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UNIVERISTY OF CALIFORNIA, SAN DIEGO

Conservation-scapes: An interdisciplinary approach to assessing cetacean bycatch in small-scale fisheries

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Oceanography

by

Tara Sayuri Whitty

Committee in charge:

Professor Lisa Ballance, Chair
Professor Paul Dayton, Co-Chair
Professor Clark Gibson
Professor Theodore Groves
Professor Ellen Hines
Professor William Perrin
Professor Stuart Sandin

2014

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Co-Chair

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Chair

University of California, San Diego

2014

DEDICATION

To my family and other loved ones,

To anyone who has shown me friendship and kindness during my field travels,

To my mentors,

To my exploration and conservation heroes
(among them, Alfred Russell Wallace, Gerald Durrell, J. Stephen Leatherwood, and Louella Dolar),

To the Malagasy fisher who inspired me to pursue
human-focused conservation research,

&

To the ‘waddies, the human communities that live alongside them,
and the people who “care a whole awful lot” about both.

EPIGRAPH

Conservation is a state of harmony between men and land.
Despite nearly a century of propaganda, conservation still proceeds at a snail's pace;
progress still consists largely of letterhead pieties and convention oratory.

Aldo Leopold

TABLE OF CONTENTS

Signature Page..... iii

Dedication..... iv

Epigraph..... v

Table of Contents..... vi

List of Supplemental Files..... vii

List of Figures..... viii

List of Tables..... xi

Acknowledgements..... xv

Vita..... xx

Abstract of the Dissertation xxi

INTRODUCTION..... 1

CHAPTER 1: The conservation-scape: An interdisciplinary framework to incorporate the human dimension into solutions-oriented conservation research 4

CHAPTER 2: Characterizing the proximate attributes of Irrawaddy dolphin (Orcaella brevirostris) bycatch in small-scale fisheries in Malampaya Sound, Philippines 46

CHAPTER 3: Variations in local-level governance of small-scale fisheries across four sites in Southeast Asia, with implications for conservation approaches 93

CHAPTER 4: Conservation-scapes of Irrawaddy dolphin bycatch in small-scale fisheries at four sites in Southeast Asia 135

CHAPTER 5: Integrating multidisciplinarity into marine conservation research: Snapshot Assessment Protocol (SnAP) for characterizing conservation-scapes of small-scale fisheries 209

CONCLUSION..... 239

LIST OF SUPPLEMENTAL FILES

Appendix 1. Rapid Bycatch and Socioeconomic Assessment questionnaire.

Appendix 2. Snapshot Assessment Protocol (SnAP) for characterizing small-scale fisheries.

LIST OF FIGURES

Figure 1.1. Conservation-scape framework 34

Figure 2.1. Map of Malampaya Sound (in northern Palawan, Philippines), with the Inner Sound study area in pale orange and the seven coastal barangay (villages) where interviews were conducted labeled. 80

Figure 2.2. Zones as used in RBSA interviews, with the number of unique entanglement reports (from 2009-2011) for each zone (Z01-Z19). 81

Figure 2.3. Locations at initial detection of *Orcaella brevirostris* sightings (marked locations are the first point of observation for each sighting). 82

Figure 2.4. Detection probability plot for all on-effort *O. brevirostris* sightings from all survey efforts, to a maximum observed perpendicular distance of 939.8m. 82

Figure 2.5. (A) Densities of *O. brevirostris* individuals as observed from line transect surveys, over all survey months and during the seasons *habagat* and *amihan*; (B) Variance in density per grid cell over all replicates within each time period bin; (C) Density of *O. brevirostris* sighting events. 83

Figure 2.6. (A) Densities of Bycatch 1 gears (crab pot and crab gillnet buoys and fishing boats) as observed from line transect surveys, over all months and during the seasons *habagat* and *amihan*; (B) Variances in Bycatch 1 gear density per grid cell over all replicates within each time period; (C) Overlap scores. 84

Figure 2.7. (A) Maximum overlap scores for grid cells for HA categories Bycatch 1 (and subgroupings within) and Bycatch 2, across all seaons, habagat, and amihan. (B) Maximum overlap scores for grid cells for the General HA Category. 85

Figure 2.8. Normalized density of Irrawaddy dolphins and normalized overlap scores for different categories of overlap, over all months, with each row representing a grid cell 86

Figure 2.9. Summary overlap scores across all cells where *O. brevirostris* were observed during the respective time periods. 87

Figure 3.1. Conceptual figure for "local-level governance of CARM", as defined for this paper. 127

Figure 3.2. Map of field sites. Red dots denote location of study villages. 128

Figure 3.3. Scale of the major problems for small-scale fisheries, as reported in response to the open ended question, "What are the worst problems that affect local fishing?" in the Rapid Bycatch & Socioeconomic Assessment (RBSA) questionnaire. 129

Figure 3.4. Institutions and associated activities reported to have some measure of positive impact on local-level coastal and aquatic resource management (CARM). 130

Figure 3.5. Contribution by various levels of institutions to community CARM activities 131

Figure 3.6. RBSA questionnaire responses rating effectiveness of current CRM management. 132

Figure 3.7. Qualitative "scorecard" for institution types across sites. 133

Figure 4.1. Conservation-scape framework, based on Chapter 1, as adapted for this project on Irrawaddy dolphin bycatch in small-scale fisheries at four sites in Southeast Asia. 173

Figure 4.2. Study sites map, with boat survey track lines in orange and study site villages marked as red dots. 174

Figure 4.3. Zones used in RBSA interviews when asking fishers about fishing effort and locations of bycatch for (A) Malampaya Sound, and (B) Guimaras and Iloilo Straits. 175

Figure 4.4. Zones used in RBSA interviews when asking fishers about fishing effort and locations of bycatch for (A) Mahakam River and (B) Trat Province coastline. 176

Figure 4.5. Densities of various human activity types, across sites. 177

Figure 4.6. Months and zones where Bycatch 1 gears were reported to be used by respondents for Malampaya Sound 178

Figure 4.7. Months and zones where Bycatch 1 gears were reported to be used by respondents for Guimaras and Iloilo Straits 179

Figure 4.8. Months and zones where Bycatch 1 gears were reported to be used by respondents for the Mahakam River 180

Figure 4.9. Months and zones where Bycatch 1 gears were reported to be used by respondents for the Trat province coastline 181

Figure 4.10. Perceived trends in dolphin abundance over (A) the past five years, and (B) the past 20 years, as reported by RBSA respondents at the five field sites. 182

Figure 4.11. Mean (with variance) RBSA scores for six of the eight attribute sets defined in Table 1 183

Figure 4.12. Exploratory conservation-scape score figures, to act as conservation-scape assessment scorecards , based on structure of the conservation-scape framework 184

Figure 5.1. (A) Basic framework for a conservation-scape unit, defined as the set of proximate, community, and governance issues pertaining to a focal conservation unit at a local scale; (B) Components of the three categories of conservation-scape categories 234

Figure 5.2. Schematic of how rapid assessment protocols can inform analyses and management at local scales and larger scales. 235

LIST OF TABLES

Table 1. Overview of dissertation chapters 3

Table 1.1. Two major categories of attributes for quantifying and describing the context of conservation problems ("Problem X"), described generally and as applied to the problem of cetacean bycatch. 35

Table 1.2. Summary of small cetacean units assessed by the IUCN Red List (IUCN 2014), for which bycatch has been demonstrated to be, or is very likely, a significant threat. 36

Table 1.3. Status of conservation-scape information for small cetacean bycatch in small-scale fisheries in Southeast Asia, as reported by delegates at the SEAMAM III workshop in 2013. 38

Table 1.4. Summary of mitigation-related research and activities reported by SEAMAM III delegates in 2013, for the six units of small cetacean where convincing evidence exists that bycatch is unsustainable. 39

Table 1.5. Known or suspected subpopulations of *O. brevirostris* in the countries represented at SEAMAM 3. 40

Table 1.6. List of references used in compiling Table 1.5, by Jackson-Ricketts 42

Table 2.1. Summary of Rapid Bycatch & Socioeconomic Assessment (RBSA) interview sampling by *barangay*. 88

Table 2.2. Malampaya Sound fishing gear, as assigned to five general fishing gear types under the General Human Activity Category 89

Table 2.3. Entanglement events for 2009-2010, reported as occurring (A) in the respondent's gear and (B) in other fishers' gear. 90

Table 2.4.. The most reliable reports (see Methods) of entanglements (and other mortalities, i.e., propeller strike) prior to 2009. 91

Table 2.5. Number of respondents reporting gear damage caused by dolphins, including tears in nets from dolphins biting at captured fish and shrimp in nets. 92

Table 2.6. Maximum and average densities per cell, and variance in density measures across cells, of *O. brevirostris* individuals and sightings (with numbers for sightings in parentheses), with the summed area of grid cells where *O. brevirostris* were observed while on-effort during line transect surveys. 92

Table 3.1. The top responses to the open-ended RBSA question explaining governance effectiveness ratings 134

Table 4.1. Rapid Bycatch & Socioeconomic Assessment (RBSA) and other attributes used to compose scores for Fishing Effort, Ties to Fishing, General Environmental Perception, Perceptions of Dolphins, Involvement, and Perception of Governance Effectiveness. 185

Table 4.2. Summary of all attributes compared using χ^2 test for independence; every attribute tested yielded p-values of 0.01 or smaller. 187

Table 4.3. Summary of number of mortalities and non-fatal entanglements by gear type. 188

Table 4.4. Fishing gears involved in entanglements. Bycatch 1 for Malampaya Sound denotes the predominant gears reported in entanglements from 2009 to 2011; for all other sites, Bycatch 1 denotes any gear reported involved in the most recent three-year period. 189

Table 4.5. Summary of the number of estimated bycatch mortalities and non-fatal entanglements for 2009 through 2011 for Malampaya Sound and Guimaras and Iloilo Straits, and for 2010 through 2012 for the Mahakam River and Trat Province 190

Table 4.6. Average densities of various human activity (HA) types at each site, as the number of gear or boats per km^2. 191

Table 4.7. Metrics of gear use at each site. number of fishing gears currently used by respondents, whether respondents reported using Byatch 1 gears, whether respondents reported using any bycatch gears at all (Bycatch 1 and 2), and whether respondents used only bycatch gears. 192

Table 4.8 . Change in gear type over the past five years, and change in the time spent fishing compared to five and 20 years ago (increased, meaning they spend more time fishing now; same; or decrease, meaning they spend less time fishing now). 193

Table 4.9. Summary of Rapid Bycatch and Socioeconomic Assesssment respondents' gender, age bin, and number of years fishing (as percentage of respondents from each site within each bin). 194

Table 4.10. Residence time information for RBSA respondents, in addition to information on the origin of respondents who had migrated to the site. 195

Table 4.11. For those respondents who in-migrated to the field sites, percentage reporting motivation for moving as coded into the categories below. 196

Table 4.12. Percent of respondents reporting fishing as their primary livelihood (defined as source of food and/or income), and the reasons reported by respondents for fishing (respondents could list more than one reason). 197

Table 4.13. Trends in earnings (net income) from fishing since 5 and 20 years ago, and respondent perceptions on whether earnings from fishing alone are enough to provide for general household needs, excluding medical care and education for children. 198

Table 4.14. Percent of respondents whose parents and grandparents fished, and whether respondents would like for their children to be fishers when they grow up. 199

Table 4.15. Perceived trends in catch size (total weight) over the past 5, 10, and 20 years. 200

Table 4.16. Perceptions regarding the condition of local fisheries and marine resources. 201

Table 4.17 . Perceptions related to importance of conservation and effectiveness of current marine/aquatic resource management. 202

Table 4.18. Responses to the open-ended question, "Why has the number of dolphins increased, decreased, or stayed the same over the past five years?". 203

Table 4.19. Responses to "Are dolphins threatened/at risk of extinction?" (this was not included in the interviews at Trat). 204

Table 4.20. Perceptions about dolphins – are they important, is dolphin conservation important, and were the explanations expressed by the respondent categorized as "positive", "negative" (but mixed with other, positive responses), or "negative only"? 205

Table 4.21. Description of previous involvement in activities (interviews, meetings, seminars, trainings, research) related to marine conservation or fisheries management. 206

Table 4.22. Summary of $\chi 2$ and Fisher's exact tests run across bins of "# of years fishing", involvement (whether respondent reported being involved in any previous activities related to marine conservation or fisheries management), and involvement in activities where the topic was dolphin conservation. 207

Table 4.23. Percent tables for the $\chi 2$ test comparing "Years fishing" (in 15 year bins) among respondents in Malampaya Sound, for whether respondents use bycatch gear, and whether respondents rely solely on bycatch gear in their fishing. 208

Table 4.24. Percent tables for the $\chi 2$ test comparing "Years fishing" (in 15 year bins) among respondents in Malampaya Sound, for whether respondents use bycatch gear, and whether respondents rely solely on bycatch gear in their fishing. 208

Table 5.1. Overview of the Snapshot Assessment Protocol (SnAP) components 236

Table 5.2. Attributes included in SnAP, as grouped in three major categories (aligned with the three conservation-scape categories) and nine subcategories. 237

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ABSTRACT OF THE DISSERTATION

Conservation-scapes: An interdisciplinary approach to assessing cetacean bycatch in small-scale fisheries

by

Tara Sayuri Whitty

Doctor of Philosophy in Oceanography

University of California, San Diego, 2014

Professor Lisa Ballance, Chair
Professor Paul Dayton, Co-Chair

In conservation research, the call for more holistic research that considers the human dimension of conservation problems has existed for decades. However, such approaches have not yet been widely operationalized and integrated in conservation studies. To promote improved operationalization of multidisciplinary, human-inclusive conservation research, I developed the conservation-scape framework. This social-ecological framework outlines the sets of attributes that inform practical conservation approaches: (1) proximate attributes, which quantify and characterize the magnitude and risk of a given conservation problem, (2) underlying social context

attributes, or the economic, social, and cultural factors that might influence human use of resources, and (3) underlying governance context attributes.

Mitigating bycatch of cetaceans in small-scale fisheries is an urgent conservation priority, inextricably linked to the pressing need for improved small-scale fisheries management. Currently, our knowledge of the extent and underlying context of this issue is limited by substantial data gaps for both the ecological and social aspects. To more holistically understand this conservation problem, I applied the conservation-scapes framework to investigate proximate and underlying attributes of Irrawaddy dolphin (*Orcaella brevirostris*) bycatch at one focal site and three comparative sites in Southeast Asia.

For three of the four sites, bycatch was demonstrated to be unsustainable, based on annual bycatch mortality rates from interviews and dolphin population estimates. Overlap between bycatch-related fishing gear use and dolphin habitat exists year-round at all sites. To present information on proximate, social, and governance conservation-scape attributes in a concise and useful manner , I developed exploratory and comparative conservation-scape assessment scorecard that summarize the need and mitigation outlook for effectively reducing fishing gear-dolphin overlap at each site. These indicate that the urgency of the bycatch problem is high, particularly for the three aforementioned sites, but that the mitigation outlook varies across sites, with cross-site differences in ties to fishing, general perceptions regarding environmental resources and dolphin conservation, general social attributes, and governance engagement and effectiveness.

To further develop the conservation-scapes approach as a practical part of the conservation research toolkit, I link it to the Snapshot Assessment Protocol (SnAP) for assessing small-scale fisheries, developed by myself and colleagues. Together, the conservation-scapes framework and SnAP hold great potential for contributing to the rising tide of collaborative, interdisciplinary research.

INTRODUCTION

In conservation research, the call for more holistic research that considers the human dimension has existed for decades. However, such approaches have not yet been widely operationalized and integrated in conservation studies. This dissertation is structured around the conservation-scape framework, a social-ecological framework that I developed to integrate interdisciplinary approaches in the study of conservation issues and to guide the development of conservation solutions. The conservation-scape is, essentially, the set of ecological and social attributes influencing a given conservation issue. This includes proximate attributes that directly define and drive the conservation problem, and underlying social and governance attributes that serve as drivers and context of human activities related to the conservation problem.

The accidental capture, or bycatch, of cetaceans in small-scale fisheries is an urgent conservation issue worldwide. Situated at the interface between human livelihoods and marine ecosystems, this issue has proven to be largely intractable. Two major challenges in mitigating bycatch are the lamentable scarcity of basic data on the problem, and the need to study the human dimension in a manner that is useful for developing practical solutions. To address both challenges, I apply the conservation-scape framework to this issue, with a focus on the Irrawaddy dolphin (*Orcaella brevirostris*), a species that is patchily distributed throughout Southeast Asia and widely threatened by bycatch. Through this process, I conducted in-depth fieldwork at my focal field site, Malampaya Sound in the Philippines, and more rapid,

comparative fieldwork at three other field sites in the region: Guimaras and Iloilo Straits in the Philippines, Mahakam River in Indonesia, and the Trat Province coastline in Thailand. This research sought to collect data and synthesize information on the rate and impact of bycatch at these sites, the risk of bycatch posed by dolphin-fishing gear overlap, and the underlying social and governance attributes that define the human context of the bycatch problem.

Motivated by the clear need to better understand small-scale fisheries in marine conservation, I founded the Small-scale and Artisanal Fisheries Research Network (SAFRN), a student-focused group that aims to facilitate interdisciplinary research of small-scale fisheries. Through this work, I and my colleagues at SAFRN developed the Snapshot Assessment Protocol (SnAP), a rapid assessment toolkit for characterizing small-scale fisheries. SnAP and the conservation-scapes approach complement each other, with one providing the methods for applying the other. Such linking of conceptual frameworks to practical research toolkits is critical to actually implementing ideas like the conservation-scape in the field.

The chapters of this dissertation represent this journey from conceptual framework, to exploratory implementation and data collection, to the development of a tool for further improving application of the framework (Table 1).

Table 1. Overview of dissertation chapters.

CHAPTER 1. **The conservation-scape: An interdisciplinary framework to incorporate the human dimension into solutions-oriented conservation research**
Introduces the conservation-scape framework as a general concept and as applied to the issue of small cetacean bycatch in small-scale fisheries, with a focus on Southeast Asia and *Orcaella brevirostris*. *Goal: Submit to Conservation Letters as a mini-review, September 2014*
CHAPTER 2. **Characterizing the proximate attributes of Irrawaddy dolphin *(Orcaella brevirostris*) bycatch in small-scale fisheries in Malampaya Sound, Philippines**
Describes the proximate attributes of bycatch magnitude, impact, and risk for *O. brevirostris* in Malampaya Sound; includes and updated population estimate, characterization of human activity-dolphin overlap, bycatch estimates from interviews, and presentation of conceptual scoring system for human activity-dolphin overlap to assist in bycatch assessment. *Goal: Submit to Marine Mammal Science, September 2014*
CHAPTER 3. **Variations in local-level governance of small-scale fisheries across four sites in Southeast Asia, with implications for conservation approaches**
Mainly qualitative, comparative assessment of governance attributes of all field sites, as related to small-scale fisheries management in the context of bycatch mitigation. *Goal: Revise & Resubmit to Applied Geography (special issue on "Cultural Geography of Marine Resource Management")*
CHAPTER 4. **Conservation-scapes of Irrawaddy dolphin bycatch in small-scale fisheries at four sites in Southeast Asia**
Integrative view of all conservation-scape attributes studied at all four field sites, including an overview of the proximate, social, and governance attributes for each site, and exploratory approaches to scoring and summarizing the conservation-scape for each site. *Goal: Journal to be determined*
CHAPTER 5**. Integrating multidisciplinarity into marine conservation research: Snapshot Assessment Protocol (SnAP) for characterizing conservation-scapes of small-scale fisheries**
Makes the case for more extensive merging of small-scale fisheries research protocols with marine conservation projects, as exemplified by the rest of the dissertation. Focuses on applying the Snapshot Assessment Protocol as a toolkit for conservation-scape-like frameworks. *Goal: Frontiers in Ecology and the Environment.*

CHAPTER 1

The conservation-scape: An interdisciplinary framework to incorporate the human dimension into solutions-oriented conservation research

ABSTRACT

The need for holistic conservation research that considers the human dimension has been highlighted for decades. Yet, there remain substantial gaps in the most basic ecological and social data on the magnitude and characteristics of conservation issues, and in the translation of data into useful recommendations and implementation. To promote improved operationalization of multidisciplinary, human-inclusive conservation research, we present the conservation-scape framework. This framework, adapted from other social-ecological systems frameworks, outlines the sets of attributes that inform practical conservation approaches: (1) proximate attributes, which quantify and characterize the magnitude and risk of a given conservation problem, (2) underlying social context attributes, or the economic, social, and cultural factors that might influence human use of resources, and (3) underlying governance context attributes. To demonstrate the need for and potential utility of the conservation-scape framework, we focus on small cetacean bycatch in small-scale fisheries, particularly in Southeast Asia. The status of conservation-scape knowledge for this urgent conservation issue is lamentably limited. Even for those sites in Southeast Asia with comparatively complete information on the conservation-scape, bycatch mitigation has not met with any demonstrable success. Even for the Irrawaddy dolphin (*Orcaella brevirostris*), the species for which conservation-scapes appears to be best understood in the region, the status of conservation-scape knowledge is largely data deficient. The conservation-scape framework, as brought to bear on bycatch and myriad other conservation issues, holds much potential for:

identifying and filling critical information gaps; assessing previous and ongoing conservation efforts; elucidating patterns and priorities through cross-site comparisons; and informing the development and implementation of conservation solutions. A major goal of the conservation-scapes framework is to package several well-established, important concepts related to conservation research, in a novel, accessible manner that clarifies the pathway to more thoroughly integrating the human dimension in conservation research.

INTRODUCTION

The need to incorporate the "human dimension" in conservation research has been recognized for decades (Leopold 1949; Henning 1970; Hooper 1970; Slocombe 1993, 1998; Folke et al. 1996; Holling 2001; Millennium Ecosystem Assessment 2005; Chan et al. 2007). Various buzzwords related to holistic conservation approaches have emerged over the years (e.g., as documented in Callicott et al. 1999), including integrated conservation and development (Kremen et al. 1994), integrated coastal zone management (Cicin-Sain 1993), sustainable development (World Commission on Environment and Development 1987), ecological sustainability (Callicott & Mumford 1997), co-management and community-based management (Jentoft 1989), social-ecological systems (Berkes & Folke 2000), and ecosystem-based management (Slocombe 1993; McLeod et al. 2005). Such approaches are particularly vital in situations where conservation problems are caused or exacerbated by a strong, direct dependence of human communities on environmental resources.

However, the general interdisciplinary, human-inclusive approach encompassed by these summons and buzzwords has not been widely operationalized in conservation research to a sufficient extent (Chan et al. 2007; Knight et al. 2008). Conservation researchers and practitioners face an extensive set of data gaps, both on the basic attributes of what we are trying to conserve and on the wider human context of conservation issues requiring mitigation. Even for mammals, a particularly charismatic group of conservation interest, the dearth of basic data is widespread, as demonstrated by the map of species listed by the IUCN Red List as Data Deficient, in Schipper et al. (2008, Figure 4B). Beyond data gaps, however, is a "knowledge-implementation gap" in conservation (Pfeffer & Sutton 1999; Knight et al. 2008), where the acquisition of knowledge does not translate to any meaningful mitigation recommendations, let alone implemented activities. In other words, we need more information on the extent and impacts of conservation problems, and we need to better understand how to navigate the related human systems in order to design and implement solutions to those problems.

Social-ecological systems frameworks can offer guidance in data collection, analysis, and application that integrate the ecological and human (social, economic, cultural) systems that are interwoven in conservation issues (Berkes & Folke 2000; Ostrom 2007, 2009). Such frameworks facilitate the actual implementation of ecosystem-based management approaches to research and mitigation, by outlining what information is needed, and how various aspects of the study systems might interact and influence each other. To some extent, social-ecological systems

frameworks have been adapted and applied to specific conservation issues, such as marine protected areas and coral reefs (e.g., Pollnac et al. 2010; Kittinger et al. 2012). This approach must be magnified and applied to a wider diversity of conservation issues.

We propose the conservation-scape as a social-ecological framework for practical, holistic studies of conservation problems (Figure 1.1). The conservation-scape comprises the **proximate attributes** and **underlying attributes** of the conservation issue at hand. The proximate attributes relate to quantifying and characterizing the nature and magnitude of human-ecosystem overlap and interactions. The underlying attributes are those social, economic, cultural, and political characteristics of human activities and associated human communities related to this conservation problem, that influence how such activities operate and are managed.

The proximate attributes of a given conservation problem can be described as various levels of information (Table 1.1): (A) presence of the problem; (B) magnitude of the problem; (C) population impacts of the problem on the taxon, habitat, or ecosystem of concern; and (D) attributes contributing to risk of that problem occurring and having a detrimental impact, such as the degree of spatial overlap between a species of concern and related human activities and other human activities impacting the species. Moving from the rudimentary information in level A to the more complete proximate information in level D allows for assessment of how urgent a threat this problem is to the taxon, habitat, or ecosystem of concern.

The quantification and basic characterization of the proximate attributes of the conservation problem must be supplemented by deeper exploration of the underlying drivers of the human activities. These attributes are grouped in the general categories of social and governance contexts of the human communities in which human interactions with organisms and ecosystems operate. Underlying social attributes include economic, social, and cultural factors that might influence human use of resources, awareness of environmental resource issues, perceptions regarding the importance of conservation or management, and willingness to support conservation or management efforts.

Governance attributes relate to how resources and their use are managed. Institutions are those entities that effect management, and can include formal bodies, such as government agencies, non-government organizations (NGOs), and official regulations, or informal entities, such as belief systems (Berkes & Folke 2000). Characterizing the current context of governance requires understanding of which relevant institutions are involved, what environmental resource management activities and efforts these institutions engage in or mandate, and the extent to which these activities and efforts are effective. Together with the social attributes, studying governance attributes is valuable in elucidating potential opportunities and obstacles for mitigation of conservation problems.

The conservation-scape encompasses the attributes, the interactions between them, and how they might influence the conservation problem and the outlook for mitigation. For example, the proximate attributes define the magnitude and risk of

human impacts, and thus define the severity of the problem. The social context attributes influence the proximate attributes, and as such, might exacerbate or mediate the severity of the problem. Governance attributes might influence proximate and social attributes, and also directly impact the mitigation outlook.

Conservation-scapes of cetacean bycatch in small-scale fisheries

Here, we focus on the incidental capture, or bycatch, of small cetaceans in small-scale fisheries as an urgent conservation issue that requires a conservation-scapes approach to fill significant data gaps and to guide the development of solutions. Small cetaceans are defined as those in the families Delphinidae (excluding *Orcinus orca*), Phocoenidae, Iniidae, Lipotidae, Platanistidae, and Pontoporiidae. Bycatch of small cetaceans in small-scale fisheries poses a well-recognized, serious threat to small cetacean populations globally (Read & Rosenberg 2002). Small-scale fisheries (SSFs), using relatively small boats and basic fishing gear primarily for subsistence fishing or local markets (FAO 2005), are increasingly recognized as a particularly significant threat for coastal marine mammals in developing countries (Moore et al. 2010). However, these fisheries tend to not be monitored, resulting in a dearth of data on SSF, including a relative lack of information on marine mammal bycatch (Read 2008; Moore et al. 2010; Lewison et al. 2011). As such, understanding and mitigating cetacean bycatch in SSFs is a key priority for cetacean conservation.

For most small cetacean species, bycatch in fisheries is recognized as a significant (if not the most significant) threat; in many cases, the fisheries involved are small-scale fisheries (IUCN 2014). Though a variety of gear is used in small-scale

fisheries, most marine mammal bycatch occurs in gillnets, which are relatively inexpensive, easily deployed from small vessels, and used throughout the world's fisheries (Read 2008). Because small-scale gillnet fisheries are common in developing nations, and most likely incidentally catch dolphins and porpoises (Perrin et al. 1994), it is probable that bycatch of small cetaceans in small-scale fisheries is widespread. Perrin et al. (1994) reviewed the known extent of bycatch of cetaceans in gillnets; bycatch in small-scale gillnets at that point had been confirmed around the world, even with noticeable gaps in observation. However, the extent of small-scale fisheries effort and impact on a global scale is poorly documented, particularly in Africa, Oceania, and Asia (Lewison et al. 2004; Read 2008).

Given the strong dependence of coastal human communities on small-scale fisheries, the conservation-scape s framework is a critical approach toward a better understanding of the human dimension and wider context of bycatch in these fisheries. For cases where bycatch is demonstrated to be an urgent issue requiring mitigation, understanding the underlying attributes can guide the development of practical conservation approaches. Because mitigating bycatch is essentially an issue of managing fisheries, it must consider social or governance attributes relevant to how fishing activities operate and are managed.

As such, the conservation-scape framework holds strong potential for assessing the significance of bycatch and the mitigation outlook for small cetaceans "units" of concern, where unit can refer to species, subspecies, or subpopulation, with subpopulation defined by the IUCN as "geographically or otherwise distinct groups in

the population between which there is little exchange"(IUCN 2014). The conservation-scape can guide research and conservation efforts through the following set of questions:

1. Is bycatch a significant threat to the unit? Is the evidence for this convincing enough to bring to decision-makers?
2. What is the effective overlap between gear and animals?
3. How can this overlap be reduced? In any case, fishing practices will need to be changed in at least one of the following ways: reduce soak time, change gear location, technical modifications to gear, switch gear, or reduce fishing effort (e.g., reduce number of gear). An approach, or approaches, to reducing animal-gear overlap must be identified.
4. Would this approach sufficiently reduce bycatch to mitigate significant population impacts?
5. How feasible is this solution? What are the obstacles to achieving this reduction of overlap? What are the opportunities for achieving this reduction of overlap?
6. What are the best, site-appropriate mechanisms for implementing this solution?

Elements of the conservation-scape are similar to previously proposed frameworks and approaches to studying and addressing bycatch risk. Harwood (1999) proposed a risk assessment framework for cetacean bycatch, based on that used by the US National Research Council and the Environmental Protection Agency to assess

potential impacts of hazardous chemicals to human and environmental health. This framework is composed of three parts: hazard identification; risk characterization, including the spatial-temporal nature of fishing effort and overlap with cetaceans; and risk management, to assess economic impacts on fishers against reductions to bycatch resulting from potential mitigation measures (Harwood 1999). Another proposed framework for risk assessment is the Productivity Susceptibility Analysis (PSA) for bycatch, developed by Brown et al. (2013) based on the precautionary assessment tool, Ecological Risk Assessment for the Effects of Fishing (ERAEF) (Hobday et al. 2011). This PSA yields a susceptibility index based on fishing effort and cetacean distribution and behavior characteristics, which describes potential vulnerability of cetacean species to interactions with given fisheries.

These proposed frameworks mainly focus on proximate attributes of bycatch, with some attention to mitigation in the risk management part of Harwood's (1999) framework. As such, they could be valuable tools in identifying urgent bycatch situations in need of prompt mitigation. This is where the conservation-scapes framework could meaningfully contribute to furthering bycatch mitigation: it extends beyond this characterization of risk, to evaluate how the priority bycatch situations identified by risk assessment can best be mitigated.

A framework for bycatch reduction was outlined by Lewison et al. (2011), with four major elements: data collection (on bycatch and socioeconomic context), quantitative analysis, engagement of communities, and engagement of governance. The conservation-scapes framework serves as a practical, more detailed complement

to this bycatch reduction framework, more clearly outlining the attributes for which data need to be collected to guide community and governance engagement. This speaks to a major goal of developing the conservation-scapes framework, which is to practically operationalize the concepts outlined by more general or abstract frameworks and calls for research improvement.

To evaluate, in a cursory manner, the status of conservation-scapes information for small cetaceans, I looked through IUCN Red List assessments of small cetacean units (IUCN 2014), applying standardized scores for known or likely magnitude of conservation threat categories (bycatch, direct catch, habitat impact, pollution, disturbance, and other) and for completeness and quality of population estimates (ranked as "good", "fair", "poor", and "none") and information on the number of mortalities due to bycatch (ranked as "yes" for cases where the numbers are thought to be relatively complete and representative, "some" for where only partial estimates or suspected underestimates are available, and "none" for cases where no data are available). Impact of the threat was ranked as 1, 2, or 3, with 1 representing a slight impact, and 3 representing a significant population-level impact. For likely, but unconfirmed, impact levels, the codes 1L, 2L, or 3L were assigned. These impact rankings were based on conclusions expressed in the IUCN Red List assessments. The small cetacean units for which bycatch received a score of 3 or 3L are presented in Table 1.2. For all of these units, small-scale fisheries contributed at least partially to bycatch.

The IUCN Red List has not yet assessed all small cetacean units, particularly subpopulations; those included on the Red List are those for which the most information is available. Even among that subset of units, there is clearly a dearth of information on basic proximate attributes of bycatch, let alone the underlying attributes, with the exception of some units with small, localized ranges (i.e., the Critically Endangered units and some of the Endangered units). This represents a serious challenge to effectively mitigating bycatch in any substantial way on national or regional scales. It strongly indicates that a conservation-scape approach must be widely implemented to guide the collection of basic proximate data, as needed to properly assess the scope of the bycatch threat.

Even for those units with relatively complete data on proximate attributes, the path to mitigation has been fraught with intractable challenges. For example, three of the small cetacean units receiving the most high-profile attention for bycatch mitigation have been the Yangtze River dolphin (*Lipotes vexillifer*), the vaquita (*Phocoena sinus*), and Hector's (*Cephalorhynchus hectori*) and Maui's dolphin (*Cephalorhynchus hectori hectori*). The Yangtze River dolphin is now considered likely extinct (Turvey et al. 2007); even though the threats facing this species were long understood to be significant, conservation actions failed to materialize in an adequately concerted and organized manner, in a highly challenging and complex context of intensive and diverse human activity (Reeves & Gales 2006). The vaquita, in the Gulf of California, faces a less severe and less diverse onslaught of human impacts than those faced by the Yangtze River dolphin, with the main threat being

bycatch (Rojas-Bracho et al. 2006). Despite longstanding recognition that bycatch poses a severe threat to this species, myriad conservation efforts have struggled to accomplish any significant reduction in fishing effort in vaquita habitat (Rojas-Bracho et al. 2006). Most recently, a government buy-out program is thought to have reduced gillnet use in the vaquita refuge, but any impact on bycatch rates is unknown (Senko et al. 2014). Additionally, the Biosphere Reserve in the Gulf of California protects only a portion of vaquita habitat (Rojas-Bracho et al. 2006). Similarly, only a portion of the range of Hector's and Maui's dolphins is included in protected areas in New Zealand (Slooten 2013). Within the protected areas, dolphin survival rates have increased; however, the overall population of these dolphins continues to decline due to bycatch outside the protected areas (Slooten 2013).

In short, there is essentially a lack of examples of successful mitigation efforts related to small cetacean bycatch in small-scale fisheries, even in cases with relatively complete data on proximate attributes, and even in countries with relatively strong infrastructure for management (e.g., New Zealand). Although the general dearth of basic data on proximate attributes is of significant concern and must be addressed, attention also must be paid to those underlying attributes that might guide the search for solutions; i.e., we need to be able to productively answer the question, "Now that we understand the magnitude and basic characteristics of the problem, what do we do?" Otherwise, we will encounter a bottleneck in conservation action, where even though we possess all of the proximate data that are needed to define the scope of the problem, we are stuck without the ability to address the problem.

This is not to say that understanding the entire conservation-scape will lead to conservation success, as many of these bycatch situations are plagued by various intractable conditions. However, the conservation-scape approach holds great potential for improving the efficiency of identifying and implementing conservation approaches. Conservation-scapes include assessment of previous and ongoing conservation actions as part of the governance context attributes, and investigating the effectiveness of conservation actions against various social and governance attributes might be helpful in elucidating contributing factors to successes or failures.

Comparing across conservation-scapes could elucidate whether general patterns exist in the degree of conservation success across sites with similar sets of attributes. For example, the conservation-scape of the vaquita is at least somewhat similar to that of the Malampaya Sound subpopulation of Irrawaddy dolphin (*Orcaella brevirostris*), in that both units are primarily threatened by small-scale fisheries, coexist with human communities for whom fishing is the major livelihood, and occur in nominal "protected areas" that are not fully enforced (Smith et al. 2004; Rojas-Bracho et al. 2006). This differs from the conservation-scape of the Yangtze River dolphin, which existed in a much more complex setting of diverse human activities that would need to be considered and addressed in any conservation plan. Though site-specific approaches are necessary for addressing bycatch in small-scale fisheries, there might well be room for generalizable approaches that could streamline the development and application of conservation solutions.

Focus on small cetacean bycatch in Southeast Asia

To further demonstrate the status of conservation-scape information for small cetacean bycatch in small-scale fisheries, we will focus on related research and conservation efforts in Southeast Asia. Southeast Asia is a priority region for future studies on cetacean conservation and small-scale fisheries due to the dearth of data on cetacean populations, artisanal fisheries, and high bycatch rates (Reeves et al. 2003, Read 2008). Much of the research on marine mammals in this region is not published; however, reports from two regional workshops, the Second and Third Workshops on the Biology and Conservation of Small Cetaceans and Dugongs of Southeast Asia (SEAMAM 2 and SEAMAM 3, respectively) provide useful information on the status of regional research and conservation.

Among the issues covered at SEAMAM 2, in 2002, seven major goals emerged for addressing the bycatch problem: (1) identify fisheries with small cetacean bycatch; (2) prioritize fisheries on a regional level; (3) develop and conduct capacity-building courses on collected data on bycatch; (4) develop regional databases; (5) draft a regional action plan for assessment and mitigation of bycatch; (6) establish a regional email discussion group; and (7) educate the public and stakeholders (Perrin et al. 2005). At SEAMAM 3, in 2013, delegates were asked: to identify at what stage (as in Table 1) their status of bycatch knowledge was for subpopulations in their country of research; whether they felt they had convincing evidence that bycatch was a serious issue, warranting mitigation action, for specific units; and what progress has been made in understanding and mitigating bycatch since SEAMAM 2 (Table 1.3).

Responses indicate that the status of bycatch conservation-scape knowledge is largely data deficient for the region, with only limited progress toward the goals listed at SEAMAM 2 made in the previous ten years. It is important to note that, even though information on bycatch in small-scale fisheries is limited, the situation may be even more dire for industrial fisheries; except for rare examples (Dolar 2006), bycatch in industrial fisheries has not been studied in the region, though it has been anecdotally reported to occur frequently.

Based on responses for the Philippines, Indonesia, Malaysia, Brunei, Thailand, Myanmar, Cambodia, and Vietnam, delegates felt that there was sufficient information on bycatch to guide mitigation for only six units (all *Orcaella brevirostris*): Songkhla Lake, Thailand; Ayeyarwady River, Myanmar; Mekong River, Cambodia; Mahakam River, Indonesia; Malampaya Sound, Philippines; Guimaras and Iloilo Straits, Philippines (Table 1.3). At each of these sites, mitigation efforts are underway (Table 1.4), though success of these efforts remains to be demonstrated (Acebes et al. 2013; Jutapruet 2013; Kreb et al. 2013; Myo Chit & Tun 2013; Ryan & Phay 2013).
It appears that even those initiatives that appear to be initially successful (e.g., gillnet ban in protected areas in the Mekong River, and enforcement against electrofishing in the Ayeyarwady) have lapsed, and are particularly dependent on a small number of highly engaged and influential individuals who lead these initiatives (Ryan, pers. comm.; Chit, pers. comm.). Efforts in the Mahakam River to engage communities and declare conservation zones for dolphins have met with success, but are still hampered by administrative time lags in official implementation, insufficient enforcement, and

the sheer diversity of human activities impacting dolphin habitat (Kreb, pers. comm.). In Songkhla Lake and Guimaras and Iloilo Straits, research and initiatives that engage the community have recently begun; as such, it is early to know how effective these efforts might be. The conservation-scapes framework can assist in assessing the mitigation efforts underway at the sites above, and in further guiding efforts at those sites and elsewhere.

Bycatch species focus: *Orcaella brevirostris*

The units of *O. brevirostris* discussed in the SEAMAM 3 bycatch workshop represent only a small portion of all suspected subpopulations in the countries included above (the Philippines, Indonesia, Malaysia, Brunei, Thailand, Myanmar, Cambodia, and Vietnam). *O. brevirostris* are patchily distributed throughout Southeast Asia in shallow coastal, estuarine, and riverine habitats (Stacey & Arnold 1999). Due to their proximity to anthropogenic activities and their fragmented distribution, Irrawaddy dolphins are among the small cetaceans that face great risk of population extinction (Smith & Jefferson 2002; Reeves et al. 2003). Although the species as a whole is assessed as VU on the IUCN Red List (Reeves et al. 2008), it comprises a number of small, geographically separated subpopulations. The five *O. brevirostris* subpopulations that have been assessed on the IUCN Red List are all considered Critically Endangered (Reeves et al. 2008), and this represents only a small number of the suspected number of subpopulations. If the status of the five assessed

subpopulations is representative of the majority of the unassessed subpopulations, there is cause for serious concern for *O. brevirostris* conservation on the species level.

Based on a review of published and unpublished literature, Jackson-Ricketts compiled a list of known or suspected subpopulations throughout the range of *O. brevirostris* (South and Southeast Asia); those subpopulations in the countries participating in the SEAMAM 3 Bycatch workshop are shown in Table 1.5 (references in Table 1.6). Looking at the subpopulation level more clearly reveals the degree to which conservation-scape data are deficient for this species, representing a similar situation of data deficiency for other species in developing countries. Basic information is lacking for the vast majority of *O. brevirostris* subpopulations in Southeast Asia.

Such a paucity of data on the proximate attributes of bycatch, let alone the social and governance context, severely constrains the ability to make informed decisions related to the actual conservation status of the species. This is particularly concerning for *O. brevirostris*, as a number of the subpopulations are likely extremely small (in the low hundreds, if not lower). Applying the conservation-scape framework to understudied subpopulations of *O. brevirostris* would yield badly needed data on the status and outlook for these subpopulations and for the species as a whole. Additionally, these *O. brevirostris* subpopulations would be good fodder for comparative studies looking at conservation-scapes and effectiveness of approaches across sites, as they occur in a diversity of ecological, social, and governance contexts.

Moving bycatch research and mitigation forward

The status of conservation-scape knowledge for bycatch of small cetaceans in small-scale fisheries is lamentably limited, with a paucity of data on even the proximate attributes of this urgent conservation issue. Despite the urgency of this issue, limited progress has been made in understanding the magnitude and context of small cetacean bycatch in small-scale fisheries. Even for those sites in Southeast Asia with comparatively complete information on the conservation-scape, bycatch mitigation has not met with any demonstrable success. Even for *O. brevirostris*, the species for which conservation-scapes appears to be best understood in the region, the status of conservation-scape knowledge is largely data deficient.

Conservation-scapes thinking could be a valuable tool in advancing progress toward the seven major goals set at SEAMAM 2 (Perrin et al. 2005), by: (1) guiding the collection of data on proximate attributes will allow for identification of fisheries where small cetacean bycatch is problematic; (2) facilitating comparison of urgency and mitigation outlook across sites, which will be critical to prioritizing bycatch mitigation efforts; (3) guiding training efforts to enhance capacity for data collection across proximate and underlying attributes; (4) providing a standard research approach that will yield comparative data with which to populate a regional database; (5) bringing attention to the practical research and mitigation steps that should be included in any regional action plan; (6) acting as a common approach throughout the region, thereby promoting focused discussions on conservation-scape methods and findings on any email discussion group; and (7) bringing researchers more into their study

communities, and yielding information of interest to stakeholders and the general public. Marine mammal research efforts in Southeast Asia are accelerating, with an emerging generation of researchers from the region eager to move conservation efforts forward. For these researchers, the conservation-scape framework offers not only practical research guidance for collecting holistic, multidisciplinary data. It can also serve as a tool for coordinating research across the region, by serving to at least somewhat standardize research approaches and acting as a conceptual platform upon which collaborations and comparative assessments can be based.

In using the conservation-scapes framework, various tools need to be further refined. In addition to standard boat surveys used to collect data on some proximate attributes, interviews are a necessary tool for collecting data across all conservation-scape attributes. The Rapid Bycatch Assessment (RBA) interview protocol, developed by Project Global Bycatch Assessment of Long-lived Species (Project GloBAL; Moore et al. 2010), is a critically important contribution to bycatch research efforts. This standardized protocol has been updated and utilized by several research projects, including the Convention on Migratory Species' regional project on dugong conservation (Pilcher and Kwan 2012). Additionally, efforts have been made to incorporate social attributes in the RBA protocol, as in megafauna bycatch projects in Nigeria (Lewison & Moore 2012), and by Whitty's (in prep.) development of Rapid Bycatch and Socioeconomic Assessments (RBSAs) to collect data for all elements of the conservation-scape. With further development, and with capacity-building

training in interview methodologies, RBSAs could function as the main vehicle for studying conservation-scapes in Southeast Asia and beyond.

DISCUSSION

As demonstrated by adopting conservation-scapes to the specific issue of small cetacean bycatch in small-scale fisheries, this framework can clearly demonstrate information gaps that must be addressed to inform mitigation, and can guide the process of collecting the needed data. As with the issue of bycatch, this conservation-scape framework would offer much potential for furthering research and informing mitigation if brought to bear on a diversity of other conservation problems driven by direct human use of environmental resources.

Looking ahead to the analysis and application of conservation-scape data, concerted efforts could yield readily comparable views of diverse conservation-scapes. Similar to the Coral Health Index (CHI) approach developed by Kaufman et al. (2011), the conservation-scape framework could be further developed to yield standardized scores for the level of knowledge and mitigation outlook for each set of attributes. Each attribute set could be assigned a core, with an overall "mitigation outlook" score assigned based on attribute scores. This would allow for rapid assessment of the status of knowledge and mitigation outlook across units/sites, which would be of great utility to regional and global priority setting, comparing successes and failures, and better understanding how various conservation-scape attributes might influence the applicability of different conservation approaches.

The conservation-scape framework would be of utility applied at multiple scales. Global-scale assessments, such as those on marine turtle bycatch (Wallace et al. 2010), cetacean bycatch (Young & Iudicello 2007), mammal conservation status (Schipper et al. 2008), and human impacts on marine ecosystems (Halpern et al. 2008), are useful for identifying conservation issues on a coarse scale; regional or global application of the conservation-scape framework would contribute to these and similar efforts. However, they do not offer enough detail with regards to threat types and quality of available knowledge to guide the prioritization of research and conservation projects (Halpern et al. 2008; Wallace et al. 2010). Referring again to the example of small cetacean bycatch in small-scale fisheries, solutions will necessitate site-specific approaches (Senko et al. 2014), particularly since small-scale fisheries management is largely decentralized and under the jurisdiction of local government (municipal and village governments) (Berkes 2010). This is particularly true for species composed of patchily distributed subpopulations, such as the Irrawaddy dolphin, *Orcaella brevirostris* (Stacey & Leatherwood 1997), for which species-level assessments of bycatch risk might obscure the significant population impacts of bycatch in subpopulations. The conservation-scape framework, as applied to specific sites, could function to inform local efforts to mitigate conservation problems.

The call for applying interdisciplinary frameworks to conservation research is not new. However, limited integration of such frameworks into conservation research indicates a need to make interdisciplinary research accessible and applicable to

conservation problems. By identifying specific attribute sets to be studied (as in Ostrom 2007), the conservation-scape framework offers practical guidance in operationalizing holistic research to address two concurrent needs: (1) collecting basic data on proximate attributes, and (2) further developing our ability to assess and design effective mitigation approaches that consider the social and governance context, including previous and ongoing conservation efforts.

As such, the conservation-scape framework aligns strongly with six of seven key steps identified by Knight et al. (2008) to ameliorate the conservation knowledge-implementation gap:

a) Acknowledge the research-implementation gap,
b) Source research questions from practitioners,
c) Situate research within a broader conservation planning model,
d) Expand the social dimension of conservation assessments,
e) Support conservation plans with transdisciplinary social learning institutions,
f) Train students in skills for "doing" conservation.

The seventh key step, to "reward academics for societal engagement and implementation" (Knight et al. 2008), will only accompany broader changes in the conservation research and academic community. More widespread pursuit of multidisciplinary, solutions-oriented research, as that outlined by the conservation-scapes framework, will be one of the drivers behind this ongoing shift toward more closely linking academic research to conservation application.

A major goal of the conservation-scapes framework is to package several well-established, important concepts related to conservation research, in a novel, accessible manner that clarifies the pathway to more thoroughly integrating the human dimension in conservation research. As adopted for specific conservation issues at localized sites, this framework promises to guide necessary research to fill data gaps, assess ongoing efforts, and develop applicable solutions in a site-specific manner. As adopted in a more concerted, large-scale manner, this framework can be broadly applied to improve the status of information, reduce the knowledge-implementation gap, and make substantial advances in how we understand and address the human element for the myriad conservation problems that arise at the interface of ecosystems and human activities.

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FIGURES

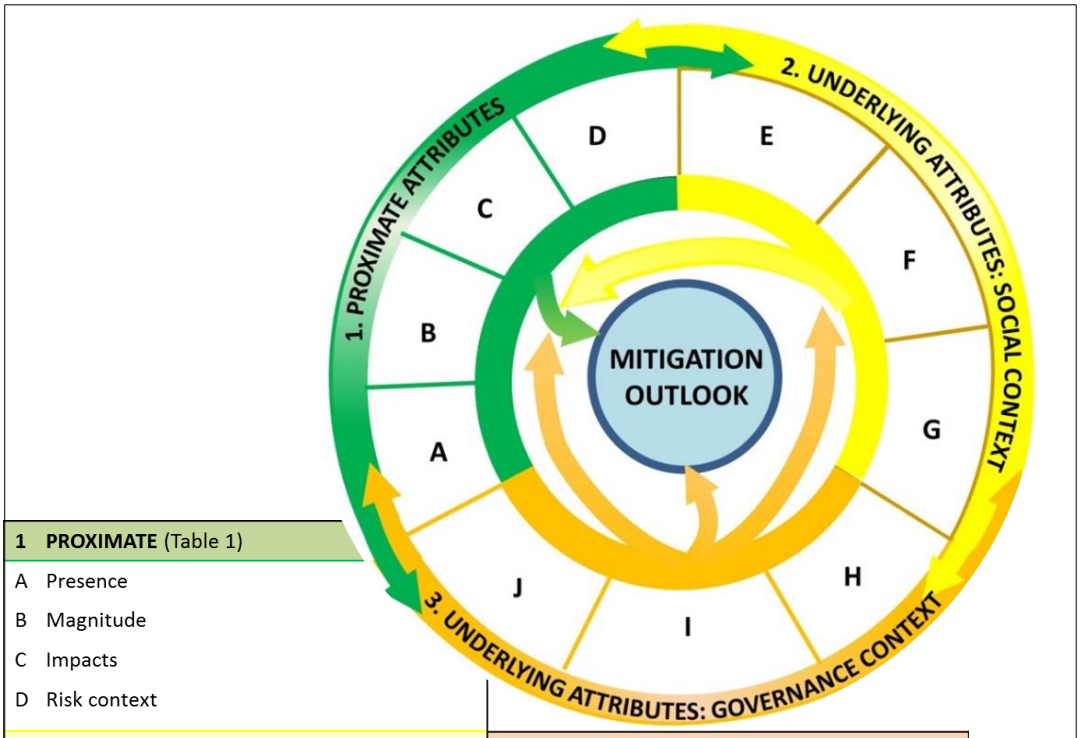


Figure 1.1. Conservation-scape framework. The conservation-scape includes (1) **proximate attributes** (Table 1), and two sets of **underlying attributes**: (2) social context, and (3) governance context. Characterizing bycatch at sites, and assessing the outlook and potential avenues for mitigation, requires interdisciplinary research to investigate these sets of attributes, including the interactions among them and how they directly might influence mitigation. As shown, for example, proximate attributes define the problem (and thus directly impact the mitigation outlook), while social context might influence the proximate attributes. Governance attributes might influence proximate and social attributes, and directly impact the mitigation outlook.

TABLES

Table 1.1. Two major categories of attributes for quantifying and describing the context of conservation problems ("Problem X"), described generally and as applied to the problem of cetacean bycatch. Proximate attributes are those that define the magnitude and impact of Problem X (A-C). They also include any factors that directly contribute to the likelihood or impact of Problem X (D). Under D for bycatch, resource use context includes fishing effort, and how that might spatially overlap with the animals of concern. Opportunistic use of animals caught as bycatch might dampen incentives to avoid bycatch, and might even lead to the transition from bycatch to directed catch. Beyond the proximate attributes, the underlying attributes define the social and governance context in which the fisheries of concern operates; these must be understood and considered to design and implement effective mitigation approaches.

	1. Proximate Attributes				*2. Underlying Attributes*
	A. PRESENCE	**B. MAGNITUDE**	**C. POPULATION IMPACTS**	**D. RISK CONTEXT**	**TOWARD MITIGATION**
KEY QUESTIONS	Is Problem X occurring at this site?	How much does Problem X occur at this site?	How does Problem X impact population abundance?	What directly affects the risk of Problem X occurring and impacting the population?	How can Problem X be mitigated? What are obstacles and opportunities?
APPLIED TO BYCATCH	Is bycatch happening? How, and where?	How many animals are caught as bycatch?	Does bycatch pose a significant threat at the population level?	What other attributes of bycatch & human activities might be important?	How can SSF be managed to reduce bycatch?
INFORMATION NEEDED	• Gear types • Locations • Seasons • Species	• # of bycatch incidents • Fishing effort • Minimum estimate*	• Potential biological removal • Conservation status	• Fate /use of bycaught animals • Other threats to population • Resource use context	• Social context • Governance context

Table 1.2. Summary of small cetacean units assessed by the IUCN Red List (IUCN 2014), for which bycatch has been demonstrated to be, or is very likely, a significant threat. For each of these small cetacean units, small-scale fisheries contribute to the bycatch problem. The baiji is considered likely extinct. Abbreviations for gear types: GN = gillnet, ELE = electrofishing, TRP = trap, TRL = trawl, PSN = purse seine, SN = seine. The quality or completeness of population estimates were rated as good (G), fair (F), poor (P), or not available (N). Information on magnitude was rated as relatively complete (yes, or Y), some minimum estimates available (S), or no numbers available (N). All information from the IUCN Red List (IUCN 2014) and references therein for the specific assessments.

Status	Species	Subspecies/ subpopulation	Bycatch Gear	SSF	Pop Est?	Magnitude
CR	Yangtze River Dolphin, Baiji* (*Lipotes vexillifer*)		Rolling hooks, GN, fyke nets, ELE	Y	G	Y
	Hector's Dolphin (Maui''s) (*Cephalorhynchus hectori*)	*C.h.maui*	Recreational GN; commercial GN; TRL	Y	G	Y
	Irrawaddy Dolphin (*Orcaella brevirostris*)	Mahakam River	GN; ELE; hooks	Y	G	Y
		Malampaya	GN; TRP	Y	G	Y
		Ayeryarwady River	GN; ELE	Y	G	S
		Mekong River	GN	Y	G	Y
		Songkhla Lake	GN; TRP	Y	G	Y
	Harbor Porpoise (*Phocoena phocoena*)	Baltic Sea	GN; TRL	Y	G	Y
	Vaquita (*Phocoena sinus*)		GN	Y	G	S
	Finless Porpoise, Narrow-ridged (*Neophocaena asiaeorientalis*)	*N. a. asiae-orientalis*	GN; ELE; rolling hooks	Y	G	Y
	Indo-pacific Humpback Dolphin (*Sousa chinensis*)	Eastern Taiwan Strait	GN; trammel net; TRL	Y	G	S
EN	Hector's Dolphin (*Cephalorhynchus hectori*)	South Island	GN; TRL	Y	G	Y
	Harbor Porpoise (*Phocoena phocoena*)	*P. p. relicta*	GN	Y	P	S
	South Asian River Dolphin (*Platanista gangetica*)		GN	Y	F	N
	South Asian River Dolphin (*Platanista gangetica*)	*P. g. gangetica*	GN	Y	F	N
	Common Bottlenose Dolphin (Black Sea) (*Tursiops truncatus*)	*T. t. ponticus*	GN, PSN, trammel net, trap net	Y	P	S

Table 1.2, Summary of small cetacean units assessed by the IUCN Red List cont'd:

Status	Species	Subpopulation	Bycatch Gear	SSF	Pop Est?	Magnitude
VU	Finless Porpoise, Narrow-ridged (*Neophocaena asiaeorientalis*)		ELE, rolling hooks, GN	Y	N	S
	Finless Porpoise (*Neophocaena phocaenoides*)		GN, TRP (line), fish stake, TRL, stow net, trammel net	Y	N	S
	Irrawaddy Dolphin (*Orcaella brevirostris*)		GN		N	N
	Franciscana, La Plata River Dolphin (*Pontoporia blainvillei*)		GN, TRL	Y	N	S
	Franciscana, La Plata River Dolphin (*Pontoporia blainvillei*)	Rio Grande del Sul/Uruguay	GN	Y	F	S
	Atlantic Humpbacked Dolphin (*Sousa teuszii*)		Net, line	Y	N	N
NT	Chilean Dolphin (*Cephalorhynchus eutropia*)		GN, anti-sea lion net	Y	P	S
	Snubfin Dolphin (*Orcaella heinsohni*)		GN, anti-shark net	Y	N	S
	Indo-pacific Hump-backed dolphin (*Sousa chinensis*)		GN, TRL, anti-shark net	Y	N	S
DD	Commerson's Dolphin (*Cephalorhynchus commersonii*)		GN; large mesh net; midwater/pelagic TRL; PSN	Y	N	S
	Long-finned Pilot Whale (*Globicephala melas*)		Driftnet; GN; PSN; TRL; TRP	Y	N	S
	Boto, Amazon River Dolphin (*Inia geoffrensis*)		GN; SN; trap	Y	N	S
	Dusky Dolphin (*Lagenorhynchus obscurus*)		GN; mid-water TRL; driftnet	Y	N	S
	False Killer Whale (*Pseudorca crassidens*)		GN; TRL; stow net; longling; PSN	Y	N	S
	Tucuxi, Guianian Dolphin (*Sotalia fluviatilis*)		GN; SN; trap	Y	N	S
	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)		GN; SN; anti-shark nets	Y	N	S

Table 1.3. Status of conservation-scape information for small cetacean bycatch in small-scale fisheries in Southeast Asia, as reported by delegates at the SEAMAM III workshop in 2013. Grey denotes lack of data, pale green denotes partial data, and bright green denotes relatively complete data for a given attribute set. "Country" indicates the general status of conservation-scape knowledge for the country, while "coastal" indicates the status of knowledge for coastal cetaceans in countries where riverine subpopulations of cetaceans have been relatively well-studied. "O.b." is the abbreviation for *Orcaella brevirostris*. Of seven subpopulations for which all proximate attribute types have been studied, there is convincing evidence for urgent need for mitigation at six; without more information on population impacts, the urgency of bycatch for the Trat *O. brevirostris* subpopulation cannot be fully determined. Mitigation efforts are present at these six sites (see Table 1.4).

Country	No Data	A. PRESENCE	B. MAGNITUDE	C. POP. IMPACTS	D. RISK CONTEXT	Enough Evidence	Progress in Past 10 yrs
Philippines		***COUNTRY***					Localized only
		Malampaya Sound O.b.				Y	Mitigation
		Guimaras & Iloilo Straits O.b.				Y	Mitigation
Indonesia		***COUNTRY***					Localized only; Nat'l stranding network
	Aceh						Project to start
		W Kalimantan O.b					Basic research
		Mahakam River O.b.				Y	Mitigation
Thailand		***COUNTRY***					Localized only
		Songkhla Lake O.b.				Y	Mitigation
					Trat O.b.	N	Outreach
Malaysia		***COUNTRY***					Basic research (localized)
		Langkawi					Basic research
		Sawarak					Basic research
		Sabah					Basic research
Myanmar		*COASTAL*					Localized only; Coastal research to start soon
		Ayeyarwady River O.b.				Y	Mitigation
Cambodia		*COASTAL*					Localized only; Collection of stranding records
		Mekong River O.b.				Y	Mitigation
Vietnam		***COUNTRY***					Some basic research
Brunei		***COUNTRY***					None

Table 1.4. Summary of mitigation-related research and activities reported by SEAMAM III delegates in 2013, for the six units of small cetacean where convincing evidence exists that bycatch is unsustainable. Information from bycatch workshop (report in preparation) and country reports: [1]Jutapruet 2013, [2]Ryan & Phay 2013, [3]Myo Chit & Tun 2013, [4]Kreb et al. 2013, [5]Acebes et al. 2013.

Small Cetacean Bycatch Mitigation Research & Activities	
Songkhla Lake, Thailand[1]	• Community-based research and outreach • Catfish gillne buy-out with sustainable aquaculture alternative • Provincial and national agencies Memorandum of Understanding (MOU); control gear, aquaculture, research, habitat protection, NGO and business support, conservation network, monitoring & assessment • 100km^2 protected area (closed to giant catfish gillnet) • Outreach and community meetings
Mekong River, Cambodia[2]	• Dolphin ecotourism zone (2006) • Protected zones for dolphins (2012): core and buffer zones • Gillnet ban in core zones • Outreach and Community meetings • Working with development groups on alternative livelihoods • Trying to establish transboundary management with Laos
Ayeyarwady River, Myanmar[3]	• Protected area • Electrofishing illegal (but enforcement has lapsed) • MOU with Dept. of Fishery and NGO on conservation of Irrawaddy dolphins • Outreach
Mahakam River, Indonesia[4]	• Research on social & governance context • Conservation zones • Gillnet zonation • Community meetings • Outreach
Malampaya Sound, Philippines[5]	• Research on social & governance context • Protected area (but limited enforcement) • Previous attempts at gear switching • Outreach
Guimaras and Iloilo Straits, Philippines[6]	• Research on social & governance context • Proposed protected areas (small portion of O.b. range) • Training in bycatch/stranding response • Local government & community meetings

Table 1.5**.** Known or suspected subpopulations of *O. brevirostris* in the countries represented at SEAMAM 3. Status of conservation-scape knowledge is denoted by colors in the categories proximate attributes, social context, and governance context. Grey denotes absence of data; yellow denotes partial or preliminary data; green denotes relatively comprehensive data. *Units in the Gulf of Thailand and Kuching Bay might comprise an unconfirmed number of multiple units. Reference information in Table 1.6, compiled by Jackson-Ricketts.

Country	Unit	Proximate	Social	Governance	Refs.
Thailand	Gulf of Thailand (GoT), Trat Province				1, 2
	Songkhla Lake				3-8
	Andaman Sea, Satun				9
	Andaman Sea, Phangnga Bay				10, 11
	Andaman Sea, Krabi Bay				10, 11
	Gulf of Thailand*				9-12
Indonesia	Mahakam River				6, 8, 13-20
	W. Kalimantan				21
	Kubu Raya				21
	Sangkulirang				22
	Berau Delta				22
	East Kalimantan				22
	Balikpapan Bay				23
	Central Kalimantan; Kumai Bay				3
	Java				3
	Mahakam Delta				19, 20, 22
	Sulawesi				3
	Sumatra				3
Brunei	Brunei Bay				3, 30
Cambodia	Mekong River				8, 24-26, 29, 31-35, 44
	Koh Kong Province, GoT				6
	Kompong Som Bay, GoT				6
	Ream National Park, GoT				6
	Tonle Sap (*extinct*)	N/A	N/A	N/A	3, 6, 25, 36

Table 1.5, status of conservation-scape knowledge for *O. brevirostris* subpopulations, cont'd:

Country	Unit	Proximate	Social	Governance	Refs.
Malaysia	Batang Rajang				6
	Batang Saribas				6
	Penang				37
	Perak				37
	Klang River				37
	Bernam River				37
	Kuala Rompin, Pahan				38
	Mersing, Johor				38
	Tanjung Manis				6
	Kuching Bay*				6, 34, 39
	Sandakan Bay				6
	Cowie Bay, Sabah				40
	Jambongan Bay				37, 41
	Baram River				37
	Kinabatangan River				40
Myanmar	Ayeyarwady River				42-44
	Ayeyarwady Delta				42-44
	Mergui Archipelago				46-48
	Rakhine State				46, 48, 49
	Costal Myanmar (unspecified)				46
Singapore					3, 6
Philippines	Malampaya Sound				6, 8, 30, 50, 51
	Guimaras & Iloilo				52
	Quezon, Palawan				53
Vietnam	Vietnam				54

Table 1.6. List of references used in compiling Table 1.5, by Jackson-Ricketts.

	References for *O. brevirostris* Subpopulations
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Table 1.6, List of references used in compiling Table 1.5, by Jackson-Ricketts., cont'd:

	References for *O. brevirostris* Subpopulations
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CHAPTER 2

Characterizing the proximate attributes of Irrawaddy dolphin *(Orcaella brevirostris*) bycatch in small-scale fisheries in Malampaya Sound, Philippines

ABSTRACT

Bycatch in small-scale fisheries is the major threat to the Critically Endangered subpopulation of Irrawaddy dolphin (*Orcaella brevirostris*) in Malampaya Sound, Philippines. To update and expand information on the magnitude and context of this conservation issue, this study used small boat surveys and multidisciplinary interviews with fishers (Rapid Bycatch and Socioeconomic Assessments; n=525) to investigate the rate of bycatch, as well as the overlap and interactions between dolphins and fisheries. These "proximate attributes" include: an estimated number of bycatch mortalities from 2009-2011, an updated population estimate (35 individuals, CV = 22.9%) and Potential Biological Removal rates (PBR; 0.06 to 0.58), and densities and spatial overlap of dolphins and human activities. The latter attribute was used to develop a spatial overlap score, to quantify the degree of overlap between dolphins and human activities, including bycatch-relevant fishing gear. Bycatch continues to exceed the PBR, and occurs mainly in bottom-set crab gillnets and crab pots, though a wide range of gears have been reported in entanglements to a lesser extent. Mitigating bycatch here will prove immensely challenging, given the small population size of *O. brevirostris*, the extensive spatial overlap between dolphins and fishing activities, and serious obstacles to effective fisheries management.

INTRODUCTION

Irrawaddy dolphins (*Orcaella brevirostris*) are patchily distributed throughout Southeast Asia in riverine, estuarine, and nearshore marine habitats(Stacey & Arnold 1999; Smith & Jefferson 2002). Their proximity to anthropogenic activities and their fragmented distribution put them at great risk of population extinction (Smith & Jefferson 2002; Reeves et al. 2003). This species is relatively little-studied, but is assessed as "Vulnerable" at the species level on the IUCN Red List, with five assessed subpopulations assessed as "Critically Endangered." (Reeves et al. 2008).

One such subpopulation inhabits Malampaya Sound, a semi-enclosed inlet in the province of Palawan (Taytay municipality), Philippines (Smith et al. 2004, NIPAP 2000; Figure 2.1). Bycatch in the local small-scale fisheries has been identified as the major threat to this subpopulation. Malampaya Sound has been a designated Protected Land and Seascape since 2000, under the National Integrated Protected Area Programme, with monitoring and enforcement mandated to the Malampaya Sound Protected Area Office (PAO) (NIPAP 2000). Irrawaddy dolphins are found only in the inner sound, which is characterized by brackish water (from riverine inputs), remnant mangrove forests along the coasts, and muddy sediments (NIPAP 2000). Due to its highly productive waters, it is called the "Fish Bowl" of the Philippines, with fishing as the major source of income (farming being the other main livelihood). Though fish stocks are thought to be depleted (and continuing to decrease), fishing effort continues to increase here as people migrate from different parts of the country seeking a better livelihood. A diversity of fishing gears are used in Malampaya Sound, as well as fish

cages for aquaculture, seaweed and mussel farms (visible at the surface as lines of multiple buoys spaced closely together), and fish aggregating devices made from tree branches and brush. Fishing activities constitute the major human activities on the waters of Malampaya Sound.

Irrawaddy dolphins are the only marine mammal in the inner sound, though *Tursiops truncatus* are found in the outer sound (Dolar et al. 2002; Smith et al. 2004). Bycatch of Irrawaddy dolphins in local small-scale fisheries has been noted as a serious threat since the first study of this subpopulation in 1999 (Dolar et al. 2002). From initial interviews with fishers in Malampaya Sound, Dolar et al. (2002) recorded reports of bycatch in bottom-set gillnets, fish corrals, liftnets, and crab pots, of at least 1 to 2 dolphins a year. Several respondents reported having consumed Irrawaddy dolphin meat (Dolar et al. 2002).

From subsequent studies(Smith et al. 2004; Aquino et al. 2006; Gonzales & Matillano 2008), bycatch reports from 2001-2006 include: 7 mortalities in crab gillnets in 2001 (6 confirmed with physical evidence and/or photographs, 1 unconfirmed); 4 in crab gillnets in 2002 (2 confirmed); 4 in crab gillnets and gillnet 9s in 2003 (2 confirmed); 4 in liftnets and an unspecified gillnet in 2004 (2 confirmed); 2 in crab pots in 2005 (1 confirmed); and 6 in crab pots, baby purse seine, and rope in 2006 (number of confirmed reports not specified). No dedicated studies or recording of bycatch of Irrawaddy dolphins in Malampaya Sound have been conducted since 2007 (PAO, pers. comm.).

Based on this previous reports, crab gillnets and crab traps - the most commonly reported gear involved in bycatch – are of particular concern. Though the collection of these bycatch reports was not comprehensive and may well have missed other incidents, they signify an unsustainable rate of bycatch as noted by Smith et al. (2004). Based on the population estimate of 77, CV = 0.27 (lower 95% CI = 45, upper 95% CI = 130), Smith et al. (2004) estimated that no more than 0.61 dolphins per year could be killed by human causes without causing the population to decline.

The research reported here aims to understand the proximate attributes of Irrawaddy dolphin bycatch in Malampaya Sound. Proximate attributes of bycatch are defined as those that directly describe the bycatch; they quantify and characterize the nature and magnitude of bycatch, as well as the overlap and interactions between dolphins and fisheries to characterize the human activity-scape encountered by the dolphins in their habitat (Whitty in prep.).

METHODS

Small Boat Surveys

Surveys were conducted from August 2011 to January 2012 along predetermined transect lines (Figure 2.1) used by Smith et al. (2004) and Aquino et al. (2006), to collect information on Irrawaddy dolphin abundance and distribution, as well as density and distribution of fishing gear and other human activity on the water. Since Smith et al.'s study (2004), some transect lines have become inaccessible due to changes in coastline topography and water depth, particularly in the southernmost part

of the sound; as such, some adjustments to the original track lines were necessary (as in Aquino et al. 2006).

Surveys were conducted aboard a 9.5m double outrigger pumpboat with a 20hp diesel motor, using standard line transect methods (Smith et al. 2004; Buckland et al. 2005) . Vessel speed while on-effort was maintained between 8 to 10 km/hr. Each survey shift included: two dolphin observers, searching with handheld binoculars and naked eye between 0 (front of the boat) and 90 degrees to starboard and port, respectively; one human activity (HA) observer, highly familiar with local fishing gear, searching with handheld binoculars and naked eye from 90 degrees starboard to 90 degrees port; one data recorder. Observer eye-height ranged from 2 to 3m above the water line. Positions were rotated every hour to 90 minutes.

Dolphin sightings were recorded as on-effort only if they were first sighted by either of the two on-effort dolphin observers. For dolphin and human activity events, location was marked using a GPS unit, and time, angle and distance from vessel, and number of individuals was recorded, along with Beaufort sea state. Angle was estimated based on two "angle boards" marked with degrees, located where observers could readily refer to them. Distance was estimated using a range-finder or using observer estimates (calibrated by range finder in training and throughout the field season). For dolphin sightings, survey effort was suspended to approach the dolphin groups to obtain group size and photographs, and to record behavior. After group follows, the vessel returned to the point on the track line where effort had been suspended.

The entire study area was surveyed a total of 16 times over five months (with 3 replicates in August, 3 in September, 4 in October, 3 in December, and 2 in January) during both the southwest, or *habagat*, monsoon (roughly June through late October) and northeast, or *amihan*, monsoon (December through March) seasons. Survey efforts were suspended when Beaufort Sea State (BSS) reached 4 and when inclement weather impeded visibility. Only observations made during BSS 0 to 3 were included in analyses.

Dolphin abundance was estimated using the program Distance 6.0, based on the number of on-effort sightings and the probability of detecting dolphins as a function of distance from the transect line (Thomas et al. 2010). Uniform, hazard-rate, and half-normal models were run, with size-bias regression to correct group size estimates for detection bias, and with Akaike's Information Criterion (AIC) used to select the best-fit model (Thomas et al. 2009).

The resulting estimate was used to calculate the potential biological removal (PBR; Wade 1998) of this population. The PBR functions as an estimate of maximum sustainable annual rate of human-caused mortality , based on a minimum population estimate, an estimate of the net productivity rate of the population, and a "recovery factor" from 0.1 (generally used for endangered populations) to 1:

$$PBR = N_{min} \frac{1}{2} R_{MAX} F_{R} \text{ (Wade 1998).}$$

Where: N_{min} is the minimum population of the stock; ½ R_{MAX} is half the maximum theoretical net productivity rate of the stock (for which I used 0.04, the default for

cetaceans, as in Beasley 2007); and F_r is the recovery factor (for which I used 0.1, 0.5, and 1) (Wade 1998).

Bycatch Interviews

Interview-based approaches are considered the most practical, time- and resource-efficient means of estimating bycatch of megafauna in small-scale fisheries (Moore et al. 2010). I developed Rapid Bycatch and Socioeconomic Assessment (RBSA) interviews, adapted from the Rapid Bycatch Assessments (RBAs) developed and refined by Project GloBAL (Moore et al. 2010), the CMS Dugong Project RBAs (Pilcher & Kwan 2012), and the Socioeconomic Monitoring Manual for Southeast Asia (Bunce & Pomeroy 2003). The RBSA used here (Appendix 2) covers a wide range of topics, from fishing effort, fisheries trends, ties to fishing as a livelihood, fisher demographics, perceptions of fisheries management and conservation, local ecological knowledge related to Irrawaddy dolphins (locally called *lampasut*), and fisheries interactions with Irrawaddy dolphins. Key questions related to bycatch were: "have you ever had a dolphin accidentally entangled in your gear?"; "do you know of a dolphin getting accidentally entangled in other fishers' gear?"; "do you know of any dolphin strandings/mortalities?"

For any reported entanglements, strandings, and other mortalities, information was collected on: year of the event, season (*amihan* or *habagat*), month, location, gear or cause of the mortality/stranding, fate of the dolphin (dead [buried, discarded, eaten], killed [eaten], or alive [escaped, released]), whether the event was reported to any

authorities, and whether the respondent had witnessed the event or had heard about it. Reported locations were assigned to zones (Figure 2.2), which were based on readily recognizable natural features and boundaries to aid in respondents' ability to identify specific zones. If the respondent was unsure of a given attribute, it was recorded as "NR" for "No response".

Additional questions included: "What would you do if a dolphin was entangled in your gear?", with options for multiple responses among: release it alive; bury it if dead; report it to authorities; kill it; give the meat to others to eat; sell the meat; consume the meat. Respondents were also asked whether dolphins ever damaged their gear, and the frequency of such damage within the past year.

RBSA questionnaires were translated and conducted in Tagalog by a team of four local field assistants, who had backgrounds and experience with local fisheries and communities, as well as marine biology and conservation. These field assistants were trained in interview methodologies through practice and pilot interviews for this project. I was present at all training and pilot interviews until I was confident that the field assistants were properly conducting the interviews; subsequently, I regularly supervised interviews to ensure that questions were asked in a standardized manner across field assistants. Interview respondents were presented with the objectives of this study and provided their consent to be interviewed. Each respondent was interviewed individually. Responses were written by field assistants in Tagalog, and translated during data entry. Field assistants also rated the reliability of the

respondent's answers on a separate, confidential form, from 1 to 5 (5 being the most reliable, 1 the least); for analyses, those interviews with scores below 4 were not used.

526 RBSA interviews were conducted in all seven coastal *barangay* in the Inner Sound (Table 2.1), in August 2010 and August 2011-January 2012, based on suggested sample sizes from the Socioeconomic Monitoring Manual for Southeast Asia for a "useful understanding of the population" (Bunce & Pomeroy 2003, p.10). Given the lack of comprehensive or accurate census information on fishing households, truly random sampling was deemed impractical; instead, estimates on the number of fishers were based on semi-structured key informant interviews with government officials, PAO rangers, and groups of fishers in each *barangay*. These qualitative interviews survey relevant experts (or particularly knowledgeable individuals) using open-ended questions guided by a list of topics (Bernard 2006).

Based on the estimated number and composition (age, gender, gear type) of fishers from these interviews, strong effort was made to conduct RBSA interviews with a representative sample of each *barangay*, stratified by estimated number of types of fishing gear, subdivisions of each *barangay* (*puroks* and/or *sitios*), and age of fisher. As such, data from these RBSAs should not be considered statistically representative, but are still useful for descriptive purposes. Institutional Review Board approval was obtained from the UC San Diego Human Research Protections Program for all interviews.

Bycatch Estimates from Interview Data

Because interviews were conducted in 2010 and again in 2011-early 2012, bycatch magnitude estimates were based only on reports from 2009-2011 (excluding reports where respondents expressed uncertainty of the exact year). To glean general information on historical bycatch, reports from all years prior to 2009 were used in the following bins: 2000s, 1990s, and pre-1990.

In quantifying mortalities, potential duplicate reports (i.e., multiple respondents describing the same mortality event) needed to be identified. Criteria for potential duplicates were based on matches between attributes considered most likely to be remembered and reported accurately: year and/or year bin, location, and cause. Preliminary sorting and matching indicated that reported season and fate of the animal were less reliably reported than other parameters, and as such, were not used to determine duplicates.

Of identified sets of potential duplicates, the report with the likely highest reliability (bycatch in the respondent's gear and bycatch or mortalities directly observed by respondents) and most complete information were selected as unique events. Results were compiled from these events only.

Density and Overlap Score Calculations

Densities for dolphins and different categories of human activity (HA) types were calculated per survey grid cell using a geographic information system (GIS; ESRI 2014) with grid cells based on the location of the major east-to-west lines

(ranging from 1.5 to 3 km apart), with even divisions longitudinally (2.5 km; Figure 1).

The effective strip widths (ESW) for sighting dolphins and observed human activities were calculated for Beaufort Sea States 0 to 3, using Distance 6.0 (Thomas et al. 2010). For each transect replicate, the number of observed dolphins or HA within the applicable ESW was divided by the effective survey effort area (length of survey effort within the grid cell * 2ESW). This resulting density value was applied to the entire cell. Densities were also calculated by month, season, and over all months and seasons combined.

To develop a useful and easily replicable metric for dolphin-HA overlap and for characterizing the landscape of HA in Malampaya Sound, I defined various HA categories: "Bycatch 1", "Bycatch 2", and "General HA" (Table 2.2)**.** Bycatch 1 is the category of HA most commonly implicated in bycatch (based on RBSA reports), and comprises buoys and fishing boats associated with crab pot and crab gillnet. Bycatch 2 gears are those in which bycatch has been reported, though with lower frequency than those in Bycatch 1, i.e. only one report of entanglement in 2009 through 2011, with fewer than 20 respondents reporting entanglements in these gear prior to 2009. Gear in this category are: two types of large fixed gear (fish corrals and liftnets), all medium boats (*talakop*, *kurantay*, *baring*, *hulbot-hulbot*), longlines, seaweed farms, and assorted gillnets (excluding crab gillnets, and with gillnet 9 pulled out as its own category due to anecdotal reports identifying this as the main gear that dolphins feed from). The General HA category encompasses all observed fishing gear, including

those in Bycatch 1 and Bycatch 2. With the General HA category are five gear types: large fixed structures (liftnet, fish corrals, fish cages), medium-sized fishing boats, small fishing boats, grouped markers (as used to mark seaweed and mussel farms, and in which I included the brush marking the *hilay* fish aggregating devices), and single buoys (or, buoys that are more dispersed than "grouped markers" and are used to mark traps and certain gillnets).

To look at overlap between these groupings and Irrawaddy dolphins, I calculated an overlap score and variance per grid cell using the following set of basic calculations:

1. General overlap with one type of HA:

$$D_{O.b.}D_{HA1}$$

Where $D_{O.b.}$ is the density of Irrawaddy dolphin sightings (or individuals), and D_{HA} is the density of the HA type.

2. General overlap with a group of HA:

$$D_{O.b.} \sum_{z=1}^{G} D_{HAz}$$

Where "G" is the number of HA types within the HA category.

This is similar to the Spatial Overlap Index used by Harden and Willard (2012), as adapted from Williamson et al. (1989); however, the overlap scores calculated here do not include expressions to determine whether overlap is spatially homogenous or aggregated, as the main goal here is to examine the magnitude, rather than the distribution pattern, of overlap.

To compare areas of high dolphin densities with overlap scores across HA groupings, I normalized scores to the maximum value within each HA grouping and displayed normalized scores by grid cells on a heat map, as a visual representation of the cells with the highest overlap between dolphins and various HA types. To produce a summary score for each grouping, I multiplied each cell score by the cell area, and then by the ratio of the cell area to the total area of cells where dolphins were observed, and summed all resulting scores to get an index of overlap per km^2.

RESULTS

Population estimate and Potential Biological Removal

The total on-effort distance between Beaufort sea state 0 and 3 was 1124.11 km. The total number of sightings during the study period was 73, with 59 sightings made while on-effort (Figure 2.3). All sightings were made during Beaufort sea states (BSS) between 0 and 3 (for on-effort sightings, n=19 for BSS0, n=22 for BSS1, n=15 for BSS2, n=3 for BSS3). Over all sightings, the mean group size was 5.9 (SD = 3.9, range = 1-15). The only other cetacean sighted was *Tursiops* sp. (group size = 2), of which one sighting was made in the very northern part of the Inner Sound.

Using data from all on-effort sightings during the study period, the estimated population size of *O. brevirostris* in Malampaya Sound is 35 (CV = 22.9%, 95% CI: 22 to 55) using the Fourier series uniform + cosine model in Distance 6.0 (selected as the best-fit model based on AIC), with no truncation deemed necessary (with the maximum width at 938.8 m; see Figure 2.4 for the detection probability plot). The

ESW was calculated as 559.60m, and expected cluster size as 5.8 (CV = 13.0%). The number of sightings was too small to stratify abundance estimates across sighting conditions and strata within the study area. Based on this population estimate and CV, the PBR for this subpopulation ranges from 0.06 ($F_r = 0.1$), to 0.29 ($F_r = 0.5$), to 0.58 ($F_r = 1$).

Annual Bycatch Estimates for 2009-2011

Of those interview responses reporting unique entanglement incidents, there were 13 reports of entanglements (with 8 mortalities) in respondents' gear from 2009 to 2011, with an additional 13 reports of entanglements (with 11 mortalities) in other fishers' gears (Figure 2.2, Table 2.3). Based on these 26 reports, entanglement of Irrawaddy dolphins occurs primarily with crab gillnets (12 entanglements, 10 mortalities) and bottom-set crab pots (6 entanglements, 4 mortalities). For 2009, bycatch mortality estimates ranged from 2 to 6; 2010, 7 to 11; 2011, 0 to 3. Because most interviews were completed before the end of 2011, sampling may not have been captured entanglement events that occurred in the latter part of the year. Other implicated gears include various other gillnets (gillnet *matang* 9.5, 1 entanglement; *pamo*, 1 mortality; gillnet *matang* 10, 1 mortality), liftnet (1 mortality), longline (1 mortality), ring net (1 entanglement), and baby purse seine (1 entanglement) (Table 2.2 for gear information).

Historical Bycatch Information and Gear Damage

Reports prior to 2009 reveal a wider diversity of gear implicated in bycatch (Table 2.4). Presented numbers indicate number of reports, which are not representative of the actual number of events – particularly since the criteria used for determining unique and duplicate reports likely involved a high degree of uncertainty for these years due to memory decay. Based on these reports, the consumption (sometimes following killing) of entangled animals has occurred throughout previous decades, with the meat being given away to friends and neighbors, or sold. One fisher reported that, during the 1960s, capture of Irrawaddy dolphins in the *talakop* purse seine was fairly common, with his vessel catching about 10 per year (of which some were released, and those found dead were consumed).

75 respondents reported dolphins causing gear damage within the past year (Table 5), due to dolphins biting at and swimming through nets as they try to feed on entangled fish and shrimp. One respondent reported damage to a *bubo* (fish/squid pot) in previous years. Reports of gear damage frequency varied widely across respondents, from 1-5 times to over 50 times in the past year. Gillnets were most frequently reported as being damaged, in particular gillnets 8-10 and other gillnets targeting assorted small fishes and shrimp. The quality of responses regarding gear damage frequency is relatively low, as respondents generally seemed to guess at the number of incidents within the past year.

Reporting Entanglements & Strandings to Authorities

Out of the 2009-2011 reports, only four entanglement or stranding events were described by respondents as being reported to authorities: one to WWF-Philippines, two to the Protected Area Office (PAO), and one to an unspecified authority. These numbers are corroborated by four official reports recorded at the Protected Area Office (which also included WWF-Philippines reports). Out of the 78 reports of bycatch and strandings in the "2000s" bin, 20 were noted as reported (9 to WWF, 6 to PAO, 2 to *barangay* authorities, 4 to unspecified authorities).

Out of 373 respondents, most stated that they would release an entangled dolphin if it were still alive (98%), bury it if dead (68%), and report it to authorities (92%), with 91% of respondents specifying that they would report it to PAO. Fewer respondents stated that they would kill an entangled dolphin (1%), or, in the case of an already dead dolphin, give (7%) or sell (1%) the meat to community members for consumption. Seven percent of respondents stated that they would consume the meat of an entangled dolphin if it were found dead.

Dolphin and Human Activity Spatial Overlap

Across all transect replicates, the maximum density of dolphin individuals within a grid cell was 8.83 dolphins/km^2 (observed in August, in grid cell I), while the maximum density of dolphin sighting events over all replicates within a grid cell was 1.06 sightings/km^2 (grid cell J in September). When looking over all months, and within both *habagat* and *amihan* seasons, the maximum density of dolphins per grid

cell was 2.06 dolphins/km^2 (grid cell I), with a maximum sighting density of 0.28 sightings/km^2 in grid cell I (Figure 2.5, Table 2.6). Other cells with relatively high dolphin densities across all months include cells J, L, M, N, O, and U (in the middle latitudes of the sound), while cells Y, ZC, and ZE (northern section of the inner sound) had relatively high dolphin densities during *habagat*.

The area of grid cells where dolphins were observed during on-effort sightings was 93.1 km^2 for the whole study season (78.4 km^2 for habagat, and 31.6 km^2 for amihan; Table 2.6), indicating a contraction of dolphin area use during *amihan*. Though this does not include off-effort sightings, only one off-effort sightings was made in a grid cell not included in on-effort sightings during *amihan* (Figure 2.3)

Gears in the category Bycatch 1 were observed at densities up to 6.81 buoys+boats/km^2 in grid cells (Figure 2.6). Overlap scores (a function of the density of dolphins and Bycatch 1 gears) ranged from 0 to 5.4 (with maximum values of 2.8 during *habagat*, 5.4 in *amihan*, and 1.05 over all months). Across maximum grid cell scores for Bycatch 1 and Bycatch 2 categories (Figure 2.7a), crab pot and crab gillnet buoys, gillnet 9, seaweed farms, and fish corrals and liftnets yield the highest overlap scores, while the scores for crab pot and crab gillnet buoys, medium boats, longlines, and gillnets other than gillnet 9 and crab gillnets are relatively low. Looking at gillnets only, the maximum cell scores for all months/*habagat*/*amihan* for crab gillnets were 0.69/1.57/0.32, (buoys) and 0.41/0.56/0.14 (boats); gillnet 9, 1.77/1.77/0.16; other gillnets, 0.13/0.13/0.00.

Over all months, the cells with the highest Bycatch 1 overlap scores are I and U, followed by O and N (Figure 2.8); for Bycatch 2, the highest scores are in cells I, J, M, N, and ZC. Looking over all HA types, cell O has the highest score. Looking over all categories (some which include other categories, e.g., "Small Fishing Boats" includes boats using gears in Bycatch 1 and 2), cells I, J, L, M, N, O, U, and ZC demonstrate the greatest levels of overlap between HA and dolphins. Focusing on gillnets, moderate to high overlap scores for gillnets 9 and crab gillnets occur in similar areas (cells G, I, and N), except for cells L and K (where crab gillnet scores are high, but gillnet 9 scores are low), and cells ZC and M (where gillnet 9 scores are high, but crab gillnet scores are low). Cell ZC is the only cell where "other gillnets" returned a high score. Cell L has moderately high dolphin density, and a high overlap score with crab gillnets, but a low Bycatch 1 score driven by a low crab pot overlap score. All cells with a nonzero value for dolphin densities also have nonzero values of overlap with Bycatch 1 and/or Bycatch 2 gears, in addition to a number of other HA categories.

Summary overlap scores for Bycatch 1 and Bycatch 2 were around similar levels (Figure 2.9), from 1.65 to 2.78 for Bycatch 1 and from 2.35 to 4.38 for Bycatch 2. Scores for all General HA types ranged from 14.50 (over all months) to 50.11 (*amihan*), with the high score for *amihan* being driven by relatively high scores for buoy lines and single buoys. Among gillnets, summary scores for crab gillnets were 0.45/0.89/0.26 (buoys) and 0.14/0.19/0.13 (boats); gillnet 9, 0.25/1.08/0.30; other gillnets, 0.04/0.06/0.00.

DISCUSSION

Bycatch reports and overlap scores: Implications

From previous studies, bycatch for this subpopulation of *O. brevirostris* has been known to be unsustainable since the early 2000s (Smith et al. 2004, Aquino et al. 2006). The situation has not improved: the rate of bycatch continues to exceed the PBR. The updated abundance estimate is lower than that from Smith et al. (2004) (35 individuals, CV = 0.23, versus 77 individuals, CV=0.27), though the CIs overlap. Key informants have perceived a decline in dolphin numbers over the previous decades, which would not be surprising given the continued unsustainable rate of bycatch. Given that estimated bycatch has exceeded PBR for at least a decade, a decline in population abundance of this subpopulation is to be expected. As stated by Smith et al. (2004), without prompt action to eliminate mortalities from bycatch, this subpopulation faces almost certain extirpation.

The two gear types most commonly reported in bycatch events, the crab pots and crab gillnets, are among the most commonly used in Malampaya Sound. In general, these gear types tend to be easily affordable and operated (Dugan et al., 2003); additionally, the construction of crab pots serves as supplementary income for the local Indigenous Peoples groups in Malampaya Sound. The crab gillnets have an untended soak time of 12 to 48 hours. They are made from nylon monofilament, the same material used in other gillnets, including the gillnet 9 (for shrimp). No mortalities were reported in 2009-2011 in the shrimp gillnets; these gillnets target known Irrawaddy dolphin prey and have a soak time of 1 to 2 hours. Respondents

mentioned that dolphins caught in these shrimp gillnets usually escape or are cut out and released. Soak time of the gillnet 9 and other gillnets is generally 1-2 hours. As the materials used among the various gillnets appears to be similar, and the overlap scores between crab gillnets and other gillnets were similar (indicating similar degree of spatial overlap), soak time might be a major factor in the relatively high rate of bycatch in crab gillnets. Another gear reported in bycatch events, longlines, can have soak times around 12 hours.

The crab pots are bottom-set in lines up to 600-700m long (Dolar et al. 2002), with about 3m of rope ground line in between each pot. According to fishers and PAO rangers, the dolphins' tails become entangled in the connecting ground lines as they feed on the bottom. These pots are left overnight or longer – among the longest soak times of fishing gear used in Malampaya Sound. These differ from the other crab, fish, and squid pots, which are set out individually on shorter ropes. Although crab pots and crab gillnets are the gear of most concern, they do not target known Irrawaddy dolphin prey items for the Malampaya Sound subpopulation, which have thus far been documented as bottom-dwelling fishes, squids, and penaeid shrimps (Gonzales and Matillano 2008), as well as sea cucumbers (M. Matillano, pers. comm.) As noted above, the soak time for these bottom-set gears is among the longest of gears used in Malampaya Sound. Thus, the potential for interaction between Irrawaddy dolphins (as they forage on the bottom) and these gears might be quite high. Because these gears are left unattended, fishers may not notice dolphin entanglements in time to release the dolphin alive.

Though the threat posed by the bottom-set crab pots has been known for this site for several years, similar gear have only rarely been noted as a risk for small cetacean bycatch in the wider literature; entanglement of *Tursiops truncatus* in the float lines of crab pots has been report in Florida (Noke & Odell 2002) and South Carolina (Burdett & McFee 2004; McFee et al. 2006), and *O. brevirostris* entanglements in bottom-set octopus trap lines have been reported in Thailand (Whitty, unpublished data). Entanglement in the ground and buoy lines of bottom-set traps has been recorded for North Atlantic right whales and humpback whales (Johnson et al. 2005) and minke whales in the East Sea of Korea (Song et al. 2010). Results from this study suggest that the focus on gillnets in bycatch studies and mitigation efforts should be broadened to include improved understanding of the threat posed by bottom-set lines of traps (particularly for species known or suspected to feed demersally) to small cetaceans.

From Figure 8, it is clear that gears reported in entanglement events (i.e., Bycatch 1 and 2) are present throughout the area used by the dolphins, and that all areas used by the dolphins overlap with a diversity of fishing activities. The grid cells with particularly high overlap between dolphins and Bycatch 1 gears could be considered "high risk" cells (cells I, N, O, U); the grid cells with high overlap for both Bycatch 1 and 2 gears (cells I, N, U) would be of particular concern. Looking at Figure 2, where the numbers of entanglement reports for broader RBSA zones have been applied to the overlapping grid cells, shows that cell O, F, K, and P are within the RBSA zones with the highest number of bycatch reports (5-6 total from 2009-2011).

Cells N, U, and I overlap with RBSA zones for which a total of 4, 3, and 2 entanglements were reported, respectively. There is no clear pattern by which these "high risk" cells are included in the zones with the highest number of bycatch reports. Given the relative rarity of entanglements and the lack of high-resolution information on entanglement locations, rigorous assessment of whether bycatch occurs primarily in these high overlap cells (e.g., Harden & Willard 2012) is not feasible.

Fishers and other Malampaya Sound residents have reported (anecdotally) that dolphins were more often seen on the western side of the sound during *habagat* and on the eastern side during *amihan*, though this might also be due to changes in fishing grounds between seasons (in particular, the high and sustained winds during *amihan* pose a challenge to navigating across the sound and to fishing in the more "open" waters in the north-central part). Results from our line transect surveys suggest a potential shift by dolphins away from the more northern sections of the sound, and somewhat greater densities along the east coast. However, this seasonal contraction does not appear to increase the overlap between dolphins and Bycatch 1 gear in the southeastern portion of the sound (Figure 6C).

If one were to assume that the high overlap cells represent the areas with highest risk of bycatch, these cell scores could, in theory, guide identification of priority zones for management actions (e.g., restriction of gear use). In reality, this approach is almost certainly not feasible for Malampaya Sound. The high dependence of local communities on small-scale fisheries and the massive challenges faced by enforcement teams, including limited personnel and funding, render any significant

changes in fisheries management practically impossible. Additionally, to save this subpopulation of Irrawaddy dolphins, a virtually complete reduction of bycatch is necessary (given a PBR of less than 1 animal per year), which would require elimination of bycatch risk, or all fishing gears in the Bycatch 1 and 2 groups, from throughout their habitat, which is essentially the entire inner sound. However, reducing overlap between dolphins and Bycatch 1 and 2 gears in a portion of Irrawaddy dolphin habitat may serve to slow the decline of the population.

Potential adaptations to fishing gears and practices may help reduce entanglements. Reduction of untended soak time for crab gillnets and crab pots would decrease the effective overlap between these gears and dolphins, and increase the possibility of fishers being able to notice and release entangled dolphins. Although this study did not look at the density of ropes currently used for crab pots, using negatively buoyant or sinking ground lines for crab pots might reduce the likelihood of dolphins getting entangled in floating segments of rope, as has been suggested for right and humpback whale entanglements in pots (Johnson et al. 2005). Another possibility includes altering ropes to include "weak points" that would break if a dolphin were struggling while entangled (Johnson et al. 2005).

Responses to entanglements

Although most (92%) respondents stated they would report an entanglement event to authorities, there were very few actual reports of entanglements. This indicates that, while fishers are aware that events can be reported to authorities

(particularly, PAO), they do not actually report events. This appeared to be mainly due to lack of awareness regarding the importance and mechanisms for reporting such events. Outreach aimed at informing communities about the importance of reporting events regularly to PAO, and how to properly report such events, might mitigate this discrepancy. We conducted 9 outreach events for preschoolers, kindergarteners, and elementary school students in Malampaya Sound, and distributed posters and informational cards to fishers on the Critically Endangered status of the dolphins, the significant threat posed by bycatch, and protocol for reporting entanglements and strandings.

The fact that some fishers stated they would kill an entangled dolphin warrants some concern, though the number of these responses was limited. Whether the responses related to consumption of dolphin meat (give away, sell, or eat meat) are of concern depends on the risk of "accidental capture" of dolphins transitioning into deliberate capture for protein (Read et al. 2006).

Limitations of and improvements to the RBSA

Limitations of interview data include biased responses and memory decay (Bradburn et al. 1987; Bernard 2006; Gomm 2008). The issue of bias is particularly relevant for the study of bycatch, as fishers may be fearful of punitive action resulting from negative interactions with protected species or may view potential conservation efforts as a threat to their livelihood (Moore et al. 2010). As was the case in Malampaya Sound, statistically rigorous sampling is extremely challenging

logistically at sites with no existing reliable data on the number and composition of fishers (Moore et al. 2010). This limits the ability to extrapolate from bycatch reports collected in interviews to beyond the sampled respondents. For these reasons, the data presented here on bycatch should be regarded as conservative estimates rather than accurate estimates of the total bycatch each year.

The inclusion of the interview question, "Do you know of a dolphin getting accidentally entangled in other fishers' gear?" was intended to collect information on bycatch incidents where the respondent might be afraid to report bycatch in their own gear. Given the small population size of this subpopulation of Irrawaddy dolphins, and the number of previous reports suggesting that bycatch is a relatively rare event, collecting this additional information was considered particularly important. This question yielded additional unique bycatch reports, though identifying unique and duplicate reports did involve subjective decisions on data reliability (see Methods). Thus, widespread use of this question to estimate bycatch magnitude without careful consideration and attention is not recommended. In particular, use of this question is only recommended in scenarios where, as in Malampaya Sound, there were concurrent assessments of respondent reliability, distinct geographic features to aid in mapping entanglement reports within zones, and a research team experienced in working with communities at the study site and familiar with the types of details likely to be remembered or forgotten by local fishers.

The RBSA, as used in this study and presented in the appendix, has since been streamlined and improved for use at other sites (Whitty, unpublished data). The goal

of the RBSA is to collect descriptive data on fishing and Irrawaddy dolphins, and is suitable for generating information on minimum bycatch estimates, bycatch gear types, and the wider context of small-scale fishing communities. A major drawback to the RBSA is its length; while interviews could be completed within 20-25 minutes, some interviews took up to 60 minutes or more. These longer time periods are less than ideal to ensure the greatest quality of responses (White et al. 2005). Since its use at Malampaya, the RBSA has been streamlined for shorter interview times and improved clarity and simplicity in wording (essential to guide proper translations)(Gomm 2008).

Further development of overlap scores

The general goal of the overlap scores is to provide a metric of human activity-dolphin overlap, and potential human impacts on dolphins and/or dolphin habitat; essentially, the set of scores across HA types would serve as an index of the human activity-scape encountered by dolphins. Caveats to these scores include the challenge of matching observed fishing gear and activities to effective fishing effort; e.g., how many crab pots are "represented" by a crab pot buoy, and what is the "bycatch risk" value of a crab pot buoy versus a boat seen carrying crab pots? These values could be estimated through more in-depth study of fishing effort.

Adding some sort of "risk factor", similar to the "bycatch risk" index in Harden & Willard (2012), to the overlap score calculations could help weight various HA categories to better represent the potential impact of human activities on dolphins:

$$\text{Potential Impact Score} = D_{O.b.} \sum_{z=1}^{G} R_{HAz} D_{HAz}$$

Where "R_{HAz}" is a risk factor between 0 and 1 for a given HA category. For the HAs most commonly involved in bycatch (or other impacts, such as propeller strikes), R could be assigned a relatively high value (*e.g.*, 0.8 to 1), while HAs that are less commonly involved would be assigned a lower value. (*e.g.*, 0.1 to 0.2). These assignments are based on the perceived relative magnitude of the threat posed by each group of HA, perhaps as determined through interviews and/or systematic mortality reports. Different categories of Potential Impact Scores could summarize the likely impacts to dolphins posed by a diversity of HAs beyond fishing, such as high-speed passenger ferries, cargo ships, etc.

The cell scores serve to identify high-impact areas/high-risk areas within a site, while summary scores characterize human impacts for the whole site in a way that is easily comparable across sites. Expanding this approach to additional sites will allow for the calibration of scores and stronger interpretation of the actual human impact represented by scores, and will require inclusion of additional HA categories not present in Malampaya Sound (e.g., high-speed passenger ferries). A challenge to developing a widely-applicable set of score interpretations is the dearth of data for densities of human activity and dolphins throughout the range of Irrawaddy dolphins and similarly little-studied species. Refining this approach, and developing related

classifications of scores as representing “high”, “medium”, and “low” human impacts, will require iterative efforts and comparisons of scores across sites.

Further development of this scoring approach would greatly facilitate rapid comparison of human impacts across Irrawaddy dolphin (and other species) subpopulations. Such a replicable, widely applicable scoring system could be a key tool in characterizing conservation outlooks and setting conservation priorities across multiple, diverse sites. The overarching goal of this scoring approach would be similar to that of the bycatch vulnerability assessment approach proposed by Brown et al. (2013), which measures the potential vulnerability of different cetacean species to interactions with fisheries (based on life history characteristics, spatial cetacean-fishery overlap, gear characteristics, and rate of mortality from entanglements) to guide research and management priority-setting. However, the scoring approach outlined here is likely more suited for the data-poor situations commonly encountered for marine mammals and small-scale fisheries in developing countries.

CONCLUSION

Although bycatch of Irrawaddy dolphins in Malampaya Sound is a relatively rare event, it exceeds the PBR for this subpopulation (and has exceeded the PBR for at least the past decade). Reducing untended soak times, altering gear, and reducing use of crab gillnets and crab pots in areas of relatively high dolphin density are possible avenues for decreasing bycatch. However, implementation of any changes to gears or soak times will be highly challenging at this site due to personnel and funding

constraints on enforcement. Reducing bycatch to below the PBR would require, essentially, completely eliminating bycatch – an unlikely scenario, particularly given the context of increasing fishing effort in Malampaya Sound, the widespread use of the two most problematic gears, and the high degree of overlap between intense small-scale fishing pressure and Irrawaddy dolphin area use.

Assessing the magnitude of bycatch and the spatial overlap between dolphins and human activities is a key element in understanding and mitigating bycatch in small-scale fisheries. Understanding these proximate attributes characterizes the actual and potential impacts of fishing activity on dolphins. However, this human activity-dolphin overlap and bycatch occur in a wider context of human communities and environmental governance, which are critical components to understanding the conservation outlook for marine mammals impacted by small-scale fisheries. Expanding the scoring approach described above to develop indicators of community and governance characteristics related to conservation outlook would promote a more practical, ecosystem-based management approach (Whitty in prep). Further application of the overlap scoring approach to other Irrawaddy dolphin subpopulations (and other species) could facilitate relatively rapid comparisons of the human activity-scape encountered by animals regionally and internationally. Expanding this approach to include social and governance attributes, and applying it widely, would promote improved identification of priorities and development of mitigation strategies for this urgent conservation threat.

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Chapter 2, in part, is currently being prepared for submission for publication of the material. Whitty, Tara S. The dissertation author was the primary investigator and author of this material.

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FIGURES

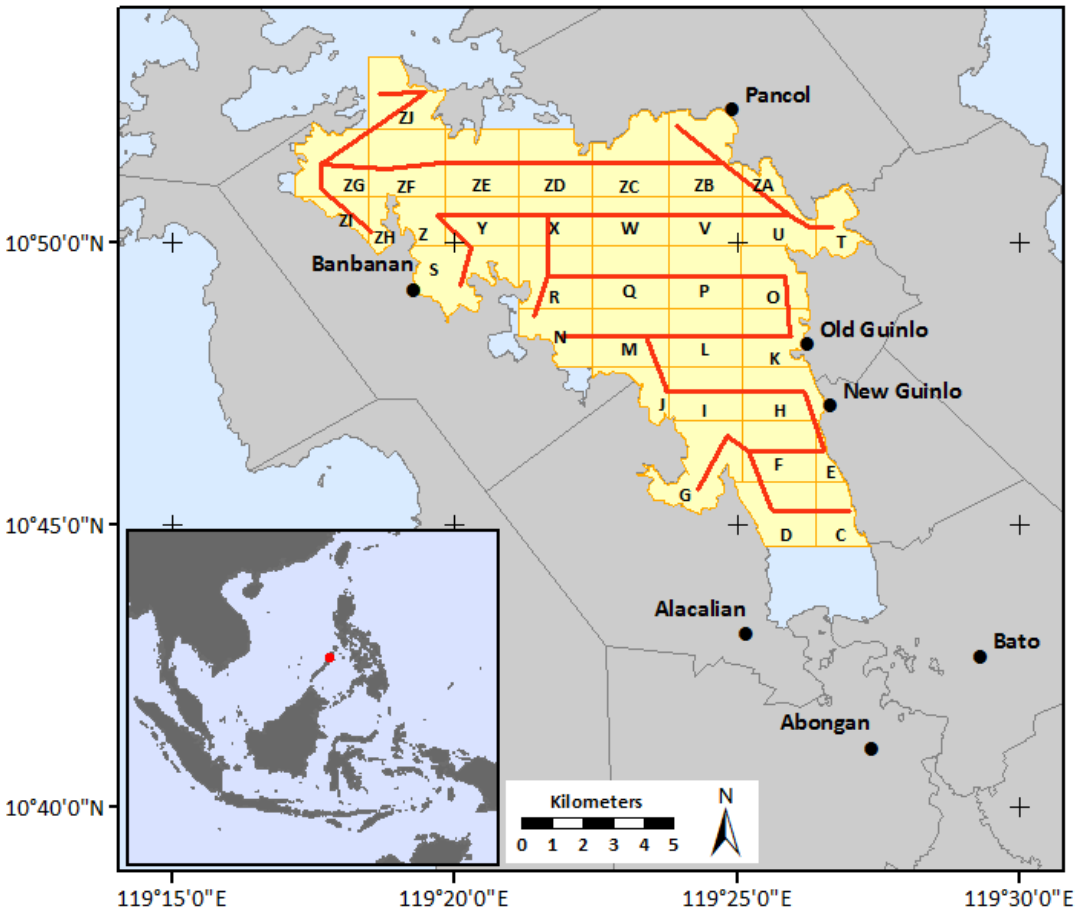


Figure 2.1. Map of Malampaya Sound (in northern Palawan, Philippines), with the Inner Sound study area in pale orange and the seven coastal *barangay* (villages) where interviews were conducted labeled. Survey tracklines are shown in red, and grid cells used in density and overlap calculations are labelled (cell names C-ZJ, from south to north).

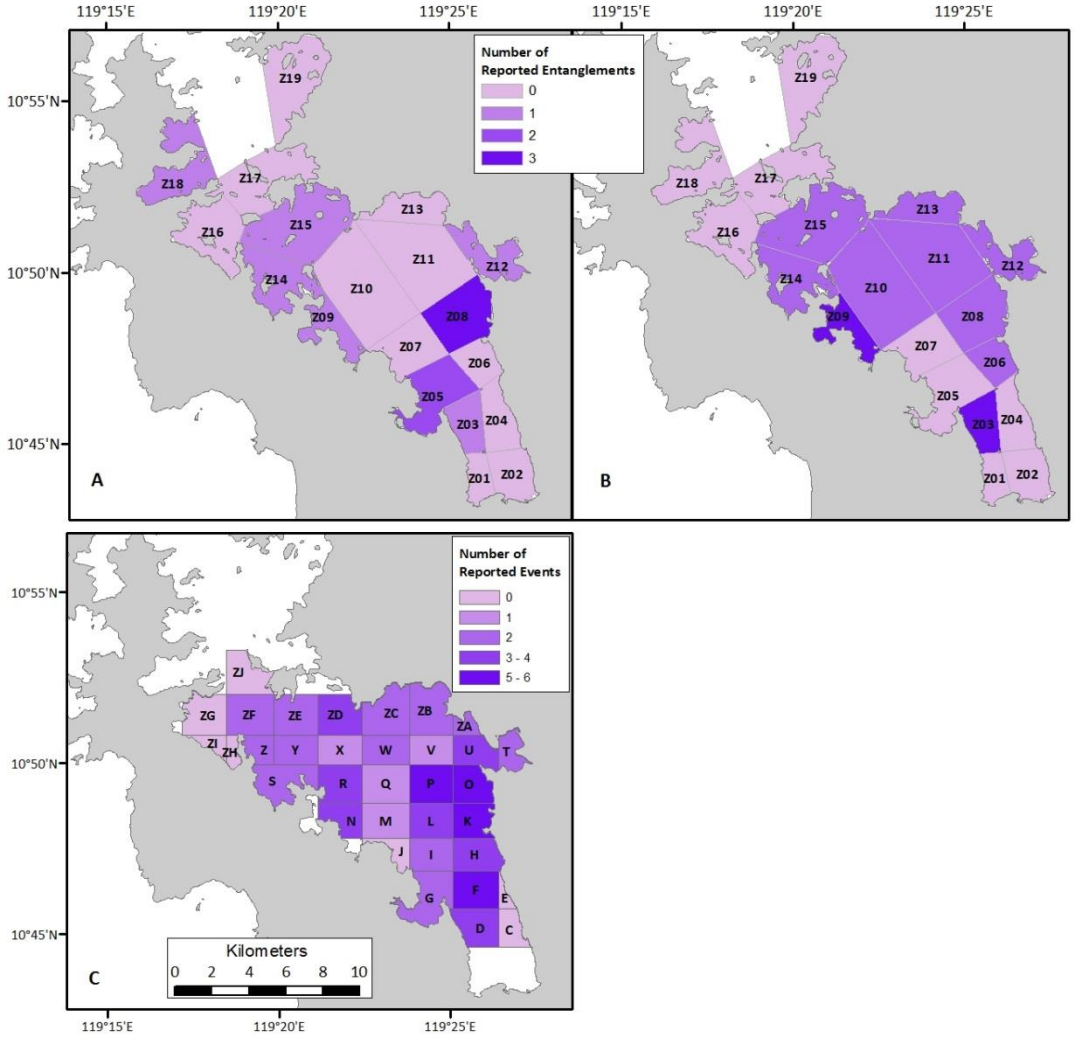


Figure 2.2. Zones as used in RBSA interviews, with the number of unique entanglement reports (from 2009-2011) for each zone (Z01-Z19). (A) Number of bycatch events reported as occurring in the respondent's gear; (B) Number of bycatch events reported as occurring in gear of fishers other than the respondent. This figure excludes strandings and three reported entanglement events for which the location was described as the "Inner Sound", which spans Z05 up to Z11. Details on the reported events are in Tables 3-5. (C) The total number of reports from (A) and (B), assigned to grid cells (see Figure 1) based on overlaps with RBSA zones (see Methods).

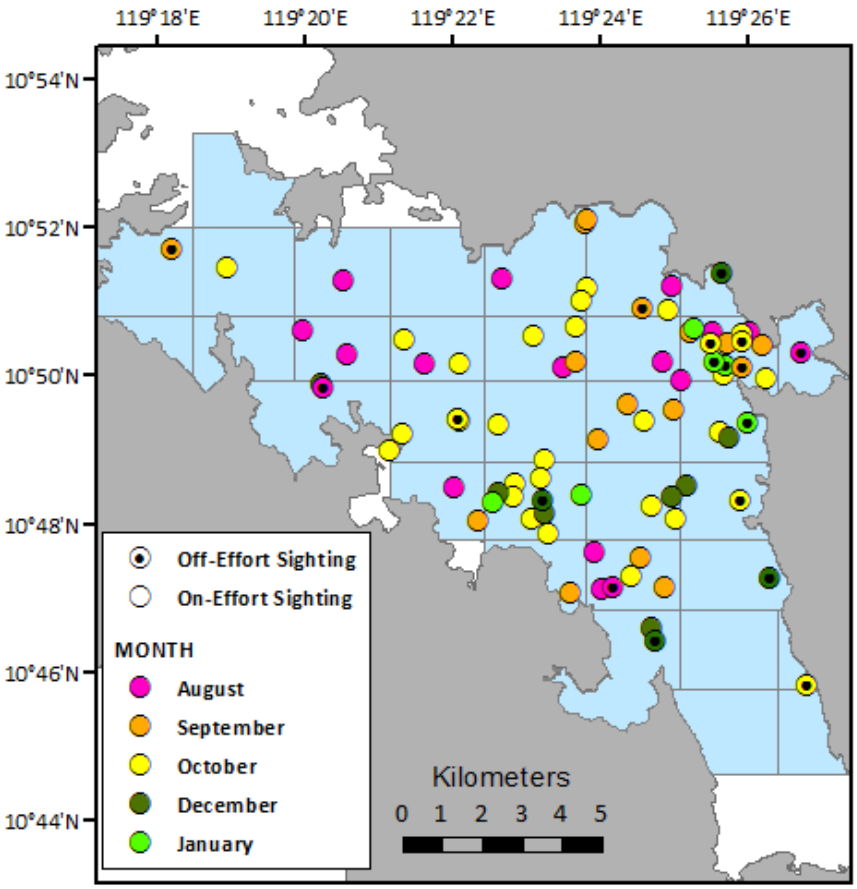


Figure 2.3. Locations at initial detection of *Orcaella brevirostris* sightings (marked locations are the first point of observation for each sighting). Grid cells as in Figure 1.

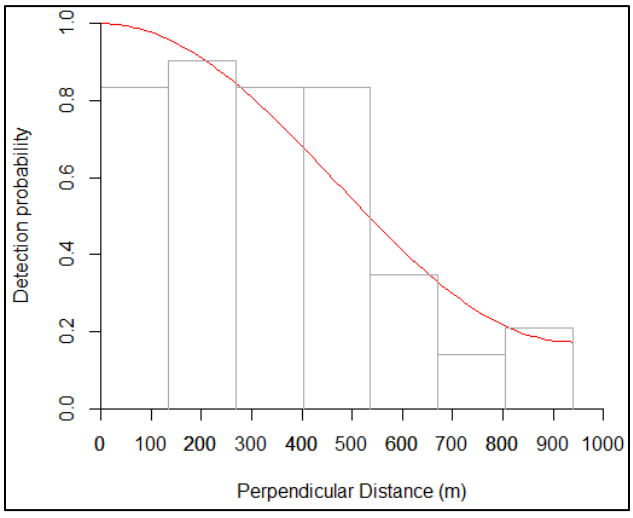


Figure 2.4. Detection probability plot for all on-effort *O. brevirostris* sightings from all survey efforts, to a maximum observed perpendicular distance of 939.8m.

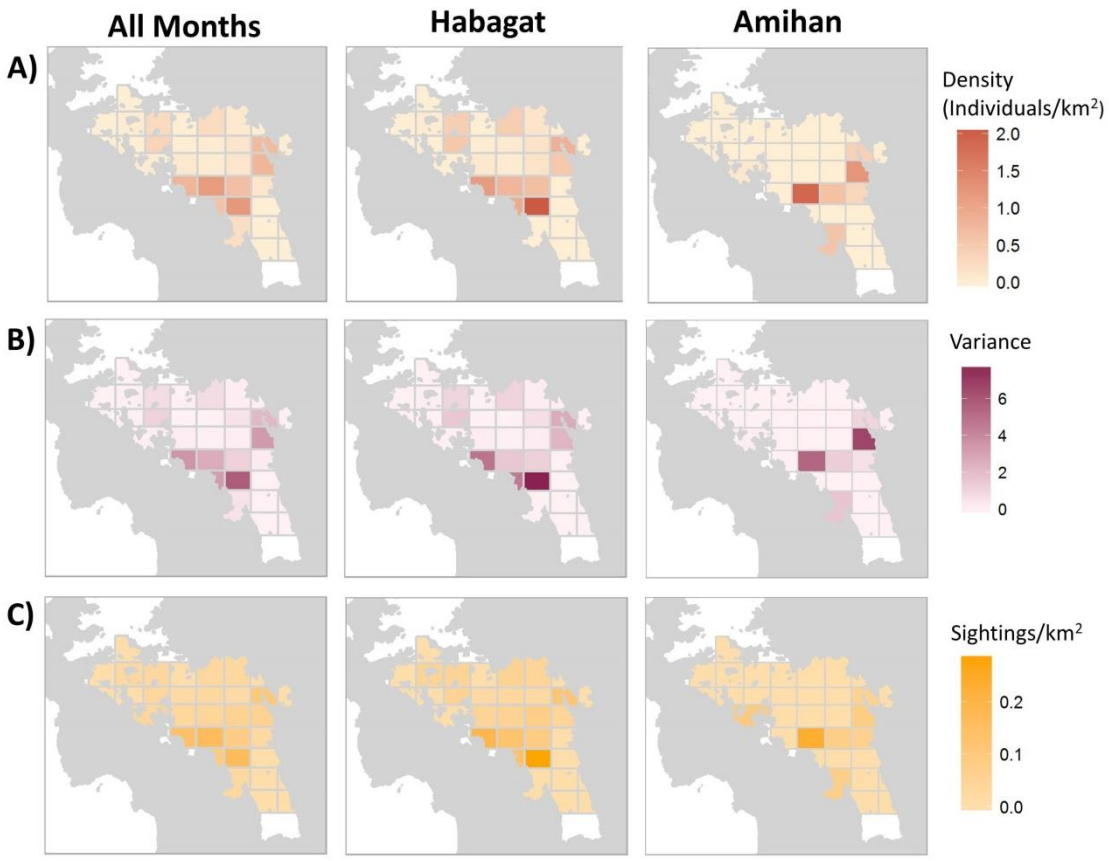


Figure 2.5. (A) Densities of *O. brevirostris* individuals as observed from line transect surveys, over all survey months and during the seasons *habagat* and *amihan*; (B) Variance in density per grid cell over all replicates within each time period bin; (C) Density of *O. brevirostris* sighting events.

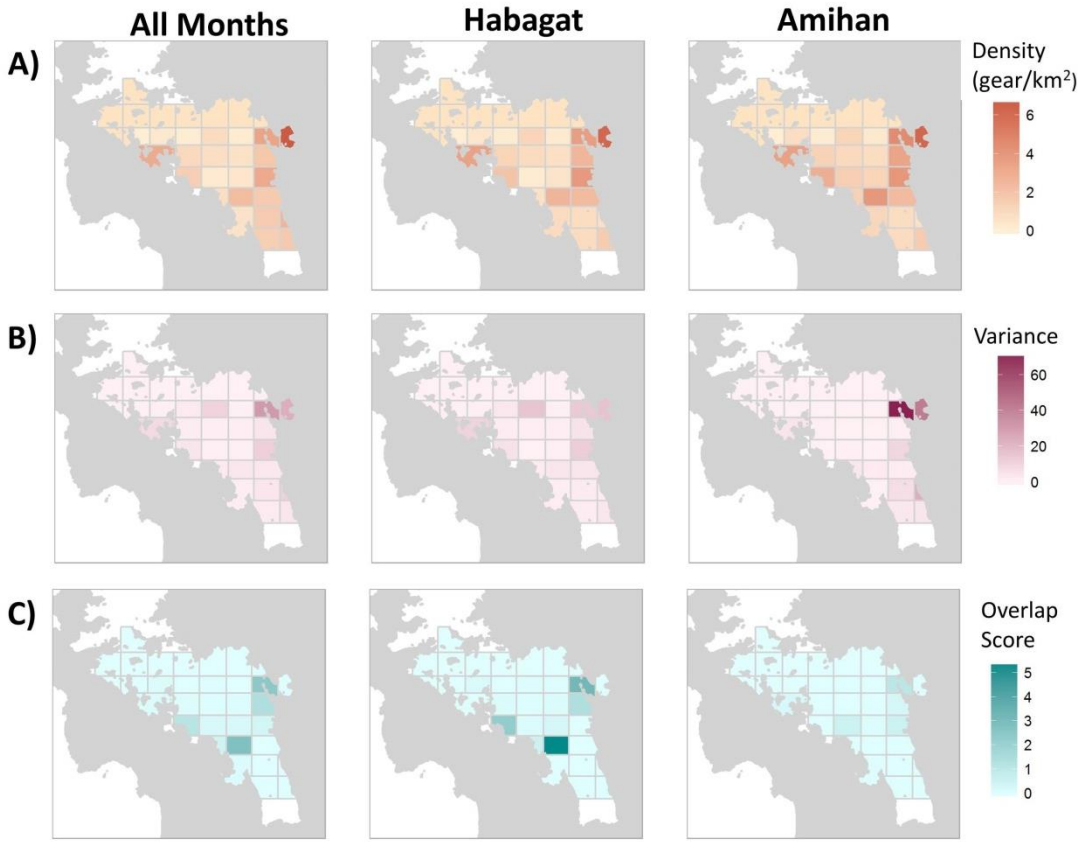


Figure 2.6. (A) Densities of Bycatch 1 gears (crab pot and crab gillnet buoys and fishing boats) as observed from line transect surveys, over all months and during the seasons *habagat* and *amihan*; (B) Variances in Bycatch 1 gear density per grid cell over all replicates within each time period; (C) Overlap scores (function of overlap with *O. brevirostris* density) per grid cell.

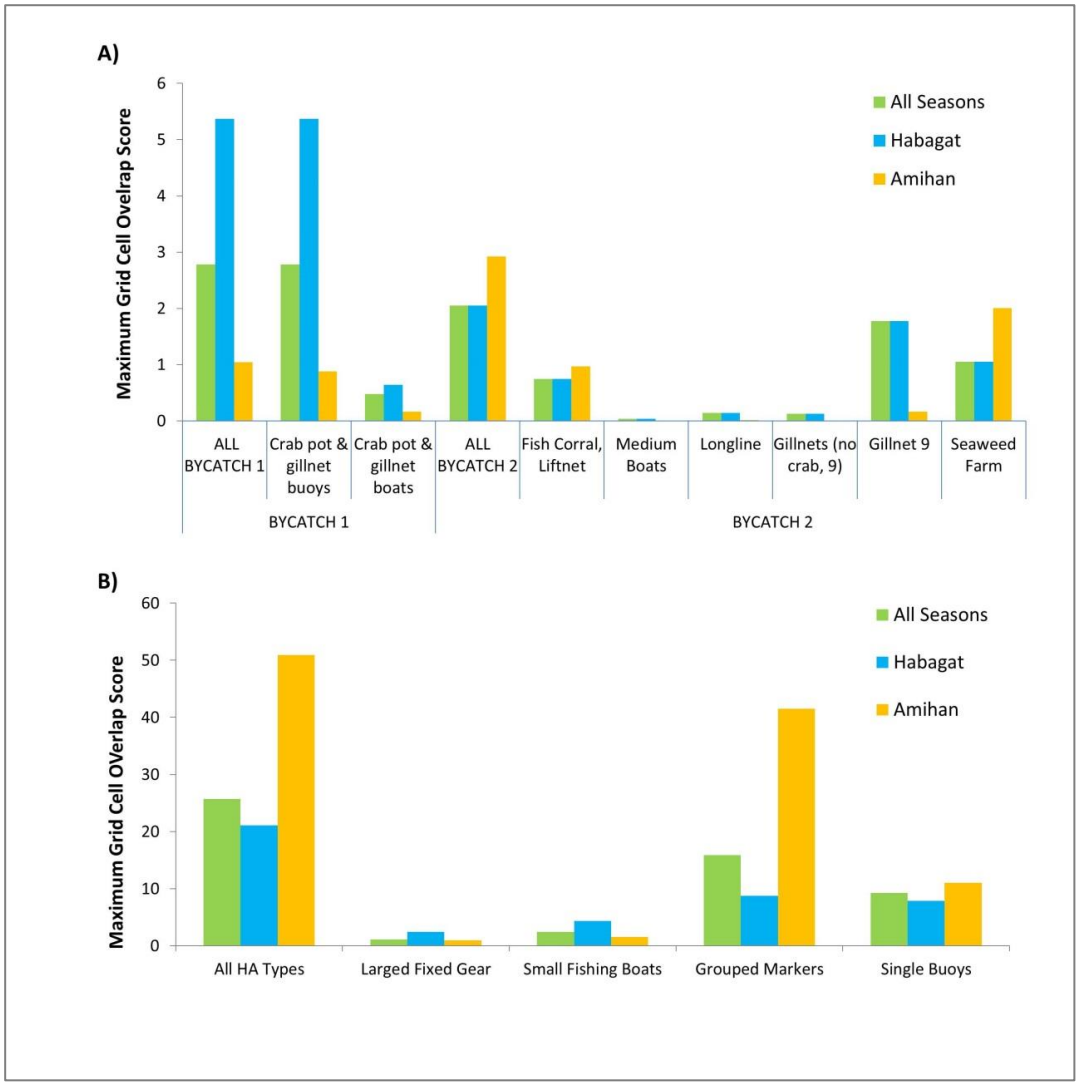


Figure 2.7. (A) Maximum overlap scores for grid cells for HA categories Bycatch 1 (and subgroupings within) and Bycatch 2, across all seaons, habagat, and amihan. (B) Maximum overlap scores for grid cells for the General HA Category; "Medium Boats" are part of the composite "All HA Groupings" score, but are already displayed in (A). Note the different axis scales between the two figures.

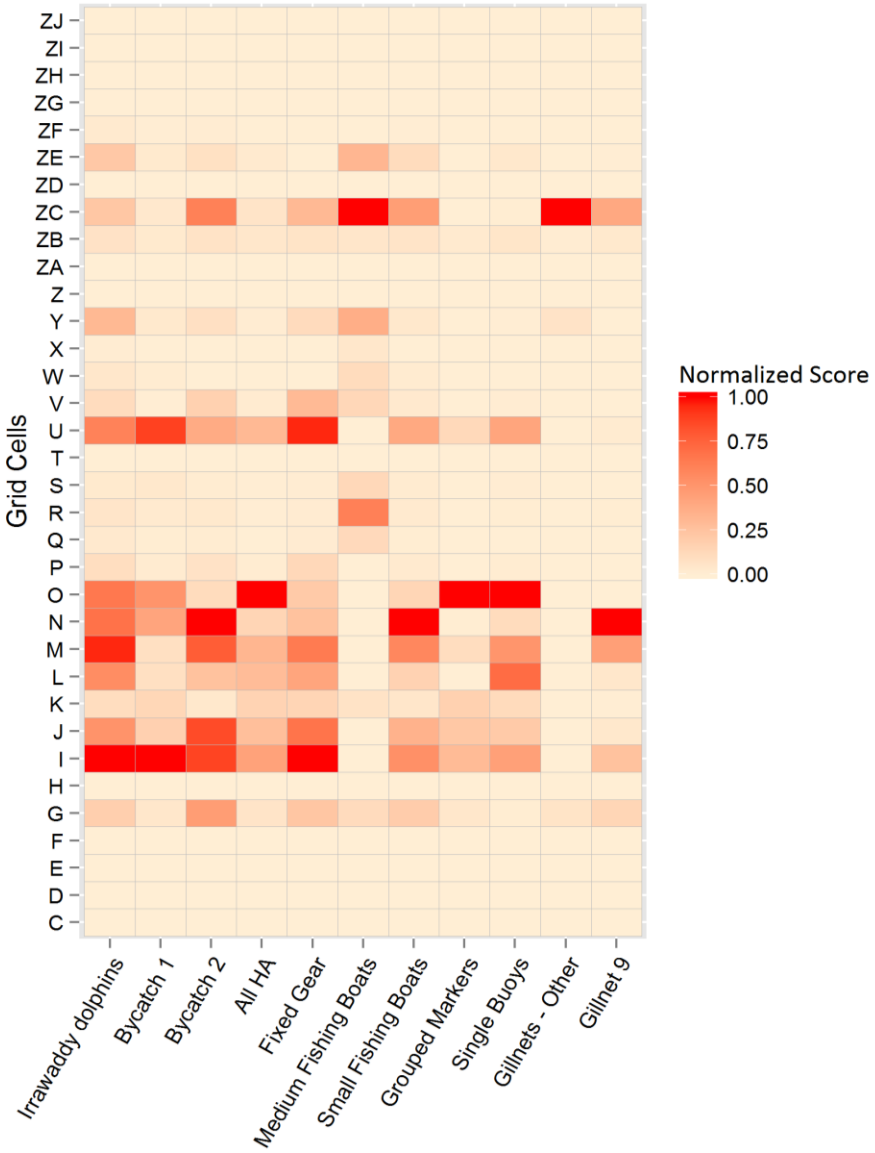


Figure 2.8. Normalized density of Irrawaddy dolphins and normalized overlap scores for different categories of overlap, over all months, with each row representing a grid cell (Figure 2.1). The order of rows is roughly the order of grid cells from north (top) to south (bottom). Densities and scores were divided by the maximum values within each category; colors represent relative magnitude of the cell score to all other cell scores in a given category. Darker cells are those with the highest scores within each category. The category "Bycatch 1" represents crab pot and crab gillnets buoys and fishing boats; "Bycatch 2" represents the composite score across all gears that have been reported in entanglement events with lower frequency than "Bycatch 1"; "All HA" is a composite score across all human activity categories.

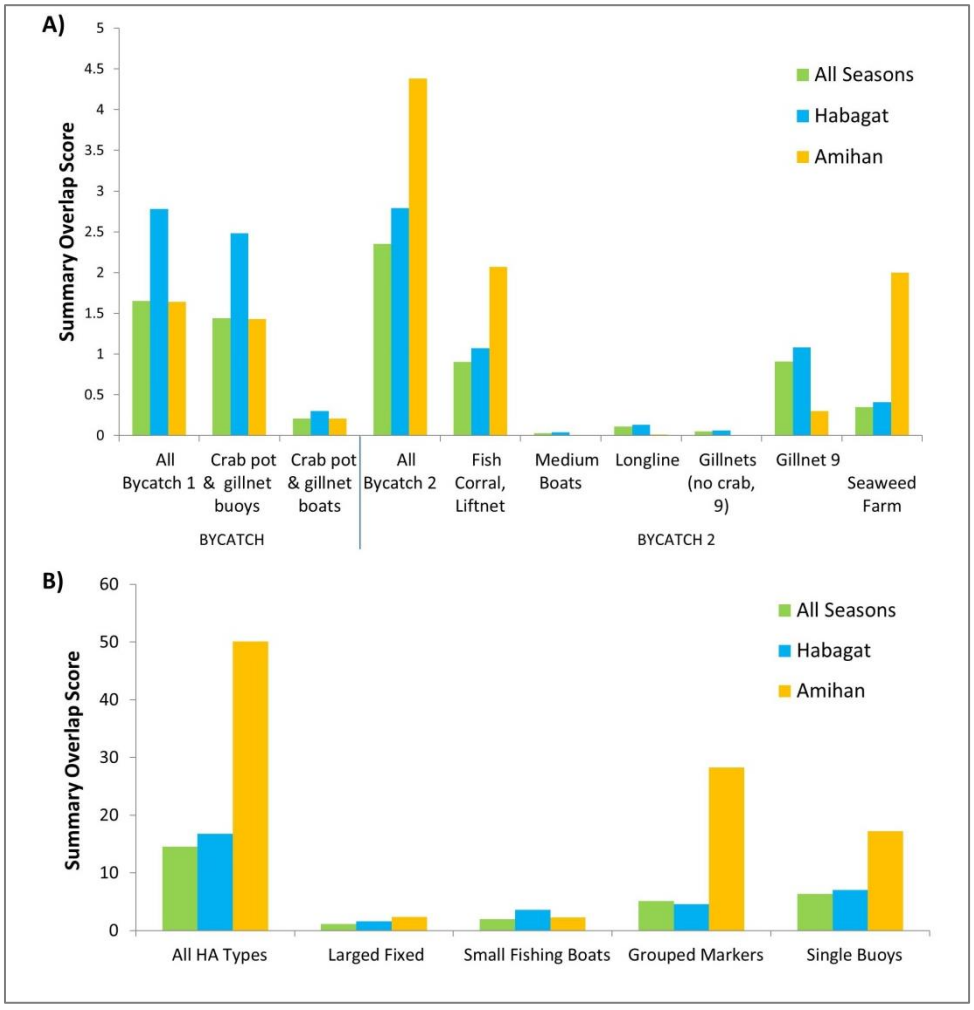


Figure 2.9. Summary overlap scores across all cells where *O. brevirostris* were observed during the respective time periods. Higher scores, as a function of *O. brevirostris* density and the density of gears within each category, indicate a greater degree of overlap. (A) Summary scores for Bycatch 1 and Bycatch 2 categories. (B) Summary scores for General HA Category. Note the different axis scale between (A) and (B).

TABLES

Table 2.1. Summary of Rapid Bycatch & Socioeconomic Assessment (RBSA) interview sampling by *barangay*. Each respondent was interviewed individually; as such, the number of respondents is equal to the number of interviews.

Barangay	**Est. total # of Fishers**	**# of Respondents**
Abongan	60	**23**
Alacalian	300	**84**
Banbanan	250	**81**
Bato	60	**23**
New Guinlo	500	**133**
Old Guinlo	300	**100**
Pancol	200	**81**

Table 2.2. Malampaya Sound fishing gear, as assigned to five general fishing gear types under the General Human Activity Category: larged fixed structures, medium-sized fishing boats, small fishing boats, single buoys (for a subset of the small fishing boat gear), and grouped markers. The Bycatch 1 category includes the most commonly reported entanglement gears (crab pots and crab gillnets). Bycatch 2 includes gear less commonly reported in entanglement events. For gillnets, the number denotes mesh size category; larger mesh sizes are marked by smaller numbers.

General HA Type	**Gear Name** (English, *Local name*)		**Bycatch 1**	**Bycatch 2**
Large Fixed Structures				
	Liftnet	*Bukatot padaraw*		•
	Fish corrals	*Baklad*		•
	Fish cages			
Medium Fishing Boats				
	Baby purse seine	*Talakop*		•
	Ring net	*Baring*		•
	Encircling gillnet	*Kurantay*		•
	Danish seine	*Hulbot-hulbot*		•
Small Fishing Boats				
	Nets			
Single Buoy	Crab Gillnet	*Matang 4*	•	
	Gillnet 9	*Matang 9*		
	Other various Gillnets	*Matang 5, 6, 7, 8, 8.5, 9.5, 10,*		•
		Palubog, Pamo		•
	Castnet	*Suklob*		
	Traps			
Single Buoy	Crab pot	*Bukatot alimasag*	•	
Single Buoy	Crab & Fish pot	*Timing*		
Single Buoy	Fish & Squid pot	*Bubo*		
	Lines			
	Longlines	*Kitang*		•
	Handlines	*Kawil*		
Grouped Markers				
	Seaweed farm			•
	Mussel Farm			
	Fish Aggregating Device	*Hilay*		
Other				
	Pushnet	*Hudhud, sudsud*		
	Speargun	*Pana*		

Table 2.3. Entanglement events for 2009-2010, reported as occurring (A) in the respondent's gear and (B) in other fishers' gear (see Methods for how these reports were selected). Zones (see Figure 2.2) denote the general area where the event was reported to have occurred; "Inner" refers to a larger area encompassing zones Z05 to Z11. Seasons are either *habagat* (southwest monsoon, June to late October) or *amihan* (northeast monsoon, December through March). "NR" indicates "No Response".

	Zone	Year	Season	Gear	Fate	
A. ENTANGLEMENT IN RESPONDENT'S GEAR	Z03	2010	Habagat	Crab Gillnet	Dead	*NR*
	Z05	2010	NR	Crab Pot	Alive	*NR*
		2010	NR	Seaweed Line	Dead	*Buried*
	Z08	2009	NR	Crab Gillnet	Dead	*Discarded*
		2010	Amihan	*Pamo* net	Dead	*Discarded*
		2011	NR	Crab Pot	Alive	*NR*
	Z09	2009	Habagat	Talakop	Alive	*Released*
	Z12	2009	Amihan	Baring	Alive	*Released*
	Z14	2010	Amihan	Gillnet 9.5	Alive	*Released*
	Z15	2010	Amihan	Crab Gillnet	Dead	*Eaten*
	Z18	2010	NR	Gillnet 10	Dead	*Eaten*
	"Inner"	2009	NR	Kitang	Dead	*Discarded*
		2010	NR	Crab Gillnet	Dead	*NR*
B. ENTANGLEMENTS IN OTHER GEAR	Z03	2011	NR	Crab Pot	Dead	*Buried*
		2011	NR	Crab Gillnet	Dead	*Buried*
	Z06	2009	Amihan	Crab Pot	Dead	*Eaten*
	Z08	2010	Amihan	Crab Pot	Dead	*Eaten*
	Z09	2009	NR	Crab Pot	Dead	*Discarded*
		2010	NR	Crab Gillnet	Dead	*Eaten*
	Z10	2009	Habagat	Crab Gillnet	Dead	*Discarded*
	Z11	2010	NR	Crab Gillnet	Alive	*NR*
	Z12	2009	Amihan	Crab Gillnet	Killed	*Eaten*
	Z13	2010	NR	Crab Gillnet	Dead	*Discarded*
	Z14	2009	Amihan	Crab Gillnet	Alive	*NR*
	Z15	2010	Habagat	Liftnet	Dead	*NR*
	"Inner"	2011	Habagat	Crab Gillnet	Dead	*Eaten*

Table 2.4. The most reliable reports (see Methods) of entanglements (and other mortalities, i.e., propeller strike) prior to 2009. Numbers denote number of records only, and are not representative of actual magnitude of bycatch in these year bins. "NR" denotes "no response recorded". Gear are as defined in Table 2.1.

Gear	Time frame			Fate of mortalities					Fate of non-fatal entanglements		
	2000s	**1990s**	**pre-1990**	Buried	Discarded	Eaten	NR	Killed, Eaten	Released	Escaped	NR
Baklad	Y	Y					2		3		2
Talakop	Y	Y	Y	4		2	2	2	2		1
Baring			Y						1		
Kurantay	Y	Y		1		2	1	1			
Hulbot-hulbot	Y									1	
Longlines	Y	Y	Y	2		2	3	2	6		2
Crab Gillnet	Y	Y	Y	16	17	19	22	3	6		6
Matang 6			Y			1					
Matang 7		Y									1
Matang 8	Y	Y	Y			3	2		3		
Matang 8.5	Y		Y			2			2		
Matang 9	Y	Y	Y			2	3	2	2		
Matang 9.5	Y						1				
Palubog	Y	Y					3				
Pamo	Y	Y			1						1
Crab Pot	Y	Y	Y	6	4	17	17	3	1	1	11
Bubo		Y							1		
Propeller	Y	Y		1			1				

Table 2.5. Number of respondents reporting gear damage caused by dolphins, including tears in nets from dolphins biting at captured fish and shrimp in nets. The number of respondents reporting a given frequency of gear damage is given in parentheses after each listed bin.

Gear	Number of Reports	Reported # of Incidents in the past year
Medium Boats		
Baring	2	1-5 (2)
Kurantay	5	1-5 (1), 21-50 (1), 50+ (3)
Talakop	2	1-5 (1) to 50+ (1)
Hulbot	2	1-5 (2)
Gillnets		
Crab gillnet	13	1-5 (10), 21-50 (2)
Matang 8-10	40	1-5 (41), 6-20 (15), 21-50(1), 50+ (2)
Other	14	1-5 (8), 6-20(3), 21-50 (3)
Liftnet	1	1 (1)
Fish/Squid Trap	1	0 (1)

Table 2.6. Maximum and average densities per cell, and variance in density measures across cells, of *O. brevirostris* individuals and sightings (with numbers for sightings in parentheses), with the summed area of grid cells where *O. brevirostris* were observed while on-effort during line transect surveys.

	All Months	Habagat	Amihan
Maximum density	1.20 (0.17)	2.06 (0.28)	1.88 (0.24)
Average density	0.23 (0.04)	0.27 (0.04)	0.15 (0.02)
Across-cell variance in average density	0.12 (<0.01)	0.21 (<0.01)	0.16 (<0.01)
Area (km^2)	93.1	78.4	31.6

CHAPTER 3

Variations in local-level governance of small-scale fisheries across four sites in Southeast Asia, with implications for conservation approaches

INTRODUCTION

Small-scale fisheries (SSFs) represent a vital interface between humans and marine ecosystems, with strong dependence and potentially significant impacts on marine species and habitats. Such impacts include overfishing of stocks, bycatch of species of conservation concern, and habitat degradation of coral reefs and seagrass beds (Hawkins & Roberts, 2004; Peckham et al., 2007). One such impact of substantial conservation concern is the bycatch of cetaceans, which represents a major threat to cetacean subpopulations and species globally (A. J. Read, 2008; A. Read & Rosenberg, 2002). Mitigating bycatch is essentially a fisheries management issue, as any attempt to reduce bycatch will require reducing the overlap between fishing gear and cetaceans through reducing the number of gear or implementing time-area restrictions, or technical alterations to gears to reduce the likelihood of cetacean entanglement. As such, assessing potential avenues for bycatch mitigation calls for understanding the governance issues associated with small-scale fisheries management.

The responsibility for small-scale fisheries management has largely been delegated to local governments due to widespread decentralization of environmental resource management and an often concomitant push for community-based management (Berkes, 2010; Engel & Palmer, 2011; Ribot, 2002). However, the resulting governance arrangements vary in terms of structure, methods, and extent to which successful co-management is actually achieved (Berkes, 2010). Numerous research efforts have attempted to elucidate explanations for successes and failures in

the process from decentralization to effective, adaptive co-management arrangements (e.g., (Berkes, 2010; Kauneckis & Andersson, 2009; Pollnac, Crawford, & Gorospe, 2001; R. S. Pomeroy, Katon, & Harkes, 2001; Sen & Raakjaer Nielsen, 1996).

For the closely-related realm of ecosystem-based fisheries management, two major categories of attributes that influence effective management are the appropriate governance arrangement and the appropriate scale for management (R. Pomeroy, Garces, Pido, & Silvestre, 2010). Governance arrangements for co-management can be characterized into five broad types (Sen & Raakjaer Nielsen, 1996): (1) instructive, where the government makes decisions and informs users of those decisions; (2) consultative, where the government is the main decision-making institution, but it consults with users in those decisions; (3) cooperative, where government and users are equal partners in decision-making; (4) advisory, where the government endorses decisions that have been advised by users; and (5) informative, where the users have full authority to make decisions and to communicate those decisions to the government.

Though decentralization and co-management efforts tend to focus on the local scale, external influences and issues must be considered; these externalities might include impacts on local fisheries (e.g., global markets, weather, industrial fishers from other communities), as well as institutions other than local governments and community groups that shape resource management (e.g., NGOs, higher governance levels, researcher institutions) (Andrew et al., 2007; Gibson, Ostrom, & Ahn, 2000). Where there is a mismatch of local institutional scales and the scale of problems to be

addressed, the situation requires coordination with external, higher-level institutions (Andersson & Ostrom, 2008; Cash et al., 2006; Gibson et al., 2000). Polycentric institutions that operate at multiple levels and feature overlapping jurisdictions are particularly suited to the task of addressing multi-scale problems (Andersson & Ostrom, 2008; Berkes, 2010; Folke, Hahn, Olsson, & Norberg, 2005). "Bridging" institutions are those that facilitate communication and coordination within and among levels, and can play vital or even catalytic roles in promoting effectiveness of management efforts over multiple scales (Cash et al., 2006; Folke et al., 2005; Ratner, Oh, & Pomeroy, 2012; White, Gomez, Alcala, & Russ, 2007).

In investigating the governance context relevant to cetacean bycatch mitigation, I will focus on a set of co-management attributes within the categories of "appropriate governance arrangement" and "appropriate scales" (R. Pomeroy et al., 2010) that have been identified as influencing resource management effectiveness: leadership; local institutional and organizational capacity; facilitating/supporting role of external institutions; multi-level, polycentric governance arrangements; coordination within and across governance levels by potentially catalytic "bridging" institutions; engagement of communities; and effective enforcement (e.g., Folke et al., 2005; Gutiérrez, Hilborn, & Defeo, 2011; Levine & Richmond, 2014; Pollnac et al., 2001; R. S. Pomeroy et al., 2001; Sen & Raakjaer Nielsen, 1996; White et al., 2007) Here I define local-level governance as those institutions, activities, and links that influence marine resource management at the level of municipalities or sub-districts, and the villages and within-village community groups under the jurisdiction of those

municipalities. Local institutions and processes are those that operate at the municipal, village, or community group level, and may include enforcement agencies, non-government organizations (NGOs), and research projects (Figure 3.1). These local institutions and processes can influence and be influenced by institutions and processes external to the local unit; for example, national fisheries regulations are applied to local waters, province-level enforcement agencies might patrol across multiple local units, and international NGOs might work with local communities (Figure 3.2).

I explored the institutions, activities, and linkages relevant to local-level governance of coastal and aquatic resource management (CARM) as relevant to cetacean bycatch mitigation at four sites in Southeast Asia. This work focused on small-scale fisheries in which bycatch of Irrawaddy dolphins (*Orcaella brevirostris*) has been recorded. Such bycatch has been identified as a major threat for those subpopulations of this species that have been assessed by the IUCN Red List (Reeves et al., 2008).

In Southeast Asia, dependence on small-scale fisheries for subsistence and income is exceptionally high; however, most nearshore fisheries in the region are largely considered to be depleted (Stobutzki, Silvestre, & Garces, 2006). Major regional problems for fisheries management include unlimited increase in fishing effort, inadequate enforcements, and general weakness in fisheries management arrangements (Seilert, 2002). Identified priorities include the organization of communities to identify and communicate needs, technical capacity at the local level

for contributing to management, exchange of information between management bodies and communities, and local presence of management bodies (Seilert, 2002).

A wide range of co-management arrangements are observed in the region (e.g., Pomeroy, Garces, Pido, & Silvestre, 2010). With the longest history of co-management initiatives in the region, the Philippines demonstrates cooperative, advisory, and informative co-management arrangements (R. Pomeroy et al., 2007). In Thailand and Indonesia, co-management arrangements have been observed to be consultative and cooperative (Pomeroy et al., 2007). These co-management arrangements exist in a wider context of rapid population growth, economic development, and technological change (R. Pomeroy et al., 2007). A common problem arising in the region is conflict between industrial and small-scale fishers (Flaherty & Karnjanakesorn, 1993; Panayotou, 1980; R. Pomeroy et al., 2007).
At the main field site, Malampaya Sound, all villages overlapping with the local range of Irrawaddy dolphins were interviewed. At the remaining field sites, only a subset of villages were sampled; these villages were selected as being representative of the area of interest based on pilot field visits.

Malampaya Sound, Philippines

Malampaya Sound is a semi-enclosed, brackish inlet in the municipality of Taytay, in northern Palawan province. Known for its productive waters, it is called the "Fish Bowl of the Philippines" and attracts migrants from all over the country seeking a better livelihood. In 2000, Malampaya Sound was declared a Protected

Land and Seascape under the National Integrated Protected Area Program (NIPAP), funded by the E.U. Research here focused on the "Inner Sound", and interviews were conducted at all seven coastal *barangays* (villages) in the Inner Sound, as well as with municipal and provincial officials.

Guimaras & Iloilo Straits, Philippines

These straits run along the provinces of Iloilo, Guimaras, and Negros Occidental. This area includes two major urban centers, Iloilo City and Bacolod City, with a diversity of human activities on the water and along the coast, including small-scale and industrial fishing, high-speed passenger ferries ("fastcraft"), cargo shipping, factories (including a coal-fired plant and an alcohol refinery), aquaculture, and agriculture near the coast. For this project, research focused on the municipality of Buenavista in Guimaras (Iloilo Strait), and the municipalities of Bago and Pulupandan in Negros Occidental (along the Guimaras Strait).

Mahakam River, Indonesia

The Mahakam River is one of the major river systems in the province of East Kalimantan, and is one of the most productive inland fishing areas in Indonesia (Christensen, 1993). This study focused on the proposed "Central Kutai conservation zone", including the sub-districts Muara Kaman (with a focus on the village Muara Kaman Ulu) and Kota Bangun (with a focus on the village Sangkuliman). Human activities here include small-scale fisheries, aquaculture, transportation (small

passenger boats, larger ferries, cargo ships), logging, coal and gold mining, and palm oil plantations.

Trat Province Coast, Thailand

Trat province, in the eastern Gulf of Thailand, shares a border with Cambodia to the south. Human activities include industrial and small-scale fishers, coastal aquaculture, agriculture, and tourism in the nearby Ko Change archipelago. This project explored communities in the district of Mueang Trat, in the sub-district (equated in this paper to "municipality") of Laem Klat, and the district of Khlong Yai, in the subdistricts of Mae Rut and Khlong Yai.

METHODS

Fieldwork was conducted between April 2010 and September 2012, over 9 months in Malampaya Sound, 3.5 months in Guimaras and Iloilo Straits, 2 months on the Mahakam River, and 2 months in Trat Province.

Key Informant (KI) Interviews

Semi-structured interviews were conducted at each site with government officials, community leaders, NGO staff, researchers, enforcement staff, fishers, fish buyers, and other community members with experience and expertise in marine resource management issues at each site. Selection of KIs was designed to collect representative information from all major institutions relevant to marine resource

governance at each site; 68 KI interviews were conducted in Malampaya Sound, 70 in Guimaras and Iloilo Straits, 29 at the Mahakam River, and 31 in Trat Province. All interviews were conducted with and translated (as needed) by local field assistants fluent in English and the local language, who were familiar with the goals of the research project.

"Rapid Bycatch & Socioeconomic Assessment" Fisher Surveys

As part of the larger project on Irrawaddy dolphin interactions with fisheries, I developed "Rapid Bycatch and Socioeconomic Assessment" (RBSA) structured questionnaires to collect information on fishing effort, fisheries trends, ties to fishing as a livelihood, fisher demographics, perceptions of fisheries management and conservation, local ecological knowledge related to Irrawaddy dolphins, and fisheries interactions with Irrawaddy dolphins. These RBSAs are adapted from the Rapid Bycatch Assessments (RBAs) developed and refined by Project GloBAL (Moore et al., 2010) and the Socioeconomic Monitoring Manual for Southeast Asia (Bunce & Pomeroy, 2003).

For each site, RBSA questionnaires were translated and the interviews conducted in the local language. Responses were written by field assistants in the local language, and translated during data entry. Sample sizes were based on suggested sample sizes from the Socioeconomic Monitoring Manual for Southeast Asia for a "useful understanding of the population" (Bunce & Pomeroy, 2003). Given the lack of comprehensive or accurate census information on fishing households, truly

random sampling was deemed impractical; instead, estimates on the number of fishers were based on information from preliminary KI interviews. Based on the estimated number and composition of fishers from these interviews, strong effort was made to conduct RBSA interviews with representative portions of each village. As such, data from these RBSAs should not be considered statistically representative, but they are still useful for descriptive purposes. 525 RBSAs were conducted in Malampaya Sound, 215 in Guimaras and Iloilo Straits, 90 on the Mahakam River, and 137 in Trat.

Responses from RBSAs were used to identify the most frequently reported "major problems for local fisheries" (as an open-ended question), and perceived effectiveness of current fisheries management (rating effectiveness from 1 to 5, with 1 meaning completely ineffective to 5 meaning highly effective) with explanations.

RESULTS

Problems for fishers

The top problems reported by RBSA and KI respondents span a diversity of levels (Figure 3.3). The problem-scape for Malampaya Sound is primarily local, with the top-reported problems related to local fishing practices, with negative fishing practices as the most frequently reported problem. In contrast, the other three sites are faced with issues that transcend municipal and provincial boundaries, and that range from local fishing practices to various types of boat traffic and industry. For Guimaras and Iloilo Straits, reported illegal fishing activities are largely by commercial fishing boats (trawls and Danish seines) permitted in other municipalities or provinces,

encroaching illegally on municipal waters; many of these were described as coming from nearby Bacolod City. Another external problem for Iloilo Strait specifically was the fastcraft (operated by companies in Iloilo and Bacolod City). On the Mahakam River, pollution from palm oil plantations was the top grievance, followed by local illegal fishing and pollution from coal mining and shipping. In Trat, as in the Guimaras and Iloilo Straits, illegal encroachment by industrial fishing operations (trawls, pair trawls, floating seines, and large pushnets) into the small-scale fishing zone (3km from the shoreline) is a top complaint, as well as damage to small-scale fishing gear caused by these larger industrial gears.

Local Activities, Coordination, Community Engagement, & Effectiveness of Institutions

The plethora of institutions and activities relevant to coastal and aquatic resource management (CARM) form a complex web of links, professed goals, and outcomes; here, the focus will be on those institutions and activities reported to have some measurable and current impact (positive or negative) on CARM. Figure 3.4 presents the scale and scope of those institutions and activities noted as contributing positively to CARM. Figure 3.5 summarizes key linkages between higher level institutions and communities, representing the extent to which various types of institutions contribute to or interact with community groups.

Malampaya Sound, Philippines

During the process of declaring Malampaya Sound a Protected Land and Seascape in the late 1990s, NIPAP and numerous institutions coordinated across levels to engage communities and local governments, and to develop and fund initial activities. Through NIPAP, the Protected Area Management Board (PAMB) was formed, along with the enforcement agency, the Protected Area Office (PAO). The NGO, Environmental Science for Social Change (ESSC), was brought in to facilitate communication between NIPAP and community members (Bryant & Lawrence, 2005; Pilien & Walpole, 2003). Overlapping with these activities, in 1995 to 2000, the national NGO Tambuyog was actively working with local communities to form community groups. This active, multi-level coordination and community engagement collapsed in the early 2000s. Following the initial 5-year period of NIPAP-EU funding, responsibility for Malampaya Sound was transferred to the municipal government of Taytay in 2000, with no sustainable mechanism for continued funding. The community groups established by Tambuyog did not endure past the early 2000s.

There are currently no active fisher associations in the Inner Sound of Malampaya. The most active people's organizations are the Indigenous Peoples (IP) groups, present in four of the *barangay*s. These IP groups, for whom the major livelihood source is either farming or fishing, can receive aid from the National Commission of Indigenous Peoples and are granted "Ancestral Domain" stewardship over tracts of land. Though the IP groups are entitled to representation in PAMB, they have been excluded in recent years without any explanation (though another member

of PAMB mentioned that they were not considered "indigenous enough" to warrant their presence on the board).

Municipal activities include the Environmental Values Resources (EVR) project, focused on improving management of environmental resources and reinforcing the activities of PAO. Smaller initiatives through the municipal Office of Agriculture include a seminar on crab fattening and previous mangrove restoration projects. Generally, however, the municipal government is seen as impeding effective CARM, through appointments of unqualified personnel to CARM-related positions based on cronyism, constraining the activities of NGOs who are afraid to displease the current administration and risk explusion, and the release of any apprehended illegal fishers without penalties (again, based on cronyism).

The main NGO operating in Malampaya Sound is WWF-Philippines, with research and outreach projects focused on the Irrawaddy dolphins, fisheries, and adaptation to climate change. WWF-Philippines works with the *barangays* and also serves on PAMB and the Fisheries Management Unit (FMU), a judicial body that is an alternative to the municipal court for hearing cases against illegal fishers. Additionally, the national NGO Environmental Legal Assistance Center (ELAC) provides trainings to communities on environmental regulations and legal representation on environmental conflicts.

Multiple entities are responsible for enforcement in Malampaya, with the primary agency being PAO. While the municipal government provides minimal funding to PAO, the long-term plan for funding relied upon revenue from registration

fees going to a trust fund. However, PAO cannot enforce registration without funding, which means that compliance with registration (and thus, contributions to PAO funding) is low. PAO struggles with this lack of funding (e.g., for fuel) and active personnel due to hiring of unqualified/unmotivated staff by the municipal government. Other enforcement teams include the EVR team (deputized by the mayor), a provincial enforcement team (KSK), and an ELAC-trained team coordinated with the military, and the Philippines Marines. However, there is currently no coordination among these disparate (and all understaffed and underfunded) patrol teams, even though a stated goal of EVR is to complement the efforts of PAO.

Some previous volunteer enforcement teams are now inactive due to lack of funding for operations; however, in the *barangays* Pancol and Banbanan, local patrolling by barangay officials is still active. Though, through NIPAP, each barangay has the opportunity to declare "core" protected zones, Banbanan is the only barangay to have done so, with one current and one planned core zone. Pancol and Banbanan are the only two barangay whose leaders are proactive in CARM; Pancol, in particular, seems to have limited illegal fishing by its residents and in its waters (through village patrols, meetings, and "booby traps" made of sharp bamboo to destroy small-scale trawl nets).

Guimaras & Iloilo Straits, Philippines

Pulupandan and Bago are associated with the Central Negros Council for Coastal Resources Development (CENECCORD), organized in 2005. CENECCORD

is an alliance of seven LGUs with the Office of the Provincial Agriculturist. The formation of CENECCORD is part of a larger initiative to promote inter-municipal alliances in the province, funded by the EU Dialogue on Governance: Strategic Projects Facility. Apart from CENECCORD, research and NGO initiatives are the most prominent vehicle for coordination of activities across municipal and provincial boundaries here. In Guimaras, the Partnerships in the Environmental Management for the Seas of East Asia (PEMSEA) coordinates with the provincial government, the Provincial Environment and Natural Resources Office (PENRO, the provincial branch of DENR) to develop an Integrated Coastal Management project. This included the development of a network of LGUs to exchange information across sites. However, this initiative (as yet) appears to have had little impact on the municipality of Buenavista.

The NGO Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) works with municipal governments and provincial agencies, providing supplies for municipal initiatives in Bago and Pulupandan (e.g., patrol boat, computer for fisher registration) and coordinating the development of coastal management plans. They were partners in convening the First Provincial Fisherfolk Congress in 2007 to develop stronger relationships between LGUs and fishers. GIZ also facilitates an ecosystem-based management (EBM) research project involving researchers from Silliman University, University of St. La Salle – Bacolod, Guimaras State College, and the consulting firm Tropical Marine Research for Conservation; this project spans Buenavista, Bago, and Pulupandan. This project has included workshops for local

communities and government officials to share information and to rally support for the establishment of additional protected areas.

The three municipal governments studied at this site are moderately to highly engaged in environmental protection, citing environmental issues high among their priorities. In particular, the mayor of Pulupandan, described as "ruling with an iron fist" by some respondents, is strongly committed to environmental protection (viewed both positively and negatively by community members). These municipalities receive support in the form of funding, supplies, and expertise, from provincial institutions (including provincial offices of national agencies, e.g., Department of Environment and Natural Resources) for various CARM initiatives, including seminars on alternative livelihoods and fishing regulations, and mangrove restoration projects.

At the village level, the BFARMC coordinates between the barangay government and fishers, generally holding meetings on fishing regulations, assistance programs, trainings, and projects. Most of the villages studied at this site had active fisher associations, with varying degrees of engagement. The formation of these associations was motivated, at least in part, by municipal and provincial institutions encouraging fishers to coalesce into formal associations, to which funding for enforcement and resource management projects could be granted. Activities by the more active associations include regular meetings, mangrove rehabilitation, and coastal cleanups. In Guimaras, the three villages of East Valencia, Sawang, and Umilig have particularly active fisher associations, which are collaborating with their respective BFARMCs to propose and implement a local marine sanctuary. However,

higher government levels desire a stronger base of community participation for community-focused CARM projects.

The main agent of enforcement is the *bantay dagat* at the municipal level, with enforcement teams comprising *bantay dagat* personnel and police officers; apprehensions of illegal fishers cannot occur without the presence of police. External institutions contribute to local-level enforcement through donation of equipment (e.g., patrol boats donated by GIZ and the provincial Bureau of Fisheries and Aquatic Resources) and training. The Guimaras bantay dagat was generally considered more effective and better equipped than the Negros Occidental bantay dagat teams, but the bantay dagat from all three study municipalities struggle to apprehend larger, faster, and occasionally armed commercial vessels. Previously, a volunteer bantay dagat in Taloc village (Bago) had patrolled the border between Bago and Bacolod (a major source of trawls), and the Bago bantay dagat would coordinate with the Taloc team to block the "escape route" of illegal trawlers; however, the Taloc team is now inactive. Similar coordination sometimes occurs between Bago and Pulupandan bantay dagat. In Guimaras, some villages have "fish wardens" mandated to monitor for illegal fishers and to coordinate with the bantay dagat (but without authority to apprehend).

Complaints about lack of enforcement effectiveness include slow bantay dagat response time, inadequate penalties, need for more funding and personnel, and networks between bantay dagat team members (including the police) and illegal fishers, providing the latter with updates on patrol times. A major enforcement frustration for officials here is that they cannot block the renewal of commercial

fishing boats in other municipalities and provinces; however, Danish seines have recently been declared illegal fishing gear nation-wide, which may well help stem illegal activities with that particular gear (though trawls were the most commonly reported illegal gear).

Mahakam River, Indonesia

The sub-district fisheries offices are responsible for the implementation of fishing regulations from higher government levels. In Muara Kaman, the fisheries office accepts proposals for project funding from the fisher associations. The office also make identification cards for member fishers, and ensures that none of the member fishers on a proposal have been apprehended for illegal fishing prior to making funding proposals. In Kota Bangun, the fisheries office can select representatives from local fisher associations to go to district-level workshops to share information on fishing techniques, aquaculture, and cooperatives. At the district level, there is a "grading system" for fisher associations to identify groups as being "beginner", "intermediate", and "advanced". However, these frameworks are not effectively implemented due to the lack of members, though similar approaches have been more effective for farmers.

The sub-district office does engage local communities through village meetings on regulations and fisheries issues (including aquaculture); community members are encouraged to attend by the village head and local religious leaders. Though there are fisher associations in several villages in the Muara Kaman and Kota

Bangun sub-districts, their level of activity appears limited. However, respondents reported that fisheries issues were discussed during regular village meetings and during meetings with neighborhood units.

The NGO Yayasan Konservasi Rare Aquatic Species of Indonesia (YK RASI) incorporates research, outreach, and community organizing efforts related to Irrawaddy dolphin conservation, protection of freshwater habitat, and livelihoods of communities. Included among their projects are the designation of the West Kutai Conservation Zone and the implementation of the proposed Central Kutai Conservation Zone. These conservation zones are essentially "high priority" areas for monitoring and implementation of existing regulations, with some additional regulations as agreed upon by community members, and projects related to fisheries, forestry, and livelihoods. Through meetings, workshops, and proposals, YK RASI coordinates closely with community members and leaders, and connects with sub-district, district, and provincial governments. Another NGO, Bioma, conducts research and outreach on the economic value of wetlands, and uses this information to encourage communities to resist the sale and development of wetlands into palm oil plantations. These activities contributed to a land concession granted to a palm oil company being rescinded in the sub-district of Muara Siran.

The sub-district fisheries offices are responsible for enforcing fisheries regulations locally, with patrol teams comprising fisheries office staff, local police, and military personnel.

Community members can register as volunteer patrol members in the sub-district office, but have no authority to apprehend illegal fishers. The process of reporting illegal fishing starts with villages reporting to the sub-district office, which reports to the district, which sends the fisheries patrol team to respond.

The frequency of sub-district patrol activities and the effectiveness of enforcement were seen as inadequate by KIs in villages in Kota Bangun. The reporting process is slow, with the time lag between the sub-district sending the report to the district office and the district office sending a patrol team cited as being particularly long. In Lake Semayang, in Kota Bangun, the task of apprehending illegal fishers was seen as almost pointless due to the high prevalence of illegal fishing practices there. Enforcement was seen as more effective in villages in Muara Kaman, with strong implementation of penalties and a limited number of repeat offenders. However, illegal fishing persists there. Perceiving these weaknesses, villages are pushing to conduct their own patrols, but they struggle with the inability to take action against observed illegal fishing. The Central Kutai office provided Sangkuliman with a boat to use for patrolling, but provided no funding for fuel.

Generally, top-down management was described by respondents as being relatively weak, hampered by financial constraints. The NGO YK RASI described the real strength and potential for management as residing within the communities themselves. However, this potential currently appears to be realized only when tapped into by an external agent (e.g., YK RASI), while self-organization remains, as yet, limited. There is the widespread perception that higher government levels do not

understand or care about the impacts of palm oil plantations on the local environment and livelihoods. An additional obstacle to lobbying against palm oil concessions is the disconnect between the Ministry of Trade, which grants such concessions, and other, more environmentally-focused government agencies.

Trat Province, Thailand

Marine resource management in Trat Province is largely defined by the highly engaged fisher associations in every study village. The strength of village community groups was explained by local frustration that government officials could not provide needed support for marine resource management. One type of fisher association, roughly translated as a "conservation group", focuses primarily on crab banks (keeping captured gravid crab females until their eggs hatch and can be released); every village that has crab fishers has one of these organizations. These efforts were largely considered successful at sites where crab banks had been established for over a year, with fishers noting a rebounding of crab stocks. A second type of fisher association focuses more on mobilizing small-scale fishers to lobby external institutions for improved representation in provincial and national policy (particularly the extension of the small-scale fishing zone from 3km to 5km), and on developing cooperatives for loans; these were only observed in Khlong Yai. Though these groups have contacted the provincial government, they have as yet received no response on the status of their efforts.

These community groups communicate closely with groups in neighboring villages, both within and across municipal boundaries; through active networking and information sharing, established conservation groups have encouraged and guided the formation of conservation groups in neighboring communities. Municipal governments support these community group activities, and municipal leaders also engage in cross-municipal communication related to environmental protection approaches.

Though the provincial branch of the Department of Marine and Coastal Resources, the Eastern Marine and Coastal Resources Research Center (EMCR), had previously attempted to foster conservation groups, these efforts gained little traction. However, EMCR and the Trat Province Department of Fisheries now act to support these community-formed conservation groups and fisher associations through provision of equipment and trainings. Additionally, the national NGO Sustainable Development Foundation (SDF) provides assistance in applying for project funds and in networking. An international research team conducting conservation-relevant research on local dolphins collaborates closely with EMCR in the "Trat Coastal Dolphin Project", through which EMCR staff actively conduct research and outreach on conservation topics in communities.

Enforcement is carried out by the DMCR and DOF patrol teams. Though community groups can assist in patrolling, they have no authority to apprehend illegal fishers; they report illegal fishing to the village leader, who will report it to the local office of the DOF or DMCR and the police. Enforcement is hampered by the vast area

to be covered by limited personnel and funding for DMCR and DOF. Additionally, though these two agencies have overlapping jurisdictions for patrol, there is little to no coordination between their patrol teams. Members of the DMCR patrol team also mentioned that there seems to be a network of informants communicating patrol schedules to illegal fishers, so that the illegal fishers can easily avoid detection. The indirect process by which local fishers can report illegal fishing often results in a slow response time by DMCR and DOF. At the local scale, tensions between local illegal fishers (mainly using pushnets) and other fishers are at least partially resolved through community meetings to negotiate ways in which to reduce SSF gear damage. Beyond these negotiations, however, the municipal and village communities are limited in the impact they can have on enforcement, and some respondents suggested developing village patrols with deputized village members authorized to apprehend illegal fishers.

Perceived Effectiveness: Governance Ratings & Explanations

Among RBSA respondents, there was a fairly even distribution of positive and negative perceptions of current management effectiveness at addressing marine resource management issues (Figure 3.6, with all negative ratings pooled together, and all positive ratings pooled together). Similar explanations for these ratings emerged across all sites, particularly for the negative ratings (Table 3.1). The most reported explanations for negative ratings were: persistence of a major problem (local illegal fishing in Malampaya Sound, external illegal/commercial fishing in the other sites); ineffective enforcement (excluding Trat, with corruption included as a complaint

against enforcement in Malampaya and in Guimaras & Iloilo Straits); insufficient patrol (including limited personnel, funding, and equipment); lack of interest or engagement from higher government levels (municipal for Malampaya, provincial or higher at the other sites); low compliance with existing fishing regulations by local illegal fishers (Malampaya Sound and Mahakam River); and weak regulations that do not consider small-scale fisheries' needs and do not sufficiently penalize illegal, commercial fishing (Trat only).

Positive ratings corresponded with perceptions that: enforcement is strong in Malampaya, Guimaras and Iloilo Straits, and Trat, and moderately strong in the Mahakam; illegal fishing has been controlled, or has decreased, at the sites in the Philippines (though respondents did state that illegal fishing remains an issue in the Mahakam); patrolling activities are satisfactory (all sites except for the Mahakam); higher levels of government are engaged in resource management (Guimaras and Iloilo); local compliance with regulations is satisfactory (Mahakam); catch has improved (Mahakam) or conservation measures have had positive results (Trat); and regulations are sufficiently strong (Trat).

DISCUSSION

Across these four sites, we see notable differences in the institutions, activities, and links related to CARM, and the extent to which various institutional levels and entities are active in CARM, effective in CARM-related goals, contributors to enforcement, coordinating within and across levels, and engaging communities

(Figures 5 and 7). Such characteristics of local-level governance at these sites would likely translate into the feasibility of mitigating bycatch in small-scale fisheries, as the effectiveness of existing governance mechanisms would determine the likelihood that bycatch reduction strategies are developed and effectively implemented. It would be worth further exploring finer-scale differences between villages at these sites, to more clearly identify characteristics that promote strong self-organization, particularly for future management activities at Malampaya Sound. It is interesting that the ratings of governance effectiveness from RBSAs were relatively similar across such different sites. This might be explained by respondents not having cross-site experience or frame of reference against which to compare governance in their own communities.

In Trat, we see the most positive outlook, with strong self-organization in communities supported by external institutions (see Fig 5). On the local level, these community groups are in an "informative" arrangement with higher governance levels; however, for addressing issues beyond the local level (e.g., outside illegal fishing), these groups encounter an "instructive" arrangement with provincial and national government. Although the local institutions in Trat are highly active and have enjoyed success in mobilizing community efforts, the disconnect between this and higher government levels regarding commercial fishing limits the extent to which communities can address major problems for their fisheries.

Guimaras and Iloilo Straits municipalities and communities range from instructive (Pulupandan) to cooperative in their governance arrangements. Similarly, the Mahakam River sub-districts and villages appear to be in largely instructive,

though in instances mediated by the NGO YK RASI, the arrangement moves more toward consultative. Though there is a framework for multi-level coordination in Guimaras and Iloilo Straits through a multitude of multi-level institutions and projects, there appears to be substantial disconnect between the on-the-ground needs of communities (e.g., dealing with outside illegal fishing) and higher government levels. So, though implementing the potential power of those multi-level institutions could effectively match the scale of the problem, these institutions do not appear to be highly active in addressing multi-scale problems. Similarly, there appears to be a gap between community concerns and higher government levels at the Mahakam River.

In contrast, Malampaya Sound has very low self-organization, limited support from high governance levels, and very low community engagement (see Figure 3.5), with the governance arrangement being instructive to consultative. This aligns with observations, by the ESSC team and by others in Palawan, of community organization efforts often being more about "going through the motions" rather than meaningfully engaging and organizing (Bryant & Lawrence, 2005; Eder, 2005). Though Malampaya's main CARM issues are local, and thus do not involve complications of scale mismatch as observed in the other sites, its local governance institutions do not have the capacity to address them, nor to facilitate assistance from higher governance levels.

Across all sites, the major suggested needs, from respondents, for addressing reported problems were related to the broad directive to "improve enforcement against illegal fishers", including more frequent patrols, additional enforcement team

outposts, stricter implementation of penalties, increased fines for illegal fishing, removal of corrupt government and enforcement officials (Malampaya), and deputization of community patrol teams. Another major request was for increased engagement by municipal, provincial, and national institutions, in alternative livelihoods programs, financial assistance for projects and fishing gear, and funding and personnel for enforcement. Additionally, engagement of higher government levels was identified as necessary to address larger-scale problems through regulations; e.g., expansion of the small-scale fishing zone in Thailand, prevention of palm oil concessions in the Mahakam, reduction of fastcraft speed or alteration of fastcraft route in Guimaras, and restriction on trawling permits from Bacolod in the Guimaras and Iloilo Straits. From other institutions, major solutions included strengthened and more engaged community organizations, coordination across institutions and levels, and full compliance with fisher registration.

These recommendations would largely ameliorate observed weaknesses in current institutions, activities, and coordination. Bridging organizations could facilitate the realization of several of these recommendations, with potential activities including community engagement and organization, providing external support to local institutions and activities, and enhancing representation of communities and coordination across jurisdiction for problems extending beyond the domain of the local government.

This comparative assessment of local-level governance across these four sites, and the summary of problems, institutions and activities, community engagement, and

general effectiveness (through the diagrams presented here) provide valuable context for understanding key aspects of CARM and for rapidly identifying apparent weaknesses/needs and strengths. For example, developing qualitative "scorecards" as in Figure 3.7 provides an easily comparable, visual representation of governance effectiveness, and can contribute to efforts to assess priority sites for conservation and management projects.

Assessments of local-level governance at these sites relate to bycatch mitigation in three ways: (1) improving fisheries management on the whole might generally reduce broad fisheries impacts on cetacean habitats and other components of marine and aquatic ecosystems; (2) identifying potential governance opportunities and obstacles to actual implementation of bycatch reduction regulations can guide the development of bycatch mitigation strategies that are more likely to succeed in a given governance context; and (3) demonstrating the comparative mitigation feasibility across sites can help identify those sites where mitigation measures will more likely be effectively implemented, which is an important consideration in developing conservation priorities.

Based on this study, Trat offers the strongest mitigation outlook for addressing bycatch of cetaceans, with a functioning infrastructure of community groups supported by cross-institutional coordination with demonstrated success at implementing community-based conservation initiatives. In contrast, Malampaya Sound offers the most negative conservation outlook, without any obvious mechanism for enforcing bycatch mitigation regulations. For bycatch mitigation to proceed in Malampaya

Sound, work must go into developing sustainable community groups with the ability to implement and enforce their own conservation initiatives, as top-down governance does not appear to be a feasible alternative at this site.

Taking a step back from the conservation issue of cetacean bycatch to examine the fisheries governance context allows for consideration of the institutions and mechanisms that could be brought to bear on bycatch mitigation, and for assessment regarding the potential success of such mitigation efforts. This offers necessary guidance for the development of mitigation strategies. Based on this study, one would approach future initiatives in bycatch mitigation differently across sites, working with the existing landscape of institutions, activities, and linkages to enhance local governance capacity for effectively dealing with cetacean bycatch and other governance challenges.

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FIGURES

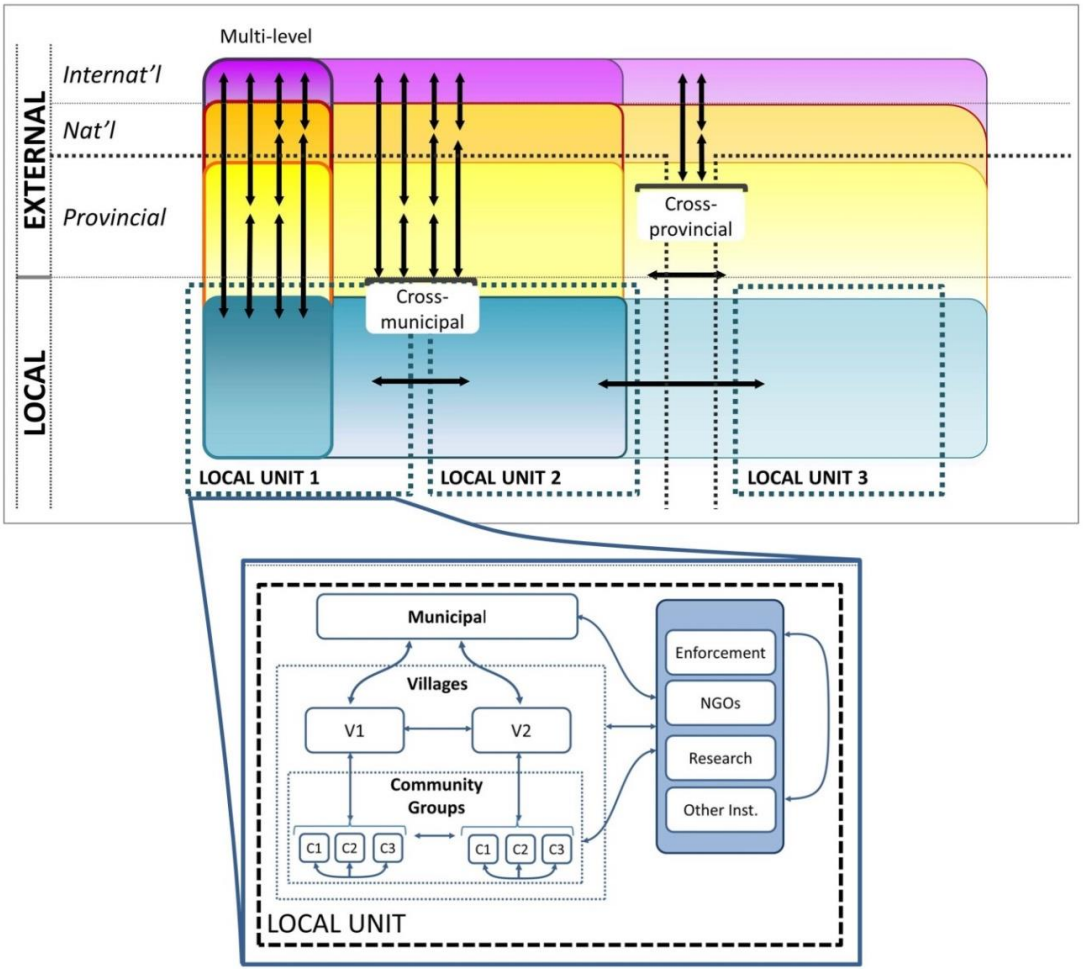


Figure 3.1. Conceptual figure for "local-level governance of CARM", as defined for this paper. The "Local Unit" (bottom) is composed of the municipal (or equivalent) government, village governments, and community groups within those villages, in addition to other institutions (including enforcement bodies, NGOs, and research entities) that influence CRM, and all of the linkages between and within each type of local institution. Zooming out to beyond the local level, external institutions (at the provincial, national, and international) can influence and interact with local-level governance of CRM, either directly or through multiple steps with intermediate institutions. Cross-municipal and cross-provincial interactions can also shape CRM in local units.

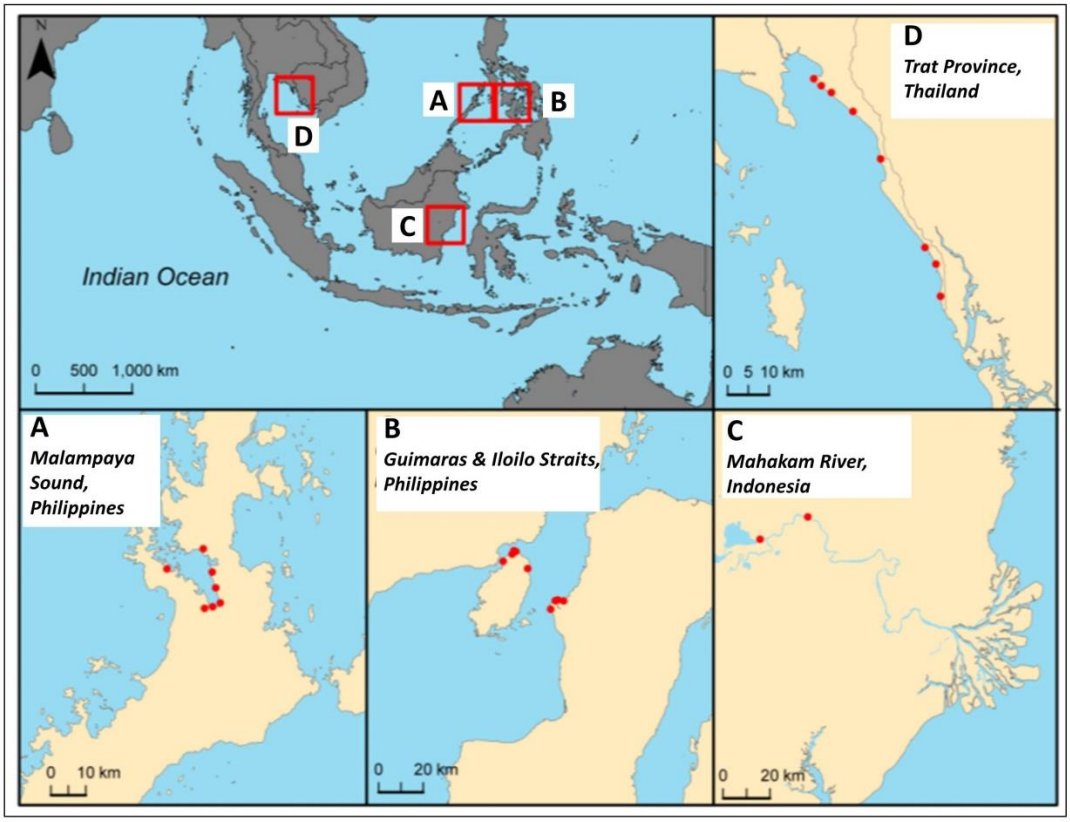


Figure 3.2. Map of field sites. Red dots denote location of study villages.

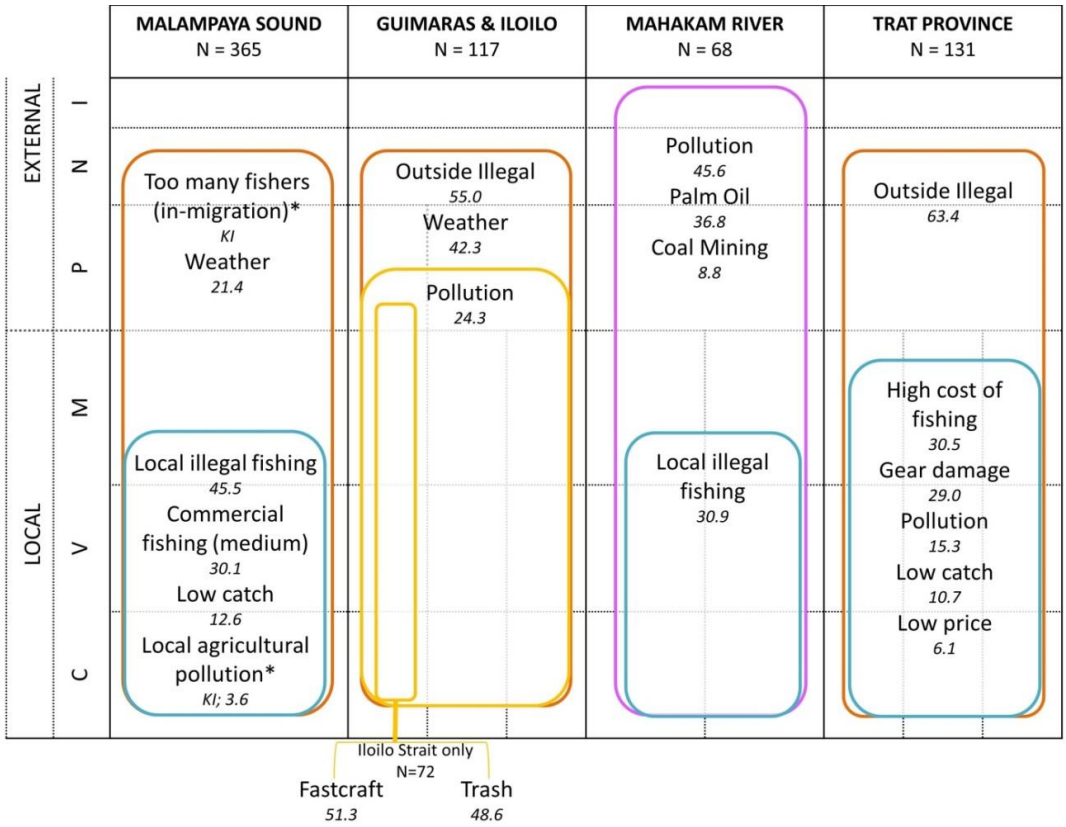


Figure 3.3. Scale of the major problems for small-scale fisheries, as reported in response to the open ended question, "What are the worst problems that affect local fishing?" in the Rapid Bycatch & Socioeconomic Assessment (RBSA) questionnaire. Italicized numbers denote the percentage of RBSA respondents listing a given problem type. Only those problems listed by more than 5% of respondents are included here, with the exception of two problems at Malampaya Sound: "Too many fishers" and "Local agricultural pollution." These problems are included here because they were heavily mentioned in key informant (KI) interviews, though not included in more than 5% of RBSA responses. For all other sites, the RBSA responses encompassed the problems discussed in KI interviews. The placement of the boxes (and color of the box outlines) represents the scale of the problem, from local to external (I = international, N = national, P = provincial, M = municipal, V = village, C = community); additionally, for sites including multiple municipalities and provinces, dashed vertical lines represent municipal and provincial units. Problem boxes that span (horizontally) these dashed lines span municipal and provincial boundaries. Though issues of cost and price are problems that are tied to broader economic systems, they are manifested locally from the point of view of the fishers.

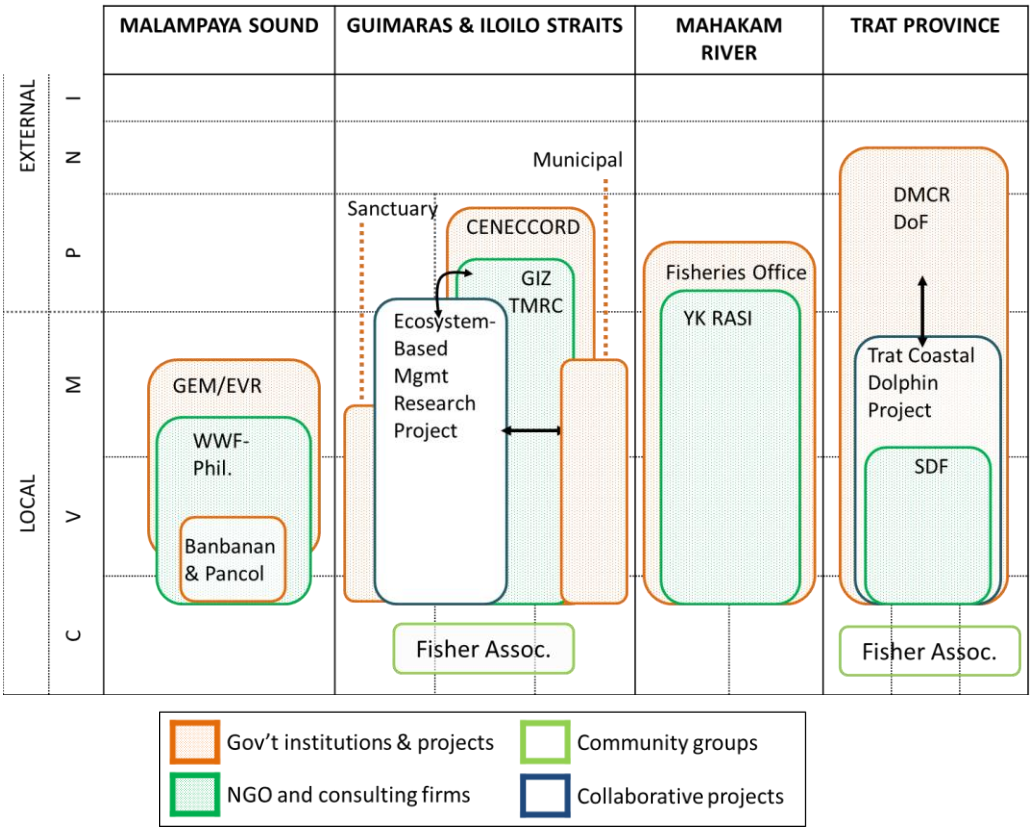


Figure 3.4. Institutions and associated activities reported to have some measure of positive impact on local-level coastal and aquatic resource management (CARM). The placement of the boxes represents the scale of the activity, from local to external (I = international, N = national, P = provincial, M = municipal, V = village, C = community); additionally, for sites including multiple municipalities and provinces, dashed vertical lines represent municipal and provincial units. The fill and border color of the box denote the type of institution. Arrows mark particularly important coordination between these institutions and activities, as determined from key informant interviews. GEM/EVR is the municipal government's General Environmental Management/ Environmental Values and Resources Project; WWF-Phil denotes World Wildlife Fund-Philippines; CENECCORD is the Central Negros Council for Coastal Resource Development; GIZ is the NGO Deutsche Gesellschaft für Internationale Zusammenarbeit; TMRC is the consulting firm Tropical Marine Research for Conservation; YK RASI is the NGO Yayasan Konservasi Rare Aquatic Species of Indonesia; DMCR is the Department of Marine and Coastal Resources; DoF is the Department of Fisheries; SDF is the Sustainable Development Fund.

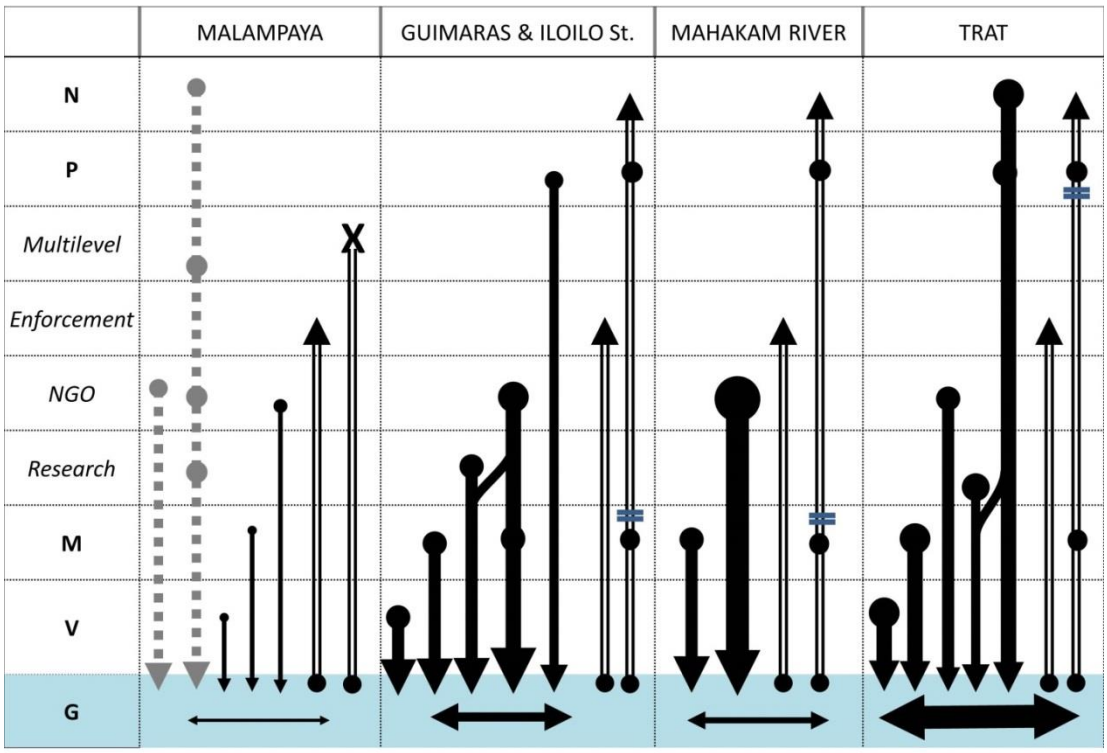


Figure 3.5. Contribution by various levels of institutions to community CARM activities (N = national, P = provincial, Multilevel = institutions created to coordinate across levels, Research = research projects, M = municipal, V = village, G = community groups). The start point of the arrow (round end) denotes the source of support or influence; any circles along the arrow denote intermediate organizations that are also involved in the source institution's activities to engage communities, and lines connecting two arrows denote close collaboration across institution types. The unfilled arrows beginning at the community level denote the level of influence desired by communities to address key CARM problems. Thickness of the line denotes the magnitude of influence, as determined by key informant interviews; an "X" marks a negative impact, while the double-dash marks a gap or loss of feedback along the process. The gray dashed lines indicate previously significant contributions and linkages that no longer exist.

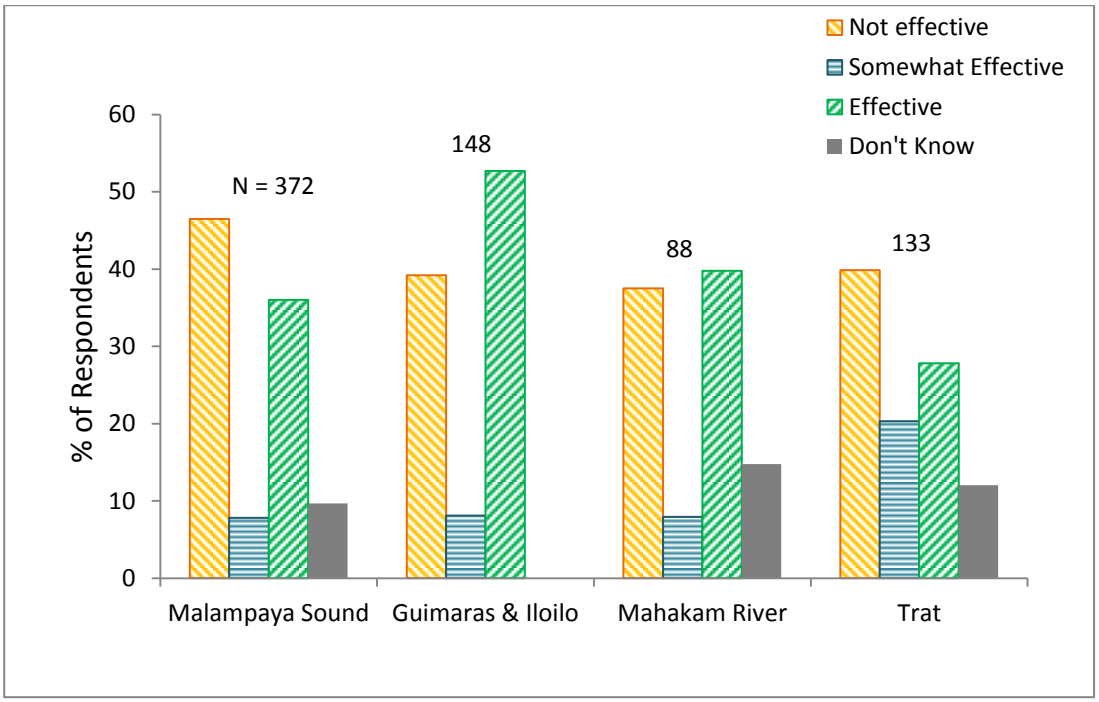


Figure 3.6. RBSA questionnaire responses rating effectiveness of current CRM management.

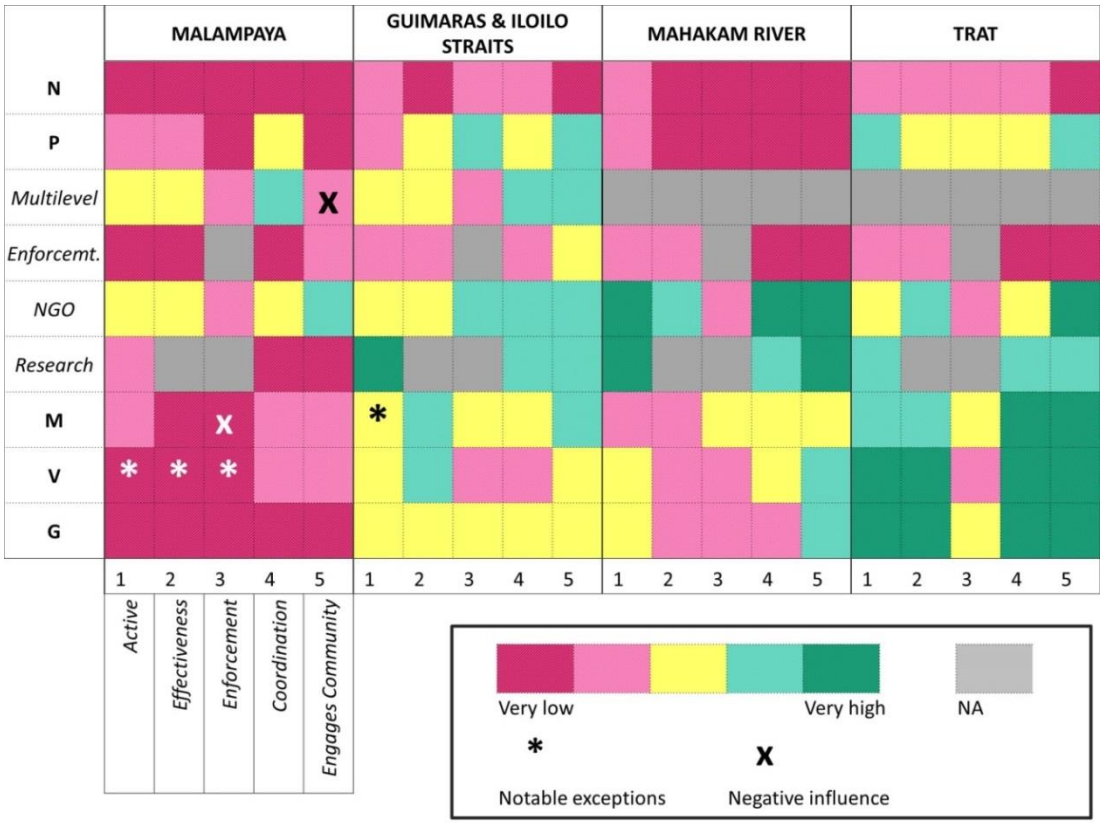


Figure 3.7. Qualitative "scorecard" for institution types across sites. For each level or type of institution (N = national, P = provincial, M = municipal, V = village, G = community group), KI and RBSA interview responses were used to rate: (1) how active that type of institution was in CRM at the local level; (2) how effective that type of institution was at contributing to CRM at the local level; (3) the extent to which that type of institution contributed to enforcement activities; (4) the extent to which that type of institution coordinated with other levels and within its own level; and (5) the extent to which that type of institution engaged local communities and encouraged local CRM activities. "*" denote notable exceptions; for Malampaya, the villages Banbanan and Pancol have relatively engaged village governments; for Guimaras and Iloilo Straits, the municipality of Pulupandan is particularly engaged in CRM issues. Gray cells denote that that particular rating category was not applicable to a given type of institution.

TABLES

Table 3.1. The top responses to the open-ended RBSA question explaining governance effectiveness ratings (see Figure 6), as grouped into negative and positive perceptions of governance effectiveness. The percentage of respondents providing answers within a given category is listed to the right of the explanation type. "*" denote categories for which included complaints related to corruption.

	Malamapaya Sound *N = 372*		Guimaras & Iloilo *N = 148*		Mahakam River *N = 88*		Trat Province *N = 133*	
NEGATIVE	Ineffective enforcement*	23.4	Ineffective enforcement*	28.4	Low compliance	22.2	Weak regulations	36.8
	Illegal fishing persists	20.2	Illegal fishing persists	20.3	Illegal fishing persists	10.0	Not enough patrol	11.3
	Inactive government*	5.7	Not enough patrol	6.8	Ineffective enforcement	5.6	Illegal fishing	9.8
	Low compliance	2.7	Inactive government	2.7	Inactive government	3		
POSITIVE	Illegal fishing reduced	13.9	Good enforcement	26.4	High compliance	17.8	Good regulations	8.3
	Good enforcement	7.8	Illegal fishing reduced	19.6	OK enforcement	10	Effective conservation projects	3.8
	Active patrol	3.2	Active patrol	10.1	Catch improved	3.3		
			Engaged government	2.7	Illegal fishing reduced	2.2		

CHAPTER 4

Conservation-scapes of Irrawaddy dolphin bycatch in small-scale fisheries at four sites in Southeast Asia

INTRODUCTION

The accidental capture, or bycatch, of cetaceans in small-scale fisheries is an urgent conservation issue worldwide (Read & Rosenberg 2002). Two major challenges in mitigating bycatch are the lamentable scarcity of basic ecological and social data on the problem (Reeves et al. 2008; Moore et al. 2010), and the need to study the human dimension in a manner that is useful for developing practical solutions. The latter is particularly important for the issue of bycatch in small-scale fisheries, as these constitute a vital source of income and food to coastal communities around the world (FAO 2010).

To address both challenges, I developed the conservation-scapes framework – a social-ecological framework that aims to guide the identification of data gaps and collection of data that define the extent and underlying human context of the conservation problem (Chapter 1). As with similar social-ecological systems frameworks (e.g., Ostrom & Cox 2010; Kittinger et al. 2012), the conservation-scapes approach outlines a set of attribute types and the interactions between them that define and influence a given conservation issue. Not only does this guide the identification and amelioration of data gaps, but it also prompts consideration of how interacting attributes might be utilized or considered when trying to design conservation approaches that could feasibly be implemented while being effective.

In adapting the conservation-scapes framework to be applied to cetacean bycatch, I outlined bycatch-related attribute types that would provide valuable insight into the proximate and underlying factors defining and influencing the magnitude,

risk, and mitigation outlook for this issue (Figure 4.1). The development of standard sets of social-ecological attributes has been a longstanding goal of interdisciplinary marine resource researchers (e.g., Pollnac et al. 2006), with the goal of demonstrating links between these data and management outcomes (Pollnac et al. 2000; McClanahan et al. 2009; Gutiérrez et al. 2011). These have thus far been applied primarily to coral reef systems, where ecological outcomes can be assessed as coral cover or fish biomass (McClanahan et al. 2006; Cinner et al. 2009; Pollnac et al. 2010), for example.

However, the challenge in applying this approach to small cetacean bycatch in small-scale fisheries is that the actual bycatch events are generally rare events, particularly for those populations of small size. As such, treating rate of bycatch as an outcome to be monitored is impractical; there will likely not be enough data points to point to any positive impact in bycatch mitigation. Therefore, in thinking about actually measuring conservation-scape attributes for small cetacean bycatch, we need to look to those factors that might represent bycatch risk, such as fishing effort attributes.

Addressing bycatch in small-sale fisheries relates to both individual and household-level attributes and to attributes related to the wider human community. On the individual level, relevant categories of attributes include those that relate to (1) how much a given individual contributes to the risk of bycatch, and (2) how receptive a given individual might be to bycatch mitigation measures. Within the first category, characterizing fishing effort can provide insight regarding the degree to which

individual fishers contribute to bycatch risk by using fishing gear in which bycatch occurs, in a way that increases the likelihood of entanglement through spatial and temporal overlap with dolphins, and extended unattended soak times. Within the second category, relevant attributes include ties to fishing as a livelihood, perceptions of environmental resource management and the importance of conservation, perceptions of the conservation status and importance of the dolphins, and engagement in environmentally-related community activities. The perceptions might be influenced by fisher age, residence time at the site, and number of years fishing. Beyond the individual level, attributes of the community, such as infrastructure, access to education and alternative livelihoods, and effectiveness of governance can influence bycatch risk and outlook for mitigation.

In elucidating how these individual and community attributes come together to shape the mitigation outlook for bycatch, comparative studies across diverse sites are necessary. Though the conservation-scape framework can inform local, site-specific action, it can also function as a vehicle for collecting comparative of information from disparate sites, allowing for the identification of any generalizable patterns that might emerge in the relationships between individual and community attributes, and bycatch risk and mitigation outlook. Such comparisons are particularly important in the early stages of linking ecological and social attributes to a conservation problem, as it can improve understanding regarding the significance of attributes and relationships observed at specific sites.

METHODS

To investigate the proximate and underlying attributes for Irrawaddy dolphin bycatch, I conducted fieldwork at four sites in Southeast Asia: Malampaya Sound, Philippines; Guimaras and Iloilo Straits, Philippines; Mahakam River, Indonesia; and Trat Province coastline, Thailand (Figure 4.1). Fieldwork was conducted from 2010 to 2013, over 8 months at Malampaya Sound, 3 months at Guimaras and Iloilo Straits, and 2 months each at Mahakam River and Trat Province.

Field site: Malampaya Sound, Philippines

Malampaya Sound is a semi-enclosed, brackish inlet in northern Palawan province. Known for its productive waters, it is called the "Fish Bowl of the Philippines", and attracts migrants from all over the country seeking a better livelihood. In 2000, Malampaya Sound was declared a Protected Land and Seascape under the National Integrated Protected Area Program (NIPAP), funded by the E.U. The local Irrawaddy dolphin subpopulation is assessed as "Critically Endangered" by the IUCN Red List (Reeves et al. 2008), with unsustainable rates of bycatch documented in the early 2000s (Dolar et al. 2002; Smith et al. 2004; Aquino et al. 2006). Research here focused on the inner part of the sound, which is the confirmed extent of this subpopulation's range, and interviews were conducted at all seven coastal *barangay* (villages) in the inner sound, as well as with municipal and provincial officials.

Field site: Guimaras & Iloilo Straits, Philippines

These straits run along the provinces of Iloilo, Guimaras, and Negros Occidental. This area includes two major urban centers, Iloilo City and Bacolod City, with a diversity of human activities on the water and along the coast, including small-scale and industrial fishing, high-speed passenger ferries ("fastcraft"), cargo shipping, factories (including a coal-fired plant and an alcohol refinery), aquaculture, and agriculture near the coast. For this project, research focuses on the municipality of Buenavista in Guimaras, and the municipalities of Bago and Pulupandan in Negros Occidental. Research by Dolar (in prep.) and de la Paz (unpublished data) has demonstrated that the local subpopulation of Irrawaddy dolphins would likely be listed as Critically Endangered if assessed by the IUCN Red List.

Field site: Mahakam River, Indonesia

The Mahakam River is one of the major river systems in the province of East Kalimantan, and is one of the most productive inland fishing areas in Indonesia (Christensen 1993). This study focuses on the proposed "Central Kutai conservation zone", including the sub-districts Muara Kaman (with a focus on the village Muara Kaman Ulu) and Kota Bangun (with a focus on the village Sangkuliman). Human activities here include small-scale fisheries, aquaculture, transportation (small passenger boats, larger ferries, cargo ships), logging, coal and gold mining, and palm oil plantations (Kreb & Budiono 2005). The local subpopulation of Irrawaddy dolphins is listed as Critically Endangered (Reeves et al. 2008).

Field site: Trat Province, Thailand

Trat province, in the eastern Gulf of Thailand, shares a border with Cambodia to the south. Human activities include industrial and small-scale fishers, coastal aquaculture, agriculture, and tourism in the nearby Ko Change archipelago. This project explored communities in the district of Mueang Trat, in the sub-district of Laem Klat, and the district of Khlong Yai, in the subdistricts of Mae Rut and Khlong Yai. The Irrawaddy dolphins here have not yet been assessed by the IUCN, and the extent of their range is not yet confirmed (Hines et al. 2009).

Boat Surveys

At all sites, surveys were conducted to collect data on the density and distribution of fishing gear and other human activity on the water (Figure 4.2). For Malampaya Sound, surveys were conducted over the entire range of the *O. brevirostris* subpopulation from August 2011 to January 2012 along predetermined transect lines (Figure 4.2a; Smith et al. 2004; Aquino et al. 2006). For Guimaras and Iloilo Straits, and the Mahakam River, only a portion of the local subpopulations' ranges was surveyed, in February 2012 and August to September 2012, respectively. The survey areas (Figure 4.2B) were selected to cover the areas of highest dolphin sighting density from previous dolphin surveys in the Guimaras and Iloilo Straits(Dolar, unpublished data; de la Paz, unpublished data), and to cover the proposed Central Kutai Conservation Zone on the Mahakam River (Figure 4.2C). For the Trat Province coastline, the survey area matched that used by an ongoing research

project on local cetaceans; it is as yet undetermined whether this survey area covers the entire extent of this subpopulation's range (Figure 4.2D). Surveys here were conducted in January 2013.

Surveys were conducted using standard line transect methods (Smith et al. 2004; Buckland et al. 2005). There was variation in methods between sites due to different vessels (ranging from 6m to 12m), research team size and composition, and conditions, as well as main goal of the survey and time constraints. In Malampaya Sound, more extensive surveys were conducted as part of a more in-depth investigation of local dolphins and human activity (see Chapter2), while in Guimaras and Iloilo Straits, surveys were brief and aimed mainly at documenting human activity in known Irrawaddy dolphin hotspots, rather than aimed at observing the dolphins. Each survey shift included: at least two dolphin observers, searching with handheld binoculars and naked eye between 0 (front of the boat) and 90 degrees to starboard and port, respectively, and one human activity (HA) observer, searching with handheld binoculars and naked eye from 90 degrees starboard to 90 degrees port. At all sites, vessel speed while on-effort was maintained between 8 to 10 km/hr. Survey efforts were suspended when Beaufort Sea State (BSS) reached 4 and when inclement weather impeded visibility. Only observations made during BSS 0 to 3 were included in analyses.

For human activity events, location was marked using a GPS unit, and time, angle and distance from vessel, and number of items (boat, buoy, etc.) was recorded, along with Beaufort sea state. Angle was estimated based on two "angle boards"

marked with degrees, located where observers could readily refer to them. Distance was estimated using a range-finder or using observer estimates (calibrated by range finder in training and throughout the field season). Specific fishing gear could consistently and reliably be identified in Malampaya Sound, where fishing gear observers were particularly familiar with local fisheries and where different gear types had distinctive buoys. For the other sites, identification of specific types of gears associated with buoys was deemed impractical; as such, mapping use and calculating density of bycatch gears was feasible only for Malampaya Sound (see Chapter 2).

Human Activity Densities

To characterize the human activity-scape at each site, observed human activities (HA) were assigned to broader HA categories: fixed fishing structures (large, exceeding 2mx2mx2m in size; medium, between 1-2 m^3 in size; fish cages for aquaculture), fishing boats (large, exceeding 15m in length; medium, 8 to 15m; small, less than 8m); buoys and markers (multiple markers, including flags, lines of buoys, and branches; single buoys); and non-fishing boats (all non-fishing boats, plus subcategories of passenger and cargo boats). Assigning more specific categories, including gear involved in bycatch, was not deemed feasible for sites besides Malampaya Sound (see Chapter 2), due to inability to distinguish between different gear types based on buoy or marker at these sites.

Densities of HA within each category were calculated over the entire survey area at all sites; though this obscures any spatial heterogeneity in gear distribution

within each site, it does provide a simple metric of the magnitude of HA. The effective strip widths (ESW) for observed human activities were calculated for Beaufort Sea States 0 to 3 for the three coastal sites, using Distance 6.0 (Thomas et al. 2010). The number of observed HA within the applicable ESW was divided by the effective survey effort area (total survey line length times 2ESW). For the Mahakam River, ESW was not calculated for HA types, due to the narrow width of the survey area (ranging from 25 to 150 meters). The mean density for each HA type at each site was calculated across all replicates.

Interviews

Semi-structured, key informant (KI) interviews were conducted with government officials, community leaders, NGO staff, researchers, enforcement staff, fishers, fish buyers, and other community members with experience and expertise in marine resource management issues at each site. Selection of KIs was designed to collect representative information from all major institutions relevant to marine resource governance at each site; 68 KI interviews were conducted in Malampaya Sound, 70 in Guimaras and Iloilo Straits, 29 in the Mahakam River, and 31 in Trat Province. All interviews were conducted with and translated (as needed) by local field assistants, fluent in English and the local language, who were familiar with the goals of the research project.

I developed "Rapid Bycatch and Socioeconomic Assessment" (RBSA) structured questionnaires to collect information on fishing effort, fisheries trends, ties

to fishing as a livelihood, involvement in marine conservation or fisheries management activities (i.e., interviews, meetings, seminars, research), fisher demographics, perceptions of fisheries management and conservation, local ecological knowledge related to Irrawaddy dolphins, and fisheries interactions with Irrawaddy dolphins (Appendix 1). These RBSAs are adapted from the Rapid Bycatch Assessments (RBAs) developed and refined by Project GloBAL (Moore et al. 2010) and the Socioeconomic Monitoring Manual for Southeast Asia (Bunce & Pomeroy 2003).

Response types include binary yes-no, Likert scale (ranging from 1 to 5, with 1 indicating strong disagreement with a statement, and 5 indicating strong agreement), closed-choice (e.g., more, less, or the same; yes, maybe, no; or from a selection of pre-determined options), and open-ended. Responses to open-ended questions were coded to standardized categories using constant comparative methods (Strauss & Corbin 1998). The RBSA evolved during the timespan of the project for improved efficiency and clarity, but most questions remained the same throughout all field seasons.

For each site, RBSA questionnaires were translated and conducted into the local language. Responses were written by field assistants in the local language, and translated during data entry. Sample sizes were based on suggested sample sizes from the Socioeconomic Monitoring Manual for Southeast Asia for a "useful understanding of the population" (Bunce & Pomeroy 2003). Given the lack of comprehensive or accurate census information on fishing households, truly random sampling was deemed impractical; instead, estimates on the number of fishers were based on

information from preliminary KI interviews. Based on the estimated number and composition of fishers from these interviews, strong effort was made to conduct RBSA interviews with representative portions of each village. As such, data from these RBSAs should not be considered statistically representative, but are still useful for descriptive purposes. 525 RBSAs were conducted in Malampaya Sound, 215 in Guimaras-Iloilo Straits, 90 on the Mahakam River, and 137 in Trat; out of the 968 RBSAs conducted, 940 were included in analyses based on reliability ratings and exclusion of RBSAs from communities with insufficient sample sizes (see Table 1).

Data analysis: Bycatch estimates

Bycatch magnitude estimates were based on information provided by RBSA respondents for events reported as occurring in the three most recent years at the time of the interview, i.e., 2009-2011 for Malampaya Sound and Guimaras-Iloilo Straits, and 2010-2012 for Mahakam River and Trat. In quantifying mortalities, potential duplicate reports (i.e., multiple respondents describing the same mortality event) needed to be identified. Criteria for potential duplicates were based on matches between attributes considered most likely to be remembered and reported accurately: year and/or year bin, location, and cause. Preliminary sorting and matching indicated that reported season and fate of the animal were less reliably reported than other parameters, and as such, were not used to determine duplicates. Of identified sets of potential duplicates, the report with the likely highest reliability (bycatch in the respondent's gear and bycatch or mortalities directly observed by respondents) and

most complete information were selected as unique events. Results were compiled from these events only.

Reports of bycatch and entanglement events from years prior to the three most recent years were similarly treated to remove potential duplicate. These reports were primarily used to compile a list of all gears ever reported in bycatch at these sites.

The most recent available population estimates for the Malampaya Sound, Guimaras, and Mahakam River subpopulations (Whitty in prep, Chapter 3; Dolar, unpublished data; Kreb & Budiono 2005) were used to calculate the potential biological removal (PBR; Wade 1998). No complete population estimate is yet available for the Trat coastline subpopulation (Hines, pers. comm). The PBR functions as an estimate of maximum sustainable annual rate of human-caused mortality , based on a minimum population estimate, an estimate of the net productivity rate of the population, and a "recovery factor" from 0.1 (generally used for endangered populations) to 1:

$$PBR = N_{min} \frac{1}{2} R_{MAX} F_{R\ (}\text{Wade 1998).}$$

Where: N_{min} is the minimum population of the stock; ½ R_{MAX} is half the maximum theoretical net productivity rate of the stock (for which I used 0.04, the default for cetaceans, as in Beasley 2007)(Kaufman et al. 2011); and F_r is the recovery factor (for which I used 0.1, 0.5, and 1) (Wade 1998).

Fishing Effort

Information pertaining to fishing effort using bycatch-related gears was collected through RBSA responses about fishing practices. To look at the use of bycatch gears over time (throughout the year) and space, I summarized the locations where respondents reporting using bycatch gears, and the months or seasons of the year when they were used. Respondents provided information on gear use location based on maps used in the RBSAs, with study areas divided into zones (Figures 4.3, 4.4).

Zones were chosen based on landmarks that would be familiar to fishers, to aid in map-reading. Distance from the coast is challenging to remember without notable landmarks; as such, those boundaries ending in relatively open waters in Guimaras and Iloilo Straits zones are not necessarily limited to the polygons shown here in that regard. For the sites in the Philippines, most respondents reported the seasons of use rather than specific months; *amihan* is the northeast monsoon season (December through March), and *habagat* is the southwest monsoon (roughly June through late October). As such, the resolution of use by months is limited to these two seasons for Malampaya Sound and Guimaras-Iloilo. The percentage of respondents who reported information on both the months/seasons and zone for bycatch gear use, who used gear in a given month and zone combination, was plotted in heat maps for each site.

Summarizing and comparing attributes

To summarize data on attributes collected by RBSAs, I calculated the percentages of respondents providing a given answer, out of all respondents for which a reply was recorded for a given question at that field site. Responses related to numbers of years, such as age, number of years fishing, and number of years living at the study site were sorted into 15-year bins. For individuals who had migrated to the study site, places of origin were classified as "local" if within the same province, "other province", and "other country". Diversity of in-migrant origin provinces was calculated using the Shannon-Weiner index, treating provinces as "species":

$$\text{Origin Diversity} = -\sum_{i=1}^{R} pi * lnpi,$$

where p_i is the proportion of respondents who have moved from province i, out of R provinces. For Trat, "other country" was counted as another province in these calculations.

Use of bycatch gears was described as binary (yes if the respondent used any bycatch gears, no if not), as well as by reliance on bycatch gear, or whether the fisher used only bycatch gears or had alternative gears not involved in entanglements. Use and reliance on bycatch were determined both for the gears most commonly reported in bycatch over the three most recent years, based on bycatch and entanglement reports from the RBSAs, and for all gears ever reported as involved in bycatch or entanglement events.

Involvement in activities related to conservation or resource management was described as binary (yes or no), by topic, by the type conducting the activity (community group, NGO, local government, provincial or national government, research teams), and by magnitude of involvement. Magnitude of involvement was rated from 1 to 4, with 1 indicating one-time participation, 2 indicating participation in "some" (2 to 3) activities, 3 indicating regular participation (on an ongoing basis), and 4 indicating a high level of involvement, such as a leadership position.

For selected attributes, Pearson's $\chi 2$ tests were run to compare responses across sites, and, in some cases, responses across various groupings based on residence time and involvement in activities. Where sample sizes were insufficient for χ^2 analyses, Fisher's exact test was used.

Exploring conservation-scape scores

To aggregate the diversity of attributes studied into a smaller number of informative summary scores, I selected the subset attributes which appeared conceptually likely to be particularly related to bycatch risk and outlook mitigation (Figure 4.1) and used them to construct eight sets of scores representative of conservation-scape attribute sets: fishing effort, ties to fishing, general environmental perceptions, perceptions related to dolphins, general demographic and social information, general information on governance-related institutions, governance-related activities, and governance effectiveness (Table 1). Of those eight, six were scored using the subset of RBSA data for which all attributes included had complete

and reliable responses – these excluded the general demographic and social information, and the general information on governance institutions, which were instead provided mainly through KI interviews. The mean of these scores was calculated for each site.

To concisely present information for all conservation-scape attributes, as collected by the various methods in this project, I developed exploratory assessment summary scorecards based on the same theme as the conservation-scape figure (and motivated by the Coral Health Index, Kaufman et al. 2011). The scorecards use a color scheme to depict how a set of attributes for a given site might contribute to the potential for bycatch mitigation, and are meant to convey both the urgency of the bycatch problem and the degree to which social and governance attributes might be conducive to mitigation solutions. These scores are largely comparative and qualitative thus far, based on relative scores from the RBSA attributes sets described above, as well as data on fishing effort and bycatch collected from boat surveys and RBSA, and data on social and governance contexts from KI interviews. These last two sets of data were used to supplement the RBSA scores with more detailed information on proximate and governance factors, as well as general community attributes not addressed by RBSA interviews.

RESULTS

For RBSA results, all attributes that were compared across sites using Pearson's χ^2 test were found to be significantly different ($p < 0.05$). Those attributes

that were tested are marked, in the summary tables, with an "*"; specific results from the χ^2 tests are presented in Table 4.1.

Bycatch estimates

Most reported bycatch mortalities and entanglement events occurred in gillnets, followed by bottom-set traps and medium-to-large commercial fishing boats (Table 4.2). At all sites except for the Mahakam River, bycaught dolphins were reported as being consumed, or even killed for consumption in Malampaya Sound and Guimaras-Iloilo Straits. In Malampaya Sound, crab gillnets and bottom-set traps for crabs were the main gear involved in bycatch, and are assigned to the Bycatch 1 category (Table 4.3). All other gears reported in bycatch are included in All Bycatch. For other sites, there was no such strong distinction among gear types reported. As such, Bycatch 1 refers to all gears reported in entanglement events in the three most recent years (Table 4.3). For Guimaras-Iloilo Straits, various gillnet types were reported to be involved in entanglements, with (unfortunately) limited specific information in the interview responses to allow for confident identification of specific gillnet type. Applying the precautionary principle, all gillnets types were included in the Bycatch 1 category, though this might be more broad than those specific gillnets actually involved in entanglements. The category All Bycatch, for these sites, refers to other gears that were reported in entanglement events prior to the three most recent years.

For Guimaras and Iloilo Straits, boat strikes were also mentioned as an anthropogenic cause of dolphin mortality. For Trat, "rope" refers to the line connecting markers to gears, though respondents could not provide more detail on the exact type of gear involved. The rope-related bycatch reported in Malampaya Sound was a line from a seaweed farm.

Bycatch mortalities exceed the PBR at the two Philippines sites and in the Mahakam River (Table 4.4), even with a conservative recovery factor of 0.5. Since interviews were conducted at a subset of villages in Guimaras-Iloilo Straits, the Mahakam River, and Trat, these bycatch mortality numbers are almost certainly underestimates and should be treated as minimum rates of bycatch.

Human activity-scape & Fishing effort

The entire survey area of Malampaya Sound was surveys a total of 16 times, with total on-effort distance being 1124 km. For Guimaras Strait, the on-effort distance was 41 km with 2 complete replicates of the survey area, while the on-effort distance in Iloilo Strait was 75 km over 3 replicates. On the Mahakam River, on-effort distance was 190 km for 2 complete replicates and a partial third, and on-effort distance for Trat was 477 km for 2 complete replicates.

Densities of different human activity (HA) categories are shown in Table 4.5 and Figure 4.5. The greatest diversity of HA was observed on the Mahakam River, where boat traffic density was particularly high (comprising coal and lumber barges, passenger ferries, medium-sized cargo boats, and small motorboats used for

transportation and fishing). Trat coastline was the only site with large, industrial fishing vessels observed. The low density and lack of medium- and large-sized fishing boats in Guimaras and Iloilo Straits does not capture the night-time encroachment by industrial fishers on coastal waters (as described by key informants).

Spatial and temporal fishing effort using bycatch gears, as described by RBSA respondents, is shown in Figures 4.6 to 4.9. In Malampaya Sound, Bycatch 1 gears are used throughout the year, and throughout the study area. Similarly, for the remaining sites, use of gears reported in entanglements within the past three years are used throughout the year. For these sites, the zones nearest the interview respondent villages are, not surprisingly, where bycatch gears are used the most. Low use in other zones does not mean that bycatch gears are not used there, but only that they are not used there by interview respondents from other villages. Since the study villages were spread fairly evenly across the study sites, it appears that bycatch gears are being used throughout dolphin habitat at all sites.

Higher proportions of fishers at the Mahakam River used a greater diversity of fishing gears than those at other sites (Table 4.6). At Trat and the Philippines sites, we see a high proportion of respondents relying entirely on bycatch gears (60.2 to 79.7%), in comparison to respondents at the Mahakam River (9.9%) (Table 4.6). Comparisons of use of bycatch gear are somewhat constrained by the relative lack of gear type resolution from Guimaras and Iloilo Straits.

Across sites, there was a significant difference in the number of fishers switching gears in the past 5 years (Table 4.7), with a greater proportion of fishers in

Malampaya Sound and Trat having changed fishing methods. The proportions of fishers adding and dropping bycatch gears over the past 5 years appear to even at each site except for the Mahakam River, with the highest percentage of fishers adding bycatch gears to their fishing practices. There was a significant difference across sites in the relative time fishers spend fishing currently compared to 5 years ago, with Malampaya Sound exhibiting the highest proportion of fishers increasing fishing effort in that time.

In response to the follow-up question, "Why did you change [or not change] the amount of time you spend fishing?", many fishers stated the fishing is more difficult now due to decreased catch and increased number of fishers. This reason was given by fishers who increased, decreased, or did not change their time spent (Table 4.7). Those who had increased their time spent fishing stated that it took longer to catch enough fish now, while those who had decreased their time spent fishing stated that it was not worthwhile to spend time fishing due to decreased catch. A combination of those explanations were presented by those fishers who had not changed their time spent fishing, along the lines of: "It's not worthwhile for me to increase the time I spend fishing, because there's nothing to catch; but if I decrease the time I spend fishing, I won't catch enough."

Based on KI interviews, community fishing effort is increasing in Malampaya Sound, driven in large part by in-migration from other parts of the country. For Guimaras and Iloilo Straits, it appears that the number of fishers is increasing with intrinsic population growth, but with some fishers leaving for alternative livelihoods,

particularly construction jobs in Iloilo City. For the Mahakam River, fishing effort seems to be increasing with intrinsic population growth. However, aquaculture is rapidly picking up as an alternative livelihood on the river, with the local district fisheries office encouraging this switch. Among the KIs involved in aquaculture, this shift is driven by frustration over decreased catches. In Trat, there has been a decrease of locally-based large commercial fishing boats, with increasing fuel costs and decreasing yields pushing many large boat owners to other livelihoods, including switching to small-scale fishing as well as non-fishing occupations such as working in local factories and starting small businesses. This has led to a reported increase in the number of small boats used for fishing. Other reasons provided for this change include the increased difficulty in finding labor for the boats. Generally, in-migrants from Cambodia provide much of the manpower on these boats, but one KI reported that many of these in-migrants are returning to their home country as livelihood options there increase.

Basic RBSA respondent attributes

Basic information on RBSA respondents is presented in Table 4.8. Respondents were predominantly male, reflecting the gender composition of the fishing community at those sites. Malampaya Sound had the greatest proportion of relatively young, new fishers out of the four sites. There was a significant difference across sites in the number of life-long residents, as opposed to in-migrants (Table 4.9), with Guimaras and Iloilo Straits having the highest proportion of the former.

Diversity of in-migrant origins was by far the greatest at Malampaya Sound, with respondents representing 31 provinces of origin, and a Shannon diversity index of 2.8, as opposed to 6 or fewer provinces and a Shannon diversity index of 1.6 or smaller for the remaining sites. Out-migration appears to happen to the least extent in Trat, though this is only a reflection of respondents who have had family members move away from the site.

Of those fishers who had moved to the study sites, main motivations for moving were related to family, seeking a better livelihood, and seeking a higher quality of life (Table 4.10). Those seeking a higher quality of life included those leaving areas of conflict, such as Koh Kong in Cambodia in the 1970s, for the relative peace of Trat, or from drug- and rebel-related violence in other provinces of the Philippines to settle down in Malampaya Sound. There was a significant different across sites in the proportion of people who had moved there seeking a better livelihood, including better fishing grounds. This might relate, if investigated more closely, to the degree of attachment to fishing.

Ties to Fishing

For most of the fishers surveyed across sites, fishing represented their primary livelihood (Table 4.11), though there was a significant difference across sites, with the Mahakam River demonstrating a somewhat lower proportion. Reasons for fishing spanned beyond its value as a source of income or food, with high proportions of

fishers stating that it was easier than other work, was a tradition at that site or in their family, was enjoyable, and was the only option (Table 4.11).

Most respondents at Malampaya Sound and Guimaras-Iloilo Straits reported a decrease in earnings from fishing compared to 5 years prior (Table 4.12). Trat had the highest proportion of fishers who perceived an increase in earnings from 5 years prior. KI interviews suggest that this is thought of as being due to the widespread establishment of community-led conservation groups along the Trat coastline in that same time frame, most of which have established crab banks as a means of replenishing crab stocks. There was a significant difference across sites in the perceived sufficiency of earnings from fishing for household needs (excluding education and medical care), with Malampaya Sound and Guimaras-Iloilo Straits having higher proportions of negative responses when compared to the other two sites.

Across all sites, most respondents had parents who were also fishers (Table 4.14). There was a significant difference across sites in whether fishers wanted their children to become fishers when they grew up, with Malampaya Sound having the highest proportion of fishers to respond "Yes". Most respondents viewed fishing as a difficult occupation, and many preferred that their children finish their education and seek better jobs. Among those who wanted their children to be fishers, common responses included lack of other options, positive perceptions of fishing as an occupation or as a tradition, and the fact that one could still earn an income from it.

Perceptions of resource conditions & conservation

A decline in catch since 5, 10, and 20 years prior was reported by most fishers (Table 4.15). Perceptions related to change in catch size over the past 5 years were significantly different across sites, with the highest proportion of fishers noting a decline in Malampaya Sound and the lowest in Trat (Table 4.15). This might relate to the recent activities of the Trat community conservation groups, as mentioned above. Responses to eight questions regarding the status of local fisheries and marine resources and the importance and effectiveness of management differed significantly across sites (Table 4.16, Table 4.17).

Perceptions related to dolphins & conservation

A perceived decline in dolphin numbers over the past 5 years was reported by a lower proportion of Malampaya Sound fishers than at other sites (Figure 4.10a). With the exception of the Mahakam River, most fishers noted a decline compared to 20 years ago (Figure 4.10b). Of the fishers noting a decline over the past 5 years, there was limited awareness of bycatch as being the cause (Table 4.18a). Among fishers noting no trend or an increase over the past 5 years were those who stated that the dolphins "are not caught or harmed" (Table 4.18b, Table 4.18c).

Unfortunately, the question "are dolphins threatened/likely to go extinct here?" was inadvertently cut out of the questionnaires in Trat. However, across the other three sites, there was a significant difference in responses, with the Mahakam River respondents being most aware of the dolphins' threatened status, and high proportions

of respondents who did not believe that dolphins were threatened at Malampaya Sound and Guimaras-Iloilo Straits (Table 4.19).

Opinions about the importance of dolphins and dolphin conservation were notably lower for the Mahakam River than at other sites (Table 4.20). A common reason provided by fishers there for not considering dolphins important was that they could not be sold or eaten, and thus were useless. Most fishers across all sites expressed positive perceptions about dolphins ("how do you feel about dolphins?"), including most of those fishers who also expressed negative perceptions. Negative perceptions including viewing dolphins as competition for prey and as a nuisance for fishing (gear damage and scaring fish away). Positive perceptions included the view that the dolphins serve as indicators of where fish and shrimp are, and that fishers simply enjoyed seeing them.

Previous involvement

For reported involvement in or exposure to marine resource management and conservation activities, Trat had the highest percentage of respondents (93.2%), while Malampaya Sound had the lowest (43.2%) (Table 4.21). A higher percentage of fishers from Mahakam River and Trat reported regular involvement in activities compared to the Philippines sites. The institution types with which respondents would engage in these activities varied significantly across sites, with respondents in Malampaya Sound mainly reporting involvement with NGOs, Guimaras-Iloilo with

research projects, Mahakam River with community groups, and Trat with community groups and provincial to national government levels (Table 4.21).

Most respondents at all sites had not been involved in activities related to dolphin conservation. Mahakam River had the highest proportion of fishers who reported engagement in any activities related to dolphins; these were largely conducted by the local NGO YK RASI.

Exploratory comparisons within sites

Selected $\chi 2$ or Fisher's Exact Test comparisons were run across different groupings within sites (Table 4.22), with a handful of significant differences. Across the different bins for number of years fishing, there were significant differences within Malampaya Sound related to use of bycatch gear, with a higher proportion of fishers in the 0 to 15 years of fishing bin reporting use of bycatch gear (Table 4.23). Fishers in this bin also reported having non-bycatch gears in addition to bycatch gears to a greater extent than those in other age groups; in other words, a higher proportion of them reported using bycatch gear, but a lower proportion were completely dependent on it (Table 4.23).

At the Mahakam River, responses to three "perceptions of the environment" questions differed significantly based on previous involvement (yes or no) (Table 4.24). Fishers with reported previous involvement in marine resource activities responded that there were more fish before, and that catch decreased due to overfishing, at a higher percentage than those who with no previous involvement. A

greater percentage of the former also reported that they thought local resources were in good condition.

Conservation-scape scores

The mean scores, with variance, from the RBSA attribute sets ranged from 0 to 4 for fishing effort, 1 to 4 for ties to fishing, 12 to 25 for general perceptions of the environment, 0 to 6 for perceptions of dolphins, 0 to 8 for previous involvement in activities, and 1 to 5 for perceived effectiveness of marine resources management (see Table 4.1 for information on scoring). Mean scores for each set, with variances, are displayed in Figure 4.11. Scores were significantly different across sites for each attribute set: fishing effort (χ^2=110.47, p<0.01), ties to fishing (χ^2=108.08, p<0.01), general perceptions of the environment (χ^2=279.71, p<0.01), perceptions related to dolphins (χ^2=83.24, p<0.01), involvement (χ^2==301.32, p<0.01), and perceptions of governance (χ^2=70.13, p<0.01).

Based on these RBSA score sets and combining them with RBSA bycatch and fishing effort, boat survey, and KI interview data, various conservation-scape attributes were assigned relative "scores" in exploratory assessment scorecards (Figure 4.12). Red colors indicate that high values for that attribute likely exacerbate the bycatch problem (so, the darker the red, the worse for the dolphins), while green colors indicate that high values might, in theory, contribute to solutions. With the exception of the proximate attributes data (A through D), these scores are largely based on comparisons across the four sites (see Figure 4.1 for attribute codes). For

attributes A through D, related to bycatch magnitude, impact, and risk, all sites with a calculated PBR received a negative score, indicating that bycatch has been documented, with minimum estimates exceeding the PBR, and with high spatio-temporal overlap between bycatch gears and dolphins. In other words, these attributes represent the urgency of the issue.

Information from KI interviews on general social and governance attributes indicate that Malampaya Sound has relatively undeveloped infrastructure, high population growth, and limited access to alternative livelihoods. Trat is on the other end of the spectrum, with the most developed infrastructure and comparatively ready access to other areas with potential for alternative livelihoods. Mahakam River and Guimaras-Iloilo Straits are intermediate, with infrastructure and access to alternative livelihoods somewhat more developed in Guimaras-Iloilo. For governance institution details, see Chapter 2. Governance effectiveness score assignment was informed mainly by KI interviews (see Chapter 2).

Based on the assessment scorecards, I assigned rankings of urgency, for which the three sites with complete data are tied, and for mitigation outlook. Malampaya Sound is ranked lowest for mitigation outlook, given its scores for ties to fishing, general community attributes, and governance. Trat is ranked the highest, with its strong scores for governance and community attributes. The Mahakam River and Guimaras-Iloilo Straits received intermediate rankings.

DISCUSSION

Even in this project, which can be considered a pilot project for applying conservation-scapes to small cetacean bycatch, this framework provided extensive information on a wide array of bycatch-relevant attributes. Some of these provide conclusive information, while others point out directions for further, more in-depth and focused investigation. Bycatch was confirmed to be unsustainable for three of the four sites, the overlap between bycatch gear and dolphin habitat was demonstrated to occur year-round, and that human activity-scape at each site provides information on the extent to which different stakeholder groups might be impacting dolphin habitat. The reports of entanglements and mortalities in crab pots in Malampaya Sound and octopus traps in Trat indicate that this gear type might need to be considered a potential threat at other sites (see Chapter 2 for more in this). The reports of mortalities from boat collisions in the Guimaras and Iloilo Straits indicate that unsustainable bycatch is not the only threat that must be mitigated.

Results pointing to further study include the remarkably high diversity of in-migrant places of origin in Malampaya Sound might influence social cohesion at that site (not studied here), which might influence the feasibility of community-based conservation initiatives. Additionally, the differences in time spent fishing in responses to increased catch difficult (Table 4.8) indicates that influencing fishing effort is not straightforward, and that efforts to do so might meet with variable success. It would also be of interest to further study whether those in-migrants who

moved to Malampaya Sound specifically seeking better fishing grounds have particularly strong ties to fishing or not.

Of concern is the apparently low awareness of bycatch as a serious threat to the dolphins at these sites (Table 4.18, 4.19). However, the fact that most fishers expressed positive perceptions regarding dolphins indicates some level of interest in their conservation, though there is no foundation for supposing that this would be sufficient to promote changes in fishing practices.

The extensive differences observed in attributes across sites reinforce the notion that mitigation approaches will always require site-specific elements. This is particularly clear with the institution types with which respondents had had the most involvement in marine resource management and conservation activities (Table 4.21). Different institution types are the main vehicle for these activities across sites, which might influence the effectiveness of the activities or might inform future outreach endeavors; for example, if the local government unit is the main source of marine resource related information to a community, then outreach efforts associated with them might benefit from their associations with the community.

These site-specific characteristics would not have necessarily been notable if not compared across other sites. Constructing the assessment scorecards would have been impossible without cross-site comparisons to lend at least relative meaning to the attribute scores. If this approach were to be continued to continually incorporate more sites, our understanding of what attributes tend to co-occur with various measures of bycatch risk and mitigation outlook would be greatly enhanced. Moving forward, the

lists of attributes to be collected could be continually refined based on exploratory studies such as this, and based on continuous comparison with similar data from other sites. A development of a more quantitative scoring system would lead to conservation-scape assessment scorecard values that do not rely on the ranking used here, which would be impractical for a large number of disparate sites. Applying path (e.g., as in Pollnac et al. 2010) or CART (Gutiérrez et al. 2011) analyses to these datasets might yield intriguing insights into what social or ecological attributes are linked to our best measure of reduced bycatch risk.

These scorecards could be readily used to search for sites with similar attributes profiles, for further investigation on whether solutions attempted at one site are transferable to other sites sharing certain characteristics. For example, the potential comparisons between the Malampaya Sound Irrawaddy dolphins and the vaquita (*Phocoena sinus*), both of which exist in human activity-scapes dominated by small-scale fishing in relatively remote areas, was mentioned in Chapter 1. The vaquita has attracted much attention from NGOs, researchers, and government agencies, and several initiatives have been undertaken to reduce vaquita bycatch (Rojas-Bracho & Reeves 2013), with limited success. What could be learned from the attempts and failures in vaquita conservation that could guide conservation efforts at sites that are similar in certain attributes, such as Malampaya Sound?

Of interest is the idea of aligning small-scale fisheries management goals with bycatch mitigation. For example, illegal coastal fishing by industrial fishing boats are perceived as a major threat to fishing by RBSA respondents in Trat; these respondents

also report that bycatch of dolphins occurs in these boats. In this case, working to keep industrial fishing boats out of the coastal small-scale fishing zone could, in theory, benefit both the dolphins and fishers (though the dolphins also get entangled in small-scale fishing gear). In contrast, the gears most commonly involved in bycatch in Malampaya Sound, the crab pot and crab gillnet, would possibly be the most challenging gears to eliminate, as they are relatively cheap, easy to use, and widely used, and were not identified by fishers as being unsustainable. Adapting the conservation-scape assessment scorecard to somehow display these alignments or misalignments in fisheries management and bycatch mitigation would further inform the determination of a mitigation outlook score.

The wealth of information provided by applying the conservation-scape frameworks to these sites is almost daunting. The process of refining those attributes that best describe the risk and urgency of bycatch and that convey the feasibility of mitigation approaches will greatly improve the utility of an already-useful framework. Further developing and applying the conservation-scape framework holds great promise for improving our understanding of and ability to resolve the bycatch problem, at specific sites and on a broader scale.

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Chapter 4, in part, is currently being prepared for submission for publication of the material. Whitty, Tara S. The dissertation author was the primary investigator and author of this material.

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FIGURES

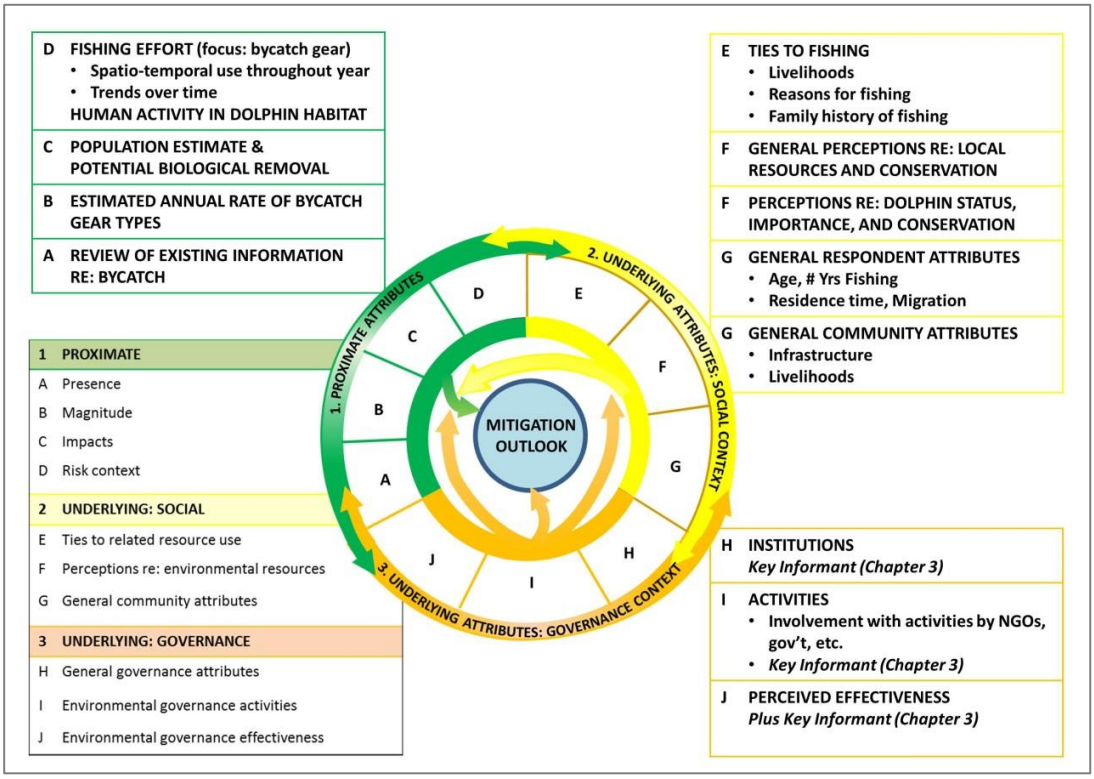


Figure 4.1. Conservation-scape framework, based on Chapter 1, as adapted for this project on Irrawaddy dolphin bycatch in small-scale fisheries at four sites in Southeast Asia. The original framework attribute categories are shown in the table in the lower left. Attributes studied through this project are shown in the three tables arranged by conservation-scape attribute type (proximate, underlying social, underlying governance). Chapter 3 focused on the governance attributes.

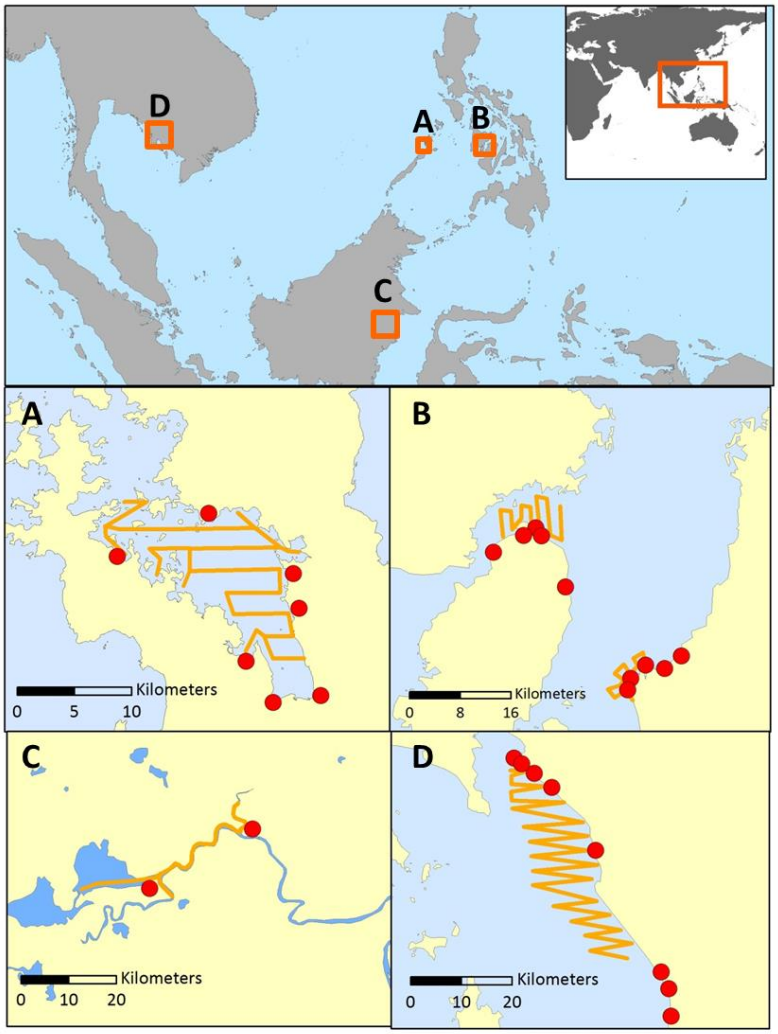


Figure 4.2. Study sites map, with boat survey track lines in orange and study site villages marked as red dots. (A) Malampaya Sound, Philippines; (B) Guimaras and Iloilo Straits, Philippines (Iloilo Strait to the northwest, Guimaras Stait in the southeast); (c) Mahakam River, Indonesia; (D) Trat Province coastline, Thailand.

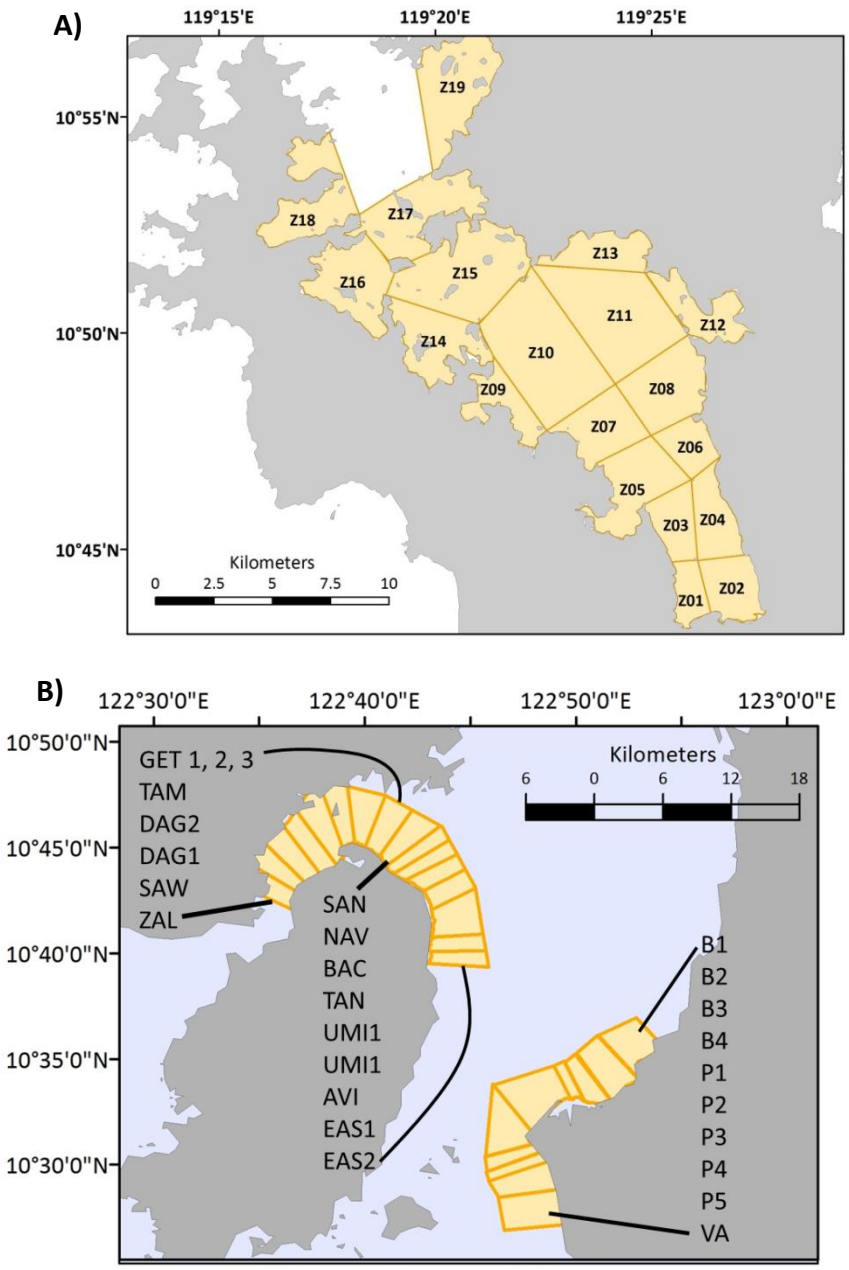


Figure 4.3. Zones used in RBSA interviews when asking fishers about fishing effort and locations of bycatch for (A) Malampaya Sound, and (B) Guimaras and Iloilo Straits. Zones were chosen based on landmarks that would be familiar to fishers, to aid in map-reading. Codes used for the zones in the fishing effort maps (Figures 4.6 to 4.7) are shown. Distance from the coast is challenging to remember without notable landmarks; as such, those boundaries ending in relatively open waters in Guimaras and Iloilo Straits zones are not necessarily limited to the polygons shown here in that regard.

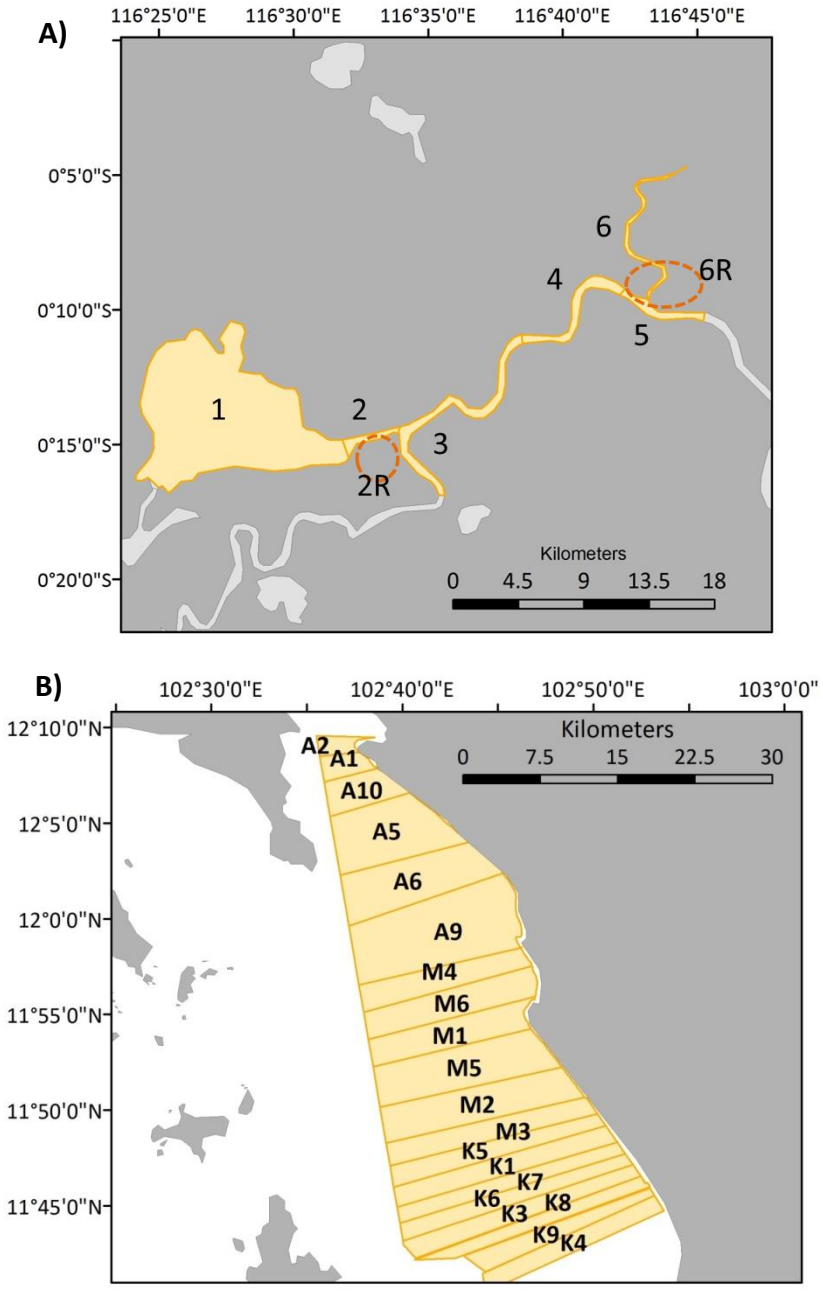


Figure 4.4. Zones used in RBSA interviews when asking fishers about fishing effort and locations of bycatch for (A) Mahakam River and (B) Trat Province coastline. Codes used for the zones in the fishing effort maps (Figures 4.8 to 4.9) are shown. Distance from the coast is challenging to remember without notable landmarks; as such, those boundaries ending in relatively open waters along the Trat coastline are not necessarily limited to the polygons shown here in that regard.

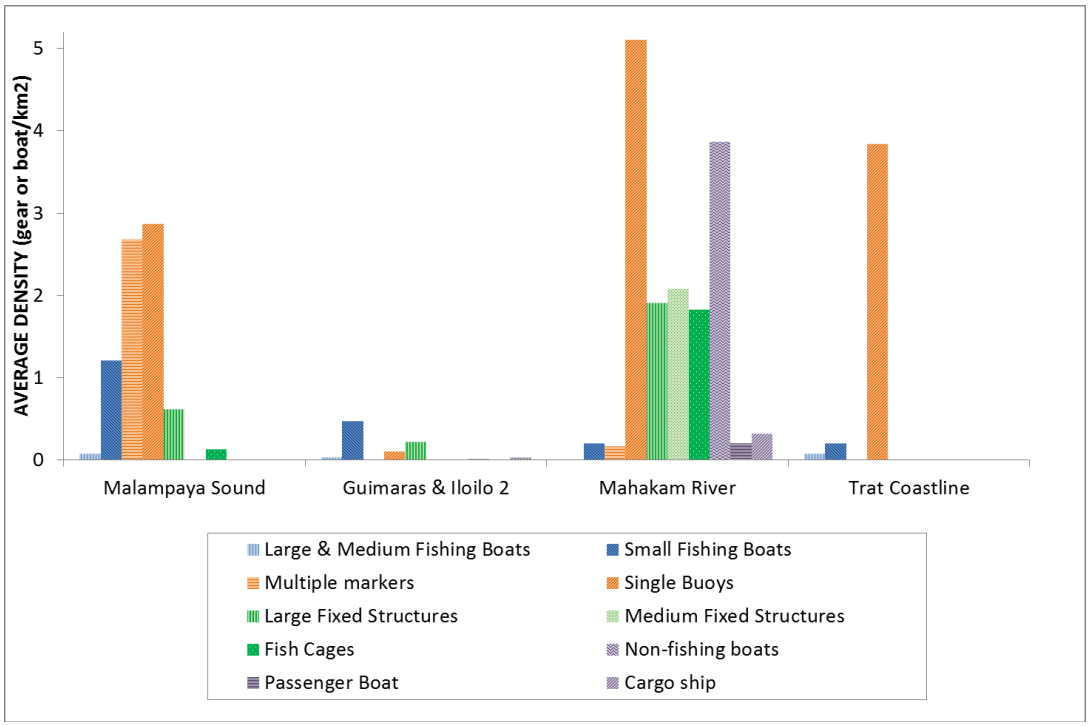


Figure 4.5. Densities of various human activity types, across sites.

ZONE	#RBSA	*Amihan*				*Habagat*						*Amihan*	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Z19		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Z18		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Z17		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Z16	4	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Z15	17	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Z14		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Z13		0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Z12		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Z11		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Z10		0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05
Z09		0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Z08	25	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Z07		0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
Z06	14	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.10
Z05	15	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08
Z04		0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05
Z03		0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
Z02		0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
Z01	7	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04

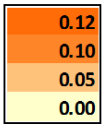


Figure 4.6. Months and zones where Bycatch 1 gears were reported to be used by respondents for Malampaya Sound (refer to Figure 4.3 for zones). For Malampaya Sound, most respondents reported the seasons of use rather than specific months; *amihan* is the northeast monsoon season (December through March), and *habagat* is the southwest monsoon (roughly June through late October). The numbers of respondents providing information on the seasonal and spatial use of bycatch gears is indicated next to the zone where their village is located; colors indicate the proportion (see legend) of all of these respondents reporting gear use in a given zone during a given month/season.

ZONE	#RBSA	*Amihan*				*Habagat*						*Amihan*	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ZAL		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
SAW	15	0.25	0.25	0.25	0.25	0.21	0.21	0.21	0.21	0.21	0.21	0.25	0.25
DAG1		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DAG2		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TAM	6	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08	0.08	0.08	0.11	0.11
TAC		0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.05	0.05
GET1		0.18	0.18	0.18	0.18	0.15	0.15	0.15	0.15	0.15	0.15	0.18	0.18
GET2	3	0.15	0.15	0.15	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.15	0.15
GET3		0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
SAN	14	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
NAV		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
BAC		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
TAN		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
UMI1		0.08	0.08	0.08	0.08	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.08
UMI2		0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03
AVI	9	0.11	0.11	0.11	0.11	0.16	0.16	0.16	0.16	0.16	0.16	0.11	0.11
EAS1	14	0.20	0.20	0.20	0.20	0.23	0.23	0.23	0.23	0.23	0.23	0.20	0.20
EAS2		0.20	0.20	0.20	0.20	0.25	0.25	0.25	0.25	0.25	0.25	0.20	0.20

0.34
0.30
0.25
0.20
0.15
0.10
0.05
0.00

Proportion of respondents

ZONE	#RBSA	*Amihan*				*Habagat*						*Amihan*	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
B1		0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
B2	7	0.30	0.30	0.30	0.30	0.32	0.32	0.32	0.32	0.32	0.32	0.30	0.30
B3	24	0.32	0.32	0.32	0.32	0.33	0.33	0.33	0.33	0.33	0.33	0.32	0.32
B4	21	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
P1	23	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
P2	2	0.47	0.47	0.47	0.47	0.45	0.45	0.45	0.45	0.45	0.45	0.47	0.47
P3	26	0.39	0.39	0.39	0.39	0.37	0.37	0.37	0.37	0.37	0.37	0.39	0.39
P4	5	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
P5	4	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11
VA		0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
GUIM		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	112												

0.51
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

Proportion of respondents

Figure 4.7. Months and zones where Bycatch 1 gears were reported to be used by respondents for Guimaras and Iloilo Straits (refer to Figure 4.3 for zones). See caption for Figure 4.6.

ZONE	#RBSA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		0.30	0.30	0.29	0.29	0.29	0.30	0.29	0.35	0.29	0.30	0.36	0.35
2	25	0.10	0.10	0.10	0.10	0.10	0.12	0.09	0.09	0.09	0.12	0.12	0.13
2R		0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07
3		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
4		0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
5		0.07	0.09	0.09	0.09	0.09	0.10	0.09	0.07	0.09	0.09	0.09	0.10
6	17	0.17	0.16	0.17	0.16	0.16	0.16	0.14	0.16	0.19	0.19	0.20	0.22
6R		0.12	0.10	0.12	0.10	0.10	0.10	0.10	0.12	0.14	0.14	0.16	0.17

N = 42

0.36
0.30
0.25
0.20
0.15
0.10
0.05
0.00

Proportion of respondents

Figure 4.8. Months and zones where Bycatch 1 gears were reported to be used by respondents for the Mahakam River (see Figure 4.4 for map of zones). See caption for Figure 4.6.

ZONE	#RBSA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A2	10	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12
A1	10	0.13	0.13	0.13	0.12	0.11	0.11	0.10	0.09	0.10	0.13	0.13	0.13
A10	8	0.09	0.08	0.08	0.07	0.06	0.06	0.05	0.05	0.05	0.08	0.09	0.09
A5	16	0.20	0.20	0.20	0.19	0.18	0.18	0.17	0.16	0.16	0.20	0.20	0.20
A6	1	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.06	0.06	0.09	0.09	0.09
A9	2	0.12	0.12	0.12	0.11	0.11	0.11	0.10	0.09	0.09	0.12	0.12	0.12
M4	32	0.25	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	0.25
M6		0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
M1	1	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
M5		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M2		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M3	20	0.13	0.13	0.14	0.13	0.15	0.15	0.15	0.13	0.13	0.13	0.13	0.13
K5		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K1	13	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
K6		0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
K7		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
K3		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
K8	15	0.09	0.09	0.09	0.09	0.09	0.09	0.12	0.12	0.12	0.12	0.11	0.09
K9		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
K4		0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
	128												

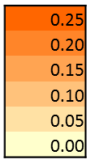


Figure 4.9. Months and zones where Bycatch 1 gears were reported to be used by respondents for the Trat province coastline (see Figure 4.4 for map of zones). See caption for Figure 4.6.

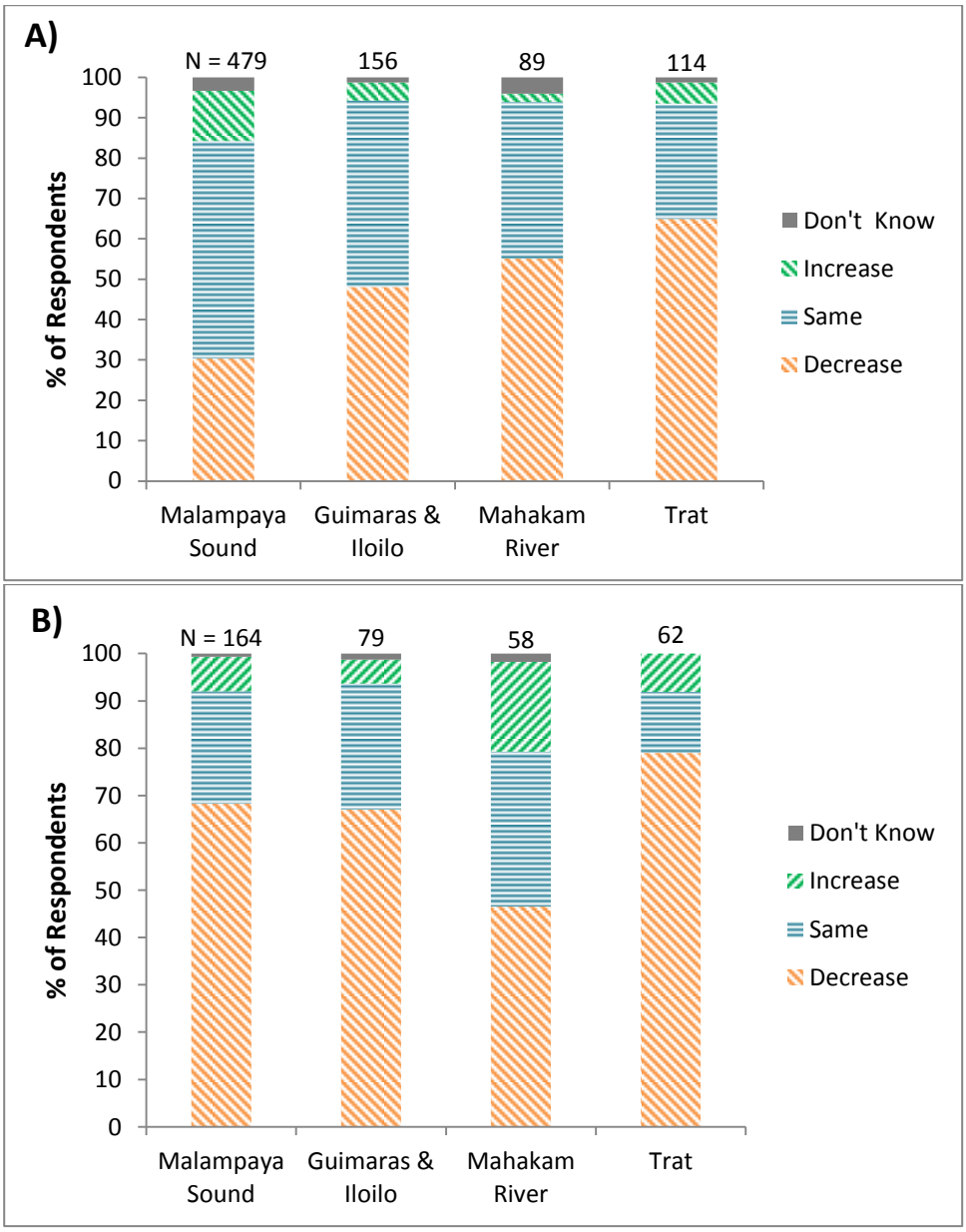


Figure 4.10. Perceived trends in dolphin abundance over (A) the past five years, and (B) the past 20 years, as reported by RBSA respondents at the five field sites. Comparisons of responses across sites using the χ^2 test yielded significant results for both (A) and (B).

	Malampaya Sound	Guimaras-Iloilo	Mahakam River	Trat
N	*313*	*108*	*67*	*92*
Fishing Effort	1.9 (1.2)	2.8 (0.7)	1.7 (0.6)	2.2 (0.7)
Ties to Fishing	2.5 (0.9)	2.1 (0.4)	2.3 (0.7)	2.5 (0.5)
General environmental perception	21.5 (3)	20.5 (4.1)	18.3 (4.6)	17.9 (3.7)
Perceptions of dolphins	5.4 (0.6)	5.2 (0.8)	4.4 (1.8)	5.2 (0.8)
Involvement	1.9 (4.2)	2.8 (2.2)	4.2 (6.2)	4.6 (2.9)
Perceptions of governance	2.9 (1.4)	3.2 (2.1)	3 (1.3)	2.8 (0.8)

Figure 4.11. Mean (with variance) RBSA scores for six of the eight attribute sets defined in Table 1 (other attribute sets were scored based on other data types). Darker colors indicate higher mean scores. Higher scores for the fishing effort and ties to fishing scores indicate a greater contribution, or potential contribution, to bycatch risk. Higher scores for the remaining four sets indicate attributes more conducive, at least conceptually, to development and implementation of conservation solutions.

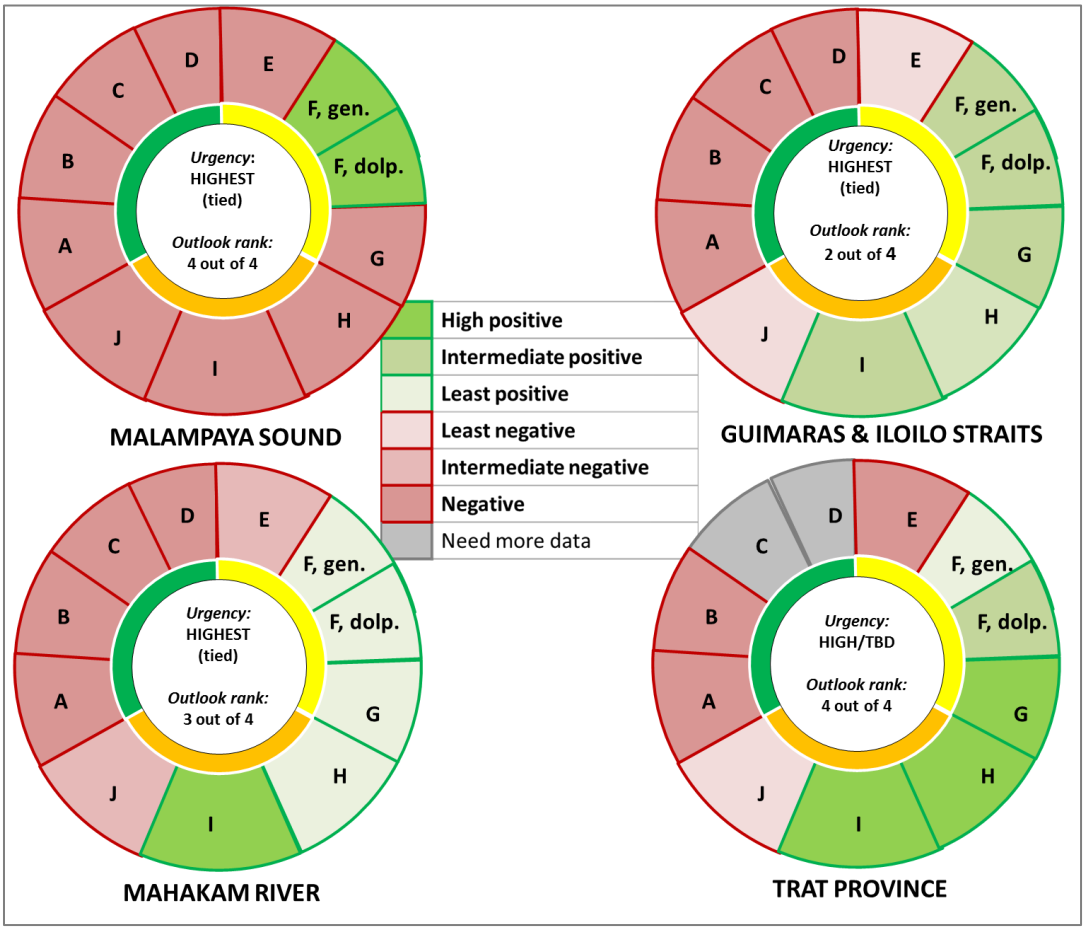


Figure 4.12. Exploratory conservation-scape score figures, to act as conservation-scape assessment scorecards , based on structure of the conservation-scape framework (see Figure 4.1 for attribute type codes A-J; "F, gen" denotes general environmental perceptions, while "F, dolp" denotes perceptions related to dolphins). Scorecards were filled based on comparisons across RBSA scores, key informant, and boat survey data across sites (see Chapter 3).

TABLES

Table 4.1. Rapid Bycatch & Socioeconomic Assessment (RBSA) and other attributes used to compose scores for Fishing Effort, Ties to Fishing, General Environmental Perception, Perceptions of Dolphins, Involvement, and Perception of Governance Effectiveness.

Score type	Attribute	Data Type	Score Assignment
FISHING EFFORT	USE BYCATCH GEAR	0 (no), 1 (yes)	Same
	RELIANT ON BYCATCH GEAR	0 (no), 1 (yes)	Reversed
	CHANGE FISHING (5Y)	More, Same, Less	More = 2, Same = 1, Less = 0
TIES TO FISHING	PRIMARY LIVELIHOOD	Yes, No	Yes = 1, N = 0
	REASON OTHER THAN INCOME/FOOD	0, 1	Same
	CHILDREN TO FISH	Yes, Maybe, No	Yes = 2, Maybe = 1, No = 0
GENERAL ENV. PERC.	CHANGE CATCH (5YA)	More, Same, Less	More = 2, Same = 1, Less = 0
	MORE FISH BEFORE	1 to 5 (no to yes)	Same
	ENOUGH FUTURE	1 to 5 (no to yes)	Reversed
	PROTECT NON COMM	1 to 5 (no to yes)	Same
	PROTECT HABITAT	1 to 5 (no to yes)	Same
	LOCAL RESOURCES	1 to 5 (no to yes)	Reversed
RE: DOLPHINS	CHANGE DOLPHINS (5YA)	More, Same, Less	More = 2, Same = 1, Less = 0
	POSITIVE	0 (no), 1 (yes)	Same
	NEGATIVE ONLY	0 (no), 1 (yes)	Reversed
	IMPORTANT TO PROTECT	Yes, Somewhat, No	Yes = 2, Maybe = 1, No = 0

Table 4.1, Rapid Bycatch & Socioeconomic Assessment (RBSA) and other attributes used to compose scores for Fishing Effort, Ties to Fishing, General Environmental Perception, Perceptions of Dolphins, Involvement, and Perception of Governance Effectiveness, cont'd:

Score type	Attribute	Data Type	Score Assignment
GENERAL DEMOG./ SOCIAL	RES LIFE	Yes, No	Yes = 1, N = 0
	YEARS FISHING	Bins (15 yrs)	Same
	COMMUNITY INFRASTRUCTURE	*KI INTERVIEW*	
	LIVELIHOODS ACCESS	*KI INTERVIEW*	
GENERAL GOV.	INSTITUTIONS	*KI INTERVIEW*	
GOV. - ACTIVITIES	INVOLVED	0 (no), 1 (yes)	Same
	MAXIMUM INV. MAGNITUDE	0 to 4	Same
	COMMUNITY GROUP	0 (no), 1 (yes)	Same
	NGO	0 (no), 1 (yes)	Same
	LOCAL GOVERNMENT	0 (no), 1 (yes)	Same
	EXTERNAL GOVERNMENT	0 (no), 1 (yes)	Same
	RESEARCH	0 (no), 1 (yes)	Same
	DETAILED INFORMATION	*KI INTERVIEW*	
GOV - EFFECTIVENESS	PERCIEVED	1 to 5 (no to yes)	Same
	DETAILED INFORMATION	*KI INTERVIEW*	

Table 4.2. Summary of all attributes compared using χ^2 test for independence; every attribute tested yielded p-values of 0.01 or smaller. The table number where the attribute and similar attributes are presented above is provided.

Compared across sites:	χ^2	**p value**	**Table #**
Lifelong residents	62.6	<0.01	4.10
Moved here for livelihood	135.94	<0.01	4.11
Changed gears (5 ya)	66.14	<0.01	4.8
Change in fishing effort (5ya)	81.43	<0.01	4.8
Change in catch (5ya)	159.57	<0.01	4.15
Change in earnings (5ya)	89.84	<0.01	4.13
Earnings support household	317.81	<0.01	4.13
Fishing as primary livelihood	19.07	<0.01	4.12
Ties other than income/food	62.57	<0.01	4.12
Children to fish	93.46	<0.01	4.14
More fish before	113.6	<0.01	4.16
Enough fish for future generations	391.28	<0.01	4.16
Site is overfished	58.63	<0.01	4.16
Important to protect non-commercial	133.65	<0.01	4.17
Important to protect habitat	34.66	<0.01	4.17
Local resources are in good condition	155.01	<0.01	4.16
Want to conserve	16.73	0.01	4.17
Governance is effective	29.66	<0.01	4.17
Change in dolphins (5ya)	118.08	<0.01	*Fig* 4.10
Change in dolphins (20ya)	23.56	<0.01	*Fig* 4.10
Positive perceptions of dolphins	34.66	<0.01	4.20
Negative perceptions of dolphins	32.7	<0.01	4.20
Dolphins important	202.67	<0.01	4.20
Important to protect dolphins	138.96	<0.01	4.20
Dolphins are threatened	71.54	<0.01	4.19
Previous involvement	138.36	<0.01	4.21
Community groups	432.78	<0.01	4.21
NGO	66.35	<0.01	4.21
Local government	59.38	<0.01	4.21
External government	186.98	<0.01	4.21
Research	169.32	<0.01	4.21

Table 4.3. Summary of number of mortalities and non-fatal entanglements by gear type. E denotes number of animals eaten after being found dead, while K denotes animals that were killed and eaten. Boat strikes are included as an additional anthropogenic cause of mortality. Rope line refers to seaweed farm line in Malampaya Sound, and for rope connecting a buoy to an unspecified gear type in Trat.

		Malampaya Sound	**Guimaras & Iloilo**	**Mahakam River**	**Trat**
Gillnet	Mortalities	12 (4E, 1K)	5(2E, 1K)	3	10 (1E)
	Non-fatal	3	5	2	2
Trap	Mortalities	4 (2E)			4
	Non-fatal	2			
Fixed net structures	Mortalities	1			
	Non-fatal		2		
Fish Corral	Mortalities		1		
	Non-fatal				
Rope lines	Mortalities	1			1
	Non-fatal				
Longline	Mortalities	1		2	1
	Non-fatal				
Medium-large boats	Mortalities				7
	Non-fatal	2	1		
Boat strike	Mortalities		2		

Table 4.4. Fishing gears involved in entanglements. Bycatch 1 for Malampaya Sound denotes the predominant gears reported in entanglements from 2009 to 2011; for all other sites, Bycatch 1 denotes any gear reported involved in the most recent three-year period. All bycatch refers to any other gear reported in entanglements in previous years. For Guimaras and Iloilo Straits, boat strikes were also mentioned as an anthropogenic cause of dolphin mortality. For Trap, "rope" refers to the line connecting markers to gears, though respondents could not provide more detail on the exact type of gear involved. For Guimaras and Iloilo Straits and the Mahakam River, a wide range of gillnets were reported as involved in entanglements, with some respondents unable to provide specific information on gillnet type; as such, any gillnet was included here.

	Malampaya Sound	**Guimaras & Iloilo**	**Mahakam River**	**Trat**
BYCATCH 1	Gillnet 4	Various gillnets	Various gillnets	Crab net
	Crab pot	Fixed net structure	Longline	Fish net
		Fish corral		Octopus net
		Trawl		Shrimp net
				Octopus trap
				Longline
				Rope
				Trawl/pair-trawl
ALL BYCATCH	Liftnet	Longline		Crab trap
	Fish corral	Danish seine		Squid trap
	Baby purse seine	*Boat strike*		Pushnet
	Ring net			Floating seine
	Encircling gillnet			
	Danish seine			
	Other gillnets			
	Longline			

Table 4.5. Summary of the number of estimated bycatch mortalities and non-fatal entanglements for 2009 through 2011 for Malampaya Sound and Guimaras and Iloilo Straits, and for 2010 through 2012 for the Mahakam River and Trat Province, with the calculated potential biological removal (PBR, using a conservative recovery factor of 0.5) for all sites with population estimates.

	Year	Malampaya Sound	Guimaras & Iloilo	Year	Mahakam River	Trat Province
Bycatch Mortalities	*2011*	3	4	*2012*	2	5
	2010	10	0	*2011*	2	12
	2009	6	2	*2010*	1	4
Entanglements (non-fatal)	*2011*	1	4	*2012*	2	1
	2010	3	3	*2011*	0	1
	2009	3	0	*2010*	0	1
PBR (F_r = 0.5)		0.29	0.21		0.8	TBD
Population estimate source:		Whitty in prep.	Dolar in prep.		Kreb & Budiono 2005	Hines, pers. Comm.

Table 4.6. Average densities of various human activity (HA) types at each site, as the number of gear or boats per km^2.

		Malampaya Sound	Iloilo Strait	Guimaras Strat	Mahakam River	Trat Coastline
Fishing Boats	Large					0.03
	Medium	0.06		0.02		0.03
	Small	1.20	0.46	0.46	0.19	0.19
Buoys/Markers	Multiple	2.67	0.18		0.15	
	Single	2.86	2.34	0.09	5.10	3.83
Fixed Structures	Large	0.60	1.43	0.20	1.89	0.01
	Medium				2.07	
	Fish Cages	0.12			1.82	
Non-fishing boats	All	<0.01	0.19	0.02	3.86	<0.01
	Passenger	<0.01	0.11	<0.01	0.19	<0.01
	Cargo		0.08	0.02	0.31	

Table 4.7. Metrics of gear use at each site: number of fishing gears currently used by respondents, whether respondents reported using Byatch 1 gears, whether respondents reported using any bycatch gears at all (Bycatch 1 and 2), and whether respondents used only bycatch gears or fished with other, non-bycatch-related gears as well.

		Malampaya Sound	**Guimaras & Iloilo**	**Mahakam River**	**Trat**
	N	*513*	*188*	*91*	*133*
# OF GEARS	1	60.6	82.4	16.5	32.3
	2	30.8	14.9	38.5	51.1
	3	5.8	2.7	33.0	16.5
	4 to 6	2.7	0.0	12.1	0.0
BYCATCH 1 GEAR	No	62.8	16.8	23.1	5.3
	Yes	41.2	83.2	76.9	94.7
ANY BYCATCH GEAR	No	23.1	14.7	19.4	27.8
	Yes	76.9	85.3	80.6	72.2
RELIANCE ON BYCATCH GEAR	All	60.2	79.6	9.9	79.7
	Has other	39.8	20.4	90.1	20.3

Table 4.8 . Change in gear type over the past five years, and change in the time spent fishing compared to five and 20 years ago (increased, meaning they spend more time fishing now; same; or decrease, meaning they spend less time fishing now). Percentage of respondents adding and switching from bycatch gears is shown as a potential indicator of whether bycatch gear use might be increasing or decreasing. A common explanation for various changes in time spent fishing over the past 5 years was "increased difficulty of fishing" due to decreased resources and increased fishing pressure; this explanation was offered as a response by fishers who increase, decreased, and did not change their fishing effort. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	**Guimaras & Iloilo**	**Mahakam River**	**Trat**	
CHANGE GEAR IN PAST 5 YRS	*N*	*490*	*185*	*85*	*128*	
	Same	58.8	88.1	78.6	62.7	*
	Changed	41.2	11.9	21.4	37.3	
Add Bycatch 1 gear?	No	89.4	94.1	81.2	90.6	
	Yes	10.6	5.9	18.8	9.4	
Drop Bycatch 1 gear?	No	93.5	97.8	96.5	93.0	
	Yes	6.5	2.2	3.5	7.0	
Add bycatch gear?	No	78.2	94.1	81.2	90.6	
	Yes	21.8	5.9	18.8	9.4	
Drop any bycatch gear?	No	79.0	95.1	96.5	93.0	
	Yes	21.0	4.9	3.5	7.0	
TIME COMPARED TO 5 YA	*N*	*425*	*181*	*87*	*125*	
	Increase	44.0	11.6	16.1	22.4	*
	Same	42.1	68.0	69.0	57.6	
	Decrease	13.9	20.4	14.9	20.0	
In response to increased difficulty	*N*	*311*	*154*	*26*	*72*	
	Increase	48.9	12.3	46.2	33.3	
	Same	7.1	4.5	0	45.8	
	Decrease	11.6	18.8	23.1	8.3	
TIME COMPARED TO 20 YA	*N*	*337*	*111*	*63*	*96*	
	Increase	49.6	14.4	47.6	44.8	
	Same	33.5	56.8	31.7	45.8	
	Decrease	16.9	28.8	20.6	9.4	

Table 4.9. Summary of Rapid Bycatch and Socioeconomic Assesssment respondents' gender, age bin, and number of years fishing (as percentage of respondents from each site within each bin).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat
# of RBSAs used		525	191	91	133
Female (N)		2	6	0	11
Male (N)		262	142	89	121
AGE	*N*	*514*	*190*	*91*	*133*
	15 to 30	28.8	17.9	8.8	7.5
	31 to 45	39.3	44.7	46.2	33.8
	46 to 60	25.3	28.4	23.1	49.6
	Over 60	6.6	8.9	22.0	9.0
YEARS FISHING	*N*	*513*	*191*	*91*	*133*
	Up to 15 yrs	45.8	32.5	20.9	27.8
	0 to 5	*11.3*	*7.3*	*2.2*	*9.0*
	6 to 10	*17.0*	*11.5*	*11.0*	*12.8*
	11 to 15	*17.5*	*13.6*	*7.7*	*6.0*
	16 to 30	38.8	40.8	44.0	48.9
	31 to 45	12.9	19.4	20.9	18.8
	Over 45	2.5	7.3	14.3	4.5

Table 4.10. Residence time information for RBSA respondents, in addition to information on the origin of respondents who had migrated to the site. Local origin means that the respondent moved from within the same province. Diversity of in-migrant province of origin is displayed as the calculated Shannon index. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
LIFELONG RESIDENT (%)	*N*	*513*	*190*	*91*	*133*	
	Yes	47.4	80.5	59.3	54.1	*
	No	52.6	19.5	40.7	45.9	
YEARS LIVING AT SITE (%)	Up to 5	3.9	3.7	8.8	4.5	
	6 to 10	3.7	0.5	2.2	4.5	
	11 to 15	5.7	3.2	1.1	0.8	
	16 to 30	38.6	21.7	25.3	16.5	
	31 to 45	29.8	40.2	36.3	42.9	
	46 to 60	17.3	23.3	16.5	27.8	
	Over 60	1.0	7.4	9.9	3.0	
IN-MIGRANT ORIGIN (%)	*N*	*268*	*37*	*34*	*60*	
	LOCAL	28.4	54.1	82.4	31.7	
	OTHER COUNTRY	0.0	0.0	0.0	51.7	
	OTHER PROVINCE	71.6	45.9	17.6	16.7	
	In-migrant provincial diversity (Shannon Index)	2.8	1.6	0.0	0.8	
	# of Origin Provinces	31	6	1	5	
OUT-MIGRATION (%)	*N*	*354*	*146*	*89*	*131*	
	No	45.5	48.6	37.1	67.2	
	Yes	54.5	51.4	62.9	32.8	

Table 4.11. For those respondents who in-migrated to the field sites, percentage reporting motivation for moving as coded into the categories below. "Avoiding floods" is specific to the Mahakam River, where several respondents moved to their current village to avoid the flooding that was problematic at their previous, neighboring village. "Adventure/vacation" means that the respondent traveled to the site on vacation or seeking adventure, liked what they encountered, and decided to stay. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras-Iloilo	Mahakam River	Trat	
	N	*270*	*37*	*37*	*61*	
FAMILY	**ALL**	**32.6**	**75.7**	**59.5**	**37.7**	
	Family moved here	17.4	13.5	5.4	18.0	
	Family here already	8.5	18.9	2.7	6.6	
	Married here	5.9	40.5	48.6	13.1	
	Family - other	0.7	0.0	2.7	0.0	
	Due to family conflict	0.0	2.7	0.0	0.0	
LIVELIHOOD	**ALL**	**73.0**	**2.7**	**32.4**	**18.0**	*
	Better livelihood	34.4	0.0	0.0	1.6	
	Good fishing here	29.6	0.0	2.7	3.3	
	For work	7.0	2.7	10.8	11.5	
QUALITY OF LIFE	**ALL**	**11.5**	**24.3**	**5.4**	**42.6**	
	Better life here	8.9	10.8	5.4	0.0	
	Avoiding conflict	2.2	10.8	0.0	42.6	
	Peaceful here	0.4	2.7	0.0	0.0	
OTHER	**ALL**	5.9	0.0	18.9	3.3	
	Avoiding floods	0.0	0.0	16.2	0.0	
	Adventure/vacation	3.0	0	0.0	0.0	
	Other	1.9	0.0	2.7	1.6	
	Don't know	1.1	0.0	0.0	1.6	

Table 4.12. Percent of respondents reporting fishing as their primary livelihood (defined as source of food and/or income), and the reasons reported by respondents for fishing (respondents could list more than one reason). "Supp" means supplementary. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
Primary livelihood	*N*	*525*	*190*	*91*	*133*	
	Yes	94.5	88.9	82.4	94.0	*
	No	5.5	11.1	17.6	6.0	
Reasons for fishing	*N*	*373*	*147*	*89*	*133*	
	Primary income	95.4	89.8	96.6	99.2	
	Supp. income	5.1	12.2	1.1	0.8	
	Primary food source	7.0	69.4	76.4	31.6	
	Supp. food source	91.2	31.3	1.1	62.4	
	Easier than other work	94.1	86.4	83.1	88.0	
	Tradition	81.0	79.6	68.5	95.5	
	Enjoy it	57.1	95.9	18.0	15.8	
	No other options	79.1	51.7	76.4	66.2	

Table 4.13. Trends in earnings (net income) from fishing since 5 and 20 years ago, and respondent perceptions on whether earnings from fishing alone are enough to provide for general household needs, excluding medical care and education for children. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
Earnings from fishing over past 5 years	*N*	*366*	*181*	*88*	*125*	*
	Increased	4.1	3.9	9.1	28.8	
	Decreased	66.9	72.4	50.0	47.2	
	Same	29.0	23.8	40.9	24.0	
Earnings from fishing over past 20 years	*N*	*333*	*109*	*88*	*95*	
	Don't know	0.3	0	27.3	0.0	
	Increased	4.8	5.5	36.4	35.8	
	Decreased	70.6	74.3	29.5	50.5	
	Same	24.3	20.2	6.8	13.7	
Fishing earnings sufficient for household needs	*N*	*524*	*148*	*89*	*133*	*
	Don't know	0.6	0.0	0.0	0.0	
	No	27.3	31.1	0.0	4.5	
	Sometimes	1.5	0.0	50.6	38.3	
	Yes	70.6	68.9	49.4	57.1	

Table 4.14. Percent of respondents whose parents and grandparents fished, and whether respondents would like for their children to be fishers when they grow up. For those responding "yes" or "no", the top reasons provided are shown. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
PARENTS FISHED	*N*	*514*	*189*	*89*	*131*	
	Yes	79.6	77.2	92.1	67.2	
	No	20.4	22.8	7.9	32.8	
G.PARENTS FISHED	*N*	*514*	*191*	*89*	*131*	
	Yes	53.5	61.3	84.3	40.5	
	No	36.2	27.7	12.4	55.7	
	Don't Know	10.3	11.0	3.4	3.8	
CHILDREN TO FISH	*N*	*509*	*189*	*80*	*118*	
	Yes	24.8	11.1	10.0	8.5	
	Depends	7.5	2.1	16.7	28.0	*
	No	67.2	86.2	70.0	61.0	
	Don't Know	0.6	0.5	3.3	2.5	
Reasons for "No"	*N*	*342*	*163*	*65*	*72*	
	Difficult	44.2	55.2	4.6	50.0	
	Catch decrease	19.0	3.1	7.7	26.4	
	Prefer edu.	23.1	8.6	40.0	9.7	
	Want better job	6.4	29.4	29.2	5.6	
	Depends	1.5	1.8	1.5	2.8	
	Low Income	4.4	14.7	9.2	1.4	
	Gender	0.9	0.0	0.0	2.8	
Reasons for "Yes"	*N*	*126*	*21*	*9*	*10*	
	No option	23.8	42.9	11.1	30.0	
	Good job	19.0	4.8	0.0	40.0	
	Tradition	18.3	19.0	44.4	30.0	
	Depends	17.5	0.0	11.1	0.0	
	Income	11.1	33.3	33.3	0.0	
	Can't afford edu.	8.7	9.5	0.0	0.0	

Table 4.15. Perceived trends in catch size (total weight) over the past 5, 10, and 20 years. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
CATCH 5YA	*N*	*507*	*179*	*84*	*125*	
	Increase	0.6	2.2	2.4	22.4	*
	Decrease	90.9	82.1	67.9	61.6	
	Same	8.5	15.6	29.8	16	
CATCH 10YA	*N*	*17*	*70*	*79*	*112*	
	Increase	0	0	1.3	8.0	
	Decrease	94.1	94.3	86.1	88.4	
	Same	5.9	5.7	12.7	3.6	
CATCH 20YA	*N*	*313*	*111*	*62*	*95*	
	Increase	1.0	0	3.2	4.2	
	Decrease	94.2	93.7	96.8	95.8	
	Same	4.8	6.3	0	0	

Table 4.16. Perceptions regarding the condition of local fisheries and marine resources. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
There were more shrimp, crabs, shimp, etc., before	*N*	*373*	*190*	*88*	*133*	
	Strong No	0.0	1.1	4.5	0.0	
	No	0.8	0.0	20.5	4.5	*
	Somewhat	1.3	3.7	2.3	1.5	
	Yes	21.7	6.8	36.4	39.8	
	Strong Yes	76.1	88.4	36.4	54.1	
There will be enough fish for future generations	*N*	*378*	*190*	*90*	*133*	
	Don't Know	1.3	4.2	7.8	1.5	
	Strong No	28.0	47.9	20.0	2.3	*
	No	67.2	14.2	56.7	6.0	
	Somewhat	1.9	15.8	3.3	43.6	
	Yes	1.3	5.8	8.9	42.1	
	Strong Yes	0.3	12.1	3.3	4.5	
Catch has decreased due to too much fishing	*N*	*375*	*190*	*90*	*133*	
	Don't Know	0.5	2.6	4.4	0.8	
	Strong No	0.5	8.4	2.2	0.0	*
	No	9.1	15.8	21.1	6.0	
	Somewhat	9.6	10.5	21.1	6.0	
	Yes	37.6	16.3	43.3	51.9	
	Strong Yes	42.7	46.3	7.8	35.3	
Local marine/aquatic resources in good condition	*N*	*366*	*148*	*90*	*133*	
	Strong No	8.2	4.7	0.0	0.8	
	No	51.6	18.9	30.0	10.5	*
	Somewhat	13.9	16.9	4.4	33.1	
	Yes	23.5	27.0	54.4	51.9	
	Strong Yes	2.7	32.4	11.1	3.8	

Table 4.17. Perceptions related to importance of conservation and effectiveness of current marine/aquatic resource management. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
Important to protect non-commercial species	*N*	*372*	*148*	*87*	*130*	
	No	0.0	0.0	17.2	12.3	
	Somewhat	0.3	1.4	13.8	6.2	*
	Yes	50.3	13.5	55.2	56.9	
	Strong Yes	49.5	85.1	13.8	24.6	
Important to protect habitat	*N*	*371*	*148*	*87*	*133*	
	Strong No	0.0	0.0	1.1	0.0	
	No	0.3	0.0	4.6	0.0	*
	Somewhat	0.5	0.0	2.3	0.8	
	Yes	35.3	6.8	64.4	57.1	
	Strong Yes	63.9	93.2	27.6	42.1	
Want to conserve for future generations	*N*	*355*	*190*	*88*	*132*	
	Strong No	1.4	0.0	0.0	0.0	
	No	1.7	0.0	3.4	0.0	*
	Somewhat	0.0	1.1	2.3	0.8	
	Yes	25.6	7.4	48.9	74.2	
	Strong Yes	71.3	91.6	45.5	25.0	
Current management is effective	*N*	*336*	*148*	*75*	*117*	
	Don't Know	10.7	0.0	17.3	13.7	
	Strong No	9.8	14.2	4.0	11.1	*
	No	41.7	25.0	40.0	34.2	
	Somewhat	8.6	8.1	9.3	23.1	
	Yes	28.6	26.4	34.7	29.9	
	Strong Yes	11.3	26.4	12.0	1.7	

Table 4.18. Responses to the open-ended question, "Why has the number of dolphins increased, decreased, or stayed the same over the past five years?". Responses related to trends in dolphin numbers were coded to the categories below, from those respondents noting (A) a decline, (B) no change, and (C) an increase.

A. Reason for Perceived Decrease	Malampaya Sound	Guimaras-Iloilo	Mahakam River	Trat
	N = 311	*N = 49*	*N = 27*	*N = 56*
Sees fewer	39.2	2.0	0.0	0.0
Bycatch	***8.2***	***16.3***	***2.1***	***23.1***
Don't know	3.7	10.2	8.3	20.0
Prey depletion	3.4	28.6	6.3	1.5
More fishing now	3.7	12.2	2.1	10.8
Behavior change	8.6	12.2	2.1	3.1
Harmed/Disturbed	4.8	10.2	4.2	12.3
Disturbed by boats	0.3	24.5	2.1	0.0
Env. Degradation	1.1	10.2	10.4	0.0
Follow food	1.1	0.0	0.0	9.2
Natural process	0.9	10.2	4.2	0.0

B. Reason for No Perceived Change	Malampaya Sound	Guimaras-Iloilo	Mahakam River	Trat
	N = 110	*N = 33*	*N = 18*	*N = 6*
Not caught/harmed	***13.6***	***33.3***	***5.6***	***50***
Natural	5.5	12.1	11.1	0
Move	1.8	21.2	22.2	0
Rare, so hard to tell	10.0	0.0	11.1	0
Don't know	0.0	9.1	0.0	16.7
More fishing effort	0.9	0.0	16.7	33.3
Bycatch	***1.8***	***3.0***	***22.2***	***16.7***
Disturbed by boats	0.0	0.0	5.6	0
Sees fewer	1.8	3.0	16.7	0
Follow food	0.9	0.0	0.0	0
Prey depletion	0.0	6.1	5.6	0

Table 4.18, Responses to the open-ended question, "Why has the number of dolphins increased, decreased, or stayed the same over the past five years?", cont'd:

C. Reason for Perceived Increase	Malampaya Sound	Guimaras-Iloilo	Mahakam River	Trat
	N = 19	*N = 7*	*N = 10*	*N = 14*
Natural	31.6	42.9	50.0	0
Not caught/harmed	***15.8***	***0.0***	***50.0***	***7.1***
Sees more	31.6	14.3	0.0	14.3
Follow food	0.0	0.0	0.0	57.1
Plenty prey	0.0	28.6	0.0	14.3
Conservation	0.0	0.0	0.0	21.4
Fishing change	10.5	0.0	0.0	7.1
Move	0.0	0.0	0.0	14.3
Past capture	0.0	28.6	0.0	0

Table 4.19. Responses to "Are dolphins threatened/at risk of extinction?" (this was not included in the interviews at Trat); the "*" denotes that this was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

Are dolphins threatened?	Malampaya Sound	Guimaras-Iloilo	Mahakam River	Trat	
	N = 524	*N = 148*	*N = 91*	*N/A*	
Yes	16.2	15.4	36.6		
Maybe	7.4	1.1	13.5		*
No	73.0	75.8	40.5		
Don't know	3.4	7.7	9.4		

Table 4.20. Perceptions about dolphins – are they important, is dolphin conservation important, and were the explanations expressed by the respondent categorized as "positive", "negative" (but mixed with other, positive responses), or "negative only"? As indicated by the "*", all of these attributes were compared across sites with a χ^2 test, with significant p-values (see Table 4.2).

	Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
Dolphins Important?	*N=374*	*N = 130*	*N = 89*	*N = 133*	
Yes, Important	97.8	93.8	47.2	78.2	
Somewhat Important	0.5	0.8	24.7	9.8	*
Not Important	0.3	5.4	27.0	6.8	
Don't Know	1.3	0.0	1.1	5.3	
Conserving Dolphins Important?	*N = 525*	*N = 190*	*N = 89*	*N =133*	
Yes, Important	96.8	94.7	71.9	97.7	
Somewhat Important	1.0	0.0	18.0	0.0	*
Not Important	1.3	3.7	10.1	0.8	
Don't Know	1.0	1.6	0.0	1.5	
Opinion of Dolphins	*N = 524*	*N = 166*	*N = 88*	*N =133*	
Positive	95.8	97.0	97.7	97.7	
Negative	9.9	15.1	30.7	6.8	*
Negative Only	2.9	1.2	3.4	0.8	

Table 4.21. Description of previous involvement in activities (interviews, meetings, seminars, trainings, research) related to marine conservation or fisheries management. Magnitude of involvement was rated from 1 to 4, with 1 indicating one-time participation, 2 indicating participation in "some" (2 to 3) activities, 3 indicating regular participation (on an ongoing basis), and 4 indicating a high level of involvement, such as a leadership position. Institution type indicates the type of entity that conducted the activity: community group, NGO, local government unit (municipal or village; LGU), provincial or national government (GOV), or research group/ university. Magnitude of participation in activities where dolphin conservation was the topic is also noted. "*" denotes that this attribute was compared across sites with a χ^2 test, with a significant p-value (see Table 4.2).

		Malampaya Sound	Guimaras & Iloilo	Mahakam River	Trat	
Any involvement	*N*	*525*	*191*	*91*	*133*	
	Yes	43.2	70.7	74.7	93.2	*
	No	56.8	29.3	25.3	6.8	
	N	*227*	*135*	*68*	*124*	
Maximum involvement magnitude	1 (Once)	34.3	66.5	8.8	11.3	
	2 (Some)	4.8	0.5	4.4	16.5	
	3 (Regular)	1.7	1.0	61.5	65.4	
	4 (Highly involved)	1.7	1.0	0	0	
Sum of involvement magnitudes	1	20.4	46.1	6.6	7.5	
	2 to 3	14.9	22.5	28.6	38.3	
	4 to 6	5.7	1.0	27.5	29.3	
	7 to 9	1.1	0.5	7.7	15.0	
	10+	0.6	0.5	3.3	3.0	
Institution type	Community	0.0	2.2	77.9	68.6	
	NGO	55.1	0.7	11.8	10.5	
	LGU	40.5	40.0	11.8	48.4	*
	GOV	31.3	21.5	47.1	72.6	
	Research	10.6	55.6	26.5	2.4	
Magnitude for Activities re: Dolphins	*N*	*525*	*191*	*91*	*133*	
	None	89.0	81.1	62.3	68.4	
	Once	9.9	15.2	36.1	10.5	
	Some	1.1	2.9	0.0	12.0	
	Regular	0.0	0.8	1.0	8.3	
	Highly involved	0.0	0.0	0.5	0.8	

Table 4.22. Summary of $\chi 2$ and Fisher's exact tests run across bins of "# of years fishing", involvement (whether respondent reported being involved in any previous activities related to marine conservation or fisheries management), and involvement in activities where the topic was dolphin conservation. "-" in the $\chi 2$ column indicates that Fisher's exact test was run due to small sample size. Comparisons yielding a p-value of 0.05 or smaller are shown in bold.

	Malampaya Sound		Guimaras & Iloilo		Mahakam River		Trat	
Across Years Fishing (bins)	$\chi 2$	*p value*	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*
More fish before	-	0.48	-	0.52	-	0.91	-	0.9
Local resources in good condition	8.14	0.23	6.22	0.4	4.75	0.59	7.17	0.3
Important to protect dolphins	1.25	0.98	0.71	1	4.05	0.69	4.27	0.2
Uses bycatch gear	**9.49**	**0.02**	2.27	0.56	0.53	0.94	4.06	0.25
Uses bycatch 1 gear	0.6	0.9	0.87	0.83	0.53	0.94	4.06	0.25
Reliant on bycatch gear	**19**	**<0.01**	1.57	0.68	3	0.45	3.6	0.3
Perception re: governance	-	0.34	-	0.28	-	1	-	1
Across Involvement (Y/N)	$\chi 2$	*p value*	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*
More fish before	3.6	0.21	-	0.22	**17.08**	**<0.01**	-	1
Enough for future generations	0.07	1	1.5	0.49	0.23	1	4.55	0.09
Catch reduced due to overfishing	0.93	0.65	1.12	0.6	**6.5**	**0.04**	0.993	0.88
Local resources in good condition	**6.04**	**0.05**	2.01	0.38	**10.55**	**<0.01**	0.59	0.79
Wants to conserve resources	3.4	0.12	-	1	3.5	0.2	-	1
Important to protect dolphins	0.56	0.9	0.01	1	4.29	0.12	-	0.07
Across Involvement in Dolphin Activities (Y/N)	$\chi 2$	*p value*	χ^2	*p value*	χ^2	*p value*	χ^2	*p value*
Dolphins are important	-	1	-	0.83	4.71	0.09	0.51	0.87
Important to protect dolphins	4.1	0.09	0.11	1	2.05	0.43	-	1
Change in dolphin numbers	1.56	0.48	2.81	0.25	1.31	0.54	0.14	0.94

Table 4.23. Percent tables for the χ2 test comparing "Years fishing" (in 15 year bins) among respondents in Malampaya Sound, for whether respondents use bycatch gear, and whether respondents rely solely on bycatch gear in their fishing.

N = 513		Doesn't use bycatch gear	Uses bycatch gear	Has other gears	Uses only bycatch gear
Years Fishing	15	19.6	80.4	51.5	48.5
	30	31.2	68.8	33.2	66.8
	45	30.3	69.7	33.3	66.7
	70	38.5	61.5	23.1	76.9
		χ2 = 9.49, p = 0.02		χ2 = 19, p < 0.01	

Table 4.24. Percent tables for the χ2 test comparing various environmental condition perception responses across respondents who had and had not been involved in activities related to marine conservation and fisheries management, at the Mahakam River. The original responses were on a Likert scale with 5 possible responses, which were pooled into 3 to yield larger sample sizes ("strong no" and "no" combined into "no", and "strong yes" and "yes" combined into "yes").

Question?	Involvement	No	Somewhat	Yes	N	χ2	p-value
More fish before	Not involved	60.0	0.0	40.0	88	17.08	<0.01
	Involved	14.7	2.9	82.4			
Overfishing	Not involved	13.6	40.9	45.5	86	6.5	0.04
	Involved	28.1	15.6	56.3			
Local resources in good condition	Not involved	45.5	13.6	40.9	90	10.6	<0.01
	Involved	25.0	1.5	73.5			

CHAPTER 5

Integrating multidisciplinarity into marine conservation research: Snapshot Assessment Protocol (SnAP) for characterizing conservation-scapes of small-scale fisheries

ABSTRACT

Small-scale fisheries are inextricably linked social and ecological systems, with significant impacts on and interactions with marine ecosystems, including overfishing, bycatch of species of conservation concern, and habitat degradation. Proper SSF management is a global priority for marine conservation, and requires understanding and consideration of the wider human context of these fisheries. However, there is a relative dearth of social and ecological data on SSF-related conservation issues needed to inform effective conservation approaches and general SSF management. We present "conservation-scapes" as a framework and the Snapshot Assessment Protocol (SnAP) as a relevant toolkit to guide multidisciplinary study of specific marine conservation issues related to SSF. A conservation-scape encompasses ecological, human activity, human community, and governance attributes of a given conservation problem. SnAP outlines and guides the collection of data for a core set of these attributes for SSF, and can be used to complement detailed research on specific SSF-related conservation issues, such as bycatch of marine megafauna. Together, this framework and toolkit function as a readily applicable approach for ecologists interested in more fully incorporating multi-disciplinary, ecosystem-based management research in their work.

INTRODUCTION

Small-scale fisheries (SSFs) represent a vital interface between humans and marine ecosystems. However, there is a relative dearth of social and ecological data on SSFs. Their contributions to food security, economics, well-being are undervalued, and their interactions with marine resources and ecosystems are not thoroughly understood (Andrew *et al.* 2007; Chuenpagdee 2011; Mills *et al.* 2011). Their impacts on marine ecosystems can be substantial, including overfishing of stocks, bycatch of species of conservation concern, and habitat degradation (Hawkins and Roberts 2004; Peckham *et al.* 2007), negatively affecting marine species and compromising human livelihoods as marine resources decline (FAO 2010). As such, quantifying and mitigating the impacts of SSFs on marine ecosystems is a major priority for marine conservation.

Given the inextricable linkages between SSFs and human income, food security, and well-being, understanding and addressing these impacts requires consideration of the human dimension of these fisheries. Such integration of the human element in ecosystems is a central tenet of ecosystem-based management, EBM (McLeod *et al.* 2005). EBM has gained much attention as a way forward for effective, holistic management (McLeod and Leslie 2012). In operationalizing EBM research, human-environment systems such as SSFs can be viewed through the lens of social-ecological systems (SES) frameworks (Berkes and Folke 2000; Ostrom 2007, 2009). SES include subsystems related to resources, users, and governance, that interact and influence each other, the overall SES, and other linked SES (Ostrom

2009).

A goal of applying SES to research is to guide collection of data that allows for the diagnosis of how linked SES subsystems, and the attributes within each subsystem, interact to produce observed or desired management or conservation-related outcomes (Ostrom 2007; Ostrom and Cox 2010). To this end, it is necessary to identify measurable, representative attributes within each SES component. Foundational work along these lines has been conducted by Ostrom and Cox (2010), and by a number of efforts to develop frameworks and operationalize social attributes for SSFs research (e.g., Pollnac 1998; Pollnac *et al.* 2006; Andrew *et al.* 2007; Grace-McCaskey 2012). More specific SES frameworks and attributes have been outlined for coral reefs (Kittinger *et al.* 2012) and marine reserves (Pollnac *et al.* 2010).

However, the elements of SES frameworks have not been largely integrated in conservation research. The **conservation-scape** concept (Whitty in prep.) is an adapted SES framework (similar to that described in Kittinger *et al.* 2012) that can be readily applied to specific marine conservation issues related to SSFs (Figure 5.1). A conservation-scape encompasses the proximate and ultimate attributes of interactions between the SSF and the marine ecosystem that pertain to a focal conservation issue (FCI), as grouped in three broad categories: (1) **proximate attributes** that describe how SSF activities, and the ecological and environmental context, interact to directly create or impact the FCI; (2) the **community context** and the social, economic, and cultural drivers of the SSF activities impacting the FCI; and (3) the **governance**

context in which the SSF and FCI exist and are, or could potentially be, managed. Within each of these categories are subcategories of attributes (Figure 5.1, Table 5.1).

Each of these categories interacts and influences the other two. For the purposes of investigating the FCI, the interaction types of particular interest are: how proximate attributes impact the FCI; how community context influences proximate attributes in ways relevant to the FCI; and how governance context influences or might influence proximate attributes, community context, and the FCI (Figure 5.1). Studying these components of the conservation-scape allows for diagnosis of the nature of the FCI, the proximate and ultimate drivers of the FCI, and the existing and potential mechanisms for addressing the FCI. This diagnosis essentially indicates the options and appropriate focus and scope of management actions (Andrew *et al.* 2007).

For SSFs and marine conservation issues in developing countries, there is a paucity of data for all three categories. Where information exists for ecological attributes in the proximate category, it is rarely accompanied by complementary information for attributes on community or governance context. As such, even where sufficient information exists to understand the magnitude of SSFs impact on a given conservation issue, researchers and managers lack the necessary contextual information to effectively use that information to address the issue.

Studying the conservation-scape: Multidisciplinary methods

Applying the conservation-scape framework can guide research of SSF-related conservation issues, to fill critical data gaps for ecology, social context, and

governance attributes. This requires multidisciplinary research, incorporating methods and concepts from ecology, geography, anthropology, economics, and political science, among others. Ecologists are increasingly acknowledging the need for such multidisciplinarity in conservation research.

Interview-based methods have been accepted as a relatively efficient approach for gathering information on environmental issues (e.g., based on local ecological knowledge) and human-ecosystem interactions (White *et al.* 2005; Moore *et al.* 2010), particularly in the absence of empirical baseline ecological data. Social science questions can complement ecological research, outlining the human dimension in conservation issues and informing decision-making that pragmatically consider human needs (Pollnac *et al.* 2000; Mascia *et al.* 2003; White *et al.* 2005; Ban *et al.* 2009).

The incorporation of social science approaches and questions by ecologists has been most active in investigations on coral reef management and marine protected areas (MPAs) (e.g., Pollnac *et al.* 2000; McClanahan *et al.* 2009; Espinoza-Tenorio *et al.* 2010; Cinner *et al.* 2012; Rossiter and Levine 2013). Social science approaches have been integrated in previous research efforts by ecologists studying marine megafauna conservation issues (Dolar et al. 2002; Moore et al. 2010; Turvey et al. 2010; Ortega-Argueta et al. 2012), though social science questions have only been integrated to a very limited extent. The Rapid Bycatch Assessment (RBA), using interview methods to estimate the magnitude of marine megafauna bycatch in SSFs (Moore et al. 2010), is a notable example of interview-based methods being brought to bear on marine megafauna conservation research. This standardized protocol has been

refined and distributed relatively widely among natural scientists, with an updated RBA is now utilized by several research projects (e.g., (Pilcher & Kwan 2012). Efforts to build upon the RBA include incorporation of social science research in megafauna bycatch projects in Nigeria (Lewison and Moore 2012) and in "Rapid Bycatch and Socioeconomic Assessments" in Southeast Asia (Whitty in prep). Such efforts must be expanded to achieve more widespread inclusion of social science attributes and methods into marine conservation research.

Rapid Assessment Protocols: Toolkits for filling data gaps across scales

Standardized rapid assessment protocols offer much potential for facilitating the greater incorporation of social science methods and questions in SSF-related conservation research, by identifying and guiding basic data collection for selected ecological and social attributes. Such protocols can fill data gaps for specific conservation-scape units, informing both directions for further, more in-depth research on specific attributes of interest and potential management pathways (Figure 5.2).

Beyond studying the local scale, research on SSFs-related conservation issues must consider attributes and interactions across multiple sites and scales (e.g., individual SSFs, sub-national, national, regional, and global). The implicit conservation-scape unit scale is local, with internal social and ecological attributes and processes (such as local overfishing) (Andrew et al. 2007). These units link to other conservation-scape units and to broader scales through influence from and on external cross-site and cross-scale drivers (Andrew et al. 2007). A critical gap in our

understanding of SSFs is the relative lack of comparable data that can be analyzed at multiple scales to help us better understand both patterns across diverse units and the cross-scale processes affecting them (Salas et al. 2007, Ban et al. 2009, Evans et al. 2011). By guiding the standardized collection of data, rapid assessment protocols based on social-ecological frameworks can enable larger scale investigation of attributes and patterns across sites and scales beyond the local conservation-scape scale (Figure 5.2) (Andrew *et al.* 2007; Salas *et al.* 2007; Ostrom and Cox 2010; Kittinger *et al.* 2012; Cinner *et al.* 2013).

With comparable data, conservation-scape units can be characterized, grouped, and analyzed based on particular attributes at higher levels of aggregation, a key step in: formulating hypotheses on links between attributes and management outcomes; developing broad theories of SES function and management; identifying sites of top conservation priority (e.g., based on conservation need or conservation feasibility); and informing policy-making beyond the local level (Andrew *et al.* 2007; Ostrom and Cox 2010; Chuenpagdee 2011). In turn, these analyses can guide necessary adaptations to research methods and frameworks to render them more widely applicable across diverse conservation-scapes.

Snapshot Assessment Protocol (SnAP) for SSFs

Here, we present the SSFs Snapshot Assessment Protocol (SnAP) as a toolkit that can be easily applied to the conservation-scapes approach (available online http://artisanalfisheries.ucsd.edu/resources/safrn-snap-protocol). SnAP is an interview-

based, rapid assessment protocol for collecting basic, multi-disciplinary SSFs data in relatively short time-frames; it is a product based on discussions from an intensive, 2-day workshop with experts from multiple disciplines, tasked with refining lists of key social and ecological attributes and appropriate methods.

SnAP is composed of protocol guidelines and instructions for use, including a set of practical research guidelines (with references to valuable resources such as RAMP and SocMon); overview and explanation of attributes to be studied; Microsoft Word and Excel templates for project information, data collection forms, and data entry (Table 5.1 for more information). This toolkit serves as a useful set of guidelines and tools for students and researchers embarking upon multidisciplinary, SSFs-related conservation research. Such research requires that researchers become conversant in basic methods outside of their main area of expertise. SnAP's guidelines and templates render such methods accessible to a wide range of researchers; in the absence of such accessibility, researchers may well struggle to "reinvent the wheel" and make avoidable errors in developing their own protocols (e.g., as detailed in Moore *et al.* 2010).

SnAP builds on the Rapid Assessment of Management Parameters for Coral Reefs (RAMP) (Pollnac 1998) and the Socioeconomic Manual for Coral Reef Management (SocMon) (Bunce *et al.* 2000). SnAP strives to incorporate improvements called for in reports and by users of previous protocols (Loper *et al.* 2008), by working toward truly standardized collection of data for a core set of indicators and by streamlining the process from data collection to analysis and

presentation through templates for data entry, project summary, and site profiles. Additionally, SnAP incorporates metrics for data source quality and for clear recording of metadata, as recommended by Moore et al. (2010).

Although SnAP is not only aimed at conservation-focused research or at ecologists, it promises to be of great utility for such projects and researchers. SnAP is recommended as a complement to ecologically-focused research projects to provide insight into the social context of conservation issues linked to SSFs. As added to investigation of attributes specific to the FCI, e.g., degree of overlap between dolphins and fishing gear as related to bycatch risk, use of SnAP would provide context for future or concurrent in-depth research efforts.

SnAP Methods

Though there are a wide array of social science and ecological tools applicable to SSFs research, SnAP utilizes those tools suited for rapid assessments (for more details on methods, see SnAP online, Berkes et al. 2001, Bernard 2011, Bunce et al. 2000):

1. Secondary sources (SS): Previously collected information, from published and grey literature, including reports, websites, and official records.
2. Semi-structured key informant interviews (KI): Interviews of relevant experts using open-ended questions guided by a list of topics.
3. Household surveys (HS): Structured questionnaires conducted over a representative sample of SSFs households.

All of these methods have limitations, with caveats related to data quality including incomplete, inaccurate, and/or outdated secondary source information, and memory decay and bias of interview respondents(Berkes *et al.* 2001; Bernard 2006). It is critical that close attention is paid to designing and implementing sampling approaches for interviews, to understanding the extent to which the sampling is representative, and to candidly describing the quality of sampling approaches (Berkes *et al.* 2001; Bernard 2006). SnAP also includes guidance in using "direct observation" of landing sites and the community center as a supplementary tool to the above three methods.

Collecting statistically representative samples has proven to be particularly challenging for similar protocols (Loper *et al.* 2008; Moore *et al.* 2010). Truly probabilistic sampling is often hindered by lack of accurate census or fisheries registration information, limited time in the field, and logistical challenges such as traveling to remote areas (Moore *et al.* 2010). SnAP includes a template for describing sampling approaches, as well as a recommendation to obtain sample sizes that at least meet basic requirements for a "useful understanding of the population" (Bunce and Pomeroy 2003), but echo Bunce and Pomeroy (2003) that more rigorous sampling is required for statistically representative data. The issue of sampling, and subsequent analyses of non-representative data, will be an ongoing challenge to be resolved by SnAP and other similar attempts.

In the use of interview methodologies, attention must be paid to human subjects issues to ensure that all participants are aware of the project objectives and any potential implications of their involvement. Researchers affiliated with institutions that have an Institutional Review Board will need to apply for human subjects approval to conduct interview-based research.

SnAP Attributes

SnAP encompasses a set of core attributes relevant to SSFs that supplement in-depth research on specific, SSFs-relevant conservation issues (Table 5.2). These are grouped into the nine conservation-scape subcategories, in addition to a set of "wider context" attributes, as described below.

Category 1. Proximate attributes

These attributes describe the direct human-environment interface of SSFs in three subcategories: (a) **the environmental context**, or the environmental resources overlapping with the SSFs, (b) **basic fishery characteristics**, or the nature and magnitude of the SSFs activities impacting those resources, and (c) **catch and ecology** of impacted resources, or the impact of those activities on those resources.

Attributes pertaining to the environmental context include background information on habitat types and natural phenomena that might influence resources of SSFs interest, and the human activities impacting those resources. These activities are not necessarily limited to SSFs; documentation of other activities that might overlap

with and impact SSFs helps identify other relevant user groups and issues for SSFs resources. More detailed information on each resource of interest pertains to its status, trends, threats, use and value, method and impact of extraction, and the user groups who extract it. This further clarifies the human-resource interactions occurring in the scope of the SSFs.

All resource extraction activities relevant to the study should be included in one's working definition of SSFs, which might not match the local definition of "fishing", which might vary across sites (e.g., gear that doesn't require use of a boat is sometimes excluded from the local definition). Fishing effort descriptors include the number of fishers, types and numbers of gear and boats, the top species caught by those gears and boats, and the spatiotemporal nature of how those gear and boats are used. Basic demographic information about fishers can identify what groups, besides those defined by gear and boat types, might exist in the fishery

Though quantitatively assessing catch and stocks requires in-depth fieldwork, general estimates and qualitative (ordinal and categorical) data can provide valuable insight. For a rapid assessment, it is necessary to focus on a subset of captured species (whether targeted, opportunistic, or bycatch). This might be the species that are most frequently caught, the species that are most important, or the species that are of particular interest (e.g., conservation concern, or foundational species).

SS and KI are efficient methods for collecting much of this information. However, quality of SS such as fisheries records varies dramatically from site to site; for example, some sites may have fully functional, up-to-date fisher and gear

registration programs, while others will not. As such, care should be taken to verify SS data, particularly since illegal fishing would likely not be documented in official records. Changes in individual effort over time might best be recorded through HS. Direct observations, including beachside and dockside visits, supplement information gathered from SS and KI on fishing effort and catch. Other biological information should be gathered (to the extent possible) from previously conducted ecological research.

Category 2. Community Context

This category pertains to underlying drivers of SSFs in a community. These drivers include subcategories (d) **economic attributes** of the SSFs, (e) social or cultural **ties to fishing,** and (f) **general attributes of the community**. Several attributes in this category apply to both individual and household, and to the community, levels. The former relates to individual decision-making regarding fishing effort and cooperation with management, while the latter is the larger arena in which those individuals and households operate and interact with management (Pomeroy *et al.* 2001). Household definitions vary across sites; as such, SnAP includes a template for describing the functional definition of household selected for study. Although delineating a "community" can impose arbitrary borders, practicality requires a clear definition of the study community – both to provide boundaries for the scale of the research project, and to clarify local versus "external" attributes as relevant to the study site.

Fishers may engage in fishing for a range of reasons, including and extending beyond economic incentives. Understanding economic ties holds implications for incentive-based approaches to SSFs management and conservation efforts. Non-economic ties to fishing can be significant, and management approaches based solely on economic ties might be ineffective without consideration of these. To assess the importance of fishing at the individual level, attributes to study include reliance on fishing for income and food, satisfaction with the income and lifestyle afforded by fishing, and relative amount of time devoted to fishing, as well as possible alternative reasons for fishing (e.g., as a hobby, lack of other options). At the community level, attributes describe the importance of fishing to the community, market structure, and the livelihood options that exist in the community. Basic community attributes, including demographic information, groups, infrastructure, and general priorities for community leaders can heavily influence fishing effort, perceptions of management and resource trends, and options for management approaches.

KI can provide a general overview of SSFs community ties to fishing, while HS could better encompass variability in ties to fishing across individuals. Understanding the economic aspect of SSFs with a rapid assessment would necessarily be limited to a qualitative understanding, with detailed quantitative data requiring greater effort and focus. In recording income from fishing, it is necessary to consider not only the money (or food) earned from catch, but also the cost of fishing trips (including time), distribution of catch among crew members, variation in income, and use of SSFs income. For these topics, KI (particularly fish buyers, exporters, etc.) and

HS can provide community-wide and household-level information, respectively. Depending on the quality of official records, SS could provide valuable information on catch value and contribution to community economics, but care must be taken to assess reliability of this information.

Category 3. Governance context

Attributes in this category describe the mechanisms for current or potential management of human activities interacting with coastal and marine resources, including (g) **general governance attributes**, (h) **institutions**, and (i) **regulations**. They help determine the "governability" of a given SSFs, which describes the extent to which governing capacity can address governance needs (Song and Chuenpagdee 2010). General governance attributes describe current and previous efforts at coastal resource management, and the degree to and means by which these efforts engage the community, are effectively implemented and enforced, relate to any traditional or customary practices, and control access to resources. The governance mode basically describes whether such efforts are generally top-down, bottom-up, externally imposed, or some combination. Several of these attributes have been shown to affect success of management efforts (Pollnac *et al.* 2001; Pomeroy *et al.* 2001; Gutiérrez *et al.* 2011; Rossiter and Levine 2013).

To delve more into governance, SnAP guides the identification and description of relevant institutions and regulations, including a basic assessment of their effectiveness. Governance of fisheries and marine resources is carried out by

governing bodies and institutions, comprising formal (e.g., government agencies) and informal (e.g., belief systems) institutions (Berkes and Folke 2000). Studying institutions, and how they function, is fundamental to understanding how management of fisheries is realized, and obstacles and opportunities for improvements.

Though thoroughly analyzing governance requires sophisticated research methods, several key elements can be studied using SS and KI. Open-endedness in KI is vital to uncovering informal, unofficial aspects of governance. Caveats include biases in the information provided by SS and KI, who may have particular agendas to promote and as such might not be candid about their organization or other institutions. HS can reveal public perception of various aspects of governance, such as effectiveness and problems in current governance efforts.

Wider Context

The attributes above focus on the local level. However, a given SSFs or conservation-scape unit does not occur in a vacuum; cross-site and cross-scale properties and processes beyond the local level are important to understand and consider (Figure 5.2) (Pollnac 1998). These include attributes at the provincial or state level, the national level, and beyond. Studying this wider context allows for greater understanding of large-scale patterns in SSFs attributes and management, including the current and potential role that national and international policy might play in governing SSFs (Chuenpagdee 2011). For the purposes of SnAP, general information on the wider context can be gleaned from SS.

DISCUSSION

Improved SSFs research and management are an emerging priority for marine conservation and application of ecosystem-based management efforts. Our goal in explicitly linking a rapid assessment protocol (SnAP) to a conservation-focused framework (conservation-scapes) is to promote more active and widespread integration of the human dimension in research on SSFs-related conservation issues. This overview of SnAP, furthermore, aims to help ameliorate the relative dearth of interview methodology in the ecology literature (White *et al.* 2005; Moore *et al.* 2010).

Applying SnAP to the conservation-scape framework holds promise for elucidating implications of and opportunities for different conservation approaches, exploring whether and how conservation-focused management approaches can be aligned with other general management or sustainable development goals, and comparing conservation outlooks across sites to guide the practical prioritization of conservation efforts among sites. For example, research by Whitty (in prep, submitted), incorporating SnAP-like elements into the study of cetacean bycatch in SSFs at four sites in Southeast Asia, revealed cross-site differences in the spatial overlap between human activity and cetaceans, community attributes, and governance (particularly as related to community participation). These differences yield very different conservation outlooks and recommended approaches across sites.

SnAP aligns with ongoing efforts to identify and incorporate widely applicable, readily-measured indicators representing key social and ecological

attributes to enhance integration of social data in environmental decision-making (Pollnac et al. 2006). Such work strives to extend the breadth of data coverage, establish standardized "common currency" to facilitate comparisons, and develop broad-scale evaluations. This larger effort serves practical and ethical purposes, as improved SSFs research, management, and representation in decision-making will promote sustained function of their important economic, social, and cultural roles around the world, in addition to better-informed conservation approaches.
These frameworks and methods could work

SnAP should be seen as a work in progress, with long-term goals including: refining the list of core, standardized attributes to be measured; creating multiple tiers , including the core protocol and various levels of add-ons with additional attributes, where time and funding allow for somewhat more in-depth rapid assessment; developing standardized codes for data entry; and honing the data entry and site profile template format.

The broader utility of SnAP, and similar efforts, would be augmented by coordinated analysis and evaluation, including feedback from and interaction with users at all scales (as outlined in Figure 5.2). The global research network for SSFs, Too Big To Ignore (TBTI), is developing a large-scale structure for this process of data collection, analysis, assessment, and feedback, in which standardized data collection will play a key role, particularly in TBTI's Information System on Small-scale Fisheries (ISSF) (Chuenpagdee 2011). Ideally, SnAP's further development will interact with and be strengthened by the TBTI structure, allowing for more wide,

sustained, multi-scale application (particularly, by ecologists) than has been observed in some previous, similar protocols. Similar initiatives for specific conservation issues, such as SSFs impacts on habitats or species of concern, would allow for a broader understanding of the magnitude and nature of these issues and the feasibility of readily replicable and broadly applied solutions.

SnAP and other rapid assessments are a strong prospect for advancing our understanding of SSFs in a time- and funding-efficient manner. As such, these tools have much to offer the diverse, but linked, endeavors of ecologists, social scientists, conservation and management practitioners, and decision-makers who seek to understand and effectively manage these critically important social-ecological systems.

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Chapter 5, in part, is currently being prepared for submission for publication of the material. Whitty, Tara S.; Bassett, Hannah R.; Johnson, Ayana E.; Sandin, Stuart A. The dissertation author was the primary investigator and author of this material.

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FIGURES

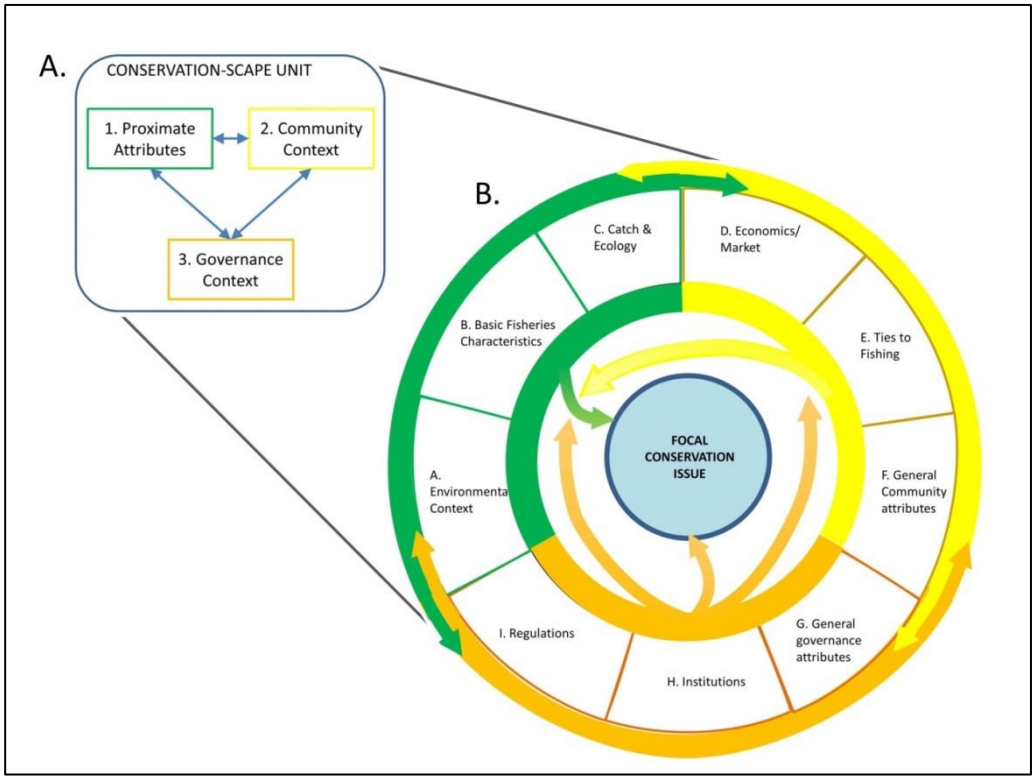


Figure 5.1. (A) Basic framework for a conservation-scape unit, defined as the set of proximate, community, and governance issues pertaining to a focal conservation unit at a local scale (e.g., a SSF village or set of villages in a specific spatial area); (B) Components of the three categories of conservation-scape categories, and the main interactions of interest (inner arrows) among the categories and between the categories and the focal conservation issue (FCI): how the proximate attributes directly influence the FCI, how the community context influences the proximate attributes, and how the governance context influences the community context, the proximate attributes, and the FCI itself.

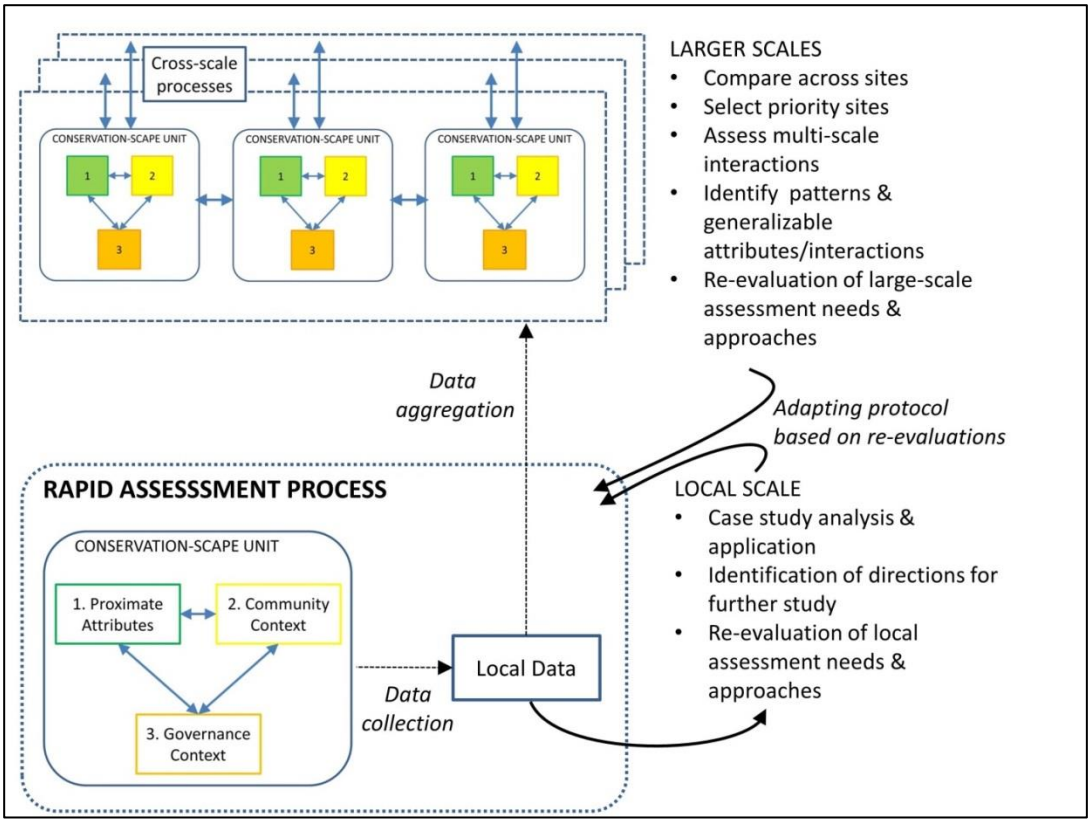


Figure 5.2. Schematic of how rapid assessment protocols can inform analyses and management at local scales and larger scales. At the local scale, social and ecological data are collected for the conservation-scape unit. These data can directly address and identify further research questions specific to that conservation-scape unit, and can be used to further refine the rapid assessment process for future monitoring. These data can also be aggregated with local-scale data from other units, to address research objectives of more broad scope, including comparisons of conservation context across sites, identification of priority sites for conservation action, assessment of cross-scale processes beyond the local level, and identification of patterns in attributes, interactions, and outcomes across sites and scales. Based on analyses and on feedback from protocol users, the protocol can be adapted to improve its continued utility.

TABLES

Table 5.1. Overview of the Snapshot Assessment Protocol (SnAP) components (available at http://artisanalfisheries.ucsd.edu/resources/safrn-snap-protocol). Asterisks denote data collection templates for data that must be kept confidential.

Protocol Guidelines	Instructions for SnAP & General guidance for SSF Research
Appendix 1	Guidelines for Planning & Logistics
Appendix 2 Microsoft Excel	Priority Topics Overview & Direct Observation Guide
Workbook A Microsoft Excel	Project Overview & Summary Templates: For background information on the research project, summary of preliminary findings, and feedback on SnAP. 1. Project Overview 2. Survey Sites Descriptions 3. Profile Template 4. Feedback on Protocol
Workbook B Microsoft Excel	Secondary Sources & Key Informants Background and Templates: Explanation of data topics to be collected by SS and KI methods, sheets for recording SS and KI metadata, and lists/data entry templates of topics by category. 1. Topics Overview 2. SS-List: List & Assessment of Secondary Sources 3. KI-List: List & Assessment of Key Informants* 4. Worksheets of topics, Organized by Category
Workbook C Microsoft Excel	Household Survey: Supporting sheets for the Household Surveys, including explanation of the questions in the HS, including potential points of confusion and suggested solutions. The questionnaire template is in Appendix 3. 1. Sampling Plan 2. List of Houses Approached* 3. Respondents* 4. Overview of Questions in HS 5. Data Entry
Appendix 3 Microsoft Word	Household Survey – Questionnaire Template

Table 5.2. Attributes included in SnAP, as grouped in three major categories (aligned with the three conservation-scape categories) and nine subcategories.

CATEGORY 1. PROXIMATE ATTRIBUTES	
A. Environmental Context	
Habitats & Site description	Habitat types and locations; natural phenomena; human activities impacting local coastal and marine resources
Resources	Threats; Use/Importance/Value; Condition; How extracted; Impact of extraction; Trends; User groups
B. Basic Fishery Characteristics	
Define "Fishers"	Age, gender, ethnicity, residence time; Full-time, part-time, seasonal; Number of fishers
Fishing Effort	Boat and gear types, numbers, caught species; Crew structure; Fishing trip duration and frequency; Fishing grounds (location, accessibility); Variability, including seasonality and long-term changes
C. Catch & Ecology	
Species caught (Top X Species)	Target & bycatch; Average weight of overall catch (individual and community); Average size of captured species (length); Good vs bad days; Seasonal variations; Long-term trends; Use/Importance/Value (market and non-market)*; Impact of fishery on & condition of stock
CATEGORY 2. COMMUNITY CONTEXT	
D. Economics/Market	
Household Focus	Relative use of catch (e.g., what % is sold, directly consumed, bartered); Average net income from SSF (fishing and processing); Short- and long-term variation in average net income from SSF; Relative contribution of SS fishing and processing to household income; Average annual income for SSF & other households; Use of income from SSF
Community	Value of community landings; Relative contribution of SSF to community "GDP"
Markets	How and where catch is bartered and/or sold (including export); Whether and where catch is processed; Identification and description of relevant subsidies, taxes, cooperatives
E. Ties to fishing (*beyond Economics*)	
Reasons for & Importance of SSF Livelihood	Identification & relative importance of motives for fishing; Proportion of time spend working in SSF; Relative importance of SSF to community; Long-term trends in community reliance on SSF
Satisfaction with SSF Livelihood	Perception of fishing as a livelihood; Satisfaction with SSF income & quality of life; Ability to meet or exceed daily needs with SSF income

Table 5.2, Attributes included in SnAP, as grouped in three major categories (aligned with the three conservation-scape categories) and nine subcategories, cont'd:

F. General community attributes	
General information & Demographics	Definition of community; Centers of activity (e.g., where fishers congregate in the community); Demographic information (age, ethnicity, religion, education level, residence time, migration); "Groups" in community and relationships between groups; Priorities for community leaders; Infrastructure
Livelihoods & Households	Livelihood activities and relative importance to community; Definition household; Roles, income sources, food sources, and expenditures in households
CATEGORY 3. GOVERNANCE CONTEXT	
G. General governance attributes	
	Governance mode; Community participation; History of environmental governance; Effectiveness, compliance, and challenges; Presence of customary/traditional governance, registration programs, protected areas; Whether/how access is controlled; Perceptions of governance
H. Institutions	
	Name; Type; Objectives; Management role; History; Activities; Outputs; Challenges; Degree of success; Perceptions of Institutions; Funding sources
I. Regulations	
	Name/Title; Type; Objectives; Process of creation, implementation, enforcement; Challenges; Degree of success; Perceptions of regulations
WIDER CONTEXT	
Province/State and/or National	Population; Coastal population; GDP and growth rate; Unemployment; Number of SS Fishers; Important events in recent history; World Bank Governance Indicators

CONCLUSION

The lofty goal of this dissertation is to develop a useful contribution to the mitigation of this serious conservation issue, in Southeast Asia and beyond. An even loftier goal is to make the case for conservation-scapes to be applied more widely, to myriad conservation problems that arise at the interface of ecosystems and human activities. The various elements of this dissertation aimed to demonstrate the utility of this approach, even in its formative and exploratory phases, in addressing two major needs for bycatch and wider conservation research: the need for better data, and the necessity of moving forward in our thinking in how to develop solutions that are informed by the data. This project also aimed to address the issue of operationalizing the use of the conservation-scapes framework, describing various methods and toolkits to guide the actual study of these interdisciplinary concepts in the field.

In applying the conservation-scapes approach to my field sites and to Southeast Asia, I highlighted the staggering data gaps with which we must contend. Focused application of conservation-scapes at specific field sites will certainly yield valuable information on a localized scale, but the scope of the bycatch problem in Southeast Asia and beyond calls for broader and comparative application of this and similar frameworks to facilitate more rapid collection of information and development of solutions. However, the limited progress made between the SEAMAM 2 and SEAMAM 3 workshops (see Chapter 1) represents the realities and struggles of making meaningful progress in conservation research.

Fortunately, there is a rising tide of researchers drawn to interdisciplinary research for conservation and management, particularly related to small-scale fisheries, coral reef ecology, and marine protected areas. For example, the global network for small-scale fisheries research, Too Big To Ignore, is spearheading a large, collaborative project to establish infrastructure for improved research training, data collection, information sharing, and connecting information to policy. As another example, the increase in student interest in interdisciplinary research is evident from the number of people reaching out to our student group, SAFRN.

Considering these emerging initiatives and growing interest, it appears to be an auspicious time for promoting frameworks like the conservation-scape and toolkits like the Rapid Bycatch and Socioeconomic Assessment (Chapters 2, 3, and 4) and the Snapshot Assessment Protocol (Chapter 5). Further work to refine these toolkits, and the development of other tools and technologies to streamline data collection and analysis, could significantly contribute to filling data gaps. Linking to larger-scale collaborations and comparing approaches and results across sites could significantly advance how we approach the development and implementation of conservation solutions.

The looming challenge lies in how to apply conservation-scapes information to actual solutions, requiring the daunting leap from vague recommendations to the development, implementation, and assessment of mitigation strategies. Conservation-scapes information should indicate pathways for focused research linked directly to solutions, such as the feasibility of promoting sustainable community conservation

groups, motivating changes in gear use, and enhancing enforcement efforts. This calls for close partnership with conservation practitioners, such that academic and practical expertises complement each other through information, application, and feedback. It would be beneficial to look to the fields of public health and development, where actions must be taken based on incomplete data and where initiatives are currently evaluated by institutions such as the Abdul Latif Jameel Poverty Action Lab at the Massachusetts Institute of Technology.

The lamentable, but glaring, truth is that such efforts might not materialize in time to save several subpopulations or even some species of cetaceans from extirpation or extinction due to bycatch. Here, the conservation-scapes approach can offer two broad types of solace. First, even though the focal conservation issue studied might remain unsolved, conservation-scapes provide a broad base of information for generally improving marine and aquatic resource management at specific sites. As such, steps can still be taken to improve related livelihoods and other aspects of the ecosystem, even if the cetacean subpopulation or species of interest is lost. Second, the conservation-scapes could provide insight into why the failures were so intractable, and why management efforts were more effective at the relatively successful sites. Lessons learned from the loss of one subpopulation, coupled with the broad understanding offered by the conservation-scape, could contribute to efforts to save other subpopulations. This is where comparative assessments of mitigation approaches across sites would be particularly valuable.

I fully recognize that the conservation-scapes concept is heavily based on previous work and thinking related to interdisciplinarity, research frameworks, and conservation in general. However, I firmly believe that this body of work can be a valuable contribution to further promoting incorporation of holistic, interdisciplinary, and human-inclusive conservation research for practical means. Much of the motivation for this dissertation, and for my pursuit of this field, stems from puzzled frustration at the "snail's pace" of conservation (as described by Aldo Leopold in his "Land Ethic" in 1949), despite the decades-old calls for improvements to research and application. As I learned from courses and conversations with one of my mentors, Paul Dayton, a good idea often has to be presented a multitude of times before it sticks and truly gains traction in the field so that we can make strides beyond "convention oratory and letterhead pieties" (Leopold 1949). And so, it is my hope that this dissertation presents several old, but important, concepts in a novel, accessible manner that clarifies the pathway to more thoroughly integrating the human dimension in conservation research and applications for mitigating cetacean bycatch and other pressing conservation issues.