An Analysis of Chemical Contaminants in Sediments and Fish from Cocos Lagoon, Guam

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December 2017

NOAA TECHNICAL MEMORANDUM NOS NCCOS 235

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ACKNOWLEDGMENTS

The authors wish to gratefully acknowledge the support provided by NOAA's Coral Reef Conservation Program (CRCP) for this project. We would like to thank Jesse Cruz, Administrator, Environmental Monitoring and Analytical Services (EMAS) Division of the Guam Environmental Protection Agency, along with Annie Leon Guerrero, Edwin Salas and Danzel Narcis (now retired) of Guam EPA for project planning, and for providing boat support and personnel for the field work, along with interpretation of the data. We would also like to thank Jason Miller, a private fisherman from Merizo for helping out with the fishing in Cocos Lagoon, and Gary Denton of the University of Guam for conversations on past work and on project design. Further, we would like to acknowledge the help provided by Adrienne Loerzel with NOAA's CRCP and Valerie Brown with NOAA's Pacific Islands Regional Office on project design and with the field work. Finally, we would like to thank Beth Lumsden of NOAA's Pacific Islands Fisheries Science Center, and Paulo Maurin of NOAA's CRCP in Hawaii for receiving the samples from Guam, and then shipping them on to our analytical laboratories in Texas.

Citation for the document:
Hartwell, S.I., D.A. Apeti, A.S. Pait, A.L. Mason, and C. Robinson. 2017. An Analysis of Chemical Contaminants in Sediments and Fish from Cocos Lagoon, Guam. NOAA Technical Memorandum NOS NCCOS 235. Silver Spring, MD. 74 pp.

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Prepared by the
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ABSTRACT

As part of the NOAA Coral Reef Conservation Program (CRCP) jurisdictional priority gathering, local agencies in Guam identified Cocos Lagoon as an area potentially impacted by land-based sources of pollution. The US Coast Guard operated a Long Range Navigation (LORAN) station on Cocos Island at the southern end of Cocos Lagoon from 1944 to 1963. Disposal of materials from the operation of the station are suspected of resulting in chemical contamination of the island and surrounding waters. To help address this, the NOAA/NOS National Centers for Coastal Ocean Science (NCCOS) collected sediment and fish samples for chemical contaminant analysis throughout Cocos Lagoon in May 2015, with local partners.

Results of the analysis indicated low levels of most chemical contaminants in sediments. The organochlorine insecticide DDT was somewhat elevated in sediment on the northern end of Cocos Island, exceeding a NOAA sediment quality guideline. Elevated levels of polychlorinated biphenyls (PCBs) along with the pesticide DDT, however, were found in most fish collected adjacent to Cocos Island. A number of the fish contained concentrations of both PCBs and DDT above subsistence and even recreational fisher Screening Values established by the US Environmental Protection Agency. Lower concentrations of PCBs and DDT were found in fish from other areas of Cocos Lagoon, however, some were above the subsistence Screening Value for PCBs.

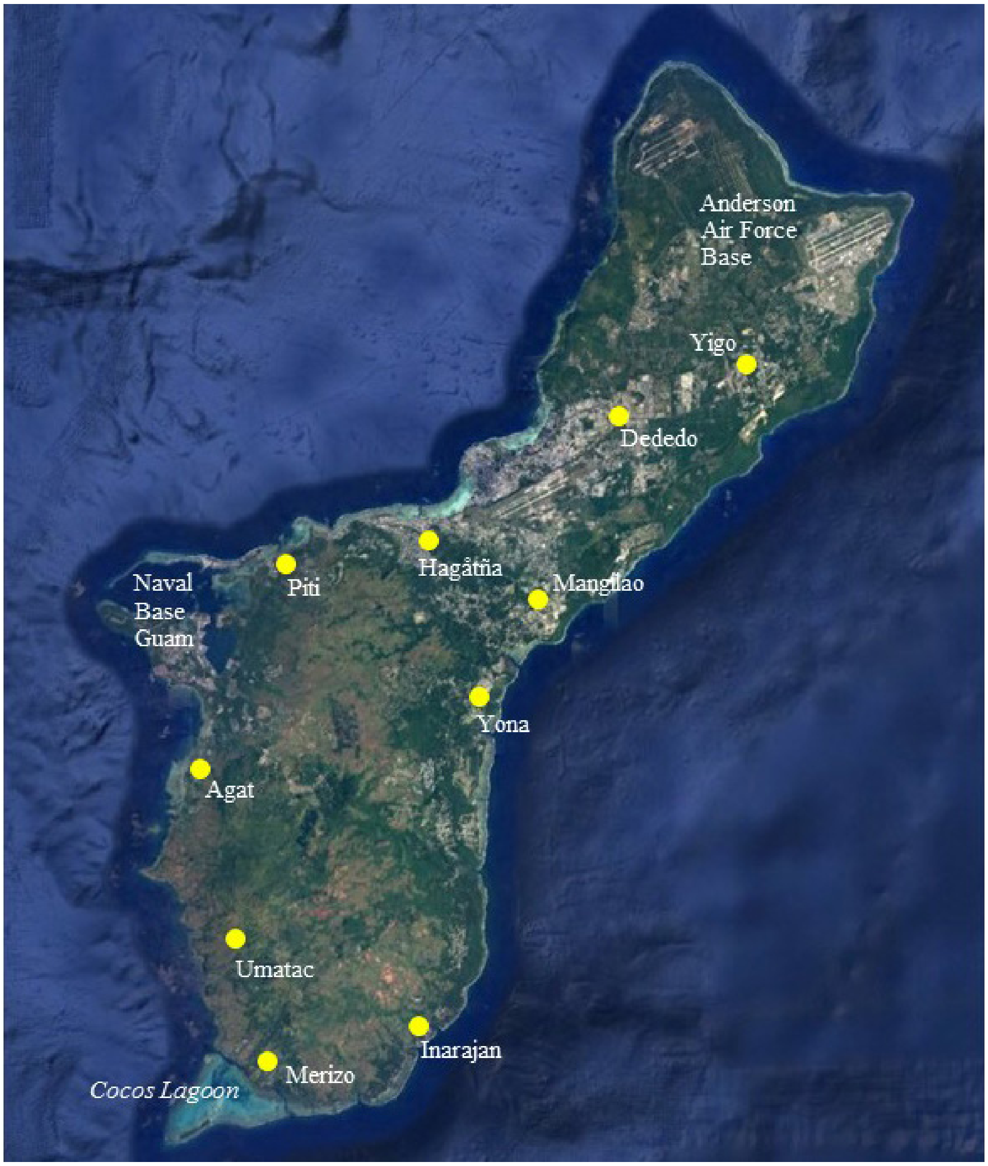


Figure 1. The island of Guam.

INTRODUCTION

Guam is the most southerly and largest (both in area and population) member of the Mariana Islands, a crescent-shaped archipelago in the western North Pacific Ocean. The Mariana Island chain extends from Guam towards Japan, and is part of the larger island group referred to as Micronesia. The island of Guam has a land area of approximately 550 square kilometers, and a maximum altitude of 405 meters (Emery, 1962). The capitol of Guam is Hagåtña, located towards the middle of the island (Figure 1).

The northern half of Guam is a broad limestone plateau bordered by steep cliffs, while the southern half of the island is a dissected volcanic upland fringed with limestone, primarily along the east coast (Tracey *et al*., 1964). At the southern tip of Guam is Cocos Lagoon (Figure 1), an atoll-like coral reef lagoon. Geologically, Cocos Lagoon is thought to have grown on the basement of the Umatac formation, a thick sequence of volcanic rock, which originated in the southern central portion of Guam, and named after the town of Umatac on the west coast of the island (Tracey *et al*., 1964).

The Manell-Geus watershed on the northeastern border of Cocos Lagoon has been selected as a Habitat Focus Area for NOAA's Habitat Blueprint, and the watershed and lagoon are a NOAA Coral Reef Conservation Program (CRCP) Priority for Guam. From the watershed, the Geus and Manell rivers flow into the Mamaon and Manell channels, respectively. High velocity runoff events of relatively short duration are frequent in the mountainous areas of southern Guam. Erosion of the steep hillsides and along stream banks made worse by wildfires, feral animals and off-roading vehicles, transport sediments and water to Cocos Lagoon and the Achang Preserve, impacting water quality there (Khosrowpanah *et al*., 2015; NOAA, 2007). Sediments associated with runoff have been identified as one of the most significant threats to coral reef ecosystems in Guam (Burdick, *et al*., 2008).

The municipality and town of Merizo border Cocos Lagoon (Figure 1). The town of Merizo is situated on a narrow coastal plain which fringes the mountainous areas of southern Guam. Behind that coastal plain, elevations rise rapidly to over 300 meters. For example, Mount Sasalaguan is within 2.5 km of the coast, and has an altitude of 337 meters. The population of Merizo was 1,850 in 2010 (Bureau of Statistics and Plans, 2011). Tourism accounts for roughly 60% of the economy in Guam (NOAA, 2007), and tourism is also important in Merizo.

Triangular-shaped, Cocos Lagoon is approximately 8.9 km long on the south side, and 4.4 km at its widest point. The lagoon is separated from the open ocean by a series of fringing reefs and barrier islands, of which Cocos Island is the largest (Figure 2). Cocos Island is thought to have formed through the accumulation of unconsolidated materials carried by waves and currents, and has a maximum elevation of two meters (Emery, 1962). Cocos Lagoon is a popular area for recreational activities including fishing, boating and diving, in addition to subsistence fishing. The lagoon is fairly shallow, with an average depth of approximately two meters. Towards the center of Cocos Lagoon depths approach 12 meters. The Manell Channel, with depths up to 11 meters drains to the Pacific Ocean, while the Mamaon Channel, with depths to nearly 26 meters, drains to the Philippine Sea. Water circulation within Cocos Lagoon under normal trade-wind conditions is toward the north or northwest, driven by waves impinging upon the southern barrier reef of the lagoon (Randall *et al.*, 1975)

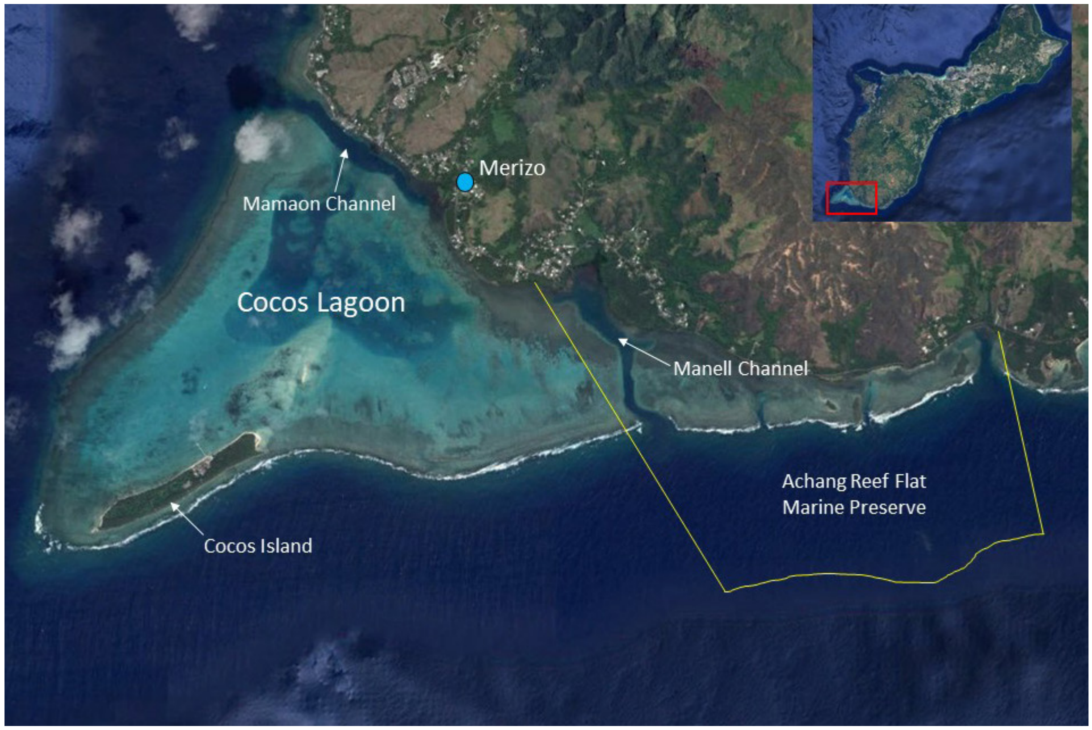


Figure 2. Cocos Lagoon, Guam including the Achang Reef Flat Marine Preserve.

There are extensive seagrass beds and patch reefs within Cocos Lagoon, which provide habitat for a variety of vertebrate and invertebrate species. Live coral cover in Cocos Lagoon has been documented at approximately 30% (Burdick *et al*., 2008). The area also provides important habitat for sea turtles, including the Endangered Species Act-listed green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles. A variety of fish can also be found in Cocos Lagoon including the thumbprint emperor (*Lethrinus harak*), honeycomb grouper (*Epinephelus merra*), convict tang (*Acanthurus triostegus*), orange-striped emperor (*Lethrinus obsoletus*), and blackspot sergeant (*Abudefduf sordidus)*. Invertebrates include the spotted reef crab (*Carpilius maculatus*), spiny lobster (*Panulirus pencillatus)*, hairy pincushion urchin (*Tripneustes gratilla*) and the common reef octopus (*Octopus cyanea*) (Guam Coastal Management Program, 2013). While fishing is important in Cocos Lagoon for recreation, food, and income, there is increasing evidence of overfishing of various species of fish and invertebrates in Guam, including in Cocos Lagoon (Porter *et al*., 2005).

In 1997, a network of marine preserves was established in Guam in response to decreasing nearshore fish stocks

(NOAA, 2007). The Achang Reef Flat Marine Preserve (Figure 2), located on the eastern end of Cocos Lagoon, was established by the Division of Aquatic and Wildlife Resources of the Guam Department of Agriculture. Since the establishment of the Achang Preserve, fish stocks have increased there by 115%, while surveys at comparison sites outside the Achang Preserve in Cocos Lagoon have shown a further 4% decrease (Porter *et al*., 2005).

Figure 3. Location of former LORAN Station Cocos Island, and current resort area.

Between 1944 and 1963, the US Coast Guard (USCG) operated a long-range navigation or LORAN station towards the southwestern end of Cocos Island. The approximate location is shown in Figure 3. LORAN was a hyperbolic radio navigation system used by the US beginning in World War II. Electrical transformers at the station were used to convert the power supplied by diesel generators to run the LORAN equipment. Anecdotal information provided by former USCG personnel stationed at Cocos Island during the time the LORAN station was operational, indicated that debris from the station was taken to the lagoon side of the island to be carried away by passing typhoons (Element Environmental, 2014), or buried in dump pits on the island (Environet, 2005). It should also be noted that passing typhoons have had significant impacts on Cocos Island, which could have washed debris from the LORAN station into Cocos Lagoon as well. In 1949, for example, Typhoon Allyn overwashed Cocos Island, and was said to have removed most of the USCG installation (Emery, 1962). Significant overwash also occurred during Typhoon Russ in 1991 (Richmond and Jaffe, 1991).

Beginning in 2005, surveys were conducted on Cocos Island by USCG contractors to remove debris from the site, and to quantify the types and levels of chemical contaminants present in soils, sediments and aquatic biota. Elevated levels of polychlorinated biphenyls (PCBs) were found in soils on Cocos Island, and in fish in the waters adjacent to Cocos Island (Environet, 2005; Element Environmental, 2008, 2013, 2014). In 2006, a fish consumption advisory was put in place for Cocos Lagoon (Guam EPA, 2006), in response to the contamination of fish by PCBs. The advisory recommended that the community limit or avoid the consumption of fish caught in and around Cocos Lagoon. That advisory is still in place.

While there has been a significant amount of work completed to assess the presence of chemical contaminants on and directly adjacent to Cocos Island, there does not appear to have been work carried out to assess the level and extent of chemical contamination throughout Cocos Lagoon. In 2014, local resource managers reached out to NOAA's National Centers for Coastal Ocean Science (NCCOS) to request a survey of chemical contaminants present in Cocos Lagoon, including the area around Cocos Island.

MATERIALS AND METHODS

With funding from NOAA's CRCP, NCCOS scientists worked with local resource managers and scientists from the Guam Environmental Protection Agency (Guam EPA), CRCP and NOAA's National Marine Fisheries Service Pacific Islands Regional Office, to develop a sampling strategy for the project. The field mission to collect sediment and fish samples in Cocos Lagoon occurred from 5-11 May 2015.

Water Quality Parameters

At each location where sediment and fish were collected, a series of water quality parameters (dissolved oxygen, temperature, salinity, and conductivity) were also measured, using a YSI® salinity/conductivity/temperature meter. The instrument probe was submerged to a depth of approximately 0.5 meters for the surface measurement, and within a meter of the sediment for the bottom measurement. At some sites, the water was too shallow for a separate bottom measurement. Secchi depth was also measured at each site.

Sediments

A series of four strata (Figure 4) for sampling were developed through conversations with partners, and were based on depth and habitat. The strata included the waters around Cocos Island (Stratum 1), the central portion of Cocos Lagoon (Stratum 2), the two channel areas around the town of Merizo (Stratum 3), and the shallower reef areas of Stratum 4. Sampling points were then randomly assigned to the four strata. This approach combines the strengths of a stratified design with the random-probabilistic selection of sampling locations, allowing the data generated within each stratum to be attributed to the size of that stratum with a quantifiable degree of confidence (Heimbuch *et al.*, 1995), and for the comparison of chemical contaminant concentrations between strata.

One of the Guam EPA vessels used to sample Cocos Lagoon.

Both primary and alternate sites were established. Alternate sites were sampled in the event that a primary site was unsuitable due to hard bottom, obstructions, etc. The samples were collected under Guam Department of Agriculture, Division of Aquatic and Wildlife Resources Permit SC-MPA-15-005. All sites were located in the field using a GPS programmed with the site coordinates. Sediment samples were collected by NOAA and Guam EPA personnel aboard Guam EPA boats (see inset). The sediments for chemical contaminant analysis 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 chemical contaminants in bivalve mollusk tissues and sediments, along with toxicity (bioeffects) in sediments.

Sediment Sampling Protocols

A PONAR grab (see cover of this report) was deployed to collect the sediment samples, and then retrieved by hand. Shell and bits of seagrass were removed. If a particular grab did not result in 200-300 grams of sediment, a second grab was made and composited with material from the first. If enough sediment had not been collected after three deployments of the grab, the site was abandoned and the boat moved on to an alternate site.

A series of standard protocols (Apeti *et al*., 2012) were used to avoid contamination of the sediment samples by equipment and cross contamination between samples and sites. All equipment was rinsed with acetone and then distilled water just prior to use at a site. Personnel handling the samples also wore disposable nitrile gloves. The top 3 cm of sediment typically represents recent deposition, and was collected using a stainless steel sediment scoop. A total of 28 sites were visited in Cocos Lagoon. At three sites (1-6, 3-5, and 3-6), sediment was not available, resulting in the collection of a total of 25 samples (Figure 5).

Sediments were placed into two 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 WhirlPack® bag, sealed and placed on ice in a cooler. At the end of each day, sediment samples for contaminant analysis were placed in a freezer at Guam EPA. The WhirlPack® bags for the grain size analysis were placed in a refrigerator rather than frozen, to avoid altering the grain size structure of the sediment.

Fish

As with sediment sampling, Guam EPA provided the boats for the project. Guam EPA and NOAA personnel along with a local fisher from Merizo collected the fish. All fish were collected under Permit SC-MPA-15-004.

Fish Sampling Protocols

Fish were collected in the same strata developed for the sediments using either a fishing rod or a cast net, at many of the same locations as sediments. At times, the boat was allowed to drift, or if the water was shallow enough, the fishers got out of the boat to collect fish. A cast net was used in shallow waters for schooling fish such as sergeant majors. Spearguns would likely have made the collection

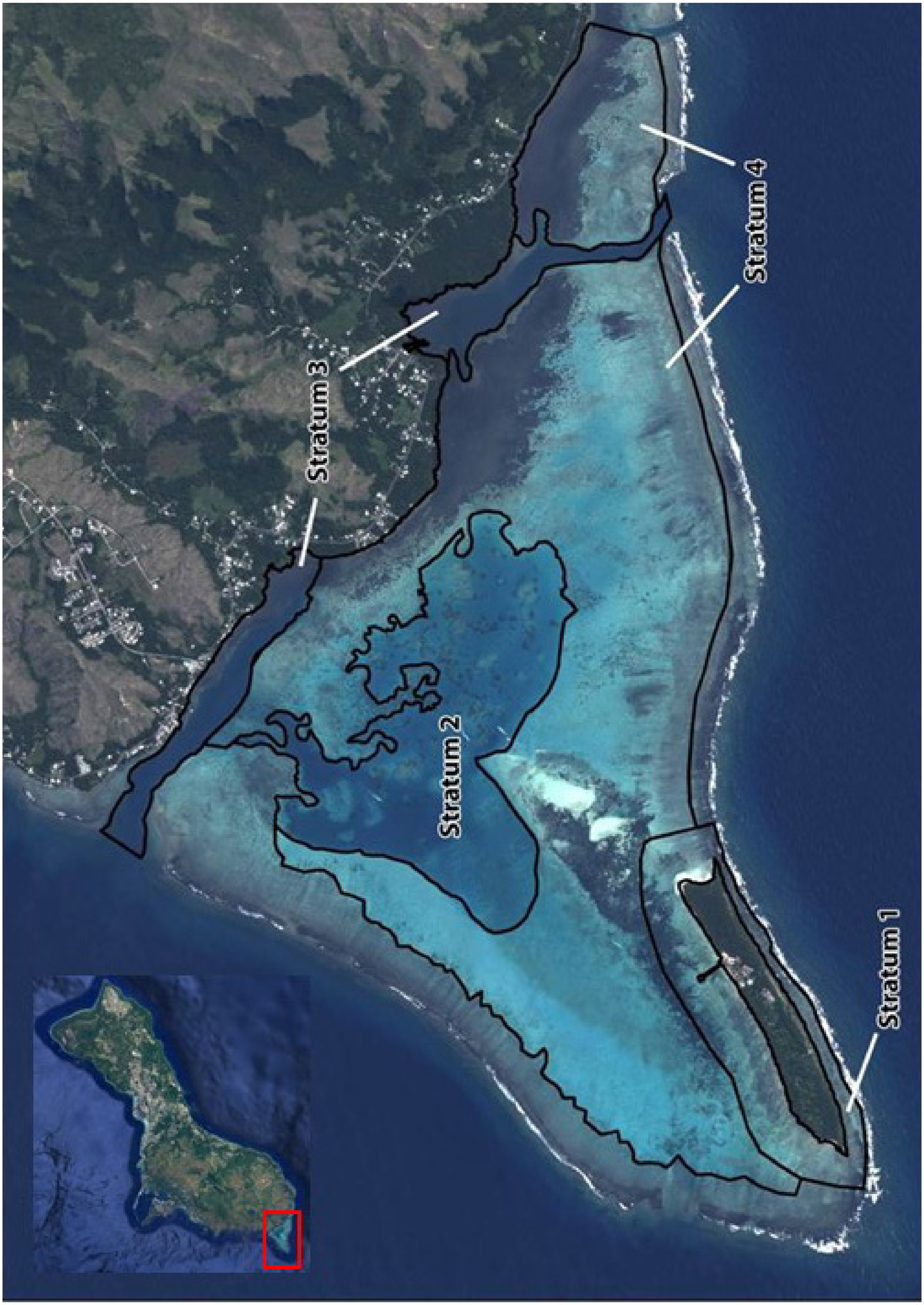


Figure 4. Strata developed for the sampling in Cocos Lagoon.

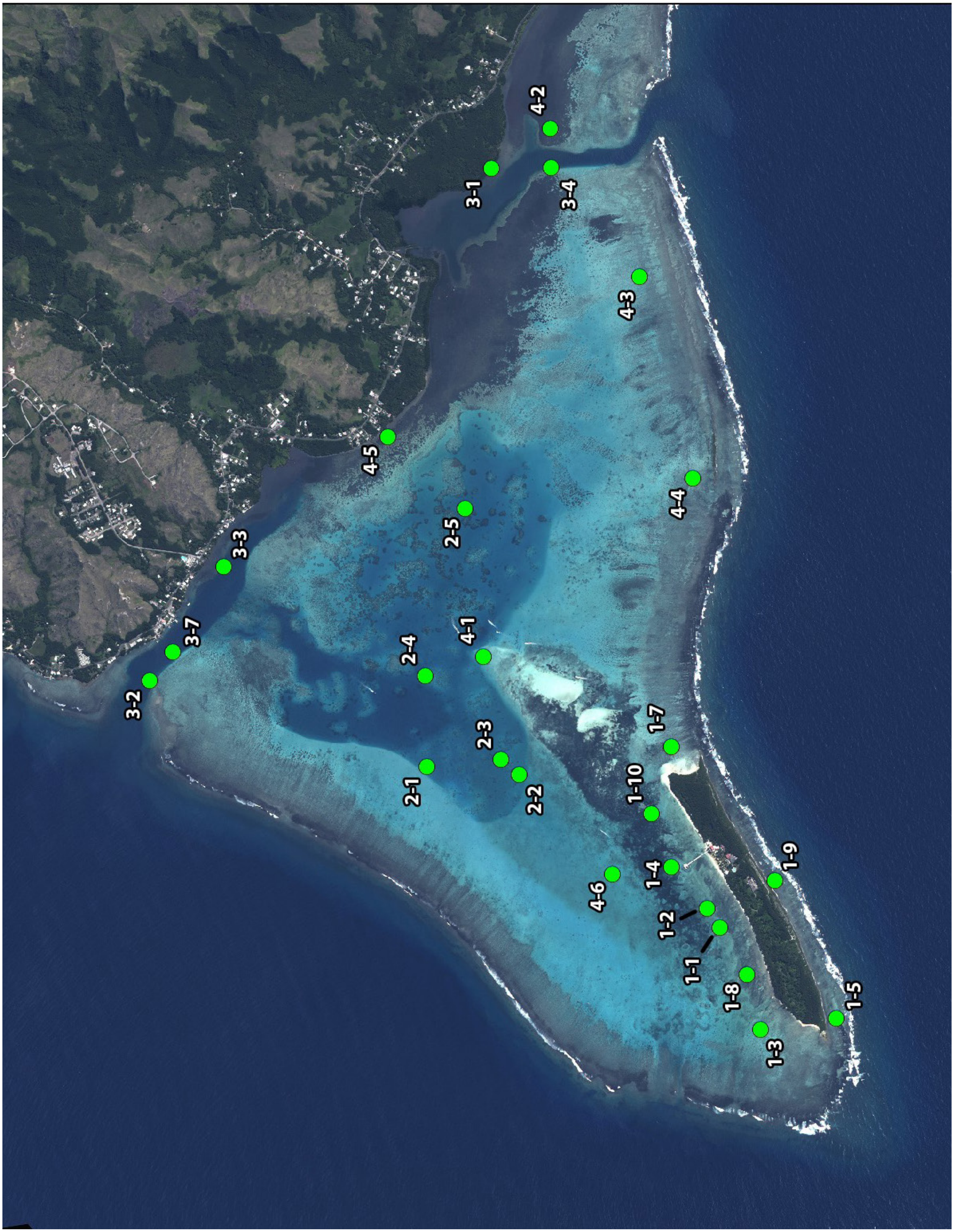


Figure 5. Sediment sampling sites in Cocos Lagoon.

of fish easier, however spearguns were not used as this could have introduced additional metals into the fish, or caused the loss of fluids, both of which could have influenced the concentration of contaminants.

The species collected represent fish that were available during the field effort, and that are also consumed locally. Eight species were collected including: banded sergeant (*Abudefduf septemfasciatus*), blackspot sergeant (*Abudefduf sordidus*), convict tang (*Acanthurus triostegus*), starspotted grouper (*Epinephelus hexagonatus*), honeycomb grouper (*Epinephelus merra*), blacktail snapper (*Lutjanus fulvus*), thumbprint emperor (*Lethrinus harak*), and orange-striped emperor (*Lethrinus obsoletus*).

Merizo fisher Jason Miller using hook and line in Cocos Lagoon.

A total of 66 fish were collected from 15 sites throughout Cocos Lagoon (Figure 6). Fish of the same species at a site were composited into a sample. A more concentrated number of sites were sampled around Cocos Island where elevated concentrations of chemical contaminants have been found. Fish samples were collected, stored and shipped according to protocols found in Apeti *et al*. (2012).

Personnel handling the fish wore disposable nitrile gloves. Fish were first placed in labeled plastic bags and then into a cooler on the boat containing ice. At the end of each day, fish were transferred to the freezers at the Guam EPA laboratory in Barrigada.

Shipping

At the end of the field mission, chain of custody forms were completed for both the sediment and fish samples. Prior to shipment, a representative from the Guam Department of Agriculture, Division of Aquatic and Wildlife Resources inspected the samples and issued Certificates of Origin for the sediment and fish samples, required in order for the samples to leave Guam.

There was no direct overnight shipping available from Guam to the analytical laboratory in Texas. To ensure that the sediment and fish samples would arrive in Texas as cold as possible, samples were first shipped to the NOAA Pacific Islands Fisheries Science Center in Honolulu, Hawaii. The samples were placed in a walk-in freezer at the facility for a few days, and then shipped out to TDI-Brooks, International, a NOAA contract analytical laboratory.

Chemical Contaminants Analyzed

The sediment and fish samples collected were analyzed for a suite of 191 organic (e.g., hydrocarbons and pesticides) and inorganic (e.g., metals) contaminants by TDI-Brooks, using protocols established by the NS&T Program. The list of chemical contaminants analyzed in sediments and fish is shown in Table 1. For this project, sediments were dried before analysis, and results are reported on a dry weight basis. Whole fish were analyzed and contaminant concentrations are reported on a wet weight basis, so as to be comparable to other recent work completed around Cocos Island, and also to compare the concentrations in fish tissue with the USEPA (US Environmental Protection Agency) fish consumption Screening Values for recreational and subsistence fishers.

<u>Polycyclic Aromatic Hydrocarbons</u>

The samples collected were analyzed for 59 polycyclic aromatic hydrocarbons or 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), and also from volcanoes (ATSDR, 1995). The PAHs analyzed are two to six ring aromatic compounds. A number of PAHs bioaccumulate in aquatic and terrestrial organisms, are toxic, and some including 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). PAHs were analyzed using gas chromatography/mass spectrometry in the selected ion monitoring mode.

<u>Polychlorinated Biphenyls</u>

Commonly referred to as PCBs, polychlorinated biphenyls are synthetic compounds that have been used in numerous applications ranging from electrical transformers and ca-

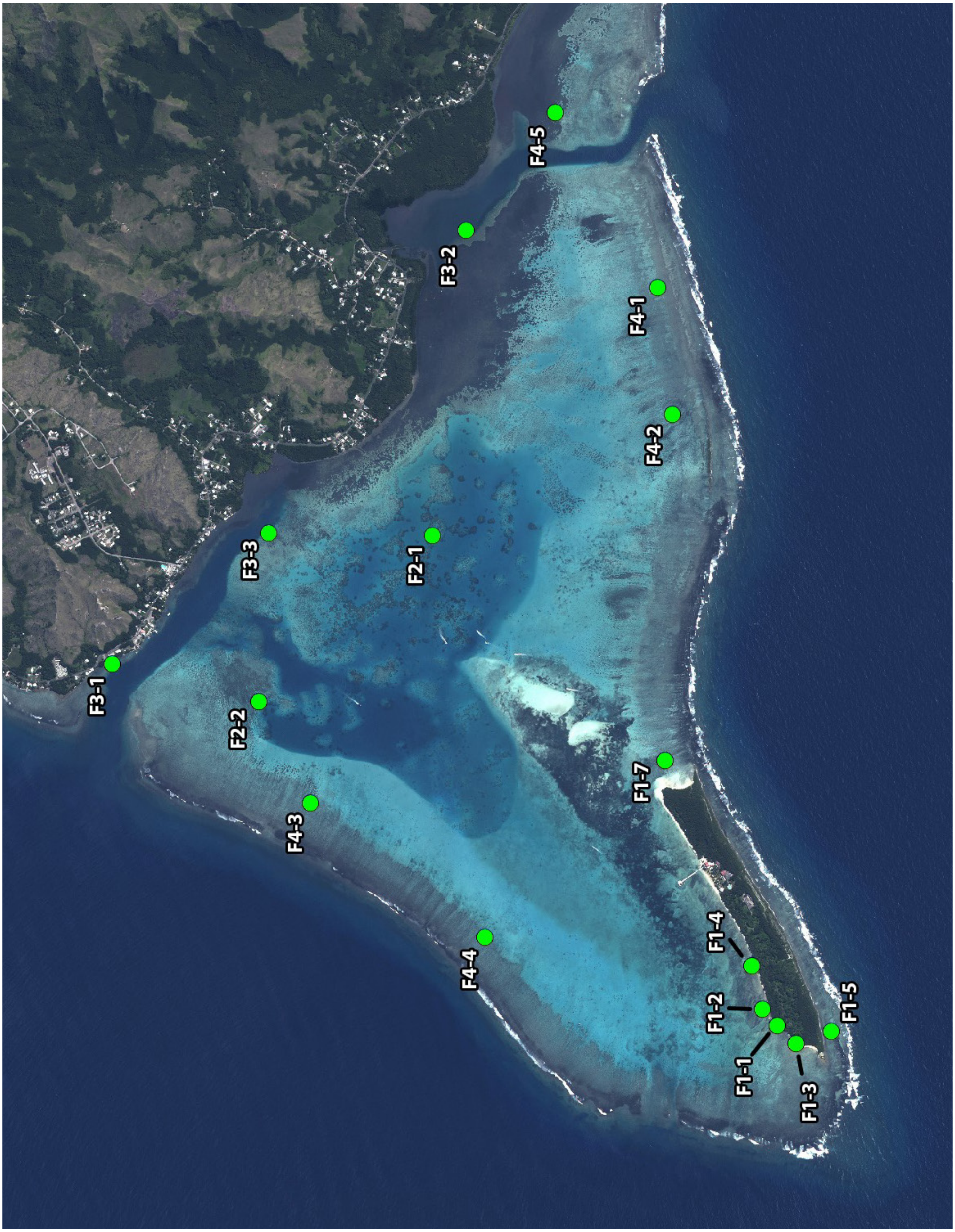


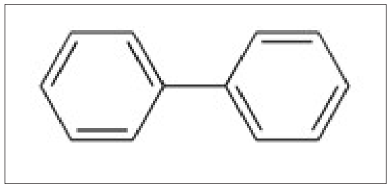
Figure 6. Fish sampling sites in Cocos Lagoon.

Table 1. Chemical contaminants analyzed in sediment and fish samples from Cocos Lagoon, Guam.

PAHs - Low MW	PAHs - High MW	Organochlorine Pesticides	PCBs	PCBs (continued)	PCBs (continued)	Major and Trace Elements
Naphthalene	Fluoranthene	Aldrin	PCB1	PCB86	PCB180	Aluminum (Al)
1-Methylnaphthalene	Pyrene	Dieldrin	PCB7/9	PCB87/115	PCB183	Antimony (Sb)
2-Methylnaphthalene	C1-Fluoranthenes/Pyrenes	Endrin	PCB8/5	PCB88	PCB185	Arsenic (As)
2,6-Dimethylnaphthalene	C2-Fluoranthenes/Pyrenes	Heptachlor	PCB15	PCB92	PCB187	Cadmium (Cd)
1,6,7-Trimethylnaphthalene	C3-Fluoranthenes/Pyrenes	Heptachlor-Epoxide	PCB16/32	PCB95	PCB189	Chromium (Cr)
C1-Naphthalenes	Naphthobenzothiophene	Oxychlordane	PCB18	PCB97	PCB191	Copper (Cu)
C2-Naphthalenes	C1-Naphthobenzothiophenes	Alpha-Chlordane	PCB22/51	PCB99	PCB194	Iron (Fe)
C3-Naphthalenes	C2-Naphthobenzothiophenes	Gamma-Chlordane	PCB24/27	PCB101/90	PCB195/208	Lead (Pb)
C4-Naphthalenes	C3-Naphthobenzothiophenes	Trans-Nonachlor	PCB25	PCB105	PCB196/203	Manganese (Mn)
Benzothiophene	Benz[a]anthracene	Cis-Nonachlor	PCB26	PCB107	PCB199	Mercury (Hg)
C1-Benzothiophenes	Chrysene	Alpha-HCH	PCB28	PCB110/77	PCB200	Nickel (Ni)
C2-Benzothiophenes	C1-Chrysenes	Beta-HCH	PCB29	PCB114/131/122	PCB201/157/173	Selenium (Se)
C3-Benzothiophenes	C2-Chrysenes	Delta-HCH	PCB31	PCB118	PCB205	Silicon (Si)
Biphenyl	C3-Chrysenes	Gamma-HCH	PCB33/53/20	PCB126	PCB206	Silver (Ag)
Acenaphthylene	C4-Chrysenes	DDMU	PCB40	PCB128	PCB209	Tin (Sn)
Acenaphthene	Benzo[b]fluoranthene	2,4'-DDD	PCB41/64	PCB129/126		Zinc (Zn)
Dibenzofuran	Benzo[k]fluoranthene	4,4'-DDD	PCB42/59/37	PCB136	Butyltins	
Fluorene	Benzo[e]pyrene	2,4'-DDE	PCB43	PCB138/160	Monobutyltin	
C1-Fluorenes	Benzo[a]pyrene	4,4'-DDE	PCB44	PCB141/179	Dibutyltin	
C2-Fluorenes	Perylene	2,4'-DDT	PCB45	PCB146	Tributyltin	
C3-Fluorenes	Indeno[1,2,3-c,d]pyrene	4,4'-DDT	PCB46	PCB149/123	Tetrabutyltin	
Carbazole	Dibenzo[a,h]anthracene	1,2,3,4-Tetrachlorobenzene	PCB47/48/75	PCB151		
Anthracene	C1-Dibenzo[a,h]anthracenes	1,2,4,5-Tetrachlorobenzene	PCB49	PCB153/132		
Phenanthrene	C2-Dibenzo[a,h]anthracenes	Hexachlorobenzene	PCB52	PCB156/171/202		
1-Methylphenanthrene	C3-Dibenzo[a,h]anthracenes	Pentachloroanisole	PCB56/60	PCB158		
C1-Phenanthrene/Anthracenes	Benzo[g,h,i]perylene	Pentachlorobenzene	PCB66	PCB166		
C2-Phenanthrene/Anthracenes		Endosulfan II	PCB70	PCB167		
C3-Phenanthrene/Anthracenes		Endosulfan I	PCB74/61	PCB169		
C4-Phenanthrene/Anthracenes		Endosulfan Sulfate	PCB77	PCB170/190		
Dibenzothiophene		Mirex	PCB81	PCB172		
C1-Dibenzothiophenes		Chlorpyrifos	PCB82	PCB174		
C2-Dibenzothiophenes			PCB83	PCB176/137		
C3-Dibenzothiophenes			PCB84	PCB177		

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 pacitors, to hydraulic and heat transfer fluids, to pesticides and paints. Typically, NOAA's NS&T Program analyzes for 38 PCBs. Because PCBs were identified by partners as a contaminant class of particular concern in Cocos Lagoon, an expanded list of 81 PCBs was analyzed for this project.

PCBs were manufactured in the US between 1929 and 1977. PCBs have a biphenyl ring structure (two benzene rings with a carbon to carbon bond, see inset) and a varying number (1-10) of chlorine atoms. There are 209 individual PCB compounds or congeners possible. In the United States, all PCBs were produced by a single manufacturer, and the commercial products were referred to as Aroclors, which are mixtures of PCB congeners. Approximately 65% of PCBs manufactured in the US were used in electrical applications (Eisler and Belisle, 1996). The manufacture of PCBs in the US was banned in 1979 due to their toxicity. Because PCBs bioaccumulate and degradation proceeds slowly, they are now ubiquitous environmental contaminants. Exposure to PCBs in fish has been linked to reduced growth, reproductive impairment, and vertebral abnormalities (Eisler and Belisle, 1996). PCBs have also been shown to cause cancer in laboratory animals and have been linked to cancer in humans (ATSDR, 2000). PCBs were analyzed using gas chromatography/electron capture detection.



Biphenyl ring structure.

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 of the organochlorine pesticides was the insecticide DDT (dichlorodiphenyltrichloroethane). For this project, 31 organochlorine pesticides including DDT were analyzed.

The use of many of the organochlorine pesticides, including DDT was banned due to their environmental persistence, potential to bioaccumulate, and chronic toxic effects on nontarget organisms. Organochlorine pesticides are typically neurotoxins, and DDT along with PCBs have also been shown to interfere with the endocrine system (Rogen and Chen, 2005). The DDT metabolite DDE was specifically linked to eggshell thinning in birds, particularly in raptors and also in pelicans (Lincer, 1975). A number of organochlorine pesticides are toxic to other nontarget aquatic organisms as well, including crayfish, shrimp and some species of fish. While DDT was banned by the USEPA for most uses in the US beginning in 1972, DDT is still used in some developing countries, for example, inside of living areas to help control mosquitoes that can transmit malaria.

Most uses of the organochlorine insecticide chlordane were banned in 1978, and all uses were banned 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 and in biota. The persistence of these compounds and toxicity to nontarget organisms continues to be an environmental concern. The organochlorine pesticides were analyzed using gas chromatography/electron capture detection.

Butyltins

This compound class has a range of uses, from biocides to catalysts to glass coatings. In the 1950s, tributyltin (TBT) was first shown to have biocidal properties (Evans, 1970; 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).

In the mid-1970s, the use of TBT was linked to abnormal shell development and poor weight gain in oysters which severely impacted oyster production in France, and more recently to an imposex (females developing male characteristics) condition in marine gastropod mollusks (Batley, 1996). Beginning in 1989, the use of TBT as an antifouling agent was banned in the US on non-aluminum vessels smaller than 25 meters in length (Gibbs and Bryan, 1996).

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). Four butyltin compounds (Table 1) were analyzed for this project using gas chromatography/flame photometric detection after derivatization.

Trace and Major Elements

All the trace and major 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. Some trace and major elements are essential micronutrients, however, a number of trace elements (e.g., cadmium, chromium, lead and mercury) are toxic at low concentrations.

Cadmium is used in a number of applications including nickel-cadmium (Ni-Cd) batteries, paint pigments and in electroplating (Ellor and Stemniski, 2007). Cadmium has been shown to impair development and reproduction in 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).

Debris scattered along the southwestern shore of Cocos Island.

Chromium is used in stainless steel production, chromium plating, wood preservation, and as a pigment. Chromium has been shown to reduce growth in fingerling chinook salmon (*Oncorhynchus tshawytscha*) (Eisler, 1986).

Copper has many applications including use in wire, electronic circuits, antifouling paints for boat hulls, copper plumbing, coinage, industrial catalysts, and in a number of alloys (e.g., brass). 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% of the nickel in the US 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% of zinc use. In the marine industry, zinc anodes are used to protect vital engine and boat parts (e.g., propellers, struts and rudders, along with 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. Elevated levels of cadmium, zinc, lead, and chromium have all been shown to interfere with vital life processes such as spawning, hatching, and development in fish (Lelan and Kuwbara, 1985; Eisler, 1985, 1986, 1998). In addition, lead, nickel, and zinc have all been shown to impact fertilization success in corals, some effects being observed in the parts per billion range (Reichelt-Brushett and Harrison, 1999; Reichelt-Brushett and Harrison, 2005). The 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).

<u>*Clostridium perfringens*</u>

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 Cocos Lagoon, to assess areas (e.g., near Merizo, or recreational areas) which might have higher concentrations. 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.

Statistical Analyses

The 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.

When data were normally distributed, an Analysis of Variance (ANOVA) was run followed by pairwise (Tukey HSD) comparisons. If the data were not normally distributed and a log10 transformation was not effective, Wilcoxon non-parametric comparisons were used.

RESULTS AND DISCUSSION

Water depths at the sites in Cocos Lagoon ranged from 0.2 to 16.4 meters. The average depth was 3.2 ±0.64 meters. The two deepest sites (15.3 and 16.4) were along the Mamaon Channel in Stratum 3 (Figure 2).

Water Quality Parameters

The average surface salinity at the sites was 33.6 ±0.13 psu; bottom salinity was 33.9 ±0.13 psu. Surface salinity was not significantly different (Chi-Square = 1.3894, p = 0.7080) between sites. A number of the sites were too shallow to measure bottom salinity, precluding a statistical analysis. Surface dissolved oxygen was significantly different (Chi-Square = 12.9053, p = 0.0048) between the sediment strata. The lowest mean surface dissolved oxygen (DO) measurements were in Stratum 2. As with bottom salinity measurements, a number of the sites were too shallow for a bottom DO measurement. Additional information on the water quality measurements can be found in Appendix A and B.

Grain Size and Total Organic Carbon in Sediments

Sand was the major grain size fraction in the sediment samples collected from Cocos Lagoon, accounting for approximately 89% of the content of each sample. Sand ranged from 67% to 98%. A nonparametric analysis (Wilcoxon) indicated that sand did not vary by stratum. Gravel was the second most common size fraction (6.7%,), although the laboratory (TDI-Brooks), indicated that this size fraction actually consisted of shell hash.

The 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. The highest silt and clay content in the sediments sampled was found at Site 3-1 (Figure 5) in Stratum 3. Sand and gravel have larger grain sizes, along with an overall smaller surface area by volume and as a result, a lower affinity for contaminants. More detailed results of the analysis of grain size in the sediments from Cocos Lagoon can be found in Appendix C.

The average percent total organic carbon (TOC) in the sediments collected was 3.31 ±0.29%, and ranged from a low of 0.73% to a high of 5.81%. An ANOVA run on the TOC values indicated significant differences in %TOC by stratum (F-Ratio = 6.1963, p = 0.0035). Pairwise comparisons (Tukey-Kramer HSD) indicated that TOC in Stratum 1 (Cocos Island, Figure 4) was significantly different (lower) from strata 2 and 3. Stratum 2 is in the deeper central portion of Cocos Lagoon, and Stratum 3 contains the Mamaon and Manell channels.

Chemical Contaminants in Sediments

Results from the analysis of each chemical class analyzed are discussed below. Additional information on the analyses of each compound analyzed can be found in the appendices.

Polycyclic Aromatic Hydrocarbons

The mean total PAH concentration found at the sediment sites was 4.33 ng/g ±0.95. Total PAH as defined in this report is the sum of the 59 PAH compounds analyzed. Detailed results of the analysis of PAHs in the sediments can be found in Appendix D. The highest total PAH concentration in the sediments was 24.5 ng/g at Site 3-1 (Figure 5), a site near Merizo, which was also the site which had the highest silt and clay content of all the sites sampled in Cocos Lagoon (Appendix C). A nonparametric analysis (Wilcoxon) indicated that although the mean total PAH concentration in Stratum 3 appeared higher, total PAHs did not vary by stratum (Chi-Square = 6.6630, p = 0.0835).

Because of the national-level contaminant monitoring carried out by NOAA's NS&T Program, data from Cocos Lagoon can be compared with data from the rest of the Nation's coastal waters. For this report, data were compared with the most recent (2006/2007) nationwide analysis of sediments from the NS&T Program. The most recent NS&T nationwide sediment analysis data were used, as the number of compounds analyzed in some of the chemical contaminant classes (e.g., total PAHs, total PCBs and total DDT), have increased over time, and the 2006/2007 NS&T sediment data contains the most comparable list of analytes. The NS&T 2006/2007 median for total PAHs is 395 ng/g, over an order of magnitude higher than the mean found in the sediments in Cocos Lagoon, as well as the location (3-1) that recorded the highest total PAH concentration in this study. The NS&T mean for total PAHs is 3,385 ng/g.

NOAA's NS&T Program has also developed effects-based, numeric guidelines to estimate the toxicological relevance of certain sediment chemical contaminants (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 value for total PAHs is 4,022 ng/g; the ERM is 42,972 ng/g.

Total mean PAHs in the sediments from Cocos Lagoon were more than two orders of magnitude below the ERM, indicating that sediment toxicity to organisms living in the sediments as a result of the PAHs present was extremely unlikely.

The USCG LORAN station on Cocos Island used diesel generators to power the LORAN equipment. Empty, above-ground storage tanks (AST) were found on Cocos Island by USCG contractors and subsequently removed, beginning in 2005. Environet (2005), contracted by the USCG to assess chemical contaminants on Cocos Island, detected PAHs in roughly 14% of the soil samples on the island in the area of the former LORAN station, with concentrations as high as 29,960 ng/g. In nearshore sediments, results using immunoassay field kits indicated PAHs were above the detection limit in approximately 20% of the samples. However, follow up laboratory analysis to verify the concentrations, failed to detect the presence of any of the PAHs analyzed in sediment samples.

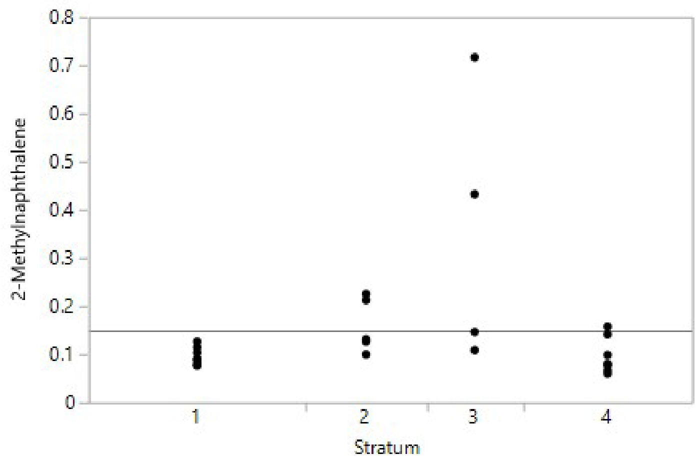


Figure 7. Sediment concentrations of the PAH 2-methylnaptha-lene in Cocos Lagoon.

Denton *et al*. (1997) quantified contaminants in four harbors in Guam (Agana Boat Basin, Outer Apra Harbor, Agat Marina, and Merizo Pier). Total PAHs (sum of 16 PAHs analyzed) in the sediments ranged from 10 to 8,140 ng/g. The highest PAH concentrations were from Outer Apra Harbor on the west side of Guam, part of the Naval Base Guam complex. At Merizo Pier in Cocos Lagoon, total PAHs ranged from 40 - 520 ng/g, higher than what was found in the current study.

For the individual alkyl isomers and hopanes that were also analyzed in the sediment samples in the current project (Appendix E), the C29 and C30 hopanes appeared slightly elevated at several sites in Stratum 1 (Cocos Island), and could be associated with the past use and combustion of fuel (Huang *et al.*, 1994; Volkman et al., 1992), possibly the diesel fuel used in the past to run the generators on the island. There were a number of lighter alkylated PAHs, such as 2-methylnapathalene (Figure 7) whose concentration although quite low, appeared elevated in some locations, for example in Stratum 3, and could be indicative of inputs of more recent, low level uncombusted fuel near the town of Merizo. A Wilcoxon test indicated a significant difference in the concentration (Chi-Square = 13.7074, p = 0.0033) between strata, and non parametric pairwise comparisons indicated that Stratum 3 was higher than strata 1 and 4.

<u>Polychlorinated Biphenyls</u>

The results of the analysis of PCBs in sediment samples can be seen in Figure 8, with more detailed results provided in Appendix F. Total PCBs, as defined in this report, is the sum of the 81 PCB congeners analyzed for the project.

The mean total PCBs concentration in the sediment samples from Cocos Lagoon was low, only 0.26 ±0.04 ng/g. The highest total PCBs concentration, 1.12 ng/g, was found at Site 1-7 on the north side of Cocos Island (Figure 5). Even though the concentrations of total PCBs were low in sediments throughout Cocos Lagoon, a nonparametric analysis (Wilcoxon) indicated a significant difference (Chi-Square = 11.00078, p = 0.0117) in total PCBs by stratum, and a Wilcoxon test run on each pair, indicated that total PCBs means in Stratum 1 were higher than in strata 2 and 4, but not significantly different from Stratum 3 in the Merizo area. As will be seen, elevated concentrations of PCBs were found in fish sampled in the area of Cocos Island.

Although total PCBs appeared slightly higher at sites in Stratum 1 relative to the rest of the sites in Cocos Lagoon, the mean concentration of total PCBs in Stratum 1 was less than 1 ppb (0.40 ±0.09 ng/g). The NS&T mean for total PCBs in sediments nationwide is 13.7 ng/g, over an order of magnitude higher than the highest total PCBs concentration found in the sediments around Cocos Island.

NOAA has established both an ERL (22.7 ng/g) and an ERM (180 ng/g) for total PCBs. Both the mean and the maximum PCB values found in the sediments in Cocos Lagoon are an order of magnitude below the ERL and over two orders of magnitude lower than the ERM, indicating that effects on biota found within the sediments are not likely from total PCBs. As noted earlier, chemical contaminants, particularly hydrophobic contaminants accumulate more readily on sediments with smaller particle sizes, characteristic of the silts and clays, and hydrophobic contami-

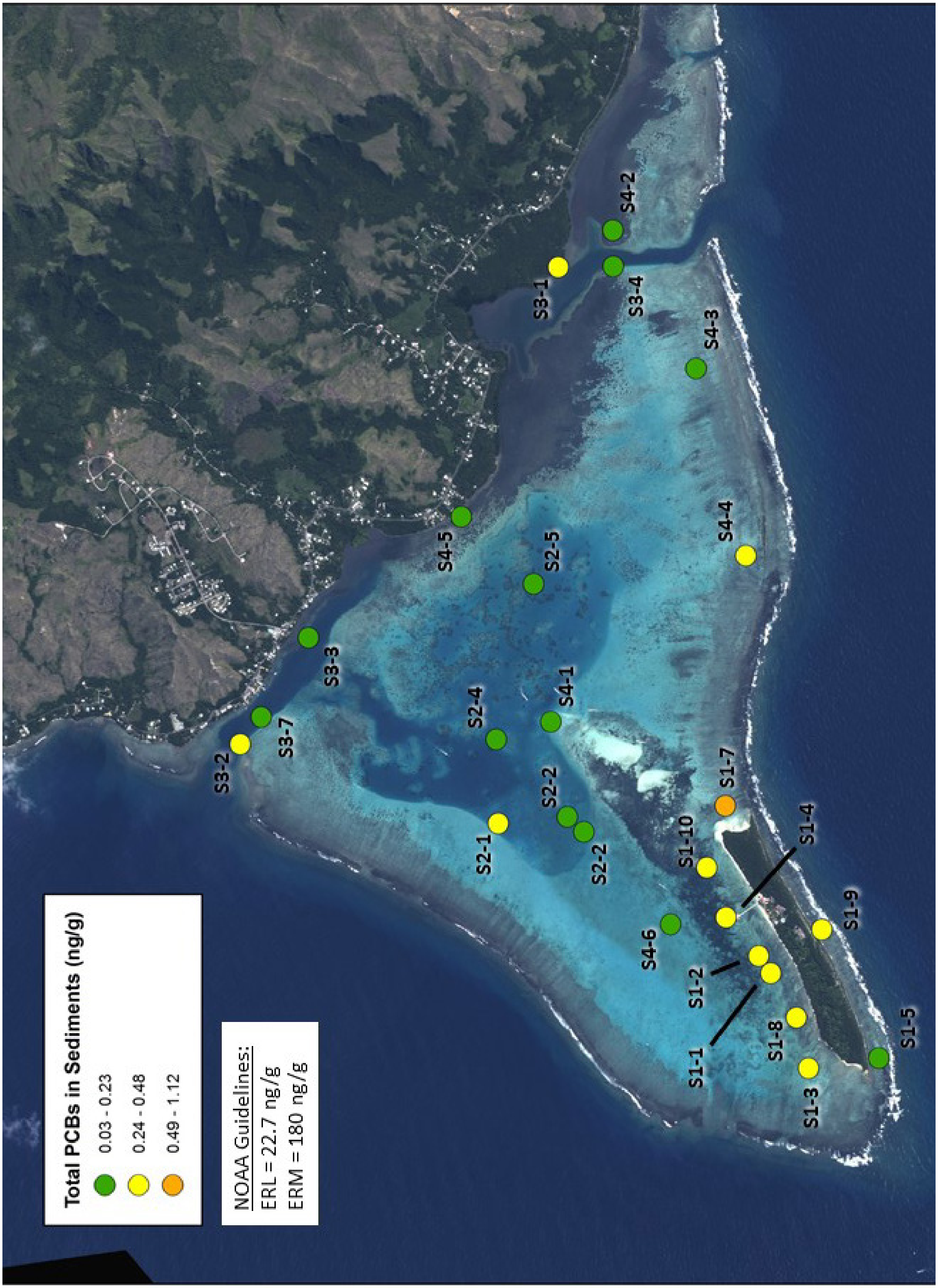


Figure 8. Total PCBs in sediments from Cocos Lagoon.

nants like PCBs and PAHs accumulate more readily on sediments with higher organic carbon levels (Karickhoff *et al*., 1979). The smaller grain size of the silts typically have a higher organic carbon content, which attract contaminants, particularly organic (carbon-containing) contaminants like PAHs and PCBs. The low concentrations of total PCBs (and also total PAHs) found in the sediments in Cocos Lagoon may be related to the high sand content (average of nearly 89%) of the sediments in the study area. The inset on this page shows an image of a typical sediment sample from Cocos Lagoon.

A survey by Environet (2005) found PCB levels as high as 1,080 µg/g (ppm) in soils on Cocos Island (note that units are not in ng/g), far above the USEPA residential Preliminary Remediation Goal (PRG) of 0.22 µg/g. Element Environmental conducted a number of studies on and around Cocos Island. In 2007, approximately 380 cubic yards of PCB-contaminated soil were removed from the site of the former LORAN station (Element Environmental, 2014). In 2008, Element Environmental conducted a follow-up assessment on Cocos Island, and did not detect PCBs in the soil above the detection level (Element Environmental, 2008).

Open PONAR grab showing sediment sample taken in Cocos Lagoon.

DDT

The results from the analysis of total DDT in sediments can be seen in Figure 9. For this project, seven DDT-related compounds, either degradation products or isomers (Table 1), were summed for the total DDT value. More detailed results can be seen in Appendix G.

The mean total DDT concentration found in the sediments was 0.30 ±0.23 ng/g. The highest total DDT concentration (5.81 ng/g) was found in Stratum 1 (Site 1-10, Cocos Island). A nonparametric analysis (Wilcoxon), however, indicated no significant difference (Chi-Square = 5.3742, p = 0.1464) in total DDT concentrations between strata.

The NS&T mean for total DDT in sediments is 3.11 ng/g, over an order of magnitude higher than the mean total DDT concentration found in the sediments in Cocos Lagoon. The ERL is 1.58 ng/g, and the ERM for total DDT is 46.1 ng/g. The mean total DDT in the sediments in Cocos Lagoon was below the ERL, making effects on organisms living within the sediments at most sites unlikely. However, there was one site (Site 1-10, 5.81 ng/g), which was above the NOAA ERL for total DDT, indicating that more sensitive life stages of organisms living in the sediment could begin to experience effects from this concentration of total DDT.

Other Organochlorine Pesticides

A number of other organochlorine pesticides were analyzed in the sediments from Cocos Lagoon (Appendix G). Most were not detected, or were below the method detection limit (MDL). The MDL is the minimum concentration of a contaminant in a sample needed to be able to report the concentration. One organochlorine pesticide, beta-HCH, or beta hexachlorocyclohexane, a byproduct from the production of the organochlorine insecticide lindane, was detected at a few sites in strata 2, 3 and 4 (Appendix G), just above the MDL. The use of lindane was restricted in the 1970s, and later banned for almost all other uses.

Butyltins

There were no detections of the antifoulant compound tributyltin (TBT) or any of the other butyltins analyzed for this project, in the sediments from Cocos Lagoon (Appendix H). Tributyltin was used as an effective antifoulant ingredient in paint formulations on boat hulls, and was subsequently banned for use in the US beginning in 1989, because of its toxicity, including endocrine disruption in mollusks (Batley, 1996).

Trace and Major Elements

A summary of results from the trace and major element analysis in sediments can be seen in Table 2. Additional information can be found in Appendix I. The highest concentrations detected were for the major earth elements silicon (82,600 µg/g), iron (38,100 µg/g), and aluminum (34,600 µg/g), and occurred at site 3-3 near the town of Merizo (Figure 5). This site is also adjacent to where the Geus River enters the Mamaon Channel (Figure 2), and may reflect the input of terrestrial materials from the watershed.

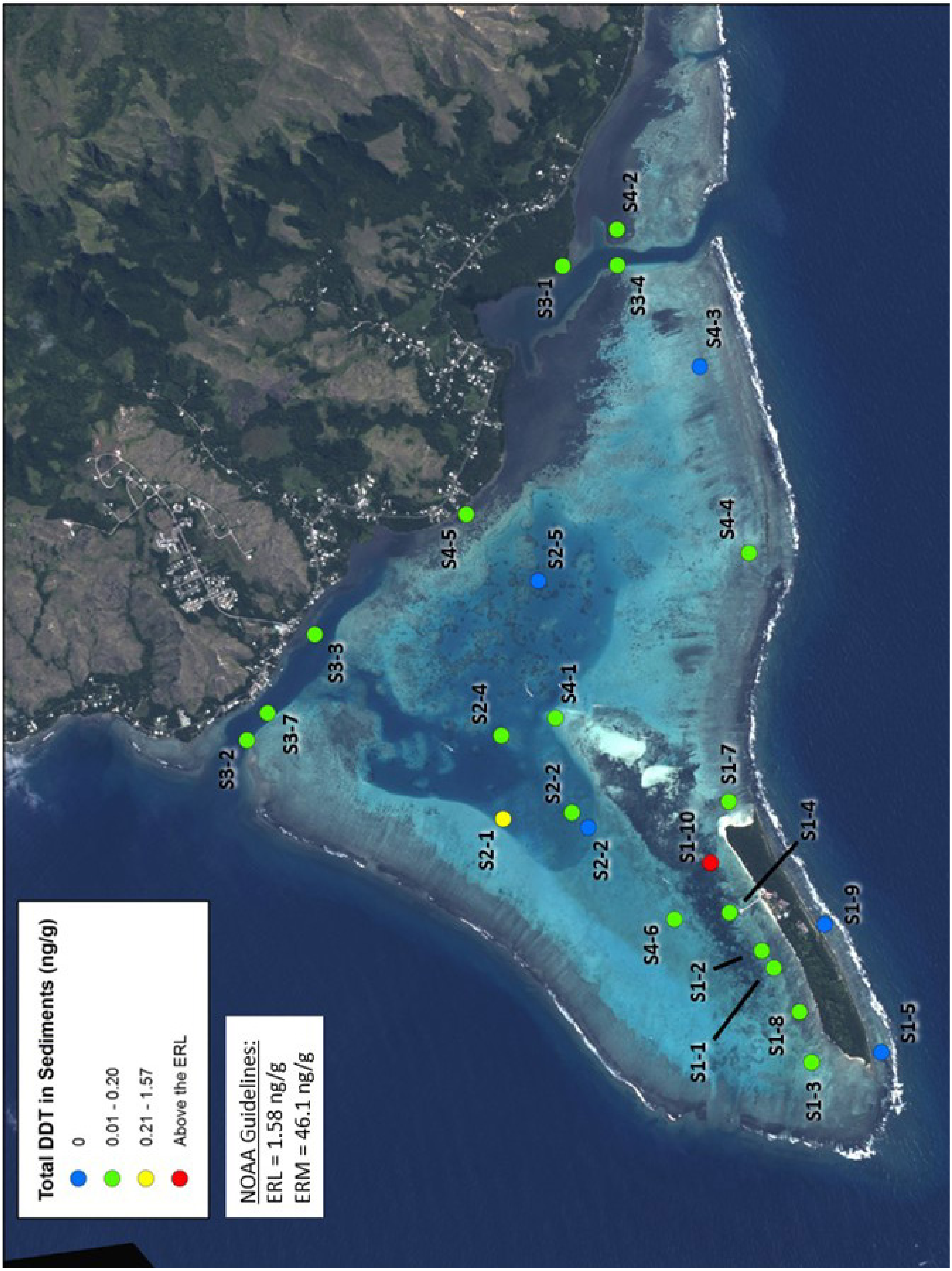


Figure 9. Total DDT found in sediments sampled in Cocos Lagoon.

The concentrations of these elements were also high at Site 3-1, near where the Manell River drains into the Manell Channel, and again may reflect the input of terrestrial materials from the watershed. Silicon (Chi-Square = 17.1622, p = 0.0007), iron (Chi-Square = 17.0618, p = 0.0007), and aluminum (Chi-Square = 19.0290, p = 0.0003) varied significantly by stratum, with Stratum 3 being the highest.

Table 3 contains the means, minimum and maximum concentrations of trace elements in sediment by stratum. It can be seen that the concentrations of a number of the trace elements appeared higher in Stratum 3, near the town of Merizo.

A nonparametric Wilcoxon test indicated that chromium concentrations in Cocos Lagoon varied by stratum (Chi-Square = 15.7980, p = 0.0012), and nonparametric pairwise comparisons indicated that chromium in sediments from Stratum 3 was higher than in strata 1 and 4. The highest concentration of chromium detected was 218 µg/g at site 3-3, near the town of Merizo (Appendix I). The second highest chromium concentration was detected at Site 3-1 (9.8 µg/g).

The major crustal element aluminum is sometimes used to normalize the concentration of metals in an effort to detect an anthropogenic signal. For this project, the crustal abundance of aluminum (CRC, 2005) was compared to chromium. Based on the aluminum concentration at Site 3-3 (34,600 µg/g), the chromium concentration was approximately five times higher than what might be expected based on the crustal ratio of these two elements, suggesting that chromium in the sediment at this location, is elevated, possibly from anthropogenic activities. Denton *et al*. (1997) analyzed trace elements in sediments (<1mm) at several harbors around Guam, including the dock area in the town of Merizo. They reported chromium concentrations in Merizo ranging from 13.5 to 39.5 µg/g, with the highest value across Guam measured in Apra Harbor (129 ug/g). Although Denton *et al*. (1997) screened out the gravel fraction of the sediment before their analysis, in the present study there was no gravel in the samples from either 3-1 or 3-3 (Appendix C).

Nickel (Chi-Square = 19.2881, p = 0.0002) and copper (Chi-Square = 10.4951, p = 0.0148) varied by stratum. Nonparametric pairwise comparisons indicated that nickel in Stratum 3 was higher than in strata 1 and 4. The same was true for copper, that is copper in the sediments in Stratum 3 was higher than in the sediments from strata 1 and 4. At Site 3-1, nickel at a concentration of 23.6 µg/g exceeded the ERL. At Site 3-3 near the town of Merizo, nickel at a concentration of 68.1 µg/g in sediments exceeded the ERM. However, as noted by Long *et al*. (1995), there was a relatively poor relationship between the concentration of nickel and the incidence of effects that were used to generate the ERL and ERM.

On Cocos Island in the area of the former LORAN station, lead and cadmium have been detected in soils at elevated concentrations, as part of the USCG assessment and restoration activities. For example, lead in surface soil samples was as high as 2,120 µg/g, while cadmium, also from a surface soil sample on the island, was as high as 136 µg/g

Table 2. Mean, minimum and maximum concentrations (µg/g dry wt.) of trace and major elements in sediments from Cocos Lagoon.

Element	Symbol	Mean ±SE	Minimum	Maximum	ERL	ERM
Aluminum	Al	2,766 ±1,557	5.62	34,600	–	–
Antimony	Sb	0.08 ±0.01	0.02	0.18	–	–
Arsenic	As	3.00 ±0.40	1.52	9.97	8.2	70
Cadmium	Cd	0.018 ±001	0.011	0.025	1.2	9.6
Chromium	Cr	11.3 ±8.61	0.22	218	81	370
Copper	Cu	4.76 ±1.59	0.65	33.3	34	270
Iron	Fe	3,265 ±1,716	132	38,100	–	–
Lead	Pb	0.65 ±0.11	0.141	2.13	46.7	218
Manganese	Mn	37.4 ±17.2	3.49	367	–	–
Mercury	Hg	0.002 ±0.001	0	0.0142	0.15	0.71
Nickel	Ni	5.16 ±2.77	0.719	68.1	20.9	51.6
Selenium	Se	0.020 ±0.011	0	0.206	–	–
Silicon	Si	6,828 ±3,765	0	82,600	–	–
Silver	Ag	0.001 ±0.001	0	0.0139	1	3.7
Tin	Sn	0.065 ±0.018	0	0.352	–	–
Zinc	Zn	4.35 ±1.98	0.39	42.9	150	410

ERL, Effects-Range Low; ERM, Effects-Range Median

Table 3. Mean, minimum, and maximum concentrations (µg/g dry wt.) for trace elements in sediment by stratum in Cocos Lagoon.

	Stratum											
	1			2			3			4		
	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.
Antimony	0.04 ±0.00	0.02	0.06	0.08 ±0.00	0.07	0.08	0.14±0.0.03	0.07	0.18	0.09 ±0.01	0.06	0.15
Arsenic	1.93 ±0.08	1.52	2.26	2.93 ±0.12	2.55	3.27	6.14 ±1.83	2.22	9.97	2.62 ±0.34	1.86	4.55
Cadmium	0.02 ±0.00	0.02	0.03	0.01 ±0.00	0.01	0.02	0.02 ±0.00	0.02	0.03	0.02 ±0.00	0.01	0.02
Chromium	1.62 ±0.28	0.22	2.73	3.85 ±0.32	2.78	4.72	58.7 ±53.1	2.98	218	2.05 ±0.27	1.17	3.12
Copper	2.07 ±0.85	0.65	8.62	3.55 ±1.76	1.58	10.6	17.8 ±7.00	5.46	33.3	1.67 ±0.24	1.07	2.72
Lead	0.81 ±0.23	0.14	2.13	0.45 ±0.12	0.29	0.91	1.12 ±0.33	0.38	1.79	0.31 ±0.07	0.15	0.68
Nickel	0.87 ±0.04	0.72	1.06	2.25 ±0.15	1.93	2.78	24.7 ±15.2	1.91	68.1	1.61 ±0.20	1.09	2.21
Tin	0.03 ±0.010	0	0.09	0.04 ±0.010	0.03	0.06	0.16 ±0.06	0.04	0.27	0.07 ±0.05	0	0.35
Zinc	1.13 ±0.34	0.39	3.27	1.69 ±0.12	1.35	2.01	20.2 ±9.8	1.24	42.9	1.33 ±0.36	0.4	2.73

Abbreviations: Min, minimum; Max, maximum; SE, standard error.

(Environet, 2005), both exceeding the established USEPA PRG for lead and cadmium. In 2008, Element Environmental detected a mean lead concentration of 5.84 µg/g in surface soils; the highest concentration found during that survey in surface soil samples was 24 µg/g. The highest subsurface lead concentration found in the same study was 19 µg/g (Element Environmental, 2008).

Environet (2005) analyzed for lead in sediments, and concentrations ranged from 3.21 - 155 µg/g. The highest lead concentration detected in sediments adjacent to Cocos Island in the current study was 2.13 µg/g at Site 1-9. A non-parametric test (Wilcoxon) indicated that the concentration of lead did not vary significantly (Chi-Square = 7.6898, p = 0.0529) between strata.

An ANOVA showed there was a significant difference in sediment concentrations for cadmium between strata (F-Ratio = 6.1850, p = 0.0035), and pairwise comparisons showed that cadmium in Stratum 2 was significantly different (lower concentration) than strata 1 and 3. Figure 10 shows cadmium concentrations found in the sediments in Cocos Lagoon. While the concentrations of cadmium in the sediments from Cocos Lagoon were far below the ERL, some of the higher concentrations detected were in the vicinity of Cocos Island.

Copper was somewhat elevated at Sites 3-1 (33.3 µg/g) and 3-3 (25.9 µg/g), and could be related to its use as an antifoulant on boats. Denton *et al*. (1997) detected copper at concentrations as high as 123 µg/g in sediments around the dock area in Merizo. The highest copper concentration they detected in harbors around Guam was 1,435 µg/g, at Apra Harbor.

NOAA has also established ERL and ERM values for a number of other trace elements which are included in Table 2. There were no exceedances of the ERM for any trace element analyzed in the sediments, however, chromium and nickel exceeded the established ERL at least once. In these cases, the exceedances of the ERL were at sites 3-1 and 3-3, adjacent to where the Geus and Manell rivers enter Cocos Lagoon. At 218 µg/g, chromium at Site 3-3 adjacent to the town of Merizo, was between the ERL and ERM.

Copper was close to exceeding the ERL at Site 3-1. The sediments at sites (3-1 and 3-3) as noted, also had the highest percent silt and percent clay content of any samples taken in Cocos Lagoon. Finer sediment particle sizes, particularly the clays, have an affinity for trace and major elements.

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. The results of the analysis of sediments for *C. perfringens* are shown in Appendix J.

C. perfringens was only occasionally detected in the sediments sampled in Cocos Lagoon. Most of the samples from Stratum 1 had no detections of *C. perfringens* at all. The highest detections in the sediments were in Stratum 3, close to the town or Merizo, and could be an indication of inputs from septic systems, along with domestic and wild animals. There are currently no NOAA 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. *C. perfringens* also has the capability of forming spores which can persist in soils and sediments.

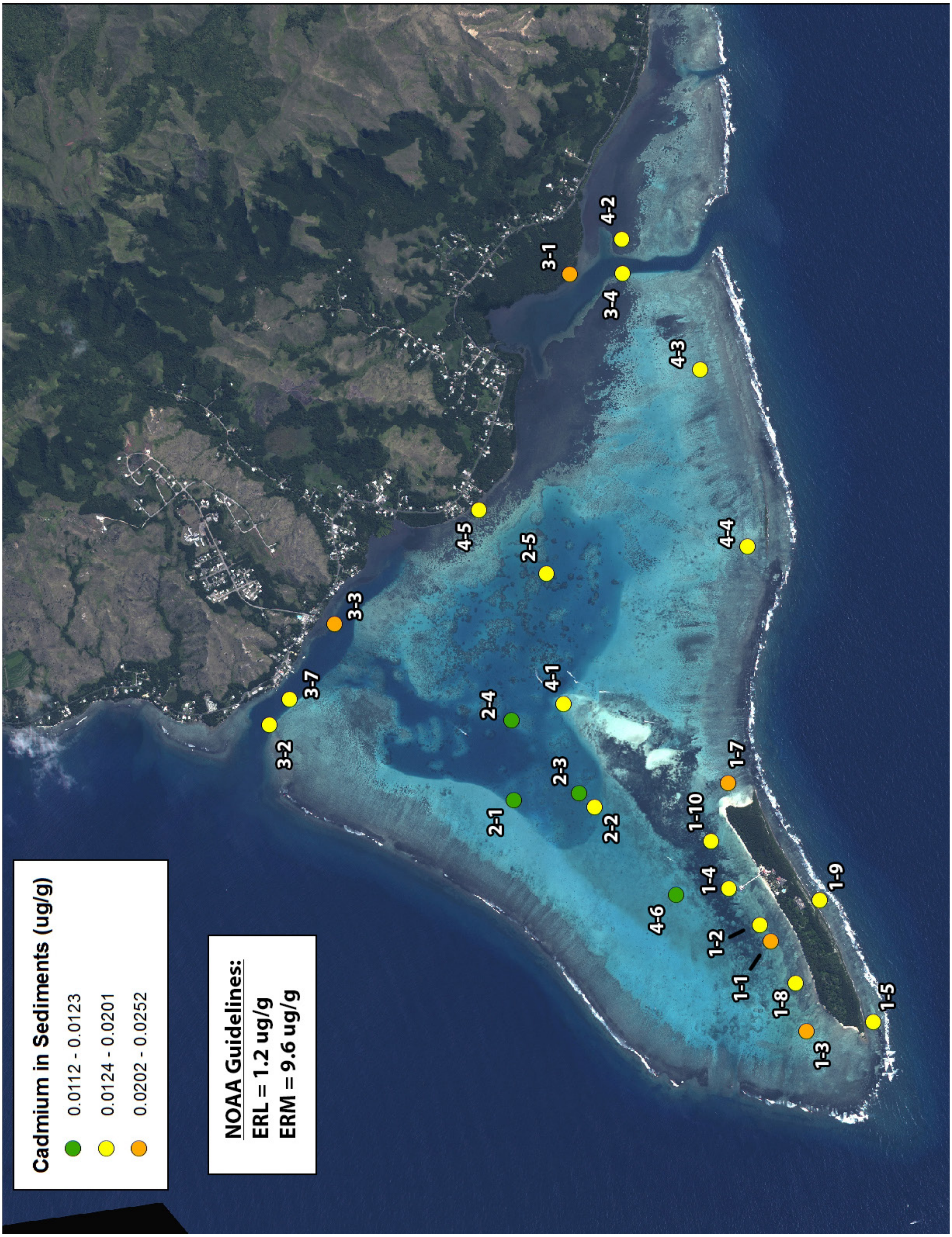


Figure 10. Cadmium found in sediments sampled in Cocos Lagoon.

Chemical Contaminants in Fish

Results from the analysis of chemical contaminants in whole fish are discussed below. A total of eight species were collected for this project. At each site, fish were composited by species. (Appendix K). A series of nonparametric statistical tests (Wilcoxon) indicated no significant differences in the concentrations of total PAH, total PCBs, total DDT or metals between fish species within a stratum, so the data for fish within a stratum were analyzed together and then compared with other strata.

Fish Consumption Guidelines

NOAA does not have guidelines to assess risk to fish species from chemical contaminants. Instead, possible risk to humans were evaluated by comparing the concentrations of chemical contaminants found in the fish with USFDA (US Food and Drug Administration) Action and Tolerance levels and with USEPA Screening Values. Table 4 includes available USFDA Action and Tolerance levels, along with USEPA Screening Values for recreational and subsistence fishers. The USFDA Action and Tolerance levels represent concentration limits at which USFDA will take legal action to remove products from the market (USFDA, 2011). The USFDA Action Levels are established according to criteria established in the Code of Federal Regulations, and then subsequently revoked once a regulation establishing a Tolerance Level becomes effective.

The USEPA Screening Values (SVs) in Table 4 were developed to provide guidance to state, local, regional and tribal environmental health officials for their contaminant monitoring programs, and for issuing fish and shellfish consumption advisories (USEPA, 2000). The SVs represent a threshold concentration of concern for a chemical contaminant in fish tissue for a critical toxic or a carcinogenic effect in humans. The SVs are based on a 70 kg body weight and for carcinogens, risk is defined as one excess cancer case per 100,000 individuals, resulting from consumption of fish contaminated with the identified contaminant. In cases where there were both carcinogenic and noncarcinogenic SVs available, the SV for the carcinogenic effect was used and included in Table 4, as recommended by the USEPA. The SVs were developed using an average fish consumption rate of 17.5 grams/day for recreational fishers, and 142.4 grams/day for subsistence fishers. Subsistence fisher SVs are lower than those for recreational fishers, as subsistence fishers consume fish at a higher rate (i.e., they eat fish more often), and therefore would potentially accumulate higher amounts of a chemical contaminant over time. Exceedances of the SVs provide an indication of when more intensive site-specific monitoring and/or evaluation of human health risk should be conducted (USEPA, 2000). As noted earlier, a fish consumption advisory was put in place for Cocos Lagoon in 2006, in response to PCBs in fish exceeding the recreational SV for PCBs.

Table 4. USFDA Action and Tolerance levels and USEPA Screening Values for chemical contaminants in fish.

Analyte	USFDA Action Level	USFDA Tolerance Level	USEPA Recreational Fishers Screening Value		USEPA Subsistence Fishers Screening Value	
			Noncarcinogenic	Carcinogenic	Noncarcinogenic	Carcinogenic
Organic Chemicals (ng/g)						
Aldrin or Dieldrin	300	–	–	2.5	–	0.307
Chlorpyrifos	–	–	1,200	–	147	–
Endosulfan (I and II)	–	–	24,000	–	2,949	–
Endrin	–	–	1,200	–	147	–
Heptachlor/Heptachlor epoxide	300	–	–	4.39	–	0.54
Hexachlorobenzene	–	–	–	250	–	3.07
Lindane	–	–	–	30.7	–	3.78
Mirex	100	–	800	–	98	
PAHs (benzo(a)pyrene)	–		–	5.47	–	0.673
Total Chlordane	300	–	–	114	–	14
Total DDT	5,000	–	–	117	–	14.4
Total PCBs	–	2,000	–	20	–	2.45
Tributyltin	–	–	1,200	–	147	–
Trace Elements (µg/g)						
Arsenic (inorganic)[1]	–	–	–	0.026	–	–
Cadmium	–	–	4	–	0.491	–
Mercury (methyl)	1	–	0.4	–	0.049	–

Note: all concentrations in wet weight; USFDA, US Food and Drug Administration; USEPA, US Environmental Protection Agency; toxic element guidance levels for arsenic, cadmium, lead, and nickel are no longer listed by the USFDA (USFDA, 2011).

[1]USEPA Guideline is for total inorganic arsenic rather than total arsenic; NOAA measures total arsenic.

Polycyclic Aromatic Hydrocarbons

Fish, like other vertebrate organisms, have a well-developed enzyme system that can metabolize xenobiotics, including alkanes, PAHs, and pesticides (Parkinson and Ogilvie, 2008), known as the cytochrome P450-dependent mixed function oxidase or P450, and initiates the metabolism of these various lipophilic compound classes as well as others (Neff, 1985). In general, the transformations that occur as a result of the P450 system tend to make the compounds more water soluble, so that they can be excreted (Lech and Vodicnik, 1985). Because of their well developed cytochrome P450 system, fish typically accumulate relatively low levels of PAHs and alkanes.

Blackspot sergeant major (*Abudefduf sordidus*) caught in the nearshore waters of Cocos Island at Site 1-4.

The mean concentration of total PAH in the fish sampled in Cocos Lagoon, was 4.98 ±0.86 ng/g (Table 5). The highest concentration of total PAH (28.6 ng/g) was found in Stratum 1 in convict tang (*Acanthurus triostegus*) at Site F1-1. The second highest total PAH concentration was in banded sergeant majors (*Abudefduf septemfasciatus*) at Site F1-3. A nonparametric Wilcoxon test indicated no difference (Chi Square = 4.2985, p = 0.2310) in total PAH concentrations in fish between strata. Additional information on total PAHs and individual alkylated hydrocarbons can be found in Appendix L and M, respectively.

The USEPA has established a Screening Value (SV) for PAHs of 5.47 ng/g for recreational fishers, and 0.673 ng/g for subsistence fishers (Table 4). To compare PAH concentrations in a sample to the Screening Values, the USEPA recommends using a series of Toxicity Equivalency Factors or TEFs, to calculate a potency-weighted total concentration or Potency Equivalency Concentration (PEC) for 14 PAHs. Toxicity is in terms of carcinogenic potential relative to benzo(a)pyrene, which has a TEF of one. Carrying out these calculations for the PAHs in the fish analyzed from Cocos Lagoon resulted in the identification of convict tang (*Acanthurus triostegus*) from Site F1-1 with a PEC of 1.23 ng/g, above the subsistence SV of 0.673 ng/g, but below the recreational SV.

No data for PAHs in fish was found in the work carried out by Environet or Element Environmental around Cocos Island.

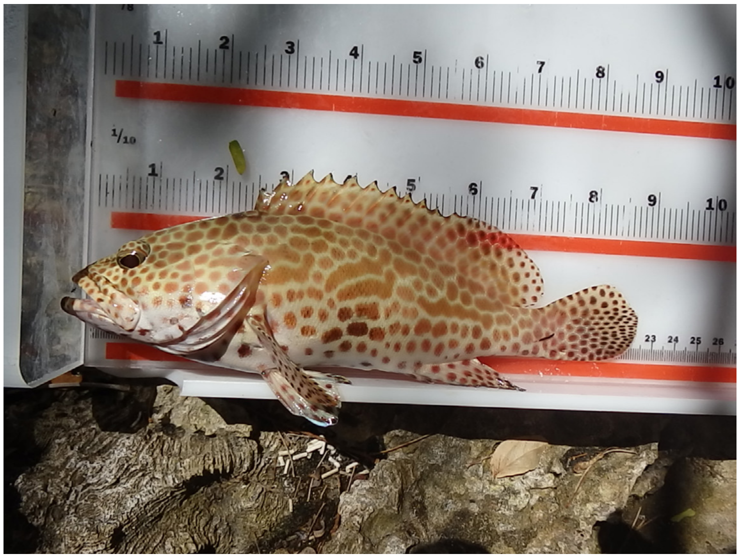
Denton *et al*. (1999) analyzed fish tissue (axial muscle and liver) from four harbors in Guam for a suite of 16 PAHs.

Table 5. Mean, minimum, and maximum concentrations of chemical contaminants in fish by stratum in Cocos Lagoon.

Contaminant	1			2			3			4			Overall		
	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.	Mean ±SE	Min.	Max.
Organic Contaminant (ng/g)															
Total PAHs	6.65 ±1.92	3	28.6	3.85 ±0.22	3.5	4.5	3.4 ±0.72	2.4	5.5	3.77 ±0.18	2.8	4.7	4.98 ±0.86	2.4	28.6
Aldrin	0.05 ±0.02	0	0.26	0.03 ±0.03	0	0.1	0.14 ±0.09	0	0.39	0.06 ±0.03	0	0.19	0.06 ±0.02	0	0.39
Total Chlordane	0.20 ±0.05	0	0.42	0.13 ±0.08	0	0.3	0..39 ±0.19	0.01	0.91	0.10 ±0.03	0	0.29	0.19 ±0.04	0	0.91
Total DDT	70.8 ±26.8	1.24	303.4	0.33 ±0.15	0.07	0.61	2.07 ±1.81	0.06	7.48	0.13 ±0.06	0	0.55	31.0 ±13.0	0	303.4
Total HCH	0.47 ±0.05	0.23	0.89	0.61 ±0.21	0.24	1.11	0.66 ±0.19	0.32	1.2	0.22 ±0.05	0	0.48	0.44 ±0.05	0	1.20
Total PCBs	61.1 ±25.3	4.51	338.1	2.80 ±0.9	1.12	4.54	3.71 ±1.44	1.05	7.69	1.07 ±0.21	0.14	2.32	27.7 ±12.0	0.14	338.1
Trace Element (µg/g)															
Cadmium	0.04±0.01	0.01	0.08	0.03 ±0.01	0.02	0.047	0.03 ±0.00	0.021	0.03	0.05 ±0.01	0.023	0.1	0.04 ±0.00	0.01	0.1
Chromium	1.48 ±0.33	0.30	4.23	1.21 ±0.23	0.94	1.91	1.13 ±0.20	0.53	1.39	0.81 ±0.18	0.12	2.00	1.20 ±0.16	0.12	4.23
Copper	0.90 ±0.15	0.41	2.48	0.76 ±0.17	0.44	1.24	0.97 ±0.37	0.55	2.07	0.65 ±0.09	0.36	1.17	0.82±0.09	0.36	2.48
Lead	0.98 ±0.38	0	3.18	0.02 ±0.01	0	0.05	0.31 ±0.29	0	1.2	0.01 ±0.00	0	0.03	0.47 ±0.18	0	3.18
Mercury	0.03 ±0.01	0.01	0.07	0.05 ±0.02	0.02	0.08	0.05 ±0.02	0.01	0.07	0.05 ±0.01	0.01	0.11	0.04 ±0.01	0.01	0.11
Nickel	0.29 ±0.04	0.09	0.63	0.17 ±0.04	0.12	0.27	0.20 ±0.08	0.09	0.43	0.14 ±0.01	0.07	0.20	0.21 ±0.02	0.07	0.63
Zinc	22.3 ±3.23	12.7	57.7	19.1 ±2.83	14.4	27.3	19.1 ±2.0	15.6	24.5	16.9 ±1.46	11.4	24.8	19.8 ±1.55	11.4	57.7

Note - all concentrations in wet weight. SE, standard error

Out of 75 fish, only 10 had detectable levels of PAHs, all in muscle tissue. Two samples from the area of Merizo (gold-saddled goatfish, *Parupeneus cyclostomus* and the manybar goatfish (*Parupeneus multifasciatus*)) had concentrations in muscle tissue of less than 1 ng/g. Denton *et al*. (1999) noted that the ability of fish to rapidly transform PAHs into more water soluble metabolites, often results in PAH levels in axial muscles close to or below the level of detection, even in moderately polluted waters.



Honeycomb grouper, (*Epinephelus merra*), collected in Stratum 1.

Polychlorinated Biphenyls

The mean total PCB concentration in the fish sampled in Cocos Lagoon was 27.7 ±12 ng/g (Table 5). The large standard error (SE) of the mean was the result of the variability of total PCBs in Cocos Lagoon. The mean concentration of total PCBs in Stratum 1 was 61.1 ng/g (Table 5). The highest concentration of total PCBs found was 338.1 ng/g in the blackspot sergeant (*Abudefduf sordidus*) sample from Site F1-4. The second highest was 137.5 ng/g in banded sergeant majors (*Abudefduf septemfasciatus*), also from Site F1-4. Detailed results from the analysis of PCBs in fish from Cocos Lagoon from this project can be found in Appendix N.

A nonparametric (Wilcoxon) test indicated a very significant difference (Chi-Square = 22.24293, $p < 0.0001$) in total PCBs between strata, and a Wilcoxon pairwise comparison indicated that total PCBs in fish from Stratum 1 were significantly higher than in strata 2, 3, and 4. The difference in concentration can be seen in Table 5; the mean total PCB concentration in the other strata were all less than 5 ng/g.

All fish were below the USFDA Tolerance Level of 2,000 ng/g (Table 4). All of the fish samples from around Cocos Island, however, were above the USEPA subsistence SV for total PCBs of 2.45 ng/g (Figure 11). In addition, nine of the thirteen fish samples or approximately 70% of the fish samples collected from around Cocos Island were also above the USEPA recreational SV of 20 ng/g for total PCBs.

In Figure 11, the species code abbreviations are color-coded to identify which fish samples were above the USEPA SV for PCBs for subsistence fishers (yellow), and which were above the recreational (red) fishers SV. From this map, it can be seen that the recreational fisher SV was exceeded in several species in waters adjacent to the southwestern portion of Cocos Island, near the area of the former LORAN station, and also once on the northeastern end of Cocos Island. Four species, including convict tang (*Acanthurus triostegus*) (At), banded sergeant (*Abudefduf septemfasciatus*) (As), blackspot sergeant (*Abudefduf sordidus*) (Aso), and honeycomb grouper (*Epinephelus merra*) (Em), were above the USEPA recreational fisher SV.

On the northeastern end of Cocos Island, orange-striped emperors *Lethrinus obsoletus* (Lo) also exceeded the recreational SV. Between 2006 and 2010, nearshore sediments in the area of sites F1-1 and F1-3 (Figure 6), may have been moved to the north side of Cocos Island, perhaps to rebuild the beaches on the northern end of Cocos Island impacted by past storms. There was a slightly elevated concentration of total PCBs in the sediment at Site 1-7 (Figure 8). However, the intentional relocation of sediments to the north side of the island could not be confirmed for this report.

Four other samples collected from around Cocos Island were above the total PCBs subsistence SV, including honeycomb grouper at Site F1-2, honeycomb grouper and blacktail snapper (*Lutjanus fulvus*) at Site F1-7 on the northern end of Cocos Island, and starspotted grouper (*Epinephelus hexagonatus*) (Eh) on the southeastern side of the island at Site F1-5 (Figure 11).

There were no other fish collected in Cocos Lagoon for this project that exceeded the recreational SV for total PCBs. There were four samples, however, all honeycomb grouper (*Epinephelus merra*) in strata 2 and 3 (Figure 11) that exceeded the subsistence SV. The highest concentration of total PCBs in these fish was 7.69 ng/g at Site F3-1, near the Merizo Pier.

Aroclors. While most of the assessments done on and around Cocos Island for PCB-related contamination, looked at individual PCBs, the work done by Environet

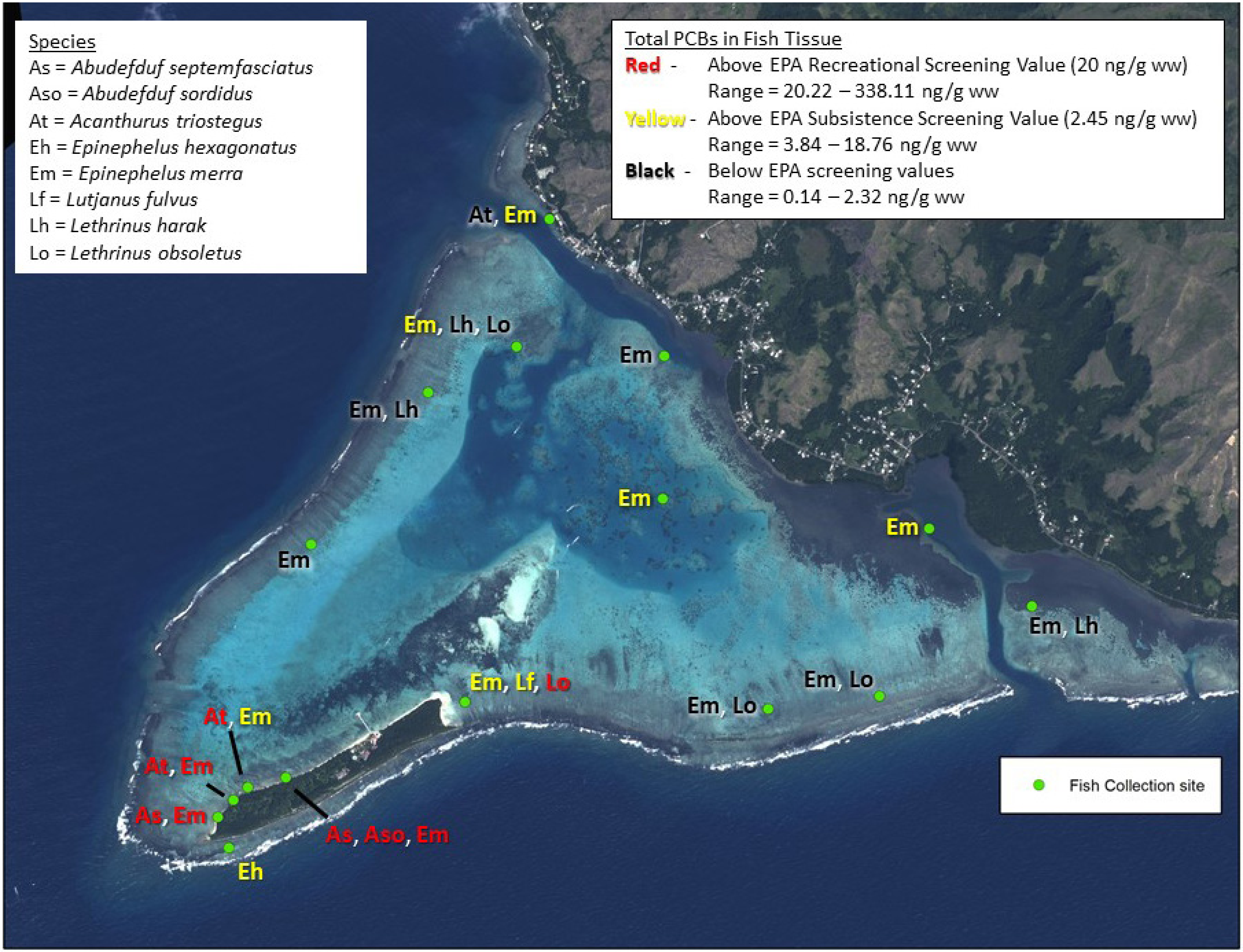


Figure 11. Total PCBs found in fish sampled in Cocos Lagoon.

(2005), examined samples for the presence of mixtures of PCBs termed Aroclors. PCB products in the US were produced by the Monsanto Corporation, and sold as Aroclor mixtures, which were named using a four digit numbering system. For Aroclor 1254, for example, the first two digits indicate the type of the mixture, and the last two digits, in this case 54, indicate the approximate percent chlorine content. (ATSDR, 2000).

Each Aroclor contained PCB homologs in certain ratios. PCB homologs are a means of grouping PCB congeners based on the number of chlorine atoms in each PCB molecule. For example, all the penta PCB homologs have 5 chlorine atoms, and would include PCB 82 through PCB 126 of the PCBs analyzed for this project (Appendix N). Hepta PCBs contain seven chlorine atoms, octa PCBs each contain eight chlorine atoms. By looking at the PCB homologs, some insights can be obtained on the PCB contamination in the fish from Cocos Lagoon in relation to the original Aroclors. In Figure 12, the PCB homologs on a percent basis for Aroclor 1254 (Figure 12a) and Aroclor 1260 (Figure 12b) are shown. Both of these Aroclors have homologs primarily in the penta through hepta range. In their work, Environet (2005) found these two Aroclors most closely matched the suite of PCBs found in the fish, noting that some degree of degradation of the PCBs in the environment likely occurred over time. In Figure 12c, the PCB homologs detected in the honeycomb grouper at Site F1-4 adjacent to Cocos Island, and at Site F3-1 adjacent to the town of Merizo, can be compared with the percent composition of the Aroclors. From Figure 12c, it can be seen that the patterns of PCB homologs in the honeycomb groupers from sites F1-4 and F3-1 appear similar to Aroclor 1254 and 1260. There are some differences, for example, a larger fraction of penta homologs, which may be an indication of the degradation of the heptachloro and hexachloro homologs in the environment over time, and perhaps some metabolism of the PCBs within the fish.

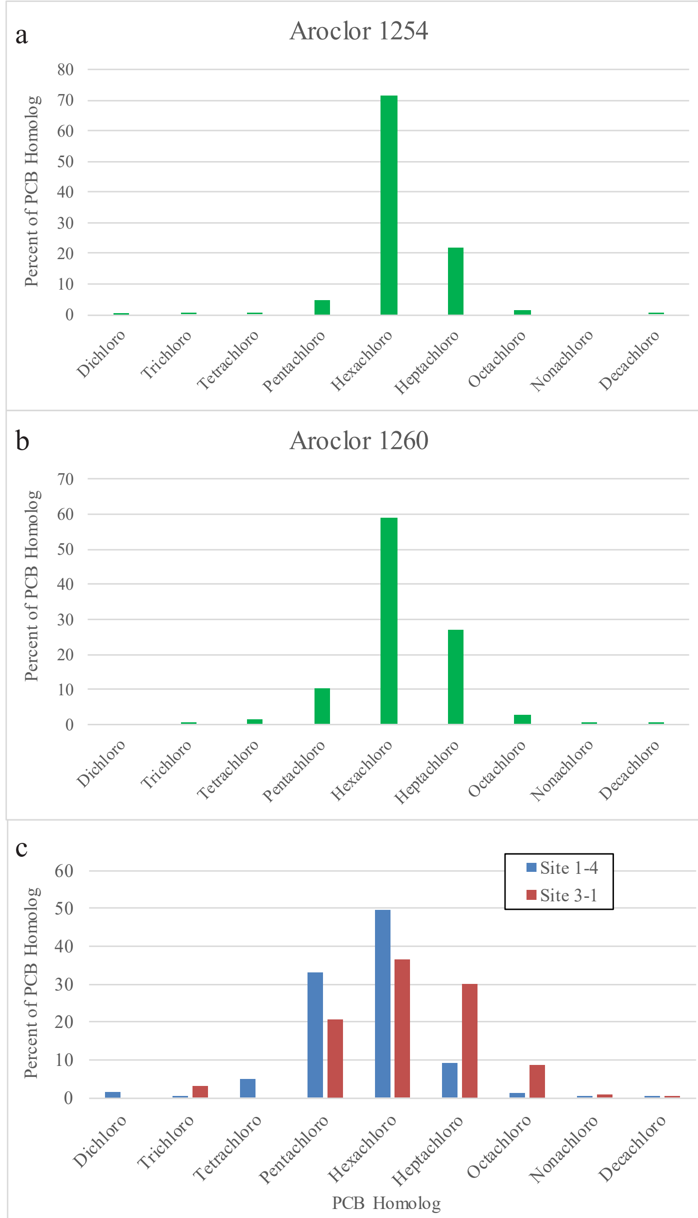


Figure 12. PCB homologs (%) in selected Aroclors (a,b), and in honeycomb grouper (*Epinephelus merra)* (c) collected in this study from Cocos Lagoon.

Figure 12c also provides an opportunity to compare the PCB homologs found in the honeycomb groupers between sites F1-4 and F3-1. The pattern of homologs between the two sites is fairly similar, although the tissues contain somewhat different ratios of the penta-, hexa- and hepta-chloro homologs. This could be an indication of different environmental conditions between the two sites resulting in differing rates of degradation of the PCBs. The concentration of total PCBs in the honeycomb grouper sample at Site F1-4 was about 38.0 ng/g; the concentration in the honeycomb groupers from Site 3-1 was 7.69 ng/g (Appendix N). The concentration of total PCBs in the honeycomb grouper at Site F3-1, was the highest of any fish sampled away from Cocos Island, although it was more than 4 times lower than the honeycomb groupers at site F1-3. Total PCBs were also slightly elevated in the sediments in this area (Figure 8). The honeycomb grouper is thought to have a fairly small home range (Loerzel, pers. comm), however, these fish could have traveled from the Cocos Island area towards Merizo. In addition, water flow through Cocos Lagoon appears to proceed in a northwest direction, with waves entering from the south (Randall *et al*., 1975). As a result, it is possible that over time, sediments containing PCBs have been transported towards Merizo, as water in Cocos Lagoon then flows out through the Mamaon Channel (and also the Manell Channel). Alternatively, there could

Table 6. PCBs that have been detected in fish from around Cocos Island.

Location	Year	Number of Samples	Percent Detections	Concentration Range	Mean	Reference
Cocos Island waters	2005	12	92	ND - 5,300	1,010	Environet, 2005
Cocos Island waters	2008	37	57	ND - 830	152.6	Element Environmental, 2008
Cocos Island waters	2013	31	90	ND - 1,114	152.6	Element Environmental, 2013
Cocos Island waters	2014	30	100	0.22 - 1,116	71.9	Element Environmental, 2014
Cocos Island waters	2015	13	100	4.51 - 338.1	61.1	This Study

Note - all values in ng/g wet weight; ND, not detected

be remnant PCB concentrations near the town of Merizo, perhaps as a result of PCB use in the past in electrical transformers containing the same Aroclors or a slightly different mixture. In any case, the PCB levels found in fish away from Cocos Island were lower.

This project appears to mark the first time that an assessment of PCBs has been conducted throughout Cocos Lagoon. The results indicated the highest PCB concentrations in the fish were from around Cocos Island, specifically adjacent to the southwestern and northern parts of the island. Total PCB concentrations in other parts of Cocos Lagoon were, for the most part, below the USEPA SVs. There does not appear to be a total PCBs contamination above recreational SVs in other parts of Cocos Lagoon, however, more work would be needed to confirm this. There were four fish samples outside of the Cocos Island area, however, whose total PCBs concentration was above the USEPA subsistence SV, which is also of concern.

The analysis of fish from around Cocos Island helps to confirm the results obtained in the studies commissioned by the USCG. Additional work is needed to better assess the occurrence and concentrations of PCBs above the subsistence SV away from Cocos Island, and whether it may be species limited, as the only fish collected that were above the subsistence SV away from Cocos Island were the honeycomb grouper *Epinephelus merra.* It could be that the honeycomb grouper more readily accumulates PCBs, although there was no significant difference in lipid content between species. Alternatively, it could be that honeycomb grouper is more mobile, and perhaps travels to other parts of Cocos Lagoon. In any case, the quantification of total PCBs in this project in fish from around Cocos Island and from other parts of Cocos Lagoon can provide valuable information for evaluating the current Guam EPA fish consumption advisory.

Table 6 summarizes results from a number of projects along with the results from the current project, for total PCBs in fish collected around Cocos Island. From the 2005 work by Environet (2005), the mean total PCBs concentration was 1,010 ng/g; 92% of the fish were above the USEPA recreational SV. Element Environmental (2008) detected total PCBs in 57% of the fish collected, with a mean of 152.6 ng/g. A number of the nondetects of total PCBs in the fish were from the eastern side of Cocos Island. In fish where total PCBs were detected, 19 were above the subsistence SV, and 14 were above the recreational SV. Element Environmental (2013) detected total PCBs in 28 of the 31 fish collected, with a mean also of 152.6 ng/g. Of those, 26 were above the USEPA subsistence SV, while 19 or 61% were above the USEPA recreational SV. In 2014, 100% of the fish collected had detectable levels of PCBs, 28 (67%) were above the USEPA subsistence SV, and 14 (33%) were above the USEPA recreational SV (Element Environmental, 2014). The mean was 71.9 ng/g.

In the current work, 100% of the fish sampled around Cocos Island had detectable concentrations of total PCBs, with a mean of 61.1 ng/g. All concentrations were above the USEPA subsistence SV, and approximately 70% of the fish samples collected around Cocos Island were above the USEPA recreational SV for total PCBs. From looking at the means in Table 6, it might be concluded that total PCBs are declining over time in fish collected from around Cocos Island, however, there are a number of important caveats. The locations of the fish collected around Cocos Island varied with each project. Some (e.g., Element Environmental, 2008) included a number of sites on the eastern side of Cocos Island where PCBs in fish were often undetectable. In 2014, Element Environmental collected fish from two locations, Area 1 which was in nearshore waters adjacent to the former LORAN station and Area 2, offshore of the former LORAN station (Element Environmental, 2014). An approach, where fish are collected from the same locations nearshore and further offshore, and then repeated periodically using one or just a few species, could provide valuable information on PCB trends in fish around Cocos Island, at least in the area of the former LORAN station.

Other work in Guam and elsewhere has documented PCB contamination in fish. Denton *et al*. (1999) analyzed a total of 20 PCBs in fish from four harbors in Guam. The concentration of total PCBs (sum of 20 congeners analyzed) ranged from 0.26 to 3.03 ng/g in muscle tissue near the Merizo Pier in Cocos Lagoon. The highest total PCBs concentration was a staggering 17,009 ng/g in the liver of a bluefin trevally, (*Caranx melampygus*) caught at Apra Harbor in Guam. In Enewetak Atoll in the Marshall Islands, PCBs in fish ranged from 22 - 392 ng/g, however these were dry weight measurements (Wang *et al*., 2011).

As noted, approximately 70% of the fish samples from around Cocos Island in the current study were above the USEPA recreational SV for total PCBs. Although an estimated 380 cubic yards of PCB-contaminated soil were removed in 2007 from the area where the former LORAN station was located, it appears that PCBs may still be available for uptake in fish. Although sediments typically serve as a reservoir for chemical contaminants that can accumulate in aquatic organisms, the sediments collected from around Cocos Island contained only low levels of PCBs (typically below 1 ppb). Because of this, sediments may not be the only source or medium through which contaminants are accumulating in the fish in the waters around Cocos Island. One possibility is that PCBs are being transported via water from Cocos Island (e.g., through surface water runoff or groundwater) and then subsequently taken up by fish. It is also possible that the fish may be accumulating contaminants through the food chain, sediments, or perhaps a combination of all three sources.

To assess the possibility that PCBs are in the water column around Cocos Island, NOAA along with Guam EPA and the USEPA are planning to deploy an array of passive water samplers known as PEDs or polyethylene devices, in the waters adjacent to Cocos Island. The PEDs accumulate low solubility chemical contaminants like PCBs from the water column, and would be deployed for a period of 30 days, and then retrieved by Guam EPA and sent to TDI-Brooks for analysis. The information generated from this project will provide local resource managers with information needed on the presence of PCBs and other organic chemical contaminants that may be making their way into the waters surrounding Cocos Island, and can help inform future assessment and restoration efforts for Cocos Island.

Danzel Narcis of Guam EPA retrieving a cast net in Stratum 1.

DDT

The mean concentration of total DDT was 31 ±13 ng/g (Table 5). A few of the fish samples from Cocos Lagoon had undetectable concentrations (Appendix O). The highest concentration of total DDT was 303.4 ng/g at Site F1-4 in Stratum 1 in blackspot sergeant majors (*Abudefduf sordidus*). This was also the same location and species where the highest total PCB concentration was found. The second highest total DDT concentration was 207.8 ng/g, also at Site F1-4, in banded sergeant majors (*Abudefduf septemfasciatus*). The majority of total DDT present was in the breakdown product DDE (Appendix O).

A nonparametric (Wilcoxon) test indicated a very significant difference (Chi-Square = 21.3808, p <0.0001) in total DDT in fish between strata, and a Wilcoxon pairwise comparison indicated the total DDT concentrations in fish from Stratum 1 were significantly higher than in strata 2, 3, and 4. The mean total DDT concentration in the other strata were all less than 3 ng/g (Table 5). Also, there were no significant differences in total DDT in fish between strata 2, 3, and 4. As with total PCBs, the highest concentrations of total DDT found in fish were around Cocos Island, and the highest concentrations were in the waters adjacent to the former LORAN station.

All of the fish caught in Cocos Lagoon were below the USFDA Action level of 5,000 ng/g for DDT (Table 4). Approximately 70% of the fish samples (9 of 13 samples) from around Cocos Island were above the USEPA subsistence SV for total DDT of 14.4 ng/g. A map showing the concentrations of total DDT in the fish samples can be found in Figure 13. Species above the USEPA subsistence SV included banded sergeant (*Abudefduf septemfasciatus*), blackspot sergeant (*Abudefduf sordidus*), convict tang (*Acanthurus triostegus*), honeycomb grouper (*Epinephelus merra*), blacktail snapper (*Lutjanus fulvus*), and orange-striped emperor (*Lethrinus obsoletus*). Of those, three samples were above the USEPA recreational SV of 117 ng/g for total DDT (Figure 13), and included two species, banded sergeant (*Abudefduf septemfasciatus*) (As), and blackspot sergeant (*Abudefduf sordidus*) (Aso).

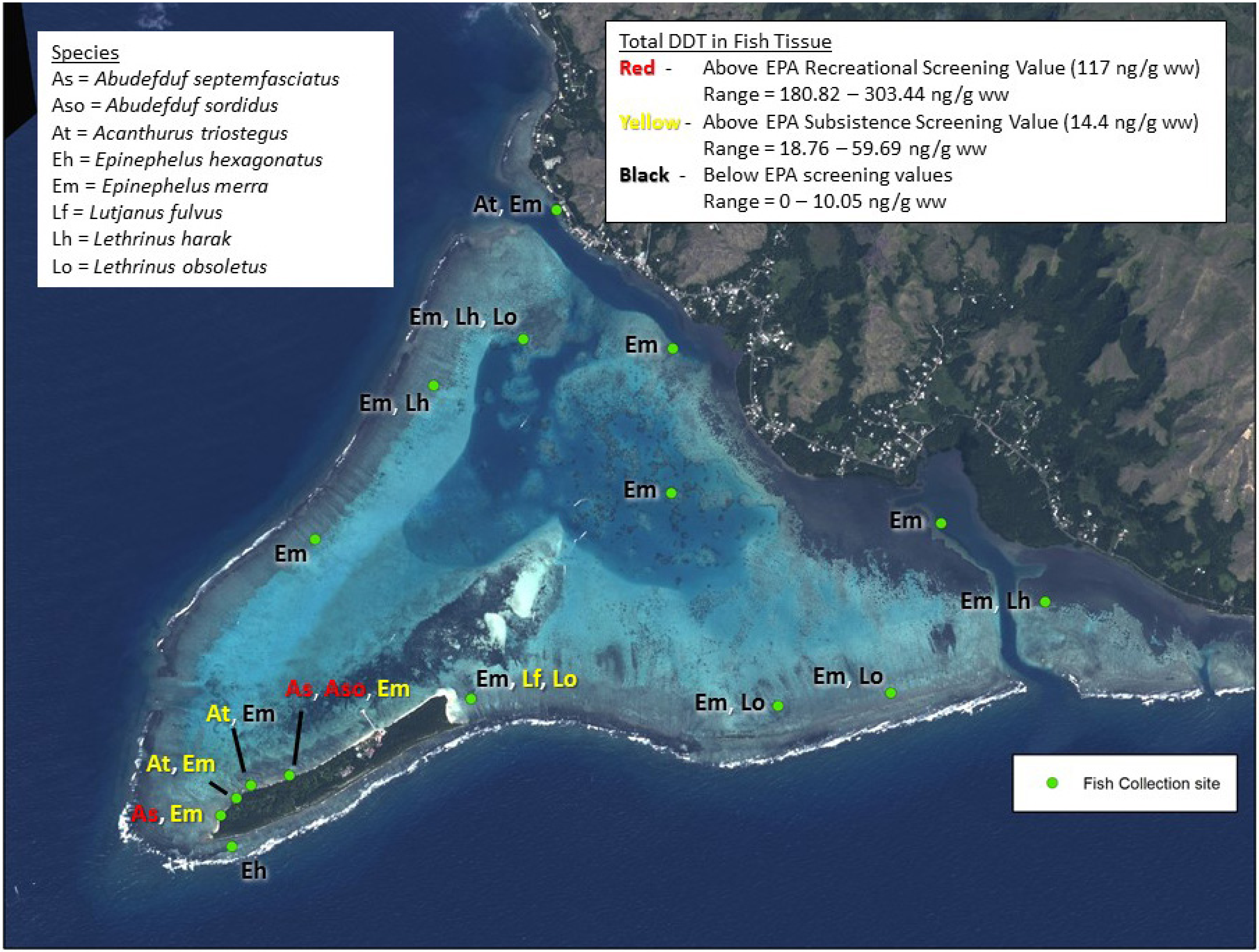


Figure 13. Total DDT found in fish sampled in Cocos Lagoon.

Similar to PCBs, the highest concentrations of total DDT occurred in the waters around Cocos Island, and would seem to reflect usage and perhaps storage or disposal of DDT on the island. DDT at the LORAN station may have been used in particular to help prevent outbreaks of malaria in USCG personnel, as there have been several outbreaks of malaria on Guam in the past (Haddock *et al*., 2010). There were also elevated concentrations of total DDT in fish collected from the northern end of Cocos Island. The highest concentration of total DDT in the strata away from Cocos Island, was 7.48 ng/g at Site F3-1 near the Merizo Pier, and could be an indication of past use of DDT in the area, or possibly migration of fish or transport of total DDT attached to sediments or dissolved in the water column as a result of the flow patterns in Cocos Lagoon.

It appears this is the first assessment of DDT in the waters around Cocos Island and also in Cocos Lagoon. This work provides an indication that in addition to PCBs in fish, the organochlorine pesticide DDT is also of concern, as a number of fish collected were above the USEPA subsistence and even the recreational SV.

Wang *et al*. (2011) analyzed six small reef fish (species not identified) from Enewetak Atoll, and found the DDE metabolite of DDT at 59 ng/g (dry weight). The authors speculated that the source of the DDE may have been from the sunken World War II ships in the area, with DDT possibly used to control pests on the ships.

Other Organochlorine Pesticides

As with sediments, a number of other organochlorine pesticides were analyzed in the fish from Cocos Lagoon (Appendix O). All of the samples analyzed had either no detection of the pesticide dieldrin or were below the method detection level. Lindane, the gamma isomer of hexachlorocyclohexane (gamma-HCH), was not detected at all in the fish collected from Cocos Lagoon. The manufacturing process for lindane also produces several byproducts or isomers, including alpha-HCH, beta-HCH, and delta-HCH. Total-HCH, the sum of these isomers varied by stratum (Chi-Square = 10.1452, $p = 0.0174$); Stratum 4 was significantly different (lower) than strata 1 and 3.

Screening Values for recreational and subsistence fishers for a number of these other chlorine-containing pesticides are included in Table 7, along with the mean, minimum, and maximum values. From this table, it can be seen that none of the samples exceeded an SV.

Butyltins

As with the sediments, there was no detection of the boat hull antifoulant ingredient tributyltin or TBT in any of the fish samples. There were two detections of monobutyltin, a breakdown product of TBT in fish at two locations, once at Site F1-1, and a second detection at Site F2-1.

Trace and Major Elements

A summary of results from the trace and major element analysis in fish can be found in Table 8 and in Appendix Q. The highest concentrations detected were for the major earth elements iron (128 µg/g) and aluminum (116 µg/g). The third highest element was zinc, (57.7 µg/g). Zinc is typically considered a trace element, and is essential for maintaining cellular function and are integral components of numerous metal-containing enzymes (Rajkowska and Protasowicki, 2013).

Table 8 includes a column indicating trace and major elements that varied by stratum. Of the 14 trace and major

Table 7. Data from Cocos Lagoon for other organochlorine-type pesticides that have established USEPA Screening Values.

Pesticide	Cocos Lagoon Mean	Cocos Lagoon Minimum	Cocos Lagoon Maximum (stratum)	USEPA Subsistence SV	USEPA Recreational SV
Total Chlordane	0.185	0	0.91 (3)	14[c]	114[c]
Dieldrin	0.009	0	0.09 (2)	0.31[c]	2.50[c]
Endosulfan (1 and II)	0.041	0	1.04 (1)	2,949	24,000
Endrin	0	0	0	147	1,200
Heptachlor Epoxide	0.015	0	0.13 (4)	0.54[c]	4.39[c]
Hexachlorobenzene	0.009	0	0.15 (4)	3.07[c]	25[c]
Lindane (γHCH)	0	0	0	3.78[c]	30.7[c]
Mirex	0.018	0	0.14 (1)	98	800
Chlorpyrifos	0.017	0	0.2 (4)	147	1,200

Note - All concentrations in ng/g wet weight. The letter c indicates carcinogenic SV; ( ) indicates stratum where highest concentration in fish was detected.

Table 8. Mean, minimum and maximum concentrations (µg/g wet wt.) of trace and major elements in fish from Cocos Lagoon.

Element	Symbol	Mean ±SE	Minimum	Maximum	Variation by Stratum?
Aluminum	Al	6.43 ±3.81	0.00	116	No
Arsenic	As	1.27 ±0.11	0.62	3.34	No
Cadmium	Cd	0.04 ±0.00	0.01	0.100	No
Chromium	Cr	1.20 ±0.16	0.12	4.23	No
Copper	Cu	0.82 ±0.09	0.36	2.48	No
Iron	Fe	29.9 ±3.97	12.1	128	No
Lead	Pb	0.47 ±0.18	0.00	3.18	Yes
Manganese	Mn	0.77 ±0.10	0.30	3.30	No
Mercury	Hg	0.04 ±0.01	0.01	0.11	No
Nickel	Ni	0.21 ±0.02	0.07	0.63	Yes
Selenium	Se	0.38 ±0.02	0.08	0.51	No
Silver	Ag	0.00 ±0.00	0.00	0.02	No
Tin	Sn	0.00 ±0.00	0.00	0.03	No
Zinc	Zn	19.8 ±1.55	11.4	57.7	No

Abbreviation: SE, standard error

elements in Table 8, only lead (Chi-Square = 14.2236, p = 0.0026) and nickel (Chi-Square = 7.9262, p = 0.0476) varied by stratum across Cocos Lagoon. Fish from Stratum 1 had significantly higher lead concentrations than fish from Stratum 4. For nickel, fish from Stratum 1 were again significantly higher than those analyzed from Stratum 4.

Environet (2005) detected lead in soil samples on Cocos Island at concentrations ranging from 466 to as high as 2,120 µg/g, and during their work they also found and removed several lead acid batteries. In 2008, lead was again detected in surface soils, with a mean concentration of 5.84 µg/g, and a range between 0.57 and 24 µg/g (Element Environmental, 2008). Environet (2005) detected lead in fish around Cocos Island at concentrations ranging from 0.58 to 6.9 µg/g. In the current study, the concentration of lead in fish from Stratum 1 ranged from not detected to 3.17 µg/g.

The USFDA no longer lists guidance levels for arsenic, cadmium, lead, and nickel (USFDA, 2011), and while there are no USEPA Screening Values for lead, it might be useful to monitor lead in the fish around Cocos Island, to see if concentrations decrease over time. Nickel was also significantly different across the strata in Cocos Lagoon (Chi-Square = 7.9262, p = 0.0476), with Stratum 1 having a higher level of nickel in the fish than Stratum 4, although the highest concentration of nickel detected in the fish was less than 1 µg/g.

Cadmium was found in a soil sample on Cocos Island by Environet (2005) at a concentration of 136 mg/kg. Concentrations of cadmium in fish in the current study ranged from 0.052 - 0.087 µg/g. A map of the cadmium concentrations detected in the fish in the current study is shown in Figure 14. The USEPA subsistence SV for cadmium is 0.491 µg/g, the recreational SV is 4.0 µg/g. Although Environet (2005) had detected elevated cadmium earlier in the soils on Cocos Island (as high as 136 µg/g), none of the concentrations of cadmium detected in the fish in the current study were above either of the SVs.

SUMMARY AND CONCLUSIONS

The goal of this project was to quantify the concentration of various chemical contaminants in sediments and in fish tissue throughout Cocos Lagoon, Guam as requested by local resource managers. Between 1944 and 1963, the US Coast Guard operated a Long Range Navigation (LORAN) Station on Cocos Island at the southern end of Cocos Lagoon, and the presence of chemical contaminants discovered on the island and in nearshore waters are thought to be the result of the use and disposal of materials from the LORAN station.

For this project, a total of 25 sediment samples and 30 fish samples were collected throughout Cocos Lagoon. Samples of both sediment and fish were analyzed for 191 chemical contaminants including 81 polychlorinated biphenyls or PCBs. The analysis of PCBs was important as these chemical contaminants had been detected in previous studies, both on Cocos Island and in adjacent waters, and were of particular concern to environmental managers and the public. The protocols used for collecting and analyzing the samples were those established by NOAA's National Status and Trends Program (NS&T), which monitors the presence and effects of chemical contaminants in the Nation's coastal waters. Whole fish were analyzed for this project to be consistent with previous work done to assess chemical contaminants in fish around Cocos Island.

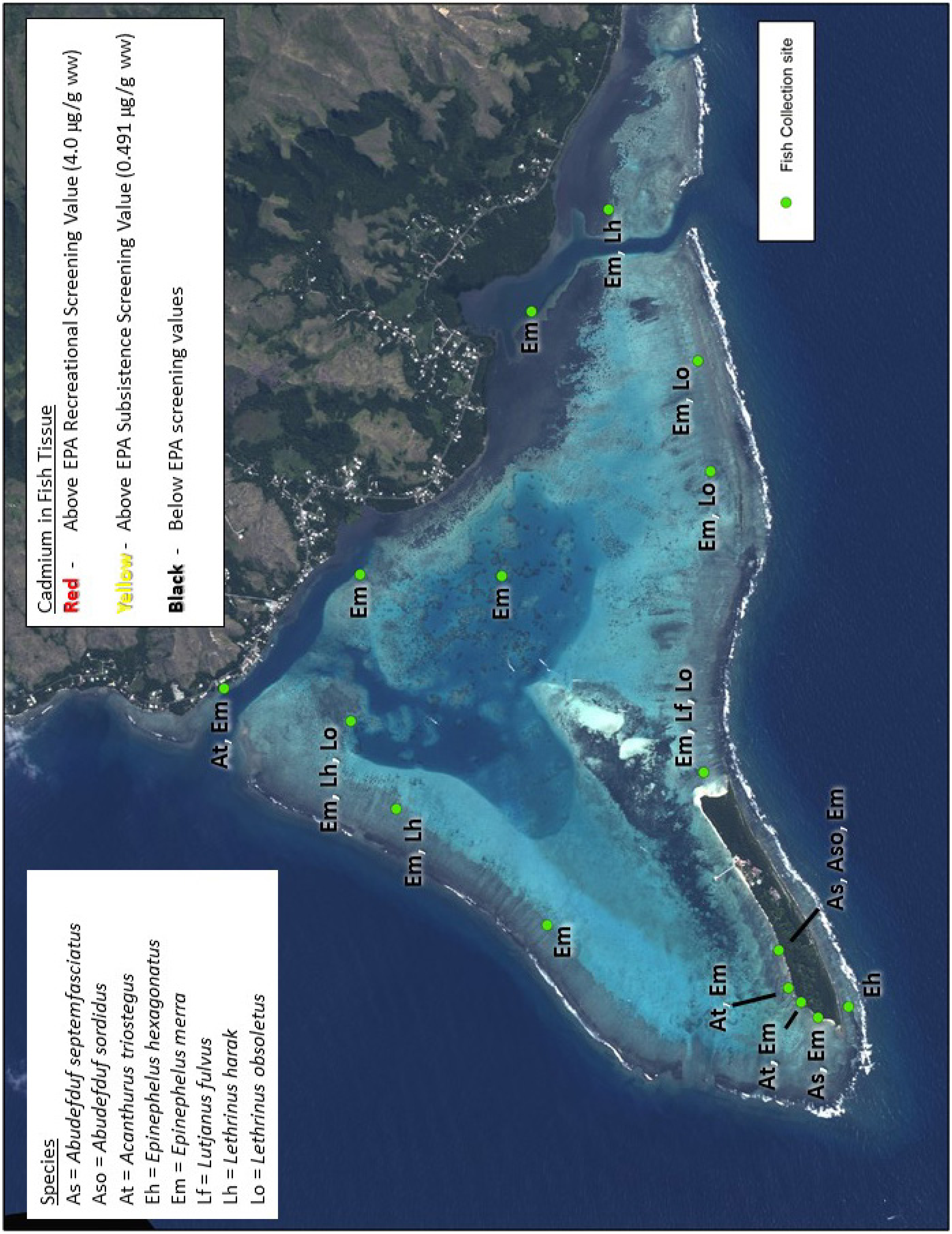


Figure 14. Cadmium found in fish sampled in Cocos Lagoon.

The results indicated that for the most part, the sediments in Cocos Lagoon contained only low levels of chemical contaminants. There was one sediment sample collected adjacent to Cocos Island that was above a NOAA sediment quality guideline for the pesticide DDT, indicating that effects were possible in more sensitive life stages or species inhabiting the sediments.

Elevated concentrations of several chemical contaminants, however, were found in fish sampled from Cocos Lagoon, particularly in the area of Cocos Island. NOAA does not have guidelines to assess risk to fish from chemical contaminants. Instead, we assessed possible risk to humans consuming the fish by comparing the concentrations of chemical contaminants found in the fish with human health screening values (SVs) established by the USEPA for recreational and subsistence fishers. A subsistence SV is lower than the recreational SV, as subsistence fishers consume fish at a higher rate (i.e., they eat fish more often), and therefore would potentially accumulate higher amounts of chemical contaminants over time. The SVs represent a threshold concentration of concern for a chemical contaminant in fish tissue for a critical toxic or a carcinogenic effect in humans. When available, the SV for the carcinogenic effect was used, as recommended by the USEPA.

Second Guam EPA boat used for sampling in Cocos Lagoon, Guam.

Using this approach, all 13 of the fish samples from around Cocos Island were above the subsistence SV for total PCBs (sum of the PCBs analyzed). Nine of theses fish samples were also above the recreational SV for total PCBs. The USEPA has indicated that exceedance of SVs is an indication that more intensive site-specific monitoring or evaluations of human health risk should be conducted.

There were four additional fish samples collected in other parts of Cocos Lagoon that were above the subsistence SV for total PCBs It is not known if these fish may have migrated from the Cocos Island area, or if contaminated sediments or water from the Cocos Island area had been transported there over time, or if the PCBs present in the fish represent contamination from local sources, possibly from past use of PCBs, for example, in the Merizo area.

This project has also identified a second contaminant of concern in the fish around Cocos Island, the organochlorine insecticide DDT. Although this pesticide has been banned since the 1970s, total DDT, which is the sum of the DDT-related compounds analyzed, was found at elevated concentrations in fish around Cocos Island. The majority of the total DDT present was in the form of DDE, one of the breakdown products from the original or parent DDT insecticide. Three fish samples from around Cocos Island were above the recreational SV for total DDT; an additional seven fish samples from around Cocos Island were above the subsistence fisher SV for total DDT. The use of DDT on Cocos Island may have been to protect USCG personnel from mosquitoes carrying malaria. Although there were fish samples containing total DDT above the subsistence and even the recreational SVs from around Cocos Island, there were no other fish samples collected in Cocos Lagoon that were above either the subsistence or recreational SVs for total DDT. From this, it appears that the concentrations of concern for total DDT in fish could be localized to the Cocos Island area.

The results from this project appear to indicate that the highest concentrations of total PCBs and total DDT in fish are around Cocos Island, and not distributed throughout Cocos Lagoon. All of the exceedances of either the USEPA recreational SVs or NOAA sediment quality guidelines were from samples taken around Cocos Island, specifically in the area adjacent to the former LORAN station, and along the north shore of Cocos Island.

Although the sediments from around Cocos Island contained low levels of chemical contaminants, it appears that PCBs and DDT are still available for uptake in fish, nearly 10 years after removal of approximately 380 cubic yards of PCB-contaminated soil from the island. Sediments typically serve as a reservoir for chemical contaminants that can accumulate in aquatic organisms, however, sediments may not be the only source or medium through which contaminants are accumulating in the fish in the waters around Cocos Island, as sediments collected for this project contained low levels of total PCBs and total DDT around Cocos Island. A follow-up project involving NOAA, Guam EPA and the USEPA will result in the deployment of passive water samplers in the nearshore waters around Cocos Island. The goal of the project will be to assess whether PCBs and perhaps DDT are being transported in the water column either as a result of surface water runoff that might occur after a rainfall event, or through some type of groundwater inputs from Cocos Island containing dissolved concentrations of contaminants like PCBs and DDT, that could subsequently be taken up by fish and other marine organisms in the area. Results from this effort should be available in late 2018.

The results from this project help confirm the findings from earlier efforts to assess contamination in fish and sediments from around Cocos Island, and along with the additional information generated by this project for other parts of Cocos Lagoon, can be used in evaluating the current Guam EPA fish consumption advisory.

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Appendix A. Site and water quality data from sediment sampling sites in Cocos Lagoon.

Stratum	Site	Site Type	Date	Depth (m)	Measured Latitude (DD)	Measured Longitude (DD)	Surface Temperature (°C)	Bottom Temperature (°C)	Surface Salinity (psu)	Bottom Salinity (psu)	Surface DO (mg/L)	Bottom DO (mg/L)	Secchi Depth (m)
1	1	S	5/5/2015	0.9	13.23909	144.64949	28.3	–	34.5	–	5.4	–	Bottom
1	2	S	5/5/2015	0.8	13.24005	144.65109	28.8	–	33.7	–	6.2	–	Bottom
1	3	S	5/5/2015	0.8	13.23743	144.64485	30.1	–	34.3	–	7.1	–	Bottom
1	4	S	5/5/2015	0.9	13.24175	144.65332	29.3	–	34.3	–	6.7	–	Bottom
1	5	S	5/5/2015	N/A	13.23347	144.64519	30.2	29.7	34.1	34.3	8.0	8.4	N/A
1	7	S	5/12/2015	1.0	13.24202	144.65920	29.5	–	34.3	–	6.9	–	Bottom
1	8	S	5/12/2015	1.4	13.23824	144.64761	29.8	–	34.1	–	8.1	–	Bottom
1	9	S	5/8/2015	0.7	13.23655	144.65239	30.2	–	34.0	–	8.8	–	Bottom
1	10	S	5/12/2015	1.8	13.24313	144.65565	29.9	29.9	33.8	34.2	8.0	7.9	Bottom
2	1	S	5/6/2015	6.6	13.25199	144.66779	28.5	28.5	34.4	34.4	5.0	5.1	N/A
2	2	S	5/6/2015	9.0	13.25465	144.65952	28.4	28.4	34.5	34.3	4.8	3.8	N/A
2	3	S	5/6/2015	6.4	13.25298	144.66162	29.1	28.8	34.6	34.3	5.6	4.3	4.5
2	4	S	5/8/2015	3.0	13.25435	144.66272	28.7	28.7	34.3	34.3	4.2	4.0	N/A
2	5	S	5/8/2015	8.3	13.25823	144.66234	29.0	29.0	31.5	34.4	5.0	4.0	6.2
3	1	S	5/7/2015	8.7	13.25287	144.68518	29.3	28.9	33.3	34.4	5.0	4.2	2.8
3	2	S	5/7/2015	7.6	13.26696	144.66359	29.8	29.0	34.4	34.5	7.1	4.7	6.5
3	3	S	5/8/2015	16.4	13.26421	144.66821	29.1	28.9	33.9	34.4	5.1	3.3	N/A
3	4	S	5/7/2015	6.2	13.24995	144.68781	29.3	28.6	34.4	34.2	4.9	2.0	3.2
3	7	S	5/8/2015	15.3	13.26702	144.66377	29.4	28.9	33.7	34.4	6.4	4.1	N/A
4	1	S	5/6/2015	2.9	13.25179	144.66353	N/A	28.6	N/A	34.2	N/A	5.2	N/A
4	2	S	5/7/2015	0.9	13.24835	144.69067	28.9	–	34.3	–	6.6	–	Bottom
4	3	S	5/7/2015	1.3	13.24405	144.68245	24.6	–	34.1	–	7.2	–	Bottom
4	4	S	5/6/2015	1.4	13.24269	144.67238	28.9	–	33.8	–	6.6	–	Bottom
4	5	S	5/12/2015	0.6	13.25632	144.67494	32.7	–	34.5	–	8.6	–	Bottom
4	6	S	5/6/2015	2.2	13.24504	144.65248	29.28	–	34.1	–	6.0	–	Bottom

Site Type: S, sediment; –, site too shallow for bottom measurements; N/A, not available

Appendix B. Site and water quality data from fish sampling sites in Cocos Lagoon.

Stratum	Site	Site Type	Date	Depth (m)	Measured Latitude (DD)	Measured Longitude (DD)	Surface Temperature (°C)	Bottom Temperature (°C)	Surface Salinity (psu)	Bottom Salinity (psu)	Surface DO (mg/L)	Bottom DO (mg/L)	Secchi Depth (m)
1	1	F	5/5/2015	0.5	13.23643	144.64610	29.2	–	33.3	–	7.21	–	Bottom
1	2	F	5/5/2015	0.2	13.23716	144.64690	31.2	–	33.3	–	10.08	–	Bottom
1	3	F	5/5/2015	0.3	13.23549	144.64522	30.1	–	33.4	–	8.25	–	Bottom
1	4	F	5/5/2015	0.2	13.23771	144.64905	32.2	–	33.3	–	11.8	–	Bottom
1	5	F	5/5/2015	0.5	13.23379	144.64586	30.7	–	33.2	–	9.69	–	Bottom
2	1	F	5/7/2015	4.3	13.25342	144.67029	28.3	28.3	31.8	33	5.14	5.13	Bottom
2	2	F	5/7/2015	3.0	13.26178	144.66194	28.9	28.7	33.0	33.1	5.94	5.66	Bottom
3	1	F	5/7/2015	0.5	13.26890	144.66374	31.4	–	32.03	–	10.47	–	Bottom
3	2	F	5/8/2015	5.2	13.25190	144.68544	29.5	29.0	32.9	33.2	5.82	2.86	1.8
3	3	F	5/8/2015	0.9	13.26135	144.67032	29.5	–	32.7	–	6.36	–	Bottom
4	1	F	5/6/2015	0.6	13.24256	144.68271	28.8	28.8	33.2	33.2	6.51	6.54	Bottom
4	2	F	5/6/2015	0.9	13.24179	144.67641	29.1	29.1	33.2	33.2	7.35	7.35	Bottom
4	3	F	5/6/2015	0.3	13.25920	144.65694	29.7	–	33.2	–	8.32	–	Bottom
4	4	F	5/6/2015	0.6	13.25069	144.65036	29.9	30.0	33.1	33.1	8.59	8.68	Bottom
4	5	F	5/8/2015	0.9	13.24764	144.69133	28.5	28.5	31.9	31.9	5.53	5.87	Bottom

Site Type. F, fish. –, site too shallow for bottom measurements.

Appendix C. Grain size (%) and organic carbon (%) in sediments from Cocos Lagoon, Guam.

Site	Total Organic Carbon (%TOC)	Total Inorganic Carbon (%TIC)	%Gravel*	%Sand	%Silt	%Clay
1-1	5.73	6.06	12.81	85.52	0.17	1.50
1-2	4.40	7.37	4.90	93.20	0.10	1.80
1-3	4.69	7.12	2.03	95.99	0.64	1.34
1-4	3.55	8.30	12.14	85.71	0.52	1.63
1-5	3.52	8.16	0.00	97.91	0.12	1.97
1-7	1.28	10.49	12.83	83.95	1.35	1.87
1-8	3.88	7.97	4.53	93.79	0.46	1.22
1-9	5.81	5.95	22.71	75.45	0.32	1.52
1-10	5.11	6.67	5.90	92.10	0.77	1.23
2-1	1.77	9.86	0.00	93.58	4.14	2.28
2-2	1.19	10.43	0.00	94.84	2.44	2.72
2-3	1.56	10.15	0.00	96.15	1.98	1.87
2-4	2.56	9.10	0.00	95.32	3.36	1.32
2-5	2.66	8.93	0.00	93.37	4.06	2.57
3-1	1.13	8.34	0.00	75.62	13.93	10.45
3-2	4.33	7.36	11.22	86.47	1.02	1.29
3-3	0.73	5.51	0.00	82.07	13.42	4.51
3-4	2.12	9.05	0.00	95.23	2.71	2.06
3-7	NA	NA	30.54	67.40	1.19	0.87
4-1	4.73	7.02	2.13	96.01	1.05	0.81
4-2	3.55	8.09	12.34	84.50	1.72	1.44
4-3	2.77	9.00	10.45	87.94	0.91	0.70
4-4	4.22	7.58	4.46	93.86	0.63	1.05
4-5	3.20	8.55	11.88	84.47	1.38	2.27
4-6	4.20	7.64	6.00	92.03	0.81	1.16
5-7	3.98	7.81	NA	NA	NA	NA

NA, not available;

*Gravel constituent for all samples was composed of shell hash.

Appendix D. PAHs detected in sediments from Cocos Lagoon, Guam (ng/dry g).

	Sites								
Compound	1-1	1-2	1-3	1-4	1-5	1-7	1-8	1-9	1-10
Naphthalene	0.175 J	0.140 J	0.190 J	0.147 J	0.241 J	0.238 J	0.181 J	0.225 J	0.184 J
C1-Naphthalenes	0.0951 J	0.0816 J	0.122 J	0.0882 J	0.0871 J	0.130 J	0.108 J	0.0945 J	0.0960 J
C2-Naphthalenes	0.235 J	0.280 J	0.238 J	0.227 J	0.437 J	0.507 J	0.501 J	0.502 J	0.340 J
C3-Naphthalenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Naphthalenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzothiophene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C1-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Biphenyl	0.839	0.697	0.757	0.166 J	0.200 J	0.971	0.852	0.353	0.327
Acenaphthylene	0.0431	0.0307 J	0.0349 J	0.0307 J	0.00 U	0.0420	0.0378 J	0.0396 J	0.0358 J
Acenaphthene	0.00 U	0.000 U	0.0271 J	0.00 U	0.00 U	0.0204 J	0.00 U	0.00 U	0.00 U
Dibenzofuran	0.588	0.422	0.472	0.149 J	0.124 J	0.514	0.606	0.187 J	0.179 J
Fluorene	0.0364 J	0.0378 J	0.0840 J	0.0534 J	0.0485 J	0.0775 J	0.0728 J	0.0462 J	0.0663 J
C1-Fluorenes	0.00 U	0.0454 J	0.0739 J	0.00 U	0.0573 J	0.00 U	0.00 U	0.00 U	0.00 U
C2-Fluorenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Fluorenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Carbazole	0.0488 J	0.0418 J	0.0537 J	0.0476 J	0.235	0.0588 J	0.0509 J	0.0800 J	0.0477 J
Anthracene	0.0334 J	0.0270 J	0.0376 J	0.0204 J	0.0165 J	0.0302 J	0.0310 J	0.0268 J	0.0240 J
Phenanthrene	0.224	0.222	0.500	0.309	0.256	0.419	0.494	0.390	0.360
C1-Phenanthrenes/Anthracenes	0.105	0.0962	0.188	0.139	0.121	0.177	0.211	0.193	0.182
C2-Phenanthrenes/Anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.327
C3-Phenanthrenes/Anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.158 J
C4-Phenanthrenes/Anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Dibenzothiophene	0.0329 J	0.0310 J	0.0517 J	0.0287 J	0.0260 J	0.0465 J	0.0484 J	0.0376 J	0.0351 J
C1-Dibenzothiophenes	0.00 U	0.0297 J	0.0457 J	0.0332 J	0.0319 J	0.0406 J	0.0493 J	0.0513 J	0.0441 J
C2-Dibenzothiophenes	0.00 U	0.0713 J	0.0911 J	0.0444 J	0.0465 J	0.0796 J	0.0949 J	0.0854 J	0.0915 J
C3-Dibenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Dibenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Fluoranthene	0.161 J	0.0729 J	0.140 J	0.105 J	0.0744 J	0.127 J	0.161 J	0.132 J	0.132 J
Pyrene	0.124 J	0.0421 J	0.0724 J	0.0668 J	0.0345 J	0.0651 J	0.0808 J	0.0624 J	0.0870 J
C1-Fluoranthenes/Pyrenes	0.0748 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.0869 J
C2-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.0816 J
C3-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.0712 J
C4-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Naphthobenzothiophene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C1-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benz(a)anthracene	0.0975 J	0.0450 J	0.0493 J	0.0515 J	0.00 U	0.0632 J	0.00 U	0.00 U	0.0657 J
Chrysene/Triphenylene	0.0619 J	0.00940 J	0.0243 J	0.0203 J	0.00 U	0.0346 J	0.00 U	0.00 U	0.0462 J
C1-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzo(b)fluoranthene	0.0732 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
Benzo(k,j)fluoranthene	0.0499 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
Benzo(a)fluoranthene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzo(e)pyrene	0.0446 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
Benzo(a)pyrene	0.0649 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
Perylene	0.0356 J	0.00 U	0.00 U	0.00 U	0.0114 J	0.00 U	0.00 U	0.00 U	0.00 U
Indeno(1,2,3-c,d)pyrene	0.0548	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Dibenzo(a,h)anthracene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C1-Dibenzo(a,h)anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Dibenzo(a,h)anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Dibenzo(a,h)anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzo(g,h,i)perylene	0.0541 J	0.0257 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Total PAHs	3.35	2.45	3.25	1.73	2.05	3.64	3.58	2.51	3.07

Notes: J, below method detection level, MDL; U, not detected

Appendix D. PAHs detected in sediments from Cocos Lagoon, Guam (ng/dry g) (continued).

	Site								
Compound	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3	3-4
Naphthalene	0.381	0.272 J	0.280 J	0.284 J	0.391	1.28	0.553	0.236 J	0.272 J
C1-Naphthalenes	0.233 J	0.103 J	0.137 J	0.148 J	0.254 J	0.774 J	0.479 J	0.121 J	0.166 J
C2-Naphthalenes	0.396 J	0.235 J	0.214 J	0.277 J	0.337 J	1.52	0.992	0.262 J	0.304 J
C3-Naphthalenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	2.75	1.02	0.00 U	0.00 U
C4-Naphthalenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzothiophene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C1-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Benzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Biphenyl	0.858	0.105 J	0.190 J	0.369	0.247 J	0.621	0.285 J	0.189 J	0.209 J
Acenaphthylene	0.00 U	0.00 U	0.00 U	0.00 U	0.0470	0.202	0.0886	0.0166 J	0.0408
Acenaphthene	0.00 U	0.00 U	0.00 U	0.00 U	0.112	0.254	0.199	0.0384 J	0.0509 J
Dibenzofuran	0.639	0.150 J	0.183 J	0.232	0.385	0.910	0.842	0.194 J	0.247
Fluorene	0.269	0.110 J	0.123 J	0.0799 J	0.359	0.743	0.535	0.0957 J	0.150 J
C1-Fluorenes	0.139 J	0.0903 J	0.0971 J	0.00 U	0.213 J	0.312 J	0.302 J	0.0908 J	0.137 J
C2-Fluorenes	0.00 U	0.00 U	0.00 U	0.00 U	0.368	0.00 U	0.00 U	0.00 U	0.00 U
C3-Fluorenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Carbazole	0.0867 J	0.00 U	0.0719 J	0.0583 J	0.0797 J	0.430	0.170	0.0784 J	0.0675 J
Anthracene	0.0477 J	0.0192 J	0.0207 J	0.0202 J	0.0481 J	0.295	0.117	0.0336 J	0.0265 J
Phenanthrene	1.33	0.561	0.645	0.392	1.54	2.54	1.79	0.512	0.744
C1-Phenanthrenes/Anthracenes	0.448	0.198	0.244	0.148	0.514	1.29	0.598	0.236	0.303
C2-Phenanthrenes/Anthracenes	0.506	0.00 U	0.216 J	0.00 U	0.00 U	0.870	0.650	0.00 U	0.275 J
C3-Phenanthrenes/Anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.398	0.00 U	0.00 U	0.0983 J
C4-Phenanthrenes/Anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Dibenzothiophene	0.281	0.0429 J	0.0459 J	0.109 J	0.176	0.175	0.0881 J	0.0462 J	0.0563 J
C1-Dibenzothiophenes	0.0875	0.0378 J	0.0384 J	0.0382 J	0.0916	0.130	0.0842	0.0453 J	0.0356 J
C2-Dibenzothiophenes	0.130 J	0.0731 J	0.0609 J	0.0597 J	0.126 J	0.198 J	0.142 J	0.0682 J	0.0722 J
C3-Dibenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Dibenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Fluoranthene	0.263 J	0.140 J	0.178 J	0.0961 J	0.322 J	1.42	0.519	0.169 J	0.222 J
Pyrene	0.128 J	0.0882 J	0.0837 J	0.0500 J	0.174	1.00	0.320	0.0873 J	0.112 J
C1-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.0784 J	0.861	0.211 J	0.00 U	0.0808 J
C2-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Fluoranthenes/Pyrenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Naphthobenzothiophene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C1-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Naphthobenzothiophenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benz(a)anthracene	0.0602 J	0.0533 J	0.00 U	0.0490 J	0.0725 J	0.414	0.160 J	0.0717 J	0.0482 J
Chrysene/Triphenylene	0.0300 J	0.0249 J	0.00 U	0.0129 J	0.0344 J	0.554	0.188	0.0262 J	0.0320 J
C1-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.0412 J	0.298	0.135 J	0.00 U	0.00 U
C2-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C4-Chrysenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzo(b)fluoranthene	0.00 U	0.00 U	0.00 U	0.00 U	0.0655 J	1.09	0.384	0.0661 J	0.0741 J
Benzo(k,j)fluoranthene	0.00 U	0.00 U	0.00 U	0.00 U	0.0177 J	0.229	0.136	0.0380 J	0.0145 J
Benzo(a)fluoranthene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzo(e)pyrene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.431	0.172 J	0.0478 J	0.00 U
Benzo(a)pyrene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.400	0.154	0.0464 J	0.00 U
Perylene	0.00 U	0.00 U	0.0368 J	0.00 U	0.0808 J	0.966 J	0.765 J	0.0791 J	0.0762 J
Indeno(1,2,3-c,d)pyrene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.378	0.172	0.0880	0.00 U
Dibenzo(a,h)anthracene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.172	0.0681	0.0957	0.00 U
C1-Dibenzo(a,h)anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C2-Dibenzo(a,h)anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C3-Dibenzo(a,h)anthracenes	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Benzo(g,h,i)perylene	0.00 U	0.00 U	0.00 U	0.00 U	0.0824 J	0.548	0.223	0.131	0.0507 J
Total PAHs	6.31	2.30	2.87	2.42	6.25	24.5	12.5	3.21	3.97

Notes: J, below method detection level, MDL; U, not detected

Appendix D. PAHs detected in sediments from Cocos Lagoon, Guam (ng/dry g) (continued).

	Site													
Compound	4-1		4-2		4-3		4-4		4-5		4-6		5-7	
Naphthalene	0.232	J	0.241	J	0.211	J	0.224	J	0.232	J	0.195	J	0.370	
C1-Naphthalenes	0.0712	J	0.157	J	0.0963	J	0.113	J	0.0864	J	0.0769	J	0.185	J
C2-Naphthalenes	0.00	U	0.242	J	0.00	U	0.124	J	0.00	U	0.525	J	0.329	J
C3-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Biphenyl	0.262	J	0.446		0.296		0.212	J	0.188	J	0.196	J	0.374	
Acenaphthylene	0.00	U	0.0325	J	0.0299	J	0.0311	J	0.00	U	0.0314	J	0.00	U
Acenaphthene	0.00	U	0.0476	J	0.00	U	0.0295	J	0.00	U	0.0286	J	0.00	U
Dibenzofuran	0.151	J	0.327		0.171	J	0.201	J	0.233		0.106	J	0.352	
Fluorene	0.0384	J	0.158	J	0.0565	J	0.111	J	0.0566	J	0.0460	J	0.167	J
C1-Fluorenes	0.00	U	0.103	J	0.00	U	0.00	U	0.0630	J	0.00	U	0.114	J
C2-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Carbazole	0.0390	J	0.0675	J	0.0444	J	0.0459	J	0.104	J	0.0376	J	0.105	J
Anthracene	0.0150	J	0.0183	J	0.0152	J	0.0233	J	0.0300	J	0.0133	J	0.0612	J
Phenanthrene	0.206	J	0.813		0.300		0.592		0.338		0.234		0.835	
C1-Phenanthrenes/Anthracenes	0.0963		0.297		0.134		0.223		0.156		0.0974		0.310	
C2-Phenanthrenes/Anthracenes	0.00	U	0.591		0.189	J	0.00	U	0.00	U	0.219	J	0.419	
C3-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzothiophene	0.0226	J	0.0543	J	0.0314	J	0.0444	J	0.0390	J	0.0256	J	0.0812	J
C1-Dibenzothiophenes	0.0295	J	0.0478	J	0.0322	J	0.0538	J	0.0415	J	0.0294	J	0.0635	J
C2-Dibenzothiophenes	0.0433	J	0.0709	J	0.0562	J	0.0941	J	0.00	U	0.0578	J	0.128	J
C3-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Fluoranthene	0.0724	J	0.206	J	0.0716	J	0.133	J	0.111	J	0.0677	J	0.232	J
Pyrene	0.0408	J	0.0767	J	0.0406	J	0.0655	J	0.0826	J	0.0390	J	0.144	
C1-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.0936	J	0.00	U	0.00	U
C2-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Naphthobenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benz(a)anthracene	0.0376	J	0.0510	J	0.0462	J	0.0469	J	0.00	U	0.0417	J	0.0902	J
Chrysene/Triphenylene	0.00800	J	0.0225	J	0.00880	J	0.00850	J	0.00	U	0.00430	J	0.0729	J
C1-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(k,j)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(e)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Perylene	0.00	U	0.00	U	0.00	U	0.04	J	0.00	U	0.0340	J	0.118	J
Indeno(1,2,3-c,d)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzo(a,h)anthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(g,h,i)perylene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Total PAHs	1.37		4.07		1.83		2.41		1.86		2.10		4.55	

Notes: J, below method detection level, MDL; U, not detected

Appendix E. Individual alkyl isomers and hopanes detected in sediments from Cocos Lagoon, Guam (ng/dry g).

	Sites																	
Compound	1-1		1-2		1-3		1-4		1-5		1-7		1-8		1-9		1-10	
2-Methylnaphthalene	0.0901	J	0.0780	J	0.114	J	0.0783	J	0.0759	J	0.126	J	0.103	J	0.0870	J	0.0888	J
1-Methylnaphthalene	0.0443	J	0.0371	J	0.0588	J	0.0473	J	0.0484	J	0.0576	J	0.0493	J	0.0470	J	0.0473	J
2,6-Dimethylnaphthalene	0.240	J	0.304		0.175	J	0.245	J	0.431		0.492		0.557		0.508		0.306	
1,6,7-Trimethylnaphthalene	0.00	U	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-Methylfluorene	0.00	U	0.0219	J	0.0416	J	0.00	U	0.0247	J	0.00	U	0.00	U	0.00	U	0.00	U
4-Methyldibenzothiophene	0.00	U	0.0201	J	0.0331	J	0.0184	J	0.0184	J	0.0241	J	0.0313	J	0.0348	J	0.0267	J
2/3-Methyldibenzothiophene	0.00	U	0.0140	J	0.0172	J	0.0145	J	0.0128	J	0.0162	J	0.0227	J	0.0230	J	0.0195	J
1-Methyldibenzothiophene	0.00	U	0.0089	J	0.0158	J	0.0151	J	0.0149	J	0.0184	J	0.0172	J	0.0163	J	0.0176	J
3-Methylphenanthrene	0.0322	J	0.0280	J	0.0644	J	0.0467	J	0.0444	J	0.0637	J	0.0692	J	0.0707	J	0.0555	J
2-Methylphenanthrene	0.0433	J	0.0409	J	0.0808	J	0.0572	J	0.0540	J	0.0757	J	0.0898	J	0.0840	J	0.0799	J
2-Methylanthracene	0.0101	J	0.0071	J	0.00640	J	0.00720	J	0.00660	J	0.0101	J	0.0131	J	0.00220	J	0.00750	J
4/9-Methylphenanthrene	0.0257	J	0.0232	J	0.0468	J	0.0377	J	0.0268	J	0.0407	J	0.0495	J	0.0461	J	0.0536	J
1-Methylphenanthrene	0.0229	J	0.0241	J	0.0423	J	0.0298	J	0.0230	J	0.0367	J	0.0489	J	0.0449	J	0.0370	J
3,6-Dimethylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.0613	J
Retene	0.00	U	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-Methylfluoranthene	0.0149	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.0128	J
Benzo(b)fluorene	0.0179	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.0143	J
C29-Hopane	1.38		1.34		1.08		1.08		0.00	U	4.10		1.14		0.00	U	0.987	
18a-Oleanane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C30-Hopane	1.48		1.38		1.18		1.48		0.00	U	4.86		1.49		0.00	U	1.10	
C20-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C21-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20R)/C27(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C27(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Notes: J, below method detection level, MDL; U, not detected

*Individual isomers contained in alkylated (C1-C4) sums

Appendix E. Individual alkyl isomers and hopanes detected in sediments from Cocos Lagoon, Guam (ng/dry g) (cont.).

	Site								
Compound	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3	3-4
2-Methylnaphthalene	0.212 J	0.0992 J	0.126 J	0.131 J	0.225 J	0.716 J	0.432 J	0.108 J	0.146 J
1-Methylnaphthalene	0.119 J	0.0673 J	0.0677 J	0.0809 J	0.130 J	0.359 J	0.235 J	0.0616 J	0.0857 J
2,6-Dimethylnaphthalene	0.232 J	0.103 J	0.108 J	0.161 J	0.246 J	1.36	0.539	0.220 J	0.227 J
1,6,7-Trimethylnaphthalene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.113 J	0.118 J	0.00 U	0.00 U
1-Methylfluorene	0.0930 J	0.0444 J	0.0441 J	0.00 U	0.100 J	0.164 J	0.156 J	0.0394 J	0.0558 J
4-Methyldibenzothiophene	0.0661 J	0.0267 J	0.0247 J	0.0228 J	0.0687 J	0.0976	0.0623 J	0.0338 J	0.0221 J
2/3-Methyldibenzothiophene	0.0370 J	0.0188 J	0.0143 J	0.0167 J	0.0392 J	0.0532 J	0.0335 J	0.0166 J	0.0160 J
1-Methyldibenzothiophene	0.0234 J	0.00830 J	0.0166 J	0.0158 J	0.0249 J	0.0371 J	0.0264 J	0.0154 J	0.0136 J
3-Methylphenanthrene	0.153	0.0641 J	0.0789 J	0.0472 J	0.163	0.317	0.187	0.0649 J	0.0850 J
2-Methylphenanthrene	0.191	0.0865 J	0.117	0.0651 J	0.224	0.806	0.274	0.0917 J	0.126
2-Methylanthracene	0.0108 J	0.00600 J	0.00550 J	0.00590 J	0.0180 J	0.0681 J	0.0247 J	0.0386 J	0.0450 J
4/9-Methylphenanthrene	0.122	0.0575 J	0.0548 J	0.0346 J	0.144	0.253	0.159	0.0564 J	0.0688 J
1-Methylphenanthrene	0.0977	0.0423 J	0.0571 J	0.0373 J	0.113	0.217	0.126	0.0518 J	0.0653 J
3,6-Dimethylphenanthrene	0.0592 J	0.00 U	0.0628 J	0.00 U	0.00 U	0.102 J	0.0412 J	0.00 U	0.0754 J
Retene	0.00 U	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-Methylfluoranthene	0.00 U	0.00 U	0.00 U	0.00 U	0.0203 J	0.107 J	0.04 J	0.00 U	0.0138 J
Benzo(b)fluorene	0.00 U	0.00 U	0.00 U	0.00 U	0.00870 J	0.113 J	0.0356 J	0.00 U	0.0097 J
C29-Hopane	0.922	0.00 U	0.746	0.739	0.944	0.00 U	1.66	0.00 U	0.00 U
18a-Oleanane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C30-Hopane	1.21	0.00 U	1.29	0.844	1.53	0.00 U	2.12	0.00 U	0.00 U
C20-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C21-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C26(20S)-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C26(20R)/C27(20S)-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C28(20S)-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C27(20R)-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
C28(20R)-TAS	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U

Notes: J, below method detection level, MDL; U, not detected

*Individual isomers contained in alkylated (C1-C4) sums

Appendix E. Individual alkyl isomers and hopanes detected in sediments from Cocos Lagoon, Guam (ng/dry g) (cont.).

	Site													
Compound	4-1		4-2		4-3		4-4		4-5		4-6		5-7	
2-Methylnaphthalene	0.0590	J	0.141	J	0.0795	J	0.0983	J	0.0770	J	0.0661	J	0.157	J
1-Methylnaphthalene	0.0414	J	0.0780	J	0.0562	J	0.0594	J	0.0435	J	0.0417	J	0.103	J
2,6-Dimethylnaphthalene	0.00	U	0.154	J	0.00	U	0.132	J	0.00	U	0.620		0.285	
1,6,7-Trimethylnaphthalene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1-Methylfluorene	0.00	U	0.0565	J	0.00	U	0.00	U	0.0231	J	0.00	U	0.0565	J
4-Methyldibenzothiophene	0.0169	J	0.0321	J	0.0220	J	0.0372	J	0.0290	J	0.0170	J	0.0460	J
2/3-Methyldibenzothiophene	0.0112	J	0.0176	J	0.0118	J	0.0227	J	0.0158	J	0.0147	J	0.0260	J
1-Methyldibenzothiophene	0.0147	J	0.0196	J	0.0131	J	0.0183	J	0.0153	J	0.0110	J	0.0201	J
3-Methylphenanthrene	0.0295	J	0.0966	J	0.0358	J	0.0698	J	0.0420	J	0.0362	J	0.100	
2-Methylphenanthrene	0.0419	J	0.138		0.0507	J	0.0962	J	0.0740	J	0.0428	J	0.135	
2-Methylanthracene	0.00340	J	0.00700	J	0.0220	J	0.00550	J	0.0161	J	0.00340	J	0.0126	J
4/9-Methylphenanthrene	0.0273	J	0.0731	J	0.0339	J	0.0591	J	0.0358	J	0.0219	J	0.0844	J
1-Methylphenanthrene	0.0219	J	0.0679	J	0.0303	J	0.0564	J	0.0336	J	0.0211	J	0.0669	J
3,6-Dimethylphenanthrene	0.00	U	0.0464	J	0.0524	J	0.00	U	0.00	U	0.0575	J	0.0463	J
Retene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2-Methylfluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.0109	J	0.00	U	0.00	U
Benzo(b)fluorene	0.00	U	0.00	U	0.00	U	0.00	U	0.00740	J	0.00	U	0.00	U
C29-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
18a-Oleanane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C30-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C20-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C21-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20R)/C27(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C27(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Notes: J, below method detection level, MDL; U, not detected

*Individual isomers contained in alkylated (C1-C4) sums

Appendix F. Polychlorinated biphenyls (PCBs) detected in sediments from Cocos Lagoon, Guam (ng/dry g).

	Sites																
Compound	1-1	1-2	1-3	1-4	1-5	1-7	1-8	1-9	1-10	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3
PCB1	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB7/9	0.11	0.10	0.10	0.12	0.10	0.13	0.13	0.10	0.11	0.11	0.00 U	0.00 U	0.11	0.00 U	0.09	0.00 U	0.00 U
PCB8/5	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB15	0.00 U	0.00 U	0.00 U	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	0.00 U
PCB16/32	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB18	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	0.00 U	0.04 J	0.05	0.00 U
PCB22/51	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB24/27	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB25	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB26	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB28	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB29	0.05 J	0.02 J	0.02 J	0.02 J	0.00 U	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
PCB31	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB33/53/20	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB40	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB41/64	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB42/59/37	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB43	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB44	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB45	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB46	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB47/48/75	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB49	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.03 J	0.00 U	0.00 U
PCB52	0.00 U	0.00 U	0.00 U	0.00 U	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	0.02 J	0.02 J	0.02 J	0.00 U
PCB56/60	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB66	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB70	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB74/61	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	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB77	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB81	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.10	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB82	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB83	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB84	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB85	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB86	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB87/115	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB88	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB92	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB95	0.00 U	0.04 J	0.00 U	0.00 U	0.00 U	0.00 U	0.04 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
PCB97	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB99	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.03 J	0.00 U	0.00 U	0.02 J
PCB101/90	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.06	0.07	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U	0.00 U	0.10	0.09	0.00 U
PCB105	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.03 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	0.00 U
PCB107	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB110/77	0.00 U	0.00 U	0.00 U	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	0.01 J	0.00 U	0.00 U
PCB114/131/122	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB118	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.05 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.02 J	0.00 U
PCB126	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB128	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB129/126	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB136	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB138/160	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.06 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	0.00 U
PCB141/179	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U
PCB146	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB149/123	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.03 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	0.00 U
PCB151	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB153/132	0.00 U	0.00 U	0.00 U	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	0.00 U
PCB156/171/202	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB158	0.00 U	0.00 U	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	0.00 U	0.00 U
PCB166	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB167	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB169	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB170/190	0.21	0.18	0.17	0.14	0.11	0.18	0.17	0.12	0.15	0.23	0.00 U	0.10	0.07 J	0.10	0.12	0.11	0.08 J
PCB172	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB174	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB176/137	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB177	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB178	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB180	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.03 J	0.04 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
PCB183	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB185	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB187	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	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB189	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB191	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB194	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB195/208	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB196/203	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB199	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB200	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB201/157/173	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	0.00 U	0.00 U	0.00 U	0.00 U
PCB205	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB206	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB209	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	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	0.37 J	0.34 J	0.29 J	0.29 J	0.23 J	1.12 J	0.48 J	0.24 J	0.26 J	0.34 J	0.03 J	0.22 J	0.18 J	0.16 J	0.43 J	0.29 J	0.10 J

Notes: J, below method detection level, MDL; U, not detected

Appendix F. Polychlorinated biphenyls (PCBs) detected in sediments from Cocos Lagoon, Guam (ng/dry g) (cont.).

	Site							
Compound	3-4	4-1	4-2	4-3	4-4	4-5	4-6	5-7
PCB1	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB7/9	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB8/5	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB15	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB16/32	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB18	0.00 U	0.00 U	0.00 U	0.05	0.06	0.00 U	0.00 U	0.00 U
PCB22/51	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB24/27	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB25	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB26	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB28	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB29	0.00 U	0.01 J	0.00 U	0.00 U	0.04 J	0.01 J	0.03 J	0.02 J
PCB31	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB33/53/20	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB40	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB41/64	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.05 J	0.00 U	0.00 U
PCB42/59/37	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB43	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB44	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB45	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB46	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB47/48/75	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB49	0.00 U	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U	0.00 U
PCB52	0.02 J	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U	0.01 J
PCB56/60	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB66	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB70	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB74/61	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB77	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB81	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB82	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB83	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB84	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB85	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB86	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB87/115	0.02 J	0.02 J	0.01 J	0.00 U	0.00 U	0.02 J	0.02 J	0.05 J
PCB88	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB92	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB95	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB97	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U	0.00 U
PCB99	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB101/90	0.05	0.04 J	0.00 U	0.00 U	0.04 J	0.00 U	0.00 U	0.00 U
PCB105	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB107	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB110/77	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U
PCB114/131/12	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB118	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB126	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB128	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB129/126	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB136	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB138/160	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB141/179	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB146	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB149/123	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB151	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB153/132	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U
PCB156/171/20	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB158	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB166	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB167	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB169	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB170/190	0.07 J	0.11	0.08 J	0.04 J	0.09 J	0.06 J	0.05 J	0.07 J
PCB172	0.01 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB174	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB176/137	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB177	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB178	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U	0.00 U
PCB180	0.01 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB183	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB185	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB187	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB189	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB191	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB194	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB195/208	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB196/203	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB199	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB200	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB201/157/17	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB205	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB206	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB209	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	0.18 J	0.18 J	0.09 J	0.09 J	0.27 J	0.16 J	0.12 J	0.15 J

Notes: J, below method detection level Notes: J, below method detection level, MDL; U, not detected

Appendix G. Organochlorine compounds (other than PCBs) detected in sediments from Cocos Lagoon, Guam (ng/dry g).

	Sites																	
Compound	1-1		1-2		1-3		1-4		1-5		1-7		1-8		1-9		1-10	
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
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	0.00	U	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	0.00	U	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	0.01	J	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	0.04	J	0.04	J	0.04	J	0.04	J	0.17		0.05	J	0.04	J	0.08		0.04	J
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	0.11	
4,4'-DDD	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.02	J	0.01	J	0.00	U	0.00	U
2,4'-DDE	0.04	J	0.05	J	0.07		0.04	J	0.00	U	0.05	J	0.04	J	0.00	U	0.05	J
4,4'-DDE	0.03	J	0.02	J	0.05		0.07		0.00	U	0.05		0.07		0.00	U	0.05	
2,4'-DDT	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.01	J	0.00	U	0.00	U	5.56	
4,4'-DDT	0.00	U	0.00	U	0.05		0.00	U	0.00	U	0.00	U	0.08		0.00	U	0.04	J
1,2,3,4-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
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	0.04	J	0.04	J	0.04	J	0.04	J	0.17		0.05	J	0.04	J	0.08	J	0.04	J
Total Chlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.01	J	0.00	U	0.00	U	0.00	U
Total DDT	0.07	J	0.07	J	0.17		0.11	J	0.00	U	0.13	J	0.20		0.00	U	5.81	

Notes: J, below method detection level, MDL; U, not detected

Appendix G. Organochlorine compounds (other than PCBs) detected in sediments from Cocos Lagoon, Guam (ng/dry g) (cont.).

	Site								
Compound	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3	3-4
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	0.04 J
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	0.03 J	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	0.00 U	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	0.00 U	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	0.01 J	0.00 U	0.00 U	0.00 U
Alpha-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.03 J	0.03 J	0.03 J	0.03 J	0.00 U
Beta-HCH	0.07	0.04 J	0.10	0.07	0.04 J	0.06	0.06	0.00 U	0.04 J
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	0.02 J
4,4'-DDD	0.00 U	0.00 U	0.01 J	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
2,4'-DDE	0.08	0.00 U	0.02 J	0.02 J	0.00 U	0.05 J	0.00 U	0.01 J	0.01 J
4,4'-DDE	0.33	0.00 U	0.01 J	0.01 J	0.00 U	0.04 J	0.05	0.00 U	0.01 J
2,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.02 J
4,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	0.00 U	0.01 J
1,2,3,4-Tetrachlorobenzene	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.03 J	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	0.01 J	0.03 J	0.02 J	0.00 U	0.01 J
Pentachloroanisole	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.04 J	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	0.01 J	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	0.07 J	0.04 J	0.10	0.07 J	0.07 J	0.09 J	0.09 J	0.03 J	0.04 J
Total Chlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.04 J	0.00 U	0.00 U	0.00 U
Total DDT	0.41	0.00 U	0.04 J	0.03 J	0.00 U	0.09 J	0.07 J	0.01 J	0.07 J

Notes: J, below method detection level, MDL; U, not detected

Appendix G. Organochlorine compounds (other than PCBs) detected in sediments from Cocos Lagoon, Guam (ng/dry g) (cont.).

	Site						
Compound	4-1	4-2	4-3	4-4	4-5	4-6	5-7
Aldrin	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
Endrin	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
Heptachlor-Epoxide	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
Alpha-Chlordane	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
Trans-Nonachlor	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
Alpha-HCH	0.03 J	0.04 J	0.03 J	0.03 J	0.03 J	0.03 J	0.03 J
Beta-HCH	0.04 J	0.05 J	0.06	0.05 J	0.03 J	0.03 J	0.07
Delta-HCH	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J	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
DDMU	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
4,4'-DDD	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J
2,4'-DDE	0.01 J	0.02 J	0.00 U	0.02 J	0.01 J	0.02 J	0.00 U
4,4'-DDE	0.00 U	0.01 J	0.00 U	0.00 U	0.00 U	0.01 J	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
4,4'-DDT	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.01 J
1,2,3,4-Tetrachlorobenzene	0.00 U	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	0.00 U
Hexachlorobenzene	0.00 U	0.01 J	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
Pentachlorobenzene	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
Endosulfan I	0.00 U	0.00 U	0.45	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
Mirex	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
Total HCH	0.07 J	0.09	0.09 J	0.08 J	0.06 J	0.07 J	0.10
Total Chlordane	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
Total DDT	0.01 J	0.03 J	0.00 U	0.02 J	0.01 J	0.03 J	0.02 J

Notes: J, below method detection level, Notes: J, below method detection level, MDL; U, not detected

Appendix H. Butyltins detected in sediments from Cocos Lagoon, Guam (ng Sn/dry g).

	Site																			
	1-1		1-2		1-3		1-4		1-5		1-7		1-8		1-9		1-10		2-1	
Monobutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

	Site																			
	2-2		2-3		2-4		2-5		3-1		3-2		3-3		3-4		4-1		4-2	
Monobutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

	Site									
	4-3		4-4		4-5		4-6		5-7	
Monobutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

Appendix I. Trace and major elements in sediments from Cocos Lagoon, Guam (µg/dry g).

	Site						
	1-1	1-2	1-3	1-4	1-5	1-7	1-8
Aluminum (Al)	5.62	18.1	41.8	22.6	33.9	52.6	33.5
Chromium (Cr)	2.39	2.73	1.31	1.73	0.697	1.17	2.08
Iron (Fe)	134	139	198	132	182	197	159
Zinc (Zn)	0.405	0.385	1.02	0.735	0.653	3.27	0.797
Copper (Cu)	0.65	8.62	2.95	1.72	0.774	0.821	1.27
Nickel (Ni)	0.719	0.797	0.835	0.798	0.828	0.767	1.02
Lead (Pb)	0.141	0.644	0.865	0.2	0.693	1.7	0.56
Antimony (Sb)	0.0433	0.0458	0.0379	0.0458	0.0239	0.0502	0.0438
Selenium (Se)	0 U	0 U	0 U	0 U	0 U	0.0411	0 U
Tin (Sn)	0 U	0.0259	0.0316	0 U	0.0622	0.0254	0.0452
Silver (Ag)	0.0139	0 U	0 U	0 U	0.00875	0 U	0 U
Arsenic (As)	1.61	1.89	1.52	1.9	2.09	2	2.16
Cadmium (Cd)	0.0234	0.0166	0.0234	0.0182	0.015	0.0252	0.0202
Manganese (Mn)	4.36	3.5	4.93	3.49	6.92	6.65	4.77
Silicon (Si)	0 U	0 U	539	0 U	0 U	0 U	0 U
Mercury (Hg)	0 U	0 U	0 U	0 U	0 U	0.00165	0 U

Note: U, not detected

	Site						
	1-9	1-10	2-1	2-2	2-3	2-4	2-5
Aluminum (Al)	11.9	80.4	1,110	953	794	918	1,200
Chromium (Cr)	0.216	2.25	3.61	4.72	4.17	2.78	3.95
Iron (Fe)	807	197	1,420	1,260	1,020	1,200	1,490
Zinc (Zn)	0.49	2.4	1.9	1.68	1.35	1.52	2.01
Copper (Cu)	0.915	0.872	1.85	10.6	1.58	1.69	2.04
Nickel (Ni)	0.961	1.06	2.27	2.31	1.97	1.93	2.78
Lead (Pb)	2.13	0.365	0.364	0.911	0.302	0.291	0.391
Antimony (Sb)	0.0291	0.0637	0.0794	0.0729	0.0696	0.0863	0.0803
Selenium (Se)	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Tin (Sn)	0.0851	0.024	0.06	0.0524	0.0262	0.039	0.0327
Silver (Ag)	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Arsenic (As)	1.91	2.26	2.99	2.55	2.91	2.95	3.27
Cadmium (Cd)	0.0176	0.0177	0.0124	0.0164	0.0122	0.0117	0.0152
Manganese (Mn)	7.47	4.5	18.6	17.5	14.8	13.6	20
Silicon (Si)	553	736	2,970	2,490	2,060	2,500	2,940
Mercury (Hg)	0 U	0 U	0.00117	0.00126	0 U	0.00138	0.00168

Note: U, not detected

Appendix I. Trace and major elements in sediments from Cocos Lagoon, Guam (µg/dry g) (cont.).

	Site						
	3-1	3-2	3-3	3-4	4-1	4-2	4-3
Aluminum (Al)	20,500	481	34,600	4,560	157	1,090	510
Chromium (Cr)	9.8	2.98	218	3.92	1.83	1.74	1.17
Iron (Fe)	23,100	698	38,100	5,790	292	1,380	677
Zinc (Zn)	29.9	1.24	42.9	6.79	0.52	2.53	0.877
Copper (Cu)	33.3	5.46	25.9	6.39	1.07	2.18	1.44
Nickel (Ni)	23.6	1.91	68.1	5.14	1.1	2.21	1.42
Lead (Pb)	1.79	0.751	1.54	0.381	0.147	0.328	0.23
Antimony (Sb)	0.18	0.0659	0.178	0.116	0.0555	0.149	0.073
Selenium (Se)	0.206	0 U	0.164	0 U	0 U	0.0836	0 U
Tin (Sn)	0.249	0.0438	0.266	0.0797	0 U	0.0309	0.0197
Silver (Ag)	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Arsenic (As)	8.42	2.22	9.97	3.96	2.45	2.77	2.1
Cadmium (Cd)	0.0235	0.0186	0.025	0.0162	0.0171	0.0183	0.0166
Manganese (Mn)	268	16.7	367	50.3	5.23	21.5	11.8
Silicon (Si)	51,700	1,330	82,600	11,000	532	2,480	1,290
Mercury (Hg)	0.0142	0 U	0.011	0.00217	0 U	0.00141	0 U

Note: U, not detected

	Site			
	4-4	4-5	4-6	5-7
Aluminum (Al)	225	1,040	87.8	613
Chromium (Cr)	1.66	1.86	2.95	3.12
Iron (Fe)	405	1,590	205	864
Zinc (Zn)	0.93	2.73	0.399	1.34
Copper (Cu)	1.14	2.03	1.12	2.72
Nickel (Ni)	1.2	2.13	1.09	2.12
Lead (Pb)	0.298	0.676	0.218	0.285
Antimony (Sb)	0.0793	0.136	0.0604	0.0713
Selenium (Se)	0 U	0 U	0 U	0 U
Tin (Sn)	0.0266	0.352	0.0173	0.0323
Silver (Ag)	0 U	0 U	0 U	0 U
Arsenic (As)	1.86	4.55	2.42	2.17
Cadmium (Cd)	0.0174	0.0154	0.0112	0.0167
Manganese (Mn)	10.2	33.2	5.02	15.8
Silicon (Si)	603	2,780	0 U	1,620
Mercury (Hg)	0 U	0.00116	0 U	0.00152

Note: U, not detected

Appendix J. *Clostridium perfringens* in sediments from Cocos Lagoon, Guam.

Site	Sample composition	% water	% sediment	Cperf dry (CFU/g)
1-1	damp sand	19.54	80.46	0
1-2	wet sand	26.39	73.61	0
1-3	damp sand	28.94	71.06	0
1-4	wet sand	27.59	72.41	0
1-5	wet sand	37.85	62.15	0
1-7	damp sand	23.32	76.68	0
1-8	wet sand	20.69	79.31	6
1-9	sandy	26.76	73.24	0
1-10	damp sand	21.31	78.69	0
2-1	sandy	23.53	76.47	0
2-2	wet sand	36.22	63.78	0
2-3	sand	23.73	76.27	0
2-4	damp sand	24.68	75.32	0
2-5	sand	26.68	73.32	19
3-1	watery mud	47.75	52.25	21
3-2	damp sand	30.03	69.97	3
3-3	wet sand	38.76	61.24	111
3-4	wet sand	28.63	71.37	3
3-7	wet sand	21.83	78.17	16
4-1	wet sand	23.44	76.56	0
4-2	wet sand	62.65	37.35	0
4-3	damp sand	20.00	80.00	0
4-4	damp sand	27.19	72.81	0
4-5	watery sand	20.25	79.75	2.46
4-6	damp sand	15.33	84.67	0

Note: CFU, colony forming units

Appendix K. Fish sampled in Cocos Lagoon, Guam.

Stratum	Site	Measured Latitude (DD)	Longitude (DD)	Date	Common name	Genus/Species	Number of fish in composite sample
1	1	13.23643	144.64610	5/5/2015	Honeycomb grouper	*Epinephelus merra*	1
1	1	13.23643	144.64610	5/5/2015	Convict tang	*Acanthurus triostegus*	5
1	2	13.23716	144.64690	5/5/2015	Convict tang	*Acanthurus triostegus*	1
1	2	13.23716	144.64690	5/5/2015	Honeycomb grouper	*Epinephelus merra*	1
1	3	13.23549	144.64522	5/5/2015	Banded sergeant major	*Abudefduf septemfasciatus*	5
1	3	13.23549	144.64522	5/5/2015	Honeycomb grouper	*Epinephelus merra*	2
1	4	13.23771	144.64905	5/5/2015	Banded sergeant major	*Abudefduf septemfasciatus*	3
1	4	13.23771	144.64905	5/5/2015	Blackspot sergeant major	*Abudefduf sordidus*	5
1	4	13.23771	144.64905	5/5/2015	Honeycomb grouper	*Epinephelus merra*	1
1	5	13.23379	144.64586	5/5/2015	Hexagon grouper	*Epinephelus hexagonatus*	3
1	7	13.24202	144.65920	7/24/2015	Honeycomb grouper	*Epinephelus merra*	4
1	7	13.24202	144.65920	7/24/2015	Orange-striped emperor	*Lethrinus obseletus*	1
1	7	13.24202	144.65920	7/24/2015	Blacktail snapper	*Lutjanus fulvus*	1
2	1	13.25342	144.67029	5/7/2015	Honeycomb grouper	*Epinephelus merra*	4
2	2	13.26178	144.66194	5/7/2015	Orange-striped emperor	*Lethrinus obseletus*	4
2	2	13.26178	144.66194	5/7/2015	Thumbprint emperor	*Lethrinus harrack*	1
2	2	13.26178	144.66194	5/7/2015	Honeycomb grouper	*Epinephelus merra*	1
3	1	13.26890	144.66374	5/7/2015	Honeycomb grouper	*Epinephelus merra*	5
3	1	13.26890	144.66374	5/7/2015	Convict tang	*Acanthurus triostegus*	1
3	2	13.25190	144.68544	5/8/2015	Honeycomb grouper	*Epinephelus merra*	2
3	3	13.26135	144.67032	5/8/2015	Honeycomb grouper	*Epinephelus merra*	2
4	1	13.24256	144.68271	5/6/2015	Orange-striped emperor	*Lethrinus obseletus*	2
4	1	13.24256	144.68271	5/6/2015	Honeycomb grouper	*Epinephelus merra*	2
4	2	13.24179	144.67641	5/6/2015	Honeycomb grouper	*Epinephelus merra*	3
4	2	13.24179	144.67641	5/6/2015	Orange-striped emperor	*Lethrinus obseletus*	1
4	3	13.25920	144.65694	5/6/2015	Thumbprint emperor	*Lethrinus harrack*	1
4	3	13.25920	144.65694	5/6/2015	Honeycomb grouper	*Epinephelus merra*	3
4	4	13.25069	144.65036	5/6/2015	Honeycomb grouper	*Epinephelus merra*	3
4	5	13.24764	144.69133	5/8/2015	Thumbprint emperor	*Lethrinus harrack*	2
4	5	13.24764	144.69133	5/8/2015	Honeycomb grouper	*Epinephelus merra*	2

Abbreviation: DD, decimal degree

Appendix L. PAHs detected in fish from Cocos Lagoon, Guam (ng/wet g).

Site	1-1		1-1		1-2		1-2		1-3		1-3		1-4		1-4	
Species	*Epinephelus merra*		*Acanthurus triostegus*		*Acanthurus triostegus*		*Epinephelus merra*		*Abudefduf septemfasciatus*		*Epinephelus merra*		*Abudefduf septemfasciatus*		*Abudefduf sordidus*	
Common Name	Honeycomb grouper		Convict tang		Convict tang		Honeycomb grouper		Banded sergeant		Honeycomb grouper		Banded sergeant		Blackspot sergeant	
Compound																
Naphthalene	1.43		1.25		1.25		1.34		1.45		1.60		1.32		3.3	
C1-Naphthalenes	0.41	J	0.43	J	0.38	J	0.41	J	0.48	J	0.45	J	0.43	J	0.53	J
C2-Naphthalenes	0.00	U	0.57	J	0.77	J	0.56	J	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Biphenyl	0.43	J	0.51	J	0.46	J	0.44	J	0.52	J	0.59	J	0.48	J	0.55	J
Acenaphthylene	0.00	U	0.00	U	0.185	J	0.168	J	0.181	J	0.00	U	0.00	U	0.48	
Acenaphthene	0.00	U	0.00	U	0.00	U	0.00	U	1.53		0.00	U	0.00	U	0.00	U
Dibenzofuran	0.30	J	0.57		0.47	J	0.33	J	0.40	J	0.40	J	0.36	J	0.45	J
Fluorene	0.114	J	0.37		0.138	J	0.096	J	0.232	J	0.00	U	0.107	J	0.187	J
C1-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Carbazole	0.214	J	0.64		0.54		0.146	J	0.56		0.245	J	1.05		0.49	
Anthracene	0.027	J	0.63		0.101	J	0.087	J	0.00	U	0.030	J	0.80		0.38	J
Phenanthrene	0.225	J	3.2		0.38	J	0.223	J	1.10		0.208	J	0.221	J	0.267	J
C1-Phenanthrenes/Anthracenes	0.00	U	0.55	J	0.00	U	0.00	U	0.29	J	0.00	U	0.00	U	0.00	U
C2-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzothiophene	0.00	U	0.128	J	0.042	J	0.00	U	0.091	J	0.00	U	0.048	J	0.085	J
C1-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Fluoranthene	0.079	J	4.6		0.137		0.062	J	1.14		0.00	U	0.094	J	0.105	J
Pyrene	0.031	J	2.00		0.055	J	0.030	J	0.63		0.00	U	0.024	J	0.056	J
C1-Fluoranthenes/Pyrenes	0.00	U	0.87	J	0.00	U	0.00	U	0.49	J	0.00	U	0.00	U	0.00	U
C2-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Naphthobenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benz(a)anthracene	0.00	U	0.42		0.00	U	0.00	U	0.38		0.00	U	0.00	U	0.00	U
Chrysene/Triphenylene	0.00	U	4.8		0.00	U	0.00	U	0.65		0.00	U	0.00	U	0.00	U
C1-Chrysenes	0.00	U	0.207	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluoranthene	0.00	U	3.3		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(k,j)fluoranthene	0.00	U	0.94		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(e)pyrene	0.00	U	1.31		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)pyrene	0.00	U	0.154	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Perylene	0.182	J	0.38	J	0.235	J	0.169	J	0.26	J	0.167	J	0.32	J	0.192	J
Indeno(1,2,3-c,d)pyrene	0.00	U	0.34	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzo(a,h)anthracene	0.00	U	0.102	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(g,h,i)perylene	0.00	U	0.39	J	0.00	U	0.00	U	0.28	J	0.00	U	0.00	U	0.00	U
Total PAHs	3.4		28.6		5.1		4.1		10.7		3.7		5.3		7.1	

Notes: J, below method detection level, MDL; U, not detected

Appendix L. PAHs detected in fish from Cocos Lagoon, Guam (ng/wet g) (continued).

Site	1-4		1-5		1-7		1-7		1-7		2-1		2-2		2-2	
Species	*Epinephelus merra*		*Epinephelus hexagonatus*		*Lethrinus obsoletus*		*Lutjanus fulvus*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus obsoletus*		*Lethrinus harack*	
Common Name	Honeycomb grouper		Starspotted grouper		Orange-striped emperor		Blacktail snapper		Honeycomb grouper		Honeycomb grouper		Orange-striped emperor		Thumbprint emperor	
Compound																
Naphthalene	2.06		1.38		1.43		1.12		1.26		1.62		1.31		1.46	
C1-Naphthalenes	0.54	J	0.46	J	0.62	J	0.44	J	0.46	J	0.53	J	0.50	J	0.52	J
C2-Naphthalenes	0.00	U	0.00	U	0.92	J	0.49	J	0.42	J	0.00	U	0.00	U	0.51	J
C3-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Biphenyl	0.47	J	0.38	J	0.37	J	0.33	J	0.32	J	0.50	J	0.50	J	0.51	J
Acenaphthylene	0.00	U	0.187	J	0.133	J	0.00	U	0.072	J	0.00	U	0.175	J	0.176	J
Acenaphthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzofuran	0.29	J	0.235	J	0.00	U	0.00	U	0.187	J	0.32	J	0.29	J	0.30	J
Fluorene	0.171	J	0.092	J	0.147	J	0.127	J	0.141	J	0.084	J	0.117	J	0.119	J
C1-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Carbazole	0.37		0.122	J	0.102	J	0.00	U	0.136	J	0.212	J	0.122	J	0.30	
Anthracene	0.00	U	0.051	J	0.0	U	0.00	U	0.0261	J	0.00	U	0.00	U	0.26	J
Phenanthrene	0.237	J	0.187	J	0.36	J	0.34	J	0.32	J	0.194	J	0.197	J	0.176	J
C1-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzothiophene	0.00	U	0.00	U	0.11	J	0.07	J	0.00	U	0.00	U	0.043	J	0.00	U
C1-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Fluoranthene	0.064	J	0.048	J	0.00	U	0.056	J	0.057	J	0.041	J	0.048	J	0.00	U
Pyrene	0.033	J	0.027	J	0.00	U	0.028	J	0.028	J	0.037	J	0.0169	J	0.00	U
C1-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Naphthobenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benz(a)anthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Chrysene/Triphenylene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(k,j)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(e)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Perylene	0.161	J	0.143	J	0.00	U	0.035	J	0.029	J	0.175	J	0.145	J	0.186	J
Indeno(1,2,3-c,d)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzo(a,h)anthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(g,h,i)perylene	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 PAHs	4.4		3.3		4.2		3.0		3.5		3.7		3.5		4.5	

Notes: J, below method detection level, MDL; U, not detected

Appendix L. PAHs detected in fish from Cocos Lagoon, Guam (ng/wet g) (continued).

Site	2-2		3-1		3-3		3-2		3-1		4-1		4-1		4-2	
Species	*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Acanthurus triostegus*		*Lethrinus obsoletus*		*Epinephelus merra*		*Epinephelus merra*	
Common Name	Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Convict tang		Orange-striped emperor		Honeycomb grouper		Honeycomb grouper	
Compound																
Naphthalene	1.56		1.06		0.90		0.83		0.90		0.90		1.39		1.17	
C1-Naphthalenes	0.52	J	0.33	J	0.244	J	0.236	J	0.38	J	0.29	J	0.44	J	0.35	J
C2-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Biphenyl	0.50	J	0.48	J	0.40	J	0.29	J	0.32	J	0.47	J	0.49	J	1.22	
Acenaphthylene	0.00	U	0.00	U	0.114	J	0.140	J	0.42		0.17	J	0.208	J	0.0	U
Acenaphthene	0.00	U	0.00	U	0.00	U	0.00	U	0.33	J	0.0	U	0.00	U	0.00	U
Dibenzofuran	0.309	J	0.33	J	0.28	J	0.191	J	0.241	J	0.29	J	0.35	J	0.26	J
Fluorene	0.092	J	0.103	J	0.071	J	0.068	J	0.173	J	0.093	J	0.111	J	0.110	J
C1-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.0	U	0.00	U	0.00	U
C2-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.0	U	0.00	U	0.00	U
C3-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.0	U	0.00	U	0.00	U
Carbazole	0.171	J	0.217	J	0.190	J	0.155	J	0.68		0.154	J	0.36		0.194	J
Anthracene	0.178	J	0.00	U	0.025	J	0.031	J	0.62		0.260	J	0.00	U	0.0	U
Phenanthrene	0.200	J	0.29	J	0.181	J	0.151	J	0.43	J	0.197	J	0.00	U	0.174	J
C1-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.206	J	0.00	U	0.00	U
C2-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.05	J	0.06	J	0.00	U	0.00	U
C1-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Fluoranthene	0.056	J	0.094	J	0.054	J	0.055	J	0.190		0.067	J	0.062	J	0.049	J
Pyrene	0.0279	J	0.00	U	0.0230	J	0.0240	J	0.00	U	0.044	J	0.0160	J	0.00	U
C1-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Naphthobenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benz(a)anthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.176		0.00	U	0.00	U	0.00	U
Chrysene/Triphenylene	0.00	U	0.00	U	0.00	U	0.00	U	0.34		0.00	U	0.00	U	0.00	U
C1-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(k,j)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(e)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Perylene	0.108	J	0.228	J	0.170	J	0.187	J	0.26	J	0.226	J	0.091	J	0.45	J
Indeno(1,2,3-c,d)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzo(a,h)anthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(g,h,i)perylene	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 PAHs	3.7		3.1		2.6		2.4		5.5		3.4		3.5		4.0	

Notes: J, below method detection level, MDL; U, not detected

Appendix L. PAHs detected in fish from Cocos Lagoon, Guam (ng/wet g) (continued).

Site	4-2		4-3		4-3		4-4		4-5		4-5	
Species	*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus harack*		*Epinephelus merra*	
Common Name	Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper		Thumbprint emperor		Honeycomb grouper	
Compound												
Naphthalene	1.15		1.85		1.99		1.60		1.63		1.30	
C1-Naphthalenes	0.29	J	0.36	J	0.37	J	0.34	J	0.46	J	0.28	J
C2-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthalenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Benzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Biphenyl	0.49	J	0.65	J	0.48	J	0.50	J	0.49	J	0.46	J
Acenaphthylene	0.225	J	0.26		0.077	J	0.198	J	0.197	J	0.191	J
Acenaphthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzofuran	0.0	U	0.37	J	0.31	J	0.32	J	0.37	J	0.27	J
Fluorene	0.109	J	0.090	J	0.098	J	0.078	J	0.097	J	0.090	J
C1-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluorenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Carbazole	0.0	U	0.46		0.243	J	0.170	J	0.105	J	0.200	J
Anthracene	0.076	J	0.0	U	0.093	J	0.048	J	0.034	J	0.0	U
Phenanthrene	0.204	J	0.197	J	0.204	J	0.175	J	0.172	J	0.167	J
C1-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Phenanthrenes/Anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzothiophene	0.00	U	0.039	J	0.00	U	0.00	U	0.00	U	0.044	J
C1-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Dibenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Fluoranthene	0.048	J	0.00	U	0.069	J	0.060	J	0.00	U	0.058	J
Pyrene	0.029	J	0.00	U	0.017	J	0.0252	J	0.00	U	0.00	U
C1-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Fluoranthenes/Pyrenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Naphthobenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Naphthobenzothiophenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benz(a)anthracene	0.00	U	0.140	J	0.00	U	0.134	J	0.00	U	0.00	U
Chrysene/Triphenylene	0.00	U	0.018	J	0.00	U	0.0200	J	0.00	U	0.00	U
C1-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C4-Chrysenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(k,j)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)fluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(e)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(a)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Perylene	0.220	J	0.29	J	0.167	J	0.236	J	0.40	J	0.42	J
Indeno(1,2,3-c,d)pyrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibenzo(a,h)anthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C1-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C2-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C3-Dibenzo(a,h)anthracenes	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(g,h,i)perylene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Total PAHs	2.8		4.7		4.1		3.9		4.0		3.5	

Notes: J, below method detection level, MDL; U, not detected

Appendix M. Individual alkyl isomers and hopanes detected in fish from Cocos Lagoon, Guam (ng/wet g).

Site	1-1		1-1		1-2		1-2		1-3		1-3		1-4		1-4	
Species	*Epinephelus merra*		*Acanthurus triostegus*		*Acanthurus triostegus*		*Epinephelus merra*		*Abudefduf septemfasciatus*		*Epinephelus merra*		*Abudefduf septemfasciatus*		*Abudefduf sordidus*	
Common Name	Honeycomb grouper		Convict tang		Convict tang		Honeycomb grouper		Banded sergeant		Honeycomb grouper		Banded sergeant		Blackspot sergeant	
Individual Alkyl Isomers and Hopanes																
2-Methylnaphthalene	0.36		0.38		0.33		0.36		0.43		0.41		0.39		0.50	
1-Methylnaphthalene	0.214	J	0.22	J	0.205	J	0.212	J	0.232	J	0.222	J	0.214	J	0.236	J
2,6-Dimethylnaphthalene	0.00	U	0.24	J	0.162	J	0.185	J	0.00	U	0.00	U	0.00	U	0.00	U
1,6,7-Trimethylnaphthalene	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-Methylfluorene	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-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2/3-Methyldibenzothiophene	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-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
3-Methylphenanthrene	0.00	U	0.190	J	0.00	U	0.00	U	0.092	J	0.00	U	0.00	U	0.00	U
2-Methylphenanthrene	0.00	U	0.25	J	0.00	U	0.00	U	0.111	J	0.00	U	0.00	U	0.00	U
2-Methylanthracene	0.00	U	0.027	J	0.00	U	0.00	U	0.0213	J	0.00	U	0.00	U	0.00	U
4/9-Methylphenanthrene	0.00	U	0.110	J	0.00	U	0.00	U	0.085	J	0.00	U	0.00	U	0.00	U
1-Methylphenanthrene	0.00	U	0.126	J	0.00	U	0.00	U	0.058	J	0.00	U	0.00	U	0.00	U
3,6-Dimethylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Retene	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-Methylfluoranthene	0.00	U	0.204		0.00	U	0.00	U	0.072	J	0.00	U	0.00	U	0.00	U
Benzo(b)fluorene	0.00	U	0.30		0.00	U	0.00	U	0.118	J	0.00	U	0.00	U	0.00	U
C29-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
18a-Oleanane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C30-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C20-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C21-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20R)/C27(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C27(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Notes: J, below method detection level, MDL; U, not detected

Appendix M. Individual alkyl isomers and hopanes detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	1-4		1-5		1-7		1-7		1-7		2-1		2-2		2-2	
Species	*Epinephelus merra*		*Epinephelus hexagonatus*		*Lethrinus obsoletus*		*Lutjanus fulvus*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus obsoletus*		*Lethrinus harack*	
Common Name	Honeycomb grouper		Starspotted grouper		Orange-striped emperor		Blacktail snapper		Honeycomb grouper		Honeycomb grouper		Orange-striped emperor		Thumbprint emperor	
Individual Alkyl Isomers and Hopanes																
2-Methylnaphthalene	0.48		0.40		0.67		0.48		0.51		0.49		0.45		0.48	
1-Methylnaphthalene	0.280	J	0.235	J	0.35		0.247	J	0.247	J	0.244	J	0.25	J	0.25	J
2,6-Dimethylnaphthalene	0.00	U	0.00	U	0.256	J	0.209	J	0.238	J	0.00	U	0.00	U	0.187	J
1,6,7-Trimethylnaphthalene	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-Methylfluorene	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-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2/3-Methyldibenzothiophene	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-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
3-Methylphenanthrene	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-Methylphenanthrene	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-Methylanthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4/9-Methylphenanthrene	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-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
3,6-Dimethylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Retene	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-Methylfluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluorene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C29-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
18a-Oleanane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C30-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C20-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C21-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20R)/C27(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C27(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Notes: J, below method detection level, MDL; U, not detected

Appendix M. Individual alkyl isomers and hopanes detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	2-2		3-1		3-3		3-2		3-1		4-1		4-1		4-2	
Species	*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Acanthurus triostegus*		*Lethrinus obsoletus*		*Epinephelus merra*		*Epinephelus merra*	
Common Name	Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Convict tang		Orange-striped emperor		Honeycomb grouper		Honeycomb grouper	
Individual Alkyl Isomers and Hopanes																
2-Methylnaphthalene	0.48		0.29		0.205		0.197		0.32		0.239		0.37		0.30	
1-Methylnaphthalene	0.248	J	0.171	J	0.138	J	0.136	J	0.212	J	0.174	J	0.250	J	0.198	J
2,6-Dimethylnaphthalene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,6,7-Trimethylnaphthalene	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-Methylfluorene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.054	J
4-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2/3-Methyldibenzothiophene	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-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
3-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.064	J	0.00	U	0.00	U
2-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.059	J	0.00	U	0.00	U
2-Methylanthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.016	J	0.00	U	0.00	U
4/9-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.081	J	0.00	U	0.00	U
1-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.045	J	0.00	U	0.00	U
3,6-Dimethylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Retene	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-Methylfluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluorene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C29-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
18a-Oleanane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C30-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C20-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C21-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20R)/C27(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C27(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Notes: J, below method detection level, MDL; U, not detected

Appendix M. Individual alkyl isomers and hopanes detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	4-2		4-3		4-3		4-4		4-5		4-5	
Species	*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus harack*		*Epinephelus merra*	
Common Name	Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper		Thumbprint emperor		Honeycomb grouper	
Individual Alkyl Isomers and Hopanes												
2-Methylnaphthalene	0.25		0.29		0.33		0.29		0.40		0.239	
1-Methylnaphthalene	0.162	J	0.220	J	0.194	J	0.190	J	0.254	J	0.155	J
2,6-Dimethylnaphthalene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,6,7-Trimethylnaphthalene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1-Methylfluorene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2/3-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1-Methyldibenzothiophene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
3-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2-Methylanthracene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4/9-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1-Methylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
3,6-Dimethylphenanthrene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Retene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2-Methylfluoranthene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Benzo(b)fluorene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C29-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
18a-Oleanane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C30-Hopane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C20-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C21-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C26(20R)/C27(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20S)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C27(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
C28(20R)-TAS	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Notes: J, below method detection level, MDL; U, not detected

Appendix N. Polychlorinated biphenyls (PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g).

Site	1-1	1-1	1-2	1-2	1-3	1-3	1-4	1-4	1-4	1-5
Species	*Epinephelus merra*	*Acanthurus triostegus*	*Acanthurus triostegus*	*Epinephelus merra*	*Abudefduf septemfasciatus*	*Epinephelus merra*	*Abudefduf septemfasciatus*	*Abudefduf sordidus*	*Epinephelus merra*	*Epinephelus hexagonatus*
Common Name	Honeycomb grouper	Convict tang	Convict tang	Honeycomb grouper	Banded sergeant major	Honeycomb grouper	Banded sergeant major	Blackspot sergeant	Honeycomb grouper	Starspotted grouper
Compound										
PCB1	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB7/9	0.79	0.65	0.69	0.62	0.56	1.21	0.37	0.78	0.64	0.66
PCB8/5	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
PCB15	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.08 J	0.00 U	0.00 U	0.00 U
PCB16/32	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.26	0.00 U	0.00 U	0.00 U	0.13 J
PCB18	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB22/51	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB24/27	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
PCB25	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB26	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB28	0.00 U	0.00 U	0.35	0.11	0.16	0.47	1.06	0.67	0.00 U	0.00 U
PCB29	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.07 J
PCB31	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB33/53/20	0.06 J	0.19	0.18	0.34	0.27	0.00 U	0.26	0.24	0.13 J	0.28
PCB40	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB41/64	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.73	0.87	0.00 U	0.00 U
PCB42/59/37	0.00 U	0.01 J	0.00 U	0.00 U	0.05 J	0.00 U	0.06 J	0.22	0.00 U	0.00 U
PCB43	0.00 U	0.04 J	0.00 U	0.00 U	0.07 J	0.13 J	0.07 J	0.10 J	0.09 J	0.54
PCB44	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB45	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB46	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB47/48/75	0.80	0.31	0.00 U	0.15	0.00 U	0.67	2.45	5.35	0.56	0.12 J
PCB49	0.51	0.29	0.65	0.13 J	0.57	0.38	0.91	3.14	0.25	0.00 U
PCB52	0.52	0.48	0.84	0.19	0.70	0.40	1.14	4.51	0.27	0.14
PCB56/60	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.81	0.00 U	0.00 U
PCB66	0.32	0.00 U	0.15	0.04 J	0.81	0.07 J	1.04	2.63	0.12	0.00 U
PCB70	0.11 J	0.00 U	0.36	0.00 U	0.64	0.00 U	0.84	1.43	0.11 J	0.00 U
PCB74/61	0.35	0.00 U	0.00 U	0.08 J	0.55	0.20	1.04	2.59	0.25	0.00 U
PCB77	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB81	0.31	0.16	0.09 J	0.07 J	0.12 J	0.12 J	0.42	2.20	0.22	0.00 U
PCB82	0.00 U	0.00 U	0.00 U	0.00 U	0.58	0.00 U	0.67	3.53	0.00 U	0.00 U
PCB83	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.21	0.00 U	0.00 U
PCB84	0.03 J	0.07 J	0.06 J	0.00 U	0.12 J	0.08 J	0.04 J	0.30	0.15 J	0.09 J
PCB85	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	3.48	0.00 U	0.00 U
PCB86	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.02 J	0.00 U
PCB87/115	0.49	0.32	0.39	0.10 J	0.65	0.18	1.12	4.49	0.30	0.05 J
PCB88	0.09 J	0.07 J	0.11 J	0.00 U	0.04 J	0.12 J	0.12 J	1.35	0.14 J	0.00 U
PCB92	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB95	0.18 J	0.00 U	0.70	0.12 J	0.26	0.23	0.45	3.32	0.36	0.00 U
PCB97	0.19 J	0.08 J	0.10 J	0.08 J	0.51	0.12 J	1.19	1.33	0.21	0.00 U
PCB99	2.68	1.52	1.63	0.81	5.90	1.35	9.05	25.41	2.05	0.09 J
PCB101/90	2.21	0.91	1.33	0.53	3.61	0.81	7.12	20.29	1.56	0.14 J
PCB105	2.17	1.05	0.84	0.71	4.11	0.96	6.74	17.97	1.56	0.22
PCB107	0.11 J	0.00 U	0.19 J	0.08 J	0.00 U	0.10 J	0.00 U	0.39	0.13 J	0.00 U
PCB110/77	0.41	0.25	0.48	0.04 J	0.46	0.22	1.67	11.41	0.42	0.00 U
PCB114/131/122	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
PCB118	9.13	2.99	2.48	2.76	14.59	3.87	20.00	42.49	5.58	0.61
PCB126	0.04 J	0.00 U	0.00 U	0.02 J	0.14 J	0.00 U	0.26	0.00 U	0.04 J	0.00 U
PCB128	1.61	0.61	0.56	0.45	3.46	0.46	5.86	18.06	1.21	0.00 U
PCB129/126	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.47	0.00 U	0.00 U
PCB136	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB138/160	9.12	2.82	2.49	2.75	14.06	3.66	22.58	33.46	6.07	0.91
PCB141/179	0.26	0.08 J	0.11 J	0.00 U	0.12 J	0.00 U	0.27	3.54	0.15	0.00 U
PCB146	1.49	0.48	0.43	0.40	1.12	0.72	2.26	7.88	1.18	0.00 U
PCB149/123	0.00 U	0.43	0.54	0.00 U	0.46	0.17	0.88	7.73	0.30	0.00 U
PCB151	0.10 J	0.11 J	0.12 J	0.03 J	0.04 J	0.09 J	0.14	1.77	0.16	0.06 J
PCB153/132	15.60	3.84	3.61	5.14	19.36	6.41	29.46	61.22	8.22	1.51
PCB156/171/202	0.16	0.08 J	0.06 J	0.10 J	0.27	0.00 U	0.35	1.13	0.19	0.00 U
PCB158	1.05	0.37	0.26	0.32	1.83	0.44	2.41	4.98	0.57	0.11 J
PCB166	0.11 J	0.00 U	0.00 U	0.10 J	0.00 U	0.00 U	0.00 U	0.00 U	0.29	0.08 J
PCB167	0.85	0.12 J	0.12 J	0.26	1.27	0.46	1.87	4.69	0.49	0.04 J
PCB169	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.06 J	0.00 U	0.00 U
PCB170/190	1.32	0.52	0.35	0.68	2.37	0.79	3.24	7.06	0.94	0.20
PCB172	0.09 J	0.08 J	0.06 J	0.03 J	0.04 J	0.11 J	0.09 J	0.69	0.18	0.00 U
PCB174	0.00 U	0.05 J	0.07 J	0.00 U	0.00 U	0.00 U	0.00 U	0.72	0.00 U	0.00 U
PCB176/137	0.64	0.09 J	0.10 J	0.20	1.10	0.29	1.41	3.48	0.39	0.00 U
PCB177	0.03 J	0.08 J	0.07 J	0.00 U	0.00 U	0.02 J	0.02 J	0.77	0.05 J	0.00 U
PCB178	0.00 U	0.03 J	0.02 J	0.00 U	0.00 U	0.00 U	0.00 U	0.27	0.00 U	0.00 U
PCB180	1.88	0.38	0.29	0.71	3.34	1.19	4.11	7.36	1.09	0.36
PCB183	0.47	0.13	0.09 J	0.13 J	0.62	0.24	0.91	2.04	0.21	0.12 J
PCB185	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB187	0.62	0.23	0.21	0.16 J	0.27	0.31	0.72	4.49	0.44	0.10 J
PCB189	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB191	0.09 J	0.04 J	0.03 J	0.00 U	0.00 U	0.06 J	0.11 J	0.57	0.09 J	0.00 U
PCB194	0.26	0.06 J	0.06 J	0.12 J	0.47	0.20	0.64	1.15	0.19	0.07 J
PCB195/208	0.07 J	0.05 J	0.04 J	0.03 J	0.19	0.06 J	0.29	0.59	0.05 J	0.00 U
PCB196/203	0.15 J	0.00 U	0.00 U	0.06 J	0.34	0.11 J	0.46	0.90	0.10 J	0.03 J
PCB199	0.00 U	0.08 J	0.09 J	0.00 U	0.11 J	0.09 J	0.12 J	0.66	0.13 J	0.00 U
PCB200	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U	0.00 U
PCB201/157/173	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
PCB205	0.05 J	0.05 J	0.03 J	0.04 J	0.04 J	0.04 J	0.05 J	0.12 J	0.03 J	0.04 J
PCB206	0.04 J	0.03 J	0.03 J	0.04 J	0.13 J	0.03 J	0.22	0.46	0.04 J	0.00 U
PCB209	0.02 J	0.02 J	0.02 J	0.01 J	0.06 J	0.02 J	0.15 J	0.29	0.02 J	0.00 U
Total PCB	57.61	20.22	21.49	18.76	86.52	27.92	137.51	338.11	37.96	6.78

Notes: J, below method detection level, MDL; U, not detected

Appendix N. Polychlorinated biphenyls (PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	1-7		1-7		1-7		2-1		2-2		2-2		2-2		3-1		3-3		3-2	
Species	*Lethrinus obsoletus*		*Lutjanus fulvus*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*	
Common Name	Orange-striped emperor		Blacktail snapper		Honeycomb grouper		Honeycomb grouper		Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Honeycomb grouper	
Compound																				
PCB1	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB7/9	0.25		0.45		0.38		0.00	U	0.76		0.67		0.75		0.00	U	0.00	U	0.00	U
PCB8/5	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
PCB15	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB16/32	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
PCB18	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB22/51	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB24/27	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.15	J	0.15		0.00	U
PCB25	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB26	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB28	0.52		0.34		1.21		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB29	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB31	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB33/53/20	0.00	U	0.00	U	0.00	U	0.05	J	0.25		0.37		0.03	J	0.07	J	0.07	J	0.20	
PCB40	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB41/64	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
PCB42/59/37	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
PCB43	0.10	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
PCB44	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB45	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB46	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB47/48/75	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.03	J	0.00	U	0.00	U	0.00	U
PCB49	0.10	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
PCB52	0.20		0.00	U	0.00	U	0.09	J	0.00	U	0.07	J	0.11	J	0.00	U	0.00	U	0.00	U
PCB56/60	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB66	0.19		0.03	J	0.04	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB70	0.22		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
PCB74/61	0.24		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
PCB77	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB81	0.11	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.04	J	0.00	U	0.00	U	0.00	U
PCB82	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB83	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB84	0.20		0.10	J	0.00	U	0.10	J	0.00	U	0.00	U	0.08	J	0.00	U	0.00	U	0.00	U
PCB85	0.30		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
PCB86	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB87/115	0.35		0.00	U	0.13	J	0.00	U	0.00	U	0.03	J	0.03	J	0.09	J	0.08	J	0.00	U
PCB88	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB92	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB95	0.43		0.12	J	0.14	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB97	0.00	U	0.06	J	0.08	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB99	1.21		0.13	J	0.36		0.15	J	0.00	U	0.00	U	0.12	J	0.21		0.08	J	0.00	U
PCB101/90	1.04		0.15	J	0.36		0.21		0.00	U	0.05	J	0.19	J	0.34		0.15	J	0.00	U
PCB105	1.30		0.18		0.36		0.26		0.00	U	0.00	U	0.21		0.29		0.22		0.00	U
PCB107	0.00	U	0.03	J	0.00	U	0.00	U	0.00	U	0.00	U	0.04	J	0.00	U	0.00	U	0.00	U
PCB110/77	0.33		0.03	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
PCB114/131/122	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
PCB118	3.96		0.35		1.22		0.50		0.00	U	0.02	J	0.39		0.66		0.37		0.04	J
PCB126	0.04	J	0.01	J	0.03	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB128	1.11		0.11	J	0.22		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB129/126	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB136	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB138/160	4.80		0.53		1.46		0.66		0.00	U	0.00	U	0.43		0.97		0.48		0.11	J
PCB141/179	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.06	J	0.00	U	0.00	U
PCB146	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB149/123	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
PCB151	0.14		0.03	J	0.07	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB153/132	5.89		0.95		2.31		1.09		0.03	J	0.04	J	0.74		1.59		0.89		0.23	
PCB156/171/202	0.10	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
PCB158	0.49		0.07	J	0.23		0.00	U	0.00	U	0.00	U	0.07	J	0.16		0.09	J	0.00	U
PCB166	0.08	J	0.09	J	0.20		0.15		0.00	U	0.00	U	0.07	J	0.03	J	0.03	J	0.00	U
PCB167	0.48		0.03	J	0.08	J	0.00	U	0.00	U	0.00	U	0.02	J	0.00	U	0.00	U	0.00	U
PCB169	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB170/190	0.66		0.16	J	0.36		0.24		0.07	J	0.13	J	0.15	J	0.48		0.29		0.19	
PCB172	0.08	J	0.00	U	0.05	J	0.10	J	0.00	U	0.00	U	0.09	J	0.00	U	0.00	U	0.00	U
PCB174	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
PCB176/137	0.26		0.00	U	0.00	U	0.10	J	0.00	U	0.00	U	0.08	J	0.08	J	0.06	J	0.00	U
PCB177	0.08	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
PCB178	0.04	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
PCB180	0.84		0.32		0.61		0.49		0.00	U	0.00	U	0.27		1.05		0.42		0.15	
PCB183	0.15		0.09	J	0.14		0.06	J	0.00	U	0.00	U	0.05	J	0.21		0.07	J	0.00	U
PCB185	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB187	0.40		0.07	J	0.22		0.17		0.01	J	0.03	J	0.08	J	0.50		0.15	J	0.05	J
PCB189	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB191	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB194	0.12	J	0.00	U	0.00	U	0.05	J	0.00	U	0.00	U	0.04	J	0.30		0.09	J	0.05	J
PCB195/208	0.05	J	0.00	U	0.00	U	0.02	J	0.00	U	0.00	U	0.01	J	0.10	J	0.03	J	0.00	U
PCB196/203	0.00	U	0.03	J	0.04	J	0.03	J	0.00	U	0.00	U	0.03	J	0.00	U	0.00	U	0.00	U
PCB199	0.13	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.22		0.00	U	0.00	U
PCB200	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB201/157/173	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
PCB205	0.06	J	0.05	J	0.05	J	0.02	J	0.00	U	0.00	U	0.02	J	0.04	J	0.06	J	0.03	J
PCB206	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.07	J	0.03	J	0.00	U
PCB209	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.02	J	0.02	J	0.00	U
Total PCB	27.07		4.51		10.33		4.54		1.12	J	1.40	J	4.15		7.69		3.84		1.05	J

Notes: J, below method detection level, MDL; U, not detected

Appendix N. Polychlorinated biphenyls (PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	3-1		4-1		4-1		4-2		4-2		4-3		4-3		4-4		4-5		4-5	
Species	*Acanthurus triostegus*		*Lethrinus obsoletus*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus harack*		*Epinephelus merra*	
Common Name	Convict tang		Orange-striped emperor		Honeycomb grouper		Honeycomb grouper		Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper		Thumbprint emperor		Honeycomb grouper	
Compound																				
PCB1	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB7/9	0.00	U	0.72		0.00	U	0.00	U	0.72		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB8/5	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
PCB15	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB16/32	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
PCB18	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.24	
PCB22/51	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB24/27	0.00	U	0.00	U	0.00	U	0.07	J	0.00	U	0.00	U	0.00	U	0.00	U	0.09	J	0.00	U
PCB25	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB26	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB28	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB29	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB31	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB33/53/20	0.25		0.48		0.00	U	0.00	U	0.28		0.51		0.00	U	0.00	U	0.00	U	0.12	J
PCB40	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB41/64	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
PCB42/59/37	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
PCB43	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB44	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB45	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB46	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB47/48/75	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB49	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB52	0.12	J	0.00	U	0.00	U	0.07	J	0.00	U	0.00	U	0.20		0.09	J	0.00	U	0.00	U
PCB56/60	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB66	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB70	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB74/61	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
PCB77	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB81	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB82	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB83	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB84	0.15	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
PCB85	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB86	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB87/115	0.09	J	0.00	U	0.00	U	0.00	U	0.08	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB88	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB92	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB95	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB97	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB99	0.13	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
PCB101/90	0.13	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
PCB105	0.07	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
PCB107	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB110/77	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
PCB114/131/122	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
PCB118	0.15	J	0.00	U	0.03	J	0.03	J	0.13	J	0.00	U	0.09	J	0.07	J	0.05	J	0.00	U
PCB126	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB128	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB129/126	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB136	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB138/160	0.30		0.00	U	0.00	U	0.08	J	0.21		0.00	U	0.15		0.17		0.15		0.00	U
PCB141/179	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB146	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB149/123	0.10	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
PCB151	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB153/132	0.37		0.00	U	0.11	J	0.08	J	0.29		0.00	U	0.25		0.25		0.29		0.00	U
PCB156/171/202	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
PCB158	0.00	U	0.00	U	0.00	U	0.03	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB166	0.05	J	0.00	U	0.00	U	0.05	J	0.08	J	0.00	U	0.00	U	0.14		0.00	U	0.00	U
PCB167	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB169	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB170/190	0.17	J	0.18		0.00	U	0.17	J	0.51		0.26		0.18		0.42		0.61		0.23	
PCB172	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.04	J	0.00	U	0.00	U
PCB174	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB176/137	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB177	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB178	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB180	0.10	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.15		0.09	J	0.18		0.00	U
PCB183	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB185	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB187	0.00	U	0.00	U	0.00	U	0.00	U	0.02	J	0.00	U	0.06	J	0.03	J	0.06	J	0.00	U
PCB189	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB191	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB194	0.07	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
PCB195/208	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
PCB196/203	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB199	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB200	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB201/157/173	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
PCB205	0.03	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
PCB206	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB209	0.00	U	0.00	U	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	2.26	J	1.37	J	0.14	J	0.59	J	2.32	J	0.77	J	1.07	J	1.31	J	1.43	J	0.59	J

Notes: J, below method detection level, MDL; U, not detected

Appendix O. Organochlorine compounds (other than PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g).

Site	1-1		1-1		1-2		1-2		1-3		1-3		1-4		1-4	
Species	*Epinephelus merra*		*Acanthurus triostegus*		*Acanthurus triostegus*		*Epinephelus merra*		*Abudefduf septemfasciatus*		*Epinephelus merra*		*Abudefduf septemfasciatus*		*Abudefduf sordidus*	
Common Name	Honeycomb grouper		Convict tang		Convict tang		Honeycomb grouper		Banded sergeant major		Honeycomb grouper		Banded sergeant major		Blackspot sergeant	
Compound																
Aldrin	0.05	J	0.26		0.15		0.03	J	0.00	U	0.12		0.00	U	0.00	U
Dieldrin	0.00	U	0.01	J	0.00	U	0.00	U	0.00	U	0.02	J	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
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
Heptachlor-Epoxide	0.01	J	0.00	U	0.02	J	0.00	U	0.00	U	0.02	J	0.00	U	0.04	J
Oxychlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.08	J	0.00	U	0.00	U	0.00	U
Alpha-Chlordane	0.04	J	0.03	J	0.00	U	0.00	U	0.00	U	0.04	J	0.04	J	0.00	U
Gamma-Chlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.03	J	0.00	U	0.00	U
Trans-Nonachlor	0.14		0.00	U	0.00	U	0.00	U	0.10	J	0.26		0.31		0.24	
Cis-Nonachlor	0.02	J	0.00	U	0.01	J	0.00	U	0.00	U	0.04	J	0.06	J	0.09	J
Alpha-HCH	0.00	U	0.11	J	0.11	J	0.04	J	0.10	J	0.05	J	0.08	J	0.07	J
Beta-HCH	0.55		0.34		0.29		0.31		0.20	J	0.78		0.25		0.32	
Delta-HCH	0.00	U	0.02	J	0.01	J	0.00	U	0.05	J	0.00	U	0.04	J	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
DDMU	0.46		2.57		2.83		0.04	J	14.82		0.30		5.58		14.14	
2,4'-DDD	0.10	J	0.23		0.12	J	0.05	J	1.33		0.00	U	0.40		1.09	
4,4'-DDD	0.86		2.62		2.42		0.20		11.82		0.60		9.37		12.89	
2,4'-DDE	0.06	J	0.14		0.13		0.00	U	0.65		0.04	J	0.85		0.57	
4,4'-DDE	43.87		21.73		52.49		9.56		148.24		17.43		185.35		267.74	
2,4'-DDT	0.07	J	0.10	J	0.08	J	0.02	J	0.27		0.04	J	0.40		0.99	
4,4'-DDT	0.83		1.99		1.62		0.18		3.70		0.35		5.86		6.00	
1,2,3,4-Tetrachlorobe	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,4,5-Tetrachlorobe	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	0.03	J	0.00	U	0.10	J	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
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
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
Endosulfan I	1.04		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.17	
Endosulfan Sulfate	0.00	U	0.00	U	0.00	U	0.10	J	0.15		0.12	J	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	0.09	J	0.14	
Chlorpyrifos	0.09	J	0.00	U	0.00	U	0.12	J	0.00	U	0.16	J	0.00	U	0.13	J
Total HCH	0.55		0.47		0.41		0.36		0.35		0.83		0.36		0.39	
Total Chlordane	0.21	J	0.03	J	0.02	J	0.00	U	0.18	J	0.39	J	0.41	J	0.37	J
Total DDT	46.25		29.38		59.69		10.05		180.82		18.76		207.81		303.44	

Notes: J, below method detection level, MDL; U, not detected

Appendix O. Organochlorine compounds (other than PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	1-4		1-5		1-7		1-7		1-7		2-1		2-2		2-2	
Species	*Epinephelus merra*		*Epinephelus hexagonatus*		*Lethrinus obsoletus*		*Lutjanus fulvus*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus obsoletus*		*Lethrinus harack*	
Common Name	Honeycomb grouper		Starspotted grouper		Orange-striped emperor		Blacktail snapper		Honeycomb grouper		Honeycomb grouper		Orange-striped emperor		Thumbprint emperor	
Compound																
Aldrin	0.06	J	0.00	U	0.00	U	0.00	U	0.00	U	0.10	J	0.00	U	0.00	U
Dieldrin	0.00	U	0.00	U	0.05	J	0.01	J	0.02	J	0.09	J	0.00	U	0.01	J
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
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
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
Oxychlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.03	J	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	0.06	J	0.00	U	0.00	U
Gamma-Chlordane	0.01	J	0.00	U	0.03	J	0.00	U	0.00	U	0.02	J	0.00	U	0.00	U
Trans-Nonachlor	0.24		0.00	U	0.35		0.00	U	0.19		0.19		0.00	U	0.00	U
Cis-Nonachlor	0.03	J	0.02	J	0.05	J	0.00	U	0.02	J	0.03	J	0.00	U	0.00	U
Alpha-HCH	0.10	J	0.00	U	0.00	U	0.00	U	0.00	U	0.07	J	0.05	J	0.05	J
Beta-HCH	0.78		0.56		0.27		0.23		0.49		1.04		0.18	J	0.25	
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
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
DDMU	0.56		0.00	U	0.78		0.05	J	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
4,4'-DDD	1.19		0.02	J	1.19		0.07	J	0.09	J	0.04	J	0.00	U	0.00	U
2,4'-DDE	0.06	J	0.00	U	0.09	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDE	31.51		2.61		17.20		1.03		2.60		0.57		0.07	J	0.08	J
2,4'-DDT	0.13	J	0.00	U	0.13	J	0.02	J	0.03	J	0.00	U	0.00	U	0.00	U
4,4'-DDT	1.55		0.00	U	2.60		0.07	J	0.13	J	0.00	U	0.00	U	0.00	U
1,2,3,4-Tetrachlorobe	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,4,5-Tetrachlorobe	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	0.08	J	0.00	U	0.07	J	0.06	J	0.12	J	0.12	J	0.02	J	0.00	U
Pentachloroanisole	0.17		0.00	U	0.00	U	0.00	U	0.00	U	0.22		0.00	U	0.00	U
Pentachlorobenzene	0.00	U	0.00	U	0.13		0.00	U	0.24		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
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
Endosulfan Sulfate	0.00	U	0.01	J	0.00	U	0.04	J	0.09	J	0.03	J	0.00	U	0.00	U
Mirex	0.11	J	0.11	J	0.00	U	0.00	U	0.00	U	0.09	J	0.00	U	0.00	U
Chlorpyrifos	0.17	J	0.00	U	0.00	U	0.00	U	0.00	U	0.12	J	0.14	J	0.10	J
Total HCH	0.89		0.56		0.27	J	0.23	J	0.49		1.11		0.24	J	0.30	J
Total Chlordane	0.28	J	0.02	J	0.42	J	0.00	U	0.25	J	0.30	J	0.00	U	0.00	U
Total DDT	35.00		2.63		22.00		1.24		2.85		0.61	J	0.07	J	0.08	J

Notes: J, below method detection level, MDL; U, not detected

Appendix O. Organochlorine compounds (other than PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	2-2		3-1		3-3		3-2		3-1		4-1		4-1		4-2	
Species	*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Epinephelus merra*		*Acanthurus triostegus*		*Lethrinus obsoletus*		*Epinephelus merra*		*Epinephelus merra*	
Common Name	Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Honeycomb grouper		Convict tang		Orange-striped emperor		Honeycomb grouper		Honeycomb grouper	
Compound																
Aldrin	0.00	U	0.00	U	0.11	J	0.05	J	0.39		0.00	U	0.19		0.06	J
Dieldrin	0.07	J	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
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
Heptachlor-Epoxide	0.02	J	0.03	J	0.01	J	0.01	J	0.02	J	0.00	U	0.04	J	0.03	J
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
Alpha-Chlordane	0.05	J	0.12	J	0.06	J	0.00	U	0.08	J	0.00	U	0.06	J	0.04	J
Gamma-Chlordane	0.00	U	0.03	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Trans-Nonachlor	0.11	J	0.59		0.14		0.00	U	0.27		0.00	U	0.00	U	0.00	U
Cis-Nonachlor	0.04	J	0.15		0.04	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Alpha-HCH	0.06	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Beta-HCH	0.73		1.20		0.64		0.32		0.46		0.22		0.00	U	0.48	
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
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
DDMU	0.00	U	0.08	J	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
4,4'-DDD	0.03	J	1.74		0.02	J	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	0.00	U	0.00	U
4,4'-DDE	0.53		1.95		0.33		0.06	J	0.24		0.00	U	0.12	J	0.07	J
2,4'-DDT	0.00	U	0.17		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDT	0.00	U	3.54		0.00	U	0.00	U	0.13	J	0.00	U	0.00	U	0.00	U
1,2,3,4-Tetrachlorobe	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,4,5-Tetrachlorobe	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	0.09	J	0.12	J	0.07	J	0.00	U	0.00	U	0.00	U	0.15	J	0.09	J
Pentachloroanisole	0.09	J	0.00	U	0.00	U	0.00	U	0.21		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
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
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
Endosulfan Sulfate	0.00	U	0.07	J	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
Chlorpyrifos	0.13	J	0.08	J	0.09	J	0.08	J	0.00	U	0.09	J	0.13	J	0.20	J
Total HCH	0.78		1.20		0.64		0.32	J	0.46		0.22	J	0.00	U	0.48	
Total Chlordane	0.22	J	0.91		0.25	J	0.01	J	0.37	J	0.00	U	0.09	J	0.07	J
Total DDT	0.55	J	7.48		0.35	J	0.06	J	0.37	J	0.00	U	0.12	J	0.07	J

Notes: J, below method detection level, MDL; U, not detected

Appendix O. Organochlorine compounds (other than PCBs) detected in fish from Cocos Lagoon, Guam (ng/wet g) (cont.).

Site	4-2		4-3		4-3		4-4		4-5		4-5	
Species	*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus harack*		*Epinephelus merra*	
Common Name	Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper		Thumbprint emperor		Honeycomb grouper	
Compound												
Aldrin	0.00	U	0.00	U	0.18		0.06	J	0.07	J	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
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	0.02	J	0.13	J	0.05	J
Oxychlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Alpha-Chlordane	0.05	J	0.05	J	0.06	J	0.05	J	0.05	J	0.05	J
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	0.08	J	0.05	J	0.11	J	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	0.19	J	0.18	J	0.00	U	0.39		0.34		0.20	J
Delta-HCH	0.02	J	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	0.49		0.00	U	0.17		0.13	J	0.11	J	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	0.06	J	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,3,4-Tetrachlorobe	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,4,5-Tetrachlorobe	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	0.11	J	0.07	J	0.05	J	0.02	J
Pentachloroanisole	0.00	U	0.00	U	0.00	U	0.13	J	0.22		0.17	
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	0.03	J	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	0.18	J	0.12	J	0.00	U	0.00	U
Total HCH	0.21	J	0.18	J	0.00	U	0.39		0.34	J	0.20	J
Total Chlordane	0.05	J	0.05	J	0.14	J	0.12	J	0.29	J	0.10	J
Total DDT	0.55	J	0.00	U	0.17	J	0.13	J	0.11	J	0.00	U

Notes: J, below method detection level, MDL; U, not detected

Appendix P. Butyltins detected in fish from Cocos Lagoon, Guam (ng Sn/wet g).

Site	1-1		1-1		1-2		1-2		1-3		1-3	
Species	*Epinephelus merra*		*Acanthurus triostegus*		*Acanthurus triostegus*		*Epinephelus hexagonatus*		*Abudefduf septemfasciatus*		*Epinephelus merra*	
Common Name	Honeycomb grouper		Convict tang		Convict tang		Starspotted grouper		Banded sergeant major		Honeycomb grouper	
Monobutyltin	0.31		0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

Site	1-4		1-4		1-4		1-5		1-7		1-7	
Species	*Abudefduf septemfasciatus*		*Abudefduf sordidus*		*Epinephelus merra*		*Epinephelus hexagonatus*		*Lethrinus obsoletus*		*Lutjanus fulvus*	
Common Name	Banded sergeant major		Blackspot sergeant		Honeycomb grouper		Starspotted grouper		Orange-striped emperor		Blacktail snapper	
Monobutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

Site	1-7		2-1		2-2		2-2		2-2		3-1	
Species	*Epinephelus merra*		*Epinephelus merra*		*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*	
Common Name	Honeycomb grouper		Honeycomb grouper		Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper	
Monobutyltin	0.00	U	0.42		0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

Appendix P. Butyltins detected in fish from Cocos Lagoon, Guam (ng Sn/wet g) (cont.).

Site	3-3		3-2		3-1		4-1		4-1		4-2	
Species	*Epinephelus merra*		*Epinephelus merra*		*Acanthurus triostegus*		*Lethrinus obsoletus*		*Epinephelus merra*		*Epinephelus merra*	
Common Name	Honeycomb grouper		Honeycomb grouper		Convict tang		Orange-striped emperor		Honeycomb grouper		Honeycomb grouper	
Monobutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

Site	4-2		4-3		4-3		4-4		4-5		4-5	
Species	*Lethrinus obsoletus*		*Lethrinus harack*		*Epinephelus merra*		*Epinephelus merra*		*Lethrinus harack*		*Epinephelus merra*	
Common Name	Orange-striped emperor		Thumbprint emperor		Honeycomb grouper		Honeycomb grouper		Thumbprint emperor		Honeycomb grouper	
Monobutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dibutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tributyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Tetrabutyltin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U

Note: U, not detected

Appendix Q. Trace and major elements in fish from Cocos Lagoon, Guam (µg/wet g).

Site	1-1	1-1	1-2	1-2	1-3	1-3
Species	*Epinephelus merra*	*Acanthurus triostegus*	*Acanthurus triostegus*	*Epinephelus merra*	*Abudefduf septemfasciatus*	*Epinephelus merra*
Common Name	Honeycomb grouper	Convict tang	Convict tang	Honeycomb grouper	Banded sergeant major	Honeycomb grouper
Silver (Ag)	0.004	0.008	0.015	0.003	0.005	0.000 U
Aluminum (Al)	0.782	1.391	1.578	1.698	8.122	0.560
Arsenic (As)	1.176	0.619	0.655	1.027	1.184	1.421
Cadmium (Cd)	0.022	0.065	0.049	0.025	0.036	0.030
Chromium (Cr)	3.352	1.133	0.499	0.462	2.345	1.328
Copper (Cu)	0.882	0.992	2.478	0.734	1.153	0.712
Iron (Fe)	35.574	24.139	25.714	17.345	47.422	22.356
Manganese (Mn	0.494	0.660	0.738	0.301	1.234	0.309
Nickel (Ni)	0.244	0.234	0.168	0.094	0.359	0.133
Lead (Pb)	0.029	3.179	3.172	0.029	3.170	0.029
Selenium (Se)	0.456	0.106	0.134	0.362	0.239	0.433
Tin (Sn)	0.007	0.000 U	0.000 U	0.000 U	0.012	0.000 U
Zinc (Zn)	19.345	21.391	57.720	16.368	26.724	14.738
Mercury (Hg)	0.043	0.008	0.014	0.024	0.011	0.036

Note: U, not detected

Site	1-4	1-4	1-4	1-5	1-7	1-7
Species	*Abudefduf septemfasciatus*	*Abudefduf sordidus*	*Epinephelus merra*	*Epinephelus hexagonatus*	*Lethrinus obsoletus*	*Epinephelus merra*
Common Name	Banded sergeant major	Blackspot sergeant	Honeycomb grouper	Starspotted grouper	Orange-striped emperor	Honeycomb grouper
Silver (Ag)	0.004	0.000 U	0.000 U	0.000 U	0.000 U	0.000 U
Aluminum (Al)	7.784	7.725	12.026	0.536	0.803	0.715
Arsenic (As)	1.540	3.337	1.184	0.857	1.897	2.334
Cadmium (Cd)	0.046	0.029	0.023	0.080	0.010	0.034
Chromium (Cr)	0.658	1.406	0.875	0.298	4.234	1.597
Copper (Cu)	0.961	0.887	0.909	0.407	0.621	0.508
Iron (Fe)	47.770	62.418	34.578	13.261	46.400	22.523
Manganese (Mn	1.104	1.570	0.655	0.676	0.528	0.647
Nickel (Ni)	0.269	0.321	0.275	0.157	0.415	0.448
Lead (Pb)	1.869	1.122	0.041	0.032	0.040	0.026
Selenium (Se)	0.261	0.436	0.395	0.412	0.505	0.450
Tin (Sn)	0.027	0.021	0.000 U	0.000 U	0.000 U	0.010
Zinc (Zn)	25.908	27.068	17.564	15.229	16.240	12.749
Mercury (Hg)	0.014	0.028	0.040	0.034	0.036	0.069

Note: U, not detected

Appendix Q. Trace and major elements in fish from Cocos Lagoon, Guam (µg/wet g).

Site	1-7	2-1	2-2	2-2	2-2	3-1
Species	*Lutjanus fulvus*	*Epinephelus merra*	*Lethrinus obsoletus*	*Lethrinus harack*	*Epinephelus merra*	*Epinephelus merra*
Common Name	Blacktail snapper	Honeycomb grouper	Orange-striped emperor	Thumbprint emperor	Honeycomb grouper	Honeycomb grouper
Silver (Ag)	0.000 U	0.003	0.000 U	0.000 U	0.005	0.000 U
Aluminum (Al)	0.000 U	1.059	4.282	1.825	5.059	1.995
Arsenic (As)	0.821	1.309	0.861	0.780	1.648	1.262
Cadmium (Cd)	0.046	0.031	0.017	0.022	0.047	0.028
Chromium (Cr)	1.077	0.998	1.907	0.940	0.995	0.532
Copper (Cu)	0.455	0.762	0.598	0.440	1.240	0.546
Iron (Fe)	17.914	23.797	27.206	20.142	23.115	20.235
Manganese (Mn	0.432	0.417	0.892	1.040	0.734	0.688
Nickel (Ni)	0.628	0.115	0.144	0.136	0.272	0.126
Lead (Pb)	0.000 U	0.020	0.051	0.000 U	0.023	0.021
Selenium (Se)	0.484	0.470	0.437	0.313	0.405	0.447
Tin (Sn)	0.000 U	0.000 U	0.000 U	0.000 U	0.000 U	0.000 U
Zinc (Zn)	18.864	17.014	14.428	17.469	27.303	19.952
Mercury (Hg)	0.057	0.084	0.023	0.033	0.079	0.067

Note: U, not detected

Site	3-3	3-2	3-1	4-1	4-1	4-2
Species	*Epinephelus merra*	*Epinephelus merra*	*Acanthurus triostegus*	*Lethrinus obsoletus*	*Epinephelus merra*	*Epinephelus merra*
Common Name	Honeycomb grouper	Honeycomb grouper	Convict tang	Orange-striped emperor	Honeycomb grouper	Honeycomb grouper
Silver (Ag)	0.000 U	0.000 U	0.004	0.000 U	0.005	0.000 U
Aluminum (Al)	0.457	1.351	115.824	4.723	1.870	0.975
Arsenic (As)	1.262	0.944	1.229	1.190	0.976	0.650
Cadmium (Cd)	0.030	0.021	0.022	0.037	0.066	0.031
Chromium (Cr)	1.293	1.386	1.313	0.538	1.997	1.001
Copper (Cu)	0.627	0.630	2.073	0.475	1.168	0.499
Iron (Fe)	22.682	28.083	127.508	19.301	33.040	19.302
Manganese (Mn	0.511	0.825	3.302	0.789	0.578	0.328
Nickel (Ni)	0.094	0.159	0.427	0.135	0.187	0.116
Lead (Pb)	0.000 U	0.029	1.196	0.000 U	0.000 U	0.000 U
Selenium (Se)	0.470	0.491	0.077	0.295	0.425	0.353
Tin (Sn)	0.000 U	0.000 U	0.013	0.000 U	0.000 U	0.000 U
Zinc (Zn)	16.408	15.610	24.486	12.886	24.839	11.392
Mercury (Hg)	0.071	0.056	0.005	0.017	0.036	0.020

Note: U, not detected

Appendix Q. Trace and major elements in fish from Cocos Lagoon, Guam (µg/wet g).

Site *Species* Common Name	4-2 *Lethrinus obsoletus* Orange-striped emperor	4-3 *Lethrinus harack* Thumbprint emperor	4-3 *Epinephelus merra* Honeycomb grouper	4-4 *Epinephelus merra* Honeycomb grouper	4-5 *Lethrinus harack* Thumbprint emperor	4-5 *Epinephelus merra* Honeycomb grouper
Silver (Ag)	0.000 U	0.000 U	0.003	0.000 U	0.000 U	0.000 U
Aluminum (Al)	0.602	2.733	0.713	1.218	1.198	3.353
Arsenic (As)	2.287	1.564	0.999	0.709	0.694	1.633
Cadmium (Cd)	0.023	0.074	0.069	0.100	0.026	0.044
Chromium (Cr)	0.116	0.559	0.635	0.506	1.157	0.792
Copper (Cu)	0.364	0.427	1.002	0.686	0.653	0.574
Iron (Fe)	12.119	14.201	19.710	16.499	27.756	24.486
Manganese (Mn	0.468	0.800	0.454	0.517	0.421	0.953
Nickel (Ni)	0.074	0.196	0.100	0.130	0.116	0.176
Lead (Pb)	0.027	0.000 U	0.000 U	0.000 U	0.017	0.020
Selenium (Se)	0.493	0.300	0.419	0.388	0.450	0.394
Tin (Sn)	0.000 U	0.000 U	0.000 U	0.000 U	0.000 U	0.000 U
Zinc (Zn)	12.903	18.105	20.493	16.294	15.317	20.193
Mercury (Hg)	0.010	0.088	0.069	0.057	0.074	0.111

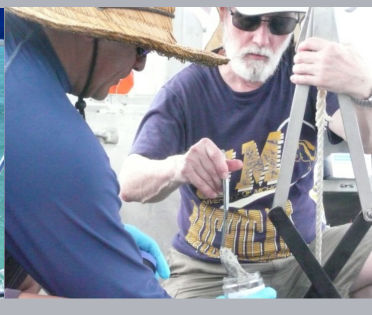
Note: U, not detected

U.S. Department of Commerce
Wilbur Ross, *Secretary*

National Oceanic and Atmospheric Administration
Tim Gallaudet, RDML (Ret.), *Acting Administrator*

National Ocean Service
Russell Callender, *Assistant Administrator for Ocean Service and Coastal Zone Management*



The mission of the National Centers for Coastal Ocean Science is to provide managers with scientific information and tools needed to balance society's environmental, social and economic goals. For more information, visit: http://www.coastalscience.noaa.gov/.