ Compliance; TURF Compliance | Human | Household | Site campaign manager | 0-100 (normalized using either binary responses or Likert-type scale) | Brazil (2015 and 2017), Indonesia (2014 and 2017), and Philippines (2014 and 2017) |
| | Management Participation | Political | | | | |
| Sustainable ecosystem | Biomass inside no-take zone | Natural | Underwater visual survey | Third-party contractors | Kg / Ha | Indonesia (2014 and |

| | | | | | | |
|---|---|---|---|---|---|---|
| (SE) | (NTZ); Biomass outside no-take zone (NTZ) | | of target species | | | 2017) and Philippines (2014 and 2017) |
| Sustainable livelihoods (SL) | Subjective Well-being | Human | Household | Site campaign manager (Brazil); Third-party contractors (Indonesia and Philippines) | 0-100 (normalized using either binary responses or Likert-type scale) | Brazil (2015 and 2017), Indonesia (2014 and 2017), and Philippines (2014 and 2017) |
| | Livelihood Stability | Human | | | | |
| | Food Security | Human | | | | |
| | Social Trust | Social | | | | |
| | Social Equity | Social | | | | |
| | Collective Efficacy | Social | | | | |
| | Household Assets | Financial | | | | |
| | Political Trust | Political | | | | |

**Table 2: Summary of indicators, descriptions of indicators, and representative survey questions and response options for each indicator in the community support, sustainable fishing practices, and sustainable livelihoods surveys; these have been reworded from the original questions for consistency and readability.**

| **Survey** | **Indicator** | **Description** | **Representative survey question** | **Representative response options** |
|---|---|---|---|---|
| Community Support | Attitude - Catch Reporting | Attitude toward catch reporting | There benefits of reporting your catch | [ ] True [ ] False [ ] Unsure |
| Community Support | Attitude - Enforcement | Attitude toward self-enforcement | It important for fishers to report intrusions to the | [ ] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly disagree [ ] No |

| | | | | |
|---|---|---|---|---|
| | | | NTZ | answer |
| Community Support | Attitude - Governance Participation | Attitude toward participating in local fisheries governance | How easy is it to engage in processes and discussions for the management of the fishery? | [] Easy [] Somewhat easy [] Hesitant [] Somewhat difficult [] Difficult |
| Community Support | Attitude - Licensing | Attitude toward enrolling in the fisher licensing system | There benefits of being a licensed fisher | [ ] True [ ] False [ ] Unsure |
| Community Support | Attitude - NTZ | Attitude toward not fishing in the NTZ | Are there benefits to the local community from having a NTZ? | [ ] Yes [ ] No [ ] No Answer |
| Community Support | Attitude - TURF | Attitude toward following specific fishery management regulations within the TURF | Obeying the rules of the TURF will maintain the availability of fish and other marine resources for a long time | [] Agree [] Disagree [] Do not know |
| Community Support | Communication - Catch Reporting | Interpersonal communication regarding catch reporting | Do fishermen talk about how to do catch reporting? | [ ] Yes [ ] No [ ] No Answer |
| Community Support | Communication - Enforcement | Interpersonal communication regarding self-enforcement | Do you discuss with other fishermen about the importance of doing community surveillance? | [ ] Yes [ ] No [ ] No Answer |
| Community Support | Communication - NTZ | Interpersonal communication regarding not fishing in the NTZ | In the past 6 months, have you talked with fellow fishermen about the importance of not fishing inside the NTZ? | [ ] Yes [ ] No [ ] Unsure |
| Community Support | Communication - TURF | Interpersonal communication regarding specific fishery management regulations within the TURF | In the past 6 months, have you talked with fellow fishermen about benefits gained from the TURF? | [] Yes [] No [] Do not remember |

| | | | | |
|---|---|---|---|---|
| Community Support | Knowledge - Catch Reporting | Interpersonal communication regarding catch reporting | Do you know how to do catch monitoring? | [ ] Yes [ ] No [ ] No Answer |
| Community Support | Knowledge - Enforcement | Interpersonal communication regarding self-enforcement | Do you know what community surveillance is? | [ ] Yes [ ] No [ ] No Answer |
| Community Support | Knowledge - NTZ | Interpersonal communication regarding not fishing in the NTZ | Is it allowed to fish or collect shells inside the NTZ? | [ ] Yes [ ] No [ ] No Answer |
| Community Support | Knowledge - TURF | Interpersonal communication regarding specific fishery management regulations within the TURF | Do you know the fishing regulations for the TURF? | [ ] Yes [ ] No [ ] No Answer |
| Sustainable Fishing Practices | BC - Catch Reporting | Participation in catch reporting | In the past 6 months, have you been reporting your catch? | [ ] Yes [ ] No [ ] No Answer |
| Sustainable Fishing Practices | BC - Enforcement | Participation in self-enforcement | Do you practice community surveillance in the TURF? | [ ] Yes [ ] No [ ] No Answer |
| Sustainable Fishing Practices | BC - Licensing | Licensing to become a fisher | In the past 6 months, which of the following options best describe your licensing status? | [ ] I do not know about licensing [ ] I am considering applying for licensing [ ] I intend to apply for licensing [ ] I have applied for licensing [ ] I have renewed my licensing |
| Sustainable Fishing Practices | BC - Management Participation | Participation in local fisheries governance | In the past 6 months, have you attended meetings and consultations about fisheries? | [ ] Yes [ ] No [ ] No Answer |
| Sustainable Fishing Practices | BC - NTZ Compliance | Not fishing in the NTZ | Do you respect the rules of the NTZ? | [ ] Yes [ ] No [ ] No Answer |
| Sustainable | BC - TURF | Following specific | How often do you | [ ] Always [ ] Most of |

| | | | | |
|---|---|---|---|---|
| Fishing Practices | Compliance | fishery management regulations within the TURF | comply with the TURF rules? | the times [ ] Half of the times [ ] Sometimes [ ] Never |
| Sustainable Livelihoods | Catch Trend 1 Year | Trends in catch compared to 1 year ago | Compared to 1 year ago, how has fish catch changed? | [ ] Improved heavily [ ] Improved slightly [ ] Stayed the same [ ] Deteriorated slightly [ ] Deteriorated a lot |
| Sustainable Livelihoods | Catch Trend 5 Years | Trends in catch compared to 5 years ago | Compared to 5 years ago, how has fish catch changed? | [ ] Improved heavily [ ] Improved slightly [ ] Stayed the same [ ] Deteriorated slightly [ ] Deteriorated a lot |
| Sustainable Livelihoods | Collective Efficacy | Collective efficacy for community management | My community has the ability to sustainably manage our fishery so that we can benefit from it long into the future | [ ] Strongly agree [ ] Agree [ ] Neither agree nor disagree [ ] Disagree [ ] Strongly disagree |
| Sustainable Livelihoods | Food Security | Food security | Which of these statements best describes food consumed in your home in the last 12 months? | [ ] Always had enough food [ ] Sometimes did not have enough food [ ] Often did not have enough food [ ] Never had enough food |
| Sustainable Livelihoods | Household Assets | Household assets | Which of the following items do you have in your household? Select all that apply | [ ] Running water [ ] Electricity [ ] Refrigerator [ ] Oven [ ] Radio [ ] TV [ ] Satellite dish [ ] Computer [ ] Internet [ ] Cellular phone[ ] Landline phone |
| Sustainable Livelihoods | Livelihood Stability | Livelihood stability | It is easy for myself and members of my household to find as much employment as is needed to provide for the household | [ ] Strongly agree [ ] Agree [ ] Disagree [ ] Strongly disagree [ ] No answer |
| Sustainable Livelihoods | Political Trust | Trust in local political systems | I am confident that the Deliberative Council will make the right decisions | 1-10 scale of agreement with statement, 10 being |

| | | | | |
|---|---|---|---|---|
| | | | on how to manage our fisheries | best |
| Sustainable Livelihoods | Fishing Costs | Fishing costs | What is your average fishing cost each time you go to sea? | [] Below 500,000 Rupiah [] 500,000 - 1,000,000 Rupiah [] 1,000,000 - 1,500,000 Rupiah [] Above 1,500,000 Rupiah |
| Sustainable Livelihoods | Social Equity | The degree to which community members benefit from the fishery equitably | My family is able to benefit from our fishery as much as any other members of the community | [ ] Strongly agree [ ] Agree [ ] Neither agree nor disagree [ ] Disagree [ ] Strongly disagree |
| Sustainable Livelihoods | Social Trust | Trust in fellow community members | Generally speaking, most fishers in my community can be trusted | [ ] Yes [ ] No [ ] No Answer |
| Sustainable Livelihoods | Subjective Well-being | Overall feeling of well-being | All things considered, how satisfied are you with your life these days? | 1-10 scale of agreement with statement, 10 being best |

**Figures**

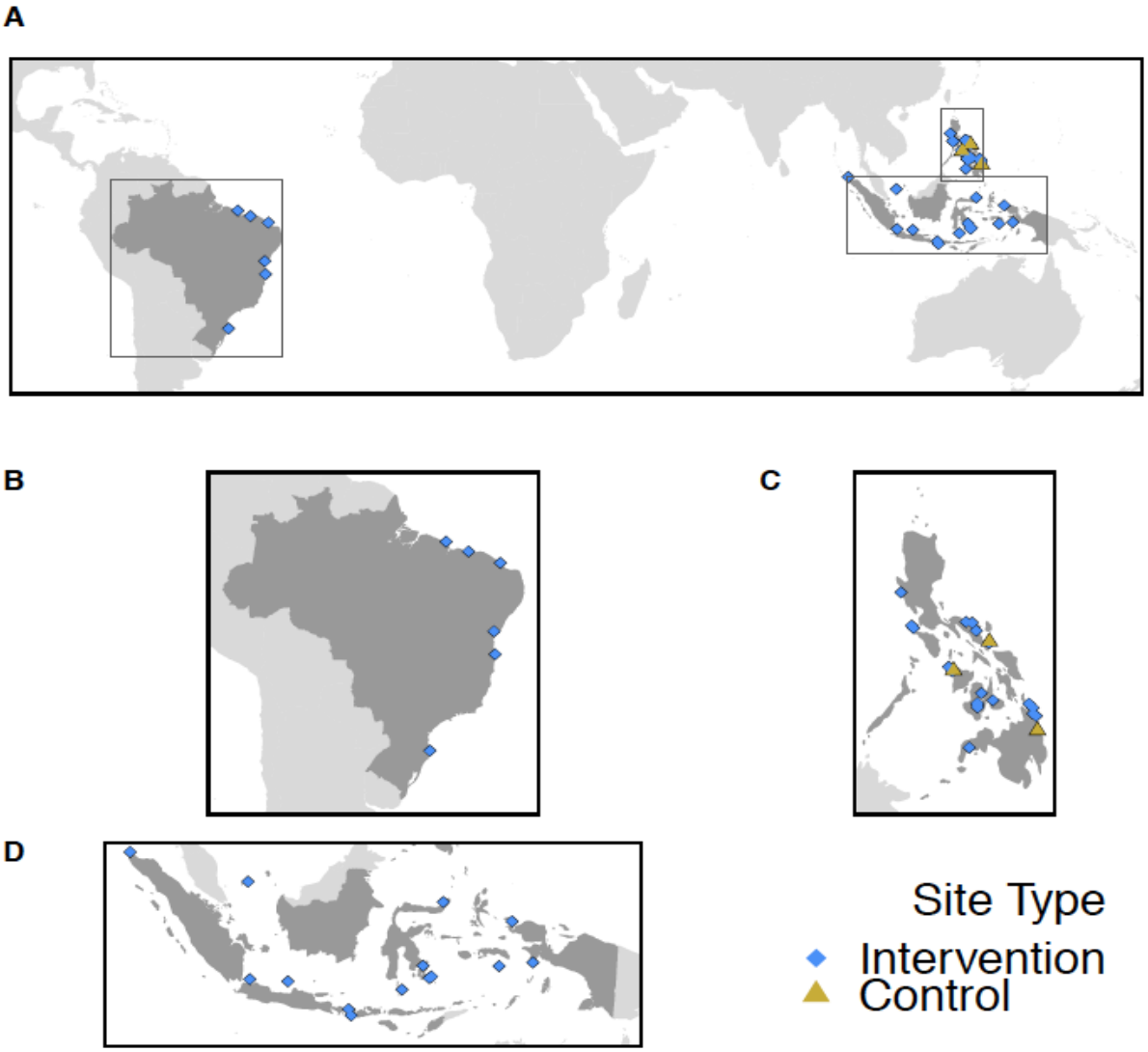


**Figure 1: Map showing intervention and control sites for: A) all sites globally; B) Brazil sites; C) Philippines sites; and D) Indonesia sites.**

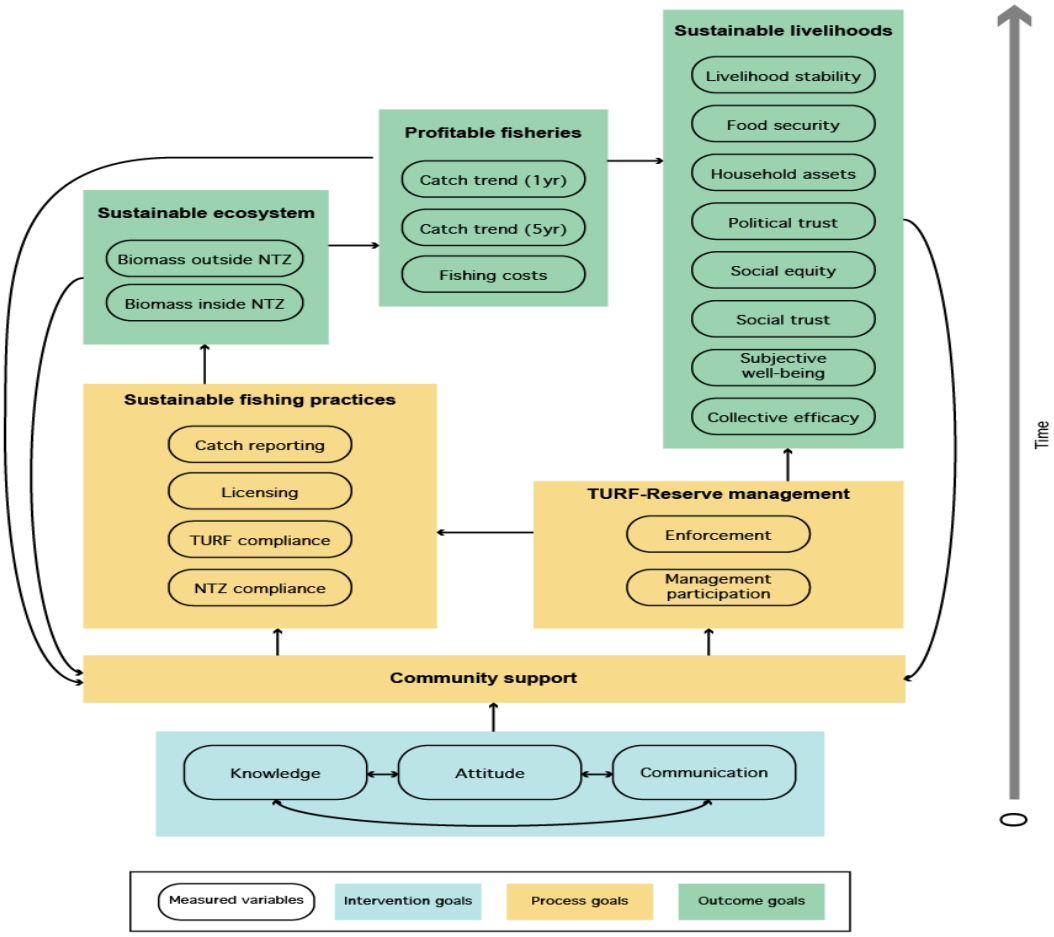


**Figure 2: Simplified representation of Fish Forever's Theory of Change (ToC) with currently monitored indicators. Rectangles show Fish Forever's overarching project goals while ovals depict monitored indicators within each category. Arrows show hypothesized relationships among larger project components. NTZ stands for no-take zone marine reserve and TURF stands for territorial use rights for fishing.**

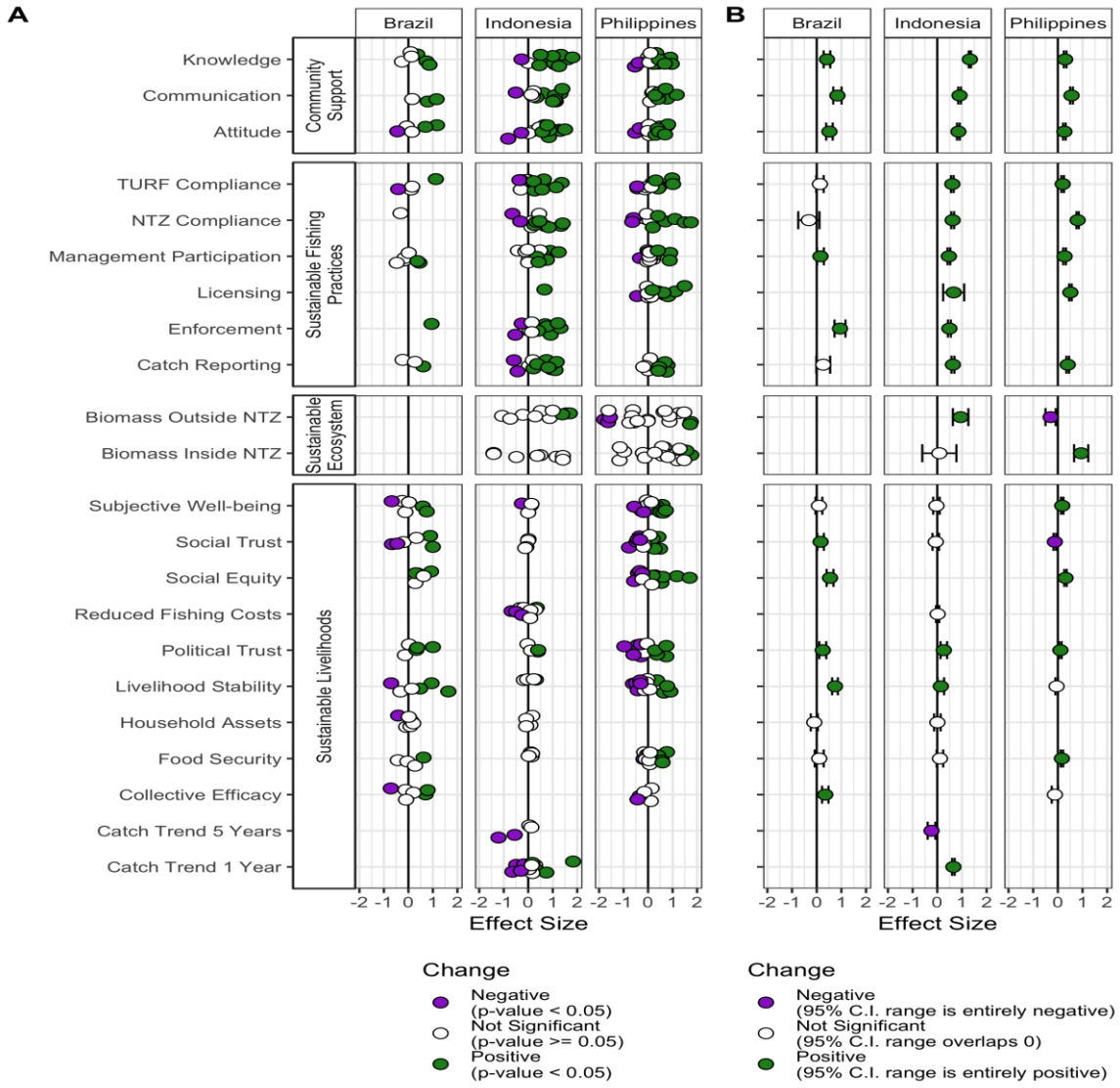


**Figure 3: Before-after standardized effect sizes for all indicators. Panel A shows model results for each individual site-indicator combination, with each point being the regression result from individual site-indicator combination. Linear regressions leverage survey respondents as the unit of observation for community support, sustainable fishing practices, and sustainable livelihoods surveys and underwater visual survey location as the unit of observation for sustainable ecosystem surveys. Results are shown with vertical jitter to allow visual differentiation between sites. Panel B shows the precision-weighted estimate across sites for each country-indicator combination from Panel A, shown with 95% confidence intervals.**

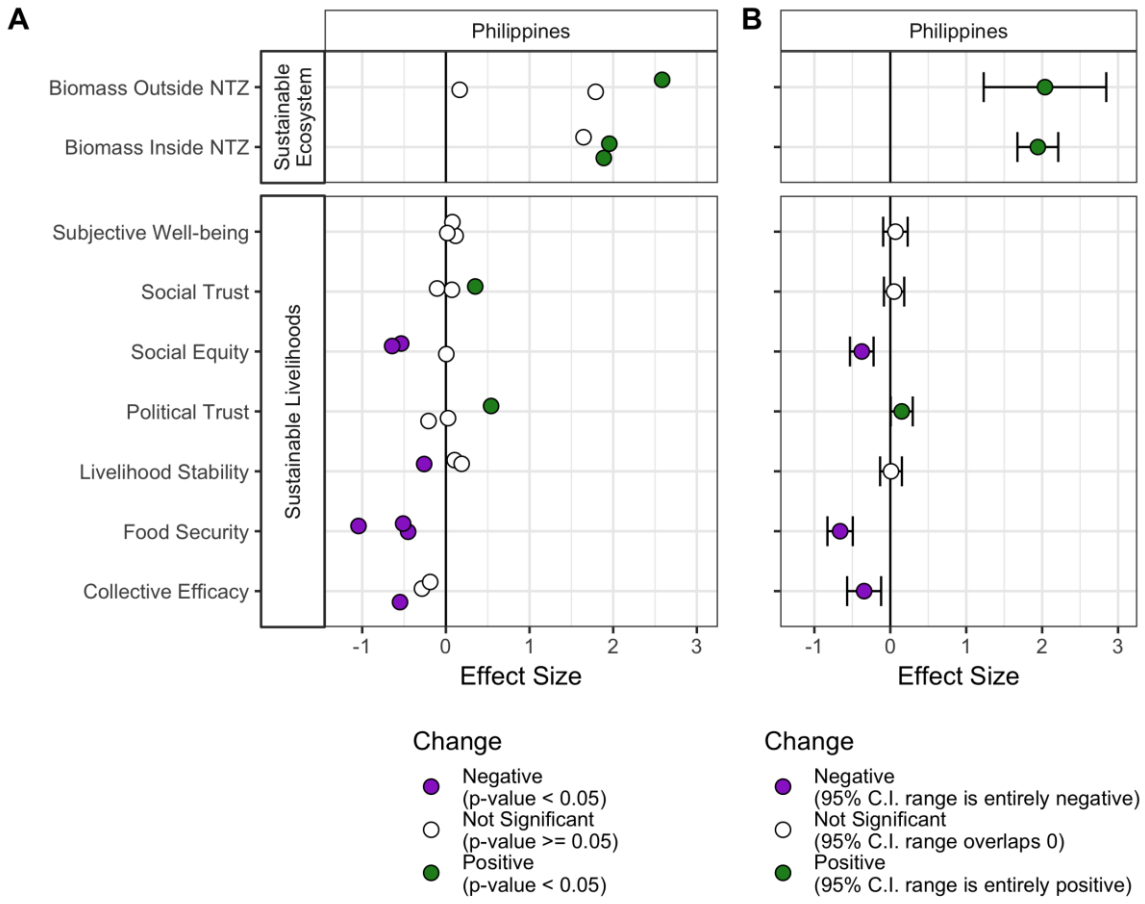


**Figure 4: Difference-in-difference standardized effect sizes for Philippines sustainable ecosystem and sustainable livelihoods indicators. Panel A shows model results for each individual site-indicator combination, with each point being the regression result from individual site-indicator combination. Linear regressions leverage survey respondents as the unit of observation for community support, sustainable fishing practices, and sustainable livelihoods surveys and underwater visual survey location as the unit of observation for sustainable ecosystem surveys. Results are shown with vertical jitter to allow visual differentiation between sites. Panel B shows the precision-weighted estimate across sites for each country-indicator combination from Panel A, shown with 95% confidence intervals.**

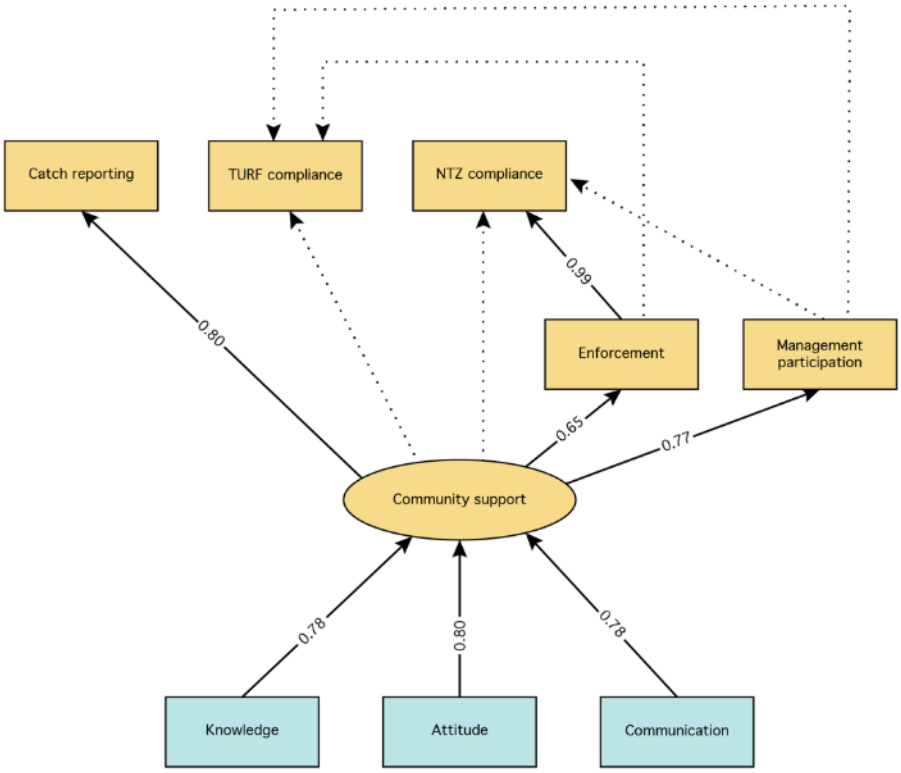


**Figure 5: Structural equation model investigating relationships among monitored intervention (blue) and process (orange) indicators. Boxes represent manifest variables and the oval represents our single latent variable. Solid arrows represent significant ($p$<0.05) relationships and are shown with factor loadings (β), while tested but non-significant relationships are presented with dotted arrows. Overall model performance is CFI=0.908.**