Fishes of War in the Pacific National Historic Park[1]

D. P. BROWN[2]
National Park of American Samoa, Pago Pago, AS 96799

M. CAPONE[3]
War in the Pacific National Historic Park, Hågatña, GU 96910

Abstract—The nearshore marine waters of Guam are known to be rich in coral reef fishes. These marine fish are a vital resource to the indigenous people of Oceania. They provide nutrition, economic gain, and cultural ties to their heritage. Using both standard belt transects (quantitative data) and the roving diver technique (qualitative data), the fishes of War in the Pacific National Historic Park (WAPA) were surveyed. Thirty-eight transects were completed at depths from 7.2–21 m. From these data 182 species in 30 families were documented. Only 24 fish exceeded 25 cm, representing just 0.45% of observed fish. Fish diversity (number of species/transect) varied from 10–36 species in Asan Beach to 18–43 in Agat Bay. The most commonly encountered fish species on transect were *Pomacentrus vaiuli* and *Chrysiptera traceyi* which were found on 36 and 33 of the 38 transects, respectively. These species, along with several other Pomacentrids, represented 50-70% of the individuals found on transect. Using the roving diver methodology, 41 dives were completed from 1–62 m. This method identified a total of 318 species, 136 species and 18 families that were not represented in the belt transects. Because of its geographic location, Guam is expected to have very high fish diversity, yet 51% of fish species found present in the WAPA were from just 5 families. While this study found many new species that were not previously recorded for this area, it also documented a disturbing trend of poor species diversity along belt transects (as compared to other reef sites in the Pacific). Fish at WAPA were small—only 0.15% of fish on belt transects were larger than 25 cm, there were few apex predators, and there was very low fish biomass. These marine resources should be

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[2] *Present address:* Isle Royale National Park, Houghton, MI 49931
[3] *Present address*: U.S. Fish & Wildlife, Utah Field Office, West Valley City, UT 84119 USA

monitored closely in the future and fisheries management guidelines should be implemented to ensure the continued presence of fish on these reefs.
Key words: Reef fish, Guam, War in the Pacific, inventory, diversity

Introduction

The nearshore marine waters of Guam are known to be rich in marine coral reef fishes. This diversity has been documented by numerous authors (Seale 1901, Kami 1971, Fowler 1925, Gawel 1977) and more recently in the landmark work of Myers (1999). Since most of this work has been carried out on an island-wide or even archipelago-wide scale, a more detailed small-scale study of the waters directly around the War in the Pacific National Historic Park (WAPA) was needed. Many of the fish species documented for the island of Guam may not range across the entire island. Instead many of these fish species may be found only in specific areas due to ecological needs, habitat use, depth strata, prey availability, and natural history needs.

Marine fish are a vital resource to the indigenous people of Oceania. These fishery resources provide nutrition, economic gain, and cultural ties to their heritage. While island societies have historically subsisted on fish protein, recent technological advances in fishing tackle have decimated what were once active and productive local fisheries (Brainard et al. 2005, Wilkinson 2004, Eldredge 1979). Throughout the Pacific, recent quantitative assessments have clearly shown a decline in standing fish biomass and a shift in fish communities (Friedlander & DeMartini 2002, Brainard et al. 2008). This research has shown that over wide areas of the Pacific, marine fish resources are highly exploited and that many stocks are "overfished." Of great concern recently are the lack of large apex predators on many reefs and the associated shifts in ecosystem species composition. The length and complexity of food webs has shortened, affecting the resiliency and prospects for sustainability in the future (Friedlander & DeMartini 2002).

Because of their importance ecologically, culturally and economically, it is critical that the National Park Service have data on the current health and long-term trends of the marine fish communities within their boundaries. Coral reefs form an important component of the ecosystem which has been compared to tropical rainforests in terms of high species diversity and complexity of interactions (Connell 1978, Birkeland 1997). Within these ecosystems, marine fish are one of the most visible resources and certainly the most exploited.

The nearshore fish species of Guam and the Mariana Islands have been inventoried and catalogued since the Linnaean system of binomial nomenclature was developed in the 18th century. Many of the fish species now known to be present in this region even received their current names from Linnaeus, though it

is unknown if any specimens were actually from collections in the Marianas Islands or Guam. One of the earliest known species list of nearshore coral reef fish from Guam comes from the work of Seale (1901). In this work, Seale described 142 species [though a review by Jordan (1902) cited the number as 274]. This work was followed by that of Fowler (1925), who listed 160 species. In 1966 Schultz et al. listed 218 species from the Southern Marianas Islands.

With the opening of the University of Guam Marine Laboratory, a series of fish lists were generated in the late 60s through the 80s (Kami et al. 1968, Kami 1971, Jones & Larsen 1974, Kami 1975, Amesbury & Myers 1982). In 1968, Kami et al. dramatically increased the knowledge of local fish in Guam by identifying 598 species from 90 families. These were qualitative inventories of species presence only, and due mostly to logistical constraints at the time, researchers were unable to quantify the distribution or abundance of reef fish species. This changed with the work of Jones & Chase (1975) who, using quantitative methods, list 276 species. Then, Amesbury & Myers (1982) described 225 fish species from Guam. Later work by Myers (1991), again using qualitative survey methods lists 763 known species from the Southern Marianas Islands with a potential for up to 817. This number, based on known zoogeographic distributions of reef fish, fits well with the distribution patterns seen in the Pacific. The most recent work by Myers & Donaldson (2003) puts the total of nearshore coral reef fish in the Marianas Islands at 1,019, though this number reflects the entire archipelago and not all species are necessarily present in Guam.

The waters within and surrounding WAPA have been less studied than other areas of Guam. For that reason and in order to better manage National Park fishery resources, a more specific effort to document fish species present in the Park was undertaken. Detailed survey work in Agat Bay by Kami (1971) and Kami et al. (1968) found just 25 reef fish species. Gawel (1977) surveyed Agat Bay using quantitative transect methodology and recorded 202 fish in 44 families. Twenty years later, a preliminary report prepared by Amesbury et al. (1999) found 193 species present in the park. The current work presented here significantly increases that number and updates the nomenclature of older reports.

Materials & Methods

The Mariana Islands are made up of 15 high volcanic islands and form a small part of Micronesia. The archipelago runs in a predominantly north-south direction and is politically divided into the Territory of Guam and the Commonwealth of the Northern Mariana Islands. The island of Guam is the southernmost island in the chain located at approximately 13°N, 144°E (Fig. 1). It has a land area of 541 km^2 and has approximately 175 km of coastline. The island is ringed by fringing coral reefs and numerous offshore seamounts and pinnacles, several of which are at shallow enough depths to support coral reefs.
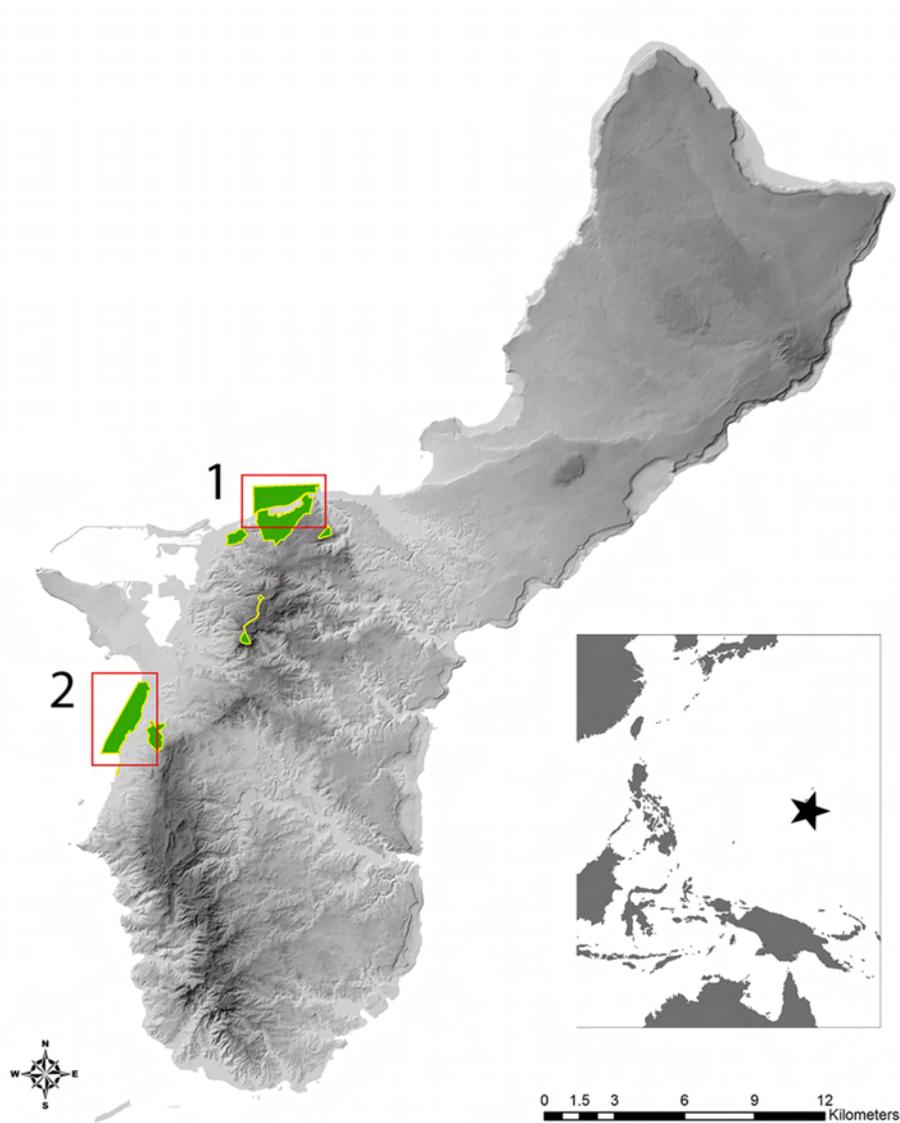
Figure 1. Map of the island of Guam showing the location of the seven non-contiguous units of War in the Pacific National Historic Park (WAPA). Area labeled (1) is the Asan Beach unit of WAPA (see Fig. 4). Area labeled (2) is the Agat Bay unit of WAPA (see Fig. 5). Inset shows the location of Guam in the western Pacific Ocean (black star). Maps by Paul Brown, derived from 2001 Dept. of Defense LIDAR data.

WAPA consists of seven non-contiguous units of beaches, adjacent offshore lands, and inland areas. In total, WAPA encompasses approximately 800 hectares

on the central west coast of Guam that were important to the invasion of Guam in World War II. There are two sections of the park with marine resources, Agat Bay and Asan Beach. These areas have extensive marine resources bounded by fringing reefs, including coral reefs, reef flats and seagrass beds. Of 175 km of coastline, WAPA represents just 5%, with shorelines of both units totaling 9.2 km. The Asan Beach unit is located on the central north coast, while the Agat Bay unit is located on the west coast (Fig. 1). The Asan Unit consists of an offshore area of 176 hectares. The coastline within this unit is approximately 4.5 km long and is characterized by an extensive reef flat extending from 100 to 1000 m from shore. The Agat Unit is slightly larger and encompasses 233 hectares, including several small offshore islands. The coastline of this unit is approximately 4.7 km long. The reef flat here extends from 180 to 630 m from shore. At both the Agat and Asan units macroalgae encrust the seascape and are the dominant substrate cover type in many places; approaching 70‑90% of the available surface area in both units of the park (Brown et al. 2011b). This agrees with Tsuda (in Amesbury et al. 1993) who, twenty-five years earlier, pointed out that one or more species of algae often dominate vast expanses of the substrate within these areas.

Figure 2. Typical low rugosity algal‑dominated pavement habitat. Image shows fixed transect 09, looking towards a 90° heading from the start pin at the Agat Bay unit (NPS photo).

Figure 3. Structurally complex high rugosity coral-dominated reef habitat. Image shows fixed transect 01 from the start pin looking toward a 180° heading in the Asan Beach unit (NPS photo).

Within the boundaries of the two marine units of WAPA there are several habitat types. Nearest to shore are extensive reef flats and shallow sandy bays. Moving offshore the bottom gradually slopes down. These slopes are characterized by extensive areas of coral pavement and high algal cover as well as areas of relatively rich coral reef (Figs 2, 3). Near the outer boundaries are several small offshore islets and rocks. These deeply pitted and eroded structures are refugia for many nocturnal and crevice dwelling fish species. Finally, in many places the reef drops abruptly as sheer drop-offs and walls. Each of these areas supports a different, yet overlapping, assemblage of fish species. The physical topography, depth, currents, and bottom compositions determine which species are present.

Numerous methodologies have been developed for the assessment and quantification of fish species in a given location. Many of these methodologies, especially many of the earlier methods, employ destructive collecting techniques. As such, less destructive methods were employed during this investigation, some quantitative (belt transect) and some qualitative (roving diver). All observations were carried out using SCUBA at depths ranging from 1–62 m. All dives were performed during daylight hours.
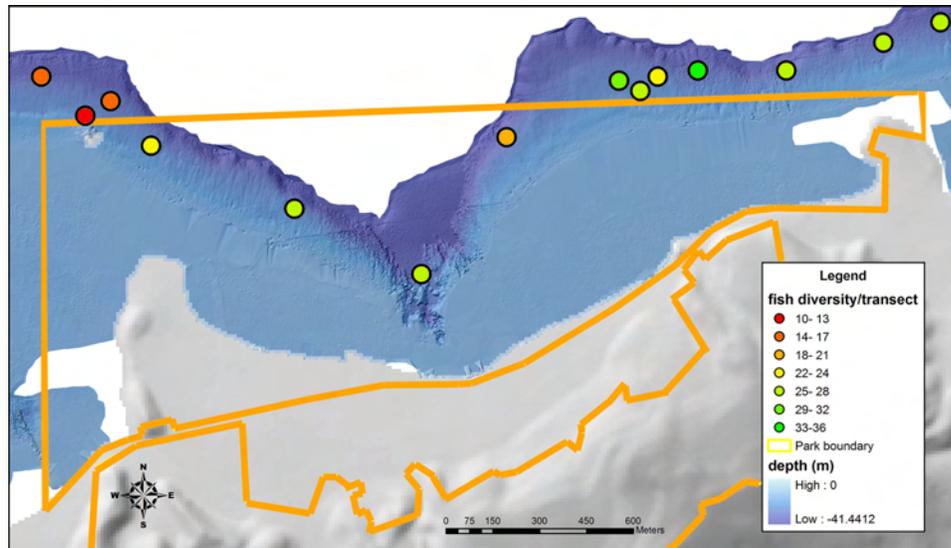
Figure 4. Map depicting locations of belt transect surveys and the resultant fish diversity (number of fish species encountered per transect) at the Asan Beach unit of WAPA. Diversity at this unit ranged from 10–36 fish species/transect. 1m LIDAR data courtesy of USGS. Yellow lines represent National Park boundary lines. Map by Paul Brown, derived from 2001 Dept. of Defense LIDAR data.

Standard belt transects were employed as the quantitative methodology. This method allows for enumerating fish species in situ as well as estimating fish length, which further allows the estimation of biomass per unit area. The methods used were those established and employed by the National Park Service (Brown et al. 2011a) as well as the National Oceanic and Atmospheric Administration's Coral Reef Ecosystem Division (Brainard et al. 2008). This allows for the merging of datasets in the future for more robust statistical calculations. These methods consist of a diver laying down a 25 m transect tape as they swim, counting all fish species greater than 20 cm that are within 2 m on either side of the transect and up to 4 m above it. This pass should take approximately 5 minutes. The diver then turns and moves more slowly (10 minute swim) back down the transect counting all fish species less than 20 cm that lie within 1m on either side of the transect and up to 4 m above it. At this time the diver is also looking for cryptic species and nocturnal species hiding within the reef structure.

While the belt transect methodology does allow quantification of the data, it does present a much more time consuming method with much less spatial coverage. Furthermore it is logistically difficult to use this methodology in certain habitats (e.g. surge zone) and at depths exceeding 35–40 m. For these reasons, the roving diver methodology (Schmitt 2002, Jeffrey et al. 2001) was
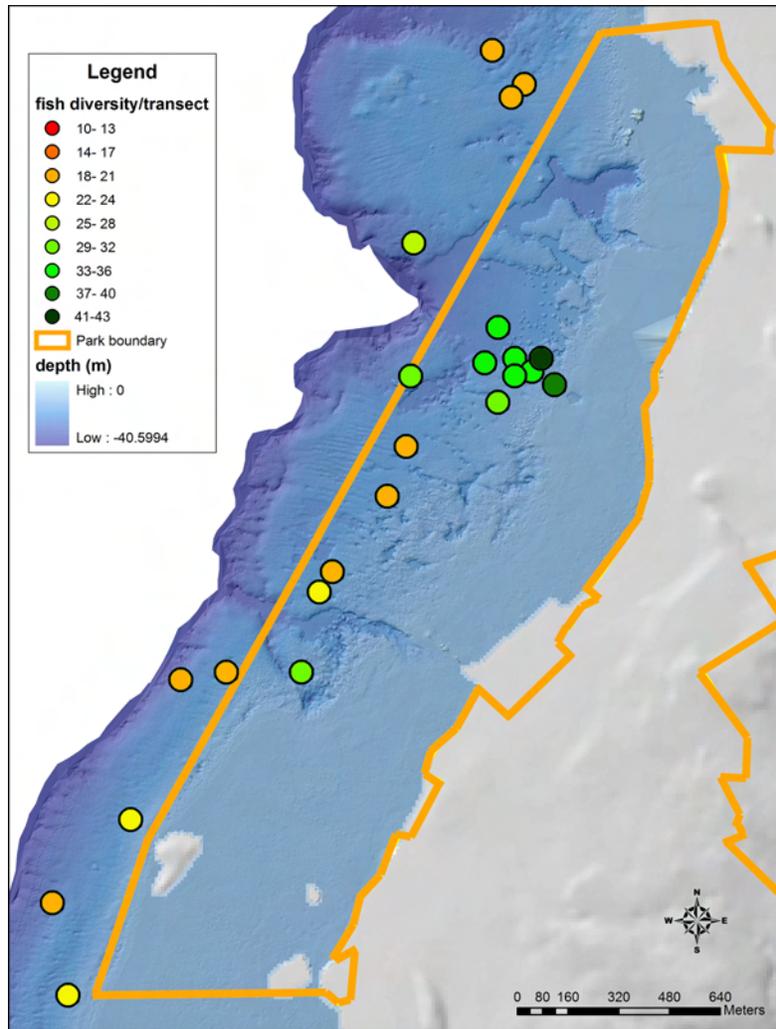
Figure 5. Map depicting locations of belt transect surveys and the resultant fish diversity (number of fish species encountered per transect) at the Agat Bay unit of WAPA. Diversity at this unit ranged from 18-43 fish species/ transect. 1m LIDAR data courtesy of USGS. Yellow lines represents National Park boundary lines. Map by Paul Brown, derived from 2001 Dept. of Defense LIDAR data.

also employed during this study. This methodology allows for little quantification of the data, but does present a huge spatial area and the likelihood of encountering a greater diversity of species, not only from being underwater for longer periods of time, but for moving across habitat types and having more freedom to look in potential areas and freeing up the "off-transect fishes" for inclusion.

Results

Using the belt methodology, 38 dives were completed at depths from 7.2–21 m representing 14.4 hours of underwater observations. Fifteen of these transects are permanently placed fixed transects within WAPA, while the remaining 22 were randomly placed throughout both the Asan and Agat units. The outcome of these dives was the identification of 182 species in 30 families. These findings are also in line with those of Amesbury et al. (1999) who found 193 species using similar methodologies, with similar effort, and within the same depth zones.

Table 1. Top twenty-five most commonly encountered species on 38 belt transects conducted at Agat Bay and Asan Beach units of War in the Pacific National Historic Park.

Family	Species	Transects present
Pomacentridae	*Pomacentrus vaiuli*	36
Pomacentridae	*Chrysiptera traceyi*	33
Serranidae	*Cephalopholis urodeta*	30
Acanthridae	*Acanthurus nigrofuscus*	28
Labridae	*Halichoeres biocellatus*	26
Scaridae	*Chlorurus sordidus*	25
Acanthridae	*Naso lituratus*	25
Pomacentridae	*Plectroglyphidodon lacrymatus*	22
Gobiidae	*Eviota guttata*	21
Labridae	*Oxycheilinus unifasciatus*	20
Blenniidae	*Meiacanthus atrodorsalis*	17
Acanthridae	*Ctenochaetus striatus*	16
Gobiidae	*Valenciennea strigata*	16
Cirrhitidae	*Cirrhitichthys falco*	15
Labridae	*Macropharyngodon meleagris*	15
Tetraodontidae	*Canthigaster solandri*	14
Labridae	*Halichoeres ornatissimus*	14
Labridae	*Labroides dimidiatus*	14
Labridae	*Thalassoma lutescens*	14
Pomacanthidae	*Centropyge flavissima*	13
Labridae	*Cirrhilabrus katherinae*	13
Gobiidae	*Gnatholepis anjerensis*	13
Labridae	*Stethojulis bandanensis*	13
Labridae	*Thalassoma quinquevittatum*	12
Balistidae	*Balistapus undulatus*	11

Fish diversity (number of species/transect) varied from 10–36 species in Asan Beach (Fig. 4) to 18–43 in Agat Bay (Fig. 5). There was no statistical difference between the Asan and Agat units when the data was pooled, however t-tests revealed significant differences ($p < 0.05$) between individual transects in each park unit. The greatest variation was found at the Asan unit. Here the lowest diversities of fish where found on the west side of the unit near Camel Rock. This area had the most depauperate fish assemblages of any survey area. The east side of the Asan Beach unit had relatively high diversity. The highest diversity however, was found in the Agat Bay unit near Hap's Reef, which had fish diversity four times higher than Camel Rock. There was a moderate to strong Spearman correlation ($r_s = 0.67$) between measured rugosity (structural complexity) and number of species encountered on each transect.

Table 2. List of fish greater than 25 cm seen during 38 belt transect surveys at the Agat Bay and Asan Beach units of War in the Pacific National Historic Park. These fish represent 0.45% of fish seen during survey efforts.

Family	Species	Number	Size (cm)
Syphraenidae	*Sphyraena barracuda*	1	95
Serranidae	*Cephalopholis argus*	1	37
Scaridae	*Scarus forsteni*	1	36
Fistulariidae	*Fistularia commersonii*	1	35
Scaridae	*Scarus schlegeli*	2	29.5
Syndontidae	*Saurida gracilis*	1	28
Serranidae	*Epinephelus merra*	1	28
Serranidae	*Cephalopholis argus*	1	27
Balistidae	*Balistapus undulatus*	1	26
Aulostomidae	*Aulostomus chinensis*	1	26
Acanthridae	*Naso vlamingii*	3	25.5
Scaridae	*Scarus forsteni*	3	25
Serranidae	*Epinephelus fasciatus*	2	25
Holocentridae	*Sargocentron spiniferum*	3	25
Serranidae	*Epinephelus merra*	1	25
Scaridae	*Scarus schlegeli*	1	25

The most commonly encountered fish species on transect were *Pomacentrus vaiuli* and *Chrysiptera traceyi* which were found on 36 and 33 of the 38 transects respectively. These species, along with several other Pomacentrids represented 50–70% of the individuals found on transects. Most of the remaining individuals

were encompassed within just 10 families of fish (Table 1). Most fish species represented in the belt transects were adult, but most were only 50–85% of standard accepted mature size. Four fish seen during the belt transect surveys exceeded 35 cm, one was an apex predator, *Sphyraena barracuda*; two were mid-size piscivorous fishes, *Cephalopholis argus* and *Fistularia commersonii*; and the last a mid-sized Scarid, *Scarus forsteni*.

Twenty-four fish exceeded 25 cm (Table 2) representing 0.45% of the total number of fish seen.

Table 3. The twenty-one most speciose families of nearshore coral reef fishes observed at Agat Bay and Asan Beach units of War in the Pacific National Historic Park.

Family	Genera	Species	% of total
Labridae	21	45	14.15
Pomacentridae	10	37	11.64
Gobiidae	16	29	9.12
Acanthridae	4	24	7.55
Chaetodontidae	4	24	7.55
Blenniidae	9	12	3.77
Scaridae	6	12	3.77
Apogonidae	2	11	3.46
Holocentridae	3	11	3.46
Balistidae	7	10	3.14
Serranidae	3	9	2.83
Lutjanidae	3	7	2.20
Pomacanthidae	4	7	2.20
Lethrinidae	3	6	1.89
Mullidae	2	6	1.89
Tetraodontidae	2	6	1.89
Carangidae	4	5	1.57
Scorpaenidae	3	5	1.57
Syndontidae	2	5	1.57
Monocanthidae	4	4	1.26
Ptereleotridae	2	4	1.26
all other genera		39	12.26

Using the roving diver methodology, 41 dives were completed from 1–62 m, representing 31.1 hours of underwater observation. This method identified a total of 308 species within park waters (Table 3, Appendix A). Of these, 136 species

and 18 additional families were not represented in the belt transects. This directly conflicts with Amesbury et al. (1999) who states "The cumulative species curves … indicate that only a few more fish species would likely be observed if more transects were run." The present study suggests that many additional species could be picked up "on-transect" with additional survey effort. An additional 10 species were seen outside National Park Service boundaries.

Discussion

The diversity of marine fish is very high in Guam given its geographic location, yet 51% of fish species found present in the War in the Pacific National Historic Park were from just 5 families: Labridae, Pomacanthidae, Gobiidae, Acanthuridae and Chaetodontidae. Most of the fishes in these families are composed of smaller varieties of fish and these data point to a noticeable lack in large apex predators. In fact, of the thousands of individual fish observed from 318 different species, only a handful of the fish seen during this study were apex predators and most of these were very small and did not approach full size for their species. The four most important families of piscivorous fishes on reefs, jacks (Carangidae), sharks (Carcharhinidae), barracudas (Syphraenidae), and the large groupers (Serranidae), were represented by just two dozen individuals.

Several species recorded by previous authors as occurring in WAPA were not observed during the present study. Several of the species listed are highly cryptic and/or nocturnal and so may have been overlooked by the authors. Others represent almost certain misidentifications by previous authors. The current list does not include any species for which there is no voucher evidence. Several species previously recorded cannot be identified without collected specimens and as such these question identifications from previous reports are excluded from the final species list. Many other species previously listed are excluded due to recent taxonomic revisions and synonymy changes; while some that are included will likely see a similar fate in future lists. Every effort was made by the authors to include the most current valid species names for fish listed in this report following Eschmeyer et al. (2012).

Though every effort was made to identify specimens to the species level, this level of identification was unfortunately not possible for a handful of species observed during this study. This is because certain fish species can only be identified positively by having a specimen in hand to determine certain morphometric characteristics. Previous reports have identified similar species, which are likely the species in question, but without voucher specimens for positive identifications, these species have been left identified to the generic level and are listed as sp. or spp. under the proper genus. The list included in this report is still incomplete and subject to nomenclatural changes resulting from future taxonomic work.

The present work adds to the number of species known to be present in this region of Guam. It is certainly incomplete as very few nocturnal fish were recorded due to logistical constraints of night surveys; however many new species were recorded for the first time in park waters during this study using both qualitative and quantitative methods. Certainly, some nocturnal fish were witnessed and recorded using both belt transect and roving diver methodologies, but carrying out nocturnal fish surveys would increase the number of fish known to be present in the waters of WAPA. In addition, several new species records were noted in deeper waters and further surveys below 30m (outside official park boundaries) will likely increase the known fish assemblage for these areas of Guam. Furthermore, no destructive collections were made, meaning that no ichthyocides were used in this study, which clearly limits the number of small cryptic species located.

The checklist of WAPA fishes (Appendix A) revises the total number of fish species found within the nearshore water of WAPA to include 318 species in 48 families. 308 of these were identified by the authors during this study, with an additional 10 included which could be verified from previous reports. Several new species sightings listed here have not previously been recorded for Guam and over 100 species are added that were not previously recorded in WAPA.

Fish diversity was highly variable, but generally followed the rule of increasing diversity with increasing structural complexity. This could be clearly seen at the Asan unit which showed both the highest and lowest diversities of fish. This was not unexpected as Brown et al. (2011b) previously found that the west side of Asan Beach had the lowest structural complexity, while the east side had the highest. Additionally, the west side of the Asan unit had the greatest amount of algae and the lowest amount of reef and live coral cover. Fish diversity/ transect was correlated to the structural complexity, with more fish species encountered on transects that had greater three dimensional reef structure. Further, the data also showed that habitat/substrate type also correlated with fish diversity and density. Sand flats and algae dominated areas showed significant decreases in the diversity of fish life present in the area. Fish diversity is affected by other factors such as anthropogenic influences like tourism, scuba diving, and fishing pressure. The west side of the Asan unit, near Camel Rock gets signifi-cant fishing pressure which undoubtedly affects the species assemblages in this area; while the opposite is true of Hap's Reef in the Agat unit, as this area is relatively free from fishing pressure and semi-protected due to its popularity with tourists as a scuba diving site.

The habitats of the two park units represent only a fraction of the available habitat on Guam. It is likely that the lack of certain habitat types precludes many fish species from colonizing WAPA. Thus it is this lack of habitat niches which is likely the driving force excluding many fish species from the park. Therefore, while Guam is known to have well over 1,000 fish species of nearshore coral reef

fish, many of these are certainly not present in the park. However, the well‑documented overfishing which has taken place, and is currently taking place on Guam is surely a contributing factor to the low biomass of marine fish found in the park.

While this study found many new species that were not previously recorded for this area, it also documented a disturbing trend of poor species diversity along belt transects (as compared to other reef sites in the Pacific). Fish at WAPA were small—only 0.15% of fish on belt transects were larger than 25 cm, there were few apex predators, and there was very low fish biomass. These marine resources should be monitored closely in the future and fisheries management guidelines should be implemented to ensure the continued presence of fish on these reefs.

References

Amesbury, S.S., D. Ginsberg, T. Rongo, L. Kirkendale & J. Starmer. 1999. War in the Pacific National Historic Park Marine Biological Survey. University of Guam Marine Laboratory, Technical Report 156.

Amesbury, S.A. & R.F. Myers. 1982. Guide to the Coastal Resources of Guam, Vol. 1: The Fishes. University of Guam Press, Agana, GU

Amesbury, S.S., R.T. Tsuda, R.H. Randall, A.M. Kerr & B. Smith. 1993. Biological communities in Tumon Bay, 1977–1991. University of Guam Marine Laboratory, Technical Report. No. 99.

Birkeland, C. 1997. Life and Death of Coral Reefs. Chapman & Hall, New York, NY.

Brainard, R.B., J. Maragos, R. Schroeder, J.C. Kenyon, P.S. Vroom, S. Godwin, R.K. Hoeke, G.S. Aeby, R. Moffitt, M. Lammers, J. Gove, M. Timmers, S.R. Holzwarth & S. Kolinski. 2005. The state of coral reef ecosystems of the Pacific Remote Island Areas *In*, J.N. Waddell (ed.). The state of coral reef ecosystems of the United States and Pacific Freely Associated States: 2005, p. 338–372. NOAA Technical Memorandum NOS NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Honolulu, HI.

Brainard, R., J. Asher, J. Gove, J. Helyer, J. Kenyon, F. Mancini, J. Miller, S. Myhre, M. Nadon, J. Rooney, R. Schroeder, E. Smith, B. Vargas-Angel, S. Vogt, P. Vroom, S. Balwani, P. Craig, A. DesRochers, S. Ferguson, R. Hoeke, M. Lammers, E. Lundblad, J. Maragos, R. Moffitt, M. Timmers & O. Vetter. 2008. Coral reef ecosystem monitoring report for American Samoa: 2002–2006. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Honolulu, HI.

Brown, E., J. Beets, P. Brown, P. Craig, A. Friedlander, T. Jones, K. Kozar, M. Capone, L. Kramer, & L. Basch. 2011a. Marine Fish Monitoring Protocol:

Pacific Island Network (Version 1.0). Natural Resource Report NPS/PACN/NRR 2011/421. National Park Service, Fort Collins, CO.

Brown, E., D. Minton, R. Daniel, F. Klasner, L. Basch, A. Snyder, P. Craig, G. Dicus, K. DeVerse, & T. Jones. 2011b. Pacific Island Network benthic marine community monitoring protocol: Version 2.0. Natural Resource Report NPS/PACN/NRTR—2011/339. National Park Service, Fort Collins, CO.

Connell, J.H. 1978. Diversity in tropical rain forests and coral reefs. Science 199: 1302–1310.

Eschmeyer, W. N. & R. Fricke, (eds.) Catalog of Fishes, electronic version. http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp accessed 12 Jan 2012.

Jordan, D.S. 1902. The fishes of Guam. American Naturalist 36: 585.

Eldredge, LG. 1979. Marine Biological Resources within the Guam Seashore study area and the War in the Pacific National Historic Park, University of Guam Marine Laboratory, Technical Report No. 57.

Eldredge, L.G., R. Dickinson & S. Moras (eds). 1977. Marine Survey of Agat Bay. University of Guam Marine Laboratory, Technical Report No. 31.

Fowler, H.W. 1925. Fishes of Guam, Hawaii, Samoa, and Tahiti. Bulletin of B.P. Bishop Museum 22: 1–38.

Friedlander, A.M. & E.E. DeMartini. 2002. Contrasts in density, size, and biomass of reef fishes between the northwestern and the main Hawaiian Islands: the effects of fishing down apex predators. Marine Ecology Progress Series 230: 253–264.

Gawel, M. 1977. Fish. *In*, L.G. Eldredge, R. Dickinson & S. Moras (eds) 1977. Marine Survey of Agat Bay. University of Guam Marine Laboratory, Tech. Rept. No. 31, pp. 115–131.

Jeffrey, C.F.G., C. Pattengill-Semmens, S. Gittings & M. E. Monaco. 2001. Distribution and sighting frequency of reef fishes in the Florida Keys National Park Service Marine Sanctuary. Marine Sanctuaries Conservation Series MSD-01-1. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Marine Sanctuaries Division, Silver Spring, MD.

Jones, R.S. & H.K. Larsen. 1974. A Key to the Families of Fishes as recorded from Guam. University of Guam Marine Laboratory, Technical Report. No. 10.

Jones, R.S. & J.A. Chase. 1975. Community structure and distribution of fishes in an enclosed high island lagoon in Guam. Micronesica 11: 127–148.

Kami, H.T., I.I. Ikhara & F.P. DeLeon. 1968. Check-list of Guam Fishes. Micronesica 4(1): 95–131.

Kami, H.T. 1971. Check-list of Guam Fishes. Supplement I, Micronesica 7: 215–228.

Kami, H.T. 1975. Check-list of Guam Fishes. Supplement II, Micronesica 11: 115–121.

Kami, H.T. & I.I. Ikehara. 1976. Notes on the annual juvenile siganid harvest in Guam. Micronesica 12: 323–325.

Myers, R.F. & T.J. Donaldson 2003. The fishes of the Mariana Islands. Micronesica 35-36: 594–648.

Myers, R.F. 1999. Micronesian reef fishes: A comprehensive guide to the coral reef fishes of Micronesia. 3rd revised and expanded edition. Coral Graphics, Barrigada, GU.

Schmitt, E.F., T.D. Sluka, & K. M. Sullivan-Sealy. 2002. Evaluating the use of roving diver and transect surveys to assess the coral reef assemblages off southeastern Hispaniola. Coral Reefs 21: 216–223.

Schultz, L.P., L.P. Woods & E.A. Lachner. 1966. Fishes of the Marshall and Marianas Islands. Bulletin of the U.S. National Museum. 202.

Seale, A. 1901. A report of a mission to Guam, Part II. Fishes. Occasional Papers of the BP Bishop Museum, 1(3): 61–128.

Tsuda R.T. 1977. Marine flora. *In*, L.G. Eldredge, R. Dickinson & S. Moras (eds). 1977. Marine Survey of Agat Bay. University of Guam Marine Laboratory, Technical Report. No. 31.

Wilkinson, C. 2004. Status of the Coral Reefs of the World. Global Coral Reef Monitoring Network.