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A Global Survey of the Incidence of FAME and Microbial Contamination in Marine Distillate Fuels.

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Changes in Marine Fuels

- On 1st Jan 2015 the sulphur limit for marine fuels used inside Emission Control Areas (ECA) reduced from 1.00% to 0.10%.
- Marine fuel specifications currently only allow FAME at *de-minimis* concentration of up to 0.1%.
- FAME is considered a contaminant in marine distillate fuel.
- Ultra Low Sulphur Automotive Diesel (ASTM D975 and EN590) and other middle distillate fuels intended for non-marine use allow Fatty Acid Methyl Esters (FAME) at up to 5 to 7%.
- These fuels are already widely used in Europe, USA and other global regions.
- Due to the complex supply chain and the increasing demand for Ultra Low Sulphur Marine distillate fuels it seems probable that some fuel containing FAME concentrations >0.1% will find their way into the marine fuel supply chain.

Why is FAME in Marine Fuel a concern?

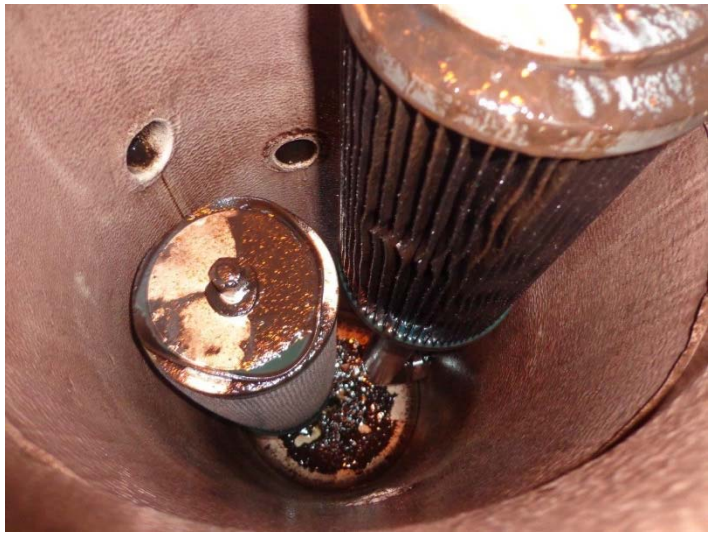
- Poor Oxidation Stability leading to long term storage issues.
- Increased risk of microbial growth.
- Hygroscopic affinity to absorb water.
- Difficulties in maintaining homogenous blends.
- Poor flow characteristics when at low temperatures.
- An increase in the total acid number (TAN) of the fuel.
- Corrosivity to certain materials. Rubber gaskets, hoses & seals may swell.
- FAME sticks to exposed surfaces (metal & glass) including filter elements.

Poor Oxidation Stability

- Distillate fuels containing FAME are more prone to oxidation stability issues.
- For automotive diesels this is usually tolerable due to the high turnover in distribution and use.
  - Diesel is usually burned within a matter of weeks of production
  - No prolonged storage
- However, marine distillate fuels may be stored on-board for prolonged periods.
  - e.g. Ultra low sulphur marine distillate can be bunkered and then stored for use when needed in ECA's.

Poor Oxidation Stability

- Fine black insoluble deposits.
- Poor fuel quality; not fit for use.
- Fuel filter and injector plugging.



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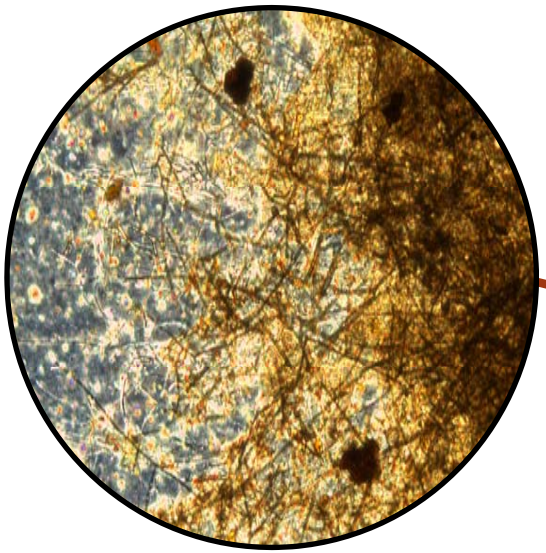
Microbial growth

- Distillate fuels containing FAME are more prone microbial growth.



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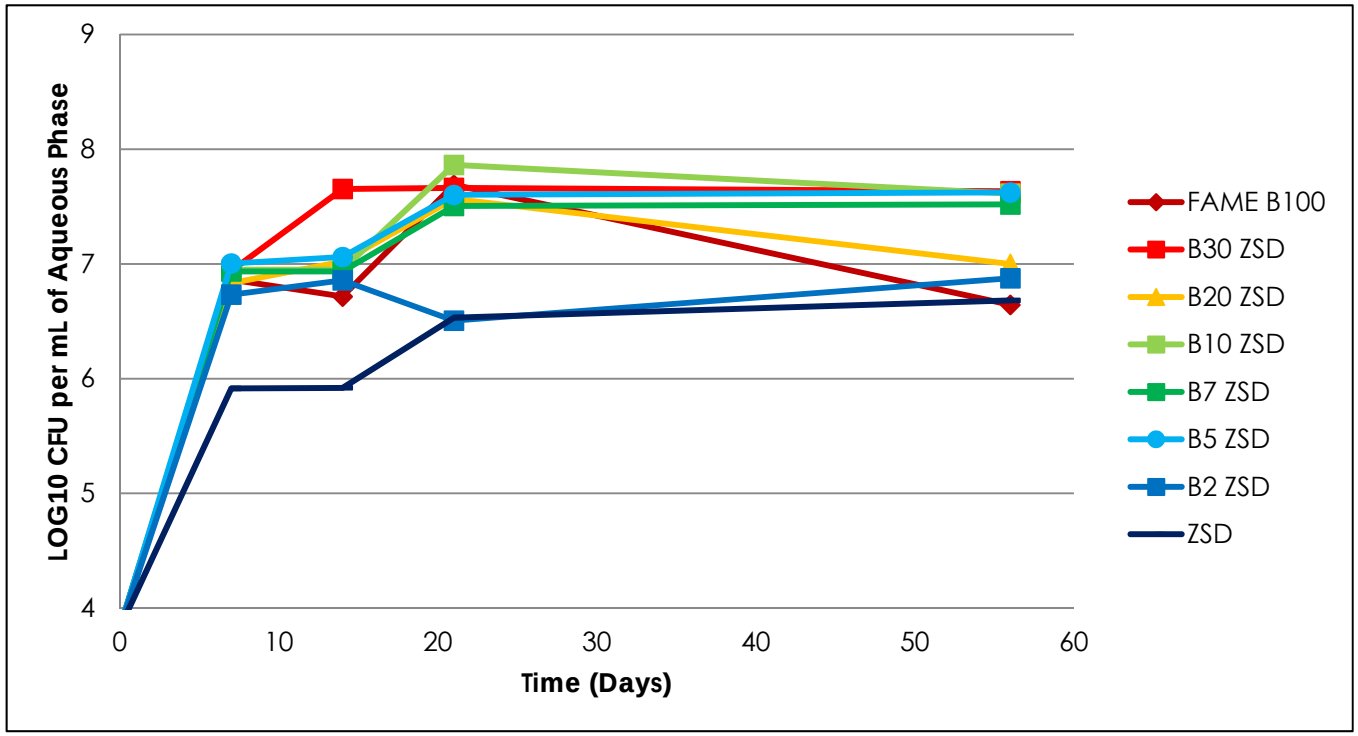
Microbial growth

- Energy Institute (EI) laboratory study showing susceptibility of zero sulphur automotive diesel with various FAME concentrations.



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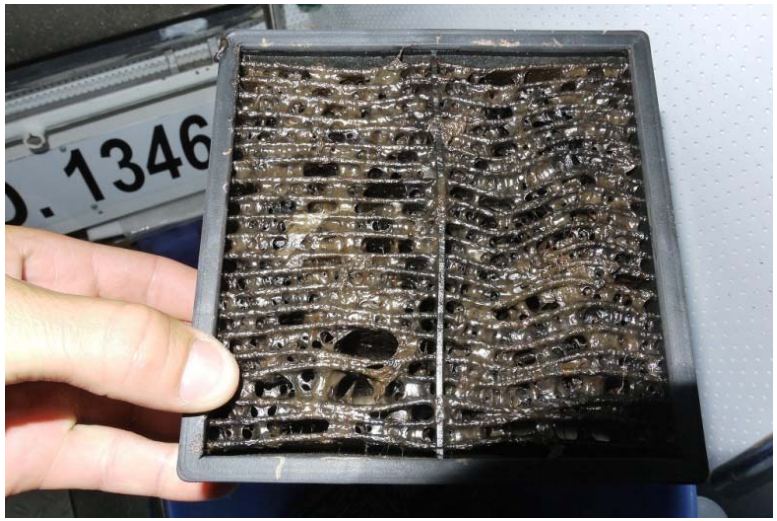
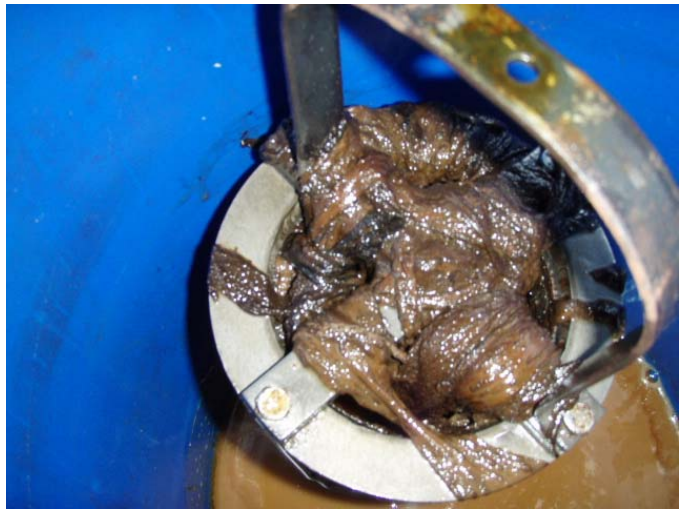
Microbial growth

- EI Lab Study Conclusions
  - Water content in diesel increased with increasing FAME concentration.
  - FAME-free diesels were notably less prone to microbial contamination.
  - Zero sulphur automotive diesel containing ≥2% FAME was significantly more susceptible to microbial growth.
  - The amount of microbial contamination and microbial biomass increased with increasing FAME concentration.

Microbial growth

- Aggregates of soft, organic particulate.
- Acids.
- Poor fuel quality; not fit for use.
- Fuel filter, fuel line and injector plugging.
- Corrosion





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2013/14 FAME Survey

- Joint project conducted by
  - ECHA Microbiology Ltd.
  - Guardian Marine Testing
  - Lloyd's Register Marine, FOBAS

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2013/14 FAME Survey

- Aimed to evaluate the true extent of FAME contamination in marine distillate fuels.
- 2346 samples tested over a period of 3 months.
- Derived from a wide range of ports, suppliers & barges and considered to represent a good overview of the global market.

Test methods

- ISO 8217 specification
  - All samples were tested for compliance with ISO 8217 DMA specification requirement.

Test methods

- FAME Screening test
  - All samples were screened by a GMT in-house FTIR (infra-red) method for presence of FAME.
  - "Go / no-go" method which can be used to routinely screen samples for FAME quickly and cost efficiently.
  - Limit of detection is 0.50% v/v.

Test methods

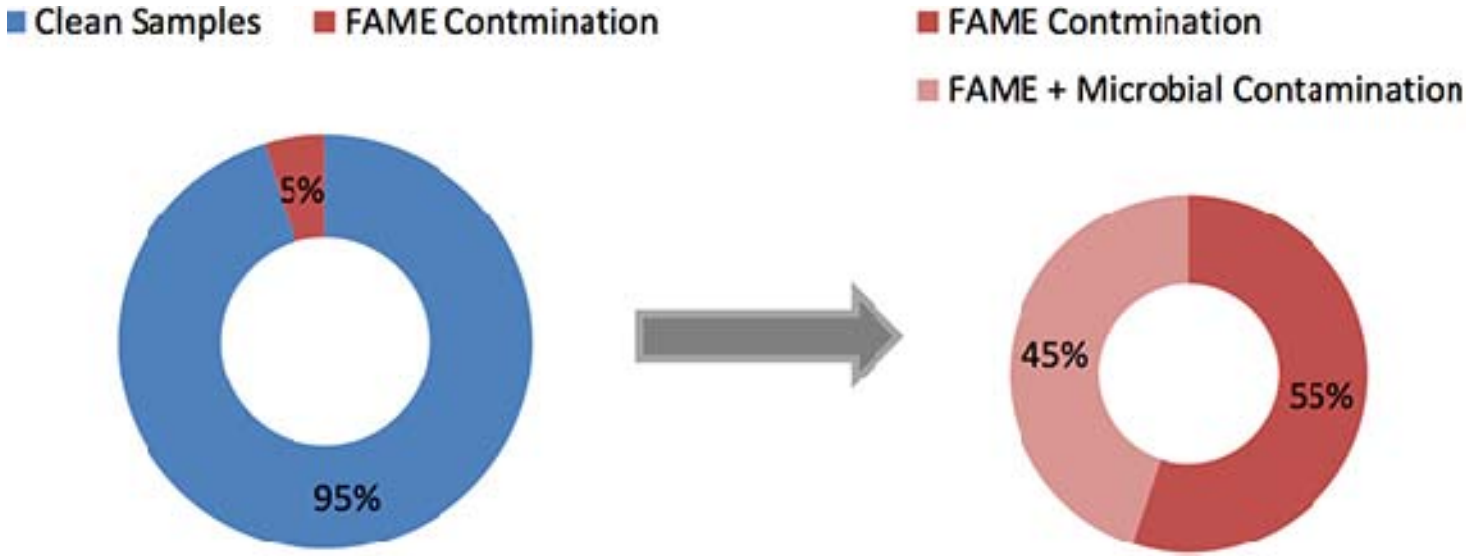
- Quantitative FAME test
  - Screened samples which contained >0.5% FAME were tested by reference method EN 14078:2009 (infrared spectrometry) to accurately quantify the level of FAME contamination.
  - EN 14078:2009 is the recognised method for the quantitative detection of FAME as stipulated in the ISO 8217 marine fuel specification.

Test methods

- Microbial contamination & Water content
  - Screened samples which contained >0.5% FAME, plus 32 randomly selected "FAME-free" samples, were also tested for;
    - Viable microbial content by IP 613 / ASTM D7978.
    - Water content by Karl Fisher analysis (ASTM D6304).

Results - Incidence of FAME and Microbial Contamination

- 1 in 20 (5%) of all samples tested positive for FAME contamination (>0.5% v/v FAME).
- Almost 45% of the FAME contaminated samples also contained microbial contamination at some level.
  - i.e. Approx. 1 in 45 (2.2%) of all samples tested positive for both FAME AND microbial contamination.



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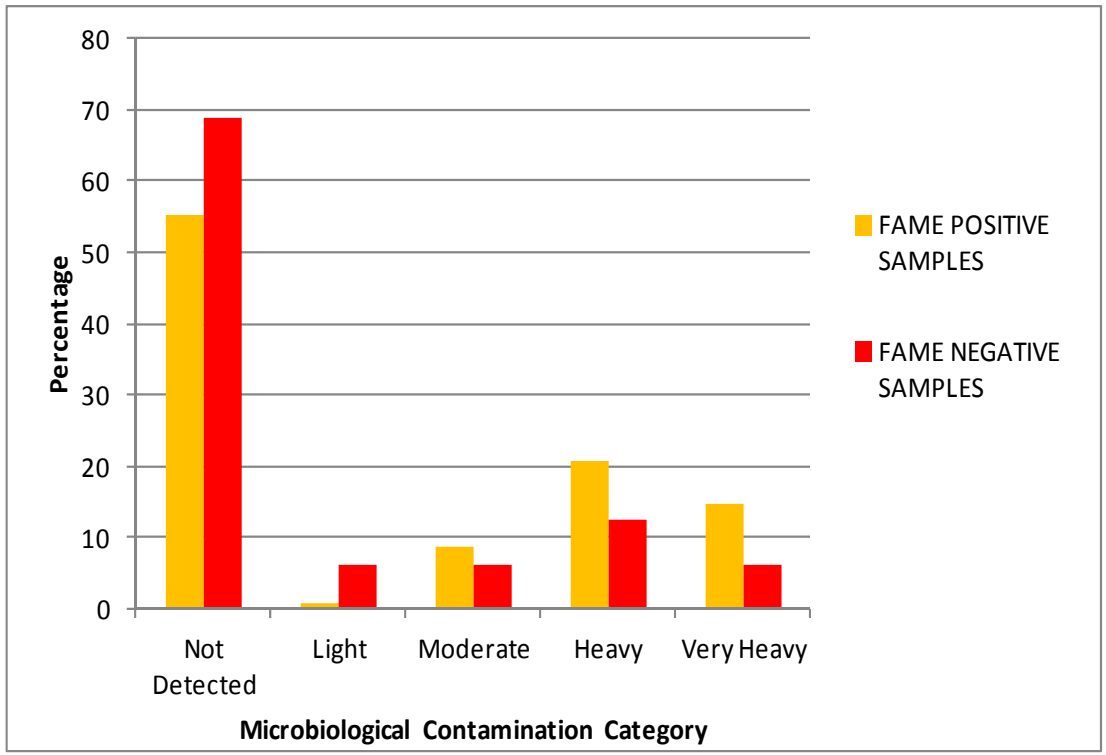
Results - Incidence of FAME and Microbial Contamination

- Level of microbial contamination for FAME "positive" (>0.5% FAME) and FAME "negative" samples.



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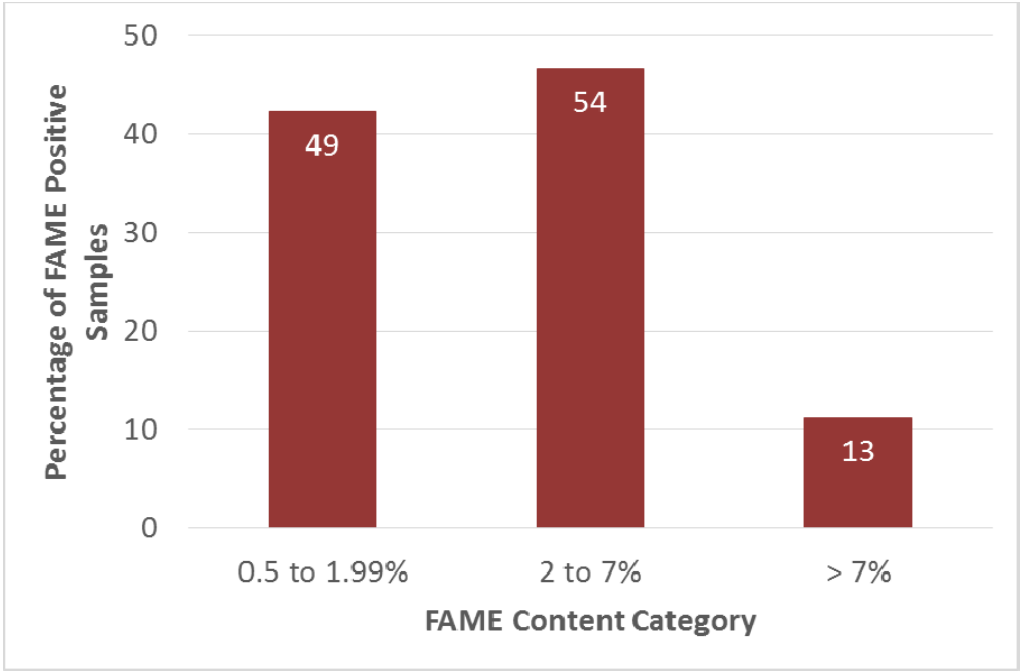
Results - % FAME Content

- % FAME content in FAME contaminated samples.



- The highest concentration of FAME detected was 57 %!

* Included in the 0.5 – 1.99% category are a few samples which tested positive for FAME on screening but on quantitative testing showed just under 0.5% FAME present.

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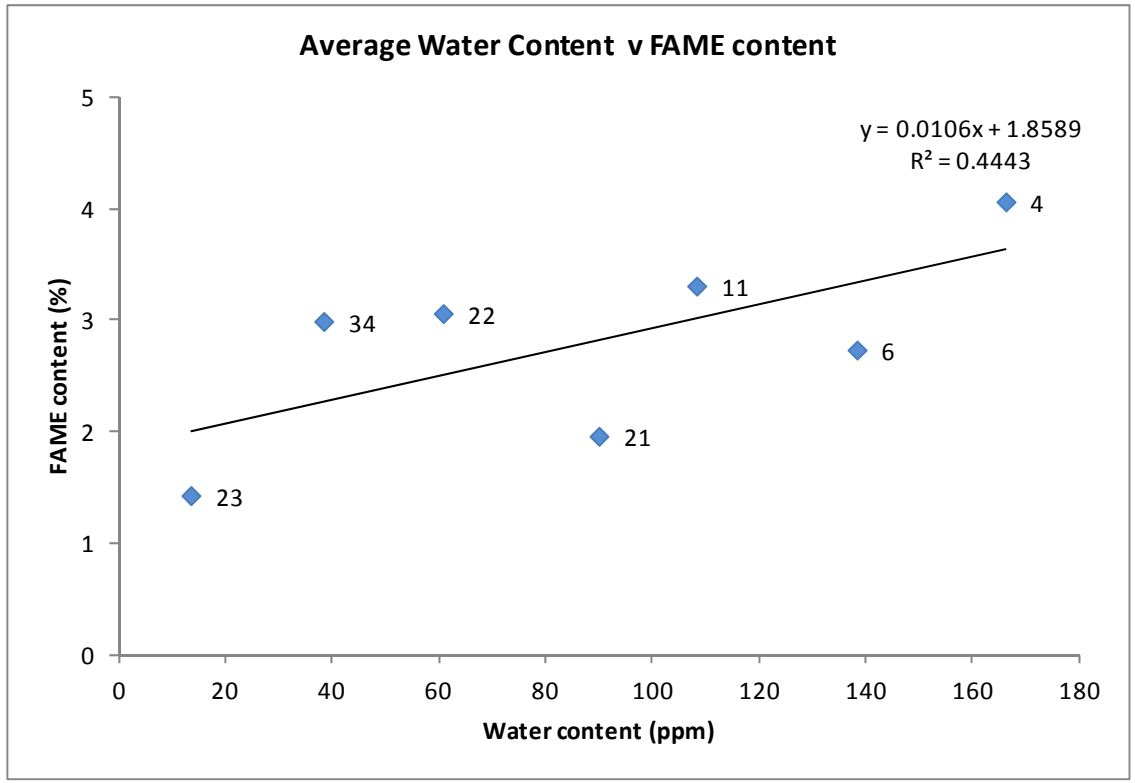
Results – FAME vs Water Content

- Correlation found between increasing FAME and water content.
- The higher FAME content, the higher water content.
- It is well recognised that excessively high water content in distillate fuels can promote contamination of the fuel with microorganisms.



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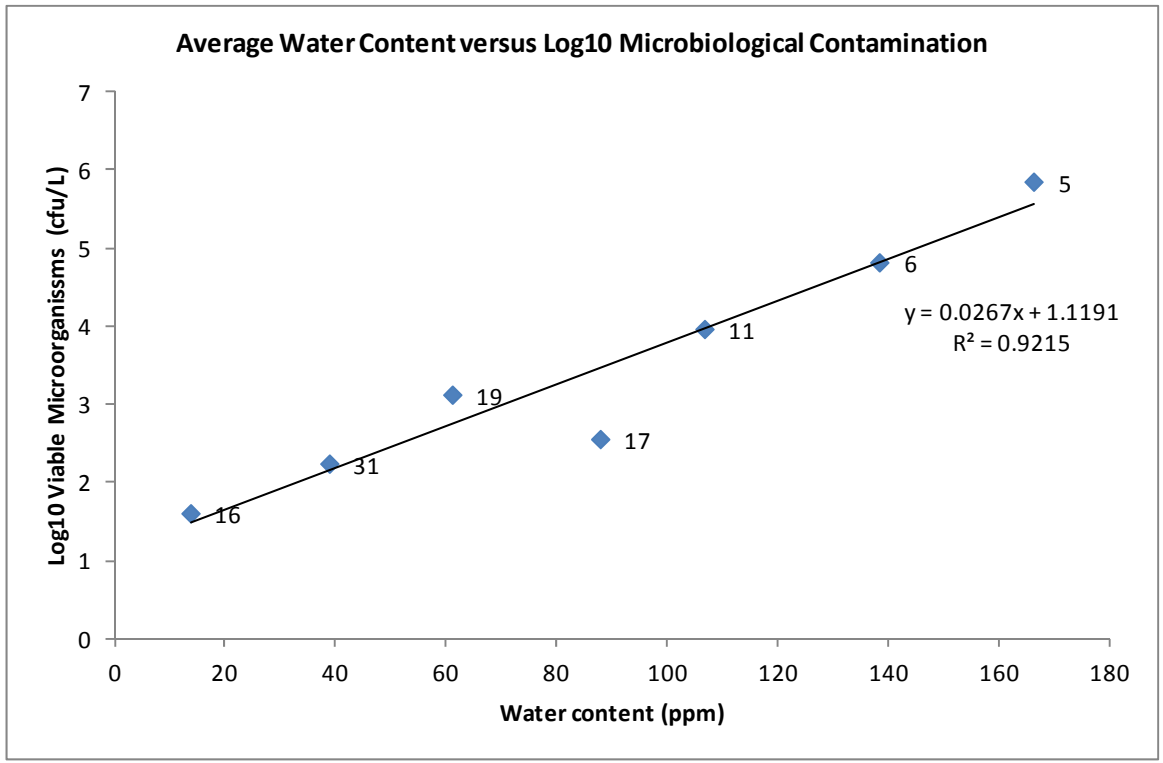
Results – Water Content vs Microbial Content

- For all samples with a notable water content (>20 ppm), there was a strong correlation between numbers of viable microorganisms and water content.
- The higher water content, the higher viable microbe count.
- This was irrespective of FAME being present in the samples.



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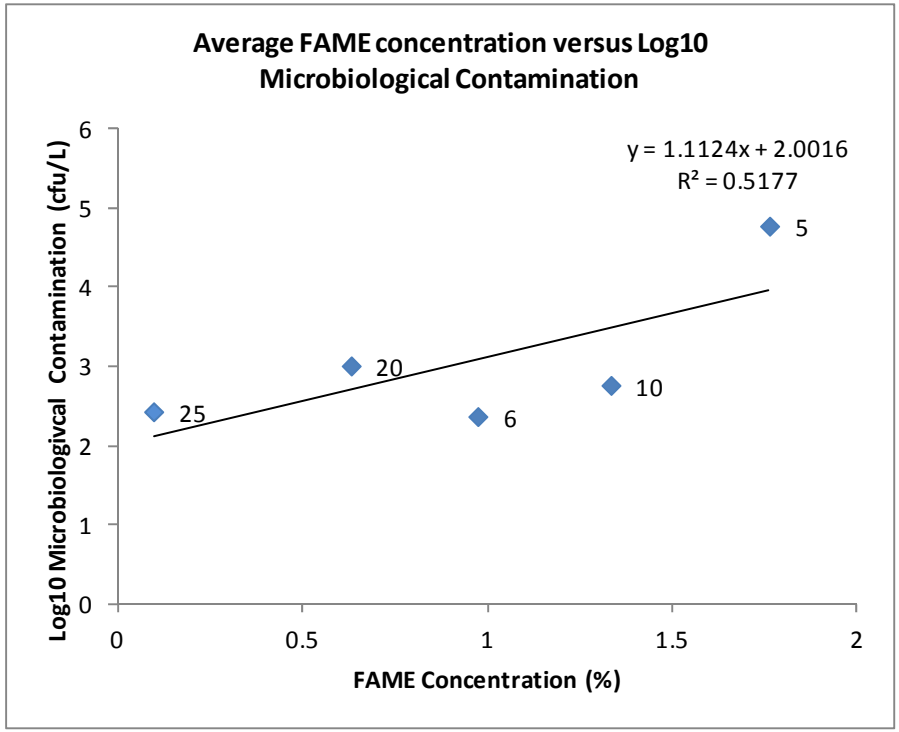
Results – FAME Content vs Microbial Content

- Marine distillate fuel containing FAME was found to be more likely to contain viable microorganisms, irrespective of the numbers of microorganisms determined.
- Over the full range of FAME concentrations detected there was no direct correlation between the **numbers** of viable microorganisms and FAME concentration.
- However, correlation was found in samples containing between 0 and 2 % FAME; the higher FAME content, the higher viable microbe count.



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Results –FAME Content by Region

- The data shows that FAME contamination in marine fuels varied by region, but was found to be most prevalent in Asia, Southern Europe and Western Africa.

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Conclusions

- The results from the joint study indicate that, on current trends, the risk of receiving FAME and/or microbial contamination should be taken seriously.
- Depending on trading patterns, some vessels are more susceptible to the supply of contaminated fuels than others.
- The changes to Sulphur regulation in Emission Control Areas (ECAs) will increase demand of marine distillates and are expected to affect the quality of fuels available for supply in these regions.
- There are specific recommended measures which are required when handling fuels which contain FAME or microbes.
- Ship owners/operators should seek guidance in such circumstances.
  - CIMAC (the International Council on Combustion Engines) have released a guide to ship owners on what to expect and what precautions to take.

Thank You

QUESTIONS?

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