Briefing for PWSRCAC Board of Directors – September 2025

ACTION ITEM

Sponsor:	Roy Robertson and the OSPR Committee
Project number and name or topic:	5640 – Alaska North Slope Crude Oil Properties

1. **Description of agenda item:** The Board is being asked to accept the report titled "Review of the 2024 Alaska North Slope Oil Properties Relevant to Environmental Assessment and Prediction," by Dr. Merv Fingas of Spill Science.

This project entailed analyzing the physical and chemical properties of a sample of 2024 Alaska North Slope (ANS) crude oil and interpreting how those properties would impact the effectiveness of oil spill response measures including mechanical recovery, in-situ burning, and dispersants. A crude oil sample was obtained from the Prince William Sound Shippers on April 16, 2024, and sent to Environment and Climate Change Canada's (ECCC) laboratory for physical and chemical analysis. The ECCC analysis report was reviewed by Dr. Merv Fingas of Spill Science, a spill response subject matter expert, to interpret how the oil's chemical and physical properties would influence various spill response techniques and to identify any changes in the oil properties from previous samples the Council has received.

2. **Why is this item important to PWSRCAC:** Understanding the physical and chemical properties of ANS crude oil is critical when planning for, responding to, and mitigating the short- and long-term impacts of an oil spill in Prince William Sound. Over time, the physical and chemical properties of ANS crude oil change based on inputs from differing North Slope fields and how field output changes over time. Therefore, it is important to monitor those chemical and physical changes to plan for effective oil spill response and mitigation measures.

Information from this project will be used to understand how the current physical and chemical properties of ANS crude oil would influence the effectiveness of spill response measures detailed in the Valdez Marine Terminal and Prince William Sound Tanker Contingency Plans.

3. **Previous actions taken by the Board on this item:**

Meeting	Date	Action
Board	5/4/2023	Accepted the report titled "Review of the 2019 Alaska North Slope Oil Properties Relevant to Environmental Assessment and Prediction" by Dr. Merv Fingas as meeting the terms and conditions of contract #5640.23.01, and for distribution to the public.
Board	5/2/24	Approved budget for 5640 ANSC Oil properties.
Board	1/25/25	Approved budget modification to increase budget by $1,000.

4. **Summary of policy, issues, support, or opposition:** None known.

5. **Committee Recommendation:** The OSPR Committee reviewed the report in detail for compliance with the contract at its July 31, 2025 meeting and recommends Board acceptance.

6. **Relationship to LRP and Budget:** Work associated with this project was included in the FY2025 budget under contract 5640.25.01 in the amount of $6,000.

7. **Action Requested of the Board of Directors:** Accept the report titled "Review of the 2024 Alaska North Slope Oil Properties Relevant to Environmental Assessment and Prediction," by Dr. Merv Fingas of Spill Science as meeting the terms and conditions of contract 5640.25.01, and for distribution to the public.

8. **Alternatives:** None recommended.

9. **Attachments:** Draft report titled "Review of the 2024 Alaska North Slope Oil Properties Relevant to Environmental Assessment and Prediction," by Dr. Merv Fingas of Spill Science.

Review of the 2024 Alaska North Slope Oil Properties Relevant to Environmental Assessment and Prediction

Prepared for

Prince William Sound Regional Citizens' Advisory Council (PWSRCAC)
Anchorage, Alaska

by

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Draft

June 2025

PWSRCAC Contract #5640.25.01

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Non-Technical Summary

Background

The Trans Alaska Pipeline System, bringing Alaska North Slope (ANS) crude oil into Valdez, carries different blends of the ANS oil depending on what oils are fed into the pipeline at Pump Station 1. After 2010, the blend of oils shifted dramatically with the absence of heavier crudes and the predominance of lighter oils. This had an influence on the possible environmental impacts of any spill of that oil, as well as on the effectiveness of countermeasures used to respond to a spill. Year by year, there continue to be slight changes in the composition of the ANS oil causing no significant effects on oil spill countermeasures.

This paper is a summary of several oil parameters and the predicted spill behavior of a 2024 ANS sample provided to Environment and Climate Change Canada (Environment Canada). Environment Canada analyzed the sample provided to them by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) for environmental and physical parameters. As per a stipulation in the Prince William Sound tanker contingency plan, PWSRCAC receives an ANS crude sample at least every five years. PWSRCAC then has the oil samples analyzed for their physical and chemical properties.

The objectives of this report are to:

- Describe how the pertinent chemical and physical properties of this 2024 ANS sample affect mechanical (e.g., skimmers) and non-mechanical (e.g., dispersants) response methods;
- Describe how those properties affect the fate and transport of oil spilled in Prince William Sound; and
- Identify how the chemical properties of this sample have changed over time.

Overall

The 2024 sample of ANS oil was found to be similar to the 2019 ANS oil sample, but different from samples in the more distant past. The essential parameters included in the analysis of the 2024 ANS oil are the viscosity, density, and emulsion formation tendency. The 2024 sample is of similar density and viscosity compared to past samples. The environmental behavior parameters of evaporation, emulsification, and dispersibility were predicted in Environment Canada's analyses. The results show the 2024 ANS is a medium viscosity oil that does not form emulsions and evaporates to an extent. Of importance, it was found that the 2024 ANS sample is poorly dispersible once weathered.

Composition Changes Effects on Oil Spill Countermeasures

The composition changes over time have generally made 2024 ANS oil lighter and less viscous, making spilled ANS easier to physically recover and easier to pump. 2024 ANS crude oil is not highly dispersible but less prone to form water-in-oil emulsions. ANS oil is especially less dispersible as the oil weathers.

Composition Changes Effects on the Environment

The composition changes over time have been small. The effect of these changes on aquatic toxicity has not been specifically measured. The decreasing viscosity and resin content have made 2024 ANS oil less adhesive to shorelines.

Technical Data Summary

The physical properties of the 2024 ANS crude oil sample are shown in Table 1. The 2024 data show that this sample is similar in density to that of the previous sample analyzed in 2019**.** The essential 2024 ANS crude oil data are:

Table 1. Physical Properties - 2024

Test	**Test Conditions**		**ANS Fresh (0%)**	**ANS W1 (11.9%)**	**ANS W2 (24.3%)**	**ANS W3 (36.2%)**
Density (g/mL)	0 °C		0.8726	0.9073	0.9326	0.9562
	15 °C		0.8635	0.8966	0.9218	0.9451
Viscosity (mPas)	0 °C	Shear (s^{-1}) 10	NA	NA	NA	16683
		Shear (s^{-1}) 100	NA	NA	852	9328
		Shear (s-1) 100	NA	NA	684	NA
		Shear (s^{-1}) 1000	20	74	583	3260
	15 °C	Shear (s^{-1}) 1000	10.9	31	147	1145
Water Content (% w/w)			0.2	<0.1	<0.1	<0.1
Sulfur (% w/w)			1	1.1	1.2	1.4
Pour Point (°C)			-63 °C	-72 °C	-57 °C	-15 °C
Flash Point (°C)			<-17 °C	15 °C	78 °C	133 °C
Evaporation equation	$\% \text{ evap} = (2.975 + 0.045T)\ln(t)$					
Chemical dispersibility 15 °C	Swirling Flask		33	22	14	3
	Baffled Flask		90	85	72	67

*** NA - not applicable due to inappropriate shear rate**

Table 2 illustrates how key properties have changed over time.

Table 2. Brief History of Physical Property Values

(all at 15°C)

Property	Value in 2024	Value in 2019	Value in 2015	Value in 2009
Density	0.8726	0.8726	0.8639	0.8626
Viscosity	10.9	10.9	9.9	13.1
Flash point	<-17 °C	<-19 °C	NM	<-5
Sulfur content (%)	1.1	1	0.9	2.6
Saturates (%w/w)	69.3	56	57.8	65.3
Aromatics (%w/w)	29,2	31	31.9	16.5
Resins (%w/w)	6.5	9	6.5	14.7
Asphaltenes (%w/w)	4	4	3.8	3.5

The essential environmental facts of the 2024 ANS sample are summarized in Table 3.

Table 3. Environmental Properties of the 2024 ANS Crude Oil

Evaporation	%Ev = (2.975 + .045T)ln(t) T is temperature in Celsius t is the time in minutes		
Emulsification	Does not form any type until heavily weathered Heavily weathered = entrained		
Dispersibilty	Weathering		
	ANS W1 (11.9%)	ANS W2 (24.3%)	ANS W3 (36.2%)
Swirling Flask Effectiveness %	22	14	3

The origin and use of these predictions are illustrated in the text of the full report.

List of Acronyms and Definitions

ANS	Alaska North Slope - This usually refers to the crude oil mixture at the end of the Trans Alaska Pipeline at the Valdez Marine Terminal
APAC	Alkylated Polyaromatic (hydro)Carbons
API	American Petroleum Institute
BTEX	Benzene, toluene, ethyl-benzene, and xylenes
ESTS	Emergencies Science and Technology Section – part of Environment and Climate Change Canada
EPA	U.S. Environmental Protection Agency
g/cm^3	Grams per cubic centimeter
GC	Gas chromatograph - This is a chemical analytical technique
PAC	Polyaromatic (hydro)Carbons
PAHs	Polycyclic aromatic hydrocarbons
PH	Phytane – an important marker found in most crude oils
PR	Pristane – an important marker, usually used in combination with Phytane to estimate biodegradation
PWSRCAC	Prince William Sound Regional Citizens' Advisory Council
SARA	Saturates, aromatics, resins, and asphaltenes
TAH	Total aromatic hydrocarbons
TPH	Total petroleum hydrocarbons
TSH	Total saturated hydrocarbons
VOCs	Volatile organic compounds

Acknowledgments
The author thanks Roy Robertson of the Prince William Sound Regional Citizens' Advisory Council for his help and guidance.

1. Introduction

1.1 Background

The overall objective of this report is to provide properties and environmental prediction information on the 2024 sample of ANS crude oil. Additional objectives include:

- Describing how the pertinent chemical and physical properties of this 2024 ANS oil sample affect mechanical and non-mechanical response methods;
- Describing how those properties affect the fate and transport of oil spilled in Prince William Sound; and
- Identifying how the chemical properties of this sample have changed over time.

1.2 Oil Properties and Alaska North Slope Crude

It is important to recognize the nature of crude oil that stems from the inputs into the pipeline and the changing blends that occur over time. A crude oil sample drawn at one point in time from a pipeline may be completely different than a sample drawn at a later time.

The ANS crude oil is an example of this principle. The trans-Alaska pipeline begins at Pump Station 1 (International Petroleum Encyclopedia, 2019). At this point, it is a mixture of crude oils in varying proportions from several fields. The characteristics of the fields vary and thus, as they are blended into Pump Station 1 at the head of the trans-Alaska pipeline, the starting crude varies as well. At the time of writing of this report, the Prudhoe Bay field is injecting less oil into the pipeline than prior to 2010. Some oil is withdrawn from the pipeline for the PetroStar refinery in Valdez where residual oils are re-injected into the pipeline. The sequence of this injection and re-injection changes the composition of the oil when it is stored in Valdez.

In 2024, a new sample was drawn, and the properties were measured and reported by Environment Canada (2025). Table 1 gives these properties (ESTS, 2025). Comparison shows that the 2024 sample is similar to the 2019 sample in many respects (see Table 2).

1.3 A Summary of Oil Composition and Behavior

Crude oils are mixtures of hydrocarbon compounds ranging from smaller, volatile compounds to very large, non-volatile compounds (Fingas, 2019). This mixture of compounds varies according to the geological formation of the area in which the oil is found and strongly influences the properties of the oil. Petroleum products such as gasoline or diesel fuel are mixtures of fewer compounds and thus their properties are more specific and less variable. Hydrocarbon compounds are composed of hydrogen and carbon, which are therefore the main elements in oils. Oils also contain varying amounts of sulfur, nitrogen, oxygen, and sometimes mineral salts, as well as trace metals such as nickel, vanadium, and chromium.

The most common smaller and more volatile compounds found in oil are often referred to as BTEX, or benzene, toluene, ethyl-benzene, and xylenes.

Polyaromatic hydrocarbons, or PAHs, are compounds consisting of at least two benzene rings.

Polar compounds are those that have a significant molecular charge as a result of bonding with compounds such as sulfur, nitrogen, or oxygen. The 'polarity' or charge that the molecule carries results in behavior that is different from that of unpolarized compounds, under some circumstances. In the petroleum industry, the smallest polar compounds are called 'resins,' which are largely responsible for oil adhesion. The larger polar compounds are called 'asphaltenes' because they often make up the largest percentage of the asphalt commonly used for road construction. Asphaltenes consist of very large molecules and, if in abundance in oil, they have a significant effect on oil behavior such as emulsification.

1.3.1 Oil Properties

The properties of oil discussed here are viscosity, density, specific gravity, flash point, pour point, distillation fractions, and interfacial tension.

Viscosity is the resistance to flow in a liquid (Fingas, 2019). The lower the viscosity, the more readily the liquid flows. For example, water has a low viscosity and flows readily, whereas molasses, with a high viscosity, flows poorly. The viscosity of the oil is largely determined by the amount of lighter and heavier fractions that it contains. The greater the percentage of light components such as saturates and the lesser the amount of asphaltenes, the lower the viscosity.

As with other physical properties, viscosity is affected by temperature, with a lower temperature giving a higher viscosity. For most oils, the viscosity varies as the logarithm of the temperature, which is a very significant variation. Oils that flow readily at high temperatures can become a slow-moving, viscous mass at low temperatures. In terms of oil spill cleanup, viscosity can affect the oil's behavior. Viscous oils do not spread rapidly, do not penetrate soil as readily, and affect the ability of pumps and skimmers to handle the oil.

The 2024 ANS oil can be compared to the previous ANS oils and from Figure 1 it can be seen that the 2024 oil is about the same as the last two samples. It can be noted in Figure 1 that the sample in 2003 showed an anomalous high reading. This was probably due to chance sampling.

A comparison of viscosities appears in Table 4. This shows that ANS oil is a typical medium crude oil in terms of viscosity.

Table 4. Typical Viscosity Comparison (data in mPa.s)

Comparison Oils [a]	Viscosity Before Spilling	Viscosity After Some Weathering (mass % lost in weathering)	Viscosity After More Weathering (mass % lost in weathering)
Light crude	1	2 (30%)	5 (60%)
Medium crude	8	16 (20%)	110 (37%)
ANS (2024)	11	147 (25%)	1145 (36%)
Heavy crude	820	8700 (10%)	475,000 (19%)
Dilbit	270	6300 (15%)	260,000 (30%)
Bitumen	260,000	300,000 (1%)	400,000 (2%)

[a] Light crude is represented by Scotia Light, Medium by West Texas Intermediate, Heavy by Sockeye Sour, and Dilbit by Cold Lake Blend

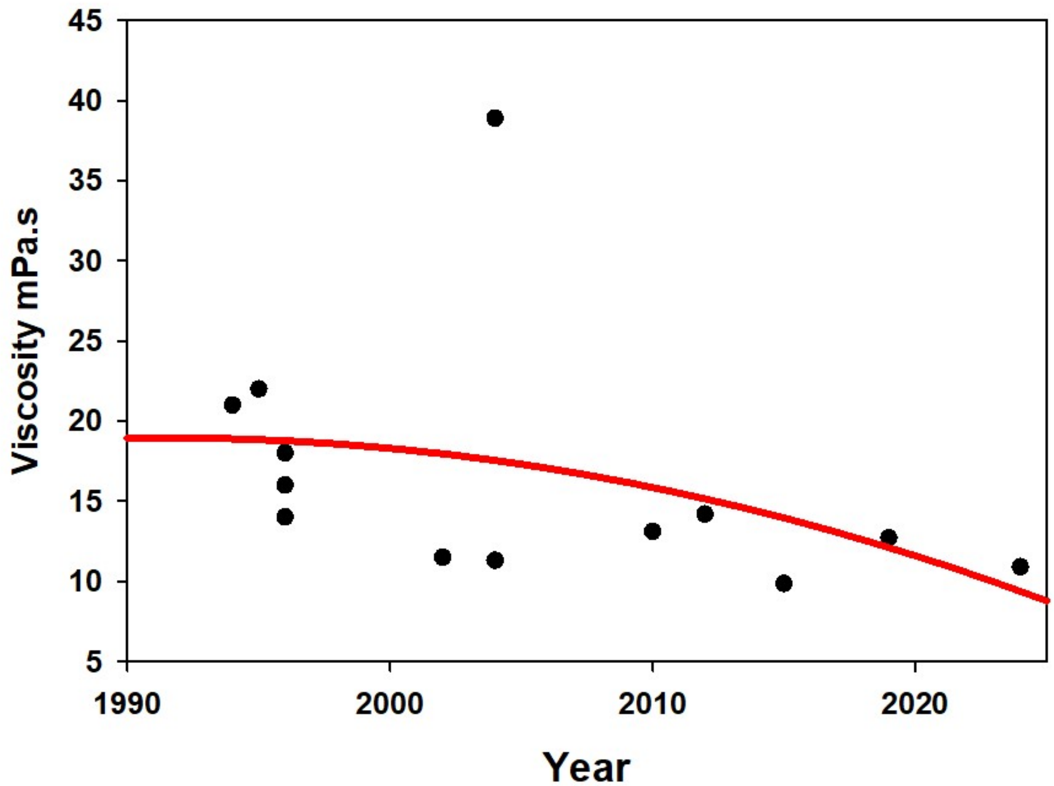

Figure 1. History of the viscosity measurements of ANS crude oil.

Density is the mass (weight) of a given volume of oil and is typically expressed in grams per cubic centimeter (g/cm^3). It is the property used by the petroleum industry to define light or heavy crude oils. Density is also important as it indicates whether a particular oil will float or sink in water. As the density of water is 1.0 g/cm^3 at 15°C and the density of most oils ranges from 0.8 to 0.99 g/cm^3, most oils will float on water. As the density of seawater is 1.03 g/cm^3, even heavier oils will usually float on it. As the light fractions evaporate with time, the density of oil increases.

Occasionally, when the density of oil becomes greater than the density of freshwater or seawater, the oil will sink. Bulk sinking is rare, however, and happens with only a few oils, usually residual oils such as Bunker C. Significant amounts of oil have sunk, by density alone, in only about 25 incidents out of thousands.

Again, to compare the 2024 sample density to the previous data, one can examine Figure 2. This shows that the 2024 ANS oil sample is quite different from the past samples, but similar to the last two samples. As can be seen from Figure 2, the ANS oil is progressing to that of a lighter oil. The progression has been constant over the past 23 years. In the past few years, there was some variance in density which is considered to be minor. Sample density is indicative of composition and the lighter or less dense that an oil is, the easier it is to clean up using mechanical techniques.

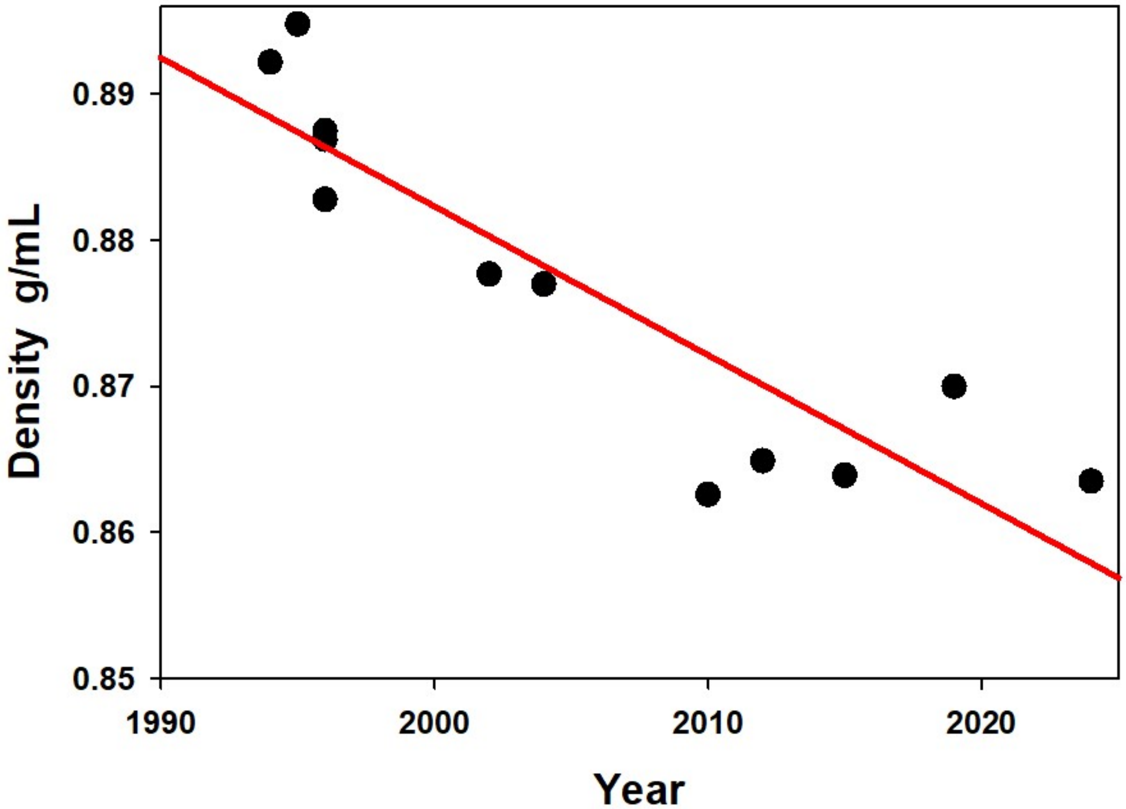

Figure 2. History of the density measurements of ANS crude oil.

Table 5 shows the comparison of density to other oils. This shows again that the density of the 2024 ANS sample is that of a typical medium crude oil.

Table 5. Typical Density Comparison
(data in g/mL at 15°C, freshwater has a density of 1.00, seawater of 1.03)

Comparison Oils[a]	Density Before Spilling	Density After Some Weathering (mass % lost in weathering)	Density After More Weathering (mass % lost in weathering)
Light crude	0.77	0.8 (30%)	0.84 (60%)
Medium crude	0.85	0.87 (16%)	0.90 (32%)
ANS (2024)	0.86	0.92 (24%)	0.93(36%)
Heavy crude	0.94	0.97 (10%)	0.98 (19%)
Dilbit	0.919	.983 (15%)	1.002 (30%)
Bitumen	0.998	1.002(1%)	1.004(2%)

[a] Light crude is represented by Scotia Light, Medium by West Texas Intermediate, Heavy by Sockeye Sour, and Dilbit by Cold Lake Blend

Another measure of density is specific gravity, which is an oil's relative density compared to that of water at 15°C. It is the same value as density at the same temperature. Another gravity scale is that of the American Petroleum Institute (API). The API gravity is based on the density of pure water which has an arbitrarily assigned API gravity value of 10° (10 degrees). Oils with progressively lower specific gravities have higher API gravities.

The following is the formula for calculating API gravity: API gravity = [141.5 ÷ (density at 15.5°C)] - 131.5. Oils with high densities have low API gravities and vice versa. In the United States, the price of a specific oil may be based on its API gravity as well as other properties of the oil.

The flash point of an oil is the temperature at which the liquid gives off sufficient vapors to ignite upon exposure to an open flame. A liquid is considered to be flammable if its flash point is less than 60°C. There is a broad range of flash points for oils and petroleum products, many of which are considered flammable, especially when fresh. Gasoline, which is flammable under all ambient conditions, poses a serious hazard when spilled. Many fresh crude oils have an abundance of volatile components and may be flammable for as long as one day until the more volatile components have evaporated. On the other hand, Bunker C and heavy crude oils are not generally flammable when spilled. Flash point generally correlates with many of the other oil properties such as density, distillation data, etc. The flash point of the weathered fractions of ANS oil shows that it is not flammable after weathering for about half of a day. There is no historical comparison point for this value past the last series of measurements. A comparison to other oils is shown in Table 6.

Table 6. Typical Flash Point Comparison

(data in °C)

Comparison Oils[a]	Flash Point Before Spilling	Flash Point After Some Weathering (mass % lost in weathering)	Flash Point After More Weathering (mass % lost in weathering)
Light crude	<-30	35 (30%)	95 (60%)
Medium crude	-10	50 (15%)	> 110 (32%)
ANS (2024)	-17	78 (24%)	133 (36%)
Heavy crude	-3	67 (10%)	>95 (19%)
Dilbit	< -35	>60 (15%)	>70 (30%)
Bitumen	> 100	> 100 (1%)	>110 (2%)

[a] Light crude is represented by Scotia Light, Medium by West Texas Intermediate

Distillation data are used to form a boiling point curve for oils. These curves can then be compared to gain insight into the oil's composition. This is particularly useful for refineries. Boiling point curves are often used to provide prediction of environmental behavior as well. Figure 3 shows the boiling point curve for the 2024 ANS crude oil sample and the samples for 10 years previous. This shows little change over the years.

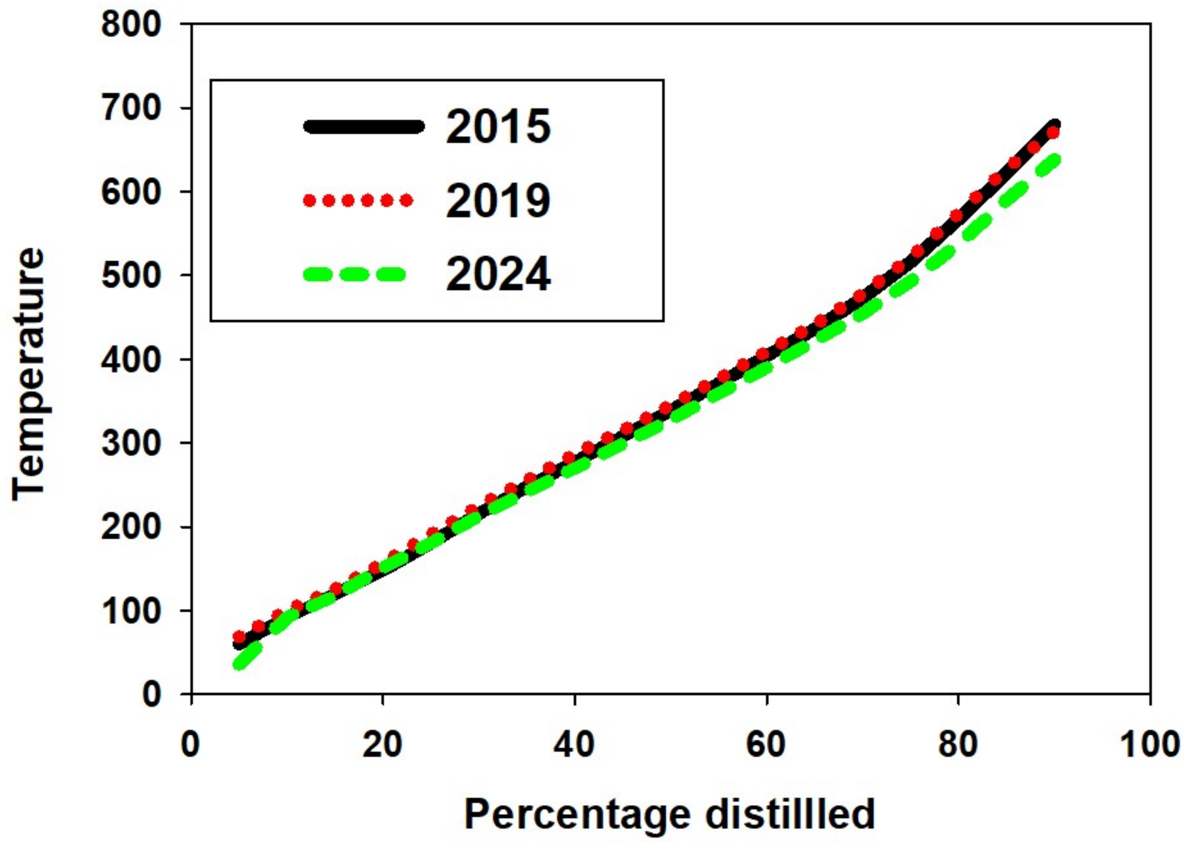

Figure 3. The boiling point curve for the 2024 sample of ANS oil and the previous samples.

Figure 4 compares the change in the fraction of oil distilled at 180°C, the point used to develop evaporation equations. This again illustrates the change in ANS oil over the years. This shows that the recent sample appears to be lower in boiling point. However, related data such as evaporation equations show that the sample is fairly consistent with previous years' samples.

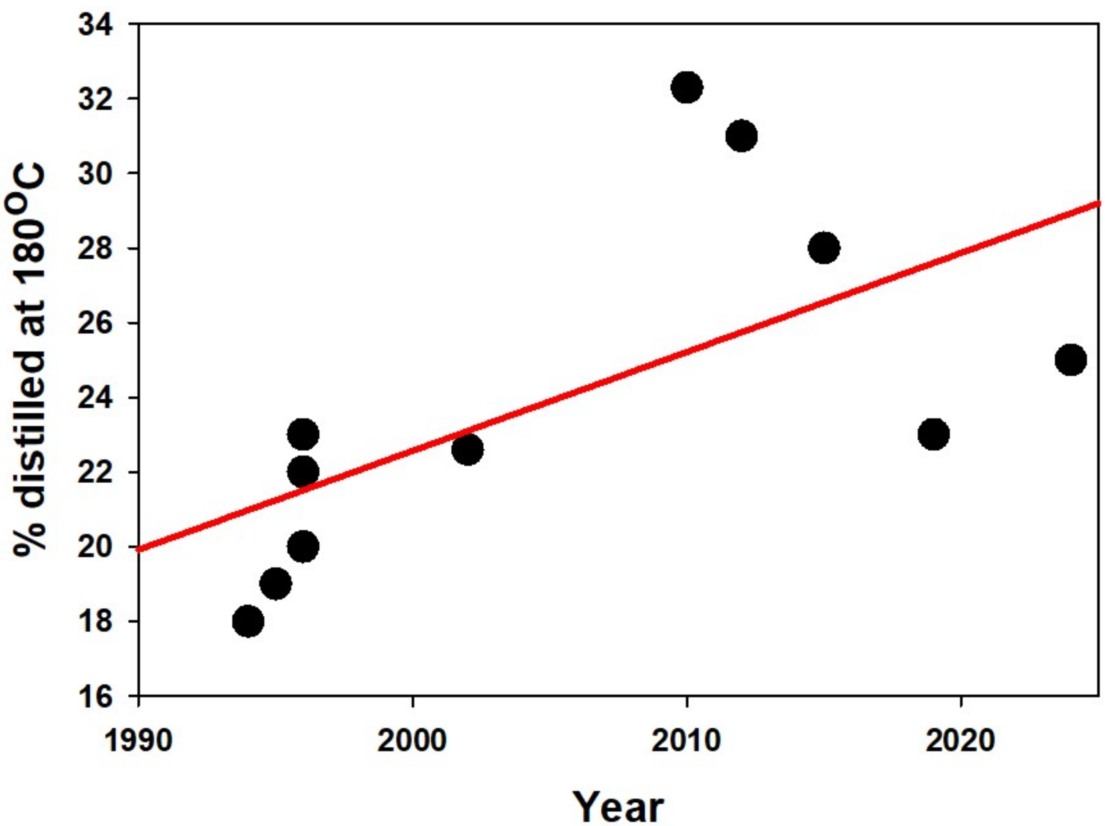

Figure 4. History of the percent distilled at 180°C.

The sulfur content of oil is sometimes included with properties, even though it is a chemical composition item. This is because sulfur content is an important consideration when considering emissions, such as automotive emissions, as well as considering the type of refining processes that are required for a particular type of oil. Sulfur content is also indicative of the number of polar compounds in the oil. Figure 5 shows the history of fresh ANS oil sulfur content over the past 21 years. Sulfur content has been reported for every sampling year. This shows that the sulfur content is decreasing.

The oil/water interfacial tension, sometimes called surface tension, is the force of attraction or repulsion between the surface molecules of oil and water. Together with viscosity, surface tension is an indication of how rapidly and to what extent an oil will spread on water. The lower the interfacial tension with water, the greater the extent of spreading. In actual practice, the interfacial tension must be considered along with the viscosity because it has been found that interfacial tension alone does not account for spreading behavior. A comparison of interfacial tension shows that there has been no significant change in the past few years, and it was not measured in earlier years.

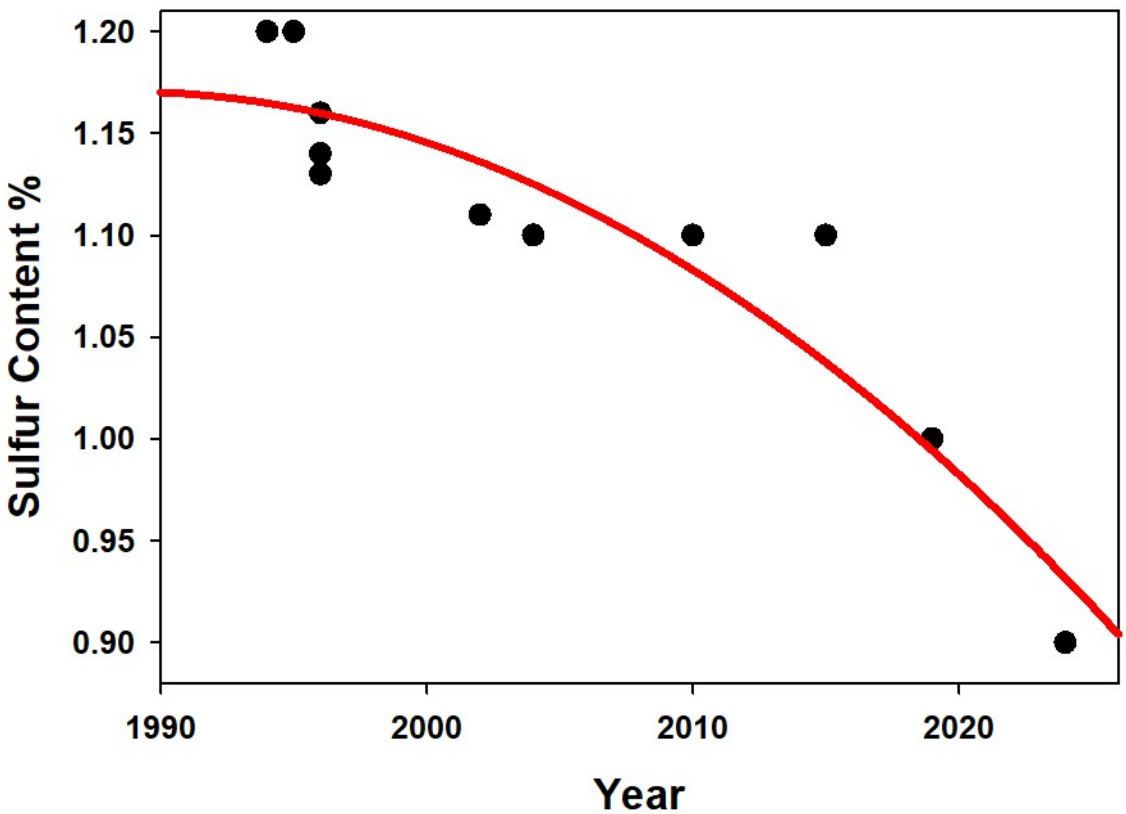

Figure 5. The history of the sulfur content of fresh ANS oil.

The vapor pressure of an oil is a measure of how the oil partitions between the liquid and gas phases, or how much vapor is in the space above a given amount of liquid oil at a fixed temperature. Because oils are a mixture of many compounds, the vapor pressure changes as the oil weathers. Vapor pressure is difficult to measure and is not frequently used to assess oil spills. Vapor pressure was measured for ANS oil for the first time in the 2019 analysis, so there is no comparison point to old measurements. This may set a baseline, however, if future measurements are carried out.

The ANS oil adhesion was measured for the first time in 2019, but not in 2024 or 2015. The adhesion test was developed to provide a standard method for measuring ‘stickiness,’ which does vary among oils. This test can give an indication of the interaction of oil with shorelines as well as the ability to recover oil with adsorbent skimmers. High values indicate oil that may be hard to clean up from shorelines, and low values indicate oils that will not adhere to shorelines but are difficult to clean up with sorbent-surface skimmers.

Table 7 shows a comparison of the adhesion of the 2019 ANS sample compared to some other oils. ANS oil fits right in as a medium oil and has the expected adhesion properties.

Table 7. Typical Adhesion Comparison (data in g/m²)

Comparison Oils[a]	Adhesion Before Spilling	Adhesion After Some Weathering (mass % lost in weathering)	Adhesion After More Weathering (mass % lost in weathering)
Light crude	0	2.5 (30%)	9 (60%)
Medium crude	12	22 (15%)	33 (32%)
ANS 2019 crude	18	34 (25%)	56 (37%)
Heavy crude	75	100 (10%)	600 (19%)
Dilbit	98	146 (6%)	1580 (20%)**
Bitumen	575		

[a] Light crude is represented by Scotia Light, Medium by West Texas Intermediate, Heavy by Sockeye Sour, and Dilbit by Cold Lake Blend

** highly weathered

1.3.2 Behavior of Oil

Oil spilled on water undergoes a series of changes in physical and chemical properties which in combination are termed 'weathering' (Fingas, 2019). Weathering processes occur at very different rates but begin immediately after oil is spilled into the environment. Weathering rates are not consistent throughout an oil spill and are usually highest immediately after the spill.

Evaporation is usually the most important weathering process. It has the greatest effect on the amount of oil remaining on water or land after a spill. Over several days, a light fuel such as gasoline evaporates completely at temperatures above freezing, whereas only a small percentage of heavier Bunker C oil evaporates. The rate at which an oil evaporates depends primarily on the oil's composition. The more volatile components an oil or fuel contains, the greater the extent and rate of its evaporation. Many components of heavier oils will not evaporate at all, even over long periods of time and at high temperatures.

Oil and petroleum products evaporate in a slightly different manner than water and the process is much less dependent on wind speed and surface area than on temperature. Oil evaporation can be considerably slowed down by the formation of a 'crust' or 'skin' on top of the oil. This happens primarily on land where the oil layer does not mix by agitation of the water. The skin or crust is formed when the smaller compounds in the oil are removed, leaving the larger compounds, such as waxes and resins, at the surface. These components seal off the remainder of the oil and prevent evaporation. Stranded oil from old spills has been re-examined over many years and it has been found that, when this crust has formed, there is no significant evaporation in the oil underneath. If this crust has not formed, the same oil could be weathered to the hardness of wood.

The rate of evaporation is very rapid immediately after a spill and then slows considerably. About 80% of evaporation occurs in the first few days after a spill. The evaporation of most oils follows a logarithmic curve with time. Some oils such as diesel fuel, however, evaporate as the square root of time, at least for the first few days. This means that the evaporation rate slows very rapidly with time in both cases. The properties of an oil can change significantly with the extent of evaporation. If about 40% (by weight) of an oil evaporates, its viscosity could increase by as much as a thousand-fold. Its density could rise by as much as 10% and its flash point by as much as 400%. The extent of evaporation can be the most important factor in determining the properties of an oil at a given time after the spill and in changing the behavior of the oil.

Emulsification is the process by which one liquid is dispersed into another one in the form of small droplets. Water droplets can remain in an oil layer in a stable form and the resulting material is completely different. These water-in-oil emulsions are sometimes called 'mousse' or 'chocolate mousse' as they resemble this dessert. In fact, both the tastier version of chocolate mousse and butter are common examples of water-in-oil emulsions.

The mechanism of emulsion formation is not yet fully understood, but it probably starts with sea energy forcing the entry of small water droplets, about 10 to 25 μm (or 0.010 to 0.025 mm) in size, into the oil. If the oil is only slightly viscous, these small droplets will not leave the oil quickly. On the other hand, if the oil is too viscous, droplets will not enter the oil to any significant extent. Once in the oil, the droplets slowly gravitate to the bottom of the oil layer. Any asphaltenes and resins in the oil will interact with the water droplets to stabilize them. Depending on the quantity of asphaltenes and resins, an emulsion may be formed. The conditions required for emulsions of any stability to form may only be reached after a period of evaporation. Evaporation lowers the amount of low-molecular-weight compounds in the oil and increases the viscosity to the critical value.

Water can be present in oil in four ways. First, some oils contain about 1% water as soluble water. This water does not significantly change the physical or chemical properties of the oil. The second way is called 'entrainment,' whereby water droplets are simply held in the oil by its viscosity to form an unstable emulsion. These are formed when water droplets are incorporated into oil by the sea's wave action, and there are not enough asphaltenes and resins in the oil, or if there is a high amount of aromatics in the oil which stabilizes the asphaltenes and resins preventing them from acting on the water droplets. Unstable emulsions break down into water and oil within minutes or a few hours, at most, once the sea energy diminishes. The properties and appearance of the unstable emulsion are almost the same as those of the starting oil, although the water droplets may be large enough to be seen with the naked eye.

Meso-stable emulsions represent the third way water can be present in an oil. These are formed when the small droplets of water are stabilized to a certain extent by a combination of the viscosity of the oil and the interfacial action of asphaltenes and resins. For this to happen, the asphaltene or resin content of the oil must be at least 3% by weight. The viscosity of meso-stable emulsions is 20 to 80 times higher than that of the starting oil. These emulsions generally break down into oil and water or sometimes into water, oil, and stable emulsion within a few days. Semi- or meso-stable emulsions are viscous liquids that are reddish-brown in color.

The fourth way that water exists in oil is in the form of stable emulsions. These form in a way similar to meso-stable emulsions except that the oil must contain at least 4 to 8% asphaltenes. The viscosity of stable emulsions is 800 to 1000 times higher than that of the starting oil and the emulsion will remain stable for weeks and even months after formation. Stable emulsions are reddish-brown in color and appear to be nearly solid. Because of their high viscosity and near solidity, these emulsions do not spread and tend to remain in lumps or mats on the sea or shore.

The formation of emulsions is an important event in an oil spill. First, and most importantly, it substantially increases the actual volume of the spill. Emulsions of all types contain about 60 to 80% water and thus when emulsions are formed the volume of the oil spill more than triples. Even more significantly, the viscosity of the oil increases by as much as 1000 times, depending on the type of emulsion formed. For example, a highly viscous oil such as a heavy fuel oil can triple in volume and become almost solid through the process of emulsification.

These increases in volume and viscosity make cleanup operations more difficult. Emulsified oil is difficult or impossible to disperse, recover with skimmers, or burn. Emulsions can be broken down with special chemicals in order to recover the oil with skimmers or to burn it. It is thought that emulsions break down into oil and water by further weathering, oxidation, and freeze-thaw action. Meso- or semi-stable emulsions are relatively easy to break down, whereas stable emulsions may take months or years to break down naturally.

Emulsion formation also changes the fate of the oil (Fingas and Fieldhouse, 2009, 2011). It has been noted that when oil forms stable or meso-stable emulsions, evaporation slows considerably. Biodegradation also appears to slow down. The dissolution of soluble components from oil may also cease once emulsification has occurred.

2. Summary of ANS Oil Behavior

An important facet of understanding the oil behavior is to use actual data on the behavior of the oil. The Environment Canada report lists several important behavior data (ESTS, 2025). These results will be reported here.

2.1 ANS Oil Evaporation

Oil evaporation was measured by Environment Canada using pan evaporation. This resulted in an equation:

$$\%Ev = (2.975 + .045T)\ln(t) \qquad (1)$$

Where %Ev is the percent evaporated at Temperature, ^{o}C
and t is the time in minutes.

This is an empirical equation derived from controlled experiments. Figure 6 shows the predicted evaporation at different temperatures. This shows that the 2024 ANS oil sample would evaporate significantly at normal ambient temperatures.

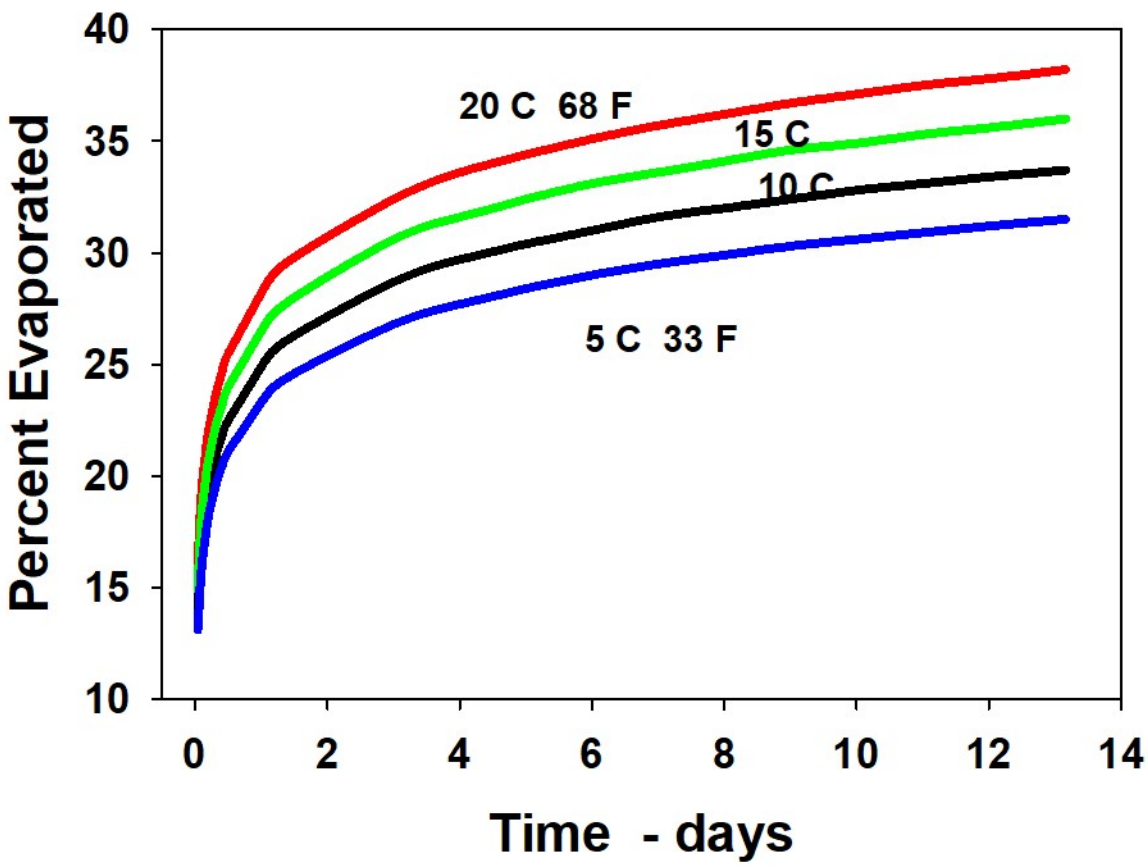

Figure 6. The evaporation of the 2024 ANS oil sample at different temperatures.

2.2 Emulsification

Water-in-oil emulsions sometimes form after oil products are spilled. These emulsions, often called “chocolate mousse” or “mousse” by oil spill workers, can make the cleanup of oil spills very difficult. When water-in-oil emulsions form, the physical properties of oil change dramatically. As an example, stable emulsions contain from 60 to 80% water, thus expanding the spilled material from two to five times the original volume. Most importantly, the viscosity of the oil typically changes from a few hundred mPa·s to about 100,000 mPa·s, an increase by a factor of 500–1000. A liquid product is changed into a heavy, semisolid material. These emulsions are difficult to recover with ordinary spill recovery equipment. A test of the emulsification of this 2024 sample of ANS oil showed that it does not produce any form of stable emulsion. This is good news, as it shows that the oil would be easy to recover even after moderate weathering. However, highly weathered oil can retain entrained water. Table 8 shows the results.

Table 8. Emulsion Tendencies and Water Pickup for the 2024 ANS Oil Sample

Emulsion	Units	ANS (Fresh)	ANS W1 (11.92%)	ANS W2 (24.28%)	ANS W3 (36.18%)
Visual Stability 15 °C (1st day)		Distinct oil water layers	Distinct oil water layers	Distinct oil water layers	Oil/water mixture
Complex Modulus 15 °C (1st day)	Pa	N/A	N/A	N/A	25.6
Storage Modulus 15 °C (1st day)	Pa	N/A	N/A	N/A	11
Tan Delta (V/E) 15 °C (1st day)		N/A	N/A	N/A	2.1
Complex Dynamic Viscosity (1st day)	mPa.s	N/A	N/A	N/A	4076
Water Content (1st day)	%w/w	0.33	0.27	0.73	19.93
Visual Stability 15 °C (8th day)		Unstable	Unstable	Unstable	Entrained
Complex Modulus 15 °C (8th day)	Pa	N/A	N/A	N/A	11.2
Storage Modulus 15 °C (8th day)	Pa	N/A	N/A	N/A	0.21
Tan Delta (V/E) 15 °C (8th day)		N/A	N/A	N/A	90.9
Complex Dynamic Viscosity (8th day)	mPa.s	N/A	N/A	N/A	1780
Water Content (8th day)	%w/w	N/A	N/A	N/A	6.96

*N/A – Not applicable as the measurement is not made on unstable mixtures that rapidly resolve into two phases.

The parameters in Table 8 are standard characterizations of heavy oils or emulsions, explanations can be found in rheological introductions (Malvern, 2016). The 2024 sample of ANS oil doesn't form stable emulsions, however highly weathered samples can retain some water by viscosity forces.

3. Chemistry of ANS Crude Oil

Crude oils are complex mixtures of hydrocarbons and hydrocarbons combined with other elements ranging from smaller, volatile compounds to very large, nonvolatile compounds. The mixture of compounds varies with the geological formation of the area in which the crude oil is found. Crude oils are often similar in a given region and when drawn from a similar reservoir. Petroleum products such as gasoline and diesel fuel are mixtures of fewer compounds and are refined to specific standards. Thus, their properties are more specific and less variable. Crude oil contains many compounds of different sizes and different classes. In fact, there are so many that as time goes by more and more compounds are identified in oil. Currently, analysts have preliminarily identified up to 100,000 compounds in an oil. In the future, this number will no doubt, rise significantly.

The gas chromatographic, or GC, characteristics of 2024 ANS oil are shown in Table 9.

Table 9. Total Petroleum Hydrocarbons for Alaska North Slope [2024]

Sample Description		ANS (Fresh)	ANS W1 (11.92%)	ANS W2 (24.28%)	ANS W3 (36.18%)
TPH	**mg/g oil**	529	537	575	600
TSH	**mg/g oil**	409	333	375	378
TAH	**mg/g oil**	120	204	199	222
Resolved components (Ft)	**mg/g oil**	121	137	106	67.8
TSH/TPH (%)	**(%)**	77	62.0	65.3	63.0
TAH/TPH (%)	**(%)**	23	38.0	34.7	37.0
Resolved Peaks/TPH (%)	**(%)**	21	21.3	17.2	11.3
TPH fractions (%)					
TPH F1 (<n-C10)	**(%)**	12	10.4	3.12	0.00
TPH F2 (>n-C10-n-C16)	**(%)**	28	28.5	29.6	16.6
TPH F3 (>n-C16-n-C34)	**(%)**	47	48.0	53.2	66.3
TPH F4 (>n-C34)	**(%)**	13	13.1	14.1	17.1

Notes: TPH indicates total petroleum hydrocarbons; TSH indicates total saturated hydrocarbons; TAH indicates total aromatic hydrocarbons.

Table 9 shows some interesting data. The TPH is the total petroleum hydrocarbons and this represents the total amount that the GC can detect out of the sample injected. For the fresh oil, Table 9 shows that this value is 529 mg (out of 1000). This amounts to 53%. The remainder of the oil did not make it through the chromatographic column. This is very important in considering an oil as any measurements made of it are only analyzing 53%. For example, if studying biodegradation, one can be fooled into thinking that the remainder is degraded, whereas it is not analyzed. Similarly, the TSH is the total saturate hydrocarbons which is the fraction of the TPH that is detected as saturate compounds. The TAH is the total aromatic hydrocarbons. This is the fraction of the oil that is detected as aromatic hydrocarbons. The ‘resolved peaks’ are the fractions of the oil detected in the peaks that have been resolved or separated by the GC. The remainder of the TPH is in unresolved peaks or in ‘humps’ in the chromatogram. The TSH/TPH and TAH/TPH ratios are indices of the saturate and aromatic components in the oil.

The saturates, aromatics, resins, and asphaltene (SARA) composition of oil is a more general analytical method that defines oils by precipitation and then weight. Newer methods now employ thin-layer chromatography, values from both methods vary somewhat. This method is still useful, however, and it provides useful data both to the refiner and to the environmental scientist. Saturates are hydrocarbon compounds with the maximum number of hydrogens. Aromatics are hydrocarbon compounds with at least one benzene ring. Resins and asphaltenes are larger compounds containing mostly carbon and hydrogen, but containing other elements such as oxygen, sulfur, nitrogen, and metals.

The parameters as shown in Table 9 may change over the years, giving indication of oil composition changes which in turn may have an influence on spill behavior. Figure 7 shows the change in Table 9 parameters over the last three samplings, approximately 10 years. This type of graphing shows only gross changes and individual parameters on the X-axis are hard to differentiate.

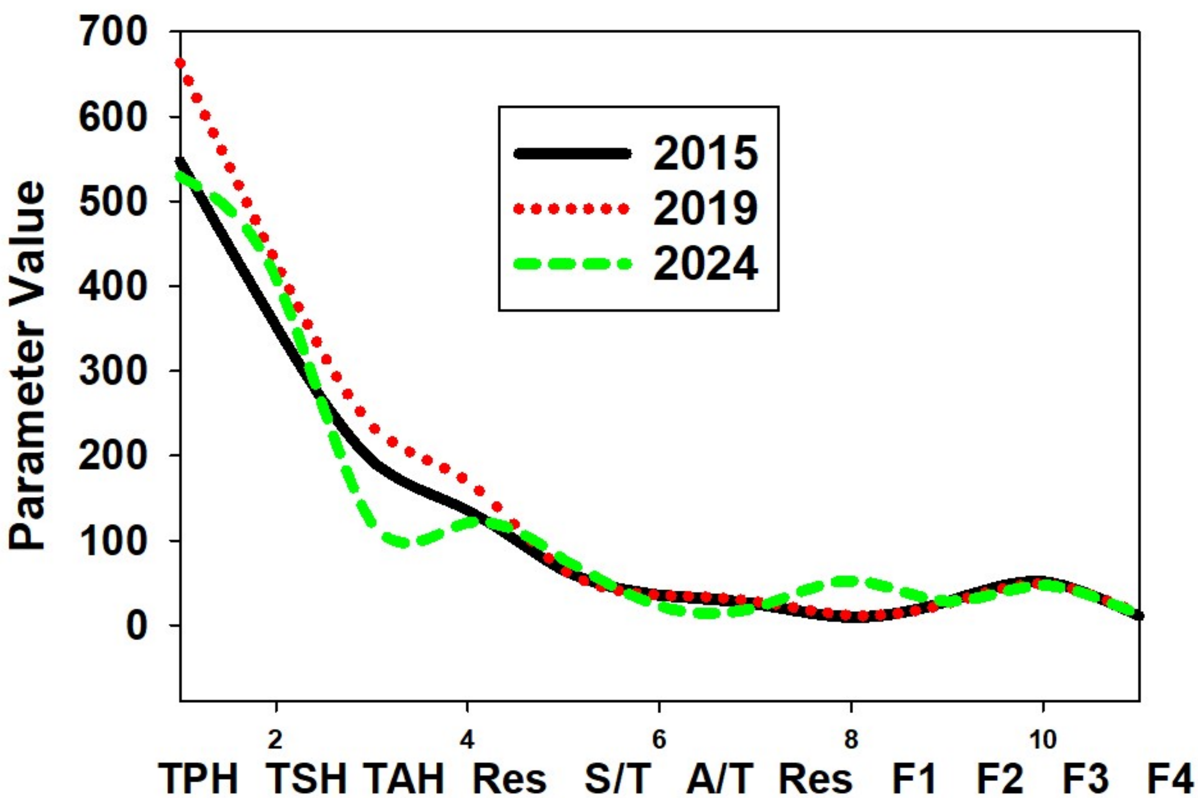

Figure 7. Change in total gas chromatographic parameters over the past 10 years.

Figure 7 shows that there were slight changes in Table 9 parameters over the past 10 years. In particular, Figure 7 shows that the TPH has fallen since 2019, as did the TAH. The effect of this on environmental parameters is likely to be small.

Alkanes, an important part of saturate composition, are hydrocarbons with a chain-like structure and without double bonds or other elements such as sulfur, nitrogen, or oxygen attached. Alkanes, sometimes called paraffins, are typically the most abundant compounds in crude oils as well as in most fuels such as diesel fuel and gasoline. Most crude oils have anywhere between a few percent up to 30% alkanes. Alkanes are typically the target compounds sought by petroleum producers. It should be noted, however, that larger alkanes are also called waxes and these are sometimes less desirable from a petroleum producer's point of view. Table 10 shows the alkane compounds in the latest fraction of ANS oil. Table 10 shows that the latest sample of oil is typical of medium crude oil and contains a large proportion of refinable material.

Further, the alkane content shows the spill responder that the oil weathers to a greater extent or a lesser extent. Many of the alkanes below about C20 are lost in the first few days.

Table 10. Alkane Analysis Results for Alaska North Slope Oil [2024]

Identifier Compounds	ANS (Fresh) µg/g oil	ANS W1 (11.92%) µg/g oil	ANS W2 (24.28%) µg/g oil	ANS W3 (36.18%) µg/g oil
***n*-Alkanes**				
n-C9	4102	4365	2412	1.61
n-C10	4202	4580	3772	3.63
n-C11	3879	4268	4359	28.5
n-C12	3380	3715	5826	934
n-C13	3021	5264	5509	3274
TMD	711	1180	1362	1045
n-C14	2662	4693	5136	4419
n-C15	2364	2682	2992	4839
n-C16	2160	2466	2758	4748
TMP	893	1012	1176	1259
n-C17	1990	2276	2561	3028
Pristane	1089	1239	1368	1679
n-C18	1674	1854	2130	2573
Phytane	950	1090	1188	1451
n-C19	1559	1762	1961	2381
n-C20	1440	1624	1824	2204
n-C21	1362	1552	1734	2101
n-C22	1277	1474	1614	1966
n-C23	1133	1278	1436	1744
n-C24	1012	1140	1933	1565
n-C25	954	1080	1720	1986
n-C26	897	1008	1679	2018
n-C27	707	793	889	1560
n-C28	564	949	726	1293
n-C29	487	776	636	1155
n-C30	376	619	469	611
n-C31	328	531	413	534

Table 10 ctd. Alkane Analysis Results for Alaska North Slope Oil [2024]

Identifier Compounds	ANS (Fresh) µg/g oil	ANS W1 (11.92%) µg/g oil	ANS W2 (24.28%) µg/g oil	ANS W3 (36.18%) µg/g oil
***n*-Alkanes** ctd.				
n-C32	254	292	326	418
n-C33	223	254	283	365
n-C34	183	207	231	299
n-C35	164	185	208	275
n-C36	130	142	163	219
n-C37	95.9	110	126	161
n-C38	72.8	86.6	99.2	122
n-C39	37.4	54.6	49.8	82.0
n-C40	27.8	30.4	38.3	45.6
Total *n*-alkanes	**46358**	**56633**	**61108**	**52385**
Diagnostic indices				
n-C17/Pristane	1.83	1.84	1.87	1.80
n-C18/Phytane	1.76	1.70	1.79	1.77
Pr/Ph	1.15	1.14	1.15	1.16
Odd alkanes	22406	27232	27288	23513
Even alkanes	18360	21367	24951	20064
CPI	1.22	1.27	1.09	1.17

The alkane distribution may be changing over the years. Figure 8 shows the alkane distribution over the last 10 years of sampling. This type of graphing shows only gross changes and individual parameters on the X-axis are hard to differentiate.

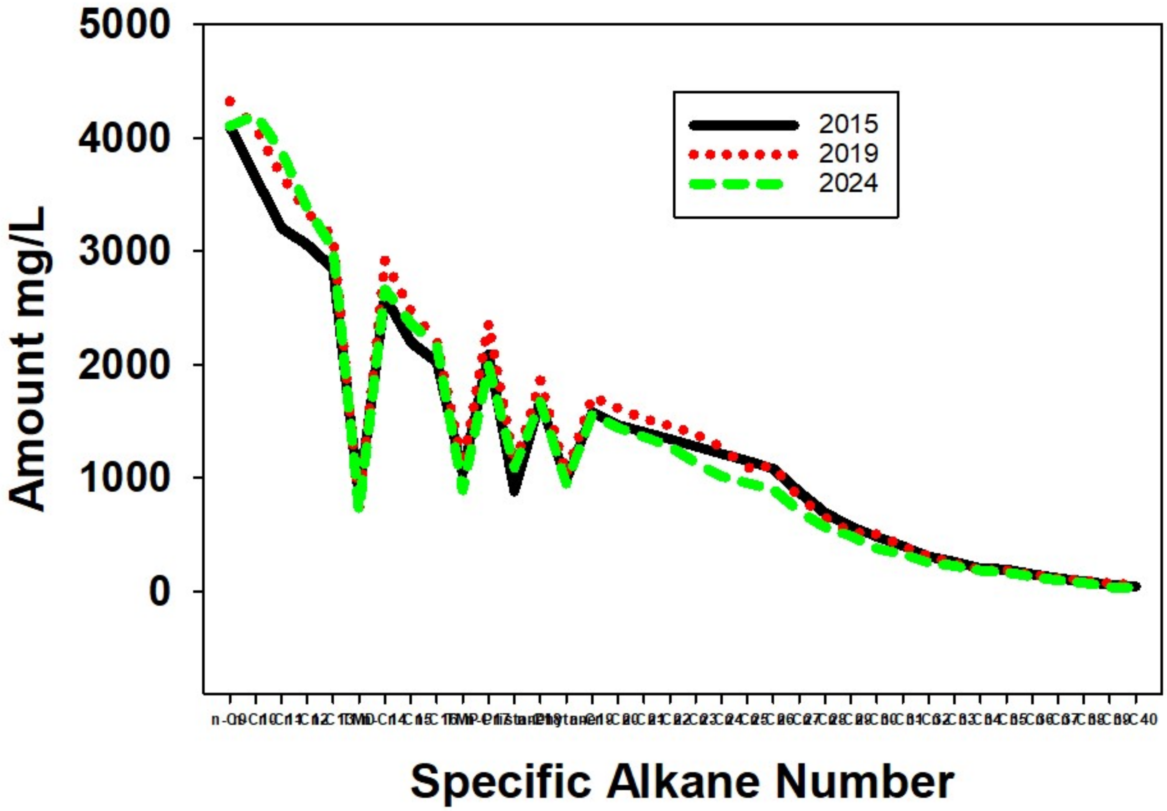

Figure 8. The distribution of n-alkane compounds over the past 10 years of sampling. This type of graphing shows only gross changes and individual parameters on the X-axis are hard to differentiate.

Figure 8 shows only minor composition changes over the past few years. The graph, however, does show that there are more smaller n-alkanes in the last samplings and fewer larger n-alkanes. This may account for the density changes in the past few years.

PAHs are compounds consisting of at least two benzene rings. PAHs make up between 0 and 60% of the composition of a typical oil. Common PAHs and their substituted counterparts in ANS oil are shown in Table 11. As these are easily separated, there are extensive data on their presence in oils. These compounds have also been used somewhat as indicators of the presence of certain types of oils. The concern with these compounds is that many of them are known to be relatively toxic and some to be carcinogenic. Few of the more toxic compounds are found in ANS oil. These and other PAHs are shown in Table 11.

Table 11. APAC and Non-Alkylated PAC Results for Alaska North Slope Crude Oil [2024]

Sample info.		ANS (Fresh)	ANS W1 (11.92%)	ANS W2 (24.28%)	ANS W3 (36.18%)
Alkylated PAHs		**µg/g oil**	**µg/g oil**	**µg/g oil**	**µg/g oil**
Naphthalene	C0-N	612	666	695	65.5
	C1-N	1741	1906	2077	1122
	C2-N	2438	2672	2957	2748
	C3-N	1931	2117	2366	2602
	C4-N	1009	684	1068	1407
	Sum	**7732**	**8044**	**9164**	**7945**
Phenanthrene	C0-P	195	217	238	284
	C1-P	575	635	710	844
	C2-P	668	734	820	1005
	C3-P	515	637	624	754
	C4-P	227	296	263	426
	Sum	**2181**	**2519**	**2656**	**3313**
Dibenzothiophene	C0-D	116	133	147	175
	C1-D	341	386	422	508
	C2-D	499	575	636	776
	C3-D	428	510	524	677
	Sum	**1384**	**1604**	**1730**	**2136**
Fluorene	C0-F	76.6	84.1	93.6	103
	C1-F	263	292	324	375
	C2-F	434	448	509	618
	C3-F	400	460	547	634
	Sum	**1173**	**1284**	**1474**	**1730**
Fluoranthene	C0-Fl	4.45	4.78	5.90	6.47
	C1-Fl	64.8	72.1	80.3	85.7
	C2-Fl	105	124	137	160
	C3-Fl	133	142	175	187
	C4-Fl	92.8	114	108	143
	sum	**396**	**453**	**500**	**575**
Benzonaphthothiophene	C0-B	37.2	41.6	46.8	56.4
	C1-B	121	139	154	189
	C2-B	172	205	226	277
	C3-B	161	181	207	255
	C4-B	108	119	134	174
	Sum	**600**	**686**	**767**	**951**

Table 11 ctd. APAC and Non-Alkylated PAC Results for Alaska North Slope Crude Oil [2024]

Sample info.		ANS (Fresh)	ANS W1 (11.92%)	ANS W2 (24.28%)	ANS W3 (36.18%)
Alkylated PAHs		**µg/g oil**	**µg/g oil**	**µg/g oil**	**µg/g oil**
Chrysene	C0-C	36.3	39.4	43.7	52.6
	C1-C	58.4	64.5	70.7	85.9
	C2-C	88.8	95.9	106	132
	C3-C	67.0	80.3	88.8	92.9
	Sum	**251**	**280**	**309**	**364**
Total alkylated PAHs		**13720**	**14875**	**16605**	**17021**
Other Priority PAHs					
Biphenyl (Bph)	Bph	149	166	180	141
Acenaphthylene (Acl)	Acl	15.2	17.1	18.7	19.5
Acenaphthene (Ace)	Ace	18.2	20.8	22.3	22.0
Anthracene (An)	An	6.91	7.74	7.11	7.35
Fluoranthene (Fl)	Fl	4.88	4.83	5.92	7.00
Pyrene (Py)	Py	18.7	20.4	20.3	27.3
Benz(a)anthracene (BaA)	BaA	4.26	4.44	5.08	5.80
Benzo(b)fluoranthene (BbF)	BbF	6.12	7.13	7.73	9.72
Benzo(k)fluoranthene (BkF)	BkF	0.34	0.30	0.36	0.48
Benzo(e)pyrene (BeP)	BeP	10.1	11.6	12.7	15.8
Benzo(a)pyrene (BaP)	BaP	2.79	3.28	3.62	4.32
Perylene (Pe)	Pe	9.27	10.8	11.7	14.6
Indeno(1,2,3-cd)pyrene (IP)	IP	0.70	0.87	0.99	1.13
Dibenzo(ah)anthracene (DA)	DA	1.63	1.92	2.12	2.43
Benzo(ghi)perylene (BgP)	BgP	3.76	4.22	4.63	5.39
Total EPA priority PAHs		**252**	**281**	**303**	**284**
Total aromatic compounds		**13972**	**15156**	**16908**	**17305**
Diagnostic Ratios					
2-m-N:1-m-N		1.40	1.40	1.40	1.25
(3-+2-)/(4-/9-+1-m-phen)		0.79	0.79	0.80	0.80
4-:2-/3-:1-m-DBT		0.66:0.33:1.00	0.67:0.35:1.00	0.67:0.34:1.00	0.67:0.34:1.00
(C2D/C2P):(C3D/C3P)		0.75:0.83	0.78:0.8	0.78:0.84	0.77:0.9
C0N:C1N:C2N:C3N:C4N		0.61:1.73:2.42:1.91:1.00	0.97:2.79:3.91:3.1:1.00	0.65:1.94:2.77:2.22:1.00	0.05:0.8:1.95:1.85:1.00
Naphs:Phens:DBTs:Fluors:Chrys		3.55:1.00:0.63:0.54:0.18:0.28:0.11	3.19:1.00:0.64:0.51:0.18:0.27:0.11	3.45:1.00:0.65:0.55:0.19:0.29:0.12	2.4:1.00:0.64:0.52:0.18:0.29:0.11

A review of the changes in aromatics over time is shown in Figure 9.

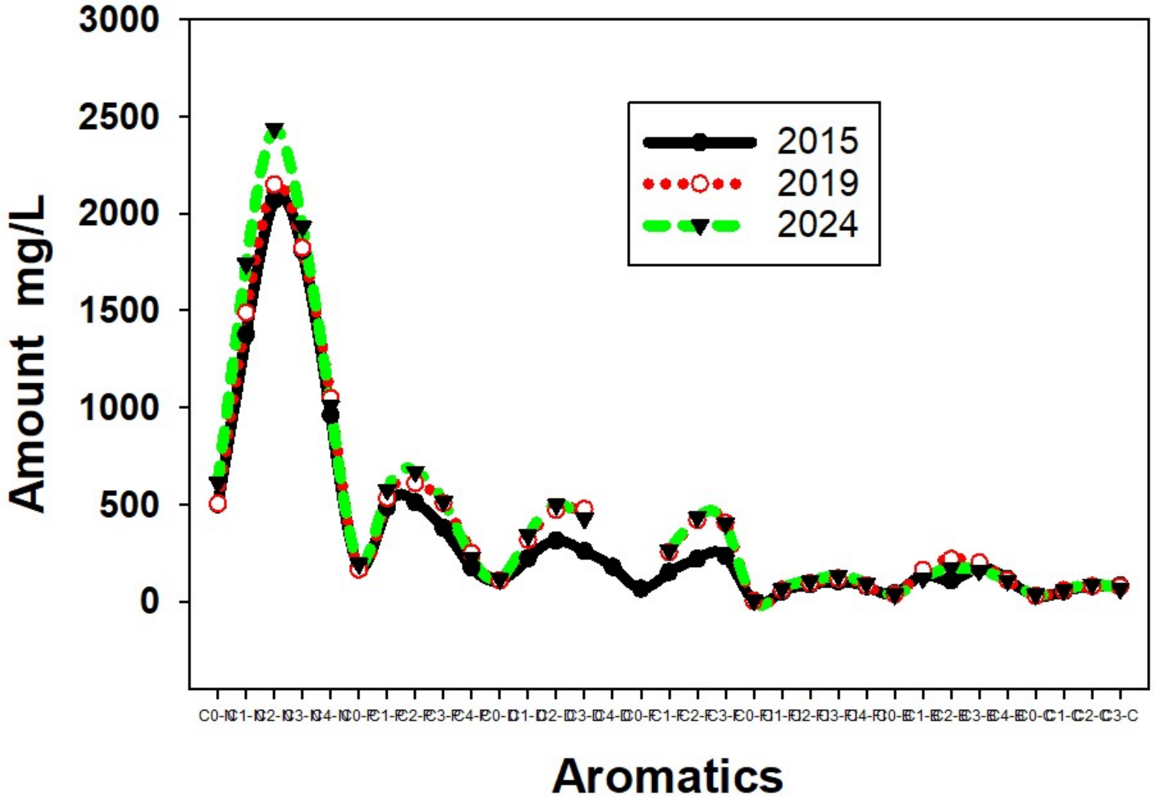

Figure 9. The changes in aromatic compounds over time. The X-axis shows specific compounds. This type of graphing shows only gross changes and individual parameters on the X-axis are hard to differentiate.

Table 12 shows the biomarkers present in ANS oil. Biomarker compounds are typically used to trace unknown oil spill samples. These values as a ratio prove valuable as a tracer of oil in the environment.

A study of the changes in biomarkers over time shows that little change occurs. This is illustrated in Figure 10. Little change in biomarkers occurred in the past 10 years.

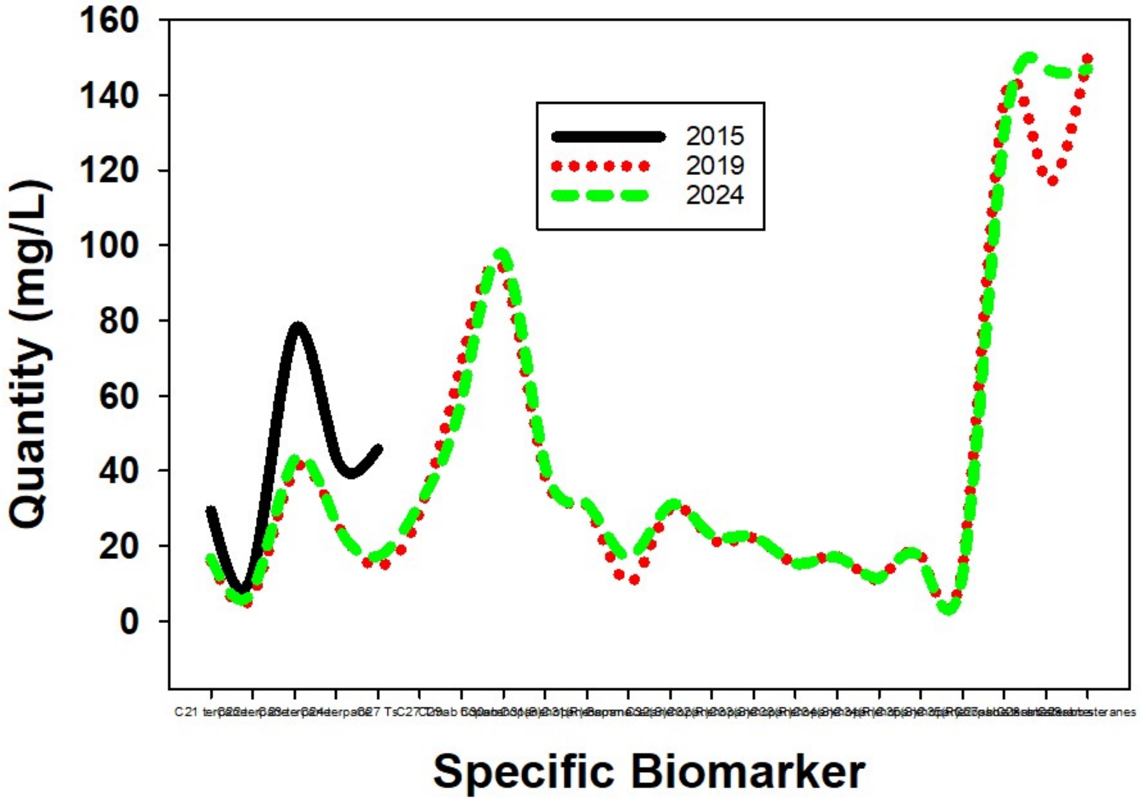

Figure 10. The changes in biomarkers over time. The X-axis shows specific compounds. This type of graphing shows only gross changes and individual parameters on the X-axis are hard to differentiate.

Table 12. Petroleum Biomarker Results for Alaska North Slope Crude Oil [2024]

Sample Description Biomarker Compounds	ANS (Fresh) µg/g oil	ANS W1 (11.92%) µg/g oil	ANS W2 (24.28%) µg/g oil	ANS W3 (36.18%) µg/g oil
C21 terpane	16.6	19.2	21.2	24.1
C22 terpane	8.13	9.53	10.4	14.1
C23 terpane	43.1	65.2	53.5	81.1
C24 terpane	26.1	40.7	31.8	50.5
C27 Ts	17.3	19.9	21.6	28.0
C27 Tm	31.5	35.2	38.9	49.8
C29ab hopane	58.8	65.0	77.0	89.2
C30ab hopane	97.8	110	120	143
C31(S) hopane	41.2	44.6	50.5	60.6
C31(R) hopane	31.3	35.1	37.8	45.7
Gammacerane	16.7	11.7	13.1	13.3
C32(S) hopane	30.9	34.3	38.0	45.0
C32(R) hopane	22.7	25.1	27.3	33.5
C33(S) hopane	22.6	25.0	28.4	33.5
C33(R) hopane	15.3	17.3	19.1	23.0
C34(S) hopane	16.9	18.0	19.8	24.1
C34(R) hopane	11.2	12.4	14.6	16.3
C35(S) hopane	16.9	18.9	20.8	24.8
C35(R) hopane	11.9	13.3	16.9	17.4
C27abb steranes	130	146	158	194
C28abb steranes	147	164	181	220
C29abb steranes	147	164	181	219
Total	**962**	**1095**	**1181**	**1449**

Table 12 ctd. Petroleum Biomarker Results for Alaska North Slope Crude Oil [2024]

Sample Description	**ANS (Fresh)**	**ANS W1 (11.92%)**	**ANS W2 (24.28%)**	**ANS W3 (36.18%)**
Biomarker Compounds	**µg/g oil**	**µg/g oil**	**µg/g oil**	**µg/g oil**
Diagnostic Ratios				
C23/C24	1.65	1.60	1.68	1.60
C23/C30	0.44	0.60	0.44	0.57
C24/C30	0.27	0.37	0.26	0.35
C29/C30	0.60	0.59	0.64	0.62
C31(S)/C31(R)	1.32	1.27	1.34	1.32
C32(S)/C32(R)	1.36	1.37	1.39	1.34
Ts/Tm	0.55	0.57	0.56	0.56
C27abb / C29abb	0.88	0.89	0.88	0.89
C30/(C31+C32+C33+C34+C35)	0.41	0.43	0.42	0.42

4. Dispersant Effectiveness and Prediction

Environment Canada measured the dispersibility using the Swirling Flask test. Results are shown in Table 13. This shows that 2024 ANS crude oil sample is somewhat dispersible until it is weathered. Weathered ANS crude oil is poorly dispersible.

Table 13. Chemical Dispersability

	Weathering	ANS Fresh (0%)	ANS W1 (11.9%)	ANS W2 (24.3%)	ANS W3 (36.2%)
Chemical dispersibility (15 °C)	Swirling Flask	33	22	14	3
	Baffled Flask	90	85	72	67

Environment Canada also measured the dispersibility using the Baffled Flask, results are also shown in Table 13.

The Swirling Flask test has been shown to be discriminating and relatable to field effectiveness (Fingas and Banta, 2009).

The effectiveness of chemical dispersion has declined somewhat over the past 10 years as can be seen in Figure 11.

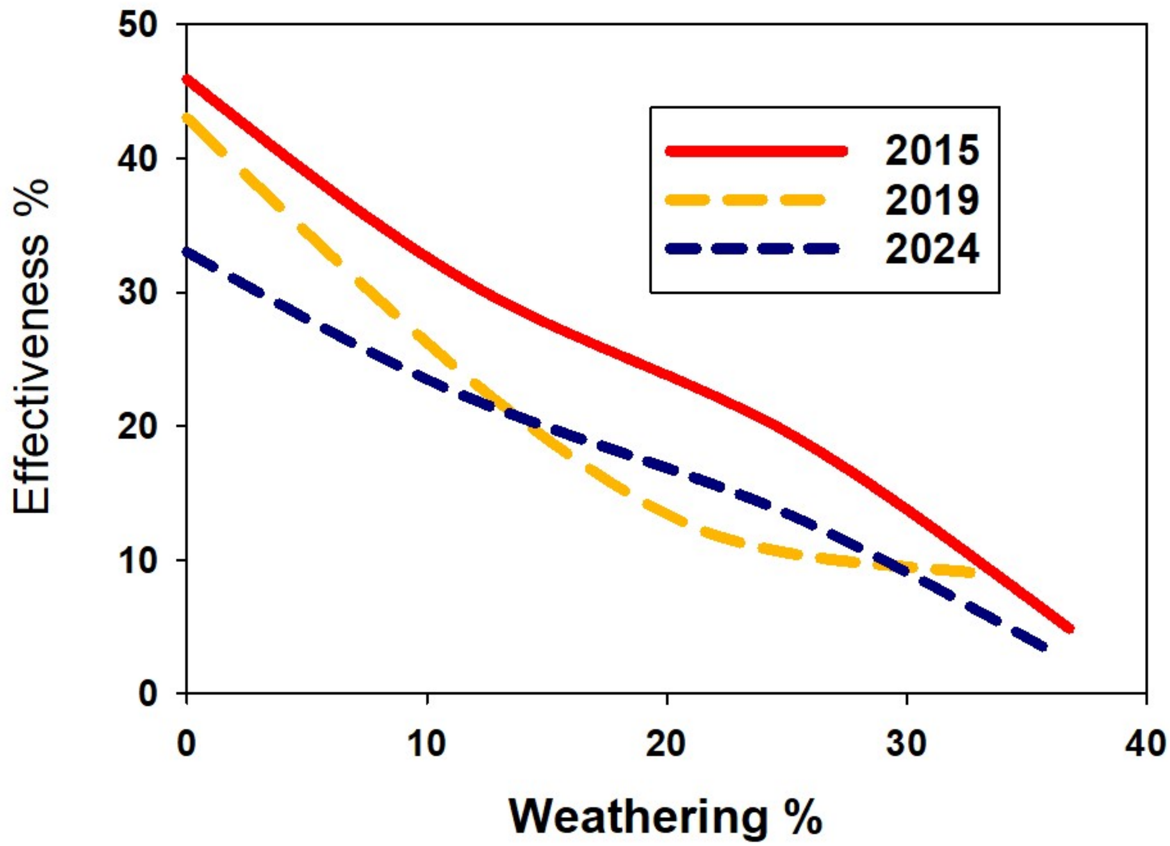

Figure 11. The change in chemical dispersibility of ANS crude oil over the past 10 years.

Oil properties can be correlated with dispersant effectiveness to estimate the amount of oil dispersion. Such correlation could be used to indicate which oil properties, such as asphaltene content, might inhibit or facilitate oil dispersion.

5. Summary

The most important tool in oil spill planning and response is an understanding of oil spill behavior, whether derived directly or through accurate modeling and prediction. Decidedly, the most important data points are for oil spill emulsification, evaporation, chemical dispersibility, and those (such as adhesion and distillation) that might be used to predict the effectiveness of other countermeasures such as recovery and burning. This paper showed that the 2024 ANS oil data from Environment Canada could be used to predict its behavior.

The 2024 emulsion formation predictions show that as a fresh oil, it will not produce a water-in-oil emulsion and that when highly weathered would still not produce an emulsion. This is quite different from older samples (pre-2001) which formed emulsions once weathered.

The dispersibility of the oil is 33% based on the standard Swirling Flask test. This implies the oil is poorly dispersible after weathering.

The oil weathers to about 37% within the standard weathering period of two weeks, which indicates that it is classified as a medium oil. Considering spill countermeasures, this percentage indicates that the oil will have low viscosity (<100 mPa.s) for a few days after spillage. This is important as spill countermeasures effectiveness deteriorates rapidly with increasing viscosity. The 2024 ANS oil can be recovered easier than older ANS oils.

Further, the fate and transport of the 2024 ANS oil would be affected. The lesser viscosity of the 2024 oil means that spills will spread further and faster than they would have in the past. The Exxon Valdez spill was of the older type of crude oil and would have a different fate than if the oil were of the newer type. The oil would have moved out of Prince William Sound faster and spread into the Gulf of Alaska faster.

The chemistry of the oil shows that it is abundant in alkanes and less so in PAHs and especially the more toxic PAHs (such as the multi-ring 5 or greater). This implies that the aquatic toxicity is moderate.

The 2024 ANS crude properties are consistent with the properties of a medium-viscosity crude oil. It should be noted, however, that the oil is much lighter than the past oils samples taken from the Trans Alaska Pipeline System.

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