Aligning Decision-making and Key Behaviors with Effective Fisheries Management

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August 2016

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Introduction

At least two-thirds of global fish stocks are overfished or fully exploited (FAO, 2014). As a result, fisheries are not producing nearly as much food, profit, or livelihood opportunities as they could be. Well implemented and effective Rights Based Management (RBM) can reverse these trends, but designing and implementing such systems is challenging.

There are good design principles based on research and experience for designing RBM systems, focused on ensuring that stakeholders buy into management measures and that fishermen can capture the benefits of their own conservation efforts. However, there are many other decisions that must be made and behaviors that must be exhibited by fishery scientists, resource managers, fishermen, and others to make the entire RBM system effective.

Because managing a fishery is a human enterprise, understanding the decisions and behaviors of fishermen and managers is imperative for achieving sustainability. The fishery management process is complex, involving multiple decisions and behaviors by several actors. Fishery managers, scientists, and fishermen are motivated and affected by a number of internal and external variables. Economic, social, political, cultural, psychological, or other personal factors influence decision-making and can induce undesired or unintended behavioral responses. Therefore, understanding human decision-making processes and their drivers is vital in ensuring the success of effective fishery management strategies.

The purpose of this report is to describe specific behaviors and decisions that have large impacts on the efficacy of fishery management, and generate ideas for interventions that may influence those behaviors such that they become more aligned with effective management. This report does not discredit top-down regulations nor advocate for an entirely behavioral approach. Rather, it seeks to establish a broader context for discussion regarding challenges in fishery management that may be amenable to behavioral interventions. Behavioral interventions deployed as part of a comprehensive management strategy would be anticipated to enhance the efficacy of fishery management, just as they have in other sectors such as health, education, and energy use (Thaler & Sunstein, 2009). Generic interventions suggested in this assessment are for illustrative purposes only, and are neither prescriptive nor a panacea for all fishery management problems. Every fishery is unique and interventions need to be specific to local needs and contexts.

The methodology for this research is a desktop analysis, an extensive literature review of the major challenges and drivers impeding effective fishery management. We begin with a background discussion of human behavior and how behavioral interventions may influence better decision-making. We then outline the fishery management process to describe the stakeholders involved in managing a fishery and the types of decisions that must be taken for its success. We examine three key groups of actors in fisheries management: the fishery management authority, fisheries scientists, and fishermen. Each group is analyzed, including their roles, level of influence within the decision-making process, and currently exhibited behaviors. There are six challenges addressed in this report that appear consistently throughout fisheries management literature and that have a major impact on fishery efficiency and sustainability: (1) resistance to data-limited assessment (2) translating science to management action (3) communicating uncertainty and risk to stakeholders (4) catch misreporting (5) bycatch and discarding and (6) destructive fishing (Peterman, 2004; Hilborn et al., 2005; Daw and Gray, 2005; OECD, 2010; OECD; 2013; Government of Canada, 2011). Drawing on theories from psychology, behavioral economics, and social sciences literature, we investigate the drivers of each challenge and craft illustrative behavioral interventions.

Background on Behavior Change

Designing effective behavioral interventions requires an understanding of how internal factors (such as individual psychological biases, values, morals, etc.) and external variable (situational environmental circumstances, social/peer influences, etc.) combine to influence a person's behavior and decision-making (Ajzen, 1991). Understanding how people think and feel about a certain issue is the first step in designing successful behavior change strategies. Several studies and theories emerging from the field of behavioral sciences and psychology reveal that humans are endlessly complex; multiple cognitive biases influence our judgments and decision-making (Kahneman, 2011; Thaler and Sunstein, 2009). We rely heavily on our automatic system (the mental processing system that operates quickly, effortlessly, and without careful reflection of an issue) to guide choice (Gilovich, Griffin, & Kahneman, 2002; Kahneman, 2011). We oftentimes lack the ability to carefully weigh and consider outcomes, or select probabilistic alternatives in situations involving risk (Kahneman, 2011). We tend to be emotional, sensitive to perceived loss, and highly influenced by social norms and peer pressures (Gilovich, Griffin, & Kahneman, 2002).

Icek Ajzen's *Theory of Planned Behavior (TPB)* integrates the elements of several behavioral models and theories to highlight the key beliefs and factors that guide and influence human behavior (Ajzen, 1991; World Bank, 2010): (1) *Control beliefs* refer to how capable or how much control a person feels they have (either internally or situationally) in executing a behavior, including their perceived access to resources, skills, or opportunities. In aggregate, an individual's control beliefs shape their *perceived behavioral control;* (2) *behavioral beliefs* are an individual's salient beliefs and evaluations about the likely consequences or outcomes of their behavior (which shapes their *attitude towards the behavior*) and (3) *normative beliefs*, the expectations of what other important groups or individuals may think of the behavior, and the motivation to comply with their wishes, which gives rise to a person's *subjective norms* (Ajzen, 1991; Ham et al. 2009; World Bank, 2010). These elements combine to shape one's *intention* to perform a certain behavior or action, which has shown to be a critical variable in predicting and motivating behavior change (Godin & Kok, 1995; World Bank, 2010). Ajzen's model explains that the more favorable the attitude towards the behavior and subjective norm are, and the higher the perceived control one has, the greater the intention to perform the behavior. Lastly, the TPB notes that when a person has a sufficient degree of *actual* control over performing the behavior, they are more likely to follow through with the intention to act when the opportunity arises (*See Appendices for chart of TPB).*

The TPB illustrates a productive way of thinking about and designing interventions. However, the human decision-making process is complex and cannot be fully understood by a single framework or model (Kollmus & Agyeman, 2002). Individuals can have favorable values, awareness, and attitudes towards certain issues and still fail to make changes to their behaviors (Kollmus & Agyeman, 2002). This discrepancy, known as the Value-Action-Gap, notes that in addition to improving favorable attitudes and beliefs, it is crucial that efforts be made to help *facilitate* the behavior change and remove barriers that may be preventing the execution of the desired behavior (Kollmus & Agyeman, 2002). Common barriers include institutional or infrastructural barriers, limited financial resources, lack of information, and other situational factors (Kollmus & Agyeman, 2002).

Fishery Management Process and Key Actors

In order to identify key behaviors that have large impacts on the effectiveness of fishery management, a definition and description of the fishery management process is needed. Our working, generic definition for the purposes of this analysis is: a process of collecting information, analyzing it, consulting with stakeholders, planning, and implementing decisions to achieve fishery objectives (FAO, 1997).

In a generalized fishery management system, a high-level, national government agency responsible for managing fisheries sets overarching fishery goals and establishes reference values (i.e., targets and limits); fishery scientists (and occasionally non-governmental organizations and fishermen) collect and analyze data to compare fishery performance indicators to reference values; the management authority consults resource users and stakeholders and defines fishery goals and objectives; managers develop management plans (ideally aligned with scientific guidance); fishery management plans are then implemented and enforced (FAO 1997; Wallace & Fletcher 2001; Fluharty 2011; NOAA Fisheries 2015).

Actors within the management process include a wide range of individuals and interest groups: fishermen, scientists, local or central governments, national and international non-governmental organizations, academics and researchers, environmental non-governmental organizations, and the public (Bonzon et al., 2013; FAO, 1997; FAO, 2006; FAO, 2009). In this analysis, we focus on three key groups of actors who directly affect fishery management policies: the fishery management authority, fishery scientists, and fishermen.

Several decisions and actions must occur for successful fishery management. In addition to establishing fishery goals and reference values, management authorities must decide whether or not to collect fishery data (and perform stock assessments), how that information will be collected, what types of data to focus on, and how to translate scientific findings and stakeholder input into fishery management plans; scientists must decide on what methods to use for analyzing and interpreting the collected fishery data, and determine a strategy for effectively communicating scientific findings and uncertainties to fishery stakeholders; lastly, fishermen must decide whether or not to report catch accurately and to comply with regulations set forth by management authorities (Hilborn & Walters, 1992; Wallace & Fletcher, 2001; Hilborn, 2003; Carruthers et al. 2014; National Research Council, 1989; Raakjaer et al., 2003; King et al. 2009) These decisions and actions are vulnerable to influences from outside variables (i.e., political, economic, and social interests) as well as internal factors (i.e, individual psychological biases), which can hinder the execution of these essential tasks.

In the following section, we describe each actor’s role within the management system and analyze their level of influence within the decision process. We describe the types of actions that must take place for sustainable fishery management, and the challenges and behaviors that prevent the execution of those duties and responsibilities.

Fishery Management Authority

A fishery management authority is a legally appointed decision-making entity that governs fishery operations (FAO, 1997). General responsibilities include determining target species and catch limits, fishing methods and gears, number of vessels and fishing effort, and permissible fishing areas (FAO, 1997; FAO, 2009). A fishery management authority usually takes the form of a Fisheries Department or Ministry of Fisheries, containing multiple sub-departments and specialists who assist with formulating and implementing management and conservation decisions. (Cochrane & Garcia, 2009; Hilborn et al. 2005). In high-seas fisheries, Regional Fishery Management Organizations (RFMOs) serve as the management authority for highly-migratory or 'straddling' fish stocks (Gillman et. al 2013). The fishery management authority is responsible for ensuring long-term fishery sustainability and conservation of marine resources.

Because the broad definition of a fishery management authority encapsulates multiple government bodies and sub-departments, we focus here on the mid-level managers (the regional fishery councils or agencies that act as the interface between local fishers and stakeholders and the national fishery authority) who are responsible for managing on-the-ground fishery operations and designing management plans. For example, in the United States, the National Marine Fisheries Service (NMFS) is the federal agency (under National Oceanic and Atmospheric Administration [NOAA]) responsible for U.S. fisheries, but the Regional Fishery Management Councils are the primary bodies who develop and implement fishery management plans (NOAA, 2015). Fishery management authorities are an integral component of the institutional management structure and hold significant power and influence as decision-makers within the system.

Achieving sustainable management has proven to be challenging and elusive. Here, we identify two behavior-related challenges that impede fishery management authorities from achieving effective management: *resistance to data-limited assessment* and *translating science to management action.* Effective fishery management relies on science to inform management policies; scientific findings help guide decision-making by estimating sustainable limits for total catch and fishing effort, predicting the consequences of certain management decisions on stock health and abundance, and illustrating how marine ecosystems operate and fluctuate (NMFS, 2001). Stock assessments form the basis for long-term, sustainable fishery management; in addition to estimating the status, trends, and thresholds of fish populations, stock assessments help managers determine if more regulations and controls are needed, or if fishing levels can be increased (Hilborn 2003; Newman et al., 2014; NMFS, 2001). Additionally, stock assessments establish a baseline for measuring fishing impacts and environmental changes (Sullivan et al, 2006; NMFS, 2001)

Unfortunately, most of the world's fisheries are not scientifically assessed, and this is associated with poor performance (Costello et al. 2012). Formal stock assessments require long-term and relatively expensive scientific monitoring programs, as well as very high levels of technical expertise. These are significant barriers to the scientific assessment of most fisheries, particularly in the thousands of small scale fisheries in developing countries (Honey et al. 2010; Newman et al., 2014; Gaines & Costello, 2013)

Resistance to data-limited assessment

<u>Desired Behavior:</u> In an ideal, well-managed fishery, the management authority acknowledges that stock assessments are a requisite for sustainable management. Managers determine the resource requirements needed for assessing target stocks, and utilize whatever tools and data are available for performing a qualitative ecosystem assessment (Apel et al. 2013; NMFS, 2001). Managers invest in consistent monitoring and data collection efforts to form a more complete picture of the target species, investigate stock vulnerabilities, at-risk species, and depletion levels; managers then determine reference points (i.e., stock indicators and thresholds) and establish precautionary catch limits and controls on fishing mortality; management authorities design data collection systems so that the process of collecting and analyzing data can be continued and improved upon as more resources become available (NMFS, 2001; Apel et al. 2013).

<u>Challenge and Undesired Behavior:</u> Here, the undesired behavior is that management authorities reject available stock assessment methods. According to Newman et al. (2014), there is a widespread perception among managers that data-limited stock assessments are less reliable and thus inferior to data-rich assessments. The value-laden terminology ("data-rich," or "data-poor," etc.) used to describe stock assessment methods may play a role in conjuring negative perceptions of this technique (Newman et al. 2014). Management authorities argue that the data-limited approach for assessing stocks is not robust enough to inform management decisions, that it contradicts fishermen's direct observations, and the science is of poor quality (NMFS, 2001). Additionally, there are several ways to assess fisheries based on available data. Navigating multiple methods and frameworks, assessing data requirements, and analyzing applicability to the fishery can be complex, time-consuming, resource intensive, and costly (Newman et al., 2015). As a result, fishery management authorities may default to simpler or familiar strategies, such as using historical average catch to set allowable catch levels (Newman et al., 2014). Rejecting available stock assessment methods and failing to establish reference values creates a high risk of overfishing (Hilborn & Walters, 1992; Costello et al. 2012). This increases the risk of fishery collapse and jeopardizes the food security and livelihoods of many (Fujita et al., 2013).

<u>Illustrative Interventions:</u>

- The messenger matters; enlist a trusted community member or individual to communicate the importance and benefits of conducting data-limited stock assessments
- Managers appear to have a preference for maintaining the status quo over changing management operations; where possible, provide individual incentives to managers (in the form of promotion opportunities, or salary raises) to those who elect to perform stock assessments
- Make the consequences of maintaining status quo much more salient; show examples of fisheries that have collapsed using case studies, stories, or peer-exchanges (conversations with other fishery managers)
- Create opportunities for participatory science or cooperative research (which can help improve trust and confidence in fisheries science)

- Management authorities take pride in their roles as managers; show managers that failing to assess fish stocks may jeopardize their position/role in the fishery due to fishery collapse or declining harvests/revenues
- To help management authorities overcome the fear of increased top-down regulations on fishery operations, frame messages so that the act of performing stock assessments can be used as proof and evidence that managers are doing a good job
- Inspire high-level figures (authorities above mid-level managers) who can help motivate (or command) management to take action and perform stock assessments

Translating science to management action

Desired Behavior: Science-based decision-making is imperative to sustainable fishery management (Hilborn, 2003; Pikitch et. al 2004; Costello et. al 2008). The dynamic, fluctuating nature of marine environments require that managers continuously adjust management policies as new scientific findings emerge and ecosystems change (Wilson et al., n.d.a). When translating science to management action, management authorities need to have a clear understanding of fishery objectives (which are ideally adopted in accordance with fishery stakeholders); they invest time and resources in data collection and research, work closely with scientists to identify sources of uncertainty and assess tradeoffs of management decisions, and apply a precautionary or risk-averse approach to decision-making that promotes the protection and conservation of the marine environment (Sullivan et al. 2006; National Aquarium 2013). In doing so, managers have a better understanding of the marine resource they are managing and will set quotas, catch limits, and controls on fishing effort at sustainable, science-based levels.

Challenge and Undesired Behavior: Fishery management authorities are often criticized for failing to heed scientific advice (Eagle et al. 2003; McClanahan, & Carlos, 2007). In addition to resisting data-limited stock assessments, oft cited criticisms include: setting quotas or catch limits too high (thus contributing to overfishing), allowing overcapitalization to occur (fishing with too many boats or too much effort), failing to follow an ecosystem-based or precautionary approach, and allowing fishing with destructive or damaging gear and methods (Wallace & Fletcher, 2001; Peterman, 2004; Rosenberg et al. 2006). Intentional catch misreporting, illegal fishing, and discarding also prevent the translation of science to management action; these problems create major distortions in fishery data, (Pauly & Zeller, 2015) causing managers to set catch limits based on inaccurate stock estimates, give out too many fishing permits, or fail to implement proper controls on fishing effort (Patterson, 1997; Peterman, 2004; Pauly & Zeller, 2015). We discuss catch misreporting, discarding, and illegal fishing in further detail in later sections of this report.

Conflicting fishery interests present a major challenge in translating science to management action. Controversies arise when scientific findings call for reductions in catch or fishing effort. (Rice & Rochet, 2004; Ludwig et al., 2001). Socio-political interests pressure managers to delay management action or ease fishing restrictions, despite scientific findings that urge otherwise (McClanahan & Carlos, 2007). When scientific findings do not align with political or industry objectives, lobbyists (i.e., stakeholders or their representatives) argue that methods are insufficient, inaccurate, or need further review (Daw &

Gray, 2005). Other tactics include suppressing the release of scientific reports or intentionally misinterpreting scientific conclusions (Sullivan et al., 2006). Translating science to management action is particularly challenging if managers lack confidence in the science. Uncertainty and lack of consensus on what the data indicates can lessen the weight given to scientific input (Mackinson et al., 2010). For example, Hilborn et. al (1992) note that distrust in data-limited assessment tools can cause authorities to grasp at management recommendations from industry interests. Distrust and uncertainty towards fishery science causes stakeholders to highly discount the future, prioritizing short-term economic gains over long-term sustainability (Daw & Gray, 2005). Political devaluation or criticism of fisheries science can fuel negative perceptions, resulting in ineffective management actions (or non-action). Failure to incorporate science in management action results in excessive fishing, poor fishery controls, and increased risk of fishery collapse (Apel et. al 2014; Daw and Gray, 2005).

<u>Illustrative Interventions:</u>

- Groups invested in the status quo have a powerful voice in management decisions because they are economic stakeholders; empower fishery stakeholders that have interests in long-term sustainability and point out that the current system is unfair in order to engage other groups and stakeholders to oppose economic pressures
- Directly relieve economic pressures via bail-outs or other compensations/payments to fishermen
- Create interventions centered around the threat of national or international scorn for failing to translate science to management action
- Use/play up perceptions of unfairness; remind stakeholders that fisheries are for the people and belong to the people; if stakeholders are aware that managers are not being good stewards, this may trigger larger and stronger emotional responses calling for change
- Put managers in contact with other fishery managers who understand the importance of and are benefiting from making science based decisions in management operations
- Increase opportunities for the public to provide input into the planning process; create more public hearings/meetings, utilize email, websites, text, etc.
- Make it easier for managers to quickly and directly access scientific information
- Increase the value of science in fishery management; promote opportunities for fisheries that use science in management can call themselves environmentally friendly or sustainable-- an extension of this would be that fisheries get sustainability certifications (which would require transparency, and for fishery products to be sold into supply chains that care about seafood sustainability).
- Make the use of science and economics in management rewarding; reward management with sustainability awards, promotions, or other individual incentives.

Fisheries Scientists

The fishery scientists' role within the institutional structure is to provide management authorities with the best available information and data to make well-informed management decisions (NOAA, 2015). In many fishery management systems, a scientific advisory group comprised of fisheries scientists, researchers, biologists, economists, and social scientists provides this information. (Mackinson et al., 2010). This group offers insights regarding the consequences of various decisions or management actions and gives estimates of uncertainty on scientific findings. Scientists analyze the biological characteristics of stocks, including abundance and biomass, predator and prey relationships, size, growth rate, and range to ensure that populations are healthy and that fishery managers are harvesting at sustainable levels (Mackinson et al., 2010).

Uncertainty is pervasive and inevitable in fisheries science. Quantifying resources in constantly changing, three-dimensional environments like the ocean is extremely challenging. Naturally occurring physical changes (such as variations in ocean temperatures) and biological changes (natural variations in fish populations) combined with long-term ecosystem trends and short-term fluctuations make predicting ecosystem functions and fishing impacts a difficult task; as a result, scientists can never have a perfect understanding of all ocean processes, and there will always be gaps and uncertainties in scientific knowledge (Government of Canada, 2011; National Aquarium, 2013). Human error in data collection and analysis add an additional degree of complexity to measuring and understanding marine ecosystems. However, communicating the science, sources, and implications of uncertainties is crucial; ineffective communication leads to improper fishing controls, frustrated scientists and managers, mistrust amongst stakeholders, and skepticism of the management system (National Aquarium, 2013; National Research Council, 1989).

Interpretations of uncertainty and risk can vary widely depending on the audience's, concerns, values, culture, socioeconomic status, and individual psychological biases (National Research Council, 1989). However, research has indicated that the way in which information is presented is also an important factor (Kahneman, 2011; Kahan, 2013). Here, we focus explicitly on the fishery scientist's ability to effectively frame and communicate science, uncertainty, and risk to stakeholders, which strongly influences one's understanding, emotional responses, and behaviors (Kahneman 2011).

Communicating Science, Uncertainty, and Risk to Fishery Stakeholders

<u>Desired Behaviors:</u> According to the National Research Council (1989), effective communication of science, uncertainty and risk involves a well-designed, analytic-deliberative process that focuses on open discussion, collective consideration, and issue reflection between scientists, policy makers, and affected parties. Scientists get to know their audience; they consider the group's resource knowledge, their salient beliefs (i.e., attitudes), cultural and social values; they ensure that the audience has a chance to express concerns and worldviews prior to sharing information about uncertainties and risks (National Research Council, 1989; CRED, 2014). Scientists understand that comprehension of science and uncertainty is enhanced when the audience participates in the learning process; they utilize two-way dialogue instead of simply disseminating information. (National Research Council, 1989). Good communicators may pre-test materials to ensure that the scientific findings and uncertainties being presented are clear and easily understood by non-experts (National Research Council, 1989; Gaspare et al. 2015) They use narrative storytelling, analogies, images, or metaphors to help explain and communicate their findings (CRED, 2014). They appeal to the audience's emotions to motivate behavior change, particularly by emphasizing long-term goals and reminding the audience of the welfare of future generations (CRED, 2014). Lastly, scientists emphasize positive solutions and the benefits of taking precautionary action over the complexities or uncertainties in the science (CRED, 2014; National Research Council 1989).

Challenge and Undesired Behaviors: Fishery stakeholders frequently cite the following frustrations regarding communication of science, uncertainty, and risk: no transparent process from scientists describing how data is collected, where sources of uncertainty originate, or how they are identified (in other words, scientists do not engage in cooperative research or actively communicate with stakeholders); no clear definitions of important terminology (i.e.,“risk,” “probability,” “tendency,” “plausibility,” “chance,” etc. can mean different things to people), confusion over what the uncertainty or risk implies in decision-making; and use of highly technical jargon and models (Daw and Gray, 2005; Latanich et al., 2016; National Aquarium, 2013; National Research Council, 1989; Teigan, 1994). While techniques for discussing uncertainties may appear clear and straightforward to fishery scientists, the language, technical charts, or models used to communicate the message may come across as obscure and convoluted to non-experts. (National Aquarium, 2013; National Research Council, 1989). At the same time, scientists may automatically assume that their audience is scientifically illiterate and significantly oversimplify their findings and data, which can actually increase perceptions that the science is unreliable (Kahan, 2013; National Research Council, 1989). Scientists, anticipating political or social resistance to their findings, may suggest overly cautious catch limits or place greater emphasis on the risks and consequences associated with particular management decisions (Daw and Gray, 2005). They may overuse emotional appeals (attempt to generate strong emotional reactions, typically by playing on the recipients’ fears), which not only causes fishery stakeholders to discredit science and perceive the information as exaggerated and manipulative, but also rarely results in behavior change-- the recipients instead continue the depreciative behaviors, but with increased anxiety (CRED, 2014; National Research Council, 1989). Individuals also have a tendency to form beliefs about information that connects them to groups sharing their same cultural or social values (known as ‘cultural cognition’); this has a major impact on weight given to scientific findings, especially if a certain group has a particular distaste for fisheries science or scientists (Kahan, 2013).

Illustrative Interventions:

- Create workshops and communication training for scientists to improve message framing
- Create/show that it is the norm to discuss science and uncertainty as two-way dialogue (as opposed to one-way dissemination/presentation of information)
- Switch up the messenger; elect a fishermen ambassador or stakeholder ambassador that is trained and well-versed in the science to convey messages
- Create a common understanding of fishery goals through audience engagement: promote or create opportunities for participatory science to improve understanding and co-create knowledge
- Make sure speakers and scientists are provided enough backstory and are aware of institutional history, previous conflicts, sensitive topics/issues, etc.
- Promote the pre-testing of materials and communication strategies to help ensure message clarity (and that data is perceived as credible)
- Create public hearings or participatory councils for stakeholders (give them a voice) to express their concerns, share their knowledge and be involved in establishing a unified vision of desired fishery outcomes; this helps establish trust, participation, and develops a sense of cohesion and teamwork between scientists and stakeholders
- Make the channels for communicating science easier by presenting information in different formats; publish findings in local magazines, bulletins, websites, etc.

Fishermen

In addition to harvesting fish and marine resources for subsistence or commercial purposes, fishermen assist scientists and managers by providing catch data and sharing observations of stock and ocean conditions (NMFS, 2001). Fishermen both directly affect and are affected by management policies; non-compliance to regulations hamstrings sustainable fishery management, causing severe distortions in fishery data and undermining conservation efforts.

Sutinen et al. (1990) note that fishermen generally fall into three archetypal groups; those that frequently comply with regulations, those that frequently violate them, and those that unintentionally break rules due to misunderstanding of regulations. For the purposes of this analysis, we consider another group: fishermen who are indifferent, or can be persuaded to go either way (towards compliance or non-compliance). A large determinant of noncompliant fishing behavior depends on context; whatever action the fisherman perceives to be in his/her best interest at the time of decision-making (Sutinen et al. 1990). Thus, strategic behavioral interventions may help “nudge” the indifferent or occasionally non-compliant fisherman towards more frequent compliance and desired behaviors (Thaler & Sunstein, 2009).

Traditional models for understanding fisher compliance typically evaluate behavior from an economic perspective, which states that the ultimate objective of a rational fishermen is to maximize personal gains and profits (Nielsen and Mathiesen, 2003). Under this assumption, individuals violate management regulations if the benefits of an illegal activity exceed the benefits otherwise yielded from complying with regulations (Sumaila et al. 2006). In response to this, regulators attempt to dis-incentivize depreciative behaviors by increasing top-down regulations and improving monitoring and enforcement efforts (Nielsen and Mathiesen, 2003). While this can help deter non-compliance and illegal activity, many fisheries lack the financial resources and capacity to engage in continuous, high-level monitoring, or follow through in prosecuting violators (Sutinen et al. 1990; King et al. 2009). Additionally, the motivations for fisher compliance or non-compliance typically extend beyond economic incentives (King et al. 2009). Extensive research by King and Sutinen (2009) found that the majority of fishermen (between 50% and 90%) comply with regulations, even in situations with a high potential for economic gains and a low potential of getting caught. A more comprehensive understanding of fisher behavior accounts for non-monetary factors such as individual perceptions and risk tolerance, moral and social norms, personal values, beliefs, and levels of confidence in the management system (Sutinen et al. 1990; Hatcher et al., 1998; National Research Center, 1989;). King et al. (2009) refer to this evolved understanding of fisher behavior as *an enriched theory of noncompliance;* one that includes perceptions of regulation fairness, altruism, peer and community pressures, reciprocity, and individual moral convictions.

Discussions of fisher non-compliance tend to revolve around *illegal, unreported, and unregulated* (IUU) fishing. IUU fishing encompasses a broad range of issues and undesirable fisher behaviors; *illegal* refers to all fishing activity that contradicts stated national or international regulations; *unreported* fishing focuses on fishing activities that are non-reported or misreported; *unregulated* describes fishing by vessels in areas without conservation or management policies, or vessels fishing without nationality (European Parliament, 2014). For the purposes of this analysis, we identify three fishery management challenges that fall under the umbrella term of IUU fishing that undermine conservation and management efforts: (1) catch misreporting (2) bycatch and discarding, and (3) destructive fishing. These problems have serious repercussions on fishery sustainability; intentional catch misreporting (i.e., underreporting or nonreporting) and discarding bycatch contribute to faulty estimates of fishing impacts on stock populations. (Pauly & Zeller, 2015). Fishing with destructive methods or illegal gear kills important marine species and causes severe and irreparable damage to habitats (Munyi, 2009). The Environmental Defense Fund analyzes the common drivers and challenges of IUU fishing in their paper: *Reducing Illegal Fishing Using Behavior Change Interventions: General Recommendations.*[1]

Catch Misreporting

Desired Behaviors: In order for fishery management authorities to establish sustainable fishing controls, all sources of fish mortality must be accounted for. This includes catch reported at landing sites as well as incidental catch (i.e., bycatch and discards) (Apel et al. 2013). Ideally, fishermen (as accurately as possible and to the best of their ability) record and report all sources of catch and instances of fishing in logbooks and at landing sites; they self-enforce and comply to regulations. Accurate catch reporting can be achieved via on-board observers and electronic-vessel monitoring systems that provide real-time monitoring at-sea, and dockside monitors that observe and record off-loadings at landing sites (FAO Observer Program Manual, 2006; Apel et al. 2013). While these techniques help promote good fisher behavior and increase compliance, not all vessels or fishing operations have the financial or human capacity to do so, and micromanaging fishing activities may not be well received by fishermen.

Challenges and Undesired Behaviors: Inaccurate catch reporting is partly attributable to human error in data entry (FAO Research Implications of Tuna Fisheries, 2006). However, intentional data-fouling or falsification of catch remains a serious issue, as it substantially distorts fishery data and contributes to the overexploitation and accelerated depletion of ocean resources (OECD, 2010; Patterson et al. 1998; Wernerheim & Haedrick, 2005). A study from researchers at the Sea Around Us estimate the disparity between what is caught at sea and what is officially reported at landing sites to be over 30% (Pauly and Zeller, 2015). Osterblom et al. (2011) explain that fleet overcapacity (resulting from restrictive limits on catch or fishing effort) and technological creep create an economic incentive for fishermen to under report or non report their catch. In anticipation of a new catch share program, fishermen may misreport their catch to receive a higher share of the quota (Yamada & Flumerfelt, 2014). Fishermen also falsify catch and landing data in an effort to reduce or avoid taxes (FAO Research Implications of Tuna Fisheries, 2006).

Trust in the management system also plays a significant role in the accuracy and ease in which catch data is obtained. Information pertaining to the source and volume of catch is a fisherman's intellectual capital--if management authorities are perceived as untrustworthy, illegitimate, corrupt, or unable to protect data-confidentiality, obtaining accurate catch information becomes significantly more challenging (FAO Research Implications of Tuna Fisheries, 2006). King and Sutinen (2009) note that individual moral and social influences can combine to "create a situation where non-compliance is an accepted norm in a fishery" (pg. 14). Social comparisons have also shown to strongly influence judgement; a study by John

[1] Battista, W., Fraire, J., Romero, R., and Fujita, R. (n.d.a) Reducing Illegal Fishing Using Behavior Change Interventions: General Recommendations. Research and Development Team, Fisheries Solution Center, Oceans Program. Environmental Defense Fund

et al. (2014) found that individuals are more likely to engage in illegal behaviors if they compare their economic standing and earnings to peers and perceive that they are doing better. If fishermen see competitors or fellow fishermen earning and achieving more, or engaging in illegal behaviors, they may be more likely to cheat and misreport their catch as well (King & Sutinen, 2009; John et al. 2014). Research by Ruedy et al. (2013) found that for some individuals, engaging in unethical “cheating” behaviors can produce feelings of delight, even in situations with no financial rewards or incentives. Fishermen may be driven to misreport their catch if they find the act of deceiving management authorities exhilarating, or if it produces other positive psychological effects (Ruedy et al. 2013).

Illustrative Interventions:

- Remind fishers that accurate catch reporting is the norm, and that most people behave responsibly
- Display aggregate catch (show what everyone reports altogether); this helps fishermen understand how little numbers and discrepancies in catch information can significantly add up (sometimes exceeding catch limits)
- Public commitment schemes (i.e., verbal or written pledges) for fishermen to signal their commitment to honestly report catch and practice sustainable fishing behaviors.
- Reward good behavior by providing rebates to fishermen who have proven to report accurately
- Reduce human error in data-reporting by creating a standardized electronic reporting system
- Signed data-confidentiality agreements between fishermen and managers can help improve trust

Bycatch and Discarding

Desired behaviors: According to Keledjian et al. (2014), up to 40% of global bycatch is discarded at sea. This wasteful practice increases the risk of fishery collapse and slows the rehabilitation of fish stocks (McIlwain, 2015). Well-designed RBM systems can help reduce bycatch and discards by eliminating the “race to fish” and allowing fishermen more flexibility in choosing when and where to fish, and what gears to use (Grimm et al. 2012; McIlwain, 2015). Fisheries under individual quota (IQ) or individual transferable quota (ITQ) systems reduce the incentive to discard by making the transfer of quotas as easy as possible; granting fishermen more flexibility in the individual quota limit via quota rollover provisions; creating bycatch risk pools (in which all bycatch quota is cooperatively pooled so that fishermen can access quota for free or at low cost); or incorporating “deemed values” in the management design (which require fishermen to pay a reasonable fee for landed species which they do not have a quota for) (Arnason, 2014; McIlwain, 2015).

Catch selectivity tools and fishing avoidance behaviors can be implemented in both RBM and conventionally managed fisheries to reduce bycatch and discards; these types of measures encourage fishermen to avoid fishing in areas with high bycatch rates; use appropriate (i.e., highly selective, environmentally friendly, and legal) fishing gear and methods; fish at various depths to avoid unwanted catch, and make time-area adjustments to the time of day or parts of the season that they fish (McIlwain, 2015; Keledjian et al. 2014). One way of incentivizing the implementation of these measures is to allow fishermen to choose which tools or fishing behaviors best suit their individual operations (McIlwain, 2015). Some fisheries also provide economic incentives, typically in the form of a larger quota allowance or financial reward to fishers who use selective fishing gears or allow on-board observers on their vessel more often (ASMFC, 2001).

Social norms that promote trust and reciprocity can motivate fishermen to engage in cooperative group behaviors that reduce social losses (IFFET, 2010). The U.S. sea scallop industry serves as a prime example demonstrating how collaboration and reciprocity among fishermen helped reduce unwanted bycatch and discards and improve the fleet's avoidance fishing techniques (O'Keefe et al. 2010). When yellowtail bycatch rates threatened the closure of the U.S. scallop fishery, fishermen began recording and reporting their location and catch data back to the fleet, providing real-time monitoring and feedback data to other fishers on key "hotspots" to avoid (O'Keefe et al. 2010). This strategy is considered a major economic and conservation success; the scallop fishery avoided closure and fishermen significantly reduced their bycatch (catching only 29% of the bycatch allocation in 2010). (O'Keefe et al. 2012).

Challenge and Undesired Behaviors: Discards are generally classified into two main categories; regulatory discards and economic discards (McIlwain, 2015). The former refers to catch that is returned to the sea (dead or alive) because the captured species did not meet quota or catch requirements (i.e., fish were too small, too young, out of season, etc.); economic discarding describes catch that is thrown back because it is lacks real or perceived marketability, either due to low quality or size, or incorrect species (McIlwain, 2015). High-grading remains a major problem in many fisheries, and is difficult to detect; high-grading refers to the practice of selectively discarding low-value (though still marketable) species to make room in catch allowances for high-value species (McIlwain, 2015).

Discarding behaviors are largely driven by economic and market forces, or quota regulations that prohibit fishermen from landing non-target species (McIlwain, 2015). As previously discussed, well-designed RBM systems can dramatically lower bycatch and discards by aligning fishermen incentives with effective management practices. However, several barriers may prevent fishermen from implementing catch selective gears or changing their fishing behaviors. McIlwain (2015) explains that the upfront costs of gear modifications or avoidance technologies can make fishermen hesitant to purchase or implement them. Campbell & Cornwell (2008) note that while some fishermen understand the long-term importance and utility of reducing unintended bycatch, others may not share the same perception that the species is threatened or problematic, or worth directing financial resources and efforts towards. Mistrust and reluctance to collaborate and share catch information between vessels can also prevent the implementation or effectiveness of avoidance fishing techniques (McIlwain, 2015).

Eayrs et al. (2015) found that cognitive biases may cause a strong resistance to change, particularly when such change involves "revolutionary" (i.e., non-incremental, sudden) changes to habitual or traditional fishing practices. The researchers discuss an instance when fishermen in New England's groundfish fishery rejected *GEARNET*, a fully-funded project that provided new catch-selective fishing gear and equipment to fishermen. Despite the fact that gears and installation came at no cost to fishermen, had great fuel saving potential, and reduced unwanted bycatch and environmental impacts, several fishermen still elected not to participate in the program (Eayrs et al., 2015). This behavior may be influenced by a number of social and cultural factors, but was largely attributed to a *competing commitments* conflict-- a subconscious desire to rationalize and maintain the status quo rather than change behavior. This cognitive bias may be due to a lack of perceived urgency regarding the bycatch and discarding problem, or mistrust of fisheries science and management authorities (Eayrs et al., 2015).

Illustrative Interventions:

- Incentivize harvest priorities: promise a greater share of the catch to fishermen who can document and prove (via vessel monitoring systems or on-board observers) that they are exceeding the selectivity standard
- Make pro environmental behaviors easy by defaulting fishing boats with eco-friendly, selective fishing gears
- Elicit recommendation and harvesting suggestions from fishermen themselves; let them play up their expertise and beliefs that they are good and effective fishermen; ask them what methods/fishing tactics are best for avoiding and reducing bycatch
- Create high impact educational devices; videos, messaging campaigns, or peer-exchanges to demonstrate the impacts and urgency of reducing bycatch and discarding behaviors
- Establish campaigns aimed at target markets to increase the demand for bycatch fish (that they are not used to buying/eating)
- Improve market access to reduce discarding (refrigeration facilities, etc.)
- Increase and improve the belief that fishermen have significant control in reducing bycatch by demonstrating the easy fishing behavior modifications they can do to avoid bycatch
- Promote the norm that bycatch is a major issue and is unacceptable

Destructive Fishing

Desired Behaviors: Responsible fishery management systems typically have bans on destructive fishing methods; fishermen are aware that their fishing practices have an impact on the marine environment and use highly selective, environmentally friendly, and legal fishing gear and methods; they avoid practices such as blast fishing, poison fishing, or bottom-trawling; fishermen practice community enforcement and self-enforcement, holding themselves and fellow fishermen accountable to management regulations; fishermen report violators, have a low future discount rate and prioritize efforts to protect and preserve the marine environment (Cinner, 2009; Andriamalala, 2013).

Social-marketing campaigns to reduce destructive fishing can improve community stewardship of marine resources and reduce destructive fishing behaviors (Andriamalala, 2013) In 2009, Blue Ventures and Rare created a successful social-marketing campaign in Velondriake, Madagascar, to reduce two major destructive fishing practices - beach seine netting and poison fishing. The campaign sought to increase fishermen's knowledge regarding the impacts of destructive fishing practices, targeted community leaders to internalize the responsibility of enforcing fishing laws, and reinforced community pride and VeZo culture and identity to encourage sustainable and traditional fishing methods rather than destructive, low-skill fishing techniques (Andriamalala, 2013).

Challenges and Undesired Behaviors: Destructive and irresponsible fishing behaviors include; low selectivity in the type of fishing gear or method appropriate to the habitat (such as fishing with bottom trawlers on coral beds or sensitive seagrass, beach seining, or using large-scale driftnets); blast fishing (using dynamite to fish), using poisons (i.e., cyanide or pesticides) to kill or stun fish; and ghost-fishing--

accidentally lost or intentionally abandoned fishing nets and gear that continue to capture and kills marine species. (Munyi, 2009). These fishing practices are indiscriminate, killing non-target species and causing considerable and irreparable damage to important coral reef and benthic communities (Munyi, 2009).

Munyi (2009) found that for many small-scale fishermen in developing countries, destructive fishing methods are often perceived as more efficient and able to yield higher returns. Blast and poison fishing techniques are appealing to fishermen and justified due to the ease of use compared to other fishing methods or gears (Pet-Soede & Erdmann, 1998). Growing populations and increased demands for fish coupled with declining stocks can lead to feelings of desperation among fishermen, who feel compelled to use destructive fishing methods in order to maximize catch in highly competitive fishing environments (Munyi, 2009). In some fisheries, there may be a passive acceptance of destructive fishing techniques due to lack of management capacity, poverty, or lack of alternative livelihood options (Cinner, 2009; Munyi, 2009). Oftentimes, cheap and readily available fishing gears tend to be the most destructive and least-selective (Pet-Soede & Erdmann, 1998; Munyi, 2009).

Research by Shah et al. (2012) found that resource scarcity creates a distinct mindset in individuals, a "focusing-effect" that causes people to hyper-focus on immediate, pressing issues they find most important (i.e., obtaining fish for subsistence or livelihoods) while largely neglecting others (the detrimental environmental impacts and long-term implications/effects of destructive fishing methods). The scarcity mindset consumes much of the attention and cognitive effort that would otherwise go towards evaluating tradeoffs or weighing the costs and benefits of destructive fishing behaviors; as a result, efforts to reduce blast-fishing, bottom trawling, or other destructive techniques are considered less urgent and a low priority (Shah et al., 2002). Lastly, Munyi (2009) notes that destructive fishing practices may be attributed to ignorance or lack of information; fishermen may be simply unaware of the long-lasting and severe damage that destructive fishing techniques inflict upon critical marine habitats and species.

Illustrative Interventions:

- Default boats with selective, eco-friendly fishing gear
- Make alternative gears cheaper (implore governments to subsidize safe fishing gear)
- Create gear exchange programs for fishermen to trade-in and upgrade their gear
- Workshops or educational campaigns to demonstrate the impact of destructive fishing
- Make the case that a ban on destructive fishing is good (if there is not ban in place)
- Provide financial incentives/awards or larger quota allocations to fishermen who utilize safe/selective fishing gear
- Find other methods to incentivize conservation behaviors (promote scuba-diving, tourism, etc.)
- Provide funding restoration from fishing impacts
- Provide more avenues to stakeholders to voice their concerns/raise awareness
- Social marketing campaign to promote awareness of destructive fishing impacts
    - Target local leaders to enforce fishing regulations
    - Reinforce cultural identities/values to pro-environmental behaviors
    - Promote the norm of local community stewardship over marine resources
- Have stakeholders pitch in to help pay for monitoring and enforcement costs

Conclusion

This paper analyzed six challenges in fisheries management; resistance to data-limited assessment, translating science to management action, communicating science, uncertainty, and risk, catch misreporting, bycatch and discarding, and destructive fishing. We investigated the drivers and behaviors of three key actors in the fishery management process; fishery management authorities, fishery scientists, and fishermen. Understanding the internal, psychological factors and social or institutional barriers that impede the execution of sustainable behaviors can provide important insights to individuals designing effective resource management strategies. As previously discussed, the generic interventions proposed in this assessment are not a panacea. It is critical that interventionists research the specific motivations, beliefs, and drivers of each stakeholder and their situational contexts prior to designing and implementing interventions. In doing so, policy makers and resource managers can have a better understanding of where interventions may be applied and what barriers must be removed in order for decision-making and key behaviors to become more aligned with effective fishery management objectives.

Appendices

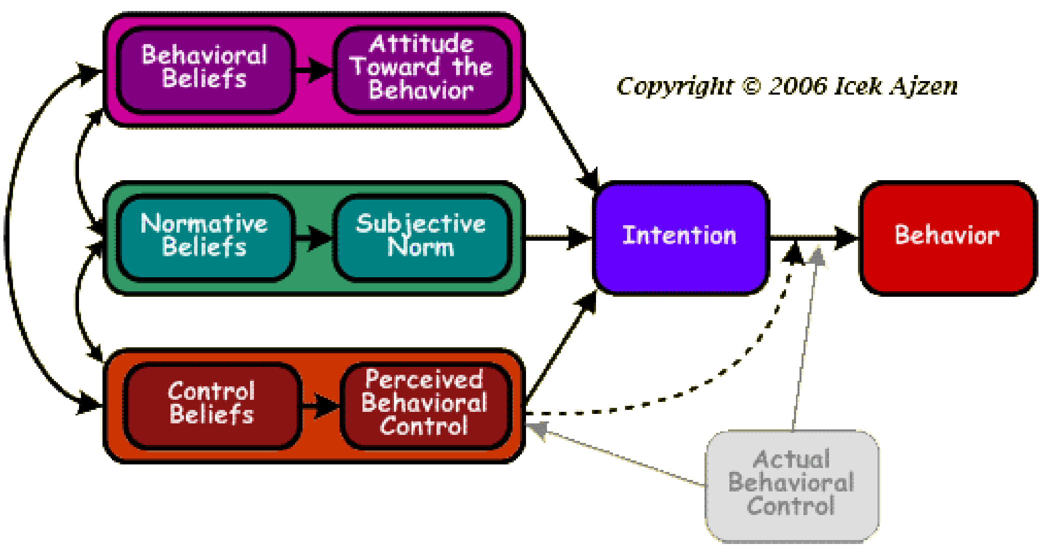

Figure 1: Image of Azjen's Theory of Planned Behavior. Source: http://people.umass.edu/aizen/tpb.diag.html

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