Executive Summary

Environmental Research and Community Health Studies in Northwest Florida

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Reports of the Grand Jury impaneled by the First Judicial Court of the State of Florida addressed the deterioration of environmental health in Northwest Florida due to pollution from a variety of point and non-point sources affecting air and water quality (Grand Jury report, 1999) and contamination of ground water (Grand Jury report, 2004). In response to these reports and to address related concerns from the community, the U.S. Congress provided funding to the University of West Florida (UWF) via EPA and CDC to conduct environmental health studies in Escambia and Santa Rosa counties. UWF formed an alliance, Partnership for Environmental Research and Community Health (PERCH), with the regional public health departments—Escambia County Health Department and Santa Rosa County Health Department—and developed collaborative relationships with other academic institutions (Georgia Institute of Technology, University of South Florida, and Florida State University) to undertake comprehensive assessments of environmental health in Northwest Florida. The studies undertaken for the PERCH project have been embodied in five different proposals that have been reviewed and approved for a cooperative agreement awarded by EPA Region 4 (2002-2009) and two proposals reviewed and approved for two grants awarded by CDC (2002-2004; 2005-2007).

Based on the availability of funds, it was necessary to propose specific projects that could be completed within each budget/project period. Accordingly, we conducted a series of interrelated studies, each building upon the results and problems revealed by a preceding study, with a goal of performing comprehensive assessments to address issues of concern related to environmental and community health in Northwest Florida. These comprehensive studies address the concerns of our community, with the results and conclusions having broader applications/implications for our area and for other regions of the state and the country. Our project results have been disseminated widely through peer-reviewed publications, presentations at professional meetings, presentations to state and federal agencies as well as to stakeholder organizations in the region, and posting of our detailed reports at the UWF-CEDB website for public access:

http://www.uwf.edu/cedb/perch.cfm

1. Construction of an environmental bibliography for Northwest Florida
http://fusionmx.lib.uwf.edu/perch/

The Grand Jury report addressed the difficulty in finding relevant information, because of the diffuse sources and difficult access to various reports. In order to alleviate this

problem, we created an electronic database of environmental studies in Northwest Florida, including more than 2000 citations (with annotated summaries), and posted it on UWF library's web site accessible to the general public. This bibliography is being used widely, with more than 4,000 hits during the recent three years on this server with visitors from the United States and abroad.

2. Air quality studies
http://cure.eas.gatech.edu/~chang/perch/

These studies, conducted by our collaborators at Georgia Institute of Technology, included evaluations of historic data, an intensive 30-day field monitoring done utilizing Georgia Tech's mobile laboratory deployed on the grounds of O.J. Semmes Elementary School, and comprehensive air quality and air toxics modeling. Initial evaluations showed that, with regard to public health, particulate matter ($PM_{2.5}$) pollution is of greater concern, than are ozone and air toxics for the Pensacola area. Detailed analysis showed that sulfate was a large fraction of the observed ambient $PM_{2.5}$ loading, with high concentrations most often associated with northerly flow. Coal and gasoline combustion were observed to account for most of the Pensacola atmosphere's particle load during a high pollution event, although open fires were also a possible source of particles during this event. Source apportionment of $PM_{2.5}$ indicated that sulfate constitutes half or more of the particulate load in the Pensacola area for the modeled episode. Rather than local sources, however, sulfate concentrations were more sensitive to distance sources. In contrast, ammonium concentrations were more sensitive to local sources. As in the case of ozone, a combination of regional and local controls may be necessary to effectively manage particulate air pollution in the Pensacola area.

Risk assessment of air toxics from various sources (e.g., point source emissions; mobile source air toxics) for cancer risks and non-cancer health risks, was done utilizing the RAIMI (Regional Air Impact Modeling Initiative) tools developed by EPA. This analysis enabled the identification of four risk zones for cancer based on point source emissions, and much higher risks emanating from mobile source emissions (additional details in the following section). In view of the community's concern for sizable and sole-source of emissions of HCl and HF from Plant Crist, an assessment was made of the potential health risks. HCl and HF are not known to be carcinogenic and, at the levels released, they do not appear to present a significant acute health risk via inhalation.

3. Health outcomes analysis
http://www.uwf.edu/cedb/PERCH_health_outcomes_air_quality.pdf

There is considerable interest in environmental health tracking studies, in which geographic patterns of exposure to pollution are being compared to variation in the health status of populations. We conducted such evaluations in Northwest Florida on the association between air pollution and health outcomes. Initial evaluation dealt with health outcomes comparisons at zip code level geographic units. This analysis showed that the overall health of the population in Escambia and Santa Rosa counties is not significantly different from that of socioeconomically and demographically similar populations in Central and North Florida regions. The health outcomes varied spatially,

with some zip codes having significantly higher or lower levels of adverse health outcomes than matching zip codes elsewhere in Florida. Among the health outcome indicators examined, Escambia and Santa Rosa counties showed notably higher incidences of mortality related to birth defects, infant mortality, and mortality in blacks for multiple diseases.

http://www.uwf.edu/cedb/Perch_USF_EPA_April04.pdf

In the next phase, we evaluated whether the observed variations in health outcomes at the zip code level are related to the geographical distribution (proximity and discharges) of air pollution emitters. This study did not find clear evidence for an influence of proximity to emission sites on "cumulative" health outcomes at the zip code level. Some of the "specific" health outcomes, however, seem to be related to the proximity to emission sites as evidenced by relationships at the zip code level within Northwest Florida and similar areas elsewhere in the state. The zip codes with a high incidence of some of the specific outcomes—mortality due to cardiac disease in whites aged >65; mortality due to lung cancer in blacks aged >65; mortality due to birth defects in blacks; morbidity (sickness/hospitalizations) due to asthma in blacks, cardiac diseases in blacks aged >65, and pneumonia in whites aged >65—have a higher proximity index than zip codes with lower incidence, pointing to an influence of the proximity of emission sources on these health outcomes.

Our geospatial statistical analysis of data for the greater Pensacola area showed that high risk of mortality due to COPD (chronic obstructive pulmonary disorder), stroke, and lung cancer was found in areas with low income level and high air pollution levels (from point sources and mobile sources), and also in blacks and population aged 65 and above. High risk of mortality due to chronic coronary heart disease (CCHD) was found in areas with elevated levels of outdoor aerosol pollution (which is correlated to $PM_{2.5}$ particulate pollution) in the eastern United States. Escambia and Santa Rosa counties of Florida (at the county level) have relatively lower rates of CCHD (SMR<1), although they have high AOD (Aerosol Optical Density) values. Nevertheless, the periodic episodes of high $PM_{2.5}$ levels observed in our area and their potential impacts on health outcomes merit further investigation.

An additional follow-up assessment included the application of EPA's RAIMI (Regional Air Impacts Modeling Initiative) tools, designed to evaluate the potential for health impacts as a result of exposure to multiple contaminants from multiple sources, at a community level resolution. In this analysis, three areas in Santa Rosa county and one area in Escambia county were estimated to have a possible elevated risk of cancer due to emissions from point sources (stationary or industrial sources). While of concern, the estimated risks are of a magnitude that is consistent with risks found near other industrial sources. Analysis using RAIMI seems to suggest that toxic emissions from point sources are not a widespread source of cancer risk via the inhalation pathway in the Pensacola area (with the caveat that we did not study other exposure pathways).

When similar modeling is done for mobile source emissions using RAIMI, elevated cancer and non-cancer risks are found to be ubiquitous in the Pensacola area with higher risks generally along more highly traveled roadways. Arising from the emissions of formaldehyde, benzene, and butadiene from cars and trucks, the health risks

diminish several orders of magnitude a few hundred meters off the roadway. It is important to note that residential and other populated areas immediately adjacent to busy roadways may incur significantly elevated cancer and non-cancer risks.

Continued reductions in industrial emissions, along with improved traffic flow and reduction/modifications in fuel consumption of automobiles, would help improve outdoor air quality. Exposure to outdoor pollution, infiltration of outdoor pollution into buildings, emissions from indoor sources, and uptake of pollutants through food are all known to be important factors to consider in reducing overall personal risk to hazardous air pollutants.

4. Clinical toxicology and health evaluation of communities near Superfund sites
http://uwf.edu/cedb/PERCH_Health_Screening_Final_Report_.pdf
http://uwf.edu/cedb/Perch_DOH_Final_ReporttoIRB.pdf

We provided health evaluations and biomonitoring for contaminants of concern for a 228-person subset of the eligible workers/residents, including 202 blacks, identified in the CEHP (Community Environmental Health Project) who had been potentially exposed to chemical contaminants at the ETC (Escambia Treating Company) Superfund site. The consulting physicians discussed the results of the evaluations individually with the participants. In a follow-up survey, 84 to 92% of the participants were very satisfied with the health evaluations performed as part of the PERCH project.

We found that the ETC cohort exhibited elevated levels of serum dioxins/furans relative to levels in the general population, and the dioxin congener profiles in the participants appeared to reflect patterns commonly observed in persons exposed to wood-treatment facilities using pentachlorophenol (PCP). We published our results in a peer-reviewed journal (Karouna-Renier et al., Chemosphere, 69 (2007): 1312-1319). Diseases usually associated with PCP/dioxin exposure, such as chloracne and/or skin cancer, were not prevalent in the ETC cohort. The ETC population exhibited a higher prevalence rate of uterine/cervical and prostate cancers than national levels, although we were unable to establish a direct link between the cancer prevalence and exposure to contaminants from the ETC site. This population also showed elevated prevalence of diabetes, hypertension, obesity, and hepatitis A, B, and C, relative to national levels.

We have conducted a supplemental health evaluation and biomonitoring for an additional 31-person subset of residents who live or had lived in the Clarinda Triangle Area near the ETC site, since EPA's re-evaluation indicated elevated levels of dioxins and arsenic in the soil samples from this area and the agency's proposed follow-up action involves relocation of residents from this area. The population from the Clarinda Triangle Area showed health profiles generally similar to those noted with the 228-person cohort examined above. In the case of hepatitis, only hepatitis A showed elevated prevalence in the Clarinda Triangle Population, whereas hepatitis A, B, and C were elevated in the ETC-cohort. The mean serum dioxin levels of Clarinda Triangle population was lower than that of ETC-cohort, possibly because the latter included data from former workers at ETC some of whom had substantially elevated dioxin residues. The overall serum dioxin levels and congener profiles of Clarinda Triangle Area residents were comparable to those seen in individuals near wood treatment plants. It was not possible to establish a link between serum dioxin levels and health status of the residents, because of the small

sample size and due to the fact that our measurements occurred many years after the plant operations ceased.

5. Environmental follow-up assessments for children with elevated blood lead levels
http://uwf.edu/cedb/Perch_Lead_Prevalence_Assessment.pdf

We provided lead assessments (in paint chips, soil, and wipe samples) for 33 homes built before 1979 in Escambia County. Among the homes tested 51.5% had detectable levels of lead contamination, and 21.2% had lead contamination levels above the HUD guidelines. In order to help protect the health of children, we provided educational materials and specific recommendations for reducing lead hazards at home to the affected residents.

6. Mercury levels in hair samples from child-bearing age women
http://uwf.edu/cedb/PERCH_CDC_Final_Report_2007.pdf
http://www.doh.state.fl.us/disease_ctrl/epi/EPI_Updates/2007/01_25_2007.pdf

Nearly 75% of the fish consumption advisories in the United States have been issued due to mercury contamination. Florida has issued fish consumption advisories due to mercury levels for three freshwater fish (largemouth bass, bowfin, and gar) and multiple marine fish (cobia, barracuda, tuna, shark, and mackerel). Thus the human population in Florida, especially in coastal areas, is potentially exposed to mercury through fish consumption. In view of the potential risks of mercury exposure, especially neurodevelopmental problems in children, we examined the mercury levels in hair samples from child-bearing age females. Our target was to recruit 400 volunteers from Escambia and Santa Rosa counties, but we accommodated 602 participants in view of the overwhelming interest. This in-depth assessment was not done earlier in any part of Florida. Of the 602 women sampled, 95 (15.8%) had hair mercury levels that exceeded the US EPA advisory level of 1.0 µg/g. Of these 95 women, 62.5% ate more than three seafood meals in the 30 days prior to sampling. Women who consumed one, two, three, or more than three fish meals during the 30 days prior to sampling had significantly higher hair mercury levels than women who did not consume fish/shellfish in that period. We published our results in a peer-reviewed journal (Karouna-Renier et al., Environmental Research, 108: 320-326, 2008).

We relayed the hair mercury results to individual participants, and the feedback indicates that women who were pregnant or planning to be pregnant utilized the results to make informed choices in fish consumption. Our surveys of the study participants indicated that nearly 70% are unaware of fish consumption advisories. Recently the Escambia County Health Department launched a campaign (billboards, news releases, and wallet cards) to increase public awareness of fish consumption advisories due to mercury, and provide information on fish with low mercury loads. We recommend that follow-up studies include the analysis of hair mercury in children, men, and families of recreational fishers as they may also be subject to neurological and cardiovascular problems associated with excessive mercury accumulation.

7. Atmospheric deposition of mercury and trace elements to the Pensacola Bay Watershed

http://www.uwf.edu/cedb/PERCH_EPA_final_report_Hg_project.pdf

Mercury contamination associated with increased fossil fuel combustion poses a growing problem in many areas. The southeast, and in particular the Gulf coast, experiences the highest levels of mercury deposition in the United States. Yet, there has not been any monitoring for mercury deposition in Northwest Florida. We have measured the concentrations of mercury, trace metals, and major ions in rainwater samples collected at 3 sites in the Pensacola Bay watershed over a three-year period. Data from our comprehensive analysis will be useful to the State of Florida as it develops a TMDL (Total Maximum Daily Loads) for mercury.

Mercury fluxes and total mercury deposition at the Pensacola Bay sites are similar to those noted at the MDN (Mercury Deposition Network) sites along the central Gulf of Mexico region. The total mercury deposition at all these sites follows the historical pattern of relatively high mercury deposition rates in the Southeastern United States. Mercury concentrations in rainwater samples show strong correlation with selenium, antimony, arsenic, and sulfate, pointing to their derivation from coal/fossil fuel combustion. We estimate that 25 to 51% of the mercury in our rain samples is attributable to coal combustion. Because of the large number of emission sources in the region and mixing of air masses from the different regions, it is difficult to determine the contribution of local sources for mercury deposited to the Pensacola Bay watershed. Plant Crist in Pensacola is adding scrubbers to reduce emissions of sulfate and mercury. Since emissions from coal-fired plants in the nearby State of Alabama far exceed the emissions from Plant Crist, it is desirable to reduce mercury discharges from coal-fired power plants at various regional locations.

The deposition rates in rain for several ions at our monitoring sites and at several other sites in Florida and Alabama show significant correlation to air emissions, with correlation coefficients of 0.95 (ammonium), 0.80 (nitrate), and 0.68 (sulfate). This is in agreement with air quality studies (reported above) in which the source apportionment of $PM_{2.5}$ in the Pensacola area revealed that ammonium concentrations were more sensitive to local sources, whereas sulfate concentrations were more sensitive to distance sources. This, again, points to the need for emission reductions at local and regional levels for improvement of air quality, ecosystem health, and human health.

The monitoring we conducted during 2005-2007 for this project is continuing uninterrupted with support from the Electric Power Research Institute. The extended monitoring is expected to complement the EPA study done in February 2008, "Mercury Speciation in Coal-fired Utility Boiler Emission Plume," at Plant Crist in Pensacola, and also aid in evaluating the effects of scrubbers being added to Plant Crist on air emissions.

8. Pollution of surface soils in Escambia and Santa Rosa counties

http://uwf.edu/cedb/Perch_report_surfacesoils.pdf

This project focuses on pollution of soils in public places such as parks, playgrounds, and sports fields where most interaction takes place between people and soils. The results, presented in a GIS format, are based on analysis of samples from 126 locations in the two

counties, including 12 from the Palafox industrial corridor, and 5 locations that had CCA-treated wood structures.

Dioxin/furan TEQs (Toxic Equivalency Quotient) in surface soils in the Palafox industrial corridor are below the EPA screening level for children (50 ng/kg), and these levels quickly drop off to background levels outside the corridor. PAHs show a very similar pattern with elevated levels being limited to the Palafox industrial corridor, except that 5 of the 12 samples exceeded Florida DEP's residential SCTL (Soil Cleanup Target Level) of 0.1 mg/kg, which merits further evaluation. Now that the clean up and burial of the contaminated soils on and around the ETC (Escambia Treating Company) Superfund Site have been completed by EPA, exposure to contaminated soils of concern has been abated. The residues we found in the areas outside the cleaned up zone, within the industrial corridor, represent the remnants of past contamination.

Concentrations of Cr, Cu, and As are markedly higher near CCA (Chromated Copper Arsenate)-treated wood structures than in the whole data set, although only As exceeded SCTL. It would be best to avoid contact with soils in very close proximity to the CCA-treated structures.

Trace metal concentrations (Cd, Cr, Cu, Hg, Ni, Pb, Zn) in samples from all other locations are generally below their respective RSCTLs, except for arsenic with levels exceeding its RSCTL of 2.1 mg/kg at 33 of the sites in both rural and urban settings without a clear spatial pattern. This indicates that these levels may reflect regionally high arsenic background concentrations (derived from parent materials of soils and/or atmospheric deposition) and also from agricultural operations. Trace metal concentrations are higher near the road, due to traffic-related activities/releases, but the levels decrease between 2 and 20 meters from the edge of the road. We have also measured radioactivity of surface soils, and the observed levels are near background levels and do not pose a health concern.

9. Pollutants in the sediments of urban bayous (Texar, Chico, and Grande) and the Escambia Bay/River

http://www.uwf.edu/cedb/Perch_pollutants_in_Bayou_Texar.cfm
http://www.uwf.edu/cedb/Perch_report_Chico_final_revision_withmaps.pdf
http://www.uwf.edu/cedb/PERCH_Bayou_Grande_Report_Environmental_Assessment.pdf
http://www.uwf.edu/cedb/PERCH_Escambia_Bay_final_report.pdf

The Pensacola Bay System components are invaluable resources for the area, as they add to the scenic beauty of the region, facilitate recreational activities, serve as navigation sources, and support tourism. Chemical pollutants from point and non-point sources affect the environmental health of the Pensacola Bay System. We conducted comprehensive assessment of selected contaminants in the sediments of urban bayous and in the Escambia Bay/River system, and presented the results in a GIS format so that this database can serve as a reference for evaluating changes in the future as well as assist agencies responsible for improving environmental and public health. Our detailed reports are accessible at our website as noted above.

Bayou Texar: This bayou receives pollutants from a variety of sources—storm water runoff, input from carpenter's Creek, and groundwater plumes from Superfund sites. We found that the groundwater plume from the AGRICO Superfund site (ACC) continues to discharge fluoride from groundwater into the northern part of the bayou.

Although the groundwater plume from the Escambia Treating Company (ETC) site is known to be migrating towards Bayou Texar, we did not find evidence for its discharge into the bayou. Pollutants derived from other (non-point) sources, such as PAHs and trace metals, are elevated with the highest levels being found in surficial sediments in the northern section of the bayou, because of diminished flushing in this part of the bayou. In this area, the PEL (probable effect level) for lead, mercury, copper, and zinc are exceeded, indicating that there is a probable effect on benthic biota. Organochlorine pesticide levels are generally low. PCB concentrations are generally lower than in the other bayous. Reflecting the non-industrial nature of this bayou's watershed, total TEQs (Mean: 3.85 ng/kg) due to dioxins/furans/dioxin-like PCBs are lower in Bayou Texar than in Bayou Chico and Bayou Grande.

Bayou Chico: This bayou has a long history of industrial pollution and is considered the most polluted of the three urban bayous in Pensacola. The bayou is adjacent to the American Creosote Works (ACW) Superfund site and the Omni-Vest landfill, and is also subject to pollution from storm water runoff from an industrial area. Two areas—a spoil island in the central part of the bayou, and an area south of the Navy Blvd bridge—have highly elevated levels of pollutants such as PAHs, PCBs, and trace metals. Vibracores taken in shallow water just offshore of Sanders beach at the mouth of the bayou did not show significant PAH concentrations in the lower levels, but similar cores taken on Sanders beach itself contained high concentrations of PAHs of creosote origin, likely originating from the ACW site. Trace metal concentrations are generally high in Bayou Chico, exceeding their TEL (As, Cr, Cd) or PEL (Cu, Pb, Hg, Zn). PCBs are ubiquitous, and their levels exceeded the PEL at 5 out of 17 sites and an additional 8 exceeded the TEL. Dioxins/furans are contaminants of concern at ACW, but they are not present in high concentration in the Sanders beach area or the mouth of the bayou. The total TEQs often exceeded their AET in the rest of the bayou, with high levels near the spoil island. There is periodic dredging in the navigation channel of Bayou Chico, and the recent and future placement of the dredged spoils and their potential impacts on pollution of groundwater and on the bayou need to be followed. The spoil island (created from the past dredged spoils), as noted above, is a major hot spot for pollutants in this bayou.

Bayou Grande: Pollutants affecting the water and sediment quality of the southern half of the bayou were studied previously in reference to possible releases from the Pensacola Naval Air Station (NAS). We conducted a more detailed study and presented the contaminant data in a GIS format. In the case of trace metals, several have exceeded TELs (As, Cr, Hg, Ni) and others exceeded PELs (Cd, Pb, Zn). Naphthalenes (reported to occur in NAS groundwater) are detected at higher concentrations in subsurface sediment in the main basin of the bayou and also in surface sediment near the shore of NAS, pointing to the influence of contaminated groundwater on the bayou. Sediment guideline levels are exceeded by several PAH species. PAHs in this bayou seem to have multiple origins, with combustion of various materials being the major source and do not seem to be caused by petroleum spills. In 15 out of 23 samples, PCBs exceeded the TEL. PCBs in the bayou do not seem to be derived solely from NAS sources, but also from other sources in the watershed. Total TEQs for 17 of the 23 samples exceeded the NOAA sediment quality guidelines, seven of them being 3-fold higher than NOAA AET. Overall the contribution of PCB-like dioxins to the TEQ was

44%, the highest proportion (relative to dioxin/furan contribution) found among other water bodies in the region.

Escambia Bay and River: In addition to addressing the community's concern for lingering residues of PCBs spilled in the 1960s from a point source (former Monsanto Company) into the Escambia River, we conducted a comprehensive analysis of various pollutants in the sediments of Escambia Bay/River System. With a few exceptions, the levels of PAHs and total petroleum hydrocarbons were generally low in the sediments. Among the trace metals, arsenic was the only one that consistently exceeded sediment quality guidelines (30 samples exceeded the TEL, and none exceeded the PEL). In some of the samples, several other metals (Cd, Cr, Cu, Pb, Ni, and Zn) exceeded their respective TELs but not PELs. Overall, the sediment concentrations of trace metals in the Escambia Bay/River System are lower than in the urban bayous of Pensacola. Pesticide levels are generally low, as in the bayous, except for the finding of DDT in 25% of the sediment samples. DDT levels in all but one sample exceeded the Florida DEP's PEL (4.77 μg/kg). The detected DDT was generally associated with sediments in wetlands and the river, and is of concern as some of these areas may serve as nurseries for marine life and DDT could impact fish and shrimp populations. The concentrations of PCBs varied with the region, with sediments from lower Escambia River and upper regions of Escambia Bay having PCBs near the TEL (21.6 μg/kg), with the highest value (125.9 μg/kg) near the original spill site. Lower Escambia Bay sediments had mean PCB concentrations of 11.9 μg/kg, and upriver of the spill site they were even lower (5.06 μg/kg). A majority of the samples (56%) in the Escambia Bay/River System had TEQs exceeding NOAA TEL, and 23% exceeding the NOAA AET. For the combined TEQs, however, PCB-like dioxins accounted for 7% and dioxins/furans accounted for 93%. Spatially, the distribution of dioxin-like PCBs did not coincide with the dioxin/furan TEQ distribution, due to differences in their origin, degradation, and transportation.

Relative pollutant loads and temporal changes: In the case of groundwater plumes from Superfund sites, the release of ACC plume contents continues to be at the same level (based on fluoride in sediments and pore water) as reported by ENTRIX in 1993. EPA has recently completed the first phase of remediation of the ETC site, involving the burial and capping of contaminated soils, and is planning to remediate the contaminated groundwater. These efforts should aid in limiting the spread of contaminants from this Superfund site. The migration and discharge of contaminated groundwater plume from NAS into Bayou Grande needs to be followed and documented. Omni-Vest Landfill does not appear to impact Bayou Chico. The creosote found under Sander's beach is in the path of the ACW plume, and merits follow-up.

Based on the samples we analyzed, the PCB concentrations are highest in Bayou Chico (Mean: 158 μg/kg), with other water bodies having mean concentrations of 61.7 μg/kg (Bayou Grande), 30.7 μg/kg (Bayou Texar), and 17.9 μg/kg (Escambia Bay/River). The mean values for the combined TEQs for dioxins/furans/dioxin-like PCBs were: 44.59 ng/kg (Bayou Chico), 8.3 ng/kg (Bayou Grande), 3.85 ng/kg (Bayou Texar), and 2.62 ng/kg (Escambia bay/River). The relative contributions of dioxin-like PCBs to the total TEQ were: 43.8% (Bayou Grande), 21% (Bayou Chico), 16% (Bayou Texar), and 7% (Escambia Bay/River). Although the mean concentrations of total PCBs and TEQs in Escambia Bay/River were the lowest in comparison to the urban bayous, due to the large geographic area covered by the Escambia Bay/River system, there are hot spots of

contamination. It is also important to note that whereas PCBs pose non-cancer risks, the homologs contributing to TEQs (dioxin-like PCBs) along with dioxins/furans pose cancer risks to humans. We do not have historic comparable data on TEQs in the water bodies studied to assess what temporal changes (if any) occurred. For PCBs, such data is available with the implicit understanding that—because of differences in the number and location of samples, and analytical methods—there are difficulties in drawing reliable conclusions on temporal trends. Nevertheless, it appears that, whereas PCB levels in Bayou Texar are relatively unchanged from the levels noted in the 1990s, the PCB levels in Bayou Grande and Bayou Chico seem to have increased (more so in the latter) which needs to be evaluated. In Escambia Bay the PCB levels seem to have gone down by nearly 50%, but it should be noted that our study included analysis of only surface sediment samples, which would not have identified buried contamination that may be exposed by bioperturbation, storms, dredging, construction, or other activities. In sum, the contamination of sediments with PCBs, dioxins/furans, and dioxin-like PCBs is of concern and should continue to be monitored.

PAH levels in the sediments of Bayou Texar, Bayou Chico, and Escambia Bay/River did not seem to change over two decades, but appear to have increased dramatically (8-fold) in Bayou Grande, although the latter may be attributable to our sampling at more sites including the most polluted areas compared to previous studies. Compared to the levels detected in the 1990s, the organochlorine pesticide levels in the sediments have decreased substantially although the current levels of DDT in the sediments of Escambia River and wetlands are of concern. Trace metal concentrations frequently exceeded SQAGs but to varying degrees in the bay/bayous. Zinc and Hg had the highest concentrations in Bayou Chico and Texar, whereas Cd and Cr were higher in Bayou Grande. Escambia Bay had the lowest trace metal concentrations, but was highest in arsenic—possibly because of its larger watershed that could contribute to the drainage of As from surface soils (natural high background levels, derived from parent soils and/or or from atmospheric deposition) and also from agricultural operations. Since the 1990s Cr, Hg, and Ni concentrations declined in all of the area estuaries. Overall, the concentrations of trace metals declined to a greater extent in Bayou Texar possibly due to stormwater management efforts in its watershed.

10. Accumulation of pollutants in fish and shellfish

http://uwf.edu/cedb/PERCH_Accumulation_of_pollutants_in_fish_and_shellfish.pdf
http://uwf.edu/cedb/PERCH_CDC_Final_Report_2007.pdf

The greatest vector for exposure to environmental contaminants in water bodies for wildlife and humans is through consumption of contaminated food. Although fish consumption advisories due to mercury content are issued for many locations in the State of Florida, including advisories for several freshwater and coastal fish in Northwest Florida, there have not been systematic surveys for other pollutants in fish/shellfish consumed by humans. Our study has contributed to filling this data gap for Northwest Florida, and our comprehensive survey of PCBs and dioxins/furans in seafood is unprecedented.

An initial screening level assessment of contaminants in blue crabs (*Callinectes sapidus*) and oysters (*Crassostrea virginica*) revealed several chemicals of concern (dioxins/furans/PCBs, arsenic, mercury, cadmium, and zinc) in crab muscle, crab

hepatopancreas, total crab tissue, and oysters based on contaminant levels exceeding Screening Values (SVs). The locations that exceeded SVs and had the highest carcinogenic or non-carcinogenic health risks were generally located in urbanized water bodies (Bayou Texar, Bayou Grande, and Bayou Chico) or downstream of known contaminated areas (Western Escambia Bay). Oysters collected from commercial oyster beds in Escambia and East Bays, and crabs collected from East, Blackwater, and Perdido Bays generally had the lowest levels of contaminants. Despite accounting for only 15% of the total tissue, inclusion of hepatopancreas in a crab meal increased contamination to levels above many SVs, and therefore, direct or indirect consumption of hepatopancreas from crabs in the Pensacola Bay system should be discouraged.

In the next phase, we conducted a survey of contaminant levels in largemouth bass (*Micropterus salmoides*) from rivers in Northwest Florida and striped mullet (*Mugil cephalus*) from rivers, bays, and bayous in the region. Largemouth bass collected from all of the study locations exceeded mercury SV (0.4 mg/kg, EPA SV for recreational fisher consumption), and the HQ (Hazard Quotient, non-cancer hazard risk) for nearly all samples exceeded a value of 1, indicating that non-cancer health effects may occur. In contrast, the levels of mercury were very low (0.008 to 0.026 mg/kg) in mullet. This is due to differences in feeding habits: bass are a top level predator, that readily accumulates mercury through the food chain, whereas mullet primarily feed on detritus and sediments.

Largemouth bass had PCB levels exceeding EPA recreational fisher consumption SV (20 ng/kg) in the samples from lower part of Escambia River, downstream of a PCB (Aroclor 1254) spill that occurred in the late 1960s, and had relatively low levels of PCBs in samples from upstream of the spill site in Escambia River and in all other locations (Blackwater, Shoal, Yellow, and Perdido rivers). The highest levels of PCBs in the mullet from the Escambia River/Bay System in this phase of the study were in fish caught in the lower Escambia River. PCB loads exceeding the EPA SV were also found in mullet from NE Escambia Bay, SW Escambia Bay, and in the upper reaches of Escambia River, whereas much lower levels were found in mullet from SE Escambia Bay. After reviewing our findings, the State of Florida Department of Health (DOH) issued a fish consumption advisory based on PCB loads (exceeding 50 ng/kg screening value, set by FL-DOH), warning consumers to restrict their consumption of mullet and bass from the Escambia River from south of State Route 184 to the mouth of the river to one meal per week. In a subsequent evaluation, we determined PCB levels in mullet and several other fish species sampled in Escambia Bay following a demolition blast of a part of the old 1-10 Bridge. Mullet collected from this sampling had the highest levels of PCBs in any of the fish we studied (280 to 1,580 ng/kg). Following our findings, Florida DOH conducted an independent analysis of mullet from several locations in the Pensacola Bay System, found PCB levels exceeding 50 ng/kg in mullet caught from Escambia Bay, and issued (on October 1, 2009) a consumption advisory for mullet caught from the Escambia Bay, thereby extending the previous advisory for fish from lower Escambia River.

We found that mullet from East Bay, Perdido River, and Yellow River have relatively low levels of PCBs (3.8 to 8.8 ng/kg), whereas higher levels were noted in mullet from urban bayous, with levels above the EPA SV for recreational fisher consumption in mullet from Bayou Chico. In all of the sampling locations, however,

TEQs were above the EPA SV for recreational fisher consumption (0.256 ng/kg). In locations with elevated PCB residues in the environment, the accumulation of dioxin-like PCBs adds to the TEQ load. Thus, the relative contribution of dioxin-like PCBs to the total TEQ varies with the species (differences in uptake/accumulation), and the relative concentrations of bio-available dioxins/furans and dioxin-like PCBs in the environment. Our studies show that the relative contribution of dioxin-like PCBs to TEQ loads in mullet varies by location: 29% (Bayou Texar), 52-53% (Bayou Chico and Bayou Grande), 57% (lower Escambia River), and 98% (Escambia Bay, samples near I-10 bridge). The PCB homolog profile seen in fish sampled near I-10 bridge was nearly identical to the profile of congeners in Aroclor 1254, the formulation that was spilled into Escambia River in the 1960s. This suggests that the bridge construction/demolition activities have disturbed the sediments, causing the PCB-laden deeper sediments to be brought up to the surface and increasing the availability of PCBs to biota in the bay. Mullet samples from the rest of Escambia Bay and River show a moderate affinity for Aroclor 1254 (due to attenuation through biotic transfers and partial degradation of the raw product), whereas PCBs in mullet samples from industrialized bayous (Chico and Grande) cluster with Aroclor 1260 homolog pattern, suggesting either enrichment of more highly chlorinated homologs with partitioning into the biota, or alternate sources of PCBs.

In evaluating the health risks from PCBs, it is necessary to consider not only the non-cancer risks posed by PCBs as a whole, but also the cancer risks posed by dioxin-like PCBs along with dioxins/furans. Mullet that were caught in the lower Escambia River had elevated levels of total PCBs for which the hazard quotient (HQ) exceeded 1, which indicates that non-cancer health effects may occur. Bass caught in the lower Escambia River had high levels of both PCBs and mercury, resulting in an HQ above 1. Mullet collected from the Escambia Bay near I-10 bridge yielded much higher HQs (3.55 to 19.75). Excess LCR (Life Time Cancer Risk) exceeded $1x10^{-4}$ (more than one excess cancer per 10,000), for two samples—in mullet from Bayou Chico and in bass from lower Escambia River. In both cases, the primary contributors to the excess LCR were dioxins/furans and dioxin-like PCBs. For mullet from Escambia Bay I-10 bridge sampling, the estimated Life Time Cancer Risks from consumption exceeded 1 per 1,000, attributable almost entirely to dioxin-like PCBs. These findings clearly point to the need for conducting systematic surveys of critical toxic pollutants—not only mercury, but also PCBs, dioxin-like PCBs, and dioxins/furans—in commonly caught and consumed fish from various locations.

In the final phase of our study finfish from seventeen zones within Pensacola Bay and Perdido Bay watersheds were surveyed for mercury and PCB loads, including TEQ loads. This study has compiled an unprecedented dataset on the accumulation of dioxins/furans in estuarine and marine biota. These contaminants are widespread, and in many instances TEQ values exceeding acceptable thresholds were found. The overall data for contaminants, coupled with earlier analysis done on offshore fishes in relation to the sinking of ex-Oriskany, includes information on contaminant loads in 1199 specimens within 48 species. Individual species information has been posted in a series of web pages at:

http://uwf.edu/cedb/Atlas_of_contaminants_in_seafood.cfm

Blackwater-East Bays, lower Pensacola Bay, Santa Rosa Sound, and Perdido Bay are relatively clean zones (based on oyster, blue crab, and mullet data), but this pattern does not hold true for fish that are highly mobile and of high trophic status—e.g., large red drum caught in East Bay and Santa Rosa Sound had the highest PCB loads recorded for this species (60 and 40 ng/kg, respectively). While most species bioaccumulate dioxins/furans, PCBs, and mercury with age, there are exceptions: Spotted seatrout and Spanish mackerel show increased loads of mercury with age, but not for PCBs. On the other hand, king mackerel has much higher loads of both mercury and PCBs with increase in age. Red snapper and groupers also show bioaccumulation of PCBs and mercury with increasing age, pointing to the need for Gulf-wide investigation of pollutant loads in offshore fishes.

In terms of protecting public health, it is necessary to conduct a systematic analysis of target contaminants in commonly caught and consumed fish and shellfish to establish justifiable and uniform (national/state) standards to enable consumers to make informed choices. Given species-specific patterns of contaminant accumulation, it is also necessary to evaluate and communicate about the risks resulting from elevated loads of multiple contaminants found, rather than issuing advisories based on only an individual contaminant. This would alleviate some of the difficulties consumers may encounter in selecting fish as they weigh the risks/benefits of fish consumption. Public health education efforts in this regard need to be augmented, as most people are unaware of fish consumption advisories or about choices in fish consumption.

Recommendations

Health Outcomes in Escambia and Santa Rosa counties

The noted higher health risks in infants, elderly (age >65), blacks, and the poor need to be followed, and appropriate measures implemented for correcting the apparent disparity in health outcomes for an overall improvement in community health.

Population near the Escambia Treating Company (ETC) Site

Although no direct link could be established between disease prevalence and exposure to toxicants from the ETC site, the relatively higher prevalence of cervical/uterine and prostate cancers, hypertension, diabetes, and hepatitis among the examined individuals requires follow-up evaluation and treatment.

Lead assessments for older homes

These assessments should continue for homes built prior to 1979, to determine potential exposure risks from lead contamination and to undertake appropriate remediation measures to protect children's health.

Air Quality

A combination of regional and local controls should be implemented to effectively manage particulate ($PM_{2.5}$) pollution in the Pensacola area.

In order to achieve reductions in atmospheric deposition of mercury to the Pensacola Bay watershed, it would be necessary to reduce emissions from coal-fired power plants at

various regional locations. Corrective measures are being implemented at Plant Crist in Pensacola, and such measures are needed throughout the southeast.

In view of the elevated cancer and non-cancer risks from emissions along highly traveled roadways, efforts should be directed towards improved traffic flow, improved fuel consumption efficiency of automobiles, usage of hybrid or electric-powered vehicles, and increased usage of mass transit systems.

Reductions in personal risks from hazardous air pollutants require measures to decrease: exposure to outdoor pollution, infiltration of outdoor pollution into buildings, emissions from indoor sources, and uptake of pollutants through food.

Surface Soils

CCA (Chromate Copper Arsenate)-treated structures should be removed from public places and playgrounds.

Areas with arsenic above RSCTL should be monitored in relation to residential areas/development.

The elevated PAH levels, exceeding Florida DEP's SCTL, detected at some locations in the Palafox industrial corridor need to be followed.

Pollutants in the Pensacola Bay System

The presence of contaminated aquifers (mostly groundwater plumes from Superfund Sites) requires continued monitoring of the sediments, pore water, and the waters of local estuaries.

The impacts of point source historical discharges of pollutants (e.g., PCBs discharged to Escambia River/Bay system) need to be monitored, and appropriate corrective/protective actions should be taken.

Whereas periodic dredging is needed to facilitate navigation in rivers/bays/bayous, the placement of the dredged spoils and the potential impacts of pollutants from this source on the corresponding water bodies have to be considered.

Monitoring of sediments for pollutant loads should continue, especially for those areas currently known to contain elevated levels of toxic pollutants in the Pensacola Bay System.

The unexpected detections of DDT above the PEL in the Escambia River and associated wetlands merit further investigation.

Contaminants in fish and shellfish

A systematic survey of target contaminants (not only mercury but also PCBs, dioxins/furans and dioxin-like PCBs) in fish/shellfish needs to be undertaken at the state

level, and also extended by appropriate agencies for similar Gulf-wide surveys of contaminants in commonly caught and consumed fishes.

Screening values used to establish consumption advisories differ considerably at state and national levels, even between federal agencies, and efforts should be made to establish uniform standards to protect public health.

Among the pollutants of concern from local water bodies, the screening value adopted by the State of Florida for PCBs (50 ng/kg) is higher than that set by EPA (20 ng/kg) for recreational fisher consumption, and the former threshold should be reevaluated and given the same resolution in its application as done for mercury screening thresholds in relation to sensitive/general population groups and variable consumption rates.

In view of the widespread dioxin/furan loads, along with dioxin-like PCBs, in fish/shellfish, the State of Florida should establish guidelines for issuing consumption advisories based on TEQ loads.

As is done in several other states, State of Florida should issue an advisory against consumption of blue crab hepatopancreas, based on toxicant loads.

At the state and national levels, there is a need to augment public awareness of fish consumption advisories and provide information that would enable consumers to understand the benefits/risks from consumption of fish/shellfish.