# UK Harvest Area Study (circa 2001)

- 6 oyster harvesting areas chosen for study
  - to reflect a variety of faecal contamination levels (category A, A/B, B and prohibited)
  - including sites with known association with disease outbreaks (NLV)
- Monitored shellfish for E.coli, FRNA bacteriophage and NLVs for up to 2 years
- Characterised all NLV isolates
- Compared NLV occurrence with harvesting area pollution status (E.coli and FRNA bacteriophage) and with association with disease outbreaks

## Faecal pollution levels and illness associated with study sites

| Site | EU Classification | E.coli MPN /100g in oysters | | | Association with illness |
|---|---|---|---|---|---|
| | | Minimum | Maximum | Geometric mean | |
| 1 | A | <20 | <20 | 0 (12) | No |
| 2 | A/B | <20 | <18,000 | 30 (44) | No |
| 3 | B | <20 | 5,000 | 40 (16) | (Yes) |
| 4 | B | <20 | >18,000 | 380 (52) | Yes |
| 5 | B | <20 | >18,000 | 820 (63) | Yes |
| 6 | Prohibited | 310 | 2,400,000 | 53,000 (35) | na |

# Summary of E.coli, RNA phage and NLV PCR results from study sites

| Site | E.coli geometric mean (n) | FRNA geometric mean (n) | NLV* % +ve (n) |
|---|---|---|---|
| 1 | 0 (12) | 0 (12) | 0 (8) |
| 2 | 30 (44) | 12 (44) | 0% (39) |
| 3 | 40 (16) | 130 (16) | 6% (16) |
| 4 | 380 (62) | 3100 (62) | 33% (39) |
| 5 | 820 (63) | 4000 (63) | 23% (49) |
| 6 | 53,000 (35) | 42,000 (35) | 47% (32) |

*amplicon confirmed as NLV by sequence analysis

# Correlation of log % positive NLV with mean log E.coli and mean log FRNA phage at 6 sites

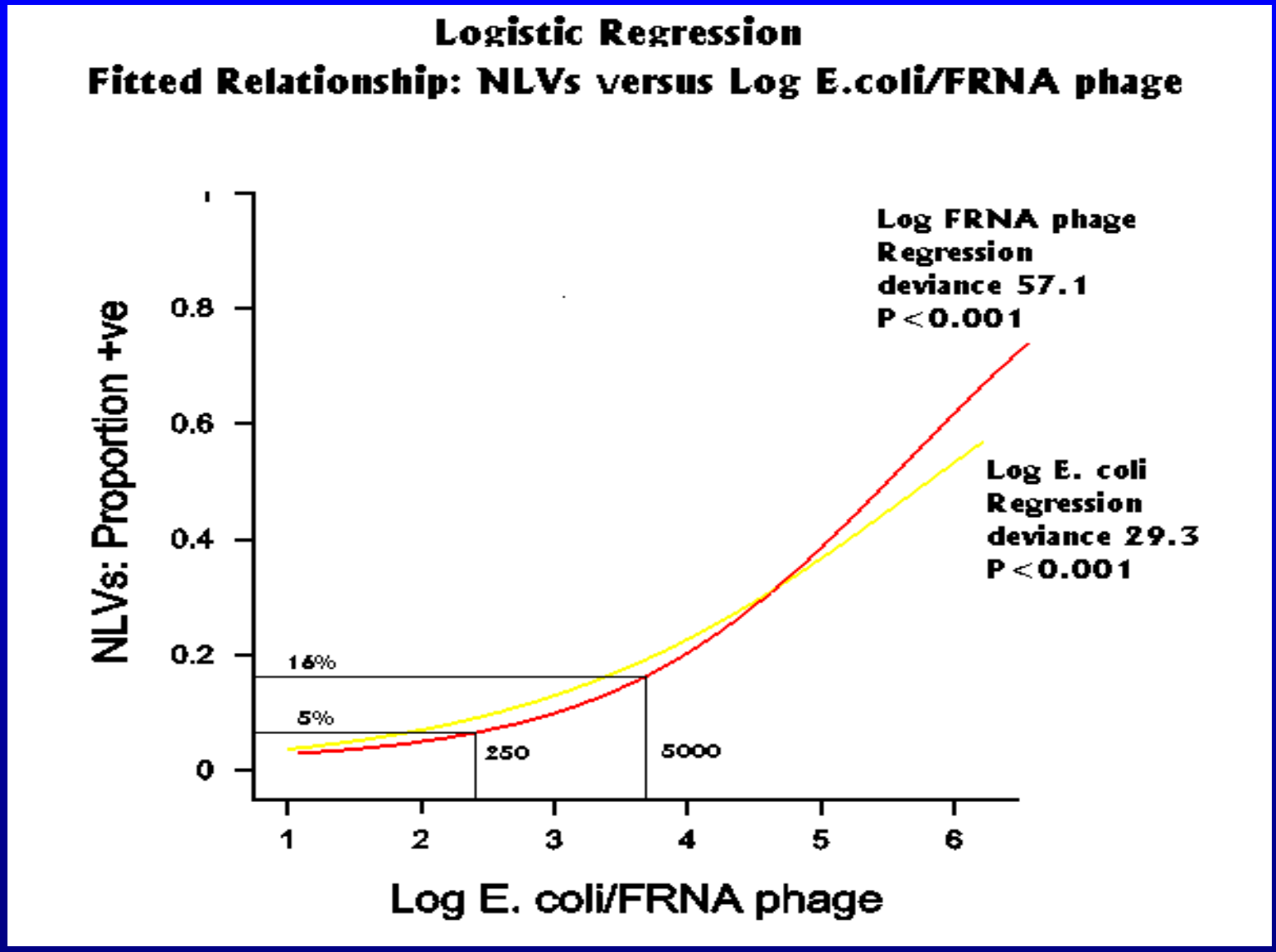
| | % NLV +ve (by sequencing) |
|---|---|
| E.coli (GM) | 0.85 |
| FRNA bacteriophage (GM) | 0.96 |

Values presented are Pearson correlation coefficients

# Risk of NLV contamination in shellfish harvesting areas

- EU wide study : 2000 – 2002 (Formiga-Cruz et al., 2003)
- range of shellfish species from commercial class A, B, C and prohibited harvesting areas
- analysis for E.coli, FRNA bacteriophage, and enteric viruses (including HAV and NLV)
- large data set : Spain (122), Greece (144), Sweden (54), UK (225), Eire (76) : total 621 samples
- all NLV positives confirmed by genome sequencing

# Risk of NLV contamination



# Comparison of MSC and norovirus by quantitative PCR in two commercial sites over 2 years

Lowther et al., 2008

TABLE 3. *Comparison of norovirus positivity and* E. coli *most-probable-number count*

| *E. coli* MPN (CFU/100 g shellfish flesh)[a] | No. of samples positive for noroviruses/total no. (%) | Avg no. of norovirus PCR units/ positive sample |
|---|---|---|
| <30 | 26/51 (51) | 73 |
| 30–299 | 57/95 (60) | 51 |
| ≥300 | 18/39 (46) | 56 |

} No significant difference

TABLE 4. *Comparison of norovirus positivity and FRNA bacteriophage count*

| FRNA bacteriophage count (PFU/100 g shellfish flesh) | No. of samples positive for noroviruses/total no. (%) | Avg no. of norovirus PCR units/ positive sample | | |
|---|---|---|---|---|
| | | Total | Area A | Area B |
| <100 | 21/68 (31) | 6 | 5 | 6 |
| 100–999 | 36/54 (67) | 22 | 20 | 23 |
| ≥1,000 | 32/46 (70) | 108 | 100 | 112 |

} Significant difference (P>0.001)

# But note of caution

Although high levels of norovirus contamination were associated with high FRNA bacteriophage counts, norovirus-positive results were also returned in some samples with bacteriophage levels below the assay limit of detection (30 PFU/100 g flesh).

Further work is required to understand the correlation, if any, between sample norovirus template titer, as judged by PCR, and human health risk. In the absence of such data, it is not possible to dismiss the significance of low-titer-norovirus results.

Nevertheless, the FRNA bacteriophage assay is considerably cheaper and less labor-intensive than are assays for noroviruses in shellfish, and has potential as a more effective risk management tool for noroviruses than does *E. coli.*

# EU regulatory proposal for MSC (not adopted)

- MSC research conducted over circa 15 years at Cefas (ending about 2006)
- Cefas designated EURL 1999 – part of remit to improve controls for enteric viruses
- Worked in parallel on MSC and PCR for viruses (1995 to date)
- Also worked extensively with other EU NRLs
- Revision of regulations for Microbiological Criteria for Food (circa 2002) gave opportunity for discussion on possible use of MSC (but only in 2 contexts – i.e. not harvest area application)
  - End product standard
  - Food processing criterion (depuration)

## 1. MICROBIOLOGICAL CRITERIA DEFINING THE SAFETY OF FOODSTUFFS

| Food category | Micro-organisms | Sam-plingplan[1] | | Limits | | Analytical reference method[2] | Stage where the criterion apply | Action in case of unsatisfactory results |
|---|---|---|---|---|---|---|---|---|
| | | n | c | m | M | | | |
| Live bivalve molluscs and live echinoderms, tunicates and gastropods | *E. coli*[12] | 1 (13) | 0 | <230 / 100g of flesh and intra-valvular liquid | | Donovan *et al.*, 1998, Communicable Disease and Public Health, 1, 188-196 | Products ready to be placed on the market and products on the market | The batch shall not be placed on the market or it shall be withdrawn from the market[4] |



## 2. CRITERIA INDICATING THE ACCEPTABILITY OF THE PROCESS

### 2.4. Live bivalve molluscs and live echinoderms, tunicates and gastropods

| Food category | Micro-organisms | Sampling plan[1] | Limit | Analytical reference method[2] | Stage where the criterion apply | Action in case of unsatisfactory results |
|---|---|---|---|---|---|---|
| | | n | m | | | |
| Live bivalve molluscs, which must be purified | FRNA bacteriophages | 1[3] | ≥95% removal or removal to ≤ 100 pfu/100g during the process | ISO 10705-1 | Before and after the purification process | Modification of temperature and/or duration of the purification process |

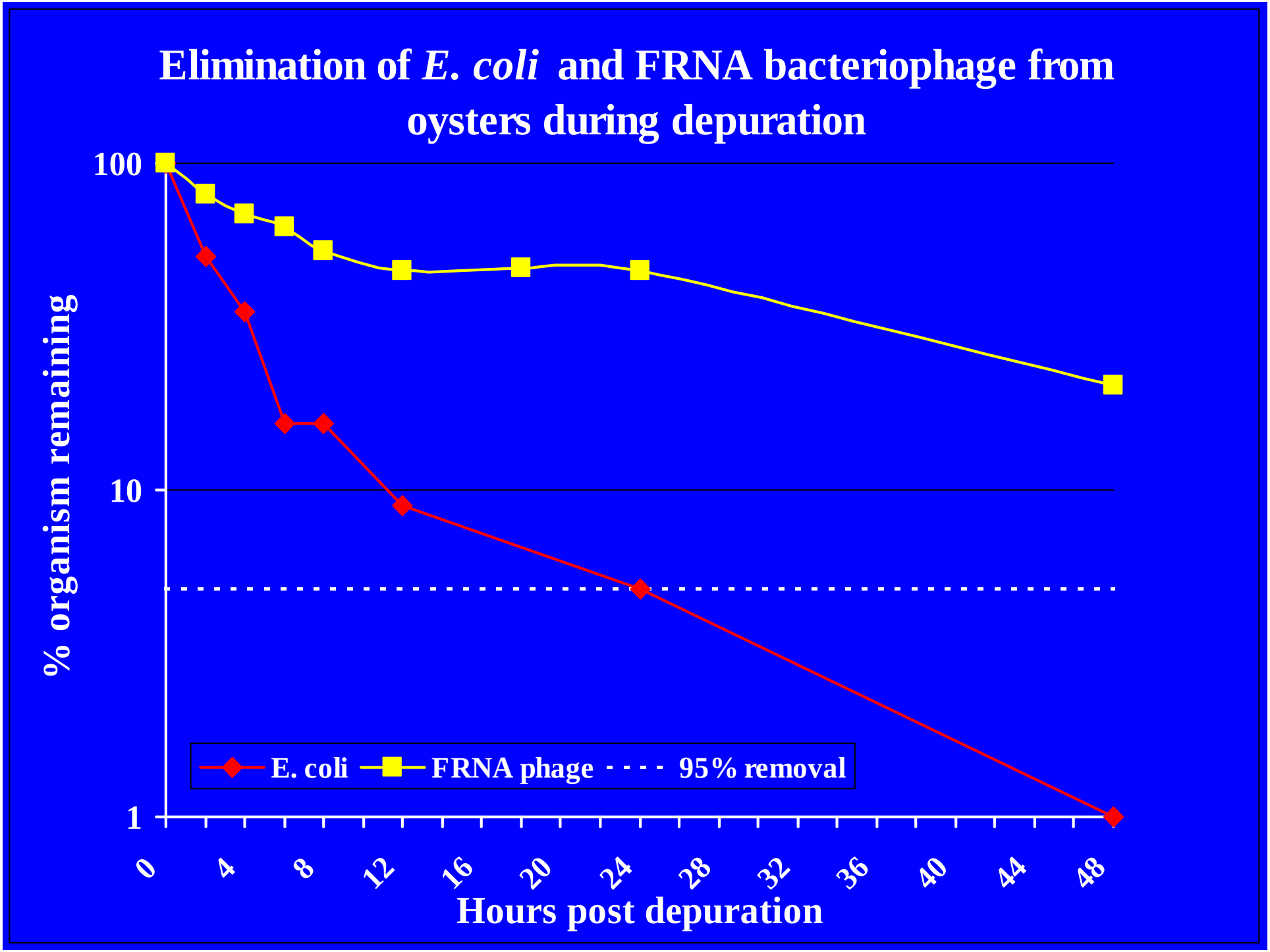
[1] n= number of units comprising the sample; c= number of samples units giving values between m and M

[2] The most recent edition of the standard shall be used

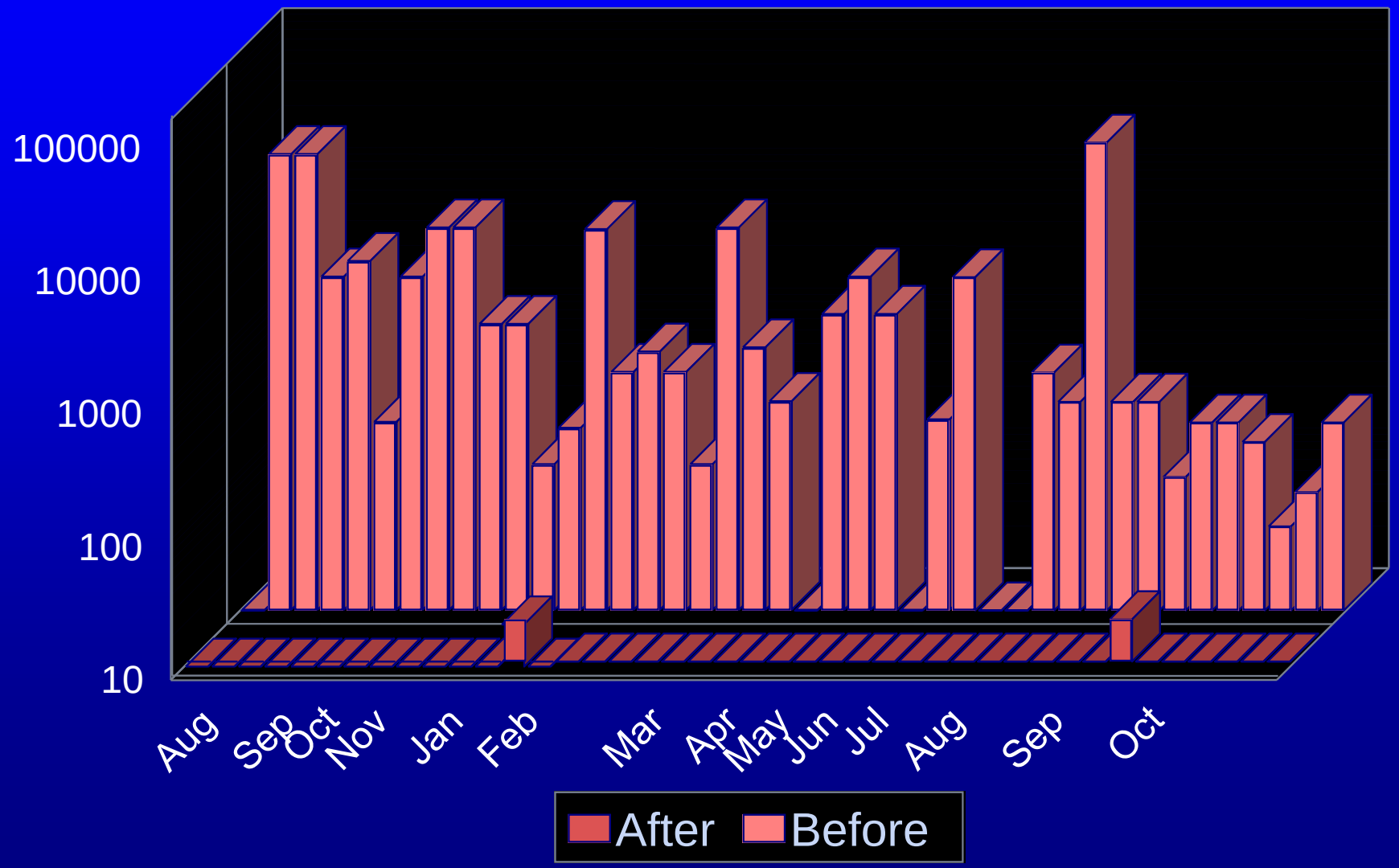
[3] A pooled sample comprising a minimum of 10 individual animals

Status of classifications in EU Member States, 2009

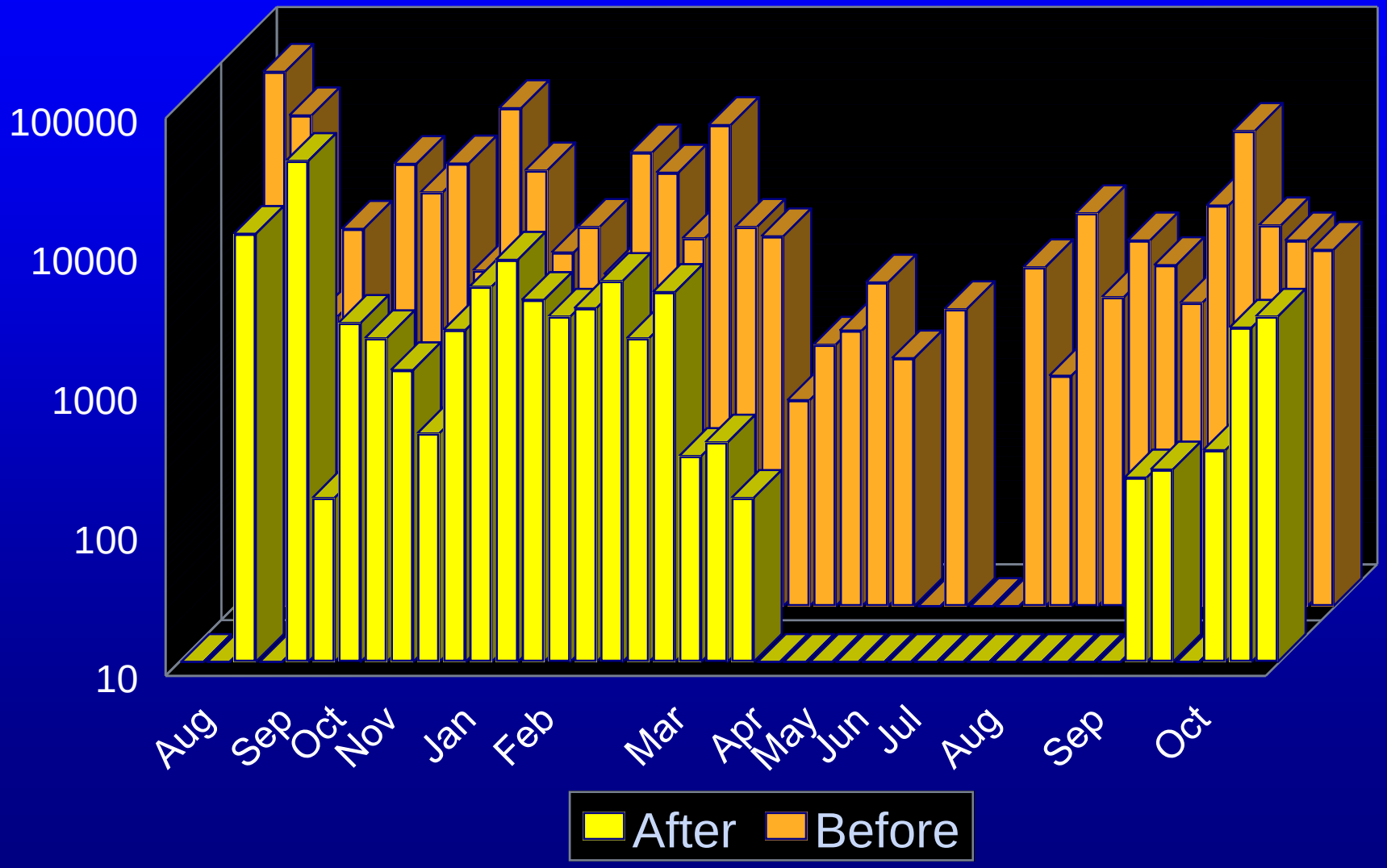
| Member State[1] | Number of classified areas[2] | % class A | % class B | % class C | % prohibited[3] |
|---|---|---|---|---|---|
| Belgium[4] | 1 | 100 | 0 | 0 | 0 |
| Denmark[5] | 49 | 76 | 24 | 0 | 0 |
| Eire[6] | 58 | 19 | 76 | 5 | 0 |
| France[7] | 785 | 24 | 57 | 5 | 15 |
| Germany[8] | 10 | 100 | 0 | 0 | 0 |
| Greece[9] | 43 | 44 | 9 | 2 | 0 |
| Italy[10] | 397 | 53 | 46 | <1 | N/A |
| Netherlands[11] | 6 | 100 | 0 | 0 | 0 |
| Portugal[12] | 44 | 18 | 59 | 16 | 7 |
| Slovenia[13] | 3 | 0 | 100 | 0 | 0 |
| Spain[14] | 951 | 58 | 37 | 5 | 0 |
| Sweden[15] | 33 | 36 | 64 | 0 | 0 |
| United Kingdom[16] | 688 | 27 | 64 | 7 | 1 |
| Overall | 3068 | 40% | 50% | 5% | 4%[17] |

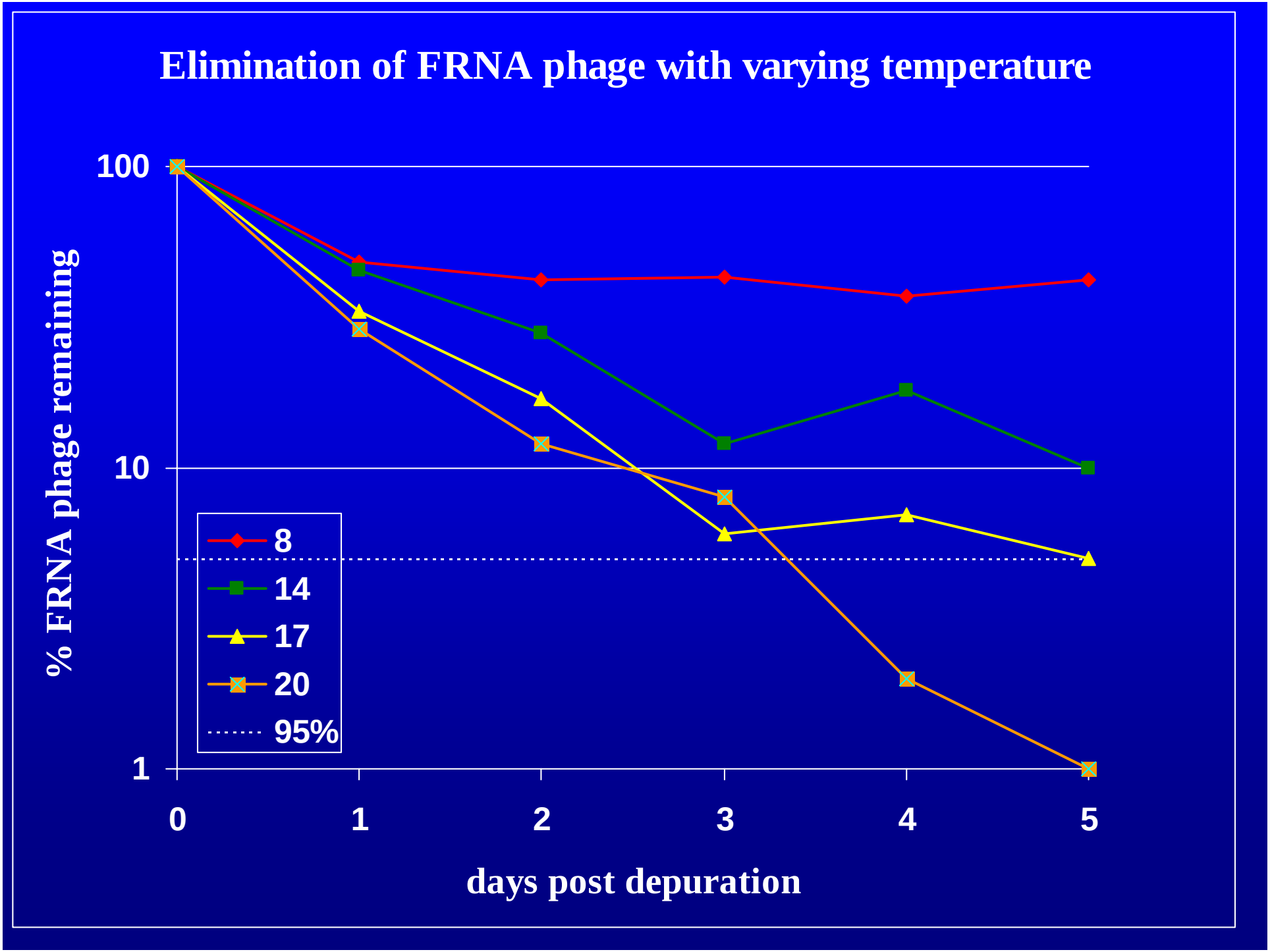

Elimination of E. coli and FRNA bacteriophage from oysters during depuration
100
10
1
% organism remaining
E. coli
FRNA phage
95% removal
0
4
8
12
16
20
24
28
32
36
40
44
48
Hours post depuration

# E.coli removal during purification



# F+ phage removal during purification




Elimination of FRNA phage with varying temperature
100
10
1
% FRNA phage remaining
8
14
17
20
95%
0
1
2
3
4
5
days post depuration

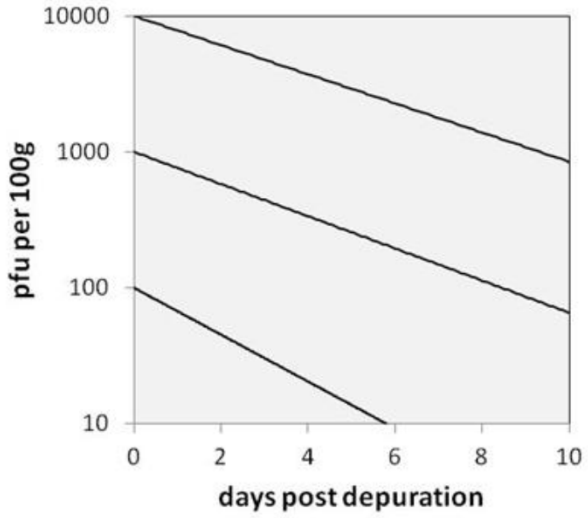
# Extensive MSC depuration studies at Cefas 2000 – 2003

- Predictable removal of MSC by time/temperature
- Some variation by species
- Not improved by feeding (limited studies)
- Not impacted by harvest month or harvest area temperature
- Little impact of higher temperature on mortality
- Similar results in commercial operations

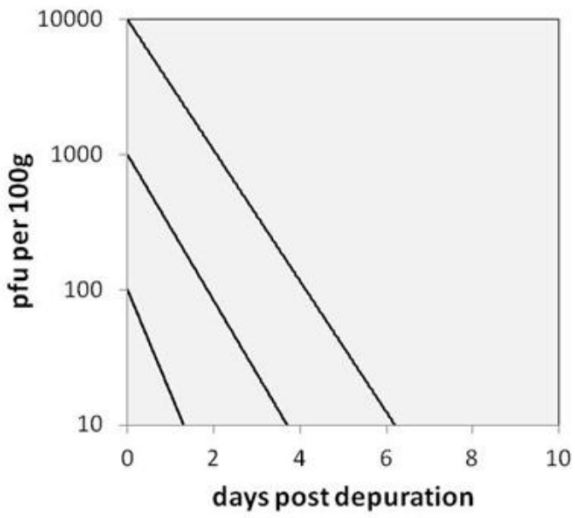
FOOD STANDARDS AGENCY

| | |
|---|---|
| FSA Project Code: | B04002 |
| FSA Project Title: | Development of procedures for improved viral reduction in oysters during commercial depuration. |
| Start Date: | 1st May 2000 |
| End Date: | 30th April 2003 |
| Project Leader's Name: | William Dore |
| Institution: | CEFAS |
| Date of submission: | 31st July 2003 |

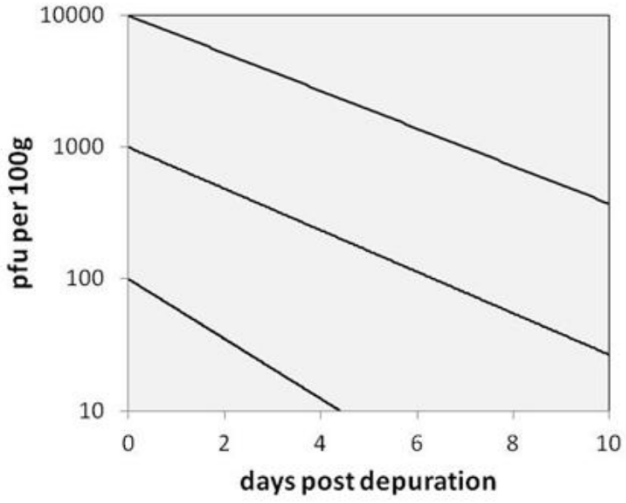
*C. gigas*
8°c



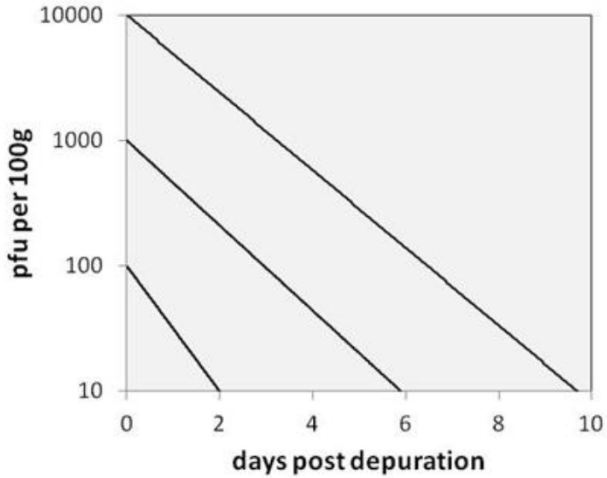

*C. gigas*
20°c

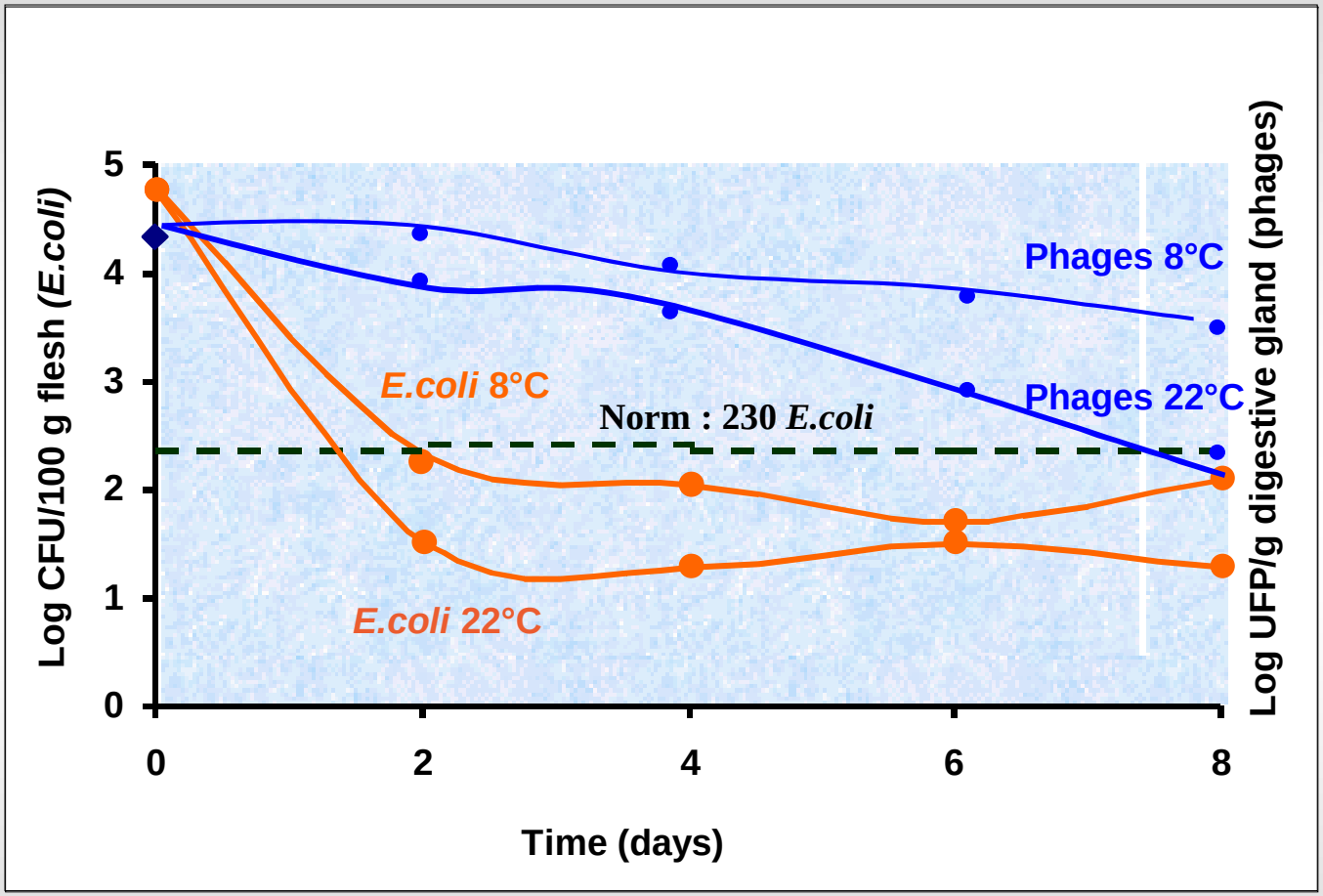



*O. edulis*
8°c




*O. edulis*
20°c






**Elimination of *E. coli* : > 99% in 2 days**

**MS2: > 99% in 8 days**

COMITE NATIONAL DE LA CONCHYLICULTURE

Ifremer

## 2. CRITERIA INDICATING THE ACCEPTABILITY OF THE PROCESS

### 2.4. Live bivalve molluscs and live echinoderms, tunicates and gastropods

| Food category | Micro-organisms | Sampling plan[1] | Limit | Analytical reference method[2] | Stage where the criterion apply | Action in case of unsatisfactory results |
|---|---|---|---|---|---|---|
| | | n | m | | | |
| Live bivalve molluscs, which must be purified | FRNA bacteriophages | 1[3] | ≥95% removal or removal to ≤ 100 pfu/100g during the process | ISO 10705-1 | Before and after the purification process | Modification of temperature and/or duration of the purification process |

[1] n= number of units comprising the sample; c= number of samples units giving values between m and M

[2] The most recent edition of the standard shall be used

[3] A pooled sample comprising a minimum of 10 individual animals

# EU survey on impact (EU funded)

COMMERIAL DEPURATION SITES (9 centres, 182 cycles)

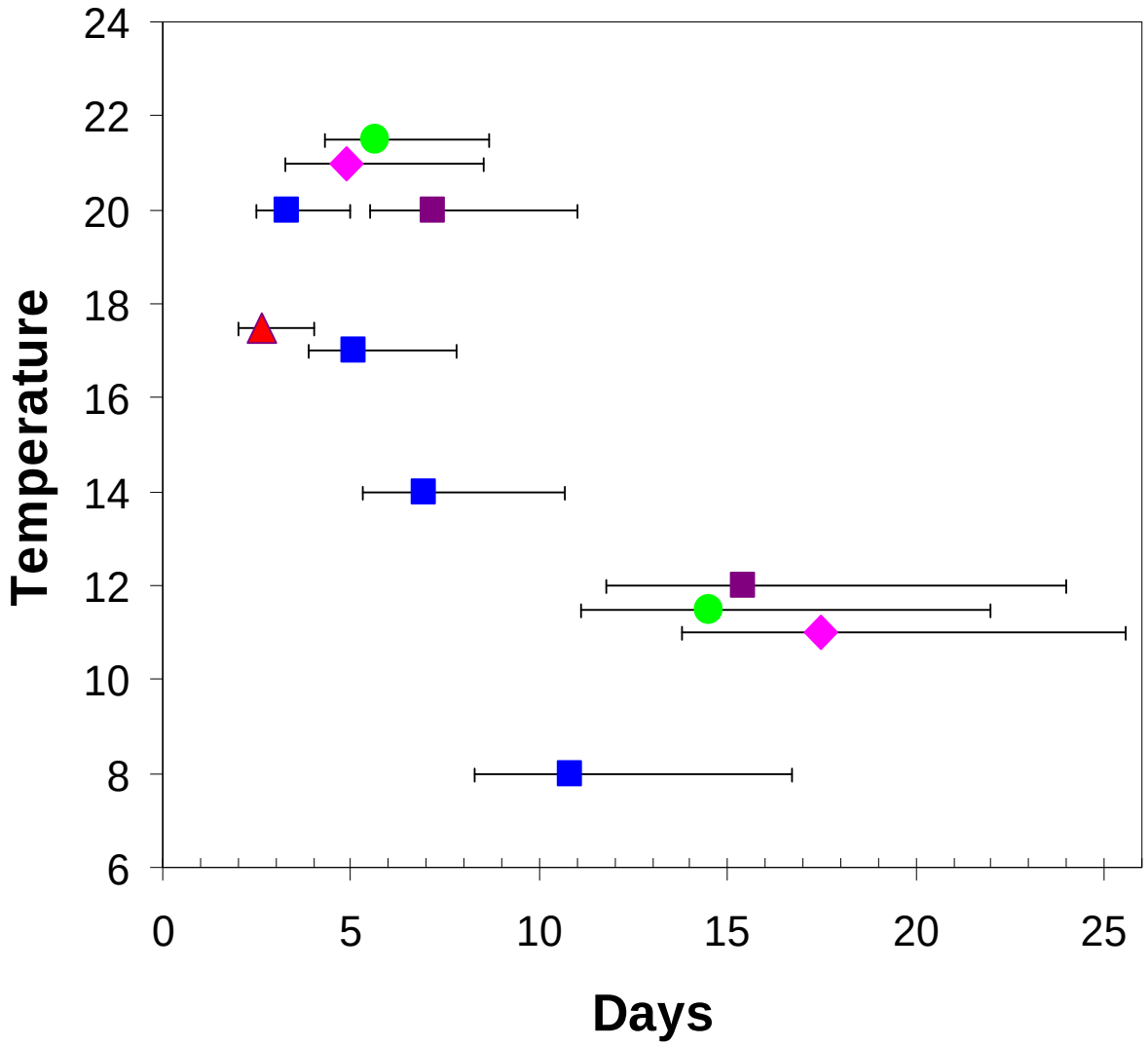
- Recirculation and flow-through
- UV, Chlorination, Ozone, Chlorine Dioxide
- Depuration periods
  - Italy 24 h
  - Spain 42 – 48 h
  - UK 42 – 95 h

**Table 1.1** reduction of E. coli and FRNA bacteriophage levels during commercial depuration and assessment of compliance with existing and proposed microbiological standards

| Centre | Country | No. of cycles tested | Percent reduction of *E. coli* | Percent failing current standard (230 E.coli /100g) | Percent reduction of bacteriophage | Percent failing proposed standard (>95% removal) |
|---|---|---|---|---|---|---|
| 1 | Italy | 21 | 83 | 10 | 60 | 33 |
| 2 | Italy | 20 | 88 | 15 | 28 | 50 |
| 3 | Italy | 21 | 100 | 0 | 46 | 33 |
| 4 | Spain | 21 | 50 | 10 | 29 | 48 |
| 5 | Spain | 21 | 43 | 5 | 34 | 29 |
| 6 | Spain | 24 | 59 | 8 | 60 | 42 |
| 7 | England | 16 | 88 | 0 | 59 | 31 |
| 8 | England | 35 | 93 | 3 | 36 | 94 |
| 9 | England | 24 | 79 | 0 | 41 | 29 |
| **TOTAL** | | **182** | **75** | **6** | **43** | **47** |

[1] Only using data from cycles with levels of *E. coli* or FRNA bacteriophage in pre-depuration samples
[2] post-depuration samples below the limit of detection treated as zero
[3] Proposed standard of 95% reduction of FRNA bacteriophage or to below 100 pfu $100g^{-1}$ shellfish flesh
[4] current standard of <230 E. coli $100g^{-1}$ of shellfish flesh

# Depuration Times for 95% (90%-99%) Removal of FRNA phage



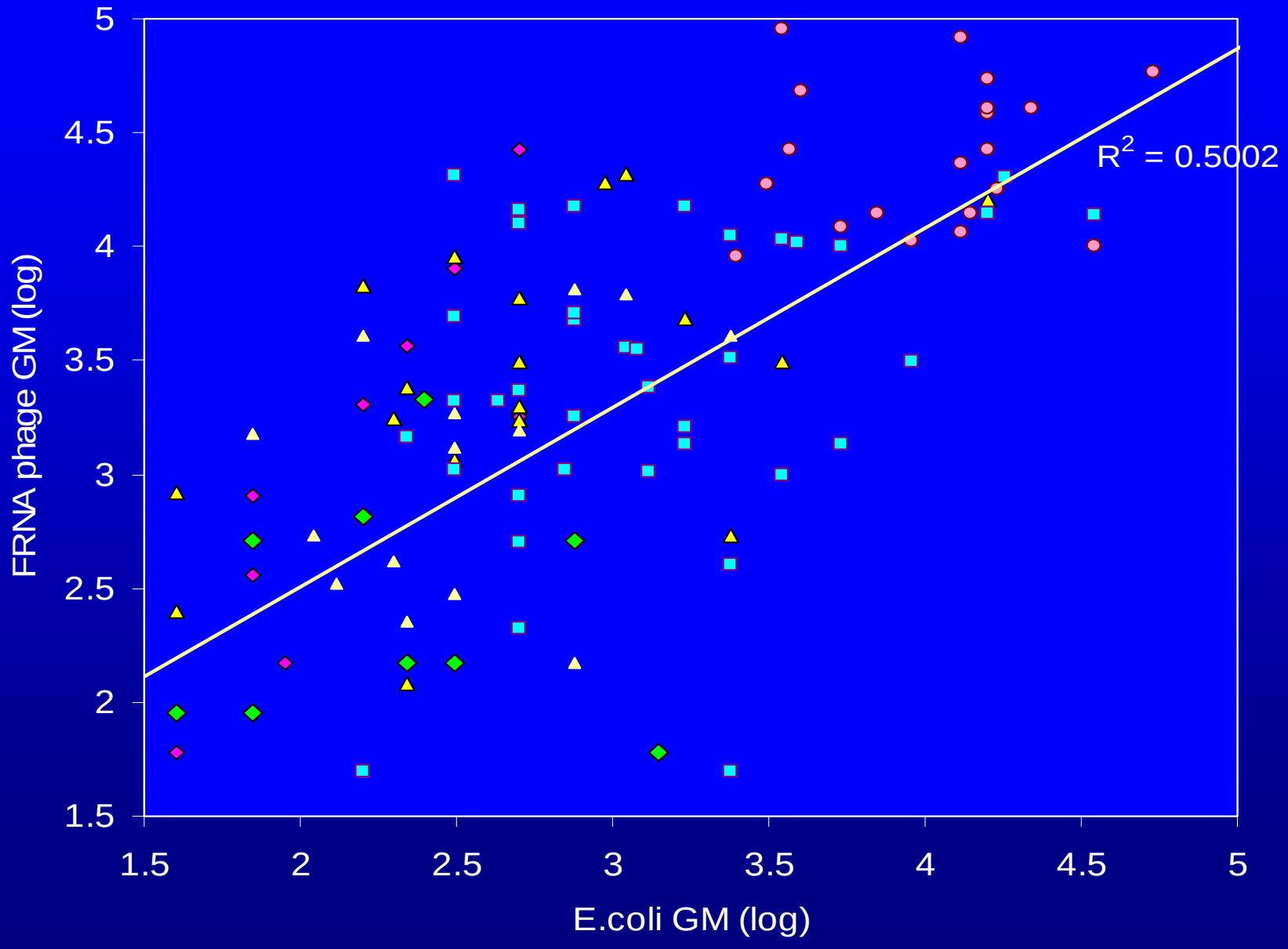

- C. gigas (UK)
- C. gigas (France)
- mussels (Spain)
- C. virginica (USA)
- M. mercenaria (USA)

1. UK data : Dore et al., 1995, Appl. Environ. Microbiol., 61,p2830 and unpublished data (funded by UK Food Standards Agency)
2. French data : IFREMER, personal communication Dr S LeGuyader
3. Spanish data : Muniain-Mujika et al., 2002, Int.J.Food Microbiol., 77, p125
4. USA data : Burkhardt et al.,1995, Proceedings Second Int Conf Molluscan Shellfish Safety, Renne, p217

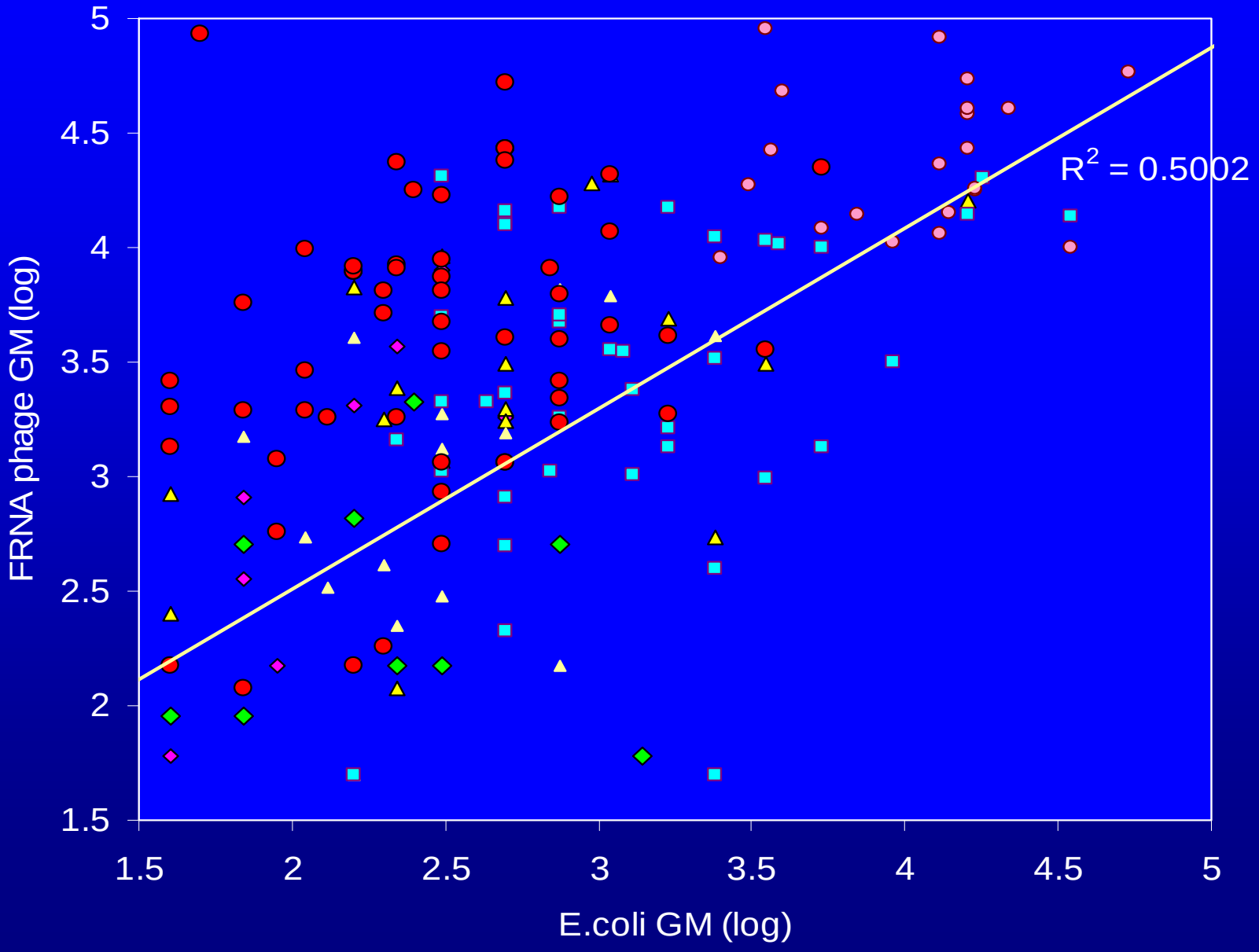
# Conclusion

- MSC standard strongly opposed by EU industry
- A number of influential scientists argued that there was not a correlation between MSC and viral pathogens
- Scientific worries about possible vibrio proliferation with depuration at high temperatures
- Policy makers concluded introduction of MSC standard for depuration was impractical (since no clear way forward for processors)
- Consensus was to focus on pathogen (norovirus/HAV) detection

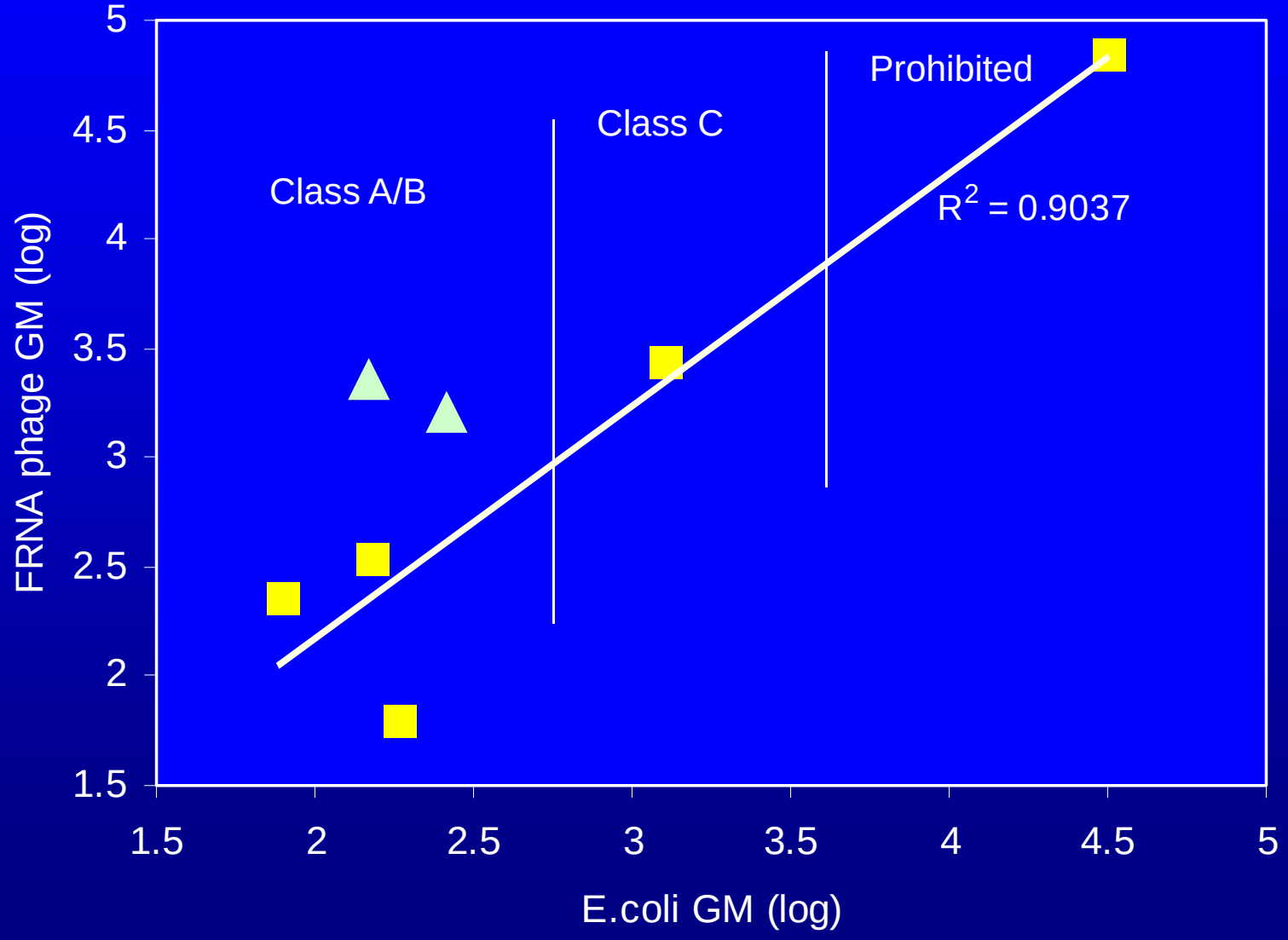
# E.coli vs FRNA phage in harvesting sites



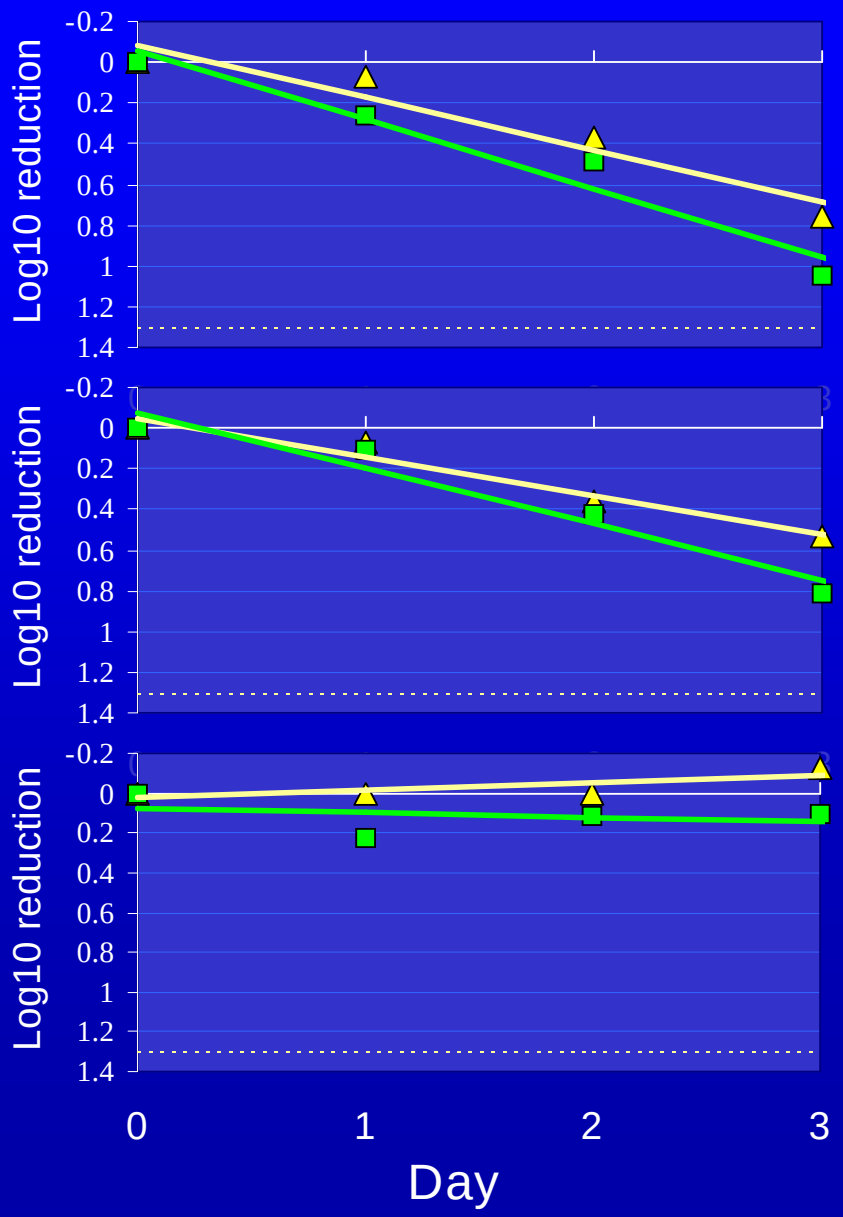
# E.coli vs FRNA phage in harvesting sites



# Comparison of E.coli geomean vs FRNA bacteriophage geomean by site



# Depuration of FRNA phage (▲) vs NV (■)




## 20°C

FRNA phage: y = 0.258x - 0.087

NLV: y = 0.338x - 0.057

## 17°C

FRNA phage: y = 0.1883x - 0.0432

NLV: y = 0.274x - 0.076

## 9°C

FRNA phage: y = -0.09x - 0.025

NLV: y = 0.0197x + 0.0802

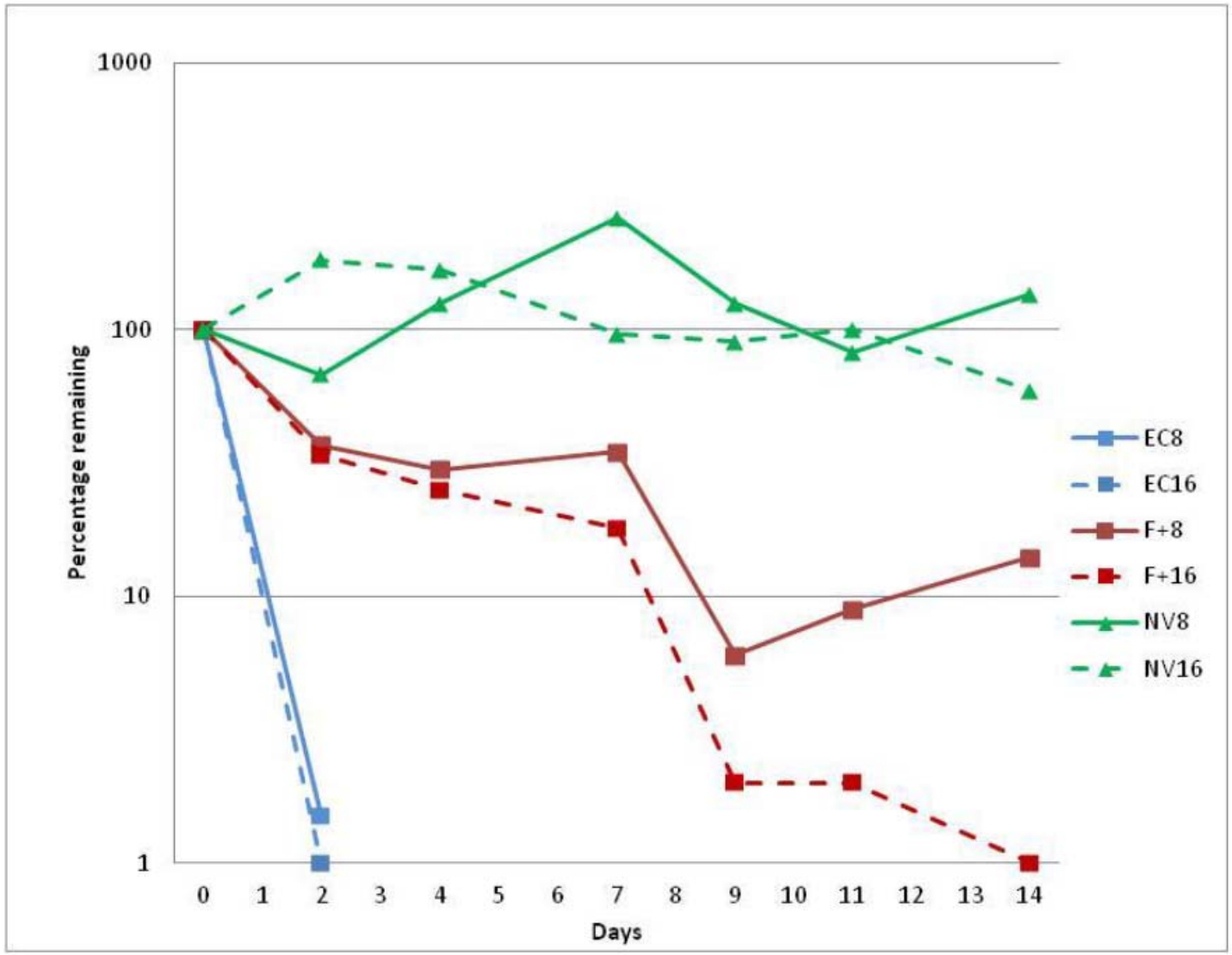



Figure 7. Comparison of *E.coli,* FRNA bacteriophage and norovirus reductions during depuration. Depuration conducted at 8$^{O}$C (solid line) and 16$^{O}$C (dashed line). EC = *E. coli*, F+ FRNA Bacteriophage, NV = norovirus. (Each data point calculated from the geometric mean of four replicates).

Neish 2013 (unpublished)

Cefas contract report C5224

# Investigative trials on the purification of oysters to identify ways of reducing norovirus

Authors: Anna Neish

Issue date: April 22nd 2013

# E.coli clearance

## 1. SURVEY RESULTS

### SITE 1. ITALY, RECIRCULATION SYSTEM WITH OZONE DISINFECTION

| | | | Harvest Area | | Depuration conditions | | | Results 100g-1 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Pre/post | Species | Temp (°C) | Salinity (ppt) | Time h | Temp (°C) | Salinity (ppt) | *E. coli* | phage | HAV (5-8g) |
| 04:06:03 | Pre | *T. philipinarum* | 24 | 32 | | | | 200 | < 30 | - |
| 04:06:03 | Post | *T. philipinarum* | | | 24 | 16 | 30 | < 180 | < 30 | |
| 11:06:03 | Pre | *T. philipinarum* | 25 | 32 | | | | 200 | < 30 | - |
| 11:06:03 | Post | *T. philipinarum* | | | 24 | 15 | 30 | < 180 | < 30 | |
| 18:06:03 | Pre | *M. galloprovincialis* | 26 | 32 | | | | < 180 | < 30 | - |
| 18:06:03 | Post | *M. galloprovincialis* | | | 24 | 16 | 29 | < 180 | < 30 | |
| 25:06:03 | Pre | *M. galloprovincialis* | 27 | 33 | | | | < 180 | < 30 | - |
| 25:06:03 | Post | *M. galloprovincialis* | | | 24 | 16 | 30 | < 180 | < 30 | |
| 09:07:03 | Pre | *T. philipinarum* | 28 | 32 | | | | < 180 | < 30 | + |
| 09:07:03 | Post | *T. philipinarum* | | | 24 | 16 | 30 | < 180 | < 30 | + |
| 16:07:03 | Pre | *M. galloprovincialis* | 27 | 30 | | | | < 180 | < 30 | - |
| 16:07:03 | Post | *M. galloprovincialis* | | | 24 | 16 | 29 | < 180 | < 30 | |
| 10:09:03 | Pre | *T. philipinarum* | 21 | 27 | | | | 1700 | < 30 | - |
| 10:09:03 | Post | *T. philipinarum* | | | 24 | 15 | 30 | < 180 | < 30 | |
| 17:09:03 | Pre | *T. philipinarum* | 21 | 27 | | | | 35000 | 1350 | + |
| 17:09:03 | Post | *T. philipinarum* | | | 24 | 15 | 30 | 680 | 960 | + |
| 24:09:03 | Pre | *T. philipinarum* | 24 | 26 | | | | < 180 | < 30 | - |
| 24:09:03 | Post | *T. philipinarum* | | | 24 | 16 | 29 | < 180 | < 30 | |
| 01:10:03 | Pre | *T. philipinarum* | 20.5 | 31 | | | | < 180 | 540 | - |
| 01:10:03 | Post | *T. philipinarum* | | | 24 | 16.5 | 30 | < 180 | 180 | |
| 08:10:03 | Pre | *T. philipinarum* | 19 | 27.5 | | | | < 180 | 60 | - |
| 08:10:03 | Post | *T. philipinarum* | | | 24 | 17 | 29 | < 180 | < 30 | |
| 15:10:03 | Pre | *T. philipinarum* | 19 | 29 | | | | 200 | 60 | - |
| 15:10:03 | Post | *T. philipinarum* | | | 24 | 16.2 | 27 | < 180 | < 30 | |
| 22:10:03 | Pre | *T. philipinarum* | 15.5 | 31 | | | | < 180 | 90 | - |
| 22:10:03 | Post | *T. philipinarum* | | | 24 | 16.2 | 29.5 | < 180 | 120 | |
| 29.10.03 | Pre | *T. philipinarum* | 13 | 31 | | | | 780 | 2040 | - |
| 29.10.03 | Post | *T. philipinarum* | | | 24 | 16.1 | 28 | < 180 | 30 | |
| 5.11.03 | Pre | *T. philipinarum* | 13.5 | 30 | | | | 450 | 3090 | - |
| 5.11.03 | Post | *T. philipinarum* | | | 24 | 16 | 28 | < 180 | < 30 | |
| 12.11.03 | Pre | *T. philipinarum* | 13 | 30 | | | | 1200 | 1890 | - |
| 12.11.03 | Post | *T. philipinarum* | | | 24 | 16 | 28 | < 180 | 30 | |
| 19.11.03 | Pre | *T. philippinarum* | 12.5 | 22 | | | | < 180 | 2430 | - |
| 19.11.03 | Post | *T. philippinarum* | | | 24 | 16 | 29 | < 180 | 1410 | |
| 26.11.03 | Pre | *T. philippinarum* | 13 | 21.5 | | | | 2700 | 125280 | - |
| 26.11.03 | Post | *T. philippinarum* | | | 24 | 16 | 27 | < 180 | 51420 | |
| 3.12.03 | Pre | *T. philippinarum* | 12.5 | 27 | | | | < 180 | 4380 | - |
| 3.12.03 | Post | *T. philippinarum* | | | 24 | 16 | 27 | < 180 | 6030 | |
| 10.12.03 | Pre | *T. philippinarum* | 9 | 21 | | | | 14000 | 15450 | + |
| 10.12.03 | Post | *T. philippinarum* | | | 24 | 16 | 26 | 2300 | 2280 | - |
| 17.12.03 | Pre | *T. philippinarum* | 9.5 | 27.5 | | | | 780 | 73200 | - |
| 17.12.03 | Post | *T. philippinarum* | | | 24 | 16 | 29 | < 180 | 436320 | |

# UK site 8

SITE 8. CONTINUED

| Date Tested | Pre/Post | Species | Harvest Area Temp (ºC) | Depuration conditions Time (h) | Temp (ºC) | Salinity ppt | Results 100g$^{-1}$ *E. coli* | phage |
|---|---|---|---|---|---|---|---|---|
| 23.10.03 | Pre | *M. edulis* | 16 | | 10 | 35 | 1850 | 660 |
| 24.10.03 | Post | *M. edulis* | | 44 | 10 | 35 | 20 | 500 |
| 23.10.03 | Pre | *C. gigas* | 16 | | 10 | 35 | 310 | 2805 |
| 24.10.03 | Post | *C. gigas* | | 46 | 11 | 35 | 20 | 1767 |
| 29.10.03 | Pre | *M. edulis* | 14 | | 10 | 34 | 1500 | 900 |
| 31.10.03 | Post | *M. edulis* | | 43 | 10 | 34 | 20 | 540 |
| 29.10.03 | Pre | *C. gigas* | 14 | | 10 | 35 | 625 | 1110 |
| 31.10.03 | Post | *C. gigas* | | 43 | 12 | 35 | 20 | 645 |
| 12:11:03 | Pre | *M. edulis* | 16 | | 14 | 35 | 1850 | 7095 |
| 14:11:03 | Post | *M. edulis* | | 48 | 15 | 35 | 20 | 4020 |
| 12:11:03 | Pre | *C. gigas* | 16 | | 14 | 35 | 405 | 5235 |
| 14:11:03 | Post | *C. gigas* | | 53 | 15 | 35 | <20 | 2175 |
| 26.11.03 | Pre | *M. edulis* | 12 | | 13 | 35 | 7250 | 4500 |
| 02.12.03 | Post | *M. edulis* | | 95 | 11 | 35 | 20 | 660 |
| 26.11.03 | Pre | *S. solida* | 12 | | 13 | 35 | <20 | 2700 |
| 02.12.03 | Post | *S. solida* | | 95 | 12 | 35 | 45 | 930 |
| 11.12.03 | Pre | *M. edulis* | 12 | | 12 | 29 | >18000 | 3150 |
| 12.12.03 | Post | *M. edulis* | | 45 | 13.5 | 29 | <20 | 1069 |
| 10.12.03 | Pre | *S. solida* | 12 | | 11 | 30 | 1415 | 2355 |
| 11.12.03 | Post | *S. solida* | | 48 | 13 | 30 | <20 | 1767 |

**Table 1.2** Elimination of FRNA bacteriophage during temperature controlled depuration experiments.

| Trial | Species | Initial conc$^{n}$ of FRNA phage pfu 100g$^{-1}$ | Temp ±1ºC | Time to 95% reduction or percent reduction after 5 days | Days to 10% mortality |
|---|---|---|---|---|---|
| 1[1] | *M. edulis* | 3184 | 10<br>20 | 5 days<br>4 days | 8<br>8 |
| 2[2] | *M. edulis* | 2205 | 10<br>20 | 83%<br>4 days | 3<br>3 |
| 3 | Clams | 57,690 | 10<br>20 | 77%<br>4 days | 9<br>7 |
| 4 | Clams | 72,400 | 10<br>15 | 72%<br>81% | 12<br>12 |
| 5 | *M. edulis* | 6,300 | 10<br>15 | 74%<br>88% | 4<br>3 |
| 6[3] | Clams | 18,525 | 10<br>18 | 65%<br>61% | ND<br>ND |

[1] approximately 15% of mussels had died by day 5 of depuration at 20ºC.
[2] approximately 10% of mussels had died by day 5 of depuration at 20ºC
[3] approximately 33% of clams had died by day 5 of depuration at 18ºC

# Estimated reduction in FRNA phage (pfu/100g) per day of depuration

Days depuration at 20°C

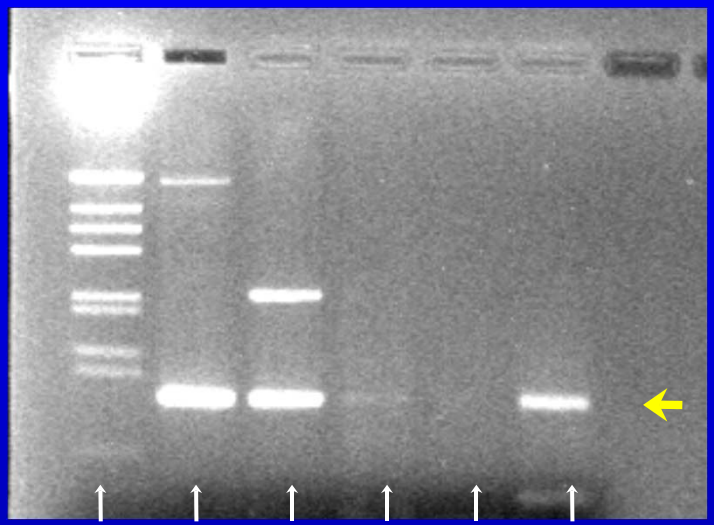
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Days to <30pfu/100g |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 40 | *16* | *6* | *3* | | | | | | | 1.3 |
| 1000 | 398 | 158 | 63 | *25* | *10* | *4* | *1.6* | | | | 3.8 |
| 10000 | 3981 | 1580 | 630 | 251 | 100 | 40 | *16* | *6* | | | 6.3 |
| 20000 | 7943 | 3162 | 1258 | 501 | 200 | 79 | 32 | *13* | *5* | | 7.1 |
| 50000 | 19952 | 7943 | 3162 | 1258 | 501 | 200 | 79 | 32 | *13* | *5* | 8.1 |

Days depuration at 8°C

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Days to <30pfu/100g |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 72 | 53 | 38 | *28* | *20* | *15* | *11* | | | | 3.7 |
| 1000 | 720 | 525 | 380 | 275 | 200 | 145 | 105 | 76 | 55 | 40 | 10.9 |
| 10000 | 7200 | 5250 | 3800 | 2750 | 2000 | 1450 | 1050 | 760 | 550 | 400 | 18.0 |
| 20000 | 14454 | 10471 | 7585 | 5495 | 3981 | 2884 | 2089 | 1513 | 1096 | 794 | 20.2 |
| 50000 | 36307 | 26302 | 19054 | 13804 | 10000 | 7244 | 5248 | 3801 | 2754 | 1995 | 23.0 |

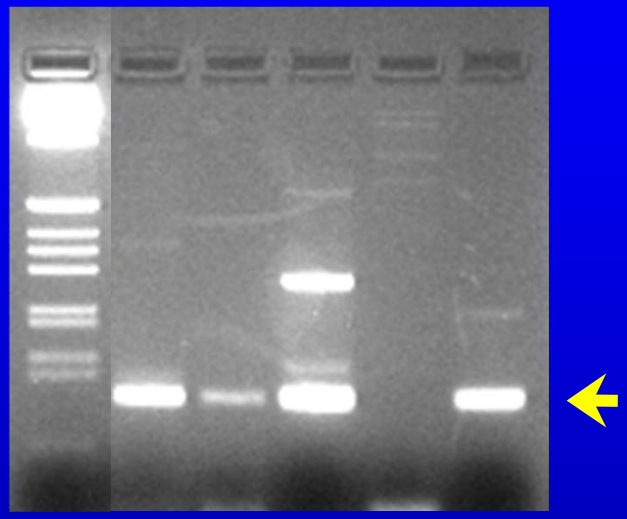
# Removal of Norovirus in commercial depuration and relaying (UK)

## Relaying



molecular weight
harvesting area
2 weeks relaying
4 weeks relaying
4 weeks+depuration
positive control

## Depuration



molecular weight
winter [ before purification
after purification
summer [ before purification
after purification
positive control