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EXECUTIVE SUMMARY

For Micronesians, the sea and its bounty have been a central part of daily life for thousands of years, as reflected in their lore and customs. However, unbalanced commercialization of coastal resources and a lack of parallel management have allowed unsustainable fishing practices to abound, with coastal fisheries now characterized by excess harvest and unethical and destructive fishing methods. Across Micronesia, poor management of commercial fishing has resulted in the virtual extinction of some species in some jurisdictions, reductions in abundance and mean fish size, age, and fecundity for many commercially important nearshore species, changes in coastal fish communities, and severe impacts to the reproductive and replenishment potential of fish spawning aggregations. Adding to this are poor land use and development activities, such as dredging, unabated pollution, and upland land clearing that have contributed to degraded coastal and nearshore habitats, particularly coral reefs**.** Today, the regional commercial reef fishery is threatening the economic potential and development of non-extractive industries (e.g., tourism), as well as socio-economic and food security. Thus, there is an urgent need to lessen the impacts through better, restructured management institutions (along with their policies and actions).

The current study examines market forces driving overfishing in the eight jurisdictions of Micronesia: Yap, Kosrae, Pohnpei and Chuuk, Palau, the Marshall Islands, the Northern Mariana Islands, and Guam. Case studies, fisher surveys, and literature reviews were used to analyze the historical context of coastal fisheries and to identify potential changes in socio-economic, political, and management practices that could improve sustainability. Similar to past research on these subjects, this study's overall conclusion is that coastal fisheries are in decline throughout Micronesia and a substantial reduction in catch volume is needed until sustainable management targets can be achieved. To accomplish this, reforms in the ways that coastal fish are marketed and managed are needed in all jurisdictions to ensure long-term socio-economic security, including providing equity to fish prices and the protection of undersized fish and spawning stocks to improve fish population growth. Catalyzing declines of marine resources in some jurisdictions are open access property regimes that dampen the sense of resource ownership and responsibility and stimulate the "race to fish." Resource declines were typically most severe in open access jurisdictions, while those with low population density and those operating under stronger and more intact customary marine tenure systems tended to be less overfished. Nonetheless, degraded fisheries and impacts to fish stocks from unsustainable fishing practices were noted in all jurisdictions, regardless of the level of traditional management being exercised.

A number of key socio-economic drivers were found to contribute to marine resource declines: (1) the change from a subsistence to cash economy; (2) an erosion of customary marine tenure; (3) a lack of political will for protecting marine resources; (4) an absence of effective, responsive fisheries management; (5) increasing population pressures and demand for reef resources, including export; (6) undervalued reef and pelagic resources; (7) high external commodity costs; (8) unsustainable use of modernized fishing gear; (9) an erosion of traditional fishing ethics and practices; and (10) a paucity of educational and alternative employment opportunities.

Based on these drivers and an assessment of current management practices, the study synthesizes the economic, policy, and stakeholder actions that can be taken to address unsustainable fishing in Micronesia. Currently, one of the biggest drivers of overfishing is the disparity between wholesale fish prices and external commodity prices, particularly fuel. This disparity, together with the inability by fishers to cooperate to effectively leverage prices, is creating the framework for overharvesting. Adding to the problem are cheap, unhealthy imported meat products that compete with locally derived fish in price and which are less impacted by the wide swings in fuel prices observed over the past decade.

Governments and stakeholders should work to institute fair commodity pricing and identify other plausible means to suppress the demand, or at least capture volume, of nearshore fishes. To assist in achieving a fair market price, regional fishers are urged to form cooperative agreements and strengthen their ability to collectively bargain. Governments should also discourage the importation and consumption of the low cost, unhealthy meat products helping to drive diabetes and obesity in the region. Alternatively, markets and governments should work together with fishers to impose mechanisms to upwardly adjust wholesale fish prices and diminish overall coastal fish consumption.

The abolition of destructive fishing practices, protection of critical habitat, and severe restrictions on the harvest of highly vulnerable species, such as green bumphead parrotfish, humphead wrasse, tridacnid clams, and turtles should be paramount management goals. SCUBA spearfishing, blast fishing, fishing with poisons, and gillnetting should be banned throughout Micronesia due to their known association with habitat destruction and overfishing. Regionally, the healthiest fish communities are found in areas free of these techniques. Nighttime spearfishing, while popular, is perhaps the primary driver for unsustainable fishing and must be severely curtailed and eventually eliminated if sustainable fisheries are to be realized. Along with managing gear, there is a need to protect known fish spawning areas and fish spawning periods, along with instituting methods that allow juveniles to attain reproductive size and age, such as size limits.

In all study locales, management success, whether at the community, state, or national level, was always associated with a dedicated environmental champion whose primary focus was to identify, design, and facilitate management and conservation laws or practices. Alternatively, management failures were linked to a weak political will to prioritize and drive legislation and enforcement for resource protection. Management success was also linked to systems with well-defined user-rights, such as customary marine tenure systems or locally managed marine areas. Enforcement was noted as a key area for improvement in all jurisdictions.

To stem declines in coastal fisheries, open access jurisdictions should be restructured to allow finer divisions of ownership and management of marine resources. The expansion and support of locally managed marine areas, which includes greater community involvement in nearshore resources monitoring and protection, should be supported. Further, recent surveys found wide interest among fishers in involvement with management decision-making, monitoring, and enforcement activities. The paucity of state and national fisheries management successes and the lack of sufficient resources within state and national governments support a move toward co-management, with greater involvement from fishers.

Fisheries development activities, specifically government loans and international subsidies, were identified as being detrimental to sustainable fisheries. The study found that subsidies overwhelmingly promote fisheries development in areas already impacted by overfishing, whereas loans provide easy entry into overpopulated fisheries, while placing greater economic burdens on fishers. There is an urgent need to restructure loan and subsidy programs that promote overharvesting to ones that assist conservation and management actions.

Finally, the export of nearshore marine products is adding to unsustainable catch volumes in the region. Many jurisdictions have relatively low export levels; however, even these smaller volumes add to the burdens on coastal ecosystems, particularly where overfishing is already severe. Restrictions on reef fish export are one of a number of methods needed to reduce nearshore marine resource harvest volumes. In other jurisdictions, where export is a major component of the local economy, fees on exports and improved pricing of export products are urged to help suppress demand from importing countries and provide greater revenue to local fishers and marine resource agencies. In all jurisdictions, the best management policy is to institute an export ban on all wild-caught coastal marine products.

The study identified a number of means to boost revenue for fisheries management, focusing on the development or expansion of marine resource user fees, airport taxes, entrepreneurial businesses, and enhanced revenue from equitable pricing and export of marine resources. New revenues, when strictly dedicated to conservation and management and separated from general funds, can be an invaluable means to prevent or reverse resource declines. Market corrections are needed to improve living standards among fishers, suppress demand and consumption, boost revenues to management agencies, and reduce the impacts of overharvesting.

To bolster monitoring and enforcement efforts, governments should enlist private industry. A number of marine resource-based industries, such as the dive tourist industry, could support management and monitoring efforts. Many private industries are better funded, better equipped, and have a greater presence in the marine environment than state-run agencies. Providing a legal framework to these industries to engage in monitoring and enforcement activities should be a priority.

Although it is relatively easy to show marine resources decline in the region, our ability to clearly characterize fisheries status and trends, and provide sharply focused management recommendations, was hindered by a lack of reliable, long-term data. This ongoing dilemma will continue to make well-informed management problematic and create difficulties in gauging successes and failures of management action. For some jurisdictions, no reliable information was available, although there were clear concerns among stakeholders about the declining state of marine resources. While precautionary, data-less management should be a key component of Micronesian marine resource management, information on marketed and exported marine resources is critical toward understanding fisheries impacts and allowing the development of sound, effective management strategies.

Regional efforts to control overfishing and provide enhanced protection for marine resources, such as the Micronesia Challenge, are crucial to long-term management success and sustained fisheries. However, these efforts alone will not prevent overfishing unless the political and socio-economic drivers identified herein are addressed. Identifying ways to reduce the harvest and demand for marine products, transitioning fishers away from fisheries, streamlining policymaking, and restoring sustainable harvest techniques are all paramount to overall conservation success. We, therefore, urge all stakeholders, government agencies, and NGO partners to place equal attention and focus on harvest reduction to enable long-term sustainable marine resource management and conservation goals to be met.

NEXT STEPS

The conclusions and recommendations summarized above and detailed in the report suggest specific actions that can be immediately implemented by governments, managers, and NGO partners to improve fisheries and management responses. Among these are:

- conduct economic surveys on the effects of price increases on exports within both import and export jurisdictions, i.e., determine what the market will bear, how NGOs and other entities can assist in improving the effectiveness of supply-and-demand;
- conduct economic and behavioral assessments of the impacts on consumers and fishers from domestic coastal marine resource price increases;
- examine ways to facilitate data collection on marketed and exported catch and export;
- identify the potential for stakeholder participation in development of jurisdiction-specific comprehensive coastal marine resource management planning;
- improve the capacity of marine resource agencies to obtain and incorporate basic fisheries information and recommendations;

- identify and train local private industries to monitor (and enforce) fishing activities;
- identify and engage conservation-minded politicians to assist in streamlining the legislative process to expedite marine resource management policy;
- conduct fisher and market surveys to identify spawning sites and times for key target and highly vulnerable species;
- work with state and national governments to pass policies to protect highly vulnerable species, i.e., to produce a regional ban on the sale (and possibly capture) of turtles and moratoria on the capture of green bumphead parrotfish, humphead wrasse, coconut crab, and tridacnid clams, amongst others;
- carry out economic evaluations of the potential and cost of fisheries buy-outs;
- assist marine resource managers and legislators in financial assessments of current fisheries revenues, proposed projects (e.g., ornamentals or mangrove crab mariculture), and negotiated agreements (e.g., pelagics, marine exports);
- conduct audio and video recordings of patriarch fishers to develop educational and awareness materials; and
- implement programs that identify and grow marine resource management capacity, e.g., more specialized internal educational and vocational programs focused on marine resource management.

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Adaptive management	A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In *active adaptive management*, management is treated as a deliberate experiment for the purpose of learning.
ADB	Asian Development Bank
BMR	Bureau of Marine Resources **(**Palau)
CCS	Chuuk Conservation Society
CMAs	Culturally Managed Areas: Areas within the marine environment where only traditional fishing practices are allowed.
CMT	Customary Marine Tenure: A socially defined agreement where individuals, groups, or communities are recognized by local or customary laws as having ownership over marine areas and aquatic species in that area. Marine tenure arrangements govern the right of access and rules of use over marine areas and aquatic species.
CNMI	Commonwealth of the Northern Mariana Islands
Collapsed	Catches well below historical levels, irrespective of the amount of fishing effort exerted (FAO 2011). Collapsed systems likely require substantial timeframes (e.g., decades) to recover even when fisheries pressure is fully released. "Collapsed fishery" is defined by Newton *et al.* 2007 as when the total catch is less than multispecies maximum sustainable yield (MSY) and the ecological footprint is <1. The authors state that the ecological footprint is "underestimated by approximately 10%" as they classified several island states, including Guam, as collapsed despite having a footprint that was sustainable (*see* Depleted).
CPUE	Catch-per-unit-effort: Catch per unit of fishing effort is the total catch divided by the total amount of effort used to harvest the catch. CPUE is often used to gauge the level of harvest relative to the actual population size.
Data-less management	Management carried out in the absence of the science-based data required for the parameterization and verification of models that predict effects of various management actions with useful statistical confidence limits. Under data-less management, anecdotal evidence can be used to justify management action if, and when, scientific data becomes available to support these actions. Positive results following data-less management action suggest success, while negative results suggest a different response is needed as part of an adaptive management strategy (*see* Adaptive Management).
DAWR	Division of Aquatic and Wildlife Resources (Guam): Agency tasked with the management of aquatic and wildlife resources.
DFW	Department of Fish and Wildlife (CNMI): Agency tasked with management of aquatic resources
DMR	Department of Marine Resources (Chuuk State, FSM)

EAF	Ecosystem Approach to Fisheries: The Food and Agriculture Organisation of the United Nations (FAO) defines EAF as an "…approach to fisheries [that] strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries." The purpose of EAF is therefore "…to plan, develop, and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by the marine ecosystem" (FAO 2003). The EAF, as promoted by FAO, is a strategy that promotes conservation, sustainable use, and equitable sharing of ecosystem services. These are concepts entrenched in the Code of Conduct for Responsible Fisheries and its associated instruments and the EAF framework contributes to their comprehensive implementation. EAF is an extension of conventional fisheries management recognizing more explicitly the interdependence between human well-being and ecosystem health and the need to maintain ecosystems productivity for present and future generations, e.g., conserving critical habitats, reducing pollution and degradation, minimizing waste, protecting endangered species" Ward *et al.* (2002).
Ecological footprint	A measure of the load imposed by a given population on nature. It represents the area of the Earth's surface necessary to sustain levels of resource consumption and waste discharge by that population. In the Micronesian marine environment, the marine ecological footprint is the load imposed on marine resources by individual jurisdictions (e.g., Newton *et al.* 2007).
EEZ	Economic Exclusion Zone: Typically for pelagic fisheries, excludes fishing by foreign vessels within EEZ boundaries.
EBM	Ecosystem-Based Management: An integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive, and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity, or concern; it considers the cumulative impacts of different sectors. ["Scientific Consensus Statement on Marine Ecosystem-Based Management" March 21, 2005. Prepared by scientists and policy experts to provide information about coasts and oceans to U.S. policy-makers. *http://www.compassonline.org/pdf_files/EBM_Consensus_Statement_v12.pdf]*
FAO	Food and Agricultural Organization of the United Nations
FSM	Federated States of Micronesia
Fully exploited	Operating at or close to an optimal yield level, with no expected room for further expansion (FAO 2011). Under fully exploited systems, fishing pressure should be maintained to achieve the *status quo* or reduced to allow population growth and recovery.
Growth overfishing	A situation in the fishery when fish are harvested at an average size smaller than the size that would produce the maximum yield-per-recruit, i.e., one that promotes a reduction in the overall population size and reduces yield. Growth overfishing can be corrected by reducing the total amount of fisheries-induced mortality (reduced overall catch) together with increasing the average size of the fish harvested.

IMF	International Monetary Fund
ITQ	Individual Transferable Quota (or ITSQ, Individual Transferable Share Quota): A management tool used to allocate a fixed share of the quota to individual fishers, vessels or companies. ITSQs are usually granted as a form of long-term fishing rights and are tradable (transferable).
KCSO	Kosrae Conservation and Safety Office
kg	kilogram
KIRMA	Kosrae Island Resource Management Authority
LMMA	Locally Managed Marine Area: An area of nearshore waters and coastal resources that is largely or wholly managed at a local level by the coastal communities, land-owning groups, partner organizations, and/or collaborative government representatives who reside or are based in the immediate area. (*http://www.lmmanetwork.org*)
Localized extinctions	The loss of individual species from localized areas due to overfishing, such as that of green bumphead parrotfish (*Bolbometopon muricatum*) in all or parts of Guam and the Marshall Islands.
LRFT	Live Reef Fish Trade, includes food fish and ornamental fish varieties: Live fish trade emanating from Hong Kong or other parts of China or Southeast Asia to supply restaurants and importers with live reef food fish; or from the U.S., Europe, and Asia for aquarium fish (*see* Sadovy *et al.* 2003).
LRFFT	Live reef food fish trade: live fish trade emanating from Hong Kong, other parts of China, or Southeast Asia to supply restaurants and importers with live reef food fish (*see* Sadovy *et al.* 2003).
MC	*Micronesia Challenge*: A commitment by the Chief Executives of the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI), the Republic of Palau, the U.S. Territory of Guam, and the U.S. Commonwealth of the Northern Mariana Islands (CNMI) to *effectively conserve at least 30% of the near-shore marine resources and 20% of the terrestrial resources across Micronesia by 2020.* (*http://micronesiachallenge.org*)
MIMRA	Marshall Islands Marine Resources Authority
MPA	Marine Protected Area: Any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical, and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment. (Guidelines for marine protected areas. Gland, Switzerland and Cambridge, UK: IUCN). MPAs include the full range of areas under conservation management, from strict no-take areas to multiple use areas controlled by communities, governments, non-government organizations, or private owners.
MRMD	Marine Resources Management Division (Yap State, FSM)
mt	metric ton (or tonne), equivalent to 2204 lbs or 1000 kilograms
NGO	Non-governmental organization
nm	nautical miles
NOAA-NMFS	National Oceanographic and Atmospheric Administration-National Marine Fisheries Service (USA)

OFCF	Overseas Fisheries Cooperative Foundation (Japan)
Open access	The condition where access to the fishery (for the purpose of harvesting fish) is unrestricted.
Overexploited	Exploited at a level *above* what is believed to be sustainable in the long-term, with no potential room for further expansion and a higher risk of stock depletion or collapse (FAO 2011). In overexploited systems, productivity is achieved, among other things, by releasing fishing pressure on spawning stocks and by increasing the number of juveniles allowed to grow and reproduce.
Overfishing	To fish (a body of water or ecosystem) to such a degree as to upset the ecological balance or cause depletion of living creatures. Overfishing is evident as changes in fish or ecosystem community structure or composition, including the loss of spawning aggregations and negative changes in the mean size, age, or reproductive capacity of targeted populations.
PICTs	Pacific Island Countries and Territories
Precautionary management	Management that greatly reduces the likelihood of stock collapse or severe environmental degradation. The main aim of precautionary management is not to control the production of living resources, but simply to protect them, to maintain their viability (Johannes 1998). The precautionary approach transfers the burden of proof to those wishing to exploit a resource. In a fisheries context, fishers would have to demonstrate beforehand that their actions would not have a deleterious effect, versus the more commonly used reactionary approach, whereby management responds following resource overexploitation.
QCs	Qualifying Certificates that give business firms a 75% rebate on corporate tax for up to 20 years
Recruitment overfishing	A reduction in the spawning stock biomass (adult population) to the point where the population is no longer about to replenish itself, i.e., there are too few adults to offset the losses from fishing. Remedies to recruitment overfishing include all means to restore adults in the population, such as protecting spawning adults at spawning sites and during spawning times and allowing juveniles to reach reproductive sizes through, for example, size limits.
RMI	Republic of the Marshall Islands
SCUBA	Self-contained underwater breathing apparatus
Severe overfishing	Overfishing characterized by changes in the ecosystem, including but not limited to fisheries-induced losses or substantial depletions in abundance of fish spawning aggregations, changes in reef/habitat community composition, such as localized species extinctions, reductions in mean fish size, age, or fecundity of individual or groups of species, declines or continued low CPUE relative to historical levels regardless of effort. *Also see* Collapsed.
SNAP	Supplemental Nutrition Assistance Program (Guam)
SPC	Secretariat of the Pacific Community

Sustainable	A fishery whose practices can be maintained indefinitely without reducing the targeted species' ability to maintain its population at healthy levels, and without adversely impacting on other species within the ecosystem, including human, by removing their food source, accidentally killing them, or damaging their physical environment.
TAC	Total Allowable Catch: A fishery management approach to assign an annual quota that, if exceeded, will terminate the fishery for that year, the total allowable catch is set at a level to prevent a catch so large that the stock will be overfished.
TNC	The Nature Conservancy
WPacFIN	Western Pacific Fishery Information Network
WPRFMC	Western Pacific Regional Fisheries Management Council, also known as Westpac
UK	United Kingdom
Underexploited	Undeveloped or new fishery. Believed to have a significant potential for expansion in total production (FAO 2011).
UOG	University of Guam
US /USA	United States (of America)
USD	US Dollar
WWF	World Wide Fund for Nature/World Wildlife Fund
yr	year

SCIENTIFIC (LATIN), ENGLISH, AND FAO COMMON SPECIES NAMES

Scientific Name	Common English Name in Micronesia	FAO Common English Name
Anguilla japonica	Japanese eel	Japanese eel
Bolbometopon muricatum	Bumphead parrotfish, Humphead parrotfish	Green humphead parrotfish
Cheilinus undulatus	Napoleon wrasse, Maori wrasse, Napoleonfish	Humphead wrasse
Cetoscarus bicolor	Bicolor parrotfish	Bicolor parrotfish
Chanos chanos	Milkfish	Milkfish
Chlorurus microrhinos	Gibbus parrotfish, Pacific steephead parrotfish, Steephead parrotfish	Steephead parrots
Crassostrea gigas	Pacific oyster	Pacific cupped oyster
Epinephelus polyphekadion	Marbled grouper	Camouflage grouper
Gracilaria edulis	Edible algae	Edible algae
Hipposcarus longiceps	Pacific longnose parrotfish	Pacific longnose parrotfish
Lethrinus harak	Black-blotch emperor, Blackspot emperor	Thumbprint emperor
Lethrinus ornatus	Ornate emperor	Ornate emperor
Oreochromis mossambica	Tilapia	Mozambique tilapia
Plectropomus leopardus	Coral grouper, Leopard coraltrout, Leopard coralgrouper	Leopard coralgrouper
Penaeus monodon	Tiger prawn	Giant tiger prawn

INTRODUCTION AND BACKGROUND

Micronesia represents a wide geographic area of the Pacific Ocean (approximately N 3°-20° latitude, E 131°-172° longitude) that covers approximately 8 million km^2 of ocean approximately equal in size to the continental United States (Myers 1999) (Fig. 1). Within this region lies a smattering of coral reef islands and atolls along three major island chains inhabited by people of similar origins, but widely varying histories, customs, languages, governance, and cultural mores. While the people and cultures of Micronesia are varied, they share one fundamental challenge, that of reversing the unprecedented depletion of their marine resources now threatening their unique natural and cultural history. As a result, there is an immediate need to transform resource management and alter the forces fostering overfishing.

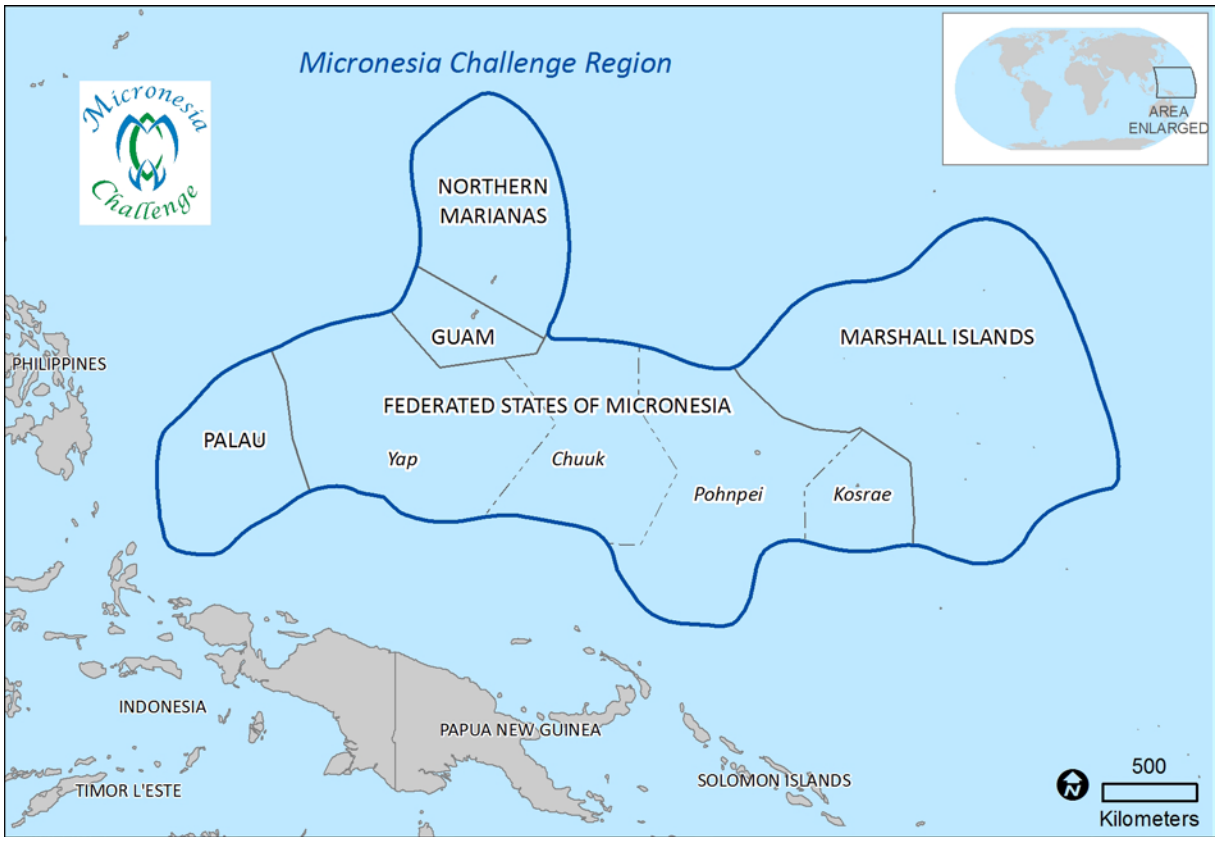

Figure 1. Map of the Micronesia Challenge jurisdictions

Beginning with the first European discovery of Micronesia in the 1500s, island life began to change. In addition to the dramatic impact to island populations through disease, colonialism brought new governments, new economies, and new systems of management (e.g., Bascom 1965; Graham 1994a; Hezel 1994, 2003). Overall, the impact of colonialism has been a steady erosion of traditional systems and a replacement of those systems by more complex, more costly, and more data-intensive Western-style systems that are a poor fit for Pacific Island countries and territories (PICTs) (e.g., Johannes 1994, Mahon *et al.* 2004). Similar to traditional management, Western systems work toward controlling resource use. In contrast to traditional management in PICTs, however, is the central focus on economic development operating under prevailing fisheries harvest and management concepts. After several decades, these concepts are still poorly practiced by Pacific island governments due in part to the intensive data

requirements, but also from an inherent lack of capacity. Along with the introduction of Western-style open access management, colonial governments instituted a cash-based economy that transformed Micronesian culture and natural resource use. In some instances this transformation resulted in a rapid demise of local marine resources (e.g., Guam; Zeller *et al.* 2007), while in others, the decline has been more gradual. Nonetheless, throughout Micronesia, where reef resources are sold and exported, there is clear evidence of decline.

Today, all Micronesian reefs are considered fully-exploited or over-exploited (Table 1)[1] and current predictions suggest that by 2030 Micronesia will need an additional 10,000 mt of reef fish to harvest annually to meet local demand (Kinch 2010). Consequently, there is a widespread recognition in the region that management improvements must be achieved to stave off economic and food insecurity (e.g., Bell et al. 2009). Beginning in the late 1970s, anthropologists, natural historians, and conservation-minded researchers familiar with Pacific Island cultures and fisheries began a movement to make Western-style management more responsive to local needs through restoring customary management techniques and instilling adaptive, data-less, and precautionary management. Simultaneously, there was recognition that to succeed, traditional resource ownership and rights needed greater support (e.g., Johannes 1978; Ruddle 1988; Acheson and Wilson 1996; Johannes 1998). This move came in observance of failing Western management policies ushered by open access to resources and the continuing decadal declines in marine resources following colonialism.

Herein, we review past and current management practices and highlight the problems currently driving overfishing. We also introduce and discuss rights-based management techniques that place greater control and ownership of resources at lower levels of government. These techniques are gaining favor because of the ongoing failure of existing management to stop unsustainable harvest of marine resources and the widespread recognition that open access systems are faring poorly in effectively managing fisheries. In doing so, we identify some local management institutions and/or practices that are working better than others, and we highlight the factors leading to their success. Newer concepts of rights-based fisheries management, such as catch shares and individual transferable quotas (ITQs), and the potential of these systems to be introduced into Micronesian reef fisheries, are discussed. We also provide a list of potential economic solutions that can be used regionally to improve the financial resource base for Micronesian communities and government marine management and conservation agencies. Several existing solutions that should be strengthened to improve under-financed marine resource agencies are discussed. These findings are directly applicable to the emerging trend toward ecosystem-based management (EBM) and the ecosystem approach to fisheries (EAF) management that operates under a more holistic view of resource management (e.g., Christie *et al*. 2007; Preston 2009; Pomeroy *et al.* 2010). These two approaches work to link terrestrial, coastal, and marine habitats and their management. In doing so, they incorporate larger areas, with a greater scope of habitats, but also create greater challenges to management.

[1] Newton *et al.* (2007), who report both CNMI and RMI as underexploited rely on unreliable and incomplete FAO statistics as a basis of their analysis. For CNMI, analyses likely include both the under-exploited northern islands and the over-exploited southern islands, resulting in an overall under-exploited designation. Based on Houk *et al. (In press)* CNMI is designated herein as overexploited.

Table 1. Jurisdictional Characteristics. The numbers and characteristics represent the best available and most recent evidence. OE=overfished, FE=fully exploited; UE=under-exploited, C=collapsed.

Jurisdiction	Pohnpei	RMI	Palau	Yap	Kosrae	Chuuk	CNMI	Guam
State of reef fishery[1]	OE; FE	OE; UE	FE; UE	FE; UE	FE	FE/OE	FE	OE/C
Reef finfish catch (mt/yr) Locally marketed reef fish (mt /yr)	596 521	910 --	-- 214±60	-- 60	-- --	-- --	~300 55 in 2009	94 61
Export reef fish (mt/yr), (best available, most recent)	47.5	--	213±60	13.6	0	200	0	0
Coral reef area (km^2)	385	1995	506	1090	21	1676	80	137
State of coral health	Fair-mod	Good-exc	Good-exc	Good-exc	Good-exc	Good exc	Fair	Fair-poor
Total fish consumption (kg/cap/yr)	69.3	39	33.4			80 (rural)	23 all, 7 reef fish	21.7-22.6
Land surface (km^2)	345	181	458	118	110	127	308	540
Population size (2000)	34,486	50,840	19,129	11,241	7,686	53,595	69,221	154,805
Pop. density (persons/mi^2)	261	886	42	244	179	1,094	1341	744
% High School graduate	64	40	74	11	54	39	69	76
% Adult college graduates	13.4	3	10	15.5	19.8	7.9	7.4	15.5
Dependency rate (15-64 yrs)	79	82	47	69	77	81	40	64
Avg. household size	6.3	7.8	3.9	5.5	7.2	7.7	3.7	3.9
Mean HH income (USD$) *median	11,249	6,840*	26,563	10,344	12,407	6,195	22,898*	39,30*
Mean per capita income (USD$)	6,793	2,281	5,785	5,016	5,625	2,133	9,151	12,722
% of work force unemployed	12.3	30.9	4.2	4.1	16.5	34.2	3.9	11.4
% working pop. engaged in subsistence activities	15	--	3	31	4	16	--	--
Visitor arrivals	7,168	5,400	57,700	5,199	3,516	7,294	400,000	1,288,000

Notes:

1. State of reef fishery: UE= under-exploited, FE= fully exploited, OE= over-exploited, and C= collapsed, from Newton *et al*. 2007; but see also for Kosrae, Yap & Chuuk (Donaldson *et al.* 1997; Beger *et al.* 2008), Pohnpei (Rhodes *et al.* 2008 and Rhodes *et al.* 2011). See also definitions in List of Acronyms and Definitions, p. 12.
2. Reef finfish and locally marketed catch: Pohnpei (Rhodes *et al.* 2008); RMI (MIMRA); Palau (D. Orrukem, Palau BMR, *personal communication*, April 2011); Chuuk (FSM Office of Food Safety, *personal communication*, March 2011); Guam (DAWR *unpublished data*; DAWR *unpublished data*; DAWR and WPacFin 2010; Guam Fishery Statistics 2008); CNMI (Houk *et al. In press*).
3. Commercial reef fish export: Pohnpei (Rhodes *et al.* 2008) Yap (Yap State MRMD 1991; A. Tafileichig, Yap State MRMD, *personal communication*, April 2011); Chuuk (FSM Food Safety Office and Cuetos-Bueno *unpublished data*).
4. Coral reef area: FSM: The Millennium Coral Reef Mapping Project *http://imars.usf.edu/MC/index.html*; other jurisdictions United Nations Environmental Programme-World Conservation Monitoring Programme (WCMC) Ocean Data Viewer *http://data.unep-wcmc.org*, unless stated otherwise; Pohnpei Island Proper=152 km^2 (Warren-Rhodes *et al. unpublished data*); Yap Island Proper=93.1 km^2 (Houk *et al. In press*); CNMI=134.6 km^2 (Houk *et al. In press*); Guam=218 km^2 (previous reef area estimates from Burdick *et al.* 2008, includes reef in federal waters > 3nm offshore.
5. State of coral reef health: FSM—Beger *et al.* 2008, Turak and DeVantier and 2005; RMI— Tupper *et al.* 2011; Guam, Chuuk and Kosrae—George *et al.* 2008.
6. Total fish consumption: FSM and Palau—Bell *et al.* 2009, national (coastal); RMI—OFCF/MIMRA State of Majuro Atoll, 2004.

7. Land surface: FSM Census 2000 (FSM Division of Statistics 2002); RMI, Palau, CNMI, and Guam (www.pacificweb.org).
8. Population size: FSM Census 2000; RMI (1998); Palau, CNMI, and Guam (www.pacificweb.org).
9. Percent urban population, education, household size, dependency rate, unemployment and labor statistics: FSM Census 2000 (FSM Division of Statistics 2002); CNMI, Guam, Palau and RMI 2000 (www.pacificweb.org). Percent working population engaged in subsistence activities: FSM Census 2000 (FSM Division of Statistics 2002); Palau (Matthews *et. al.* 2004).
10. Mean household income and per capita incomes: FSM Census 2000 (FSM Division of Statistics 2002); CNMI, Guam, RMI and Palau 2000 (www.pacificweb.org).
11. Visitor arrivals: Guam, CNMI, Palau, and RMI (www.pacificweb.org); Kosrae, Pohnpei, Yap and Chuuk (FSM Division of Statistics 2007).
12. Based on 30m depth and all lagoon area (Houk *et al. In press*).

In Micronesia, the most recent drive to incorporate EBM and EAF into practice is the Micronesia Challenge, which seeks to "…effectively conserve at least 30% of the near-shore marine resources and 20% of the terrestrial resources across Micronesia by 2020" (http://www.micronesiachallenge.org). The Micronesia Challenge focuses on five main activities: (1) identifying hotspots of highest biodiversity; (2) creating science-based, resilient protected area networks, or PANs, and developing local management plans for individual sites; (3) addressing key threats, such as watershed degradation and coastal development, invasive species, and destructive fishing and over-fishing; (4) designing and implementing government policies supportive of sustainable resource management; and (5) providing local capacity-building through community group and NGO training in marine conservation. To be successful, this huge undertaking will not only incorporate additional terrestrial and marine ecosystems, but will also necessitate improvements in the way regional, state, and local management bodies operate. Given the current and predicted regional resource needs, it is imperative these goals be met. However, to do so will, in some jurisdictions, require a sea change in the way management and enforcement are conducted, with accompanying changes in marine resource financing structure. A failure to achieve these and other related conservation goals will put more pressure on governments, increase poverty and food insecurity, and reduce the potential to develop non-extractive industries, such as ecotourism.

METHODS[2]

The current review encompasses the major island groups and population centers throughout Micronesia: Pohnpei, Chuuk, Yap, and Kosrae of the Federated States of Micronesia (FSM), the Republic of Palau (Palau), the Republic of the Marshall Islands (RMI), the U.S. Territory of Guam, and the southernmost islands of the Commonwealth of the Northern Mariana Islands (CNMI) that include Saipan, Rota, and Tinian[3]. Using data and reports from these eight jurisdictions, five questions were approached:

1. What are the internal and external market drivers of unsustainable fishing and their impacts on coastal fisheries?
2. What is the present status and future direction for traditional and contemporary rights-based fisheries management systems?

[2] The Terms of Reference for this study are provided in Appendix A.

[3] The southern islands were the focus of the current study due to known population and fisheries pressures on marine resources. The northern islands are currently under U.S. federal protection, are uninhabited, and are experiencing low levels of fishing pressure.

3. What are the current stakeholder perceptions of coastal fishery resources and management?
4. What are the best suited management solutions, and are they transferable across the study locales?
5. What are the best options for developing sustainable financing to reduce unsustainable fishing in Micronesia?

Data and reports were collected throughout the region by conducting in-depth reviews and analyses of primary and secondary literature, including peer-reviewed journals, policy briefs, reports, public databases, national or state census data, and available grey literature. An examination of internal and external drivers of regional overfishing was conducted through interviews with fisheries-associated individuals (e.g., marine resource personnel, local NGO staff, market owners, fishers), literature reviews, collection of available unpublished datasets, and a combined analysis with country statistics (*see* References and Appendix Table A1). Interviews were conducted with upper-level marine resource agency staff, patriarch fishers, scientists, policymakers, and local NGOs involved in marine conservation in the eight study jurisdictions. Where they existed, coastal fisheries data were collected to examine fisheries trends, as well as successes and failures of past and current management approaches. We chose four jurisdictions that represented a range of traditional and Western management styles, (CNMI, Pohnpei, Palau, and Chuuk) to conduct fisher interviews that identify contemporary perceptions of fishery resources and management by stakeholders (e.g., Fig. 4)[4]. Building from the collective information, syntheses were prepared using a case-study format.

REVIEW OF INTERNAL AND EXTERNAL MARKET FORCES

SOCIOECONOMIC CONTEXT AND DRIVERS OF UNSUSTAINABLE FISHING

Throughout Micronesia, unsustainable fishing practices and long-term failures in management have led to deteriorating fish populations and reef ecosystems. The paucity of reliable fisheries statistics continues to impede our understanding of the causes and magnitude of the problem and the ability to make informed management responses. Regardless, it is clear that *the primary driver of unsustainable marine resource use is the transition from subsistence to a market-based fishery that is focused on profit*. A number of other primary and secondary drivers are interwoven with and contribute to this trend. These include:

1. A weakening of traditional ownership rights and customary marine tenure (CMT) systems;
2. The absence of effective, adaptive modern fisheries management systems;
3. The modernization of fishing gear and practices, leading to overly efficient reef and coastal fisheries, including technologies that facilitate marketability and export;
4. Excess capacity;
5. An erosion of traditional fishing ethics and practices;
6. A paucity of educational and employment opportunities, particularly for younger fishers;
7. Population increases leading to a growing local demand for marine resources; and
8. A lack of political will to institute strong reef fisheries management policy.

[4] The authors chose four of the eight jurisdictions to depict the state of coastal fisheries and management as perceived by Micronesian fishers These jurisdictions were chosen to represent the range of management (open and traditional) that exists in the region, with CNMI, Chuuk, and Palau surveys based those taken in 2009 during a much broader and more comprehensive survey in Pohnpei by co-author Rhodes.

DRIVERS OF UNSUSTAINABLE FISHING

Transition from Subsistence to a Cash Economy

A common theme throughout the Western Pacific has been the transition from a largely subsistence living to a cash-based society, becoming increasingly prominent since World War II, but beginning as early as the 1800s (Denoon *et al.* 1997)[5]. While the key transitional dates (late 1880s-present) and players (e.g., Spain, Germany, Japan, U.S.) have varied regionally, the overall pattern has been similar—colonization created commercialization of resources that were previously for subsistence use. Consequently, the need to generate cash for the purchase of imported household goods (e.g., flour, rice, and animal protein) and basic occupational items (fishing hooks, fishing line, fuel, storage) began to transform traditional harvesting and fishery resources management, as well as the social structure of Micronesian communities (Dahl 1988; ADB 2005). During the 1900s, for example, Pohnpei reportedly traded 500-600 pounds (225-275 kg) of turtle shell annually, a commodity previously reserved for the traditional chief (ADB 2005). *The net outcome of commercialization of reef fisheries, decades to centuries later, has been the emergence of unsustainable fishing practices and catch volumes and exports in excess of sustainable productivity*.

Lack of Effective Modern Fisheries Management Systems and Resources

As traditional customary marine tenure (CMT) systems weakened or became obsolete, an effective, responsive, and adaptive functional modern management and enforcement equivalent failed to materialize. In place of CMT came a Western-derived management system modeled to varying degrees on U.S. fishery laws, regulations, and governing institutions. Now decades old, these *Westernized management systems have become increasingly dysfunctional and largely unresponsive to local management needs* (Johannes 1994). In most instances, state budgets and capacity are insufficient to meet management, monitoring, and enforcement requirements.

[5] In Pohnpei, "missionaries encouraged congregants to produce commodities for sale (*sic*)…to facilitate the civilizing process and engender a healthy respect for…exchange and profit." (Denoon *et al.* 1997)

Figure 2. Young CNMI fisher with the catch of the day. (Photo: J. Ouan)

Modern Gear and Practices and Erosion of Traditional Fishing Ethics

Motorized boats and modern fishing gear, often obtained with state, national, or international subsidies and grants, have enabled greater access to distant fishing grounds and increased catch efficiency. Imported gears, including SCUBA, steel hooks, fishing line, small mesh nets, including gillnets, underwater flashlights, and spears, and increasingly, in some jurisdictions, depth sounders and global positioning systems, have (i) allowed easy entry into the fishery; (ii) increased the range of depth, fish size, and species captured; (iii) broadened the potential for nighttime fishing (Gillett and Moy 2006); and (iv) increased overall efficiency. *Nighttime spearfishing and small-mesh nets that include surround nets, gillnets, and drag nets have been identified as causing the greatest damage to coastal resources and are the primary gears associated with overfishing* (e.g., for Palau, Johannes 1981; for Yap, Smith, 1991; for Pohnpei, Rhodes *et al.* 2008; McClanahan 2010) (Fig. 3). In Guam and CNMI, where overfishing has been documented for decades, SCUBA spearfishing has eliminated the depth refugia of several reef fish species, similar to that observed elsewhere (Bascom 1965; Goetze *et al.* 2011). As McClanahan (2010) concludes, many of the most efficient and economically rewarding modern practices inflict the greatest harm to fish and habitats.

Figure 3. Pohnpei fisher Taylor Paul with catch taken during a brief nighttime spearfishing excursion. (Photo: Steve Lindfield, March 2010)

The transition to a cash economy has also altered local customs and exposed subsistence economies to external market forces. Instead of improving living standards, the cash economy has created a loss of "subsistence affluence" within fishing communities in most jurisdictions (Sahlins 1972; Johannes 1981). Fishers have become more economically marginalized and are experiencing greater overall disadvantage relative to other societal segments (Kronen *et al.* 2010; Marshall *et al.* 2010). This has led to the *abandonment of long-standing ethical fishing traditions and methods*, such as sharing fishing effort and resources and limiting catch to daily needs. Fluctuating external commodity prices and the lure of commercial sales and export have increased competition among fishers, with some coastal fisheries mirroring the "boom and bust" characteristic of other commercial fishery sectors (Sadovy *et al.* 2003). Younger fishers in particular have adopted a "race to fish" mentality to purchase coveted imported goods (Fig. 4). In many areas, fishing grounds closest to large urban centers have been depleted, with fishers moving further afield. This, in turn, has created ever-greater operating costs and dependency upon imported goods (e.g., fuel) and eliminated past ethical practices that buffered resource overexploitation (Johannes 1981).

Paucity of Education and Employment Opportunities

A lack of educational and employment opportunities, manifested by high dependency and unemployment rates, can justly be considered as an underlying cause of unsustainable fishing in Micronesia (Table 2). In most locales, fishers are poorly educated (Fig. 5) and do not have formal work skills in professional trades, decreasing their opportunities and potential for alternative livelihoods or salaried employment.

In the FSM, nearly 50% of fishers typically attain at most an elementary-level education, leaving few job opportunities outside fishing. Indeed, nearly 95% of the subsistence sector of the FSM economy consists of persons with a high school education or less (FSM Division of Statistics 2002). In Chuuk, for example, with the highest population density in the FSM, 19% of men over 25 years of age have no formal education (Lambeth and Santiago 2001). *The link between high unemployment, minimal education, and*

resource overharvesting is evident, particularly in the FSM. In these locales, higher numbers of unemployed have no economic alternative but to fish.

Population Pressures

Population growth (e.g., 2.6%/yr in FSM, 1973 to mid-1980s) has elevated pressure on reef resources throughout Micronesia. From 1973 to 2000, FSM's population increased by 70% (Bascom 1965; FSM Division of Statistics 2002). While declining fertility and increasing emigration have slowed growth in many states over the last decade, *small land and reef areas coupled with high population densities continue to drive unsustainable demand* (Houk *et al. In press*). In Pohnpei, a moderately sized population of approximately 35,000 residents is outstripping current sustainable reef fisheries supply by around 1.5 times sustainable yield, primarily from local demand (Warren-Rhodes *et al. unpublished data*). Likewise, in Kosrae and southern CNMI, where population densities are low, overfishing is driven both by high local demand and a small reef area. High population pressure is directly linked to limited educational opportunities and negative impacts to human and ecosystem health (ADB 2004).

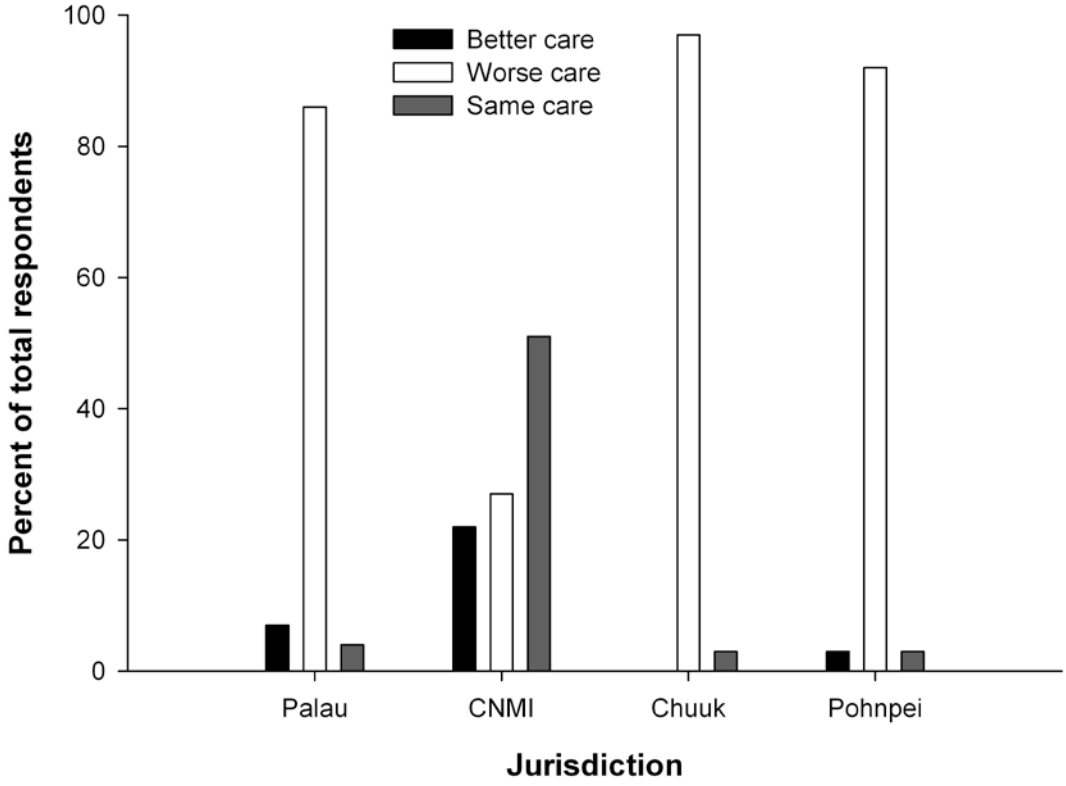

Figure 4. Responses from patriarch fishers (40+ years) when asked if the younger generation was better, worse, or the same at taking care of marine resources. Typical reasons associated with "worse care" included "taking too much fish," "no regard for the size of fish selected," "only care about money," and "no concern for future generations." (n = Pohnpei-647: Chuuk-105; Palau-83; CNMI-100)

Local Market Demand for Reef and Pelagic Fish

High per capita fish consumption (Table 1) has led to strong commercial (to supply both local and export markets) and subsistence demand for reef fish in Micronesia (Fig. 5). Nearly 50% of reef fish captured on Yap (around 100 mt/ yr) is supplied to local retail markets, while in Chuuk at least 200 mt /yr is shipped to Guam (Houk *et al. In press*)[6]. In Pohnpei, an estimated 596 mt of reef fish is extracted annually from reefs near the main island, with an estimated three-fourths slated for local sale (Rhodes *et al.* 2008). In Pohnpei and Guam, mean annual per capita reef fish consumption is around 20 kg (Table 1; Warren-Rhodes *et al. unpublished data*).

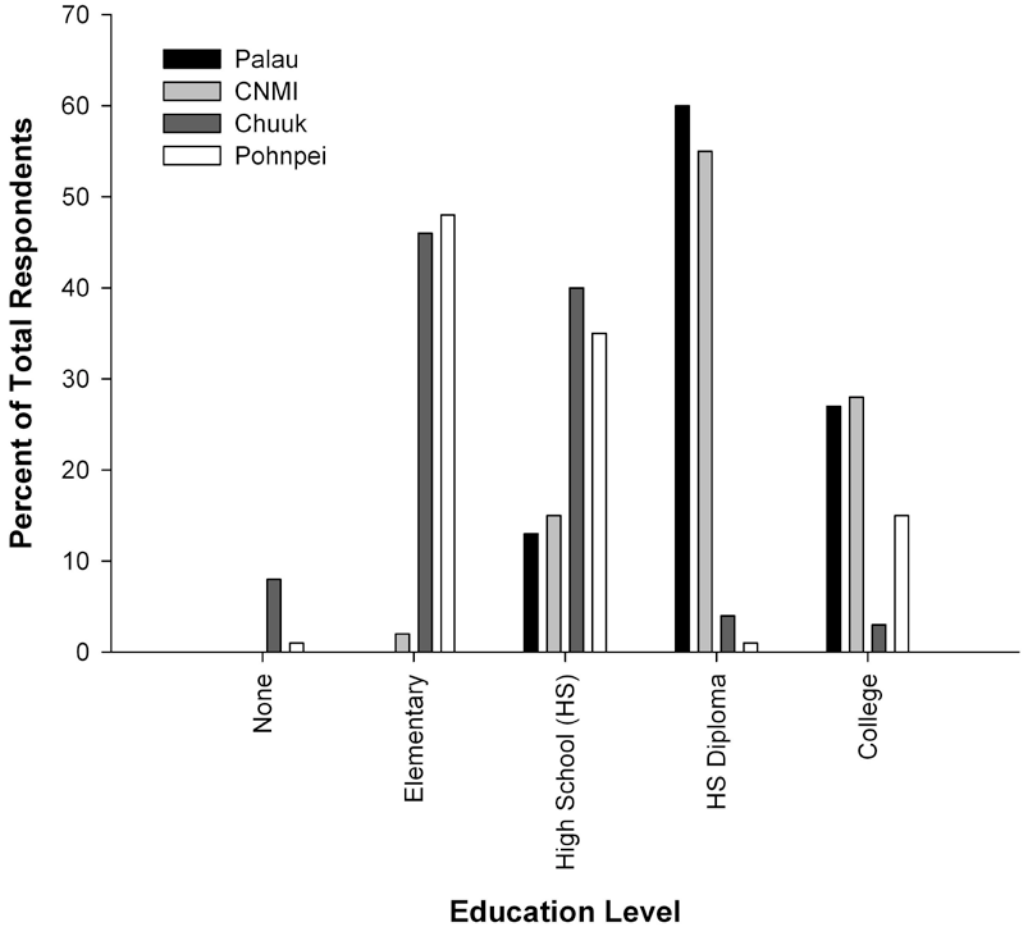

Figure 5. Education levels of fishers surveyed from four Micronesian jurisdictions. (n = Pohnpei-647: Chuuk-105; Palau-83; CNMI-100). High School (HS) implies no diploma was attained.

We estimated that the total locally consumed reef fish for Chuuk is roughly 2,000-3,000 mt /yr (FAO 2010; Kronen *et al.* 2006). According to Houk *et al. (In press),* reef fish demand was higher in CNMI than

[6] Chuuk records export statistics for reef fish through the FSM Food Safety Office.

in either Yap or Pohnpei. *In most locales, studies that include ecological footprint analyses*[7]*, have estimated Micronesian reef fisheries yields to be unsustainable* (e.g., Zeller *et al.* 2007; Newton *et al.* 2007; Rhodes *et al.* 2008). In Guam, overfishing occurred as early as the 1950s (Zeller *et al.* 2007) due to high demand for reef resources, small reef area, and high population density.

Figure 6. Competition to purchase fish is fierce at a Weno market in Chuuk. (Photo: J. Cuetos-Bueno, February 2011)

Limited Political Will

Long-term declines in marine resources have been reported regionally within Micronesia (e.g., Graham 1992; Zeller *et al.* 2007; Richmond *et al.* 2008), much of it due to fishery managers' inability to react quickly to observed resource impacts (Fig. 7). Despite obvious and ongoing overharvest and degradation, reef fisheries in Micronesia remain relatively unconstrained by legislative or management action (Houk *et al. In press*). In a recent global review of fisheries co-management, strong leadership was shown to be the primary factor influencing success (Gutiérrez *et al.* 2011). However, *in most of Micronesia, strong political support and action is sorely lacking* and in some cases is even actively working against management measures to improve and sustain resources (see Jurisdictional Case Studies: Pohnpei). Based on findings from a recent stakeholder study in Pohnpei, a vast majority of Pohnpeians supported greater and more responsible management, yet politicians are reluctant to enact stronger measures (Hopkins and Rhodes 2010). Moreover, the same survey showed that stakeholders wanted management change 1-2 years after reliable recommendations were forwarded and felt that politicians worked too slowly in

[7] Marine ecological footprint analyses examine the relative reef area needed to supply reef fish and seafood to a given populace (Warren-Rhodes *et al.* 2003).

responding to legislative needs for management. In contrast to overall regional trends, the Palau case describes a joint commitment by traditional and political leaders to create a proactive national strategy for long-term marine conservation and development (*see* Jurisdictional Case Studies: Palau). This strong commitment led to the creation of the Micronesia Challenge (*see below*) that provided the impetus for regional marine protected area network development and dedicated funding and initiatives for conservation action. In concert, Palau's ongoing political actions have enabled and improved management and enforcement of fisheries and exports compared with other regional jurisdictions. These actions include bans on the fishing of sharks, endangered fishes, and invertebrates, protection of key spawning aggregation sites and seasons, and prohibitions on deep-sea bottom trawling and the live reef fish trade (*also see* Appendix Table A2). While Palau's conservation and management successes are a work in progress, these political initiatives could serve as a model for pioneering marine conservation and management elsewhere in the region. Despite this support, Palau is still plagued by poaching due to inadequate enforcement and monitoring, and there remain significant challenges to sustainable reef fisheries. Nonetheless, in Palau, there are several dedicated individuals, chief among them politicians, championing conservation action and improvement, with visible benefits. According to Gutiérrez *et al.* (2011, p. 388), "*legitimate community leaders, when guided by collective interests and not self-benefits, give resilience to changes in governance, influence users' compliance to regulations, and enhance conflict resolutions…*"

Figure 7. A humphead wrasse (*Cheilinus undulatus*) being processed at a Kolonia (Pohnpei) market. Although this iconic species is in regional decline and is a major tourist draw, most end up in markets for less than two dollars per pound. (Photo: J. Cuetos-Bueno, February 2011)

INTERNAL AND EXTERNAL MARKET FORCES DRIVING OVERFISHING

The cumulative evidence suggests that a number of specific market forces underlie unsustainable fishing practices across Micronesia. These forces are the direct outcomes of the drivers described above. As an example, the transition from subsistence to a market-based economy impacts local fishers through fluctuating commodity prices, particularly imported fuel and food. Behavioral responses by fishers can be directly traced to external market drivers. However, unlike a traditional market response, where commercial fishers might align their fish prices to external commodity prices, *Micronesian fishers typically respond to rising external commodity prices by increasing catch volumes to offset financial loss in direct conflict with traditional economic theory. This response is both economically self-defeating and ecologically unsustainable.* As our case studies show, in regions where fishery data suggest the most compromised stocks exist, illegal or unethical fishing practices continue to be a problem, driven in part by the need to increase catch volume. Examples of unethical fishing include SCUBA spearfishing, overfishing of

spawning aggregations, blast fishing, or entering marine protected areas to catch fish that would otherwise replenish stocks. Below we provide an overview of the specific internal and external market forces and how they work to influence overfishing.

EXTERNAL MARKET FORCES

Reliance upon Imported Goods & Rising External Commodity Prices

Micronesian fishers are reliant upon imported materials for fishing. The most important of these is boat fuel, which is a critical commodity and primary market-based driver of overfishing. As fuel prices rise, fishers in many locales respond by increasing fish volumes, rather than by raising prices, thus driving overexploitation trends. When catch sales no longer cover basic fuel costs, some fishers choose not to fish, reducing their overall income and that of retail fish market owners (A. George, Kosrae Island Resources Management Authority, *personal communication,* March 2011). As an example, Figure 8 shows the incongruity between wholesale fish prices and fuel prices in Palau. By 2008, Palauan fishers would have needed to catch more than twice as much fish to cover fuel costs than in 2003. During September 2008, the Consumer Price Index (CPI) experienced a 16.8% change from the previous year, yet the real difference between wholesale fish prices and fuel reached its widest gap over the 6-year period examined (Palau Office of Planning and Statistics 2011). In addition to fuel, most commercial fishing gear is also imported: boats, motors, fishing line, steel hooks, metal spears, nets, plastic fuel containers, and coolers. Similar to fuel, *the associated costs of these external commodities necessitate larger catch volumes to cover daily occupational expenditures* (Table 2). In Pohnpei, for example, around 55% of commercial fishers use motorized boats island-wide, with 86% of the primary commercial fishers that serve Kolonia markets reliant on fueled boat engines (Rhodes et al. 2008). A substantial percentage of basic food items consumed in Micronesia, such as rice, canned and frozen meats, or fish, are also imported (Corsi *et al.* 2008). This reliance on imported foodstuffs is a major culprit in the growing obesity epidemic in Micronesia and the wider Pacific. In Palau, for example, by the early 1970s over 30% of all animal protein consumed was imported (Johannes 1981). Currently, over 38% of income in Micronesia is spent on imported goods (Cassels 2006). Even in the remote outer island subsistence-based communities of Yap, people are increasingly reliant upon imports (Kronen *et. al.* 2010).

The purchasing power of fishing families, like other non-salaried and government salaried workers in Micronesia, has continued to erode as inflation rises but wages stagnate (FAO 2011). In Palau, the CPI in late 2008 increased by 10-15% relative to the previous year (Palau Office of Planning and Statistics 2011). Imported food and commodity prices also impact retail and consumer behavior. For example, when imported chicken or canned fish prices decrease, market owners reduce retail fish prices to stay competitive with imports. Conversely, consumers respond to higher local fish prices by buying lower-priced, less healthy canned or frozen meats.

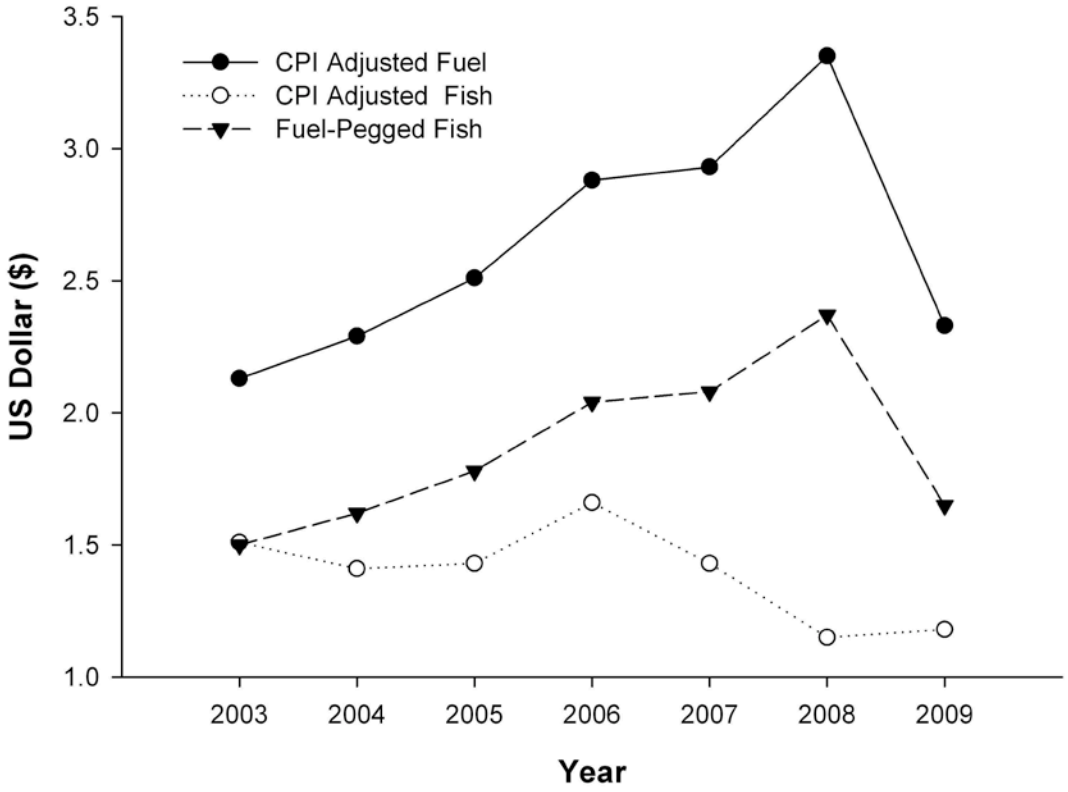

Figure 8. Palau—A comparison of observed CPI-adjusted wholesale reef fish prices, fuel prices and fuel-pegged wholesale reef fish prices (based on the 2003 fish-fuel price ratio). (CPI 2004 = 100).

Table 2. Internal and External Market Forces Driving Overfishing. Pohnpei=PO; RMI=Marshall Islands; PA=Palau; Y=Yap; K=Kosrae; CH=Chuuk; GU=Guam. (not important=blank; moderate importance=**M;** high importance/ main driver=**H**)

	PO	RMI	PA	Y	K	CH	CNMI	GU
External								
Reliance on imported goods	H	H	H	M	M	H	H	H
Export market demand	M	H	M	M	M	H		
Internal								
Undervalued export products	H	H	H	H	H	H	H	H
Low internal commodity price	H	H	H	H	H	H	M	M
Subsidies for fishing	M	H				H		
Consumer preferences	M	M					H	H
Fisher lack of capacity	H	M	M	H	H	H	M	M
Local retail sales markets	H	H	H	H	H	H	M	M

Export Market Demand for Reef Fish

The advent of a cash economy produced an ever-increasing need to obtain foreign currency for imported goods. In some Micronesian jurisdictions, particularly Chuuk, this resulted in the development of a reef fish export market (Table 3; Fig. 8). Following the decline of the Guam reef fishery in the decades following World War II, a significant regional trade for fresh reef fish ensued (*see* Jurisdictional Case Studies: Guam; Appendix Table A1) (Zeller *et. al* 2007). By 2007, Guam had begun to import substantial volumes of reef fish from within the region, much of it from Chuuk's already impacted reef ecosystems[8]. As a whole, the FSM reported 244,241 kg (244 mt) of reef fish exports in 2007, valued at $841,376 (Gillett 2009). This value is likely an underestimate, since Chuuk alone reported 200 mt of exported reef fish in 2010. Recent estimates based on per capita consumption place the volume of extracted reef fish at 2,000-3,000 mt/yr, far beyond their sustainable capacity (Cuetos-Bueno, J. *In preparation*). For other Micronesian jurisdictions, less than 10% of overall catch volume is exported (e.g., Yap State MRMD 1991; Rhodes *et al.* 2008; D. Orukkem, Palau Bureau of Marine Resources, *personal communication*, April 2011). These exports are typically shipped to friends and relatives, with primary destinations in Guam, Hawaii, and the U.S. mainland (Rhodes *et al.* 2008; A. Tafileichig, Yap Marine Resources Management Division, *personal communication*, April 2011). While relatively minor, *exported reef fish volumes for personal consumption are significant, particularly where overfishing is already a problem, e.g., Pohnpei*.

Table 3. Relative Importance of Drivers to Overfishing in Micronesia (not important = blank; moderate importance = **M**; high importance/ main driver = **H**). Pohnpei=PO; RMI=Marshall Islands; PA=Palau; Y=Yap; K=Kosrae; CH=Chuuk; GU=Guam

	PO	RMI	PA	Y	K	CH	CNMI	GU
CMT (C), Open Access (O) or mixed (X)	O	X	C	C	O	X	O	O
Strong (S), weakening (W) or no (N) CMT	N	W	S	S, W	N	W	N	N
Lack of effective management and resources	**H**	**M**				**H**	X	X
Move to modern & unsustainable fishing practices (e.g., SCUBA) & erosion of fishing ethics	**H**	**H**	**M**	**M**	**M**	**H**	**H**	**H**
Low education and lack of alternative livelihoods	**H**	**M**		**H**	**M**	**H**	**M**	
Population size/density		**H**		**M**	**H**	**H**	**H**	
Local reef fish demand	**H**	**H**	**H**	**H**	**H**	**H**	**H**	**H**
Lack of political will	**H**			**M**		**H**	**H**	
Status of reef fisheries, ecological footprint[1]	>1	1 or >1	<1	<1	1 or >1	>>1	>>1	>>1

[1]Newton *et al.* (2007)

[8] The lack of reliable catch, trade, and export statistics throughout the region continues to hamper our ability to assess and compare trends in fisheries.

Figure 9. Groupers packaged for export from Chuuk to Guam. Large numbers of individual species in markets often suggests fishing of spawning aggregations. (Photo: J. Cuetos-Bueno, March 2011)

Since the 1980s, a number of Micronesian countries have exported reef fish internationally for the Southeast Asia-based live reef fish food trade (LRFFT) (Sadovy *et al.* 2003). *During periods of participation in trade, export countries experienced substantial declines in targeted species, including the loss of spawning aggregations of locally important fish* (e.g., Johannes *et al.* 1999). These losses, and a history of LRFFT vessels fishing illegally in locales outside licensed areas (including marine sanctuaries), resulted in most countries abandoning licensing agreements for live fish exports. Nonetheless, Chuuk is still considering entering into a licensing agreement, even with reports of recent unlicensed LRFFT activity in the state (*see* Jurisdictional Case Studies: Chuuk). In other instances, countries such as the Marshall Islands are allowing the export of chilled or frozen fish to Asian markets, including both deepwater and shallow water reef species (F. Edwards, MIMRA, *personal communication,* March 2011), and the transport of live aquarium fish to the U.S. mainland. Overfishing is already impacting coastal fisheries in Majuro and nearby atolls, suggesting a need to reduce, not increase, fish harvest volumes and export.

INTERNAL MARKET FORCES

Undervalued Export Products

All Micronesian fishery resources, including nearshore and pelagic fishes and invertebrates, are undervalued both domestically and for export. While undervaluation characterizes coastal fisheries in general, the starkest example is for pelagic fisheries. With the recent collapse of Eastern Atlantic tuna stocks (Safina and Klinger 2008), the Western Pacific tuna fisheries now represent the last healthy tuna fishery in the world, with 100,000 mt/yr of sustainable export potential (FAO 2011; ISSF 2011). Yet, Western and Central Pacific countries, including RMI, FSM, and Palau, receive on average only 5% of the value of landed tuna catch, with the bulk of revenues going to fishing nations, particularly Japan, China, Korea, and the U.S., which long ago overfished their own stocks and are now reliant on external supplies. Nevertheless, these demand countries' political clout enables them to purchase tuna and other marine resources from Micronesian and Melanesian countries at highly undervalued prices (Leuth and Yang 2008). The under-valuation of these increasingly scarce commodities is an economic trap that deprives

Micronesian governments of deserved revenue, making it more difficult to address domestic needs, including proper monitoring, management, and enforcement of coastal (and pelagic) fisheries.

Low Internal Market Prices for Reef Fish

Domestic Micronesian coastal reef fisheries have been undervalued and affected by price erosion and stagnation for years (Figs. 8 and 10). Undervaluation of reef fisheries is a key driver of poverty in stakeholder communities, with poverty levels currently at about 30% (ADB 2004). Poverty, in turn, helps drive overfishing, particularly when prices are stagnant. Specifically, in Pohnpei, the wholesale reef fish price rose from $0.85 in 1987 to only $1.25 in 2011. During the same period, fuel increased from $1.50/gal to $4.50/gal. In 2008, fuel prices peaked at $7.00/gal, with annual inflation at about a 4% (FSM Division of Statistics 2008). In 2008, the consumer price index in Palau reached 16.8%, yet fish prices declined (Palau Office of Planning and Statistics 2011; D. Orrukem, Palau Bureau of Marine Resources, *personal communication*, April 2011).

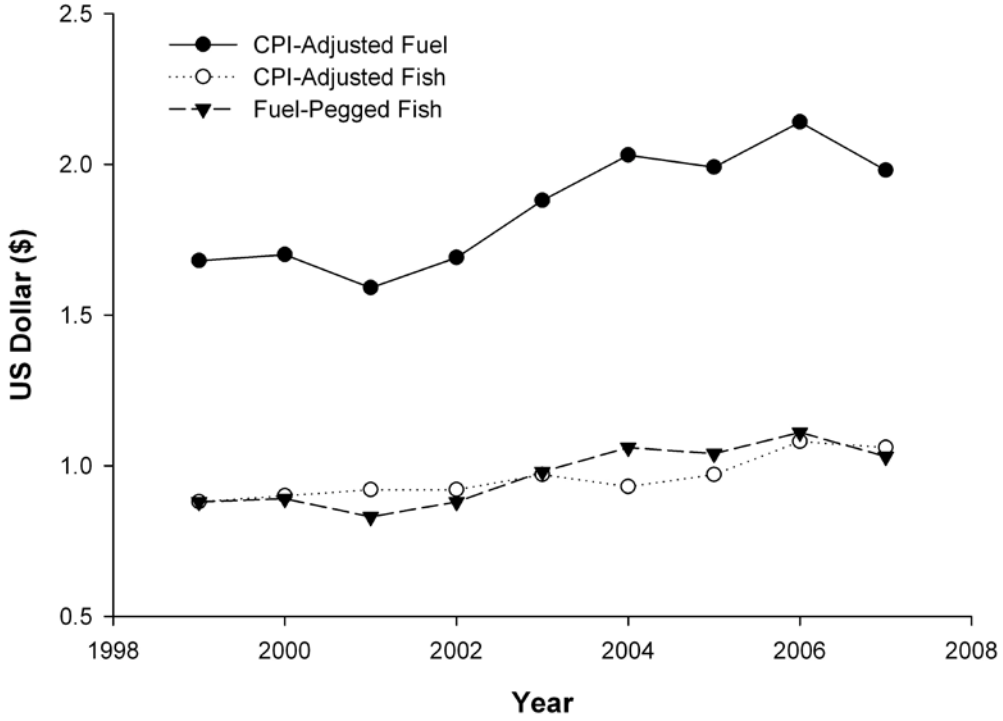

Figure 10. Pohnpei, FSM—A comparison of observed CPI-adjusted wholesale reef fish prices, fuel prices, and wholesale fuel-pegged reef fish prices. (Consumer Price Index, CPI 2000=100). Although trends between commodities are similar, reef fish prices in the FSM are substantially lower relative to other Micronesian jurisdictions.

In RMI, the 2011 wholesale price for reef fish ranges from $0.70 to $1.00/lb ($1.54 to $2.20 /kg), while fuel costs on the outer islands of RMI where marketed fish are captured is US$8-10/gallon (F. Edwards, MIMRA, *personal communication,* March 2011). Retail fish prices in Chuuk are currently $1.25-$1.50/lb, with fuel exceeding $4.00/gal (C. Graham, Chuuk Conservation Society, *personal communication,* March 2011). Simultaneously, food price inflation has outpaced fuel price inflation in all locales. These *price disparities have driven fishers in most jurisdictions to extract ever-higher fish volumes to cover daily household and occupational expenditures*.

Guam and CNMI, in response to increased fishing effort, decreases in local supply, and the higher costs of imported fish, are the only two jurisdictions where substantial upward reef fish price adjustments have occurred. In Guam, for example, fish sold for nearly $4/kg ($1.80/lb) in 1987, while in 2010 pricing was up to $6.87/kg ($3.10/lb). *In real terms, however, prices adjusted using the Consumer Price Index (CPI) show that wholesale reef fish price has declined considerably.* On Saipan, the current reef fish price is $8.80/kg ($4.00/lb). Despite these exceptions, in nearly all jurisdictions surveyed, reef fish remain undervalued relative to nearly all other commodity prices, while *governments, markets, and fishers appear unable or unwilling to assist fishers in setting reef fish prices that reflect the overall economy*. Inadequate pricing structures have allowed many regional fishers to "receive less than the free-market price for their catch" for decades (Ruddle and Hickey 2008) (Fig. 11). *To be equitable and sustainable, reef fish prices should reflect external costs, i.e., could be pegged to fuel or other external commodity prices.* To improve the potential for sustainable fisheries, fishers need greater involvement in pricing, which could be accomplished through collective price setting and bargaining or through fisher owned-and-operated markets. Indeed, a recent review of co-management success showed that the influence of fishers in local markets characterized the most successful co-management regimes (Gutiérrez *et al.* 2011). While not widely practiced, such cooperative agreements among fishers could assist in pricing and potentially result in reduced overall catch volumes, a smaller, more efficient fishery, and improved incomes.

Subsidies for Loans and Fisheries

The provision of national, state, or local subsidies to promote fishing is a global phenomenon that has contributed to overcapacity and overfishing (Worldwide Fund for Nature 2002). In Micronesia, subsidies typically originate with an international donor that supplies money to national, state, or local entities to increase fishing capacity and marketability, such as fish storage or transport. As an example, Japan's Overseas Fisheries Cooperative Foundation (OFCF) continues to allocate funds for ice plants and fish storage facilities throughout Micronesia. More recently, there have been some changes to Japan's policies, with increased focus on management and away from fisheries promotion.

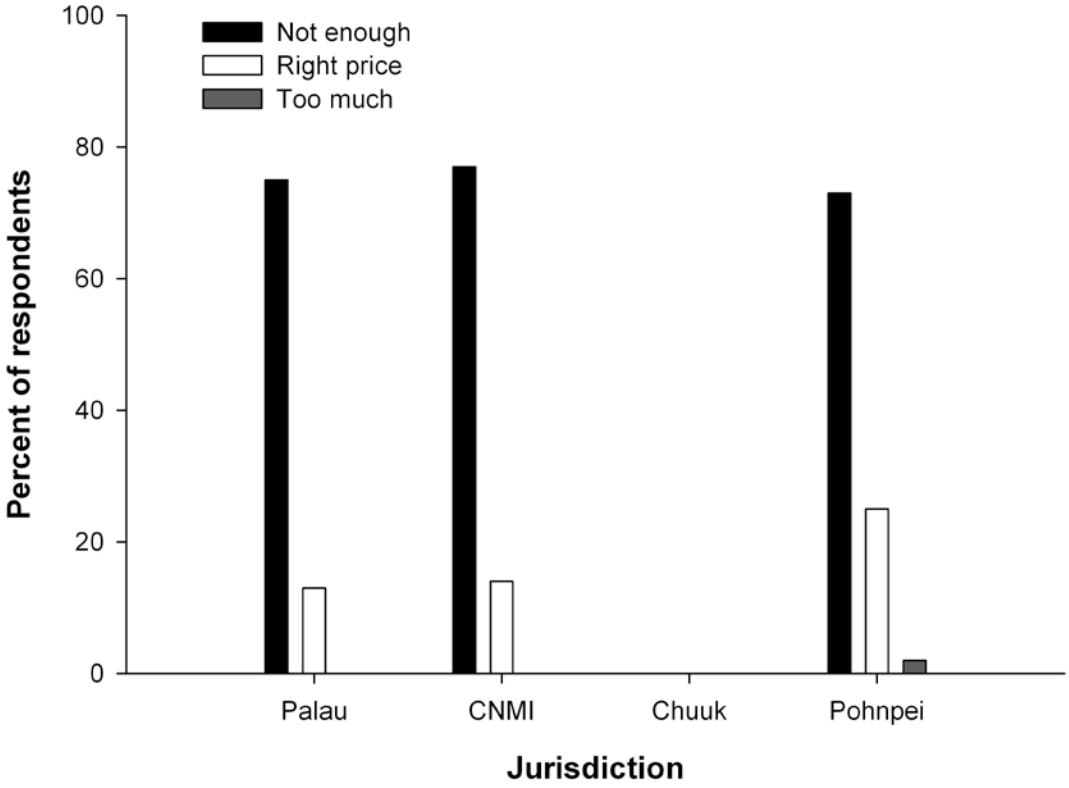

Figure 11. Summary of fishers' responses from three (of four) jurisdictions surveyed when asked about the price paid to them for fish. (n = Pohnpei-647; Palau-83; CNMI-100)

While the intent of subsidies may be positive, the resultant impacts to coastal fisheries are generally negative. In the RMI, for example, funds were recently provided from Japan for a cold storage plant in Majuro. The plant was designed to allow storage of marketable reef fish from outer islands (F. Edwards, MIMRA, *personal communication*, April 2011). On these same outer islands, however, fish populations are already impacted from overfishing, with declining catch and alterations in fish communities (D. Hess, College of the Marshall Islands, *personal communication*, April 2011; Beger *et al.* 2008). Thus, *subsidies for development of reef fisheries, however well intentioned, reduce long-term sustainability of the Micronesian reef fishery*.

In addition to subsidies, loans for the purchase of boats and gear are also common via local banking institutions, such as the FSM Development Bank. These institutions provide loans for gear to promote expansion of the coastal and nearshore pelagic fisheries. In Pohnpei, for example, loans for boats and motors are common; however, the fishery is already oversaturated and in need of a reduction in effort, not an increase in entry-level fishers. Loans also provide another manner of debt entrapment for fishers struggling to meet daily financial needs.

Figure 12. This photo of the Archangel Raphael in Saipan reflects the strong cultural relationship between Micronesians and fishing (Photo: J. Cuetos-Bueno, 2010)

In one example of how subsidies are misguided attempts at boosting fisher incomes, the Japanese government spent $2 million on a fish processing and storage facility on Ailinlaplap Atoll (RMI) in 1994 (Hart 2001). Over 6 years following the plant being built, combined annual fisher income from marine products totaled a mere $58,611, equal to an average of $7,326/yr, or $3.73/person/yr. The same income, if contributed directly to islanders, represents 3.73 years of per capita income (based on an average per capita income of $273/yr) for all inhabitants, or, distributed over 20 years, an additional $51 per person/year (=19% increase in annual income) would have been available to individuals as a direct contribution.[9]

Consumer Dietary Preferences

Pacific Islanders consume large quantities of fish per capita, with average consumption in the FSM ranging at 69-77 kg/capita, more than twice the level of protein required for daily health (Corsi *et al.* 2008). Likewise, *seafood comprises the majority of daily animal protein in island diets, with 82% of protein consumption by FSM residents originating from fresh fish* (Bell *et al.* 2009). Recent estimates from Pohnpei gauged annual reef fish consumption at 18 kg/capita, while Guam consumption is estimated at 22 kg/capita (Table 1). Poor dietary habits have led to widespread health problems in Micronesia and other parts of the Pacific, including epidemic levels of obesity, early onset diabetes, and heart disease (Cassels 2006). In Kosrae, fully 88% of adults over 20 years old are obese, while in Pohnpei, 73% of people are overweight and 46% are obese.

While attributable to the consumption of unhealthy imported goods, such as rice, canned meats, and other imports high in fat (Hodge *et al.* 1995; Secretariat of the Pacific Community 2002; Corsi *et al.* 2008), obesity is also being driven by overconsumption of protein, in general, that necessarily includes fish (Corsi *et al.* 2008). As mentioned previously, the undervaluation of nearshore fish prices allows greater

[9] The 20-year timeframe represents the expected lifetime of the processing plants, assuming no maintenance allowance by OFCF.

quantities of fish to be purchased and consumed, thereby adding to obesity, as well as to overfishing. Alternatively, higher fish prices will likely drive Micronesians to purchase and consume more imports, which traditionally contain higher levels of salt and fat than fresh products. Prices for such unhealthy commodities should be set to discourage their consumption, and alleviate obesity and obesity related non-communicable diseases, such as diabetes. The balance between ecological, economic, and personal health is one that will require more effort and educational awareness. For fisheries managers, *the biggest challenge is to reduce the catch and intake volume of fish, while simultaneously increasing the economic livelihoods of fishers* (Figure 13). Micronesian cultures must also come to grips with unhealthy dietary habits and prepare for less fish at higher costs, whether from price increases or depleted fisheries. From a fisheries management perspective, the linkages between socioeconomics, resource consumption, personal health and fisheries is evident, but needs to be put into perspective through a wider, more comprehensive educational and nutritional awareness program in Micronesia.

Figure 13. Reef fish market in Kolonia, Pohnpei. As often occurs, multiple markets were saturated with fish taken from a spawning aggregation, here for Pacific longnose parrotfish (*Hipposcarus longiceps*). Photo: K. Warren-Rhodes, March 2010)

Poor Fisher Economic and Organizational Capacity

Fishers overall tend to be one of the poorest and most marginalized segments of island societies (Cinner *et al.* 2008, 2010; Kronen *et al.* 2010). In general, a lack of education, technical skills, organizational capacity, access to information, and economic and political clout hinder fishers from improving their economic welfare. The organizational capacity that characterizes fisheries in much of the developing world, such as fishing cooperatives for price leveraging, are lacking in most of Micronesia. In contrast, Guam has a strong fisheries cooperative, with fishers setting prices and directing sales (*also see*

Jurisdictional Case Studies: Guam). As mentioned, however, even Guam reef fish prices have declined relative to external commodities. *The lack of capacity to organize and collectively bargain works against fishers by keeping reef fish prices artificially low.* High operating costs (motors, fuel, ice, maintenance,) and poor organizational and marketing skills among fishers hamper poverty reduction and sustainable reef fisheries (Kronen *et al.* 2010; McClanahan 2010). Further, for the poorest fishers, a lack of alternative job options, occupational mobility, or education places them within a "poverty trap" in which they are unable to mobilize the resources needed to exit "chronic low-income" situations, such as declining or collapsed reef fisheries (Cinner *et al.* 2008; Ruddle and Hickey 2008). Social immobility, lower social status, and/or a "fisher ethos" (i.e., personal enjoyment of a fishing livelihood) may further limit fishers' capability or desire to change or diversify their occupation (Ruddle and Hickey 2008).

Local Retail Sales Markets

Currently, there is generally a low interest among fish market owners to raise retail prices, and in turn, wholesale prices paid to fishers. This is often due to intense price competition between fresh fish and imported proteins, such as canned meats, (fresh or frozen) chicken, turkey tail, or beef. In Micronesia, consumers are known to switch to these products as a response to higher fish prices. In most areas surveyed, there is also high competition among fish market owners. In some areas, market owners' reluctance to raise prices has resulted in fishers' refusal to sell product. However, such boycotts rarely persist because of the need for continued income, the lack of organizational capacity, and the low economic status of fishers. *This cycle keeps fish prices artificially low and drives fishers to continue overfishing despite low returns.* In addition, foreign pelagic fishes provide local markets and individuals access to non-export grade tuna (as salted or fresh) at below market prices (e.g., $0.80/lb), also leading to shifts in buying patterns when coastal fish prices increase. These practices also depress wholesale fish prices.

IMPACTS ON CORAL REEF FISHERIES

All Micronesian countries have experienced significant resource declines from overfishing since the 1950s (e.g., Johannes *et al.* 1999; Zeller *et al.* 2007; Rhodes *et al.* 2011) (Fig. 14). In addition to overfishing, coastal development, land-use impacts (dredging, sedimentation from road-building, and inappropriate land use practices), pollution, biotic invasions, or population explosions (e.g., crown-of-thorns starfish *Acanthaster planci*), El Niño-induced coral loss, and typhoon damage have also taken their toll on regional reef ecosystems (e.g., Beger *et al.* 2008) (Fig. 15). For example, significant localized declines in coral cover and associated coastal marine ecosystems have occurred due to major natural disasters [e.g., Palau, 1998 El Niño, with 80% loss of coral cover in some locales (Golbuu *et al.* 2007); Yap, 2004 Typhoon Sudal, with a 6-32% mangrove tree mortality (Kauffman and Cole 2010)]. Of these natural and man-made threats, however, overfishing has been identified as the most urgent problem for the future sustainability of Micronesian marine environments (George et al. 2008), irrespective of the overall health of individual states' coastal ecosystems (National Biodiversity Team of the Marshall Islands 2000; Turak and DeVantier 2005; Beger et al. 2008). Newton et al. (2007) go further to state "overexploitation is one of the principal threats to coral reef diversity, structure, function, and resilience" (Fig. 16).

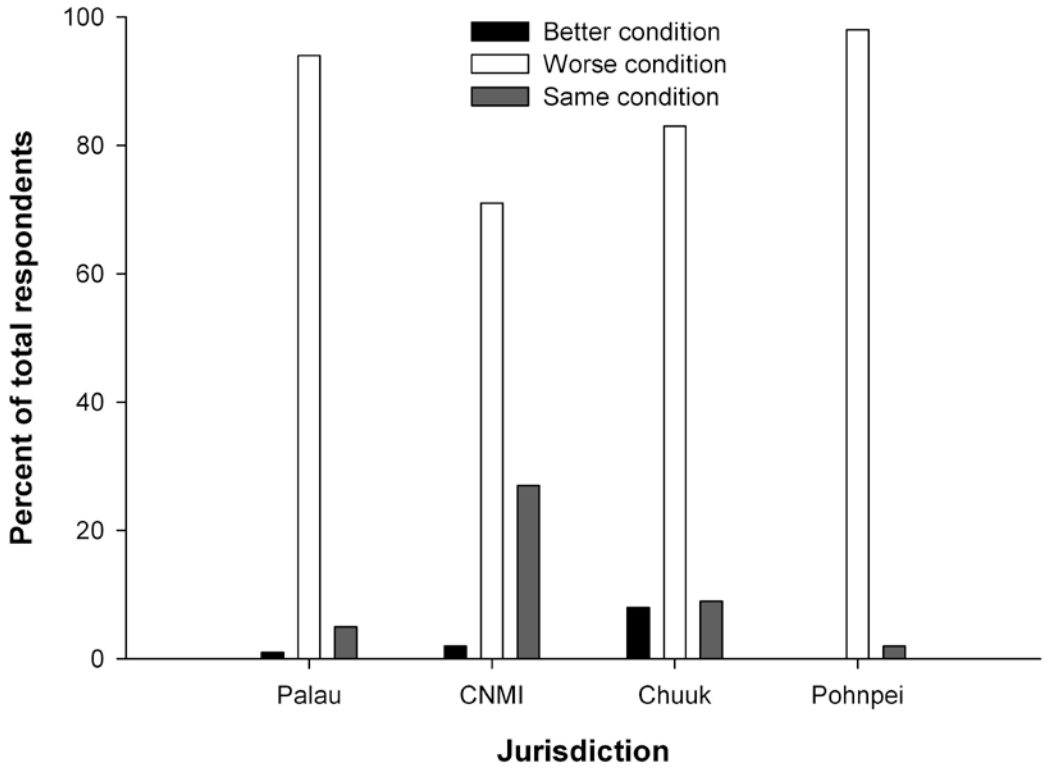

Figure 14. Responses when fishers were surveyed about the current condition of reefs relative to when they first started fishing. The response in Chuuk is based on a set of four criteria that included algal growth on corals, water quality, amount of crown-of-thorn starfish, and percent coral cover. (n = Pohnpei-647: Chuuk-105; Palau-83; CNMI-100)

Figure 15. Massive dredging near Sokehs Rock, an important tourist spot in Pohnpei. The dig is to complete a new airport extension to bring in more tourists. A lack of environmental control allows sedimentation plumes to spread throughout the lagoon near Sokehs following Pohnpei's infamous rains (Photo: K. Rhodes, February 2010)

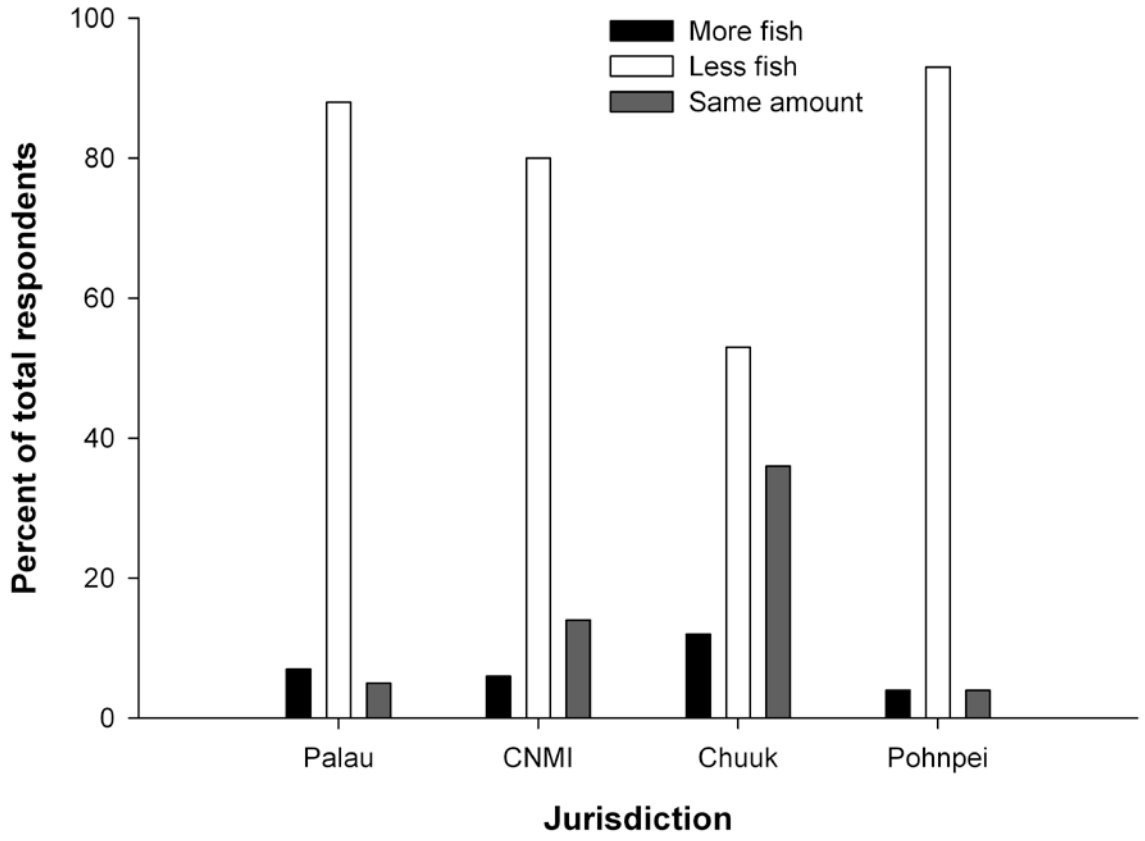

Figure 16. Responses from fishers when asked whether there are more, less, or the same number of fish on the reefs relative to when they first started fishing. (n = Pohnpei-647: Chuuk-105; Palau-83; CNMI-100)

Among the jurisdictions surveyed, Guam and Chuuk have experienced the greatest impacts to coastal marine ecosystems from unsustainable fishing practices and land-based development and pollution (Lambeth and Santiago 2001; Zeller et al. 2007). *In Guam, which today imports more than 90% of its reef fish* (*also see* Jurisdictional Case Studies: Guam), commercial extinction and spawning aggregation loss is known for some previously abundant coastal fishes (e.g., large-bodied groupers, sharks, long-live, late maturing parrotfish (Donaldson and Dulvy 2004)) and invertebrates (e.g., giant clam, *Tridacna gigas*). In Kosrae, reports of substantial declines in some nearshore fish species were noted between 1986 and 2006 (Donaldson *et al.* 2007). In Pohnpei, both unsustainable fishing methods (Rhodes *et al.* 2008), unsustainable yield (Warren-Rhodes *et al. unpublished data*), and impacts to fish spawning aggregations, mean fish size and fecundity (Rhodes *et al.* 2011) have been reported (Fig. 17). High sedimentation in some areas of Pohnpei has already reduced coral cover (Turak and DeVantier 2005; Victor *et al.* 2006) and unabated dredging poses additional threats to reefs around the main island. Palau and Yap are generally described as having reefs in the healthiest condition (George *et al.* 2008; Donaldson *et al.* 2007; Newton *et al.* 2007); however, there are few reliable long-term ecosystem health or fisheries sustainability indices for the study locales to detect actual trends. Pohnpei and Marshall Islands currently appear to be at a crossroads in the state of their reef fisheries, i.e., just recently exceeding sustainable capacity (Warren-Rhodes *et al. unpublished data*; Newton *et al.* 2007) (Table 3 and Appendix Table A1), with concomitant losses in species abundance, size, and diversity (Newton *et al.* 2007; Rhodes *et al.* 2011). However, the

lack of data impairs our ability to judge the severity of fisheries declines or define the most appropriate responses.

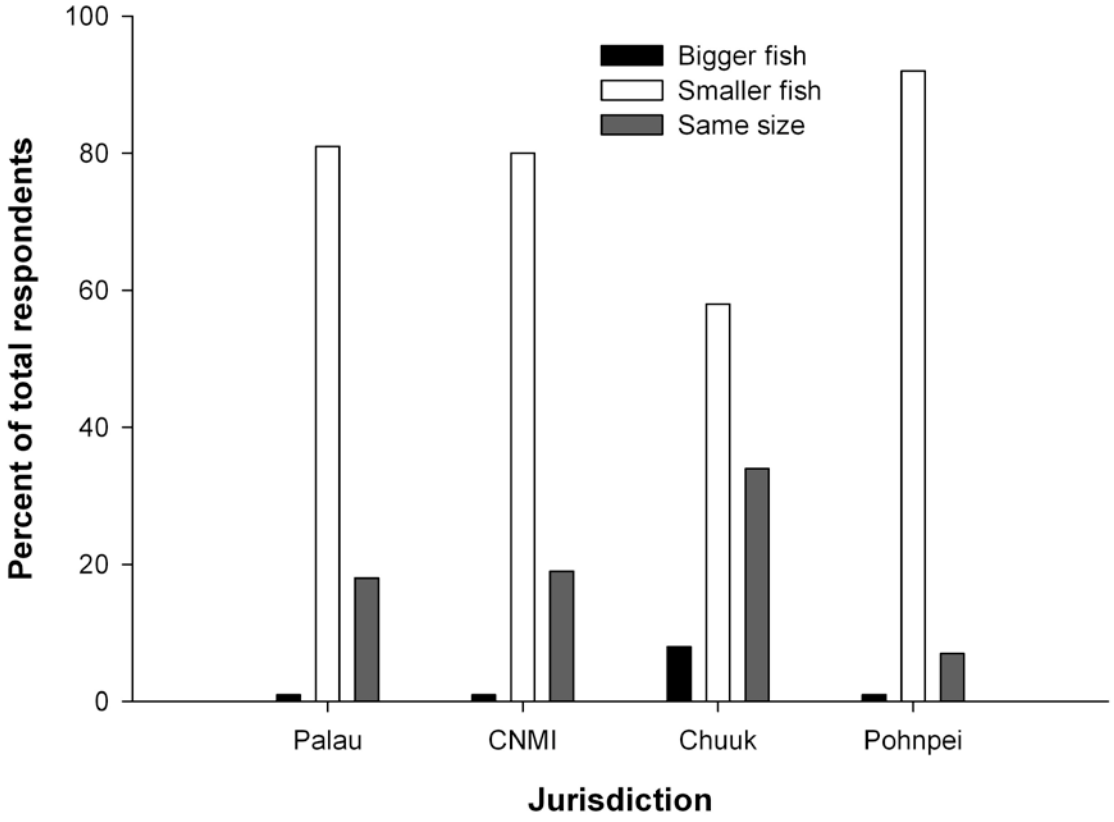

Figure 17. Responses from fishers surveyed about the average size of fish on the reefs relative to when they first started fishing. (n = Pohnpei-647: Chuuk-105; Palau-83; CNMI-100)

CONTEMPORARY MANAGEMENT AND ENFORCEMENT

Contemporary coastal fisheries management in Micronesia reflects an American regulatory and management system introduced following World War II under the U.S. Trust Territory of the Pacific Islands. Each of the Micronesian jurisdictions varies in the type and number of reef fisheries management laws, ranging from only a few in Chuuk to 34 in Palau (Appendix Table A2). In general, like in many fisheries in the U.S., contemporary centralized government management in Micronesia has failed to stem overfishing, resulting in serious changes to reef ecosystems, the loss of species and spawning aggregations, and declines in mean species size and fecundity. Although a clear need exists to develop functional management systems, an equally important challenge lies in improving compliance and enforcement. Among Micronesian jurisdictions, only Guam, CNMI, and Palau have truly active enforcement for coastal fisheries, with enforcement sporadic in most other locales. However, in Palau, only Koror State is relatively effectively enforced. In Guam, directed enforcement has been in place for many years and has varied with funding levels and officer capacity. In recent years, enforcement of

marine reserves and other fisheries laws has improved and is currently considered effective. In most of the FSM, enforcement is minimal. The reasons for this vary widely, but include poor political and managerial leadership and accountability, as well as societal obligations and occasional conflicts of (traditional) rank or title between violators and enforcement officers.

RIGHT-BASED FISHING: THE EVOLUTION OF CATCH SHARES

ORIGINS

The second half of the 20th century signified rapid population growth and a global rise in middle class income. With this came an increase in the demand for goods and services due to higher disposable spending, together with an increase in productivity due to technological advances. As a result, many of the world's natural resources, including fisheries, came under immense pressure, so that by the mid-1990s approximately 70% of the fish stocks around the world were fully to heavily exploited, overexploited, or depleted (e.g., Garcia and Newton 1997; Myers and Worm 2003).

One explanation that gained traction concerns the theory of common property resources or "the tragedy of the commons" (e.g., Gordon 1954; Hardin 1968; Bell 1972; Haveman 1973). Concisely stated in fisheries, when marine resources are open to all users, the fishery becomes a free-for-all, with fishers competing against one another for a greater share of the catch, to the detriment of the fishers, the fishery resource, and society. In sum, an open access fishery resulted in "race-to-fish" without consideration of the long-term effects (e.g., Brubaker 2000; NMFS 2000).

TOWARDS FISHERY REGULATION

Today, governments are working to control open access fisheries and protect the biological sustainability of the fishery resources. For instance, catch limits (e.g., Total Allowable Catch, or TAC), size restrictions, seasonal closures, etc., are imposed on the fisheries to ensure biological sustainability. Thus regulatory agencies adopted a "command and control" type of approach to fishery management (e.g., Brandt 2005).

While regulations are designed to prevent the depletion of fish stocks, the command and control form of fishery management has produced mixed results in developed countries and few positive results in developing nations, including Micronesia. For example, under the command and control management approach the New England groundfish and Atlantic cod fisheries (Canada) have failed, while many fish stocks remain under threat of collapse (e.g., Leal 2005). Several long-lived species neared extinction (e.g., Coleman *et al.* 2000). The fact that this threat remains in spite of regulating catch limits is due to the lack of effective control in commercial fishing capacity, as well as the failure to adequately control recreational and sport fishers (e.g., Coleman *et al.* 2004). Although there is a cap on catch, fishing enterprises continue to increase their fishing power and efficiency, that is, to catch more fish in less time or to harvest the fish before everybody else does. This increase in overcapacity (i.e., too many boats chasing too few fish) can be financially devastating (Ward and Sutinen 1994). Moreover, this derby-style "race-to-fish" fishery also leads to harvesting beyond the species total allowable catch (e.g., Dinneford *et al.* 1999).

TOWARDS RIGHTS-BASED FISHING

In order to reduce overcapacity, regulators started to limit the number of participants in the fishery by requiring fishing permits or licenses to harvest, i.e., limited entry (e.g., Sutinen 1999). With limited entry, only license or permit holders have the right to fish. However, limited entry failed to curtail the "race-to-fish," since licensed vessels continued to invest in more efficient technology. In response, fishery managers tried to control fishing effort by introducing time and area closures, vessel catch limits, and gear and vessel restrictions. Evidence shows, however, that such management schemes do not guarantee resource conservation, and may in fact increase harvesting and fishery enforcement cost (Arnason 1993; Sutinen 1999).

RIGHTS-BASED FISHING

To many environmental and resource economists, overfishing, air pollution, deforestation by logging, and other environmental degradation and resource depletion can be attributed in part to a lack of well-defined property rights to users or user groups (e.g., Tietenberg 1998). In fishery economics, two forms of rights-based management approaches are proposed: (1) territorial, where geographical or spatial areas are assigned to specific user groups (Christy 1982); and (2) catch quotas or shares, where an individual vessel or entity is given a share of the catch and, thus, becomes the owner of the allocated fishery resource (Christy 1973; Scott 1979). An example of the quota system is found in the Gulf of Alaska rockfish pilot cooperative program in which the rights to fish for rockfish are divided among two cooperatives, a catcher-processor cooperative and a catcher cooperative (NOAA Fisheries Service 2009). Examples of the territorial approach are the CMT systems in the Pacific islands (e.g., Goodenough 1963) and the community-based fishery management system in Japan (Yamamoto 1995).

The attraction of right-based fishing, particularly catch shares, is that they are transferable (i.e., individual transferable quotas (ITQs) (Branch 2008). Catch shares, by allotting specific quantities of territory or total harvest, provide owners with the flexibility of when to fish, thus eliminating the race-to-fish harvest mentality. Moreover, fishers do not need to overinvest in fishing technology to outcompete fellow fishers (e.g., Wilen 2004; Sanchirico *et al.* 2006; Lock and Leslie 2007). This flexibility also allows the fisher to fish based on market signals, i.e., fish when market prices are high (e.g., Wilen 2004). Since the fisher now "owns" a share of the resource, there is greater incentive to look at the future and take steps to ensure the sustainability of this resource (e.g., National Research Council 1999). Similarly, ITQs favor more efficient fishing enterprises that engage in cost-cutting and quality-enhancing measures to maximize profits. Less efficient fishers will sell their quotas and leave the fishery, resulting in reducing the overall cost of fishing and overcapacity (e.g., National Research Council 1999). Thus, catch share programs, depending on the design, can be used to achieve economic, sustainability, and/or social objectives (e.g., Bonzon *et. al.* 2010), but alternatively, may not lead to ecosystem-based fisheries management objectives (e.g., Gibbs 2010).

Some examples of fisheries that adopted catch shares program are the Alaska halibut and sablefish fisheries, Denmark's' entire commercial fisheries sector, and the Mid-Atlantic surf clam and ocean quahog fishery (Adelaja *et al.* 1998; National Research Council 1999; Andersen *et al.* 2010). Individual catch shares and community-based programs are currently being developed and/or implemented in the Gulf of Mexico red snapper and grouper fisheries, Alaska ground fish trawl fishery, and the Pacific trawl ground fish fishery (e.g., Bonzon *et al.* 2010). The performance of rights-based programs, whether they are community-based or catch shares, depends on the structure and the strength of the property rights attributes (Tietenberg 1998).

Figure 18. Chamorro girl in Saipan with an ornate emperor (*Lethrinus ornatus*) (Photo: J. Cuetos-Bueno, 2011)

CHARACTERISTICS OF A RIGHTS-BASED FISHERY MANAGEMENT PROGRAM

Whether the objectives of rights-based management are economics, biological, or social, or a combination of the objectives, a program that would be most efficient would contain the following characteristics (e.g., Christy 1973; Scott 1979; Tietenberg 1998; Leal 2005; Bonzon *et. al.* 2010):

1. **Exclusivity –** all benefits and costs accrued as a result of owning and using the resources should accrue only to the owner of that right, whether it is an individual, a group, or a community. Having a fisher know he/she owns the right to the fish for a given season allows him/her to determine when to fish without having the race-to-fish mentality. Not only does the fisher have the option to wait for favorable pricing, but he or she can also chose not to fish in unfavorable meteorological or oceanographic conditions.

2. **Duration** – the length of time the community/individual entity has the rights to the property. The right (share) holder should have a sufficient length of time to realize future benefits. Rights-based fisheries allow the quota holders to get the pay-off in later years from the investments they made in earlier years. If the duration is short, the rights holder may not have incentive to make the investments to sustain the fishery. For example, if a grouper fisher in Majuro has rights to an area or quota of

groupers in perpetuity, he/she may not fish all of his/her quota this year, but instead wait for the size and age structure of the stock to become bigger and older when the return for larger fish improves his/her profit. In addition, older larger grouper increase the reproductive potential and future potential yield, so there is an inherent benefit in delaying the size and age of catch.

3. **Transferability** – all shares should be transferable from one owner to another in a voluntary exchange. This gives the flexibility to the rights owner to determine the best use of his/her time and capital by selling or leasing the rights if he/she decides to.

4. **Security** – all entitlements should be specified. Using land titles as an example, in some systems of law, especially in a new territory, being the first user may entitle one to become the owner. This would induce a race-to-fish type of situation and may not be beneficial to the best use of the resources. From a fisher's point of view, an insecure title would force the fishers, cooperative, or community to constantly defend their rights to the resource. In the West, fishing associations and/or gear groups spend considerable sums of money and time in lobbying to secure allocations (share of the TAC) to the fishery.

In a Micronesian setting, legislated rights-based systems utilizing fine-scale management or legislated quotas are in most jurisdictions impractical due to the lack of existing information on fish populations and fisheries and a paucity of established, reliable monitoring programs. *The foundation for all effective rights-based management systems is the ability to collect good fishery information and subsequent effective monitoring and compliance (i.e., enforcement) (Burke 1999; Crothers 1999; Bonzon et al. 2010). Under the current state of monitoring in most Micronesian jurisdictions, and without knowledge of current or future status of either the fishery or targeted population, a rights-based system established on quotas is unrealistic.* In addition, many catch share systems use a "user pays" system, whereby the fisher is required to cover systematic monitoring and enforcement costs. This is not meant to imply that an area rights-based system cannot work in Micronesia, as it has under CMT for thousands of years. Those types of rights-based systems are perfectly suited for Micronesian jurisdictions, particularly where CMT is strong. However, in all instances, the effectiveness of area rights-based systems increase as the amount and quality of information increases. This does not imply that scientific data is a necessary requirement; however, there should be good monitoring of resources and an inherent ability within the system to respond to negative changes therein, a rare combination in the current Micronesian management setting.

JURISDICTIONAL CASE STUDIES (ABRIDGED)[10]

THE REPUBLIC OF THE MARSHALL ISLANDS (RMI)

The current status of coastal fisheries resources in the RMI is overfished or fully exploited (Table 1) (Newton *et al.* 2007). Common signs of fishery decline include lower catch volumes, spawning aggregation loss, smaller fish sizes and reduced catch-per-unit-effort (CPUE) (D. Wase, former director of MIMRA, *personal communication*, 1997; F. Edwards, *personal communication*, March 2011). In some areas, late-maturing, slower-growing species such as green bumphead parrotfish (*B. muricatum*) have become virtually extinct (Donaldson and Dulvy 2004; Hamilton *et al.* 2008), while top predators are rare

[10] Expanded Jurisdictional Case Studies, which contain greater detail of nearshore fisheries and management, may be found in Appendix B.

in some atolls (Beger *et al.* 2008). Fish populations have also been impacted on nearby reefs (e.g., Arno), as a direct result of fishing subsidies (K. Rhodes *personal observation*).

The main drivers of overfishing in RMI are *population pressure* and *fish exports* to overseas markets. *Local demand is manifested in RMI's strong subsistence and commercial market fisheries*, which exert significant pressure on available resources. According to local NGO and fisheries resource management representatives (A. Ishoda, Marshall Islands Conservation Society, *personal communication,* March 2011), *overfishing has occurred in the majority of fishing grounds proximate to Majuro*, with commercial demand increasingly being met from the outer islands (F. Edwards, MIMRA, *personal communication*, April 2011). Overexploitation of nearshore fish resources close to Majuro is driven by unsustainable fishing practices and under-valued fish pricing, similar to other Micronesian jurisdictions. Volume overfishing has been exacerbated by SCUBA and nighttime spearfishing.

Alternative livelihoods are growing in RMI, with private and government-backed aquaculture projects on several of the outer islands (S. Ellis, Marine and Environmental Research Institute of Pohnpei, *personal communication*, May 2011; M. Haws, Pacific Aquaculture and Coastal Resources Center, *personal communication*, May 2011). Currently, aquaculture employs about 40 Marshallese. In addition to aquaculture, RMI has a thriving marine ornamental fish and coral aquarium trade.

Figure 19. Marketed whole and filleted fish from nearby Arno Atoll in one of Majuro's 10 fish markets. (Photo: J. Cuetos-Bueno, February 2011)

Contemporary Western-style management initiatives for RMI are listed in Appendix Table A2. Similar to other jurisdictions with large geographic area, RMI is struggling with enforcement and has had particular problems with foreign vessels fishing illegally on outer atolls. In the Marshalls, all land and nearshore resources are owned and managed under a matriarchal lineage (Beger *et al.* 2008). In the past, CMT was strong in RMI, but recently has declined in importance, with varying degrees of effectiveness (Tobin 1958; A. Ishoda, Marshall Islands Conservation Society, *personal communication,* February 2011; D.

Hess, College of Marshall Islands, *personal communication*, April 2011). Paramount chiefs control the laws regarding fishing times and fishing areas for the reefs they have tenure over. Adjacent coral reef and lagoon areas near Majuro are open access, whereas outer islands and atolls are still controlled under traditional CMT. The current conservation action plan seeks to strengthen CMT throughout the country.

REPUBLIC OF PALAU

In Palau, the *transition to a cash-based economy* and the commercialization of fishing resulted in rapid localized overfishing and the erosion of long-standing traditional CMT systems (Johannes 1981). Changes to fishing gears and methods, including nighttime spearfishing and access to nearshore resources by foreign enterprises, such as the Southeast Asia-based live reef fish food trade (Johannes and Riepen 1995; Johannes *et al.* 1999), quickly led to overexploited stocks.

Unlike many other Micronesian jurisdictions, Palau had several characteristics that allowed it to initiate and sustain conservation practices: (1) an eroded, but still functional traditional management system, (2) available funds to initiate and develop monitoring and enforcement activities, particularly within Koror State, (3) interest and drive among locally respected individuals who could champion conservation actions, (4) world-class reefs and natural resources that still remain among the best in the region for tourists, (5) a direct air link to Asia and other tourist-rich destinations, (6) clear ownership rights of terrestrial and marine resources, (7) a large reef area often difficult to access and, (8) a relatively low population density. These and the pursuit of long-term conservation and development goals have allowed revenue growth for continued improvements to natural resource management. Tourism now accounts for 60% of national revenues, with $90 million in tourist-based revenues in 2010 (Palau Office of Statistics and Planning 2011).

Within Palau, *Koror State stands out as the regional champion in conservation*, in part because of the development of a viable natural resource-based tourism industry. Koror State used this opportunity to create the Department of Conservation and Law Enforcement (Koror State Rangers) and the Rock Island visitor fee that provide a steady revenue stream to allow the Rangers to monitor and enforce resources[11]. *In 2010, the $25 Rock Island visitor fee generated $3.1 million dollars in revenue for conservation activities* (I. Olkeriil, Koror State Government, Department of Conservation and Law Enforcement, *personal communication*, April 2011). In 2009, Palau added a $15 Green Fee to its airport tax to generate revenue for management activities of protected area networks (PANs).

Although successful in many ways, Palau should also be viewed as a cautionary tale to those who envision tourism and alternative livelihoods as a final solution to overfishing. While full-time commercial and subsistence fishers have declined in number relative to the earlier years, marketed volumes of fish have not, due to the growing demand by tourists for nearshore resources (D. Orrukem, Director, Palau Bureau of Marine Resources, *personal communication*, April 2011). Both marketed supplies and exports have held steady, each at 214±60 mt /yr (2001-2009). Thus, *while alternative livelihoods and tourism have developed, the demand for coastal resources has not declined*. Recent examinations show that Palau's fisheries are fully exploited (Newton *et al.* 2007) and there is no evidence to suggest that current levels of fishing are sustainable (N. Idechong, Palau National Congress, House of Delegates, *personal communication*, April 2011).

[11] In 2007, the Koror State Legislature established two permit types and fees: $25 for the Rock Islands only permit and $35 for a combined Jellyfish Lake and Rock Islands permit.

Appendix Table A2 provides details on Palau's modern fisheries management practices that include, among others, seasonal bans on sales and catch, species moratoria, marine protected areas, and gear restrictions, and bans on shark fishing and nearshore bottom trawling. In addition to modern fisheries management, *Palau has a well-documented history of traditional customary management (e.g., Johannes 1981) that has been able to successfully integrate its traditional CMT system with state government* (Appendix Table A3). Recent actions to expand local resource protection and management include the use of LMMAs (locally managed marine areas) that include Helen Reef. At 163 km^2, Helen Reef represents the largest LMMA in Micronesia. At Helen Reef, recent monitoring efforts have resulted in a dramatic decline in illegal fishing and its *use of adaptive management strategies allow its custodians to constantly adjust management to suit both the needs of the community and marine resources*.

CHUUK STATE, FEDERATED STATES OF MICRONESIA

Intense population growth since the 1960s, destructive fishing practices, and a vast export market have placed increasing pressure on Chuuk's resources, with roughly 2,000-4,000 mt/yr of coastal fisheries resources consumed locally (FAO 2010; Kronen et al. 2006) (Fig. 6). However, very little reef fish is sold directly to individuals, but instead is purchased locally and exported, primarily to Guam. Government subsidies to buy gear have increased pressure on resources by making fishing easier and distant fishing grounds more accessible. Depletions of resources are evident throughout Chuuk Lagoon. Due to a lack of alternative livelihoods, most households outside Weno now depend primarily on fishing for income (I. Penno, Chuuk Department of Agriculture, personal communication, March 2011), although high fuel prices have sharply reduced fishing profits.

Figure 20. Young Chuukese boy fishing from a Weno pier (Photo: J. Cuetos-Bueno)

Data from two surveyed markets showed highly variable supplies. In 2001, the price per pound of reef fish was $1.00/lb ($1.26/kg) wholesale and $1.25/lb ($2.76/kg) retail. After costs, one market owner reported monthly profits of $350/mo, well above the $2,800 annual median household income (FSM Division of Statistics 2002). For fishers, however, profits from commercial fishing activities are limited by high external commodity prices, especially fuel.

The main fishing methods used in Chuuk are spearfishing (metal arrows with rubber bands) and nets, with commercial fishing typically conducted by nighttime spearfishing. *Fisher interviews point to a clear reduction in catch abundance and size* (Figs. 16 and 17)*, with an increasing scarcity of once-common species.* Reports of the use of Chlorox® for octopus fishing, blast fishing, live fish trading, shark finning, and uncontrolled lagoon dredging and pollution were also noted. Although illegal, blast fishing is still common, with loss of life and

paralysis still occurring as a result [R. Osiena, Chuuk Department of Marine Resources (DMR), *personal communication*, April 2011]. In addition, *sporadic fishing for the live reef food fish trade still occurs*, although DMR does not have the legal capability to enforce it.

Modern fisheries management in Chuuk is limited (Appendix Table A2). No restrictions on gear, species, or fish size are in place, with the exception of *Trochus* and blast fishing. Although foreign boats are required to obtain a permit to fish in Chuuk, there is little enforcement. *Chuuk has a long history of traditional marine resource management, (Lambeth and Santiago 2001), which is still strong in the outer islands, but weak or nonexistent within Chuuk Lagoon where coastal resources are openly accessed*. The only traditional custom still widely practiced is the "*mechen,*" the traditional closure of reef areas (normally 3 months) after a death. In some outer islands, 3-month closures still occur under traditional tenure to repopulate overfished areas. In Piis Municipality, permission to fish must be granted by either the reef owner or the chief. Due to its partial isolation from the other inhabited islands of Chuuk's lagoon, Piis has managed to effectively monitor and enforce its rights. Several reports of boat confiscation and local prosecution have occurred in Piis in recent years.

Although traditional management is generally weak for the Chuuk Lagoon, interviews suggest customary marine tenure may offer the best foundation for fisheries management and conservation, reflected in the high level of support shown by traditional fishers for a return to strong CMT. This potential is particularly important given the lack of enforcement and unreliable funding to DMR.

KOSRAE STATE, FEDERATED STATES OF MICRONESIA

Kosrae is a single, high volcanic island surrounded by a narrow fringing coral reef and lagoon of 22 km^2 (Donaldson *et al.* 2007) that remain some of the healthiest in Micronesia (Donaldson *et al.* 2007; George *et al*. 2008). Although the population is low, population density is high and reef fisheries are reportedly overharvested (Appendix Table A1), with both fishers and marine resource and conservation officials indicating that, compared with the past several decades, Kosrae is now experiencing overexploitation. Based on these anecdotal reports, coastal fisheries are now experiencing (1) smaller fish sizes in catch, (2) significantly greater fishing effort per unit return and (3) declines in overall catch volumes, collectively and for individual species, that often result in an insufficient marketable supply.

Similar to other FSM states, the *transition to a cash economy* was cited as a key driver for increased fishing activity. *Local food consumption*, both as subsistence and/or commercial purchases from the local retail fish markets, is also one of the *strongest main sources of reef fish demand*. Previous surveys (Donaldson *et al.* 2007), and anecdotal data from interviews support Newton *et al.'s* (2007) assessment that Kosrae is at or beyond the sustainable yield.

Three main retail markets and several smaller markets operate in Kosrae. In 2010, local wholesale fish prices ranged from $1.75/lb ($3.85/kg) for lower grade species to $2/lb ($4.40/kg) for the preferred fish. Similar to other jurisdictions, in 2008 fish prices were insufficient to cover high fuel costs, with some fishers increasing catch volumes or lowering fishing activity. Reef fish export from Kosrae is limited to family for personal consumption. In contrast, mangrove crabs are exported to Guam, RMI, and Hawaii for commercial sale.

Improvements in gear and storage also underlie the increase in fishing activity, which has enabled fishers to keep and sell fish for longer periods and, thus, catch more per trip. Traditional methods are now rare, with the exception of the use of (banned) poisonous leaves and roots. Based on interviews, there are significantly *more fishers* in Kosrae today, with "anyone who has access to a boat or motor now going out to fish" (M. Luckymis, KCSO, *personal communication*, March 2011). Common fishing methods include

spearfishing (both night and daytime), "torch" fishing, gillnets, cast netting, and hook-and-line (KIRMA, *personal communications,* March 2011).

In Kosrae, there is generally *strong awareness* of the need and importance of conservation, coupled by *political support* for conservation and management measures. Local NGOs and state fisheries agencies both felt that grass-roots awareness campaigns and activities (e.g., in schools) have led to growing community support in the past several years for resource management and conservation, including MPAs. This, in turn, has encouraged higher-level *support among legislators* to approve marine and terrestrial conservation-oriented bills and regulations. Within the Marine Resources Act of 2000, size limits were created for crabs (reproductive restrictions), turtles (seasonal restrictions), *Trochus* and lobsters (reproductive restrictions), and quotas for sea cucumbers (Appendix Table A2). In 2010, the state passed the Kosrae State Protected Area Act of 2010. Consequently, communities have been empowered to designate areas and resources (marine and terrestrial) that they would like to protect and manage, with the aid of the state in terms of monitoring and enforcement. Although no state-recognized MPAs exist, several community-based marine protected areas are in place, including the Tafunsak LMMA founded in 2008. This focus on *bottom-up approaches to marine management* was mentioned as a more successful (versus top-down strategies) means of gaining support for marine protection in Kosrae at all levels, from the community to the executive and legislative branches.

In addition to MPAs, bans on spearfishing with SCUBA, quotas on sea cucumbers, and other gear restrictions (e.g., gillnet mesh sizes, which are currently under review) and bans on illegal fishing practices, namely poisons and chemicals, have been promulgated and are actively enforced. Enforcement is currently conducted by: (1) a "coastwatch," whereby enforcement agents patrol the island via land to observe near-shore fishing activity, and (2) "territorial surveillance," in which patrol boats are used to monitor (e.g., turtles) and spot illegal fishing (e.g., foreign fishing vessels).

YAP STATE, FEDERATED STATES OF MICRONESIA

In part because of its comparatively *low population size and density* (11,241 persons, FSM 2000 census; 95 persons km^2), Yap's coastal fisheries resources are in relatively healthy condition compared to most other Micronesian jurisdictions. Nonetheless, localized overfishing of certain species and areas has occurred as a result of the *transition from a subsistence to a cash economy* and *weakening of the traditional marine tenure system*, particularly on the main island (Houk *et al. In press*). In Yap, there is still a small domestic nearshore fishing economy; however, subsistence still forms a mainstay of the fishery (Kronen and Tafileichig 2008). Most fishers *do not obtain their main income from fishing*, but instead rely on government salaries, or income from small businesses or other sources (remittances, welfare/retirement funds) (Kronen and Tafileichig 2008). Local markets in the urban center sell about half of the annual total finfish captured, such that *local demand and retail sales are the main drivers* of localized overfishing. Exports from Yap are mainly to supply friends and relatives living off-island and are not significant drivers of overfishing (A. Tafileichig, Yap Bureau of Marine Resources, *personal communication,* April 2011). Like other jurisdictions, *unsustainable fishing gear and practices, such as gillnets and nighttime spearfishing, contribute to localized reef fish overfishing* (Houk *et al. In press*).

In Yap, nearshore marine resources are managed by both traditional and Western management systems, with strong CMT on the outer atolls and a weaker version of CMT on the main island. Western management includes bans on explosives and poisons, restrictions on the sale of turtles, and seasonal and export restrictions on coconut crab and giant clam (Appendix Table A2). *Trochus* are harvested by permit only during specifically designated periods every few years. However, the strength and position of the CMT system do not provide for a strong Western-style management system to be imposed. Recently, there

has been increased interest and use of marine protected areas and there is at least one actively monitored and enforced LMMA on the main island.

Customary reef and lagoon tenure in Yap represents the strongest and most intact CMT system in Micronesia, with the forms of management restrictions varying across the islands and atolls (Some described in Appendix Table A4). In Yap, traditional political and socioeconomic institutions began to erode in the 1990s and early 2000s (Smith 1991; Tafileichig and Inoue 2001; Kronen and Tafileichig 2008). Smith (1991) and Falanruw (1994) note that earlier colonial pressures took their toll on CMT systems beginning in the early 1900s, when Yap had a mostly fully functioning traditional system.

Waters surrounding Yap State are divided into three zones. The first is the internal waters, which are those from the shore to the island baseline (the line following the contour of the seaward edge of the outer reef). The State Fishery Zone extends from the island's baseline to 12 miles seaward, while fishing rights from 12-200 miles offshore EEZ are controlled by the national government. Traditional authority to control fishing is provided for the State's waters (internal waters and State Fishery Zone), with rights and ownership of marine areas and resources acknowledged by the State, which nonetheless "may provide for the conservation and protection" of those resources. . . "but any resource management involving the utilization of inshore resources must be accepted and approved by the Council of Chiefs" (Tafileichig and Inoue 2001, p. 114). In this way, fishing is regulated by geographical area and the habitat that can be fished, as well as the fishing practices, type of gear, and target species that can be caught (Kronen and Tafileichig 2008). In these traditional reef tenure systems attached to the regulations were explicit "rules of conduct and obligations for distribution of catch" (Falanruw 1994; Kronen and Tafileichig 2008). In terms of fishing rights, the water within the lagoon is divided among the villages, according to their boundaries, which stretch from the edge of the village to the outer edge of the reef; outsiders who do not hold land within a particular village are not permitted to fish within these nearshore waters (Sudo 1984). If an outside fisher is caught taking resources from the waters belonging to another village, those villagers may seize his gear and the entirety of his catch.

POHNPEI STATE, FEDERATED STATES OF MICRONESIA

Pohnpei is a high island (791 m) surrounded by eight atolls. Most of its approximately 36,000 inhabitants reside on the main island, where the majority of commercial fishing activity occurs (Pohnpei Statistics Office 2002). On the main island, there is a substantial local commercial market for coastal marine products, with a minimum of 521 mt of reef fish sold in 2006, valued at *ca.* $2 million. Including subsistence catch, at least 600 mt of reef fish are captured annually. Of this, 4-10% is exported to the U.S., Hawaii and Guam for personal consumption (Rhodes *et al.* 2008) (Fig. 21). Based on per capita consumption estimates, *Pohnpei is now extracting nearly 1.5 times (150%) its sustainable productive capacity (Warren-Rhodes et al. unpublished data).*

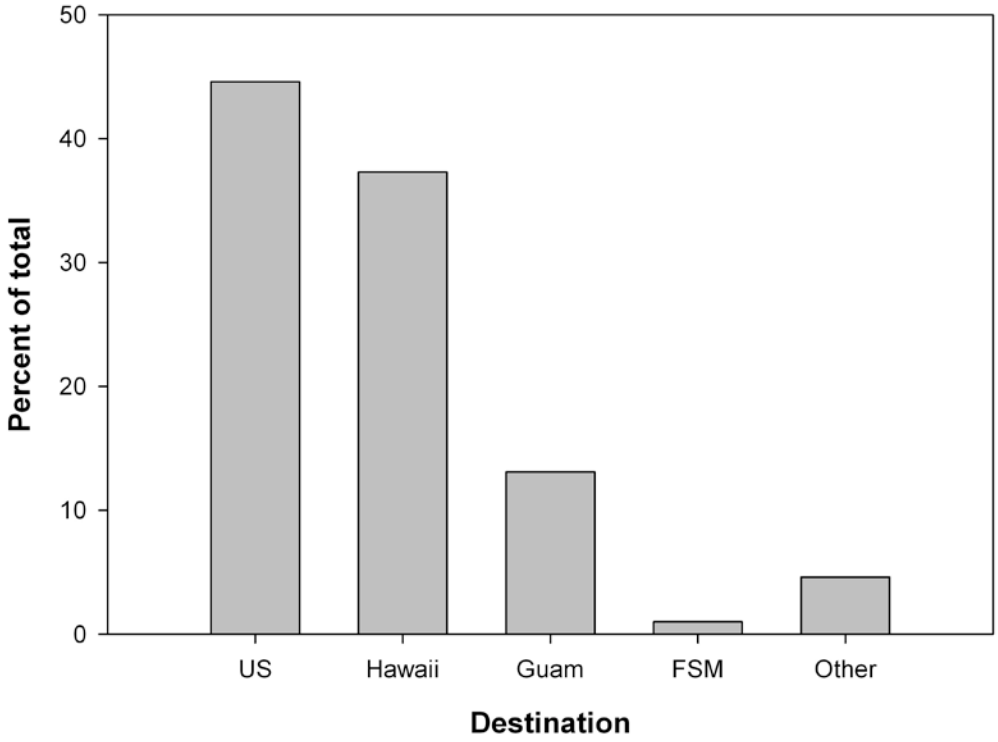

Figure 21. Export destinations of reef fish by 72 passengers surveyed in Pohnpei (2006).

Thus, there is an immediate need to reduce catch volume, restore productivity, and enact sustainable fisheries management policies. Unsustainable fishing practices driving overfishing include an over-reliance on juveniles, the use of nighttime spearfishing and small-mesh gillnets, and the targeting of spawning aggregations (Rhodes *et al.* 2008; Rhodes *et al*. 2011). Sedimentation and coral loss from dredging and mining are adding to the degradation of coastal resources (Turak and Devantier 2005). Reductions in the abundance of highly vulnerable species, such as green bumphead parrotfish (*Bolbometopon muricatum*), coastal sharks (Allen 2005), and giant clams (*Tridacna gigas*) are widely evident. Substantial reductions in fecundity, mean size, and abundance have been recorded for some commercially important species (Rhodes *et al.* 2011).

Contemporary management includes legal protection for threatened or endangered species, seasonal restrictions on catch, and size restrictions on some species (Appendix Table A2). Marine protected areas are widely used, including those protecting Minto, Ahnd, and Oroluk atolls. *Similar to many other study jurisdictions, Pohnpei is lagging in its monitoring, enforcement, and data collection efforts*. As a result, poaching is common, including within marine protected areas, and existing laws are openly disregarded.

Figure 22. Young Pohnpeian fisher with an undersized camouflage grouper (*Epinephelus polyphekadion*) (Photo: J. Cuetos-Bueno, February 2011)

Customary marine tenure on the main island of Pohnpei has not been widely practiced. Certain practices may have been used, including: (i) village leaders having authority over certain spawning areas, (ii) sustainable fishing practices, such as releasing undersized and reproductive fish, and iii) traditional rules limiting catch of certain vulnerable species, such as large green bumphead parrotfish (*B. muricatum*) and green turtle (*Chelonia mydas*) (Sudo 1984; Shimizu 1990).

In an effort to re-assert whatever CMT may have existed in Pohnpei historically, contemporary traditional leaders and community members are becoming increasingly engaged in local monitoring and management. *The locally managed marine area (LMMA) at Enipein (Kiiti) stands as an example of local stewardship over marine resources, with strong enforcement and monitoring in place*. Violations are prosecuted at the village level, with punishment coming through community consensus (Furlich 2010). *Recent fisher surveys and workshops found strong support among fishers for improved management and an expressed interest in improved rights-based ownership at the municipal level* (K. Rhodes *unpublished data*).

GUAM

During the post-World War II period, a dramatic shift occurred in Guam from subsistence to a cash-based economy that coincides with the substantial declines noted in local fish populations (Zeller *et al.* 2007). Currently, nearshore marine products enter the commercial market from full-time and part-time commercial fishers, or subsistence or recreational fishers who sell a part of their catch (Guam Division of Aquatic and Wildlife Resources, DAWR 2010). A recent survey on Guam revealed 35-45% of households (n=400) are involved in fishing activities, either as experienced fishers or as accompanying members on fishing trips (van Beukering *et al.* 2007). Fisheries data on Guam are collected via two programs: (1) the creel survey program (Fig. 23), and (2) total commercial landings. The first, a dedicated program for estimating catch data, is conducted by DAWR, through the Guam Department of Agriculture. In 1982, DAWR initiated island-wide estimates of total catch and the collation and tabulation of total commercial landings through the voluntary use of trip tickets (DAWR 2010). A summary of the commercial landing data is published yearly at www.pifsc.noaa.gov/wpacfin/.

Regardless, there is considerable uncertainty as to the status of Guam's reef fish fishery. A recent re-estimation of the nearshore, non-pelagic catch suggests Guam has suffered an 86% decline over a 50-year period to 2002 (Zeller *et al.* 2007). Zeller *et al.* (2007) also found a 2.5 fold discrepancy between the reported catch from the DAWR creel surveys and their own re-estimation. The largest drop in catch was noted between 1950 and the early 1980s, from approximately 1000 t (907 mt) to less than 200 t (181 mt)—a level of overexploitation related to its high population density, small reef area, and open access systems of management. Continuous declines in fish abundance have been noted in recent years (Wilkinson 2000). For example, the boat-based and shore-based catch from the creel surveys show a decline of more than 70% from 306 t (277 mt) in 1999 to 94 t (85 mt) in 2009 (Fig. 23). In contrast, the decline in the commercial landing data, for the same period, was 35% from 93 t (84 mt) to 61 t (55 mt).

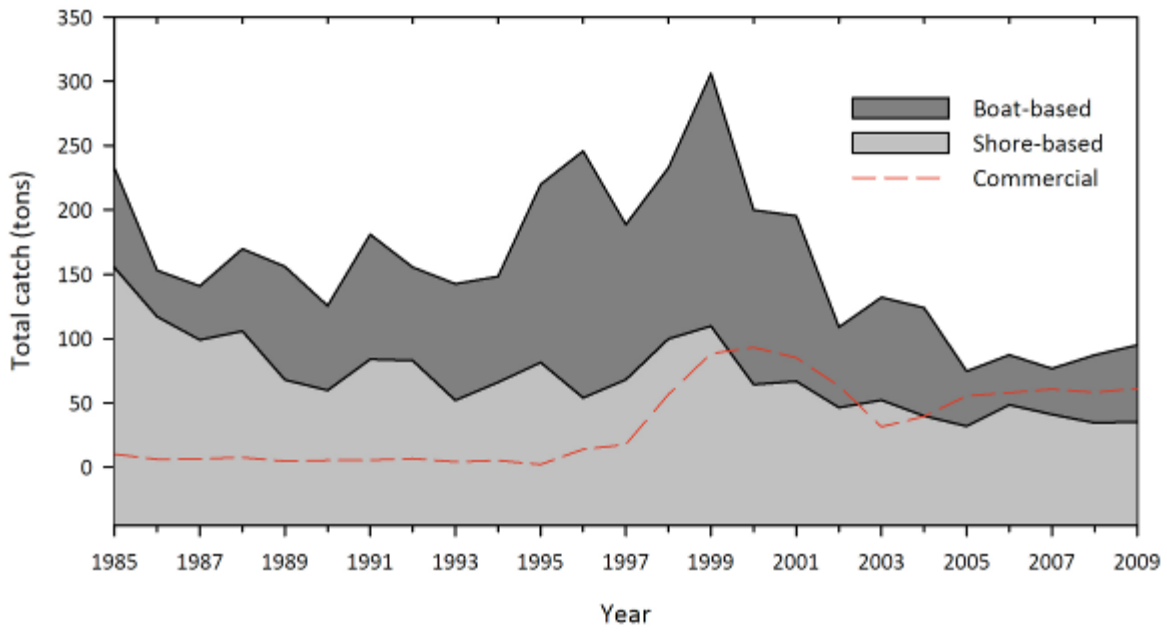

Figure 23. Total landings of reef fish from 1985-2009 collated from the DAWR creel surveys of the boat-based and shore-based fishery (details of how these data were collected and collated are included in the text). The red line is the volume of reef fish sold by commercial vendors participating in the WPacFin program.

For other fishery techniques that harvest reef fish, the patterns are much clearer. Since the start of the surveys in 1985, the CPUE for shore-based hook-and-line and cast netting have declined by more than 50% and 75% respectively (Burdick *et al*. 2008). At the same time there has been a significant shift in the species composition, with a greater proportion of the catch comprised of faster growing, shorter-lived species that reach size at maturity early. A decline in mean size, a key indicator of overexploitation, has been observed for several large-bodied scarids such as *Chlorurus microrhinos*, *Hipposcarus longiceps,* and *Cetoscarus bicolor* from 1981 to 2009 (McIlwain and Taylor 2009). For other heavily targeted species like *Lethrinus harak*, the greatest spawner biomass is within the network of marine preserves, with some fished sites making little or no contribution to the total reproductive output on Guam (Taylor and McIlwain 2010).

The total commercial landing of reef fish caught around Guam for 2009 was 134,768 lbs (61.1 mt) worth $390,614 (based on average reef fish price of $6.39/kg for the same year; Fig. 23). A substantial amount of reef fish is imported from other Micronesian jurisdictions and is not reflected in official statistics (Hensley and Sherwood 1993). Previous published statistics show that from 1999-2002 Guam imported between 2,962–3,359 t (2,687-3,047 mt) of fish (Zeller *et al.* 2007). Consumption rates for the period 1985-2002, which include the total fish imports, plus the reported catches from the commercial non-pelagic landings and creel survey landings converted to per capita, range from 21.7-22.6 kg/yr, which is similar to findings for reef fish consumption in other recent studies (e.g., Warren-Rhodes *et al. unpublished data*).

Since 1990 the average price of reef fish (unadjusted for the Consumer Price Index, CPI), sold through the Guam's Fishermen's Cooperative has been steady ($5.30/kg and $6.40/kg), with only a slight increase to $6.84/kg in 2010. In reality, the inflation-adjusted average price would have declined significantly over the same time period (WPFRMC Annual Report 2008, p. 117).

Guam's fisheries are managed according to the Magnuson-Stevens Fishery Conservation and Management Act, amended in 1996. Management of the fishery is divided between two entities: (1) the Western Pacific Regional Fishery Management Council (WPRFMC), which is based in Hawaii and is responsible for creating management policy for activities from 3 to 200 nautical miles from shore, and (2) DAWR, which manages inshore and nearshore fishing activities (<3 n miles). To augment existing federal laws, local fisheries legislation is proposed and amended by 15 elected legislators (senators). In 1997, five marine protected areas were established that represent around 11% of the coastline and span from the northern-most to the southern-most reaches of the island, excluding much of the central east (windward) coast, and represent the most substantial fisheries management regulations. Full enforcement of preserve regulations was not initiated until 2001, with 293 arrests for illegal fishing in preserves made between 2001 and 2007 (DAWR 2008 *in* King 2008). For most species, unlimited harvest is allowed outside of preserves, with some exceptions for invertebrates (Appendix Table A2).

Tourism lies at the heart of Guam's economy and in 2005 was estimated at $429.3 million. In the last two decades, recreational SCUBA diving has become a very popular sport, with *ca.* 300,000 dives annually with an economic value of more than $5 million (van Beukering *et al.* 2007).

Guam has a checkered past in developing a sustainable, long-term aquaculture industry, with numerous organisms trialed for commercial purposes. Tilapia (*Oreochromis mossambicus*) is the primary species, with 162 mt of tilapia grown, valued at $1.4 million. While some remain optimistic about the expansion of the aquaculture industry on Guam, there are considerable impediments to the development of large-scale production.

COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI)

Extensive commercial fisheries are developed in the southern CNMI islands (Saipan, Tinian, Rota, and Anguijan); however, most fishing activity is centered in Saipan (62,392 inhabitants), CNMI's capital. In the southern CNMI, reef fish are mainly harvested through nighttime spearfishing (>80%), followed in rank by hook-and-line (Houk *et al. In press*). Both gillnets and SCUBA spearfishing are illegal (Appendix Table A2), nevertheless, fish derived from illegal SCUBA fishing is considered substantial (Houk *et al. In press*). In Saipan, several professional locally owned fishing operations supply markets, each consisting of 3-4 full-time, low-paid, non-resident workers. The remaining contributions to marketed landings are from "semi-subsistence" CNMI fishers. In 2009, 55 mt of reef fish was sold in Saipan in 2009, valued at almost half a million dollars (Houk *et al. In press*). Subsistence catch could be up to 4-5 times the commercial volume.

Evidence for unsustainable harvesting of reef fish is most prevalent in the inhabited southern islands (Houk *et al. In press*). A recent survey found high fishery pressure (e.g., Jennings *et al.* 1999; Dulvy and Polunin 2004; Graham *et al.* 2005) and substantially reduced abundances in comparison to other Micronesian jurisdictions. As early as the 1950s, Smith (1947) reported signs of overexploitation in Saipan lagoon. In subsequent decades (1979-1996), Duenas and Associates (1997) found strong evidence of reductions in most fish groups, with the greatest apparent impacts to lower trophic level fishes. There is clear evidence of high fishery pressure, with reduced abundances, size, and catch (Graham 1994b; Jennings *et al.* 1999; Dulvy and Polunin 2004; Graham *et al.* 2005; Starmer *et al.* 2005; Williams *et al.* 2010; Houk *et al. In press*) (Fig. 24). Further, juveniles contributed disproportionally to the catch of most targeted species (i.e., size-at-capture significantly below reproductive maturity, or L_{50} estimates) (Fig. 25). Zeller *et al.* (2007) suggested that total reef catches in CNMI had declined by about 54% between 1950 and 2002 (500 mt in 1950s to about 150 mt in 2004). Reef fish around the southern islands has declined by nearly 80% over the last 60 years, with a 4-fold decrease in CPUE (Smith 1947; Graham 1994b; Cuetos-Bueno *in preparation*). This decrease is even more striking when considering the recent changes in technology that have improved catch efficiency, and confirm suggestions of unsustainable fishing in the southern islands.

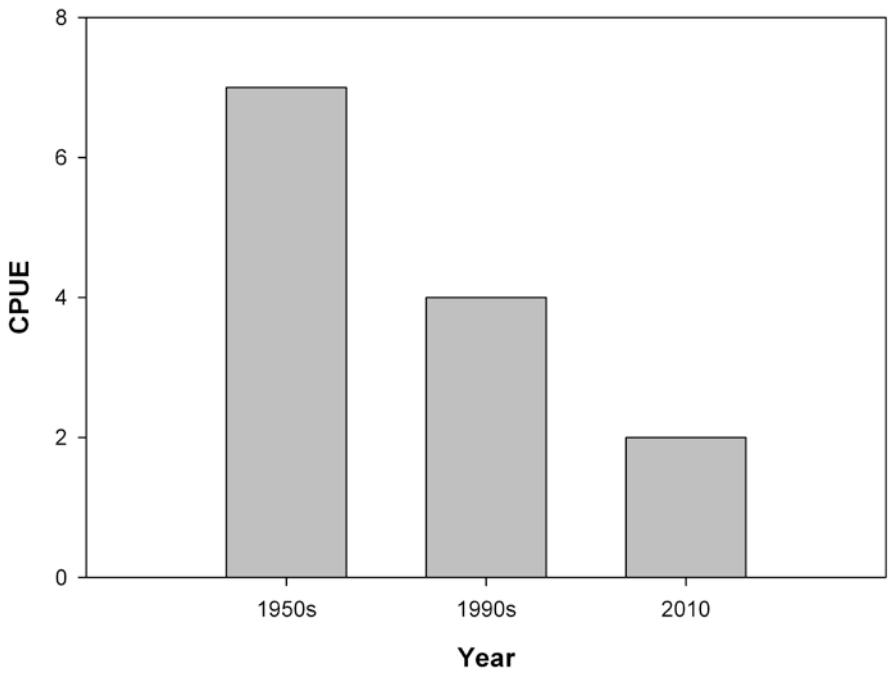

Figure 24. Changes in the catch-per-unit-effort (CPUE) between the 1950s and 2010 in Saipan, Guam. (Source data: Graham 1994b; van Beukering *et al.* 2006; J. Cuetos-Bueno, in preparation)

To date, several fisher perception studies have been carried out in CNMI. All surveys provide strong support for the negative trends reported herein (Figs. 16 and 17), with some 80% of respondents noting declines in size

and abundance of target species (van Beukering *et al.* 2006; Cuetos-Bueno *in preparation*). Fishers from all surveys identified increased fishing pressure as the primary cause in fish declines and the need for greater management and fisher participation in decision-making. No traditional management for marine resources exists today in CNMI. Instead, fisheries are managed through the Magnuson-Stevens Fishery Conservation and Management Act, in conjunction with local government policies. Aside from the fishing regulations included in Appendix Table A2, there are a number of marine protected areas in the southern islands.

Concomitant with decreases in subsistence fishing and increases in population, the importation of coastal marine products surged, with import volumes climbing from 0.5-23 mt/yr (DFW *unpublished data*; Starmer *et al.* 2005; Continental Airlines spokesperson, CNMI, *personal communication,* April 2011). Current imports are now estimated to be around 14 mt/yr. The bulk price is $4.4/kg, while the retail price is $7.70/kg, lower than that of local reef fish ($8.80/kg). Nonetheless, between the mid-1980s and 1990s, fish prices remained relatively stagnant and then steadily increased to current levels (Graham 1994b).

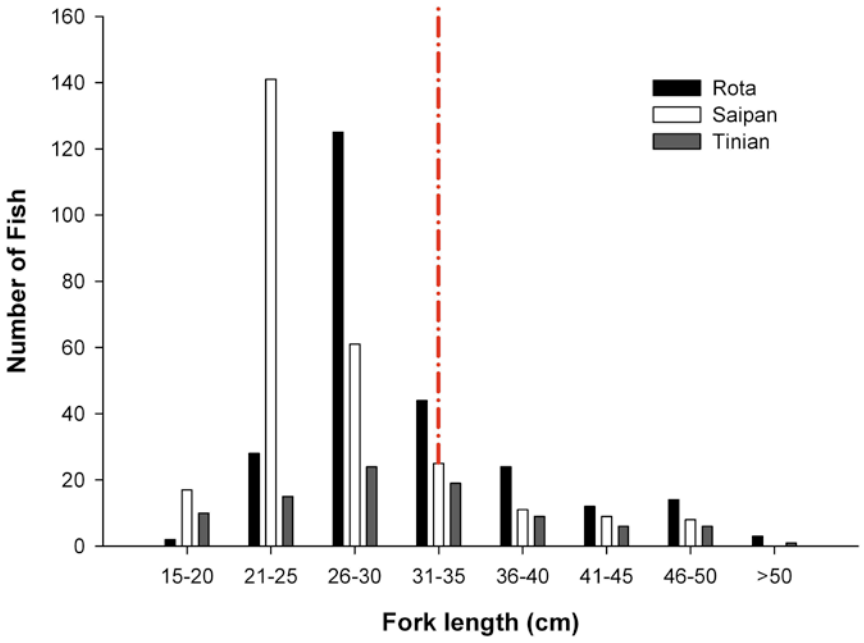

Figure 25. A size comparison of catch of bluespine unicornfish among southern CNMI islands. The red dashed line represents the 50% size of maturity, with the catch mean reflecting an over-reliance on juveniles in catch or, alternatively, a lack of adults in populations.

INTEGRATION OF MODERN MANAGEMENT WITH TRADITIONAL AND COMMUNITY MANAGEMENT

OVERVIEW

As should be apparent within the eight jurisdictional case studies, management and culture vary widely among, and even within, Micronesian states. For this reason, no "one size fits all" approach exists for integrating or improving management systems. Instead, each jurisdiction will require case-by-case development of new management systems or a strengthening of existing ones. For some jurisdictions, a complete overhaul of the existing management system is suggested to ensure functionality, that is, to allow efficient and effective monitoring and enforcement that is in line with long-term management goals, and reflects the political and social characteristics of the jurisdiction. Regionally, there are some examples where countries recognized the need for management restructuring. Specifically, the Solomon Islands national government restructured marine resource management to support and strengthen the inherent social and cultural characteristics of governments and communities. Although these experiments are recent, the new design was implemented to reduce the burdens of the state, while strengthening the potential for community input and involvement in management and enforcement. As such, the state's role is now one of providing financial, material, and legal support (e.g., Solomon Islands Government 2010). This type of endeavor could be useful to a number of Micronesian jurisdictions where communities could bear a greater share of the monitoring, management, and enforcement burdens, such as the FSM.

In Micronesia, there are examples of (relatively) functional management systems, but not at the national level. These smaller systems, e.g., LMMAs, can potentially be used to build larger, stronger more successful management if properly nurtured. Here we provide descriptions of the management spectrum in Micronesia and in the next section identify what is working or not, and why.

THE SPECTRUM OF MANAGEMENT

Traditional Management

The outer atolls of Yap State represent one of the best examples in Micronesia where customary marine tenure is still strong and acting, for the most part, as the sole agent of marine resource protection. While this centuries-old system cannot be fully duplicated elsewhere, some of its fundamental strengths are identified here and might be useful principles to guide management improvements and reforms in other locales. The first principle is to have clearly defined reef resource boundaries, ownership, and property rights. Secondly, there must be strength in leadership such that enforcement and punishment can be levied regardless of family or social affinities. Third, management must be responsive, flexible, and adaptive. When resources show decline, a management response must be timely to stem declines and allow recovery. The system must also be flexible and adaptive to allow changes in management or management response when initial responses fail. In this and a number of other traditional (and Western) systems, there is a recognition that (1) spawning times and areas are important and need protection, (2) limits must be imposed on catch volume, (3) some species are inherently more vulnerable than others and need stronger regulations to conserve them, and (4) destructive gears must be carefully controlled or restricted from use.

Integrated Modern and Traditional Management

Koror State in Palau provides the clearest example of how integrating traditional and contemporary right-based management systems can work. However, there are several key elements inherent in Koror that are not present in most other Micronesian jurisdictions, making the transition of their experience and success to other locales difficult. Unlike other jurisdictions, by the time Koror recognized the need for management improvement, the state was already well financed. The CMT system was by that time somewhat weakened. In addition, Koror State had a plethora of unique natural resource attractions for the development and facilitation of eco-tourism (Y. Golbuu, Palau International Coral Reef Center, *personal communication*, May 2011). One of the key differences between Palau and other jurisdictions is that Koror State linked tourism with a relatively effective management and conservation policy, which the state continues to improve upon. Thus, for Palau, management was a strengthening exercise (versus an inventive or development exercise) whereby CMT was reinforced by national and state government management policy. In addition, and perhaps most importantly, Koror State had conservation champions who identified ways forward in building management, understood the importance of resource protection, and worked to develop methods to empower state-community (and NGO) partnerships. In other locales, including other Palauan states, the successful merger of traditional and contemporary management systems is still emerging, with each requiring individual approaches and financial commitments either through the states or by individuals or organizations. A few possible sustainable financing options to assist future management efforts in other jurisdictions are provided below (*see* Sustainable Financing Options).

Open Access and Weakened CMT Systems

Most of the jurisdictions studied operate entirely (Guam, Kosrae, CNMI, Pohnpei) or in part (RMI, Chuuk) under an open access system. Not surprisingly, these are also the jurisdictions with the greatest impacts to marine resources. In the case of non-CMT open access jurisdictions, a transformation to a rights-based system is achievable, but only if resource divisions are made and community or individual property rights fully delineated. To allow such divisions, changes in the legal and structural framework of management will be required; however, there are major impediments to such changes. For example, in Pohnpei, such divisions would require a state constitutional amendment for municipalities or communities to gain legal control of reef and lagoon areas for management purposes. In these locales, an alternative approach would be to strengthen existing management systems by improving capacity and revenue. However, similar efforts over the past several decades have largely failed, with management in many open access systems increasingly unreliable and dysfunctional. Providing additional funds without restructuring these agencies is unlikely to improve fisheries.

In locales where CMT has been weakened, there is great potential to strengthen these systems and provide a supportive role for the state to provide material assistance. Such is the case in RMI where the government recognizes the importance of strengthening CMT systems in the outer atolls, and has created partnerships with local and international NGOs and industry. The RMI government is assisting in the development of marine protected areas and alternative livelihoods (e.g., aquaculture) to generate non-fishing income. Perhaps unwisely, MIMRA is also supporting the development of coastal fisheries, in some cases where impacts from overfishing are already known. Nonetheless, this example can serve as a model for other jurisdictions and should be extended to Majuro where the impacts from overfishing are most severe.

In Guam, much stronger conservation, enforcement, and education measures will be needed if residents and resource managers wish to have any chance of restoring their resources. Indeed, there is increasing pressure on fish stocks from an expanding human population and diminished adult populations of fish stocks, making recovery difficult, but achievable, if clear, long-term management and enforcement goals

are implemented. In other jurisdictions, the potential success for resource recovery can be improved by dividing reef resources and implementing greater ownership rights. On Guam, a recent bill passed in the Guam Legislature (the Indigenous Fishing Bill 190) would see the introduction of culturally managed areas (CMAs) where only traditional fishing practices would be allowed. To date, the regulations governing this law are still in a draft form with the locations of the proposed CMAs yet to be decided.

CONCLUSIONS AND RECOMMENDATIONS

Based on the case studies, published findings, recorded statistics and interviews, our study concludes that *all Micronesian coastal reef fisheries are currently unsustainable,* with some individual jurisdictions overfished in their entirety and others overfished in localized areas, e.g., in and nearby population centers. As we view it, there are four key steps to rebuilding coastal fisheries in the region.

- **Reduce volume**—For all jurisdictions, the primary aim of management should be to *reduce catch, market, and export volumes until fisheries can be returned to sustainable levels*. Much of this aim can be achieved by raising prices of nearshore and pelagic fish and other coastal marine resources to suppress local consumption and export demand. A number of ways exist to accomplish this, for example by pegging fish prices to fuel prices or placing government or market-based fees on sales. While price rises are unpalatable, suppressing catch volume and consumption is the principle component of preventing and reversing unsustainable fishing[12].

- **Increase fish productivity**—In addition to reducing catch volumes and demand, managers need to promote fisheries productivity by *protecting fish and invertebrates* during known *reproductive periods* and at known *spawning sites.* Productivity is best achieved by maximizing reproductive potential of existing and future stocks, i.e., increasing the spawning stock biomass. Maximizing reproductive potential also means allowing juveniles to reach maturity, which includes *minimum size-at-catch restrictions*. Expanding the reproductive base (i.e., spawning stock biomass) is key to promoting fisheries health and persistence.

- **Raise revenues and institute fair pricing**—An overarching aim of marine management should be to optimize revenues from existing (e.g., pelagics) and new sources (*described below*), while achieving sustainable harvest levels. These revenues should be kept separate from general funds and instead be directed solely towards fisheries resource management and conservation. In addition, unfair pricing schemes for wholesale coastal marine products must be corrected to suppress unsustainable harvest yields.

- **Expedite the political process for management**—Because Micronesia is culturally, economically, and politically complex, no one universal policy or recommendation will fix all current problems. Managers, NGOs, stakeholders, and politicians must work together to streamline the political process to allow quick, responsive management action when problems arise. To date, the slow legislative response to management recommendations (e.g., years to decades) is one of the key impediments to preventing or reversing overfishing. We reiterate that in some states the timescale for needed change to prevent outright fisheries collapse is quickly passing, for example, in Pohnpei and Chuuk.

[12] Responses to price adjustments should be tracked to ensure that goals are being met and that no negative repercussions emerge, such as black markets or increases in subsistence catch.

- **Develop an integrated program that produces local fishery managers**—One of the key impediments to developing proper and responsive management in many of the jurisdictions is the lack of trained managers with appropriate educational skills, including biology, ecology, statistics, sampling, and experimental design. Many of these skills can be attained through an undergraduate and master's level formal university education. A program is needed, starting with the College of Micronesia and perhaps in collaboration with the University of Guam or University of the South Pacific, that can produce local fishery managers.

We begin the next section by highlighting activities and policies that are negatively affecting the sustainable use of marine resources regionally in "*What Isn't Working.*" The following sub-section, "*What Is Working,*" illustrates policies and actions that can help promote sustainable fishing and economic improvements to fishing communities. Finally, we conclude the section with "*What Could Work,*" which includes suggestions for changes in policy and revenue sourcing to improve management and conservation outcomes. A summary table of recommendations follows that is jurisdiction-specific in the level of need and urgency.

WHAT ISN'T WORKING

Undervalued Marine Resources

Nearshore and pelagic fishes and invertebrates are undervalued as export and sales commodities. Micronesian countries that are Parties to the Nauru Agreement (PNA) receive on average only 5% of the value of landed tuna catch, which points to a highly undervalued resource that could with fair pricing bring in substantially greater revenue for coastal marine resource monitoring and protection (Gillet 2009)[13]. This under-pricing of commodities is an economic trap robbing Micronesian governments of income. There is some hope that the signatories to the Nauru Agreement can effectively optimize efforts to attain far greater revenues than currently garnered. Maximization of existing export revenues should be a main priority for Micronesian officials negotiating international contracts. In our view, *a strategy to maximize existing export revenue is one of the single most important policies for Micronesia's socio-economic future*.

Export of Nearshore Fisheries Resources

The export of coastal fisheries resources is exacerbating existing burdens on marine ecosystems and is particularly damaging where overfishing is already prevalent. Reducing export is a necessary solution to renewing fisheries and suppressing catch volumes. With current (and future) levels of fishing pressure and future societal needs (Bell et al. 2009; Kinch 2010) it is highly unlikely that export, even for personal consumption, can be sustained. Most Micronesian jurisdictions are already overexploited or fully exploited, with underexploited reefs found only in remote areas or those with low population pressure. In other areas, reductions in species abundance and size, loss of fish spawning aggregations, and rarity or extinction of long-lived species, such as green bumphead parrotfish, humphead wrasse, and sharks (e.g., Beger et al. 2008; Houk *et al. In press*), have already occurred. Any nearshore fisheries export, if allowed, should be heavily taxed to discourage the practice, depress external demand, and assist in funding local monitoring and enforcement efforts.

[13] Based on dividing volumes by overall values of exported pelagics.

Subsidies, Loans, and Other Fisheries Development Activities

Subsidies and loans are promoting overfishing while burdening fishing communities. Increased debt of fishers, combined with reduced fish abundance and biomass, are diminishing fishers' potential to boost their socio-economic standing. With all Micronesian jurisdictions at or beyond sustainable harvest levels, efforts to promote or further develop reef fisheries should be replaced by programs that limit harvest and obtain an equitable living wage for impoverished fishers. Subsidies from regional and international agencies could be better applied to improve sanitation in existing markets, develop marketing skills among market owners, improve collective bargaining rights among fishers to achieve fair wholesale commodity pricing, raise conservation awareness among stakeholders, and educate younger fishers on sustainable harvest techniques.

Lack of Jobs and Alternative Livelihoods

Within most study jurisdictions, jobs alternatives for fishers and others seeking non-government employment are lacking. As a result, an increasing number of individuals are joining the fishery, including recent college graduates. In most study jurisdictions, unemployment is high, entrepreneurial opportunities are limited, and the timeframe for development of new markets and business sectors may, in many jurisdictions, be too long to prevent fisheries collapse.

In some locales, such as Palau, Guam, and CNMI, where marine tourism is a dominant industry, fishers have greater potential to find alternative livelihoods. Moreover, fishers in these jurisdictions generally are more highly educated, thus allowing more upward mobility compared with those where education lags (Fig. 5). In addition to tourism, several study jurisdictions have invested in aquaculture as an alternative livelihood (e.g., RMI). In these jurisdictions, training, infrastructure, and financial assistance is being supplied by local government, international donors, and private industry. Regionally, Palau and RMI have the longest continuing aquaculture projects, including those for giant clam (Palau, since 1980s; RMI, since 2001) and bêche de mer (Palau). Other projects in Palau include milkfish and rabbitfish. The Palau House of Delegates recently passed (15 May 2011) a bill to provide tax incentives to develop aquaculture projects. Ongoing aquaculture production is also occurring in the RMI (clam—*Tridacna* spp., blacklip mother-of-pearl oyster, corals) and Pohnpei (blacklip mother-of-pearl oyster pearl and bath sponge), with some trials for rabbitfish, and tilapia by the Pohnpei State Office of Fisheries and Aquaculture. Fishers participating in these activities appeared to have limited their fishing activities (S. Ellis, Marine and Environmental Research Institute of Pohnpei, *personal communication*, May 2011). However, to take tangible pressure off fisheries, the scope of these projects would need to be greatly expanded and monitored for success (D. Hess, College of the RMI, *personal communication*, April 2011; ADB 2005).

The Loss of Traditional Ethics and Practices

Fishers in all study jurisdictions identified the loss of fishing ethics among younger fishers as a driver of unsustainable fishing, with 87-97% of fishers considering younger fishers worse at taking care of reef resources[14]. One option highlighted in recent fisher workshops is the development of a fisher school, such as the Yap Traditional Navigation Society Navigational and Canoe Carving Institute, where young fishers come to learn traditional theory, concepts, and techniques for sustainable fishing from patriarch fishes. The University of Guam also provides educational and cultural awareness programs for younger students on traditional fishing. To promote fisher schools and promote alternative livelihoods, user fees (*discussed*

[14] Curiously, only 27% of CNMI fishers felt younger fishers were worse at caring for resources, while 51% felt they were similar in the level of care to older patriarch fishers

below) could be directed toward school financing, with patriarch fishers paid (as an alternative livelihood) to educate younger fishers. Young fishers could be provided business and marketing skills from local business experts. Similarly, traditional fishing and conservation methods could be documented through patriarch fisher interviews and used for regional broadcasts to better inform the general public and other fishers about sustainable traditional fishing methods.

Poor Use of Existing Marine Management Resources

Within most study jurisdictions, existing personnel, funds, and equipment for marine conservation are not used with maximum effectiveness. Such inefficiencies are not always due to a lack of revenue but also to resource agencies not optimizing available opportunities and resources. For example, markets in many jurisdictions, such as Pohnpei, are both centralized and in close proximity to marine resource agency facilities, thus providing an easy, cost-effective means for monitoring and enforcement. Greater efforts to maintain existing equipment should be made. Too often equipment purchased or supplied to regional marine resource agencies is poorly maintained, lost, or loaned to non-government personnel for private use. As a result, the lifetime of existing equipment is reduced.

Weak Enforcement and Monitoring

Enforcement and monitoring effectiveness is mixed among jurisdictions, but is generally weakest in FSM open access jurisdictions. The lack of stringent monitoring and enforcement remains a key obstacle to reducing overfishing and ensuring the sustainability of marine resources. Examples of effective monitoring and enforcement efforts include the Koror State Department of Conservation and Law Enforcement in Palau, the Coastwatch program in Kosrae, the MPA enforcement efforts by DAWR in Guam, and the monitoring and enforcement of Helen Reef (Palau), Enipein Marine Sanctuary (Pohnpei), and Nimpal (Yap) by local communities. Such examples serve as templates for improved monitoring and enforcement elsewhere.

Poor monitoring and enforcement also affects businesses dependent on these marine resources, including hotels, dive shops, restaurants, and sportfishing industries. Many of these businesses spend tremendous time on the water and witness violations of existing laws or practices that damage reefs (e.g., anchoring in MPAs). Regional governments should consider empowering marine-oriented private industries that have an economic stake in preserving resources to boost monitoring and enforcement capacity (e.g., Danielson *et al.* 2008; de Groot and Bush 2010).

WHAT IS WORKING

Clearly Defined Resource Ownership and Rights and Strong Traditional Management

Nearshore fisheries in Micronesia are generally more sustainable where there are clear divisions of resource ownership and property rights. In Palau and Yap, resource rights have been central to enabling the potential for sustainable fisheries. In Palau, for example, the constitution provides each of the 16 states ownership over inshore resources (Graham and Idechong 1998) that, in turn, grants opportunities for traditional and locally elected leaders to exercise some control over resource use, and assists the national government in defining needs. In recent years, both state and national governments have supported this system and have increasingly provided the means and support for monitoring and enforcement of marine laws.

Yap, much like Palau, has combined traditional and Western styles of government for more effective marine resource management, monitoring, and enforcement. Unlike Palau, however, constitutional authority provides Yap's traditional leaders veto power over legislation relating to tradition, including fishing. As in all customary systems in the Pacific, marine resources in Yap are more clearly defined in terms of their ownership, access, and use. The current system (and a combination of low population size and limited export) has provided Yap with the ability to maintain a higher level of sustainability and resource protection than in other systems, particularly those with open access.

The ability of resource users in open access systems to fish out an area and then move to another leaves little incentive for sustainable use. Interestingly, fisher surveys in Pohnpei and Chuuk showed strong support for greater divisions of resource ownership (Pohnpei = 78% of 647 respondents), and customary marine tenure (Chuuk = 93% of 107 respondents). Similarly, in Pohnpei community workshops found widespread interest in community-based management of reef resources at the municipal level. Mechanisms to allow greater divisions of resources in these jurisdictions should be pursued.

In Palau and Yap, where CMT has eroded since pre-colonial times (e.g., Smith 1994; Graham and Idechong 1998), local leaders can work to strengthen these systems to ensure resource rights, allowable use, and resource owner responsibilities are retained. Jurisdictions such as the RMI and Chuuk have considerably weakened CMT and higher levels of associated resource impacts. In Majuro, for example, where CMT is weakest among RMI's atolls, fish populations are heavily impacted, with the known loss of fish spawning aggregations and other long-lived fish, such as green bumphead parrotfish (*B. muricatum*) (D. Wase, MIMRA, *personal communication*, 1997; Donaldson and Dulvy 2004). Nonetheless, recent efforts are underway in RMI to strengthen and rebuild CMT systems to promote coastal resource management and conservation. Similar strengthening exercises in Chuuk could improve resource use and reduce monitoring and enforcement pressure on state marine resource agencies.

Strong Political Leadership

Strong political leadership is a cornerstone of marine resource protection. In Micronesia, however, there has been limited political will to support marine laws, with only Palau, and increasingly RMI and Kosrae, placing marine resource protection at the forefront of political decision-making (e.g., Baker *et al.* 2011). In Kosrae, the intensification of political action came directly from the *recognition of resource declines and a subsequent demand for management change and improvement at the community level*. RMI recently devised a national action strategy for marine resource conservation, which is now being implemented throughout the country (F. Edwards, MIMRA, *personal communication,* April 2011). Fisher surveys and community workshops in Pohnpei have highlighted widespread recognition and concern over resource decline and management failure, but these have not yet resulted in change. In Palau, marine resource protection is the primary focus of several state and national leaders, who champion the development of marine resource protection policy. This dedication is reflected in Palau's marine conservation laws (Appendix Table A2). In Guam, governments have created the political and financial means to monitor, enforce, and successfully prosecute violators of marine laws. The introduction of marine resource legislation on Guam over the last 5-10 years has often stemmed from special interest groups (e.g., Indigenous Fishing Rights Bill) or from one or two senators who have a keen interest in conservation (e.g., Shark Fin Bill and Coral Conservation Act).

In other jurisdictions, political consideration of marine resource protection and enforcement issues vary. Both RMI and Kosrae have proactive management plans, while Chuuk and Pohnpei State, whose needs for improved management are perhaps greatest, seriously lag in both management planning and legislative action. In Pohnpei, with the exception of the State Sanctuary Act (1999), no significant action to protect marine resources has been undertaken by the State Legislature in more than two decades, despite abundant scientific and anecdotal evidence to justify management actions.

Participatory Management

Grassroots community demands for improved marine management have often led to political action. In many jurisdictions, notably Kosrae and Palau, political support and legislative action for marine conservation did not come without strong community calls for change. Grassroots and community activism signal to elected officials and policymakers there is support for their risk-taking legislative actions.

Among grassroots activities in Micronesia, locally managed marine areas (LMMAs) may hold the greatest promise for effective management of marine ecosystems. In many jurisdictions there is a clear sense that local communities want to take greater responsibility for managing marine resources. To be effective, however, LMMAs need clear ownership and authority, which is difficult in open access systems. Similar to CMT, LMMAs place management with local individuals or communities. Within Micronesia, a number of small-scale (e.g., Enipein (Nahtik) Marine Sanctuary, Pohnpei) (Furlich 2010) and large-scale (Helen Reef (Hotsarihie), Palau; 163 km^2) LMMAs have been created (Andrew 2011). These areas are the result of local marine resource conservation champions who, working with state and national governments and NGOs, took action to achieve greater local authority in monitoring, management, and enforcement of local reef areas.

In Pohnpei and Chuuk, communities have expressed a desire for greater responsibility to manage their resources locally. In a recent survey of stakeholders, 78% of respondents (647 households) in Pohnpei stated they wanted more localized management control. In Chuuk, nearly all respondents expressed interest in returning to stronger CMT-type management. Throughout Micronesia, the size and scope of reef systems and current budget limitations suggest localized management through LMMAs are not only necessary, but could become the most effective tool for protecting and sustaining reef resources.

Stakeholder Involvement in Decision-Making

Governments and marine resource managers should increase the involvement of stakeholders in decision-making processes. *Recent studies have shown stakeholder involvement is a key element in engendering management success* (e.g., Danielson *et al*. 2008; Gutiérrez *et al*. 2008; Scholz *et al.* 2008; Pita *et al*. 2010). In Palau, Pohnpei, and Chuuk, >97% of fishers stated that participation in management decision-making was very important (Fig. 26), and that they were more willing to assist in monitoring and enforcement when they had a role in its development. These results provide strong support for the need of fishers to be involved in developing marine resource management plans and ensuring future compliance. To maximize opportunities for fisher involvement, jurisdictions are urged to provide and interpret data for fishers to consider far in advance of developing management plans (e.g., Johannes 1994).

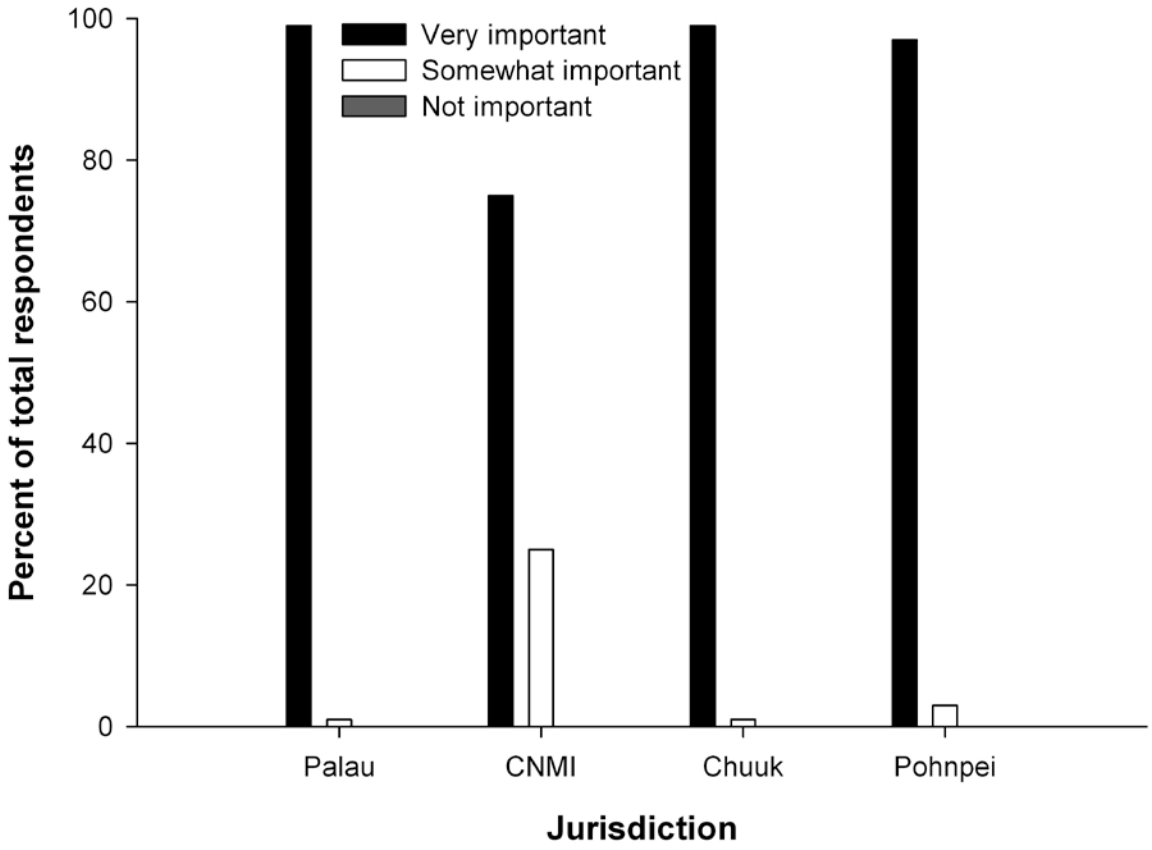

Figure 26. Responses by fishers when asked how important it is for them to be involved in management decision-making. (n = Pohnpei-647: Chuuk-105; Palau-83; CNMI-100)

Recognition of Resource Value

Economic valuations of marine resources clearly show intact, protected resources have far greater value and revenue-generating potential than degraded and/or exploited ones (Polunin and Roberts 1993; Cesar et al. 1997; Pet-Soede et al. 1999; Cesar 2000; Subade 2008). In Indonesia, for example, the destruction of corals from blast fishing was shown to cause a net loss after 20 years of US$306,800 per km^2 of reef (Pet-Soede et al. 1999), highlighting the value of reef protection and loss from ineffective management action. In contrast, the government of Palau has clearly recognized the potential revenue from marine resource protection, and in 2010 generated $90 million from tourism, with around $60 million directly from dive activities. Similarly, Koror State generated more than $3.1 million dollars in visitor permits for the Rock Islands (I. Okeriil, Koror State Government, personal communication, April 2011). In recognition of the special interest in large iconic species by tourists, Palau recently instituted the strictest regional limits on fishing for green bumphead parrotfish (*B. muricatum*), humphead wrasse (*C. undulatus*), and sharks (Appendix Table A2).

Palau has also created a large and expanding marine Protected Area Network that includes both large- (e.g., Rock Islands) and small-scale sanctuaries (e.g., Ngerumekaol). These sanctuaries work to protect species during critical life history phases and across habitats and enable the maximum economic and biological returns through their protection. In 2008, Palau banned the export of live reef food fish, known to have severe impacts on coral reef and other coastal fish communities, particularly spawning

aggregations (e.g., Sadovy *et al.* 2003). As an example of the economic value of spawning aggregations protection, Ruitenbeek (2001) estimated that fully protected spawning aggregations in Komodo National Park (Indonesia) were worth $629,000 annually. Unfortunately, this potential revenue was recently lost when Komodo aggregations were fished out following a 2-year enforcement lapse (S. Mungubhai *et al.* 2011). Similar losses have been and continue to be experienced through Micronesia from a failure to recognize their long-term economic value.

Other study jurisdictions have generated substantial tourism revenue from non-extractive use of coastal marine resources. For example, reported revenue from tourism in Guam was $1.35 billion in 2011—nearly 60% of the total revenue for the territory (compared to 20% in the 1960s) (Guam Economic Development Authority 2011). Much of this revenue is derived from marine activities, such as sport fishing, diving, and snorkeling. Despite the large visitor numbers who participate in reef-related activities, there is no legislation in place to generate revenue via a visitor activity and access fee to support marine conservation efforts. DAWR recently proposed an Eco-Permit System whereby users of marine preserves, including those engaged in commercial activities, special events, and projects undertaken by government/scientific/ research or education institutes, pay a fee into the Wildlife Conservation Fund. These monies would be used to administer and enforce permitting and provide education and outreach services.

WHAT CAN WORK

Sustainable Financing Mechanisms and Economic Approaches

Insufficient resources are often an impediment to effective coastal resource conservation and management. For Micronesian governments, a range of opportunities exist to improve revenues, including several sustainable financing options and market-based approaches.

Obtain Increased Revenue from Existing Reef and Pelagic Fish Exports

As mentioned, the export of wild-caught coastal marine resources is unsustainable and should be discouraged. Nonetheless, fishers in some jurisdictions, such as Chuuk, are heavily reliant on coastal fisheries exports as a primary source of income, yet are receiving far less potential revenue from those products than can be achieved. In these jurisdictions, *higher revenues can be easily generated by raising unit (per pound) prices, taxing exports, or both*. For Chuuk, where state budget shortfalls are common, marine resource conservation and monitoring activities can be bolstered by export taxes on reef fish. The additional costs from price increases to taxation would be borne by importers and passed to consumers (e.g., tourists, hotels, restaurants, and military personnel) who can more readily absorb higher priced commodities. These same revenues can be reinvested in conservation and management, export monitoring, and fisheries enforcement. Price increases, in turn, could act as a mechanism to reduce demand, thereby providing greater potential for long-term sustainability.

At current export levels (anecdotally reported at ≥1 million lbs annually), a $1/lb ($2.2/kg) export tax would provide exporting states such as Chuuk with an additional $1 million in funding for conservation and enforcement activities. Similar taxes could be levied on individual exports in all Micronesian states, for example *a $10-15 per individual export tax on coolers of fish to cover airport monitoring and discourage the practice.* Surplus revenues from the tax could be allocated to marine conservation. With 5-10 coolers typically on each outbound flight daily, revenues would be relatively small ($15,000-$20,000/yr /FSM jurisdiction). Put into perspective, however, for FSM states this value represents salaries for a minimum of 4-5 full-time marine resource staff or 3,000-4000 gallons of fuel (at $4/gal) for patrolling.

Similar to coastal resources, export prices of pelagic fish are well below their potential. For example, in Palau, the current export tax on tuna is $0.35/kg. This is in spite of a recommendation by the Tax Review Task Force to set the tax at $0.85/kg (Lueth and Yang 2008). *The IMF also suggested placing an export tax on other species*. *Recent caps on allowable catch and a growing international demand for pelagics support a rate hike.* The IMF made a number of similar recommendations to raise additional revenue for Palau, some which have yet to be instituted. This same situation applies to all jurisdictions, i.e., one of *missed opportunities to obtain equitable and lucrative returns on their increasingly scarce and valuable marine resources.* The key to any price increase is to separate the revenue from the General Fund(s) to allow added or enhanced management objectives to be met.

Figure 27. Young leopard coralgrouper (*Plectropomus leopardus*) sold in Chuuk for at <$1.50 lb^{-1} and in a Guam supermarket for $8.99 lb^{-1}. (Photo: J. Cuetos-Bueno)

Increase Domestic Prices for Reef Fish

Coastal marine resources are substantially undervalued within Micronesia. Once plentiful, reef resources are now overfished, and there is an immediate need to reduce volumes. One mechanism to achieve this aim is through a value-added tax or a price increase. The reliance on fuel as a major commodity for fishing supports a wholesale fish-fuel price linkage. Fish price increases have generally lagged behind other external commodity prices (*see* Fig. 8) or are set well below their true value (Fig. 9). *In all jurisdictions, marine resource commodity price changes do not reflect their increasing scarcity.* A price increase, both domestically and for exported fish, is warranted with the objectives of suppressing demand in overharvested areas and improving living standards within fishing communities by ensuring a more equitable living wage and return for fishers. Under a supply-and-demand scenario, consumers should reduce fish purchasing as prices increase. Such a scheme would require careful monitoring to ensure the objective of lowering demand is met and that negative impacts to health do not occur as a result of

switching to higher fat, lower cost imported meat products. To offset this potential, imported meat products should be equally taxed or restricted as import items. Regionally, imported meats have been identified as a menace to good health and more responsible government efforts are needed to curb their import and consumption, as well as providing fair commodities pricing to domestic goods, such as reef fish. These types of mechanisms require careful monitoring and involvement by economists, marine resource managers, and health experts. However, with fuel projected to continually increase, a failure to adjust fish prices can be potentially fatal to nearshore fisheries and exacerbate existing issues with food and economic security.

User Fees and Export Taxes

Some jurisdictions have utilized user fees and export taxes to effectively boost revenue. Although visitation varies among Micronesian locales, *user fees could be used in all other jurisdictions* to promote staffing, enforcement, and monitoring of marine resources.

CNMI provides one example of how user fees could promote monitoring and enforcement of reef resources. In CNMI, around 400,000 tourists visit annually, with around 30,000 participating in dive activities (Saipan). A tourist-based environmental fee (similar to the Palau Green Fee) could provide additional revenue for natural resources management and marine conservation throughout the region (e.g., Terk and Knowlton 2010; Thur 2010). Based on average tourism levels, potential annual revenue for marine resource conservation and management in CNMI ranges from $5.6 million ($15 fee) to $19 million ($50 fee) under a Green Fee mechanism and from $450,000 to $1.5 million with only a dive fee ($15-$50 fee, 30,000 divers). While the potential revenue is less in other jurisdictions (e.g., Pohnpei received 1,500 international visitors in 2005-2006), any user-based revenue could provide financial resources for a range of management options**,** including tourism development, support of LMMAs, or partial area fisher buy-outs (*see below*), as examples.

Stimulate Entrepreneurial Activity

Micronesia holds a number of untapped entrepreneurial opportunities, particularly for upscale overseas niche markets. Health foods and medicines are a growing billion-dollar retail market in the U.S. and other countries. Fiji has targeted this market, particularly to meet U.S. demand for kava ($1.4 million, 2005) and spring water ($12.5 million, 2008) (Prasad *et al.* 2006). Until now, the FSM has relied on raw material exports such as bananas, copra, tuna, *Trochus*, and bêche de mer to earn revenue. These resources are often undervalued and subject to price fluctuations that have greatly affected incomes, particularly fluctuations in copra. To broaden export potential, Micronesia should develop alternative industries, for example, organic and natural cosmetics ingredients and products—a global industry valued at $7 billion dollars in 2007 and doubling yearly[15]. A micro-credit loan system, supported by business training and mentoring, would assist young graduates and interested persons in developing small businesses for the local retail and export sectors, particularly for niche markets.

Local entrepreneurism could also be targeted towards fair trade, USDA organically certified health foods. An example would be export of healthy Micronesian snacks, such as baked and fried banana, taro, yam, and breadfruit chips[16]. The use of coconut oil for frying, already being processed and sold in some locales (e.g., Pohnpei), is a rapidly growing health trend in the U.S. Other business options include the extraction and processing of cosmetic-grade fragrances, such as ginger and *Plumeria*. Micronesian chili peppers could be used for export-grade hot sauce, traditionally made in the U.S. from only salt, vinegar, and

[15] http://www.enn.com/top_stories/article/23236

[16] The US potato chip industry revenue in 2005 was $16.4 billion dollars.

peppers. In Pohnpei, where annual rainfall is 400 in/yr (10.1 m/yr), bottled water could be exported. *Potential niche export markets abound throughout Micronesia but have not been well investigated.*

Increase Tourism Revenues

Effective tourism promotion, particularly within RMI and the FSM, is woefully inadequate for creating vibrant, self-sustaining, and ecologically sustainable tourism options. This is particularly surprising given the cultural, marine, and terrestrial tourism opportunities. The FSM, for example, has some of the most intact mangrove ecosystems in the world, several UNESCO World Heritage sites, a host of anthropological wonders, such as Nan Madol (Pohnpei), lush waterfalls, and rare forest ecosystems like the Yela Ka Forest Reserve (Kosrae). Despite this, a mere 20,000 tourists visited FSM in 2000. Major impediments to tourism development in Micronesia include a lack of vision and local revenue input for tourist development and, in some cases, an unwillingness to lure additional foreign investment. Currently, there is limited infrastructure to support a tourism increase, particularly in the FSM, and the quality and scope of the service industry will require significant improvement. Any increase in tourism should examine the impacts on resource use.

Fishery Buy-outs

In Micronesia, the total value of the coastal fishery is estimated to be roughly $24 million per year (Gillet 2009). In Pohnpei, annual revenue from the coastal fishery is about $1,600,000, but current harvest volume is approximately 1.5 times sustainable yield (Warren-Rhodes *et al. unpublished data*). Similar to other jurisdictions, in Pohnpei there is thus a clear need for volume reduction. Fisher buy-outs could assist in this effort. In a far-reaching scenario, all fishers could be bought out, with *temporary* abandonment of commercial fish sales. Such a buy-out would allow fishers to maintain an income while assisting resource managers in crafting a proactive management strategy, re-educating fishers in sustainable techniques, and allowing short-term recovery for overfished stocks.

Conservation Easements

"A conservation easement is a legal agreement between a landowner and an eligible organization that restricts the activities that may take place on a property in order to protect the land's conservation values. Each easement's restrictions are tailored to the particular property, to the interests of the individual landowner, and to the purposes and policies of the easement holder. Conservation easements are recorded as deed restrictions and the restrictions apply to all future owners of the land. The right to enforce the restrictions is held by the easement holder. When an easement restricts the full use and enjoyment of a property, the value of the property is necessarily affected. The value of a conservation easement is the difference between the value of the land without conservation restrictions and the value of the land after restrictions have been imposed" (Captain, Hutapea and Associates 2009).

Conservation easements may be an effective marine resources management tool for Micronesia. Also known as "legacy lands" they can enable landowners to protect and conserve diverse, valuable, and important ecosystems, including marine habitats such as mangrove forests and coral reef ecosystems, particularly critical habitats, such as spawning sites, nesting habitat, or nursery grounds. Conservation easements are widely used in the U.S., including Hawaii, to preserve wetlands and buffer mainland watersheds that impact offshore habitats. In Micronesia, one prominent conservation easement is the Yela Ka forest reserve in Kosrae. The Yela easement protects 87 acres of freshwater wetlands that contain the largest intact area of Ka trees (*Terminalia carolinesis*) remaining in the world. By paying family landowners the difference in reduced value of the land due to it being held only in conservation versus the higher value of the land were it to be sold or converted for development or extractive uses (e.g., such as timber) at market value, the conservation easement assists landowners in preserving their land and natural

resources in perpetuity. One issue, however, is that, like many other conservation programs, an organization or individual is still needed to contribute funding for the purchase of the easement, amidst many other competing needs for scarce funding.

Changes in Existing Management

Shift to Data-less, Precautionary, and Adaptive Management

Contemporary *open access management in Micronesia has failed and there is a need for restructuring*. This observation has been widely reported for decades (e.g., Johannes 1994) and numerous attempts to make improvements have been undertaken without notable success. The current study represents the latest in these attempts. Here we resurrect three management concepts that fit well within the Micronesian setting but are rarely used: adaptive, precautionary, and data-less management. *These three management concepts provide Micronesian marine resource managers with a simple means to prevent ecosystem-wide declines in resources.*

Data-less management suggests when resources appear to be in decline, managers act on anecdotal evidence rather than wait for scientific data (Johannes 1998). In doing so, they invoke the *precautionary principle*, meaning that if managers do not have a full understanding of what is happening in fisheries, yet are aware of notable declines or other negative changes, they withhold resources from exploitation until resource improvements are noted (Bohnsack 1999). This principle is best illustrated by the use of marine protected areas in both CMT and Western systems. Finally, where science-backed, anecdotal, or data-less management decisions do not provide the desired result, *adaptive management* can be adopted to test solutions under a trial-and-error framework. Adaptive management encourages managers to assess a problem, design and implement a solution, and monitor and evaluate the outcome. If the outcome is not the desired one or is ineffective, the manager adjusts the design and re-implements a new strategy (e.g., Falanruw 1982; Hilborn and Walters 1992, Stankey *et al*. 2005). Such approaches have potential in Micronesia only if marine resource managers are motivated and empowered to make responsive management decisions and have the support of policy-makers and enforcement (Walters 2007)**.**

Continued Support of the Micronesia Challenge

Initiated in 2006 by President Remengesau of Palau, the Micronesia Challenge (MC) is a region-wide pledge by the five governments of Micronesia to effectively conserve at least 30% of near-shore marine resources and 20% of terrestrial resources within their jurisdictions by the year 2020. Efforts by the five governments are being assisted by NGO partners, communities, and multinational international donors and agencies, such as The Nature Conservancy.

The current study focuses on analyzing the origins of, and solutions to, one of the most pressing threats to biodiversity to be tackled by the Micronesia Challenge: destructive fishing practices, including overfishing. Based on our findings, efforts through the MC should be redoubled to further implement LMMAs, push for immediate legislative and enforcement actions to ban destructive fishing practices, expand community and NGO actions to nurture conservation champions and press for urgent political progress on marine conservation, and expand sustainable financing to combat overfishing (*http://www.micronesiachallenge.org*). These activities to reduce overfishing will assist in restoring sustainable coastal fisheries resource use. Further actions, including revitalizing tourism development, taking action to eliminate unsustainable fishing gears and practices, improving enforcement, protecting spawning aggregations, and preserving and promoting traditional fishing traditions, will also spur regional conservation efforts within the Micronesia Challenge.

WAY FORWARD

This study analyzed and discussed the factors contributing to overfishing in Micronesia and highlighted the policies and approaches that are working, not working, or could work to improve coastal fisheries management. Based on these conclusions, a synthesis table of recommendations, with an emphasis on jurisdictions where these recommendations are best applied, is provided below. A smaller subset of specific "next step" activities that managers and NGOs can initiate within the next 12 to 18 months to address the most pressing recommendations (Table 4) are also outlined.

Table 4: Recommendations for Improving Coastal Fishery Resource Management and Conservation in Micronesia. Recommendations in **bold** are considered the most urgent to address overfishing and are immediate action steps that should be taken. Pohnpei=PO; RMI=Marshall Islands; PA=Palau; Y=Yap; K=Kosrae; CH=Chuuk; GU=Guam. Not important or not applicable = blank; Needs to be addressed or strengthened, low priority action = **L**; Urgent need, high priority action = **H**).

RECOMMENDATION	JURISDICTION							
	PO	RMI	PA	Y	K	CH	CNMI	GU
MARINE RESOURCE PROPERTY RIGHTS and CUSTOMARY MARINE TENURE								
Strengthen/clarify rights, amend open access policy	**H**	**H**			**H**	**H**	L	L
Limit access to the fishery	**H**	**H**	L	L	**H**	**H**	L	L
Strengthen CMT		**H**	L	L		**H**		
COMMUNITY PARTICIPATION TO REDUCE OVERFISHING AND IMPROVE FISHERIES MANAGEMENT								
Increase stakeholder participation in decisions, monitoring, enforcement	**H**	L	L	L	L	**H**	**H**	**H**
Intensify grass-roots community pressure on legislators and managers	**H**	L				**H**	L	L
Expand/Support LMMAs	**H**	L	L	L	**H**	**H**	**H**	L
Identify and support conservation champions	**H**	L	L	L	L	**H**	**H**	**H**
Start fisher schools to teach sustainable practices	**H**	**H**	L		**H**	**H**	**H**	L
Perhaps modeled on Yap Traditional Navigation Society Navigational and Canoe Carving Institute and Yap State Education Department Culture Teachers Program (see conclusions section above).								
Urgent legislative action to address overfishing	**H**	L		L		**H**	L	
Support the Micronesia Challenge	**H**	**H**	**H**	**H**	**H**	**H**	**H**	**H**
MANAGERIAL								
Ban wild reef fish & invertebrate exports	**H**	**H**	**H**	L	**H**	**H**	L	L

RECOMMENDATION	JURISDICTION							
	PO	RMI	PA	Y	K	CH	CNMI	GU
Prohibit and punish destructive fishing	H	H	L	L	H	H		L
Prohibitions should include nighttime spearfishing, gillnetting, fishing with poisons, and SCUBA spearfishing.								
Protect reproductive fish, highly vulnerable species	H	H	H	H	H	H	H	H
Restrictions or prohibitions should include protection of spawning aggregation sites and times, size limits on key target species that allow them to reach maturity, and regional bans on catch and sale of green bumphead parrotfish, humphead wrasse, turtles, tridacnid clams, and all other locally endangered species.								
Strengthen enforcement	H	H	L	L	H	H	L	L
Enforcement and monitoring improvements could include tailoring patrols to actual fishing times, particularly where nighttime fishing predominates, and a greater focus on market activities.								
Improve accountability of marine resource agencies	H	H	L	H	L	H	L	L
Improve maintenance of existing equipment at marine resource agencies and require resource agency workers to be at least partly responsible financially for lost or damaged equipment.								
ECONOMIC-MARKETING and FINANCE								
Raise domestic reef fish and seafood prices	H	H	H	H	H	H	H	H
Improved pricing to fishers is key to preventing impoverishment of fishing communities. Improved pricing can also be used as a mechanism to suppress reef fish demand. Price increases should be coupled with a survey of consumer and fisher behavior to assure that the desired outcomes are being met.								
Raise prices for exported reef fish and seafood		H				H		
Increase reef fish and seafood prices to dissuade export, or at a minimum, to obtain greater revenues for existing exports, such as an export tax that is allocated to marine resource management funds.								
Impose reef fish export fees	H	H	H	H	H	H		
If allowed, reef fish export fees could be initiated at $1.00/lb on fish exports or $10-$15 tax on individual coolers. All revenues should be used for management and conservation activities and be directed away from the general fund.								
Increase revenues from pelagic exports	H	H	H	H	H	H		
Nauru Agreement signatories must improve their ability to obtain better prices for pelagic fish exports. Some percentages of improved pricing should be provided to management of coastal resources.								
Institute or expand user fees for marine resources	H	H		H	H	H	H	H
Marine user fees and airport tax fees could be based on models from Palau and used strictly for marine management and conservation purposes, with fees set to cover all administration costs.								
Develop airport fee system for conservation activities	H	H		H	H	H	H	H
Marine user fees and airport tax fees could be based on models from Palau and used strictly for marine management and conservation purposes, with fees set to cover all administration costs.								
Ban or alter fisheries loan and subsidy programs	H	H		H	H	H		
Future subsidies should emphasize marine resource conservation and management and not fisheries development.								

RECOMMENDATION	JURISDICTION							
	PO	RMI	PA	Y	K	CH	CNMI	GU
Commission independent, third party economic assessments to value fisheries, set prices and develop fee programs	H	H		H	H	H		
Economic and financial management studies could assist Micronesian jurisdictions in improving revenue and negotiating maximum financial returns for resources. International organizations and independent, third-party advisors can assist governments in contract negotiations, identifying and (re-) evaluating the value of key industries, and empowering states to seek higher prices and, therefore, greater revenues.								
Increase tourism revenues	H	H		H	H	H	L	
Commission job creation, studies, especially niche business markets	H	H		H	H	H	L	
This could be via entrepreneurial and marketing experts. Under-performing Micronesian jurisdictions should consider hiring the services of a tourist and industry development consultant to help structure development of infrastructure and activities around tourism. All Micronesian jurisdictions should look to develop tourism opportunities from existing (e.g., Japan) and developing tourist communities (e.g., China). Jurisdictions should not be looking to aquaculture as a sole means of job diversification or re-stocking, but instead should work harder to protect wild stocks.								

NEXT STEPS

The conclusions and recommendations above suggest specific actions that can be immediately implemented by governments, managers and NGO partners to improve fisheries and management responses. Among these are:

- Conducting economic surveys on the effects of price increases on exports within both import and export jurisdictions, i.e., determine what the market will bear, how NGOs and other entities can assist in improving the effectiveness of supply-and-demand;
- Conduct economic and behavioral assessments of the impacts on consumers and fishers from domestic coastal marine resource price increases;
- Examine ways to facilitate data collection on marketed and exported catch and export;
- Identify the potential for stakeholder participation in development of jurisdiction-specific comprehensive coastal marine resource management planning;
- Improve the capacity of marine resource agencies to obtain and incorporate basic fisheries information and recommendations;
- Identify and train local private industries to monitor (and enforce) fishing activities;
- Identify and engage conservation-minded politicians to assist in streamlining the legislative process to expedite marine resource management policy;
- Conduct fisher and market surveys to identify spawning sites and times for key target and highly vulnerable species;
- Work with state and national governments to pass policies to protect highly vulnerable species, i.e., to produce a regional ban on the sale (and possibly capture) of turtles and moratoria on the capture of green bumphead parrotfish, humphead wrasse, coconut crab, and tridacnid clams, amongst others;
- Carry out economic evaluations of the potential and cost of fisheries buy-outs;
- Assist marine resource managers and legislators in financial assessments of current fisheries revenues, proposed projects (e.g., ornamentals or mangrove crab mariculture), and negotiated agreements (e.g., pelagics, marine exports);
- Conduct audio and video recordings of patriarch fishers to develop educational and awareness materials;
- Implement programs that identify and grow marine resource management capacity, e.g., more specialized internal educational and vocational programs focused on marine resource management.

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APPENDIX A: STUDY TERMS OF REFERENCE: INTERDISCIPLINARY STUDY OF MARKET FORCES AND FISHERY MANAGEMENT IN MICRONESIA

Statement of Purpose:
To undertake an interdisciplinary assessment and analysis of the market forces, both internal and external, that are driving the increasing demand for coastal fish resources within Micronesia; and to investigate the potential opportunities to reinforce community and traditional rights-based coastal fisheries management with contemporary rights-based and market-based fisheries management approaches that are increasingly being applied internationally to manage fisheries. At a time when Micronesia's coastal fisheries are recognized by its leaders as being increasingly overharvested, there is also a weakening of traditional rights-based coastal fisheries management. This is occurring at a time when internationally there is mounting recognition of the potential of rights-based and market-based fisheries management approaches.

The study will:

- Identify, review, and analyze the internal and external market forces and their impacts on coastal fisheries sustainability in Micronesia;
- Review the range of existing community and traditional rights-based marine resource management practices in Micronesia and assess them in terms of modern rights-based fisheries management approaches and the Ecosystem Approach to Fisheries management;
- Evaluate and propose possible approaches to incorporate modern rights-based fisheries management with community and traditional Micronesian fisheries management systems to reinforce local management of coastal fisheries, preferably within an ecosystem approach context;
- Identify appropriate and innovative sustainable financing options for coastal fisheries management within Micronesia, including market-based approaches and alternative livelihood options.

The study will contribute to the discussions around a shift in Micronesia's coastal fisheries policies to support and reinforce community and traditional rights-based fisheries management systems and the adoption of an ecosystem approach to fisheries management. The protection of vital coastal fisheries for communities and the development of innovative approaches to coastal fisheries management and financial sustainability are being undertaken within the context of the Micronesia Challenge. While the initial focus is on applying these approaches within Micronesia, they will also be more broadly relevant within the Pacific, including Hawaii.

Context:
Micronesia's diverse natural resources are the natural capital for local people. Recognizing the growing local and global threats to their natural resources and the Micronesian way of life, the leaders took action by launching the Micronesia Challenge, an unprecedented commitment to protect the habitats and resources that sustain their people. The Micronesia Challenge jurisdictions are facing significant threats to the management of their coastal fisheries due, in part, to internal and external market forces placing increasing demands on the coastal fisheries resources at a time of weakening traditional resource management systems. All five jurisdictions have identified the overharvesting of reef fisheries as a priority threat that needs prompt attention, but in a manner appropriate to the existing governance systems, both traditional and legislative. Micronesia offers a wide spectrum of fisheries governance, from strong traditional management practices that reinforce tenure and access rights, such as those in Yap State (FSM), to government-managed, open access fisheries like Guam that are driven primarily by market forces. As a result, the region provides the scope for innovative coastal fisheries management

approaches—developing culturally appropriate fisheries management systems that build on the region's long traditions of sustainability while at the same time incorporating modern market-based responses.

The importance of coastal fisheries to the economies of Micronesia is reflected in the increasing attention they are receiving: from the value of fisheries to the national economies (see Gillett 2009), to the significance of local markets (see Rhodes *et al.* 2008; Houk *et al. In press*). Internationally there has been a shift to market-based and rights-based approaches to fisheries management to increase the ecological and economic performance of fisheries, while improving the sustainability of coastal communities (see Costello *et al.* 2008; Essington 2010; Jacquet, *et al.* 2009). Similarly there has been recognition within the Pacific region, including Micronesia, of the need to adopt and implement an Ecosystem Approach to Fisheries (EAF) management (see Preston 2008 and 2009). The purpose of this study is to undertake an interdisciplinary—fisheries, economics, and social science—assessment and analysis of the internal and external market forces that are driving the increasing demand for coastal fish resources within Micronesia; and to investigate the potential opportunities to reinforce community and traditional rights-based coastal fisheries management with contemporary rights-based and market-based fisheries management approaches that are increasingly being applied internationally to more effectively manage fisheries. The long-term goal is to ensure sustainable coastal fisheries management practices that address the three contemporary challenges of overharvesting, escalating market forces, and a continuing shift away from the traditional management of fishing.

This project contributes to the ongoing work to implement EAF in support of the Micronesia Challenge goals. To ensure that improved fishing practices are sustainable in the long term, any changes in fisheries management must be implemented within existing government and traditional mechanisms. What is learnt in Micronesia can inform coastal fisheries work in other parts of the Pacific, including Hawaii.

Scope of Work:

Scope: The geographic scope of the study is the Micronesia Challenge jurisdictions: the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, the U.S. Territory of Guam and the U.S. Commonwealth of the Northern Mariana Islands. It is recognized that some jurisdictions will, by necessity, be considered in greater detail than others, based on availability of information and data. The study will focus on coastal and nearshore fisheries (including catches of reef-associated nearshore pelagic fish by coastal fisheries).

Objectives & Tasks: To undertake an interdisciplinary assessment and analysis of the internal and external market forces that are driving the increasing demand for coastal fish resources within Micronesia; and to investigate the potential opportunities to reinforce community and traditional rights-based coastal fisheries management with contemporary rights-based and market-based fisheries management approaches that are increasingly being applied internationally to manage fisheries.

The study will:

- Identify, review, and analyze the internal and external market forces and their impacts on coastal fisheries sustainability in Micronesia;
- Review the range of existing community and traditional rights-based marine resource management practices in Micronesia and assess them in terms of modern rights-based fisheries management approaches and the Ecosystem Approach to Fisheries management;
- Evaluate and propose possible approaches, including innovative options, to incorporate modern rights-based fisheries management with community and traditional Micronesian fisheries management systems to reinforce local management of coastal fisheries, preferably within an ecosystem approach context;

- Identify appropriate and innovative sustainable financing options for coastal fisheries management within Micronesia, including market-based approaches and alternative livelihood options.

Appendix Table A1: Communications and Contact Organizations.

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Benito		Chuuk	Piis Mayor, Piis Municipality	
Pachu		Chuuk	Piis Chief, Piis Municipality	
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Innocente	Penno	Chuuk	Chuuk Department of Agriculture	
Nana		Chuuk	Food Safety Office, Weno	
Fran	Castro	CNMI	CNMI coral reef point of contact	
Steven	McKagan	CNMI	NOAA Fisheries Biologist	
Eleanor	Cruz	CNMI	Nutritional Assistance Program	
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Appendix Table A2: Contemporary Management in Micronesia. Specific details of some management techniques that may be found in individual country profiles.

Technique	Country or State							
	RMI	**Chuuk**	**Kosrae**	**Pohnpei**	**Yap**	**Palau**	**CNMI**	**Guam**
Marine protected areas • Permanent • Temporary/seasonal • Preserves, some allowances for fishing	√			√	√	√	√	√ √
Seasonal bans on sales or catch of individual species or families • Seasonal grouper sales ban • Seasonal grouper catch ban • Seasonal rabbitfish sales and catch ban				√		√ √ √		
Ban on fishing with SCUBA						√	√	
Ban on trawling with EEZ						√		
Ban on the use of explosives	√	√	√	√	√	√	√	
Ban on the use of chemicals, poisons	√		√	√	√	√	√	
Restrictions on export of live fish			√				√	
Ban on shark finning						√	√	√
Restrictions on net mesh size					√	√		
Ban of weirs and gillnets							√	
Ban on export of top 5 commercial species of nearshore fishes						√		
Licensing requirements								
Boat registration						√ (Koror and Ngarchelong States)		
Species restrictions								
Coral removal or destruction							√	
Bolbometopon muricatum • Catch • Sale				 √		 √ √		

Technique	Country or State							
	RMI	Chuuk	Kosrae	Pohnpei	Yap	Palau	CNMI	Guam
• Possession • Export • Seasonal • Reproductive condition • Size restriction						√ √		
Cheilinus undulatus • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction						√ √ √ √		
Giant clam (*Tridacna sp., Hippoppus hippoppus*) • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction • Bag limit					√ √ √	 √		√ √ √
Mangrove crab (*Scylla serrata*) • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction			√ √	√ √ √		 √ √ √ √		
Black-lipped mother-of-pearl oyster (*Pinctada margaritifera*) • Catch • Sale • Possession • Export • Seasonal	 √ √	 √	 √ √	 √ √		 √		

Technique	Country or State							
	RMI	Chuuk	Kosrae	Pohnpei	Yap	Palau	CNMI	Guam
• Reproductive condition • Size restriction		√		√		√		
Lobster • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction • Gear restriction			 √ √	 √		 √ √	 √ √ √	 √ √ √ √
Coconut crab • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction • Bag limit or quota				 √	 √ √ √	 √ √ √		 √ √ √ √
Turtle • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction • Permit required Hawksbill • 5-yr moratorium on take or possession from 2010	 √ √ √	√	 √ √ √	 √ √ √	 √	 √ √ √	√	
Trochus sp. • Catch • Sale • Possession • Export • Seasonal		 √	 √	 √	 √	 √	 √	 √

Technique	Country or State							
	RMI	Chuuk	Kosrae	Pohnpei	Yap	Palau	CNMI	Guam
• Reproductive condition • Size restriction • Quota • Area restriction • Licensing requirement • Permit required	√	√		√ √	√	√ √		√ √ √ √
Black coral (*Antipathes* sp.) • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction • Permit required				√ √ √ √				
Sea cucumbers • Catch • Sale • Possession • Export • Seasonal • Reproductive condition • Size restriction • Permit required						√	√	
Aquarium (ornamental) fishes • Permit require • Permits limited • Reporting required						√ √ √		
Live Reef Food Fish • Trade prohibited • Export prohibited						√ √		
Marine products (general) • Declaration required • Export tax ($0.35 lb^{-1} imposed						√ √		

APPENDIX B: JURISDICTIONAL CASE STUDIES (EXPANDED)

THE REPUBLIC OF THE MARSHALL ISLANDS (RMI)

The current status of the nearshore fisheries resources in the Republic of the Marshall Islands (RMI) is overfished or fully exploited (Table 1) (Newton *et al.* 2007), particularly near the urban center of Majuro, but also on some but not all of the outer atolls (D. Hess, College of Marshall Islands, *personal interview*, April 2011). Common signs of fishery decline are evident, including lower catch volumes, spawning aggregation loss, smaller fish sizes, and reduced catch-per-unit-effort (CPUE) (D. Wase, former director of MIMRA, *personal communication*, 1997; F. Edwards, *personal communication*, March 2011). In some areas, late-maturing, slower-growing species such as green bumphead parrotfish (*B. muricatum*) have become virtually extinct (Donaldson and Dulvy 2004; Hamilton *et al.* 2008), while some individual atolls have seen noted reductions or the absence of top predators, such as sharks (Beger *et al.* 2008). In other locales, top predators are abundant, suggesting variable levels of (over) exploitation (P. Houk, *personal observation*). In Majuro, known spawning aggregations of some key target species were lost decades ago at some known sites (D. Wase, former director of MIMRA, *personal communication*, 2005). Fish populations have also been impacted on nearby reefs (e.g., Arno), as a direct result of fishing subsidies for development and other fisheries incentives that placed pressure directly on spawning aggregations (K. Rhodes *personal observation*).

In Majuro, a 2004 survey estimated that around 900 mt of fish are caught each year from the atoll supplying roughly 23,000 people with food. Current consumption in Majuro is 39 kg/capita/yr (OFCF/MIMRA 2004). About 60% of this catch is sold in Majuro's 10 retail markets, earning an estimated $1.6 million dollars for 237 fishing households (approximately 7.7% of all Majuro households). The remaining 40% of catch is kept for subsistence purposes, with an equivalent value of $1.3 million/yr, or around $675/yr for each of the estimated 1,916 fishing households.

The main drivers of overfishing of reef fish in RMI are *population pressure* and *fish exports* to overseas markets, which lead to a high demand for reef fish. Although there is a relatively low total population of 61,000 people (World Bank 2011), a small land area results in an extremely high population density of 342 persons/km^2 (up from 280 persons /km^2 in 1999 (Marshall Islands Planning and Statistics Office 2011). This *local demand is manifested in RMI's strong subsistence and commercial market fisheries*, which exert significant pressure on available resources. Currently, Taiwan is the only licensed exporter of reef fish [F. Edwards, Marshall Islands Marine Resource Authority (MIMRA), *personal communication*, April 2011], although there are reports that China and the Philippines are fishing for export from distant outer islands (D. Hess, College of Marshall Islands, *personal communication,* March 2011). Existing fish markets supply local residents in Majuro, with additional reef fish exports shipped out on commercial flights to family and friends overseas.

According to local NGO representatives (A. Ishoda, Marshall Islands Conservation Society, *personal communication,* March 2011), *overfishing has occurred in the majority of fishing grounds proximate to Majuro*. These locales, including Majuro, Arno, and Mili atolls, are also considered by MIMRA to be overexploited (OFCF/MIMRA 2004; D. Hess, College of Marshall Islands, *personal communication,* March 2011). Commercial demand is increasingly being met by imports from the outer islands through a MIMRA-supported development scheme (F. Edwards, MIMRA, *personal communication*, April 2011) that began in the 1990s to improve and diversify rural livelihoods. However, there is some concern that the program is boosting overfishing. To maintain freshness and improve marketability, a storage facility has been developed in Majuro with Japanese funding (D. Hess, College of Marshall Islands, *personal communication,* March 2011), while similar facilities have operated on Kwajalein for more than two

decades, with collection vessels servicing outer islands to transfer fish to Majuro. Volume overfishing has been exacerbated by certain fishing practices, including fishing on SCUBA and nighttime spearfishing (e.g., surgeonfish, unicornfish).

Overexploitation of nearshore resources close to Majuro is driven by unsustainable fishing practices and under-valued fish pricing. Majuro reef fish command a premium wholesale price (USD $2.00/lb) over outer island fish ($1.25/lb) due to local preferences. Similar to other jurisdictions, fish prices are stagnant due to high market competition (F. Edwards, MIMRA *personal communication*, April 2011). Fuel prices on Majuro are currently $4.55/gal (April 2011), but have reached $8.00-$10.00/gal on the outer islands (April 2011). As in other Micronesian jurisdictions, social and religious obligations helps drive the need to increase catch.

Figure A1. Marketed whole and filleted fish from nearby Arno Atoll in one of Majuro's 10 fish markets. (Photo : J. Cuetos-Bueno, February 2011)

Alternative livelihoods are growing in the RMI, with private and government-backed aquaculture projects on several of the outer islands that include coral farming, clam farming (Likiep, Arno), and black-lipped mother-of-pearl oyster (Arrak, Namdrik, Rongelap) (S. Ellis, Marine and Environmental Research Institute of Pohnpei, *personal communication*, May 2011; M. Haws, Pacific Aquaculture and Coastal Resources Center, *personal communication*, May 2011). There is interest in developing mariculture of rabbitfish and other lower trophic level reef fish. It is currently unclear whether these are having any overall impact on reducing fishing pressure (D. Hess, College of Marshall Islands, *personal communication*, April 2011). Profitability varies with product, international market prices, competition and demand; however, the giant clam farm has been operating successfully for more than 10 years and there appears to be potential for the pearl hatchery to be economically successful. Currently, aquaculture in the RMI employs about 40 Marshallese either through part-time or full-time employment. In addition to aquaculture, RMI has a thriving marine ornamental fish and coral aquarium trade. Aquarium export destinations include the U.S., Hong Kong, and Japan, while prior to 2003 a European market existed,

primarily for Germany and the U.K. (F. Edwards, MIMRA, *personal communication*, April 2011). The industry employs a number of local fishers as well as government employees. RMI is reportedly constrained by the number of species of corals it can produce, survivorship of all products during shipping from outer islands, and the overall small-scale of existing operations (S. Ellis, Marine and Environmental Research Institute of Pohnpei, *personal communication*, May 2011).

Fisheries Management and Enforcement

RMI consists of 29 low-lying atolls and five islands with a total of 181 km^2 of land, spread across nearly 1300 km (770,000 km^2) of ocean. Each atoll has its own government. Contemporary Western-style management initiatives for RMI are listed in Appendix Table A2. MIMRA has a marine resources management plan and an income diversification scheme targeted at the grassroots level. This strategic plan includes revitalizing traditional management of reefs, providing training and assistance in monitoring, and supporting the development of locally managed marine areas (LMMAs), including those on Namdrik and Ailuk. In terms of conservation management and planning, RMI would fall ahead of most jurisdictions, but behind Palau. Similar to other jurisdictions with large geographic area, RMI is struggling with enforcement and has had particular problems with foreign vessels fishing illegally on outer atolls. At the national level, MIMRA has a legal advisor to help develop fisheries management policy within the necessary legal framework to view regulations and fishing laws. RMI also has a national conservation action plan developed in 2008 that is currently being implemented (Baker *et al.* 2011). This proactive plan sets clear conservation goals, including the establishment of community-based fisheries and resource management, strengthening the legal management framework, building capacity, and securing sustainable financing. For a number of years, MIMRA has maintained an Advisory Committee to cover coastal fisheries.

Traditional Marine Management

In RMI, all land and nearshore resources are owned and managed under a matriarchal lineage (Beger *et al.* 2008). In the past, CMT was strong in RMI, with a traditional leader of the highest ranked family group on the island or atoll filling the role of "paramount chief." This chief also controlled surrounding marine ecosystems, including coral reefs (Sudo 1984). A chief could apply a *taboo* to any section of a reef to control fishing. Otherwise, the residents of any atoll or island were permitted to fish along any section of the reef. However, "outsiders were strictly prohibited from exploiting the resources of an atoll without obtaining permission from the chief" (Sudo 1984, p. 214). In 1934, following colonization, the Japanese declared reef areas open to everyone (Tobin 1958). By 1958, Tobin noted that "…the power of the paramount chief has become weakened since the arrival of the foreigners, but the concept that the right to exploit the marine resources of an atoll is the prerogative of the inhabitants of that atoll still persists" (Tobin 1958, p. 69). Today, traditional CMT still exists in RMI, but has declined in importance, with varying degrees of effectiveness depending on geographical location (Tobin 1958; A. Ishoda, Marshall Islands Conservation Society, *personal communication,* February 2011; D. Hess, College of Marshall Islands, *personal communication*, April 2011). Paramount chiefs control the laws regarding fishing times and fishing areas for the reefs they have tenure over. Adjacent coral reef and lagoon areas near Majuro are open access, whereas outer islands and atolls are still controlled under traditional CMT. The current conservation action plan seeks to strengthen CMT throughout the country.

REPUBLIC OF PALAU

As in other jurisdictions, the *transition to a cash-based economy*, initiated in about the 1940s in Palau, resulted in rapid localized overfishing and the erosion of long-standing traditional CMT systems (Johannes 1981). With the *expansion of export markets* and import of *modern fishing gear and practices*, including motorized boats and improved fishing nets, increased pressure on reef resources began. *Erosion of traditional fishing mores and ethics* also became a problem, with fishers electing to catch fish for sale rather than for subsistence use. With this fundamental economic transition, fishers became subject to external market forces, including the export market. Foreign exporters began looking to Palau and other Micronesian jurisdictions that in the 1980s resulted in the rapid overfishing of fish spawning aggregations to supply the Southeast Asia-based live reef fish food trade (Johannes and Riepen 1995; Johannes *et al.* 1999). During the same period, when the price of fuel or imports rose, both competition and the need to increase volumes ensued (Johannes 1981). By the 1980s, fishing for cash to purchase imported goods and cover rising occupational costs was a key driver of overfishing of near-shore reefs and lagoons in Palau. Moreover, as in other locales, gears and fishing methods became further modernized in the 1980s and 1990s, including the increasing use of nighttime spearfishing (Johannes 1981) that led to overexploited stocks, particularly in Koror State.

Unlike many other Micronesian jurisdictions, Palau had several characteristics working in its favor to initiate and sustain conservation practices: (1) an eroded, but still functional traditional management system, (2) available funds to initiate and develop monitoring and enforcement activities, particularly within Koror State, (3) interest and drive among locally respected individuals who could champion conservation ideas and actions, (4) world-class reefs and natural resources that, while impacted from past natural disasters (e.g., 1998 El Nino), remain among the best in the region to lure tourists, (5) a direct air link to Asia and other destinations rich in potential tourists, (6) clear ownership rights of terrestrial and marine resources, (7) a large reef area often difficult to access and, (8) a relatively low population density. These and the pursuit of long-term conservation and development goals by Palau's national and state governments allowed the initiation and growth of revenues for continued improvements to natural resource management. As a result, tourism now accounts for 60% of national revenues, with $90 million in total tourist-based revenues in 2010, 60% of which was derived from dive-based tourism (Palau Office of Statistics and Planning 2011). Notably, this increase in revenue has not resulted in substantially improved funding to the one key government agency charged with marine resource monitoring and management, the Palau Bureau of Marine Resources.

Within Palau, *Koror State stands out as the regional champion in conservation*. As the center of political and economic activity, Koror State was endowed with funding to develop a viable natural resource-based tourism industry. From this and other funding through local land leases, Koror State was able to grow revenues, some of which were dedicated to monitoring and enforcement of the state's marine resources. Two critical visionary actions that have enabled Koror State to achieve conservation success, while simultaneously developing marine resource-based tourism, were the creation of (1) the Koror State Department of Conservation and Law Enforcement (commonly known as the Koror State Rangers, an effective and dedicated monitoring and enforcement unit) and (2) the Rock Island (Chelbacheb) visitor fee that provides a steady revenue stream to sustain monitoring and enforcement activities[17]. As an example of its utility, *the $25 Rock Island visitor fee generated $3.1 million dollars in revenue in 2010 for conservation activities* (I. Olkeriil, Koror State Government, Department of Conservation and Law Enforcement, *personal communication*, April 2011). To put this into perspective, the 2010 Rock Island fee revenue represents more than the total budget of other individual Palauan states. More recently, in 2009,

[17] In 2007, the Koror State Legislature established two permit types and fees: $25 for the Rock Island only permit; and $35 for a combined Jellyfish Lake and Rock Island permit.

Palau added a $15 Green Fee to its airport export tax to generate revenue for management activities of protected areas that are members of the Protected Area Network. The Green Fee would benefit those states that lack resources to actively manage their MPAs (Y. Golbuu, Palau International Coral Reef Center, *personal communication*, May 2011).

Palau did not come to this place on its own. To accomplish its current and ongoing achievement, there were *effective and politically and culturally respected environmental champions* who continue to push for conservation at the state and national levels. These visionary, dedicated individuals are largely responsible for Palau's success. In addition, Palau has also been able to *successfully integrate its traditional CMT system with a strong and relatively functional reef fisheries management structure* that is most evident in Koror State. The constitution gives the states power to control their marine resources from the high water mark out to 12 nautical miles, while the national government controls the waters from 12 to 200 miles. It also provides leeway for traditional, state, and village leaders to help develop marine management policy and assist in controlling resource use (Graham and Idechong 1998). As part of the overall process, Palau's political and administrative bureaucracies have increasingly worked together with industry and NGOs to implement sustainable resource use policies.

Although Palau serves as a model for conservation stewardship throughout the region, it should also be viewed as a cautionary tale to those who envision tourism and alternative livelihoods as a final solution to overfishing. Specifically, while the number of full-time commercial and subsistence fishers have clearly declined relative to the early years of commercialization, marketed reef fish volumes have not (D. Orrukem, Director, Palau Bureau of Marine Resources, *personal communication*, April 2011). Instead, *local demand for reef fish, which dropped as a result of fuel-induced price increases, was replaced by tourist demand*, with market supplies holding steady at 214±60 mt /yr (2001-2009). This latter volume does not account for fish sold directly to hotels and restaurants. *Tourist demand has also put pressure on species not traditionally targeted in previous years for local consumption, resulting in unsustainable harvests*. Such species include highly vulnerable green bumphead parrotfish (*B. muricatum*) and aggregation-forming groupers (Epinephelidae) (Y. Golbuu, Palau International Coral Reef Center, *personal communication*, May 2011). The depletion of green bumphead parrotfish recently led the country to pass a catch, sale, possession, and export moratorium. Other iconic and regionally threatened species, such as humphead wrasse (*C. undulatus*), have received similar protection due to local and foreign demand. Similar to local market demand, exports appear stable at 213±60 mt annually (2001-2009) (D. Orrukem, Director, Palau Bureau of Marine Resources, *personal communication, April 2011*). Thus, *while alternative livelihoods and tourism have developed in Palau, reef fish demand has not necessarily declined*. Recent examinations of Palau's fisheries suggest that the country is fully exploited (Newton *et al.* 2007) and there is no evidence to suggest that current levels of fishing are sustainable (N. Idechong, Palau National Congress, House of Delegates, *personal communication*, April 2011).

As a result of the price increase of fish and a shift in food preference, Palauans, like most Micronesians, shifted to cheaper imported meats and away from fresh local fish (Cassels 2006). Canned fish consumption and frozen chicken are now the mainstays of local diets. In addition to tourism, rising export of reef fish to Guam, usually through informal channels and by air, has also been noted as a problem. Based on official market and export figures, Palau extracts approximately 417 mt of reef fish per year for non-subsistence purposes. The value of the commercial reef fishery is approximately $675,000/yr.

Fisheries Management

Appendix Table A2 provides details on Palau's modern fisheries management practices that include seasonal bans on sales and catch, species moratoria, marine protected areas, and gear restrictions, similar to a number of other Micronesian jurisdictions. In addition to the information listed in the table, Palau has enacted legislation for a national Protected Area Network (2003) that enables long-term protection of reef

resources, versus short-term traditional area closures, or *bul* (Ridep-Morris 2010). Recent actions in response to overfishing include a 2001 ban on shark fishing within Palau's EEZ and a veto of a bill in 2010 to open fishing and sales on humphead wrasse and green bumphead parrotfish.

Traditional Marine Management

Palau has a well-documented history of traditional customary management (e.g., Johannes 1981). Johannes formally referred to this centuries-old system of traditional marine conservation as "reef and lagoon tenure," and defined its practice as "quite simply, the right to fish in an area is controlled and no outsiders are allowed to fish without permission" (Johannes 1981, p. 64). Appendix Table A3 below provides a non-comprehensive list of aspects of the past and present CMT system operating in Palau.

Traditionally, fish and other nearshore resources (e.g., clams, sea cucumbers) were caught solely for subsistence purposes or were given away or shared. This system began to be eroded with the arrival of Japanese colonists in the early 1900s, who started stores for which goods could only be purchased (Johannes 1981). This was the first time fish were caught for sale, including to export markets (e.g., *Trochus* shell, sea cucumbers, reef fish). Moreover, fish were caught with the use of motorized fishing boats and improved nets and other fishing gears. The cash income system was further supported by U.S. influence from the 1950s to the present (Johannes 1981).

The erosion of traditional CMT in Palau was relatively complete by the late 1970s, with only a few of the laws and practices still in full force. Although a parallel system of Western government laws, namely the U.S. Trust Territory of the Pacific Islands and later Palauan National Government (2001) regulations, were put in place, these were also routinely ignored or only weakly enforced, such that in essence by the late 1970s no effective conservation and management was in place.

Locally Managed Marine Areas

At 163 km^2, Helen Reef represents the largest LMMA in Micronesia. Traditional ownership of the reef belongs to the Tobian people of Hatotobei State, who, recognizing the need for greater monitoring and enforcement following years of unsustainable and illegal fishing, began working with the Palauan government and international NGOs to procure funding and development assistance for a long-term management plan (Andrew 2011). Recent monitoring efforts have resulted in a dramatic decline in illegal fishing. The Helen Reef LMMA represents a model for developing local management and for working with state and national governments and international partners to build capacity and procure sustainable financing for long-term management. As part of the Palau Protected Area Network, Helen Reef is eligible for a portion of the proceeds from the recently increased Green Fee (Y. Golbuu, Palau International Coral Reef Center, *personal communication*, May 2011). *Perhaps most important is the use of adaptive management strategies, with Helen Reef custodians constantly adjusting management to suit both the needs of the community and marine resources*.

Appendix Table A3. Palau Customary Marine Tenure Characteristics and Restrictions[1].

Component of CMT	Past	1970s	2011
Traditional reef tenure: fishing rights are controlled by chiefs for the benefit of villages, which exercise right to limit access to fishing grounds to their outer boundary.	Yes. Outer boundary ~75-150 miles from village.	Yes. From village to just beyond outer reef dropoff.	Yes. All but Koror municipality.
Power of chiefs to enforce traditional CMT laws	Strong	Eroded	Variable
Closures & bans			
- Area closure (stocks): moratorium (*bul*) to manage resources			
- Season (stocks)	Yes	Yes	Yes
- Custom (funeral)	Yes	Yes	Yes
Punishment (e.g., poaching)			
- Chief of poacher's village fined by Palau's traditional high chiefs	Yes	Yes	
- Clan of fisher poaching pay cash fine	Yes	Yes	
- Boat/gear confiscation as punishment	Yes	Yes	Yes
Outsider access			
- Temporary fishing permits	Yes	Yes	No
- Outsiders (neighbors) allowed to fish for subsistence purposes, if ask permission			
- Outsiders allowed to fish commercially, if ask permission & pay portion of catch	Yes	Varies	No
- Outright gift of fishing grounds to other villages	Yes	Yes	No
- Fishing grounds shared by two villages	Yes	Yes	No
Ethics to avoid waste (take only what will be consumed)	Yes	Yes	No
Restrict species capture to ensure supply	Yes	Yes	
- Milkfish	Yes	Yes	
- Giant clams	Yes	Yes	
- Sea cucumber	Yes	Yes	
Restrict use of fish poisons (*Derris* root)	Yes	Yes	
Restrictions on fishing on spawning aggregation	Yes	Yes	Yes
- Close areas w/aggregations			Yes
- Ban on harvesting of certain species	Yes	Yes	
- Allow fish to spawn for ≥1 day before catch	Yes	Yes	
- Stranded jacks returned to water during cod running	Yes	Yes	
Restrictions on turtles	Yes	Yes	
- Certain islands prohibited	Yes	Yes	
- Do not kill nesting turtle until laid eggs	Yes	Yes	
- Leave some turtle eggs to hatch	Yes	Yes	
Communal fishing	Yes	No, for cash	No, for cash
Self-reliant for food	Yes	No	No

Main sources: Johannes (1981); Alma (2004)

[1] The table should not be considered comprehensive, but instead representative of some of the many restrictions associated with CMT in Palau.

CHUUK STATE, FEDERATED STATES OF MICRONESIA

Intense population growth since the 1960s, destructive fishing practices, and a vast export market have placed increasing pressure on Chuuk's coastal fisheries resources. Although population growth has eased in recent years due to emigration, Chuuk's population is still high, with 48,600 individuals and a population density 4-5 times higher than surrounding states (FSM Division of Statistics 2002). Although no formal fisheries statistics are available, we estimate that *the total locally consumed reef fish for Chuuk is roughly 2-4 million kg/yr*, based on current consumption levels (40-80 kg/person, FAO 2010; Kronen *et al.* 2006). While volumes of locally marketed fish are unknown, reef fish export in 2010 was estimated at 200 mt (FSM Food Safety Department 2010). Dalzell *et al.* (1996) estimated the commercial harvest at 150 mt and the subsistence sector at 500 mt. *Without reliable statistics, estimates of total harvest volumes are problematic.*

To boost local fishing activity, subsidies by the Chuuk government (through U.S. Compact of Free Association funds) have provided free and wide access to boats and motors (reportedly over 2,000 boats in Chuuk lagoon, FAO 2010) to the general public (Lambeth and Santiago 2001). These *subsidies have made fishing easier and distant fishing grounds more accessible*. Depletions around the population center of Weno have now spread to other parts of the lagoon. Marketed catch shows that individuals in many target species are still being found within the maximum size class, suggesting that growth overfishing is not widespread (J. Cuetos-Bueno *unpublished data*).

Motorized boats have allowed the continuous supply of fresh fish to local and export markets. Due to a lack of alternative livelihoods and the recent collapse of copra[18], most households outside Weno now depend primarily on fishing for income (I. Penno, Chuuk Department of Agriculture, personal communication, March 2011). For example, as of 2006, 90-100% of households relied on fishing as the primary source of income at two communities surveyed in the Chuuk lagoon (Kronen et al. 2006). As within other Micronesian locales, imports have been an increasing component of daily household sustenance, thus driving the need to fish for sale. High fuel prices have sharply reduced fishing profits, with about one-third of daily fishing income expended on gas (and ice).

No official records of commercial reef fish catch are available for Chuuk. The FSM Food Safety Department is currently collecting reasonably reliable, parallel data on fish exports. The department reports that *reef fish exports (100% to Guam) have been steadily increasing since 2005, from 130 to 200 mt/yr*. In 2010, reef fish exports produced a gross income of $2 million. Importantly, however, when all the key steps of the exporting chain are included, the benefits to fishers in Chuuk were only around $400,000, with a net benefit of roughly $250,000 when operational and external commodity costs are factored in.

Interestingly, very little reef fish in Chuuk is sold directly to individuals. Instead, *most reef fish in Chuuk are exported*. Observations and personal communications regarding the market process reveal that *most marketed fish in Chuuk is immediately purchased by small food processing businesses or exporters*. The little remaining is sold to local consumers within minutes (Fig. 6). Nonetheless, there is a thriving internal market for reef fish (Lambeth and Santiago 2001; K. Rhodes *personal observation*), with several stalls selling as much as 450 kg/d, although most averaged half this amount or less. Data from two markets surveyed showed highly variable supplies, with no reef fish available on some days and average monthly sales of about 2,000 kg/market. In 2001, the price per pound of reef fish was $1.00/lb ($1.26/kg) wholesale and $1.25/lb ($2.76/kg) retail. After costs, one market owner reported monthly profits of

[18] Current pricing for copra is on the rise, with the growing demand for biodiesel, with March 2011 prices at ~$1,500/mt (http://www.mongabay.com/images/commodities/charts/chart-copra.html).

$350/mo, well above the annual median household income of around $2,800 (FSM Division of Statistics 2002). Current costs for reef fish are $1.00/lb wholesale and 1.50/lb retail, a reflection of the stagnating costs to fishers for wholesale fish.

As suggested from discrepancies in wholesale fish and fuel prices, profits from commercial fishing activities are limited. Fishers are hindered from further financial investment other than for fuel and ice purchases. Thus, a potential expansion of the fishery is limited. Present and future state budgetary limitations could result in further financial pressure on fishers, since subsidies are less likely. Thus, any increase in profits or expenditures for new supplies or maintenance would need to come from increased catches. Currently in Chuuk, a large number of boats can be seen perishing on shorelines due to a lack of funds for repair and maintenance.

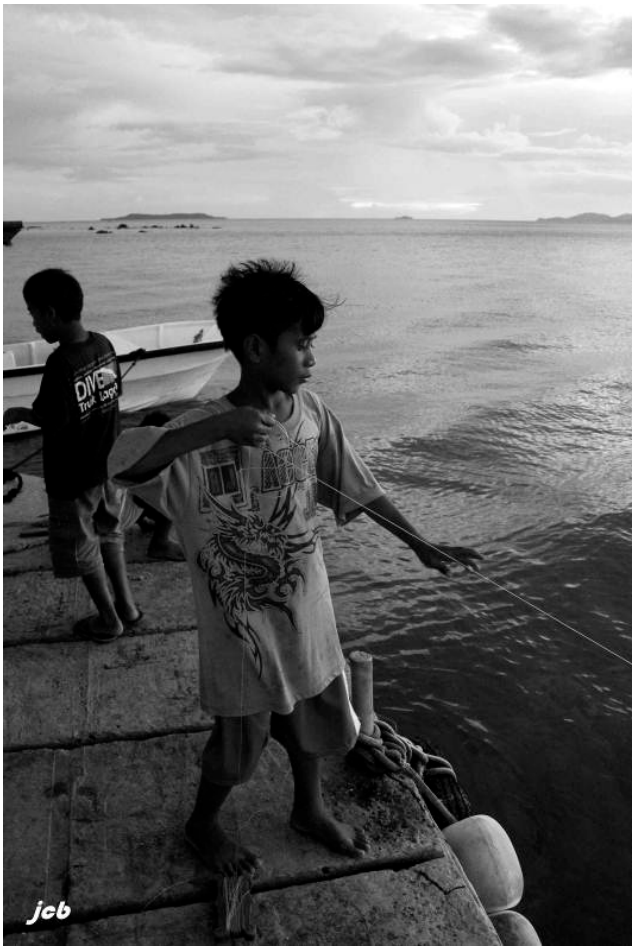


Figure A2. Young Chuukese boy fishing from a Weno pier (Photo: J. Cuetos-Bueno)

The main fishing methods used in Chuuk for reef fish are spearfishing (metal arrows with rubber bands) and nets. While daytime fishing dominates subsistence fishing, commercial fishing is typically conducted by nighttime spearfishing. *Fisher interviews point to a clear reduction in catch abundance and size* (Figs. 16 and 17)*, with an increasing scarcity of once-common species*, such as large-bodied parrotfish. Formerly common, but highly susceptible species, such as humphead wrasse, green bumphead parrotfish, and large-bodied groupers have, in the last decades, become commercially and economically extinct in Chuuk Lagoon (e.g., Donaldson and Dulvy 2004). The use of gill nets is uncontrolled, with reports of nets up to 300 ft in length. Reports of the use of Chlorox® for octopus fishing, blast fishing, live fish trading, shark finning, and uncontrolled lagoon dredging and pollution were also noted. Below we examine these issues in more detail.

Unsustainable Fishing Practices and Land-based Impacts

Blast Fishing

While illegal, blast fishing is still being practiced on Chuuk (Lambeth and Santiago 2001). Due to the possibility of serious penalties for market owners, however, blast-caught fish do not appear to be sold in markets. In 2005, at least one boat was confiscated for blast fishing (K. Rhodes *personal observation*), while a vehicle was confiscated in 2010 for selling blast-caught fish (C. Graham, Chuuk Conservation Society, *personal communication*, May 2011). Several outreach campaigns have created public concern

about blast fishing, but some fishers continue to use this destructive fishing method, especially in more isolated parts of the lagoon. A shortage of funding due to budget cuts and shortfalls has prevented Chuuk Department of Marine Resources (DMR) from monitoring and enforcement in recent years, causing an uptick in blast fishing. Reports of explosions from blast fishing across different areas of the lagoon are common, with the loss of life and health impacts from the use and acquisition of explosives still occurring [R. Osiena, Chuuk DMR, *personal communication*, April 2011]. DMR officials stated that some Japanese residents had offered to provide free boats and nets in return for switching from destructive fishing to alternative methods. Most fishers strongly believe that the recent reduction in reef fish stocks is a direct result of blast fishing. Nonetheless, the lack of alternatives and a lucrative export trade are likely to continue to drive the use of unsustainable gears, including blast fishing, gillnets, and nighttime spearfishing.

Live Reef Food Fish Trade

There is currently no law prohibiting the live reef food fish trade (LRFFT) in Chuuk. In the past, a local operation existed that bought live humphead wrasse (*C. undulatus*), green bumphead parrotfish, and groupers from local fishers for shipment to Hong Kong markets (C. Graham, Chuuk Conservation Society, *personal communication,* March 2011). These fish were reportedly captured using dive gear and chemicals (e.g., cyanide). This same vessel was reported to visit the Pohnpei State sanctuaries of Oroluk and Minto Reefs, which have limited monitoring and enforcement capacity[19]. *Sporadic LRFFT operations still occur*, the last reportedly in 2009. All LRFFT operations are coordinated with local Chuukese partners and there are reports that Chuukese fishers have also captured and sold live reef fish directly to Asian vessels moored in Chuuk. DMR has knowledge of the LRFFT operations but does not have the legal capability to enforce or prevent the trade. In the most recent event, the Chuuk Conservation Society (CCS) attempted to board a LRFFT vessel to inspect the catch, but access was denied (W. Nakayama, Chuuk Conservation Society, *personal communication,* March 2011). As in other locales where the LRFFT operated, localized abundance declines and the loss of both fish spawning aggregations and species were likely outcomes of this fishery.

Shark Finning

While few acknowledge *shark finning still occurs in Chuuk*, Weno-based dealers currently export shark fins to Asia (W. Nakayama, Chuuk Conservation Society, March 2011). Interestingly, many interviewees complained about the large number of sharks in Chuuk. In the course of interviews, several persons requested assistance in contacting foreign fishers to help reduce shark numbers so Chuuk can be similar to Guam (with few sharks). This request may be related to an observed increase in aggressive behavior by sharks toward divers. There are anecdotal reports that sharks now associate divers with feeding, since fish become more available to them both from blast fishing and shark feeding operations by local dive operations (C. Graham, Chuuk Conservation Society, *personal observation*).

[19] Oroluk Atoll is inhabited by a single family, while Minto Atoll is uninhabited. Neither atoll has active monitoring or enforcement capacity (D. David, Western and Central Pacific Tuna Commission, *personal communication,* March 2011).

Uncontrolled Dredging and Pollution

Several dredging operations can be seen around Weno[20]. Limited or no controls over dredging operations are in place. Water pollution is potentially a big concern (both for the health of the reef and humans) for nearshore waters along the main populated islands, but no water quality measurements are being conducted. *A majority of fishers interviewed in Chuuk point to declines in water quality as responsible for reductions in catch* (Fig. 7). Shore-based pollution and sedimentation have been reported as contributing to changes in fish abundance and habitat (Lambeth and Santiago 2001).

Fisheries Management and Enforcement

Modern fisheries management in Chuuk is limited (Appendix Table A2). No restrictions on gear, species, or fish size are in place, with the exception of *Trochus* and blast fishing. *Management of marine resources in Chuuk is poor*, primarily due to severe State government budgetary shortfalls that result in little funding to marine resources management agencies. Although foreign boats are required to obtain a permit to fish in Chuuk, there is little enforcement.

Traditional Marine Management

Chuuk has practiced marine and land tenure for generations (Lambeth and Santiago 2001). While traditional management of marine resources is still strong in the outer islands, it is weak or nonexistent within Chuuk Lagoon with a few exceptions. In Weno, although the reefs still have private owners, access to the reefs has in practice become fully open. The only traditional custom still widely practiced and respected is the "*mechen,*" the traditional closure of reef areas (normally 3 months) after a death. During this time access to the reef is prohibited, including for fishing. Traditionally, such closures were put in place at the discretion of the reef owners or the village chiefs when resources become scarce. For example, prior to the 1960s, in Uman Municipality, all reefs and uninhabited islands away from Uman Island were subject to rotational 3-month openings and closures (J. Albert, Uman Municipal Chief, *personal communication,* March 2011). Presently, Uman Municipal "ordinances" mandate that all fishing vessels not from Uman obtain permission from Uman resource owners to fish in their waters. Although there is no regular surveillance, resource owners will approach and confiscate the vessel, catch, and or fishing gear of those in violation of the ordinance (C. Graham, Chuuk Conservation Society, *personal communication,* March 2011). In some outer islands, 3-month closures still occur under traditional tenure to re-populate overfished areas.

Today, there are some restrictions in Chuuk on fishing by outsiders. For example, within Piis Municipality, which includes the northern quarter of the lagoon, permission to fish must be granted by either the reef owner or the chief. The same applies at Uman Municipality, which includes the southeastern lagoon reefs and Neoch Atoll. However, Uman restrictions were passed by prominent local families without the consent of the whole community, thus these restrictions are not well respected by local fishers.

In the past, access to closed reefs, or to reefs owned by specific families or villages, was strongly respected, with violations resulting in severe punishment and social stigmatization. However, improved gear and declining catch has allowed access to more distant, less monitored areas. Monitoring potential is

[20] Dredging is done under permission from state environmental protection agencies and is common within the FSM. However, enforcement by these agencies in preventing excessive sedimentation to surrounding live coral is lax and permits are freely given without environmental restrictions or monitoring.

lessened by nighttime fishing activity, which is harder to detect. In contrast, Piis Municipality, due to its partial isolation from the other inhabited islands of Chuuk's lagoon, has managed to effectively monitor and enforce its rights. Several reports of boat confiscation and local prosecution have occurred in Piis in recent years.

Although traditional management is generally weak for the Chuuk Lagoon, interviews suggest customary marine tenure may offer the best foundation for fisheries management and conservation, reflected in the high level of support shown by traditional fishers for a return to strong CMT. This potential is particularly important given the lack of enforcement and unreliable funding to DMR. DMR does, however, appear to play a supportive role in community-based management.

KOSRAE STATE, FEDERATED STATES OF MICRONESIA

Kosrae is a single, high volcanic island surrounded by a narrow fringing coral reef and lagoon of 22 km^2 (Donaldson *et al.* 2007). Historically, Kosrae was a monarchy until the early 1900s (Denoon *et al.* 1997). At that time, the king and high chiefs owned all terrestrial and marine resources and possessed full authority over their access, use, and management, such as the institution of moratoriums on fishing for certain species. Although there was strong land tenure, customary marine tenure in Kosrae appeared to be weak. Currently, marine resources are open access and most land is privately owned.

Both subsistence and commercial reef fishing activities occur in Kosrae. Kosrae's coral reefs remain some of the healthiest in Micronesia (Donaldson *et al.* 2007; George *et al*. 20087), with high coral cover. Although the population is low, population density is high and reef fisheries are reportedly overharvested.

Signs suggesting localized overfishing are evident (Kosrae Conservation and Safety Organization, (KSCO) interviews and fisher surveys, Kosrae Island Resource Management Authority (KIRMA) interviews; Appendix Table A1), with both fishers and marine resource and conservation officials indicating that, compared with the past several decades, Kosrae is now experiencing overexploitation. Based on these anecdotal reports, fisheries are now experiencing: (1) smaller reef fish sizes in catch, (2) significantly greater fishing effort per unit return, and (3) declines in overall catch volumes, collectively and for individual species. Based on fisher reports and recent socioeconomic surveys, green bumphead parrotfish (*B. muricatum*) have been rare since the 1990s (S. Palik, KIRMA, *personal communication*, March 2011), resulting in a 2007 state ban on their possession.

Overall, fishers, NGOs, and officials report declining catches with increasing effort. As recently as the 1990s, fishers state, "We could just walk out on the reef and get fish to fill our line in an hour, whereas now you might need to use 4 or 5 hours and swim up to a mile to get this same amount of fish." Overexploitation of soldierfish, surgeonfish, unicornfish, and fish spawning aggregations (e.g., rabbitfish) were also identified as key problems affecting long-term sustainability (KCSO 2010). Changes in fish behavior were also noted, such as taking refuge in deeper water.

Similar to other FSM states, the *transition to a cash economy* was cited as a key driver for increased fishing activity. In particular, fishing is used to *generate cash to purchase imported household items,* especially frozen chicken and meats, canned fish, and rice. *Local food consumption*, both as subsistence and/or commercial purchases from the local retail fish markets, is also one of the *strongest main sources of reef fish demand*. Localized overfishing is evident as smaller catch, smaller sizes, increased effort, and insufficient marketable supply of reef fish. Previous surveys (Donaldson *et al.* 2007), anecdotal data, and interviews in Kosrae thus support the assessment by Newton *et al* (2007) suggesting Kosrae is at or beyond the sustainable yield of near-shore marine resources, with sustainability reflecting the ability of

fishers to harvest and maintain species across a healthy population and being a function of species, size of fish, fishing effort by gear type, and yield, among other factors.

The main preferred food fish species in Kosrae are rabbitfish, rudderfish, mullets, jacks, and certain snappers. Three main retail markets and several smaller markets operate in Kosrae. Unlicensed sales of fish, often at lower prices, contribute to the difficulty of management and enforcement. In 2010, local wholesale fish prices ranged from $1.75/lb for lower grade species to $2.00/lb for the preferred fish. Similar to other jurisdictions, in 2008 fish prices were insufficient to cover high fuel costs, with some fishers increasing catch volumes or lowering fishing activity. In contrast, the recent price rise for imported chicken and canned meats has led to increasing demand for lower-priced fresh reef fish. Reef fish export from Kosrae is limited to family for personal consumption. In contrast, mangrove crabs are exported to Guam, RMI, and Hawaii.

Improvements in gear and storage also underlie the increase in fishing activity, which has enabled fishers to keep and sell fish for longer periods and, thus, catch more per trip than in the past. Traditional methods are now rare, with the exception of the use of (banned) poisonous leaves and roots. Based on interviews, there are significantly *more fishers* in Kosrae today, with "anyone who has access to a boat or motor now going out to fish" (M. Luckymis, KCSO, *personal communication*, March 2011). Common fishing methods include spearfishing (both night and daytime), "torch" fishing, gillnets, cast netting, and hook-and-line (KIRMA, *personal communications,* March 2011).

Despite these issues, Kosrae maintains relatively healthy coral reefs. Although the *population is comparatively low* and *exports are minor*, as mentioned above, signs of overexploitation are apparent, from a lack of large fishes on some sites (Donaldson *et al.* 2007) to increasing fisher effort. This is in spite of the availability of *job opportunities* that allow most people to hold second jobs—many of them in the salaried government or private sectors. Those that cannot find work in Kosrae often *immigrate* to other states, leading to less overall local pressure.

A generally *strong awareness* of the need and importance of conservation, coupled by *political support* for conservation and management measures (with less of a development imperative and mindset, according to some we interviewed) from the Kosrae State Legislature were mentioned as factors that are working to improve marine resource conservation. Local NGOs and state fisheries agencies both felt that grass-roots awareness campaigns and activities (e.g., in schools) has led to growing community support in the past several years for resource management and conservation, including MPAs. This, in turn, has encouraged higher-level *support among legislators* to approve marine and terrestrial conservation-oriented bills and regulations, such as the Kosrae State Protected Area Act of 2010. Consequently, communities have been empowered to designate areas and resources (marine and terrestrial) that they would like to protect and manage, with the aid of the state in terms of monitoring and enforcement. This focus on *bottom-up approaches to marine management* was mentioned as a more successful means (versus top-down strategies) of gaining support for marine protection in Kosrae at all levels, from the community to the executive and legislative branches.

Fisheries Management

Within the Marine Resources Act of 2000, size limits were created for crabs (reproductive restrictions), turtles (seasonal restrictions), *Trochus* and lobsters (reproductive restrictions), and quotas for sea cucumbers (Appendix Table A2). In December 2010, the Kosrae State Legislature passed the Kosrae State Protected Area Act of 2010, which established both terrestrial and marine protected areas. To date, no state-recognized MPAs exist, which is expected to change once management plans are approved. One exception is that of the UNESCO Utwe Biosphere Reserve, which was created in 2005. Nonetheless, several community-based marine protected areas are in existence, including the Tafunsak LMMA founded

in 2008. These, and other community MPAs, are currently awaiting state approval of their management plans, which will allow them to be included in the State MPA network. At such time, these MPAs will be eligible for state management assistance and enforcement.

In addition to MPAs, bans on spearfishing with SCUBA, quotas on sea cucumbers, and other gear restrictions (e.g., gillnet mesh sizes, which are currently under review) and bans on illegal fishing practices, namely poisonous roots and leaves or Chlorox® or battery acids, have been promulgated and are actively enforced. According to KIRMA, enforcement is currently conducted by: (1) a "coastwatch," whereby enforcement agents patrol the island via land to observe near-shore fishing activity, and (2) "territorial surveillance," in which patrol boats are used to monitor (e.g., turtles) and spot illegal fishing (e.g., foreign fishing vessels). Foreign commercial fishing for coastal marine resources, excluding pelagics, within the EEZ is prohibited.

YAP STATE, FEDERATED STATES OF MICRONESIA

Overall, coastal fisheries in Yap are in relatively healthy condition compared to most other jurisdictions, but localized overfishing of certain species and areas has occurred (Houk *et al. In press*). One explanation for the overall positive state of reef fisheries to date in Yap is the comparatively *low population size and density* (11,241 persons, FSM 2000 census; 95 persons/km^2). Nevertheless, when analyzing the root causes of localized overfishing in Yap, a story similar to those described above for other jurisdictions unfolds. First was the *transition from subsistence to a cash economy*, followed by a substantial *weakening of the traditional marine tenure system*, particularly on Yap Proper (the main islands of Yap are referred to as "Yap Proper"). In Yap, however, this transition has occurred much more slowly than in other FSM states or Palau, such that subsistence still forms a mainstay in the local economy and many aspects of CMT still function today (Kronen and Tafileichig 2008). The persistence of these traditional facets of the socioeconomic structure in Yap provides in part, one explanation for its relatively healthy coastal fisheries.

Significantly, in Yap today (2010) most households continue to catch fish for personal household consumption. Most fishers *do not obtain their main income from fishing*, but instead rely on government salaries, or income from small businesses or other sources (remittances, welfare/retirement funds) (Kronen and Tafileichig 2008). Nonetheless, local markets in Colonia, the main urban center, sell about half of the annual total finfish captured. Thus, *local demand and local retail sales of reef fish and seafood are the main drivers* of localized overfishing in Yap. Exports, the other potential source for overharvesting, is mainly done to supply friends and relatives living off-island, similar to other jurisdictions (A. Tafileichig, Yap Bureau of Marine Resources, *personal communication,* April 2011). Due to the small population size overall, export volume is likely a minor portion of the total catch. No commercial export of reef fish is currently being conducted in Yap, but is subject to change, depending on development goals.

Like other jurisdictions, unsustainable fishing gear and practices, such as gillnets and nighttime spearfishing are contributing to localized reef fish overfishing. According to Kronen and Tafileichig (2008, p.21), "fishing at night and with flashlights, and outside the permitted fishing ground is now common," with the majority (57%) of reef finfish caught by spearfishing.

Fisheries Management

Yap is somewhat different from other jurisdictions in having a mix of traditional and Western management, with strong CMT on the outer atolls and a weaker version of CMT in Yap Proper. The following section examines CMT. Currently Western management in Yap includes bans on explosives and

poisons, restrictions on the sale of turtle, and seasonal and export restrictions on coconut crab and giant clam (Appendix Table A2). *Trochus* are harvested by permit only during specifically designated periods every few years. However, the strength and position of the CMT system do not provide for a strong Western-style management system to be imposed. Recently, there has been increased interest and use of marine protected areas, and there is at least one actively monitored and enforced LMMA in Yap Proper. It is still too early to tell whether these can be sustained within the current traditional management system.

Traditional Marine Management

Customary reef and lagoon tenure represents the strongest and most intact CMT system in Micronesia. Although the systems are basically similar throughout Yap, the forms of management restrictions vary widely across the islands and atolls. In addition, like some other jurisdictions, Yap is socially complex and stratified, giving rank to different segments of households, villages, and communities (Foale 2007). For the purposes of this report, we will not describe these systems in detail, although some of the management methods are provided in Appendix Table A4. These are not meant to represent all of the methods used and, in some cases, may be relevant to only to one or more atoll or area.

Unlike other jurisdictions, where customary systems began to weaken in the mid-20th century, it was not until the 1990s and early 2000s that Yap's CMT and other traditional political and socioeconomic institutions began to erode (Smith 1991; Tafileichig and Inoue 2001; Kronen and Tafileichig 2008). This is not to say that evolution of these systems had not yet occurred. Smith (1991) and Falanruw (1994) note that earlier colonial pressures, and subsequently the American administration, took their toll on CMT systems beginning in the early 1900s, when Yap had mostly a fully functioning traditional system. Until that time, many of Yap's customary marine use rights and tenure system were still in effect (Smith 1991).

In Yap, the CMT systems, headed by two Councils of Chiefs, is nested equally alongside State government, and encompasses not only traditional reef ownership and fishing rights (Appendix Table A4), but also restrictions and controls on these rights (Smith 1992; Smith and Dalzell 1993; Tafileichig and Inoue 2001; Kronen and Tafileichig 2008). Waters surrounding Yap State are divided into three zones. The first is the internal waters, which are those from the shore to the island baseline (the line following the contour of the seaward edge of the outer reef). The State Fishery Zone extends from the islands baseline to 12 miles seaward, while fishing rights from 12-200 miles offshore EEZ are controlled by the national government. Traditional authority to control fishing is provided for the State's waters (internal waters and State Fishery Zone), with rights and ownership of marine areas and resources acknowledged by the State, which nonetheless "may provide for the conservation and protection" of those resources. . . "but any resource management involving the utilization of inshore resources must be accepted and approved by the Council of Chiefs" (Tafileichig and Inoue 2001, p. 114). In this way, fishing is regulated by geographical area and the habitat that can be fished, as well as the fishing practices, type of gear and target species that can be caught (Kronen and Tafileichig 2008). In these traditional reef tenure systems attached to the regulations were explicit "rules of conduct and obligations for distribution of catch" (Falanruw 1994; Kronen and Tafileichig 2008).

Appendix Table A4. Examples of Traditional Management within Yap State

Component of CMT	Past	2008
Reef tenure rights (customary control of marine usage area and resources usage).	Yes. Inshore waters of each village.	Yes, still strong
- Ownership of reef areas and fishing rights by small groups (estate, or household & associated resources)	Yes	Yes
- Quasi-private ownership of reef areas and fishing rights, subject to hierarchical systems of control	Yes	Yes

Component of CMT	Past	2008
- Individuals within clan have right to fish any of own clan's waters, with no restrictions	Yes	Yes
- Individuals within clan require permission of chief, or head of the estate or clan	Yes	Yes
Power of chiefs to enforce traditional CMT laws	Strong	Moderate - strong
Use of closures		
- Area (stocks)	Yes	Yes
- Season (stocks)		
- Custom (funeral)	Yes	Yes
Punishment for infractions	Yes	Yes
Outsider access	No	No
Ethics to avoid waste (take only what will be consumed or not more than one's share)	Yes	Yes
Restrictions to maintain subsistence fisheries		Yes
- Chiefs banned boats & outboard motors; only paddling & sailing canoes permitted		Yes
- Banned nighttime spearfishing & monofilament gill nets		Yes
- Line only, no trolling, for tuna		Yes
Restrict access of species to ensure supply		
- Milkfish		
- Giant clams		
- Sea cucumber		
- Coconut crabs		
- Turtles		Yes
Restrict use of fish poisons (*Derris* sp. root)		
Restrictions on fishing on spawning aggregation		
- Ban on harvesting of certain species		
- Allow fish to spawn for ≥1 day before catch		
- Stranded jacks returned to water during cod running		
Fishing restrictions on species	Yes	Yes
- Certain species are property of high-ranking people/clans	Yes	Yes
Fishing methods or gear restrictions	Yes	Yes
- Certain gear (e.g., fish traps) can only be used by higher-ranking people/groups	Yes	Yes
- Maintain traditional skills—no boat & motors; only paddle & sailing canoes in some areas		Yes Yes
- Banned use of monofilament gill nets		Yes
- Banned use of flashlight spearfishing		Yes
- - Restrict use of pelagics for bait		Yes
Communal fishing	Yes	Yes
Self-reliant for food	Yes	Yes, weakening.

Sources: Smith (1991); Falanruw (1994); Smith and Dalzell (1993); Tafileichig and Inoue (2001); Kronen and Tafileichig 2008.

Two main levels comprise the Yapese traditional CMT system: (1) higher-ranked chiefly villages ("chief" level) and their inhabitants, and (2) lower-ranked allied ("servant" level) villages and their inhabitants. In general, with a few exceptions, the latter level possesses no land or fishing rights. In Yapese culture,

"people are not chief, but rather the land is chief"—the land provides not only resources and space, but also social status (Sudo 1984). With certain land comes authority and rights. In terms of fishing rights, the water within the lagoon is divided among the villages, according to their boundaries, which stretch from the edge of the village to the outer edge of the reef; outsiders who do not hold land within a particular village are not permitted to fish within these nearshore waters (Sudo 1984). If an outside fisher is caught taking resources from the waters belonging to another village, those villagers may seize his gear and the entirety of his catch.

Exports

Currently, there is no commercial export of reef fish from Yap, although this type of export has been conducted in the past. Current export volumes are unknown, but are primarily for personal consumption, similar to other jurisdictions (A. Tafileichig, Yap Marine Resources Management Division, *personal communication*, April 2011). In the past, however, substantial volumes of reef fish were exported for commercial purposes. In 1991, for example, estimates showed 30,000 lbs (13.6 mt) of reef fish was exported, equivalent to around 4% of the total yield (Yap State MRMD 1991). At the time, there was a growing interest in export, particularly to Guam, as well as a concern that these exports would put additional pressure on Yap's reefs. No records of reef fish export are currently kept.

POHNPEI STATE, FEDERATED STATES OF MICRONESIA

Pohnpei is a high island (791 m) surrounded by eight atolls. Most of its approximately 36,000 inhabitants reside on the main island, where the majority of commercial fishing activity occurs (Pohnpei Statistics Office 2002). The main island is endowed with a wide lagoon and encircled by a barrier reef that is divided through by a number of channels. Pohnpei Island is divided into five municipalities, each headed by a traditional chief (*Nanmwarki*). Prior to colonial times, Pohnpei's coastal fishery was largely restricted to nearshore waters and dominated by relatively shallow water, inner reef, net fishing that focused on up to 123 different species of fishes (Bascom 1965). Hand nets, throwing nets, and seines were traditionally made from hibiscus twine, with wooden throwing spears, tipped with a stingray's barb, were used from dugout canoes. This pre-colonial tradition changed significantly beginning with the arrival of the whalers and missionaries in the 1880s and was continually altered with the arrival of each foreign entity. Whalers introduced metal spear tips, Germans (1898-1911) provided metal hooks, the Japanese (1911-1945) brought fishing line, while Western-style (Hawaiian sling-style) spears—the now predominant method of fishing—arrived from Kosrae following the American liberation in 1945. Today, fishing materials are dominated by imports that include battery-powered flashlights, SCUBA goggles and fins, coolers, motorized boats, and an additional range of modern equipment to make fishing more efficient. Along with gear changes, the Japanese introduced the concept of a market economy, resulting in the commercialization of fisheries in the early 1900s with the sale of bonito (*Katsuwamus pelamis* and *Euthynnus affinis*). Most of these changes occurred in the absence of either rights-based or traditional management controls.

Contemporary Fishing

The cumulative and continually evolving post-colonial changes have resulted in a substantial local market for reef fish, with an annual production in 2006 of 1.1 million pounds (521 mt) at an estimated value of approximately $2 million. The inclusion of subsistence catch brings this total to nearly 600 mt/yr. Of this total, only 4-10% is exported, with exports destined primarily to the U.S. and Hawaii for personal consumption (Rhodes *et al.* 2008) (Fig. A3). Based on commercial catch (Rhodes *et al.* 2008) and subsistence values of consumption, an examination of sustainability was conducted to show that *Pohnpei*

is now extracting nearly 1.5 times (150%) its sustainable productive capacity (Warren-Rhodes *et al. unpublished data*). Thus, as in other Micronesian jurisdictions, there is an immediate need to reduce catch volume and restore productivity. In addition to the historical changes in fishing and change to a market economy, there are a host of specific unsustainable fishing practices driving overfishing: (1) an over-reliance on juveniles in catch; (2) the use of nighttime spearfishing and small-mesh gillnets; and

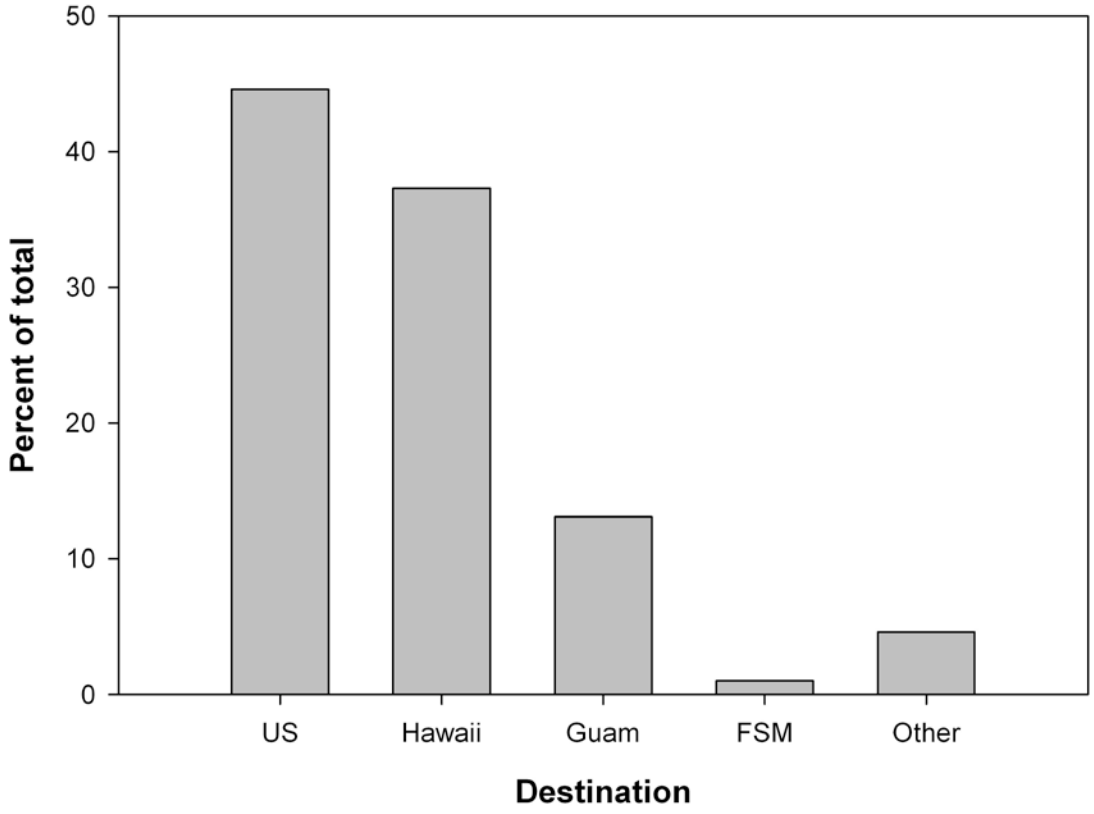


Figure A3. Export destinations of reef fish by 72 passengers surveyed in Pohnpei (2006).

(3) the targeting of spawning aggregations (Rhodes *et al.* 2008; Rhodes *et al*. 2011). Adding to the observed and perceived changes in fish communities are the loss of nearshore coral reef and seagrass habitat from dredging and associated sedimentation, and coral and sand mining for construction (Turak and Devantier 2005). Extensive habitat loss (circa 1960-1990) appears to have also occurred from typhoon damage, crown-of-thorns starfish outbreaks, and past sedimentation of nearshore corals from dredging and mangrove removal (Marsh and Tsuda 1973; George *et al*. 2008). Reductions in the abundance of humphead wrasse (*Cheilinus undulatus*), green bumphead parrotfish (*Bolbometopon muricatum*), and coastal sharks have been noted (Allen 2005). Giant clams (*Tridacna gigas*) are now absent from many of Pohnpei's reefs and there have been anecdotal declines in lobster (*Panulirus* sp.). Following extensive fishing on one of Pohnpei's known multi-species fish spawning aggregations (1999), changes in fecundity, mean size, and abundance were immediately noted (Rhodes *et al.* 2011). The aggregation has shown little recovery over the past 10 years of monitoring (Conservation Society of Pohnpei *unpublished data*).

Marine Resource Management

Contemporary management in Pohnpei includes several prohibitions put into place beginning in 1975, with the Pohnpei State Endangered Species Act (of 1975). The Endangered Species Act provides legal protection for any species designated as threatened or endangered by the Director of the Department of Land and Natural Resources. In 1981, the Marine and Aquatic Resources Act was passed under Title 26, Chapter 6, that allowed the state to control fishing on individual species and during certain seasons. These protections are identified in Appendix Table A2. In 1982, Pohnpei enacted the Conservation and Resource Enforcement Act (of 1982) that provides the Director of the Department of Land and Natural Resources power to design and oversee conservation efforts on behalf of the state. Most recently, the state enacted the Marine Sanctuary and Wildlife Refuge Act of 1999 that provided for the establishment, monitoring, and enforcement of 11 marine protected areas, including two that protected the entire marine systems of Minto and Oroluk atolls. In subsequent years, Ant Atoll and the Mwahnd Marine Sanctuary have been added into the network.

Figure A4. Young Pohnpeian fisher with an undersized camouflage grouper (*Epinephelus polyphekadion*) (Photo: J. Cuetos-Bueno, February 2011)

Enforcement and Monitoring

Pohnpei, similar to many other study jurisdictions, is lagging in its monitoring and enforcement efforts. There are no reliable statistics that can be used to measure historical or contemporary trends in the fishery. Sporadic efforts to document the fishery have been made (e.g., Fishery Engineering 1995; Rhodes and Tupper 2007; Rhodes *et al.* 2008), but there has been no consistent monitoring by the state. This lack of information is hindering the ability to make an informed management response to what is now perceived as severe overfishing.

Similar to monitoring, enforcement in Pohnpei is poor. Many of Pohnpei's enforcement problems are common to other PICTs: (1) lack of awareness, (2) lack of revenue, (3) insufficient staff and material resources, (4) poor leadership, (5) ineffective strategic planning, and (6) improper use and care of existing equipment, leading to the inability to monitor and enforce. As a result, poaching is common and widespread, including within marine protected areas. In many jurisdictions, existing laws are openly disregarded. In Pohnpei, monitoring times (0800-1700) are generally inconsistent with fishing times (2200-0600). Similarly, *the use of cost-effective techniques for monitoring and enforcement are overlooked or not pursued, such as market monitoring*. In many cases, violations go unpunished due to an ineffectual judiciary. As an example of the political problems of enforcement, in 2006, Pohnpei's then-Governor was caught fishing illegally in the Nahtik MPA, which resulted in the state legislature's hindering of patrol efforts by trimming the budget and moving the conservation unit out of the Department

of Public Safety (Furlich 2010). As a result, fishers have a general lack of respect for enforcement, resulting in a continuing cycle of fishing violations that are now impacting the ability to manage or conserve dwindling resources.

More recently, in 2010, three fishers were caught poaching in the Nahtik MPA. Protectors of the sanctuary organized a large community meeting of chiefs, government officials, and conservation advocates—the poachers were required to provide food for the event, a significant contribution. At the meeting, the poachers presented their side of the story and then asked for forgiveness from the attendees. The chiefs reminded everyone "of their collective responsibility over the natural resources in the community" (Furlich 2010). These actions signal the potential for greater participation in monitoring, management, and enforcement by community organizations through locally managed marine areas (LMMAs).

Customary Marine Tenure

Little information exists on marine tenure in Pohnpei. Based on interviews and literature reviews, marine tenure was not practiced widely in the state but is still in force in many outer island communities (B. Raynor, The Nature Conservancy, *personal communication,* February 2011). In contrast, traditional tenure systems for terrestrial forests and land remain in force today, although like other jurisdictions, these systems have become considerably weakened and devitalized (Foster and Poggie 1993). Briefly, a traditional leader, a *Nahnmwarki,* leads each of the five municipalities (*wehi*) comprising Pohnpei Proper—U, Net, Sokehs, Madolenihmw, and Kitti. Sub-chiefs (*Nahnken* and *Soumesenkousapw*) manage smaller divisions of each municipality (known as *Kousapw*) under the guidance of the *Nahnmwarki* (Foster and Poggie 1993). In indigenous Pohnpei, the Nanmwarki held the title to all of the oceanfront and land in his municipality. According to Sudo (1984), this practice died out during the Spanish period when the island adopted the open access model of fisheries management. Nonetheless, the king was not granted any portion of his villagers' catch based on his authority as "titular owner" (Sudo 1984) and all catch was typically divided among the fisher's immediate and extended family. *The persistence of the traditional chiefly system (chiefs and sub-chiefs) for land tenure may be a consequence of Pohnpei's continuing strong cultural emphasis on land ownership and farming as a key source of status and wealth, versus the comparatively lower status attributed to those associated with marine ownership or fishing rights*. Marine products appear to have long had a different, and ostensibly lower, value than farmed items such as pigs, taro, and *sakau* (kava). Indeed, persons that must fish for a living tend to be viewed as of lower status or a somewhat marginalized segment of society, i.e., those that do not possess land—the "poor" of Pohnpei.

Certain aspects of current forest-based rights and tenure systems in Pohnpei proper hint of the existence in the past of some form of marine tenure, but there remains little evidence as to what form that system may have taken. For instance, the *Sou-Madau* (Master of the Ocean) was given oversight of managing all marine resources. The marine-oriented traditional title of *Souset* (master fisher) still exists, but the status of *Souset* has waned considerably with weakening of the traditional authority structures (Foster and Poggie 1993). Indeed, contemporary fishers argue that no *Souset* exist in Pohnpei today. As a master fisher, the *Souset* was endowed with rights to fish over all waters, including the open ocean and outer reef (barrier reef) (B. Ioanis, Pohnpei State Department of Marine Resources, retired, *personal communication, 1998*). For other fishers, unlimited fishing was allowed within their area of the lagoon, without needing to request access from the *Nanmwarki*, but was mostly limited to shallow nearshore waters (Sudo 1984). Interviews with older residents also hint that certain practices in the past may have been customary rules or restrictions, including (i) some traditional village leaders having authority over certain areas where fish spawn; (ii) fishers practicing sustainable or ethical practices, such as releasing portions of undersized catch and reproductive fish during fishing; and (iii) rules that certain species of fish, such as large green bumphead parrotfish (*B. muricatum*), humphead wrasse (*C. undulatus*) or green turtle (*Chelonia mydas*), must be given to the *Nanmwarki* (Sudo 1984; Shimizu 1990). These practices are only loosely followed today. Likewise, inhabitants of Parem Island (Nett Municipality) still have access to places in the

mainland forest for farming, and it is likely that reciprocal marine rights for land-locked families may also have existed at one time.

Part of the ambiguity surrounding CMT for Pohnpei Proper may revolve around the strong current systems of CMT for some outer island communities of Pohnpei, including Pingelap and Mwoakilwoa (Foster and Poggie 1993; Oles 2007). In Mwoakilwoa (Mokil), community leaders have banned nighttime spearfishing (except for two weeks around Christmas). These leaders have also established a turtle sanctuary. All restrictions are strongly enforced. Although strong, outer island CMT does not resemble historical customary practices (Foster and Poggie 1993).

In an effort to re-assert what CMT may have existed in Pohnpei historically, traditional leaders and community members in Enipein (Kitti Municipality) have procured funding and support for local monitoring and management of the Enipein Marine Sanctuary, one of 13 MPAs in Pohnpei. Led by the traditional leader Soulik en Soamwoai, *the locally managed marine area (LMMA) at Enipein stands as an example of local stewardship over marine resources*. Enforcement in the sanctuary is strong, with violations prosecuted at the village level by the village chief. Decisions on punishment come from the community, with recent poachers charged with infringement made to pay fines through the provision of a community feast (Furlich 2010). Violators were also made to issue an apology to the community. This system, though in its infancy in Pohnpei, may serve as a blueprint for other LMMA leaders in the state. *Recent fisher workshops, together with results from 2008 fisher perception surveys, showed strong support for improved management and inclusion of fishers in management decision-making* (K. Rhodes *unpublished data*). Fishers also expressed interest in improved rights-based ownership at the municipal level and away from open access. In Pohnpei, such divisions in marine resources must be made by changes in the state constitution, which is a daunting task. Nonetheless, the apparent success of the Enipein LMMA suggests that, until legally challenged, LMMAs may be managed and enforced at the village or community level.

GUAM

Historically and contemporarily, the Chamorro people of Guam have exploited the inshore reef fish fishery more than deeper, offshore banks (Amesbury *et al.* 1986). Indeed, fishery statistics show that less than 20% of all shallow-water fish species are caught offshore (> 3 nm) (Myers 1993). While commercial pelagic fishing was encouraged by the U.S. after it acquired Guam in 1898, it was not until the 1950s that pelagic species were recorded. During the post-World War II period, a dramatic shift occurred from subsistence to a cash-based economy that coincides with the substantial declines noted in local fish populations (Zeller *et al.* 2007).

Currently, reef fish enter the commercial market from full-time and part-time commercial fishers, or subsistence or recreational fishers who sell a part of their catch (Guam Division of Aquatic and Wildlife Resources, DAWR 2010). As there are few full-time commercial fishers, there is no distinction in the contribution made between subsistence, recreational, or commercial fishers (Zeller *et al.* 2007). A recent survey on Guam revealed 35-45% of households (n=400) are involved in fishing activities, either as experienced fishers or as accompanying members on fishing trips (van Beukering *et al.* 2007). The respondents fished on average once a week for approximately five hours, with a significant 12% increase in effort (days fishing per year) over a 10-year period. While some of this increase was attributed to greater availability of time, many felt they had to spend more time fishing to catch the same number of fish. In a separate study of Guam's pelagic fishers, 81% of respondents perceived trolling was more difficult than in the preceding five years (Rubenstein 2001). While there are no formal statistics published on the total number of full-time, commercial fishers participating in the nearshore fishery, it is believed to be less than five individuals (J. McIlwain *personal observation*).

Fisheries Data Collection

Unlike most Pacific Island nations that rely on official reporting from organizations like FAO, fisheries data on Guam are collected via two programs: (1) the creel survey program and (2) total commercial landings. The first, a dedicated program for estimating catch data, is done via creel surveys conducted by DAWR, through the Guam Department of Agriculture (Fig. A6). That program started in the mid-1960s and continues today. In 1982, with support from the Western Pacific Fishery Information Network (WPacFIN), DAWR modified their collection technique and included expansion methods, allowing for island-wide estimates of total catch. In the same year, the second program was implemented by WPacFin in collaboration with DAWR and several local fish dealers and involved the collation and tabulation of total commercial landings through the voluntary use of trip tickets (DAWR 2010). The Guam Fishermen's Co-operative, the largest and most central distribution point for marketing fresh local fish, has worked with WPacFin in developing a cooperative fishery data collection system providing data that is adjusted using an annual percent coverage factor to create total estimated commercial landings (DAWR 2010). A summary of the commercial landing data is published yearly at www.pifsc.noaa.gov/wpacfin/.

Figure A5. Roadside sale of octopus in Guam. These sales do not appear in official statistics (Photo: J. Cuetos-Bueno)

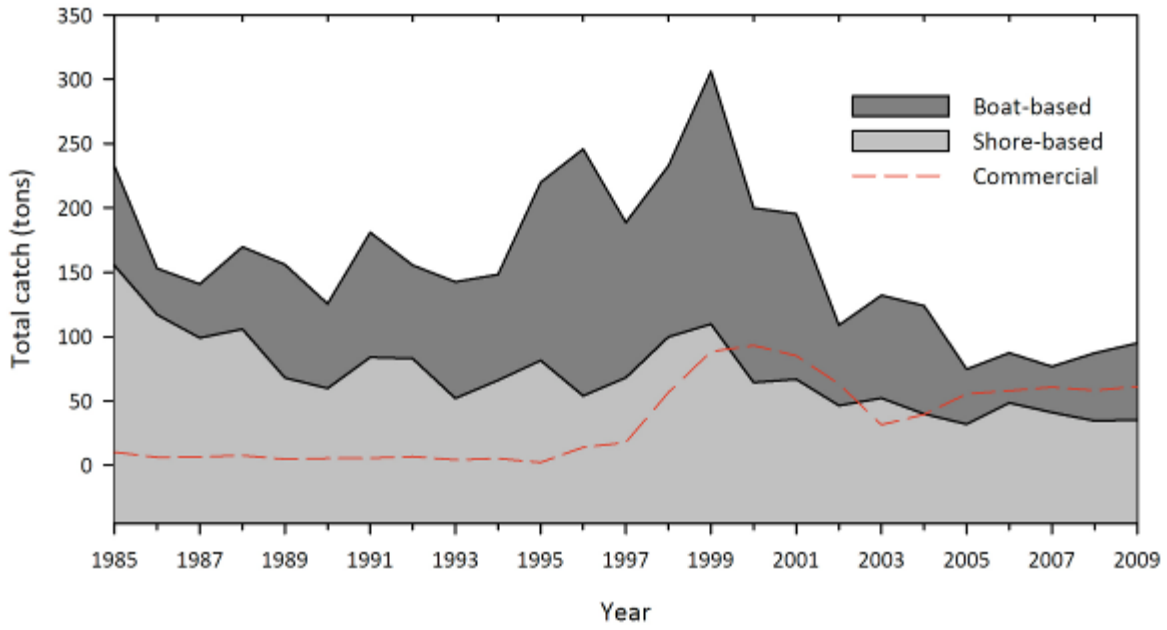


Figure A6. Total landings of reef fish from 1985-2009 collated from the DAWR creel surveys of the boat-based and shore-based fishery (details of how these data were collected and collated are included in the text). The red line is the volume of reef fish sold by commercial vendors participating in the WPacFin program.

Trends in Exploitation

There is considerable uncertainty as to the status of Guam's reef fish fishery. A recent re-estimation of the nearshore, non-pelagic catch suggests Guam has suffered a decline of 86% over a 50-year period to 2002 (Zeller *et al.* 2007). Zeller *et al.* (2007) also found a 2.5 fold discrepancy between the reported catch from the DAWR creel surveys and their own re-estimation. The largest drop in catch was noted between 1950 to the early 1980s, from approximately 1000 mt to less than 200 mt. During this time, DAWR had no data collection program in place. Similarly, Newton *et al*. (2007), using FAO and DAWR statistics, categorized Guam fisheries as collapsed. The level of overexploitation is no doubt related to its high population density, small reef area, and open access systems of management. Continuous declines in fish abundance have been noted in recent years (Wilkinson 2000), although the true magnitude and cause of those declines remain contentious (Burdick *et al.* 2008). For example, the boat-based and shore-based catch from the creel surveys show a decline of more than 70% from 306 mt in 1999 to 94 mt in 2009 (Figs. A6 and A7). In contrast, the decline in the commercial landing data, for the same period, was 35% from 93 t to 61 t. While the total volume of commercial reef fish appears to be stable for the last 8-10 years at approximately 60 t, it is unclear whether these are sustainable without corresponding data on catch effort, information which is currently not made available by WPacFin. The discrepancy in the magnitude of the decline between the creel surveys and commercial data is from the lack of reporting by commercial SCUBA spearfishers. This fishery sector has not participated in the creel surveys since 2006 (Brent Tibbetts, DAWR, *personal communication*, January 2011), yet makes the largest contribution to the total landing of reef fish reported by the Guam Fishermen's Cooperative. Despite the lack of reporting by SCUBA spearfishers, fishery-independent data revealed large grouper, wrasse, and parrotfish common in the fishery in the early 1990s when the CPUE was about 9kg/gear/hr; however, these groups have declined or disappeared from Guam's reefs in recent years (Burdick *et al.* 2008; J. McIlwain *unpublished data*).

For other fishery techniques that harvest reef fish, the patterns are much clearer. Since the start of the surveys in 1985, the CPUE for shore-based hook-and-line and cast netting have declined by more than 50% and 75% respectively (Burdick *et al*. 2008). At the same time, there has been a significant shift in the species composition, with a greater proportion of the catch comprised of faster growing, shorter-lived species that reach size at maturity early. A decline in mean size, a key indicator of overexploitation, has been observed for several large-bodied scarids such as *Chlorurus microrhinos*, *Hipposcarus longiceps,* and *Cetoscarus bicolor* from 1981 to 2009 (McIlwain and Taylor 2009). For other heavily targeted species like *Lethrinus harak*, the greatest spawner biomass is within the network of marine preserves, with some fished sites making little or no contribution to the total reproductive output on Guam (Taylor and McIlwain 2010). While the creel-survey database is an obvious and valuable resource for Guam's fisheries managers, most of the data have never been analyzed for long-term trends, in particular key parameters like biological indicators, due to a lack of qualified staff at DAWR. Nonetheless, it has proved useful to DAWR staff for making management recommendations, particularly at the site level.

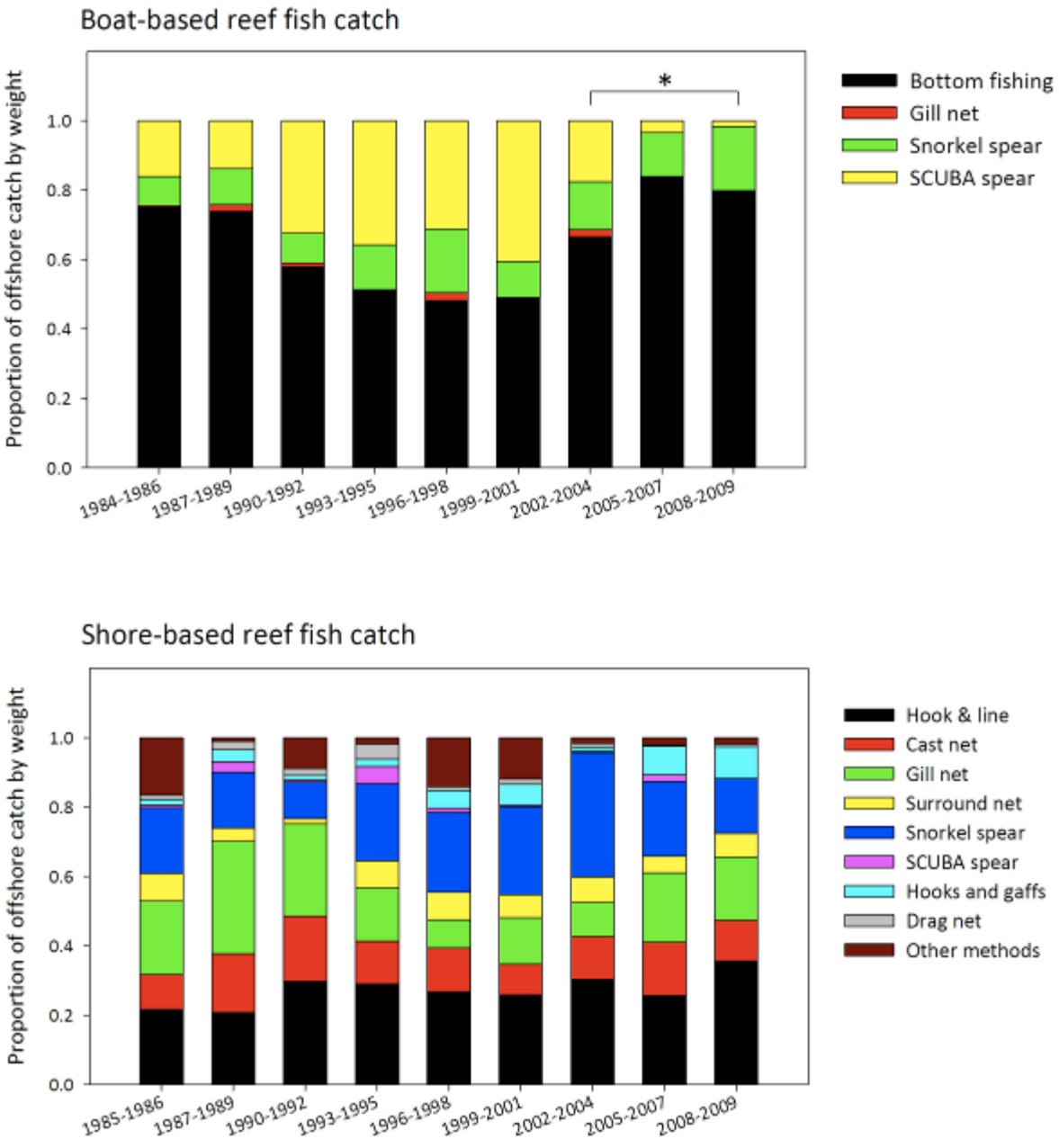


Figure A7. The proportion of reef fish caught in the boat-based (top panel) and shore-based (bottom panel) reef fish fishery sectors according to different fishing technique. * denotes period when SCUBA spearfishers did not participate in creel-surveys.

Reef Fish Market Value

The total commercial landing of reef fish caught around Guam for 2009 was 134,768 lbs (61.1 mt) worth $390,614 (based on average reef fish price of $6.39/kg for the same year; Fig. A6). This fish, sold through the Guam Fishermen's Cooperative and several other vendors, represents only 4% of the $9 million worth of fresh or frozen and preserved fish imported to the island each year (Bureau of Statistics and Planning 2009; DAWR 2010). Another avenue for commercial sales is small roadside or flea market vendors. While some researchers have identified this as a problem in monitoring the sale of local and imported fish (Hensley and Sherwood 1993), it makes up a small fraction (3% and 6% respectively) of the reef fish consumed on Guam (van Beukering *et al.* 2007).

Among fish volumes unaccounted for in official statistics are the undocumented reef fish imported from other Micronesian jurisdictions (Hensley and Sherwood 1993). Similar to other locales, Micronesians living in Guam import or request import of reef fish from home countries. Like other jurisdictions, these fish arrive to Guam usually whole frozen and typically for non-commercial use. No records on fish volumes or country of origin are kept and there are no restrictions on importation (Hensley and Sherwood 1993). It is common for 20-30 coolers (each with a 20-40 l capacity) to be included in checked-in baggage on flights from other Micronesian jurisdictions. Recent increases in baggage fees have not appeared to offset either imports or exports of fish or other meat products. Currently, Pohnpei State's government is considering an export ban on reef fish that may impact imports to Guam. During recent discussions with Continental Airlines management, it was stated that the airline is incapable of banning the practice (A. Day, Continental/United Airlines, *personal communication,* March 2011), thus any restrictions on reef fish imports to Guam must come from regional governments. The conclusion by van Beukering *et al.* (2007) that 32% of fish consumed by survey respondents comes from Guam's reefs conflicts with other available evidence showing that 51% of fish consumed is either a retail or a restaurant purchase. While the country of origin of fish is labeled by some supermarkets, consumers have no way of knowing the origin of fish sold in restaurants. The findings of van Beukering *et al.* (2007) also do not agree with the import statistics and data from the commercial landing, which reveal that only 4% of all fish sold on Guam is local. For the shore-based fisheries, creel survey data suggests only one-quarter and one-third of the total catch is sold, with the remainder kept for personal consumption or given away to family, friends, or to the church (WPRFMC 2009). Disentangling the origins and actual volumes of fish captured and sold on Guam is, therefore, problematic.

Price Fluctuations

Since 1990 the average price of reef fish (unadjusted for the Consumer Price Index, CPI) sold through the Guam's Fishermen's Co-operative has been steady ($5.30/kg and $6.40/kg), with only a slight increase to $6.84/kg in 2010 (Fig. A8). In reality, the inflation-adjusted average price would have declined significantly over the same time period, similar to that of the price of pelagic fish (WPFRMC Annual Report 2008, p. 117). Prices of between $8-10/kg have been reported (DAWR website), but not substantiated. Van Beukering *et al*. (2007) suggest that because this price represents 90% of the market value of reef fish sold, it can be used to calculate the direct (market) value of all reef fish caught (calculated from the creel survey data – see Figure 12). With an average of 109 mt caught per year (since 2001), the direct market value of reef fish would be $577,809. The problem of under-reporting in the creel survey data again becomes apparent, as this figure suggests that nearly 70% of all fish landed on Guam is sold for commercial purposes (*see previous section on Market Value*), which is in contrast to creel survey data that suggests only one-quarter to one-third of the total catch is sold (WPRFMC 2009).

Market Demand, Imports, and Consumption

Although no import volume data is available (only dollar values), previous published statistics show that between 1999-2002 Guam imported between 2,962–3,359 mt of fish (Zeller *et al.* 2007). Consumption rates for the period 1985-2002, which include the total fish imports, plus the reported catches from the commercial non-pelagic landings and creel survey landings converted to per capita, range from 21.7-22.6 kg/yr, which is similar to findings for reef fish consumption in other recent studies (e.g., Warren-Rhodes *et al. unpublished data*).

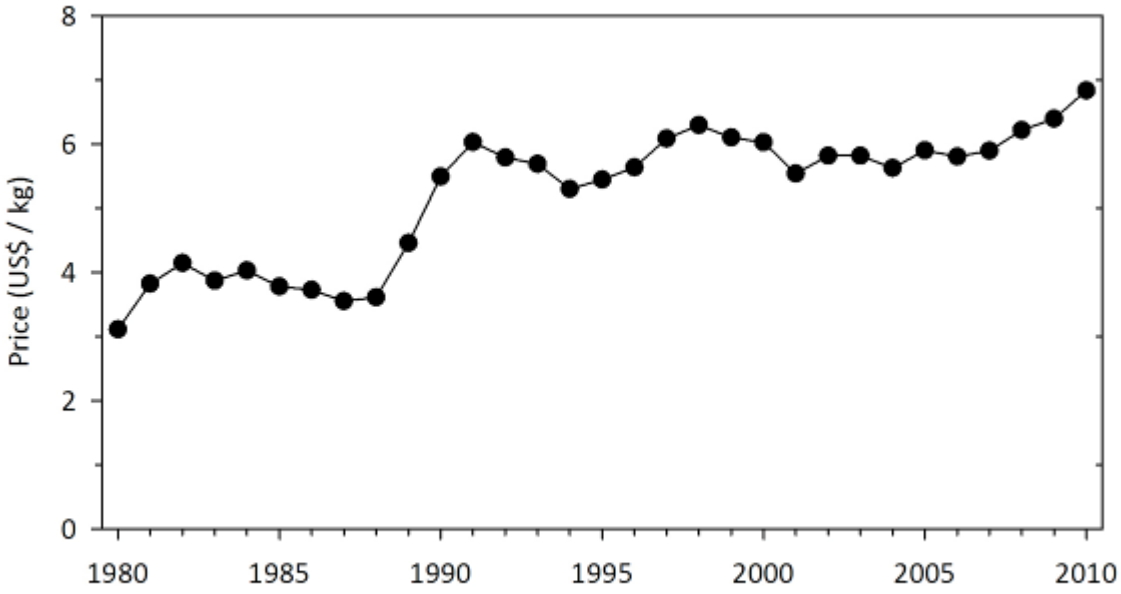


Figure A8. Fluctuations in the average price of whole reef fish sold by the Guam Fishermen's Co-op since 1980. Note these data are not adjusted to include inflation.

The Role of Subsidies

In 2010 nearly 22% (36,926 persons) of Guam's total population participated in the Supplemental Nutrition Assistance Program (SNAP). This is an increase of 13% on the previous year and a 33% increase over the previous five years. The average benefit amounts to $218/mo/individual or $694/month/household (www.fns.usda.gov). Unlike the Micronesian states, Guam's reliance on food stamps has, in fact, relieved pressure on reef fish stocks. When commodity and imported food prices increase (even in the short-term), it has little impact on the fishery as recipients absorb this extra cost by decreasing their total purchases. The reliance on food stamps has also contributed to the decline in fishing activities and the lack of subsistence fishing *per se*.

Fisheries Management

Fishing practices and fishery resources on Guam experienced a significant change during World War II. Japanese forces, which occupied Guam from 1941 to 1944, restricted traditional fishing practices by locals in order to increase production of agriculture and other land-based industries (Amesbury *et al.* 1986). Very few individuals were permitted to fish and those allowed were tasked with supplying fish for consumption by the Japanese military. Toward the end of the war, as U.S. military forces interrupted Japanese supply lines, Guam's reefs became subject to increasingly destructive fishing techniques (e.g., explosives) to meet food requirements. After the war, fisheries fell under the jurisdiction of the agricultural division of the U.S. Military Government. Initially, the island was surveyed for the potential to increase economic fisheries production, but at that time was found to have a paucity of reef fish and a low number of skilled fishers (Smith 1947). Nevertheless, reef fisheries were further developed through the introduction and expansion of modern fishing techniques, including motorboats, monofilament nets and line, high-powered spearguns, and later SCUBA equipment (Hensley and Sherwood 1993).

Today, Guam's fisheries are managed according to the Magnuson-Stevens Fishery Conservation and Management Act, amended in 1996. Management of the fishery is divided between two entities: (1) the Western Pacific Regional Fishery Management Council (WPRFMC), based in Hawaii and responsible for creating management policy for activities from 3 to 200 nautical miles from shore, and (2) DAWR, which manage inshore and nearshore fishing activities (<3 n miles). To augment existing federal laws, local fisheries legislation is proposed and amended by 15 elected legislators (senators).

Fisheries-dependent data, essential for informed decision-making, is collected via creel surveys performed by fisheries biologists from DAWR. The primary objective of surveys is to attain accurate estimates of total fisheries harvest over time (Hensley and Sherwood 1993). Such surveys began as early as the 1960s, but the current format was standardized (adapted from Malvestuto *et al.* 1978) in the early 1980s. These surveys are conducted semi-weekly and stratified by sectors: a boat-based survey at local marinas (offshore) and a shored-based survey (inshore) (Amesbury *et al.* 1991). For each survey, data is collected on targeted species, size, fishing method, type of bait, location, time, reef zone, tide, weather conditions, cloud cover, wave height, and amount of time fishing. Results are presented through the Western Pacific Fishery Information Network (WPacFIN) of the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA-NMFS).

Marine Preserves

Changes in fishing success (catch-per-unit-effort) and reef fish community composition have not improved in recent years (Flores 2006; DAWR *unpublished data*, presented in Burdick *et al.* 2008). In recognition, five marine protected areas were established in 1997 that represent around 11% of the coastline. The primary objectives of these marine preserves are the restoration of fishery resources and the protection, management, and conservation of marine communities and ecosystems (Gombos *et al.* 2007). The five marine preserves include Pati Point (20 km^2), Tumon Bay (4.52 km^2), Piti Bomb Holes (3.63 km^2), Sasa Bay (3.12 km^2), and Achang Reef Flat (4.85 km^2). These preserves span from the northern-most to the southern-most reaches of the island, excluding much of the central east (windward) coast. Full enforcement of preserve regulations, which include limited seasonal harvest of certain species using specific methods, was not initiated until 2001. The marine preserves are supplemented by the War in the Pacific National Historic Park (U.S. National Park Service; including two marine parks in the villages of Asan and Agat: 4.05 km^2) (Amesbury *et al.* 1999), the Navy Ecological Reserve Areas (Department of Defense; including the Haputo and Orote Point Ecological Reserves: 0.83 km^2), and the Ritidian National Wildlife Refuge (Fish and Wildlife Service: 1.50 km^2). Among these additional marine parks, only the Ritidian National Wildlife Refuge has any regulations regarding harvesting of marine life.

Other Management Practices

The five marine preserves represent the most substantial fisheries management regulations. For most species, unlimited harvest is allowed outside of preserves and catches are often sold through various fish markets including the Guam Fisherman's Cooperative. Some exceptions do exist, however, mostly for invertebrate species (Appendix Table A2). For example, enforceable minimum size limits exist for tridacnid clams, *Trochus*, spiny and slipper lobsters, and coconut crabs. Bag limits exist for tridacnid clams, *Trochus*, sea cucumbers and urchins, and coconut crabs. The use of explosives, poisons, or stupifactants to harvest marine life and the capture of endangered species (including sea turtles) is prohibited.

Illegal fishing

Data compiled by the DAWR indicates that a total of 293 arrests were made for illegal fishing in preserves between 2001 and 2007 (DAWR 2008 *in* King 2008). These data suggest poaching is quite common and is probably having a significant effect on the protected fish communities. Of those arrested, Micronesian immigrants represented a disproportionately high number of the total. King (2008) extensively reviewed these data in the context of public awareness of marine preserves and their regulations. Because Micronesian societies are traditionally based on land rights and governed by chiefs, environmental stewardship is a by-product of such collective societies where personal gain is a low priority (King 2008). On Guam, where personal gain is a high priority in a free-market, centralized economy, equal rights laws and the lack of ownership of marine resources are new concepts to Micronesian immigrants. Alternatively, these individuals may be used to the lax enforcement in home countries.

Traditional Marine Management

Knowledge of the Chamorro's reliance on marine resources prior to the European conquest of 1695 (a period known as the Latte Phase) is taken from archeological data and stable isotope and food residue studies (Amesbury and Hunter-Anderson 2003). These data suggest early settlements were a maritime subsistence-based society, which shifted to a land-based economy with mixed farming and fishing activities. After Spanish colonization, there was a change in the use of marine resources as key activities like pelagic fishing were halted when oceangoing canoes and the canoe houses were destroyed. The introduction of the post-conquest subsistence system saw the development of small farms and orchards near villages. With no pelagic fishing and a lack of interest in sea turtles, the primary source of marine protein came from reef fish and gleaning for inshore invertebrates (Amesbury and Hunter-Anderson 2003). Like the CNMI, there are no written accounts of a traditional management system for Guam either before or after European arrival.

As there are currently no rules that explicitly govern permanent ownership of marine resources, the inshore reefs of Guam are essentially open access (Vaughn 1999). Local Chamorro fishermen, however, particularly those who maintain a strong identity with their village, observe a system described by Vaughn (1999) as "pliant tenure." This means that in places that are publicly accessible, fishermen utilizing the same space undergo informal negotiations in order to regulate the "social distance" between them. Fishing patterns of fishermen on Guam vary considerable from highly dispersed to only those reefs within a municipality. For Chamorros, fishing tends to take place in the municipalities where they were either born or are currently living or both (Vaughn 1999).

Alternative Livelihoods and Economic Incentives

Tourism

Tourism lies at the heart of Guam's economy. Over the past two decades, the island has averaged over a million visitors per year, a number that has remained relatively stable since the mid-1990s (Fig. A9). In 2005, the total economic value of tourism was estimated to be $429.3 million, with $222.4 million representing wages and salaries for 10,737 tourism sector employees. Nearly one in four workers in Guam are employed by the tourism sector. Total island tax revenue from tourism in 2010 was $148.9 million.

In the last two decades, recreational SCUBA diving has become a very popular sport for tourists visiting Guam. The number of dive certifications has increased steadily since 1982 with over 10,000 divers certified per year (van Beukering *et al.* 2007). Of these, 88% are from Japan and 9% are local (mostly military personnel). Approximately 300,000 dives are made each year, yielding a total annual economic value of more than $5 million (van Beukering *et al.* 2007). The number of SCUBA divers and snorkelers is set to increase with the impending military buildup (Burdick *et al.* 2008).

According to a 2010 study, tourism is regarded as important amongst Guam residents. However, the vast majority of residents (88%) feel that the community needs to be more involved in the tourism sector, stating that outsiders profit the most from it. Further, 79% of respondents feel detached or secluded from the tourism industry and 85% feel there should be more government efforts to boost tourism. Clearly, there is a general sentiment among residents that tourism is not providing the benefits it should, irrespective of the tremendous employment, tax, and gross revenue coming from the tourist industry.

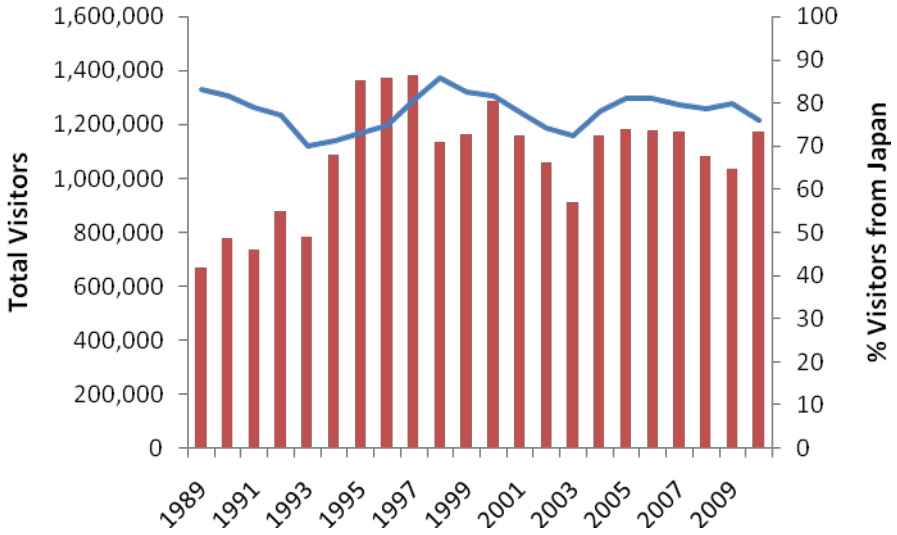


Figure A9. Total number of visitors to Guam (vertical bars) over a 21-year period and the percent originating from Japan (blue line).

Business Incentives

The Guam Economic Development and Commerce Authority offers significant business incentives to local investors that generate new employment, build new facilities, and decrease imports and consumer prices. These include issuing Qualifying Certificates (QCs) that give firms a 75% rebate on corporate tax for up to 20 years. Trade incentives are provided on products manufactured on Guam that include reduced tariff rates to Japan, Australia, and countries of the European Common Market. To participate, manufacturers must both transform the original material(s) and add value that incorporates at least 50% of the total production costs (Guam Pacific Daily News 2007).

Aquaculture

Guam, like other Micronesian jurisdictions, has a checkered past in developing a sustainable, long-term aquaculture industry dating back to the early 1970s. Since then, numerous organisms have been trialed in the hope of commercial success, including (but not limited to) edible seaweed *Gracilaria edulis*, freshwater eel (*Anguilla japonicus*), milkfish (*Chanos chanos*), and the Pacific oyster (*Crassostrea gigas*). Most trials were unsuccessful, with reported problems ranging from disease to the limited availability of fry and small local market. The tilapia (*Oreochromis mossambicus*), first introduced from Taiwan in 1972, is the primary species grown by local farms. In 2007, 162 mt of tilapia was grown, valued at $1.4 million. The second biggest product is the marine shrimp *Penaeus monodon*, although total production for this species is currently unknown due to a lack of reporting (Secretariat of the Pacific Community 2011).

While some remain optimistic about the expansion of the aquaculture industry on Guam, there are considerable impediments to the development of large-scale production. The expanding population and the concomitant increase in demand for fresh seafood, which cannot be met from Guam's reef or the pelagic fishery, means there is a large domestic market that includes the substantial hotel and restaurant industries. Other key points include the availability of transport services to Asian markets to support export and the accessibility of local broodstock reared at the UOG Guam Aquaculture Development and Training Center. The constraints on any expansion are considerable and include limited land area, with the southeast sector the only place with a suitable soil type and terrain for pond aquaculture (Nelson 1990). This is now confounded by competition for land use, a direct result of the rapidly expanding population driven by the military relocation. There is also no economic incentive for private companies to invest in aquaculture and few Federal programs to assist with start-up funds or the expansion of existing facilities (Brown 2009).

COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI)

Extensive commercial fisheries are developed in the southern CNMI islands (Saipan, Tinian, Rota, and Anguijan); however, most fishing activity is centered around Saipan (62,392 inhabitants), the capital of the CNMI. Saipan-based boats also frequent the coastal waters of Tinian (population 3,540), Aguijan (uninhabited), and, less often, Rota (population 3,283). In the CNMI, reef fish are mainly harvested through nighttime spearfishing (>80%), followed in rank by hook-and-line (Houk *et al.* 2011). Both gillnets and SCUBA spearfishing are illegal; however, current legislation aims to release the ban on gillnets. In Saipan, several professional, locally-owned fishing operations supply markets in Saipan. These operations each consist mainly of 3-4 full-time, low-paid, non-resident workers that have catch-based incentives as part of their salary. A few of the fishing operations are market-owned, while other fishing operations remain independent. Most professional operations will travel as far as Rota (70-120 km), but typically fish in Saipan, Aguijan, or Tinian. The remaining contributions of marketed landings come from "semi-subsistence" CNMI fishermen that sell a portion of their catch to generate additional income. These operations are usually land-based (i.e., no boat used) and typically operate at night. In culmination, more

than 50 professional are estimated to work for formal businesses, while the number of independent and semi-subsistence fishers remains unknown. In Tinian and Rota, fish markets are absent. On those islands, fish are occasionally sold through local stores or door-to-door by fishers themselves.

In contrast, the remote uninhabited northern islands are less frequently fished due to their long distances from Saipan and persistent rough weather associated with the strong northeast tradewinds. During calm periods, the nearest of the northern islands, Farallon de Medenilla, is occasionally frequented when U.S. military air-to-surface bombing activities are not ongoing. The local fisheries management agency (Division of Fish and Wildlife) is tasked with keeping records of fishing activity and catch composition from boats that fish in these remote waters; however, despite a formal request, no information was provided to the authors at the time of this reporting. Finally, anecdotal evidence suggests that illegal foreign vessels infrequently visit the most remote northern islands (Schroeder *et al.* 2006), although confirmed sightings have been rare.

State of the Reef Fishery

The amount of reef fish sold in Saipan-based markets in 2009 was estimated at 55 mt, with a total market value of almost half a million dollars (Houk *et al.* 2011). Subsistence catch could be up to 4-5 times the commercial volume, with over 16% of households actively fishing (estimates based on a re-analysis of van Beukering *et al.* 2006). Fisher surveys suggest that less than 5% of subsistence catch enters markets.

In comparison to other Micronesian jurisdictions, evidence for unsustainable harvesting of reef fish is most prevalent in the inhabited southern islands of the CNMI (Houk *et al. In press*). This contrasts with reports by Newton *et al*. (2007) who, using FAO statistics and combining statistics with the remote, lightly fished northern islands, suggested that CNMI resources were underexploited. However, a recent analysis of Saipan fish markets showed clear evidence that fish populations around Saipan, Tinian, and Rota have been affected by fishing pressure (Houk *et al. In press*). In that study, an examination of targeted fish sizes, species, and trophic levels indicate high fishery pressure (e.g., Jennings *et al.* 1999; Dulvy and Polunin 2004; Graham *et al.* 2005) and substantially reduced abundances in comparison to other Micronesian jurisdictions. In the southern CNMI, unsustainable fishing trends correspond with human population and population density increases that have occurred over the past several decades. Until the early 1900s only a few thousand people resided in CNMI, while the current population is around 70,000 inhabitants (U.S. Census Bureau 2000). In Saipan, densities are among the highest in Micronesia (518 persons km^2 all; 826 person km^2 coastline). As population and tourism grew, fish demand and fishery pressure increased without a parallel management response, similar to other parts of Micronesia.

Today, CNMI and Palau are the only locales in Micronesia where the use of SCUBA is illegal, while the banning of gillnets is exclusive to CNMI. No limits exist on the quantity or size of fish harvested in CNMI (Appendix Table A2). Nonetheless, illegal SCUBA fishing was corroborated as the main vector that delivered fish to commercial markets in 2009 (Houk *et al. In press*). The resultant high fishery pressure and effort is readily evident through size, composition, and catch rates comparisons of preferred target species (southern islands and Saipan) (Graham 1994b; Starmer *et al.* 2005; Williams *et al*. 2010; Houk *et al. In press*) (Fig. A10). Further, juveniles contributed disproportionally to the catch of most targeted species (i.e., size-at-capture significantly below reproductive maturity, or L_{50} estimates) (Fig. A12). Today, the remote northern islands have four times the reef fish biomass and a significantly higher density of larger, predatory fish than the populated southern islands (Williams *et al.* 2010; PIFSC 2010). Similarly, fisher interviews suggest that catch-per-unit-effort (CPUE) from spearfishing may be several times of that of the southern islands (J. Cuetos-Bueno *unpublished data*).

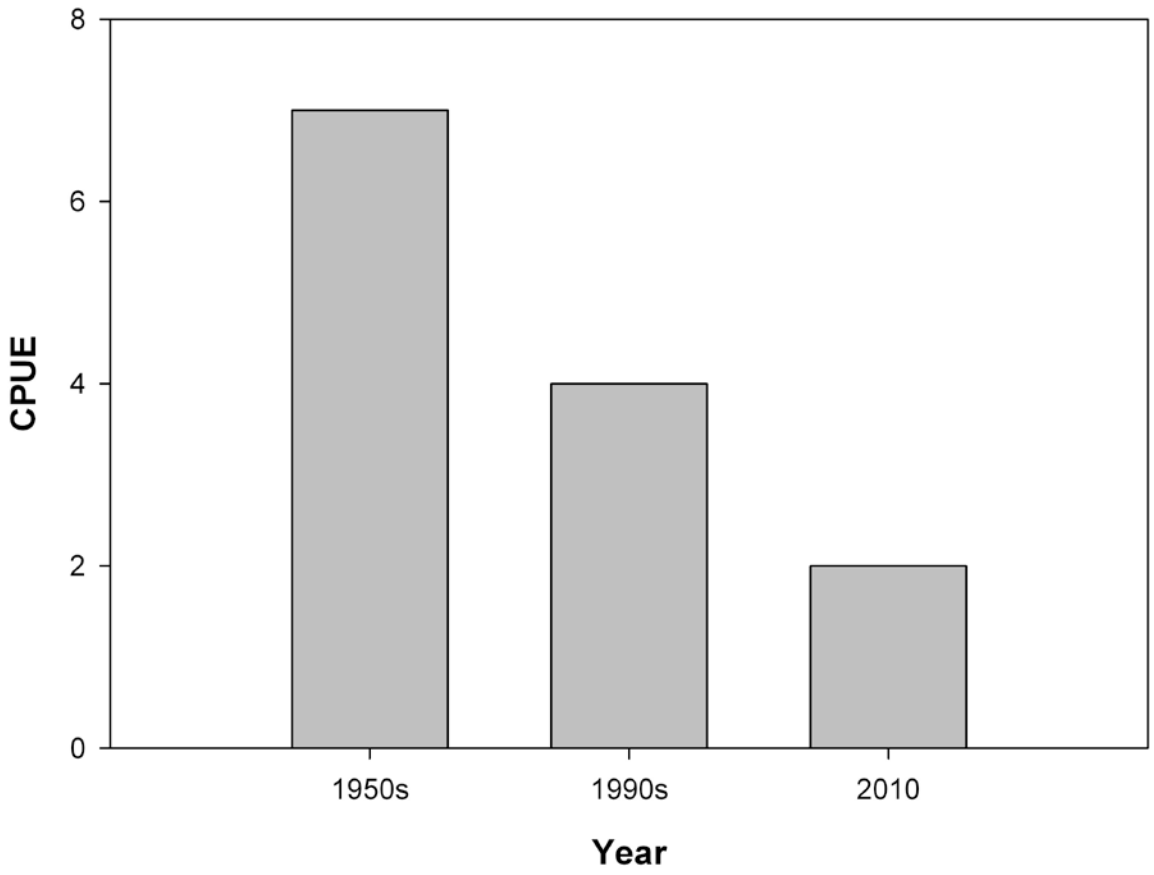


Figure A10. Changes in catch-per-unit-effort (CPUE) between the 1950s and 2010 in Saipan. (Source data: Graham 1994b; van Beukering *et al.* 2006; J. Cuetos-Bueno, in preparation)

Among the southern islands, fishing pressure is highest on Saipan's leeward reefs. As early as the 1950s, Smith (1947) reported signs of overexploitation in Saipan lagoon. In subsequent decades (1979-1996), Duenas and Associates (1997) found strong evidence of reductions through time in most fish groups, with the greatest apparent impacts to lower trophic level fishes. The only fish family increasing in catch was ponyfishes (Leiognathidae). The Division of Fish and Wildlife (DFW) conducted a series of catch-based surveys that suggested smaller fish sizes and lower CPUE on more accessible reefs around Saipan than Tinian (Graham 1994b).

More recently in Laolao Bay, Saipan, Houk *et al. (In press)* found up to 15% declines in abundances and functional redundancy of targeted reef fish assemblages that, in conjunction with land-based pollution, were suggested as drivers of declining coral condition over the past two decades (**Fig. A13**). Fish assemblage data from Tinian and Rota, while limited, suggests moderate levels of fish depletion, especially on leeward reefs (Graham 1994b).

Figure A11. A variety of parrotfish species at a Saipan Reef fish market (Photo: J. Ouan)

Reef fish populations near the main population center of Tinian have suffered from considerable fishing pressure, with low abundances of many targeted fish families (Trianni 1999). The recent analysis of Saipan fish markets showed clear evidence that fish populations around Saipan, Tinian, and Rota have been affected by fishing pressure (Houk *et al. In press*), with sizes, species, and trophic levels of targeted species indicating of high fishery pressure and reduced abundances compared to other Micronesian locales (Jennings *et al.* 1999; Dulvy and Polunin 2004; Graham *et al.* 2005).

Evidence for Longer Term Trends

The CNMI Division of Fish and Wildlife (DFW), in collaboration with Western Pacific Fisheries Management Council program (WPacFIN), has been collecting and reporting commercial catch data in the CNMI since the early 1980s. The catch data is collected through a voluntary receipt reporting system, and exists online through the WPacFIN website (*www.pifsc.noaa.gov/wpacfin*). Several attempts have been made to estimate total (including non-commercial) annual reef fish landings in CNMI using these datasets (Dalzell 1993; Radtke and Davis 1995; Zeller *et al.* 2007). Ultimately, the dependence upon a voluntary, receipt-based data collection system may limit their representativeness and accuracy. In support, several studies have suggested that the data collection methods may have introduced influential deficiencies that have led to underestimating the actual catch (Graham 1994b; Radtke and Davis 1995; Houk et al. *In press*).

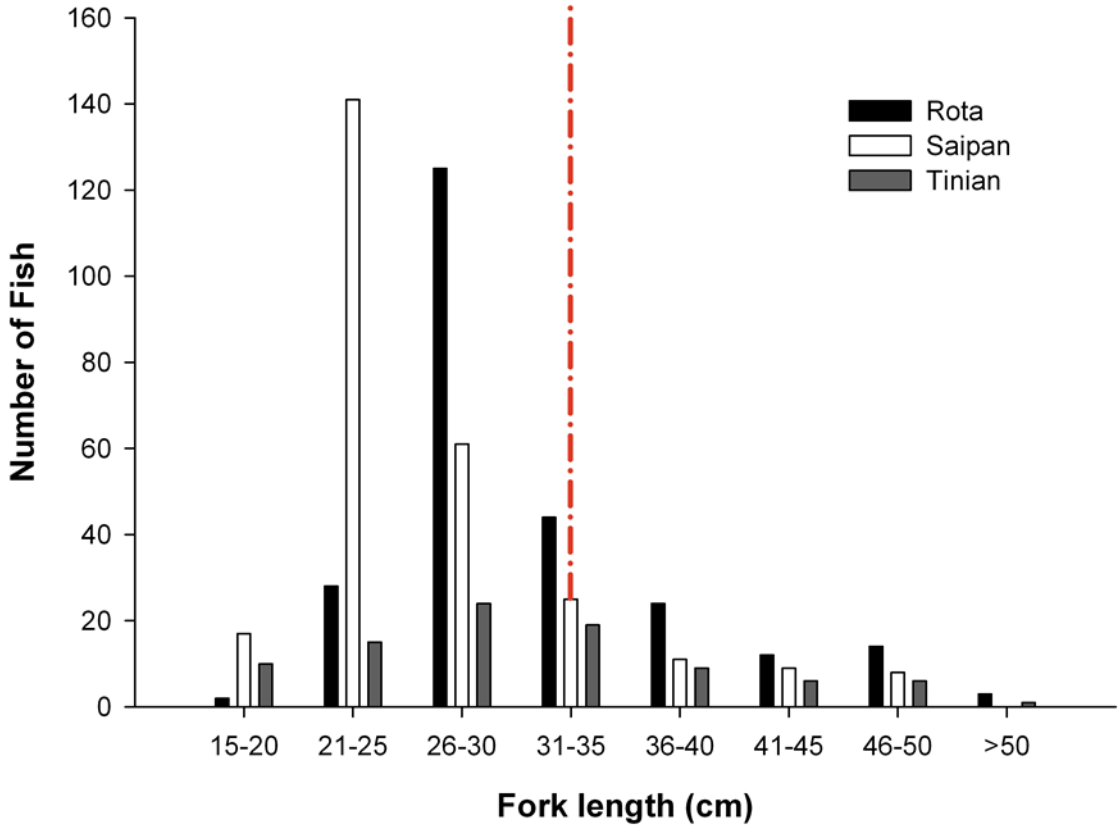


Figure A12. A size comparison of catch of bluespine unicornfish among southern CNMI islands. The red dashed line represents the 50% size of maturity, with the catch mean reflecting an over-reliance on juveniles in catch or, alternatively, a lack of adults in populations.

A general summary is presented. Zeller *et al.* (2007) suggested that total reef catches in CNMI had declined by about 54% between 1950 and 2002 (500 mt in 1950s to about 150 mt in 2004). However, a re-analysis of household and fisher surveys by the present authors indicated that subsistence reef catch is probably several times higher than that of the commercial sector (Cuetos-Bueno *in preparation*). In light of this (best available) evidence, total catch volumes through time may have remained substantially more stable than reported; however, catch effort trends have not. Using historical and recent estimates of spearfishing CPUE, the catch volume of reef fish around the southern islands has declined by nearly 80% over the last 60 years, with a 4-fold decrease in CPUE (Smith 1947; Graham 1994b; Cuetos-Bueno *in preparation*). This decrease is even more striking when considering the recent changes in technology that have improved catch efficiency, and confirms suggestions of unsustainable fishing in the southern islands.

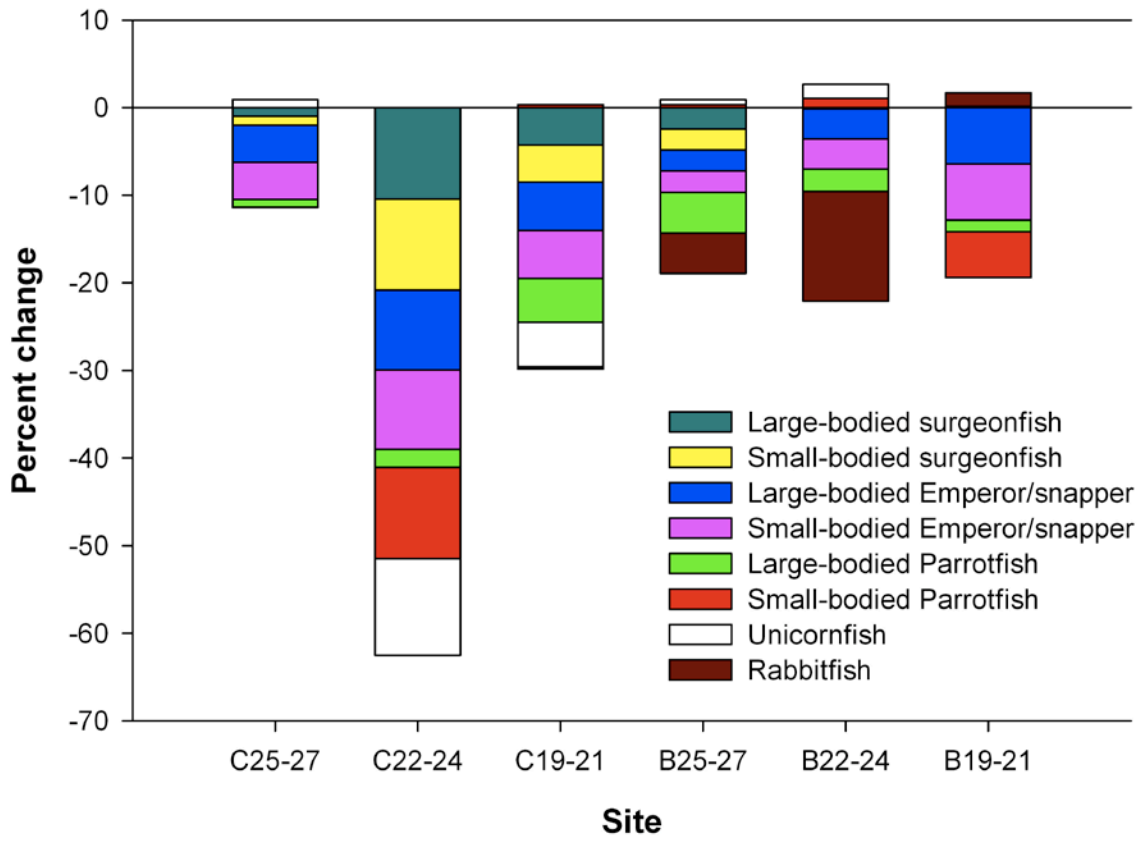


Figure A13. The percent change in fish density in Laolao Bay (Saipan) for major target species between 1991 and 2010, showing a major decline.

Fisher Perception

Several fisher perception studies have been carried out in the CNMI. All surveys provide strong support for the negative trends reported herein (Figs. 16 and 17), with some 80% of respondents noting declines in size and abundance of target species (van Beukering *et al.* 2006; Cuetos-Bueno *in preparation*). Fishers from all surveys agree that increased fishing pressure is the primary cause in fish declines and that there is a greater need for management and fisher participation in management decision-making. The summary graphic below (Fig. A14) depicts catch success through time in the Marianas (Guam and Saipan), highlighting reduced catch success despite improved technology (Journal of Micronesian Fishing, Spring 2011, p.14).

Traditional Marine Management

No contemporary form of traditional management for marine resources exists today in the CNMI. Based on interviews, the Carolinians, who settled CNMI in the 1800s, may have brought traditional forms of resource management. While many Carolinian and Chammoro people interviewed discuss several specific forms of traditional management, no formal written records exist to our knowledge, and the influence of Western colonization has dominated in the past century. Today, all marine areas in CNMI are subject to open access, and gear-and-area-based restrictions are enforced mainly through top-down approaches by the local Division of Fish and Wildlife.

Fisheries Management

Fisheries in the CNMI and Guam are managed through the Magnuson-Stevens Fishery Conservation and Management Act in conjunction with local government policies. Currently, all offshore and most deepwater bottom fisheries fall under federal mandate, while the coastal waters (0 to 3 nm) were expected to reside under local control. However, there is an ongoing legal controversy surrounding federal versus local control and enforcement of coastal waters, with the local government attempting to gain greater control. Aside from the fishing regulations included in Appendix Table A2, CNMI has a number of marine protected areas in the southern islands (Managaha Marine Conservation Area (2000), Kagman Wildlife Conservation Area (1998), Bird Island Marine Sanctuary (2001) and Forbidden Island Marine Sanctuary (2001), Saipan, Tinian Marine Reserve (2007), Sasanhaya Fish Reserve, Rota (1994)) and Northern Islands (Marianas Trench Marine Monument (2009), Uracas, Asuncion and Maug Islands). While unsustainable fishing practices have resulted in several forms of local depletion as noted above, visual evidence and unpublished data suggest increasing stocks in some of marine sanctuaries, in particular those that are least accessible and highly visible. Similarly, unpublished data reports improved fish stocks in the Saipan lagoon as a result of the ban on gill-net fishing that was unfortunately lifted this year.

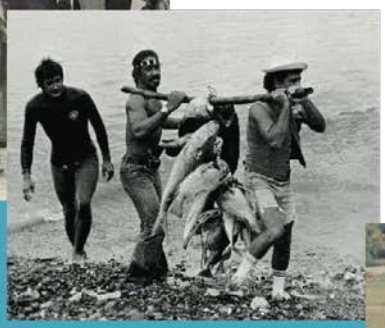
Reef Fish Consumption and Demand

The dependence on reef fish for subsistence has decreased 90-98% since the 1950s (J. Cuetos-Bueno *in preparation*). Concomitantly, population has increased dramatically, with a 400% increase between the 1980s and 1990s. In the early 2000s, CNMI had a surge in the importation of fresh reef fish, with import volumes climbing from 0.5-23 mt/yr (DFW *unpublished data*; Starmer *et al.* 2005; Continental Airlines spokesperson, CNMI, *personal communication,* April 2011). However, recent increases in cargo costs, as well as enhanced administrative requirements associated with security measures, caused a decline. Current imports are now estimated to be around 14 mt $4.40 /kg, with a supermarket retail price of $7.70 /kg, lower than that of local reef fish ($8.80/kg/yr, 9 mt of which is made up of frozen parrotfish from the Philippines to supply tourist resorts (6 mt) and local supermarkets (3 mt). The remaining 5 mt of estimated fish imports come from Palau and supply two fish markets on an intermittent basis (J. Cuetos-Bueno *unpublished data*). Imports for personal consumption have not been evaluated.

Since 1962 nutritional programs have provided food subsidies to families in need. These programs, together with the market economy, have reduced the overall dependence upon local seafood for subsistence, while increasing the purchasing power of individuals. Access to food coupons resulted in a general decrease in local food production, with only 20% of households involved in subsistence fishing by the mid-1980s (Denman and Dewey 2002). This reduction in local fish consumption has been accompanied by an increase in the purchase of imported goods from $117/person/yr in the early 1970s to $1,270/person/yr in the late 1990s (Denman and Dewey 2002; CNMI Statistical Yearbook 2000), with an overall import of over 1000 mt/yr of imported seafood in 2009 (Saipan Seaport Authority).

1940s

Day catch of a military personnel and Okinawan fishermen from 1946-1947. Catch was from the shallow Saipan lagoon using boots, goggles, and a pole spear with no rubber. Photo provided from the Brand Collection, courtesy of the NMI Council for the Humanities.



1970s

Day spearfishing catch from an experienced fisherman who participated in one of the first competitions that was held in Guam's southern embayments. Photo courtesy of the TTPI archives, University of Hawaii.

1990s

Luis Cepeda, an experienced day fisherman from Tinian, shows his catch from the south-west side of Tinian in the mid 1990s.

Evolution of Your Catch

2000s

A team of experienced day spearfishermen, with a boat and operator, show their catch from Saipan's western coastline.

Throughout Micronesia, when many interviewed fishermen reflect upon the past, they tell stories of having better catches, not having to travel as far to harvest what they need, and not having the more efficient technology that is available today. Reduced stocks not only hurt our economy and food supply, but they also threaten the integrity of the oceans that are intertwined with Micronesian livelihoods. Take a moment to talk with your elders, and spread the knowledge you gain to improve the future.

Figure A14. Evolution of catch from the annual CNMI fishing tournament (Journal of Micronesian Fishing, Spring 2011, p.14).

Fish Prices

As reef fish stocks declined over the years, demand and purchasing power grew. Eventually, less available reef fish became higher valued than both pelagic fish and other imported goods. During the early 1980s average reef fish prices steadily increased. However, between the mid-1980s and 1990s prices remained relatively stagnant and then steadily increased again to current levels (Graham 1994b). Today, fresh reef fish sells for \$8.80 kg^{-1}, several times higher than that of pelagics (\$3.30-\$5.50 kg^{-1}), frozen imported fish (e.g., tilapia: \$3.20 kg^{-1}), or other protein sources (e.g., chicken drumsticks: \$3.70 kg^{-1}). This price discrepancy may be responsible for the reduced demand for fresh fish and the greater demand for cheaper imports that currently exists.

Figure A15. A roadside fish market in Saipan. (Photo: J. Cuetos-Bueno, 2011)

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