

Using the National Coastal Assessment Methodology to Evaluate the Water, Sediment, and Fish Tissue Quality of American Samoa's Near-Shore Marine Resources

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Introduction

American Samoa, located in the South Pacific approximately 4,500 kilometers south-southwest of Hawaii, is the southernmost United States Territory. The Territory consists of five volcanic high islands (Tutuila, Aunu'u, Ofu, Olosega, and Ta'u) and two atolls (Rose and Swains), with a combined land area of nearly 200 square kilometers). The climate is tropical, with warm temperatures year-round. The year is divided into a dry season (June to November) dominated by the Trade winds and a wet season (November to May). Tutuila, the largest and westernmost of the high islands, receives up to 650 centimeters of rain annually.

Since 1980, human population in the Territory has increased from approximately 35,000 to over 60,000, over 95% of which lives on Tutuila. This population growth rate (approximately 1.8% per year) is a major concern to the islands of American Samoa as land use impacts pose a threat to limited island natural resources, including near shore shallow water habitats.

Quality environmental monitoring is a logistically and financially challenging endeavor. For this reason, the National Park of American Samoa (NPSA) developed partnerships with the American Samoa Environmental Protection Agency (ASEPA) and the United States Environmental Protection Agency (USEPA) to conduct a Territory-wide ecological assessment in 2004. Each party benefits greatly from the collaboration. For instance, ASEPA gets data that can be used for 305(b) reporting needs and can provide a robust summary of the status and condition of Territorial waters to the USEPA. NPSA obtains water quality monitoring data that can be used for the park's Vital Sign and Coral Reef monitoring programs. Before this survey, there had never been a comprehensive near shore water quality assessment effort for either NPSA or the Territory. A significant benefit to all parties is the identification of emerging environmental concerns, particularly water quality, in this remote island Territory.

This assessment utilized the Environmental Monitoring and Assessment Program (EMAP) protocols and a probabilistic design. This design relies on random sample locations to attain an unbiased estimate of environmental condition. Fifty (50) randomly-selected sites in Territorial coastal waters (defined as waters extending out ¼ mile from shore) were targeted for water, fish, and sediment collection. Of these 50 stations, approximately ½ were constrained to within park boundaries, while the other ½ were cast around the Territorial waters. It is important to recognize that this probabilistic study design is intended for assessing the resource and does not allow for statements of causality. Instead, it is our hope that these data will first and foremost assist Territorial Resource Managers in further understanding their resources, as well as inspire future research questions and necessary investigations.

Methods

Sampling Design

This study utilized a probabilistic design. This design was used because it provides a scientifically and statistically rigorous way to sample a subset of a habitat (in this case, the near-shore coastal waters of the American Samoa archipelago) and subsequently generates estimates describing the status or condition with regard to specific indicators for the entire population along with a measurable level of uncertainty. Fifty stations were randomly selected for sampling in the near-shore environment of the 5 high islands (Tutuila, Aunu'u, Ofu, Olosega and Ta'u). The near-shore coastal resource, also known as the target resource, was defined as all near-shore coastal waters, including all embayments, extending out to ¼ mile off-shore. The ¼ mile standard was selected because that is the distance that the National Park of American Samoa typically extends into the ocean. The resource was further divided into waters included in the National Park Service boundaries (hereafter called "NPS waters") and Territorial waters. Within those habitat strata, approximately half were cast in each stratum to represent that habitat. Figures 1 and 2 show the target resource and the randomly selected stations. Data from these stations were used to estimate environmental condition for the larger Territory; furthermore, the stratified design allowed a comparison of condition (e.g., water quality) within the boundaries of the National Park of American Samoa to the larger Territory.

Field Methods

Field methods for this survey were guided by the USEPA's National Coastal Assessment Field Operations Manual (2001). Due to some logistical issues based on the location of the survey, acceptable alternatives to standard field methods were developed by the Principal Investigators in consultation with USEPA. Prior to collecting any field samples, required permits were obtained from the American Samoa Government Department of Marine and Wildlife Resources, and village Pulenu'u (mayors) were contacted for permission to sample in their village waters.

Station Observations Once on station, information was recorded in order to document the station visit and characterize the habitat. The station visit was documented with the official station name, water body name, date, arrival and departure times, and crew names. Habitat was characterized using information on station depth, GPS location, weather conditions, habitat type and types of marine debris present, if any. A replica of the Station Form is provided in Appendix A.

Water Column Parameters All water column samples and measurements were collected/taken prior to sediment collections to avoid contaminating samples with resuspended sediments. At each site a vertical hydrographic profile was collected using a YSI 6000 series datalogger. Parameters such as dissolved oxygen (mg/l), pH, temperature, and salinity were recorded at the surface, every meter down to 5 meters, then every 5 meters to near bottom or to the end of the field cable (25m), whichever came first. For sites with a depth of 1-2m, a surface and bottom reading were taken, and for

sites that were < 1m in depth, one reading was taken at mid-depth (USEPA, 2001). Profile readings were recorded twice: once on the downcast and again on the upcast. Water column light penetration data were collected using a LiCor LI1000 which measured near-simultaneous light readings using a sensor on the deck (ambient light) and an underwater sensor. Light readings were taken at the same depth locations as the hydrographic data using the YSI datalogger. Secchi depth was also noted at each station. A replica of the Hydrographic Profile Form is provided in Appendix A.

Water chemistry samples were collected at each station using a Niskin bottle. Samples were taken at approximately 0.5m below surface, mid-water column, and approximately 0.5m above bottom. For stations with a depth of $\leq 1\text{m}$, a single sample was taken at mid-depth; for stations between 1m and 2m, a sample was taken approximately 0.5m below surface and approximately the same distance above bottom. An example Water Sample Collection Form is provided in Appendix A. Water samples were taken in the field and stored on ice in a closed container until returned to the laboratory and processed. All samples were processed within 5 hours of collection. Water samples were analyzed for a standard suite of analytes: ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), urea, phosphate (PO_4), dissolved silicate (Si), total nitrogen (TN), total phosphorus (TP), chlorophyll a (Chl a) and total suspended solids (TSS). For the purposes of this report, we summed NH_4 , NO_2 and NO_3 together to estimate dissolved inorganic nitrogen (DIN). Phosphate is considered dissolved inorganic phosphate and will hereafter be referred to as DIP.

After samples were processed using standard protocols (USEPA 2001), they were frozen until shipped to the USEPA laboratory in Gulf Breeze, Florida. From American Samoa, this meant shipping frozen samples on ice overnight to Hawaii where samples were picked up the next morning by a contracting laboratory and held frozen until they were repackaged and shipped with dry ice to Florida via Federal Express.

Water samples were also collected for enumeration of *Enterococcus*. These samples were collected at all depths where chemistry samples were collected, but only at stations around the islands of Tutuila and Aunu'u. This sampling was not possible for the Manu'a Islands (Ofu, Olosega and Ta'u) due to logistical constraints of sample holding time.

Sediment Sediment samples for chemical and grain analyses were collected via two methods. The method of choice was dropping a petit-Ponar grab from the boat and processing the collected sediments using standard methods (USEPA 2001). However, because of the volcanic nature of the islands, only a few of the stations were in areas where sediment samples could be collected using a grab sampler. At very shallow sites close enough to shore to be accessed by wading, sediments were scooped directly into a stainless steel bucket using a stainless steel spoon. Any and all sediments collected, either by grab or via wading, were homogenized and apportioned to the appropriate sample containers following standard protocols (USEPA 2001). An example Sediment Sample Collection Form is provided in Appendix A. Sediments collected were analyzed for a standard list of common sediment contaminants (Table 1).

Benthic Community Benthic community data were not included in this assessment for two reasons. First, sample collection can be very difficult. The boat-deployed grab used in estuarine surveys is ineffective at many stations because of the substrate (see above), so alternative methods for collecting benthic samples must be used. The State of Hawai'i used SCUBA collections as part of their sampling methodology. For the survey in American Samoa, however, the small staff dedicated to the field portion of this project, and the depth of many of these stations, made using SCUBA infeasible. Second, even if benthic samples could be collected, a meaningful benthic community index has not been worked out for these islands, and interpreting those data would be difficult.

Fish Tissue Collection Fish samples were collected at each station using hook and line methods. A list of mid-trophic level fish species (e.g., grouper and snapper) was generated and used as a 'target' species list for collections (Table 2). At each station, a catch of three to five individuals (minimum total length 6"- maximum total length 12") from the species list was targeted. If fishers were unable to catch fish from the target list at any given station they were asked to obtain three to five individuals of any species caught in the size class given. If after 90 minutes of fishing no target fish were caught at a specific station, no further attempts were made at that station. Each individual fish was identified to species and measured for total length. Fish were then rinsed with site water and placed in a plastic Ziploc-type bag labeled with the station information. All fish were held on wet ice in the field until they were transferred to shore where they were hard-frozen. Maximum holding time in the field was eight hours. Efforts were made to insure that fish were not contaminated or cut during processing. From each station, all individuals of one selected species were pooled and analyzed for 81 chemical contaminants in whole-body tissue by an EPA contracted laboratory. Of those 81, 16 contaminants were examined closely for their concentrations in collected fish tissues (Table 3). These 16 contaminants are listed as target analytes for fish sampling programs (USEPA 2000). This report will not use any of these fish contaminant data to evaluate consumption limits; this has been done elsewhere (Peshut and Brooks 2005). Instead we only use these contaminants as benchmarks to evaluate the potential exposure of fish to persistent environmental contaminants.

Summary Methods

Water Quality Water quality data from each station, when applicable, were first averaged across all depths to get a station average. The coefficient of variation (CV), a measure that standardizes the variability relative to the mean and is expressed as a percentage, was calculated to provide an indication of the within-station variability. Summary data from all stations were next averaged to provide a water quality summary for the Territory as a whole. These same data were also pooled within the two sampling strata (NPS waters, Territorial waters) and compared using a nonparametric Kruskal-Wallis test.

Beyond the basic statistical summary, we further evaluated the water quality data using summary and analytical methods similar to those used for other coastal surveys (e.g., Macauley et al. 2002). In this case, the water quality data were analyzed using two different sets of criteria. First, the overall Territorial assessment and the NPS-Territory

comparison were done using the water quality standards (1999 version) outlined by the American Samoa Code Annotated (ASCA) for the appropriate coastal environments. These standards are used to determine if coastal waters are in compliance and are considered pass/fail determinations. The ASEPA uses these standards to prepare its 305(b) report to the US Congress on the status of Territorial waters, and the standards as they apply to the data collected for this study are listed in Table 4. Most stations were considered Open Coastal Waters. Station 8 was located within Pago Pago Harbor; harbor standards applied to that site only. All samples collected at a station were averaged, and if the calculated value exceeded (was below or was outside the range of) the ASEPA standard, the station was out of compliance. Water clarity is an important component of coastal water quality (Smith et al. 2006), and the American Samoa standards have specific requirements for clarity. The ASCA requires that light penetrate coastal waters to a certain depth (65 feet within Pago Pago Harbor, 130 feet in open coastal areas; Table 4). In order to evaluate whether light would penetrate to that depth (assuming the station were that deep), we calculated the light extinction coefficient that would allow for 1% penetration at the required depth. We next calculated the necessary percent transmission at the bottom of each station that would leave 1% light at the required depth. This number was compared to the measured percent transmission. If the measured value exceeded the estimated value, then the station complied with the standard (that is, light would reach the target depth). If the measured value was less than the estimated value, the site failed.

The second set of criteria used to evaluate these data were those used by the USEPA National Coastal Assessment (NCA) for tropical estuarine ecosystems. These criteria have been peer reviewed by scientists in various regions and have been applied to assessment data from Puerto Rico and Hawaii (National Coastal Condition Report II, USEPA 2004) and are also intended for use in assessments for American Samoa, Guam, Saipan and the US Virgin Islands. These criteria classify a station as Good, Fair, or Poor. We felt it useful to analyze these data using a framework that was more detailed than simply pass/fail and instead may allow a more nuanced view of water quality. The levels for the tested water quality indicators are presented in Table 5. Following NCA criteria, water clarity was evaluated as the percent transmission at 1 m.

Lastly, we compared the station quality within NPS waters to the quality of Territorial waters by calculating the percentage of stations sampled within each stratum that showed a certain assessed level (using both sets of criteria). We also calculated the confidence interval for that proportion using standard techniques (<http://davidmlane.com/hyperstat/B9168.html>).

Sediment Contaminants For many of the stations, there was no sediment collection due to extensive hard bottom habitats around the station. What sediment was collected, though, was analyzed for 82 individual analytes (Table 1). These analytes comprised 4 classes of contaminant: metals, polycyclic aromatic hydrocarbons (PAHs), poly biphenylchlorides (PCBs), and pesticides.

For the purposes of this report, sediment contaminant data were summarized by calculating the concentration (average, minimum, and maximum) of individual

parameters. When a concentration was below the minimum detection limit (MDL), a concentration of 0 was used in all calculations. Chemical concentrations were compared to the effects range-low (ERL) and effects range-median (ERM) values published by Long et al. (1995). The ERL for each contaminant is the threshold level below which biological effects are rarely observed, while the ERM is the threshold level at which toxic biological effects are often (50%) observed. Furthermore, we calculated the percent of the overall coastal area that was represented by the contaminants that exceeded either the ERL or ERM.

Fish Tissue Contaminants We summarized the chemical contaminant data for the fish tissue samples by calculating the species averages (minima and maxima) of the 16 priority contaminants (Table 2; USEPA 2000). We further tabulated across species and stations for any of the priority contaminants with unusually high concentrations. We also calculated the estimated percent of the overall coastal area characterized by fish contaminants that exceeded those fish tissue guidelines.

Results and Discussion

Water Quality Of the 50 target sites (Figures 1 and 2), we collected water quality data at 49 of those stations; there were no water quality data collected at station #41. The average value for each parameter collected at each station is provided in the Appendix (Appendix B, Tables B2 through B4). Using the station averages, the overall averages, maxima, and minima were calculated across all 49 stations. Those data are provided in Table 6. Briefly, station dissolved oxygen levels in coastal waters are good, averaging 7.17 mg/L and never going below 6.5 mg/L. PH, for which there was a coastal standard, averaged 8.01. Both DO and pH showed a significant negative correlation with station depth.

DIN averaged 0.0122 mg/L, ranging from 0.0065 to 0.0265 mg/L. Nitrate was generally the largest fraction of the DIN (comprising approximately 50%) in American Samoa coastal waters. But overall, the fraction of dissolved inorganic nitrogen compared to the total nitrogen in the water was low, averaging only 11.1% and comprising at most 28% of the total N pool. This was similar to results from a recent survey done in selected coastal areas of American Samoa. That survey found that DIN averaged ca. 10% of the TN in bottom marine waters (Hansen et al. 2006). Urea, the only measured organic N constituent, was similarly low, typically equaling the DIN total at each station. DIP averaged 0.0115 mg/L across all stations. Furthermore, the DIP fraction was nearly 100% of the TP pool across all stations. Hansen et al. (2006) found that DIP comprised on average 61% but up to 94% of the TP in marine waters. These two studies suggest that the majority of nitrogen in marine waters around American Samoa is organic while the majority of phosphorus in those same waters is inorganic.

If station depth is used as a proximate measure for distance from shore (that is, stations closer to the islands are in general shallower than those stations farther from the islands), the concentrations of most parameters do not vary with distance from shore. However, there are a few exceptions. Both DO and pH were higher at shallower stations. DO in

particular was highest (between 8-10 mg/L) at stations that were <2 m deep. Craig et al. (2001) documented the wide DO fluctuations at the shallow Ofu Lagoon. Furthermore, there was a significant relationship between the average DIN concentration and the station depth (Figure 3). This result implies a significant concentration gradient in DIN from shore.

There was no difference between the two strata (NPS waters and Territorial waters) for most of the parameters. Indeed, the distributions of DO, DIP, and TSS were equivalent at stations representing the park and the Territory. There were differences between the pH and DIN, with NPS sites having lower values than those outside the park. However, both of these differences were mediated by a significant difference in station depth; that is, there was a significant gradient across depth (see above, Figure 3). Once the effect of depth was removed as a covariate, there was no difference between the two strata. Lastly, there were differences in 3 parameters (Chl a, TN, and TP). Sites within NPSA boundaries had lower Chl a and TN but higher TP values than stations representing the larger Territorial waters (Figure 4). In fact, the stations with the highest TP levels (0.016 mg/L) are stations #1, 2, and 4. These stations are located along the north shore of Tutuila (Figure 1) near the Pola. There is a significant population of boobies living on the Pola, and the high TP values may reflect the input of guano. Guano can be a significant input to marine ecosystems and can have significant impacts on marine ecological processes (Bosman and Hockey 1986).

Water Quality Assessment Summary

Assessment Results using Territorial Standards

The results of the overall assessments using the Territorial water quality standards (Table 4) are presented in Figure 5, and results for specific sampling stations are detailed in Appendix C (Figures C1 – C7). Only the results for pH, for which all of the samples collected complied with the standard (that is, 100% of Territorial waters complied with the standard), are not shown in Figure 5. All *Enterococcus* samples collected around Tutuila and Aunu'u comply with Territorial standards and this represents 64% of Territorial Waters. For DO, all samples collected comply with the Territorial standard, although there were several stations that did not have DO data. We calculate that this represents 81% of the Territory. Chl a and water clarity showed slightly different results. For Territorial waters, $66 \pm 18\%$ of the Territory complied with the chlorophyll standard, while $34 \pm 18\%$ failed to comply with the standard. For water clarity, $54 \pm 18\%$ of the Territorial waters complied with the standard while $42 \pm 7\%$ failed to comply. Clarity data were missing for the remaining 4% of Territorial waters. Of the 13 sites that failed to meet the chlorophyll standard and the 20 stations that failed to meet the clarity standard, only 5 of those stations failed to meet both, implying that high chlorophyll is not generally the cause of reduced clarity. In fact, the overall total suspended solids (TSS) value for waters that failed the clarity standard was significantly higher (3.45 ± 0.22 mg/L) than at stations that passed the clarity standard (2.99 ± 0.16 mg/L), implying that TSS may be a significant factor in water clarity at the station level and may be a significant problem Territory-wide. Nutrient standards were assessed for TN and TP. For

Territorial waters, $72 \pm 17\%$ complied with the TN standard, while $21 \pm 10\%$ failed to comply with the standard. In addition, $92 \pm 10\%$ complied with the TP standard, while $1 \pm 10\%$ failed to comply with the standard. Approximately $7 \pm 10\%$ of the Territory did not have data for either TN or TP.

Assessment Results using NCA Criteria

Using National Coastal Assessment criteria for tropical estuaries, 5 individual water quality parameters were assessed; then a composite “Water Quality” parameter was evaluated based on those previous assessments. These results are shown in Figure 6, and results for specific stations are presented in Appendix C (Figures C8 – C13).

Stations representing $22 \pm 16\%$ of the Territory were missing dissolved oxygen data. For those stations having DO data, all values ranked ‘Good’; this equaled the remaining $78 \pm 16\%$ of the Territory. For chl a, $93 \pm 10\%$ of the Territory ranked ‘Good’ and $7 \pm 10\%$ ranked ‘Fair’. For water clarity, based on the % light transmission at 1 m depth, $85 \pm 13\%$ of Territorial waters ranked ‘Good’; $11 \pm 7\%$, ‘Fair’; and $4 \pm 1\%$, ‘Poor’. There was a small portion (0.4 %) of the Territory for which data were missing. Using the NCA criteria for DIN, all stations ranked ‘Good’; however, an overwhelming amount of Territorial waters ($84 \pm 12\%$) ranked ‘Poor’ for DIP, while only ($16 \pm 12\%$) ranked as ‘Fair’.

In order to determine the overall Water Quality Index Rating for the Territory, USEPA’s criteria were used (this report, Table 4; general methods following National Coastal Condition Report, 2004). Since overall $12 \pm 12\%$ of the Territory ranks ‘Good’, $84 \pm 7\%$ of the Territory ranks ‘Fair’, and $4 \pm 7\%$ ranks ‘Poor’, the overall water quality index rating for the Territory is ‘Fair’.

There are few data on coastal water quality for tropical and/or subtropical island systems. The State of Hawai’i completed in 2002 a comprehensive survey of estuarine resources; however, those data are not yet available in a summarized format. Puerto Rico completed an assessment in 2000, and the results of that assessment are summarized in the NCCR II (USEPA 2004). The NCA survey of Puerto Rico (PR) targeted estuaries, while our survey targeted coastal waters (out to $\frac{1}{4}$ mile, including embayments). Because of the slightly different target, we would expect a better assessment from the coastal waters of American Samoa. However, the overall Water Quality Index from PR has 35% of the estuaries in ‘Good’ condition, 54% in ‘Fair’ condition, and 9% in ‘Poor’ condition. In AS, 84% of the coastal waters are in ‘Fair’ condition, while 12% and 4% are in ‘Good’ and ‘Poor’ condition, respectively. For the most part, this difference in the overall assessment is being driven by the high DIP levels in the waters around American Samoa. Since 84% of the Territory ranked as ‘Poor’ (Figure 6), at least that same percentage of the Territory will have an overall ‘Fair’ Water Quality ranking. The PR assessment instead is not driven by the results of one particular parameter; instead, several parameters show that significant proportions ($>20\%$) of the island’s estuarine resources are considered ‘Poor’ (USEPA 2004). More comparisons will be possible when Hawai’i and the Mariana Islands complete and report their survey results.

Comparison of National Park and Territorial Assessment Results using Territorial Standards

Using the ASEPA standards, there was very little indication of differences in the status of the 2 target strata (Territorial and NPS waters). The comparisons for the evaluated parameters are shown in Table 7. In general, confidence intervals are relatively large, and the degree of overlap suggests no statistically significant differences. For 2 parameters, however, the results of this summary support the results of the earlier comparison between NPS waters and Territorial waters. Specifically, the TN concentration in Territorial waters is significantly higher than NPS waters. Indeed, 91% ($\pm 12\%$) of NPS stations pass the ASEPA standards for TN, while only 70% ($\pm 17\%$) pass for the Territory as a whole. While these are not significantly different (i.e., there is overlap between the confidence intervals), their divergence mirrors the results of the earlier comparison (Figure 4). TP, on the other hand, is higher in NPS waters than in the Territorial waters. The percent of NPS stations that pass the ASEPA standard is 86% ($\pm 14\%$), while 93% ($\pm 10\%$) Territorial stations pass. While there is still a great deal of overlap in the confidence intervals, the result does support the earlier result of significant differences in TP concentration between samples collected in NPS and Territorial waters (Figure 4). The reason for these differences is unclear at this time; however, it could result from the larger populations of seabirds in NPS waters. Both the north side of Tutuila and the south side of Ta'u have substantial populations of seabirds; whether these are different from other areas within the Territory is unknown to us.

Comparison of National Park and Territorial Assessment Results using NCA Criteria

Using the NCA criteria for tropical estuaries, there was very little indication of differences in the status of the 2 target strata (Territorial and NPS waters). The comparisons for the evaluated parameters are shown in Table 8. In general, confidence intervals are relatively large, and the degree of overlap suggests no statistically significant differences in assessed condition.

Sediment Contaminants Of the 49 stations visited, sediments were collected at 16 stations, but there was only enough sediment material to analyze for 13 of those stations (Appendix B, Table B1). In general, there were no detectable levels for PAHs, PCBs, or pesticides; however, most sediment samples had metal levels well above the MDLs. The only metals that did not consistently equal or exceed the detection level were silver (Ag), cadmium (Cd), selenium (Se), and mercury (Hg). While the first three were undetected in all samples, Hg was detected at 8 of the 13 stations. Metal averages, minima, and maxima are presented in Table 9.

Of note, 3 metals were present in sediments at levels that exceeded established thresholds of interest. Arsenic (As) was detected at all stations (average concentration = 4.26 mg/kg, range = 0.84 to 16.3), but three stations (#11, 16, and 17) showed concentrations that exceeded the published ERL level of 8.2 mg/kg. Concentrations were 11.3, 9.3, and 16.3 mg/kg, respectively, at those stations. Sediment chromium (Cr) was detected at all

sampled stations as well, and average levels were 16.4 mg/kg (range = 0.79 to 90); the concentration at station #30 was 90 mg/kg, which exceeded the ERL of 81 mg/kg. Nickel (Ni) was detected at all stations in amounts ranging from 0.64 to 83.9 mg/kg, with an average concentration of 18.8 mg/kg. At two stations (#17, 36), though, the Ni concentration was 35.6 and 21 mg/kg, respectively, and both exceeded the ERL (20.9). Two other stations (#11, 30) had concentrations (62.7 and 83.9 mg/kg, respectively) that exceeded the ERM of 51.6 mg/kg. At the time of this writing, there was no data available on the sediment grain size or total organic carbon content. Sediments collected at deeper sites like stations #11, 16, and 17 were generally finer with more organic material. Sediments collected at shallow stations like #30 and 36 were generally composed of course sands. In terms of the overall percentage of the Territory, 7% and 6% of the Territory had 1 or 2 metals, respectively, that exceeded the ERL level. Only 4% of the Territory was represented by samples that exceeded the ERM level. While this suggests a low level of sediment contamination in the Territory, 68% of the Territory is not represented by any sample (significant hard bottom habitat). Furthermore, there was only 1 station within the boundaries of Pago Pago Harbor. This area is known to have significant sediment contamination from previous military and industrial usage.

The level of these metals at all sampled sites suggests that natural sources may be important in determining metal concentrations around the Territory. However, natural weathering or atmospheric deposition (common sources of metals) may not explain the higher levels of those metals found at specific sites. Instead, there may be some anthropogenic sources. Anthropogenic sources of arsenic can be sewage sludge, urban runoff, atmospheric deposition and treated wood used for piers, pilings and bulkheads. Anthropogenic sources of chromium include domestic waste water effluents and ocean dumping of sewage. Domestic waste water is a possible anthropogenic source of nickel along with waste streams from households and businesses, water treatment chemicals from wastewater treatment, and landfill leachate. The fact that the concentrations of these metals exceed the ERL and/or ERM values may merit further attention in the form of more intensive sampling (Agency for Toxic Substances and Disease Registry 2000, 2005a, b). Of particular interest are stations #30 and 36. Both of these are in waters around the less-populated Manu'a islands; station #30 is within NPSA's Ofu segment while #36 is adjacent to Faleasau.

Fish Tissue Contaminants All stations were visited for fish collection, but we only have data for collections from 47 of those stations (Appendix B, Table B1). There were no fish collected (or data are missing) from stations # 11, 12, and 24. The fish that were processed and examined for contaminants from each station is presented in Table B6 (Appendix B). Table 10 summarizes the results of the priority contaminants listed in Table 2 in the sampled species.

In general, of the priority contaminants, metals were the most often and consistently detected. Arsenic, mercury, and selenium were detected in all of the fish species analyzed. Furthermore, mercury levels in samples of *Aphareus furca* collected at station #26 were much higher (0.387 µg/wet g) than in any other samples (<0.11 µg/wet g). This elevated Hg level also exceeds the guidance levels provided for consumption limits by

the US EPA (2000). In comparison, only a few of the non-metal priority contaminants were quantified in the fish tissue composites. Of those, only Total PAH concentration exceeded the guidance limits set by the USEPA (2000), and that only happened with one composite from one station. The detected concentration of Total PAHs was 62.400 ng/g in *Cephalopholis argus* tissue from station #38. Based on the data for the two exceedances (Hg at #26, Total PAHs at #38), an estimated 4% of the territory's near-shore habitat has fish that contains contaminants at levels that may be unsafe to eat. There are a few interesting spatial patterns that emerge from the fish contaminant data. First, the darkfin hind (*Cephalopholis urodeta*) caught at station #7 and the blacktail snapper (*Lutjanus fulvus*) caught at station #8 were the only specimens to have measurable PCBs in their tissues. PCBs are a persistent contaminant documented in Pago Pago Harbor, and fish caught in the Inner Harbor have high levels of many contaminants, including PCBs (Peshut and Brooks 2005). The only fish to have those in the tissues were caught from the most proximate stations. Furthermore, the only fish to have measurable levels of pesticides in them are the ones caught at stations #7, 8, 10, and 18. Station 10 is off Leone, while station 18 is in Fagasa Bay. The measured pesticides were all congeners of DDT. While none were measured in concentrations to raise concern with respect to human consumption, these data do show that persistent chemicals (especially metals) are bioaccumulating in the tissues of fish around the territory.

General Conclusions

This study is the first broad-scale investigation of the ecological condition of near-shore waters around the main islands of American Samoa. Up to this point, there has been intensive study of Pago Pago Harbor, and piecemeal investigations concerning water quality, reef community dynamics, and fish populations in other parts of the Territory. Our main objective here was to assess the current condition of the territory with respect to certain indicators (water quality, sediment contaminants, fish contaminants), that is, take a broader perspective and draw conclusions about the near-shore area of the larger Territory.

Water quality around the Territory is at least fair and might even be considered good, depending on the criteria used. However, one of the major findings of this study was that DIP levels in near-shore waters are consistently high. Lapointe (1997) proposed nutrient thresholds (DIN: 1.0 μM ; PO₄: 0.1 μM) for oligotrophic marine waters that, when exceeded, might indicate or portend nutrient-related reef degradation. These data show that 11/49 stations (22%) exceed Lapointe's threshold for DIN; however, all 49 stations exceeded the 0.1 μM threshold for PO₄. These data suggest that the source(s) of that PO₄ are to an extent natural (e.g. natural weathering of volcanic rock, seabird inputs); however, there should be significant concern that increasing inputs of nitrogen from anthropogenic activities will influence productivity and increase the likelihood of a shift in near-shore reefs from hard corals to macroalgae.

Coral reefs worldwide are endangered from a myriad of causes, and there is concern that the reefs of American Samoa are threatened by some of those stressors, particularly pollution from land-based anthropogenic activities and overfishing (Craig et al. 2005,

Abraham et al. 2005). While there has been a great debate on the relative importance of these two stressors on marine ecosystems worldwide (e.g., Burkepille and Hay 2006), this assessment can only provide insight into the current status of nutrients in American Samoa near-shore marine waters.

Obviously, the data set on sediment contaminants is very limited, and future efforts on this topic should explore other methods for sediment collection. While limited, the data did show that there was a significant accumulation of some metal contaminants. Some of these contaminants even reached thresholds of concern (ER-L and ER-M, Long et al. 1995). Of greater interest is exploring the potential sources for sediment contaminants found at the stations over in Manu'a. With their small human populations, the Manu'a islands are expected to have good water quality and fewer potential sources for environmental contamination (DiDonato 2004). However, the elevated concentrations of chromium and nickel observed at station #30 in Ofu Lagoon could indicate leachate from a nearby landfill. This topic merits further exploration.

Lastly, the levels of contamination in the collected fish were often low and only rarely reached levels of concern for human consumption. At this time, the contaminant levels in fish around the Territory suggest that the bioaccumulation of toxins is minimal. However, there is bioaccumulation occurring. Sometimes this accumulation is interpretable. For example, there were certain contaminant signatures in the proximity of Pago Pago Harbor that likely indicate that the harbor is a source of these contaminants. The detection of pesticide residues in fish from near the harbor, near Leone, and near Fagasa likely results from pesticide usage in these highly populated areas of the island. However, the two instances where contaminant levels exceeded the thresholds of concern were in composites from around Manu'a. This implies that contamination is accumulating in fish collected from areas outside the harbor. The overall amount of the territory impacted by fish contamination is currently low (ca. 4%); future monitoring should remeasure this to insure that the percent does not increase.

Acknowledgements

The partnership that produced this report was developed from the overlapping vision and shared interests of many people from many different institutions. There are numerous people that we need to acknowledge for the work they did to help make this project possible. Doug Neighbor, former Superintendent of the National Park of American Samoa (NPSA) provided institutional support, encouragement, and guidance from start to finish, without which this project would not have been possible. A big fa'afetai goes to Tui Tasi and Lina Fuamatu (NPSA) for their administrative support throughout the project. Captain Fale Tuilagi (NPSA) worked long, hard days with us in the field and always kept us safe – malo lava! John Macauley (USEPA) proved again to be a real go-to guy by getting necessary field gear to us, managing our samples, and always providing reliable information. Pete Bourgeois (USGS) provided the study design for this assessment and later provided mapping-related assistance. From the ASEPA, Peter Peshut offered valuable feedback and advice on contracts. His daily weather reports were essential to identifying favorable upcoming weather and (if necessary) navigating rough

seas. Edna Buchan (ASEPA) and Carl Goldstein (USEPA) were behind this project 100% from the start. Ms. Buchan provided necessary laboratory space, resources, and staff to accomplish all of this work. The ASEPA laboratory staff, Iose Vaouli, Joe Kim, and Ati Tago, analyzed bacteria samples and assisted in field collections. Lance Smith (UH) assisted with field work while we were in Manu'a. Finally, we thank the Pacific Island Network (Tahzay Jones, Fritz Klasner, Leslie Haysmith, Kimber Deverse, and Darcy Hu) for supporting this project and bringing it to publication.

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Table 1. Complete list of sediment contaminant analytes for benthic sediment samples. Analytes are divided into the 4 major classes of contaminants. See text for details.

METAL	ALUMINUM	PCB	2,2',3,3',4,4',5,5',6,6'-DECACHLOROBIPHENYL
	ANTIMONY		2,2',3,3',4,4',5,5',6-NONACHLOROBIPHENYL
	ARSENIC		2,2',3,3',4,4',5,6-OCTACHLOROBIPHENYL
	CADMIUM		2,2',3,3',4,4',5-HEPTACHLOROBIPHENYL
	CHROMIUM		2,2',3,3',4,4'-HEXACHLOROBIPHENYL
	COPPER		2,2',3,4,4',5,5'-HEPTACHLOROBIPHENYL
	IRON		2,2',3,4,4',5'-HEXACHLOROBIPHENYL
	LEAD		2,2',3,4',5,5',6-HEPTACHLOROBIPHENYL
	MANGANESE		2,2',3,5'-TETRACHLOROBIPHENYL
	MERCURY		2,2',4,4',5,5'-HEXACHLOROBIPHENYL
	NICKEL		2,2',4,5,5'-PENTACHLOROBIPHENYL
	SELENIUM		2,2',5,5'-TETRACHLOROBIPHENYL
	SILVER		2,2',5-TRICHLOROBIPHENYL
	TIN		2,3,3',4,4'-PENTACHLOROBIPHENYL
	ZINC		2,3,3',4',6-PENTACHLOROBIPHENYL
			2,3',4,4',5-PENTACHLOROBIPHENYL
PESTICIDE	ALDRIN		2,3',4,4'-TETRACHLOROBIPHENYL
	ALPHA-CHLORDANE		2,4,4'-TRICHLOROBIPHENYL
	ALPHA-ENDOSULFAN		2,4'-DICHLOROBIPHENYL
	BETA-ENDOSULFAN		3,3',4,4',5-PENTACHLOROBIPHENYL
	DIELDRIN		3,3',4,4'-TETRACHLOROBIPHENYL
	ENDOSULFAN SULFATE		TOTAL PCB
	ENDRIN		
	HEPTACHLOR	PAH	(I)1,2,3-C,D-PYRENE
	HEPTACHLOR-EPOXIDE		1-METHYLNAPHTHALENE
	HEXACHLOROBENZENE		1-METHYLPHENANTHRENE
	LINDANE (GAMMA-BHC)		2,3,5-TRIMETHYLNAPHTHALENE
	MIREX		2,6-DIMETHYLNAPHTHALENE
	O,P'DDD		2-METHYLNAPHTHALENE
	O,P'DDE		ACENAPHTHENE
	O,P'DDT		ACENAPHTHYLENE
	OPDDD+PPDDD		ANTHRACENE
	OPDDE+PPDDE		BENZO(A)ANTHRACENE
	OPDDT+PPDDT		BENZO(A)PYRENE
	P,P'DDD		BENZO(B)FLUORANTHENE
	P,P'DDE		BENZO(G,H,I)PERYLENE
	P,P'DDT		BENZO(K)FLUORANTHENE
	TOTAL DDT		BIPHENYL
	TOXAPHENE		CHRYSENE
	TRANS-NONACHLOR		DIBENZ(A,H)ANTHRACENE
			DIBENZOTHIOPHENE
			FLUORANTHENE
			FLUORENE
			HMW PAH
			LMW PAH
			NAPHTHALENE
			PHENANTHRENE
			PYRENE
			TOTAL PAH

Table 2. Target fish species for whole-body tissue chemical analyses.

Grouper	<i>Cephalopholis argus</i>
	<i>Cephalopholis leopardus</i>
	<i>Cephalopholis urodeta</i>
	<i>Epinephelus fuscoguttatus</i>
	<i>Epinephelus howlandi</i>
	<i>Epinephelus merra</i>
	<i>Epinephelus spilotoceps</i>

Snapper	<i>Aphareus furca</i>
	<i>Lutjanus bohar</i>
	<i>Lutjanus fulviflamma</i>
	<i>Lutjanus fulvus</i>
	<i>Lutjanus gibbus</i>
	<i>Lutjanus kasmira</i>
	<i>Lutjanus monostigma</i>
	<i>Macolor macularis</i>
<i>Macolor niger</i>	

Table 3. Analytes examined in fish tissues.

ALPHA-CHLORDANE

ARSENIC

CADMIUM

TOTAL DDT

DIELDRIN

ENDOSULFAN (SUM:SULFATE,I,II)

ENDRIN

HEPTACHLOR-EPOXIDE

HEXACHLOROBENZENE

MERCURY

LINDANE (GAMMA-BHC)

MIREX

TOTAL PAH

TOTAL PCB

SELENIUM

TOXAPHENE

Table 4. Water quality standards used by the American Samoa Environmental Protection Agency to evaluate marine waters. Most sites sampled for this study were classified as Open Coastal; only 1 site was within Pago Pago Harbor.

Parameter	Pago Pago Harbor	Open Coastal
Total P (mg/L)	0.03	0.015
Total N (mg/L)	0.2	0.13
Chlorophyll (µg/L)	1	0.25
Light penetration (feet)	65	130
DO (%sat, mg/L)	>70%, 5.0	>80%, 5.5
pH	6.5 - 8.6	6.5 - 8.6
<i>Enterococcus</i> (single sample)	104	124

Table 5. National Coastal Assessment (NCA) criteria for tropical estuaries used to assess water quality parameters in American Samoa.

	Good	Fair	Poor
Dissolved Inorganic Nitrogen	<0.05 mg/L	0.05-0.1mg/L	>0.1 mg/L
Dissolved Inorganic Phosphorus	<0.005 mg/L	0.005-0.01 mg/L	>0.01 mg/L
Chlorophyll a	<0.5 ug/L	0.5-1 ug/L	>1 ug/L
Dissolved Oxygen	>5 mg/L	2-5 mg/L	<2 mg/L
Water Clarity (% Transmission at 1 m)	>40 %	21-39 %	<20 %

Table 6. Average, maximum, and minimum values of water quality parameters collected during the American Samoa survey.

	Average	Maximum	Minimum
Depth (m)	14.17	38.1	0.15
Nitrate (mg/L)	0.0061	0.0133	0.0035
Nitrite (mg/L)	0.0016	0.0046	0.0001
Nitrate+Nitrite (mg/L)	0.0077	0.015	0.0046
Ammonium (mg/L)	0.0045	0.0168	0.0005
DIN (mg/L)	0.0122	0.0265	0.0062
Urea (mg/L)	0.0108	0.0224	0.0066
TN (mg/L)	0.111	0.149	0.073
DIP (mg/L)	0.0115	0.168	0.0095
TP (mg/L)	0.012	0.016	0.008
Silicate (mg/L)	0.1045	0.5051	0.0472
TSS (mg/L)	3.16	5.33	1.08
Chl a (µg/L)	0.222	0.602	0.067
pH	8.01	8.23	7.6
DO (mg/L)	7.17	9.87	6.50

Table 7. Comparison of % stations (± 1 SE) representing NPS waters and Territorial waters and their status with respect to the American Samoa water quality standards.

	NPSA		Territory	
	Pass	Fail	Pass	Fail
DO	91% ($\pm 12\%$)		81% ($\pm 15\%$)	
Chl a	82% ($\pm 16\%$)	18% ($\pm 16\%$)	67% ($\pm 18\%$)	33% ($\pm 18\%$)
Water Clarity	51% ($\pm 21\%$)	41% ($\pm 21\%$)	56% ($\pm 19\%$)	41% ($\pm 19\%$)
Enterococcus	31% ($\pm 19\%$)		66% ($\pm 18\%$)	
pH	100%		100%	
TN	91% ($\pm 12\%$)	9% ($\pm 12\%$)	70% ($\pm 17\%$)	22% ($\pm 16\%$)
TP	86% ($\pm 14\%$)	14% ($\pm 14\%$)	93% ($\pm 10\%$)	

Table 8. Comparison of % stations (± 1 SE) representing NPS waters and the Territorial waters and their status with respect to the NCA criteria for tropical estuaries.

	NPS waters			Territorial waters		
	Good	Fair	Poor	Good	Fair	Poor
DO	91% ($\pm 12\%$)			78% ($\pm 16\%$)		
Chl a	100			93% ($\pm 10\%$)	7% ($\pm 10\%$)	
Water Clarity	86% ($\pm 14\%$)	5% ($\pm 9\%$)		85% ($\pm 13\%$)	11% ($\pm 12\%$)	4% ($\pm 7\%$)
DIN	100			100		
DIP		23% ($\pm 18\%$)	77% ($\pm 18\%$)		15% ($\pm 13\%$)	85% ($\pm 13\%$)
Water Quality	18% ($\pm 16\%$)	82% ($\pm 16\%$)		11% ($\pm 12\%$)	85% ($\pm 13\%$)	4% ($\pm 7\%$)

Table 9. Metal contaminant levels in benthic sediments collected from American Samoa coastal waters. All values are expressed in mg/kg. Range is given as (minimum, maximum). MDL= minimum detection limit

	N	Avg	Range	MDL
Ag	13	0.045		0.045
Al	13	255.89	(13.1, 990)	8.9
As	13	4.25	(0.84, 16.3)	0.41
Cd	13	0.14		0.14
Dr	13	16.4	(0.79, 90)	0.49
Cu	13	4.3	(0.58, 18.2)	0.25
Fe	13	2858.3	(10.6, 17700)	10.6
Hg	13	0.018	(0, 0.068)	variable ¹
Mn	13	88.85	(5, 322)	0.16
Ni	13	18.81	(0.64, 83.9)	0.25
Pb	13	2.14	(0.34, 18.2)	0.34
Sb	13	0.22	(0.22, 0.26)	0.22
Se	13	0.84		0.84
Sn	13	3.17	(2.1, 6.2)	0.38
Zn	13	13.29	(0.82, 44)	0.42

¹ranged from 0.0074 to 0.01

Table 10. Concentrations of 16 priority contaminants in fish whole-body tissue samples collected in coastal waters of American Samoa. When 2 numbers are presented for a contaminant, the number on the top is the minimum concentration observed in that fish species, while the number on the bottom is the maximum concentration observed in that species.

Species	N	Lindane												Total DDT	Endosulfan	Total PAH	Total PCB
		Alpha-Chlordane	Dieldrin	Endrin	Heptachlor-epoxide	Hexachloro-benzene	(Gamma-BHC)	Mirex	Toxaphene	Arsenic	Cadmium	Mercury	Selenium				
		ng/wet g	ng/wet g	ng/wet g	ng/wet g	ng/wet g	ng/wet g	ng/wet g	ng/wet g	µg/wet g	µg/wet g	µg/wet g	µg/wet g	ng/g	ng/g	ng/g	ng/g
Cephalopholis urodeta	16	0 7.500	0 0	0 0	0 9.500	0 0	0 0	0 0	0 0	0.014 0.069	0 0.090	0.018 0.066	0.280 0.700	0 26.500	0 0	0 9.600	0 2.600
Variola louti	8	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0.006 0.193	0 0	0.009 0.066	0.700 1.110	0 0	0 0	0 1.100	0 0
Lutjanus kasmira	5	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0.058 0.198	0 0.040	0.024 0.063	0.340 0.670	0 3.800	0 0	0 0	0 0
Epinephelus spilotoceps	4	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0.011 0.128	0 0.020	0.013 0.082	0.440 0.600	0 0	0 0	0 0	0 0
Cephalopholis argus	3	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0.030 0.172	0 0.040	0.031 0.081	0.400 0.500	0 0	0 0	0 62.400	0 0
Balistapus undulatus	2	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0.141 0.212	0.120 0.160	0.014 0.019	0.440 0.540	0 0	0 0	0 1.000	0 0
Aphareus furca	1	0	0	0	0	0	0	0	0	0.078	0	0.387	0.950	0	0	0	0
Caranx sexfasciatus	1	0	0	0	0	0	0	0	0	0.024	0	0.069	0.900	0	0	15.400	0
Cephalopholis spiloparaea	1	0	0	0	0	0	0	0	0	0.061	0.030	0.052	0.950	0	0	0	0
Epinephelus fasciatus	1	0	0	0	0	0	0	0	0	0.104	0.090	0.032	0.500	0	0	7.900	0
Epinephelus howlandi	1	0	0	0	0	0	0	0	0	0.017	0.030	0.013	0.770	0	0	4.500	0
Epinephelus merra	1	0	0	0	0	0	0	0	0	0.015	0.030	0.027	0.390	0	0	0	0
Lutjanus bohar	1	0	0	0	0	0	0	0	0	0.198	0	0.033	0.600	0	0	0	0
Lutjanus fulvus	1	2.000	0	0	2.000	0	0	0	0	0.014	0	0.108	0.500	7.400	0	4.000	10.100
Oxycheilinus degrammus	1	0	0	0	0	0	0	0	0	0.090	0	0.019	0.600	0	0	0	0

Figure Legend

Figure 1. Station locations around Tutuila and Aunu'u islands.

Figure 2. Station locations around the Manu'a islands (Ofu, Olosega, and Ta'u).

Figure 3. Linear relationship between station depth (m) and the concentration (mg/L) of dissolved inorganic nitrogen (DIN) in near-shore waters around the high islands of American Samoa.

Figure 4. Box-and-whisker plots showing the distribution of parameter concentrations in the two study strata (NPS waters, labeled NPSA; Territorial waters, labeled TERR). Concentrations of TN and TP (in mg/L) and chl a (in $\mu\text{g/L}$) showed significantly different distributions in the different study strata.

Figure 5. Pie charts showing the assessment results for the evaluated water quality parameters. ASEPA standards were the basis for these assessments. Since the entire Territory complied with the pH standard, those results are not shown.

Figure 6. Pie charts showing the assessment results for the evaluated water quality parameters. NCA criteria for tropical estuaries were the basis for these assessments.

Figure 1.

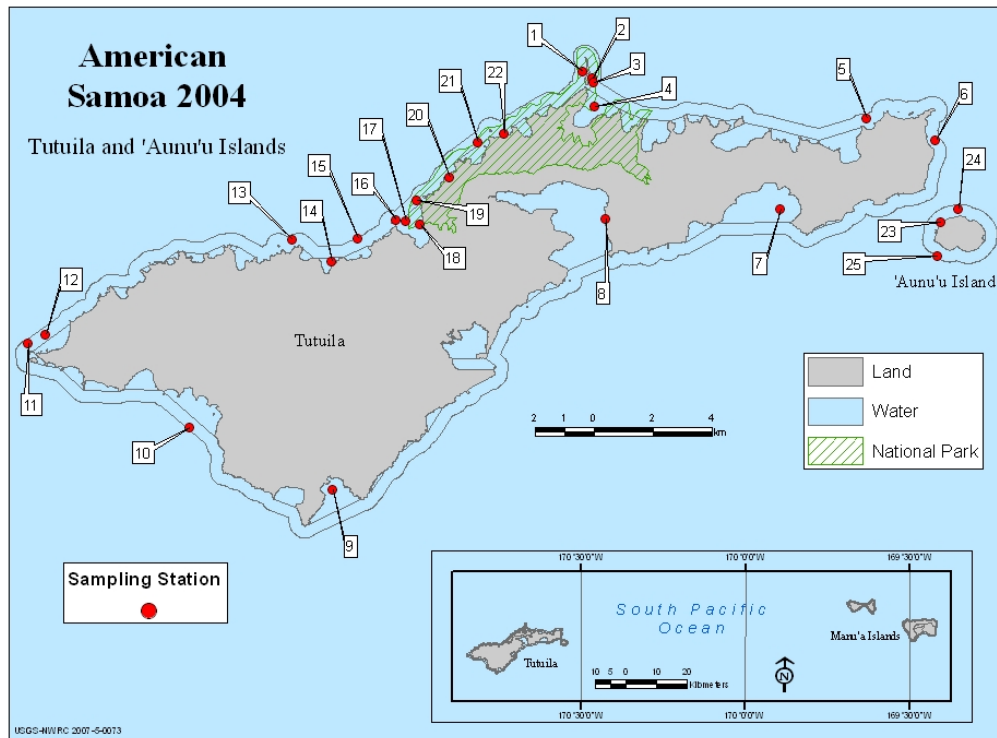


Figure 2.

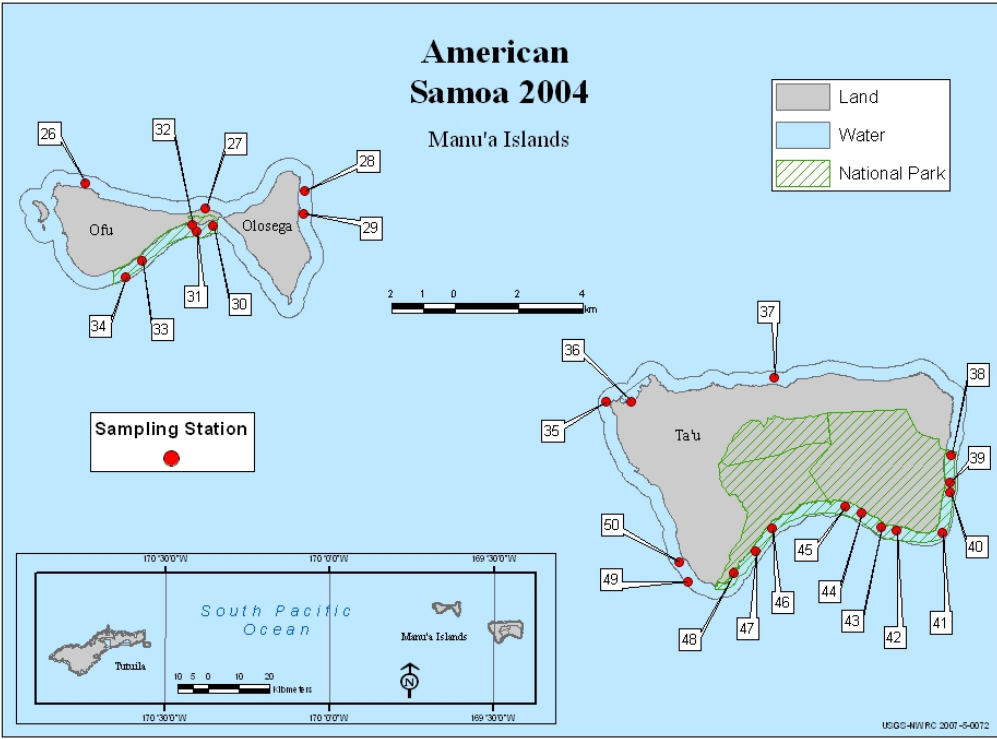


Figure 3.

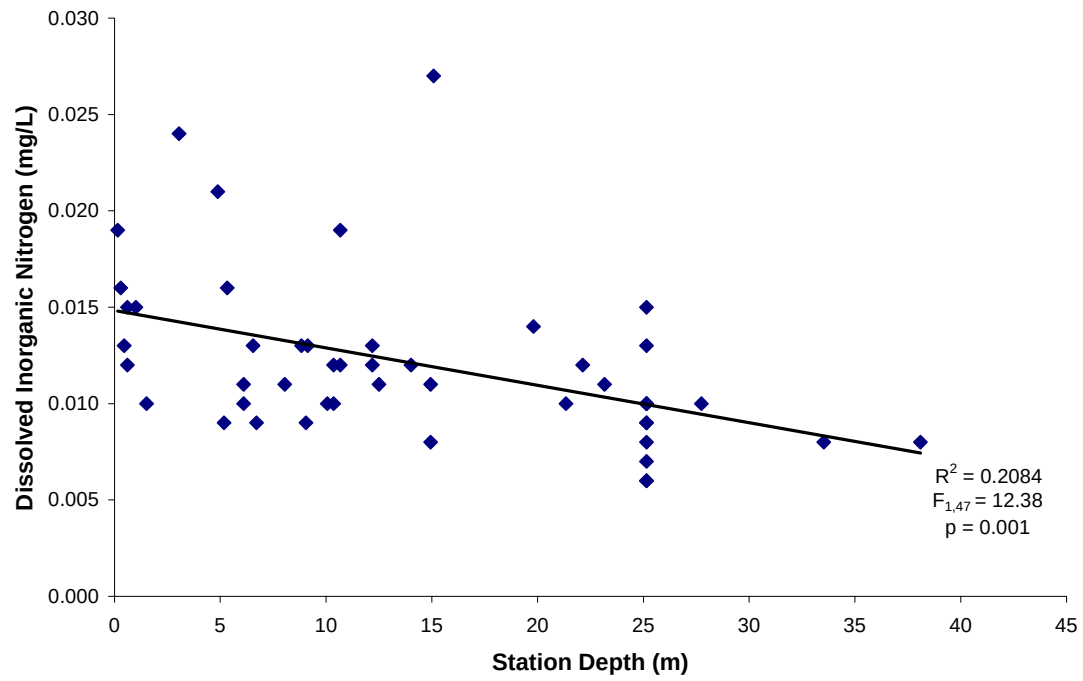


Figure 4.

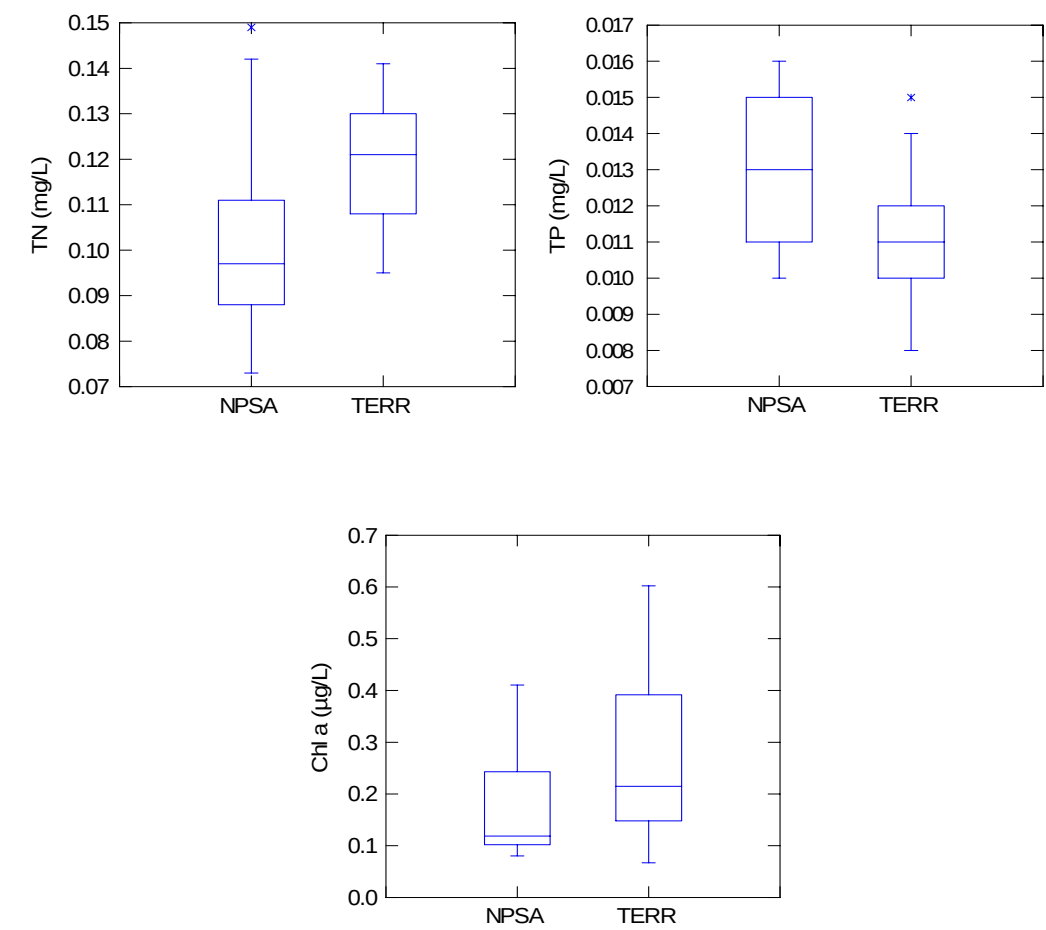


Figure 5.

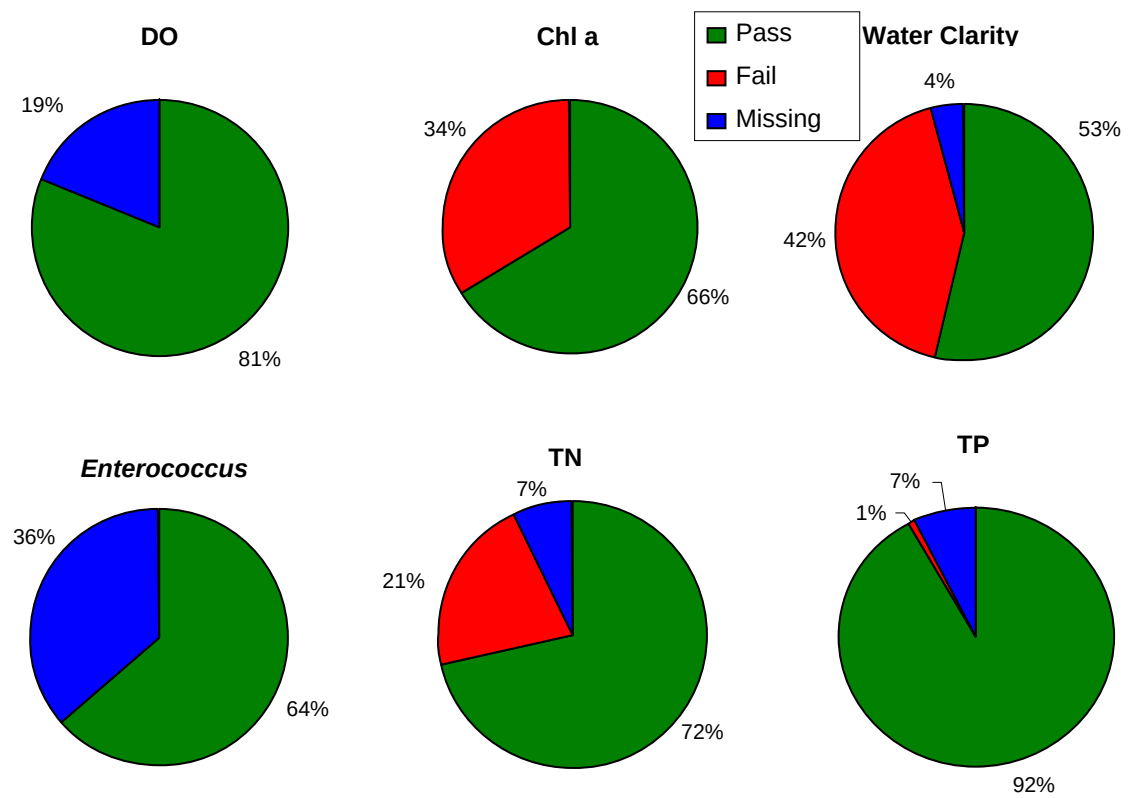
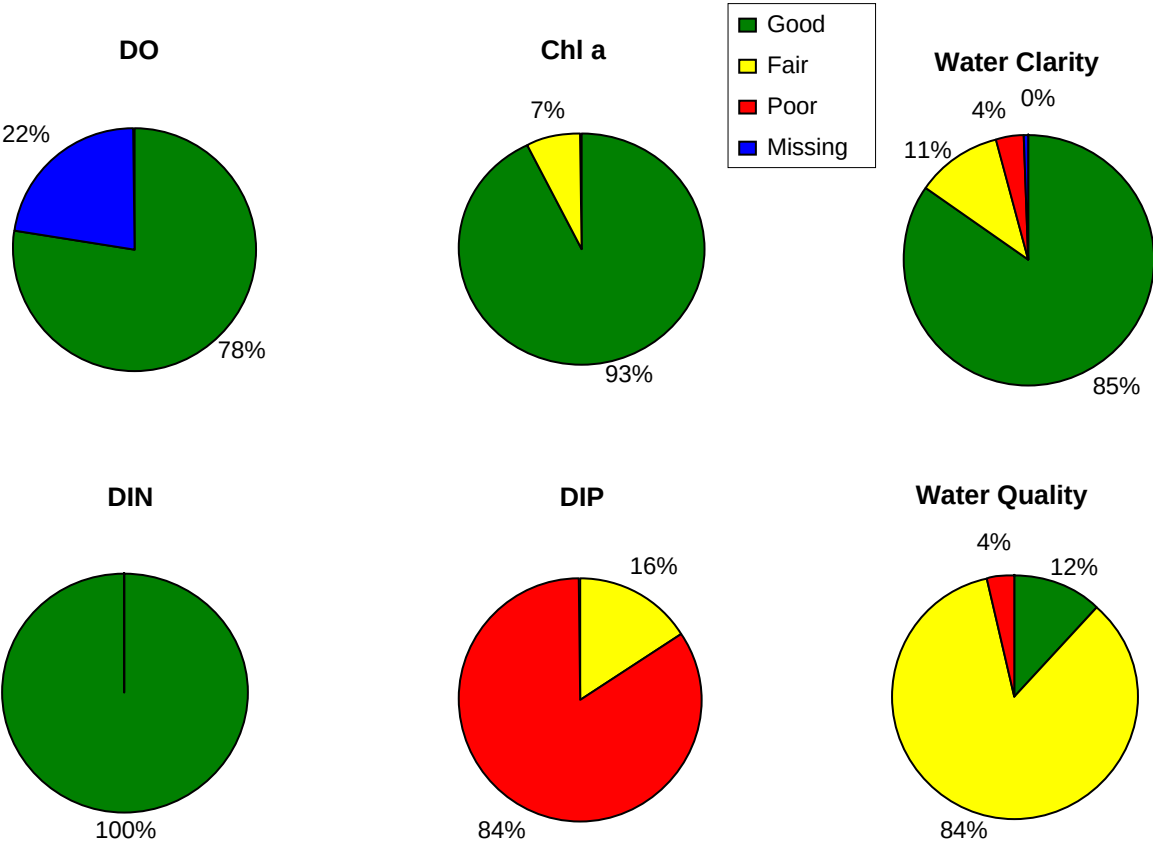


Figure 6.



APPENDIX A

STATION FORM

Coastal Assessment - American Samoa

WATER BODY NAME/
STAGING AREA: _____

STATION DEPTH (ft.): _____

STATION NAME

DAY

DATE: (MM/DD/YY)

TIME ZONE:

ARRIVAL TIME: (HH:MM)

DEPART TIME: (HH:MM)

GPS

LAT: (00° 00.00')

LON: (00° 00.00')

Site Within 0.02 NM:

☐

Yes

or

☐

No

If NO, explain in 'NOTES'

CREW

CAPTAIN:

CREW 1:

CREW 2:

VISITOR 1:

VISITOR 2:

VISITOR 3:

WEATHER

CONDITIONS AT STATION:

HABITAT
TYPE

☐

TIDAL RIVER

☐

ROCKY/SHELL BOTTOM

☐

MARINA

☐

OPEN WATER

☐

CORAL REEF

☐

OTHER...

☐

BAYOU/INLET

☐

MARSH

☐

INTER-TIDAL

☐

OYSTER BED

SAV

Present ?

☐

YES

or

☐

NO

MARINE
DEBRIS

Present ?

☐

YES

or

☐

NO

Type

☐

GLASS

☐

CANS

☐

WOOD

☐

PLASTIC

☐

OTHER.

PLACE COMMENTS ON BACK OF FORM

RECORDED BY:

COMPUTER ENTRY BY:

HYDROGRAPHIC PROFILE

Coastal Assessment - American Samoa

STATION NAME

QC CHECK

TIME: (HH:MM)

QC'd BY:

PARAMETER	TEMP (°C)	SAL	pH 7	pH 10	DO (%)	DEPTH
STANDARD:			7.0	10.0	100.0	0.0
MEASURED:						
CALIBRATE:						

DATE: (MMDDYY)

TIME: (HH:MM)

INSTRUMENT #:

R E P E T I T I O N 1	DEPTH (m)	TEMP (°C)	pH	DO (mg/l)	SAL (o/oo)	LIGHT (AMB)	LIGHT (UW)	DOWN	PLACE COMMENTS ON BACK
R E P E T I T I O N 2	DEPTH (m)	TEMP (°C)	pH	DO (mg/l)	SAL (o/oo)	LIGHT (AMB)	LIGHT (UW)	UP	PLACE COMMENTS ON BACK

RECORDED BY:

COMPUTER ENTRY BY:

WATER SAMPLE COLLECTION

Coastal Assessment - American Samoa

STATION NAME

DATE:

(MMDDYY)

FILTRATION METHOD: ☐ SYRINGE **or** ☐ VACUUM

SURFACE (0.5m)

NUTRIENTS ☐ (SNF)* (Filtered Sample - 60 ml) Salinity: _____
☐ (SNUF)* (Unfiltered Sample - 60 ml)

CHLOROPHYLL (SCL)* (25 mm Filter) Volume Filtered: _____ (ml)

TSS (SSS)* (Filtered Sample) Filter Wgt. _____ (g) Vol. Filtered _____ (ml)

MID-DEPTH

N/A (< 2m)

NUTRIENTS ☐ (MNF)* (Filtered Sample - 60 ml) Salinity: _____
☐ (MNUF)* (Unfiltered Sample - 60 ml)

CHLOROPHYLL (MCL)* (25 mm Filter) Volume Filtered: _____ (ml)

TSS (MSS)* (Filtered Sample) Filter Wgt. _____ (g) Vol. Filtered _____ (ml)

BOTTOM (0.5 off bottom)

NUTRIENTS ☐ (BNF)* (Filtered Sample - 60 ml) Salinity: _____
☐ (BNUF)* (Unfiltered Sample - 60 ml)

CHLOROPHYLL (BCL)* (25 mm Filter) Volume Filtered: _____ (ml)

TSS (BSS)* (Filtered Sample) Filter Wgt. _____ (g) Vol. Filtered _____ (ml)

* Sample label to be placed on container is listed in parentheses

RECORDED BY:

COMPUTER ENTRY BY:

SEDIMENT SAMPLE COLLECTION

Coastal Assessment - American Samoa

STATION NAME

DATE: (MMDDYY) _____

SEDIMENT CHEMISTRY

I.

☐

Organics (SO)*

(Glass Jar)

II.

☐

Metals (SM)

(Nalgene 125 ml)

GRAIN SIZE
(SG)

☐

(250 ml - Nalgene)

SEDIMENT TOC
(TOC)

☐

(60 ml)

(Sample label to be placed on container is listed in italics)

RECORDED BY:

COMPUTER ENTRY BY:

SEDIMENT SAMPLES ONLY

FISH DATA

Coastal Assessment - American Samoa

STATION NAME

DAY

DATE: (MM/DD/YY)

ARRIVAL TIME: (HH:MM)

STATION DEPTH (ft.):

DEPART TIME: (HH:MM)

GPS

LAT: (00° 00.00')

LON: (00° 00.00')

Site Within 0.02 NM:

☐ Yes or ☐ No

If NO, explain in 'NOTES'

CREW

CAPTAIN:

CREW 1:

CREW 2:

Collection Info

Fish Sample Id	Fish Name (Common)	Fish Length	Fish Length Units

Event Notes:

APPENDIX B

Table B1. Station information and data collected as part of the 2004 coastal survey. For location of stations, see Figures 1 and 2.

Station	Strata	Waterbody		Longitude	Water Quality	Sediment	Fish
		Class	Latitude				
1	NPSA	OC	-14.23332	-170.66666	X		X
2	NPSA	OC	-14.23332	-170.66666	X		X
3	NPSA	OC	-14.23332	-170.66666	X		X
4	NPSA	OC	-14.23332	-170.66666	X		X
5	TERR	OC	-14.23332	-170.56666	X	X	X
6	TERR	OC	-14.24999	-170.54999	X	X	X
7	TERR	OC	-14.21666	-170.59999	X		X
8	TERR	PPH	-14.26666	-170.64999	X	X	X
9	TERR	OC	-14.34999	-170.74999	X		X
10	TERR	OC	-14.33332	-170.78332	X		X
11	TERR	OC	-14.31666	-170.83332	X	X	
12	TERR	OC	-14.29999	-170.83332	X		
13	TERR	OC	-14.28332	-170.74999	X	X	X
14	TERR	OC	-14.28332	-170.74999	X		X
15	TERR	OC	-14.28332	-170.73332	X		X
16	TERR	OC	-14.26666	-170.71666	X	X	X
17	TERR	OC	-14.26666	-170.71666	X	X	X
18	NPSA	OC	-14.26666	-170.71666	X		X
19	TERR	OC	-14.26666	-170.71666	X		X
20	NPSA	OC	-14.24999	-170.69999	X		X
21	TERR	OC	-14.24999	-170.69999	X		X
22	NPSA	OC	-14.24999	-170.68332	X		X
23	TERR	OC	-14.26666	-170.54999	X	X	X
24	TERR	OC	-14.26666	-170.54999	X		
25	TERR	OC	-14.28332	-170.54999	X		X
26	TERR	OC	-14.14999	-169.66666	X		X
27	TERR	OC	-14.14999	-169.63332	X	X	X
28	TERR	OC	-14.14999	-169.59999	X		X
29	TERR	OC	-14.16666	-169.59999	X		X
30	NPSA	OC	-14.16666	-169.63332	X	X	X
31	NPSA	OC	-14.16666	-169.63332	X		X
32	NPSA	OC	-14.16666	-169.63332	X	X	X
33	NPSA	OC	-14.16666	-169.64999	X	X	X
34	NPSA	OC	-14.18332	-169.64999	X		X
35	TERR	OC	-14.21666	-169.51666	X		X
36	TERR	OC	-14.21666	-169.49999	X	X	X
37	TERR	OC	-14.19999	-169.46666	X		X
38	NPSA	OC	-14.23332	-169.41666	X		X
39	NPSA	OC	-14.23332	-169.41666	X		X
40	NPSA	OC	-14.23332	-169.41666	X		X
41	NPSA	OC	-14.25725	-169.42117			X
42	NPSA	OC	-14.24999	-169.43332	X		X
43	NPSA	OC	-14.24999	-169.43332	X		X
44	NPSA	OC	-14.24999	-169.43332	X		X
45	NPSA	OC	-14.23332	-169.43332	X		X
46	NPSA	OC	-14.24999	-169.46666	X		X
47	NPSA	OC	-14.24999	-169.46666	X		X
48	NPSA	OC	-14.26666	-169.46666	X		X
49	TERR	OC	-14.26666	-169.48332	X		X
50	TERR	OC	-14.24999	-169.48332	X		X

Table B2. Average hydrographic parameters collected at 49 coastal stations during the 2004 coastal water quality survey. For location of stations, see Figures 1 and 2. nd=no data

Station	Depth (m)	% Bottom Transmission	% Transmission at 1 m	Avg pH	Bottom DO (mg/L)	Avg DO (mg/L)
1	25.15	12.5	39.9	7.90	6.7	6.83
2	19.81	12.9	47.7	7.87	6.5	6.69
3	15.09	17.8	58.4	7.90	7.0	6.93
4	25.15	11.4	59.6	7.84	6.6	6.69
5	25.15	5.7	66.2	7.90	6.4	6.71
6	10.06	23.9	65.8	8.07	6.5	6.67
7	25.15	nd	66.1	7.65	6.5	6.98
8	1.01	65.8	65.8	7.95	8.0	8.10
9	25.15	17.6	53.6	7.90	nd	nd
10	25.15	9.8	63.5	8.07	nd	nd
11	25.15	12.9	41.6	7.98	6.5	6.61
12	25.15	8.7	54.6	8.10	6.6	6.82
13	25.15	3.7	35.5	7.90	6.6	6.96
14	8.05	8.9	17.4	7.90	nd	nd
15	25.15	6.8	35.7	7.92	nd	nd
16	25.15	6.9	22.1	7.84	nd	nd
17	27.74	11.0	65.4	7.68	6.7	6.77
18	22.13	6.8	49.1	8.00	nd	nd
19	33.53	13.9	78.4	7.80	6.6	6.64
20	6.1	41.4	80.5	7.78	nd	nd
21	38.1	19.8	60.4	7.60	6.3	6.50
22	3.05	56.0	71.0	7.83	6.7	6.78
23	0.46	75.4	75.4	7.80	8.5	8.60
24	9.05	28.6	83.6	8.00	6.7	6.77
25	6.55	27.1	78.1	7.76	7.0	7.16
26	4.88	33.3	72.2	8.21	7.3	7.34
27	1.52	82.1	82.1	8.17	9.6	9.61
28	14.94	13.8	83.2	8.08	6.6	6.65
29	9.14	40.0	82.9	8.14	6.4	6.60
30	0.61	95.6	95.6	8.20	8.9	8.88
31	10.36	37.1	58.7	8.14	6.8	6.88
32	0.61	43.4	43.4	8.17	8.4	8.40
33	0.15	93.5	93.5	8.11	9.6	9.87
34	6.71	39.9	56.8	8.13	6.8	6.78
35	21.34	29.7	57.3	8.10	6.9	6.98
36	0.3	78.9	78.9	8.17	8.2	8.18
37	23.16	22.0	77.2	8.08	nd	6.65
38	12.19	30.1	57.7	8.23	6.5	7.19
39	10.36	34.7	58.3	8.02	7.0	7.32
40	8.84	30.7	68.0	8.14	7.2	7.34
41	nd	nd	nd	nd	nd	nd
42	12.5	nd	nd	8.07	6.6	6.66
43	10.67	42.3	69.2	8.18	6.7	6.65
44	6.1	46.6	68.3	8.21	6.7	6.75
45	10.67	35.5	63.3	8.22	6.7	6.83
46	14.02	35.4	79.2	8.16	6.5	6.57
47	5.18	42.3	73.7	8.20	6.9	7.03
48	5.33	nd	nd	8.13	7.2	7.19
49	14.94	31.4	53.5	8.12	6.7	6.76
50	12.19	29.8	53.8	8.07	6.6	6.69

Table B3. Station averages and associated coefficients of variation for water chemistry samples collected at up to 3 depths in the water column. For location of stations, see Figure 1. nd=no data

	NH ₄		NO ₂		NO ₃		NO ₃ +NO ₂		DIN		HPO ₄		Si		Urea	
	Avg (mg/L)	CV	Avg (mg/L)	CV	Avg (mg/L)	CV	Avg (mg/L)	CV	Avg (mg/L)	CV	Avg (mg/L)	CV	Avg (mg/L)	CV	Avg (mg/L)	CV
1	0.0016	117.54%	0.0001	127.94%	0.0058	24.20%	0.0059	21.21%	0.0075	0.0099	7.53%	0.0926	17.20%	0.0092	21.15%	
2	0.0056	93.62%	0.0025	60.85%	0.0061	145.64%	0.0085	89.38%	0.0141	0.0168	30.31%	0.1401	4.80%	0.0107	12.87%	
3	0.0115	169.43%	0.0017	33.36%	0.0133	8.56%	0.0150	5.00%	0.0265	0.0102	6.71%	0.1157	7.98%	0.0107	26.92%	
4	0.0038	51.26%	0.0046	38.12%	0.0070	49.06%	0.0116	18.54%	0.0154	0.0108	7.24%	0.1199	8.14%	0.0123	17.93%	
5	0.0022	103.22%	0.0031	47.47%	0.0052	23.68%	0.0083	10.69%	0.0105	0.0109	2.68%	0.0705	3.56%	0.0105	10.98%	
6	0.0035	69.94%	0.0014	14.29%	0.0053	12.92%	0.0067	12.88%	0.0102	0.0113	1.71%	0.0980	14.56%	0.0117	9.88%	
7	0.0048	34.15%	0.0013	14.41%	0.0068	12.76%	0.0081	12.04%	0.0129	0.0109	7.75%	0.0889	22.95%	0.0152	32.02%	
8	0.0025		0.0034		0.0087		0.0121		0.0146	0.0144		0.1394		0.0135		
9	0.0040	41.98%	0.0008	58.53%	0.0053	4.08%	0.0061	6.88%	0.0100	0.0106	2.78%	0.1089	22.34%	0.0224	20.30%	
10	0.0005	86.60%	0.0013	29.22%	0.0079	55.86%	0.0091	51.97%	0.0097	0.0113	13.18%	0.1415	69.58%	0.0106	15.92%	
11	0.0005	173.21%	0.0017	21.79%	0.0040	15.54%	0.0056	17.09%	0.0062	0.0097	1.67%	0.0863	21.64%	0.0104	13.52%	
12	0.0018	60.09%	0.0015	19.33%	0.0041	3.30%	0.0057	7.45%	0.0074	0.0095	10.43%	0.0689	10.63%	0.0115	24.01%	
13	0.0023	7.01%	0.0013	66.92%	0.0050	31.19%	0.0063	35.87%	0.0085	0.0107	11.10%	0.0961	21.43%	0.0137	22.84%	
14	0.0047	44.13%	0.0014	27.89%	0.0054	7.47%	0.0068	5.81%	0.0114	0.0105	8.44%	0.1115	5.63%	0.0110	12.30%	
15	0.0010	93.58%	0.0013	18.25%	0.0041	13.84%	0.0054	11.58%	0.0064	0.0106	1.82%	0.1085	5.90%	0.0106	21.03%	
16	0.0019	45.99%	0.0017	18.49%	0.0058	6.28%	0.0074	1.56%	0.0093	0.0120	12.97%	0.1361	30.37%	0.0130	38.28%	
17	0.0051	74.50%	0.0011	4.62%	0.0042	24.13%	0.0053	19.91%	0.0104	0.0123	0.58%	0.1036	13.78%	0.0106	6.57%	
18	0.0012	173.21%	0.0019	88.07%	0.0086	27.58%	0.0106	8.06%	0.0118	0.0116	6.12%	0.1403	18.17%	0.0086	6.04%	
19	0.0031	65.52%	0.0011	5.26%	0.0042	1.34%	0.0053	0.00%	0.0084	0.0116	0.15%	0.0696	15.04%	0.0105	15.99%	
20	0.0011	100.04%	0.0028	63.90%	0.0058	13.65%	0.0085	11.63%	0.0097	0.0115	1.25%	0.1107	9.98%	0.0123	14.31%	
21	0.0027	22.89%	0.0011	7.59%	0.0038	29.88%	0.0049	24.74%	0.0076	0.0112	1.25%	0.0680	4.63%	0.0095	8.10%	
22	0.0168	32.73%	0.0010	24.40%	0.0066	19.04%	0.0076	19.72%	0.0244	0.0112	12.90%	0.0856	19.30%	0.0076	15.31%	
23	0.0072		0.0012		0.0051		0.0063		0.0135	0.0098		0.0486		0.0120		
24	0.0026	112.16%	0.0022	28.69%	0.0038	15.63%	0.0059	1.01%	0.0085	0.0101	3.15%	0.0823	3.05%	0.0139	12.62%	
25	0.0029	51.81%	0.0037	56.24%	0.0061	17.71%	0.0098	32.10%	0.0127	0.0119	8.32%	0.0920	8.82%	0.0125	5.67%	
26	0.0128	58.77%	0.0014	16.42%	0.0070	48.81%	0.0084	43.28%	0.0213	0.0129	23.40%	0.0770	43.66%	0.0213	31.13%	
27	0.0029	50.29%	0.0015	3.61%	0.0058	0.95%	0.0074	0.01%	0.0103	0.0119	0.46%	0.0652	16.51%	0.0066	2.56%	
28	0.0038	25.09%	0.0013	13.54%	0.0064	6.96%	0.0077	8.03%	0.0115	0.0127	1.01%	0.0815	26.02%	0.0102	3.25%	
29	0.0038	36.00%	0.0013	3.80%	0.0079	13.17%	0.0093	11.75%	0.0130	0.0122	3.31%	0.0788	26.19%	0.0100	11.87%	
30	0.0039		0.0016		0.0068		0.0084		0.0123	0.0133		0.0472		0.0125		
31	0.0033	18.03%	0.0011	16.00%	0.0055	14.12%	0.0066	12.03%	0.0099	0.0105	6.44%	0.0909	5.84%	0.0079	12.89%	
32	0.0090		0.0013		0.0050		0.0063		0.0153	0.0127		0.1178		0.0076		
33	0.0105		0.0015		0.0069		0.0084		0.0189	0.0125		0.0486		0.0093		
34	0.0019	12.92%	0.0012	24.20%	0.0058	2.59%	0.0070	6.10%	0.0089	0.0109	2.21%	0.0881	5.74%	0.0083	20.43%	
35	0.0050	80.59%	0.0010	8.76%	0.0039	13.72%	0.0049	12.37%	0.0099	0.0109	4.88%	0.0616	8.27%	0.0075	8.55%	
36	0.0060		0.0016		0.0089		0.0105		0.0164	0.0107		0.5051		0.0162		
37	0.0042	110.03%	0.0011	5.06%	0.0059	19.88%	0.0070	17.55%	0.0112	0.0119	2.21%	0.0862	29.95%	0.0079	8.11%	
38	0.0048	78.02%	0.0011	9.57%	0.0074	32.76%	0.0085	27.35%	0.0134	0.0120	11.06%	0.1078	16.57%	0.0131	20.43%	
39	0.0031	76.18%	0.0013	12.90%	0.0080	3.28%	0.0093	3.23%	0.0124	0.0122	1.31%	0.1440	11.44%	0.0124	10.94%	
40	0.0037	74.77%	0.0027	52.45%	0.0066	7.40%	0.0093	19.62%	0.0130	0.0119	4.13%	0.1203	7.44%	0.0094	6.63%	
41	nd		nd		nd		nd		nd	nd		nd		nd		
42	0.0030	36.43%	0.0013	1.99%	0.0071	0.36%	0.0084	0.00%	0.0114	0.0131	1.99%	0.1239	24.92%	0.0077	5.12%	
43	0.0142	141.31%	0.0007	41.89%	0.0043	32.69%	0.0050	33.90%	0.0192	0.0095	14.44%	0.0931	36.83%	0.0072	10.71%	
44	0.0031	52.88%	0.0014	4.14%	0.0067	9.90%	0.0081	7.55%	0.0111	0.0130	2.90%	0.0866	2.96%	0.0080	7.58%	
45	0.0058	8.30%	0.0009	12.85%	0.0052	16.73%	0.0062	12.60%	0.0120	0.0105	7.11%	0.1021	14.61%	0.0088	2.80%	
46	0.0039	98.30%	0.0026	52.07%	0.0058	28.25%	0.0084	3.68%	0.0123	0.0113	5.14%	0.1056	6.11%	0.0085	8.96%	
47	0.0005	86.78%	0.0015	26.76%	0.0071	4.99%	0.0086	5.17%	0.0091	0.0116	1.41%	0.1091	2.38%	0.0089	7.41%	
48	0.0100	124.72%	0.0011	36.61%	0.0047	39.01%	0.0058	38.57%	0.0158	0.0112	28.56%	0.0717	76.74%	0.0078	44.27%	
49	0.0032	85.02%	0.0011	4.62%	0.0035	18.33%	0.0046	13.32%	0.0078	0.0116	0.86%	0.0865	14.95%	0.0074	2.62%	
50	0.0032	112.15%	0.0012	7.23%	0.0071	8.32%	0.0084	8.02%	0.0116	0.0112	5.40%	0.0985	26.03%	0.0083	10.60%	

Table B4. Station averages and associated coefficients of variation for water chemistry samples collected at up to 3 depths in the water column. For location of stations, see Figures 1 and 2. nd=no data

	Total Nitrogen		Total Phosphorus	
	Avg (mg/L)	CV	Avg (mg/L)	CV
1	0.086	15.78%	0.016	6.43%
2	0.105	21.87%	0.016	53.73%
3	0.107	37.52%	0.012	12.13%
4	0.094	12.42%	0.016	6.09%
5	0.133	5.20%	0.012	9.76%
6	0.129	27.20%	0.010	0.57%
7	nd		nd	
8	0.130		0.015	
9	0.133	18.18%	0.010	6.06%
10	0.097	15.96%	0.010	6.18%
11	0.108	6.36%	0.011	5.94%
12	0.138	6.16%	0.011	1.57%
13	0.125	17.58%	0.011	9.04%
14	0.101	8.15%	0.014	1.77%
15	0.098	10.06%	0.014	10.85%
16	0.105	21.02%	0.014	9.46%
17	0.095	8.67%	0.012	18.34%
18	0.091	11.94%	0.015	2.93%
19	0.141	8.01%	0.011	0.57%
20	0.090	(39.51%)	0.010	18.29%
21	0.121	30.37%	0.010	3.80%
22	0.084	16.20%	0.014	28.04%
23	0.125		0.010	
24	0.131	14.66%	0.010	0.52%
25	0.125	14.21%	0.011	2.31%
26	0.128	13.92%	0.014	6.73%
27	0.107	6.50%	0.010	1.37%
28	0.109	12.15%	0.011	7.21%
29	0.112	21.39%	0.011	3.60%
30	0.094		0.011	
31	0.088	25.99%	0.015	3.86%
32	0.149		0.011	
33	0.142		0.010	
34	0.073	31.06%	0.014	19.61%
35	0.116	20.55%	0.010	5.67%
36	nd		nd	
37	0.109	5.29%	0.010	5.28%
38	0.100	22.36%	0.014	16.81%
39	0.093	14.05%	0.012	3.16%
40	0.128	31.19%	0.014	17.49%
41	nd		nd	
42	0.111	7.51%	0.011	4.11%
43	0.102	9.67%	0.014	9.91%
44	0.117	5.03%	0.011	3.32%
45	0.101	9.86%	0.015	1.49%
46	0.084	52.34%	0.010	17.57%
47	0.086	23.13%	0.011	13.48%
48	0.122	18.40%	0.011	1.52%
49	0.133	19.62%	0.011	12.29%
50	0.119	28.77%	0.008	34.89%

Table B5. Station averages and associated coefficients of variation for total suspended solids, chlorophyll a, and *Enterococcus* samples collected at up to 3 depths in the water column. For location of stations, see Figures 1 and 2. nd=no data

	Total Suspended Solids		Chl a		<i>Enterococcus</i>	
	Avg (mg/L)	CV	Avg (µg/L)	CV	Avg (CFU/100mL)	CV
1	3.42	14.7%	0.242	2.2%	3.33	173.2%
2	3.20	10.2%	0.270	23.0%	0	
3	3.08	13.1%	0.271	17.5%	0	
4	3.12	17.3%	0.411	29.0%	0	
5	3.50	13.6%	0.256	11.0%	0	
6	5.33	45.8%	0.219	28.1%	3.33	173.2%
7	2.70	32.9%	0.485	23.0%	0	
8	4.2		0.481		0	
9	3.00	6.0%	0.194	27.9%	0	
10	4.23	40.0%	0.314	35.9%	3.33	173.2%
11	2.58	15.0%	0.178	51.7%	0	
12	2.82	6.7%	0.215	55.2%	0	
13	3.40	14.7%	0.438	33.3%	0	
14	4.10	13.2%	0.349	55.3%	0	
15	3.25	14.7%	0.434	26.1%	0	
16	3.20	6.2%	0.468	17.5%	0	
17	5.32	44.6%	0.228	23.1%	0	
18	3.18	16.1%	0.307	4.4%	0	
19	3.98	20.7%	0.128	50.8%	0	
20	3.43	13.5%	0.165	4.8%	0	
21	3.28	14.9%	0.173	20.4%	0	
22	3.25	0.0%	0.156	3.3%	0	
23	3.80		0.602		0	
24	4.08	19.0%	0.194	0.1%	0	
25	4.13	9.2%	0.225	42.3%	0	
26	3.83	8.5%	0.161	2.6%	nd	
27	2.95	7.2%	0.177	8.5%	nd	
28	1.57	10.3%	0.115	14.5%	nd	
29	2.60	15.3%	0.091	31.7%	nd	
30	2.7		0.246		nd	
31	1.08	18.7%	0.116	12.1%	nd	
32	4.1		0.217		nd	
33	3.85		0.243		nd	
34	1.25	8.0%	0.121	9.7%	nd	
35	2.42	10.2%	0.067	2.6%	nd	
36	4.4		0.579		nd	
37	2.63	10.5%	0.104	2.6%	nd	
38	2.78	3.7%	0.092	31.3%	nd	
39	3.62	13.3%	0.113	4.3%	nd	
40	2.85	18.5%	0.080	7.0%	nd	
41	nd		nd		nd	
42	2.48	14.8%	0.109	10.1%	nd	
43	2.57	6.0%	0.105	7.2%	nd	
44	2.93	20.5%	0.091	5.3%	nd	
45	2.88	7.0%	0.102	3.2%	nd	
46	2.52	13.2%	0.103	8.8%	nd	
47	2.42	3.2%	0.098	1.8%	nd	
48	2.87	8.2%	0.095	9.3%	nd	
49	2.08	41.0%	0.135	1.6%	nd	
50	1.87	28.1%	0.094	19.9%	nd	

Table B6. Fish species collected and number of individuals used for each station's composite. nd=no data

	Species	# indiv per composite
1	<i>Lutjanus bohar</i>	1
2	<i>Cephalopholis urodeta</i>	2
3	<i>Variola louti</i>	2
4	<i>Cephalopholis urodeta</i>	2
5	<i>Cephalopholis argus</i>	1
6	<i>Balistapus undulatus</i>	2
7	<i>Cephalopholis urodeta</i>	2
8	<i>Lutjanus fulvus</i>	2
9	<i>Lutjanus kasmira</i>	4
10	<i>Lutjanus kasmira</i>	3
11	nd	
12	nd	
13	<i>Variola louti</i>	2
14	<i>Variola louti</i>	1
15	<i>Cephalopholis urodeta</i>	1
16	<i>Oxycheilinus degrammus</i>	2
17	<i>Caranx sexfasciatus</i>	1
18	<i>Cephalopholis urodeta</i>	3
19	<i>Cephalopholis urodeta</i>	2
20	<i>Epinephelus spilotoceps</i>	1
21	<i>Lutjanus kasmira</i>	3
22	<i>Epinephelus spilotoceps</i>	3
23	<i>Epinephelus spilotoceps</i>	1
24	nd	
25	<i>Cephalopholis urodeta</i>	1
26	<i>Aphareus furca</i>	1
27	<i>Balistapus undulatus</i>	1
28	<i>Cephalopholis urodeta</i>	4
29	<i>Cephalopholis urodeta</i>	1
30	<i>Epinephelus merra</i>	1
31	<i>Cephalopholis urodeta</i>	5
32	<i>Epinephelus howlandi</i>	2
33	<i>Cephalopholis urodeta</i>	3
34	<i>Variola louti</i>	1
35	<i>Epinephelus fasciatus</i>	2
36	<i>Epinephelus spilotoceps</i>	1
37	<i>Variola louti</i>	1
38	<i>Cephalopholis argus</i>	1
39	<i>Cephalopholis argus</i>	2
40	<i>Cephalopholis urodeta</i>	5
41	<i>Lutjanus kasmira</i>	2
42	<i>Cephalopholis urodeta</i>	3
43	<i>Cephalopholis spiloparaea</i>	2
44	<i>Cephalopholis urodeta</i>	5
45	<i>Variola louti</i>	1
46	<i>Variola louti</i>	2
47	<i>Cephalopholis urodeta</i>	3
48	<i>Lutjanus kasmira</i>	1
49	<i>Variola louti</i>	1
50	<i>Cephalopholis urodeta</i>	4

APPENDIX C

Figure Legend

Figure C1. Assessment results for dissolved oxygen from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C2. Assessment results for chlorophyll a from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C3. Assessment results for water clarity from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C4. Assessment results for enterococci from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C5. Assessment results for total nitrogen from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C6. Assessment results for total phosphorus from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C7. Assessment results for pH from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The standards from the ASCA used by the ASEPA were the basis for this assessment.

Figure C8. Assessment results for dissolved oxygen from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The USEPA's criteria for tropical estuaries were the basis for this assessment.

Figure C9. Assessment results for chlorophyll a from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The USEPA's criteria for tropical estuaries were the basis for this assessment.

Figure C10. Assessment results for water clarity from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The USEPA's criteria for tropical estuaries were the basis for this assessment.

Figure C11. Assessment results for dissolved inorganic nitrogen from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The USEPA's criteria for tropical estuaries were the basis for this assessment.

Figure C12. Assessment results for dissolved inorganic phosphorus from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The USEPA's criteria for tropical estuaries were the basis for this assessment.

Figure C13. Assessment results for the water quality index from the 2004 ecological assessment of coastal areas around Tutuila and the Manu'a islands. The USEPA's criteria for tropical estuaries were the basis for this assessment.

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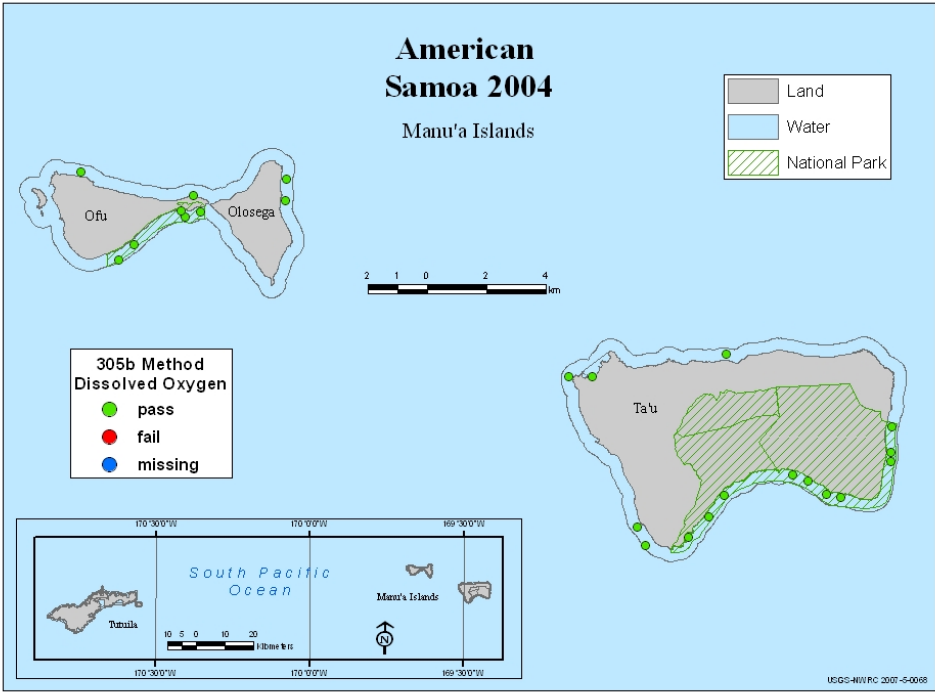
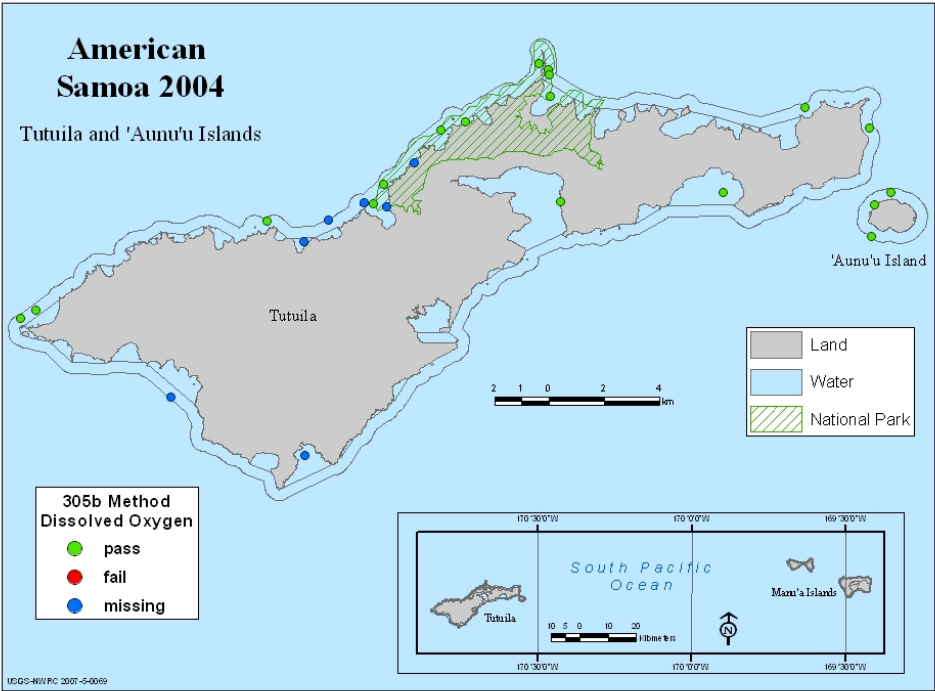


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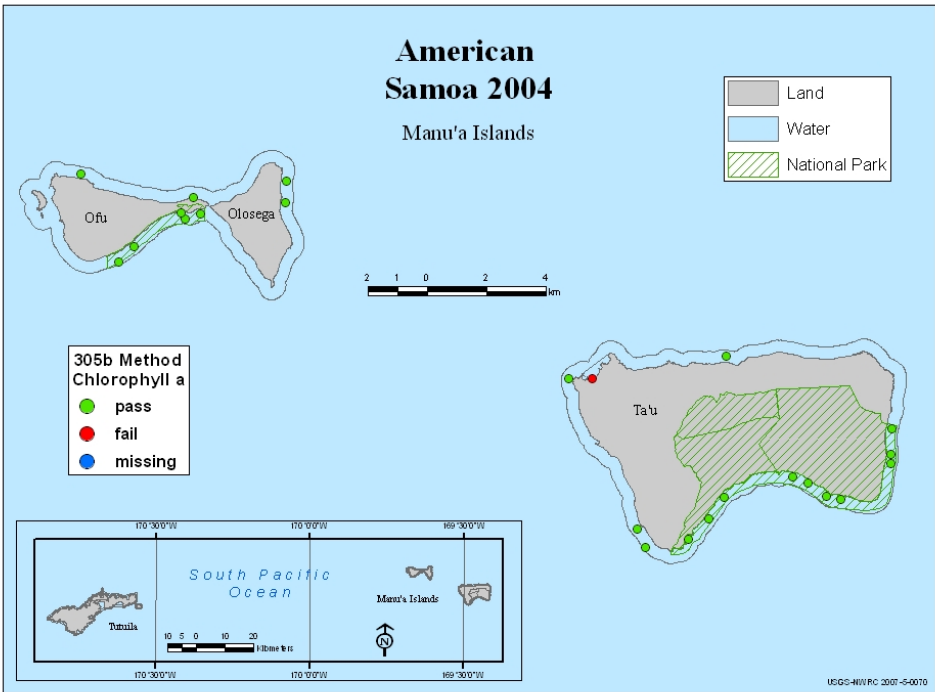
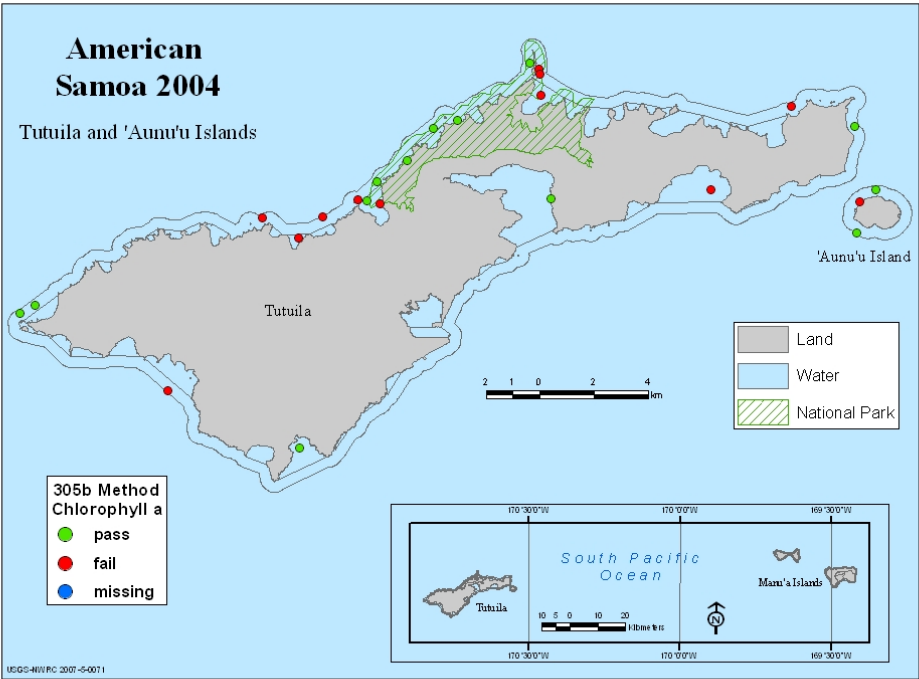


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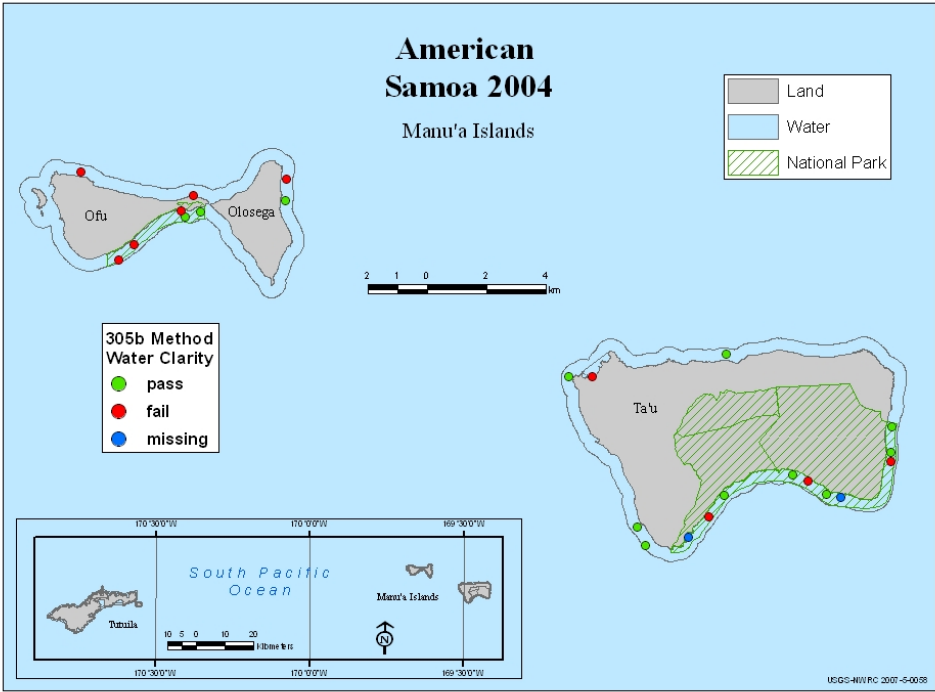
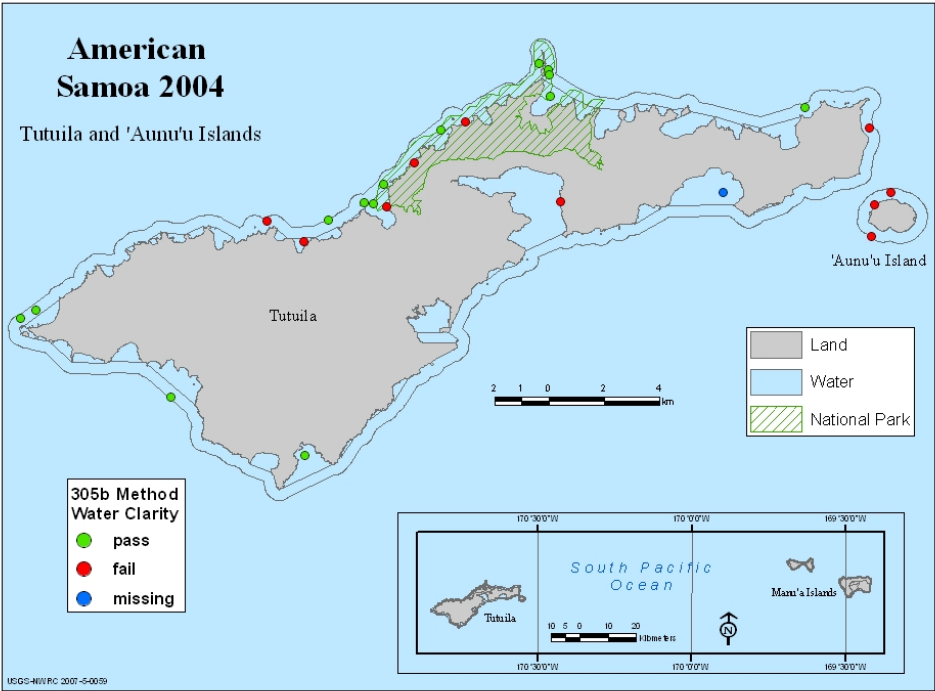


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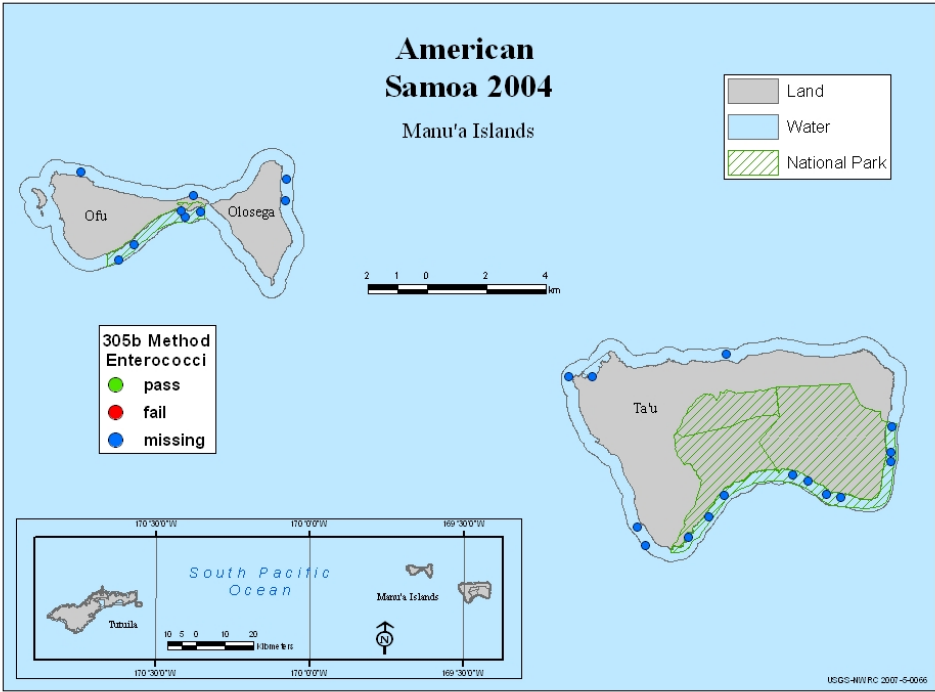
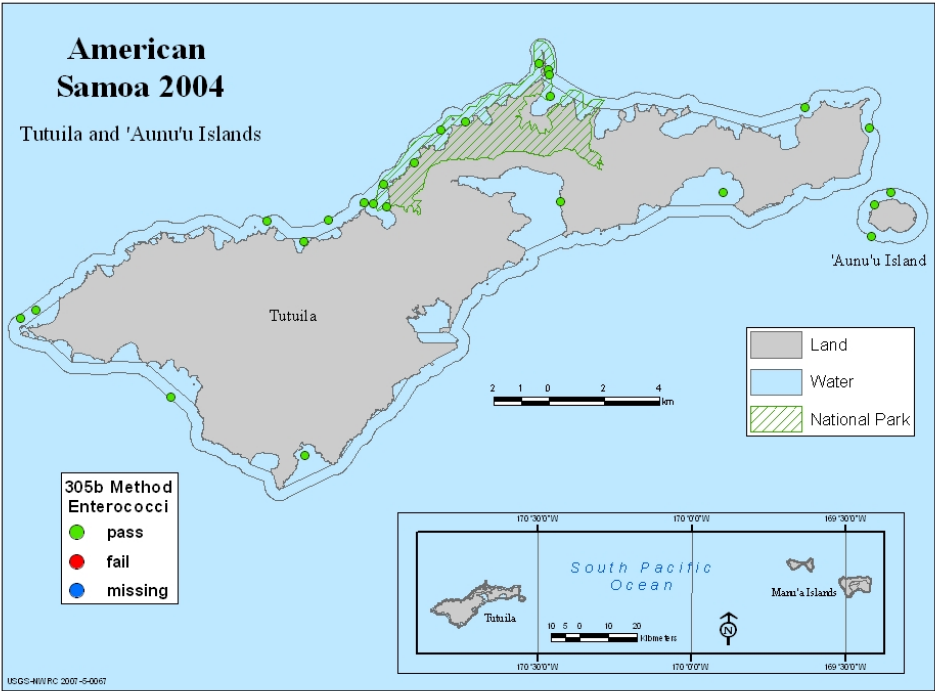


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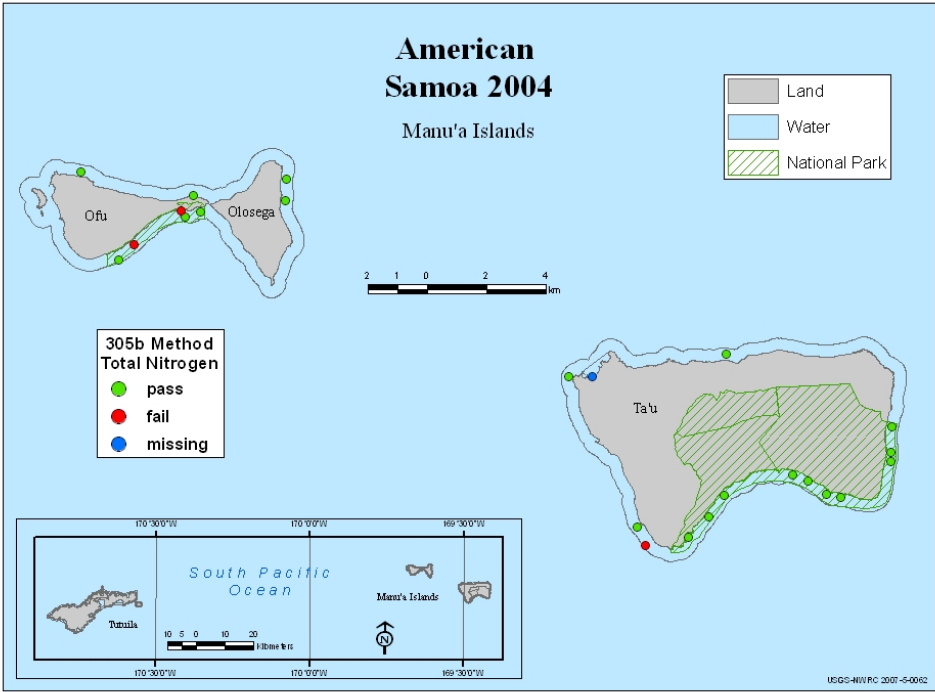
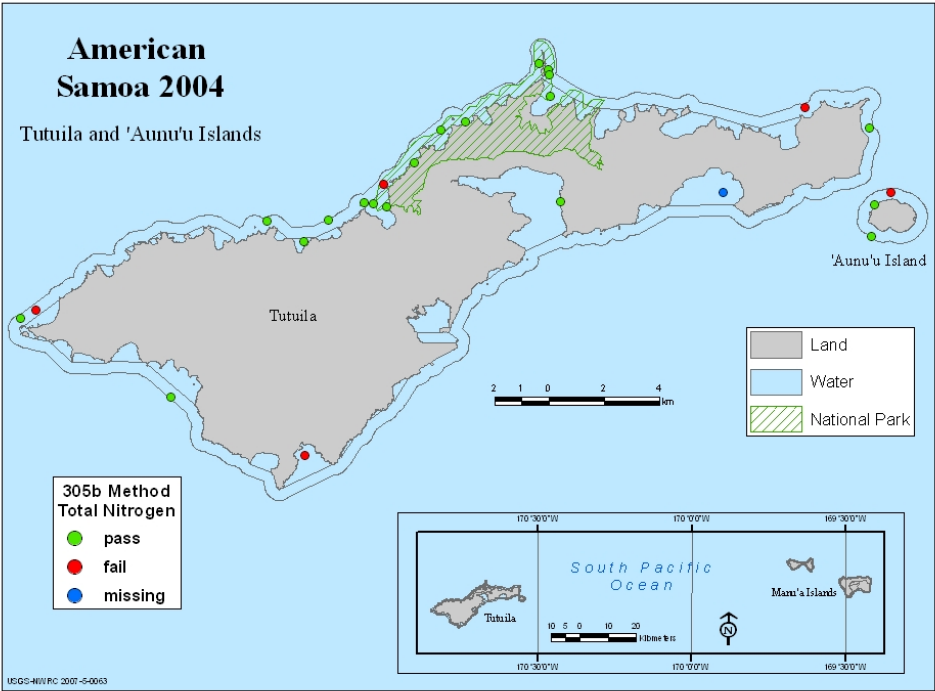


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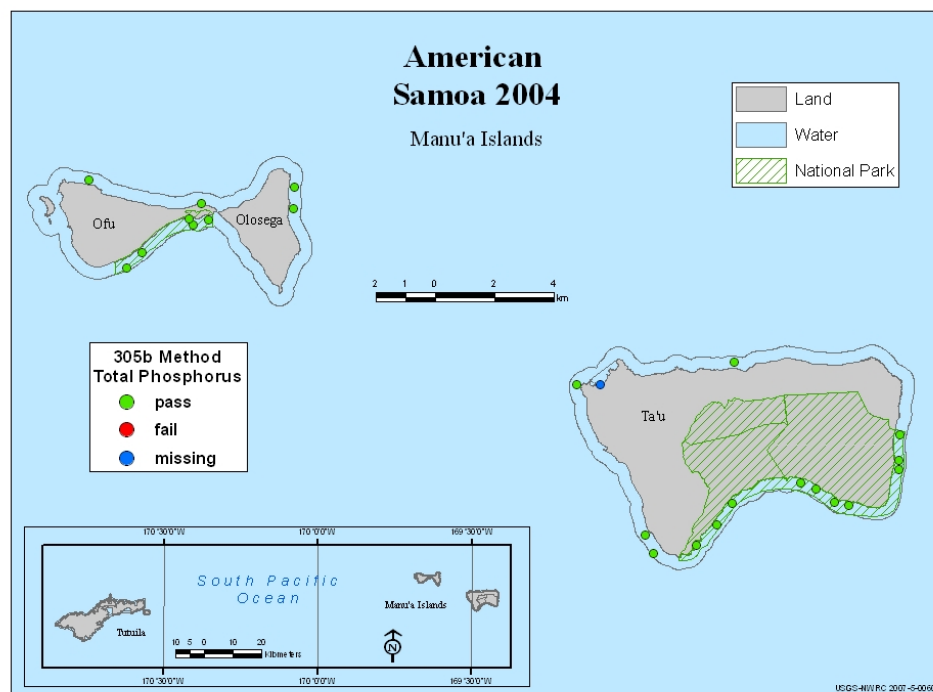
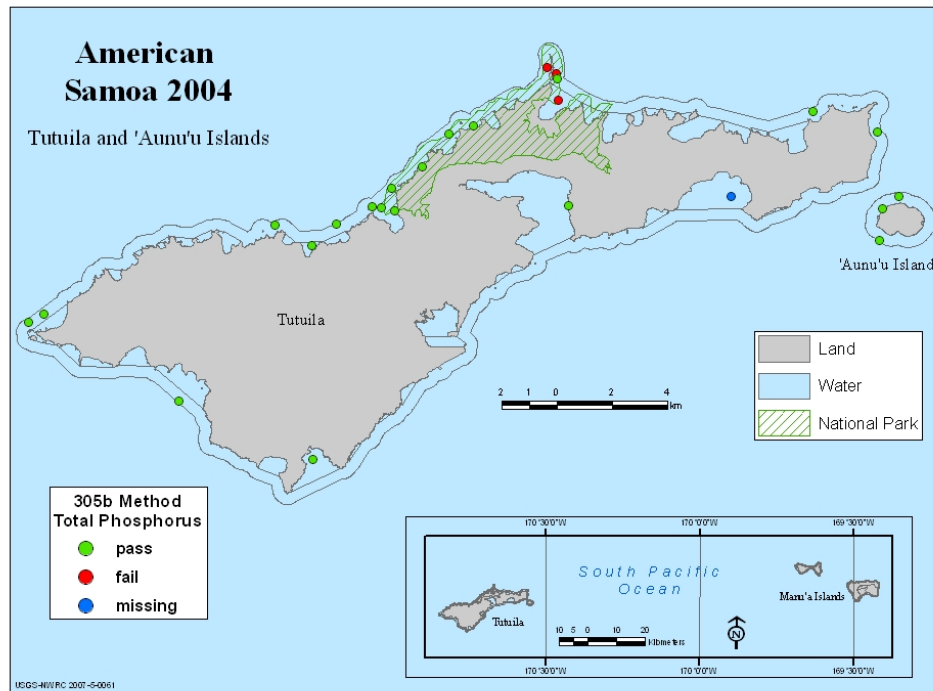


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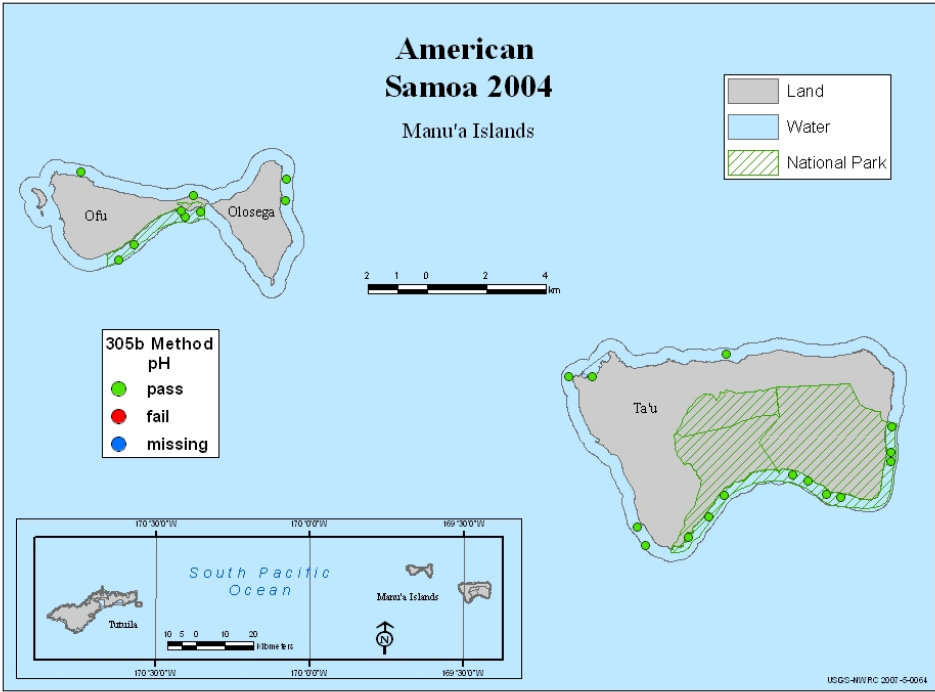
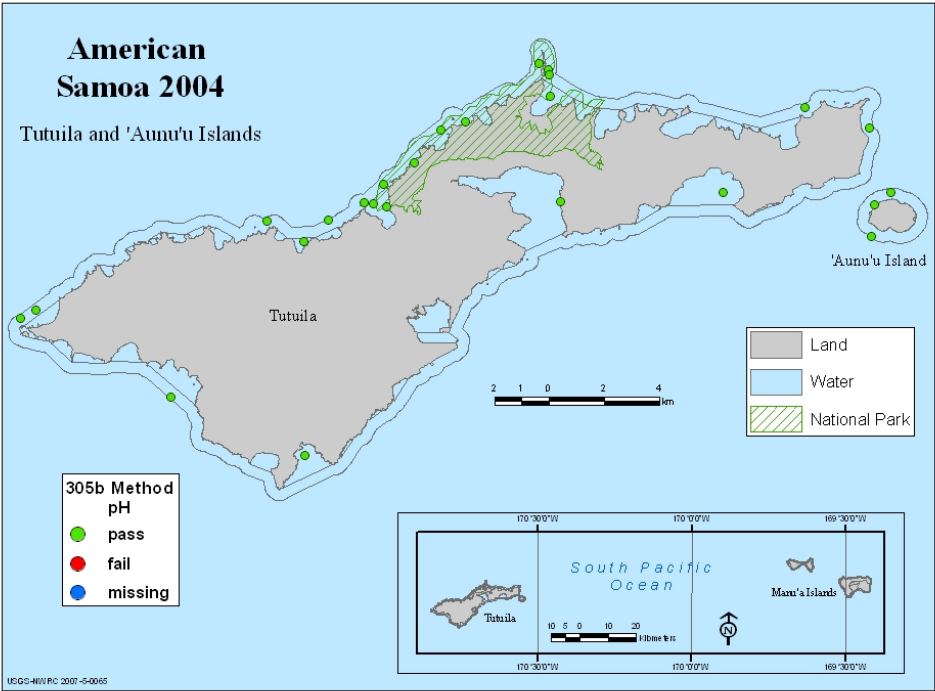


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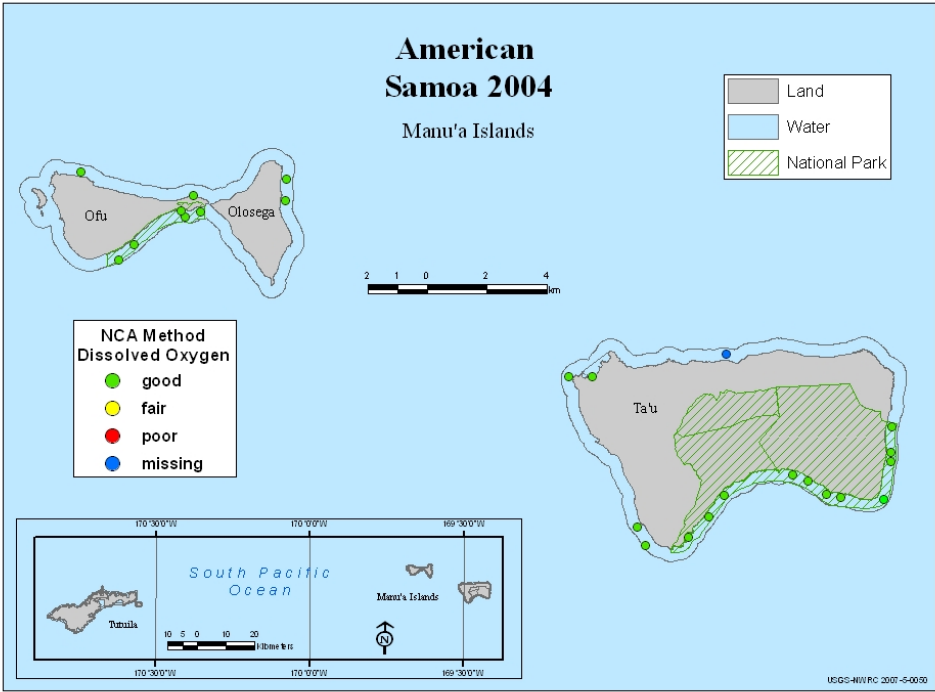
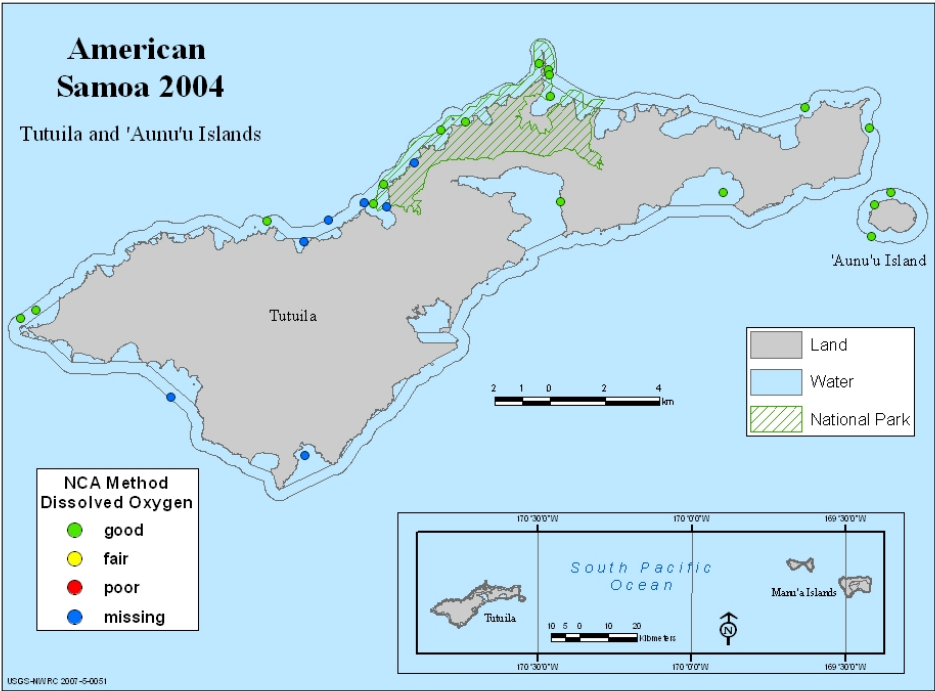


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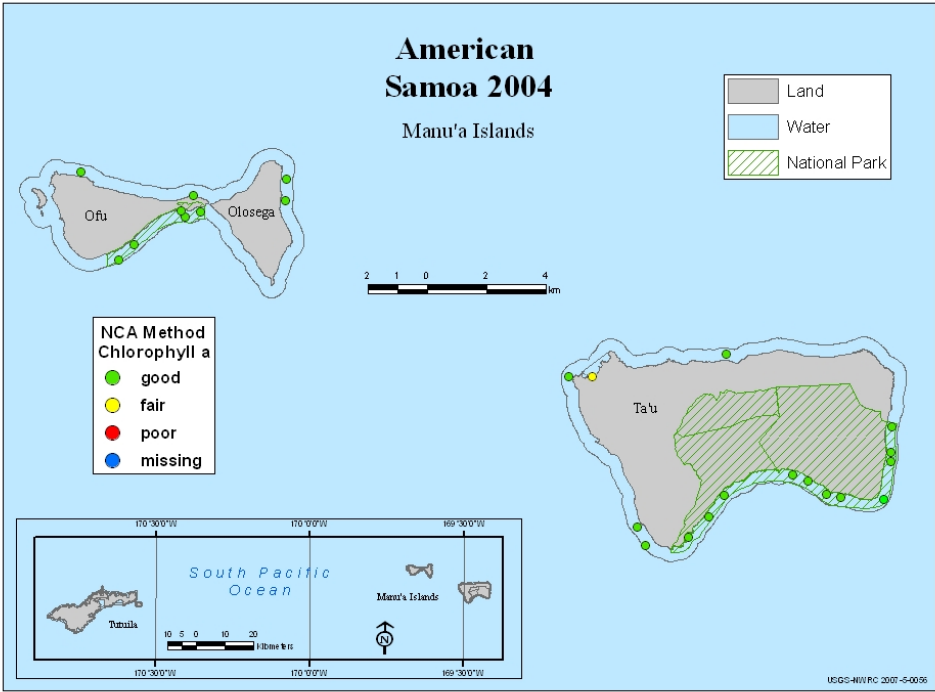
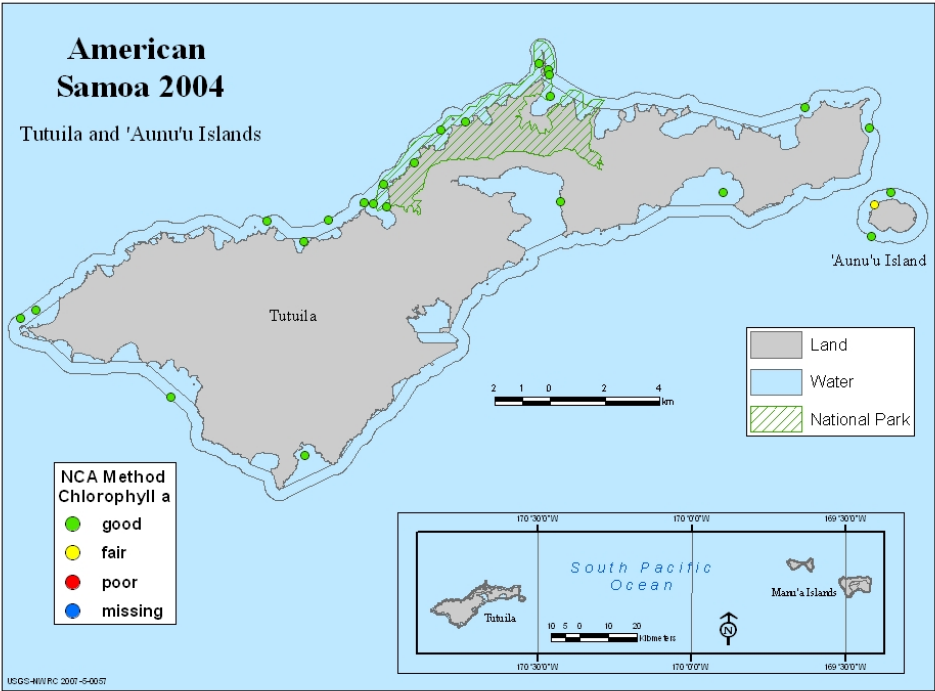


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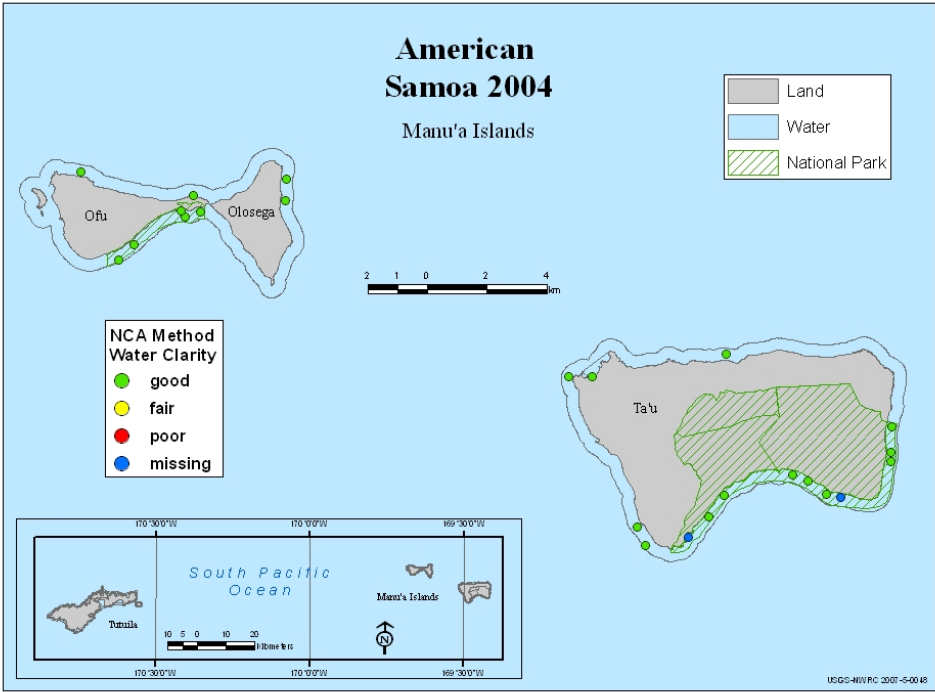
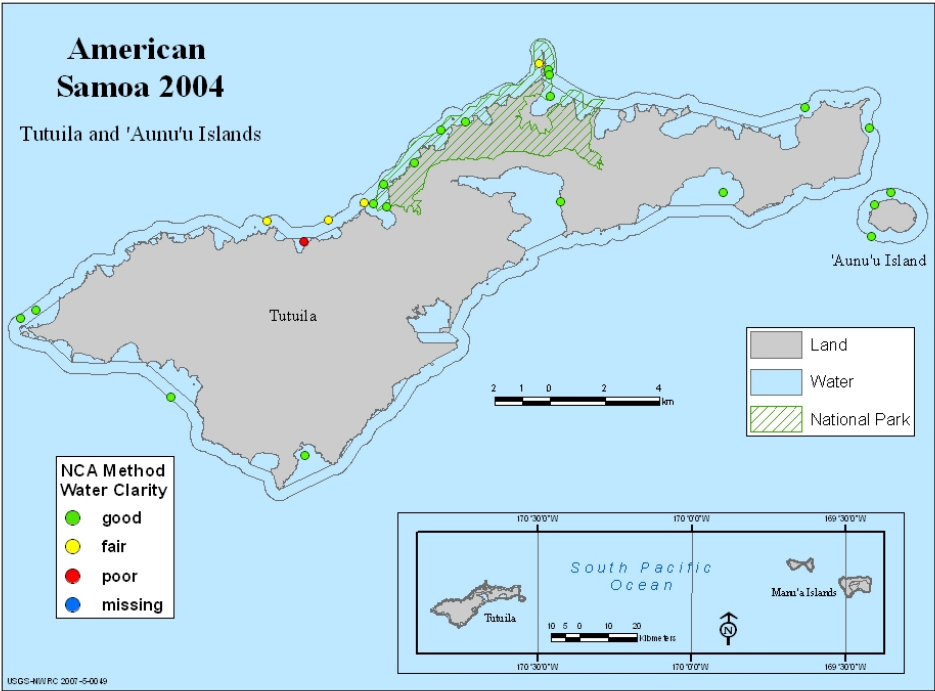


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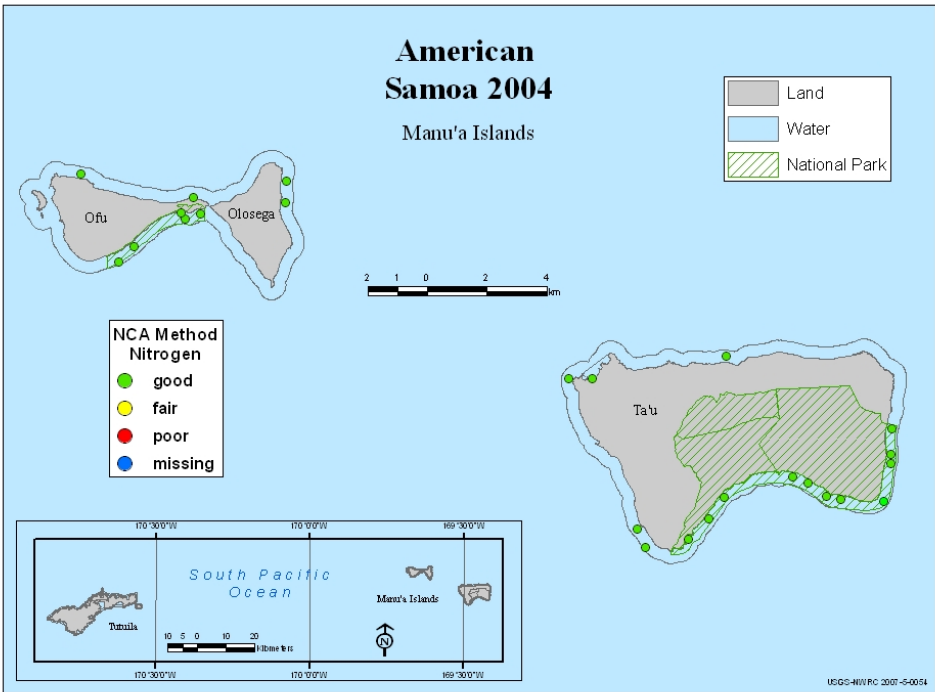
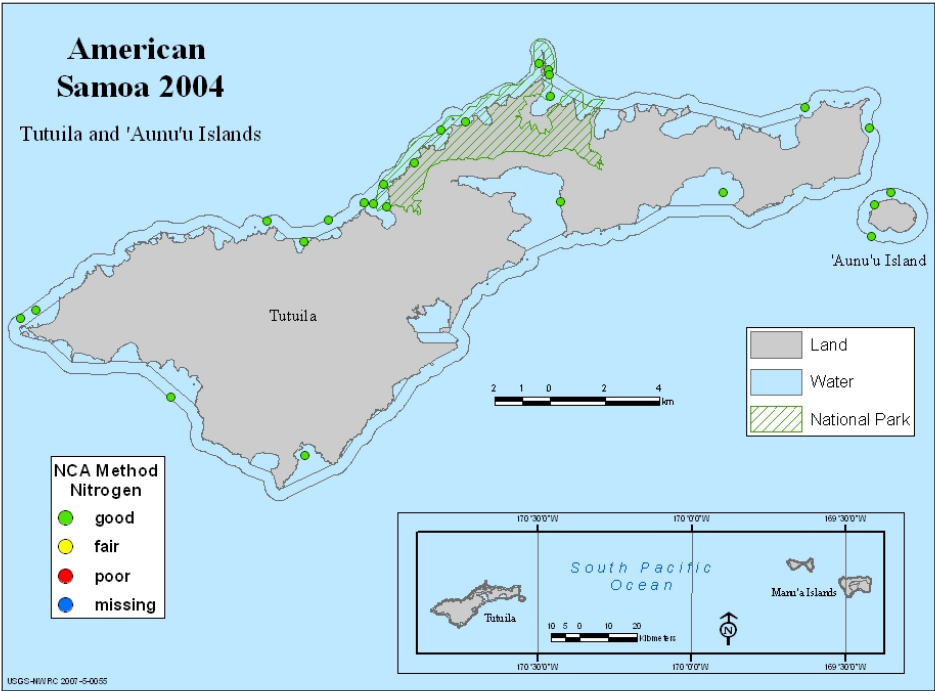


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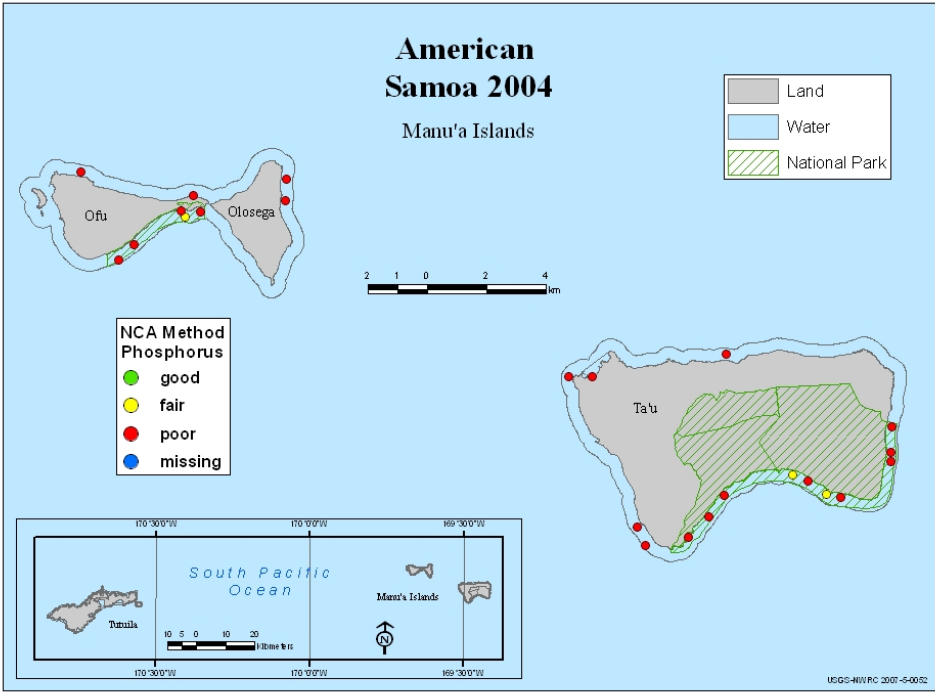
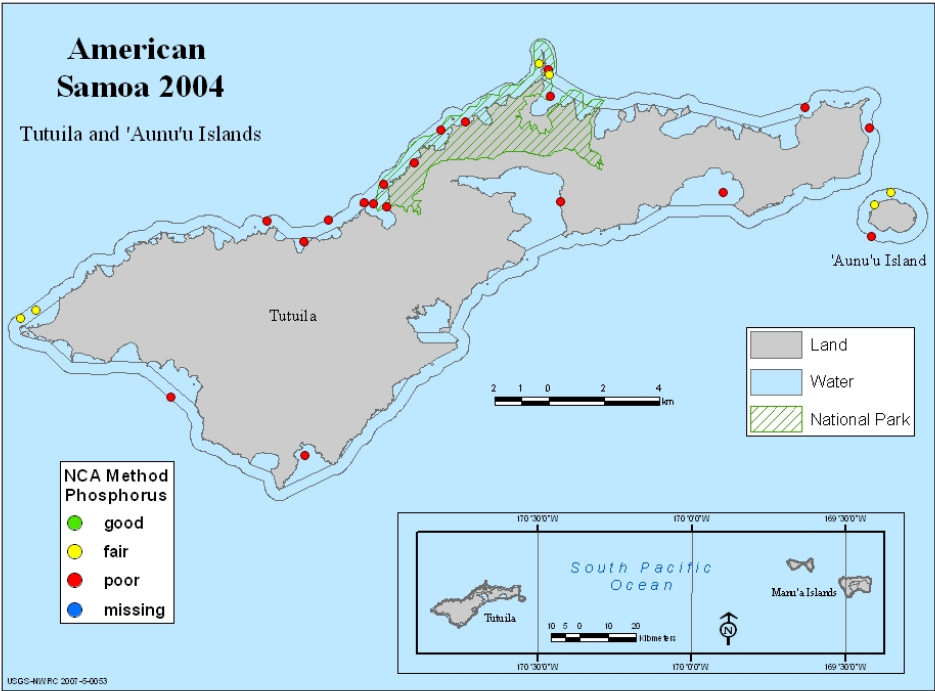


Figure C13.

