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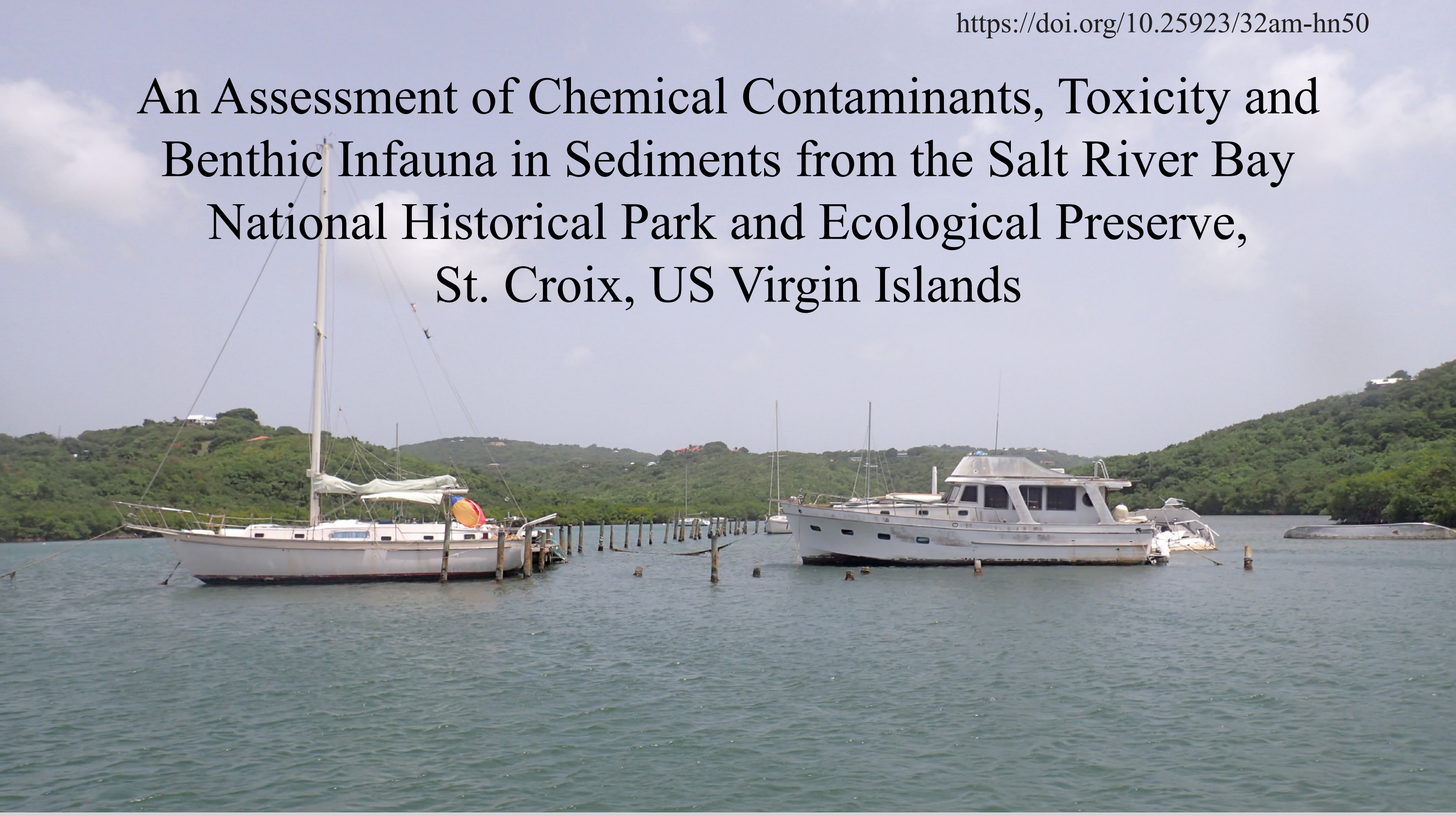
An Assessment of Chemical Contaminants, Toxicity and Benthic Infauna in Sediments from the Salt River Bay National Historical Park and Ecological Preserve, St. Croix, US Virgin Islands



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Abstract

This project resulted in the collection and analysis of sediments for chemical contaminants and bioeffects within the estuarine portion of the Salt River Bay National Historical Park and Ecological Preserve or SARI. Working closely with partners from the USVI Department of Planning and Natural Resources and the National Park Service, four strata were established in the estuarine portion of the SARI, and 13 sediment samples along with a sediment core were collected. Samples were analyzed for a suite of over 270 organic (e.g., hydrocarbons and pesticides) and inorganic (e.g., metals) chemical contaminants. The 13 samples collected were also analyzed for bioeffects, including the HRGS P450 assay, sea urchin embryo development assay, and an assessment of the benthic infaunal community.

The results of the chemical contaminant analysis indicated low to moderate concentrations of the contaminants analyzed relative to published sediment quality guidelines. The only contaminants which exceeded a published sediment quality guideline were zinc and copper, both in the Marina stratum. Copper was close to a concentration at which impacts occur.

The sea urchin development assay results were confounded by high levels of ammonia in the sediment samples, and may have been related to recent rainfall, or to the remnant effects (i.e., plant detritus) from the 2017 hurricanes. The HRGS P450 assay indicated the presence of toxic contaminants in both the Marina and Mangrove Lagoon strata, some of which may have been beyond the list of compounds analyzed.

The assessment of benthic infaunal organisms in the sediments indicated no significant differences between strata. However, diversity was lowest at a site in the Marina stratum, and at one of the sites in the Mangrove Lagoon stratum. Correlations between the benthic infaunal community and contaminants, indicated a significant negative correlation between taxa richness (number of species at the sites), and the ERMq, an indicator of pollution due to the presence of multiple contaminants.

INTRODUCTION

Located on the north shore of the island of St. Croix in the US Virgin Islands (USVI), the Salt River Bay National Historical Park and Ecological Preserve or SARI (Figure 1) has an area of approximately 410 hectares (1,015 acres). Throughout this report, the area will be referred to as SARI (for Salt River) or the park. The SARI was created in 1992 by Public Law 102-247 of the 102d Congress, in order to "preserve, protect, and interpret for the benefit of present and future generations certain nationally significant historical, cultural, and natural sites" (USC, 1992). The legislation also established that management of the park was to be carried out as a partnership between the federal government and the Government of the USVI.

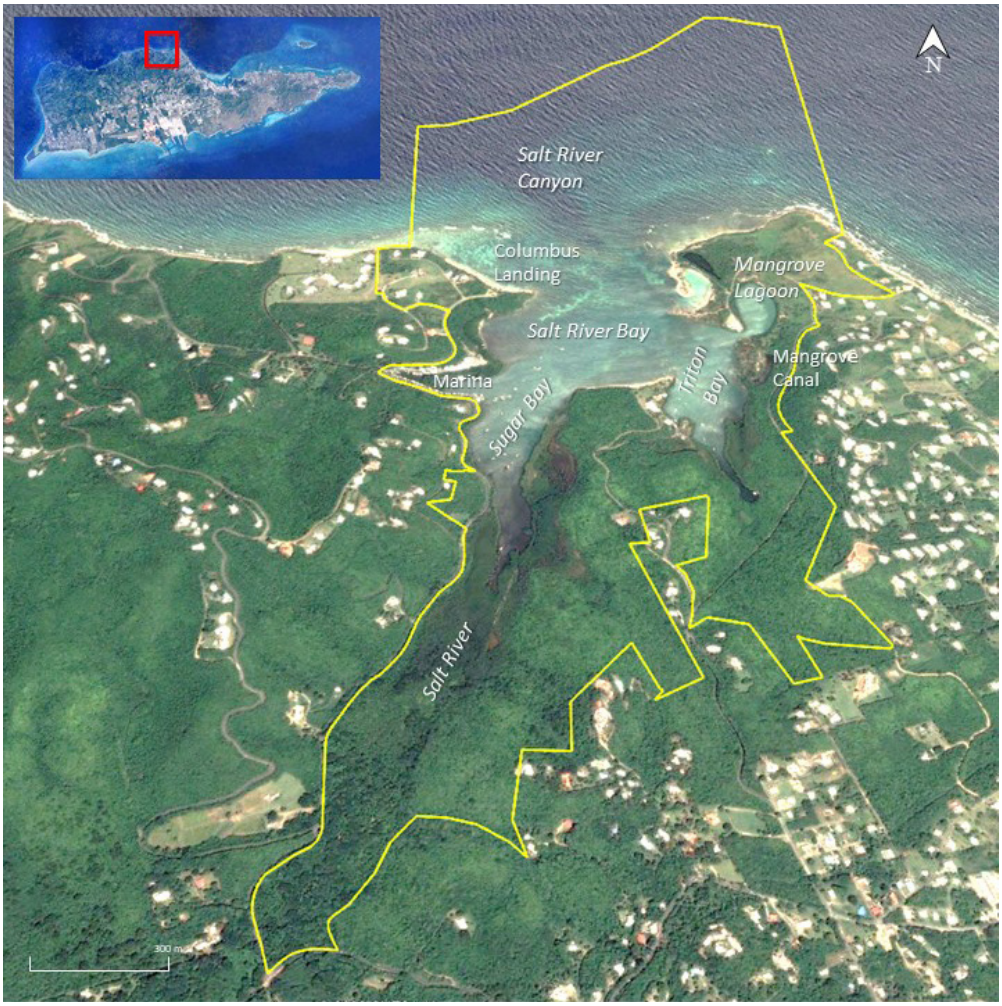

Figure 1. Borders and areas within the Salt River National Historical Park and Ecological Preserve (SARI).

History

The area around the SARI has been occupied for more than 2,000 years. Archaeological evidence indicates that the Igneri, Taino, and Carib civilizations occupied the area up until the late 15th century. In 1493, Christopher Columbus, on his second voyage to the Americas, landed at a point near the entrance to Salt River Bay (Figure 1). In the years following the arrival of Columbus, the island of St. Croix changed hands numerous times, including the Spanish, English, Dutch, French and Danes. In 1916, St. Croix was purchased from Denmark by the US along with St. Thomas and St. John. In addition to the Columbus landing site, prehistoric artifacts from around 350 AD, including a ceremonial ball court and village, along with a burial ground have been discovered. Remnants of Fort Sale, originally an eleven gun earthen fortification started in 1641 by English colonists were also found in the area near the Columbus landing site.

Estuary and Watershed

Salt River Bay (Figure 1) along with Triton Bay and Sugar Bay, have been classified as an estuary that drains to a well-developed submarine canyon (Hubbard, 1989). Salt River is the principal gut that drains to the SARI (IRF, 1993). Currently, freshwater flows down into Sugar Bay only during periods of high rainfall, as might occur during thunderstorms or tropical storms (Kendall *et al*., 2005). The watershed (Figure 2), has an area of approximately 1,165 hectares (NPS, 2008), making it the second largest watershed on St. Croix.

The estuary is separated from the submarine canyon by a narrow barrier reef. The Salt River Canyon (Figure 1) has a depth of nearly 300 meters. Salinity within the estuary ranges from 33 to 36 parts per thousand (ppt) during most of the year with drops in salinity, particularly in the upper reaches of Sugar and Triton Bays as a result of heavy rainfall (Hubbard, 1989). Higher salinities can also occur in these areas, as a result of evaporation and low rainfall.

SARI Habitats and Biota

The SARI contains a variety of habitats including mangrove forests, dry forests, a salt pond, a freshwater marsh, extensive seagrass beds and coral reefs. Salt River Bay has been described as the most productive nursery area for both commercial and recreational species of fish and crustacea in St. Croix, and possibly in the USVI (Sladen, 1988). Factors that have been associated with this productivity include the relatively large area of the estuary, nutrient-rich waters supporting a complex food web, extensive seagrass meadows and mangrove forests providing habitat and food for larval and juvenile species, and adjacent and extensive coral reefs, all in relatively close proximity.

Species of fish found in Salt River Bay include white mullet (*Mugil curema*), dwarf herring (*Jenkinsia lamprotaenia*), bonefish (*Albula vulpes*), schoolmaster snapper (*Lutjanus apodus*), and gray snapper (*Lutjanus griseus)* (IRF, 1993). In a companion study, the results of which will be reported in a later publication, horse-eye jack (*Caranx latus*), sea bream (*Archosargus rhomboidalis*), and dog snapper (*Lutjanus jocu*) were collected for chemical contaminant analysis, in addition to schoolmaster snapper. IRF (1993) also identified queen conch (*Lobatus gigas*), Caribbean spiny lobster (*Panulirus argus*), and the flat tree oyster (*Isognomen allatus*) as inhabitants.

Figure 2. Salt River Bay watershed, with an area of approximately 1,165 hectares (2,880 acres), is the second largest on St. Croix (NPS, 2008). The watershed is composed of the Northcentral St. Croix USGS HUC unit (21020002010020).

Within the SARI, mangroves were estimated to cover approximately 19 hectares as of 2000 (Kendall *et al.,* 2005). At one time, the highest concentration of mangroves in the USVI could be found in the SARI. However storms, particularly hurricanes, along with development have reduced the amount of mangroves present. Mangroves have a variety of functions including providing habitat for biota, particularly juveniles, and are also important in trapping sediments. In the St. Thomas East End Reserves (STEER), mangroves were shown to provide an important buffer, protecting the adjacent marine protected area of the STEER from inputs of terrestrial contaminants (*e.g*., metals) from an adjacent landfill, through a process of sediment trapping and slowing of water entering from upland areas (Keller *et al*., 2017).

In 1988, a year prior to Hurricane Hugo, mangroves within the SARI had an area estimated at 22 hectares. Following Hugo, the area of mangroves within SARI decreased to only 12 hectares, but as of 2000, had recovered 54 percent of the extent of the 1988 forest (Kendall *et al*., 2005). In September 2017, Irma and then Maria, both Category 5 hurricanes severely impacted the USVI including St. Croix, and likely again reduced the extent of mangroves in the SARI. During the field work for this project in September 2018, dead mangroves were seen in Sugar Bay and also in Mangrove Lagoon (Figure 3).

The seagrasses in the SARI, primarily turtlegrass (*Thalassia testudinum)* and manatee grass (*Syringodium filiforme)* are found in Salt River Bay and extend out to the barrier reefs. Further southward in Sugar Bay and Triton Bay, waters are too turbid for seagrasses to flourish. The area of seagrasses in SARI was estimated at 21.6 hectares by Kendall *et al.* (2005) using imagery from 2000.

The barrier reefs at the mouth of the bay mark the beginning of a broad expanse of coral reefs in the SARI. The reefs occur in an east/west axis, and includes Salt River Canyon. The total area of coral reef and hardbottom area in SARI estimated by Kendall *et al.*, (2005), was slightly over 116 hectares. The authors acknowledged this figure is likely an underestimate, as deeper waters, particularly in the northern part of the SARI, precluded visual identification. Much of the floor of the canyon is characterized as uncolonized hardbottom and reef rubble, while the walls are colonized with corals.

Figure 3. Dead mangroves seen in Mangrove Lagoon, possibly related to the effects of Hurricanes Irma and Maria.

Most of the research on the species of coral, fish, crustacea, and other organisms in the reefs in SARI, have taken place in Salt River Canyon. From that work, over 40 species of corals, including *Montastraea cavernosa* (great star coral), *Madracis decactis* (ten-ray star coral), *Porites astreoides* (mustard hill coral), *Siderastrea siderea* (massive starlet coral), *Orbicella* spp. and *Agaricia* species, have been identified. In addition, over 85 species of sponges, along with nearly 200 species of fish have reportedly been recorded over the years in the area of Salt River Canyon (Kendall *et al.,* 2005; Ennis *et al.*, 2019). The west wall of the canyon is steeper than the east wall, and has greater coral coverage (Kendall *et al.,* 2005). It is thought that the longshore (east to west) transport and impact of sediments on organisms on the east wall, is responsible for the lower cover and smaller size of corals present there (Hubbard, 1989).

Water Currents and Sediments

Water currents within the SARI are largely driven by wind and wave action, with a smaller contribution from tides (Kendall *et al.*, 2005). Trade winds blowing from east to west typically transport water over the barrier reef and into Salt River Bay. Depending on the wind and waves, water can pile up in SARI, which then exits through Salt River Canyon once the winds have subsided or during the ebb tide. Sediments within the SARI vary greatly in terms of texture and composition. In Salt River Canyon, course-grained carbonate sediments dominate, derived from the bioerosion of corals (Kendall *et al.,* 2005). Carbonate sediments predominate in the main body of Salt River Bay, and along the sides of Sugar Bay. In the central portions of Salt River Bay and also in Sugar Bay, there is a transition to finer sediments, including silts and clays of terrestrial origin.

Hubbard (1989) noted there is little evidence of significant transport of terrigenous sediments out of Salt River Bay and into Salt River Canyon. This has been attributed to the emergent barrier reefs at the mouth of Salt River Bay, which under normal circumstances separate estuarine from open marine sedimentation (Hubbard, 1989). Tropical storms or hurricanes likely result in some terrestrial sediment being transported past the barrier reefs and out into Salt River Canyon. Williams (1988) noted, however, that even after winds from a tropical storm in 1984 that produced three meter high waves breaking over the barrier reefs, there was only a thin brown layer of terrestrially-derived sediment on the marine sediments in Salt River Canyon, indicating how effectively the barrier reefs function in preventing the transport of sediments out of the estuary and into the canyon. Because of this, it would appear that the finer-grained sediments transported from terrestrial sources would likely tend to remain in the estuarine portion of the SARI, along with any attached chemical contaminants.

Moving further up into Sugar Bay, terrestrial sediments tend to dominate. Sediments with higher silt and clay content readily accumulate contaminants including organics (carbon-containing chemical contaminants) and metals that may be present, compared to larger grained sediments such as sand or gravel found further out in Salt River Bay. The reason for this is that finer grain size sediments (silt and clay) have correspondingly higher surface areas, along with sediment particle characteristics (*e.g.*, typically higher organic carbon content) that increase the adsorption of chemical contaminants. IRF (1993) noted that the relatively poor flushing capacity of this estuary, particularly in the back waters of Sugar Bay and Triton Bay, makes these areas more vulnerable to the effects of pollution.

Land Use and Land Cover

Using aerial photography, Kendall *et al.*, (2005) estimated the coverage of various land cover/land uses. The total land area within SARI was estimated at 145 hectares. The benthic habitat within the SARI has an area of approximately 250 hectares. There has been substantial modification of the shoreline in SARI (IRF, 1993; Kendall *et al.*, 2005; NPS, 2008) Dredging activities have been used to create a number of features within SARI including the marina, Mangrove Lagoon, and also Mangrove Canal which is from an abandoned marina project on the east side of Triton Bay (Figure 1). Dredged material has been placed at several locations around the perimeter of the SARI creating new land and influencing the composition (*e.g.*, salt content) of the soils (NPS, 2008).

The largest land cover within the SARI has been identified as dry forest. Kendall *et al.* (2005) estimated total forest cover at 106 hectares, or roughly 73 percent of the land area in the SARI from 2000 imagery. As noted in NPS (2008), the bulk of the semi-deciduous dry forest is located in the southern inland portions of SARI. Naturally vegetated fields accounted for approximately 14 hectares in 2000, concentrated in the northeastern and northwestern portions of the park (Kendall *et al.*, 2005). Shrubs and bushes accounted for roughly 11 hectares, concentrated mostly in the northern part of the SARI, on either side of mouth of Salt River Bay. IRF (1993) indicated some agricultural activity in the lower reaches of the Salt River floodplain at the time. Kendall *et al.* (2005) estimated approximately 1.4 hectares of what appeared to be crop rows. In the current project, no clear evidence of agricultural row crop activity could be seen in this area or other parts of the SARI.

Developed areas in 2000 accounted for 3.1 hectares, or 2 percent of the land area in the SARI (Kendall *et al.*, 2005). Developed residential areas accounted for 1.7 hectares; developed commercial areas accounted for 1.4 hectares. At the writing of their report, the authors noted land clearing on the bay slopes of Estate Judith's Fancy which borders SARI on the east side. More recently, NPS (2008), indicated over 30 residential homes in this area. There are also residential developments in other areas in or bordering the SARI including Estate Salt River on the northwest side, Estate St. John in the southeast, Estate Morningstar in the southwest, and Estate Montpelier to the south.

Soils

Top soils within SARI range from 0 to approximately 23 cm deep, and consist of gravelly, sandy stony or clay loam of the Arawak, Cramer-Victory, Glynn, Solitude, and Victory-Southgate series, and are not particularly well suited for crops (NPS, 2008). The USDA/NRCS has indicated the soils of these series are more suited for rangeland due to their shallow depth along with the presence of stones (USDA, 2000). As a result, agriculture particularly row crops, are not a dominant land use in the SARI.

Human Population

The total population in the vicinity of the SARI using 2000 US Census data was 773 (NPS, 2008). Septic systems are used to treat wastewater in the residences adjacent to the SARI (NPS, 2008). McKinzie *et al.* (1965) noted that the types of soils found in this part of St. Croix have severe limitations in terms of their use for septic systems, which could increase the likelihood of increased input to the SARI.

Water Quality

The USVI has established Areas of Particular Concern or APCs. While recognizing the importance of all areas within the coastal zone, APCs are defined as those areas of greater significance. Among the factors considered for designation include significant natural, culturally important, and recreational areas. In 1991, the Coastal Zone Management (CZM) Commission of DPNR adopted 18 APCs. The SARI and the surrounding watershed are one of the APCs in the USVI. Salt River has also been highlighted by the Virgin Islands Coral Reef Advisory Group (VICRAG) for management intervention and protection (Rothenberger, and Henderson, 2019).

As noted, the SARI has been subject to a variety of human activities, including dredging, along with commercial and residential uses. Upland erosion from development and land clearing activities within the watershed, some of which appears to have been abandoned, have likely increased sediment delivery, accompanied by turbidity and sedimentation within the estuarine waters of the SARI.

In accordance with the Clean Water Act, the USVI has designated waters as Class A, B or C based on their desired use. Each class has associated with it water quality criteria concentrations that should not be exceeded if the water body is to meet a designated class. The water quality criteria for the USVI include dissolved oxygen, enterococcus bacteria, phosphorus and turbidity (USVI, 2015). The waters in the SARI have designated as Class B which sets specific maximum concentrations of the above listed parameters.

The Division of Environmental Protection of DPNR has conducted regular monitoring in the SARI over the years.

Kendall *et al.* (2005) analyzed data collected from 1981 - 2002, mostly from EPA's STORET data base, for a number of monitoring stations within SARI for dissolved oxygen, fecal coliform, salinity, temperature, and turbidity. The USVI water quality criteria for dissolved oxygen in Class B waters is 5.5 mg/L. Results from the analysis of the 1981 - 2002 data by Kendall *et al.* (2005) indicated the mean dissolved oxygen concentration at the marina was 5.3 ±0.1 mg/L, below the criteria. At 5.4 ± 0.3mg/L, the mean Sugar Bay dissolved oxygen concentration was also slightly below the water quality criteria. In general, monitoring stations further upstream in the estuarine portion of the SARI had lower dissolved oxygen levels and higher turbidity levels. Kendall *et al.* (2005) also found that turbidity was elevated in Sugar Bay and Triton Bay above the turbidity criteria of 3.0 NTU (nephelometric turbidity unit), however, Sugar Bay is exempted from this criteria due to naturally occurring conditions (USVI, 2015). The mean fecal coliform bacteria concentration (50.5 ±24.5 bacterial colonies/ 100 mL) also appeared elevated, however, the USVI criteria is for enterococcus bacteria and not for the fecal coliform bacteria measurement.

As part of the requirements of Section 303(d) of the Clean Water Act, states and territories are required to develop a list of impaired waterbodies that do not attain or maintain compliance with the applicable water quality criteria (DPNR, 2016). To address impaired waters, TMDLs or Total Maximum Daily Loads are developed that identify how much pollution a waterbody can receive and still meet the applicable water quality criteria. In the SARI, a TMDL has been established for dissolved oxygen. Low dissolved oxygen levels are thought to be the result of BOD or biochemical oxygen demand, in parts of the SARI including those adjacent to residential areas and the marina, and also from derelict or barren lands in the watershed (DPNR, 2004). Biochemical oxygen demand is the amount of oxygen consumed in a water sample during a test of the decomposition of oxidizable organic matter. It should be noted that other impairments have been cited in the SARI including enterococcus bacteria, fecal coliform bacteria and turbidity. To date, TMDLs have not yet been developed to address these criteria.

Assessments of chemical contaminants in the SARI appear to be limited. Oostdam (1986) sampled sediments in Salt River Bay for the presence of metals. As will be discussed later in this report, copper appeared to be above a published sediment quality guideline (Long *et al*., 1998). Bayless (2019) sampled sediments in Salt River Bay for organic chemical contaminants. Sediments were sampled in July 2017 and that September, Hurricanes Irma and Maria hit the USVI. The current project sampled in some of the same locations as Bayless (2019), and a comparison of chemical contaminant concentrations at these sites before and after the hurricanes will be presented later in this report.

NCCOS Involvement

In 2013, Woodley *et al*. (2016) investigated the reproductive health of elkhorn coral (*Acropora palmat*a) in the US Caribbean, and included sites within the SARI. Reproductive health at four sites within the SARI was found to be poor, as 20% or less of the colonies had gametes present. Beginning in 2014, DPNR and the National Park Service (NPS) requested NOAA's National Centers for Coastal Ocean Science (NCCOS) conduct follow up chemical contaminants assessments in the SARI, to see if contaminants were present at concentrations that could impact coral health and the health of other biota within the SARI.

Working with local partners DPNR and NPS, a sampling strategy was developed and implemented. NCCOS has worked closely with DPNR on a number of contaminant-related projects in the past including in Coral Bay on St. John, and in the STEER on St. Thomas. In addition and as noted, NCCOS' Biogeography Branch worked closely with NPS to conduct an ecological characterization of Salt River in 2005.

MATERIALS AND METHODS

In consultation with local resource managers about conditions and habitats in the SARI, and using available bottom-type data, a stratified-random sampling design was developed for sampling sediments in the SARI. A stratified-random design allows for the statistical comparison of contaminant concentrations between strata. A map of the four strata developed for this project can be seen in Figure 4. The strata include Sugar Bay, Marina, Triton Bay, and Mangrove Lagoon, and were set up to sample those areas in the SARI more likely to have finer grain sediments, such as might be found in Sugar and Triton Bays. Areas with sandy sediments and heavy seagrass, which occur in the outer part of Salt River Bay, were not included in the sampling design. Sediments in these areas would be less likely to accumulate chemical contaminants compared to areas further in the estuarine portion of the SARI.

The field work for this project took place in September 2018 aboard a National Park Service boat (Figure 5), piloted by a member of NCCOS' Biogeography Branch. A total of 13 sediment samples (Figure 6) were collected from the Sugar Bay, Triton Bay, Mangrove Lagoon and the Marina strata, and were analyzed for chemical contaminants, sediment toxicity, and the benthic infaunal community. In addition, a sediment core was taken in the Sugar Bay stratum (Figure 6) to look at chemical contaminants that might be present in older, deeper sediments. In the STEER, high levels of metals like copper and zinc, and the banned antifoulant paint ingredient tributyltin or TBT were found in the marina areas.

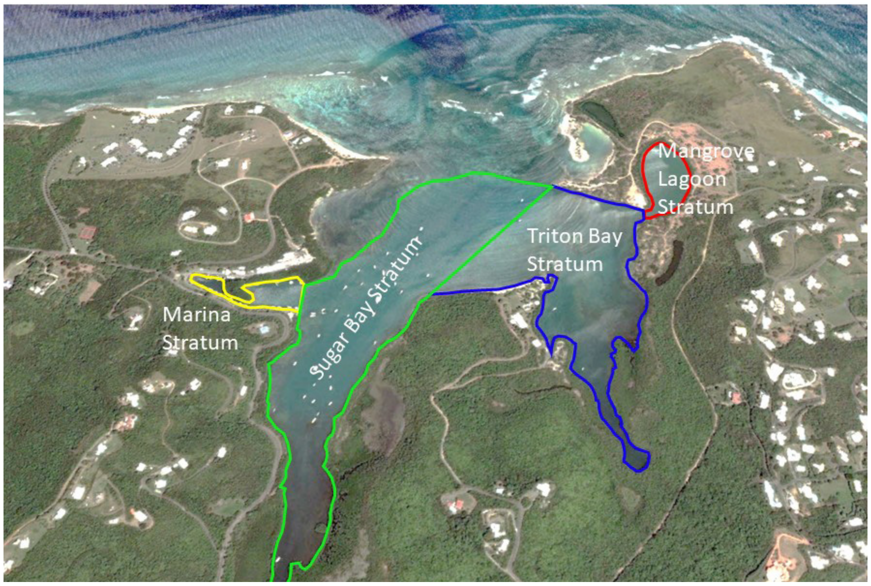

Figure 4. Strata developed for sampling sediments in the SARI.

Water Quality Measurements
A series of water parameters (dissolved oxygen, temperature, salinity, and conductivity) were measured at each site, using a YSI® salinity/conductivity/temperature meter. The instrument probe was submerged to a depth of approximately 0.5 meters (m) for the surface measurement, and within a meter of the sediment for the bottom measurement.

Sediment Collection
At each site, the PONAR sediment grab (Figure 7) was deployed multiple times to get enough sediment for the different analyses. Sediments were collected using standard NOAA National Status and Trends (NS&T) protocols (Apeti *et al.*, 2012). The NS&T Program within NCCOS monitors the Nation's estuarine and coastal waters for contaminants in bivalve mollusk tissues and sediments, along with the toxicity (bioeffects) of sediments. For the chemical contaminant sample, the top 3 cm of sediment was collected from the PONAR grab, using a stainless steel sediment scoop. This top layer of sediment is referred to as surficial sediment, and is typically indicative of more recent deposition. The PONAR was deployed using a pulley and davit, and retrieved by hand. Rocks and bits of seagrass were removed from the PONAR sample. If a particular grab did not result in 200-300 g of sediment, a second grab was made and composited with material from the first.

A series of protocols (Apeti *et al.*, 2012) were used to avoid contamination of the sediment samples by equipment and cross contamination between sites. Personnel handling the samples wore disposable nitrile gloves. All equipment was rinsed with site water and then wiped down with alcohol wipes, and finally rinsed with distilled water, just prior to use at a site.

A sediment core sample (Figure 6) was also taken, to look at chemical contaminants in deeper sediments. The corer was a standard design (Aquatic Research Instruments) for collection of undisturbed cores of the sediment. The corer drove a 7-cm diameter polycarbonate tube into the sediment with a hand-held weight. Once the sediment corer was retrieved, the core was capped and 2-cm sections were extruded by means of a plunger provided with the corer.

Sediments collected from both the PONAR and the sediment corer were placed into certified clean (I-Chem®) 250 ml labeled jars, one for organic chemical analysis, the other for major and trace element analysis, capped and then placed on ice in a cooler. Sediments for grain size analysis were placed in a WhirlPak® bag, sealed and placed on ice in a cooler. At the end of each day, sediment samples for contaminant or bioeffects analysis were placed in a freezer at the NPS facility in Christiansted. The WhirlPak® bags for the grain size analysis were placed in a refrigerator rather than frozen, to avoid altering the grain size structure of the sediment.

Figure 5. Boat provided by the National Park Service for sampling sediments in the SARI.

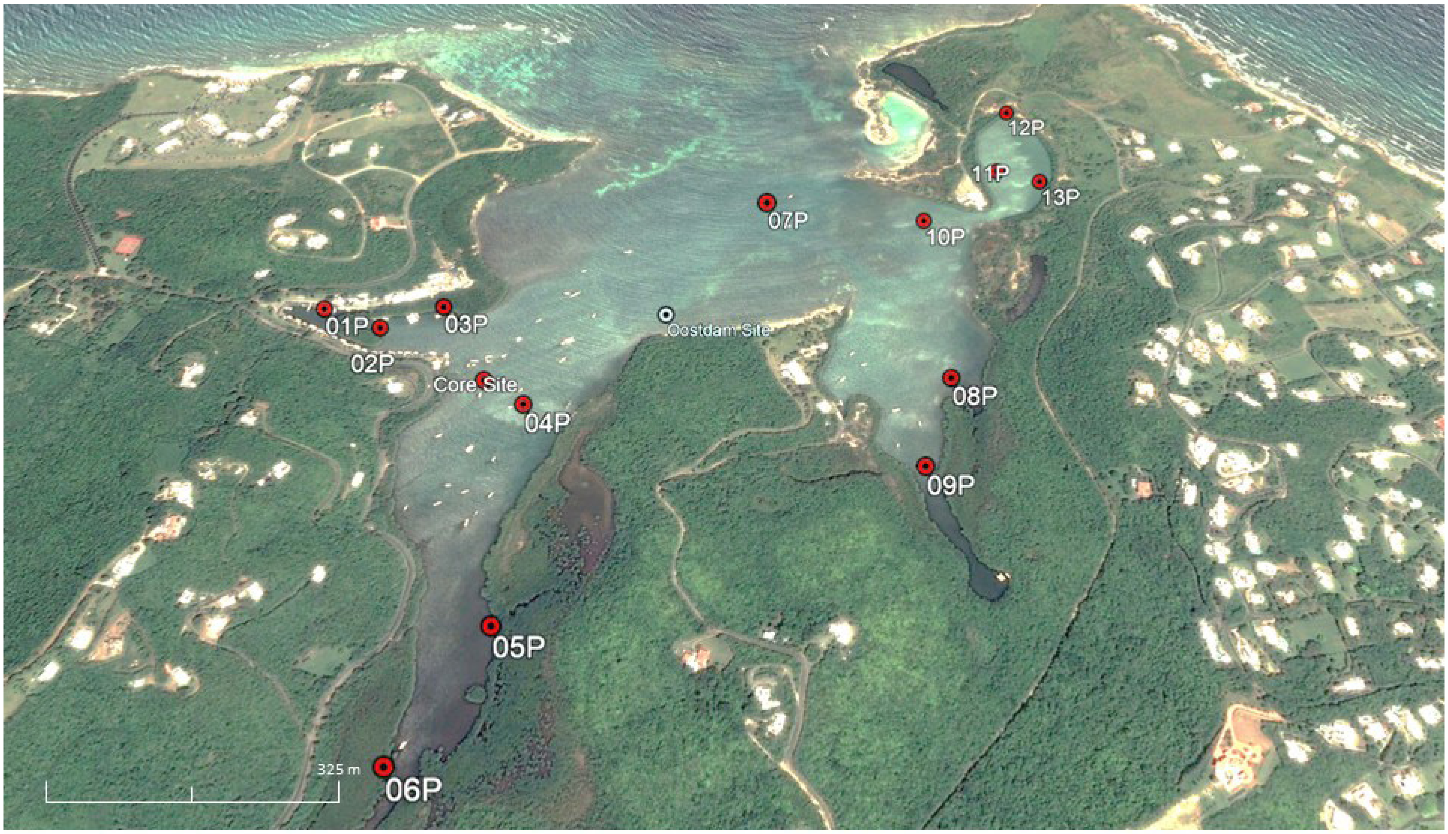

Figure 6. Sediment sites sampled for chemical contaminant and bioeffects analysis in the SARI.

Sediment Chemical Contaminants

The sediment samples collected were analyzed for a suite of over 270 chemical contaminants, including organic (*e.g.*, hydrocarbons and pesticides) compounds by TDI-Brooks International, and major and trace elements (*e.g.*, metals) by the NCCOS Charleston laboratory, using protocols established by the NS&T Program. The list of chemical contaminants analyzed in the sediments is shown in Table 1. The 64 polycyclic aromatic hydrocarbons (PAHs) were analyzed using gas chromatography/mass spectrometry in the selected ion monitoring mode. The 33 organochlorine pesticides and 157 polychlorinated biphenyls (PCBs) were analyzed using gas chromatography/electron capture detection. Four butyltins were analyzed using gas chromatography/flame photometric detection after derivatization. The 16 major and trace elements were analyzed using inductively coupled plasma mass spectrometry and atomic-fluorescence spectroscopy. Detailed descriptions of the NS&T protocols, including quality assurance/quality control (QA/QC) used in the analysis of the organic contaminants, can be found in Kimbrough *et al.* (2006); for inorganic analyses, Kimbrough and Lauenstein (2006). Each of these contaminant classes contains individual compounds or elements shown to be toxic to aquatic biota. A brief summary of the generation, use and impacts of these contaminants follows.

Polycyclic Aromatic Hydrocarbons. Also referred to as PAHs, polycyclic aromatic hydrocarbons are associated with the use and combustion of fossil fuels (*e.g*., oil and gas) and other organic materials (*e.g*., wood and trash). Natural sources of PAHs include forest fires and the decay of vegetation. The PAHs analyzed are two to six ring aromatic compounds. An example of a three ring PAH (1-methylphenanthrene), is shown on the cover of this report. A number of PAHs bioaccumulate in aquatic and terrestrial organisms, are toxic, and some including 1-methylphenanthrene, benzo[a]pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenzo[a,h]anthracene, and indeno[1,2,3-c,d]pyrene, are likely carcinogens (USDHHS, 1995).

Alkylated Hydrocarbons. In addition to the PAHs, another group, the alkylated hydrocarbons were analyzed in the sediments. Alkylated hydrocarbons are straight chain or branched nonaromatic structures. Aliphatic hydrocarbons are typically associated with uncombusted fuels such gasoline, diesel or oil.

Polychlorinated Biphenyls. Commonly referred to as PCBs, polychlorinated biphenyls are synthetic compounds which have been used in numerous applications ranging from electrical transformers and capacitors, to hydraulic and heat transfer fluids, to pesticides and in paints. Approximately 60 percent of PCBs manufactured in the U.S. were used in electrical applications (EPA, 1997). PCBs have a biphenyl ring structure (two benzene rings with a carbon to carbon bond) and a varying number of chlorine atoms. There are 209 PCB congeners possible. PCBs were manufactured in the U.S. between 1929 and 1977. In the United States, all PCBs were produced by a single manufacturer, and the commercial products were referred to as Aroclors. Aroclors are mixtures of PCB congeners. The manufacture of PCBs in the U.S. was banned in 1979 due to their toxicity. Because PCBs bioaccumulate and degradation in the environment proceeds only slowly, they are now ubiquitous contaminants. Exposure to PCBs in fish has been linked to reduced growth, reproductive impairment and vertebral abnormalities (EPA, 1997). PCBs are also probably carcinogenic to humans (ATSDR, 2000).

Organochlorine Pesticides. Beginning in the 1950s and continuing into the early 1970s, a series of chlorine containing hydrocarbon insecticides were used to control mosquitoes and agricultural pests. One of the best known organochlorine pesticides was the insecticide DDT (dichlorodiphenyltrichloroethane). Other organochlorine insecticides included aldrin, dieldrin, and chlordane.

The use of many of the organochlorine pesticides, including DDT, was banned due to their environmental persistence, potential to bioaccumulate, and especially the chronic (*i.e.*, longer-term) effects on nontarget organisms. Organochlorine pesticides are typically neurotoxins, and DDT along with PCBs have also been shown to interfere with the endocrine system. The DDT metabolite DDE, for example, was specifically linked to eggshell thinning in birds, particularly raptors, but also in pelicans (Lincer, 1975). A number of organochlorine pesticides are toxic to nontarget aquatic life as well, including crayfish, shrimp and some species of fish. While DDT was banned by the EPA for most uses in the U.S. in 1972, it is still effectively used in some developing countries, particularly on the inside of living areas to help control mosquitoes that can transmit malaria. Most uses of the organochlorine insecticide chlordane were canceled in 1978, and all uses were canceled by 1988. A primary non-agricultural use of chlordane was in the treatment of wooden structures to prevent damage by termites. Because of their persistence and heavy use in the past, residues of organochlorine pesticides can be found in the environment, including in biota. The persistence of these compounds and toxicity to nontarget organisms continues to be an environmental concern.

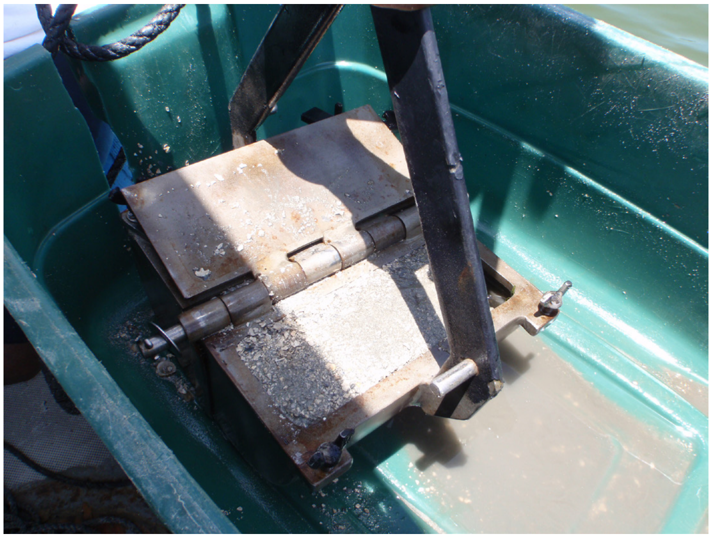
Figure 7. Image of the PONAR grab used to collect sediments in the SARI.

Butyltins. This compound class has a range of uses, from biocides to catalysts to glass coatings. In the 1950s, tributyltin, or TBT, was first shown to have biocidal properties (Bennett, 1996). In the late 1960s, TBT was incorporated into an antifoulant paint system, quickly becoming one of the most effective paints ever used on boat hulls (Birchenough *et al.*, 2002). TBT was incorporated into a polymer paint system that released the biocide at a constant and minimal rate, to control fouling organisms such as barnacles, mussels, weeds, and algae (Bennett, 1996). TBT was linked to endocrine disruption, specifically an imposex (females developing male characteristics) condition in marine gastropods, and in other mollusks (*e.g.*, oysters) abnormal shell development and poor weight gain (Batley, 1996). Beginning in 1989, the use of TBT as an antifouling agent was banned in the U.S. on non-aluminum vessels smaller than 25 meters in length (Gibbs and Bryan, 1996). In a survey of TBT in the USVI, Strand *et al.* (2009) found evidence of elevated levels of TBT and its degradation products in gastropod species, as well as imposex at several locations, including the harbor in Charlotte Amalie, St. Thomas. In the aquatic environment, TBT is degraded by microorganisms and sunlight (Bennett, 1996). The transformation involves sequential debutylization resulting in dibutyltin, monobutyltin, and finally inorganic tin (Batley, 1996).

Major and Trace Elements. All of the major and trace elements occur naturally to some extent in the environment. Aluminum, iron, and silicon are major elements in the Earth's crust. As their name implies, trace elements occur at lower concentrations in crustal material, however, mining and manufacturing processes along with the use and disposal of products containing trace elements can lead to elevated concentrations in the environment.

A number of trace elements are toxic at low concentrations. Cadmium, used in metal plating and solders, has been shown to impair development and reproduction in

Table 1. Chemical contaminants analyzed in the sediment samples from the SARI.

PAHs - Low MW	PAHs - High MW	Organochlorine Pesticides	PCBs	PCBs (continued)	PCBs (continued)	PCBs (continued)	PCBs (continued)
cis/trans Decalin	Fluoranthene	Aldrin	PCB 1	PCB 51	PCB 88	PCB 134/133	PCB 170/190
C1-Decalins	Pyrene	Dieldrin	PCB 2	PCB 45	PCB 91	PCB 165/131	PCB 189
C2-Decalins	C1-Fluoranthenes/Pyrenes	Endrin	PCB 3	PCB 46/69/73	PCB 92	PCB 142/146/161	PCB 202
C3-Decalins	C2-Fluoranthenes/Pyrenes	Endrin Aldehyde	PCB 4/10	PCB 52	PCB 101/84/90	PCB 153/168	PCB 201
C4-Decalins	C3-Fluoranthenes/Pyrenes	Endrin Ketone	PCB 7/9	PCB 43	PCB 89/113	PCB 132	PCB 204
Naphthalene	C4-Fluoranthenes/Pyrenes	Heptachlor	PCB 6	PCB 49	PCB 99	PCB 141	PCB 197
C1-Naphthalenes	Naphthobenzothiophene	Heptachlor-Epoxide	PCB 8/5	PCB 48/75/47	PCB 119	PCB 137	PCB 200
C2-Naphthalenes	C1-Naphthobenzothiophenes	Oxychlordane	PCB 14	PCB 65	PCB 112	PCB 130	PCB 198
C3-Naphthalenes	C2-Naphthobenzothiophenes	Alpha-Chlordane	PCB 11	PCB 62	PCB 120/83	PCB 138/164/163	PCB 199
C4-Naphthalenes	C3-Naphthobenzothiophenes	Gamma-Chlordane	PCB 12	PCB 44	PCB 97/125/86	PCB 160/158	PCB 203/196
Benzothiophene	C4-Naphthobenzothiophenes	Trans-Nonachlor	PCB 13	PCB 59	PCB 116/117	PCB 129	PCB 195
C1-Benzothiophenes	Benz(a)anthracene	Cis-Nonachlor	PCB 15	PCB 42	PCB 111/115/87	PCB 166	PCB 194
C2-Benzothiophenes	Chrysene/Triphenylene	Alpha-HCH	PCB 19	PCB 72	PCB 109	PCB 159	PCB 205
C3-Benzothiophenes	C1-Chrysenes	Beta-HCH	PCB 30	PCB 71	PCB 85	PCB 162	PCB 208
C4-Benzothiophenes	C2-Chrysenes	Delta-HCH	PCB 18	PCB 68/41/64	PCB 110	PCB 128/167	PCB 207
Biphenyl	C3-Chrysenes	Gamma-HCH	PCB 17	PCB 40/57	PCB 82	PCB 156	PCB 206
Acenaphthylene	C4-Chrysenes	DDMU	PCB 27	PCB 67	PCB 124	PCB 157	PCB 209
Acenaphthene	Benzo(b)fluoranthene	2,4'-DDD	PCB 24	PCB 58	PCB 106/107	PCB 169	
Dibenzofuran	Benzo(k,j)fluoranthene	4,4'-DDD	PCB 16/32	PCB 63	PCB 123	PCB 188	Major and Trace Elements
Fluorene	Benzo(a)fluoranthene	2,4'-DDE	PCB 34	PCB 61/74	PCB 118/108	PCB 184	Aluminum (Al)
C1-Fluorenes	Benzo(e)pyrene	4,4'-DDE	PCB 23	PCB 76/70	PCB 114/122	PCB 179	Antimony (Sb)
C2-Fluorenes	Benzo(a)pyrene	2,4'-DDT	PCB 29	PCB 66/80	PCB 105/127	PCB 176	Arsenic (As)
C3-Fluorenes	Perylene	4,4'-DDT	PCB 26	PCB 55	PCB 126	PCB 186/178	Cadmium (Cd)
Carbazole	Indeno(1,2,3-c,d)pyrene	1,2,3,4-Tetrachlorobenzene	PCB 25	PCB 56	PCB 155	PCB 175	Chromium (Cr)
Anthracene	Dibenzo(a,h)anthracene	1,2,4,5-Tetrachlorobenzene	PCB 28/31	PCB 60	PCB 150	PCB 187/182	Copper (Cu)
Phenanthrene	C1-Dibenzo(a,h)anthracenes	Hexachlorobenzene	PCB 21/20/33	PCB 79	PCB 152	PCB 183	Iron (Fe)
C1-Phenanthrenes/Anthracenes	C2-Dibenzo(a,h)anthracenes	Pentachloroanisole	PCB 22	PCB 78	PCB 148/145	PCB 185	Lead (Pb)
C2-Phenanthrenes/Anthracenes	C3-Dibenzo(a,h)anthracenes	Pentachlorobenzene	PCB 36	PCB 81	PCB 136/154	PCB 174	Manganese (Mn)
C3-Phenanthrenes/Anthracenes	Benzo(g,h,i)perylene	Endosulfan II	PCB 39	PCB 77	PCB 151	PCB 181	Mercury (Hg)
C4-Phenanthrenes/Anthracenes		Endosulfan I	PCB 38	PCB 104	PCB 135	PCB 177	Nickel (Ni)
Dibenzothiophene	Butyltins	Endosulfan Sulfate	PCB 35	PCB 96/103	PCB 144	PCB 171	Selenium (Se)
C1-Dibenzothiophenes	Monobutyltin	Mirex	PCB 37	PCB 100	PCB 147	PCB 173	Silicon (Si)
C2-Dibenzothiophenes	Dibutyltin	Chlorpyrifos	PCB 54	PCB 94	PCB 149/139	PCB 192/172	Silver (Ag)
C3-Dibenzothiophenes	Tributyltin		PCB 50	PCB 102/98	PCB 140	PCB 180/193	Tin (Sn)
C4-Dibenzothiophenes	Tetrabutyltin		PCB 53	PCB 121/93/95	PCB 143	PCB 191	Zinc (Zn)

Abbreviations: MW, molecular weight; PAH, polycyclic aromatic hydrocarbons; HCH, hexachlorocyclohexane; DDMU, 1-chloro-2,2- (p-chlorophenyl)ethylene; DDT, dichlorodiphenyltrichloroethane; DDD, dichlorodiphenyldichloroethane; DDE, dichlorodiphenyldichloroethylene; PCB, polychlorinated biphenyl several invertebrate species, and osmoregulation in herring larvae (USDHHS, 1999; Eisler, 1985). Mercury is volatile and can enter the atmosphere through processes including mining, manufacturing, combustion of coal and volcanic eruptions (Eisler, 1987). Mercury is currently used in compact and other fluorescent light bulbs, electrical switches and relays, thermostats and in some dental amalgams. Effects of mercury on copepods include reduced growth and rates of reproduction (Eisler, 1987). Chromium is used in stainless steel production, chromium plating and wood preservation, to name a few uses. Chromium has been shown to reduce survival and fecundity in the cladoceran *Daphnia magna*, and reduced growth in fingerling chinook salmon (*Oncorhynchus tshawytscha*) (Eisler, 1986). Copper has a number of uses, such as in antifouling paints for boats, wood preservatives, heat exchangers in power plants, electrical wires, coinage, and in agricultural fungicides. While an essential biological element, elevated levels of copper can impact aquatic organisms, including the functioning of gills along with reproduction and development (Eisler, 1998). Most of the current uses of lead appear to be in lead-acid batteries, although other uses include oxides in glass and ceramics. In the past, lead was used in paints and also in gasoline, however, these uses have ended due to environmental and human health concerns. Nickel has many applications in both industrial and consumer products. Approximately 65 percent of the nickel in the U.S. is used to make stainless steel. Other uses include its incorporation into a series of alloys, in rechargeable batteries (Ni-Cd), catalysts, coins, plating, and in foundry products. Corrosion-resistant zinc plating of steel (hot-dip galvanization) is an important application, accounting for roughly 50 percent of zinc use. In the marine industry, zinc anodes are used to protect vital engine and boat parts (*e.g*., propellers, struts, rudders, and outboard and inboard engines), and is a component in some antifoulant paint formulations. Zinc is also used in batteries, and in alloys such as brass.

Full Scan

A new and developing analytical approach within NS&T provided by TDI-Brooks, International, and referred to as full scan, was used to qualitatively identify the presence of additional, unknown chemical compounds in some of the sediment samples. The results from this untargeted analysis technique provides the opportunity to reexamine the data, or reanalyze the samples in the future focusing in on the unknown compounds, in order to try and identify them. The full scan analysis for this project used both gas chromatography/mass spectrometry (GC/MS) at 50-800 m/z (mass-to-charge ratio) for semi-volatile compounds, and liquid chromatography coupled to a mass spectrometer (LC/MS) in full scan positive and negative ion modes. The LC/MS has the capability of detecting compounds that are less volatile, more water soluble, and heavier. It should be noted that volatile compounds that might be present in an area and perhaps noticeable in the air, are not as likely to be found in sediments, as these compounds tend to dissipate and not accumulate in sediments.

Bacterial Indicator

Although not a chemical contaminant, the bacterium *Clostridium perfringens* has been used as an indicator of fecal pollution and was analyzed in the sediment samples from the SARI. This bacterium occurs in the intestines of humans and in some domestic and feral animals, and is a common cause of food poisoning. To assess the presence of viable *C. perfringens*, sediment extracts are plated on growth medium, and the number of colonies that develop are counted.

Sediment Toxicity Bioassays

The protocols for the bioassays were based on standard methods, as outlined by the U.S. EPA (1999, 2002) and ASTM (2008). A 500 mL sediment sample was collected for the sea urchin embryo (porewater extraction) test. For the P450 test, a sample of sediment was taken out of the 250 ml organics jar and extracted.

Sea Urchin Embryo Development Assay. The green sea urchin (*Lytechinus variegatus*) was used in this test following the methods of Carr and Chapman (1992) and Carr *et al.* (1996). Gravid sea urchins were induced to spawn using potassium chloride (0.5 M) injections. Embryos were exposed to sediment porewater for 48 hours, and after that time, embryo developmental stage and developmental aberrations were scored, with a target of 100 embryos evaluated per sample replicate.

P450 Toxicity Assay. The HRGS P450 test was used to determine the presence of toxic organic compounds in sediments. Cytochrome P450s are a family of membrane-bound enzymes that metabolize a diverse number of compounds, including natural substrates, drugs, hormones, and many toxic compounds. They are present in a wide variety of animals, plants and other organisms. P450 is shorthand for Pigment and 450 is the wavelength at which they most strongly absorb light. HRGS stands for Human Reporter Gene System. In this case, a reporter gene is a DNA sequence in a human cancer cell line that has been genetically engineered to include a gene (the reporter gene) from the firefly that produces luciferase, the chemical that produces light in the insect when presented with the proper substrate. The gene is spliced into the region of the DNA strand that is activated to produce P450 enzymes when the cell is exposed to chemicals that stimulate metabolic activity. The more stimulated the cell is to metabolize a foreign compound, the more the reporter gene produces luciferase, which can be measured by increased light output.

Different compounds stimulate P450 production to differing degrees, which can be calibrated. PCBs and PAHs stimulate certain Cytochrome P450 enzymes (*e.g.* CYP1A), but each individual compound exhibits its own level of stimulation. Heavy metals do not stimulate P450 at all. Under appropriate test conditions, induction of CYP1A is evidence that the cells have been exposed to one or more xenobiotic organic compounds, including dioxins, furans, planar PCBs, and several PAHs. When run in parallel with a serial dilution of a standard PAH toxicant benzo[a]pyrene (BaP), or TCDD (dioxin), test results can be expressed in terms of standard toxicant equivalents based on the relative reporter gene response. Samples that exhibited a response greater than 50 percent of a standard 10 nM TCDD threshold control were again tested against a B[a]P serial dilution to calculate responses normalized to the B[a]P EC50 (effective concentration for 50 percent of the test cells) or the B[a]P equivalents (B[a]P Eq).

Anderson *et al.* (1999a) calculated the mean and 95 percent confidence interval of HRGS values from 527 sampling points in the NOAA biological effects database to be 22.7 ±10.1 (CI=12.6-32.8) mg B[a]P Eq/kg. Hence, values less than 12.6, forming the tail of the distribution in the direction of low induction (or impact) could be interpreted as a minimal (background) level. This is consistent with data from pristine sites in Alaska and California where HRGS values did not exceed 10.4 mg B[a]P Eq/kg (Anderson *et al.*, 1999b; Fairey *et al.*, 1996). Fairey *et al.* (1996) demonstrated that HRGS values above 60 mg B[a]P Eq/kg were highly correlated with degraded benthic communities in San Diego and Mission Bays, and with PAH concentrations above the 9,600 ng/g Probable Effects Level (PEL) guideline (MacDonald, 1993), which are similar to the published ERL sediment quality guideline (Long *et al*., 1998) discussed later. Based on these data, HRGS values of 10 or less, and greater than 60 mg B[a]P Eq/kg were considered to represent marginal and highly contaminated thresholds, respectively.

Benthic Infaunal Analysis

A benthic community sample was taken with the PONAR grab sampler, in addition to the samples for chemical analysis and toxicity testing. The entire contents of an acceptable grab (at least 5 cm deep) was sieved on site through a 0.5 mm mesh. All organisms were retained in plastic containers and preserved in buffered 10 percent formalin containing Rose Bengal stain and sodium borate buffer. The following data and information were recorded at each site: stratum, site, date, water depth, time, latitude, longitude, and depth of sediment in the grab. Also included was a written description of each sampling site including digital color photographs of the site, a physical description of sediment characteristics (texture, color, odor, benthos, sheen) and photographs of the undisturbed sediment. In the laboratory, all animals were carefully segregated into major groups (*e.g.* worms, clams, shrimp and crabs). They were then identified to species unless the specimen was a juvenile or damaged. At a minimum, 10 percent of all samples were resorted and recounted on a regular basis. Also, 10 percent of samples were randomly selected and reidentified. The minimum acceptable sorting and taxonomic efficiency was 95 percent. A voucher collection composed of representative individuals of each species encountered in the project was accumulated and retained.

The benthic communities were characterized by abundance (number of animals), number of species, and diversity (a type of ratio of abundance and number of species). Abundance was calculated as the total number of individuals per grab; species richness as the total number of species represented at a given site; and Diversity (H') was calculated with the Shannon-Weiner Index (Shannon and Weaver, 1949), using the following formula:

$$H' = -\sum_{i=1}^{S} pi\ (\ln pi)$$

where, S = is the number of species in the sample, i is the ith species in the sample, and pi is the number of individuals of the ith species divided by the total number of individuals in the sample.

The sediment contaminant data were analyzed using JMP® statistical software. A Shapiro-Wilk test was first run on individual parameters to see if the data were normally distributed. None of the data were normally distributed, and transformations were not effective. As a result, nonparametric tests (*i.e.*, Wilcoxon and Kruskal-Wallis tests) were used to compare differences in contaminant levels between strata.

RESULTS AND DISCUSSION

Water Quality Parameters

A summary of the water quality parameters measured can be seen in Table 2, and in Appendix A. The mean surface water temperature was 31.1 ±0.2 ^{0}C, bottom temperature was 31.0 ±0.2 ^{0}C. The were no differences in water temperature between strata (Table 2). The mean surface salinity was 35.4 ± 0.2 psu (practical salinity unit), the mean salinity at the bottom water was 35.6 ±0.2 psu. A nonparametric comparison using the Kruskal-Wallis test,

Table 2. Summary of water quality parameters at sampling sites (n = 13) in the SARI.

Parameter	Mean ±SE	Minimum	Maximum	Varied by Stratum?
Suface temperature (°C)	31.1 ±0.2	30.1	32.2	No
Bottom temperature (°C)	31.0 ±0.2	30.3	32.1	No
Suface salinity (psu)	35.4 ±0.2	33.7	36.4	Yes
Bottom_salinity (psu)	35.6 ±0.2	34.6	36.5	Yes
Surface dissolved oxygen (mg/L)	5.3 ±0.3	2.8	6.8	No
Bottom dissolved oxygen (mg/L)	5.4 ±0.2	4.0	6.9	No

psu, practical salinity unit

indicated a significant difference between strata for surface salinity (ChiSquare = 9.7410, *p* = 0.0209), and that the mean salinity in the Sugar Bay stratum was significantly different (lower) than the salinity in the Mangrove Lagoon stratum.

The bottom salinity also varied by stratum (ChiSquare = 8.7170, *p* = 0.0333), although the Kruskal-Wallis test was not able to identify which strata were different. The mean surface salinity in the Mangrove Lagoon stratum was 36.4 ±0.0 psu, while the mean surface salinity in the Sugar Bay stratum was 35.3 ±0.1 psu (Table 3). Salt River, the principal gut that drains to the SARI, receives freshwater input during periods of heavy rainfall. The slightly lower salinity in Sugar Bay could be an indication of freshwater input from Salt River around the time of sampling, and higher salinities in Mangrove Lagoon could be an indication of evaporation in this semi-enclosed area.

Table 3. Summary of water quality parameters by stratum in the SARI.

	Stratum			
Parameter	Marina	Sugar Bay	Triton Bay	Mangrove Lagoon
Mean surface temperature (°C)	31.3 ±0.5	31.05 ±0.4	31.5 ±0.2	30.6 ±0.2
Mean bottom temperature (°C)	31.2 ±0.4	31.1 ±0.5	31.3 ±0.2	30.5 ±0.1
Mean surface salinity (psu)	35.4 ±0.0	35.3 ±0.1	34.6 ±0.5	36.4 ±0.0
Mean bottom salinity (psu)	35.4 ±0.0	35.3 ±0.1	35.0 ±0.2	36.4 ±0.0
Mean surface dissolved oxygen (mg/L)	5.5 ±0.4	4.6 ±0.8	6.1 ±0.7	5.2 ±0.2
Mean bottom dissolved oxygen (mg/L)	5.4 ±0.3	4.9 ±0.6	6.2 ±0.4	5.1 ±0.3

psu, practical salinity unit

The mean dissolved oxygen level in the surface waters sampled in the SARI was 5.3 ±0.3 mg/L, while the mean bottom dissolved oxygen was 5.4 ±0.2 mg/L. In Table 3, it can be seen that the mean dissolved oxygen concentrations in Triton Bay appeared higher than in the other strata. Likewise, dissolved oxygen in the Sugar Bay stratum appeared somewhat lower. A nonparametric comparison using the Kruskal-Wallis test, however, indicated no significant difference in the mean dissolved oxygen concentration between strata for surface (ChiSquare = 2.2198, *p* = 0.5281) or bottom (ChiSquare = 4.7216, *p* = 0.1934) waters at these sites.

As noted earlier, the USVI has established water quality criteria for a number of parameters in accordance with the Clean Water Act. For dissolved oxygen, the criteria for Salt River (Class B water) is 5.5 mg/L or above. The mean dissolved oxygen concentration at the sites sampled in the SARI for this project (Table 2) were slightly below this criteria, for both surface and bottom waters. Analyzing data from EPA's STORET database from 1981 - 2002, Kendall *et al* (2005), reported a mean dissolved oxygen concentration of 5.3 ±0.1 mg/L for the marina site. For this project, STORET data from 2003 to 2019 were analyzed. The mean dissolved oxygen concentration at the marina site in STORET during this time was 5.4 mg/L. The mean surface and bottom dissolved oxygen levels found in the current study in the Marina stratum were 5.5 and 5.4 mg/L, respectively, (Table 3). From this, it appears that the dissolved oxygen concentration over time is fairly stable, or perhaps increasing slightly. Dissolved oxygen in the Sugar Bay and Mangrove Lagoon strata (Table 3), however, were below the criteria.

Sediment Grain Size

Table 4 contains a summary of the sediment grain size by stratum. More detailed information can be found in

Table 4. Grain size of sediments by stratum in the SARI.

	Stratum			
Grain Size	Marina	Sugar Bay	Triton Bay	Mangrove Lagoon
Gravel	6.0 ±6.0	0.0	1.6 ±1.6	0.0
Sand	37.4 ±14.3	32.0 ±8.8	49.7 ±6.6	22.2 ±1.0
Silt	38.7 ±15.8	45.0 ±9.9	28.2 ±1.3	48.0 ±2.0
Clay	17.9 ±4.7	23.0 ±5.4	20.6 ±4.3	29.9 ±2.3

All values are %

Appendix B. The grain size distribution of the sediments sampled were fairly similar between strata, with sand and silts comprising roughly 75 percent of the samples from the Marina, Sugar Bay, and Triton Bay strata. Interestingly, Triton Bay had a numerically higher percentage of sand than the other strata, however, a Kruskal-Wallis test indicated no differences between strata for any of the grain size classes. Transport of sediment out of the SARI appears to be limited by barrier reefs at the mouth of Salt River Bay, likely resulting in the finer grain sediments being redistributed throughout the estuarine portions of the park.

In September 2017, hurricanes Irma and Maria devastated the USVI with wind gusts of up to 246 km/hour (178 miles/hour). The hurricanes occurred within two weeks of each other. Hurricane Irma (September 6th) passed just to the north of St. Thomas and St. John. Hurricane Maria (September 20th) severely impacted St. Croix, passing just to the south of the island.

In July 2017, less than two months before these hurricanes struck the Caribbean, Bayless (2019) collected and analyzed a number of sediment samples from the SARI, three of which were less than 50 m from sites 02P, 06P, and 09P sampled in the current project. As a result, data from the 2017 grain size analysis can be compared with results from the current project. Figures 8a - c show the sediment composition at the sites sampled in 2017 (orange bars, Bayless, 2019), and then in 2018 (blue bars) for the current project. From these graphs, there appear to be differences in the sediment composition between the sampling dates. For example, in Figure 8a gravel was present in the sediment sample at Site SARI 8 (2017) (orange bar) but was not found when the site (06P) was collected in 2018 (0 percent gravel). In addition, while the amount of silt appeared to be the same, the amount of clay material (smallest grain size) appeared to be higher in 2018 (blue bar) than before the hurricanes in 2017 (orange bar).

The same trend can be seen in Figure 8b, gravel accounted for roughly 40 percent of the sample in 2017 at SARI 6, while no gravel was found in the sediment sample at Site 09P in 2018. In addition, the clay fraction was less than one percent in 2017, and 23 percent in 2018. One possible explanation for a decrease in the gravel fraction and an increase in the amount of clay in the sediment samples, would be erosion of soils from the terrestrial environment during the hurricanes and subsequent deposition of clays and silts into the SARI, covering up the gravel that was present. It should be noted that the grain size analysis of the sediments from the SARI in 2018, revealed that the gravel fraction present was actually shell hash (Appendix B).

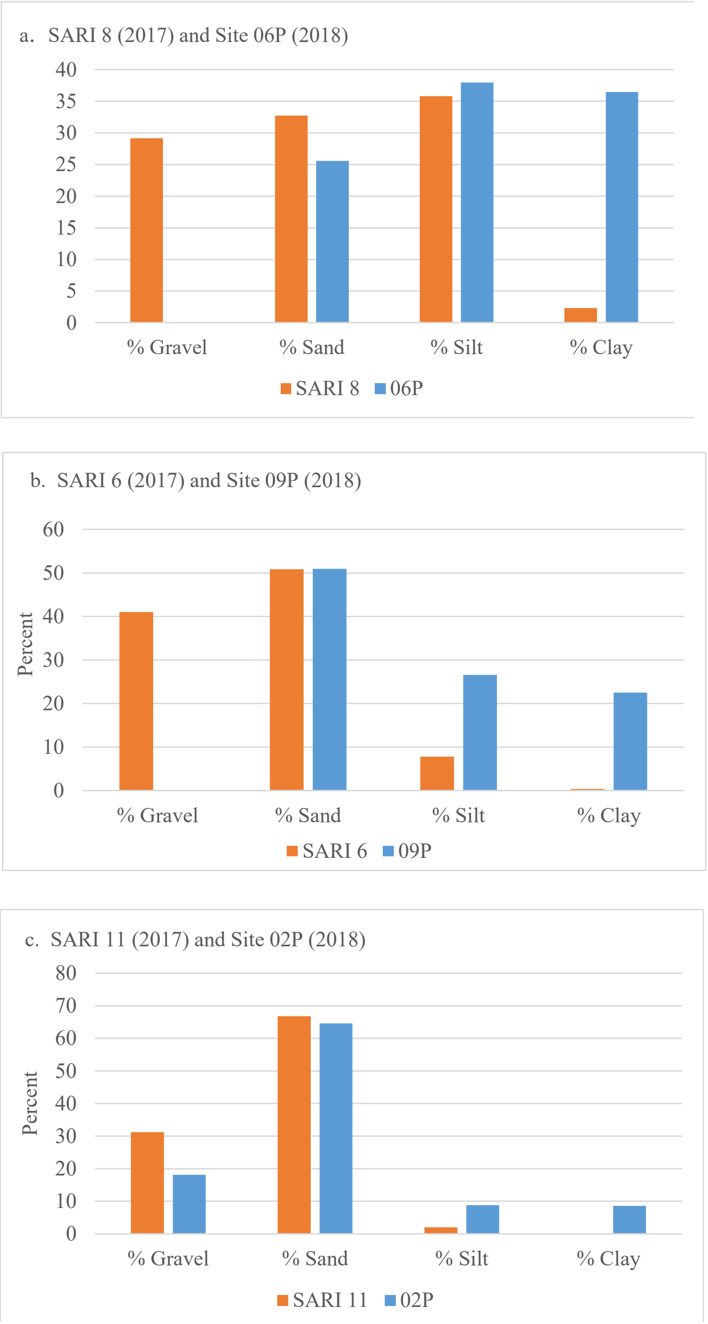

Figure 8. Comparison of sediment grain size for sites sampled in 2017 and 2018.

In Figure 8c, the change in sediment composition was not as evident. The gravel and sand fractions appeared to remain the same, while the percent silt and percent clay fractions showed some evidence of an increase. The sites (SARI11 and 02P) were in the Marina stratum, and may have been sheltered by a small island landward of the sites (Figure 6).

A Wilcoxon nonparametric test run to assess differences between grain size distributions at these sites, indicated there

Figure 9. Total PAHs in sediments collected from the SARI.

were significant differences in both the gravel (ChiSquare = 3.9706, $p = 0.0463$) and the clay (ChiSquare = 3.8571, $p = 0.0495$) fractions between the 2017 and the 2018 samples.

For this project, total organic carbon (TOC) and total inorganic carbon (TIC) of the sediments were also measured. Total organic carbon in the sediment, along with smaller sediment grain sizes (*i.e.*, silts and clays) are often correlated with chemical contaminants. Carbonates, typically derived from calcareous organisms (*e.g.*, corals) make up a large portion of the TIC. If present, chemical contaminants in the environment tend to adsorb onto sediments with higher organic carbon content and smaller grain sizes. Appendix C provides detailed information on the analysis of the sediment samples for TOC and TIC.

The mean TOC content (percent) of the sediment was 3.97 ±0.43, TIC was 4.47 ±0.64. A Kruskal-Wallis test indicated no difference in the TOC (ChiSquare = 1.3590, $p = 0.7152$) or TIC (ChiSquare = 2.5897, $p = 0.4593$) content between strata.

Polycyclic Aromatic Hydrocarbons (PAHs)

Results from the analysis of sediments for PAHs are shown in Figure 9. Additional, more detailed information can be found in Appendix D. The mean concentration of total PAHs in the sediments collected in the SARI was 124.2 ± 54.0 ng/g. Total PAHs in this report is the sum of the 64 PAHs measured (Table 1). The minimum concentration detected was 11.3 ng/g (Table 5, Appendix D). Sites in the Marina stratum as well as some of the sites in the Sugar Bay stratum tended to have higher concentrations of total PAHs. This is perhaps to be expected because of the boating activity there and in Sugar Bay. Exhaust from boat engines would be one source of the PAHs in the sediments. As can be seen in Figure 6, in addition to the boats in the marina area, there are also boats moored out in Sugar Bay.

Table 5. Mean concentrations of organic contaminant classes in sediments sampled in the SARI.

Compound Class	Mean ±SE	Minimum	Maximum	ERL	ERM
Total PAHs	124.2 ±54.0	11.3	745.0	4,022	44,792
Total PCBs	3.63 ±1.77	0.00	19.6	22.7	180
Total DDT	0.02 ±0.00	0.00	0.29	1.58	46.1
Tributyltin (TBT)	4.56 ±2.07	0.21	26.1	–	–

PAHs, polycyclic aromatic hydrocarbons; PCBs, polychlorinated biphenyls; DDT, dichlorodiphenyltrichloroethane; ERL, Effects-Range Low; ERM, Effects-Range Median; –, not available

The highest total PAH concentration, 745 ng/g, was found at Site 01P in the Marina Stratum. The second highest concentration, 209 ng/g was also in this stratum at Site 03P. A Kruskal-Wallis nonparametric test, however, indicated no difference in the concentration of total PAHs by stratum (ChiSquare = 2.8571, $p = 0.4142$).

Total PAHs in the sediments at the three sites sampled in 2017 by Bayless (2019), can be compared with the 2018 results, in order to assess if there were any obvious changes in total PAH composition just before and then again after (~ 1 year) the hurricanes. The list of PAHs analyzed by the two laboratories (NOAA Charleston and TDI-Brooks, Inc.) were slightly different. As a result, only those PAHs that were analyzed by both laboratories were included in the data analysis. A Wilcoxon test indicated a significant (ChiSquare = 3.8571, $p = 0.0495$) difference in total PAHs between the three sites in 2017 and in 2018. As will be seen, some of the other contaminant classes showed changes between 2017 and 2018 at the three sites, while others did not. The difference in total PAH concentration at these three sites was driven by the concentration at one site (Figure 10). Specifically, the concentration at SARI-8 (3,808 ng/g) was substantially higher than was found at 06P.

SARI-8 and 06P were located in the upper reaches of Sugar Bay (Figure 11). One explanation for a difference in the concentration of contaminants could be related to the effects of the two hurricanes, either depositing another layer of less contaminated sediment in the area that was then sampled in 2018, flooding of Salt River Gut leading to the flushing of sediments out of Sugar Bay, or perhaps a combination of both. Finally, it is also possible that the SARI-8 site still contains high levels of total PAHs in the sediment. Even though SARI-8 and 06P were less than 50 m apart, resampling at the exact location of SARI-8 would be needed in order to confirm the current concentration of total PAHs there.

The sediment core taken in the Sugar Bay stratum (Figure 6) was also analyzed for total PAHs, however, because the core site was not randomly selected, the results from the analysis can not be included in the assessment of differences in contaminant concentrations between strata. The results of the analysis of the sediment core for total PAHs can be seen in Appendix D. The highest concentration of total PAHs in the sediment core was 41.3 ng/g, at the surface. The deeper sections or slices of the core ranged from 13 to 24 ng/g.

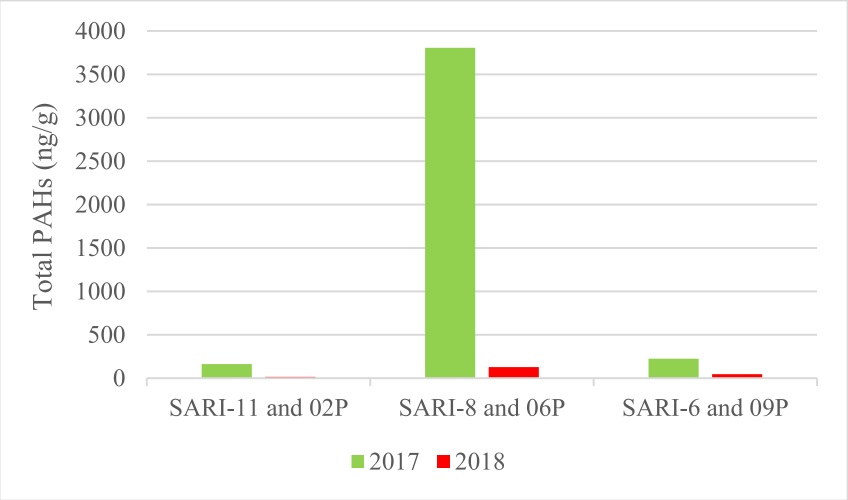

Figure 10. Comparison of total PAHs at sites sampled in 2017 and 2018.

A series of effects-based, numeric guidelines to estimate the toxicological relevance of certain sediment chemical contaminants were developed for NOAA (Long *et al.*, 1998). These guidelines, the Effects Range-Low (ERL) and the Effects Range-Median (ERM) define sediment contaminant concentration ranges that are rarely (<ERL), occasionally (ERL to ERM), or frequently (>ERM) associated with toxic effects in aquatic biota (NOAA, 1998). The ERL and ERM values for total PAHs are also shown in Table 5. The ERL for total PAHs is 4,022 ng/g. Total PAHs in the sediments sampled in 2018 were well below both the ERM and ERL. The concentration of total PAHs at SARI-8 in 2017 (3,808 ng/g) was also below the ERL of 4,022 ng/g, however, it was not far under this criteria.

Figure 11. Location of 06P (2018) and SARI-8 (2017) sites.

Figure 12. Total PCBs in sediments collected from the SARI.

A number of studies have been conducted in the USVI by NOAA's NCCOS, and the results from these studies can be compared with what was found in the SARI in the current project. In the St. Thomas East End Reserves or STEER, the mean concentration of total PAHs in the sediments was 142 ±58 ng/g (Pait *et al.,* 2013), similar to the mean in the sediments sampled in the SARI. In Coral Bay in St. John, Whitall *et al.* (2014) detected a mean total PAH concentration of 31.7 ng/g, somewhat lower than the mean found in the SARI. In southwest Puerto Rico, in the La Parguera area, the mean concentration of total PAHs was 80.6 ng/g. From these results, it appears that the concentration of total PAHs found in the SARI in this project, were in the range of concentrations found elsewhere in the USVI.

Alkylated PAHs were also analyzed in the sediment samples for this project (Appendix E). The presence of alkylated (*e.g*., containing methyl groups) PAHs has been used to assess petrogenic (uncombusted) versus pyrogenic (combusted) sources (Colombo *et al*., 1989). Alkylated PAHs are more abundant in petroleum products than in combusted materials. From the analysis of the sediment samples in the SARI, only the C29 and C30 hopanes appeared slightly elevated at Site 01P in the Marina stratum, and could be related to the use and discharge of fuels (Huang *et al.*, 1994; Volkman *et al*., 1992), or lubricating oils. The concentration of alkylated PAHs at other sites were quite low.

Polychlorinated Biphenyls (PCBs)

The results from the analysis of PCBs in sediments collected from the SARI can be seen in Figure 12 and in Appendix F. Overall, the concentration of total PCBs in the sediments were low. The mean concentration of total PCBs (sum of the 157 congeners analyzed) was 3.63 ±.1.77 ng/g. The minimum total PCB concentration detected was 0 ng/g at Site 10P. The maximum concentration was 19.6 ng/g at Site 01P in the Marina stratum (Figure 12). A Kruskal-Wallis nonparametric test indicated no difference in the concentration of total PCBs by stratum (ChiSquare = 2.7975, p = 0.4239). Total PCBs found in the sediments at the three sites sampled in 2017 by Bayless (2019), can be compared with the adjacent sites sampled for the current project in 2018. As was done with the PAHs, only the PCB congeners that were analyzed by both laboratories (TDI-Brooks and NCCOS Charleston) were included in the data analysis. Unlike total PAHs, however, there was no significant difference (ChiSquare = 2.3333, p = 0.1266) between the concentration of total PCBs at the three sites in 2017 versus 2018.

The sediment core sections were also analyzed for total PCBs. The results of that analysis can be seen in Appendix F. The concentrations were low throughout the core without much variation. The mean concentration was 0.23 ±0.08 ng/g. The highest total PCB concentration in the core was 0.44 ng/g, and was found in the third section (6 cm down) in the core. The ERL for total PCBs is 22.7 ng/g and the ERM is 180 ng/g (Table 5). The maximum concentration of total PCBs detected in the SARI (19.6 ng/g) was below the ERL, indicating that effects on biota related to the concentration of total PCBs present would not be likely.

Other NCCOS work in the USVI and Puerto Rico has shown variability in total PCB concentrations in sediments. In the STEER in St. Thomas, Pait *et al.* (2013) detected a mean total PCB concentration of 1.00 ng/g. In Coral Bay, Whitall *et al.* (2014) detected a mean total PCB concentration of 0.68 ng/g, both lower than in the samples from the SARI. In southwest Puerto Rico, Pait *et al.* (2007) detected a mean total PCBs concentration outside of Guanica Bay of 18.2 ng/g, higher than what was found in Salt River. Inside Guanica Bay, however, concentrations as high as 2,710 ng/g were detected, and may have been related to an abandoned site adjacent to Guanica Bay where electrical transformers containing PCBs had been used.

DDT

Although total DDT, the sum of the seven degradation products that were analyzed, was detected in the sediments collected in the SARI, the mean concentration was low, only 0.02 ±0.01 ng/g, the maximum concentration detected was 0.29 ng/g. The ERL (1.58 ng/g) for total DDT was higher than both the mean and maximum found in the sediments from the SARI, indicating that effects on aquatic biota from these concentrations were unlikely. A number of other chlorine-containing pesticides including chlordane, endosulfan, chlorpyrifos, endrin, and dieldrin were analyzed for this project. The only one of these compounds detected in the sediments was chlordane, at a concentration of only 0.64 ng/g at Site 01P.

Full Scan

Three sediment samples were chosen for the full scan analysis for this project, including 1P, 3P, and 5P. As noted, the full scan can be used to qualitatively identify the presence of organic compounds not included in the current suite of compounds analyzed. The sites were chosen based on preliminary results from the analysis of contaminants such as PAHs. The results of the full scan using GC/MS at 50-500 m/z indicated a significant hydrocarbon background at all three sites. This is perhaps not surprising as sites 1P and 3P were in areas where boats are moored or constructed, and the use and combustion of fuels likely has resulted in the introduction of hydrocarbons into the environment. It should also be noted that certain biogenic hydrocarbons are produced naturally by a number of plant species. Site 5P had a lower relative hydrocarbon background compared to sites 1P and 3P. The GC/MS scan at 500-800 m/z revealed no predominant unidentified peaks. The results from the LC/MS full scan indicated one predominant unidentified peak at Site 3P and two predominant unidentified peaks at Site 1P.

From these results, it appears that there are additional compounds present, certainly a number of hydrocarbons, but also a few compounds identified by LC/MS which could benefit from further analysis or "data mining", resulting ultimately in their identification. This approach is currently in the development phase and will be refined further.

Tributyltin

The results from the analysis of TBT in the sediment samples can be seen in Figure 13 and in Appendix H. Tributyltin or TBT was the key ingredient in a very effective antifoulant paint formulation for boat hulls, that was banned for use in the US beginning in 1989. The mean concentration of TBT in the sediments was 4.56 ±2.07 ng Sn/g. The highest concentration of TBT was found in sediments from the Marina stratum. Site 01P had a TBT concentration of 26.08 ng Sn/g. The second highest concentration was found at Site 05P in the Sugar Bay stratum (12.47 ng Sn/g).

A Kruskal-Wallis nonparametric test indicated no difference (ChiSquare = 5.5945, p = 0.1331), however, in the concentration of TBT between strata. A Kruskal-Wallis test was also run on differences in the concentration of the degradation products dibutyltin and monobutyltin. Interestingly, while there was no difference in the concentration of dibutyltin (ChiSquare = 5.7935, p = 0.1221) between strata, the concentration of monobutyltin did vary between strata (ChiSquare = 10.6296, p = 0.0139), with the Marina stratum having the higher concentrations, possibly indicating the presence of higher concentrations of the parent compound TBT in the past, which subsequently degraded to monobutyltin.

The results of the analysis of TBT in the sediment core taken in the SARI can also be found in Appendix H. The concentrations of TBT were fairly low throughout the core without much variation. The mean concentration was 0.50 ±0.25 ng Sn/g. The highest total TBT concentration in the core was 1.38 ng/g and was found in the surface section of the core. A Kruskal-Wallis test indicated no difference (ChiSquare = 4.0000, p = 0.4060) in the concentration of TBT in different sections of the core. There are no pub-

Figure 13. Tributyltin in sediments collected from the SARI.

lished sediment quality guidelines for TBT, due in part to the complex chemistry of this compound, including its bioavailability largely being governed by partitioning into porewater (water in between sediment particles), which is in turn is governed by a number of parameters of the sediment at a site.

NOAA's NCCOS has assessed TBT in a number of areas in the USVI. In Coral Bay in St. John, Whitall *et al.* (2014) detected a mean TBT concentration of 1.01 ng Sn/g, somewhat lower than the mean found in the SARI. In the STEER in St. Thomas, the mean TBT concentration in the sediments was 1.85 ± 1.30 ng Sn/g. As can be seen from the standard error, there was a substantial amount of variation in the concentration of TBT in the STEER. In the marina area of Benner Bay in the STEER, concentrations as high as 247 ng Sn/g were found (Pait *et al.,* 2013). A follow up study in the STEER by Hartwell *et al.* (2017) found highly elevated levels of TBT in samples from sediment cores taken adjacent to marina areas. Concentrations exceeding 5,000 ng Sn/g were found in the deeper sections of the cores taken in the Benner Bay area. In the SARI, elevated concentrations of TBT were not found in the deeper sections of the core.

Major and Trace Elements

Mean values, along with minimum and maximum concentrations of the major and trace elements detected in the sediments from the SARI can be seen in Table 6. More detailed results can be found in Appendix I. The table also includes the ERL and ERM for elements where those values have been established. Not surprisingly, the major crustal elements, aluminum and iron had the highest concentrations in the sediments. A Wilcoxon nonparametric test indicated no differences in the concentration of either aluminum or iron between strata.

There were no detections of either cadmium or antimony in any of the sediments sampled. Chromium was detected in all the sediments sampled (Appendix I). The highest concentration of chromium (Table 6) was at Site 01P in the Marina stratum, at 27.2 µg/g. There were no differences in the concentration of chromium between strata (ChiSquare = 0.3297, *p* = 0.9544).

There was a significant difference (ChiSquare = 3.9706, *p* = 0.0463) in the chromium concentrations at the three sites sampled in 2017 by Bayless (2019), and then again in 2018 for the current project. The concentration of chromium in

Table 6. Mean (µg/g), minimum and maximum concentrations of trace and major elements in sediments from the SARI.

Element	Symbol	Mean ±SE	Minimum	Maximum	ERL	ERM
Aluminum	Al	16,388 ±1,510	7,366.00	24,970	–	–
Antimony	Sb	0	0	0	–	–
Arsenic	As	11.7 ±0.97	5.04	19.1	8.2	70
Barium	Ba	11.3 ±0.60	7.43	13.80	–	–
Beryllium	Be	0.110 ±0.016	0.00	0.198	–	–
Cadmium	Cd	0	0	0	1.2	9.6
Chromium	Cr	18.5 ±1.60	6.72	27	81	370
Copper	Cu	58.2 ±16.4	14.0	**244.1**	34	270
Iron	Fe	23,701 ±2,518	8,973	38,234	–	–
Lead	Pb	8.31 ±1.05	2.43	15.5	46.7	218
Manganese	Mn	450 ±85.3	110	1,039	–	–
Mercury	Hg	0.056 ±0.007	0.018	0.093	0.15	0.71
Nickel	Ni	13.4 ±0.52	10.6	17.1	20.9	51.6
Selenium	Se	0.929 ±0.161	0	1.88	–	–
Silver	Ag	0.00	0	0	1	3.7
Tin	Sn	0.561 ±0.103	0.167	1.53	–	–
Zinc	Zn	59.8 ±10.1	23.7	**166**	150	410

Concentrations above the ERL are highlighted in **bold**; ERL, Effects-Range Low; ERM, Effects-Range Median

2017 was significantly higher at the three sites compared to 2018.

The ERL for chromium is 81 µg/g (Table 6). The highest concentration of chromium found in the sediments in 2018 was below the ERL, indicating that effects on biota related to the concentration of chromium present in the samples would not be likely.

Oostdam (1986) detected a chromium concentration of 23.5 µg/g in the SARI. The location of that site is included in Figure 6. The concentration found by Oostdam (1986) was slightly less than the highest concentration found in the current study. In the STEER, Pait *et al.* (2013) detected a mean chromium concentration of 14.1 ±1.76 µg/g. In Coral Bay, Whitall *et al.* (2014) detected a mean chromium concentration of 10.9 µg/g, both lower than the mean concentration in samples from the SARI. In southwest Puerto Rico, Pait *et al.* (2007) detected a mean concentration outside of Guanica Bay of 12.4 ± 1.29 µg/g. Inside Guanica Bay, however, concentrations as high as 440 µg/g were detected, and may have been related to some of the industrial activities that took place in the bay in the past.

Copper was detected in all the sediments sampled (Figure 14). The mean concentration of copper in the sediments sampled in the SARI was 58.2 ±16.4 µg/g (Table 6). The highest copper concentration detected was from the Marina stratum at Site 01P, with 244 µg/g. As noted earlier, copper has a number of applications including use in antifouling paints for boat hulls, wood preservatives, and in electrical wires. Although the mean concentration of copper in the Marina stratum was numerically higher than in the other strata, there was no significant difference (ChiSquare = 4.000, $p = 0.2615$) in the concentration of copper between strata. The elevated mean concentration in the Marina stratum was driven by the concentration found in the sediments at Site 01P. A comparison in the concentration of copper found at the three sites sampled in 2017 (Bayless, 2019), and again in 2018, indicated no significant difference (ChiSquare = 1.1905, $p = 0.2752$).

The relationship between copper and sections of the sediment core from Sugar Bay was also examined. Figure 15 contains a plot of total copper concentration against the core sections. A nonparametric analysis of the data revealed a significant negative correlation between the copper concentration and depth in the core (Spearman Rho = -1.0000, $p < 0.0001$), indicating a significant decrease in the copper concentration in the deeper, older sections of the core. The sediment core was taken just outside of the Marina stratum, in a part of Sugar Bay that has a number of boats moored in the area (Figure 6). The increase in the copper concentration in the sediments in the shallower, more recent sections of the core, could be an indication of the increased use of copper in antifoulant paints as banned tributyltin (TBT) was replaced.

The ERL for copper is 34 µg/g, the ERM is 270 µg/g. The concentration of copper in the sediments at Site 01P was above the copper ERL, and just below the copper ERM, indicating that effects on biota from the copper concentra-

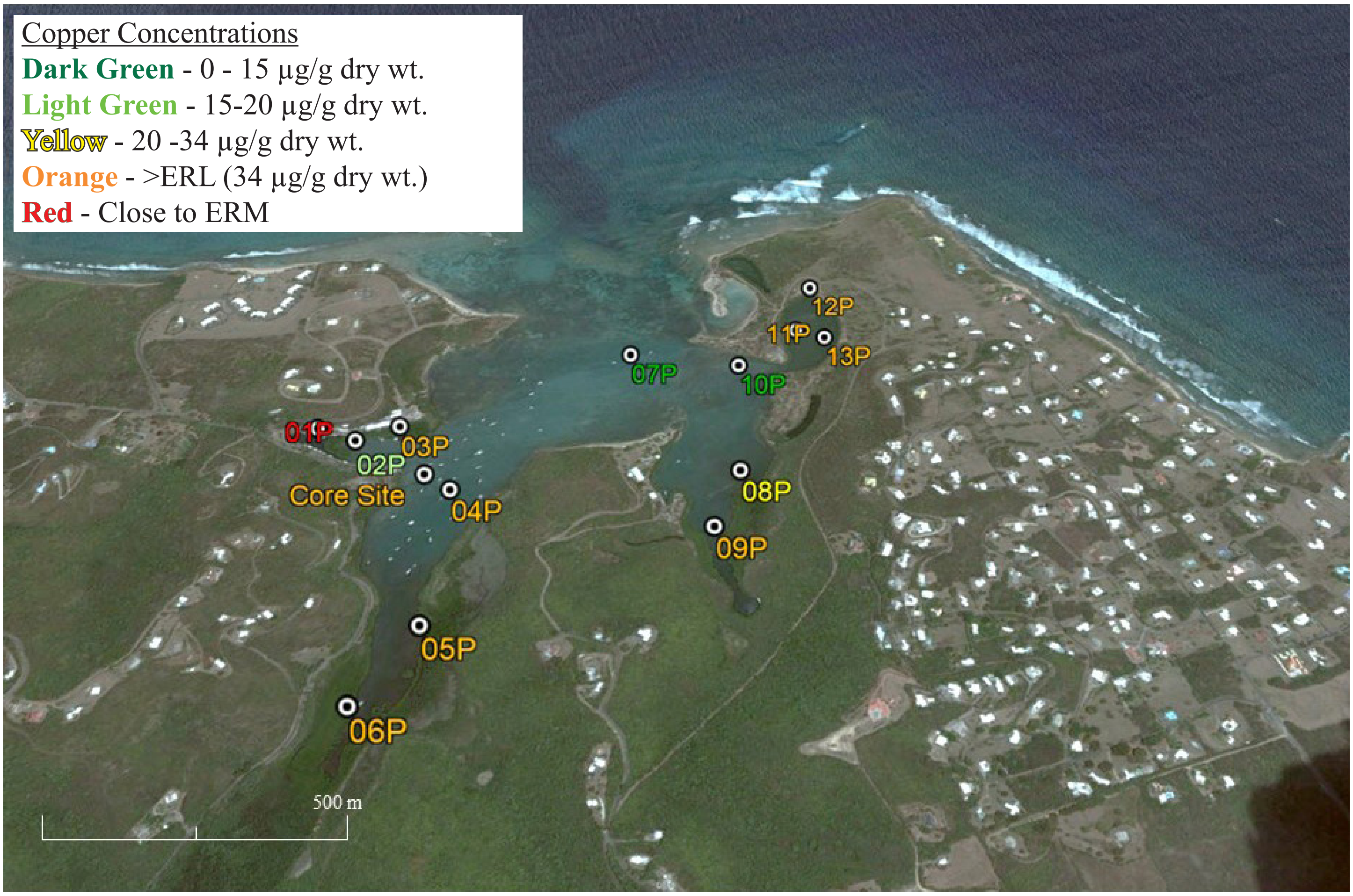

Figure 14. Copper in sediments collected from the SARI.

tion in the area of Site 01P were likely. As noted earlier, elevated levels of copper can impact reproduction and development in aquatic organisms.

Oostdam (1986) analyzed copper in the sediments at a site in the SARI (Figure 6). The concentration detected by Oostdam (1986), 198 µg/g, was higher than the ERL but lower than the ERM and also lower than the highest copper concentration found in the current study.

Pait *et al.* (2013) detected a mean copper concentration of 21 ±7.46 µg/g in the STEER. In Coral Bay, Whitall *et al.* (2014) detected a mean copper concentration of 8.79 µg/g, both lower than the mean concentration in the samples collected from the SARI. In southwest Puerto Rico, Pait *et al.* (2007) detected a mean copper concentration of 5.21 ± 2.02 µg/g. From these results, it appears that the mean concentration at the sites sampled in the SARI were somewhat higher than in the other NCCOS studies. A couple of factors could be related to this, including the selection of sites within the estuarine portion of the SARI which are more likely to consist of fine-grain sediments which tend to accumulate metals, along with the influence of the barrier reefs at the mouth of Salt River Bay, trapping the finer grain sediments within the estuarine portion of the park.

The mean concentration of lead in the sediments from the SARI was 8.31 ±1.05 µg/g. The maximum lead concentration found was 15.5 µg/g from Site 06P in the Sugar Bay stratum, followed by 13.1 µg/g at Site 01P in the Marina stratum (Appendix I). There was no significant difference (Chi-Square = 3.1154, $p = 0.3742$) in the concentration of lead between the strata. Within the sediment core, there was a significant decline in the concentration of lead with

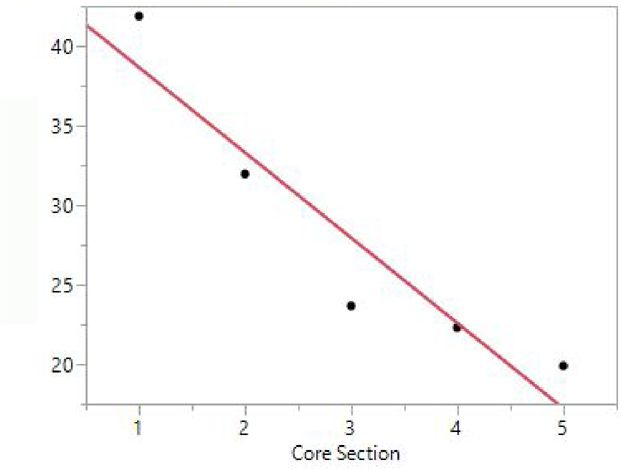

Figure 15. Bivariate fit of copper concentration going down the sediment core.

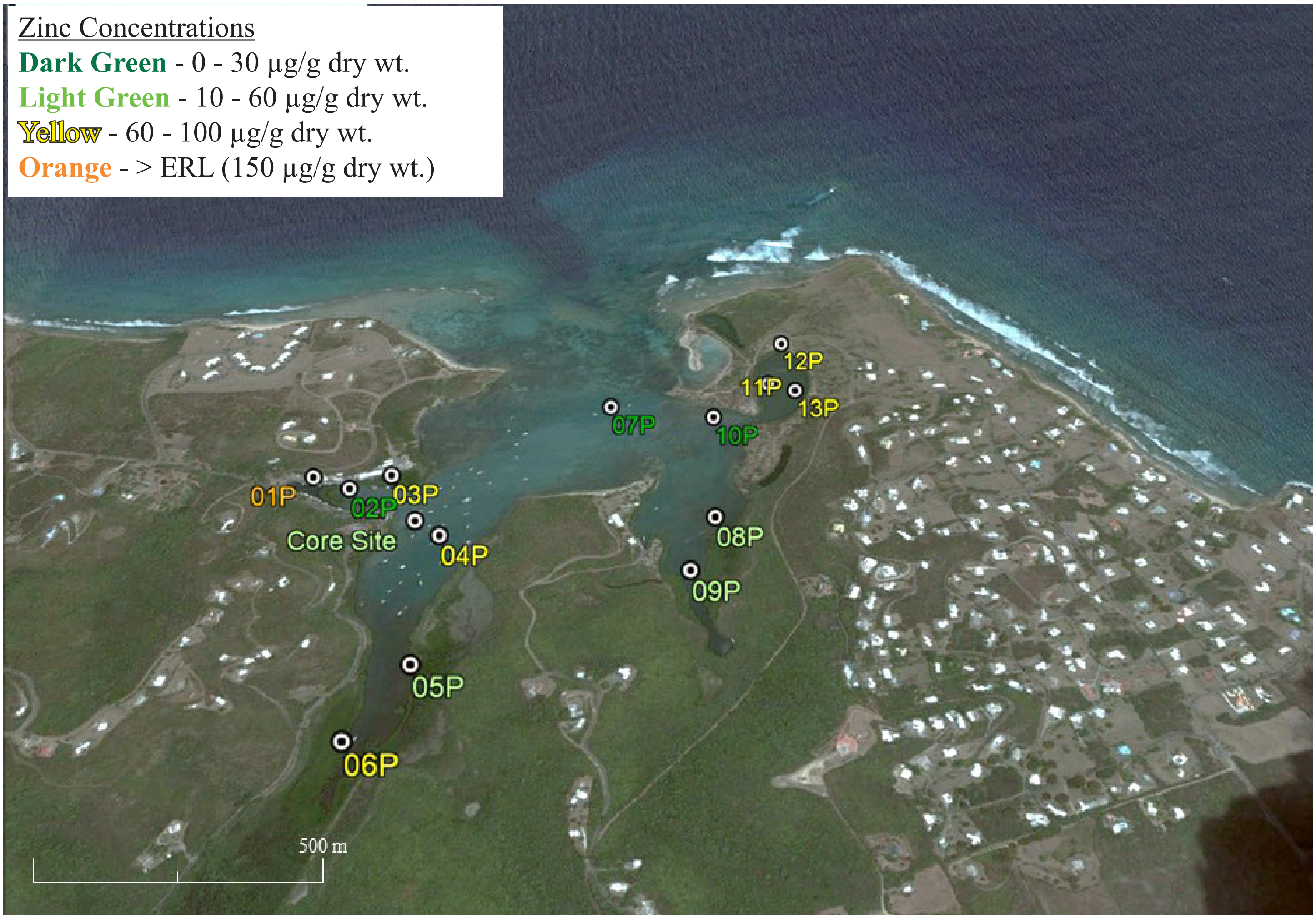

Figure 16. Zinc in sediments collected from the SARI.

depth (Spearman Rho =-0.9000, *p* = 0.0374). There was no significant difference (ChiSquare = 0.4286, *p* = 0.5127) in the lead concentration at the three sites sampled in 2017 by Bayless (2019), and then again in 2018 in the current project. The ERL for lead is 46.7 µg/g. The maximum concentration of lead found in the sediments for the current project was less than the ERL, indicating that effects on biota from lead at the sites sampled was unlikely.

Oostdam (1986) detected a lead concentration of 13.5 µg/g, similar to the concentrations found in the current study. Pait *et al.* (2013) detected a mean lead concentration of 5.87 ±1.90 µg/g in the STEER. In Coral Bay, Whitall *et al.* (2014) detected a mean lead concentration of 2.08 µg/g, slightly lower than the mean concentration in the samples collected from the SARI. In southwest Puerto Rico, Pait *et al.* (2007) detected a mean lead concentration of 1.93 ± 0.42 µg/g.

The mean concentration of nickel in the sediments from the SARI was 13.4 ±0.52 µg/g. The maximum found at the sites was 17.1 µg/g (Site 01P). There were no significant differences (ChiSquare = 4.0000, *p* = 0.2615) in the concentration of nickel between sites. In the sediment core, nickel did not vary (Spearman Rho = -0.1000, *p* = 0.8729) with depth. There was also no significant difference (ChiSquare = 0.4286, *p* = 0.5127) in the nickel concentration at the three sites sampled in 2017 by Bayless (2019), and in 2018 for the current project. The ERL for nickel is 20.9 µg/g. The highest concentration of nickel found at the sites in the SARI (17.1 µg/g) was below the ERL, indicating the effects on biota from the concentrations found at the sites in the SARI would be unlikely.

The results of the analysis of zinc in sediments from the SARI can be seen in Figure 16. Zinc has a number of uses in boating-related activities including use in anodes to protect engines and rudders, in antifoulant paint formulations and in brass. The mean concentration of zinc was 59.8 ±10.1 µg/g. The highest concentration of zinc found in the SARI was at Site 01P in the Marina stratum, at a concentration of 166 µg/g (Appendix I).

An analysis of the variation of zinc between strata (Kruskal-Wallis nonparametric test), indicated no significant difference (ChiSquare = 5.0934, *p* = 0.1651) in the concentration of zinc. In the sediment core, there was no difference in the concentration at the surface versus the deeper sections (Spearman Rho = 0.4000, $p = 0.5046$).

An analysis (Wilcoxon nonparametric test) of the zinc concentration at the three sites sampled in 2017 by Bayless (2019), and then resampled again in 2018 for the current project, indicated a significant difference (ChiSquare = 3.8571, $p = 0.0495$) in zinc concentrations. The mean concentration in 2017 was higher than in 2018.

The ERL for zinc is 150 µg/g. The concentration of zinc at Site 01P was 166 µg/g, above the ERL, which could indicate that more sensitive species or life stages show some degree of impact from the concentration of zinc. Higher levels of zinc have been shown to impact the functioning of gills in a number of aquatic organisms.

Oostdam (1986) detected a zinc concentration of 10.6 µg/g at a site in the SARI (Figure 6), lower than the mean in the current project. In the STEER, Pait *et al.* (2013) detected a mean zinc concentration in the sediments of 37.3 ±10.7 µg/g. Whitall *et al.* (2014) detected a mean zinc concentration of 17.94 µg/g in Coral Bay in St. John. In southwest Puerto Rico, Pait *et al.* (2007), detected a mean concentration of 4.82 ±0.76 µg/g. From this, it appears that the zinc concentration in the sediments sampled in the SARI was similar, although perhaps a little higher than what was found from the studies in St. Thomas, St. John, and in Puerto Rico. Other than the sediment sample from Site 01P, the concentration of zinc found in the SARI was below the concentration that would indicate impacts to aquatic biota living at these sites.

Clostridium perfringens

This anaerobic, gram-positive staining rod-shaped bacteria frequently occurs in the intestines of humans, as well as in domestic and wild animals, and has been used as a sewage indicator. There were quite a few elevated levels of *C. perfringens* in the sediments from the SARI (Appendix J), in all four strata, and is likely indicative of inputs from septic systems and boats, along with domestic animals. The mean concentration of *C. perfringens* in the samples was 1,608± CFU/g. The mean concentration in the STEER was lower (291 ±167 CFU/g). There do not appear to be any guidelines for *C. perfringens* in sediments. *C. perfringens* is a common cause of foodborne illnesses. A more severe form of the disease can be fatal, and results from ingesting large numbers of the active bacteria, typically from food.

Sea Urchin Development Assay

The results from the sea urchin development assay using *Lytechinus variegatus* can be seen in Figure 17. Sample 09P from Triton Bay was not run in time for inclusion in this report. The sea urchin development assay is an important and well established test used to assess sediment toxicity. Porewater, which is the water that occurs in the spaces between sediment particles, is extracted and then exposed to the sea urchin embryos for a period of 48 hours. After that time, embryo development stage along with any developmental abnormalities are scored. It can be seen in Figure 17 that sea urchin development was either arrested or the embryos were underdeveloped or malformed in all the samples, indicating the sediment extracts were toxic to the sea urchin embryos. In most of the samples, development of the sea urchin embryos was totally arrested. The TMASW (Tropic Marin artificial seawater) and the SDS (sodium dodecyl sulfate) were the negative and positive controls, respectively run as part of the assays.

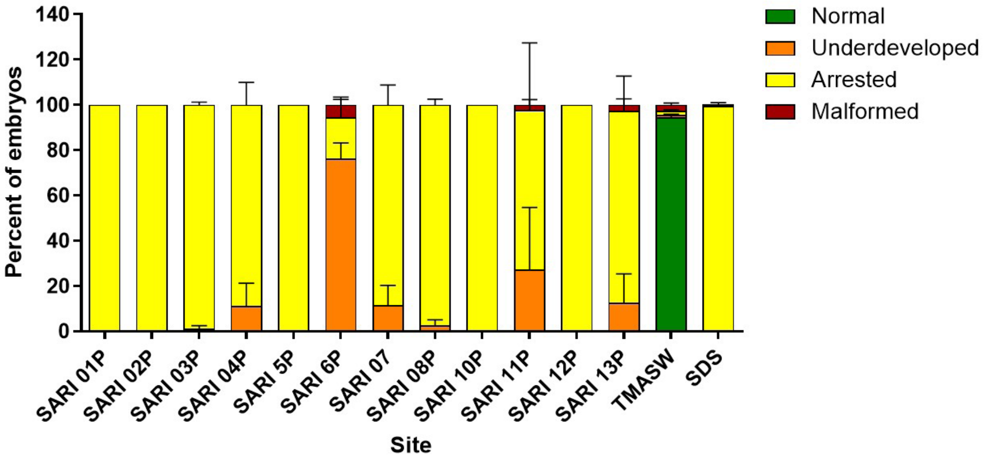

Figure 17. Results of the sea urchin development assays from the SARI.

In preparation for the toxicity test, a series of water quality measurements (Table 7) of the sediment were made, including salinity, dissolved oxygen, and pH. In addition, total ammonia nitrogen and unionized ammonia were also quantified in the sediment samples, prior to running the test. Ammonia exists in two forms, NH_3 which is unionized ammonia, and NH_4^+, which is referred to as ionized ammonia or ammonium. The sum of these two forms is total ammonia nitrogen or TAN. NH_3 is the principal form of toxic ammonia. Concentrations of UAN (unionized ammonia nitrogen) (NH_3-N) of 149.7 µg/L have been found to be toxic to *L. variegatus* (May and Woodley, 2016). While the concentration of dissolved oxygen and the pH of the samples were within the normal range (May, 2020), the concentration of the UAN was high. In 11 out of the 13 sediment samples (Table 7), the concentration of UAN was above the concentration (149.7 µg/L) found to be toxic to *L. variegatus* by May and Woodley (2016).

Table 7. Water quality measurements made in the sediments for the sea urchin development assay.

Site	Volume (mL)	Salinity (ppt)	DO (%)	pH	TAN (mg/L)	UAN (µg/L)
01P	108	28	92.4	8.16	4.45	299.2
02P	45	36	90	8.15	3.49	229.5
03P	72	28	90.3	8.17	5.12	351.4
04P	71	28	89	8.1	4.51	266.3
05P	79	28	87.9	8.19	2.8	200.6
06P	99	23	88.6	8.2	1.84	135
07P	46	28	88.5	8.1	4.12	243.2
08P	88	26	91	8.15	4.45	293.2
10P	81	25	90.5	8.17	4.37	299.9
11P	98	39	87	7.96	3.34	145.3
12P	89	28	87	8.06	4.09	221.2
13P	88	25	90.3	8.12	3.42	211
TMASW	-	36	89.4	8.25	0.01	0.9
SDS	-	36	90.1	8.28	0.01	1

Abbreviations: DO, dissolved oxygen; ppt, parts per thousand; TAN, total ammonia nitrogen; UAN,unionized ammonia nitrogen; TMASW, Tropic Marin artificial seawater (negative control); SDS, sodium dodecyl sulfate

In 2015, May and Woodley (2016) collected sediment samples from various locations around St. Croix, and analyzed them for porewater toxicity using the sea urchin fertilization assay. Sites were also located within the estuarine portion of the SARI. The mean concentration of UAN (16.5 µg/L) found by May and Woodley (2016) in the sediments within the estuarine portion of the SARI was over an order of magnitude lower than the mean (241 µg/L) found at the sites in the current project. It is not clear why the UAN values were so much higher in the sediment samples collected for the current project. A review of the rainfall data from the Henry E. Rohlsen Airport south of Christiansted, St. Croix from NOAA's National Centers for Environmental Information, indicated that on August 30th, five days before the 2018 sampling took place, approximately 30.7 mm (1.21 inches) of rain fell. Rainfall and subsequent runoff could have resulted in the introduction of excess nitrogen into the SARI, perhaps from failing septic systems.

Another possibility was suggested by the analyst at the NOAA NCCOS laboratory in Charleston, SC, the same laboratory that analyzed the samples from 2015. It was noted during the preparation of the 2018 sediment samples, that they contained fairly high amounts of plant detritus, possibly remnant effects from Hurricanes Irma and Maria. It seems likely that the destructive winds along with flooding from these storms would have introduced substantial amounts plant material into the SARI, which in turn may have contributed to the higher levels of detritus and subsequently high levels of ammonia (from the degradation of plant material), seen in the 2018 sediment samples, compared to sediments collected in 2017.

HRGS P450 Assay

The results from the P450 toxicity assay are presented in Table 8. The P450 assay responds to the presence of contaminants like PAHs and PCBs in sediment extracts. From Table 8, it can be seen that there were a number of samples that resulted in elevated B[a]P-Eqs (benzo[a]pyrene equivalents). As noted earlier, HRGS values less than 10 and greater than 60 µg B[a]P Eq/g, can be considered to represent marginal and highly contaminated thresholds, respectively.

There were three sites, 4P, 5P, and 9P that were below the lower threshold indicating marginally contaminated sites. The highest B[a]P-Eq was at Site 01P in the Marina stratum, and also at sites 11P, and 12P in the Mangrove Lagoon stratum. The B[a]P-Eqs at Site 01P was above the 60 µg B[a]P Eq/g threshold for degraded benthic communities.

Table 8. Results of P450 assays in the sediments from the SARI, St. Croix.

Site	EC50 for B[a]P (g)	EC50 (mg sample)			Overall B[a]P-Eqs* (ug/g sample)
1P	3.01E-08	0.33	0.40	0.60	72.05±20.36[a]
2P	3.01E-08	3.57	3.83	4.25	7.79±0.68
3P	3.01E-08	0.61	2.18	1.99	26.09±20.10
4P	3.37E-08	1.81	2.00	2.03	17.35±1.10
5P	3.37E-08	3.30	3.30	3.57	9.96±0.45
6P	3.37E-08	2.03	2.18	2.35	15.46±1.15
7P	2.22E-09	1.82	3.08	2.05	10.80±2.59
8P	2.22E-09	2.39	1.99	1.87	10.78±1.34
9P	2.22E-09	2.71	2.30	2.95	8.46±1.09
10P	2.03E-08	1.79	2.12	2.12	10.19±1.02
11P	4.30E-08	0.70	1.03	0.86	51.22±9.94
12P	4.30E-08	0.82	1.32	1.14	40.80±10.22
13P	1.89E-08	1.86	1.67	0.68	16.43±9.86

*Values represent the mean ± SD of the triplicate EC50 values.

Sites 11P and 12P in Mangrove Lagoon were the second and third highest readings in the sediment samples collected from the SARI for this project, although the readings were below the suggested threshold for degraded benthic communities.

A bivariate plot of total PAHs in the sediments versus B[a]P-Eqs can be seen in Figure 18. The r^2 value was 0.61. It can be seen in Figure 18 that there was fairly good agreement between the B[a]P-Eqs and the concentration of total PAHs. However, there appeared to be a couple of outliers, in terms of higher B[a]P-Eqs, with somewhat lower total PAH concentrations. These two points in Figure 18 represent sites 11P and 12P in the Mangrove Lagoon stratum.

Figure 19 contains a plot by site of total PAHs and B[a]P-Eqs. Again, there was a fairly good match between these two parameters, that is the concentration of total PAHs, and the corresponding B[a] P-Eqs values. At sites 11P and 12P, that relationship appeared to break down. While the B[a]P-Eqs values were elevated, the total PAH concentrations were fairly low. The HRGS P450 assay responds to a variety of chemical contaminants including PAHs and PCBs, but also dioxins (*e.g.*, polychlorinated dibenzo-p-dioxins (PCDDs)) and furans (*e.g.*, dibenzofurans (PCDFs) (He and Dennison, 2019).

A plot of B[a]P-Eqs against total PCBs in the sediments can be seen in Figure 20. Sites 11P and 12P were outliers, however, and the concentration of total PCBs at sites 11P (1.47 ng/g) and 12P (0.16 ng/g) were low (Appendix F). The r^2 value was 0.42, less than it was for total PAHs, indicating that the B[a]P-Eqs had an even lower correlation with the concentration of total PCBs. It may be that other chemical pollutants, beyond the list of analytes quantified in this study, are present at sites 11P and 12P, and resulted in the elevated B[a]P-Eqs. Pait *et al.* (2013) also used the HRGS P450 assay to assess the toxicity of sediments in the STEER. The highest B[a]P-Eqs (44.8) was found in the western portion of the STEER, adjacent to the Bovoni Landfill, which serves St. Thomas and St. John. Of the 24 sediment samples analyzed from the STEER, only 10 of the samples had responses high enough that B[a] P-Eqs could be calculated. The highest B[a]P-Eq found in the STEER was lower than that found at Site 01P site in the Marina stratum, and Site 11P in the SARI.

Benthic Infaunal Analysis

A total of 3,615 organisms were enumerated, comprised of 97 taxa (species or higher taxonomic level). Of that, 67 taxa were found at only one location. Annelids (segmented worms) were by far the dominant taxa, accounting for

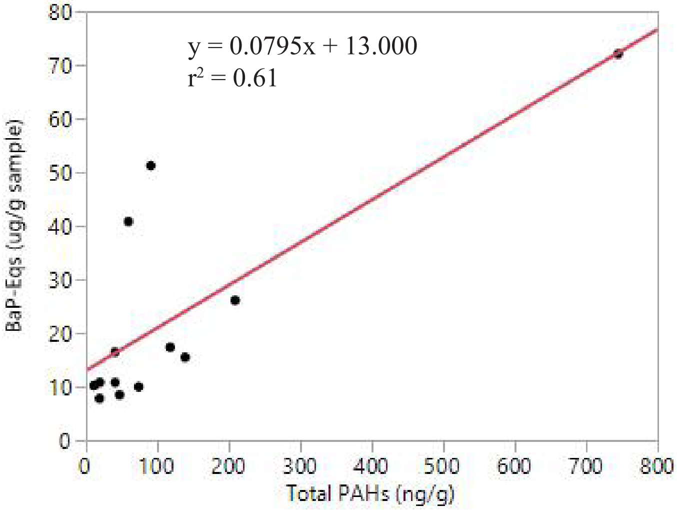

Figure 18. Bivariate fit of total PAHs versus benzo(a)pyrene equivalents (B[a]P-Eqs.)

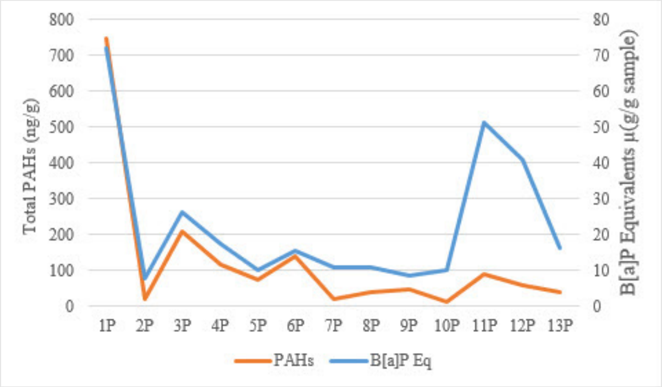

Figure 19. Comparison of total PAHs in the sediments and benzo(a)pyrene equivalents (B[a]P-Eqs.).

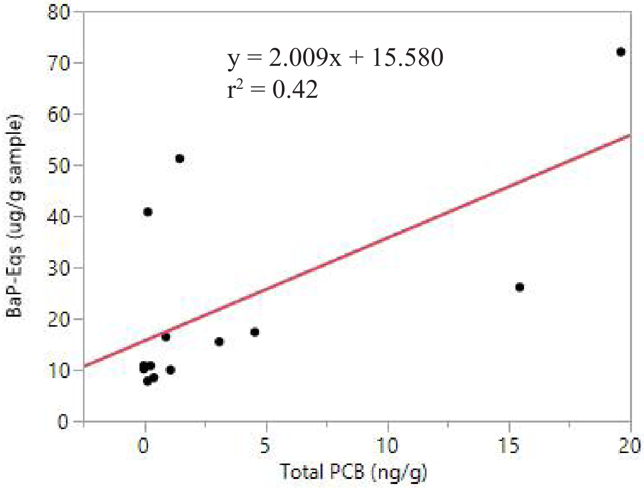

Figure 20. Bivariate fit of total PCBs versus benzo(a) pyrene equivalents (B[a]P-Eqs).

82.2 percent of all the organisms counted in the sediment samples collected from the SARI. The dominance of annelids can readily be seen in Table 9. Mollusks and arthropods accounted for 14.1 and 2.68 percent, respectively at the sites sampled in the SARI. Less than 1% of the animals were echinoderms. Abundance was dominated by roughly 15 taxa that were found throughout most strata and accounted for over 80 percent of the total abundance of organisms. In addition, there were a large number of taxa that were only represented by a few individuals. This can be seen graphically in Figure 21.

Table 9. Percent abundance of major taxonomic groups.

Site	Annelida	Mollusca	Arthropoda	Other Taxa
Marina-1P	87.6	12.4	0	0
Marina-2P	74.8	15.0	8.9	1.3
Marina-3P	84.8	14.7	0.5	0.0
Mean	82.4	14.0	3.1	0.4
Sugar Bay-4P	95.3	2.7	0	2.0
Sugar Bay-5P	83.5	16.1	0.2	0.2
Sugar Bay-6P	94.3	3.6	1.9	0.1
Sugar Bay-7P	59.6	38.0	0	2.4
Mean	83.2	15.1	0.5	1.2
Triton Bay-8P	83.3	9.5	6.3	0.8
Triton Bay-9P	96.8	0	0	3.2
Triton Bay-10P	48.4	45.7	2.2	3.8
Mean	76.2	18.4	2.8	2.6
Mangrove Lagoon-11P	79.2	19.9	0	0.9
Mangrove Lagoon-12P	97.7	0.8	0	1.5
Mangrove Lagoon-13P	92.2	7.8	0	0
Mean	89.7	9.5	0	0.8
Overall	82.2	14.1	2.68	0.69

Table 10 contains a summary of the benthic infaunal parameters measured in the strata sampled in the SARI. The average abundance (number of individuals) showed some variation, with the Mangrove Lagoon stratum having the lowest mean abundance at 135 organisms (Table 10). The highest abundance at a site was at 6P, with 721 organisms. The lowest was at 13P, with only 51 organisms. A Kruskal-Wallis test, however, indicated no significant (ChiSquare = 3.5989, $p = 0.3082$) difference in the abundance of benthic infaunal organisms between strata.

Taxa richness (number of species) also showed some variation between strata (Table 10). The lower values tended to be in the Marina and the Mangrove Lagoon strata (Figure 22). There was, however, no significant difference in taxa richness between strata (ChiSquare = 2.1058, $p = 0.5507$). A significant and positive correlation (Spearman Rho = 0.7884, $p = 0.0014$) was found between abundance and taxa richness, indicating that as the number of individuals increased, the number of species also tended to increase.

A number of authors have investigated pollution tolerant species. Authors including Lenihan and Micheli (2001) and Llanso *et al.*(2002) noted that several types of polychaetes, such as the Capitellids, and some members of the Naididae family (formerly oligochaete tubificids), are considered

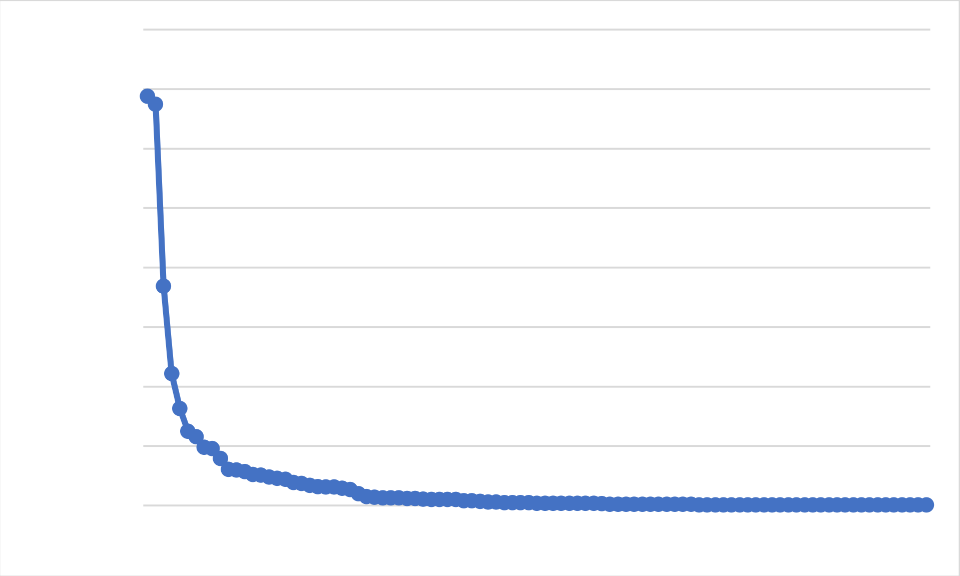

Figure 21. Plot of total abundance of each taxa used in the analysis. Each point represents the abundance of each individual taxa collected in the SARI.

to be tolerant of contamination and/or other stressful conditions, such as low oxygen levels. Harlan (2008) published a review on using polychaetes of the family Capitellidae, as indicator species for marine pollution. Members of the *Capitella capitata* species complex, along with the genus *Ophryotrocha* are often dominant in areas with high organic material. In Table 11, it can be seen that both were abundant at Site 01P. In addition, members of the Naididae family which were also abundant at Site 01P, are highly resistant to lower oxygen levels and higher organic pollution levels.

Table 10. Summary of the benthic macroinfaunal assemblage parameters for the SARI sites.

Site		Abundance (# of individuals)	Taxa Richness (# of species)	Density (numbers/m^2)	Diversity (H')	Evenness (J')
Marina-1P		105	10	2,625	1.64	0.71
Marina-2P		528	46	13,200	2.71	0.71
Marina-3P		204	24	5,100	2.35	0.74
	Mean	279	26.7	6,975	2.24	0.72
	SD	221	18.1	5,531	0.54	0.02
Sugar Bay-4P		148	15	3,700	1.92	0.71
Sugar Bay-5P		534	23	13,350	2.17	0.69
Sugar Bay-6P		721	24	18,025	1.72	0.54
Sugar Bay-7P		250	27	6,250	2.52	0.76
	Mean	413	22.3	10,331	2.08	0.68
	SD	262	5.1	6,556	0.34	0.09
Triton Bay-8P		473	39	11,825	2.55	0.70
Triton Bay-9P		63	11	1,575	1.82	0.76
Triton Bay-10P		184	24	4,600	2.19	0.69
	Mean	240	24.7	6,000	2.19	0.72
	SD	211	14.0	5,266	0.36	0.04
Mangrove Lagoon -		221	20	5,525	2.29	0.76
Mangrove Lagoon -		133	13	3,325	1.49	0.58
Mangrove Lagoon -		51	11	1,275	1.79	0.75
	Mean	135	14.7	3,375	1.86	0.70
	SD	85	4.7	2,125	0.40	0.10

Abundance, H', Shannon's diversity index; J', Pielou's evenness index.

The density of organisms at each site is also included in Table 10. The highest density was at Site 06P in the Sugar Bay stratum. While this site had the highest number of organisms, it was dominated by the Annelida (Table 9), including the Naididae (Table 11).

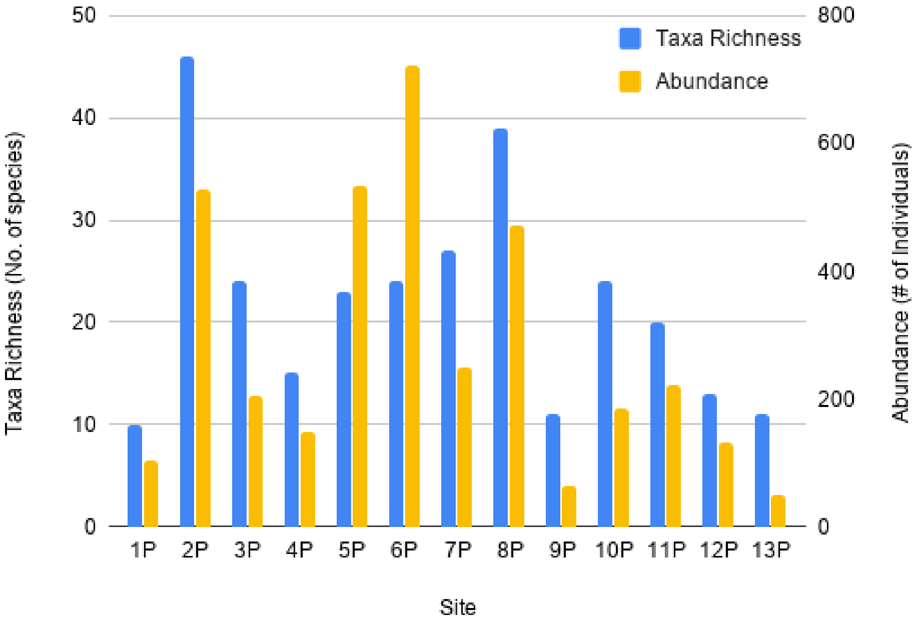

Figure 22. Plot of taxa richness and total abundance by site in the SARI.

Diversity (H’ or Shannon-Wiener index) is included in Table 10 as well. Species diversity or biodiversity, has two components; the number of species present (taxa richness), and the relative abundance of those species. The Shannon-Wiener index integrates both parameters. From Table 10, it can be seen that the lowest diversity values occurred in the Mangrove Lagoon stratum (Site 12P) and at Site 01P in the Marina stratum. The Mangrove Lagoon stratum had the lowest mean diversity value (1.86) of any stratum sampled in the SARI. This

Table 11. Percent abundance of dominant benthic macroinfaunal taxa (> 10% of the total) in sediments from the SARI.

Phylum	Family	Taxa	1P	2P	3P	4P	5P	6P	7P	8P	9P	10P	11P	12P	13P
Annelida															
	Naididae	Naididae (LPIL)	47.6		16.7	10.8	20.8	57.1							
	Capitellidae	*Capitella capitata*	11.4												
	Capitellidae	*Mediomastus* (LPIL)		24.4			11.2				17.5		14	21.8	37.3
	Corbulidae	*Caryocorbula contracta*							19.2						
	Cossuridae	*Cossura soyeri*				14.9									
	Dorvilleidae	*Ophryotrocha* (LPIL)	15.2												
	Paraonidae	*Cirrophorus lyra*			19.6	34.5	27.9			33.4	42.9	17.9	29	54.1	27.5
	Spionidae	*Prionospio heterobranchia*		19.3											
	Spionidae	*Prionospio steenstrupi*				20.9									
	Spionidae	*Prionospio* (LPIL)			13.7				13.6	10.1	11.1		19.5		
	Spionidae	*Spio* (LPIL)			21.1										
	Syllidae	*Exogone rolani*						10.3							
Mollusca															
	Caecidae	*Caecum pulchellum*										40.2			
	Tellinidae	*Macoma sp. G*	11.4				12.9								
	Ungulinidae	*Diplodonta punctata*							13.2						

was also reflected in the low taxa richness and abundance values for the sites within the Mangrove Lagoon stratum. As was seen earlier, the results from the P450 toxicity assay perhaps indicated the presence of unknown chemical contaminants in the Mangrove Lagoon stratum.

Interestingly, Site 02P, within the Marina stratum had the highest diversity value (2.71) of any site sampled in the SARI (Table 10). This can also be seen in Figure 22. In addition, the density of organisms at this site was over 13,000/m^2, and had a mix of mollusks and arthropods. As was seen earlier, Site 02P tended to have lower levels of chemical contaminants, which may have been a factor, along with higher levels of sand, and correspondingly lower levels of silt and clay.

While there were variations in diversity at the sites sampled in the SARI, a Kruskal-Wallis nonparametric test by stratum, failed to show any significant differences (ChiSquare = 0.7967, p = 0.6157) in diversity by stratum. This could be linked to the sediments in the estuarine portion of the SARI, which were sampled for this project, being somewhat homogeneous as a result of the mixing in this portion of the SARI. Pielou's evenness (J') values shown in Table 10 indicated fairly consistent values across the sites sampled in the SARI. As with diversity, there were no significant (ChiSquare = 0.6408, p = 0.8870) differences. The evenness values provides a measure of how numerically equal the community is across species.

Table 12 contains a series of correlations that were run between the benthic infaunal analysis parameters and some of the other parameters measured in this project. The results from the sea urchin development assay were not included as those appeared likely influenced by the high unionized ammonia values found in the samples. From Table 12, it can be seen that the only significant correlation was between taxa richness and the ERMq, indicating that the areas with higher levels of all the contaminants analyzed in this project were negatively correlated with the number of species present in an area. The ERMq is calculated by dividing the concentration of each contaminant analyzed in the sediment by its available ERM to produce a quotient. While there was a significant correlation between ERMq and taxa richness, the correlation between the B[a]P Eqs and taxa richness was above the 0.05 level of signif-

Table 12. Spearman rank correlation coefficients and significance level for community parameters and selected physical and chemical parameters, and toxicological results.

Parameter	Statistics	Stratum	ERMq	B[a]P Eqs	%Silt	%Clay	% Sand
Taxa	Speannan Rho	-0.3054	-0.6031	-0.4924	-0.3707	-0.2849	0.4952
(# of species)	Significance	0.3103	0.0291*	0.0874	0.2124	0.3454	0.0853
Abundance	Spearman Rho	-0.3543	-0.3901	-0.3571	-0.4176	-0.0769	0.4011
(# of individuals)	Significance	0.235	0.1876	0.2309	0.1557	0.8028	0.1744
Diversity	Spearman Rho	-0.2579	-0.533	-0.456	-0.3736	-0.3956	0.4231
(H')	Significance	0.3949	0.0607	0.1173	0.2086	0.1809	0.1497

*, statistically significant (0.05); ERMq, ERM quotient; B[a]P Eqs, benzo[a]pyrene equivalents; H', Shannon's diversity index

icance, indicating no significant correlation. Likewise, the correlation between diversity and ERMq was just above the 0.05 level of significance. While not shown in Table 12, there was a significant correlation (Spearman Rho = 0.7692, p = 0.0021) between %silt of the sediment and B[a]P Eqs, indicating that the higher concentrations of chemical contaminants were associated with the finer grain sizes of sediment. Also, there was a negative correlation (Spearman Rho = -0.7857, p = 0.0015) between chemical contaminants and the sand fraction.

SUMMARY AND CONCLUSIONS

Working closely with partners from the USVI Department of Planning and Natural Resources and the National Park Service, this project resulted in the collection and analysis of sediments for chemical contaminants and bioeffects within the estuarine portion of the Salt River Bay National Historical Park and Ecological Preserve or SARI. Four strata were established in the estuarine portion of the SARI, and 13 sediment samples were collected randomly within those strata. In addition, a sediment core was collected in the Sugar Bay stratum, to assess contaminant levels in deeper, older sediments. Samples were analyzed for grain size and organic/inorganic carbon, and for a suite of over 270 organic (*e.g.*, hydrocarbons and pesticides) and inorganic (*e.g.*, metals) chemical contaminants. The 13 samples collected were also analyzed for bioeffects, including the HRGS P450 test, used to identify the presence of organic chemical contaminants, along with the sea urchin embryo development assay, and lastly an assessment of the benthic infaunal community.

There were no differences in the distribution of grain sizes (*i.e.*, gravel, silt and clay) between the strata in the samples collected in 2018 from the SARI. A comparison of grain size in samples collected by NCCOS researchers in 2017 at three sites before the hurricanes that year, and then collected again in the same area in 2018 for the current project, indicated possible changes in the grain size structure of the sediments. Higher levels of clay and lower levels of the gravel fraction in the samples collected in 2018, could be an indication of the effects of hurricanes Irma and Maria that swept through the USVI in September 2017.

The results of the chemical contaminant analysis indicated, for the most part, low to moderate concentrations of the contaminants analyzed, relative to the published sediment quality guidelines (Long *et al*., 1998) discussed in this report. There were no differences in the concentrations of the chemical contaminants analyzed between strata. One factor that may be involved in the observed lack of differences in grain sizes and contaminant concentrations between strata is the mixing of sediments that likely occurs within the portion of the SARI that was the focus of this project. The estuarine portion of the SARI is separated from the outer coral reef areas of the park by a series of barrier reefs at the mouth of Salt River Bay. This barrier has been shown to restrict the movement of sediments, likely causing them to be recirculated and redistributed within this portion of the SARI.

As with grain size, there was a difference in the concentration of some chemical contaminants at the three sites analyzed in 2017 and again in 2018. Concentrations of PAHs, chromium, and zinc were higher at the three sites in 2017 compared to 2018.

The analysis of the sediment core indicated decreasing concentrations of chemical contaminants in the deeper sections of the core. The concentration of copper increased in the shallow sections of the core, with the surface section having the highest concentration, and may be a result of the replacement of the banned boat hull antifoulant tributyltin or TBT, with copper containing antifoulant paint formulations.

The only contaminants analyzed which exceeded the published ERL and ERM sediment quality guideline (Long *et al*., 1998), were zinc and copper, both in the Marina stratum. The concentration of zinc exceeded a concentration above which effects on benthic organisms begin to occur. Copper was close to a concentration where effects on benthic organisms are likely to occur.

The results of the sea urchin embryo development assay were confounded by the presence of high levels of unionized ammonia, which has been shown to be toxic to the sea urchin embryos used in the assay. The high levels of unionized ammonia found in the sediment samples may have been related to rainfall that occurred prior to sampling. Another interesting possibility is that the substantial amounts of plant detritus that were found in the sediment samples, was a result of the hurricanes that impacted the USVI in 2017, and that the degradation of the plant material may have led to the elevated levels of unionized ammonia found in the samples, and subsequent toxicity of the sediments.

The results of the HRGS P450 assay indicated the presence of toxic contaminants at some of the sites in both the Marina and Mangrove Lagoon strata. The response at one site in the Marina stratum was at a level associated with degraded benthic communities. In the Mangrove Lagoon stratum, the HRGS P450 assay also indicated the presence of toxic contaminants. Because the HRGS P450 assay responds to a variety of contaminants, in addition to PAHs and PCBs, it may be that there are other chemical contaminants present at these sites that were beyond the list of contaminants quantified.

The assessment of benthic infaunal organisms in the sediments collected indicated no significant difference in the community between strata. However, diversity was lowest at a site in the Marina stratum and in one of the Mangrove Lagoon stratum sites. Correlations between the benthic infaunal community and contaminants, indicated a significant negative correlation between taxa richness (number of species at the sites), and the ERMq, an indicator of pollution due to the presence of multiple contaminants.

Overall, the levels of the chemical contaminants and bioeffects found in the estuarine portion of the SARI were low to moderate. The Marina stratum and the Mangrove Lagoon stratum had concentrations of contaminants, or the presence of bioeffects that indicated that there may be impacts on benthic infaunal communities. Additional work in these two areas, including the identification of unknown compounds that might have influenced the P450 results, particularly in Mangrove Lagoon, could further help determine the degree of impacts of the contaminants identified on the benthic communities there, and if there are other contaminants present which may be impacting these sites, and areas further out in the SARI. Finally, there is currently only one TMDL established for the SARI, and that is for oxygen. Additional TMDLs for bacteria and turbidity would be useful for the management of the area.

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Appendix A. Site and water quality data from the sampling sites in the SARI, St. Croix.

Stratum	Site	Date	Depth (m)	Latitude (DD)	Longitude (DD)	Surface Temperature (°C)	Bottom Temperature (°C)	Surface Salinity (psu)	Bottom Salinity (psu)	Surface DO (mg/L)	Bottom DO (mg/L)	Notes
Marina	1P	9/6/2018	2.38	17.775111	-64.761661	32.2	32	35.41	35.4	5.76	5.45	Center of marina basin
Marina	2P	9/6/2018	0.91	17.774749	-64.760780	31.2	31.1	35.42	35.4	5.91	5.88	Just off mangrove island; hard packed shell hash, probably dredge spoil
Marina	3P	9/6/2018	2.74	17.775149	-64.759924	30.5	30.5	35.43	35.5	4.72	4.78	Marina outside island
Sugar Bay	4P	9/5/2018	3.05	17.773378	-64.758572	31.4	31	35.26	35.4	6.32	5.93	
Sugar Bay	5P	9/6/2018	0.61	17.770104	-64.758610	30.1	–	35.44	–	2.76	–	Benthos was mostly undecomposed vegetation
Sugar Bay	6P	9/5/2018	0.61	17.768429	-64.759581	32.1	32.1	35.12	35.2	3.85	3.99	Benthos was mostly undecomposed vegetation
Sugar Bay	7P	9/5/2018	3.66	17.777302	-64.755143	30.6	30.3	35.27	35.4	5.59	4.86	
Triton Bay	8P	9/4/2018	0.91	17.773835	-64.752671	31.9	31.5	34.98	35.1	6.61	6.09	Triton Bay just outside a seagrass bed
Triton Bay	9P	9/4/2018	1.83	17.772376	-64.753189	31.2	30.9	33.71	34.57	4.74	5.45	
Triton Bay	10P	9/4/2018	1.52	17.776938	-64.752709	31.4	31.5	35.21	35.4	6.84	6.9	
Bio Bay	11P	9/5/2018	2.77	17.778080	-64.751396	30.3	30.3	36.3	36.4	4.98	5.39	
Bio Bay	12P	9/5/2018	1.95	17.779546	-64.751015	30.7	30.6	36.4	36.5	5.01	4.58	
Bio Bay	13P	9/5/2018	2.35	17.777833	-64.750748	30.9	30.6	36.4	36.4	5.45	5.26	
Sugar Bay	Core Sample	9/6/2018		17.773795	-64.759165	N/A	N/A	N/A	N/A	N/A	N/A	

Abbreviations: DO, dissolved oxygen; DD, decimal degrees; psu, practical salinity unit – indicates that site was too shallow for bottom measurements; N/A, not available

Appendix B. Sediment grain size at the sites sampled in the SARI, St. Croix

	Sites								
Parameter	Site 1P (Marina)	Site 2P (Marina)*	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar Bay)	Site 8P (Triton Bay)*	Site 9P (Triton Bay)
% Gravel	0.00	18.07	0.00	0.00	0.00	0.00	0.00	4.77	0.00
% Sand	16.04	64.60	31.59	24.64	58.07	25.58	19.75	37.65	50.93
% Silt	62.50	8.76	44.87	50.05	22.40	37.97	69.46	30.83	26.54
% Clay	21.46	8.57	23.54	25.31	19.53	36.45	10.79	26.75	22.53

*Gravel component at site was shell hash; sand component was smaller shell.

	Sites					
Parameter	Site 10P (Triton Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)*
% Gravel	0.00	0.00	0.00	0.00	0.00	25.30
% Sand	60.37	23.01	23.41	20.10	58.70	49.84
% Silt	27.19	44.20	51.21	48.49	23.07	12.43
% Clay	12.44	32.79	25.38	31.41	18.23	12.43

*Gravel component at site was shell hash; sand component was smaller shell.

	Sites		
Parameter	Core Sample 3 (Sugar Bay)*	Core Sample 4 (Sugar Bay)*	Core Sample 5 (Sugar Bay)*
% Gravel	27.42	27.65	28.35
% Sand	47.02	43.42	50.04
% Silt	13.23	14.72	11.17
% Clay	12.33	14.21	10.44

*Gravel component at site was shell hash; sand component was smaller shell.

Appendix C. Total organic carbon in the sediments from the SARI, St. Croix.

	Sites								
Parameter	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Salt River Bay)	Site 8P (Triton Bay)	Site 9P (Triton Bay)
Total Carbon (%TC)	7.08	10.29	9.52	7.92	6.88	N/A	9.56	9.84	10.20
Total Organic Carbon (%TOC)	5.56	2.91	5.00	4.10	5.01	N/A	1.33	4.80	6.45
Total Inorganic Carbon (%TIC)	1.52	7.38	4.52	3.82	1.87	N/A	8.23	5.04	3.75

	Sites					
Parameter	Site 10P (Salt River Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)
Total Carbon (TC)	10.32	7.52	5.53	6.60	8.87	9.53
Total Organic Carbon (TOC)	2.60	4.19	2.70	2.93	2.98	3.29
Total Inorganic Carbon (TIC)	7.72	3.33	2.83	3.67	5.88	6.25

	Sites		
Parameter	Core Sample 3 (Sugar Bay)	Core Sample 4 (Sugar Bay)	Core Sample 5 (Sugar Bay)
Total Carbon (TC)	9.08	9.05	9.58
Total Organic Carbon (TOC)	3.49	3.04	3.19
Total Inorganic Carbon (TIC)	5.60	6.01	6.39

Appendix D. Total PAHs in the sediments from the SARI, St. Croix.

	Sites								
Compound	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar Bay)	Site 8P (Triton Bay)	Site 9P (Triton Bay)
cis/trans Decalin	5.1	0.0 U	0.0 U	0.0 U	0.0 U	7.6	0.0 U	0.0 U	0.0 U
C1-Decalins	2.2	0.0 U	0.0 U	0.0 U	0.0 U	2.9	0.0 U	0.0 U	0.0 U
C2-Decalins	10.0	0.0 U	0.0 U	0.0 U	0.0 U	6.2	0.0 U	0.0 U	0.0 U
C3-Decalins	37.9	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Decalins	81.6	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Naphthalene	3.1	0.4	3.6	2.8	4.0	6.4	1.4	4.2	3.8
C1-Naphthalenes	2.0	0.4 J	1.8	2.0	2.2	3.7	0.7 J	2.4	1.8
C2-Naphthalenes	6.0	0.0 U	4.8	6.2	6.2	9.6	1.9	5.1	5.5
C3-Naphthalenes	5.1	0.0 U	4.2	4.6	3.7	6.8	0.0 U	3.4	3.5
C4-Naphthalenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzothiophene	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C1-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Biphenyl	0.1 J	0.3 J	0.6	1.0	0.6	2.4	0.2 J	0.8	0.6
Acenaphthylene	12.3	0.6	4.2	1.3	0.5	0.6	0.2	0.1	0.2
Acenaphthene	1.2	0.0 U	1.2	1.2	1.1	2.7	0.3	1.2	1.0
Dibenzofuran	0.2	0.2 J	0.5	0.7	0.5	1.2	0.3	0.7	0.5
Fluorene	0.3	0.2	0.3	4.5	4.7	8.2	2.2	5.6	5.1
C1-Fluorenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Fluorenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Fluorenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Carbazole	0.0 U	0.0 U	1.5	0.0 U	0.9	0.0 U	0.0 U	0.1 J	0.6
Anthracene	26.1	1.2	8.9	2.5	1.1	1.5	0.2	0.7	0.8
Phenanthrene	23.4	0.5	2.6	2.4	1.5	3.2	0.7	1.3	1.1
C1-Phenanthrenes/Anthracenes	10.1	0.8	5.2	3.2	2.4	5.7	0.6	1.0	1.3
C2-Phenanthrenes/Anthracenes	22.7	0.0 U	9.9	7.2	5.8	10.4	0.0 U	0.0 U	0.0 U
C3-Phenanthrenes/Anthracenes	38.0	0.0 U	17.3	6.5	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Phenanthrenes/Anthracenes	34.3	0.0 U	23.0	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Dibenzothiophene	0.0 U	0.0 U	0.3	0.3	0.3	0.8	0.0 U	0.2	0.3
C1-Dibenzothiophenes	0.0 U	0.0 U	0.6	0.5	0.0 U	1.3	0.0 U	0.0 U	0.0 U
C2-Dibenzothiophenes	0.0 U	0.0 U	0.0 U	1.2	0.0 U	3.3	0.0 U	0.0 U	0.0 U
C3-Dibenzothiophenes	0.0 U	0.0 U	0.0 U	1.8	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Dibenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Fluoranthene	19.9	1.2	11.5	7.0	4.5	5.0	1.0	1.5	1.7
Pyrene	31.9	1.6	11.9	7.3	4.4	6.3	1.1	1.4	1.7
C1-Fluoranthenes/Pyrenes	32.1	1.0	9.7	5.0	0.0 U	0.0 U	0.7	0.0 U	0.0 U
C2-Fluoranthenes/Pyrenes	54.3	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Fluoranthenes/Pyrenes	27.7	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Fluoranthenes/Pyrenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Naphthobenzothiophene	7.7	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C1-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benz(a)anthracene	16.0	0.8	7.9	4.4	3.0	3.7	0.7	1.3	1.3
Chrysene/Triphenylene	20.2	1.2	10.9	5.3	3.4	4.4	0.9	1.2	1.4
C1-Chrysenes	19.7	0.9	6.7	4.0	2.7	6.2	0.0 U	0.0 U	0.0 U
C2-Chrysenes	24.0	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Chrysenes	24.0	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Chrysenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzo(b)fluoranthene	30.6	1.5	12.8	5.8	3.4	4.0	0.9	1.2	1.3
Benzo(k,j)fluoranthene	23.6	1.3	10.3	4.8	2.9	2.8	0.7	0.7	0.8
Benzo(a)fluoranthene	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.3	0.2
Benzo(e)pyrene	21.6	1.1	8.1	4.0	2.3	2.7	0.7	0.8	0.8
Benzo(a)pyrene	17.0	1.0	7.9	4.3	2.6	2.6	0.8	0.7	0.7
Perylene	11.2	0.7 J	5.8	8.2	4.5	12.0	1.4	3.2	10.0
Indeno(1,2,3-c,d)pyrene	14.9	0.9	6.1	3.4	2.0	0.9	0.6	0.6	0.6
Dibenzo(a,h)anthracene	5.2	0.2	2.1	1.1	0.4	0.6	0.1	0.3	0.0 U
C1-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzo(g,h,i)perylene	21.6	1.2	6.3	3.8	2.3	3.1	0.8	0.8	0.8
Total PAHs	745	19.2	209	118	73.8	139	19.5	40.9	47.1

Qualifiers: J, below method detection limit; U, not detected

Appendix D. Total PAHs in the sediments from the SARI, St. Croix (cont.).

	Sites					
Compound	Site 10P (Triton Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)
cis/trans Decalin	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	1.9
C1-Decalins	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Decalins	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Decalins	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Decalins	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Naphthalene	0.7	3.3	2.1	0.5	2.2	0.5
C1-Naphthalenes	0.4 J	1.3	0.9 J	0.5 J	1.2	0.3 J
C2-Naphthalenes	1.1	4.4	3.0	1.5	3.1	0.0 U
C3-Naphthalenes	0.0 U	3.5	3.1	1.9	2.5	0.0 U
C4-Naphthalenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzothiophene	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C1-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Benzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Biphenyl	1.1	0.8	0.4	0.3	0.4	0.5
Acenaphthylene	0.0 U	2.3	0.6	1.0	0.3	0.3
Acenaphthene	0.3	1.9	1.5	1.3	0.5	0.2
Dibenzofuran	0.2 J	0.5	0.4	0.4	0.2	0.3
Fluorene	1.6	6.2	5.8	2.9	3.6	0.4
C1-Fluorenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Fluorenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Fluorenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Carbazole	0.0 U	0.1 J	0.3	0.5	0.5	0.1 J
Anthracene	0.2	4.4	1.6	2.2	0.7	0.5
Phenanthrene	0.4	1.3	0.9	0.9	0.9	0.7
C1-Phenanthrenes/Anthracenes	0.4	3.7	1.3	1.4	1.1	0.8
C2-Phenanthrenes/Anthracenes	0.0 U	5.6	3.5	0.0 U	2.1	0.0 U
C3-Phenanthrenes/Anthracenes	0.0 U	3.4	3.3	0.0 U	2.0	0.0 U
C4-Phenanthrenes/Anthracenes	0.0 U	2.6	0.0 U	0.0 U	0.0 U	0.0 U
Dibenzothiophene	0.2	0.3	0.2	0.1	0.1 J	0.1 J
C1-Dibenzothiophenes	0.0 U	0.0 U	0.3	0.0 U	0.0 U	0.0 U
C2-Dibenzothiophenes	0.0 U	0.0 U	1.4	0.0 U	0.0 U	0.0 U
C3-Dibenzothiophenes	0.0 U	0.0 U	5.2	0.0 U	0.0 U	0.0 U
C4-Dibenzothiophenes	0.0 U	0.0 U	2.5	0.0 U	0.0 U	0.0 U
Fluoranthene	0.5	4.6	2.5	3.1	1.8	1.4
Pyrene	0.6	4.6	2.5	3.1	2.1	1.7
C1-Fluoranthenes/Pyrenes	0.0 U	0.0 U	1.9	2.2	1.3	1.2
C2-Fluoranthenes/Pyrenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Fluoranthenes/Pyrenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Fluoranthenes/Pyrenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Naphthobenzothiophene	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C1-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benz(a)anthracene	0.3	3.2	1.6	1.9	1.2	0.9
Chrysene/Triphenylene	0.4	3.9	1.8	2.4	1.5	1.2
C1-Chrysenes	0.0 U	3.1	0.0 U	0.0 U	1.6	1.1
C2-Chrysenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Chrysenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C4-Chrysenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzo(b)fluoranthene	0.5	5.8	2.3	3.0	1.7	1.3
Benzo(k,j)fluoranthene	0.4	4.3	1.7	2.4	1.4	1.0
Benzo(a)fluoranthene	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzo(e)pyrene	0.3	3.4	1.5	2.0	1.2	1.0
Benzo(a)pyrene	0.3	2.8	1.3	1.7	1.2	1.0
Perylene	0.7 J	3.3	1.4	0.3 J	2.3	1.4
Indeno(1,2,3-c,d)pyrene	0.3	2.6	1.1	1.4	1.0	0.9
Dibenzo(a,h)anthracene	0.0 U	0.8	0.2	0.3	0.2	0.2
C1-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C2-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
C3-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
Benzo(g,h,i)perylene	0.4	2.8	1.2	1.7	1.5	1.3
Total PAHs	11.3	90.9	59.6	40.7	41.3	22.0

Qualifiers: J, below method detection limit; U, not detected

Appendix D. Total PAHs in the sediments from the SARI, St. Croix (cont.).

	Sites		
Compound	Core Sample 3 (Sugar Bay)	Core Sample 4 (Sugar Bay)	Core Sample 5 (Sugar Bay)
cis/trans Decalin	0.0 U	0.0 U	0.0 U
C1-Decalins	0.0 U	0.0 U	0.0 U
C2-Decalins	0.0 U	0.0 U	0.0 U
C3-Decalins	0.0 U	0.0 U	0.0 U
C4-Decalins	0.0 U	0.0 U	0.0 U
Naphthalene	0.4	0.9	0.9
C1-Naphthalenes	0.3 J	0.6 J	0.4 J
C2-Naphthalenes	0.0 U	1.1	0.0 U
C3-Naphthalenes	0.0 U	0.0 U	0.0 U
C4-Naphthalenes	0.0 U	0.0 U	0.0 U
Benzothiophene	0.0 U	0.0 U	0.0 U
C1-Benzothiophenes	0.0 U	0.0 U	0.0 U
C2-Benzothiophenes	0.0 U	0.0 U	0.0 U
C3-Benzothiophenes	0.0 U	0.0 U	0.0 U
C4-Benzothiophenes	0.0 U	0.0 U	0.0 U
Biphenyl	0.7	0.2 J	0.2 J
Acenaphthylene	0.2	0.3	0.1
Acenaphthene	0.0 U	0.2	0.2
Dibenzofuran	0.3	0.4	0.3
Fluorene	0.1 J	1.0	1.2
C1-Fluorenes	0.0 U	0.0 U	0.0 U
C2-Fluorenes	0.0 U	0.0 U	0.0 U
C3-Fluorenes	0.0 U	0.0 U	0.0 U
Carbazole	0.0 U	0.2	0.4
Anthracene	0.3	0.5	0.2
Phenanthrene	0.5	0.7	0.6
C1-Phenanthrenes/Anthracenes	0.6	0.7	0.4
C2-Phenanthrenes/Anthracenes	0.0 U	0.0 U	0.0 U
C3-Phenanthrenes/Anthracenes	0.0 U	0.0 U	0.0 U
C4-Phenanthrenes/Anthracenes	0.0 U	0.0 U	0.0 U
Dibenzothiophene	0.0 U	0.1 J	0.0 U
C1-Dibenzothiophenes	0.0 U	0.0 U	0.0 U
C2-Dibenzothiophenes	0.0 U	0.0 U	0.0 U
C3-Dibenzothiophenes	0.0 U	0.0 U	0.0 U
C4-Dibenzothiophenes	0.0 U	0.0 U	0.0 U
Fluoranthene	0.6	1.2	0.6
Pyrene	0.9	1.4	0.6
C1-Fluoranthenes/Pyrenes	0.8	1.3	0.7
C2-Fluoranthenes/Pyrenes	0.8	1.4	0.0 U
C3-Fluoranthenes/Pyrenes	0.4 J	0.0 U	0.0 U
C4-Fluoranthenes/Pyrenes	0.0 U	0.0 U	0.0 U
Naphthobenzothiophene	0.0 U	0.0 U	0.0 U
C1-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U
C2-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U
C3-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U
C4-Naphthobenzothiophenes	0.0 U	0.0 U	0.0 U
Benz(a)anthracene	0.4	0.8	0.4
Chrysene/Triphenylene	0.6	1.0	0.5
C1-Chrysenes	0.6	1.0	0.0 U
C2-Chrysenes	0.0 U	0.0 U	0.0 U
C3-Chrysenes	0.0 U	0.0 U	0.0 U
C4-Chrysenes	0.0 U	0.0 U	0.0 U
Benzo(b)fluoranthene	0.7	1.3	0.5
Benzo(k,j)fluoranthene	0.6	0.9	0.4
Benzo(a)fluoranthene	0.0 U	0.0 U	0.0 U
Benzo(e)pyrene	0.6	1.0	0.4
Benzo(a)pyrene	0.5	0.9	0.4
Perylene	0.9 J	2.5	3.0
Indeno(1,2,3-c,d)pyrene	0.5	0.8	0.4
Dibenzo(a,h)anthracene	0.1	0.3	0.1
C1-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U
C2-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U
C3-Dibenzo(a,h)anthracenes	0.0 U	0.0 U	0.0 U
Benzo(g,h,i)perylene	0.7	1.3	0.7
Total PAHs	13.3	23.8	13.8

Qualifiers: J, below method detection limit; U, not detected

Appendix E. Alkylated PAHs in the sediments from the SARI, St. Croix.

	Sites								
Compound	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar Bay)	Site 8P (Triton Bay)	Site 9P (Triton Bay)
2-Methylnaphthalene	2.1	0.4 J	1.8	2.0	2.2	3.9	0.7 J	2.5	1.9
1-Methylnaphthalene	0.93	0.3 J	0.98	1.08	1.18	1.98	0.4 J	1.24	1.0
2,6-Dimethylnaphthalene	3.85	0.0 U	4.20	3.62	4.23	5.78	1.2	3.55	3.6
1,6,7-Trimethylnaphthalene	0.45	0.00 U	0.33	0.42	0.25	0.49	0.00 U	0.2	0.2
1-Methylfluorene	0.0 U	0.00 U	0.00 U	0.00 U	0.00 U	0.0 U	0.0 U	0.0 U	0.0 U
4-Methyldibenzothiophene	1.43	0.0 U	0.41	0.39	0.00 U	1.28	0.00 U	0.0 U	0.0 U
2/3-Methyldibenzothiophene	0.41	0.00 U	0.22	0.20	0.00 U	0.24	0.00 U	0.0 U	0.0 U
1-Methyldibenzothiophene	0.137	0.00 U	0.145	0.13	0.00 U	0.215	0.00 U	0.0 U	0.0 U
3-Methylphenanthrene	2.05	0.2	1.20	1.0	0.5	1.29	0.2	0.29	0.3
2-Methylphenanthrene	2.15	0.2	1.71	1.0	1.4	2.79	0.3	0.51	0.7
2-Methylanthracene	4.702	0.16	1.30	0.36	0.23	0.32	0.04 J	0.096 J	0.1
4/9-Methylphenanthrene	4.02	0.2	1.78	1.2	0.6	0.4	0.20	0.190	0.2
1-Methylphenanthrene	0.76	0.2	1.09	0.8	0.5	2.96	0.15	0.290	0.4
3,6-Dimethylphenanthrene	2.29	0.0 U	0.86	0.59	0.30	0.87	0.00 U	0.000 U	0.0 U
Retene	7.45	0 U	34.8	1.8	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U
2-Methylfluoranthene	4.04	0.2 J	1.89	1.0	0.0 U	0.0 U	0.2 J	0.1 J	0.0 U
Benzo(b)fluorene	3.34	0.2	1.68	1.1	0.0 U	0.0 U	0.2	0.3	0.0 U
C29-Hopane	140.4	4.6	29.0	27.3	24.6	45.2	5.4	14.5	20.3
18a-Oleanane	15.9	0.0 U	4.5	4.0	3.5	26.3	1.1	1.7	0.0 U
C30-Hopane	165.8	5.1	39.8	34.9	22.8	28.9	7.1	17.4	15.5
C20-TAS	2.71	0.0 U	0.00 U	0.00 U	0.00 U	0.31 J	0.00 U	0.3 J	0.0 U
C21-TAS	5.14	0.4 J	2.29	1.51	2.59	5.67	0.41 J	1.0	2.7
C26(20S)-TAS	10.25	0.55 J	2.50	2.66	1.22	0.57 J	0.67	0.2 J	0.3 J
C26(20R)/C27(20S)-TAS	57.46	1.2	8.33	10.59	7.84	9.28	2.12	2.3	2.5
C28(20S)-TAS	46.91	1.43	10.26	11.10	11.56	23.45	2.08	7.3	9.0
C27(20R)-TAS	42.97	1.07	7.84	8.8	6.36	13.03	2.07	2.3	2.7
C28(20R)-TAS	29.1	0.74	4.5	5.3	3.8	34.3	1.19	1.5	0.5 J

Qualifiers: J, below method detection limit; U, not detected

Appendix E. Alkylated PAHs in the sediments from the SARI, St. Croix (cont.).

	Sites					
Compound	Site 10P (Triton Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)
2-Methylnaphthalene	0.4 J	1.4	0.9 J	0.5 J	1.19 J	0.3 J
1-Methylnaphthalene	0.2 J	0.7	0.5 J	0.3 J	0.64	0.2 J
2,6-Dimethylnaphthalene	0.7	2.7	3.0	1.4	2.35	0.0 U
1,6,7-Trimethylnaphthalene	0.0 U	0.3	0.3	0.1	0.16	0.00 U
1-Methylfluorene	0.0 U	0.0 U	0.0 U	0.0 U	0.0 U	0.00 U
4-Methyldibenzothiophene	0.0 U	0.0 U	0.2	0.0 U	0.0 U	0.0 U
2/3-Methyldibenzothiophene	0.0 U	0.0 U	0.1	0.0 U	0.00 U	0.00 U
1-Methyldibenzothiophene	0.0 U	0.0 U	0.1 J	0.0 U	0.0 U	0.00 U
3-Methylphenanthrene	0.1	0.5	0.3	0.3	0.33	0.2
2-Methylphenanthrene	0.2	0.6	0.5	0.5	0.40	0.3
2-Methylanthracene	0.0 J	3.2	0.3	0.5	0.12	0.1
4/9-Methylphenanthrene	0.1	0.4	0.4	0.3	0.33	0.3
1-Methylphenanthrene	0.1	0.2	0.3	0.3	0.27	0.2
3,6-Dimethylphenanthrene	0.0 U	0.2	0.2	0.0 U	0.20	0.0 U
Retene	0.0 U	0.7	0.0 U	0.0 U	0.00 U	0.0 U
2-Methylfluoranthene	0.0 U	0.0 U	0.4	0.5	0.31	0.2 J
Benzo(b)fluorene	0.0 U	0.0 U	0.3	0.4	0.3	0
C29-Hopane	5.9	24.2	16.8	17.0	13.7	7.4
18a-Oleanane	0.6 J	4.1	3.2	3.7	2.1	1.2
C30-Hopane	8.2	28.4	24.5	24.4	16.9	9.2
C20-TAS	0.0 U	0.0 U	0.2 J	0.0 U	0.00 U	0.00 U
C21-TAS	0.2 J	1.0	1.4	0.0 U	0.68	0.00 U
C26(20S)-TAS	0.4 J	0.3 J	1.0	0.0 U	1.23	0.74
C26(20R)/C27(20S)-TAS	1.3	4.0	3.8	3.7	3.8	2.32
C28(20S)-TAS	1.9	12.8	5.4	6.0	4.3	2.46
C27(20R)-TAS	1.3	3.8	3.6	3.1	3.69	2.1
C28(20R)-TAS	0.7	1.4	1.7	1.5	1.9	1.3

Qualifiers: J, below method detection limit; U, not detected

Appendix E. Alkylated PAHs in the sediments from the SARI, St. Croix (cont.).

Compound	Sites Core Sample 3 (Sugar Bay)	 Core Sample 4 (Sugar Bay)	 Core Sample 5 (Sugar Bay)
2-Methylnaphthalene	0.2 J	0.5 J	0.4 J
1-Methylnaphthalene	0.2 J	0.3 J	0.2 J
2,6-Dimethylnaphthalene	0.0 U	0.5	0.0 U
1,6,7-Trimethylnaphthalene	0.0 U	0.00 U	0.0 U
1-Methylfluorene	0.00 U	0.00 U	0.0 U
4-Methyldibenzothiophene	0.00 U	0.00 U	0.0 U
2/3-Methyldibenzothiophene	0.00 U	0.00 U	0.0 U
1-Methyldibenzothiophene	0.00 U	0.00 U	0.0 U
3-Methylphenanthrene	0.2	0.2	0.13
2-Methylphenanthrene	0.2	0.3	0.16
2-Methylanthracene	0.1 J	0.08 J	0.032 J
4/9-Methylphenanthrene	0.2	0.2	0.12
1-Methylphenanthrene	0.2	0.2	0.11
3,6-Dimethylphenanthrene	0.0 U	0.0 U	0.00 U
Retene	0 U	0 U	0.00 U
2-Methylfluoranthene	0.1 J	0.2 J	0.12 J
Benzo(b)fluorene	0	0.4	0.21
C29-Hopane	4.1	10.4	0.0 U
18a-Oleanane	0.7	1.8	0.0 U
C30-Hopane	5.0	14.6	0.0 U
C20-TAS	0.0 U	0.00 U	0.0 U
C21-TAS	0.2 J	0.00 U	0.0 U
C26(20S)-TAS	0.55 J	1.23	0.8
C26(20R)/C27(20S)-TAS	1.7	3.23	1.1
C28(20S)-TAS	1.6	3.51	1.8
C27(20R)-TAS	1.3	2.86	0.5 J
C28(20R)-TAS	0.93	1.68	0.6

Qualifiers: J, below method detection limit; U, not detected

Appendix F. Polychlorinated biphenyls (PCBs) in the sediments from the SARI, St. Croix.

	Sites												
Compound	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar Bay)	Site 8P (Triton Bay)	Site 9P (Triton Bay)	Site 10P (Triton Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)
PCB 1	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 2	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 3	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 4/10	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 7/9	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 6	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 8/5	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 14	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 11	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 12	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 13	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 15	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 19	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 30	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 18	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 17	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 27	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 24	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 16/32	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 34	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 23	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 29	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 26	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 25	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 28/31	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 21/20/33	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 22	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 36	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 39	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 38	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 35	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 37	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 54	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 50	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 53	0.07	0.00 U	0.07	0.02	0.01	0.11	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 51	0.00 U	0.00 U	0.07	0.00 U	0.00 U	0.10	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 45	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 46/69/73	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 52	0.91	0.00 U	0.20	0.12	0.12	0.20	0.00 U	0.03	0.03	0.00 U	0.11	0.00 U	0.06
PCB 43	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 49	0.60	0.00 U	0.17	0.12	0.11	0.25	0.00 U	0.03	0.03	0.00 U	0.11	0.00 U	0.05
PCB 48/75/47	0.00 U	0.00 U	0.11	0.10	0.08	0.23	0.00 U	0.02	0.03	0.00 U	0.07	0.00 U	0.03
PCB 65	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 62	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 44	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 59	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 42	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 72	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 71	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 68/41/64	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 40/57	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.21	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 67	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.13	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 58	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 63	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.37	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 61/74	0.41	0.00 U	0.12	0.08	0.04	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 76/70	0.30	0.00 U	0.13	0.07	0.05	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.02	0.00 U	0.00 U
PCB 66/80	0.14	0.00 U	0.07	0.07	0.04	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.06	0.00 U	0.00 U
PCB 55	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 56	0.00 U	0.00 U	0.00 U	0.04	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 60	0.00 U	0.00 U	0.00 U	0.02	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 79	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 78	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 81	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 77	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 104	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 96/103	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 100	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 94	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 102/98	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 121/93/95	0.88	0.00 U	0.40	0.11	0.05 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.08	0.00 U	0.06
PCB 88	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 91	0.00 U	0.00 U	0.07	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 92	0.00 U	0.00 U	0.13	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 101/84/90	2.02	0.00 U	0.96	0.20	0.11	0.20	0.00 U	0.02 J	0.03 J	0.00 U	0.12	0.00 U	0.10
PCB 89/113	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 99	1.07	0.00 U	0.46	0.15	0.08	0.17	0.00 U	0.05 J	0.04 J	0.00 U	0.16	0.00 U	0.08
PCB 119	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 112	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 120/83	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 97/125/86	0.40	0.00 U	0.11	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U

Appendix F. Polychlorinated biphenyls (PCBs) in the sediments from the SARI, St. Croix (cont.).

	Sites				
Compound	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)	Core Sample 3 (Sugar Bay)	Core Sample 4 (Sugar Bay)	Core Sample 5 (Sugar Bay)
PCB 1	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 2	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 3	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 4/10	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 7/9	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 6	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 8/5	0.00 U	0.00 U	0.00 U	0.06	0.00 U
PCB 14	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 11	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 12	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 13	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 15	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 19	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 30	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 18	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U
PCB 17	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 27	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 24	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 16/32	0.00 U	0.00 U	0.00 U	0.05	0.00 U
PCB 34	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 23	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 29	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 26	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 25	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 28/31	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 21/20/33	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 22	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 36	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 39	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 38	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 35	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 37	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 54	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 50	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 53	0.00 U	0.00 U	0.02	0.02	0.00 U
PCB 51	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 45	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 46/69/73	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 52	0.00 U	0.00 U	0.03	0.02	0.00 U
PCB 43	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 49	0.00 U	0.00 U	0.03	0.01	0.00 U
PCB 48/75/47	0.00 U	0.00 U	0.05	0.03	0.00 U
PCB 65	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 62	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 44	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 59	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 42	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 72	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 71	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 68/41/64	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 40/57	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 67	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 58	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 63	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 61/74	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 76/70	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 66/80	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 55	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 56	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 60	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 79	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 78	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 81	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 77	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 104	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 96/103	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 100	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 94	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 102/98	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 121/93/95	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U
PCB 88	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 91	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 92	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 101/84/90	0.00 U	0.00 U	0.03 J	0.00 U	0.00 U
PCB 89/113	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 99	0.00 U	0.00 U	0.04 J	0.00 U	0.00 U
PCB 119	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 112	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 120/83	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 97/125/86	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U

Appendix F. Polychlorinated biphenyls (PCBs) in the sediments from the SARI, St. Croix (cont.).

	Sites												
Compound	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar Bay)	Site 8P (Triton Bay)	Site 9P (Triton Bay)	Site 10P (Triton Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)
PCB 116/117	0.00 U	0.00 U	0.31	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 111/115/87	0.48	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 109	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 85	0.00 U	0.00 U	0.08	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 110	1.77	0.00 U	0.87	0.16	0.00 U	0.25	0.00 U	0.00 U	0.00 U	0.00 U	0.12	0.00 U	0.08
PCB 82	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 124	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.11	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 106/107	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.09	0.00 U	0.00 U
PCB 123	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 118/108	1.76	0.00 U	0.70	0.17	0.04 J	0.11	0.00 U	0.00 U	0.00 U	0.00 U	0.08	0.00 U	0.05
PCB 114/122	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 105/127	0.00 U	0.00 U	0.23	0.08	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.05	0.00 U	0.00 U
PCB 126	0.00 U	0.00 U	0.12	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 155	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 150	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 152	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 148/145	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 136/154	0.29	0.00 U	0.22	0.07	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U
PCB 151	0.00 U	0.00 U	0.26	0.07	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 135	0.29	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 144	0.26	0.00 U	0.16	0.08	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 147	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 149/139	0.00 U	0.02 J	0.94	0.29	0.05	0.11	0.00 U	0.02 J	0.02 J	0.00 U	0.05	0.02 J	0.07
PCB 140	1.23	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 143	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 134/133	0.00 U	0.00 U	0.06	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 165/131	0.00 U	0.00 U	0.26	0.08	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 142/146/161	0.42	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 153/168	1.81	0.04	1.43	0.46	0.15	0.26	0.00 U	0.07	0.12	0.00 U	0.19	0.09	0.17
PCB 132	0.60	0.00 U	0.36	0.07	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 141	0.00 U	0.00 U	0.22	0.06	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 137	0.00 U	0.00 U	0.05	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 130	0.00 U	0.00 U	0.09	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 138/164/163	2.59	0.05	1.77	0.51	0.14	0.30	0.00 U	0.04	0.12	0.00 U	0.15	0.05	0.18
PCB 160/158	0.00 U	0.00 U	0.37	0.07	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 129	0.00 U	0.00 U	0.05	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 166	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 159	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 162	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 128/167	0.51	0.00 U	0.24	0.04	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 156	0.00 U	0.00 U	0.21	0.05	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 157	0.00 U	0.00 U	0.08	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 169	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 188	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 184	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 179	0.00 U	0.00 U	0.11	0.03	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 176	0.00 U	0.00 U	0.06	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 186/178	0.00 U	0.00 U	0.03	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 175	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 187/182	0.26	0.01 J	0.28	0.15	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U
PCB 183	0.00 U	0.00 U	0.18	0.11	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 185	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 174	0.00 U	0.00 U	0.27	0.13	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 181	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 177	0.00 U	0.00 U	0.18	0.10	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 171	0.00 U	0.00 U	0.10	0.07	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 173	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 192/172	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 180/193	0.39	0.02 J	0.70	0.44	0.02 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 191	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 170/190	0.18	0.01 J	0.43	0.18	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 189	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 202	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 201	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 204	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 197	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 200	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 198	0.00 U	0.00 U	0.33	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 199	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 203/196	0.00 U	0.00 U	0.61	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 195	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 194	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 205	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 208	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 207	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 206	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 209	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Total PCB	19.62	0.15	15.46	4.56	1.09	3.10	0.00	0.27	0.41	0.00	1.47	0.16	0.91

Qualifiers: J, below method detection limit; U, not detected

Appendix F. Polychlorinated biphenyls (PCBs) in the sediments from the SARI, St. Croix (cont.).

	Sites				
Compound	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)	Core Sample 3 (Sugar Bay)	Core Sample 4 (Sugar Bay)	Core Sample 5 (Sugar Bay)
PCB 116/117	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 111/115/87	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 109	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 85	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 110	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 82	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 124	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 106/107	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 123	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 118/108	0.00 U	0.00 U	0.07	0.00 U	0.00 U
PCB 114/122	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 105/127	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 126	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 155	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 150	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 152	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 148/145	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 136/154	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 151	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 135	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 144	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 147	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 149/139	0.02 J	0.03 J	0.03 J	0.02 J	0.00 U
PCB 140	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 143	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 134/133	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 165/131	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 142/146/161	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 153/168	0.07	0.05	0.06	0.04	0.00 U
PCB 132	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 141	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 137	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 130	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 138/164/163	0.07	0.05	0.07	0.00 U	0.00 U
PCB 160/158	0.00 U	0.00 U	0.00 U	0.03 J	0.00 U
PCB 129	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 166	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 159	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 162	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 128/167	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 156	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 157	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 169	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 188	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 184	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 179	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 176	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 186/178	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 175	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 187/182	0.02 J	0.02 J	0.01 J	0.02 J	0.00 U
PCB 183	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 185	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 174	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 181	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 177	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 171	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 173	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 192/172	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 180/193	0.03	0.00 U	0.00 U	0.01 J	0.00 U
PCB 191	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 170/190	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U
PCB 189	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 202	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 201	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 204	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 197	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 200	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 198	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 199	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 203/196	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 195	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 194	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 205	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 208	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 207	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 206	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB 209	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Total PCB	0.22	0.14	0.44	0.35	0.00

Qualifiers: J, below method detection limit; U, not detected

Appendix G. Organochlorine pesticides in the sediments from the SARI, St. Croix.

	Sites								
Compound	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar Bay)	Site 8P (Triton Bay)	Site 9P (Triton Bay)
Aldrin	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Dieldrin	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endrin	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endrin Aldehyde	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endrin Ketone	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Heptachlor	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Heptachlor-Epoxide	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Oxychlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Alpha-Chlordane	0.36	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Gamma-Chlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Trans-Nonachlor	0.28	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Cis-Nonachlor	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Alpha-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Beta-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Delta-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Gamma-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
DDMU	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
2,4'-DDD	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
4,4'-DDD	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.29	0.00 U
2,4'-DDE	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
4,4'-DDE	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
2,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
4,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
1,2,3,4-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
1,2,4,5-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Hexachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Pentachloroanisole	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Pentachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endosulfan II	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endosulfan I	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endosulfan Sulfate	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Mirex	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Chlorpyrifos	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Total HCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Chlordane	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total DDT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00

Qualifiers: J, below method detection limit; U, not detected

Appendix G. Organochlorine pesticides in the sediments from the SARI, St. Croix (cont.).

	Sites					
Compound	Site 10P (Triton Bay)	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)
Aldrin	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Dieldrin	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endrin	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endrin Aldehyde	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endrin Ketone	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Heptachlor	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Heptachlor-Epoxide	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Oxychlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Alpha-Chlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Gamma-Chlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Trans-Nonachlor	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Cis-Nonachlor	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Alpha-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Beta-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Delta-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Gamma-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
DDMU	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
2,4'-DDD	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
4,4'-DDD	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
2,4'-DDE	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
4,4'-DDE	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
2,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
4,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
1,2,3,4-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
1,2,4,5-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Hexachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Pentachloroanisole	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Pentachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endosulfan II	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endosulfan I	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Endosulfan Sulfate	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Mirex	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Chlorpyrifos	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Total HCH	0.00	0.00	0.00	0.00	0.00	0.00
Total Chlordane	0.00	0.00	0.00	0.00	0.00	0.00
Total DDT	0.00	0.00	0.00	0.00	0.00	0.00

Qualifiers: J, below method detection limit; U, not detected

Appendix G. Organochlorine pesticides in the sediments from the SARI, St. Croix (cont.).

Compound	Sites Core Sample 3 (Sugar Bay)	Core Sample 4 (Sugar Bay)	Core Sample 5 (Sugar Bay)
Aldrin	0.00 U	0.00 U	0.00 U
Dieldrin	0.00 U	0.00 U	0.00 U
Endrin	0.00 U	0.00 U	0.00 U
Endrin Aldehyde	0.00 U	0.00 U	0.00 U
Endrin Ketone	0.00 U	0.00 U	0.00 U
Heptachlor	0.00 U	0.00 U	0.00 U
Heptachlor-Epoxide	0.00 U	0.00 U	0.00 U
Oxychlordane	0.00 U	0.00 U	0.00 U
Alpha-Chlordane	0.00 U	0.00 U	0.00 U
Gamma-Chlordane	0.00 U	0.00 U	0.00 U
Trans-Nonachlor	0.00 U	0.00 U	0.00 U
Cis-Nonachlor	0.00 U	0.00 U	0.00 U
Alpha-HCH	0.00 U	0.00 U	0.00 U
Beta-HCH	0.00 U	0.00 U	0.00 U
Delta-HCH	0.00 U	0.00 U	0.00 U
Gamma-HCH	0.00 U	0.00 U	0.00 U
DDMU	0.00 U	0.00 U	0.00 U
2,4'-DDD	0.00 U	0.00 U	0.00 U
4,4'-DDD	0.00 U	0.00 U	0.00 U
2,4'-DDE	0.00 U	0.00 U	0.00 U
4,4'-DDE	0.05	0.00 U	0.00 U
2,4'-DDT	0.00 U	0.00 U	0.00 U
4,4'-DDT	0.00 U	0.00 U	0.00 U
1,2,3,4-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U
1,2,4,5-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U
Hexachlorobenzene	0.05	0.00 U	0.00 U
Pentachloroanisole	0.00 U	0.00 U	0.00 U
Pentachlorobenzene	0.00 U	0.00 U	0.00 U
Endosulfan II	0.00 U	0.00 U	0.00 U
Endosulfan I	0.00 U	0.00 U	0.00 U
Endosulfan Sulfate	0.00 U	0.00 U	0.00 U
Mirex	0.00 U	0.00 U	0.00 U
Chlorpyrifos	0.00 U	0.00 U	0.00 U
Total HCH	0.00	0.00	0.00
Total Chlordane	0.00	0.00	0.00
Total DDT	0.05	0.00	0.00

Qualifiers: J, below method detection limit; U, not detected

Appendix H. Butyltins in the sediments from the SARI, St. Croix.

	Sites								
Compound	Site 1P (Marina)	Site 2P (Marina)	Site 3P (Marina)	Site 4P (Sugar Bay)	Site 5P (Sugar Bay)	Site 6P (Sugar Bay)	Site 7P (Sugar	Site 8P (Triton Bay)	Site 9P (Triton Bay)
Monobutyltin	27.05	6.20	9.73	4.61	1.73	0.79	1.39	0.80	0.71
Dibutyltin	15.76	1.31	8.95	3.20	4.20	0.65	0.50	0.70	0.72
Tributyltin	26.08	1.93	8.54	4.36	12.47	1.87	0.39	0.82	1.13
Tetrabutyltin	0.84	0.06 J	0.19	0.10 J	0.12 J	0.00 U	0.03 J	0.00 U	0.05 J

Qualifiers: J, below method detection limit; U, not detected

	Sites					
Compound	Site 10P (Triton	Site 11P (Bio Bay)	Site 12P (Bio Bay)	Site 13P (Bio Bay)	Core Sample 1 (Sugar Bay)	Core Sample 2 (Sugar Bay)
Monobutyltin	0.70	0.88	0.85	1.30	3.78	5.06
Dibutyltin	0.22	0.60	0.58	0.43	2.10	1.36
Tributyltin	0.21	0.68	0.49	0.37	1.38	0.68
Tetrabutyltin	0.00 U	0.00 U	0.08 J	0.00 U	0.03 J	0.04 J

Qualifiers: J, below method detection limit; U, not detected

	Sites		
Compound	Core Sample 3 (Sugar Bay)	Core Sample 4 (Sugar Bay)	Core Sample 5 (Sugar Bay)
Monobutyltin	2.67	1.79	0.37
Dibutyltin	0.58	0.52	0.14
Tributyltin	0.17	0.20	0.09 J
Tetrabutyltin	0.00 U	0.03 J	0.00 U

Qualifiers: J, below method detection limit; U, not detected

Appendix I. Trace and major elements in the sediments from the SARI, St. Croix.

Site	Stratum	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg	Li	Mn	Ni	Pb	Sb	Se	Sn	Tl	U	V	Zn
Site 1P	Marina	0.00	24970	8.84	13.6	0.131	0.00	11.4	27.2	244	38234	0.061	16.0	492	17.1	13.1	0.00	1.01	1.53	0.205	2.18	81.7	166
Site 2P	Marina	0.00	7366	5.04	7.43	0.00	0.00	2.57	6.73	24.5	8973	0.018	5.06	110	12.2	2.43	0.00	0.00	0.237	0.00	2.25	23.9	26.7
Site 3P	Marina	0.00	15961	11.7	11.4	0.122	0.00	5.88	21.9	79.2	23870	0.059	12.7	318	14.5	9.83	0.00	1.27	0.666	0.183	2.33	48.8	77.3
Site 4P	Sugar Bay	0.00	17129	13.6	11.9	0.140	0.00	6.84	22.6	60.2	25736	0.093	13.4	401	14.9	11.4	0.00	1.08	0.643	0.128	1.87	53.0	60.5
Site 5P	Sugar Bay	0.00	15922	11.6	9.37	0.149	0.00	8.34	15.8	46.7	25303	0.077	11.7	277	10.6	8.75	0.00	1.11	0.577	0.244	3.20	53.7	51.9
Site 6P	Sugar Bay	0.00	22421	10.0	10.9	0.198	0.00	10.2	22.0	69.1	32545	0.081	17.7	335	13.9	15.5	0.00	1.88	1.04	0.174	8.96	75.4	64.0
Site 7P	Sugar Bay	0.00	9029	8.10	8.58	0.067	0.00	2.61	11.7	15.3	10064	0.020	6.16	219	13.3	4.06	0.00	0.00	0.204	0.00	2.11	24.5	23.7
Site 8P	Triton Bay	0.00	17752	15.0	12.7	0.125	0.00	4.76	20.4	31.1	20645	0.043	13.7	315	14.9	6.38	0.00	1.29	0.425	0.00	2.71	45.5	44.4
Site 9P	Triton Bay	0.00	15617	19.1	11.1	0.114	0.00	5.38	22.0	40.1	25632	0.068	14.3	249	14.9	7.17	0.00	1.38	0.493	0.179	3.64	41.7	45.0
Site 10P	Triton Bay	0.00	7842	9.81	8.66	0.00	0.00	2.63	10.2	14.0	9965	0.022	6.74	242	13.2	3.05	0.00	0.00	0.167	0.00	2.18	22.3	24.6
Site 11P	Bio Bay	0.00	20493	12.8	13.5	0.132	0.00	7.20	21.1	46.4	28686	0.068	19.4	929	12.5	9.52	0.00	1.10	0.464	0.00	2.82	59.4	64.1
Site 12P	Bio Bay	0.00	19554	13.4	13.8	0.121	0.00	7.04	19.1	43.2	30213	0.057	17.5	1039	10.8	8.47	0.00	0.952	0.383	0.00	1.58	58.5	65.9
Site 13P	Bio Bay	0.00	18984	13.5	13.4	0.127	0.00	6.89	19.5	43.0	28257	0.065	17.1	924	11.7	8.44	0.00	1.00	0.465	0.00	1.80	55.9	62.8
Core Sample 1	Sugar Bay	0.00	8482	10.8	9.06	0.076	0.00	4.63	16.2	41.9	15299	0.001	9.77	233	14.1	6.52	0.00	0.00	0.326	0.00	2.20	33.2	40.7
Core Sample 2	Sugar Bay	0.00	6375	10.1	8.29	0.00	0.00	3.94	13.0	32.0	12254	0.060	7.99	174	13.3	5.08	0.00	0.00	0.272	0.00	2.26	26.8	34.1
Core Sample 3	Sugar Bay	0.00	6500	9.98	7.21	0.00	0.00	4.03	12.2	23.7	12050	0.054	8.22	152	12.2	4.30	0.00	0.00	0.223	0.00	2.74	28.8	25.5
Core Sample 4	Sugar Bay	0.00	7800	11.4	7.41	0.066	0.00	4.59	11.0	22.3	13768	0.060	9.98	174	14.0	4.61	0.00	0.00	0.235	0.00	3.68	32.0	28.6
Core Sample 5	Sugar Bay	0.00	8177	10.2	7.48	0.073	0.00	4.50	10.8	19.9	13946	0.049	10.7	183	14.1	3.51	0.00	0.00	0.274	0.00	4.46	33.4	23.9

Appendix J. *Clostridium perfringens* in the sediments from the SARI, St. Croix.

Site	Stratum	% sediment	% water	Colonies/g	Cperf dry (CFU/g)
1P	Marina	32	68	1104	3440
2P	Marina	57	43	643	1130
3P	Marina	72	28	1299	1810
4P	Sugar Bay	35	65	71	201
5P	Sugar Bay	38	62	992	2610
6P	Sugar Bay	24	76	735	3110
7P	Sugar Bay	52	48	126	243
8P	Triton Bay	35	65	117	330
9P	Triton Bay	36	64	770	2150
10P	Triton Bay	51	49	325	642
11P	Bio Bay	31	69	915	2910
12P	Bio Bay	36	64	560	1580
13P	Bio Bay	34	66	256	747
Core 1	Sugar Bay	45	55	495	1100
Core 2	Sugar Bay	50	50	84	168
Core 3	Sugar Bay	61	39	81	132
Core 4	Sugar Bay	55	45	18	32
Core 5	Sugar Bay	62	38	0	0

Note: CFU, colony forming units

Appendix K. Benthic infaunal data from the SARI, St. Croix.

Site	Phylum	Class	Order	Family	Taxa	Count
Marina-1P	Mollusca	Bivalvia	Veneroida	Lucinidae	Myrtea pristiphora	1
Marina-1P	Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma sp. G	12
Marina-1P	Annelida	Polychaeta	Scolecida	Capitellidae	Capitella capitata	12
Marina-1P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	50
Marina-1P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Ophryotrocha (LPIL)	16
Marina-1P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos rudolphi	2
Marina-1P	Annelida	Polychaeta	Phyllodocida	Nereididae	Stenoninereis martini	4
Marina-1P	Annelida	Polychaeta	Phyllodocida	Syllidae	Syllidae (LPIL)	1
Marina-1P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	5
Marina-1P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	2
Marina-2P	Nemertea				Nemertea (LPIL)	1
Marina-2P	Cnidaria	Anthozoa	Actiniaria		Actiniaria (LPIL)	2
Marina-2P	Nemertea	Anopla	Paleonemertea	Tubulanidae	Tubulanus sp. A	3
Marina-2P	Arthropoda	Malacostraca	Amphipoda	Aoridae	Grandidierella bonnieroides	41
Marina-2P	Arthropoda	Malacostraca	Decapoda	Xanthidae	Rhithropanopeus harrisii	1
Marina-2P	Arthropoda	Malacostraca	Tanaidacea	Leptocheliidae	Leptochelia forresti	3
Marina-2P	Arthropoda	Malacostraca	Cumacea	Nannastacidae	Nannastacidae (LPIL)	1
Marina-2P	Arthropoda	Malacostraca	Decapoda	Penaeidae	Penaeidae (LPIL)	1
Marina-2P	Sipuncula				Sipuncula (LPIL)	1
Marina-2P	Mollusca	Bivalvia	Venerida	Veneridae	Chione cancellata	1
Marina-2P	Mollusca	Gastropoda	Cephalaspidea	Haminoeidae	Haminoea elegans	3
Marina-2P	Mollusca	Gastropoda	Cephalaspidea	Bullidae	Bulla striata	3
Marina-2P	Mollusca	Gastropoda	Cephalaspidea	Scaphandridae	Acteocina (LPIL)	4
Marina-2P	Mollusca	Gastropoda	Mesogastropoda	Caecidae	Caecum pulchellum	21
Marina-2P	Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma sp. G	43
Marina-2P	Mollusca	Bivalvia	Veneroida	Tellinidae	Tellinidae (LPIL)	1
Marina-2P	Annelida	Polychaeta	Opheliida	Opheliidae	Armandia agilis	5
Marina-2P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	13
Marina-2P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma tenuis	6
Marina-2P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	129
Marina-2P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio heterobranchia	102
Marina-2P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos rudolphi	10
Marina-2P	Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Nereiphylla fragilis	5
Marina-2P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarke obscura	23
Marina-2P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	25
Marina-2P	Annelida	Polychaeta	Phyllodocida	Syllidae	Sphaerosyllis piriferopsis	3
Marina-2P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Lumbrineridae (LPIL)	1
Marina-2P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	14
Marina-2P	Annelida	Polychaeta	Phyllodocida	Syllidae	Grubeosyllis clavata	1
Marina-2P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	7
Marina-2P	Annelida	Polychaeta	Phyllodocida	Syllidae	Exogone rolani	19
Marina-2P	Annelida	Polychaeta	Spionida	Spionidae	Scolelepis texana	1
Marina-2P	Annelida	Polychaeta	Phyllodocida	Nereididae	Nereididae (LPIL)	2
Marina-2P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Ancistrosyllis jonesi	2
Marina-2P	Annelida	Polychaeta	Phyllodocida	Nereididae	Nereis falsa	1
Marina-2P	Annelida	Polychaeta	Phyllodocida	Syllidae	Syllis broomensis	2
Marina-2P	Annelida	Polychaeta	Sabellida	Sabellidae	Branchiomma nigromaculata	6
Marina-2P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Naineris grubei	3
Marina-2P	Annelida	Polychaeta	Phyllodocida	Syllidae	Syllidae (LPIL)	1
Marina-2P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	2
Marina-2P	Annelida	Polychaeta	Terebellida	Terebellidae	Eupolymnia nebulosa	4
Marina-2P	Annelida	Polychaeta	Spionida	Spionidae	Spionidae (LPIL)	1
Marina-2P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus californiensis	6
Marina-2P	Annelida	Polychaeta	Terebellida	Ampharetidae	Melinna maculata	1
Marina-2P	Mollusca	Gastropoda	Neotaenioglossa	Caecidae	Meioceras nitidum	1
Marina-2P	Mollusca	Gastropoda	Heterostropha	Pyramidellidae	Turbonilla (LPIL)	2
Marina-3P	Arthropoda	Malacostraca	Amphipoda	Aoridae	Grandidierella bonnieroides	1
Marina-3P	Mollusca	Gastropoda			Gastropoda (LPIL)	1

Appendix K. Benthic infaunal data from SARI, St. Croix (cont.).

Site	Phylum	Class	Order	Family	Taxa	Count
Marina-3P	Mollusca	Bivalvia	Veneroida	Tellinidae	Tellinidae (LPIL)	2
Marina-3P	Mollusca	Gastropoda	Cephalaspidea	Haminoeidae	Haminoea elegans	1
Marina-3P	Mollusca	Gastropoda	Neogastropoda	Olividae	Olivella bullula	4
Marina-3P	Mollusca	Gastropoda	Cephalaspidea	Scaphandridae	Acteocina (LPIL)	2
Marina-3P	Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma sp. G	13
Marina-3P	Mollusca	Gastropoda	Mesogastropoda	Caecidae	Caecum pulchellum	4
Marina-3P	Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta punctata	3
Marina-3P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	40
Marina-3P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	43
Marina-3P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	34
Marina-3P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	8
Marina-3P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos rudolphi	3
Marina-3P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarke obscura	2
Marina-3P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma tenuis	1
Marina-3P	Annelida	Polychaeta	Cossurida	Cossuridae	Cossura soyeri	3
Marina-3P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis levifuscina	2
Marina-3P	Annelida	Polychaeta	Phyllodocida	Syllidae	Exogone rolani	2
Marina-3P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Sigambra tentaculata	2
Marina-3P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Naineris grubei	1
Marina-3P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	3
Marina-3P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	28
Marina-3P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	1
Sugar-4P	Nemertea	Anopla	Paleonemertea	Tubulanidae	Tubulanus sp. A	2
Sugar-4P	Nemertea				Nemertea (LPIL)	1
Sugar-4P	Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta punctata	2
Sugar-4P	Mollusca	Bivalvia			Bivalvia (LPIL)	1
Sugar-4P	Mollusca	Bivalvia	Myoida	Corbulidae	Corbulidae (LPIL)	1
Sugar-4P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	51
Sugar-4P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	4
Sugar-4P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	16
Sugar-4P	Annelida	Polychaeta	Scolecida	Capitellidae	Capitella capitata	1
Sugar-4P	Annelida	Polychaeta	Cossurida	Cossuridae	Cossura soyeri	22
Sugar-4P	Annelida	Polychaeta	Cossurida	Cossuridae	Cossura delta	1
Sugar-4P	Annelida	Polychaeta	Canalipalpata	Sternaspidae	Sternaspis scutata	5
Sugar-4P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	9
Sugar-4P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio steenstrupi	31
Sugar-4P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos rubra	1
Sugar-5P	Nemertea	Enopla	Hoplonemertea	Amphiporidae	Amphiporidae (LPIL)	1
Sugar-5P	Arthropoda	Malacostraca	Amphipoda	Aoridae	Grandidierella bonnieroides	1
Sugar-5P	Mollusca	Gastropoda	Neogastropoda	Olividae	Olivella bullula	2
Sugar-5P	Mollusca	Bivalvia	Veneroida	Lucinidae	Myrtea pristiphora	6
Sugar-5P	Mollusca	Bivalvia	Myoida	Corbulidae	Caryocorbula swiftiana	1
Sugar-5P	Mollusca	Bivalvia			Bivalvia (LPIL)	1
Sugar-5P	Mollusca	Gastropoda	Mesogastropoda	Caecidae	Caecum pulchellum	7
Sugar-5P	Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma sp. G	69
Sugar-5P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	60
Sugar-5P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	149
Sugar-5P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	111
Sugar-5P	Annelida	Polychaeta	Scolecida	Capitellidae	Capitella capitata	7
Sugar-5P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos rudolphi	14
Sugar-5P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos texana	1
Sugar-5P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus californiensis	23
Sugar-5P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	2
Sugar-5P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	1
Sugar-5P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	43
Sugar-5P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio heterobranchia	6
Sugar-5P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	12
Sugar-5P	Annelida	Polychaeta	Cossurida	Cossuridae	Cossura soyeri	2

Appendix K. Benthic infaunal data from SARI, St. Croix (cont.).

Site	Phylum	Class	Order	Family	Taxa	Count
Sugar-5P	Annelida	Polychaeta	Phyllodocida	Syllidae	Sphaerosyllis piriferopsis	14
Sugar-5P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Synelmis klatti	1
Sugar-6P	Arthropoda	Malacostraca	Amphipoda	Aoridae	Grandidierella bonnieroides	12
Sugar-6P	Arthropoda	Malacostraca	Tanaidacea	Leptocheliidae	Leptochelia forresti	2
Sugar-6P	Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	Amphiuridae (LPIL)	1
Sugar-6P	Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma sp. G	22
Sugar-6P	Mollusca	Bivalvia	Veneroida	Lucinidae	Myrtea pristiphora	3
Sugar-6P	Mollusca	Bivalvia	Veneroida	Psammobiidae	Tagelus divisus	1
Sugar-6P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	412
Sugar-6P	Annelida	Polychaeta	Phyllodocida	Nereididae	Nereis falsa	3
Sugar-6P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarke obscura	2
Sugar-6P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos rudolphi	23
Sugar-6P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	18
Sugar-6P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis levifuscina	2
Sugar-6P	Annelida	Polychaeta	Sabellida	Sabellidae	Branchiomma nigromaculata	1
Sugar-6P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	25
Sugar-6P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Ophryotrocha (LPIL)	18
Sugar-6P	Annelida	Polychaeta	Scolecida	Capitellidae	Capitella capitata	26
Sugar-6P	Annelida	Polychaeta	Phyllodocida	Syllidae	Exogone rolani	74
Sugar-6P	Annelida	Polychaeta	Phyllodocida	Syllidae	Sphaerosyllis piriferopsis	12
Sugar-6P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio heterobranchia	7
Sugar-6P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Orbiniidae (LPIL)	1
Sugar-6P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	1
Sugar-6P	Annelida	Polychaeta	Phyllodocida	Syllidae	Odontosyllis enopla	1
Sugar-6P	Annelida	Polychaeta	Sabellida	Sabellidae	Sabellidae (LPIL)	53
Sugar-6P	Annelida	Polychaeta	Terebellida	Terebellidae	Streblosoma hartmanae	1
Sugar-7P	Cnidaria	Anthozoa	Actiniaria		Actiniaria (LPIL)	3
Sugar-7P	Nemertea	Anopla	Paleonemertea	Tubulanidae	Tubulanus sp. A	2
Sugar-7P	Nemertea				Nemertea (LPIL)	1
Sugar-7P	Mollusca	Bivalvia			Bivalvia (LPIL)	2
Sugar-7P	Mollusca	Gastropoda	Mesogastropoda	Caecidae	Caecum pulchellum	1
Sugar-7P	Mollusca	Gastropoda	Cephalaspidea	Scaphandridae	Acteocina (LPIL)	2
Sugar-7P	Mollusca	Gastropoda	Neogastropoda	Olividae	Olivella bullula	2
Sugar-7P	Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta punctata	33
Sugar-7P	Mollusca	Bivalvia	Myoida	Corbulidae	Caryocorbula contracta	48
Sugar-7P	Mollusca	Bivalvia	Myoida	Corbulidae	Caryocorbula swiftiana	4
Sugar-7P	Mollusca	Bivalvia	Veneroida	Tellinidae	Angulus versicolor	1
Sugar-7P	Mollusca	Bivalvia	Veneroida	Tellinidae	Eurytellina alternata	1
Sugar-7P	Mollusca	Bivalvia	Veneroida	Lucinidae	Lucinidae (LPIL)	1
Sugar-7P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	11
Sugar-7P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	17
Sugar-7P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	37
Sugar-7P	Annelida	Polychaeta	Scolecida	Maldanidae	Maldanidae (LPIL)	1
Sugar-7P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	22
Sugar-7P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos texana	4
Sugar-7P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	34
Sugar-7P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarke obscura	3
Sugar-7P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Leitoscoloplos fragilis	1
Sugar-7P	Annelida	Polychaeta	Canalipalpata	Sternaspidae	Sternaspis scutata	9
Sugar-7P	Annelida	Polychaeta	Cossurida	Cossuridae	Cossura soyeri	5
Sugar-7P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	3
Sugar-7P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos rubra	1
Sugar-7P	Annelida	Polychaeta	Phyllodocida	Syllidae	Ehlersia ferrugina	1
Triton-8P	Arthropoda	Malacostraca	Tanaidacea	Leptocheliidae	Leptochelia forresti	22
Triton-8P	Arthropoda	Malacostraca	Amphipoda	Isaeidae	Photis (LPIL)	1
Triton-8P	Arthropoda	Malacostraca	Amphipoda	Aoridae	Grandidierella bonnieroides	6
Triton-8P	Arthropoda	Malacostraca	Amphipoda	Ischyroceridae	Ischyroceridae (LPIL)	1
Triton-8P	Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	Amphiuridae (LPIL)	1

Appendix K. Benthic infaunal data from SARI, St. Croix (cont.).

Site	Phylum	Class	Order	Family	Taxa	Count
Triton-8P	Mollusca	Gastropoda	Mesogastropoda	Caecidae	Caecum pulchellum	18
Triton-8P	Mollusca	Bivalvia	Venerida	Veneridae	Chione cancellata	4
Triton-8P	Mollusca	Gastropoda	Cephalaspidea	Scaphandridae	Acteocina (LPIL)	1
Triton-8P	Mollusca	Gastropoda	Neogastropoda	Cysticidae	Gibberula lavalleeana	2
Triton-8P	Mollusca	Bivalvia			Bivalvia (LPIL)	3
Triton-8P	Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma sp. G	4
Triton-8P	Mollusca	Bivalvia	Veneroida	Tellinidae	Eurytellina alternata	1
Triton-8P	Mollusca	Bivalvia	Veneroida	Cardiidae	Laevicardium mortoni	1
Triton-8P	Mollusca	Bivalvia	Veneroida	Tellinidae	Tellina mera	1
Triton-8P	Mollusca	Bivalvia	Veneroida	Lasaeidae	Lasaeidae (LPIL)	10
Triton-8P	Annelida	Polychaeta	Sabellida	Sabellidae	Sabellidae (LPIL)	4
Triton-8P	Annelida	Polychaeta	Canalipalpata	Sternaspidae	Sternaspis scutata	4
Triton-8P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	158
Triton-8P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Ancistrosyllis jonesi	1
Triton-8P	Annelida	Polychaeta	Terebellida	Ampharetidae	Isolda pulchella	5
Triton-8P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	31
Triton-8P	Annelida	Polychaeta	Terebellida	Cirratulidae	Cirratulidae (LPIL)	1
Triton-8P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio heterobranchia	1
Triton-8P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	14
Triton-8P	Annelida	Polychaeta	Phyllodocida	Syllidae	Odontosyllis enopla	1
Triton-8P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	52
Triton-8P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos pectinata	34
Triton-8P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis levifuscina	4
Triton-8P	Annelida	Polychaeta	Sabellida	Sabellidae	Branchiomma nigromaculata	1
Triton-8P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	5
Triton-8P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarke obscura	6
Triton-8P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	4
Triton-8P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos rubra	5
Triton-8P	Annelida	Polychaeta	Phyllodocida	Syllidae	Exogone rolani	3
Triton-8P	Nemertea	Anopla	Paleonemertea	Tubulanidae	Tubulanus sp. A	3
Triton-8P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Naineris grubei	7
Triton-8P	Annelida	Polychaeta	Spionida	Spionidae	Laonice cirrata	4
Triton-8P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Sigambra (LPIL)	1
Triton-8P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	48
Triton-9P	Nemertea				Nemertea (LPIL)	1
Triton-9P	Porifera				Porifera (LPIL)	1
Triton-9P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos pectinata	3
Triton-9P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	27
Triton-9P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	11
Triton-9P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	4
Triton-9P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	7
Triton-9P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	2
Triton-9P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	4
Triton-9P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis levifuscina	2
Triton-9P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarke obscura	1
Triton-10P	Arthropoda	Malacostraca	Decapoda	Alpheidae	Alpheus (LPIL)	1
Triton-10P	Arthropoda	Malacostraca	Cumacea	Bodotriidae	Vaunthompsonia floridana	1
Triton-10P	Arthropoda	Malacostraca	Cumacea	Bodotriidae	Cyclaspis unicornis	2
Triton-10P	Mollusca	Gastropoda			Gastropoda (LPIL)	1
Triton-10P	Mollusca	Gastropoda	Mesogastropoda	Caecidae	Caecum pulchellum	74
Triton-10P	Mollusca	Gastropoda	Cephalaspidea	Scaphandridae	Acteocina (LPIL)	1
Triton-10P	Mollusca	Gastropoda	Neogastropoda	Olividae	Olivella bullula	5
Triton-10P	Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta punctata	1
Triton-10P	Mollusca	Bivalvia	Veneroida	Tellinidae	Tellinidae (LPIL)	1
Triton-10P	Mollusca	Bivalvia	Veneroida	Tellinidae	Tellina mera	1
Triton-10P	Sipuncula	Sipunculidea	Golfingiida	Phascolionidae	Phascolion strombus	4
Triton-10P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	33
Triton-10P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	4

Appendix K. Benthic infaunal data from SARI, St. Croix (cont.).

Site	Phylum	Class	Order	Family	Taxa	Count
Triton-10P	Annelida	Polychaeta	Canalipalpata	Sternaspidae	Sternaspis scutata	5
Triton-10P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	4
Triton-10P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	4
Triton-10P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	9
Triton-10P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	13
Triton-10P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos rubra	6
Triton-10P	Annelida	Polychaeta	Eunicida	Dorvilleidae	Schistomeringos pectinata	7
Triton-10P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis levifuscina	3
Triton-10P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Leitoscoloplos (LPIL)	1
Triton-10P	Nemertea	Anopla	Paleonemertea	Tubulanidae	Tubulanus sp. A	1
Triton-10P	Cnidaria	Anthozoa	Actiniaria		Actiniaria (LPIL)	2
Bio Bay-11P	Mollusca	Bivalvia	Veneroida	Tellinidae	Eurytellina alternata	7
Bio Bay-11P	Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta punctata	11
Bio Bay-11P	Mollusca	Bivalvia	Veneroida	Psammobiidae	Tagelus divisus	17
Bio Bay-11P	Mollusca	Gastropoda	Cephalaspidea	Scaphandridae	Acteocina (LPIL)	5
Bio Bay-11P	Mollusca	Bivalvia			Bivalvia (LPIL)	4
Bio Bay-11P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	64
Bio Bay-11P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	31
Bio Bay-11P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus californiensis	5
Bio Bay-11P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	2
Bio Bay-11P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	2
Bio Bay-11P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos texana	3
Bio Bay-11P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	5
Bio Bay-11P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	43
Bio Bay-11P	Annelida	Polychaeta	Sabellida	Sabellidae	Sabellidae (LPIL)	3
Bio Bay-11P	Annelida	Polychaeta	Canalipalpata	Sternaspidae	Sternaspis scutata	7
Bio Bay-11P	Annelida	Polychaeta	Eunicida	Lumbrineridae	Scoletoma (LPIL)	1
Bio Bay-11P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Synelmis klatti	5
Bio Bay-11P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Naineris grubei	1
Bio Bay-11P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Ancistrosyllis jonesi	3
Bio Bay-11P	Cnidaria	Anthozoa	Actiniaria		Actiniaria (LPIL)	2
Bio Bay-12P	Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta punctata	1
Bio Bay-12P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	72
Bio Bay-12P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	29
Bio Bay-12P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	10
Bio Bay-12P	Annelida	Polychaeta	Phyllodocida	Pilargidae	Synelmis klatti	2
Bio Bay-12P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	4
Bio Bay-12P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos texana	1
Bio Bay-12P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus californiensis	4
Bio Bay-12P	Annelida	Oligochaeta	Tubificida	Naididae	Naididae (LPIL)	1
Bio Bay-12P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	6
Bio Bay-12P	Nemertea	Anopla	Paleonemertea	Tubulanidae	Tubulanus sp. A	1
Bio Bay-12P	Cnidaria	Anthozoa	Actiniaria		Actiniaria (LPIL)	1
Bio Bay-12P	Annelida	Polychaeta	Canalipalpata	Sternaspidae	Sternaspis scutata	1
Bio Bay-13P	Mollusca	Bivalvia	Veneroida	Psammobiidae	Tagelus divisus	2
Bio Bay-13P	Mollusca	Bivalvia	Myoida	Corbulidae	Caryocorbula swiftiana	1
Bio Bay-13P	Mollusca	Bivalvia	Veneroida	Tellinidae	Eurytellina alternata	1
Bio Bay-13P	Annelida	Polychaeta	Orbiniida	Orbiniidae	Scoloplos texana	5
Bio Bay-13P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus californiensis	1
Bio Bay-13P	Annelida	Polychaeta	Spionida	Magelonidae	Magelona pettiboneae	2
Bio Bay-13P	Annelida	Polychaeta	Scolecida	Capitellidae	Mediomastus (LPIL)	19
Bio Bay-13P	Annelida	Polychaeta	Scolecida	Paraonidae	Cirrophorus lyra	14
Bio Bay-13P	Annelida	Polychaeta	Spionida	Spionidae	Spio (LPIL)	1
Bio Bay-13P	Annelida	Polychaeta	Spionida	Spionidae	Prionospio (LPIL)	4
Bio Bay-13P	Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis levifuscina	1

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