



# Creosote Treated Timber in the Alaskan Marine Environment

## Volume I



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# SI\* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yard	0.836	square meters	m <sup>2</sup>
ac	acres	0.405	hectares	ha
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>
<b>VOLUME</b>				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>
NOTE: volumes greater than 1000 L shall be shown in m <sup>3</sup>				
<b>MASS</b>				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
<b>TEMPERATURE (exact degrees)</b>				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
<b>ILLUMINATION</b>				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>
<b>FORCE and PRESSURE or STRESS</b>				
lbf	poundforce	4.45	newtons	N
lbf/in <sup>2</sup>	poundforce per square inch	6.89	kilopascals	kPa
<b>APPROXIMATE CONVERSIONS FROM SI UNITS</b>				
Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<b>AREA</b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>MASS</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
<b>TEMPERATURE (exact degrees)</b>				
°C	Celsius	1.8C+32	Fahrenheit	°F
<b>ILLUMINATION</b>				
lx	lux	0.0929	foot-candles	fc
cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b>FORCE and PRESSURE or STRESS</b>				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in <sup>2</sup>

\*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.  
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*Front cover photo: Removing Creosote Piles, Washington State Ferries.*

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## EXECUTIVE SUMMARY

The Alaska Department of Transportation (ADOT) is responsible for many structures that incorporate wood pilings and other timber in Alaskan waters. Most of these are treated with preservative to inhibit marine borers that will quickly destroy unprotected wood. Creosote is generally the most economical method of wood preservation and has been in use for over a hundred years. It is preferred by owners of marine structures because of its economy and efficiency. Creosote contains many toxic chemicals and some governments and organizations are limiting creosote use. This report reviews the current science regarding the use of creosoted wood in marine waters, the current regulatory matrix that controls its use, and develops recommendations for its use by the ADOT. Some future research may help clarify some issues raised.

Creosote is a coal tar product consisting mostly of polycyclic aromatic hydrocarbons (PAH). PAHs are ubiquitous in the environment and are naturally made by forest fires and anaerobic reduction of organic matter in sediments. There are many PAH chemicals that are known to be toxic to humans, marine animals, and many other forms of life. Indeed, the PAHs in creosote must be toxic to the marine borers in order to be effective. In creosote's long history of beneficial use, harmful effects on unprotected workers and environmental damage from sloppy and unregulated wood treatment plants have been a significant issue. Today, proper worker protection and careful environmental controls in the wood treatment industry have ameliorated these harms. In addition, modern use of creosote involves Best Management Practices (BMP) that leave less creosote on the surface of the timbers and specify construction processes that reduce transfer of the PAHs from the wood to the environment.

Even with BMP, PAH from new creosote timber will be transferred to the marine environment. Laboratory tests and field observations show that PAH chemicals will slowly diffuse from the wood into the water column. Then the heavier PAH chemicals sink to the bottom directly or adsorb to organic or inorganic moieties in the water and then sink. The PAH is then incorporated into the sediment. The lighter PAH chemicals are quickly volatilized and oxidized. Scientific observations of creosote behavior in meso-scale tests verify that the concentrations of PAH from marine piles in the water column are negligible, after the first few weeks. The fate of PAH in the sediment depends on the oxygen status of the upper sediment layers. If the sediment is not anoxic, the PAH will be oxidized. Hence, with sufficient oxygen in the upper layers of sediments the PAH concentration will initially rise, then decline. Thus, with BMP timber, if the sediments are not anoxic and the surrounding waters are not stagnant, and the area is not already contaminated, creosote marine timbers unlikely to have a significant long-term effect on the environment. Further, meso-scale testing has indicated that effects were confined to a region close to the structures themselves.

Are the rapidly declining levels of PAH in the water column and the slowly declining levels in the sediment nonetheless harmful to marine life? The most pertinent meso-scale tests, that installed several sets of treated and untreated piles in pristine marine waters, indicated there was not harm. However there are many papers and reports on this topic, and some do indicate harm. However most are clear that effects, if any, are limited to the timber itself and regions very close to the timber.

The only federal regulation of creosote is by the EPA under FIFRA. The EPA recently issued a favorable re-registration decision on creosote. That decision considered the ecological and economic aspects of creosote and required BMP in sensitive environments, but did not otherwise limit creosote use.

NMFS, and to a lesser extent ADF&G, are involved in decisions about wood treatment methods through a consistency review. That is, other federal agencies, especially the Army Corps of Engineers, when considering issuing a permit to construct in navigable waters, must ask other agencies to review the permit application and comment. The NMFS is always asked for this review in marine waters. They will review the application with respect to the Essential Fish Habitat (EFH) and Endangered Species Act issues. Thus, by finding that creosote treatment of wood may impact an EFH or harm a Threatened or Endangered Species (TES), the NMFS may object to the permit and based on that, the Corps may deny the permit or require other changes.

NMFS should have some definite criteria on which to base its evaluation of permit applications. Publishing definite criteria is difficult because pesticide-treated wood is a nationwide issue and there are many types of wood treatment at many locations all having different climate and ecology. Recently NMFS drafted some guidelines for all types of preservatives, including creosote, in marine waters. These and other NMFS guidance agree that creosote can be used in many marine applications, but the risks need to be evaluated for each proposed use, but the effort required to evaluate the risks should be commensurate with the likely effects and many applications could be approved without an elaborate risk evaluation. Although the NMFS Guidance is not a “cookbook” for approval or disapproval of creosote, its basic guidelines are sound. They are similar to the FIRFA regulations of the EPA and the recommendations of the Western Wood Preservers Institute.

Recommendations for use of creosote in marine waters by the ADOT.

1. Recognize that creosote does introduce contaminants into the marine waters, albeit at very low levels, and some care is needed before specifying its use.
2. Attach to each permit application that involves creosote use a brief statement that it is the material of choice in that particular application and that BMP will be specified in the materials and installation.
3. The wood preservative issue is usually a small part of a larger project, so identification of EFH and TES issues are usually needed, regardless of wood treatment. As part of the design process, note the maximum current velocity and that the sediment is not anaerobic or the site is not already heavily contaminated with PAH.

4. If the number of piles or pile equivalents is less than 100 piles, use the simple WWPI risk assessment chart that indicates if a more elaborate risk assessment is needed. If not, attach to the permit application a brief document with the current velocity, oxygen status, and other notes, to the application, that the WWPI risk assessment chart indicated more risk assessment was not required.
5. If the number of creosote piles is greater than 100, there are other creosote structures in the project or nearby, or the current and sediment parameters indicate a risk assessment is needed, there are two options: One, determine if the project at worst will effect an EFH or TES. Since any risk assessment done will be in relation to EFH and TES, if the site is a small part of the EFH and there is not a TES issue, a risk assessment might not be necessary. Two, use the more advanced recommended risk assessment models distributed by the WWPI. These are slightly more complex and require more input parameters than that matrix and yield conservative results. These models could be used by engineers or others with technical backgrounds within the ADOT.
6. Finally, at worst, unless the waters were actually stagnant, the only significant environmental effect would be the accumulation of PAH in the sediment. Installing creosote in situations where the sediment PAH will increase with time is surely not recommended, but if a situation arises where it is the only effective option, it may be acceptable. The ADOT would need to balance the effects on public safety and the direct effect on EFH or TES. This would probably take a consultant to evaluate these effects, although generally, sediment dwelling organisms are not a TES issue. Contamination of shellfish would need to be considered.

Other Management recommendations:

1. Some of the guidelines indicate a preference for water-borne copper-based preservatives over creosote. Copper too has toxicity issues and there are other disadvantages in Alaska. Thus we have not identified any reason to prefer copper-based over creosote in Alaska.
2. Since in almost all cases the concentrations of PAH decrease with time, there is almost never a net environmental benefit from pulling old marine piles to improve the environment.
3. It seems unlikely that creosote treated wood glulam float material would be different than the equivalent amount of wood pile material – regarding total PAH released to the environment or its fate and transport.
4. There are models for overwater creosote structures that likewise transfer to the water and sediment. These are not too complicated to use.
5. There are not standard models for structures such as bulkheads. However if the sediments are aerobic and there is reasonable current flow, for small structures, they would not be much different than the equivalent amount of wood. For larger structures, more effort would be needed to adopt the standard models.
6. Disposal of creosote treated wood is not a hazardous waste.

# Chapter 1 Introduction

The Alaska Department of Transportation and Public Facilities (ADOT) is responsible for many structures that incorporate wood pilings in Alaskan marine waters. Most of these are treated with creosote, which is generally the most economical method of wood preservation. However, creosote contains many toxic chemicals, and some governments and organizations are limiting creosote use. ADOT needed to be informed about the best policies for the safe disposal of any creosoted wood removed from its structures and for making decisions about the use of creosoted wood for maintenance and new construction.

In October, 2007, ADOT contracted with the Institute of Northern Engineering of the University of Alaska Fairbanks via Task Order #RES-07-06 for a research project titled, *Environmental Impact of Creosoted Treated Marine Piles*. The objectives of that project were:

- Evaluate the current laws, regulations, and public policies, as well as their likely future changes.
- Evaluate the human and ecological risks of creosoted wood products, as they are used in Alaska.
- Evaluate alternatives to creosote, both their efficacy and safety
- Evaluate the costs of any changes to the current use of creosote, as well as the risks of not changing.

The results of these evaluations have been compiled into this report on creosote use and impacts in Alaska

The major tasks were:

- Task 1. Identify and contact all interested parties,
- Task 2. Literature search and report on the current status of creosote
- Task 3. Economic study
- Task 4. Eco-toxicity in Alaska
- Task 5. PAH status of Alaska piles
- Task 6. Creosote Piles in Alaska Roundtable

Based on early research and input from ADOT professionals, the original scope was modified. Creosoted wood other than piles was included in the research, such as glulam float material, bridge endwalls, and other structures. Some other needed research was identified and the proposal for that work is included in this report and the results will be reported in a separate paper when they are available.

Task 2, the literature review, was largely completed in spring 2008 and reported in a paper given at the Arctic and Marine Oilspill Program organized by Environment Canada. An updated version of that paper forms that background of this report. Tasks 1 and 6 were completed in the summer and fall of 2008. The roundtable was held at the October 2008 convention of the Alaska Harbormasters and Port Administrators in

Haines. All of the interested parties interested in creosote were invited to the harbormasters and all were copied with the results of the roundtable meeting. Some comments on those results were received.

Task 4, the economic study, also drew some quantitative and qualitative data from the roundtable. That was supplemented with surveys and reviews for this report.

Task 4 and 5 were included in the literature review insofar as practical and an important research component was identified for future work. This is discussed in Chapter 9.

Evaluating the laws and regulations pertaining to creosote and their likely changes resulted in some interesting findings, which are discussed in depth in Chapter 7. Briefly, while the laws and regulations seems fairly stable, the guidance documents used by agencies involved in creosote-related decisions are changing and some are not final as this report is written. This requires some extrapolation for policy recommendations, but enough seems clear that these can be done. Commentaries and information on these guidance documents are contained in appendices. A second volume of this report contains those documents and commentaries, as well as catalog cuts and other information too bulky for the main report.

Recommendations to ADOT are in Chapter 8.

## Chapter 2, Background

This Chapter presents a paper given at the **31st AMOP Technical Seminar on Environmental Contamination and Response** *June 3 to 5, 2008, Calgary, AB, Canada* . The paper was updated and revised slightly. The references are now in the reference section of the main report. A more complete discussions of several topics in the paper are given in other chapters of the report.

# To Pull or Not to Pull: Risk Management of Creosote Piles in Marine Waters

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## Abstract

Creosote, a coal tar product used as a wood preservative, contains polycyclic aromatic hydrocarbons (PAHs) known to be harmful to humans and marine organisms. Many studies indicate that PAHs from creosote-treated piles (wood columns supporting structures such as docks) leach into the surrounding waters and accumulate in marine sediments. Because of the great utility of creosote piles, they are still commonly used in most jurisdictions. Recent studies demonstrate that any lasting contamination due to installed piles is confined to a region near the pile. Do the toxic effects of creosote contamination, if any, outweigh the benefit to society from their use? Here we present a conceptual risk assessment model. We also examine some research issues that will assist risk management decisions.

## 1 Introduction

Wood marine piles treated with creosote are in common use in US and Canadian waters. Because of their low initial cost and ease and flexibility of installation, wood piles are frequently the most economical design solution for marine applications. However in saltwater wood is readily attacked and degraded by marine borers and must be treated with a preservative. Creosote has been the preservative of choice since the 1850s because of its durability and ability to resist attack. Creosote is the only oil-type wood preservative currently recommended for saltwater. Creosote is a mixture of many chemical constituents and their proportions vary with manufacturers and batch, but the principle components are polycyclic aromatic hydrocarbons (PAHs). Many PAHs are toxic to marine life and some are carcinogenic to humans. Special precautions are needed for workers exposed to creosote during the pile treating and installing process.

Several agencies ban or discourage using PAHs, with some agencies initiating programs to remove creosote-treated piles and replace them with steel or concrete (Washington State Ferries, 2008). Here we review the main issues regarding the use of creosote piles in northern waters and examine them in the context of a risk management decision about the future of creosote piles based on a risk assessment. Some gaps in the existing knowledge are noted and some research questions raised – the answers will enable a better evaluation.

## **2 Background**

### **2.1 History**

Without bacteria, fungi and insects to biodegrade cellulose and lignin, dead wood would choke the landscape. These useful forest recyclers have been the bane of civilization's wood structures. The ancient Egyptians smeared wood funerary objects with cedar oil to preserve them. In the 1800s, the American railroad industry, when faced with a shortage of durable wood for crossties, started saturating them with creosote (Smulski, 2008). Creosote is highly effective against terrestrial fungi, insects and saltwater marine borers such as crustaceans (gribbles, *limnaria* spp.) and mollusks (boring clams, *teredo* or *bankia* spp.).

### **2.2 Description**

Although there are several standards and formulations of creosote, the American Wood-Preservers Association (AWPA) currently approves only the P1/P13 creosote standard. The AWPA defines creosote as a "100% distillate derived entirely from tar produced by the carbonization of bituminous coal." (AWPA, 2007) Currently only creosote treated to 16 to 20 pounds per cubic foot retention is recommended for saltwater use. (WWPI, 2006a) Estimates vary with wood type and installation location, but creosote-treated wood piles may last from 40 to 75 years in marine environments. They cost less than concrete or steel piles to purchase and do not require corrosion protection after installation. Installation is cheaper because of the lighter weight, flotation, and the ease of field modifications. Wood is more flexible than the alternatives and has a greater capacity to absorb shocks. On a whole project basis, wood costs about half the amount of concrete or steel (Smith, 2007).

### **2.3 Chemistry**

Creosote is derived from coal tar. Physically, coal tars are usually black or dark brown viscous liquids or semi-solids with a naphthalene-like odor. The coal tars are complex combinations of polycyclic aromatic hydrocarbons, phenols, and heterocyclic oxygen, sulfur and nitrogen compounds. Creosote is a distillation product of coal tar with an oily liquid consistency and ranges in color from yellowish-dark green to brown. At least 75% of the coal tar creosote mixture is polycyclic aromatic hydrocarbons (PAHs). There are up to 190 identified PAHs in coal tar. Benzo[a]pyrene, a component whose individual toxicity has been examined extensively, ranges from non-detectable levels to 3.9 g/kg of coal tar (ATSDR, 2002).

### **2.4 Toxicity**

Toxicity from human industrial exposure to coal tar and coal tar creosote is well known, and precautions are required for their safe use. Creosote is a restricted-use pesticide and only people who have been trained to use it safely are permitted to use it. (EPA, 2008) NIOSH considers coke oven emissions, including creosote, to be potential occupational carcinogens (NIOSH, 2005). Creosote can also cause chemical burns to the skin, and irritate the eyes and respiratory system. We discuss the toxicity to marine organisms below.

## **2.5 Occurrence**

PAHs form in nature by three general routes: high-temperature pyrolysis of organic materials (forest fires); low- to moderate-temperature diagenesis of sedimentary organic material to form fossil fuels; and direct biosynthesis by many species of microbes and plants (Neff, 1979). Recent research indicates that diagenesis occurs more quickly than geologic time, and diagenetically produced PAH can be found in recent sediments. (Baker, 1980) Thus small quantities of PAH are ubiquitous in the marine and terrestrial environment. Most of the PAH found in the environment near industrialized areas is from pollution including sewage and industrial effluents, waste incineration, oil spills, asphalt production, creosote oil and the combustion of fossil fuels (Kennish, 1997). Until recently, wood treatment sites were a frequent source of contamination from creosote and other wood preservatives.

## **2.6 Alternatives**

There are alternative materials; concrete and steel are common, as well as alternative wood preservation methods. For marine and estuarine waters, creosote is the only oil-type preservative in common use for piles. Because the tar-like surface of creosote is unsuitable for painting and foot traffic, other types of wood preservative are used in marine applications where they are not immersed in the water. Wood is structurally limited, and for heavy structures, steel or pre-stressed concrete are often used; steel and concrete need corrosion protection. Often a mixed system is used with creosote wood for dolphins and fender piles that must accept some shocks, with steel or concrete for the main bearing structure. Today mechanical and elastic devices are sometimes used in place of wood to absorb shocks. Plastic coated piles and plastic piles are still in the experimental stage and need to be vetted in warmer climates before they are tested in colder climates. In general, when wood is used, it is because of its inherent economic value in the particular application. Creosoted wood is often used in floating dock or finger piers for the wood members that contact the water. Often this wood is laminated wood, or “gluelam.”

The only water-borne wood preservative recommended for Alaskan marine waters is ACZA. The limitations of ACZA are discussed in Chapter 4.

# **3 Risk Assessment and Management**

## **3.1 Introduction**

Here we examine the issue of creosote marine piles in regard to risk management decisions. First, should existing creosote marine piles be pulled and replaced with other,

presumably less toxic, piles and second, should creosote piles be continued to be used in marine waters in new installations and to repair existing installations?

Traditional risk management starts with a four-step risk assessment: hazard identification, toxicity (dose-response) relations, exposure assessment (fate and transport analysis), which result in the fourth step— the risk characterization that contains a statement of the probability and severity of the harm. Following the risk assessment, management decisions may be made to accept the risk or mitigate (NAS, 1983). There are many scenarios of exposure and many management alternatives that arise from the risks associated with chemicals in the environment. While traditional risk management presumes that a strict separation of risk assessment and risk management is possible and desirable, a more recent view insists these two issues are not really separable and considers management matters as well as input from the stakeholders as valuable in the risk assessment, which may now be considered an iterative process (NRC, 1996).

### **3.2 Assessment**

#### **3.2.1 Hazard Identification**

The principal hazards facing marine organisms due to creosote are the PAHs released into the water column via leaching from the piles. The toxicity of PAHs are well known and generally accepted. When piles are newly installed, there is often sheen on the water, which, although temporary, indicates transfer of creosote components directly to the marine environment. While PAHs are the principle components of creosote, there are heterocycles as well; however these are typically very minor components and they are not treated separately in discussions of creosote toxicity (Neff, 1979, 1985, Eisler, 2000). Additionally older piles often had a heavy surface coating of creosote. Today, the best management practices (BMP) minimize this coating. In general, it is assumed that the sheen and the lighter PAHs evaporate and/or are oxidized at the surface quickly; thus, are primarily of interest regarding acute toxicity. The heavier PAHs are largely adsorbed by particulates in the water column and/or settle directly to the bottom. These heavier PAH may be of more chronic toxicity – they certainly persist much longer.

#### **3.2.2 Exposure Assessment**

We can identify several routes of PAH exposure to marine life from the creosote in piles. They are:

- (1) Organisms can be exposed in the water column directly and absorb the PAH.
- (2) Organisms can cling to the wood and absorb PAH by a direct route
- (3) Organisms can absorb PAH from sediments.
- (4) Higher trophic levels can ingest lower trophic levels and bioconcentrate the PAH.

#### **3.2.3 Properties**

The cycle of creosote-derived PAHs in the aquatic environment appears to be relatively simple. Creosote leaches from the wood into the water as one of the PAH chemical species and enters the water. The solubility of PAHs varies with their structure and number of aromatic rings. Two-ring naphthalene is soluble to 30 ppm, while five-ring PAHs are soluble in the range of 0.5 to 5 ppb. The solubility also varies with

temperature. The solubility of the three ring PAH phenanthrene ranges from 423 to 1277 ppb between 8.5 and 29.9 C and the solubility of the similar three ring PAH anthracene ranges from 12.7 to 55.7 ppb between 5.2 and 28.7 C. (Neff, 1979) Lighter PAHs rise to the surface and quickly evaporate or are oxidized. Heavier PAHs quickly become adsorbed on organic and inorganic particulate matter and large amounts are deposited in bottom sediments. (Eisler, 2000)

#### **3.2.4 Fate**

Leaching or biological activity in the sediments may return a small fraction of these PAHs to the water column. PAHs are readily accumulated by aquatic biota, reaching levels higher than those in the ambient medium. Relative concentrations of PAH in aquatic ecosystems are generally highest in the sediments, intermediate in the aquatic biota, and lowest in the water column. PAH concentrations in sediment are, depending on the percentage of organic carbon in the sediments, usually 1000-fold more than the water column. (Eisler, 2000) Techniques for removing PAH from the aquatic environment include volatilization from the water surface (mainly low molecular weight PAH), photooxidation, chemical oxidation, microbial metabolism, and metabolism by higher metazoans; however, once in the sediments they are subjected to lesser photochemical, chemical, or biological degradation than they were in the water column. When incorporated into anoxic sediments, they may persist for a long time, possibly on a geologic timescale. Concentrations in the sediment vary from 100 mg/kg in industrial areas to low ppb range in remote areas. (Eisler, 2000) There is some evidence that creosote can enter the water as micro-droplets and sink into the sediment. (Goyette and Brooks, 2001)

In some controlled water column experiments with creosote piles, all the PAHs were undetectable in the water column at day 17, with approximately 40% deposited in the sediments. (Kang et al., 2005) So the general observation supported by laboratory experiments determined that PAH in the water column due to creosote piles is very low or undetectable. In all but a few cases PAH concentrations that are acutely toxic to aquatic organisms are several orders of magnitude higher than the concentrations found in even the most heavily polluted waters (Eisler, 2000). Field data of sediments from polluted regions, however, may contain PAH concentrations similar to those that are acutely toxic, but their limited bioavailability would probably render them substantially less toxic than PAHs in solution.

#### **3.2.5 Best Management Practices (BMP)**

Modern creosote piles are manufactured using “best management practices” (BMP), which reduce the amount of creosote on the surface of the pile. Also, significant reductions in pollution are possible by using BMP for installation, such as keeping the sawdust and wood chips created during cutting and drilling operations out of the water. (WWPI, 2006b) Nonetheless, despite BMP, some creosote can be forced to the surface of the wood by solar heating, and the wood can be abraded in service. Whether or not PAH release is significant if BMP is used is yet to be determined; yet caution is needed when interpreting data from piles treated prior to BMP.

### **3.3 Toxicity**

In general, the toxicity data indicate that the water column concentrations of PAH are very low and not likely to be harmful to pelagic organisms after a few weeks of new pile installation. The body burden of fish and crustaceans is likely to be low and thus, a low threat to humans. Bivalves, muscles from piles or clams from the region near piles may be of concern, however, there are many sources of PAH and other pollution from most dock areas besides the piles, and eating mollusks from these areas is unwise. See the Sooke Basin data below.

Laboratory experiments report large differences in the ability to absorb and assimilate PAH from food between species. Crustaceans and fish readily assimilate PAH from contaminated food, whereas mollusks and polychaete annelids had only limited assimilation. In all cases where assimilation of ingested PAHs was demonstrated, metabolism and excretion of PAHs were rapid. Thus little potential exists for food chain biomagnifications of PAHs. (Eisler, 2000)

The ability of organisms to metabolize and excrete PAHs depends on the species' complement of metabolizing enzymes. Mixed function oxidase (MFO) or P450 enzymes are principally responsible. Fish, arthropods including crustaceans, and annelids have MFO systems, while coelenterates and ctenophores apparently lack MFO. Among echinodermata, *strongylocentrotus sp* and starfish *asterias sp* have low MFO activity (Neff, 1985). Molluska is more complicated; there is no MFO activity in *Mytilus edulis*, the common blue mussel and others, but there are low levels of MFO in oysters, and low levels in the snails and squid.

Toxicity evaluation of creosote-derived PAH is complicated by several factors. Toxicity is often measured relative to a specific PAH chemical. For example, benzo[a]pyrene, a known human carcinogen, is one of many PAH chemicals studied in detail. Another factor is the nature of the exposure. Most PAH chemicals are not very soluble in water and in most practical applications, the concentrations found in the water column are several orders of magnitude less than the test concentrations reported for acute toxicity, typically expressed as a 96-hour LD-50. More relevant perhaps is the possibility of chronic toxicity from smaller concentrations, through direct contact or a photo-induced toxicity.

Certain PAHs exhibit a great (on a scale of several orders of magnitude) increase in toxicity in the presence of sunlight. This phototoxicity has been reported from crude oil and water accommodated fractions of crude oil. In addition, phototoxicity has been reported at light intensities in Alaskan waters (Duesterloh et al., 2002). This toxicity is most important for the very young of the species that are essentially transparent. For pelagic organisms, after the initial pile installation, the PAH in the water column is essentially background. The possibility that an organism could absorb PAH near the sediment then move to waters with more light would imply shallow waters or stronger swimming life stages.

Direct contact is possible if the piles are not fouled. For example, the eggs of the herring cling to whatever they contact. The toxicity of creosote piles to herring eggs was noted. Herring spawn near shore, often near kelp beds. The clouds of sticky eggs are slightly heavier than water, but generally travel with the current and stick to any substrate they encounter, or eventually settle to the bottom. It has been shown that eggs that stick to marine piles have very low survival rates and the larvae that do hatch are often deformed. This was not the case with an untreated wood control (Vines et al., 2000).

#### **4 Combined Fate and Transport and Toxicity, Sooke Basin Studies**

While there have been many laboratory studies of PAH toxicity, their relevance to creosote from marine piles is limited due to the very low level concentrations of PAH available from the piles in the water. The concentrations in the sediment, however, will remain relatively high for a long time, although the exposure of fauna from the sediment is uncertain. The Sooke Basin study was a full-scale field test of the effects of creosote piles on the marine environment. Sooke Basin is a pristine waters with low current velocity and ideal for isolating the effects of creosote on the marine environment. It involved the installation of three dolphins constructed with six piling each. The Weathered Piling (WP) dolphin was constructed with eight-year old pilings treated by conventional methods. The second dolphin was constructed with pilings treated using BMP. The third structure, referred to as the Mechanical Control (MC), was constructed of untreated Douglas fir pilings. It was designed to evaluate the environmental response to the physical structure and to organic compounds released from untreated wood. In addition there was an area in the basin that was generally up current from the study area that was chosen as an Open Control (OC). The area was relatively undisturbed without ambient PAH (Goyette and Brooks, 1998, 2001).

The results of the first-year study indicate that PAH lost from creosote-treated wood can create toxic conditions in sediment within 0.65 m of high densities of piling installed in worst case environments. Goyette and Brooks report one year following piling installation, the maximum predicted and observed total PAH concentrations were significantly elevated (5.5 µg/g and 4.8 µg/g, respectively) to a distance of 7.5 m down current from the BMP treated dolphin. Biologically significant increases in sediment PAH were not observed at further distances. Observed total PAH concentrations in sediment declined sharply between 7.5 and 10 m averaging 0.53 µg/g (n=13) at 10 meters and beyond below the Threshold Effects Level or TEL of 0.75 µg/g, dry weight of sediment.

By year four of the study, a diverse and abundant epifaunal community had established itself on the BMP piling. Grazing by starfish and crabs results in significant biodeposits on the benthos. The biological oxygen demand created by the microbial catabolism of this material exceeds the assimilative capacity of the sediments resulting in anaerobic conditions and elevated concentrations of sulfide. “Both the BMP and MC dolphins were covered with an abundance of mussels, barnacles, numerous starfish (15-20 individuals in any given section), plumose sea anemones, calcareous tube worms, hermit crabs, coonstripe shrimp, tunicates, marine snails, sea cucumbers, sponges, filamentous algae and other marine organisms. Large plumose anemones were attached to the inside of the catchment containers, which had been installed only four months previously. Whether they had grown there from juveniles or somehow found another way into the containers as adults is unknown” (Goyette and Brooks, 2001).

In general the Sooke Basin study indicated that the toxicity, if any, is limited to the region near the piles. An interesting confounding factor is the piles quickly became covered with epifauna, which sloughed off and increased the quantity of biomaterial on top of the sediment, which then became anaerobic with high sulfide content. This shuts off oxidation of the remaining PAHs. In any case, there is a decline in PAH with

distance. Depending on the sediment criteria used, the significant effects were confined to the two meters down current of the BMP dolphins.

Some of the sediment was used in standard laboratory assays of sediments toxicity. Slight adverse effects were observed at 2.0 m down current but not in the infaunal community. No significant effects were observed on mussel growth, survival, or spawning success. Sediment concentrations of PAH at the BMP dolphin peaked sometime between Day 384 and Day 1360 and then declined.

Water column concentrations of PAH remained close to background concentrations throughout the study. Biologically insignificant increases in mussel tissue concentrations of PAH were observed during the first two weeks of the study. By Day 185, mussel tissue concentrations declined to those observed at the reference station. Mussels growing directly on the heavily fouled BMP treated piling did not contain elevated tissue concentrations of PAH at the end of the study.

#### **4.1 Summary of Sooke Basin Study**

The four-year study indicated little ecological effect due to the creosote piles. The region closest to the piles had sediment concentrations that were of theoretical concern, but these seemed to have little effect on the benthic community. The concentrations of PAH were slightly elevated in mussels early in the study, but quickly declined to ambient values. There was no evidence of effect further than 10 m from the piles. One of the study's authors had earlier developed a model of PAH distribution from creosote-treated piles (Brooks, 1997) and this study indicated the model was conservative, - it over-predicted the concentrations.

## **5 Risk Management**

The main risk management options are: 1) Pull piles and replace with non-creosote supports; 2) ban new use of creosote, but let existing remain; 3) continue to use creosote when economy indicates it is the most feasible material; and 4) continue to use creosote piles, but do a risk analysis of each new installation. Here we will review the main issues and suggest data needs.

### **5.1 Pull and Replace**

Pull and replace will eliminate any new PAHs from creosote. Pile pulling will stir the sediments and the effects pulling and construction activities should be examined using standard methods from dredging decisions. The benefits are uncertain, since existing piles do not transmit much PAH to the ecosystem. If the piles predate BMP and had a heavy surface coating some PAH may continue to be transmitted to the sediments. Also, abrasion of the piles by marine traffic may chip the piles and release some fresh creosote. In existing applications, especially in waters that are used by cargo, fishing boats, ferries, and recreational boaters, it is doubtful any beneficial effect of pulling piles could be noted. If it were combined with careful dredging, a long term decrease in PAH from the sediments could be recorded, however a short term increase in PAH in the water column would occur. The harmful effects from PAH in the sediments, if any, is likely confined to the area very near the piles. While the economic costs and ecological effects of pulling and replacing are unlikely to justify it, there may be an intangible benefit from

the public relations, especially for industries or facility owners with a history of poor environmental practices.

## **5.2 Ban New Creosote Piles**

Banning new applications of creosote will gradually eliminate PAHs derived from creosote in the local environment. As a practical matter for maintenance and repair, generally wood must be used to replace wood. Creosote is the only oil-type marine preservative recommended by wood preservers for northern waters. The only water-borne preservative is also toxic, not known to last as long as creosote, and has other issues discussed in Chapter 4. Thus, the regulators would need to balance the ban with a provision for maintenance and repair of existing piles. Banning new applications would double the cost for building structures that are currently built of wood. In addition, the skill level required for installation and repair will increase an issue that may decrease the ability of small communities and enterprises to maintain their facilities. This increased cost would not be balanced by any benefit, except possibly as noted below regarding herring.

## **5.3 Continue to Use Creosote Piles Wherever Economical or Use Risk Assessment**

The benefits of continued use, primarily cost, are noted above. The risks to the environment from introducing PAH from new creosote piles in general are small, localized and brief. PAHs from natural sources provide a background level in water and sediments. PAHs from anthropogenic activities have increased this level in most locations where piles are likely to be installed. After a brief initial period, two to three weeks, it is unlikely any increase in PAH could be measured in the water column. It is unlikely that, except for the sediment close to the pile, any increase in PAH could be measured in sediment. Analysis of blue mussels growing directly on BMP piles showed an initial small increase in PAH, but shortly this effect disappeared. Risks to the environment that need to be considered are:

- 1.) Is there sufficient current that initial burden of PAH in the water column dissipates quickly? Quantification of the required current is needed.
- 2.) Is there a threatened or endangered marine species that could be affected by the brief burden of PAH in the water column? Generally, only the early life stages, would be affected. This would indicate that certain construction windows should be closed, however this would be related to the currents – it would be less of an issue if the currents were sufficient.
- 3.) Is this in an area where herring are known to spawn and is the herring stock stressed in this location? If the answer to both is “yes,” then creosote piles should not be used – but see research issues below.

These are discussed in more detail in Chapter 8.

## **6 Conclusions**

Creosote-treated wood marine piles do release PAHs to the marine environment. The quantity and location of the PAHs vary with time, but within a few weeks of installation there is little or no measurable PAH in the water column. PAH remains in the

sediment and in the wood itself. Field measurements indicate that the amount of PAH in the sediment is generally limited to the region (within 10 m) closest to the piles. This concentration tends to decrease with time. This decrease is less if the sediments become anoxic. Field data indicate that installation of piles increases the benthic load of organic matter under the piles due to organisms coating the piles, which in turn cause the sediment under the piles to become anoxic, thus prolonging the presence of PAH in the sediment. However, the presence of this PAH in the sediments is unlikely to be of any significance to either the local fauna or to humans. PAH in the piles increases PAH in mussels in laboratory experiments, but not in field experiments. Human consumption of mussels attached to creosote-treated piles and clams nearby is probably not advised; most harbors and similar locations of marine piles are not very clean in any case, and in general such consumption is discouraged.

Data indicates that herring eggs attached to creosote-treated wood have a very high mortality and the resultant embryos will be deformed. Herring spawn typically near kelp beds and rocks, and the sticky eggs sink as they are slightly heavier than water. However, herring could spawn near creosote-treated piles and the data indicate the eggs that attach to piles will have a very low survival rate. This indicates placing piles in a critical habitat of a stressed species that spawns sticky eggs into the water column could hinder their survival. However, an issue that should be explored is flora and fauna quickly covered (fouled) the BMP marine piles, while the herring-egg experiments dealt with bare treated wood. Given the absence of PAH measured in the fauna associated with the fouled BMP piles, it seems likely that herring eggs that attached to the fouled piles would have a much higher survival rate than those attached to bare piles. Also, the herring experiments used a new wood control. Wood in marine environments without preservatives is quickly colonized by marine borers, which may likewise not be hospitable to sticky eggs. Finally, some experimentation with the success of herring eggs would need to be done with wood alternatives such as steel or concrete that has corrosion protection systems.

The following are research questions, the answers to which would help in risk management decisions relating to creosote piles.

- Are herring eggs adversely affected by attaching to fouled piles?
- What is the mass transfer mechanism between the wood and herring eggs?
- How long does it take for fouling to occur - what are the key parameters and structural issues?
- Could the BMP piles be treated to encourage fouling?
- What is the survival rate of herring eggs attached to fresh steel or concrete piles?
- What is the survival rate of herring eggs attached to weathered or fouled steel or concrete piles?
- Does the presence of corrosion protection matter?

Today all major owners of marine facilities are committed to protecting the environment. Creosote piles present an interesting conflict between their inherent economic value and their release of PAH to the environment – albeit at very low levels. Another interesting conflict is between the laboratory evaluation of toxicity that indicates toxicity under laboratory conditions and the field studies that indicate no untoward effects. Certainly some caution is needed because one could postulate conditions where

creosote may have some measurably adverse effects. These situations are likely rare and in the author's opinion, application-specific evaluation of these conditions rather than banning creosote is a wise use of society's resources.

## **7 Acknowledgements**

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## Chapter 3 Discussion of Alternatives

### Non-wood Materials

For new marine construction there are alternatives to wood piles; concrete and steel are common. Wood is structurally limited and for heavy structures steel or pre-stressed concrete are often used. In addition, long wood piles of sufficient quality are harder to procure. Thus for piles, the nature of the structure will sometimes preclude wood. However if wood will suffice structurally, wood will be preferred since the initial costs (both procurement and installation) are about half that of concrete or steel. For the long term maintenance costs, both steel and concrete need corrosion protection.

### New Installation

Plastic piles and timbers, some made from recycled plastic, are available for structures and fender piles. One brand features a pile that is filled with recycled plastic with fiberglass reinforced plastic rebar and a UV light and abrasion resistant outer skin. These are available in both pile and beam shapes. (In this chapter we present URLs to manufactures' sites with illustration of these alternates. In addition, catalog cuts of illustrative alternates are bound in Volume II of this report. We are not endorsing any particular manufacturer.) See [http://www.trelleborgms.com/catalogue\\_1.aspx?id=1:30038&cat=1:469203&pagenum=1&pagesize=20](http://www.trelleborgms.com/catalogue_1.aspx?id=1:30038&cat=1:469203&pagenum=1&pagesize=20) for plastic piles and [http://www.trelleborgms.com/catalogue\\_1.aspx?id=1:30038&cat=1:469282&pagenum=1&pagesize=20](http://www.trelleborgms.com/catalogue_1.aspx?id=1:30038&cat=1:469282&pagenum=1&pagesize=20) for a plastic beam. The reinforced members are generally slightly stronger than wood. They deform more under compressive stress and this might limit their use for heavy structures in our high seismic regions. See cost information in Chapter 6. Due to the great expense, concrete, steel, or mechanical fenders would probably be the design choice.

Another method of plastic encapsulation is to coat a pile with plastic before it is installed. Spray on polyurea ("truck bed liner") is one type of plastic used and the finished coat may be 250 mil (1/4 inch) thick. See <http://www.schraderco.com/pdf/poly1.pdf> for a catalog cut of plastic coated pile. These are generally applied over a treated wood to reduce transfer of the treating chemicals to the environment and the coating is not structural. If the coating remains intact, there would be no transfer of creosote components to the marine environment. However the service life of these coatings in Alaska is not known and, once torn or severely abraded, the creosote will be transferred. The coating may be used in lieu of treating the wood, but in that case any tear in the coating would allow marine borers access to the wood. Again the added cost might make wood uneconomical. Since the only benefit of the plastic encapsulation is inhibiting creosote release to the environment, this method would only be practical in very sensitive area, where a risk analysis indicated creosote would harm the marine environment.

### Tropical Woods

Several species of wood are inherently decay resistant. Ekki timber (*Lophira elata*) is used for high abrasion applications in the marine highway system in Alaska. It is generally not

used for piling or structures. An issue with many tropical hardwoods is the “green” issue of tropical deforestation. The Forest Stewardship Council (FSC 2009) certificate is an example of an international standard to insure sustainable harvesting of such timber. FSC certification is not available for Ekki from some sources. Ekki is listed as “vulnerable” by the International Union for Conservation of Nature (IUCN 2009; Greenpeace 2009). This adds another dimension to cost-benefit analysis of substituting tropical woods for treated domestic wood.

#### Retrofit

Plastic products are available that attach to the outside of piles. One brand features a petrolatum mat that lays between the plastic and the wood, that, when compressed, seals the wood preventing oxygenated water from reaching the wood and thus preventing marine borers. See [http://www.tapecoat.com/marine\\_pages/seriesr.html](http://www.tapecoat.com/marine_pages/seriesr.html). These might be used on installed piles. They attach with fasteners or bands. The durability of these, for example in fender piles is suspect. Installation would required divers and would be expensive. If they were extended from the splash zone to the sediments, they would prevent transfer of creosote from the pile. See next.

Another retrofit method that should work with installed piles is an epoxy grout that will bond to wet wood (or concrete or steel). A metal form sleeve is placed around the pile and the mixed epoxy is placed in the form. [http://www.schraderco.com/pile\\_res.cfm](http://www.schraderco.com/pile_res.cfm) The system is advertised for applications at the waterline, but could be extended to the sediment.

Both the plastic and epoxy sleeves and coatings could be used to prevent creosote transfer. Since most of the creosote transfer occurs in the early years of pile installation, there is less benefit from installing these sleeves later in the piles life.

#### Other

Even if steel or concrete are used in the piles and main structure, a mixed system is used with creosote wood for dolphins and fender piles that must accept some shocks, with steel or concrete for the main bearing structure. Today mechanical and elastic devices are sometimes used in place of wood to absorb shock, but wood is the most common for docks that handle smaller ships. Generally, for docks for large ships, mechanical systems are used.

#### Float Material

Most Alaska harbors have finger docks that move with the tide. These are attached to a main dock with hinges and a sliding ramp. The finger docks have vertical guide piles to keep them in horizontal position. There are a variety of other structures that likewise move with the tide, such as seaplane docks. These are collectively known as “floats.” The buoyant material under the floats may be a plastic, such as Styrofoam or urethane foam, steel drums or similar material, concrete floats, or a variety of other materials and combinations. However the most common material for the structure of the floats in the water or splash zone is creosote treated glulam wood. Since creosote is a tar-like coating and unsuitable for painting, the walking surface of the docks is generally treated with a

different preservative. Although there is some use of concrete for the float system, including the floatation material and the walking surface, these are expensive and not much used in Alaska, where freeze thaw cycles may damage the surfaces. In general, only creosote glulam wood is used in Alaska for float structures.

#### Alternate Wood Treatment Methods

There are alternative wood preservation methods. For marine and estuarine waters, creosote is the only preservative in current common use for piles, and is the only oil-based preservative recommended for saltwater immersion subject to marine borer attack. Creosote is an oil-type preservative. There are two types of waterborne preservatives recommended by the WWPI (WWPI 2008) for marine use. They are ACZA and CCA. Both are copper containing preservatives. The most common wood in the Pacific Northwest and Alaska is Douglas Fir. “Doug fir” is resistant to the penetration of CCA and thus it is not in common use in Alaska. Therefore we will only discuss ACZA.

ACZA stands for Ammoniacal Copper Zinc Arsenate; its commercial name is Chemonite®

(<http://www.archchemicals.com/Fed/WOLW/Products/Preservative/Chemonite/default.htm>) ACZA should contain approximately 50% copper oxide, 25% zinc oxide, and 25% arsenic pentoxide dissolved in a solution of ammonia in water. (Ibach 1999) Because copper is highly toxic to marine invertebrates and fish larvae, ACZA gathers almost as much environmental concern as creosote. (Stratus “copper”) Thus, ACZA would likely not, based on environmental issues, be proposed as a replacement for creosote. Unlike creosote, ACZA can be painted and walked upon.

ACZA and probably other waterborne preservatives have several disadvantages compared to creosote. First, ACZA tends to split the ends of the glulam lumber – “brooming.” This may be overcome with special hardware. Second, ACZA tends to absorb some water and thus, in freezing and thawing environment leads to splitting the wood. Third, galvanic action of the ACZA metals and the iron tends to corrode fasteners in salt water. Stainless steel fasteners or a plastic sleeve for steel fasteners is recommended. See <http://www.archchemicals.com/Fed/WOLW/Products/Preservative/Chemonite/hardware.htm> for examples. Most of the difficulties with ACZA have been described anecdotally by engineers familiar with its performance in Alaska. To the author’s knowledge, there have not been side by side tests of ACZA versus creosote regarding its durability in Alaskan waters. However, based on the similarity of the environmental concerns of creosote and ACZA, testing may not be worthwhile see next.

## Chapter 4 Other Creosote Uses

### Creosote in marine structures other than piles

First we should consider the effects of creosote from the structure above the piles, if the structure is creosote. Migration of creosote via micro droplets seem likely. In addition, the structure will block sunlight from the water, thus inhibiting photo-degradation. Finally, currents are likely to be attenuated in the region below the structure. All these indicate that the sediments below the structure will have elevated levels of PAH. This needs to be considered in the overall environmental assessment of the project. For example, if a creosoted dock were replaced with a sheet pile bulkhead and concrete pier, all the marine waters below would be lost to the marine environment. This is sometimes called the “technozone,” and acknowledges that any structure will consume some of the environment. This needs to be balanced with the net good to society from the structure. The weight of evidence reviewed elsewhere indicate the contamination is limited to the area near the structure.

Creosoted wood is used for applications other than piles, docks, and marine structures. For structures such as marine grids and retaining walls that are submerged in the water, either continually or by tides, what has been said in the other chapters would apply. The modeling an risk assessment of these may be different, see Chapter 8. Creosoted wood is used in other applications, such as bulkhead walls and bridge end walls, which are usually out of the water. Will creosote runoff from these might affect the marine environment? Since the transfer of creosote from these types of structures would be essentially the same in fresh as in salt water regions, there are two mesocosm experiments that are pertinent. And, by combining these with known effects in marine systems, a reasonable estimate of effects can be made.

There has been research related to bridges made of creosote treated wood.(Brooks 2000) The researcher investigated the PAH concentrations in water and sediment downstream from two creosote treated wooden bridges, one a new bridge and one an older bridge. In general these found that some creosote-derived PAHs are found in the sediments downstream from these structures, but the concentrations, which depend on the current flow and other parameters, are usually not of environmental concern – below standard toxicity benchmarks. Occasionally higher concentrations were found.

There was a significant research project that related to creosote treated railroad cross ties. That study simulated a railroad across a wetland using a mesocosm study of three sets of two ties each. One set was new creosoted ties, one had old creosote ties, and one had wood without creosote. The ties rested on clean railroad ballast, 0.5in to 1.5in gravel, which overlaid wetlands soil. The study over 18 months indicated that PAH from the creosote did migrate into the ballast, but the most of this happened in the first year and there was little migration after that. Further, the PAHs were mostly heavy PAH, 3 to 5 rings. The lighter PAH were not present.

The rail ties used in this study were red oak, a hardwood that does not absorb creosote readily, and were treated to a refusal standard, rather than a retention standard recommended for Doug fir and other softwoods likely to be used in Alaska. The results however coincide with what would be expected. *In the Updated Ecological Risk Assessment for Creosote* the EPA recognized that “and the PAHs do not move any substantial distance from the railway ballast.” (EPA 2008)

Based on these studies, our general knowledge of creosote in the marine environment, we can generalize to these near marine applications. PAHs are degraded by photo- and chemical oxidation (weathering). In addition, PAHs and other hydrocarbons will biodegrade if sufficient oxygen, moisture and nutrients are available. The reason PAHs accumulate in marine sediments is that these are often anaerobic. In surface soils or tidal areas, small amounts of PAH should be biodegraded quickly. This would be the typical case of gradual leaching or runoff from creosoted wood, especially if it had been treated with BMP. If a large amount of creosote ran onto the soils, it would likely remain as a tar-like coating on the surface soils, since the biodegrading microbes only function at the water-hydrocarbon interface. Sunlight, however, can degrade these tar substances rather quickly. In the rail tie experiment, the gravel ballast was “clean” and thus lacked nutrients and rainwater quickly washed over through it. Thus the heavy PAHs formed a tar on the gravel near the surface.

Even in BMP treated wood, heating by sunlight will force some creosote out of the wood and thus creosote particles will make their way to the soil or sediment beneath the wood.

So, in general, bulkheads or other structures in shallow or tidal marine water would be expected to perform similar to piles. For endwalls and similar structures generally out of the marine water, some migration of the PAHs from creosote would be expected to occur and these would bind to the soils. The LPAH would quickly dissipate and the HPAH would remain longer. If the amounts were small and the local soils aerobic or if the HPAH were exposed to sunlight, the HPAH would soon be degraded. If the soils were anaerobic and the soils not exposed to sunlight, the HPAH would remain in the soils longer. In general, little migration to the water from rain would be expected. Earlier we noted that if the migration is to water via dissolved PAH, they are quickly oxidized. If they migrate to water via particles, or adsorb on particles and sink to the bottom and the bottom sediments are anaerobic, the PAH will remain much longer.

Both studies note that the greatest migration of creosote out of the wood is in the first year, and that BMP such as not storing new creosote wood directly on the soil, will decrease the amount of PAH transferred to the environment. Also, the migration of creosote may be largely due to particulates from the surface and this is reduced, but not eliminated, by BMP that reduces the amount of creosote on the surface of the timber.

## Chapter 5 Disposal

In general, disposal of creosote treated wood is not a problem. It is not a hazardous waste under the federal RCRA regulations (Woodpoles, 2009; Porter, 1986) and can be placed in a municipal solid waste landfill under state and federal regulations. Some landfills may choose to treat it specially and charge an extra fee for it. The Fairbanks and Anchorage landfills do not. Creosote-treated wood cannot be burned in Alaska in open burning (18 AAC 50.400).

Creosote wood can be reused and there is a ready market, for example, for creosote-treated railroad ties. Creosote-treated wood can be chipped and used in coal fired power plants. Creosote-treated wood is still a safety hazard from handling and should not contact foodstuffs. There is a standard EPA-approved caution statement that should be given to parties that purchase or accept creosote wood for reuse. (UPF 2009) If the creosote-treated wood is likely to enter the stream of commerce, an MSDS sheet should be provided. (SIRI 2009) Since creosote-treated wood is not a hazardous waste under RCRA, it can be sold, that is liability for its future uses can be transferred to the purchaser. However the transfer should be documented with a bill-of-sale. “Deep pockets” such as state agencies should exercise some caution when disposing of creosote products.

## Chapter 6 Economic Impact

### Economic Impact of Replacing Creosote Wood in Alaskan Harbors

One option for managing creosote in Alaskan waters is the removal of all creosote wood products. As discussed in other sections, this would have little positive effect on the environment. Any positive effect would be very gradual over many years, except, perhaps, in herring spawning areas of stressed herring stocks. A second option is banning the use of creosote for new marine structures. Again, the environmental benefits would be small, especially if the new structure is a replacement for an existing creosote structure. Either way, the removal of PAH could be accelerated by dredging the sediment near the existing creosote wood, but this is unlikely to be a net benefit to the environment, since the dredged material would need disposal and the dredging would stir the local sediments, as would construction operations. However, assuming there is some benefit, albeit a small one, it is prudent to examine the costs.

Estimating the costs has many complexities, for example the replacement material design, steel and concrete have higher design loads, but cost more than wood. One study examined two projects that were bid once with creosote wood, not built, then re-bid using steel. Steel was 2.33-fold more expensive in the smaller of those jobs and 1.58-fold more expensive in the larger. (Smith, 2006) The author, who was writing for a wood preservers trade group, used a factor of two for economic comparisons. (Smith 2007) while the re-bids may be the closest to a “apples to apples” comparison available, there were only two of them and that is a very small data base.

The EPA accepted the premise that plastic piles were not a viable alternative to wood. (EPA 2008c) Plastic piles are generally not used for structural members because they are too flexible. Their modulus of elasticity is less than half that of wood. (Perkins 2009)

Here are some approximate costs of creosote and plastic products base on list prices from suppliers. Bid prices would presumably be lower. Prices do not include freight from the dealers in the lower-48 to the Alaska location.

Pile Butt Diameter, inches	Creosote Wood \$/linear foot	Plastic Coating of Creosote. * \$/linear foot	Plastic Pile** \$/linear foot
10	25		45
12	25		
13			75
14	25	53	
16		70	120f
18	45		

\*Note only the part of the pile in the water would need to be coated. Also, this cost does not include the pile itself, only the coating.

\*\*These are might be used for structures, if deflection is tolerable.

Many harbors have a mixture of creosoted wood and other materials, such as steel and concrete, other treated wood, and plastics. It may not be practical to replace the creosote piles without destroying the rest of the structure. While steel and concrete can replace wood piles, there is little alternative to using creosote wood in the submerged portions of float systems in Alaska. Mobilization costs and economies of scale are large estimating parameters in Alaska. In addition, there are many small harbors in Alaska. It is impractical to perform an estimate for all the harbors.

We approached estimating the costs by surveying the attendees the 2008 Alaska Harbormasters and Port Administrators Convention in Haines. There were 9 responses, about 25% of the attendee's responded. While this too small a sample to extrapolate with great confidence, it is a representative sample and, with a little judgment, provides some insight into the economics of creosote in Alaska.

Below is a question by question analysis of the results. Here is a summary: Eight of nine respondents had creosote wood in their harbors. It is present in finger dock guide piles, float material, the understructure of fixed docks, structural piles, fender piles, dolphins and navigation structures, and miscellaneous structures such as bulkheads, launch ramps and curtain fenders. There was little concrete used for piles, but steel is the second most common material.

We asked about the expected service life of the respondents' creosoted wood, since if it would need to be replaced soon for service reasons, the economics of removing for environmental reasons would be affected. About 22% of the respondents report some creosote wood must be replaced within the next five years – but generally only a portion of their creosote. About 33% reported that they would need to replace some creosote in 5 to 15 years and 44% reported that their existing creosote would last more than 15 year. Thus, only a small portion of the existing creosote would need to be replaced in the normal course of maintenance, and thus would have only a small effect on these economic calculations.

The survey respondents felt the economic consequences of removing creosote were heavy. Most, 80%, felt it would be a large consequence. Half of those felt it was unlikely they could get the funding to remove it without special appropriations or bonding and the other half felt it was unlikely they could finance it at all.

When asked to estimate the costs of removing creosote, the responders gave a variety of answers – many did not try to present a cost. However five of the nine did present an estimate. When normalized for the size of their harbors, the result was consistent, about \$16,000 per berth with a standard deviation of only \$8,000.

From those numbers, some rough order of magnitude estimates can be done. For example, the 1995 Alaska Harbor Directory lists 101 harbors that were managed by the

state in 1995, although many of them have been transferred to municipal governments and other entities since then. Those harbors had approximately 11,000 berths. At \$16,000 per berth, it would cost \$176 million to remove the creosote and replace it. Not included above is the Alaska Ferry System Harbors. Most of these are large modern structures which have steel piles to support the heavy loads, but these often have wood in fender systems and sometimes dolphins. A few of the ferry terminals are older structures of wood and these are all creosoted.

Besides the listed harbors, there are many unlisted harbors, many private and some industrial associated with fishing or mining activities. Some of these are abandoned.

The cost for berthing at municipal harbors is generally shared between state and federal governments, which contribute capital costs for some new harbor construction, local governments, which pay for some maintenance and overhead, and berthing fees that pay for some of the ongoing maintenance costs. The ratio between these contributors is quite varied, but in general, berthing costs do not cover the cost of current O&M, which includes needed repairs and environmental upgrades. Municipalities that benefit from tourism and fishing, both commercial and sport, often contribute to the O&M, and the beneficiaries of these industries strive to keep the berthing fees down through the political process. Communities with many sport boaters do likewise. Thus, most harbors are currently in a whipsaw between mandated low berthing fees, which are set by the municipality, and dependency on local government contributions, which is stress by non-beneficiaries of the harbor through the political process. Grants by the federal and state government are generally for new harbors, major expansions, or total renovations. The AMHS is run at a cost to the state government of over \$50 million a year.

Clearly funding for the removal of creosote treated wood from publically-owned harbors would need to come via some sort special appropriation. While some minor removal might take place as part of routine maintenance, for example replacing worn fenders and fender piles, any program to remove creosote from structures would be out of the economic range of most municipal harbors. The effect on non-municipal harbors cannot be estimated, but some industries, a prosperous mine or cannery, might be able to support such an operation, but many of these, commercial fishing, are currently economically stressed and it might be economically impossible for them to do it.

Thus, it seems likely that for any significant removal of creosote, it would need to be paid by direct appropriations from the state or federal government. A rough estimate of this might be \$175 million for state affiliated harbors and perhaps the same for non-state affiliated, for a total of \$350 million.

#### Details of the economic survey

There were 9 responses. One of those was an anomaly, a harbor in Washington, but the description seemed typical of Alaskan harbors and was retained. One harbor, a recent harbor built by the Corps of Engineers did not report any creosote.

Most of the respondents describe their harbors as larger rather than smaller

Qualitative Description of Harbor	
11%	Large, ferry terminal, or non-fish industrial
44%	Large, commercial fishing and fish handling
33%	Medium, commercial and sport fishing, recreational, transportation
	Medium, sport fishing, relational, transportation
	Small, mostly transportation and mixed non-commercial
11%	Small, some commercial

Quantitatively, over half had more than 400 berths, but a third had 100 or less berths.

Number of berths in harbor	
22%	More than 700 berths
33%	400 to 700 berths
	200 to 400 berths
11%	100 to 200 berths
33%	50-100 berths
	Less than 50 berths.

The guide piles for the finger docks are about evenly divided between creosote wood and steel. There is some concrete and ACZA wood used for this. All the respondents have finger docks.

Finger dock guide pile material	
54%	Creosote wood
4%	Concrete,
48%	Steel,
6%	ACZA wood,
	Other
	Don't have finger docks

The understructure of the floats are about 40% creosote wood and ACZA wood. However 22% reported "other," but not "plastic." Concrete is often used for this, but the survey did not query that material.

Is the understructure of your floats, mostly:	
39%	Creosoted Wood
39%	ACZA wood
	Plastic
22%	Other

The understructure of the fixed docks are 60% creosote.

Is the understructure of your fixed docks	
61%	Creosote Wood,
11%	Concrete,
33%	Steel,

	ACZA wood,
6%	Other

Creosote is the predominant pile material for fixed docks over water, with almost 70%. About 30% are steel. There were no concrete or ACZA piles reported

For your fixed docks that are over water and supported by piles, what is the pile material?	
69%	Creosote Wood,
	Concrete,
31%	Steel,
	ACZA wood

Creosote is the predominate fender system

The fender system of your fixed docks is:	
22%	Mechanical/rubber,
56%	Creosote wood piles
22%	ACZA wood plies
	Other

The answers to the question, “If you have mooring or guide dolphins within the general purview of “your” harbor, about how many piles of each type” were difficult to interpret. The answer would indicate 325 creosote wood and 680 steel, however the majority of those were at one harbor. Also, there were “curtain fenders” mentioned, which were creosote timber.

The answers to the question about other structures with creosote were varied. It would appear that the majority have such structures

Do you have other structures such as breakwaters, retaining bulkheads, or bridges associated with your harbor that have creosoted wood? Please describe:
Creosote at bulkhead wall
No
Old main dock no longer used is creosote.
Creosote at other docks
Launch ramps
Large dock mostly creosote
Curtain fender on deep draft docks
Bulkhead

Some, 22%, indicated that they had creosote that would need changing within the next five years, but those were generally limited to smaller sections of the harbor. 33% indicated they had portions of their harbor that would need changing in 5 to 15 years, and 44% indicated they would be unlikely to replace their creosote within 15 years.

In general and broad terms, what is the status of your creosote wood relative to its life cycle: (check one)	
22% (Answers were qualified, generally indicating only a small portion of the harbor would need to be replaced, for example: 1. “some floats,” 2. “fender curtain,” “80 piles.”)	Under normal circumstance, we would have to replace all or most of the creosote wood within the next five years.
33% (One was qualified to a portion of the	Under normal circumstance, we would have to

harbor that need to be replaced.	replace all or most of the creosote wood within the next five to 15 years.
44%	Our wood is unlikely to need replacement within 15 years.

To the question, “Do you have significant (relative to the size of your facility) quantities of creosoted wood that are difficult to replace, such as a dock understructure. (yes or no)” 86% answered “yes.”

Most, 80%, believe it would have a large economic consequence to remove creosote wood. One harbor did not have any creosote.

In general, if you were required for environmental concerns to remove all your creosoted wood within five years and replace it with non-creosote, what would be the economic consequence for your sized harbor:	
11%	Small, since we have little or no creosote.
	Small, since we are likely to replace for other reasons.
	Small, we could accomplish within our maintenance budget or a slight increase.
	Moderate, we would need at least a doubling of our maintenance budget.
11%	Moderate, it would be a capital project requiring funding from our owner city/agency.
39%	Large, it would be major capital project requiring funding from outside sources, our owner city/agency would not fund it without special appropriations or bonding.
39%	Large to impractical, the economics of our harbor make it unlikely we would get

The free answers were interesting.

In general, if you were required for environmental concerns to remove all your creosoted wood with five years and replacement with non-creosote, what would you estimate your costs to be, in current dollars, for your sized harbor.
(Has no creosote)
No idea
No idea - over 2000 piles
\$4 million,
Substantial
\$10-15 million
one harbor, \$8 million
\$20 million
1 million, 250-300 creosote piles at \$4,000/pile

They seem quite varied, but by comparing those that gave a definite answer to their number of berths from question 3 (using 800 berths for the >700), the answers averaged out to \$16,000 per berth with a standard deviation of \$8,000.

## Chapter 7 Consultations

### Consultations with Agencies, Regulations and Guidance

#### Nature and necessity of consultations

##### Introduction

Use of creosote-treated wood products in marine waters presents an interesting policy choice for the ADOT. There is current opposition to the use of creosote and other treated wood in the marine environment and some of this opposition is based on many scientific studies that show some of the components of creosote are quite toxic, and some of these components can be extracted from even old creosote-treated wood or nearby sediments, and these extracted components are likewise toxic. However many of these scientific studies are based on laboratory procedures that are not equivalent to the natural situation. Others tests were done in locations with many sources of non-creosote contamination that confound the results. Meso-scale testing of creosote piles in a pristine area did not demonstrate any significant effects on the biota. The effects demonstrated some contamination, but the effects were short term and localized. Most marine piles are quickly covered by fouling organisms, most of which migrate to the pile as larvae or other immature life stage. Since these life stages are presumably the most susceptible to the toxic effects of the creosote components, their presence demonstrates lack of observable toxicity to those organisms. More details are presented elsewhere in this report. Thus there is a policy stress from the choice between using an economical and efficient product that has been in common use for over a century but that has components that under some circumstances are toxic to marine life.

We should note a fallacy of the comparative risk analysis. While outboard motors or bilge pumping might introduce more toxic components into a harbor, the ADOT is not doing those things. While with the use of creosote the ADOT is deliberately introducing these toxic components albeit at a level not likely to harm marine life. This stress may be ameliorated by considering the ADOT's primary obligation to provide for safety for highway, airport, and marine traffic. Inefficient or uneconomical structures may impact safety directly if the structures fail, or indirectly by consuming resources that might be used on other safety improvements. The stress should be eliminated if the ADOT is confident that the harm is minuscule and unlikely to have measurable adverse effects on the environment.

The policy stress could be avoided if there were laws or regulations of other agencies that clearly addressed the use of creosote. There are few laws or regulations that apply directly to the DOT's use of creosoted wood in marine structures. Since creosote is a pesticide, it is regulated by the federal EPA under FIFRA. FIFRA does have regulations, but these are mostly labeling and manufacturing instructions. We discuss these in some detail below because the EPA performed a careful risk assessment on use of creosote and made its risk management decisions – approval – based on that risk assessment. The guidance provided by the regulations requires things that the ADOT is already doing.

The chief constraint to DOT's use of creosote comes from indirectly through the consistency reviews of other agencies, chiefly the NMFS and ADF&G. Briefly, the usual mechanism for these reviews is the Corps of Engineers permit required to construct structures in navigable waters. The permit will often require a consistency review whereby other state and federal agencies are requested to review the project and comment. Such reviews are required if an EIS is needed, but also if the work is in an Essential Fish Habitat (EFH) or might affect a threatened or endangered species (TES). Most Alaska waters are EFH for some species and TES must be considered in any case. For marine waters, NMFS is the lead agency. However regarding anadromous species, ADF&G has a joint responsibility with NMFS and ADF&G will also be asked for a consistency review. For smaller or routine projects the Corps has general or area-wide permits, however if project may affect an EFH or TES, the Corps may still ask for the consistency review. In addition, any project in the "coastal zone" must meet the requirements of the "Coastal Zone Management Plan." This likewise requires a consistency review by all the agencies. Thus, even a treated wood project that did not directly affect navigable water, such as replacing a wood retaining wall near the water, might likewise be subject to consistency reviews.

The consistency reviews will pertain the project as a whole. The use of treated wood may be only a small issue in the overall project approval cycle. However regarding the treated wood, we ask, what are the standards the agencies use in their review? Below we discuss those standards and attempt to fill in some details. But note that the standards, such as they are, are not a cookbook that NMFS or other agency personnel must follow. Rather, those agency personnel must extrapolate from their knowledge of the science relating to wood treatment and the biology of the many organisms in the environment as well as the population biology of the species to found their recommendation. Since for any chemical or any species these are topics about which experts disagree, the agency personnel should have more specific guidance. NOAA has tried to provide these by generating two "technical reviews and use recommendations" by a firm Stratus, and a more recent document draft, *The Use of Pesticide Treated Wood Products in Aquatic Environments: Guidelines to NOAA Fisheries Staff for the Endangered Species Act and Essential Fish Habitat*. (NMFS 2009) One of the Stratus documents deals with non-creosote wood treatments and we will not discuss that further. (Stratus Copper 2006) The other Stratus document deals exclusively with creosote and that is one we will refer to as "Stratus." (Stratus 2006) We will refer to the other more recent document as "draft Guidelines." We discuss these and the EPA's review and NOAA documents in detail Appendices, C, D, and E, but here we will quickly review them.

#### Regulatory Basis of Reviews

Since creosote is used as a pesticide, the agency that had direct regulatory control over creosote in the federal EPA, under FIFRA, the Federal Insecticide Fungicide and Rodenticide Act. In late 2008, the EPA completed its Reregistration Eligibility Decision (RED) for creosote and found it eligible for reregistration. (EPA 2008a)

The National Marine Fisheries Service (NMFS), an agency of the National Oceanic and Atmospheric Administration, has input into creosote-related decisions through is

consultative role in the actions of other agencies, especially the US Army Corps of Engineers, and many agencies through the Coastal Zone Management Act. The Corps must issue a permit for any new structures or alteration to existing structures in navigable waters. The CZMA requires a “consistency evaluation” for any agencies actions that affect the coastal zone. In either case, the agency considering issuing a permit, or an action of the agency itself, must consult with the NMFS. The two laws that NMFS will consider are the Endangered Species Act (ESA) and the Magnuson-Stevens Act (MSA), the NMFS is responsible for managing commercially harvested aquatic species by implementing fishery management plans and designating Essential Fish Habitat (EFH) areas. Under the ESA the NMFS will consider if the action threatens a listed or endangered species or its habitat. Under the MSA, NMFS will consider if the action threatens an “Essential Fish Habitat” of a protected species. In the event NMFS finds that the agencies action, such a approving a permit, will threaten a listed species under the ESA or an EFH, NMFS will convey that to the agency. This may result in the action such as a permit being disapproved, or may result in negotiations or design changes to remove the threat. Thus, via an ESA or EFH consultation process, NMFS may determine creosote piles are not an issue, or essentially ban the use of creosote, or delay a project while creosote-related details are revised or determined. Of course the permit applicant might protest the decisions to ban creosote, alternatively, a third party, such as an environmental group, may protest the decision to allow creosote. Either approach will be an action against the agency issuing or denying the permit, probably not NMFS directly.

## Guidance

### EPA

Since creosote is used as a pesticide, the agency that had direct regulatory control over creosote in the federal EPA, under FIFRA, the Federal Insecticide Fungicide and Rodenticide Act. Especially interesting for the ADOT is the fact that the EPA decision is “risk management” decision that is founded upon a “risk assessment.” Certainly some if not most of FIFRA regulated substances are toxic, thus the agency’s decisions will considered the benefits to society from the application of the substance versus the stress to humans and the environment from its application. In late 2008, the EPA completed its Reregistration Eligibility Decision (RED) for creosote. (EPA 2008) “As a result of this review, EPA has determined that creosote containing products are eligible for reregistration, provided that risk mitigation measures are adopted and labels are amended accordingly. The reregistration eligibility decision and associated risk mitigation measures are discussed fully in this document.” That is, after characterizing all the risk associated with creosote, the EPA considered the benefits and economics, including those of reasonable alternates. The EPA FIFRA Office of Pesticide Program then promulgates “mitigation measures” and “labeling requirements” that the manufacturers and distributors of FIFRA controlled substances must in turn follow. Because creosote, as all coal tar volatiles, is toxic to humans, most of the mitigation and labeling requirements relate to human exposure in the manufacturing process, some of which would apply to field construction, but this is chiefly a concern of federal OSHA and Alaska DOL.

The most stringent interpretation of the EPA FIFRA requirements is that Best Management Practices (BMPs) must be used in sensitive environments. Since elsewhere we suggest BMPs be used for all creosote applications, this is not a burdensome requirement for the ADOT.

#### NOAA NMFS Guidance

##### Stratus

Since the NOAA draft guidance is still in draft not final, and that document frequently refers to the Stratus documents, we will discuss Stratus here and in Appendix D

In 2004 NMFS commissioned a consulting firm, Stratus, to write a report titled “Treated Wood in Aquatic Environments: Technical Review and Use Recommendations.” The preface to that document states:

These reports are the findings of Stratus Consulting regarding the use of treated wood. They have been subject to peer review and public comment. NMFS may utilize these reports and other available information, as appropriate, to develop or update guidelines on the use of treated wood in aquatic environments. Accordingly, these documents are not NMFS guidelines themselves.

The original report dealt with copper treated wood only. (Stratus Copper 2006) A second report was commissioned about that same time that dealt exclusively with creosote. (Stratus 2006)

Both documents were available in late 2005 or early 2006 and the version placed on the NMFS website is dated December 31, 2006. A notice of the availability of these documents was placed in the Federal Register March 3, 2006, which requested public comment. That notice said

The intent of the reports is to ensure NMFS is informed of relevant studies and recommendations when making decisions related to the use of treated wood in aquatic environments. This information may be used for future development or revision of NMFS treated wood-use guidelines. NMFS is soliciting public comment on whether the treated wood documents sufficiently summarize the existing body of knowledge concerning copper and creosote treated wood products, including the fate and transport of leached materials, the appropriate use of treated wood products, and the potential effects on living marine resources and their habitats. In addition to this public comment opportunity, the reports will also be subject to independent peer review.

There were three sets of public comments, one set by the Creosote Counsel and Dr. Brooks, who consults for the WWPI, which might be considered industry comments, one set by the USDA Forest Products Lab and a university researcher that would not be considered industry. The third set would be the three peer reviews. Together six of those seven documents were quite critical of the Stratus Creosote Report. The extent of changes provoked by those reviews is not clear, but it appears the specific comments were not changed in the final document.

Although this author finds the Stratus document strangely inconsistent, as discussed in the appendix, the main conclusion of the document is that creosote is a useful product and can be safely used in the marine environment, but that certain risk factors should be considered.

#### NOAA Guidance

The Public Review Draft of *The Use of Pesticide Treated Wood Products in Aquatic Environments: Guidelines to NOAA Fisheries Staff for the Endangered Species Act and Essential Fish Habitat* is dated December 5, 2008, and was placed in circulation via a Federal Register announcement in January, 2009. The FR stated the comments period was closed in March 2009. At this writing (August 2009) the status of the document was uncertain, and emails from the author have not been answered. The only comment document this author received was from the WWPI. My comments and the WWPI comments are in the appendix. Both agree the NOAA Guidance is a reasonable treatment of the issues. WWPI believes that more specific guidance is needed. Until that is provided, individual biologists are free to use their own bias in the process, and project owners, sensing this bias might hold up their permit, might not use creosote in favor of less economical or efficient design solutions. While I don't disagree more guidance would help, I don't believe with the proactive approach outlined in Chapter 8 more specific guidance is needed. In the final analysis, the consultation will depend on the professional opinion of the NMFS experts.

The main conclusions of the Draft Guidance are that:

- The use of creosote-treated wood in aquatic environment could be acceptable in many proposed projects.
- They are not categorically safe and require risk assessment
- Many projects only require a screening assessment for pesticide treated wood impacts.
- Local knowledge is needed to make a case by case determination
- Information is limited, but creosote may not impact ESA listed salmonids in a manner that can be detected

All of which the author agrees with. The report does express a preference of copper over creosote for EFH. The document is intended for nationwide application, however because of the poor performance of copper treated wood in Alaska, that preference, which is not that strong to start with, would not be appropriate in Alaska.

## Chapter 8 Management Policy

Management Policy for ADOT use of creosote in the marine environment.

In most applications of creosoted wood in Alaskan marine waters any contamination released is likely to be slight and confined to an area near the installation and unlikely to significantly affect marine life. Nonetheless the installation of creosote adds something to burden of contamination in the environment. The perception of this burden will vary considerably with individuals and will evoke negative responses from some even where the science indicates harm is unlikely. In addition, the charge of the agency will alter the perspective: DOT's primary concern is the safety of the public, while NMFS and ADFG primary concern, in this regard, is the protection of the fisheries and endangered species. In addition, and this may be often the case, the science does not give a firm answer, the negative perception regarding creosote will bias decision makers towards other materials and approaches – this despite the fact that the alternates may be no better – for example steel pilings need painting with its possible contamination and cathodic protection with its unknown effects on immature life stages. So, when planning a project where creosoted wood is the material of choice, the risks to the environment from its use must be assessed by the designers and DOT's opinion of the risks must be communicated. Further, this risk evaluation should be done early in the project and transmitted to the agencies with the initial permit applications.

Here we will make recommendations for the ADOT to proceed in the permit process. We assume that the ADOT designers have already made a determination that wood is the material of choice and that creosote wood treatment is required. Also, that the wood treatment method is a small part of the project and that the ADOT designers have been communicating with NMFS and ADF&G about the project and are aware of their general concerns regarding EFH and TES.

The first step in the risk evaluation we will call “preliminary evaluation.” It is similar to the hazard identification of a standard risk assessment or the environmental assessment portion of an EIS. The point is simply to determine if more evaluation is warranted. In this regard, the preliminary evaluation phase will likely be part of a more complete permit application.

First some in almost all cases where creosoted wood is the material of choice, a statement should be made in the initial permit application or attached to it. The statement has two parts, first an acknowledgement that the ADOT is aware of the creosote issues and second that BMP will be taken.

1. The DOT should state at the beginning that it recognizes that creosote is a pesticide and not a benign material, but that the ADOT has evaluated the situation and determined that the public interest is best served by use of creosote in this particular application. The boilerplate language would indicate

- a. Wood is the most economical material for initial cost/ shock absorption/ ease of installation and replacement.

- b. The threat of marine borers is present and threaten the wood
- c. Creosote will only be used for wood that is subject to borer attack
- d. Copper-based preservative, ACZA, is not benign either and in addition, does not hold up as well in freeze thaw cycles and has corrosion issues.

It is not necessary to provide detailed calculations, just an assertion by a responsible designer, presumably a PE.

2. That BMP will be taken, specifically that the wood will be treated to the WWPI BMP specifications that allows less retention for northern waters. All other WWPI and EPA recommended BMP will be in the specifications. (This is somewhat redundant, since the WWPI BMP are more stringent than the EPA.) Those WWPI specifications are found at WWPI *Best Management Practices for the Use of Treated Wood in Aquatic and Other Sensitive Environments* (WWPI) and the EPA's in the RED (EPA 2008a).

The next will be project specific. For most small or medium sized projects, unless the project planning and discussions with the agencies indicates there is a specific EFH or TES issue, the risk analysis may be brief and simply note that after a few weeks there is no creosote derived PAH in the water column, and PAH in the sediment near the structure is unlikely to affect any EFH or TES.

- 2. Is the project in an EFH or will a TES species be affected.
  - a. Most Alaskan waters are mapped as EFH for one species or another. However within the EFH is the concept of a habitat areas of particular concern (HAPC). The risk analysis should note that the project is or is not in an HAPC.
  - b. In general, in order for an activity to adversely affect an EFH, it will be a larger activity, such as: “port development, marine disposal of dredged materials, development of coastal wetlands, coastal transportation projects such as roadways, pollutant discharges, and certain resource extraction activities such as mining, logging, and oil and gas exploration.” (NOAA 2009) Thus smaller projects such as replacing a worn fender system are unlikely to affect an EFH. On the other hand, larger project such a new marina are likely to require an analysis. However for these projects, the wood treating method would be a small part of the general impact to the EFH – these projects will often require an EIS.
  - c. In general construction activities of all types will be scheduled or staged to avoid contact with endangered species, typically salmon fry migration
  - d. The project as a whole will be evaluated with respect to EFH and TES . So, it seems unlikely that a creosote-related issue will arise independent of other major concerns about the project.

With this risk evaluation, if there no HAPC and the construction will be staged to avoid TES, the ADOT could conclude the ecological risks from creosote use are small and further inquiry is not warranted. A simple statement to this effect would be needed in the permit application, perhaps saying, “ We examined the use of creosote with respect to EFH and TES and determined any adverse effects are unlikely.

If an EFH or TES is an issue, the next step is a risk assessment. We may divide these projects into four categories:

1. Small pile structures less than 100 piles
2. Large pile structures over 100 piles
3. Floats and other light structures
4. Bulkheads and other special structures.

In all cases, some basic data about the harbor is needed:

1. maximum current velocity
2. oxygen status of the sediments
3. pollution status of the harbor

These should be obtained from the project design documents of field investigations.

1. Small pile structures less than 100 piles
  - a. Here the risk assessment is adequately covered in the WWPI document, *Treated Wood in Aquatic Environments*. (WWPI 2008)
  - b. Table C of WWPI provides a matrix of current speed and oxygen status of the sediments. With moderate current speeds, only anoxic sediments require a more elaborate risk assessment, see below.
  - c. Some special considerations may be needed if the area is already polluted, creosote has large surface area, such as a bulkhead, or is close to other large projects using the same preservative.
2. Large pile structures, more than 100 piles
  - a. A risk assessment is generally required.
3. Floats and light structures
  - a. Compare the area of creosote treated wood with an equivalent area of a pile. Use the criteria from small pile structures, above.
4. Bulkheads and other special structures
  - ii. If these are largely above high tide, see Chapter 4. These are unlikely to have any effect on marine life or pollution.
  - iii. If they are submerged, use the equivalent pile method to screen
    1. Very small area, treat as small project, above
    2. Area is larger, say equivalent to 20 piles, do a risk assessment.

#### Risk Assessments in General

Risk assessments can be simple or complex. Some can easily be done by ADOT staff and others would require the help of consultants. As a general rule, the simple risk assessments are very conservative. That is, they save field work and analysis by making reasonable assumptions that are conservative. However, if the risk characterization is acceptable, even though it overstates the risks, there is no need to spend the time and expense doing a more detailed risk assessment. We mention the WWPI screening risk assessment, which requires only a few easily determined parameters and little computation time. Next level, are Dr. Brooks models, which require a few more parameters, although these can be assumed with conservative default assumptions, and require some computational effort. Central to these risk models is a conservative maximum level of PAH in the sediment of 10 mg/kg based on 1% organic carbon. If the models yield terminal PAH concentration higher than 10mg/kg, a more in depth assessment is needed that looks at the specific species

affect, their habitats, and other biological, chemical, and oceanographic data specific to the project.

#### Basic assumptions

We can simplify the risk assessment process by noting that water column concentrations of creosote-derived PAH fall to background very quickly after pile installation. There is some leaching of PAH for the life of the pile, but the LPAH are degraded quickly and the HPAH settle to the bottom quickly. Therefore the steady state water column concentrations are too low to be of practical concern. The initial concentrations may be of concern, but avoiding the critical seasons in step 2 above will take care of that.

The sediment quality may be of some concern and the next steps consider that. If there were no PAH other than that derived from newly installed creosote piles, and the sediments were not anoxic, the sediment PAH would be expected to increase for a time, then decrease. The rate of increase can be computed for BMP piles for water temperature and salinity and current velocity. The chief factor influencing the degradation of PAH and its subsequent decrease in the sediment is the oxygen status of the sediment. This can be estimated from RPD and the current velocity.

However if there is PAH in the sediments prior to the pile installation, these must be considered. The pre-construction sediment concentration of PAHs is affected by natural and anthropogenic PAH deposition, the basic sediment concentration of organic carbon, and the BOD placed in the water. These affect both the background PAH concentrations and the oxygen available to degrade new PAH from creosote. Thus, if the background PAH were over 10mg/kg based on 1% OC, the sediment would be considered polluted already and not suitable for creosote piles.

Next from the HPAH leached from the piles, the settling depends on the current velocity. Once in the sediments, the rate of degradation of the PAH depends on supply of oxygen in the upper layers of the sediment. More exactly, it depends on the depth of the reduction potential discontinuity (RPD), which in most sediment is the depth at which the color of the sediment changes brown or light grey to black or dark grey.

5. What is the current flow and sediment conditions?
  - e. The WWPI risk model present a simple matrix based on current speed and sediment quality. If the current is high enough and the sediment quality (aerobic and not already polluted) is sufficient, a more detailed risk assessment is not needed.
  - f. The parameter is the maximum current velocity, which is generally known to the designers and
  - g. The depth to the RPD – the reduction-oxidation potential discontinuity. Roughly the depth at which the character of the sediment changes from aerobic to anaerobic
  - h. The WWPI guidelines provide a conservative estimation of the maximum sediment PAH concentration due to the piles.

- i. If the matrix indicates the sediment concentrations will exceed a given value, more evaluation is needed.

In Appendix F we discuss Dr. Brooks models. These allow the introduction of more parameters than the WWPI screening risk assessment and thus more exact predictions.

#### More complex risk assessment

The goal of the risk assessments process is termed the “risk characterization.” It states the probability and severity of harm to a receptor. For ecological risk assessments, determining the receptor involves considerations of species and life stage, as well as exposure duration. Selection criteria for the receptor species should include its role in the food chain of other organisms. The risk characterization depends on two parallel processes, a toxicity evaluation and an exposure assessment. The toxicity evaluation determines, for each species and life stage, determines the likely effects for each dose or, for aquatic species, the exposure concentrations. The exposure assessment evaluates the fate and transport of the contaminant from the source to the receptor and it’s the likely time course of exposure to the receptor.

While this algorithm is simple and based on scientific principles, its practical application can be extremely complex, and therefore time consuming and costly. For example deciding which of the PAH constitutions is the chemical of concern – of course many of them are. The risk assessment process can be facilitated by using various benchmarks with the assumption that meeting them will protect relevant species and the ecosystem. For example, assuming that if the sediment concentrations of PAH remain below 10 mg/kg, the ecosystem will be protected. Since most of the approved benchmarks are quite conservative, this is probably a good assumption. A second aide to risk assessment is to only examine the species important by their listing as a TES species or part of a fishery. Of course the prey of these species needs to be considered as well. For many of these, there is a definite time window when they are present in a particular location. Further, for most of these, it is only the immature life stages that need be considered. Finally, since projects that use creosoted wood are very limited in area, and science indicates the PAH contamination is limited, one may determine that even if the affected are were “removed” from the ecosystem, there would be not measurable affect of TES or fisheries.

Further, based on science, the effects of creosote are limited. In the water column, PAHs decline to background values very quickly. Thus, water column effects are limited in time even in a still basin. In currents typical of Alaskan harbors, the effects in the water column may be nil. There is a definite transport of creosote from piles and creosote structures into the sediment, and these may persist if the sediments are anaerobic. However this effect is limited to a region close to the structure. There is one research paper that indicates that herring eggs that stick to creosote piles have very poor survival rates. However at worst this would be a localized effect. See Chapters 2 and 9 regarding that issue.

Thus, if construction is staged so that immature life stages are avoided (or not important at that location) the risk assessment can be limited to the likely sediment concentrations.

However water column concentrations, which decline with time, can be used to determine the length of closure. The models in Appendix F can help with this, but generally 17 days is the maximum that any PAH above background was detected and that was with non-BMP piles. (Kang, et al., 2005) Thorough evaluations of sediment require the sediment triad: sediment chemistry; benthic survey, and sediment toxicity. However for a prospective evaluation, we can only use the likely sediment chemistry – the predicted concentrations of PAH. Further, we should look at the steady state concentrations, considering organic content of the sediment and RPD. The organic content reduces toxicity by binding PAH. The RPD determines the rate of degradation. An often accepted sediment criteria is 10 mg of PAH/ kg of dried sediment. For sediment with more organics, the allowable concentration would be higher. A review of the literature shows an enormous range of sediment toxicity value, because of the number of species tested and the varying test conditions. Also, for sediments, there are often many other contaminants besides PAH. And other organics in the sediment affect bioavailability. Also, many sediment criteria are promulgated for environmental remediations or dredging spoil disposal, activities that purposely disturb the sediment, which may not be an appropriate model for the gradual disposition of PAH or creosote particles.

However, 10 mg/kg of PAH in sediment with 1% organic is accepted by, for example, the State of Washington, Sediment Quality Guidelines, and thus 10 mg/kg should be conservative, unless there is good evidence, based on the species and site specifics, for a lower standard.

The most expedient method of estimating the sediment PAH is to use a model. The models of Dr. Brooks have been tested and found to generally predict the levels of contamination, although they tend to be conservative. That is, to overstate the risk. A recent version of Dr. Brooks' model is described in Appendix F.

Once the time course of contamination is estimated, it may be used as input into the risk management decision. For example, if the final sediment concentration predicted by the model is 100 mg/kg, ten times the benchmark level, caution is required. Although this level will be confined to a region with about 10 meters of the structure, it will be there for a long time – many years. Thus, a region of the structure's footprint, plus a 10 meters margin may have toxic levels in the water above the sediment. However the nature of the ecosystem may indicate that does not matter to the health of fishing stock or TES. For example if the structure will be behind a breakwater and not in migration channels of fish.

## Chapter 9 Research Workplan

### Revised Research Workplan

The research to date, literature search and interviews with persons knowledgeable in creosote use, has indicated research gaps that should be addressed which are different than the research originally proposed. The three main gaps are the effects of fouling on the toxicity potential of creosote treated marine piles, the nature of creosote emissions from treated wood material, usually glulam, used in marine floats, and performance of copper treated wood in Alaska.

### Background

The most relevant mesocosm studies of the effects of creosote piles on the marine environment were the Sooke Basin studies.[ref] These demonstrated that, after a small time, there was no measurable PAH from the creosote in the water column. PAHs were found in the sediment, but these sediments were anoxic because of deposits from the vast increase in marine life growing in and around the piles, and were not likely to be transferred to pelagic (water column) species. Low levels of PAH were found in mussels growing on the piles in the first year, but none in following years. So, while there are reams of studies that indicate that PAHs are harmful to marine life and that creosote treated piles do release PAHs to the environment, the effects of that PAH are small to start with, limited to a region close to the pile, and diminish rapidly with time. There was one study, however, that did indicate some potential for harm from creosote treated piles. The relevant part of that study compared the mortality of herring eggs and larvae that were scrapped from a pile that had been in the water for 40 years versus those that were scrapped from a nearby plastic pipe. Virtually all the eggs and larvae were dead or deranged while those from the plastic had only a normal death rate. At first impression, this would seem to indicate that creosote piles should not be used in regions where the herring stock is stressed. The author of that study said the piles were not fouled – covered with marine growth. Also, chemical analysis of the old piles was not done. But the more common experience is that marine piles are quickly covered with marine growth. So, there are two questions that need to be answered before we suggest creosote should not be used if the herring stocks are stressed in the region and herring are likely to spawn on them. One, would a modern BMP pile, especially one that was fouled, be harmful to herring eggs, and two, how does a creosote BMP pile compare with other wood treatments, such a ACZA or copper Napenthate, or with alternate pile materials, such as galvanized steel or steel with cathodic protection, or concrete piles?

The second issue is that the greatest need for creosote treated wood today is not in piles, for which alternates are available, but in wooden material used in floats – floating docks – in which the creosote is in members that are only partially submerged. Studies have shown that in a pile, the creosote is not in the water column after only a short time, 17 days in one study. Thus, if we wanted to determine a window for which creosote piles would not be allowed because of issues related to the water column, there is data to support that window need only be two weeks long. However for wood float material,

which is only partly submerged, this window might be longer. Of course since there is less material than from piles, the amount of creosote might be less. In any case, there is nothing in the literature about the transfer of creosote from floats. As part of this study, it may be useful to determine if the transfer from the wood is via chemical diffusion or via micro-droplets of creosote that are squeezed out of the wood due to solar heating cycles.

The third issue is the serviceability of copper-treated (ACZA) wood in Alaska marine environment. Some of the issues are well-known, such as corrosion, because they are not particular to cold regions. However in cold regions, there are often freeze thaw cycles. In wood in Southeast Alaska marine waters, there may be hundreds of cycles per year. A water soluble wood treatment absorbs water and this freezing and expansion of the water may lead to brooming or other deterioration of the wood. Anecdotal evidence confirms this, but there have not been controlled studies to verify this. Controlled studies might indicate a clear preference for creosote (or other oil-based treatment) for cold regions, and this could result in a standard design specification.

#### Outline of research

I. Test of herring egg toxicity of creosote treated piles that have been fouled and alternate pile systems.

There are two hypotheses to be tested.

1. Are BMP piles a substrate harmful to herring eggs?
2. Does the fouling of piles reduce the toxicity to herring eggs?
3. Are alternate pile systems toxic to herring eggs?

Both are tested in the same general experimental procedure. Pile sections will be hung below the low tide line for varying amounts of time and permitted to foul. Then sections will be tested for their toxicity to herring eggs. Since that will be limited to a year or two, an effort will be made to procure some sections of creosote treated piles that have been in the water for several years. The nature of the creosote of these sections will be assessed and compared with recently tested piles by laboratory testing.

II. Creosote transfer from float material.

The hypothesis to be tested

1. Does the transfer of creosote to the water column diminish quickly?
2. Does the PAH content of the sediment increase measurably?
3. Does the transfer of creosote to the sediment occur by diffusion/ adhesion, or by transfer of microdroplets.

These will be tested by observing the removal and replacement of a long existing dock and its replacement with creosote treated floats without creosote treated plies. The water column will be tested at one week intervals for several months after the installation and the sediment tested before and after the installation at one month interval. In addition, sediment traps will be sample the sediment directly below the floats and the sediments examined to determine if the creosote in droplets or dispersed into other particles.

### III. Use of ACZA wood in Alaska marine float material.

The hypothesis to be tested is

1. Does ACZA float material compare favorably with creosote treated float material in Alaska?

This will be tested with a “case control” method of comparing applications of ACZA float material with creosote material of the same age and application situation. The method will be observations, interviews, and photographs.

### **Detailed Herring Egg Proposal**

#### Creosote Piles and Pacific Herring Eggs - Research Need and Outline Plan

The use of Creosote treated wood in marine environments has been reviewed by several agencies. Creosote was recently approved by the EPA with its *Reregistration Eligibility Decision for Creosote* (RED). (EPA 2008a) Another agency, the NMFS of NOAA has presented a public review draft, *THE USE OF PESTICIDE-TREATED WOOD PRODUCTS IN AQUATIC ENVIRONMENTS: Guidelines to NOAA Fisheries Staff for the Endangered Species Act and Essential Fish Habitat Consultations*. (NMFS 2009) The EPA document proposes a ecological risk assessment for creosote use, but the result would be if the risks were large, Best Management Practices (BMP) should be used. A plain reading of the RED is that BMP would not be needed, unless the ecological risks were large. Since BMP is more or less standard today, as a practical matter, the EPA document would not require a risk assessment. The NMFS document also requires a risk assessment but is more ambiguous about the details. However that document recommends the Western Wood Preservers Institute (WWPI 2006a) BMP and the WWPI risk assessment method for smaller projects, but recommend a site specific risk assessment for larger projects.

Two studies are often mentioned in these another other policy reviews, one is the series of Sooke Basin studies where creosote and non-creosote piles were driven in a pristine bay and the environment near the piles monitored for four years. (Goyette and Brooks, 1998a and 1998b) That study indicated that shortly after installation, the PAH from the piles was not detected in the water column nor were marine life affected. PAH was transferred from the piles to the sediment, but these effects were confined to a region close to the piles and declines with time. The low current speeds (<2 cm/sec) and other factors made this a worst-case test. Thus, in general, the Sooke Basin studies are cited as indicating a low level of risk to marine life from BMP treated marine pile.

The other study, by Vines, et al., (Vines 2000) seemed to indicate extreme toxicity of creosote to herring eggs, even creosote from 40-year old piles. The bulk of that study was made with pieces of wood from the interior of the piles, and thus did not replicate the normal situation, where creosote from the interior of the pile must diffuse cross-grain to enter the water. It was not surprising that there were high levels of PAH from the interior

of the piles, since it is this PAH that allows the pile to resist the marine borers. Thus the bulk of the Vines, et al., study is not directly applicable to creosote-treated piles in situ.

However a preliminary study made by Vines was quite pertinent. In that study, herring eggs were scrapped from a 40-year old pile and from a nearby plastic pipe. The eggs scrapped from the pile had a very low survival rate and deformities of the larvae – it essentially lethal to 100% of the eggs. This preliminary study of Vines would indicate that creosote piles, even older piles, may be highly toxic to herring eggs. However, in a personal communications with Dr. Vines, I learned that the 40-year old piles from which she scrapped the herring eggs were not visibly fouled. This is unusual, since most creosote piles are quickly covered by fouling organisms. Thus, in the preliminary study of Vines, the eggs were stuck to pile directly, where in most applications, the eggs would stick to fouling organisms on the surface of the pile, not the creosote-treated wood. Since this preliminary study of Vines is the only research that directly indicates the toxicity of creosote-treated in situ piles to marine organisms and conflicts with the Sooke Basin studies, some research is needed that examines the toxicity of in situ marine piles, with their typical fouling organisms, to herring eggs. Also, since the pile in Vines preliminary study was not fouled, it may have had an atypical creosote formulation. It surely was not treated to BMP. In addition, alternate piling materials have not been tested, to my knowledge, for toxicity to herring eggs. Thus, I propose testing, pile sections, in three replicates:

1. A BMP pile that has been transported and conditioned in sea water for a short time, a week or two.
2. A BMP pile that has been in salt water for over a year, and presumably fouled.
3. A older pile, verified to be creosote treated, that has been in service for several years.
4. ASZA pile, similar to 1.).
5. A plastic coated pile
6. A steel pile with corrosion resistant paint
7. A steel pile with cathodic protection
8. A concrete pile, new or brushed
9. A concrete pile that has been in service
10. A PVC control pipe.

The basic exposure set up is that the ends are sealed and a bag placed around the center of the pile, sealed top and bottom with hose-clamp type bands. The unit is placed in a seawater bath at the Seward marine center with flowing seawater. The bath keeps the temperature of the bag at sea water temperature and supports the bag. The bag has an influent and effluent water supply from a peristaltic pump. The influent line is filtered seawater. The lines are tapped to use the influent line for feeding and the effluent line for taking samples. The fertilized eggs are introduced and monitored through larvae stage. At the stated time the success is measured by comparing the groups with the control. In addition, the PAH content of the influent and effluent water will be tested.

Clearly there are some issues that must be resolved for this test:

- a. Herring eggs are extremely sticky after fertilization. Fertilizing them and then transferring them to the bags may be difficult.
- b. The unfertilized eggs may be introduced into the bags and then the sperm. I need expert advice on this, but it may work. But
- c. The fertilization success would be difficult to assess through the bag material.
- d. The larvae should be easier to observe, but difficult to count. Thus, the endpoint needs to be chosen, and then the contents of the bag counted. Thus, observing the larvae at intermediate times would be difficult.
- e. The nature of the fouling organisms must be considered. Some are toxic and other organisms may be predators or harbor predators.
- f. However it may be possible to test 50 or 100 eggs on each pile segment, thus making the test robust to fate of individual eggs.
- g.
- h. The fouling organisms are alive and thus need to be handled carefully to keep them healthy.

Here I would propose gather sections of BMP piles and placing them in seawater in early summer and leaving them until the following year. Also, we can locate older piles and that may be available, and take samples to verify the creosote content.

### **Detailed Proposal for Creosote-treated floats**

Creosote treated floats

Creosoted wood float material is likely to be in use of a long time. In service, most of the wood should be above the water. However the wood will be in the water during installation. After installation, creosote may be transferred to the water by micro drops spalling off the wood, especially if they are warmed by the sun. Here our hypotheses are:

1. There will be a measurable increase in PAH in the water column near the newly installed floats
2. The PAH in the water column will decrease to ambient levels in a week or two.
3. There will be some PAH transferred to the sediment, even though there is very little in the water column.

#### Method

Identify a project that will install floats in the summer of 2010, preferably one in a location not expected to be heavily polluted. Take sediment samples in a grid pattern where the flats will be installed. Take some water samples at different tides. During the installation, take water samples at different tides. Take sediment samples at one week, one month, and several months after the installation. It would be nice to take some the following year, as well.

#### ADOT issue

While there are viable alternates to wood piles, float material is more problematic. If the float material is assumed to be above the salt water, other wood treatments might be used. However this may not be good practice. We need to evaluate that.

### Expected results

I would expect the water column to have some PAH immediately after installation and that this would decrease to ambient very quickly. Also, the sediment would slowly increase, but that the absolute levels would be quite small.

## **List of Appendices**

Appendix A Guidance and Risk

Appendix B Sediment Quality

Appendix C EPA RED

Appendix D Stratus Creosote

Appendix E NOAA Draft Guidelines

Appendix F, Risk Assessment Models

## **Appendix A Guidance and Risk**

### **Introduction**

The scope of work of this research involved an assessment of “likely future laws and regulations.” Our analysis to date indicates that new laws or regulations are unlikely, but that agencies “guidance” will be very important. In this appendix we examine some issues related to “guidance,” especially as it effects NMFS consultations. In later appendixes we treat the two main guidance documents, Stratus and Treated-Wood.

Because wood preservatives are a contentious issue nationwide, NMFS is desirous of having a policy or guidelines to aid their staff in such consultations. First we should consider the nature of such policies or guidelines in the legal context of agency decisions. Agencies promulgate regulations (“rules”) under two laws. First the enabling law that requires the agency to regulate the subject matter, and second the Administrative Procedures Act (APA), that requires the agency to go through a definite process in the promulgation of the rule. The rule-making process may be long and arduous, requiring public notice, publishing of drafts, public hearings, revision of proposals, and if there are major revisions, the entire process is often repeated. Once the process is complete, the regulation is a “law” as binding as the statute law that mandated it. Contrasted with regulations, all agencies have myriad “procedures” that guide the work of the regulators. These may be very definite articles, such as published laboratory procedures, or administrative things like, “all applications originating north of Anchorage are processed by our Fairbanks office.” These may be published in “Standard Operating Procedures” (SOPs) or simply arise by habit and custom within the agency. Using term “SOPs” to include all variations of procedures, we note several issues. The largest is that once an SOP is established, it may have a profound effect on the interpretation of regulations and thus itself become a regulation itself, but one that was not vetted under the APA. However in a contentious matter, if an agency “fails to follow its own procedures,” aggrieved parties will use this as proof of unfairness and often prevail in the ensuing dispute. This makes it difficult for agency staff to vary SOPs in contentious situations. Thus, once an SOP is established, agency personnel feel bound by it. On the other hand, without such SOPs the agency staff could not function efficiently or perhaps at all.

### **Risk, Guidance, and the Precautionary Principle**

#### **Risk**

Risk involves the probability and severity of some harm. (Sometimes the word “opportunity” is used for the opposite of risk, the probability and severity of some benefit.) In complex human transactions, the various risks are a “cost” to the party who bears the risk. They might be insured against, in which case the risks have a definite monetary cost, or the risks are simply borne by one or the other parties to the transaction with the costs “real but uncertain.” Of course the costs of these risks must be balanced by some benefit to the parties, or the transaction would not complete. Note these benefits may be opportunities, that likewise have a probability associated with them. The balancing of risks and benefits is difficult for a government agency, where the risks include bad

publicity, time lost responding to increased scrutiny of the public and the media, possible loss of budget, job insecurity for top administrators, and so on. Benefits on the other hand are very nebulous, other than the satisfaction of doing one's job well.

#### Caution about *Precaution*

In a later appendix we treat the Stratus document in some detail, but here want to comment on a section of the report that cites the "precautionary principle" as dictating some courses of action regarding creosote. The irrelevance of that is discussed in the Stratus appendix, but here we will discuss the underlying principles of precaution and risk.

We have learned that risks are characterized by stating the probability and severity of some harm. Later those characterized risks are used in a risk management decision. We also recognize that do-nothing is a management option and different than simply ignoring a risk. Both the risks and the management decisions from a current hazard, say MTBE in a city's water supply, is different from the risks and management decision regarding the possibly of some future hazard, say building a landfill near the city's water supply wells. The nature of the do-nothing alternative is quite different. If the hazard existed prior to the management decision, the decision itself did not contribute to the hazard. Thus, the moral implications of the decision for the decisions makers are quite different. Of course prior decisions by that same manager may have contributed, but that is a "sunk cost" and not relevant to the decision of the moment. Conversely, if all the effects of the decision will occur in the future, the decision itself may contribute to the hazard. Thus a present decision to change or not change the current state of nature in the future that has risks in the future is quite different than making a decisions about a present hazard. Here the decision itself invokes the hazard. Now of course there were other hazards in the likely future states of nature, that's why we are making the decision – for example the city's current landfill is at capacity we have a court order to close it in two years. But no hazard at all existed for the City's wells, prior to our decision - the do-nothing alternative eliminates the risk to wells.

#### "Soft precautionary principle"

The precautionary principle was stated by the Rio Conference<sup>1</sup> "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." [Emphasis mine.]

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<sup>1</sup> The **Rio Declaration on Environment and Development**, often shortened to **Rio Declaration**, was a short document produced at the 1992 United Nations "Conference on Environment and Development" (UNCED), informally known as the Earth Summit. The Rio Declaration consisted of 27 principles intended to guide future sustainable development around the world.

[[http://en.wikipedia.org/wiki/Rio\\_Declaration\\_on\\_Environment\\_and\\_Development](http://en.wikipedia.org/wiki/Rio_Declaration_on_Environment_and_Development)]

The "precautionary principle" is one of the 27 principles. Of course these do not have the effect of law in any country.

So Rio requires serious or irreversible damage, albeit only a threat of those, would trigger measures to prevent this, but only if they are cost-effective. This could mean that the costs would be overwhelming in themselves or that the costs are large in relationship to the damage. The damage may be hard to evaluate. For example, the extermination of a rare species that is little known or useful, might be regarded as of infinite value, since the species will never appear again, or no value, since it would not be missed. Of course real world decisions are always complicated by economics and politics.

Hard precautionary principle.

The more recent 1998 Wingspread Conference<sup>2</sup> issued a document that states: “When an activity raises threat upon to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically”

Note a broad reading of this is simply that if there is a “threat” some precaution is warranted – a notion that is hard to argue with. However it seems to demand that some measures be taken, even if the science does not establish causation.

While these general policy notions might be thought provoking, the application of them is hardly scientific. As van den Belt (2003) notes:

[Definitions such as Wingspread] beg many questions. Is there ever full scientific certainty? Do we need a minimal threshold of scientific certainty or plausibility before we may (or should) undertake preventative action? And do we really know how to prevent harm if we are so much ignorant about the underlying cause-effect relationships? The definitions that are currently on offer fail to spell out the precise conditions that have to be fulfilled before the PP may be invoked or the nature of the preventative action that has to be taken. The types of action suggested range from implementing a ban, imposing a moratorium while further research is conducted, allowing the potentially harmful activity to proceed while closely monitoring its effects, to just conducting more research. The PP does not have a very precise meaning as long as such crucial aspects are left largely unanswered.

In practice, however, the PP is often given a more definite meaning by reducing it to an absurdity. Normally, no minimal threshold of plausibility is specified as a “triggering” condition, so that even the slightest indication that a particular product or activity might possibly produce some harm to human health or the environment will suffice to invoke the principle. And just as often no other preventative action is contemplated than an outright ban on the incriminated product or activity. The intervention of Greenpeace in the monarch butterfly case seems to fit this pattern.

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<sup>2</sup> The **Wingspread Conference on the Precautionary Principle** was a three day [academic conference](#) where the [precautionary principle](#) was defined. The January 1998 meeting took place at [Wingspread](#), headquarters of the [Johnson Foundation](#) in [Racine, Wisconsin](#), and involved 35 [scientists](#), [lawyers](#), policy makers and [environmentalists](#) from the United States, Canada and Europe.  
[[http://en.wikipedia.org/wiki/Wingspread\\_Conference\\_on\\_the\\_Precautionary\\_Principle](http://en.wikipedia.org/wiki/Wingspread_Conference_on_the_Precautionary_Principle)]

Closely linked to various versions of the PP is the idea of reversing the onus of proof. Thus, the adherents of the Wingspread Statement declare that “the applicant or proponent of an activity or process or chemical needs to demonstrate that the environment and public health will be safe. The proof must shift to the party or entity that will benefit from the activity and that is most likely to have the information” ([Raffensberger and Tickner, 1999](#)). Greenpeace also holds that effective implementation of the PP requires a shift in the burden of proof ([Greenpeace, 2001](#)). Shifting the burden of proof seems a fairly straightforward way to ensure, as Jonas demanded, that greater weight will be given to the “prognosis of doom” than to the “prognosis of bliss.”

Before looking into the proper assignment of the burden of proof, we must first examine more closely the underlying justification for the strong version of the PP. Why should the prospect of harmful effects of a new technology take precedence over the prospect of beneficial effects, quite apart from the inherent likelihood of each of these possibilities? The obvious answer seems to be that such a priority is defensible only when the harmful effects are of such magnitude that they carry catastrophic (or, as Jonas would say, “apocalyptic”) potential. The infinite costs of a possible catastrophic outcome necessarily outweigh even the slightest probability of its occurrence.

This type of reasoning exhibits a remarkable resemblance to a well-known example of a “zero-infinity dilemma,” namely Pascal’s famous “wager.” When it comes to wagering on the existence of God, the 17th century French philosopher argued incisively in his *Pensées* that it is better to be safe than sorry ([Haller, 2000](#); [Graham, 2002](#); [Manson, 2002](#)). Given an unknown but nonzero probability of God’s existence and the infinity of the reward of an eternal life, the rational option would be to conduct one’s earthly life as if God exists.

Alas, Pascal’s reasoning contains a fatal flaw. His argument is vulnerable to the “many gods” objection ([Manson, 2002](#)). Consider the possible existence of another deity than God, say Odin. If Odin is jealous, he will resent our worship of God, and we will have to pay an infinite price for our mistake. Never mind that Odin’s existence may not seem likely or plausible to us. It is sufficient that we cannot exclude the possibility that he exists with absolute certainty. Therefore, the very same logic of Pascal’s wager would lead us to adopt the opposite conclusion not to worship God. Pascal’s argument, then, cannot be valid.

If the reader will pardon another long quote, Chauncey Starr writes in *Risk Analysis* (2003):

This brings us back to the precautionary principle. Governments asked to regulate public exposure to risks from man-made sources (food, water, air, radiation, pollutants, electromagnetic fields, etc.) face a tortuous decision process because of the above uncertainties of risk analysis. The use of the precautionary principle as a politically defensible umbrella is a tempting escape from this difficulty. However, it

is not cost-less, as protection from a risk that may be nonexistent or trivial may deprive the public of attractive and valuable lifetime choices. The only defensible approach is a comparative risk analysis of alternative pathways, taking into account our most credible projections of the lifetime economic, environmental, and health values of these alternatives.

The precautionary principle exists only as a rhetorical statement; it provides no useful input to decision making. Expert opinions should be sought, but be recognized as conservatively biased. The search for science-based guidance is commendable, but is rarely achievable. In areas of public health and safety, comparative benefit/cost/risk analysis of all options should provide the judgmental base for decision making. Between the horserace bet and a credible, scientifically established projection, the decision maker will always be faced with a choice and no guarantees. There will always be room for pragmatic judgments on the limitations of long-range management.

Or to summarize, the agency must make a decision based on the best available science and other issues, then apply judgment. Citing “precaution” to avoid a decision is not valid, since most decisions will be made with many uncertainties involved.

## Appendix B Sediment Quality

### PAH Sediment Quality Levels

The threat to marine organisms from creosote derives from exposure of those organism to PAHs. Elsewhere we establish that water column concentrations are close to zero after a short time and not of long-term concern. (Chapter 2) The most likely source of PAH exposure to marine life would come via the PAH in sediments. The Brooks model provides an estimate of the sediment PAH concentrations, albeit a conservative estimate. Further, the basic risk analysis guidelines preclude the use of creosote if the sediments are anoxic or already polluted with PAH. Thus, the question is, what the level is of PAH, predicted by the Brooks model, or other trusted models, which would be acceptable. In general, the Brooks models show in increase in sediment PAH concentrations that reaches a maximum and then declines.

While there is much publish research and many standard methods about sediment toxicity, most of those refer to issues relating to dredging and deposition of dredge spoil. That is, will the relocated dredged material harm the marine life at the location where it is dumped? Ideally the in situ sediment quality is assayed using the “sediment triad” which combines first, a chemical analysis of the sediment, second a benthic survey of the marine life in the sediment, and thirdly a laboratory toxicity test of sediment taken from location. The results of these three are then used to make a qualitative decision about the dredged material. Indeed, the Sooke Basin study did a sediment quality tirade investigation of the creosote piles which is discussed elsewhere. However for a prospective analysis of the effects of adding some PAH at a location, only the first step of the triad can be used, the chemical analysis, or better, an estimate of what the chemical analysis would yield in the future. Thus, some notion of the acceptable levels of PAH as demonstrated by the sediment chemistry may be useful.

First, the acceptable sediment concentrations would need to be related to the exposed organisms, especially the organisms identified by the ESA/TES or EFH. These are seldom sediment dwelling organisms. The toxicity of sediment to pelagic species is seldom reported. The one study that resulted in several papers (Horness et al. 1998) often quoted regarding the toxicity of PAH in sediment to English sole, a bottom dwelling but free swimming fish. That study was confounded by many other contaminants in the sediment studied and likely migration of the fish to more highly contaminated areas prior to the study.. See Brooks (2006) and Poston (2001) for a discussion of the Horness paper.

Second, levels of organic contaminants in sediments are usually expressed in weight of contaminant per dry weight of sediment, but then some allowance is made for the percentage of organic carbon in the sediment. Binding of the organic contaminant to the organic carbon reduces the bioavailability of the contaminant. Another approach is to express contamination in weight of contaminant per weight of organic carbon. In any case, the relation is not straightforward and involves the Koc or partitioning of the

contaminant between organic carbon and water, which is different for each PAH chemical. For example, if the weight of Benzo(a)pyrene was 10 mg/kg of dry weight of sediment, and the organic carbon content were 2%, the equilibrium concentration of BaP in the water would be about 4 ppb. However in the water near creosote treated piles placed in the pristine water of Sooke Basin, there was little PAH measured in the waters, about 20 nanograms per liter, or approximately background. These are measured by an extraction process, so the free PAHs are likely uncommon, they are more likely sorbed to organic centers in the water and not directly bioavailable to free swimming fish.

Swartz tried to reconcile the many published standards for PAH levels in sediments and came up with a consensus Threshold Effects Level of 2.9 ppm for sediment with 1% organic content or 5.4 ppm for 2% OC. (Swartz 1999). This level would be protective for sediment dwelling organisms. The state of Washington developed sediment quality standards for their regulations, (Chapter 173-204 WAC) of 370 ppm LPAH and 960 ppm HPAH both as wt/wt carbon. So for sediment with 1% organic carbon, the level of heavy PAHs would be 9.6 mg/kg, if the sediment had a 2% organic carbon, a more common situation, the acceptable level of heavy PAH would be 19.2 mg/kg.

There has been some published research that indicates water column concentrations of PAH in the 1 ppb range may be harmful to salmonid eggs and larvae. (Heintz, 1999) Although this seems a very low level, since ambient level are often higher in many locations, it is not incompatible with a sediment level of 10 ppm. For the heavier PAHs, which are assumed to be most harmful to the eggs and larvae, benzo(a)pyrene for example, the sediment-water partition coefficient would indicate most of the PAH would remain bound to the organic carbon in the sediment. For example, if the sediment were 2% organic carbon, 10 ppm BaP would result in a concentration in the water of 0.5 to 1.0 ppb of BaP. The lighter PAHs are more soluble, but these are also assumed less toxic. In addition, the salmonid eggs studies were done with weathered Alaska North Slope Crude, presumed from the Exxon Valdez. The nature of PAH from weathered ANS is quite different than PAH from weathered creosote from piles. Weathered ANS (and petrogenic PAH in general) have many alkylated PAHs, while weathered creosote and pyrogenic PAHs have mostly parent (unalkylated) PAHs. For example, a sample of heavily weathered EVC PAH has less than 1% parent phenanthrene but it has 30% C1, C2, C3 and C4 phenanthrenes. On the other hand, PAH from creosote 32% parent phenanthrene and only 6% total alkylated phenanthrenes. Although the body of research related to the toxicity of alkylated versus parent PAH in the marine environment is not large, there is some evidence they are more toxic in mammals, and likely more toxic in any animals that have a robust p-450 xenobiotic metabolizing system.

Unless there were specific knowledge that sediment dwelling organism were a TES or the sediment itself was a EFH, a final sediment concentration of 10 ppm PAH dry weight should be amply protective of pelagic species if the OC is 1% or greater. If there is a sediment dwelling organism that is a TES or if the sediment itself were a EFH, some research would be needed regarding the levels of PAH that might be acceptable.

## Appendix C EPA RED

### EPA's Reregistration Eligibility Decision

Since creosote is used as a pesticide, the agency that had direct regulatory control over creosote is the federal EPA, under FIFRA, the Federal Insecticide Fungicide and Rodenticide Act. Especially interesting for the ADOT is the fact that the EPA decision is “risk management” decision that is founded upon a “risk assessment.” Certainly some, if not most, of FIFRA regulated substances are toxic, thus the agency’s decisions will consider the benefits to society from the application of the substance versus the stress to humans and the environment from its application. In late 2008, the EPA completed its Reregistration Eligibility Decision (RED) for creosote. (EPA 2008a) “As a result of this review, EPA has determined that creosote containing products are eligible for reregistration, provided that risk mitigation measures are adopted and labels are amended accordingly. The reregistration eligibility decision and associated risk mitigation measures are discussed fully in this document.” That is, after characterizing all the risk associated with creosote, the EPA considered the benefits and economics, including those of reasonable alternates. The EPA FIFRA Office of Pesticide Program then promulgates “mitigation measures” and “labeling requirements” that the manufacturers and distributors of FIFRA controlled substances must in turn follow. Because creosote, as all coal tar volatiles, is toxic to humans, most of the mitigation and labeling requirements relate to human exposure in the manufacturing process, some of which would apply to field construction, but this is chiefly a concern of federal OSHA and Alaska DOL.

The only mitigation measure germane here is that “for treated wood that will be used in marine or other aquatic or sensitive environments, a double vacuum must be used....” This is the same as the AWWA BMPs that are already standard practice in Alaska. (WWPI 2006b)

The labeling requirements require the AWWA BMPs discussed elsewhere. This means that BMPs are required if a risk assessment indicates there is acute or chronic risk and implies that BMPs are not required if the risk assessment indicates no such risk. This is probably not important to the ADOT because elsewhere we recommend BMP be used and indeed piles not treated to BMP may not be available. However it may be important for endwalls and other structures that would not need to be treated to BMP, if risk to aquatic organisms is not demonstrated. (The rail road tie studies indicated there is not a significant risk, for most end wall locations, as discussed elsewhere.)

The risk management decision appears to be well thought out and followed public comment on a draft version. It should be pointed out that the ecological risk assessment (2008b) that was part of the risk assessment considered was likewise published in draft and likewise subject to public comments. The risk assessment makes clear that there are ecological risks associated with the use of creosote in the marine environment; while the risk management indicates that the EPA believes these risks are reduced to levels acceptable to the EPA, with proper mitigation and labeling. However even the EPA’s

risk assessment document concludes the chief mitigation measure is a label to preclude effluent, presumably from wood treating plants, from being discharged to aquatic environment. It indicates that acute exposures for some species is above the level of concern for some species, but indicates the chronic level is uncertain, although several risks were mentioned. In the latest and final version of EPA's ecological risk assessment says "chronic RQs (risk quotients, the ratio of exposure divided by toxicity) can not be calculated due to lack of chronic toxicity data, but available evidence indicates that chronic risk (survival, growth, reproduction, immunotoxicity) is possible to aquatic organisms inhabiting the water column." The term "is possible" is not very definite and difficult to input into a risk management decision.

The final document also states, "impacts of creosote-treated aquatic pilings are likely to vary locally, depending on abiotic and biotic factors such as current speed, amount of structure per unit area, air and water temperature, salinity, and the aquatic species occurring in the immediate area of the structures; thus, a site evaluation is essential prior to installation of new structures.

However, regarding a "site evaluation" the final RED seems to limit that evaluation to determining if BMP is required. That is not a burdensome requirement.

## Appendix D Stratus Creosote

Stratus report: Creosote-Treated Wood in Aquatic Environments: Technical Review and Use Recommendations

When the draft is accepted, the more recent NOAA Guidelines document described in Chapter 7 and Appendix E will supersede this Status report. However, since the NOAA Guidelines are still in draft and the draft often references this Stratus document, some consideration of the document is warranted. Here we review the main findings of the document and its criticisms.

### Introduction

The National Marine Fisheries Service, an agency of the National Oceanic and Atmospheric Administration has input into creosote-related decisions through its consultative role in the actions of other agencies, especially the US Army Corps of Engineers, and many agencies through the Coastal Zone Management Act. The Corps must issue a permit for any new structures or alteration to existing structures in navigable waters. The CZMA requires a “consistency evaluation” for any agencies actions that affect the coastal zone. In either case, the agency considering issuing a permit, or an action of the agency itself, must consult with the NMFS. The two laws that NMFS will consider are the Endangered Species Act (ESA) and the Magnuson-Stevens Act (MSA), the NMFS is responsible for managing commercially harvested aquatic species by implementing fishery management plans and designating Essential Fish Habitat (EFH) areas. Under the ESA the NMFS will consider if the action threatens a listed or endangered species or its habitat. Under the MSA, NMFS will consider if the action threatens an “Essential Fish Habitat” (EFH) of a protected species. In the event NMFS finds that the agency’s action, such as approving a permit, will threaten a listed species under the ESA or an EFH, NMFS will convey that to the agency. This may result in the action such as a permit being disapproved, or may result in negotiations or design changes to remove the threat. Thus, via a ESA or EFH consultation process, NMFS may determine creosote piles are not an issue, or essentially ban the use of creosote, or delay a project while creosote-related details are revised or determined. Of course the permit applicant might protest the decisions to ban creosote, alternatively, a third party, such as an environmental group, may protest the decision to allow creosote. Either approach will be an action against the agency issuing or denying the permit, probably not NMFS directly.

Because wood preservatives are a contentious issue nationwide, NMFS is desirous of having a policy or guidelines to aid their staff in such consultations. In 2004 NMFS commissioned a consulting firm, Stratus, to write a report titled “Treated Wood in Aquatic Environments: Technical Review and Use Recommendations.” The preface to that document states:

These reports are the findings of Stratus Consulting regarding the use of treated wood. They have been subject to peer review and public comment. NMFS may utilize these reports and other available information, as appropriate, to develop or update

guidelines on the use of treated wood in aquatic environments. Accordingly, these documents are not NMFS guidelines themselves.

The original report dealt with copper treated wood only. (Stratus Copper 2006) A second report was commissioned about that same time the dealt exclusively with creosote. Stratus 2006.

Both documents were available in late 2005 or early 2006 and the version placed on the NMFS website is dated December 31, 2006. A notice of the availability of these documents was placed in the Federal Register March 3, 2006, which requested public comment. That notice said

The intent of the reports is to ensure NMFS is informed of relevant studies and recommendations when making decisions related to the use of treated wood in aquatic environments. This information may be used for future development or revision of NMFS treated wood-use guidelines. NMFS is soliciting public comment on whether the treated wood documents sufficiently summarize the existing body of knowledge concerning copper and creosote treated wood products, including the fate and transport of leached materials, the appropriate use of treated wood products, and the potential effects on living marine resources and their habitats. In addition to this public comment opportunity, the reports will also be subject to independent peer review.

There were three sets of public comments, one by the Creosote Counsel and one by Dr. Brooks, who consults for the WWPA, which might be considered industry comments, and two by the USDA Forest Products Lab and one by an academic researcher that would not be considered industry. There were three peer reviews. Together six of those eight documents were quite critical of the Stratus Creosote Report. The extent of changes provoked by those reviews is not clear, but it appears the specific comments were not changed in the final document.

Before we examine the draft NMFS guidance in Appendix E, we should examine some details the Strauss report, since some of them appear to be the chief basis of the NMFS guidance.

With that introduction, we consider what the Stratus report says with respect to marine creosote applications of the ADOT. We begin with the Stratus conclusions. The first paragraph comports with the author's analysis based on the literature:

Overall, the laboratory and field studies described above indicate that treated wood structures can leach PAHs and other toxic compounds into the environment. However, the degree of PAH accumulation to sediment associated with these structures appears to be relatively minor in many settings, particularly in well-circulated waters and over time. PAH accumulation also appears to be relatively limited spatially (within approximately 10 m of the structure) and has not generally been associated with measured, significant, biological effects except in close proximity to the structures. The duration of any biological effects also appears to become attenuated within several months of construction (the time period when leaching rates are likely to be highest).

The first part of the second paragraph is difficult to interpret:

Nevertheless, there are several factors that suggest that a precautionary principle might be applicable to certain treated wood uses. First, the above studies typically have evaluated responses at the community level (e.g., the benthic invertebrate studies) or to tolerant life stages (e.g., adult oysters and mussels). However, the level of environmental protectiveness applied to T&E species (such as endangered salmonids) should occur at the *individual* rather than the *population* or *community* level.

The first difficulty is that, unlike human health risk evaluations, ecological risk evaluations are always carried out at the population level. The “precautionary principle” has many interpretations and is subject to many criticisms. However the basic statement of that principle is

“Nations shall use the precautionary approach to protect the environment. Where there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation.”

That statement has two important qualifiers. First the damage must be “serious or irreversible” and second the measures must be “cost effective.” With those qualifiers, the precautionary principle seems sound. However it could not be applied to threats to individuals, as Stratus holds, unless those threats to individuals would lead to be serious or irreversible to the population. We discuss the precautionary principle itself further in Appendix A.

The last part of the Status conclusion is a qualitative basis for a risk assessment. Here we quote it:

Moreover, field studies have indicated that PAHs can accumulate to potentially deleterious concentrations in poorly circulated water bodies or when the density of treated wood structures is high compared to the overall surface area of the water body. As a result, site-specific evaluations of risk should be conducted for treated wood projects that are proposed for areas containing sensitive life stages, species of special concern, or where water circulation and dilution are potentially low.

Note the use of qualifiers, such as “can accumulate” and “potentially deleterious concentrations.” A general reading of that statement would seem to limit the need for a “site specific evaluation,” that is a risk assessment, only if those special conditions exist. That is if the application is an area “containing sensitive life stages, species of special concern, or where water circulation and dilution are potentially low.” Creosote would not be banned even from these areas, but a risk assessment, presumably limited to the sensitive life stages of key species, would be required. If those conditions were not there, a risk assessment would not be needed. We discuss considerations associated with such site specific risk assessments below.

Thus, this author agrees with those qualitative descriptions and indeed, so does the creosote industry, since the “Treated Wood in the Aquatic Environment” published by the WWPI (2006a) has essentially the same general recommendations.

The conclusions list the major “factors to be considered” in an aquatic risk assessment” regarding creosote use. Again, the author notes these are the same, or vary similar to those implied by the US Forest Products Lab (Lebow and Tippie, 2001), The Canadian Fisheries (Hutton and Samis, 2000) and are included in Dr. Brooks models.

- **Background water quality variables such as salinity** The salinity of the receiving environment should be considered because leaching increases with decreasing salinity, as in estuarine environments.
- **Current velocity and direction** Although total leaching rates from treated wood can be relatively low, potential environmental effects will be dictated by local water mixing, with poorly mixed waters at greater risk. Information on current velocities – at the specific micro-environment – of the project location (including the influence of the structure itself on ambient current velocities) should be developed and integrated into a site-specific risk evaluation.
- **Proximity to sensitive fish habitat** The presence of sensitive life stages, especially T&E species or their essential prey species, should prompt an evaluation of potential risks at that location. Essential fish habitats for Pacific salmon include all streams, lakes, and other water bodies currently or historically accessible to salmon. This includes essentially all estuarine and marine waters of the Pacific Coast. The most sensitive life stages for these species are fry (particularly post swim-up) and juveniles. Because the initial leach rates are higher for treated wood, risk assessments should consider the timing of PAH releases relative to periods when sensitive life stages of fish are present.
- **Timing of proposed construction** Because initial leach rates tend to be greater, the timing of proposed construction should be considered with respect to the presence of sensitive life stages of aquatic receptors, water flow rates and temperature, environmental and climatic factors that can influence mixing and dilution, and the relationship between season, annual hydrograph, and water quality conditions.
- **Size of proposed structure** As discussed previously, environmental effects are likely to be greatest when the size of the proposed structure is large relative to the receiving environment. Factors to consider include number and size of pilings, surface area of exposed wood area relative to a mixing zone, density of pilings relative to the mixing zone (to evaluate potential behavioral avoidance responses), and potential effects of structure size on current flows.
- **Application methods** Treatment and application methods should be confirmed to meet industry BMPs.
- **Proximity of other treated-wood structures and other sources of contamination that may contribute to cumulative effects** In

evaluations of site-specific risks, assessments should consider potential effects in light of the cumulative effect of the proposed structure relative to other existing environmental perturbations at the site.

All of these seem quite reasonable and should be considered. The salinity may not be too important in Alaskan waters, since cold temperatures predominate over salinity in determining leaching rates. Also, leaching reaches a steady state soon enough, regardless of salinity. Also, almost all Alaska construction is limited to a window that protects salmon fry migrations.

However, following those quite reasonable (in this author’s opinion) guidelines, Status finishes up their conclusions with examples of local agencies that have banned or reduced creosote use and, without presenting scientific justification, then concludes:

[Corps of Engineers, Los Angeles policy] shows that regulatory agencies are increasingly recognizing that creosote treatments in marine environments can cause ecological harm under common enough circumstances that new structures should avoid the use of creosote-treated wood, and creosote should be isolated from the environment wherever it is used. Based on the findings of this report that creosote moves into the environment under a variety of realistic conditions, and environmental levels of contaminants originating from creosote-treated wood are often toxic, precautions to avoid creosote-treated wood where practical, and measures to isolate potential toxic effects appear to be justified. We recommend that similar precautions be implemented by regulating agencies throughout the United States.

Thus, presenting as justification for eliminating creosote, the fact that a few agencies have banned it, and ignoring their 50 some pages of scientific evidence, that the summarize above – that if there are sufficient currents and the sediment is aerobic, there is unlikely to be any significant environmental harm from BMP piles.

We will proceed by assuming that the later is an interpolation by a biased contributor in otherwise reasonable science and not deal with it further.

Because they are not available on-line, I have bound the comment documents into Volume II of this report. Most of the reviewers were commenting on the Stratus reports, the copper and the creosote. We could summarize the comments as follows:

Name	Employer/Industry	Comments
David Webb	Creosote Council III/Creosote trade group	Strongly critical
David Brooks	Consultant/ WWPI	Strongly critical, believes risks overstated
Chris Risbrudt	Director/ USDA Forest Products Lab	Transmits critical document by Lebow. But says: “Forest Service scientists have reviewed the reports and have noted that

		the recommendations have the potential to significantly impact construction projects conducted by the Forest Service and other government agencies. In several cases, the recommendations in the reports do not appear to be well-supported by the relevant science. “
Stan Lebow	Researcher/ USDA Forest Products	Strongly critical, believes risks overstated.
William B. Smith	Wood Products Engineering/ SUNY Syracuse	Critical, including: “Unfortunately, the use of inappropriate analysis, editorializing without scientific justification, and suggestions without merit that alternative materials such as steel or plastic pilings and timbers (which take considerably more energy, petroleum and other non-renewable resources to manufacture, are of considerably higher cost, and have questionable performance characteristics as compared to wood) would be better than treated wood, make the conclusions in these reports unusable and much of the rest of the information provided potentially suspect.
Peter Townsend	(Unclear)	Neutral. Suggests more work is needed to translate into good decision tool.
Jason M Weeks	CEFAS, UK	Neutral on the whole. Positive and negative in places. Emphasizes uncertainties in the data.
Judith S. Weis	Rutgers/ part of the Univ. of Miami Independent Peer Review System.	Strongly critical of the report, but believes the report understates the risk. Notes many of her own publications that were not used in the Stratus documents.

Finally, this author’s evaluation is that, besides what appear to be interpolations by a biased reviewer, such as the “precautionary principle” and LA District Corps of Engineers references, the Stratus document as a whole is sound, and its recommendations: do a risk assessment only if certain key risk factors are identified, otherwise creosote piles are acceptable, as well as the outline of the risk assessment process, are protective of the environment and marine species. Of course some sort of preliminary investigation and analysis is needed to determine if those key factors are present. We discuss that further in Chapter 8.

## Appendix E NOAA Draft Guidelines

Comments on NOAA's Draft Guidelines for Use of Pesticide-Treated Wood Products.

NOAA produced a guide document that became available in early January 2009. *The Use of Pesticide-Treated Wood Products in Aquatic Environments : Guidelines to NOAA Fisheries Staff for the Endangered Species Act and Essential Fish Habitat Consultations*, which I'll call "guidelines" in this appendix. (NOAA 2009) Public comments were solicited with the comment period closing on March 16, 2009. (FR 2009). The public notice gives a succinct purpose of the document:

The intent of the guidelines is to aid NMFS personnel conducting Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) Essential Fish Habitat (EFH) consultations in making consistent determinations regarding projects proposing to use pesticide-treated wood products in habitats utilized by NOAA trust resources. The guidelines attempt to convey a summary of information that should be considered when examining the effects determinations made by the action agency and to direct personnel to documents containing more detailed information when needed.

The author was unable to get copies of the comments submitted to NOAA, however I was able to get the comments made by the WWPI, which are part of this appendix. The guidelines address all the common types of wood preservatives in use nationwide. Thus the guidelines and WWPI's comments have much that is not pertinent to Alaska. My comments are limited to creosote in Alaska.

The major finding in the conclusions of the Guidelines is:

Overall, the use of pesticide-treated wood products in aquatic environments with the examined formulations (ACZA, CCA, and creosote) could be acceptable in many proposed projects. However, the products can not be considered categorically safe, and therefore, require project and site-specific assessment. Many projects, that still propose to use pesticide-treated wood, may pass a screen level examination and require relatively little assessment for the pesticide-treated wood impacts. These determinations require a level of local knowledge that may be applied on a case-by-case basis, or through regional watershed based procedures. The variability between locations makes it difficult to provide guidance on the scale of the entire west coast of the U.S. and Alaska.

Elsewhere the conclusions recommend BMP in all situations that involve EFH and TES and appear to limit the requirement for risk assessments to structures with over 100 piles and further imply that if the current exceeds 10 cm/sec (roughly 0.25 mph) likewise a more detailed risk assessment is not needed. This section of the conclusions is vague and

probably refers to studies with copper in the Columbia River, but in general, it fits with the WWPI recommendations.

The conclusions seem to recommend copper over creosote, although the conclusions are not specific to Alaska.

#### Author's Review of *Guidelines*

Because the *Guidelines* covers many situations and at times to appear to present conflicting information, and because these draft guidelines may be pressed into service in lieu of final guidelines, I will present my review of them. The WWPI review and comments that pertain to creosote are listed in this appendix. The entire *Guidelines* and *Comments* are copied in Volume II.

Page 6, end of first paragraph, says models are uncertain and therefore need to be used with site specific information – relying on Status [3, and discussed in Appendix D]. The Brooks Model [see Appendix F] has been field tested in several locals and shown to be conservative. That is, it overpredicts the sediment concentration. The Brooks Model does require site specific information.

Page 6, second paragraph, tries to determine the level of impact deduced by a screening that would not require a full risk assessment and further differentiates an ESA issue from an EFH issue. It explains that the screening is similar to an “initial review” in an ESA determination, where a finding that the action “may affect” but is “not likely to adversely affect” an endangered species. If there were established local procedures for making that determination, they could be used to screen the project. The next paragraph then refers this process to local knowledge, rather than the *guidelines*. My comment is that this “local knowledge” would refer to the species under ESA or EFH consideration, not the effects of creosote, which are established by nationwide science.

Page 7, first paragraph, states “concrete pilings are cost-competitive with pesticide-treated wood pilings over the long-term and are competing in those markets.” This is often not true. In any case, the choice between wood, concrete, and steel is made by the design engineer. In general, if wood will work for structure, wood is about half the cost of concrete.

Page 12, middle paragraph has some toxicity information that needs to be clarified. Two of the most interesting studies are those of Vines (2000) and Carls (1999) [5]. The main thrust of Vines study was that toxic levels of creosote diffusible material exist in the interior of 40-year old piles. This was determined by taking pieces out of old creosote piles and placing them in static renewal chambers with herring eggs, etc. This is quite unlike the potential exposures from in situ creosote piles, since the cutting the piles into pieces for the laboratory experiment exposes new creosote faces and allows end grain transfer of PAH to the water. In order for the pile to maintain its integrity in water with marine borers, the pile must have creosote within its wood structure. Thus Vines' findings were not unexpected. The most intriguing part of the paper, however, was not those laboratory studies, but rather a study of eggs scrapped from the exterior of old

creosote piles. Compared with eggs scrapped from a nearby PVC pipe, the eggs scrapped from the pile had a very low survival. Because this was a preliminary part of the study and not controlled, the eggs may have come from different fish or been exposed to slightly different environmental conditions. However, more interesting, was that Dr. Vines did not note any fouling on the piles. (Vines 2008) Generally piles in marine waters foul very quickly, usually within a year. Lack of fouling may indicate the piles were atypical in other respects. In any case, one would expect that BMP piles underwater would have much less creosote on their surfaces than piles treated 40 years ago. The Carls study used PAHs that were leached from oil contaminated gravel and indicated toxicity in the range of 1 ppb, mostly of heavier PAHs, to salmon larvae. The methods seem quite thorough and the researchers are well known, thus this study is often quoted to indicate that a PAH level of 1 ppb may be toxic to salmon eggs. However I would note that Neff found levels of PAH in “pristine waters” of 1 to 2 ppb [Neff 1979]. And fish and invertebrates spawn and thrive in non-pristine waters that have much higher concentrations of PAHs. Thus, there may be a disconnect between the Carls study and nature. Two other issues are the nature of the oil and its location. In general crude oil, and certainly ANS from which the PWS oil came, is highly alkylated. Often the parent PAH is present in only very small quantities. On the other hand, creosote is often pure parent PAH and has few alkylated compounds. Alkylated PAHs are metabolized at different rates than the parent and are often assumed to be more toxic. The second is that in the natural environment the heavier PAHs are bound to organic particulates or other organic matter and are not bioavailable. Also, see the “Page 12” comments from WWPI below.

Page 13, top paragraph, states that main concern is for PAHs that leach from creosote and they “accumulate in sediments and are assimilated into the food web.” This implies that the PAHs that enter the sediment find their way into the food web. That is not the case. In oxygenated sediments most of the PAH are oxidized. Regardless of oxygen state, most PAH do not make it into the food web. Also misleading in that paragraph it says, “chronic and dietary exposure to the higher weight PAHs remain in sediments that cause the [harmful] effects ...[which are] more prominent in benthic species due to their frequent contact with the sediment. (Citing Stratus). The only study that purports this used a sediment that was contaminated with many things other than PAHs. True, toxic PAHs can be extracted from sediments, but this is not their course in nature. Further, that paragraph can be read that pelagic species are affected by PAH in the sediment, and that is simply not true.

Page 13, third paragraph, is key to risk assessment, since it strives to present sediment levels that may be harmful. This analysis for PAHs is always limited, because PAH is not a chemical, but a mixture of many chemicals, all of differing chemical, physical, and toxicity characteristics. The paragraph is not easy to read or interpret but seems to say that levels above some very low conservative limit should not be exceeded. Several problems with that are first, that these levels are frequently encountered in harbors and other habitat that seem to have thriving marine life communities. Second, science shows that the PAH in sediment is limited to the regions very close to the piles. Thus, regarding

an EFH, the question would be, “even if the entire area beneath the structure were removed from the fishery habitat, would it affect the fishery?”

Page 20, middle paragraph, again repeats the tumors from sediment issue that is not accurate. It says that if the water body is “impaired” additional PAH from piles should not be permitted. Certainly if the water body is impaired by PAHs, creosote should not be used. This is stated in all the risk assessment paradigms. The third paragraph is particularly poor science. It extrapolates from the work of Vines to pelagic concentrations of creosote, but actual measurements of the pelagic concentration of PAH are essentially zero after a few weeks. It then goes on to cite the Corps of Engineers in Los Angeles requiring wrapping of creosote piles, which has no relevance – is not science-based. The last paragraph seems to say that a region could adopt a standard number of piles, below which a risk assessment is not needed. The reference quoted, SLOPES III, used 50 piles as the cut off. That is, a project with less than 50 piles was considered not to require a full consultation – the Corps could grant the permit without NMFS consultations.

Page 22, first sentence, says copper-based and creosote treatments are interchangeable. This is not true in Alaska, as discussed in Chapter 4. Also, they discuss use of creosote in fresh water, which is not recommended anywhere, but is not allowed in Alaska.

Page 25, second paragraph, is erroneous. It seems to recommend coating piles with wraps in projects proposed for “sensitive locations” and could have been written by a supplier of coated piles. It cites “unnecessary environmental risk” which misuses both the words “unnecessary and “risk.” Coatings or wraps are expensive and should not be used unless there is a demonstration that the EFH or ES would be harmed if they were not used. If the currents are slow, sediment anoxic, or background PAH are high, they may be a useful alternative. True Pacific herring may spawn onto wood, but they spawn everywhere, especially on eel grass in Alaska. Only a minuscule proportion would land on piles. The last part about pile replacement does not fit. If they are only replacing a few piles, they will not matter.

Coatings are fine also, but only if somewhere is demonstrated if they are not coated there would be some problem. This section of the guidelines is not science-based.

Page 27, second paragraph, is not appropriate. If another material will be more cost effective, the engineer will specify it. This says nothing and implies that concrete is comparative. If it is, it will be used. It is generally not comparable in Alaska.

Page 28, first paragraph, regarding costs - Status is not competent to estimate prices, which will vary with location. In general treated wood will last a long time. Wood is much more resilient than concrete. Concrete life is quite variable. Intact it may last forever. If it is damaged, the rebar will corrode and the pile may not last long. Steel is more resilient, but needs cathodic protection or coating which may not be benign. In addition, steel needs repainting or coating and this is an operation that can contaminate the environment.

Page 32, first paragraph of Conclusions, says “leaching stays at easily detectable levels.” The word “easily” is a poor word choice. PAH can be detected, but “easily” implies there is a lot, which in fact there is not. It is at very low levels. In the Sooke Basin study, which was in a pristine area, the PAH after a year was not different than background, by the most sensitive methods. In the last sentence again implies that PAH from sediment is “most often associated with impacts to benthic species,” this not correct. PAH can cause those effects in all species, but there is little evidence that the low levels from creosote in a natural sediment can cause them.. The tests they cite were done in sediment contaminated with other chemicals and/or with PAH extracted from the sediments.

Page 33, top paragraph again refers to Vines study which we discuss above.

Effect would at worst be seen in unfouled piles with eggs laid directly on the wood. The next sentence is incorrect. Heitz et al (1999) dealt with weathered crude oil extracted from gravels not marine sediments. There is no connection between the work of Heitz and the creosote contamination under piles, which diminishes with time.

Page 33, second paragraphs, says models did not over- or underpredict. The model of Brooks consistently overpredicted the concentrations at Sooke and several other sites. In addition all the models take some “site specific” data to work.

Page 35, last paragraph of Conclusions, express a preference for copper over creosote. This would assume that the benefits of either treatment are the same. That is not true for Alaska, where creosote has a much longer service life for most applications. However it does say, “the limited available information shows that, in some specific instances, the proper use of creosote-treated products may not impact ESA listed salmonids in a manner that can be meaningfully measured, detected or evaluated. “

#### Notes on WWPI comments

Since the attached WWPI comments address all the treatment methods discussed in the draft *guidelines* I copied two related to creosote that might be especially pertinent.

Page 12 [of guidelines]. When citing the Vines et al. (2000) study, which found adverse effects on herring spawn associated with creosote treated wood, the report omits reference to Goyette and Brooks (1998, 2000), which found that spawn from mussels growing directly on the creosote treated piling developed normally to the trochophore stage. While it is true that fish (vertebrates) and invertebrates (with planktonic early life stages) face different contaminant pathways and therefore different challenges, we recommend that either (1) both reports should be discussed or (2) neither report should be included. We are aware that there are some concerns being raised about the protocols used in the Vines et al. study.

Page 13. We believe the Threshold Effects Level (TEL) and Effects Range Low (ER<sub>L</sub>) are not appropriate sediment quality benchmarks. Washington State has published EPA approved marine Sediment Quality Criteria (SQC) in WAC 173-204 and is currently developing freshwater Sediment Quality Values (WDOE 2002, 2003). Goyette and Brooks (1998, 2000) conducted a detailed assessment of the efficiency and protectiveness of a range

of possible SQC applicable to the Sooke Basin Study. Similar to WDOE (2002, 2003) they found that the TEL and ER $\square$ L were unacceptably inefficient because they predicted far too many toxic effects in Sooke Basin Sediments when the very large bioassay database generated in that study did not find toxicity. Goyette and Brooks (1998, 2000) found that the arithmetic mean of the TEL and the Probable Effects Level (PEL) and/or the Washington State SQC were both protective and efficient. Other SQC are available, such as the Consensus SQC proposed by Swartz (1999) and we recommend that NMFS should review these standards and consider them for inclusion in the guidelines. The reports of Goyette and Brooks (1998, 2000) are particularly appropriate for consideration here because they apply to the mixture of PAH that accumulates in sediments in association with the use of creosote treated wood.





## Appendix F, Risk Assessment Models

For a large complicated project where creosote piles were the best design option, if the screening risk evaluations described in Chapter 9, were not sufficient, a more formal risk assessment would be needed. This would likely require consultants in many fields and be a large expense and time commitment for the project. However, by assuming that is the levels of PAH in the water column and sediment that are unlikely to be harmful to sensitive marine life, there are several models, all by Dr. Brooks, that may be useful. In Appendix B we discuss level of sediment PAH and note that the Washington State SQG are generally accepted and, based on the Sooke Basin studies, conservative.

For structures less than 100 piles, the WWPI model, Table C of Treated Wood in Aquatic Environments provides a useful conservative model. Its default assumptions are for warmer water, and it has other conservative assumptions. However, it provides an answer with only two input parameters, maximum current speed and depth to the reduction-oxidation discontinuity. The former is generally known to the designers, the later is often taken as the depth at which the sediment changes from light brown or grey to black, or where the sediment begins to smell of hydrogen sulfide. More exact standards for determining the redox potential discontinuity are available. The WWPI model indicates if the currents are very slow or the sediments anoxic, further risk assessment is needed. Thus, if the structure is greater than 100 piles or the WWPI model indicates it, a risk assessment is needed.

The most expedient risk assessment model is available from the WWPI in two files:

And Excel sheet: <http://www.wwpinstitute.org/researchdocs/creosote/creorisk.XLS>

And a pdf file which has the derivation of the model and some explanation.

<http://www.wwpinstitute.org/mainpages/documents/01creo497.pdf>

The model in the spread sheet is set up with two piles set two meter apart. The sediment concentrations are derived from linear superposition of the second pile on the first. Since the concentrations fall off rather quickly, working with the model can quickly yield sediment concentrations for any number of piles by superposition. However, in general, if the sediments are aerobic, Dr. Brooks notes:

The model assumes that contaminants are dispersed in a 30 degree cone downcurrent from each piling. To assess complex projects involving numerous piling, one simply needs to superimpose the footprint of one piling on another. The further apart the piling are in a bent, the less effect one piling has on the next. The [WWPI] model does that for several piling. For more - you need to do it as you suggest [superposition] However, based on the Sooke Basin Study and other risk assessments, PAH appear to be restricted to the area within about 7.5 to 10 meters from even dense clusters of piling. Therefore, if piling are say 4 meters apart, then one would only need to consider the interaction of three piling. (Brooks 2009)

Thus, using Dr. Brooks heuristic or superposition of the entire structure, a maximum sediment concentration can be derived. Note in the overall risk evaluation of the project, if there are no TES or the area of the project will not diminish an EFH, the area under a

large structure may be discounted, that is, assumed to be lost to the environment or habitat. For most EFH issues, it would need to be a very large structure or be in an very critical location to make any difference to the fishery.

#### Other models

Dr. Brooks and others are working on a book about wood preservatives and this has chapters that present risk assessment models for creosote, not only from piles, but also from overhead structures, such as bridges, and other wood treatments, such a ACZA. The likely title and authors are: “Managing Treated Wood in the Environment” by J.J. Morrell, K. Brooks, T. Ledoux, and D. Hayward, which has a chapter titled, *Modeling migration of preservatives under varying regimes*, which this author reviewed and noted it was very complete. That book should be available soon.



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## List of Acronyms

# Acronyms and Abbreviations

AAC	Alaska Administrative Code
ACZA	Ammoniacal Copper Zinc Arsenate
ADOT	Alaska Department of Transportation and Public Facilities (ADOT) AAC
AMOP	Arctic and Marine Oilspill Program
APA	Administrative Procedures Act
ANS	Alaska North Slope
AMH	Alaska Marine Highway
ATSDR	Agency for Toxic Substances Disease Control
AWPA	American Wood-Preservers' Association
BaP	benzo[ <i>a</i> ]pyrene
BMPs	best management practices
BOD	Biochemical oxygen demand
CCA	Chromated copper arsenate
CZMA	Coastal Zone Management Act
DOL	Department of Labor
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
ER-L	Effects Range-Low
ER-M	Effects Range-Median
ESA	Endangered Species Act
EFH	Essential Fish Habitat
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HAPC	habitat areas of particular concern
HPAH	heavy PAH
kg	kilograms
Koc	Organic carbon partition coefficient
LD	Lethal dose
LC	Lethal concentration
LC50	Concentration lethal to 50% of the organisms
LPAH	Light PAH, two or three rings
LOEC	lowest observable effects concentration

LPAH	light PAH
MFO	Mixed function oxidase
mg	Miligrams
MSA	Magnuson-Stevens Act
NAS	National Academy of Science
NIOSH	National Institute of Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observable effects concentration
NOEL	no observable effects level
O&M	Operations and maintenance
OC	organic carbon
OSHA	Occupational Safety and Health Agency
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PEL	Probable Effect Level
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PWS	Prince William Sound
RED	Reregistration Eligibility Decision
RPD	redox potential discontinuity
RCRA	Resource Conservation and Recovery Act
RQs	risk quotients
SOP	Standard Operating Procedure
SPMDs	semipermeable membrane sampling devices
SPME	solid-phase microextraction
SQGs	sediment quality guidelines
SQC	sediment quality criteria
SUNY	State University of New York
TEL	Toxicity Effect Level
TES	Threatened and endangered species
TOC	total organic carbon
TPAH	total PAH
U.S. EPA	U.S. Environmental Protection Agency
USFS	Forest Service
USDA	USDA

USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WWPI	Western Wood Preservers Institute