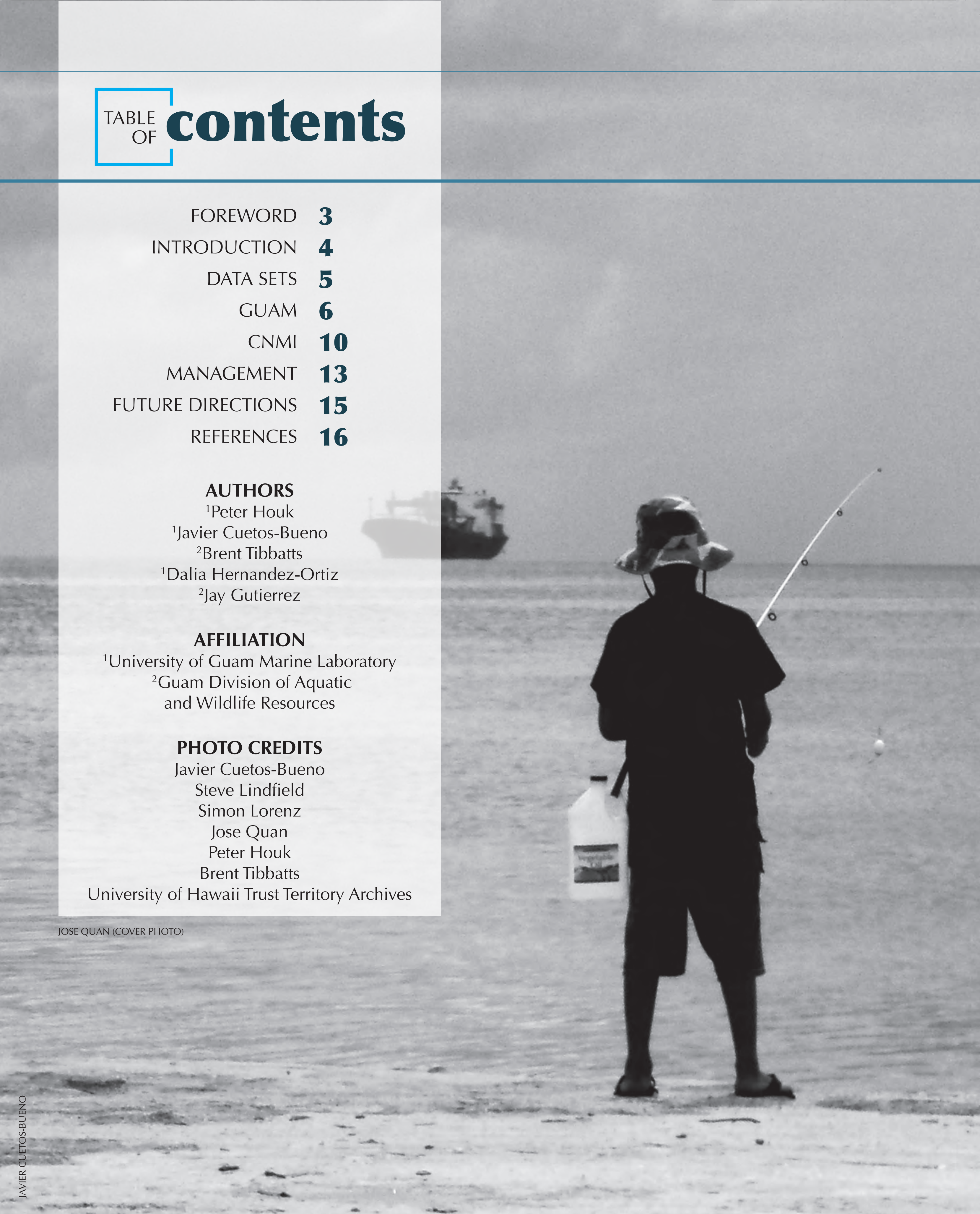
Evolution of Guam and CNMI coastal fisheries over the past three decades

COMPILATION OF AVAILABLE DATASETS, PUBLISHED REPORTS, AND GREY LITERATURE

Marine Laboratory University of Guam
Sea Grant University of Guam
NOAA CORAL REEF CONSERVATION PROGRAM



JAVIER CUETOS-BUENO

TABLE OF contents

FOREWORD 3

INTRODUCTION 4

DATA SETS 5

GUAM 6

CNMI 10

MANAGEMENT 13

FUTURE DIRECTIONS 15

REFERENCES 16

AUTHORS

[1]Peter Houk
[1]Javier Cuetos-Bueno
[2]Brent Tibbatts
[1]Dalia Hernandez-Ortiz
[2]Jay Gutierrez

AFFILIATION

[1]University of Guam Marine Laboratory
[2]Guam Division of Aquatic and Wildlife Resources

PHOTO CREDITS

Javier Cuetos-Bueno
Steve Lindfield
Simon Lorenz
Jose Quan
Peter Houk
Brent Tibbatts
University of Hawaii Trust Territory Archives

JOSE QUAN (COVER PHOTO)

FOREWORD

We are grateful to the Guam Division of Aquatic and Wildlife Resources staff and Guam fishers that have provided invaluable catch datasets between the mid-1980's and 2006. Similarly, the CNMI Nutritional Assistance Program and commercial fish vendors have provided monthly records over the past decade describing fish landings based upon their participation in the territorial food-stamp program. Together with available governmental reports and published papers, these datasets help to reveal how coastal fisheries in the Mariana archipelago have evolved through time. We hope the summary of these datasets offered here will foster better discussions between fishers, communities, resources managers, scientists, and governmental officials, thereby improving the way coastal fisheries are managed. The scientific messages presented within represent summaries of peer-reviewed scientific papers where a full suite of technical details can be found. Contact the authors for reprints of these studies and for further information regarding public presentations of these findings. Lastly, we thank the University of Guam Sea Grant Program for supporting the printing of this publication and dissemination through their extension and outreach activities, bringing science to the Guam and CNMI communities.

STEVEN LINDFIELD

INTRODUCTION

Coastal fisheries are one of the most challenging resources to manage because there are a diverse set of users, each with differing management and economic objectives. Commercial fishers may want to maximize their catch and economic profit, subsistence/recreational fishers want to be able to enjoy fishing and feed their families, while the tourism industry benefits from providing our foreign visitors with exciting diving experiences on healthy reefs with abundant fish. However, sustained fisheries declines impact all users by reducing economic profits, food security, and tourist experiences alike. In both Guam and CNMI, many studies that have examined fisheries datasets and conducted interviews with fishers in recent years revealed a common trend that fewer, smaller fishes now exist compared to the past (Figure 1,[1–3]). While there appears to be a general agreement with the overall trends, there is less agreement on how to solve the problem. Here, we look deeper to the cumulative fisheries trends to reveal a better understanding of the problem, and link the findings with potential management solutions that better blend modern and traditional forms of resource management.

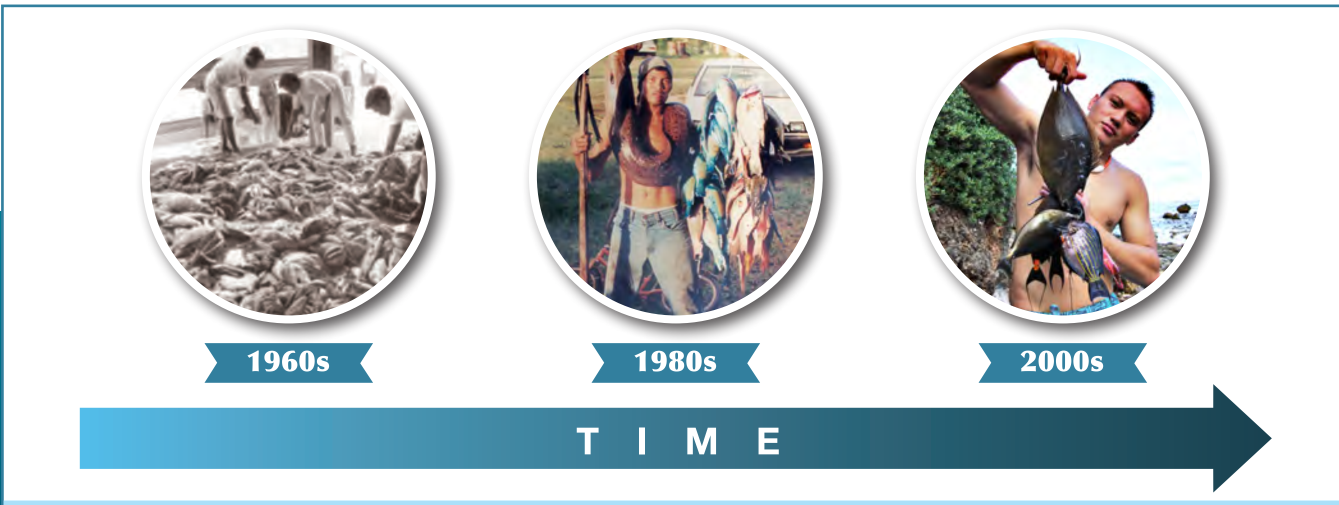


Figure 1. Evolution of coral-reef fisheries through time. The perception of fisher, resource managers, and existing biological studies all convey the same simple fact that fish catches are now less abundant and consist of smaller species through time. The present study agrees with these findings and provides specific details that aim to help refine a holistic management framework.

Figure 2. Shifting composition of SCUBA and freedive landings on Guam over the study period.

DATASETS


JAVIER CUETOS-BUENO

Two influential datasets are described here that come from local governmental programs in Guam and CNMI. First, the Guam Division of Aquatic and Wildlife Resources (DAWR) has conducted standardized fisher surveys that documented fishing catch-and-effort statistics since the mid-1980's. These data provided species-based catch records that were coupled with fisher surveys. These datasets were filtered to include fishing methods and years with sufficient data to detect trends through time. This resulted in a final dataset with 131 species covering the SCUBA, free dive, and bottom fisheries. Second, the CNMI Nutritional Assistance Program has been collecting monthly sales records from all fish vendors that participate in their territorial food-stamp program. These data help to characterize the CNMI's commercial fisheries by describing fish sales for some target species and families, such as parrotfishes, as well as for all reef fish grouped together. In addition, species-based data from CNMI were extracted from the few available published studies and grey-literature reports that examined size structures through time for a subset of target species. *Unfortunately, modern datasets collected between 2010 and the present in both CNMI and Guam by the United States National Marine Fisheries Service were not available for the present study. It is our hope to eventually link modern datasets with the present study framework if they become accessible to the public into the future.*


STEVEN LINDFIELD

GUAM

STEVEN LINDFIELD

Guam catch data were analyzed for three dominant fisheries, SCUBA, free-dive, and bottom. In total, the block of analyzed data included over 78,000 individual fish measurements representing over 30,000 kg of fish recorded from a subset of fishing trips between 1985 and 2005. The DAWR data became limited after 2006 when many significant commercial fishers decided to stop participating in the catch-interview program. This serves as a reminder of how difficult fisheries management can be due to differing stakeholder opinions. Based upon these data, our analyses for Guam described how the fisheries have evolved between the late 1980's and the mid-2000's.

JOSE QUAN

Similar overall patterns were found for all three fisheries sectors. Commercial fisheries appeared to grow extensively in the early years, with observed landings tripling between the mid-1980's when the standardized data collection program started until the mid-to-late 1990's. DAWR observed landings do not necessarily reflect total landings, because they are only a subset that was sampled. However, previous studies have interpreted that catch-per-unit-effort followed these same patterns, peaking in the mid-1990's and declining sharply after that [4]. Keeping this in mind, we next focused on how species and sizes shifted over the years.

For all three fisheries sectors, there was a slow and gradual replacement of large, slow-growing fish with smaller, fast-growing counterparts (Figure 2). Large, slow growing fish included groupers, large trevally, Napoleon wrasse, and some snappers. Beyond diminishing contributions from these large and iconic species, there was also a shift in common target families. For example, parrotfishes were primary components of SCUBA and free-dive fisheries that have been replaced by a mixture of "other fishes", representing goatfish, surgeonfish, and squirrlfishes (Figure 3, left side). Similarly, groupers and snappers were initially primary target families for bottom fishing, but catches have now been replaced by a suite of smaller emper-

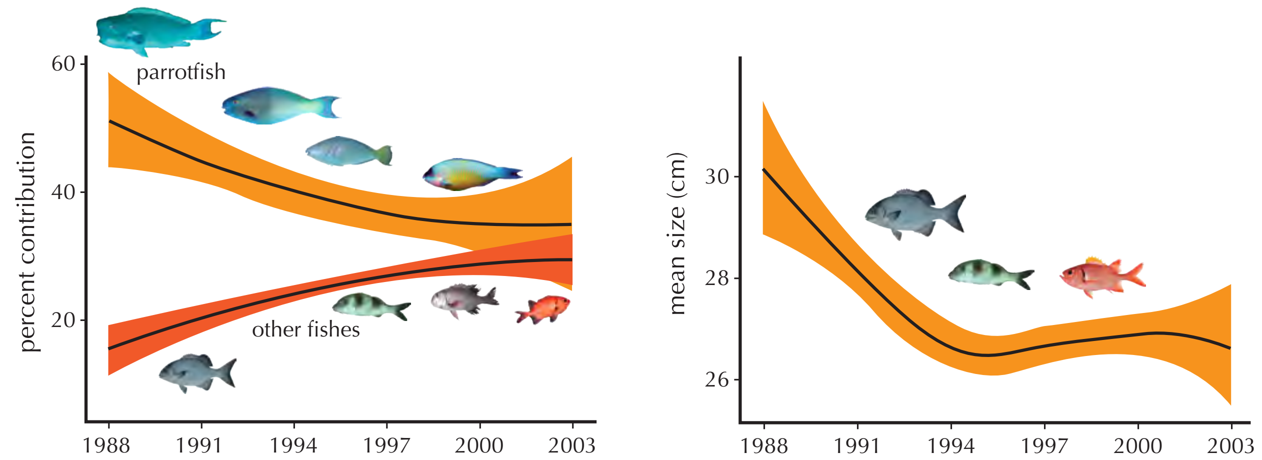


Figure 3. An example of shifting landings through time within Guam's SCUBA fishery. Beyond the reduction of large and iconic species such as Napoleon wrasse and groupers, entire target families of fish, such as parrotfishes, are gradually being replaced with a suite of "other" fishes that are smaller in size (left graph). While there has been a growing contribution from "other" fishes, this has been coupled with a declining size structure (right graph). Circle sizes on the graph are proportional to the biomass or number of fish measured.

orfish, smaller trevally, and a few, potentially-ciguatoxic large species (barracuda and red snapper). Last, while the suite of "other fishes" have increased their contribution to modern landings, their sizes have diminished (Figure 3, right side). This overall pattern of species and size replacements is not unique to Guam, and has been reported elsewhere with growing fishing intensity. Here, we look deeper into the trends to reveal how individual species may have responded over the years to offer improved guidance for management.

JAVIER CUETOS-BUENO

SPECIES-BASED TRENDS

Understanding how populations of individual species change through time is a fundamental basis for both modern and traditional forms of fisheries management. The problem is that we have so many different species on our reefs, so developing the "perfect" set of information to manage each species will take a *long* time. Each year new information is developed by fisheries scientists, and revived through interviews with elder fishers. The present results integrated available knowledge to provide a framework that addresses the complex problem of multispecies fisheries.

JOSE QUAN

The DAWR datasets recorded over 130 species during the study period; however, over 70% of the landings came from only 17-20 species for all three dominant fisheries. We use the term primary target species for this subset of dominant fishes. Target fisheries species can gradually change through time in terms of size and contribution. We highlighted that 18%, 24%, and 10% of primary target species in the early 1990's slowly disappeared from landings through time, respectively for bottom, SCUBA, and free dive fisheries. In contrast, 29%, 29%, and 35%, respectively, of target species slowly became smaller through time but their contribution to landings remained the same or even grew. Interestingly, only 5%, 12%, and 0%, respectively, of species showed equal responses in terms of size and contribution declines, suggesting these differences are useful criteria to help us better manage our fish stocks.

A good example of this comes from a closer look at two of the most popular fish, the steephead parrotfish and the unicornfish (Laggua and Tataga, respectively). The contribution of steephead parrotfish to annual SCUBA landings decreased by 45% during the study period, but the size only decreased by 11%. In contrast, the contribution unicornfish landings did not change through time, and the size actually increased by 23%. The free-dive fishery was similar, but declining trends for parrotfish contributions were stronger, and sizes of unicornfish decreased.

The collective trends provided several key messages. First, the SCUBA fishery targeted disproportionally larger fish sizes and larger fish species worth more

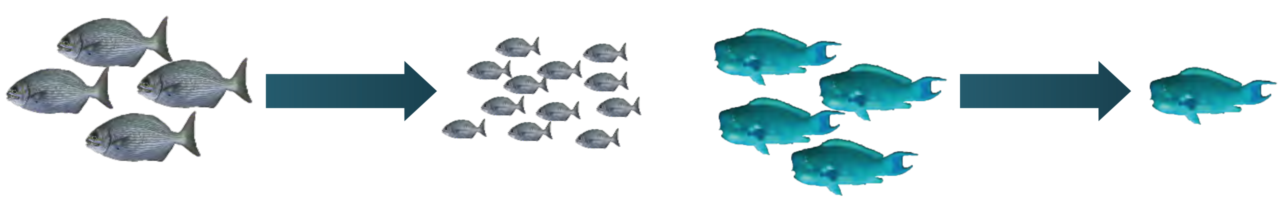


Figure 4. Samples of different responses to fishing pressure. Left, some species like rudderfishes and unicornfish responded to fishing pressure by shifting their size structures. Other species such as the steephead parrotfish on the right responded by declining in proportional contribution. These differing responses provide clues to how we can better manage diverse coral-reef fisheries.

for commercial sales (Figure 5). Second, the suite of target species with negative trends showed differing responses to fishing pressure by either decreasing in size or contribution, but only few showed both. Last, the SCUBA and bottom fisheries showed similar trends in terms of large fish declines, however the bottom fishery switched focus onto two large species that are potentially ciguatoxic. We next link these responses from Guam with the trends in CNMI fisheries to provide a holistic view of fisheries management for the Marianas.

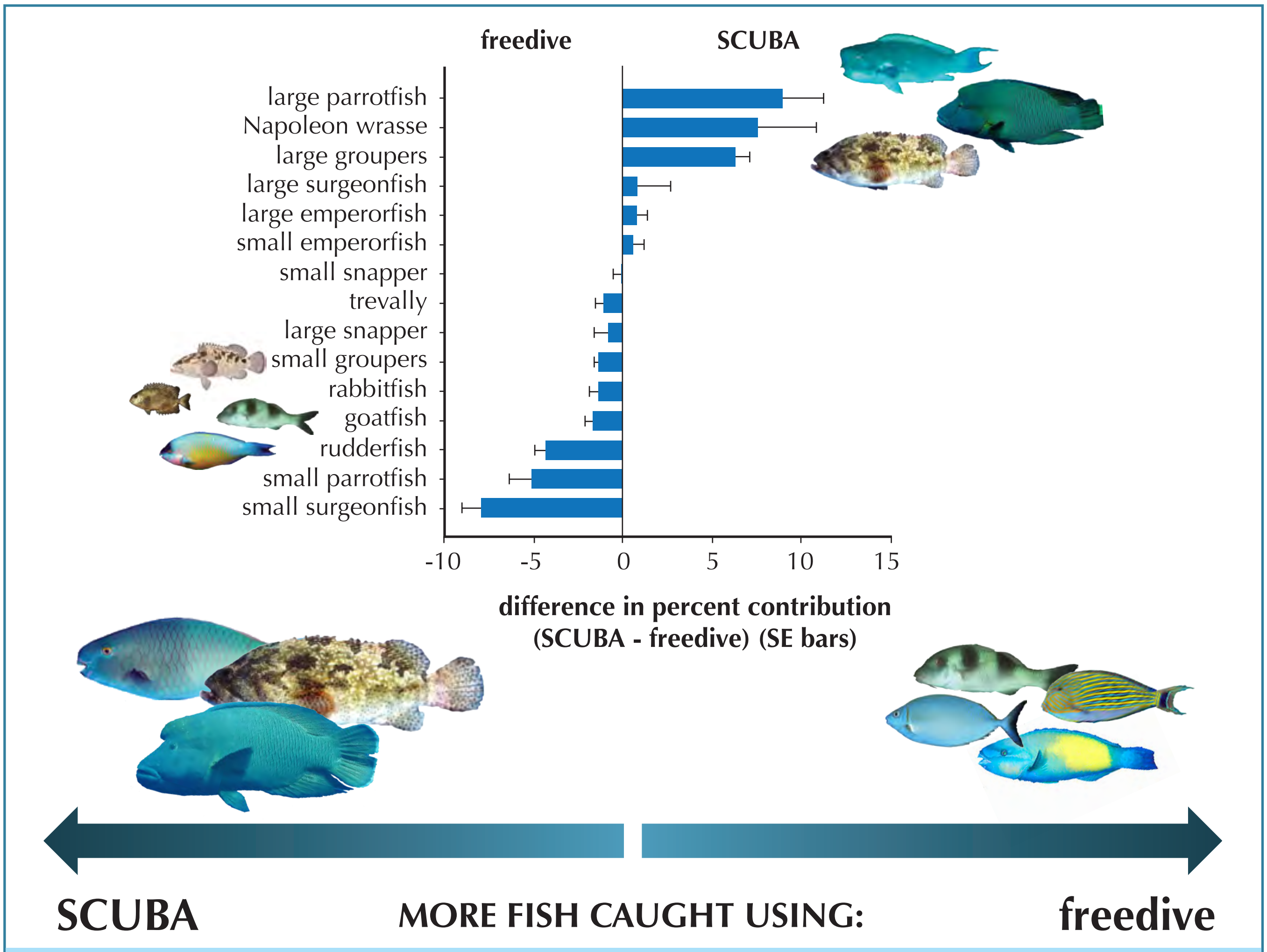


Figure 5. Differences in catch composition between SCUBA and free dive landings. SCUBA fishing rapidly depleted larger fish during the 1990's while free dive fishing focused more on smaller species throughout the study period.

CNMI

The CNMI Nutritional Assistance Program (NAP) dataset contained nearly 6,000 reef-fish monthly landings that combined to describe over 1 million pounds of commercial fish sales between 2006 and 2016.

Overall annual landings remained fairly stable across the study period (~90,000 lbs per year). This may seem counter intuitive because fisheries were perceived as declining by CNMI stakeholders. Yet, similar trends have been observed elsewhere, whereby a consistent supply to markets is maintained by fishers who expand their 'footprints' (fishing deeper, further, and for longer). In CNMI, further analysis of the NAP datasets revealed that while annual landings remained stable overtime, they became more dependent upon pulsed fishing events during times when less exploited fishing grounds were accessible (i.e. windward reefs during the calm seasons, Figure 6a-b). This finding suggested that localized depletions on the accessible leeward reefs were forcing fishers to rely on infrequent trips to further, less-accessible reefs during the calm season to maintain their net annual supply. Interestingly, even stronger trends were found for the desirable parrotfish family that developed a "race to fish" dynamic. Parrotfish landings during the calm season were previously stable (similar landings between May

JAVIER CUETOS-BUENO

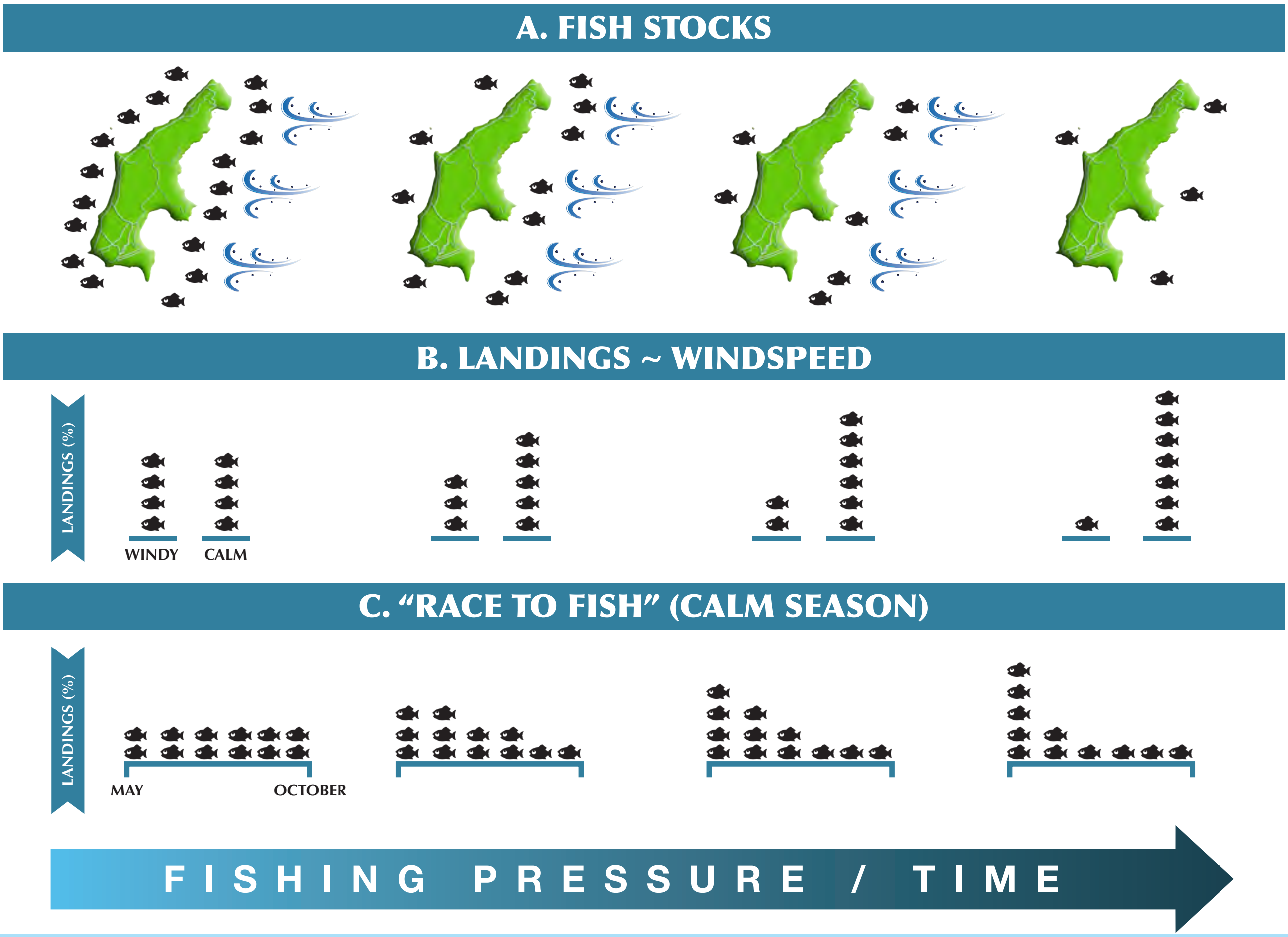


Figure 6. Conceptualization of differential depletion expected alongside unchecked fisheries expansions at a location (Saipan used as example) subject to prevalent wind patterns that limit access to the windward reefs (a), and expected increasing variability in landings alongside these depletions associated to low windspeed periods (b), and "race to fish" dynamics (c).

to October), but over the past 11 years we report a growing pulse in parrotfish landings right away at the start of the calm season, with contributions diminishing until October (Figure 6c). This may not be too surprising as CNMI Division of Fish and Wildlife reports back in the 1990's already identified compromised populations of parrotfishes in the southern inhabited islands alongside critical exploitation[5]. In sum, consistent landings and sales within commercial markets have likely provided a false sense of sustainability to consumers. This was further supported by the limited sets of species-specific data available to examine size changes through time.

Size comparisons were made for 19 target fishery species between 1993 and 2009. The results revealed decreasing sizes-at-capture for 15 out of 19 species, ranging between 1% and 33%, (Figure 7, left). In ad-

JAVIER CUETOS-BUENO

dition to declining sizes through time, we also found similar evidence when comparing sizes for several target species across the populated CNMI islands (Figure 7, right). Rota, where the smallest human population exists, consistently had the largest sizes of common target species, while Tinian and Saipan had smaller sizes Fishing pressure is well known to reduce fish sizes, as we similarly found with the Guam results, but reduced sizes have repercussions for the fishery, profits, and the ecosystem alike. We last place the combined results from both Guam and CNMI within a holistic management framework.

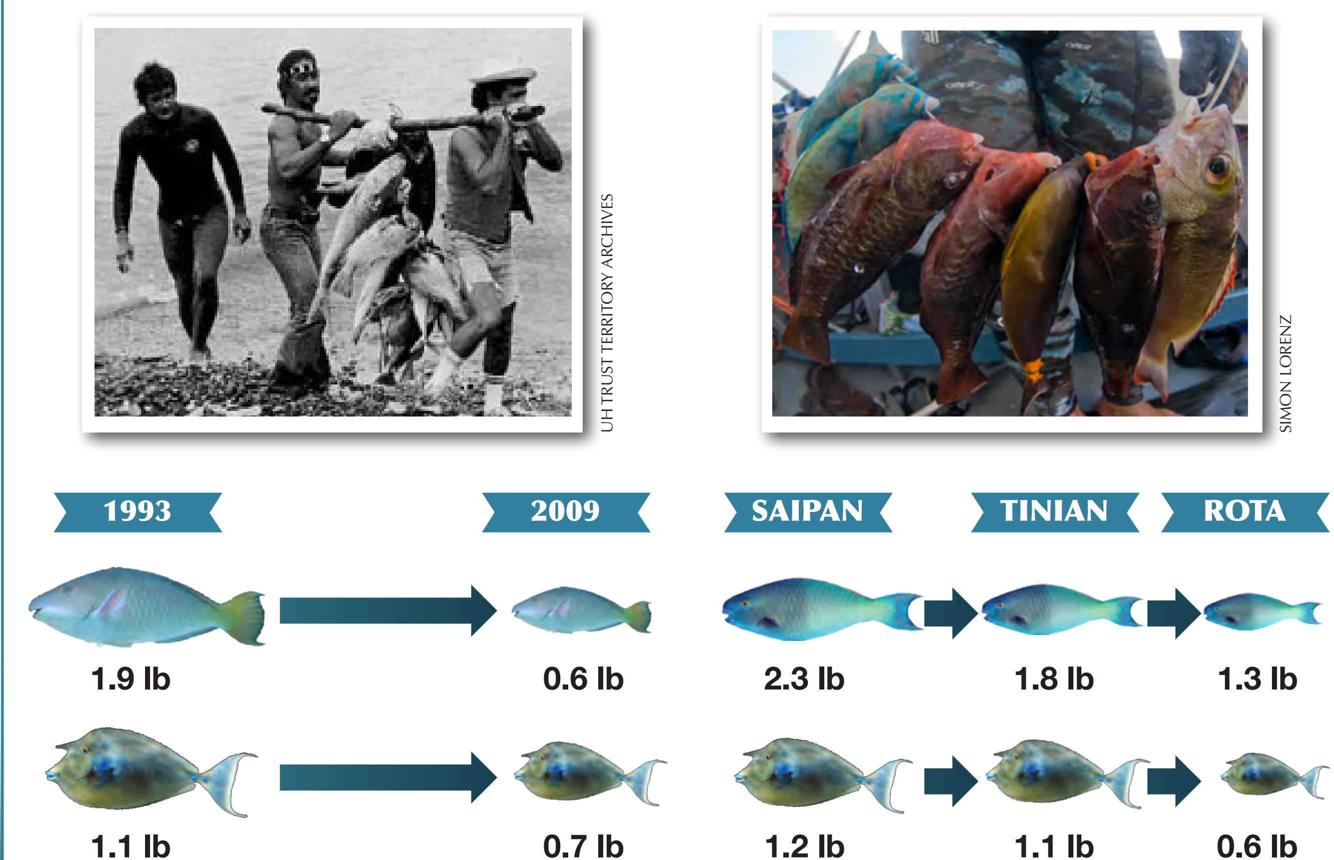


Figure 7. Examples of reductions of mean weight at markets of popular species across time (left) and islands subject to decreasing fishing pressure (in 2009; right)

MANAGEMENT

Results from this study agree with previous reports of unsustainable fishing regimes in both Guam and CNMI, described by declining catch-per-unit-effort, compromised size structures, and long-term depletions (1950's to the present) across the inhabited islands of the Mariana archipelago [2–6,8–11]. Declining fisheries have serious implications for all stakeholders who are finding it harder to fulfill their subsistence, recreational, or economic needs. Beyond fishing, key ecological functions of fish populations are also lost along the way, magnifying the global problem of climate-change-induced reef decline evidenced in Guam and CNMI by the recent coral bleaching in the summer and fall of 2017. Healthy fish stocks enable the reefs to be as resilient as possible to these global stressors that we have less control over. Yet, there are many opinions and objectives among fisheries stakeholders, making it very difficult for local and federal agencies to create tangible improvements. In hopes of improving upon this situation, we next discuss how the present results could refine fisheries management and facilitate discussions among fishers, scientists, resource managers, and decision makers.

Management of Guam and CNMI coral-reef fisheries is complicated by the large number of species targeted. Yet, our combined results described that only a few target species make up the bulk of landings, suggesting a good place to start focusing efforts. Among these target species the findings highlight two distinct ways fishes responded to fishing pressure: 1) species tended to disappear from landings through time, or 2) species got smaller through time. Realigning management to account for the way species respond through time would set the stage for more effective strategies. For instance, this could begin with discussions about size-based regulations for species that get smaller through time. Meanwhile, species that tend to disappear through time would respond better to gear, area, and/or quota policies. Management could be further simplified by grouping species into "units" based upon body sizes, diet, and how they respond to fishing pressure. For example, several large parrotfish that tended to disappear from landings could be grouped into a management unit that is regulated by gear, area, or quota policies. Meanwhile, other species like the palenose parrotfish and unicornfish which are similar in size and response, could be grouped and managed by size policies. While this approach may seem simple in concept, it represents a significant departure from current management in both Guam and CNMI.

Federal policies applied to some of CNMI and Guam reefs have instead grouped species into management units based upon taxonomy only. The entire family of parrotfishes represents one unit that is managed using a quota system [12]. This is problematic because there are many species of parrotfishes with differing growth rates and responses to fishing pressure. Taking this approach would lead to undesirable large-to-small species replacements, such as what has been observed through time (Figure 8). A further issue with the current quota system is that it considers the entire reef area of CNMI and Guam as their respective area-based management units. The NAP dataset from CNMI teaches us that this approach would mask localized depletions, as captured stocks from more remote reefs give the appearance of a healthy fishery in CNMI, but localized depletions around the reefs most accessible occur (i.e. Saipan). This is important because the majority of fishers that rely upon local stocks for subsistence needs don't have access to larger boats and more remote fishing grounds.

In contrast, local policies on both Guam and CNMI include a suite of no-take marine protected areas, net bans (CNMI) or size-and-time restrictions for nets (Guam), and bans against some fishing gears (i.e., dynamite fishing bans, or SCUBA fishing ban in CNMI). These policies have provided clear benefits to the local fisheries; but have been established over the same time period when significant fisheries declines were documented suggesting more is needed. A further problem with local policies is that no overarching framework exists to connect policies. A broader discussion of how policies might fit together, holistically, to create a desirable management framework is needed. Within this discussion, it may be beneficial to consider why traditional management in Guam, CNMI, and the Pacific was successful. Therefore, we last blend our results within the framework of traditional knowledge.

Traditional management created limited-entry policies that defined fishing rights based upon social status and fishing methods. More than 50 different traditional fishing techniques have been documented on Guam and the Mariana Islands that target certain species at specific timeframes, life stages, and sizes[13]. Similar policies also existed across the Pacific to limit fishing for large iconic fish, protect large spawning events, create no fishing taboo areas for reefs to recover [14–16]. The hierarchy and diversity of traditional management could only be derived through extensive species-specific knowledge about how fish respond to fishing pressure. Unfortunately, this knowledge has been lost over the years and modern science, such as the present effort, is still catching up. Local reef ownership may be difficult to reinstate in our modern world, however, a collaborative network of village-based management units with a core set of shared policies may help revive local support for improved fisheries management.

UH TRUST TERRITORY ARCHIVES

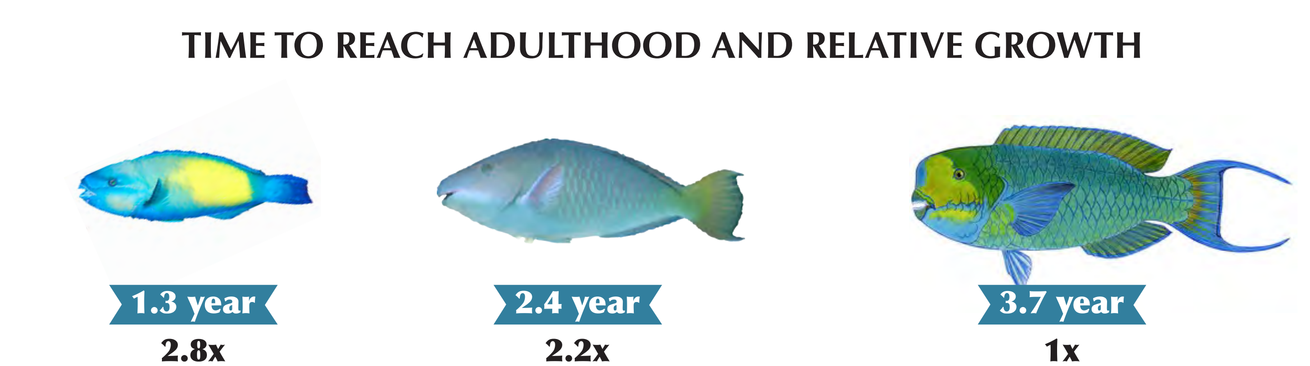


Figure 8. Implications of federal fisheries policies applied to Guam and CNMI reefs. Here, these three species are all part of the parrotfish management unit, but they differ in how fast they grow and reach maturity. Numbers indicate average time to reach maturity and relative differences in growth rates. The species that grow slower and become reproducibly active at a later age are less resilient to fishing. Through time, setting a consistent quota for the parrotfish management unit is expected to lead to the species shifts observed in the present study.

REFERENCES

1. Rhodes, K. L., Warren-rhodes, K., Houk, P., Cuetos-bueno, J. & Fong, Q. *Market Forces and Nearshore Fisheries Management in Micronesia. The Nature Conservancy, Asia Pacific Conservation Region Marine Program* (2011).
2. Van Beukering, P. *et al. The Economic Value of the Coral Reefs of Saipan, Commonwealth of the Northern Mariana Islands*. (Cesar Environmental Economics Consulting, 2006).
3. Van Beukering, P. *et al.* The economic value of Guam's coral reefs. *University of Guam Marine Laboratory Technical Report* **116**, 102 (2007).
4. Weijerman, M. *et al.* Trends in biomass of coral reef fishes, derived from shore-based creel surveys in Guam. *Fish. Bull.* **114**, 237–257 (2016).
5. Trianni, M. S. *Summary and Further Analysis of the Nearshore Reef Fishery of the Northern Mariana Islands*. (CNMI Division of Fish and Wildlife technical report, 1998).
6. Graham, T. *Biological analysis of the nearshore reef fishery of Saipan and Tinian. CNMI Division of Fish and Wildlife Technical Report* (1994).
7. Houk, P. *et al.* Commercial coral-reef fisheries across Micronesia: A need for improving management. *Coral Reefs* **31**, 13–26 (2012).
8. Cuetos-Bueno, J. & Houk, P. Re-estimation and synthesis of coral-reef fishery landings in the Commonwealth of the Northern Mariana Islands since the 1950s suggests the decline of a common resource. *Rev. Fish Biol. Fish.* **25**, 179–194 (2014).
9. Lindfield, S. J. Depth refuge and the impacts of fishing on coral reef fish communities. (The University of Western Australia, Doctoral Thesis, 2015).
10. Duenas & Associates, I. *Saipan lagoon use management plan, Survey of sea cucumbers and fish in the Saipan lagoon, Northern Mariana Islands (NMI)*. (1997).
11. Taylor, B. M. & Cruz, E. Age-based and reproductive biology of the Pacific Longnose Parrotfish (Hipposcarus longiceps) from Guam. *PeerJ* **5**, e4079 (2017).
12. Sabater, M. & Kleiber, P. in *Interrelations between corals and fisheries* 195–214 (2014).
13. Kerr, M. A. Fishing methods of the Mariana Islands, Micronesia. *Univ. Guam Mar. Lab. Techincal Rep.* **132**, (2011).
14. Johannes, R. Traditional marine conservation methods in Oceania and their demise. *Annu. Rev. Ecol. Syst.* **9**, 349–364 (1978).
15. Cunningham, L. J. *Ancient Chamorro Society*. (Bess Press, 1992).
16. Lieber, M. D. *More than a living: fishing and the social order on a Polynesian atoll.* (Westview Press, Inc., 1994).

FUTURE DIRECTIONS

Clearly there is no perfect way to approach fisheries management. Instead, improvements will require collaborative groups of fisheries stakeholders, scientists, communities, and governmental resource managers to discuss ideas and approaches, test concepts, and change paths when something is not working. Feedback loops are an essential component of our history and future. Hopefully the information presented will help build a stronger network of individuals who are willing to share their knowledge and data, and contribute to an improved holistic fisheries management framework for the Marianas.

JAVIER CUETOS-BUENO