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A 10-year comparison of the Pohnpei, Micronesia, commercial inshore fishery reveals an increasingly unsustainable fishery

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ABSTRACT

In Pohnpei, Micronesia, a 10-year (2006–2015) follow-up market survey was conducted to provide the basis for a comparative assessment of the status of the commercial inshore fishery, to inform management and to identify the most relevant management options. Within this timeframe, marketed coral reef fish volumes declined by 50 mt (*ca.* 20%), the use of unsustainable fishing methods (nighttime spearfishing and small-mesh gillnets) increased from 75.5% to 81.9%, and catch-per-unit-effort decreased from 3.4 ± 0.1 to 3.2 ± 0.4 kg h^{-1} $fisher^{1}$. Simultaneously, the economic return as price per unit effort was nearly halved for all gear types. Trip volumes increased, however, this was paralleled by a rise in the average number of fishers per trip, particularly for nighttime spearfishing. Effort shifted from inner to outer reef areas and further away from high fisher density communities. At the family level, increases in the percentage of lower tropic level catch were observed, with herbivores and planktivores increasing in frequency in catch more than other trophic level fishes. The only weight increase among top carnivores was for epinephelids, however this was accompanied by a greater contribution by juveniles for the most commonly targeted grouper, Camouflage grouper, *Epinephelus polyphekadion*. Among fish families, eight epinephelids were absent in catch in 2015 compared to 2006, with additional species observed in speared catch in 2015 that were absent in 2006. To reverse continuing declines and prevent the potential for fisheries collapse, government needs to institute rights-based management, ban the use of nighttime spearfishing and small-mesh gillnets, and improve existing enforcement within marine protected areas and markets.

1. Introduction

Coastal communities in developing Pacific Island countries and territories (PICTs) are highly dependent on inshore coral reef resources for food and income (Bell et al., 2009), however rarely are they properly managed, in part due to a lack of information on their status and trends. In many PICT fisheries, anecdotal reports of declines in catch volumes and mean species size and abundance are common, and there are a number of documented accounts to support widespread changes to inshore fish resources (*e.g.*, Hensley and Sherwood, 1993; Friedlander and DeMartini, 2002). Throughout the central and western Pacific coral reef communities are becoming increasingly devoid of once-common fish species important to ecosystem maintenance, *e.g.*, Green humphead parrotfish (*Bolbometopon muricatum*) and iconic species that contribute to local economies through eco-tourism, *e.g.*, Humphead wrasse (*Cheilinus undulatus*) (*e.g.*, Hensley and Sherwood, 1993; Dalzell et al., 1996; Houk et al., 2012). Perhaps more troubling is the demise throughout the region of fish spawning aggregations for some of the main target species of coastal commercial fisheries (*e.g.*, Rhodes et al., 2014a). The causes for these impacts are typically broad and often interconnected, and include natural, economic and anthropogenic effects, such as under-valued target species (*e.g.*, Rhodes et al., 2011a), human population increase, common (open) access or proximity to fishing grounds (*e.g.*, Kaunda-Arara et al., 2003), fishing (Jennings and Polunin, 1997; DeMartini et al., 2008), commercialization (*e.g.*, Brewer et al., 2009), sedimentation from terrestrial activities (*e.g.*, Edinger et al., 1998; Victor et al., 2006), destruction of nursery habits (*e.g.*, nearshore corals, seagrass beds and mangroves) (*e.g.*, Hamilton et al., 2017), targeting of spawning aggregations (*e.g.*, Sadovy de Mitcheson et al., 2008; Rhodes et al., 2011b) and extreme weather

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events and climate change (Knowlton and Jackson, 2008).

In the Federated States of Micronesia (FSM), there is increasing evidence that these various impacts are having dire effects on coral reef fisheries (*e.g.*, Rhodes and Tupper, 2007; Rhodes et al., 2008, 2011b; Houk et al., 2012; Bejarano et al., 2013; Rhodes et al., 2014b; McLean et al., 2016), with a potential concomitant loss to fisheries income and longevity. Specifically, Houk et al. (2012) (for all of Micronesia) and Rhodes and Tupper (2007) and Bejarano et al. (2013) (for Pohnpei) reported the harvest of a number of species below the size-at-sexual maturity, with a diminution of many top carnivores and a reliance on unsustainable nighttime spearfishing. McLean et al. (2016) (in Kosrae) identified shifting baselines in the fishery with a greater reliance on lower trophic level species and a paucity of top carnivores among catch that were reportedly reducing coral reef resilience and reef decline. In Pohnpei, Rhodes et al. (2014b) used socio-economic and market data to show that Pohnpei's inshore fishery is well above biocapcity (*i.e.* consumption is outstripping production), while Rhodes et al. (2014a) show year-over-year declines in spawning aggregations of some of the most important target species. Thus, there are clear indications throughout much of the FSM of a troubling trend in fisheries that will undoubtedly impact future socio-economic and food security.

In Pohnpei, a 2006–2007 (2006, hereafter) market-based inshore commercial fishery survey identified more than 153 species among 15 fish families that contributed to the fishery, with nighttime spearfishing overshadowing all other fishing methods (71.3% of the total) (Rhodes et al., 2008). Acanthurids (surgeonfish and unicornfish) comprised more than a quarter of total catch volume with Epinephelids (groupers, hinds and lyretails) and Scarids (parrotfishes) each contributing an additional 15% of caught volumes. Substantial variations were observed in species composition among speared, lined and netted fish. Ten species that included Bluespine unicornfish (*Naso unicornis*), Orangespine unicornfish (*Naso lituratus*), Paddletail snapper (*Lutjanus gibbus*) and Pacific steephead parrotfish (*Hipposcarus longiceps*) were common to two or more gear types, while nearly 2/3 of species were represented by only a few individuals over the 12-month survey. Overall catch-per-unit-effort varied across gears, with gillnets yielding the highest volumes ($3.9\,kg\,h^{-1}\,fisher^{-1}$), followed by nighttime spearfishing ($3.6\,kg\,h^{-1}\,fisher^{-1}$) and line ($2.6\,kg\,h^{-1}\,fisher^{-1}$). For combined gears, juveniles and small adults dominated catch. The 2006 survey also focused on epinephelids, which showed juveniles comprising between 34 and 100% of the catch by species, including nearly 50% of the most commercially targeted species, Camouflage grouper, *Epinephelus polyphekadion* (Rhodes and Tupper, 2007).

The objectives of the current study were (1) to procure additional data from the Pohnpei, Micronesia, inshore commercial fishery and compare it to 2006 data in order to (2) examine possible changes within fished populations and the fishery over a 10-year timeframe and (3) provide recommendations to the Pohnpei State Government for management decision-making. Pohnpei State, as with many other PICTs, has no comprehensive fisheries management plan and has not responded to evidence showing long-term declines over at least a 20-year timeframe. Existing management in the state is piecemeal and outdated, while enforcement efforts are relatively poor and conducted in lieu of a strategic plan, which is directly contributing to fisheries decline. Finally, there has been anecdotal evidence of further decline in the fishery since the 2006 surveys were conducted, with markets and restaurants now struggling to find fish, along with observed shifts to even smaller individuals within target species.

2. Methods

The 2006 and 2015–2016 (2015, hereafter) market surveys were conducted in Pohnpei, Micronesia (07°00′N, 158°15′E) to examine coral reef and nearshore pelagic fish markets around the island (Fig. 1). Pohnpei is one of 8 islands and atolls within the state and is the only high island (791 m), with a population of around 33,000 inhabitants

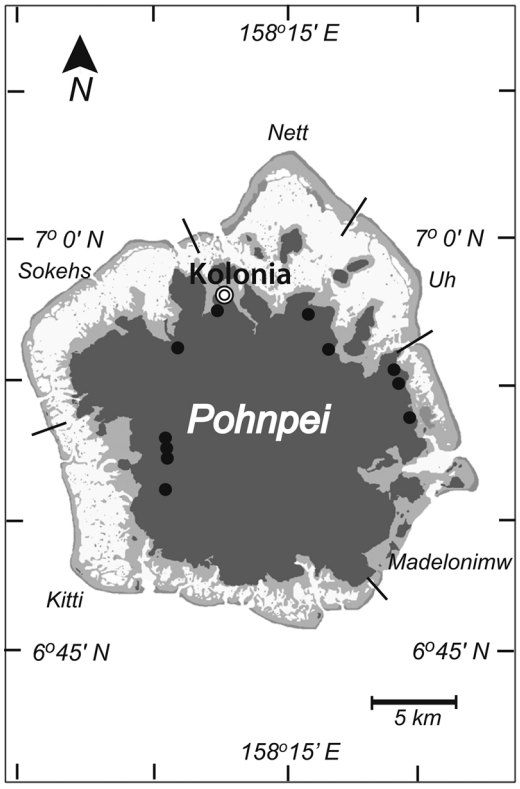

Fig. 1. Map of Pohnpei, Micronesia. The population center of Kolonia (open circle) is where approximately one-half of markets occur, whereas minor and outlying markets (closed circle) are dispersed among each of Pohnpei's five municipalities (italicized text).

living on the main island. The local economy is varied, with about 1/3rd of the workforce employed by government and another 1/3rd living through subsistence. The number of commercial fishers on-island as well as the number and kinds of boats contributing to the fishery is still unknown. Fully 27% of Pohnpeians are dependent on remittance from outside the state and fishing communities are economically marginalized. The island is perhaps best known for its rainfall (*c.* $800\,cm\,yr^{-1}$) and sakau (*Piper methisticum*), which is farmed in loose soil and sold and consumed locally for its narcotic properties, and is a primary source of terrestrial runoff and subsequent inshore reef sedimentation and nursery habitat loss, particularly in fringing reef environments. Coral dredging, which is active at 25 sites around the island, is also likely impacting fisheries through additional sedimentation and loss of critical nursery habitat for some species (*e.g.* Hamilton et al., 2017).

Based on anecdotal reports, commercialized fisheries have been operating in Pohnpei since the 1960s, with an expansion starting in the 1980s to the current 20+ markets operating in the state. Impacts to the fishery and to individual species prior to 2006 are unknown, however anecdotal reports of the abundance and distribution of marine resources suggest major impacts well before the 2006 market study occurred, *e.g.* the loss of giant clam, changes in depth distribution and abundance of Green humphead parrotfish. Market surveys in both 2006 and 2015 were conducted using the same format (Rhodes et al., 2008) with the exception that the latter surveys benefitted from the use of a digital image capture system (DICS) to electronically document catches. We assume any errors or bias associated with fisher or market owner responses are consistent between surveys. Surveys were concentrated in Kolonia, the population center and economic and state government hub, where most markets operate. As in 2006, additional assessments and fisher interviews were conducted at market locations outside of Kolonia. Marketed volumes of inshore catch were obtained daily from market owners at all locations. The first surveys were conducted 10 January 2006–31 January 2007, while the 10-year follow-up surveys