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ICORR ABERDEEN BRANCH WELCOMES

Introduction to Oilfield Microbiology

Presented By Dr Carol Devine,

Consultant Microbiologist

ICR. Integrity Monitoring Business Unit

ICR.

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ICR. INTEGRITY AND MAINTENANCE SOLUTIONS

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ICR is committed to delivering **smarter integrated solutions** to support clients with **maintenance and integrity** related challenges.

We provide a wide range of products, services and technologies all of which support **safe** operations**,** production **uptime** and operational cost **efficiency** at every stage of the asset lifecycle with a particular focus on **preservation**, **inspection** and **repair**.

Integrated solutions include:

- Weldless connections
- Chemical Injection solutions
- Specialist Onsite Machining
- Integrity Monitoring
- Engineered Composite Repairs

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ICR. JOURNEY

2009

JUNE
Walker Technical management buy-in

2011

JULY
Formation of ICR Integrity Ltd

OCTOBER
Acquisition of NECE

2012

AUGUST
JV in Australia - IC Integrity
Acquisition of MOSS

NOVEMBER
Creation of ICR Gulf

DECEMBER
Acquisition of CIU

2014

OCTOBER
Acquisition of Quickflange

2016

OCTOBER
ICR Norway formed

2017

JUNE
ICR Integrity Ltd becomes legal trading entity

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CHEMICAL INJECTION SOLUTIONS

SPECIALISED MACHINING SOLUTIONS

INTEGRITY MONITORING SOLUTIONS

WELDLESS CONNECTION SOLUTIONS

ENGINEERED COMPOSITE SOLUTIONS

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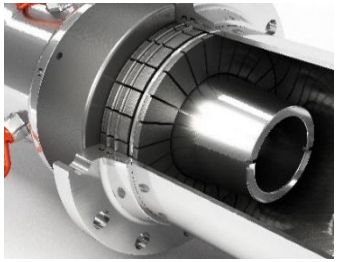
Weld-less Connection



quickflange

Technology for piping and flange repairs and modifications avoiding hot work.

- Patented, permanent pipe-to-flange connection
- Site technicians and training
- Localised joint testing
- Size and pressure ratings for most applications
- No hot work required

Chemical Injection

CIU

Specialist provider of chemical injection and metering pump units and associated equipment.

- Equipment rental and sales
- Maintenance and repair
- Extensive rental fleet
- Bespoke engineered solutions
- Offshore services

Engineered Machining

moss

Mechanical On-Site Services. Provider of all types of specialist on-site machining.

- Hydraulic bolt tensioning
- Cold repair system - No hot work
- Spark erosion services
- Engineering support

Integrity Monitoring

nece

Complete integrity monitoring services to help maintain assets, reducing risk and ensure productivity.

- Corrosion monitoring
- Oilfield microbiology
- Thermography
- Chemical monitoring
- Sand monitoring
- Rental equipment
- Data management
- Optical gas detection

Composite Engineering

WALKER TECHNICAL

Composite repair solutions for a wide range of pipework, pipeline and structural integrity issues.

- Cold repair systems and no hot work required
- Application to live systems with no impact on production
- Exceptional strength and adaptability
- Long term alternative to steel replacement

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Dr CAROL DEVINE,
CONSULTANT MICROBIOLOGIST

- BSc in Microbiology, University of Aberdeen
- PhD in Subsurface Molecular Microbial Ecology
- Commercial Microbiology - Intertek for 11 years
- **ICR.** (formerly NECE) for 6 years

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CORROSION MONITORING & MICROBIOLOGY

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- Introduction to Oilfield Microbiology
- Microbiological Issues
- Systems
- Samples
- Analytical Techniques
- Data Trending

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CORROSION AWARENESS DAY 2017

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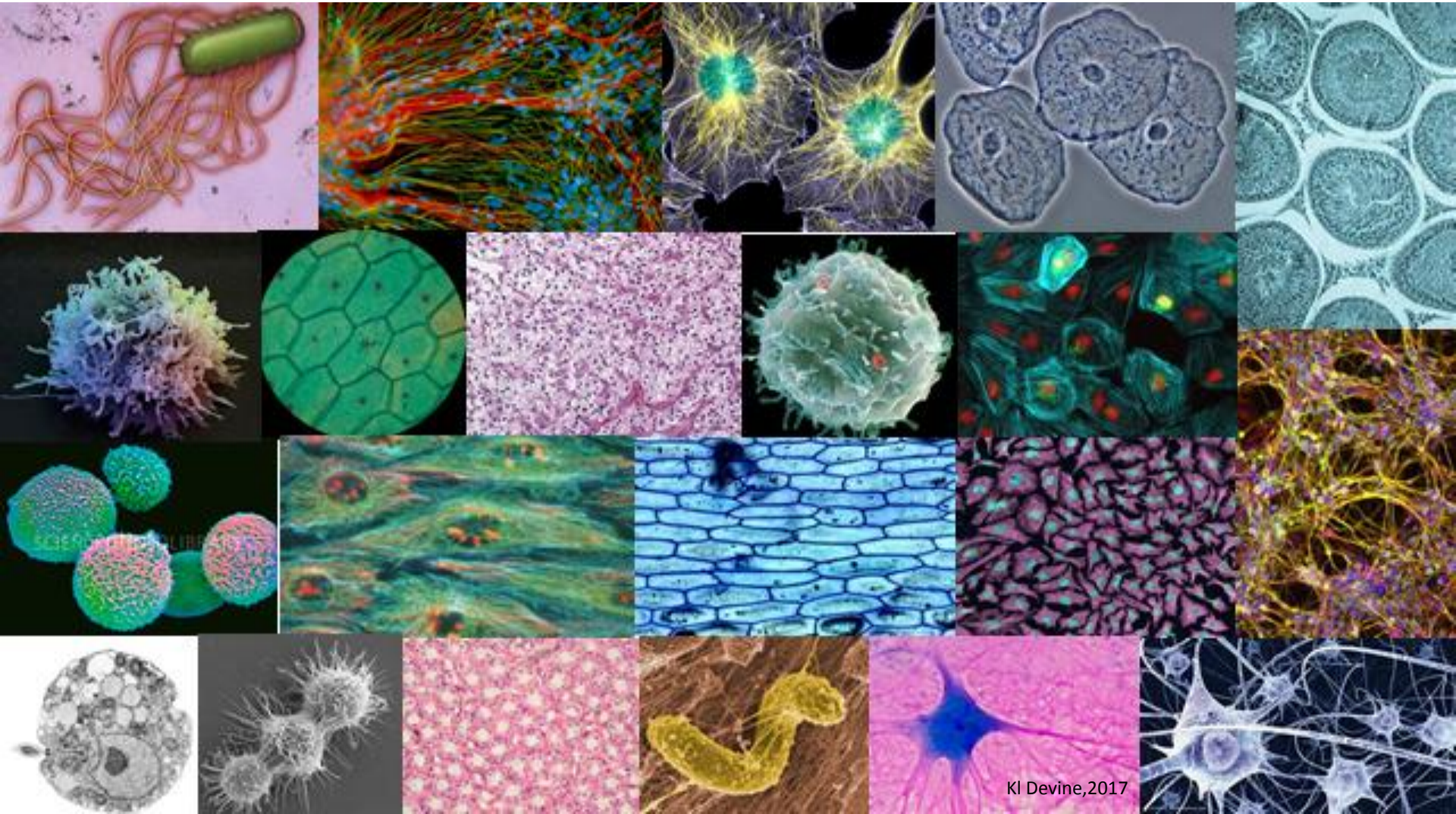

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CORROSION AWARENESS DAY 2017

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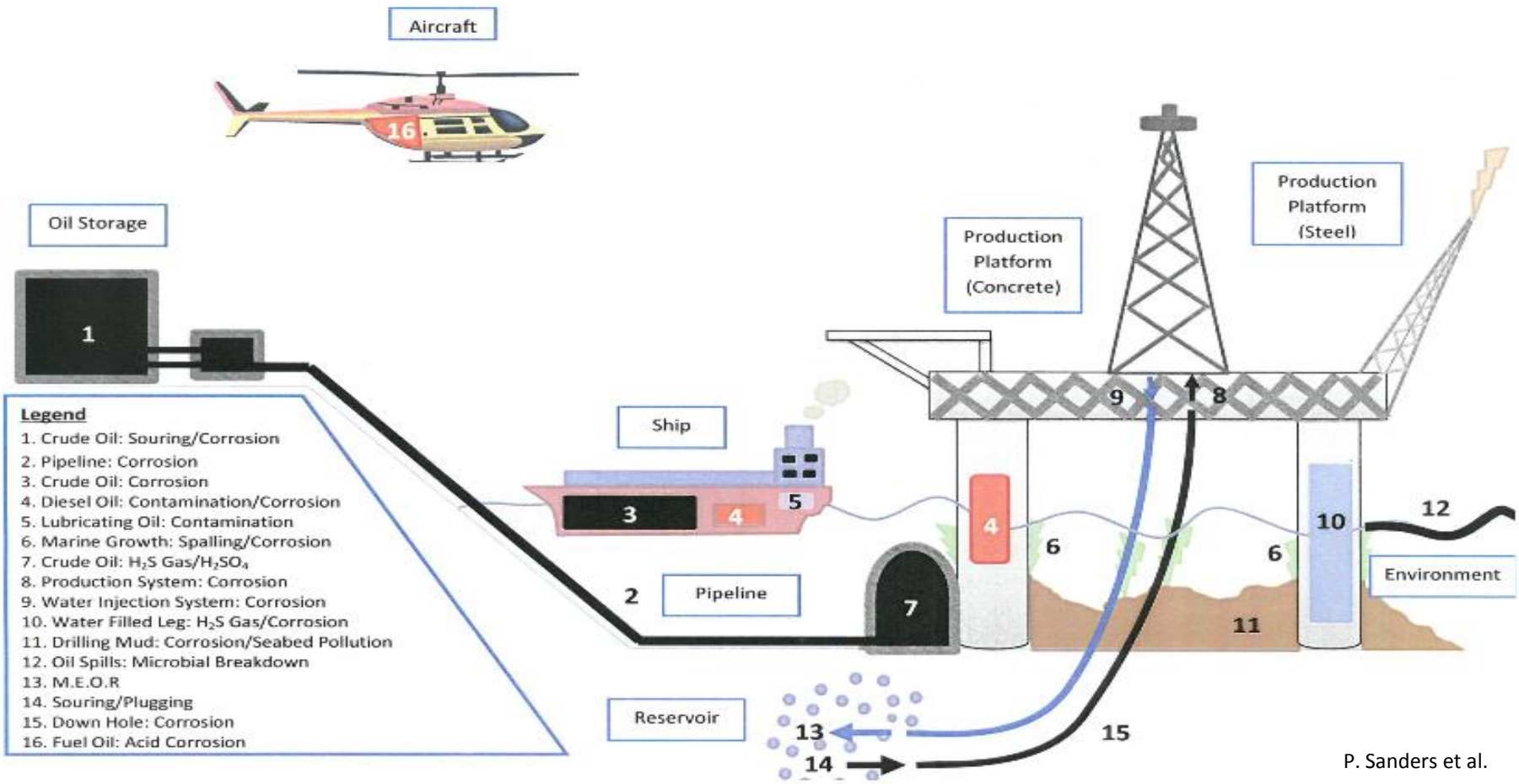

P. Sanders et al.

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CORROSION AWARENESS DAY 2017

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MICROBIAL ISSUES

- Biofouling
- Reservoir souring
- Microbiologically influenced corrosion (MIC)

MITIGATION STRATEGIES

- Biofouling – filtration, chlorination and biociding
- Souring – above plus sulphate removal or nitrate injection
- MIC – filtration, chlorination, biociding – and pigging

OILFIELD MICROBIOLOGISTS

The aim of the oilfield microbiologist is to generate useful and appropriate data in order to:

- **Predict** which particular systems, vessels, pipelines, locations are under threat from microbiologically influenced corrosion (MIC)
- **Prioritise** areas for treatment according to budget and time available
- **Apply** and monitor appropriate strategies to mitigate against the effects of MIC

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SYSTEMS

- Production
- Water Injection
- Produced Water Reinjection (PWRI)
- Ballast water
- Seawater Cooling
- Cooling/heating
- Firewater
- Diesel storage and distribution

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SAMPLES

Two main types of samples:

Planktonic – water, crude, diesel, cooling medium

Sessile – biofilm from coupons, bio-sidestreams and/or other intrusive devices

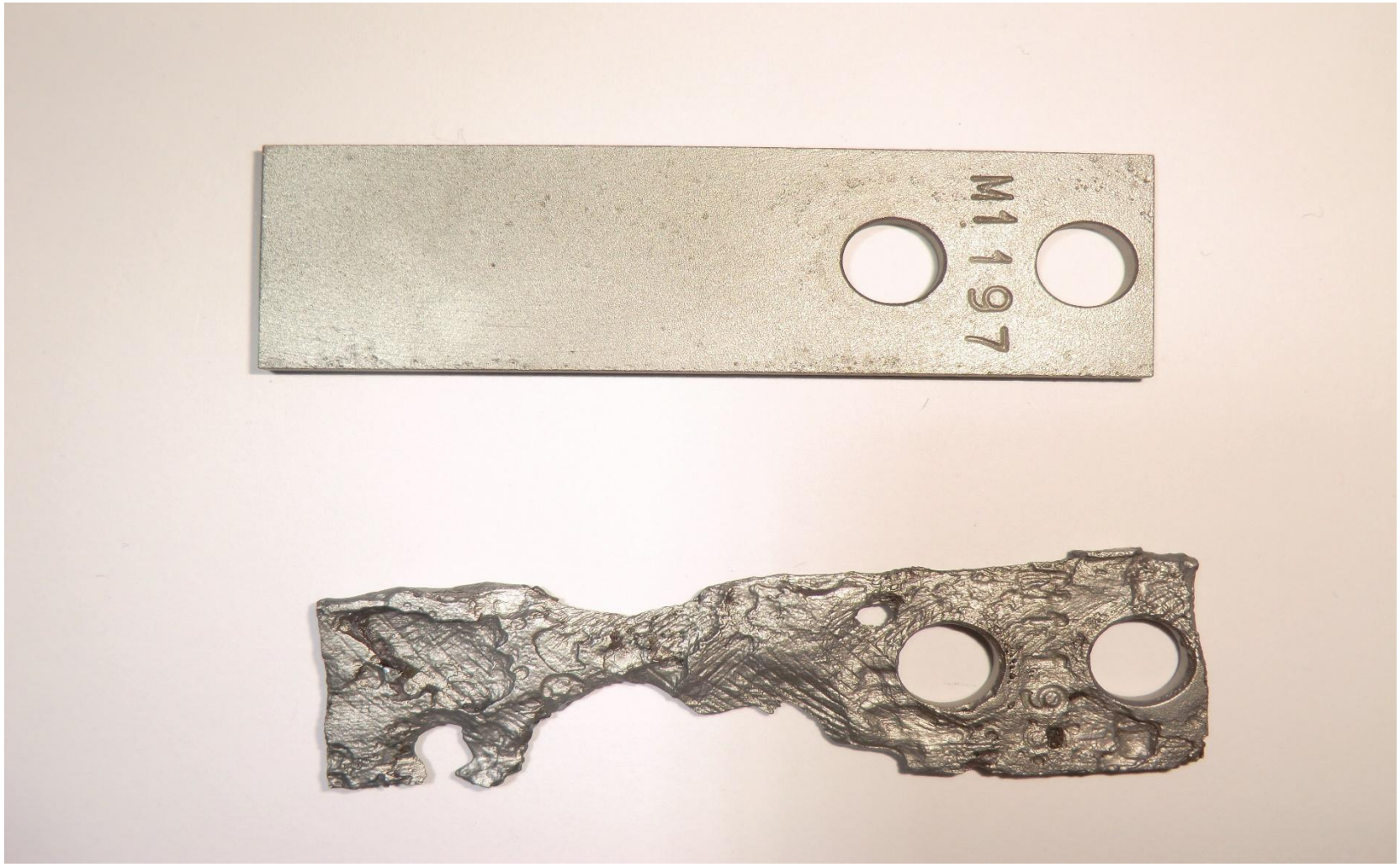
SESSILE SAMPLES - COUPONS

Direct system exposure

Sessile Microbial Samples and Weight Loss analysis

FLUSH DISC & STRIP COUPONS

3” STRIP COUPONS



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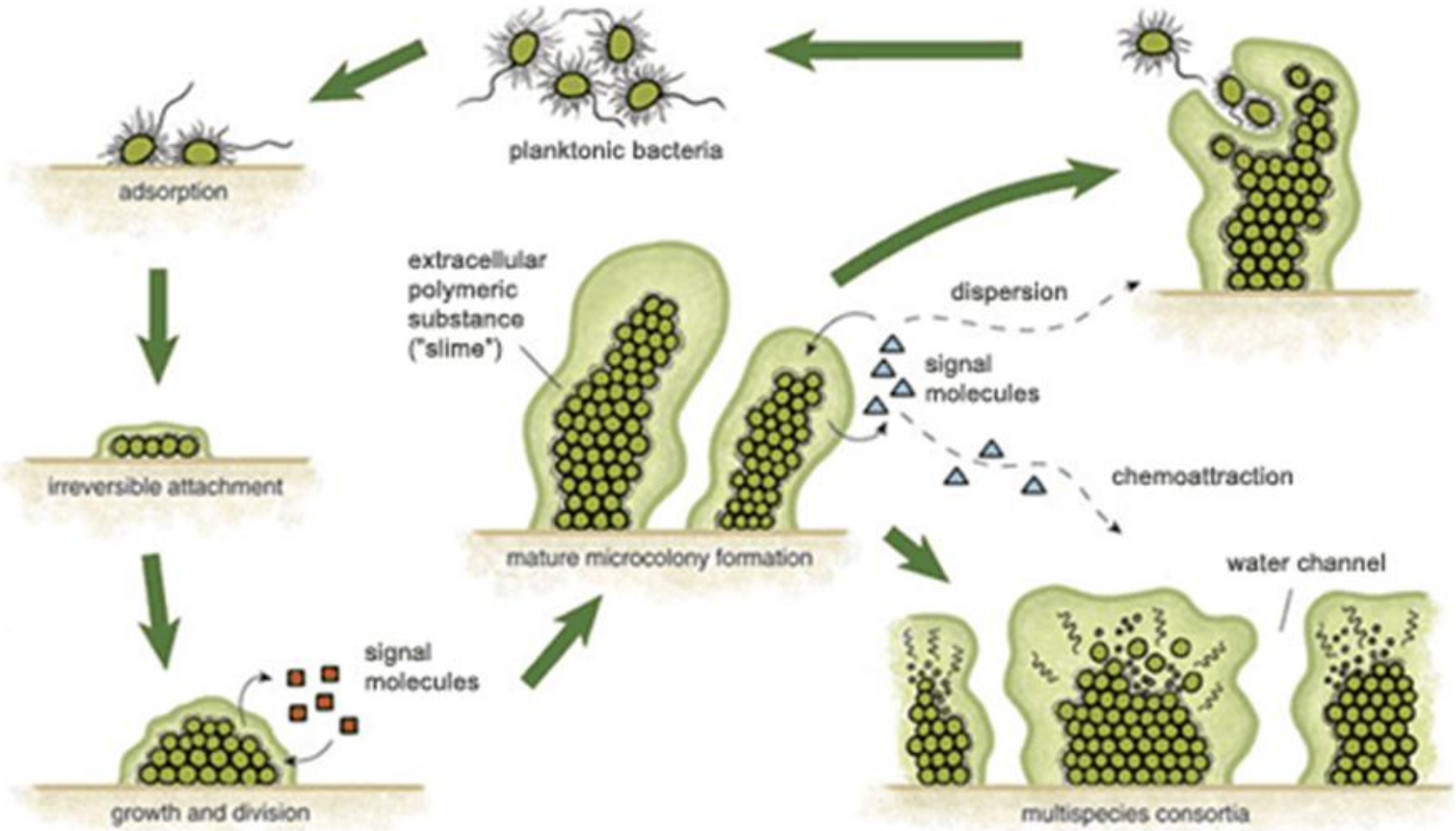
BIOFILM GROWTH & DISPERSION



MICROBES & MACROBES

Production

Originally clean - but now contaminated with indigenous reservoir micro-organisms, plus contamination from injected seawater and from chemicals injected over the years.
Those microbes most suited to the environment will proliferate.

Seawater Injection

High levels of microbes and macrobes in seawater from psychrophiles to extreme thermophiles.
Main control regime is chlorination, with filtration and organic biocide treatments downstream of the D/A.
Poor water quality means a high threat of corrosion with high populations of a diverse microflora being injected into the reservoir = accelerated reservoir souring.

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DEAERATOR – POOR WATER QUALITY

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ALGAL BLOOM, SCOTTISH COAST

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ANALYTICAL TECHNIQUES

Choice depends on what you are looking for – and on the budget!

Three groups of microbes – **archaea**, **bacteria** and **eukaryotes**

MIC is a highly complex microbial process which is thought to involve:

- sulphate-reducing bacteria
- sulphate-reducing archaea
- methanogens
- acid-producing general heterotrophic bacteria (APB)
- iron utilising bacteria
- (general heterotrophic bacteria)

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VIABLE CELL COUNTS

1. Triplicate MPNs

- Can detect a variety of active microbes
- Can be performed in field by trained personnel
- Vast body of historic data

- Media must match the conditions of the environment the sample comes from i.e., temperature and salinity
- Detects less than 5% of the total community
- SRB incubation period is 28 days

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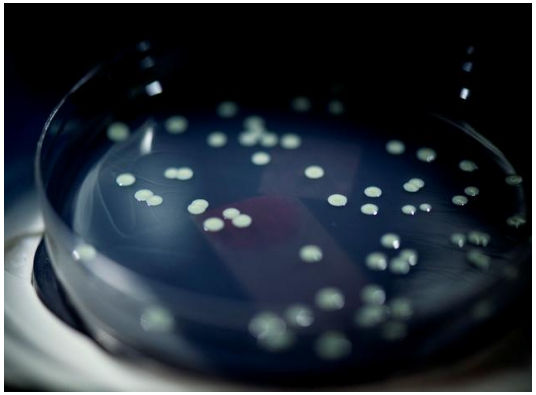
VIABLE CELL COUNTS

2. Plate counts

- Can detect a variety of active microbes
- Difficult to perform in the field/offshore as plates do not travel well
- Need sterile anaerobic chambers to incubate plates for anaerobic bacteria
- Routinely used for diesel analysis, potable water monitoring and Legionella counts



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MOLECULAR TECHNIQUES

1. qPCR

- A laboratory technique based on the polymerase chain reaction
- Used to amplify and simultaneously quantify a targeted DNA molecule
- The cells are lysed and a chemical reaction set up where the DNA is amplified exponentially
- A DNA-binding dye binds to all double-stranded (ds)DNA in the PCR reaction, causing fluorescence of the dye
- An increase in DNA product therefore leads to an increase in fluorescence
- Allows DNA concentrations to be quantified and the number of cells present in the original sample to be estimated.

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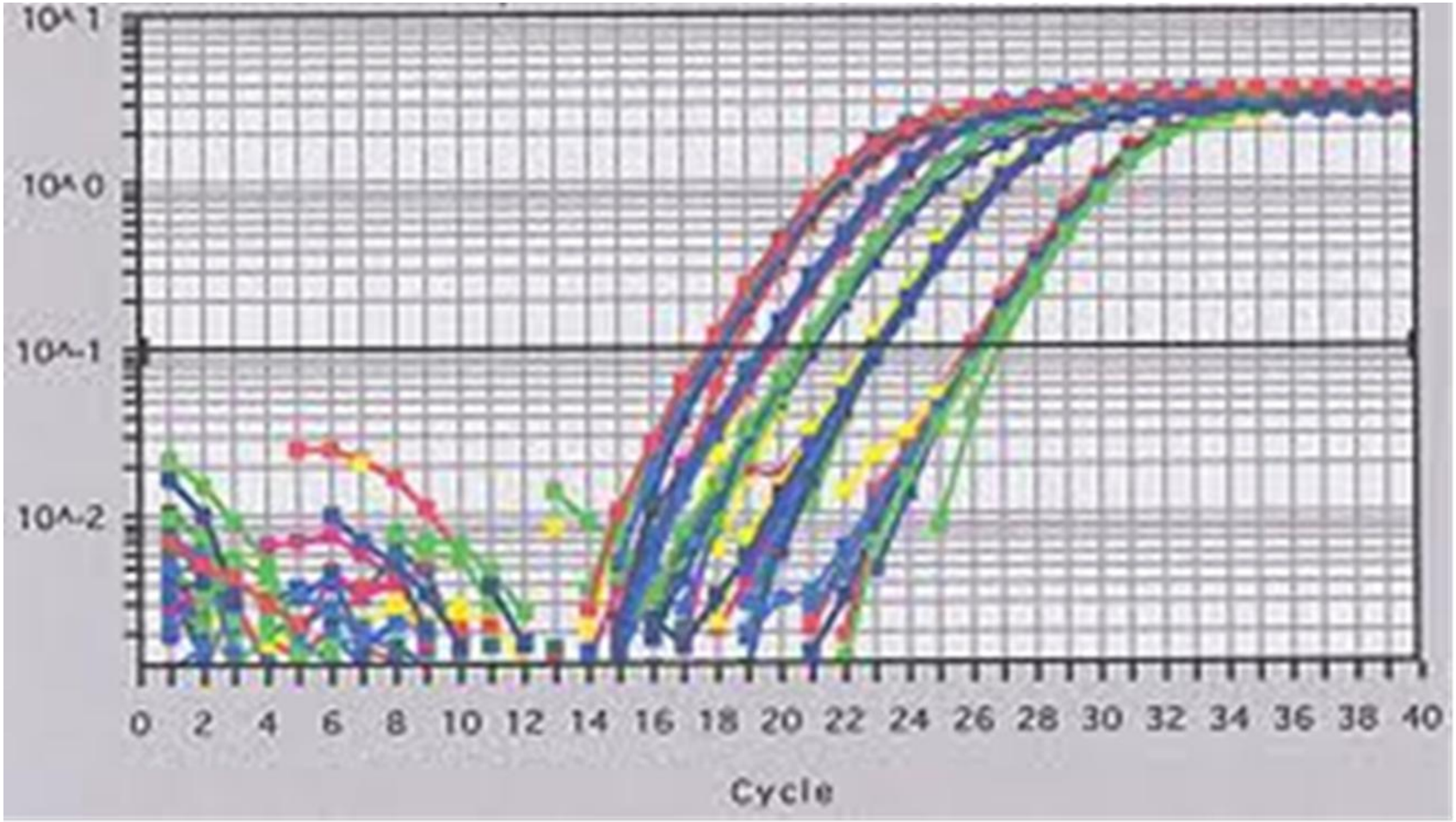
qPCR - AMPLIFICATION



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MOLECULAR TECHNIQUES

2. FISH

- A laboratory technique based on fluorescent microscopy
- Sample is fixed on site and fixative must be fresh
- In the lab, a DNA dye called DAPI, is added to give a 'Total Cell Count'
- A DNA probe (a short section of nucleic acid labelled with a fluorescent dye) is added and hybridised to the nucleic acid in the target bacteria
- The cells are viewed under a UV microscope

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FLUORESCENT *IN-SITU* HYBRIDISATION (FISH)

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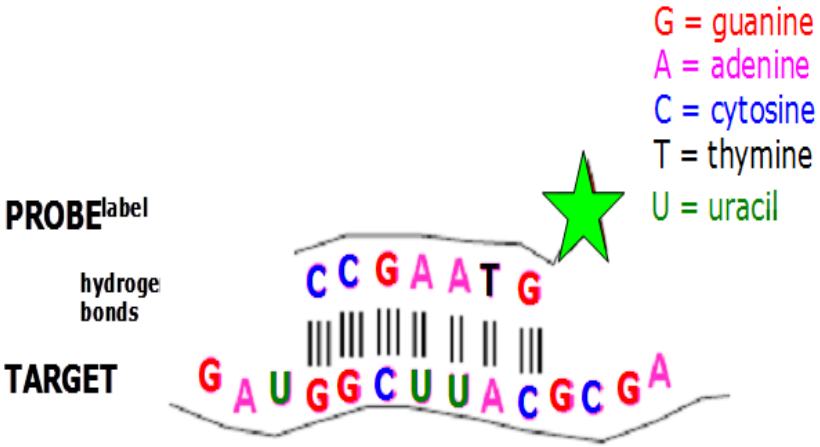

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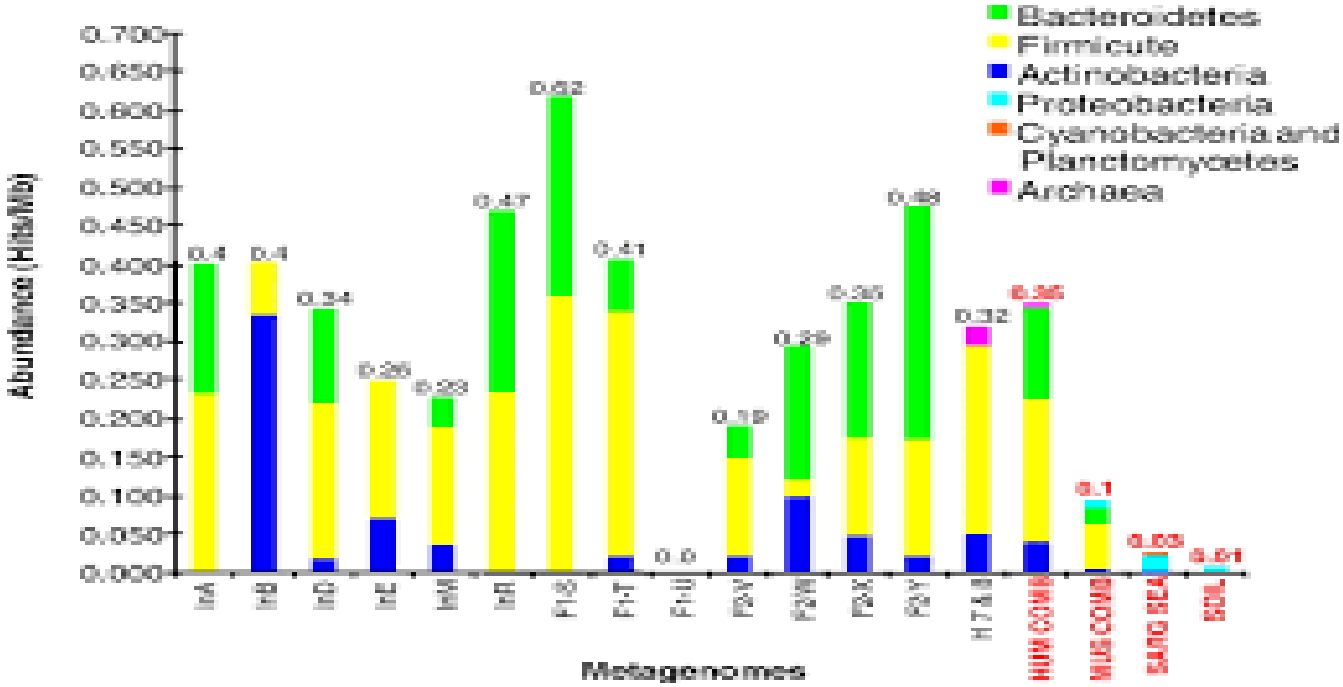
METAGENOMICS

- Application of New Generation Sequencing to characterise the total microbial community
- Identifies all micro-organisms



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ATP TESTING

- Tests for actively growing cells
- ATP (adenosine triphosphate) plus Luciferase = light
- Results in relative light units is proportional to the quantity of ATP
- Non specific test designed for clean systems

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ADVANTAGES & DISADVANTAGES

Advantages (over traditional methods for bacterial enumeration)

- Speed
- Accuracy
- Picks up viable non-culturable cells and archaea
- Can determine which genera and species of bacteria are present
- Relatively easy to take, preserve and ship samples

Disadvantages

- Accuracy
- Cost
- Has to be carried out in the lab
- Samples should be kept chilled during shipping
- Cannot be carried out by offshore chemists (need skilled technicians and expensive equipment)

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TESTING & TECHNIQUES

Testing for : sulphate-reducing prokaryotes (SRB)
general heterotrophs
acid-producing bacteria
nitrite-reducing bacteria
bacteria and fungi in diesels
nitrate-reducing bacteria

sulphate-reducing archaebacteria (SRA)
archaebacteria
methanogens

Techniques: traditional viable counts (MPNs)
molecular techniques – qPCR, FISH, DAPI,

Chemistry: pH, sulphide, bisulphite, Volatile Fatty Acids (VFAs), chlorine residuals, total iron, nitrite, nitrate etc

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SAMPLES FROM A FIREWATER SYSTEM

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DATA TRENDING

WORKSCOPE System	Current status	Actions required
PRODUCTION	Moderate to high planktonic SRB, low to moderate sessile SRB with low corrosion and moderate pitting rates. Risk of MIC.	**Regular kill dose of biocide required. Post biocide planktonic samples should sent in for analysis.**
WATER TREATMENT VESSELS	Moderate thermophilic SRB at Vessel B water outlet, low numbers at the remaining locations. Low sulphide levels. SRB growth and activity still occurring across vessels with a high risk of MIC.	**Close monitoring required as early intervention may be required to ensure control is maintained.**
DRAINS	Low thermophilic SRB in *Closed Drains*, moderate sulphide levels measured. Low risk of contamination being recirculated and of MIC	**No immediate action currently required. Regular monitoring should be maintained.**
WATER INJECTION	Low planktonic and sessile SRB numbers, sulphide levels below detection limit. Moderate to high corrosion and pitting rates. Risk of microbial proliferation and MIC	**System currently under reasonable control. Further investigations required to determine the cause of the high pitting measured at *CC-XOX-017*. The use of molecular techniques such as qPCR should be used to confirm or eliminate the role of MIC.**
DIESEL SYSTEM	Low aerobic bacteria, yeast and mould enumerated from all the tanks sampled. Low particulate contamination, fungal fragments and water content.	**No immediate action is required as the diesel tanks are currently under good control and water content is at a minimum. Regular monitoring should be maintained.**
FIREWATER SYSTEM	No SRB, but high GHB measured in all the hydrants sampled. No residual chlorine, high potential risk of biofouling.	**A regular firewater ring main flushing routine should be implemented to prevent stagnation and bring in freshly chlorinated water.**

Green	Good Control, Low Risk, No Immediate Action Required
Yellow	Requires Careful Monitoring/Possible Early Intervention
Red	Risk Of MIC, Urgent Action Recommended

DATA TRENDING & INTERROGATION

All data should be graphed/trended on a regular basis – pipelines, drains, deaerator tower etc.

- Trending of data pre and post biocide applications – especially if it is a long term project
- Biocide treatments can then be optimised
- Monitoring essential

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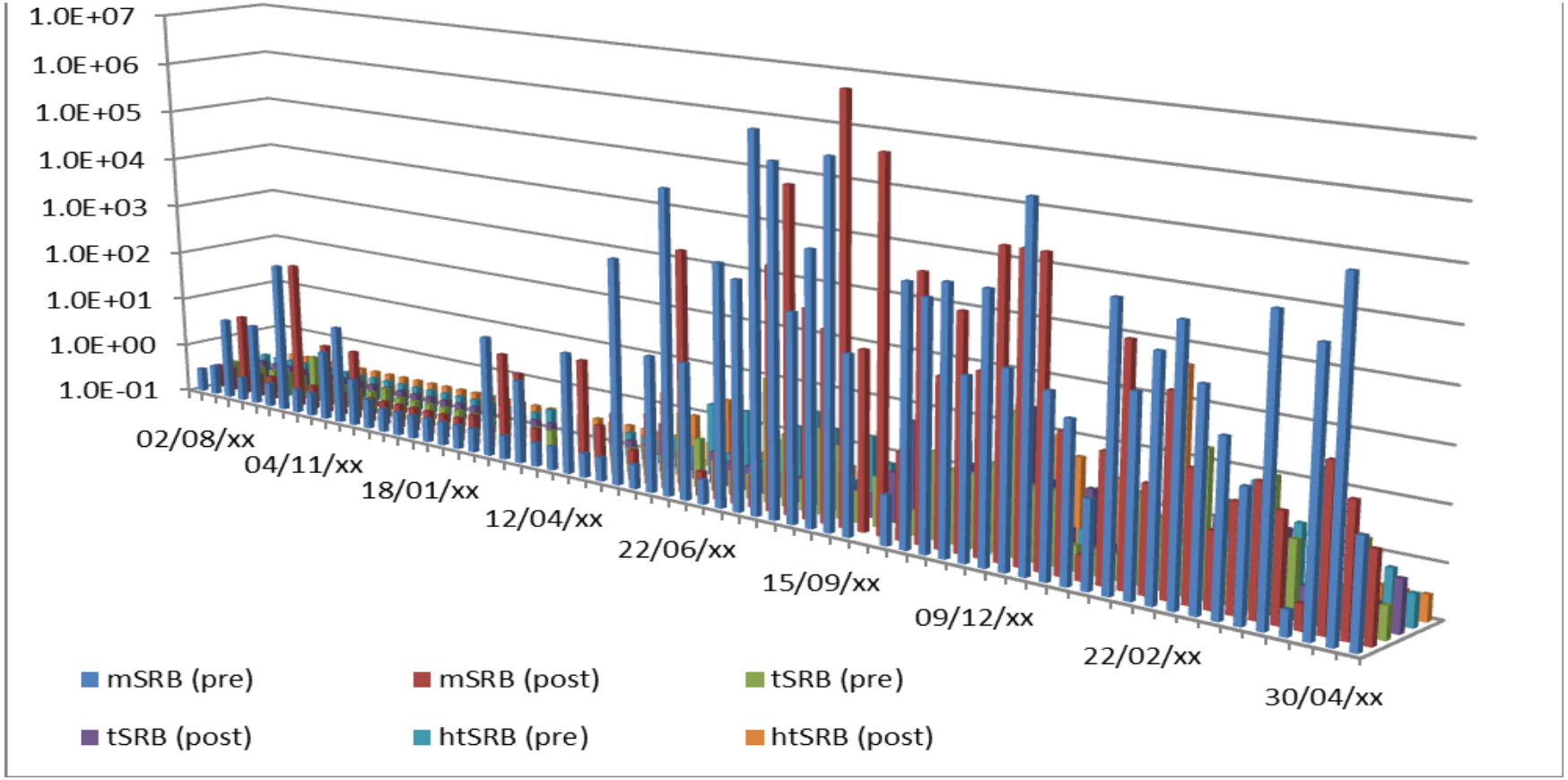
SRB BY MPN ENUMERATION PRE & POST BIOCIDE DOSES



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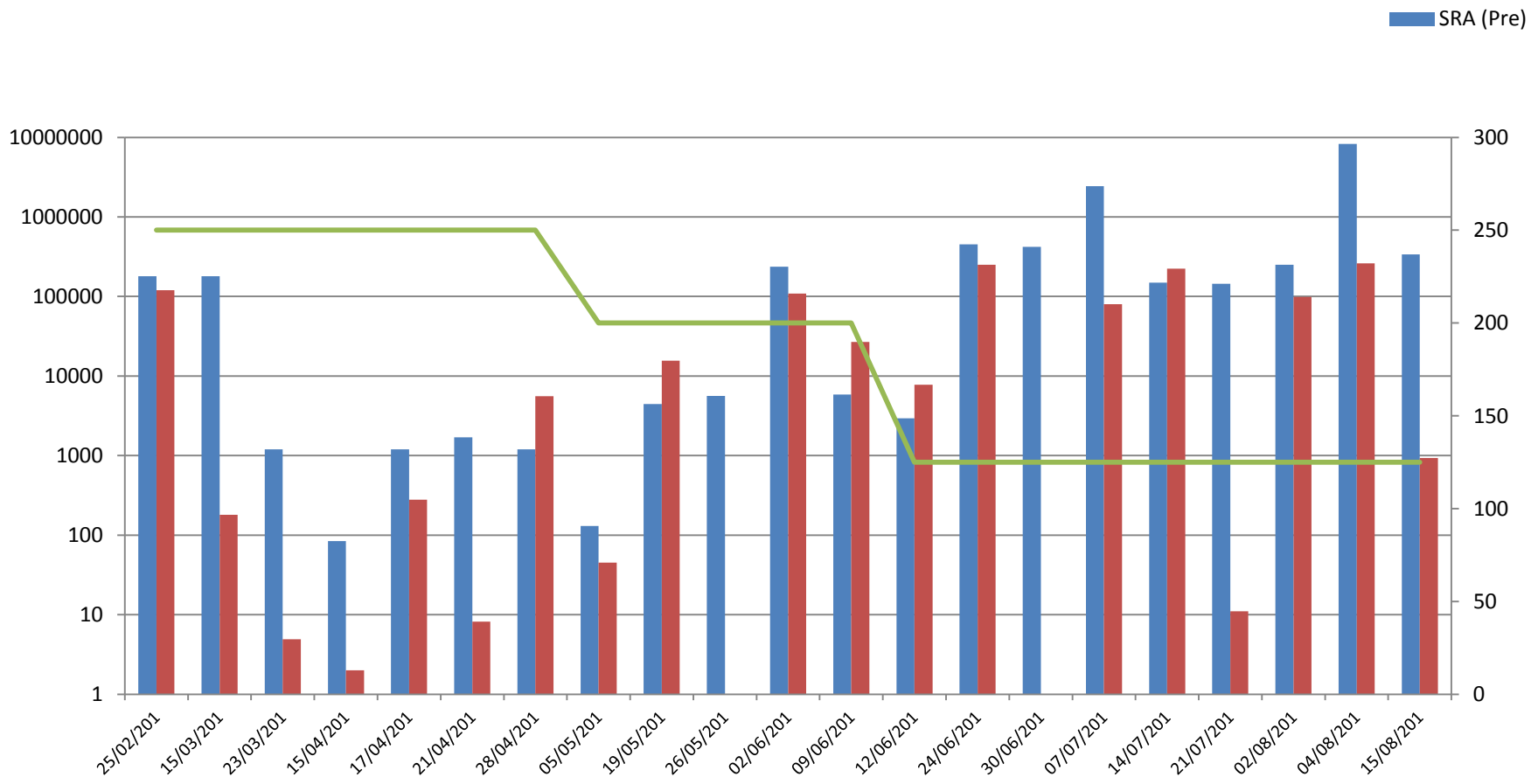
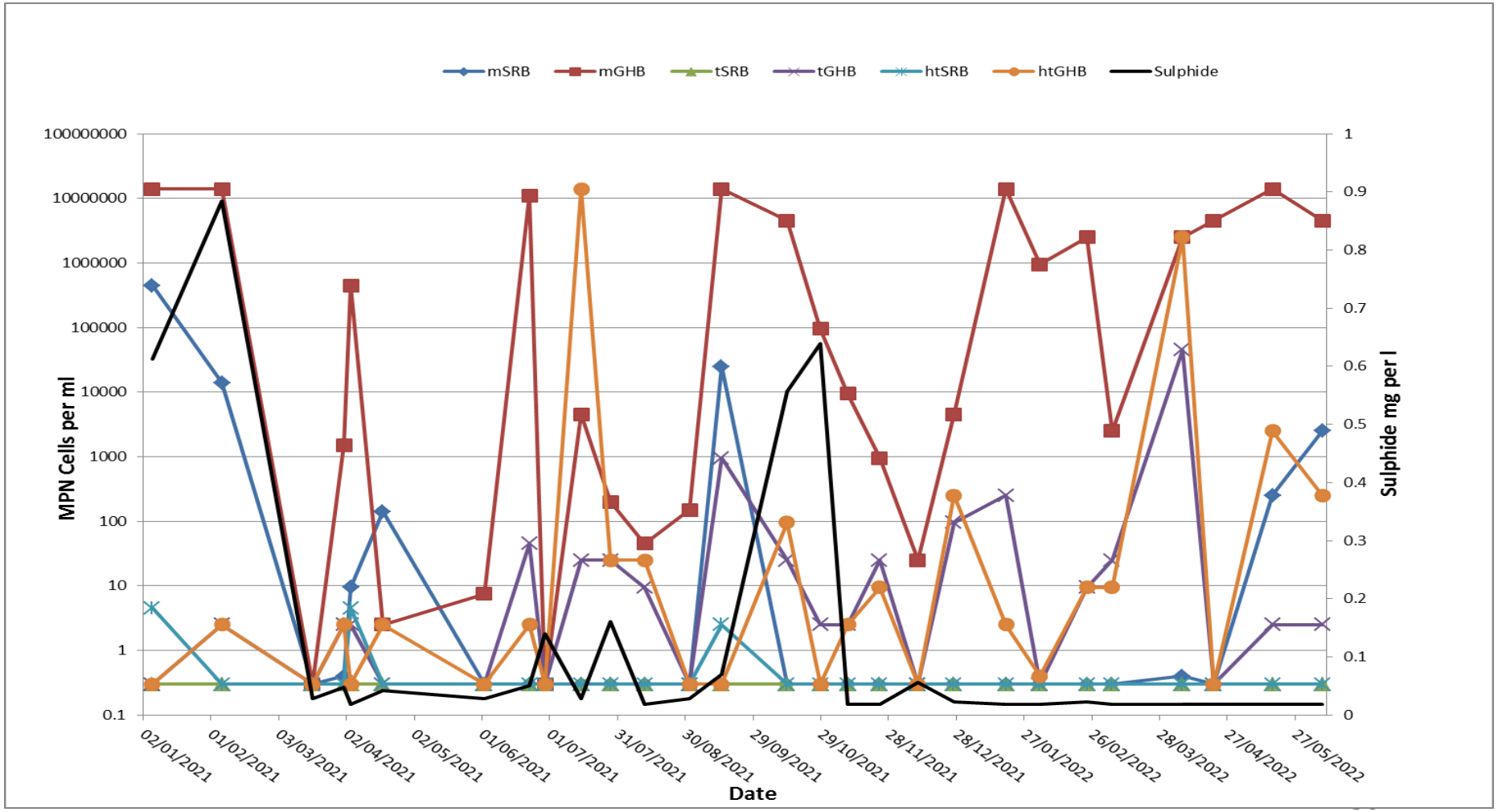
SRA NUMBERS BY qPCR
PRE & POST BIOCIDE DOSES



OPEN DRAIN VESSEL (MPNs)



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BIOCIDE APPLICATION STRATEGYS

Strategies
Monitoring
Programmes
Optimisation

Lab and field based biocide trials against planktonic/sessile bacteria

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PITS – MIC?

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THANK YOU FOR YOUR ATTENTION
ANY QUESTIONS?