draft
2006

Coastal Ecological Assessment for American Samoa: Water Quality

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The sampling design for the American Samoa assessment followed the US EPA's National Coastal Assessment approach. Fifty (50) stations were randomly selected in the near coastal waters around the islands of Tutuila, Aunu'u, Ofu, Olosega, and Ta'u, and "near coastal waters" were defined as waters extending up to 0.25 miles from shore. Because the National Park Service was interested in how the waters adjacent to park lands compare to the waters around the Territory in general, approximately half of the stations were located (randomly, of course) within the boundaries of the park. Of the original 50 stations, 49 were visited and sampled during the target sample period (April-August). During that first visit, water hydrography, chemistry, and sediment (when possible) were sampled. Fish were collected for contaminant analysis from all 50 original stations during the September to November window.

Maps of Tutuila and Manu'a, with the water quality sample stations, are presented in Figures 1 and 2, respectively.

Field Methods

Field methodology followed the NCA protocols (US EPA 2001). Every attempt was made to get to the target location (± 0.02 nautical miles, or 37 ft), but often we had to sample outside of that target for safety reasons. In some cases, the station was too close to shore and located in the breakers. In other cases, at Manu'a for example, the station was just off the coastal shelf and the rapid bottom drop off precluded setting an anchor. Every effort was made in these circumstances to avoid introducing bias into the station location (e.g., always moving the boat landward, or only doing stations less than 30 deep).

After reaching a station, the anchor was set, and the coordinates of the station were recorded. Station depth was also recorded. Water hydrography parameters (temperature, salinity, pH, dissolved oxygen) were measured using a YSI 6600 EDS data sonde at the surface, at 1 meter intervals down to 5 meters, and then at every 5 meters thereafter. Readings were taken at the same depth intervals when pulling the sonde up to the surface for quality assurance purposes. The sonde cable was less than 30 meters in length, so the deepest measurement recorded during our field survey was 25 m (82 feet). After hydrography readings, we measured light penetration using a LiCor light meter. Light intensity was measured at the surface and at equivalent depth intervals on the down and up casts. A Secchi disk reading was collected. Our disk cord was only 25 meters long, so anything beyond this was reported as >25 m. Water samples were collected using a Niskin bottle at the surface, mid water column, and bottom (up to 25 m). When the depth exceeded 25 m, we collected the mid water column at 12 m. In very shallow stations (< 1m), we sampled the water midway in the water column. For stations around Tutuila, water returned on the first cast from each depth was poured into sterile 100 mL plastic bottles for bacterial analysis (*Enterococcus*). Bacterial samples were not collected for stations around Manu'a due to equipment and holding time restrictions. Remaining water

from initial and any subsequent casts at each depth were pooled in clean plastic containers and stored in ice chests until processing in the laboratory. After water sampling was complete, a benthic grab (modified van Veen of 0.04 m^2 area) was dropped to collect available sediment. Multiple grabs were attempted, and if sediment was collected it was homogenized in a clean plastic tub and partitioned in to sample jars (glass for organic analysis, plastic for total organic carbon and sediment grain size). Sediment samples were also stored on ice and kept refrigerated until analysis. When depth was shallow (<1 m), we collected sediments via snorkeling.

Laboratory Methods

After returning to the lab, stored water was processed for total nitrogen (TN) and phosphorus (TP), nitrite+nitrate (NN), ammonium (NH_4), phosphorus (PO_4), and silica (Si). Whole water samples (60 mL) were collected for TN and TP determination, and 60mL of water filtered through a GF/F (Whatman) was collected for NN, NH_4, PO_4, and Si quantification. Large volumes (> 1 L) of water were filtered using a vacuum filtration system to measure both chlorophyll a and total suspended solids, and the volume was recorded. Filter papers with residual pigment or sediment on them were frozen until analysis, and processed water samples were also frozen until laboratory analysis. For the Tutuila samples, *Enterococcus* was enumerated using Enterolert following standard ASEPA laboratory methods.

Data Analysis

Water hydrography data were averaged across all depth measurements to determine the average value for a station, and that value was compared directly to the ASWQS for that particular location. For the purposes of this analysis, all stations were considered open coastal, with the exception of one station inside the Pago Pago Harbor boundary. The average dissolved oxygen, pH, *Enterococcus* (MPN), and chlorophyll *a* from each station were calculated and compared to the water quality standard. Water clarity was based on an estimate of the depth to which 1% of the light would penetrate. The water quality standard for open coastal waters, for example, requires that light penetration exceed 130 feet 50% of the time. Since we only have one measurement for any particular station, we evaluated water clarity by calculating the depth to which 1% of the light would penetrate, regardless of how deep the station was.

Every parameter for which there is a standard was judged as having complied with the standard or having failed to comply with the standard. A station for which we do not have data for a particular parameter (e.g., because of a probe failure, or a missing sample, or no bacterial samples from Manu'a) is recorded as missing. Each sample station has a representative weight, and the areal estimates are weighted estimates complete with 95% confidence limits. For every parameter, then, we have an estimate of the area of Territorial coastal waters that pass or fail the standard, as well as an estimate of the area for which we have no data.

Results

Hydrography None of the stations that we sampled failed to attain the water quality standard for dissolved oxygen, pH, and *Enterococcus*. For dissolved oxygen, there were no data for 7 of the 49 stations, and we calculate that 83 ± 13.3% of the Territorial waters meet the dissolved oxygen standard. 100% of all the sampled stations satisfy the water quality standard for pH. All of the Tutuila sites satisfied the bacterial indicator standard, and we can calculate that 63 ± 16.1% of the overall Territory satisfies the standard, while data for the other 37% of the Territory are missing. The summary figures for dissolved oxygen, pH, and *Enterococcus* are Figures 3 through 5, respectively.

Chlorophyll a and water clarity showed slightly different results. For Territorial waters, 68 ± 16.1% complied with the chlorophyll standard, while 32 ± 16.1% failed to comply with the standard. For water clarity, 58 ± 6.6% of the Territorial waters complied with the standard while 37 ± 16.6% failed to comply. Data were missing for 5% of the Territorial waters. Of the 13 sites that failed to meet the chlorophyll standard and the 19 stations that failed to meet the clarity standard, only 4 of those stations failed to meet both, implying that high chlorophyll is not generally the cause of low clarity. The summary figures for chlorophyll a and water clarity are shown in Figures 6 and 7, respectively.

What does it mean?

These data show that the water quality parameters around the Territorial coastline (excluding Rose and Swain's) generally comply with the ASWQS. We expected this. The only parameters that failed to comply with the standards are chlorophyll *a* and water clarity. It is difficult to understand why this might be the case. Many of the stations that exceeded the chlorophyll standard were on the north shore of the island, both inside and outside the area of the National Park. There were no egregious violations of that standard; the average chlorophyll concentration in samples that exceeded the standard was 0.40 µg/L. Furthermore, only 4 of the sites that failed the chlorophyll standard actually failed the water clarity standard as well, suggesting that other aspects of turbidity (e.g. suspended sediments) must be responsible for reduced light penetration. Whether this signifies some localized eutrophication can not be addressed with these data.

References

U.S. EPA. 2001. National Coastal Assessment: Field Operations Manual. U. S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72

Figure 1. Map of Tutuila showing the sample locations for the coastal water survey, 2004.

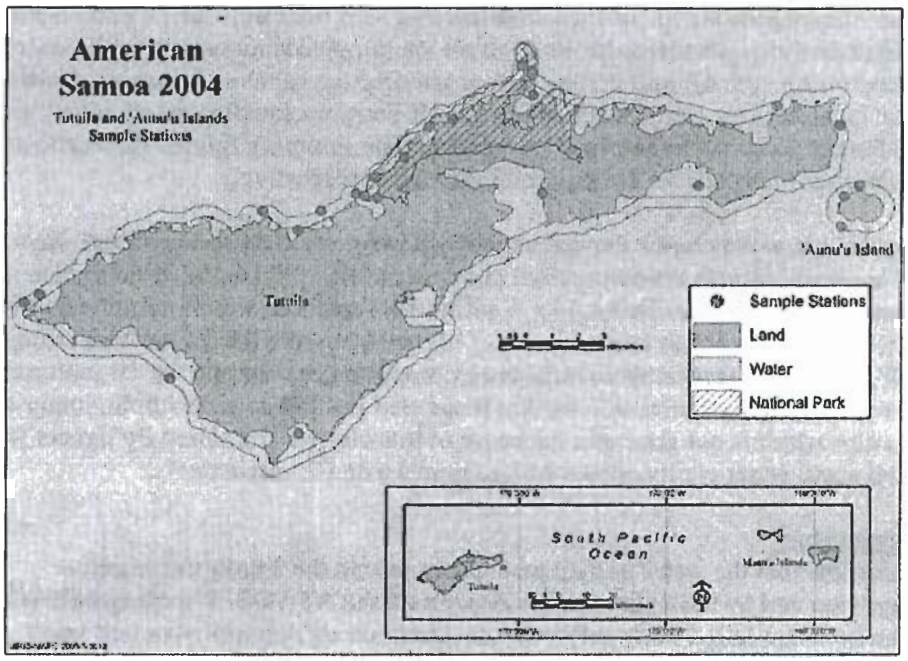

Figure 2. Map of Manu'a showing the sample locations for the coastal water survey, 2004.

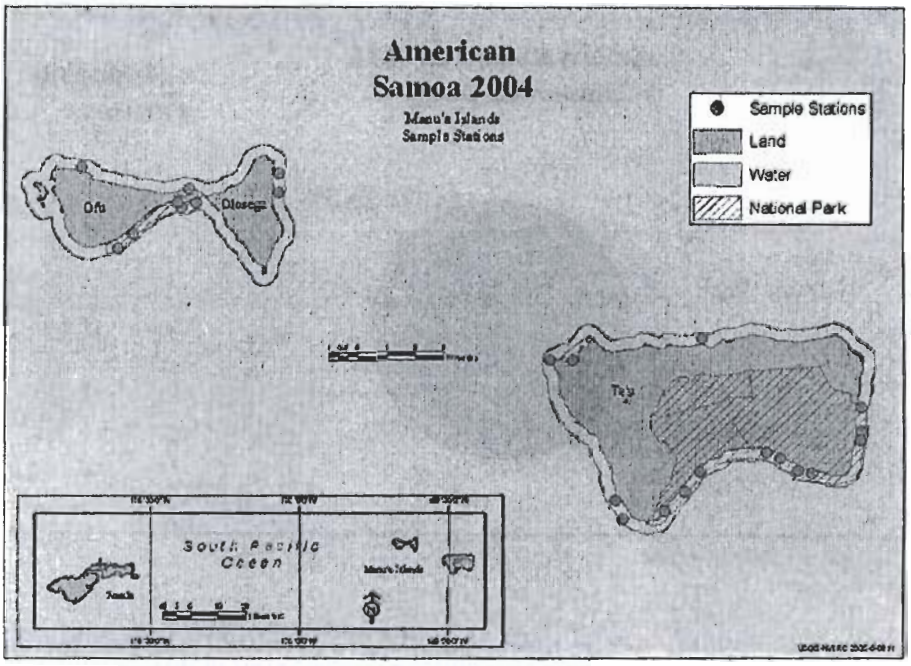

Figure 3. The percentage of Territorial waters that either comply with the Territorial water quality standards for dissolved oxygen, fail to comply with those standards, or for which data are unavailable.

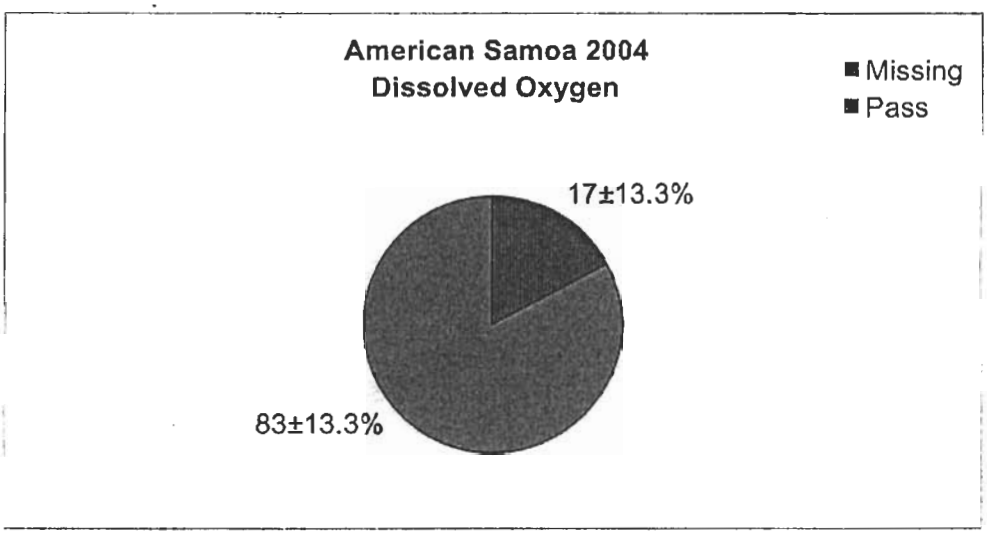

Figure 4. The percentage of Territorial waters that either comply with the Territorial water quality standards for pH, fail to comply with those standards, or for which data are unavailable.

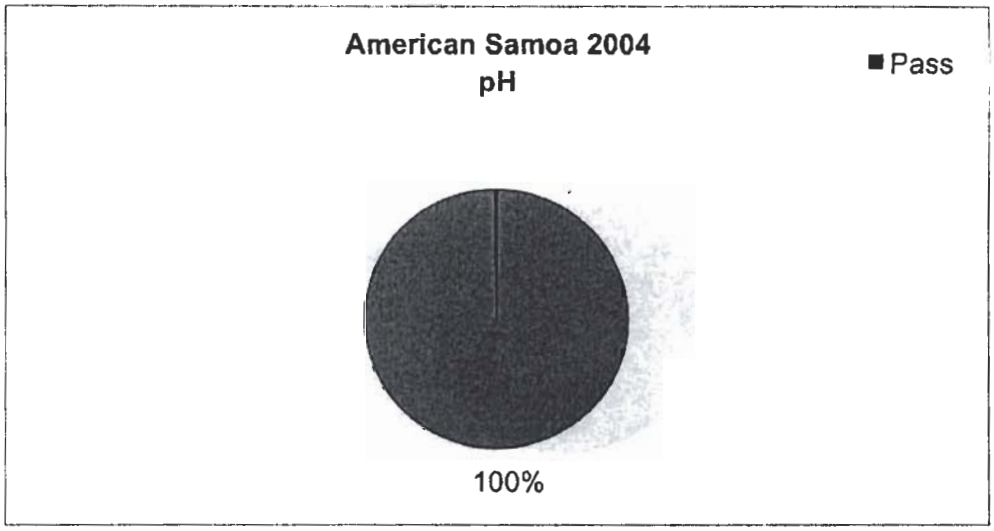

Figure 5. The percentage of Territorial waters that either comply with the Territorial water quality standards for *Enterococcus*, fail to comply with those standards, or for which data are unavailable.

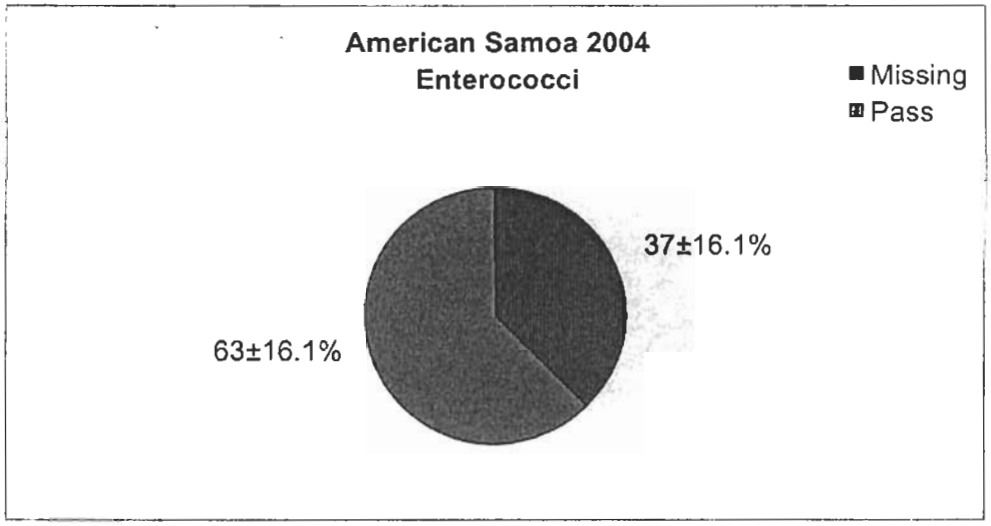

Figure 6. The percentage of Territorial waters that either comply with the Territorial water quality standards for chlorophyll *a*, fail to comply with those standards, or for which data are unavailable.

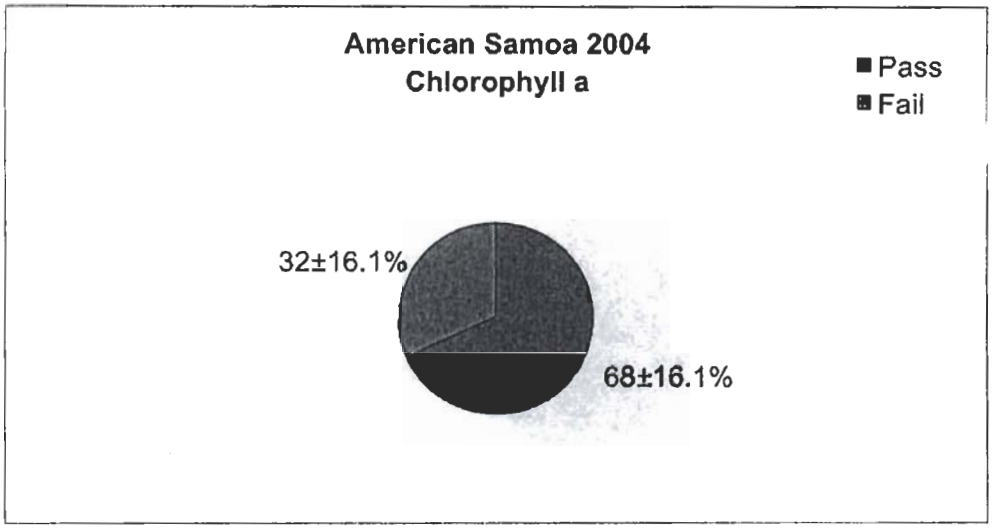

Figure 7. The percentage of Territorial waters that either comply with the Territorial water quality standards for water clarity, fail to comply with those standards, or for which data are unavailable.