



**HAVFORSKNINGSINSTITUTTET**  
*INSTITUTE OF MARINE RESEARCH*





# Effects of acute oil spills on the Norwegian marine environment

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# Oil spills in the marine environment

| Name             | Source                | Location       | Year | Spill, t  |
|------------------|-----------------------|----------------|------|-----------|
| Gulf War         | Oil terminal/ tankers | Kuwait         | 1991 | 1,000,000 |
| Deep Horizon     | Oil platform/ well    | Gulf of Mexico | 2010 | 780,000   |
| Atlantic Empress | Oil tanker            | Tobago         | 1979 | 287,000   |
| ...              |                       |                |      | ...       |
| Braer            | Oil tanker            | Shetland       | 1993 | 85,000    |
| Prestige         | Oil tanker            | Galicia, Spain | 2002 | 63,000    |
| Exxon Valdez     | Oil tanker            | Alaska, south  | 1989 | 37,000    |
| ...              |                       |                |      | ...       |
| Statfjord A      | Oil platform          | North Sea      | 2007 | 4,000     |
| Rocknes          | Rock discharge vessel | Near Bergen    | 2004 | 540       |
| Server           | Cargo vessel          | Near Bergen    | 2007 | 380       |
| Full City        | Cargo vessel          | Telemark       | 2009 | 200       |
| Godafoss         | Cargo vessel          | Østfold        | 2011 | 100       |

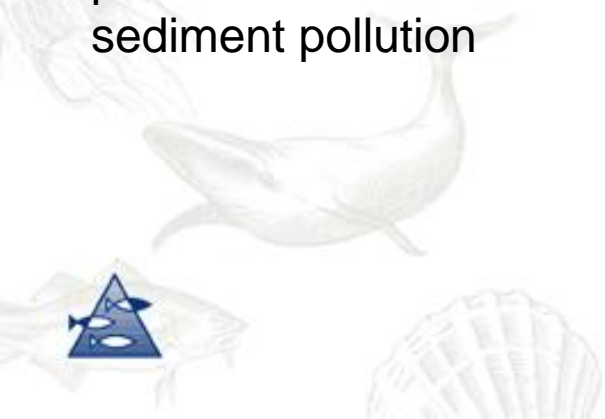


# ***Braer* oil spill, 85 000 tonnes**

- Nr.14 on tanker oil spills list
- Largest oil spill in Scotland
- Light naphthenic oil cargo
- Easily degradable
- Strong stormy conditions
- >1,500 birds dead
- Acute effects rapidly reduced
- Long-term effects to various parts of the environment, e.g. sediment pollution



Photo: <http://www.wrecksite.eu>



# *Exxon Valdez* oil spill, 37 000 tonnes

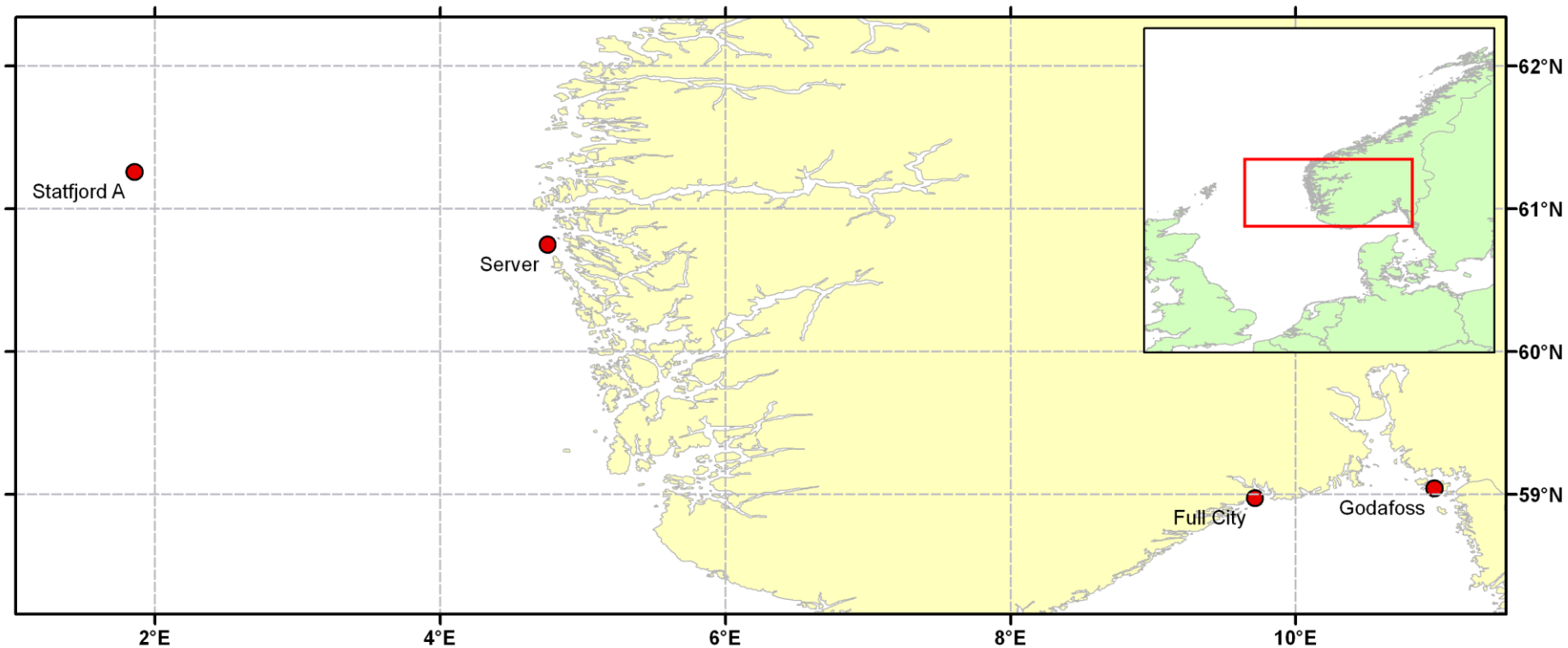
- Nr.35 on tanker oil spills list
- Largest oil spill in US waters until Deep Horizon
- Ca. 2,400 km coastline polluted
- 3 years' direct cleanup effort
- Extremely ecologically vulnerable area, e.g. pink salmon spawning
- >250 thousand seabirds, >2,800 otters, 300 harbour seals dead
- Numerous long-term effects



Photo: AP



# Oil spills in Norwegian waters (2007-2011)



Map: Kjell Bakkeplass, IMR



# Sampling and analyses

| Type of sample                  | Sampling                      | Sample treatment                            | Analysis, analyte                  | LOQ                                  |
|---------------------------------|-------------------------------|---|------------------------------------|--------------------------------------|
| <b>Sediments</b>                | Van Veen grab                 | ASE extraction, Si column cleanup           | GC-MS (SIM EI), PAH<br>GC-FID, THC | PAH: 0.5 µg/kg dw<br>THC: 2 mg/kg dw |
| <b>Seawater</b>                 | Subsurface samples            | Liquid-liquid extraction, Si column cleanup | GC-FID, THC                        | 2 µg/l                               |
| <b>Fish (liver, muscle)</b>     | Net or trawling               | Soapification, Si/Al column cleanup         | GC-MS (SIM EI), PAH                | 0.2 µg/kg ww                         |
| <b>Fish (bile)</b>              | - " -                         | SPE extraction, derivatisation              | GC-MS (SIM NCI), PAH-OH            | 1-12 ng/ml                           |
| <b>Shellfish, crab, shrimps</b> | Diving or directly from shore | Soapification, Si/Al column cleanup         | GC-MS (SIM EI), PAH                | 0.2 µg/kg ww                         |



# PAH analyses

- "PAH16"

- Naphthalene
- Acenaphthylene
- Acenaphthene
- Fluorene
- Phenanthrene
- Anthracene
- Fluoranthene
- Pyrene
- Benz[*a*]anthracene
- Chrysene
- Benzo[*b*]fluoranthene
- Benzo[*k*]fluoranthene
- Benzo[*a*]pyrene
- Indeno(1,2,3-*cd*)pyrene
- Dibenz(*a,h*)anthracene
- Benzo[*ghi*]perylene

- "NPD"

- Naphthalene
- Total C1- Naphthalenes
- Total C2- Naphthalenes
- Total C3- Naphthalenes
- Phenanthrene
- Total C1- Phenanthrenes
- Total C2- Phenanthrenes
- Total C3- Phenanthrenes
- Dibenzothiophene
- Total C1-Dibenzothiophenes
- Total C2-Dibenzothiophenes
- Total C3-Dibenzothiophenes

## ***Norwegian Pollution Authority:* contamination scale**

| Mussels                              | Insignificant | Moderate | Marked     | Strong      | Very strong |
|--------------------------------------|---------------|----------|------------|-------------|-------------|
| PAH16 (µg/kg w.w.)                   | <50           | 50 - 200 | 200 - 2000 | 2000 - 5000 | > 5000      |
| Benzo[ <i>a</i> ]pyrene (µg/kg w.w.) | <1            | 1-3      | 3-10       | 10-30       | >30         |





# *Statfjord A* oil spill, 4 000 tonnes

- Second largest oil spill in Norway
- Took place in December 2007 during tanking of *Navion Britannia*
- Area with large fish resources and active fishery
- **IMR** has studied
  - **THC, NPD, PAH16** in water, fish filet and fish liver
  - The metabolites (**PAH-OH**) and **biomarkers** in fish samples

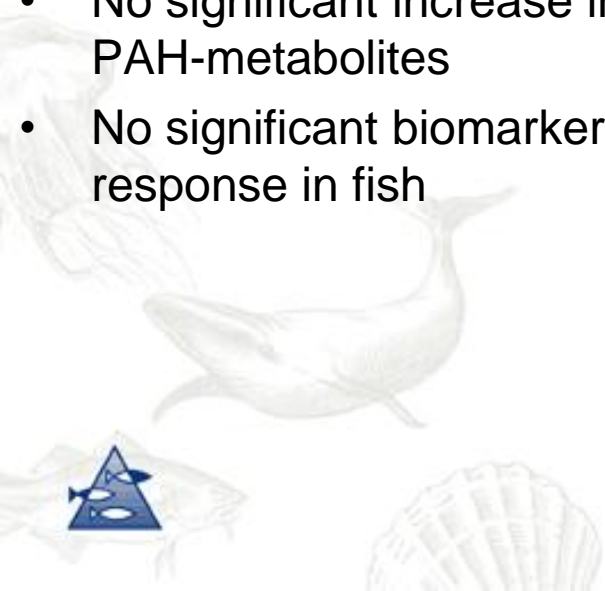
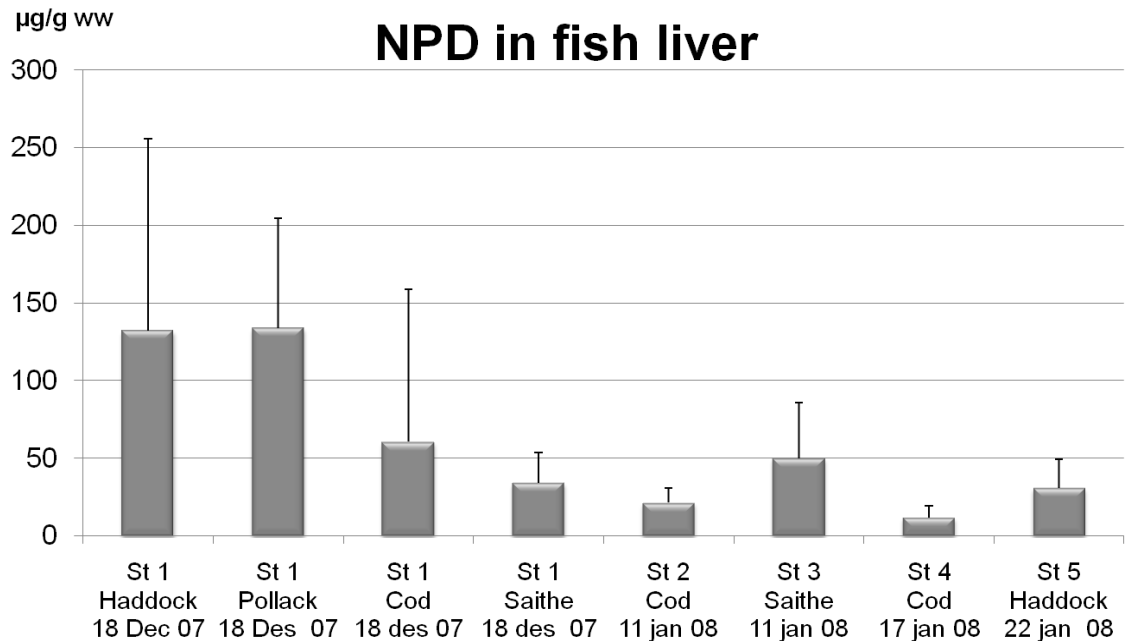
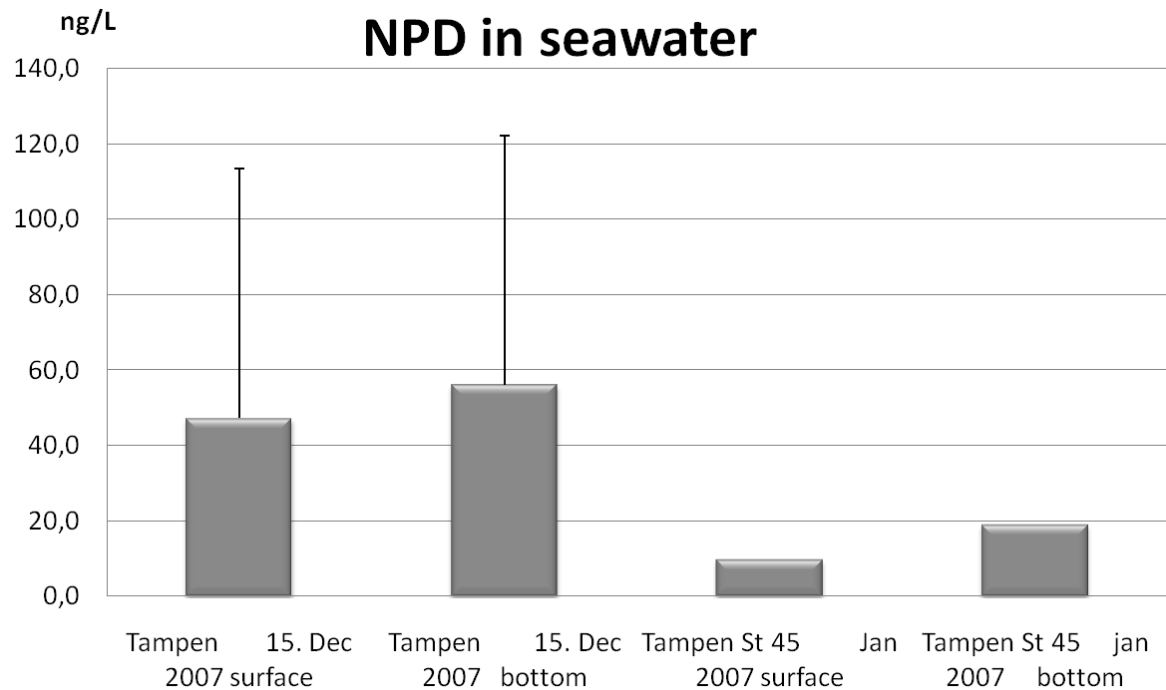


Photo: Bjørn Einar Grøsvik, IMR



# Statfjord A

- Elevated NPD levels in water after the spill
- Elevated NPD levels in liver of haddock, pollack and cod
- No increase in PAH16 in liver
- No oil components in fish filet
- No significant increase in PAH-metabolites
- No significant biomarker response in fish



# Server oil spill, 380 tonnes

- Sank in January 2007 near Fedje, Western Norway
- Very poor weather conditions
- Oil found on the neighbouring islands
- 3,200 to 8,000 birds dead
- **IMR** has studied
  - **THC, NPD, PAH16** in water, fish filet and fish liver, crabs and scallops
  - The metabolites (**PAH-OH**) in fish samples



Photo: The Norwegian Coastal Administration

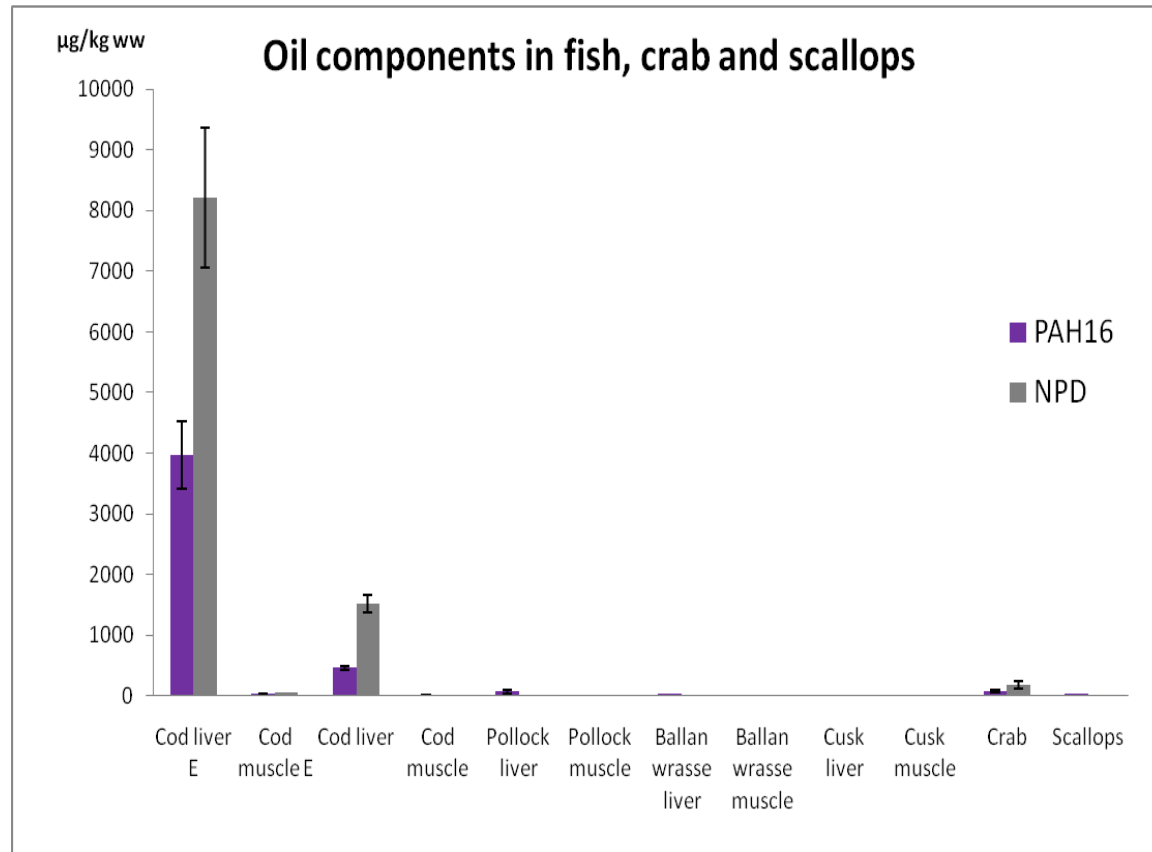


# Server

## Oil components in surface water

|              | Near the shipwreck | Other locations |
|--------------|--------------------|-----------------|
| PAH16 (ng/l) | 16±4               | 2±1             |
| NPD (ng/l)   | 27±10              | 12±9            |
| THC (µg/l)   | 6±2                | 2±1             |

- Elevated levels of oil components in seawater
- Strongly elevated levels of NPD/PAH16 in codfish caught right afterwards (liver)
- Elevated levels of NPD in codfish liver 1 month later
- No increase in fish filet
- No significant increase in other biota
- No significant long-term effects expected



# *Full City* oil spill, 200 tonnes

- Sank in July 2009 in Telemark, Eastern Norway
- Nearby coastline strongly contaminated
- 2,000 to 2,500 seabirds dead
- **IMR** has studied
  - **THC, NPD, PAH16** in water, fish filet and fish liver, crabs, shrimps and mussels
  - The metabolites (**PAH-OH**) in fish samples
- 4 samplings



Photo: Henning Steen, IMR



# Full City

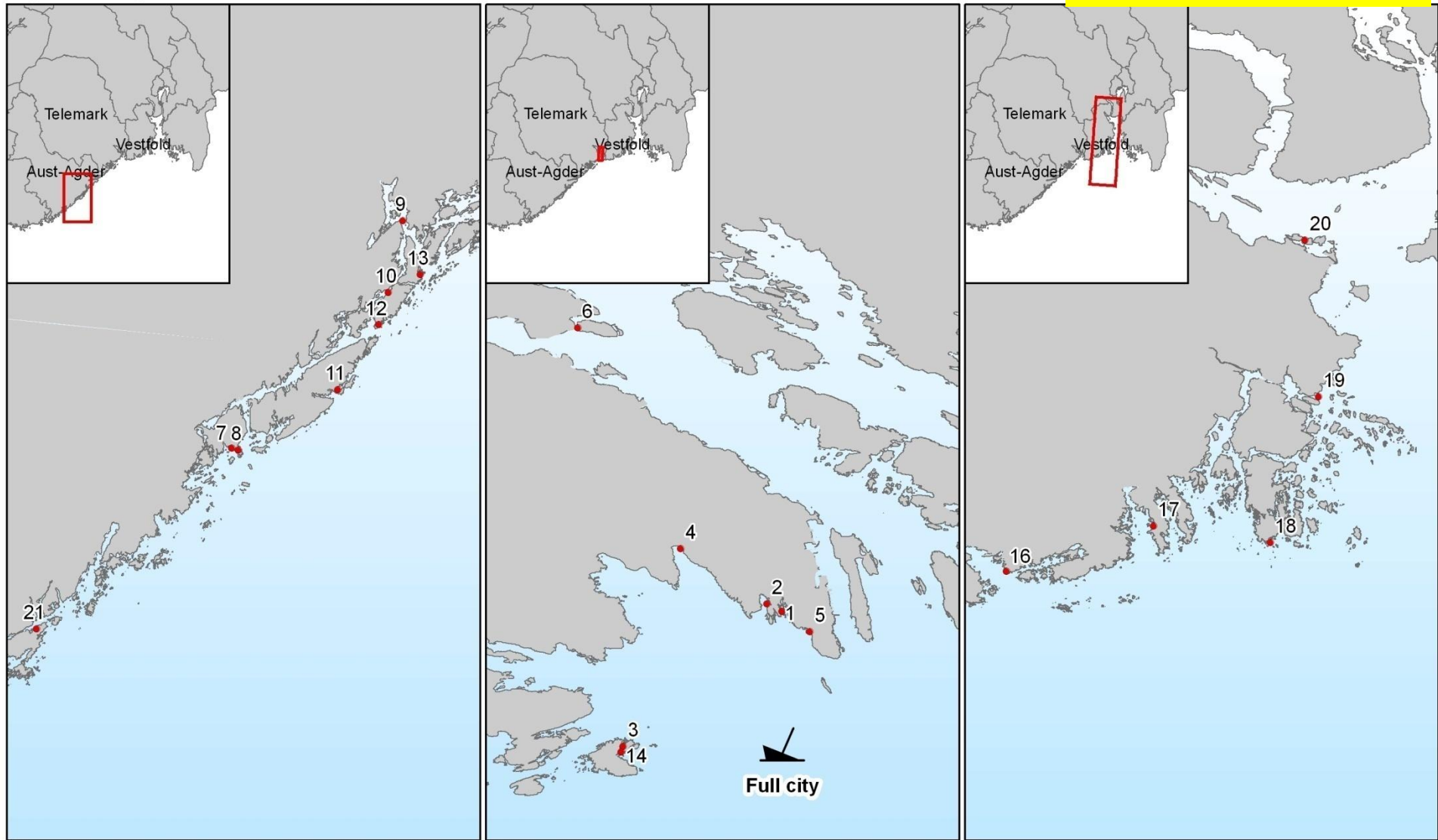
| Sampling | Seawater          | Fish liver, muscle         | Fish bile               | Crab | Shrimps | Mussels           |
|----------|-------------------|----------------------------|-------------------------|------|---------|-------------------|
| Aug 2009 | Slightly elevated | Elevated near shipwreck    | Elevated near shipwreck | Low  | -       | Strongly elevated |
| Dec 2009 | -                 | Slightly elevated in liver | -                       | -    | Low     | Strongly elevated |
| Apr 2010 | -                 | -                          | -                       | -    | -       | Strongly elevated |
| Nov 2010 | -                 | -                          | -                       | -    | -       | Elevated          |



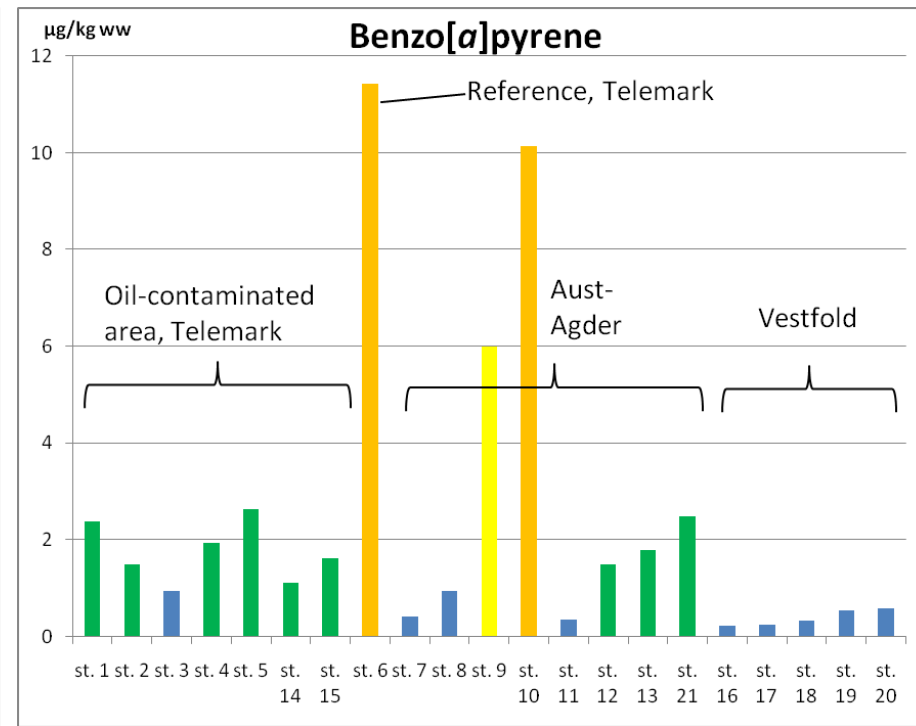
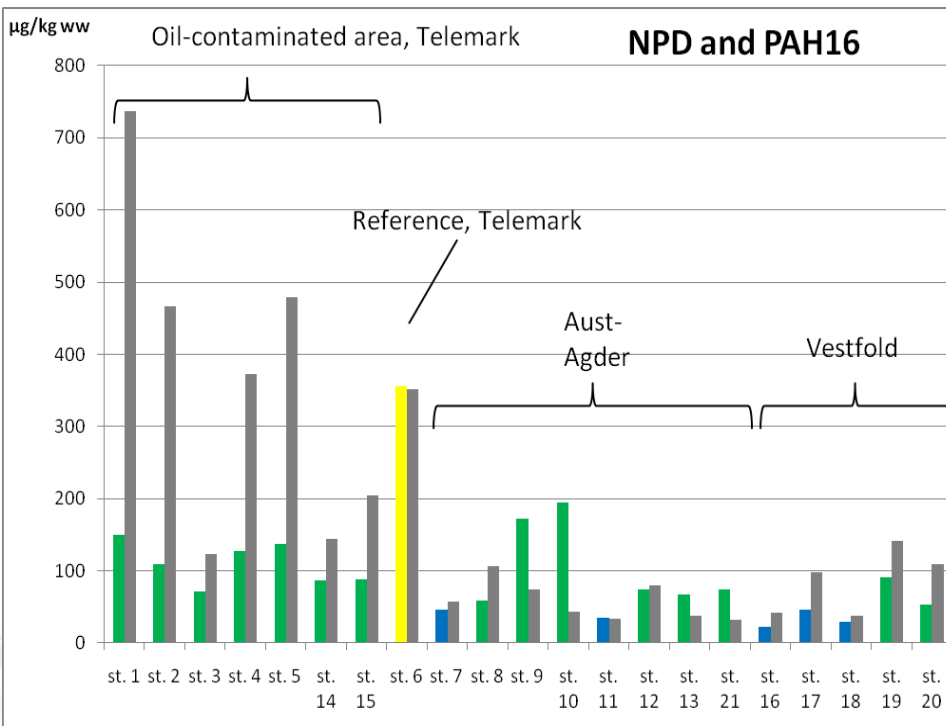
# Full City sampling April 2010

- Only mussels

Sjømatprøver blåskjell



# Full City April 2010 – PAH in mussels



■ **NPD**

**PAH16**

- Class I <50 µg/kg ww, "Insignificant"
- Class II 50-200 µg/kg ww, "Moderate"
- Class III 200-2000 µg/kg ww, "Marked"
- Class IV 2000-5000 µg/kg ww, "Strong"
- Class V >5000 µg/kg ww, "Very strong"

**Benzo[a]pyrene**

- Class I <1 µg/kg ww, "Insignificant"
- Class II 1-3 µg/kg ww, "Moderate"
- Class III 3-10 µg/kg ww, "Marked"
- Class IV 10-30 µg/kg ww, "Strong"
- Class V >30 µg/kg ww, "Very strong"





# Godafoss oil spill, 100 tonnes

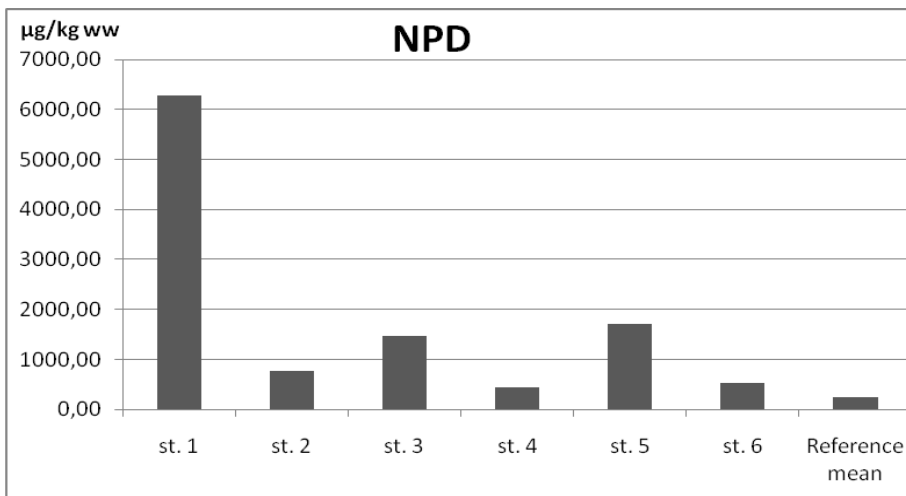
- Ran aground in February 2011 in Østfold, Eastern Norway
- Sea surface covered with ice
- >120 seabirds dead
- **IMR** has studied
  - **THC** in sediments
  - **NPD, PAH16** in fish filet, fish liver, mussels
- 2 samplings of mussels



Photo: Kjartan Mæstad, IMR



# Godafoss March 2011 – PAH in mussels



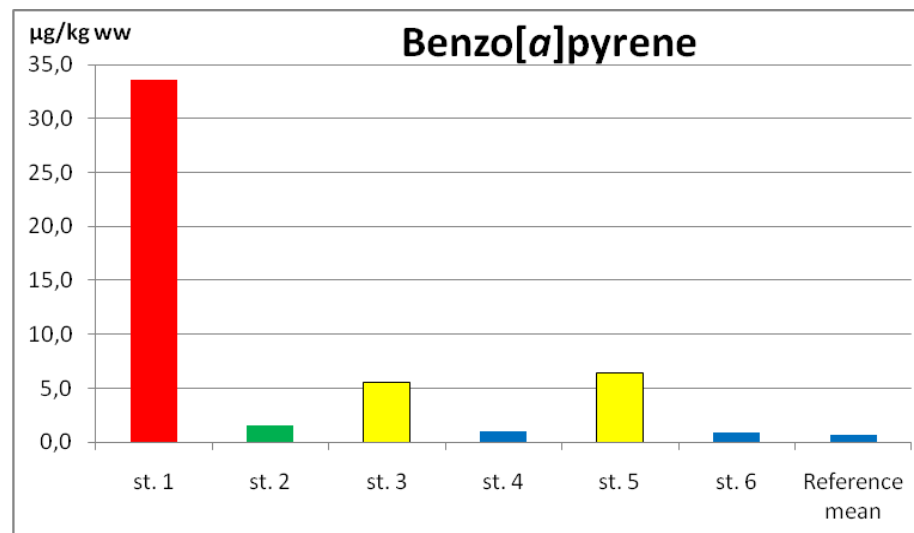
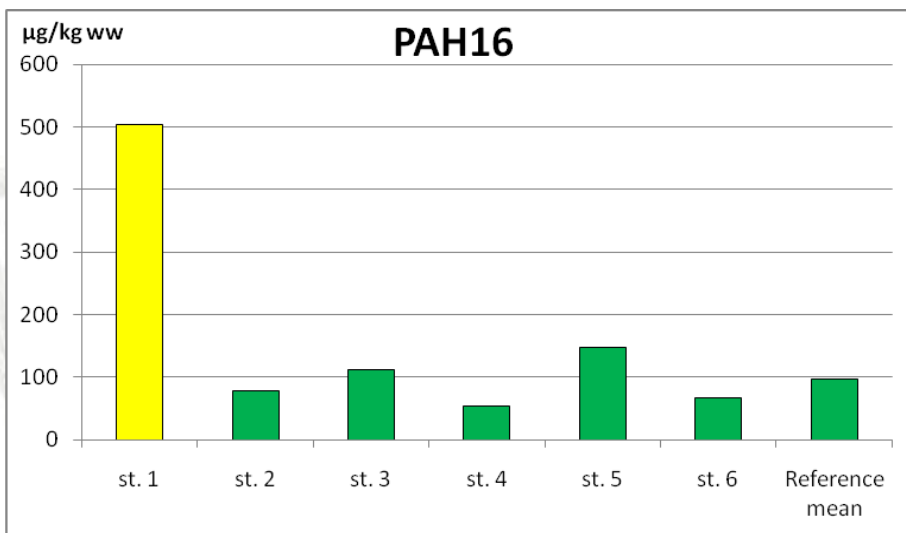
■ NPD

**PAH16**

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# Conclusions

- Small-to-moderate size oil spills lead to a temporary contamination of the marine environment
- The levels in seawater and mobile biota are low and return quickly to background
- The highest levels are found in stationary organisms (trapped fish, mussels)
- The degree of harm also depends on
  - the weather during the spill
  - pre-existing contamination from other sources

