WAR-IN-THE-PACIFIC NATIONAL HISTORICAL PARK MARINE BIOLOGICAL SURVEY

Steven S. Amesbury, David Ginsburg, Teina Rongo, Lisa Kirkendale, and John Starmer

A report to the U.S. National Park Service

University of Guam Marine Laboratory
Technical Report No **156**

July 1999

WAR-IN-THE-PACIFIC NATIONAL HISTORICAL PARK
MARINE BIOLOGICAL SURVEY

INTRODUCTION

The War-in-the-Pacific National Historical Park (WAPA) consists of 1,960 acres (958 land, 1002 water) in seven discontiguous units. The purpose of the park is "to commemorate the bravery and sacrifice of those participating in the campaigns of the Pacific Theater of World War II and to conserve and interpret outstanding natural, scenic, and historic values on the island of Guam." Two of the park's seven units contain significant coastal water resources, including both coral reefs and reef flats (Map 1).

The Asan Unit consists of 109 land acres and 445 offshore acres and is the site of the northern invasion beach. The coastline within this unit is approximately 1.8 miles long and is characterized by a fringing reef platform extending from 300 feet to 1000 feet in width. The Agat Unit consists of 38 land acres and 557 offshore acres and is the site of the southern invasion beach. The coastline within this unit is approximately 2.2 miles long with a fringing reef platform extending from 1000 to 1500 feet in width. In both units, an inner reef flat occurs along most of the shoreward side of the fringing reef. Impounded water in this reef flat varies from 1 to 4 feet in depth during low tides, when sections of the outer reef flat may be exposed.

In order to assess the marine resources within the War-in-the-Pacific Park, a marine biological survey was designed to provide a qualitative and quantitative assessment of the fish, coral, and marine plants throughout the marine habitats of the park; a less complete assessment of marine macroinvertebrates was also made. Four fish transects surveyed in 1974 (Gawel 1977) were also resurveyed to determine whether any significant changes in the fish communities had occurred over the intervening years.

METHODS

Survey Design

Within both the Agat Unit and the Asan Unit there are two major marine habitats -- the reef flat (the shallow region between the shoreline and the reef edge) and the reef slope (the region beyond the edge of the reef). The marine biological survey was designed to provide a stratified random sample of the habitats and geographical units of the Park. Each of the two habitats were surveyed in two zones: the inner reef flat (which is generally deep enough to be covered by water at low tide) and the outer reef flat (which is shallower and usually exposed at low tide), and the reef slope at 30' and the reef slope at 50'. The Asan Unit was divided into a western and an eastern sector, and the Agat Unit was divided into northern, central, and southern sectors. Two transect surveys were run at random locations within each combination of unit, sector, and zone as follows:

	Agat			Asan	
	North	Central	South	East	West
Inner reef flat	2	2	2	2	2
Outer reef flat	2	2	2	2	2
Reef slope, 30'	2	2	2	2	2
Reef slope, 50'	2	2	2	2	2

Random latitudes and longitudes for each of the transects were generated with the random number function of a Sharp EL-531GH Scientific Calculator, and a Magellan Pioneer GPS was used to find the location in the field. This spot became the end-point of a 50-m transect line along which the biological surveys were conducted. For the reef slope transects, only a latitude (Agat transects) or a longitude (Asan transects) was used to locate the survey site, and this latitude (or longitude) was followed in toward shore until the appropriate depth (30' or 50') was encountered, and this point became the starting point of the transect line. Transects were aligned parallel to the beach (reef flat transects) or along the appropriate depth contour (reef slope transects). Forty transects were run in all. Scuba gear was used for the reef slope transect surveys and snorkeling gear for the reef flat surveys.

Transecting Methods

Benthic macroalgae were surveyed by an investigator who placed a 0.5 m × 0.5 m gridded quadrat at 5-m intervals along the length of each transect line (see Tsuda 1977, Amesbury et al. 1993). The quadrat frame was divided into 25 squares (5 cm^2) using nylon thread which provided 16 interior points where the grid lines intersected. Individual algae species observed under each of the grid crossing points were recorded. If no alga or seagrass was observed under the grid point, no data were recorded. Algae in the genera *Dictyosphaeria, Dictyota, Halimeda,* and *Padina* were recorded by genus. Crustose coralline algae were not surveyed.

The percent cover of each taxon was determined by dividing the number of points at which the taxon was recorded by the total number of points per 50-m transect. For example, 10 quadrats × 16 points yielded a total of 160 points; thus the number of points recorded/160 X 100 = the percent cover for that taxon. Because different algae species often overlie one another, some transect lines had total percent cover values greater than 100.

Corals were surveyed by an investigator who haphazardly tossed a cross-shaped object every 5 m along the transect line and then recorded the species name, diameter, and distance from the center of the cross of the coral colony which was closest to the center in each of the four quadrants of the cross. Only coral colonies within 2 m of the center in any quadrant were recorded. From these data, an estimate of percent cover of coral species along the transect line was calculated according to the methods of Randall in Amesbury et al. 1993.

Fish were surveyed by an investigator swimming the length of the transect line enumerating by species fish which were seen within 1 m of either side of the line (an area of 100 m^2). The enumeration was followed by a listing of additional species observed near the transect line but which had not been seen during the enumeration. The same technique was used for the surveys of macroinvertebrates.

Marine plants, corals, and fishes were surveyed at each of the forty transects. Invertebrates were surveyed as opportunities were available, for a total of 27 transects.

Four of the fish transects surveyed by Gawel (1977) are located within the present boundaries of the park. These were resurveyed using Gawel's survey methods to assess changes in the fish communities that may have taken place between the time of his surveys and of those reported here.

RESULTS AND DISCUSSION

Marine Plants

The results of the quantitative algal surveys from both the Agat and Asan study areas are presented in Tables 1 and 2. Additionally, a checklist of the macroalgae observed in the different habitats at each location is presented in Tables 4 and 5.

A total of 34 species of macroalgae and seagrasses was recorded in this study, with 27 species from the Agat and 21 species from the Asan study areas. Interestingly, however, species richness varied between habitats and locations. For example, in the Agat Unit there were a greater number of algal species observed on the reef flat habitat than on the reef slope (Figures 1 and 2), while in the Asan Unit algal species were more abundant on the reef slope than on the reef flat (Figures 3 and 4). In Agat, species richness of marine plants was noticeably higher on the outer reef flat than on the inner, and was higher on the upper (30') slope than at 50', whereas in Asan, species richness was comparable between the inner and outer reef flat habitats, but noticeably higher on the deeper (50') reef slope than at 30' (Table 3).

Overall macroalgal and seagrass density (averaged across all transects) was 6 plants/50 m (Tables 1 and 2). There were no clear patterns that could explain the abundance of algal species between habitats at either the Agat or Asan study areas (Figures 5 and 6). The percent coverage of algal species at the Agat site was nearly twice that at Asan (Table 3). Likewise, in Agat algae were more abundant on the reef slope than in reef flat habitats, while algal abundance was nearly equal between reef flat and reef slope zones within the Asan site (Table 3).

These results of the Agat study area are similar to findings by Tsuda (1977) in his study of the benthic algae of Agat Bay. Tsuda (1977) showed, however, that algal species richness is greatest on the outer reef slope; this is in contrast to data presented in this study, which showed the outer reef slope to have the lowest algal diversity (Table 3). As pointed out by Tsuda (Amesbury et al

1993), one or more species of algae often dominate vast expanses of the substrate. At both the Agat and Asan study areas, *Amphiroa, Halimeda, Neomeris*, and *Padina* were the most common algal species present; in some cases they covered more than 75 % of the available surface area (Tables 1 and 2).

The cumulative species curves (Figures 1 through 4) indicate that few additional marine plant species would likely be encountered in the study areas with increased numbers of survey transects.

Corals

Thirty-six species of corals were recorded on the transects and an additional 21 species were seen in adjacent areas, giving a total of 57 species observed within the study areas. An earlier qualitative study of Agat reef (Eldredge et al. 1977) recorded a total of 164 species of corals. Because the point quarter method used in the present study is one which involves more intensive observations within relatively small areas, fewer coral species were encountered.

Reef flats were less diverse and had lower coral coverage than did reef slope habitats (Tables 6 through 9). Coral cover on the Agat reef flat was consistently low, ranging from less than 0.01 % to nearly 10 %, while at Asan, coral cover on reef flats was quite variable, ranging from about 0.01 % to more than 80 %. The inner reef flats of both Agat and Asan are, for the most part, unfavorable environments for coral settlement and growth, primarily because of the influence of fresh water inflow. Almost all of the Asan inner reef flats survey sites that were in close proximity to stream mouths yielded percent coral cover of less than 0.01.

At both Agat and Asan there were no clear differences in the coral cover and diversity between the shallow (30') and deeper (50') reef slope habitats. However, the coral cover between Agat and Asan showed a significant difference (Tables 6 and 8). This may be because of the more turbid waters in Agat as a result of the sediments coming from the streams. Although the percentages of coral cover were different, the diversities were about the same.

The most common coral within the study area was _Leptastrea purpurea_ . It was present at almost all the sites, even in extreme habitats. At several sites the occurrence and diversity of corals was low due to the large colony sizes of species such as _Porites rus_ and _Porites cylindrica_ At other sites average coral size was small; however, this does not indicate that there was a recent recruitment event because most of the corals that were measured had reached their maximum size. The cumulative species curves (Figures 7 through 10) indicate that the number of coral species recorded from the study areas would not likely increase significantly with additional survey transects.

Invertebrates

One hundred ninety one species of macroinvertebrates (other than corals) were recorded from the study areas, 121 on the transects (Table 10) and 69 others observed in the vicinity (Table 11).

Cumulative macroinvertebrate diversity was fairly equal among reef slope and reef flat environments at both sites surveyed (Table 10). However, both reef slope sites exhibited higher densities of invertebrates than those at the reef flat sites.

Echinoderms were the most conspicuous component of the macroinvertebrate fauna in this study. Holothurians were common in reef flat environments, whereas echinoids were more abundant on the reef slopes. *Holothuria atra* was the most common sea cucumber encountered on both Asan and Agat reef flat sites, and, along with other holothurian species observed, may play an important role in sediment bioturbation. *Echinostrephus* sp. was the most abundant and conspicuous echinoid present on the reef slope. However, *Echinometra* spp., which were also observed but in lesser numbers than *Echinostrephus* spp., are more important ecologically as they construct burrows which, over time, can weaken the structural integrity of the reef. Encouragingly, only two individuals of the corallivorous crown-of-thorns starfish *Acanthaster planci* were recorded, one from each of the reef slope sites. Other macroinvertebrates that were common included the sponge *Dysidea granulosa*, which formed a conspicuous gray, encrusting mat at both reef slope sites. The vermetid gastopod *Dendropoma* spp. was found at almost all sites surveyed. It was especially abundant in reef flat environments where, at one transect site in Asan, it reached numbers of over 100 individuals. High numbers of *Dendropoma* spp. may be indicative of areas with an elevated sediment load, which would be detrimental to corals; however, no experimental studies have addressed this relationship to date.

The cumulative species curves (Figures 11 through 14) indicate that additional macroinvertebrate species would likely be encountered in the study areas if additional survey transects were run.

Fishes

One hundred ninety three species of fish were seen within the study areas (Tables 12 through 15).. The reef slope habitat was more diverse in fishes than the reef flat (Table 16), and slightly more species were observed in the Asan Unit than in the Agat Unit, despite the greater number of transects run in the latter area. The cumulative species curves (Figures 15 through 18), indicate that only a few more fish species would likely be observed if more transects were run. Species richness was comparable between reef slope habitats at 30' and at 50' (Figures 19 and 20) and between the inner and outer reef flat zones at Asan (Figure 21); however, at Agat species richness was significantly higher ($p = .0054$, t-test) in the outer reef flat zone than in the inner (Figure 22).

Overall fish density (averaged across all transects) was 101 fish/100 m^2. Fish were more abundant in reef slope habitats than on the reef flat (Table 16) and were slightly more abundant on the Asan reef flat than on the reef flat at Agat. Fish abundance was more-or-less equivalent between 30' and 50' on the reef slope at Asan (Figure 23), but was significantly higher ($p = .0411$, Mann-Whitney test) at 50' than at 30' at Agat (Figure 24). Fish abundances between the inner and outer reef flats at both Asan and Agat (Figures 25 and 26) were not significantly different.

In a comprehensive study of the reef organisms within the Andersen Air Force Base Marine Preserve (Amesbury et al. 1995) along the northern coast of Guam, 221 species of fish in 40 families were recorded. This is quite comparable to the diversity of fishes observed during the present study (193 species in 37 families).

Zonation of fishes on the reef flat was most noticeable at Agat where the inner reef flat had fewer fish and fewer fish species than the outer reef flat (Figures 22 and 26); at Asan there were no clear differences in fish abundance or diversity between the inner and outer reef flats (Figures 21 and 25). At both Agat and Asan there were, however, differences in fish distributions among the two reef flat zones, as indicated in Table 16. Although fish abundance and diversity did not vary noticeably between 30' and 50' in reef slope habitats, there were differences in the frequency with which various species were observed in these two depth zones (Table 16).

An interesting feature of reef fish communities on Guam is the occurrence of periodic "runs" of juvenile rabbitfishes of the species *Siganus spinus* and *S. argenteus* (Kami & Ikehara, 1976). The young of these species are known as *manahak* locally and they recruit to the reefs in the spring at the last quarter moon phase. The strength of these runs is variable from year to year, but in early April of 1999 there was a moderate run of *S. spinus*, and these showed up in the surveys of reef flat transects 22, 23, and 24 in Agat. Because the numbers of these fishes distorts the normal fish community structure on the reef, they are omitted (although noted in the footnote) from the tables.

Comparison of 1974 and 1999 Fish Transects

Four 100-m transects were surveyed at the locations and using the methods employed by Michael Gawel (Eldredge et al. 1997) in 1974. Table 17 exhibits the results of both the 1974 and 1999 surveys of these transects (with scientific name of the fish species brought up to date according to Myers, 1999). As Figure 27 shows, somewhat fewer species of fish were recorded in 1999, especially at transect 3. This apparent decline in species richness may not be biologically significant for two reasons: 1) the high species diversity at transect 3 in 1974 may be something of an anomaly, as this transect was by far the richest in species of all of Gawel's transects, and the large number of species recorded in 1974 may be fortuitous; and 2) Gawel records many species of cryptic fishes (e.g. apogonids, gobiids, blenniids, and muraenids) that were quite likely present in 1999 but which were not observed during the transect surveys.

Transect counts in 1999 indicated generally higher fish abundance than at the time of Gawel's counts (Figure 28). The reason for this is not clear, and it is curious that the most abundant species along transect 3 in 1999, *Chrysiptera traceyi*, was not recorded at all on this transect in 1974, while *Stegastes fasciolatus*, abundant on transect 3 in 1974 (recorded as *Pomacentrus melanopterus*), was not recorded at this transect in 1999. Perhaps relatively minor differences in the depth of the transect line resulted in large differences in the counts of these two highly zoned species.

On the whole, comparison of the 1974 and 1999 data for these four transects does not suggest that there have been major changes in the fish communities over the intervening years.

REFERENCES CITED

Amesbury, S.S., R.T. Tsuda, R.H. Randall, A.M. Kerr, and B. Smith. 1993. Biological communities in Tumon Bay, 1977 - 1991. Univ. Guam Mar. Lab., Tech. Rept. No. 99, 111 p.

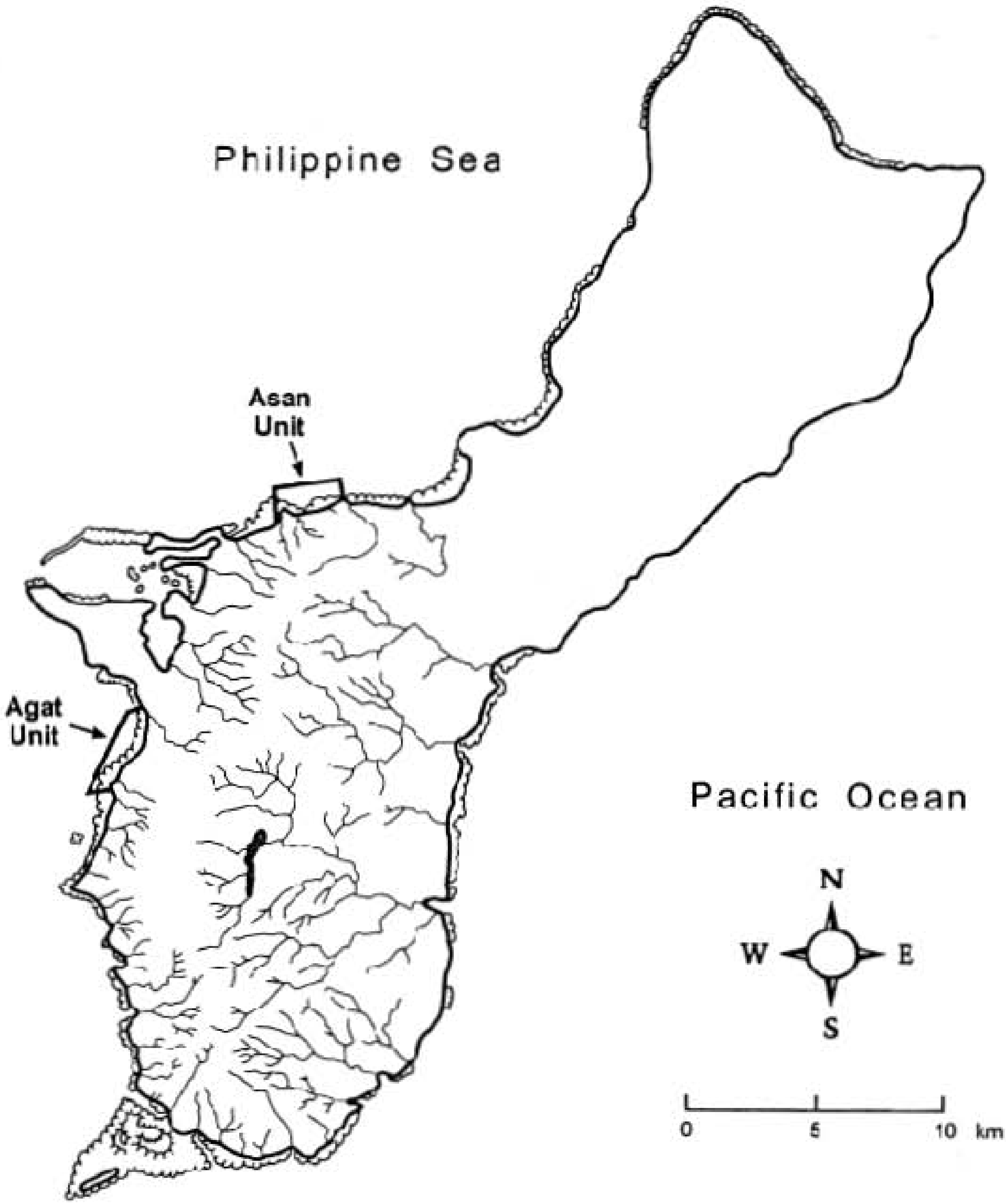
Eldredge, L.G., R. Dickinson, and S. Moras (eds.) 1977. Marine Survey of Agat Bay. Univ. Guam Mar. Lab., Tech. Rept. No. 31, 251 p.

Gawel, M. 1977. Fish. *In*: Eldredge et al. 1977, pp.115-131.

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

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, Guam. 330 p.

Tsuda, R.T. 1977. Marine flora. *In*: Eldredge et al. 1977, pp. 132-142.



Map 1. Guam, with locations of Asan and Agat survey areas.