Lessons learned about dispersant use at the *Deepwater Horizon* incident

Mr. Alun Lewis, Oil Spill Consultant

SLIDE 1 - Title Slide

Good morning / afternoon. My name is Alun Lewis and I am an independent oil spill consultant. I am not representing the oil industry, any oil company or any Government. My presentation today about dispersant use at the *Deepwater Horizon* incident is based only on publicly available information. Many facts about the incident are still not known with certainty, some will never be known and some facts are, or have been, the subject of legal proceedings.

SLIDE 2 - *Deepwater Horizon* burning

At 9:45 pm on the night of April 20th 2010 an explosion occurred on the *Deepwater Horizon* drilling rig in the Gulf of Mexico and was followed by a fire. There was loss of life. The *Deepwater Horizon* burned and sank two days later.

SLIDE 3 - Oil and gas leaking from the riser diagram

Crude oil and gas was escaping from several places along the broken and buckled riser in the sea floor in a water depth of 1500 metres. This is far deeper than divers can operate. The water pressure is around 150 atmospheres, it is permanently dark and the water is cold. All work must be conducted with ROVs (Remotely Operated Underwater Vehicles) with operators on ships on the sea surface.

The BOP (Blow Out Preventer), the device designed to stop the oil flow, failed to do so.

SLIDE 4 - Photo of oil and gas coming out of end of broken riser

This is oil and gas flowing out of the end of the riser. Crude oil continued to flow into the sea for the next 87 days despite a variety of methods being used to try and stop it.

SLIDE 5 - What made this incident different from other oil spills?

- The total amount of oil that could be released and the flow rate at which the oil was being released.

At an oil spill involving a damaged oil tanker, the maximum amount of oil that could be spilled is known. It will be the amount of the total cargo carried by the tanker. The amount of oil in each tank on a tanker is known and damage to tanks can be estimated on basis of inspection. It is therefore possible to get a reasonably good estimate of the amount of oil spilled at any time.

At the *Deepwater Horizon* / Macondo well incident, the maximum amount of oil that could have been spilled was unknown, but could be enormous; the entire contents of the oil reservoir. The actual flow rate from the well-head could not be measured.

- The time for which the oil release could continue.

At an oil spill involving a damaged tanker, the oil is often released into the sea over a matter of days or weeks, depending on how badly the ship has been damaged. If the weather and sea conditions permit, the oil cargo can be taken off the damaged tanker, thereby removing the source of the oil pollution.

"Source control" was a very important part of the efforts at the *Deepwater Horizon* / Macondo well incident. Several ingenious techniques were used in attempts to stop the flow, or to capture the oil, but many of these failed.

The 'classic' way to deal with an out of control oil well is to drill a relief well to intercept the original well and diver the oil and gas flow, but this can take a long time, at least 3 months, to complete. Drilling of a relief well started on May 2nd and on a second relief well on May 16th.

There have been previous oil releases from out of control offshore oil wells such as the Montara oil release in August 2009 in the Timor Sea and the Ixtoc 1 release in 1979 off of Mexico, but the water depth of the release, the apparent oil flow and the time for which the oil flow continued made the Deepwater Horizon a particularly large oil spill.

SLIDE 6 - Oil flow rate estimates
There was no way to measure the flow rate of oil and gas coming out of the broken riser or the well-head after the riser had been cut off on June 3rd.

The precise flow rate, and therefore total amount of oil released, later came to have a high degree of importance as fines under the Clean Water Act are levied on a per barrel basis. I present these figures without comment as to whether they are accurate or not. They are the estimates of the oil flow rate that were available on the dates given.

For most of the time that the oil was flowing and oil spill response at sea was being conducted, the oil rate was estimated by various people at various times. The earliest estimates of flow rate were 1,000 barrels/day or 5,000 barrels/day and these rose to 10,000 barrels / day and higher estimates later on.

After a 30 second long sub-sea video of the oil flow was released on May 12th and a live video feed was made available on May 27th, a very large number of people, with varying degrees of expertise or knowledge, produced their own flow rate estimates using various methods.

The US Government established a FRTG (Flow Rate Technical Group) in late May to try and establish a quantitative estimate of oil flow rate. What has since become the US Government's most widely publicised estimate of the total amount of oil released, approximately 4.9 ($\pm$ 10%) million barrels, is based on flow rate estimates that were only established after the oil flow had been stopped.

SLIDE 7 - The response
The largest oil spill response operation ever undertaken anywhere in the world was started. At its peak the response involved over 48,000 responders. That had dropped to about 900 people by last month (January 2013).

Nearly ten thousand ships and boats of various sizes were used. Over 1,100 kilometres of hard boom and nearly 3,000 kilometres of soft boom were deployed and there were over 400 controlled burns. And a lot of dispersant was used. I will go into some detail about this aspect of the response.

Up until now, February 2013, BP has spent over US$ 14 billion on clean up operations.

SLIDE 8 - The response graphic
Organising such a response involved an enormous amount of planning and co-ordination.

SLIDE 9 - Use of dispersants on oil on sea surface
The use of specific dispersants had been pre-authorized in the relevant oil spill contingency plans. These plans were activated and dispersant spraying from aircraft began on April 22nd as soon as the first oil on the sea surface had been seen.

SLIDE 10 - Purpose of using dispersants on spilled oil on sea surface
The purpose of using dispersant on the oil at sea was to prevent oil from drifting ashore and contaminating oil-sensitive marshes and coasts. This was explained in the oil spill contingency plans and the principle had previously been agreed with the relevant US Government authorities.

Some members of the public and academics later gave their own interpretations about dispersant use; that it had been done to "*hide the oil from sight*, or that it had been done to "*prevent the amount of oil that had leaked out from being known*".

As with any successful use of dispersants, the oil is transferred from the sea surface and into the water column as very small oil droplets. These do not sink, bit are retained in the upper water column by the prevailing turbulence. The dispersed oil would be rapidly biodegraded by the naturally occurring micro-organisms in the waters of the Gulf of Mexico.

The potential benefits and risks of using dispersants were well-understood and appreciated by the responders and the relevant US authorities.

SLIDE 11 - Use of dispersants on oil on sea surface
Dispersants were sprayed onto the oil on the sea surface from aircraft and from ships and boats.

The initial location of the oil was about 50 miles from the shore and aircraft sprayed the oil as it drifted on the sea surface. There were exclusion zones around ships and offshore rigs for the safety of their crews and the safety of the air crews. Dispersant spraying from aircraft is conducted at low altitude, from around 50 feet up to 150 feet and requires great skill. It is also a potentially dangerous activity if not well controlled.

Dispersant spraying from ships and boats was carried out close to, and by, the response vessels on the sea surface. This was done to disperse the oil and also to suppress the VOCs (Volatile Organic Compounds) to prevent the responders from breathing them.

SLIDE 12 - Basler BT-76 photo
This is a Basler BT-76 aircraft spraying dispersant onto oil. The Basler BT-76 is a turbo-jet powered DC-3 that is particularly suited to dispersant spraying. It can fly low and slow and this is required for accurate targeting of the dispersant onto the oil.

SLIDE 13 - US Air Force Hercules photo
This is a US Air Force Hercules aircraft spraying dispersant from the MASS (Modular Airborne Spray System). Four of these USAF aircraft were used and other civilian Hercules aircraft were also used.

SLIDE 14 - Aircraft dispersant-spraying sorties
Dispersant spraying from aircraft began on April 22nd and as the number of available aircraft increased the number of spraying sorties, or "missions" rapidly increased. Within a week there were 10 to 15 dispersant spraying missions each day. After two weeks this had risen to over 20 on some days.

SLIDE 15 - Dispersant sprayed on surface oil
As the oil continued to be released from far below the sea surface, the amount of dispersant used began to rise. Over 100,000 US gallons of dispersant were sprayed in the first week and after a month of spraying over 600,000 US gallons of dispersant had been used.

This use of dispersant in large quantities caused supply problems. The existing stockpiles of dispersant were quickly depleted. The dispersant manufacturer boosted production so that dispersant stocks did not run out.

SLIDE 16 - How effective was dispersant spraying?

- The effectiveness of dispersant spraying **cannot** currently be directly measured at sea.

Dispersants have been used on several large oils spills over the years, for example at the *Sea Empress* oil spill in the UK in 1996. It was known at the *Deepwater Horizon* incident that it would not be possible to directly measure, or quantify, how much oil was being dispersed by the dispersant spraying. This is because it is currently **not possible** to:

- Quantify the total amount of oil dispersed into the water at any time, or
- Quantify the amount of oil remaining on the sea surface at any time.

There are no measurement systems that can quantify the amount of oil that is being dispersed into the water at all locations under the oil with enough resolution in time and space to allow the total amount of oil that is being dispersed to be calculated.

Similarly, there are no remote sensing systems in either aircraft or satellites that can accurately measure the amount of oil on the sea surface before and after dispersant spraying.

Indications of effectiveness are possible, but accurate quantification is impossible.

SLIDE 17 - Challenges to dispersant spraying

Dispersant spraying from aircraft is not an easy thing to do. Oil on the sea surface was not present as a single massive oil slick. Instead, it was broken up into widely-scattered 'ribbons' and streamers. This made it extremely difficult to accurately target the thicker patches of oil with dispersant.

In addition, the US Government Agencies were becoming uneasy about the use of large quantities of dispersant for such a long time. They developed and increasingly complex system specific permission to be granted before spraying could be done. Permission had to be sought the day before spraying was conducted. It was then difficult to find the patches of thicker oil that had drifted during the night.

SLIDE 18 - Photograph of oil on the sea surface

This photograph shows how the oil looked close to the area where it arrived at the sea surface. Dispersant spraying from aircraft was not permitted in this area and you can see boats and ships carrying out booming and skimming operations. You can see that there are areas of thicker oil, areas of thinners oil and areas of open, clean water.

Further away, where the aircraft were spraying dispersant, the oil was much more scattered and very difficult to spray accurately.

SLIDE 19 - Sub-sea dispersant use photo

This is the oil and gas flowing from the sub-sea well-head. You can see that there is a lot of turbulence (mixing) as the oil and gas flowed out into the sea. Some of the escaping oil was being dispersed - turned into very small oil droplets in the water - by the mixing caused by the oil and gas release.

SLIDE 20 - Sub-sea dispersant use

- Sub-sea dispersant use was first tried out On May 1st.
- Sub-sea dispersant use had never been used before and no regulations existed about sub-sea dispersant use.

The aim was the same as that of using dispersants on oil on the sea surface; to prevent the oil from reaching the sea surface so that the oil could not drift ashore and pollute the coast and marshes.

SLIDE 21 - Oil being dispersed sub-sea photo

Dispersant was injected threw a pipe, or 'wand', held by an ROV and into the oil and gas flowing out of the well-head.

SLIDE 22 - Different dispersant addition systems photo

Several different designs of dispersant addition pipes were tried. The dispersants is the white coloured liquid against the background of the brown oil. A plain pipe, a pipe with a T-shaped end with 3 nozzles and a circular pipe with many nozzles were tried. They were not all successful.

SLIDE 23 - Why use sub-sea dispersant addition?

Spraying the oil with dispersant from aircraft when the oil arrived at the sea surface was proving difficult; it was too scattered. Why wait for the oil to come up before dispersing it back into the sea?

Sub-sea addition of dispersant was into turbulent mixing zone as the oil and gas flowed out into the water. The dispersant was very effective in these mixing conditions and less dispersant would be needed.

Sub-sea dispersant addition could be carried out 24 hours a day, 7 days a week. Dispersant spraying from aircraft could only be done during the day, not at night, and was limited by weather conditions.

SLIDE 24 - Sub-sea dispersant addition stopped

A few days after it was started, sub-sea dispersant addition was stopped on May 7th by the US Environmental Protection Agency - the EPA.

"*It was unclear whether the National Contingency Plan's pre-approval of the use of dispersants in the Gulf applied to subsea use in addition to surface use and therefore whether additional EPA approval and NOAA consultation were required*"

"*Notwithstanding those uncertainties regarding governing law, on May 7, 2010, EPA halted subsea dispersant operations, awaiting additional test results*"

SLIDE 25 - How effective was sub-sea dispersant addition?

The EPA wanted to be reassured that sub-sea dispersant addition was working, that is, being effective and dispersing a lot of the oil that was flowing from the well. They also wanted reassurance that sub-sea addition was not causing harm to marine organisms.

As sub-sea dispersant addition had not been used or investigated in any detail before, such information was not readily available.

- The effectiveness of sub-sea dispersant addition **could not** be directly measured for similar reasons to those about dispersant spraying onto oil on the sea surface.
- Various methods gave <u>indications</u> that oil was being dispersed by dispersant addition.

These included echo-location or sonar, measuring the dispersed oil in water concentrations and trying to estimate how much oil was reaching the sea surface. Not of these methods could accurately quantify the amount of oil being dispersed, but they could indications of dispersant effectiveness.

SLIDE 26 - May 9th: before sub-sea dispersant addition photo
This is an aerial photograph taken on May 9th. Sub-sea dispersant addition had been stopped days before and was not taking place at this time.

I have marked the position of the Q4000 drilling rig with a yellow circle to help you understand what you are seeing. It was positioned in the middle of the area where the oil was reaching the sea surface.

I have also marked the extent of the thicker, brown-coloured oil on the sea surface with the yellow dotted line.

SLIDE 27 - May 10th: After 3 hrs of sub-sea dispersant addition
This aerial photograph was taken on May 10th, 3 hours after sub-sea dispersant addition was started at around 05:40. The area of thicker oil on the sea surface is much smaller.

SLIDE 28 - May 10th: After 11 hrs of sub-sea dispersant addition
After 11 hours of sub-sea dispersant addition, the areas of thick oil on the sea surface are much smaller - just a few scattered patches.

SLIDE 29 - May 11th: 5 hrs after sub-sea dispersant addition ended
Sub-sea dispersant addition was stopped during the night at 04:00 and this photograph was taken 5 hours later on the morning of May 11th. Thicker oil now covers a much large area. The oil is reaching the sea surface again.

SLIDE 30 - May 12th: 28 hrs after sub-sea dispersant addition ended
And finally, this is the last photograph in this sequence taken on the morning of May 12th, 28hours after sub-sea dispersant addition ended. The thicker oil is once again on the sea surface.

It has drifted some way from the Q4000 rig because of the wind, but the amount looks similar to that which was on the sea surface before sub-sea dispersant addition was started.

It is not possible to accurately quantify the amount of oil that had been dispersed, but it is visually obvious that sub-sea dispersant addition significantly reduced the amount of oil reaching the sea surface.

SLIDE 31 - Diagram
This is a diagram to explain what was happening. When there was no added dispersant, a lot of the oil rose up thorough the water column as relatively large oil droplets and reached the sea surface.

When sub-sea dispersant addition was taking place, much more of the oil flowing out of the well was converted into very small oil droplets. These very small oil droplets rise much more slowly because their buoyancy is less. They were carried horizontally be the slow sub-surface current and were kept in the water column by a pycnocline (a water density difference) at about the 1200 metre water depth.

SLIDE 32 - Sub-sea dispersant addition resumed
On May 15th, after laboratory testing for effectiveness and toxicity had been conducted, and the tests that I have just described were carried out at sea, sub-sea dispersant use was allowed to resume.

SLIDE 33 - Concerns over dispersants
Many people, including the general public, pressure groups and some administrators in the US Government, began expressing concerns about the scale and duration of dispersant use.

Dispersant spraying of oil on the sea surface had been going on for nearly a month and sub-sea dispersant addition for 10 days. The attempts at source control to stop the oil flow had so far failed. There seemed to be no end in sight to the oil flow or to the use of dispersants.

These concerns were magnified by misinformation circulating on the internet and in the media. The dispersant composition was not known to public and incessant media reports of "toxic dispersants" unsettled many people. There were concerns about the possible toxic effects of dispersants to marine organisms and to humans, including the general public who were far from the response and the dispersants.

SLIDE 34 - US EPA Limits dispersant use
On May 24th, the EPA issued amendments to Directives that demanded:

- A 75% reduction in the amount of dispersant being used.
- The elimination of surface application of dispersants, except in exceptional circumstances.
- Restricted sub-sea dispersant use to a maximum of 15,000 gallons/day (357 barrels/day) of dispersant.

The restriction in the maximum amount of dispersant that could be used sub-sea had consequences.

At the time, towards the end of May, it was though by most people that the oil flow rate was 5,000 to 10,000 barrels / day. A these oil flow rates the dispersant treatment rate would have been approximately 1 part of dispersant to 20 parts of oil, with a range of 1to 14 or 1 to 28 parts of dispersant to oil. This is close to the treatment rate of 1:20 recommended for dispersant spraying on oil on the sea surface.

If, as was estimated by the FRTG on 2nd August, the oil flow rate was 53,000 barrels /day, the dispersant treatment rate would have been 1 part dispersant to 148 parts of oil, much lower than had been intended.

SLIDE 35 - Continued dispersant use
Despite these restrictions of dispersant use on oil on the sea surface and dispersant use sub-sea, dispersant use continued under the direction of the NIC (National Incident Commander), USCG Admiral Thad Allen, sub-sea dispersant use continued until the oil flow was stopped on July 15th.

Sub-sea dispersant addition stopped on July 15th.

Dispersant spraying from aircraft stopped two days later as there were no more easy oil 'targets' to be sprayed.

SLIDE 36 - Total amounts of dispersant used
Dispersant spraying of oil on the sea surface by aircraft had begun on April 22nd and sub-sea dispersant addition was authorized on May 15th.

By the time that dispersants operations ceased nearly 7,000 cubic metres of dispersant had been used; nearly 4,000 cubic metres sprayed onto oil on the sea surface from the air, and nearly 3,000 cubic metres added to the oil sub-sea. This is the largest amount of dispersant that has ever been used at an oil spill response.

SLIDE 37 - Effectiveness of dispersant use
What did this use of a very large quantity of dispersant achieve?
How much oil was dispersed by the use of nearly 7,000 cubic metres of dispersant?

This is still not known with any degree of certainty. As I have explained earlier, the amount of oil dispersed by the use of dispersant on oil on the sea surface or by sub-sea addition of dispersant could not be measured directly. There are currently no techniques that would make this possible.

US Government Agencies published two Oil Budgets with estimates of the fate of the oil. I stress that these are estimates because they were both based on the professional opinions of a panel of relevant experts because no direct measurements were taken, or could have been taken.

The first was presented at the White House on August 4th 2010.

The second, much more comprehensive Oil Budget report was published almost nearly four months later on November 23rd 2010. The report is 217 pages long.

SLIDE 38 - August 4th 2010 Oil Budget
This pie-chart was presented at a White House press conference with almost no background data or explanation.

It uses an estimated total of 4.9 million barrels of oil release. The numbers that I will draw your attention to are the 16% naturally dispersed (in the orange box) and the 8% chemically dispersed (in the red box).

These estimates were heavily criticized by a large number of people for many different reasons.

SLIDE 39 - Differences between 4th August and 23rd November Oil Budgets
The US Government Team, with assistance from 'outsiders' (non US Government people), prepared the 217 page report and came up with different estimates.

*The most significant change is a doubling of the expected amount of oil classified as "chemically dispersed" — revised from **8%** to an estimated **16%** with a possible range of between **10%** and **29%***

Three estimates given; "Best" Case, "Expected" Case and "Worst" Case.

SLIDE 40 - November 23rd Oil Budget estimates "Expected" Case
This is the "expected" case. Why it is called "expected" is difficult to say. It is the middle estimate of three. It could have been called the "middle" estimate.

It requires some explanation.

- **Direct Recovery** refers to oil captured at the well head and taken onboard ships for flaring. This oil never entered the sea.
- **Naturally dispersed** refers to oil dispersed only by turbulence at sub-sea release without the addition of any dispersant at all.
- **Chemically dispersed** is the additional oil dispersed by addition of dispersant

It was estimated that 13% of the total oil was dispersed by the turbulence of the oil and gas flow at the well head without dispersant addition.

It was estimated that the use of dispersants (both sprayed on oil on the sea surface and by sub-sea addition) caused another 16% of the total amount of oil to be dispersed

SLIDE 41 - "Worst" case
In the "Worst" case it was estimated that 12% was naturally dispersed and 10% was chemically dispersed.

Most other things remained the same (except for the"Other Oil).

SLIDE 42 - "Best" case
In the "Best" Case it was estimated that 13% was naturally dispersed and 29% was chemically dispersed.

SLIDE 43 - Oil dispersed into the sea
It is easier to compare these numbers in a table than as three pie-charts.

The first thing to note is that the probability of each estimate is equivalent. It is as equally probable that the "Best" case occurred as it is likely that the "Worst" Case or the "Expected" case occurred. Nobody knows which of these estimates best represents the reality.

Secondly, the estimates of the amounts of naturally dispersed oil are almost identical at 12% or 13%, but the estimates of the amounts of chemically dispersed oil are very different, from only 10% for the "Worst" Case to 29% for the "Best" case. This is a factor of three difference.

SLIDE 44 - Oil dispersed into the sea

These estimates indicate that, if no dispersant had been used at the *Deepwater Horizon* incident, 13% of the oil would still have been dispersed into the sea. It would have been naturally dispersed rather than chemically dispersed, but it would have been dispersed.

That could be a lot of oil. If 4.9 million barrels of oil had flowed from the well-head approximately 640,000 barrels would have been dispersed into the sea without any dispersant use.

The use of dispersants increased the amount of oil dispersed into the sea to approximately:
- 2,000,000 barrels of oil if the "Best" Case is correct, or
- 1,400,000 barrels of oil if the "Expected" Case is correct, or
- 1,000,000 barrels of oil if the "Worst" Case is correct

So, which estimate is the most correct estimate?

Nobody knows.

A Congressional report published on January 31st, 2013, referring to the November 23rd Oil Budget, states

"It is debatable whether the fate of the remaining oil will ever be established conclusively. Multiple challenges hinder this objective, and as time progresses, determining the fate of the oil will likely become more difficult. Researchers are continuing to study and publish results addressing various aspects of the spill."

(Deepwater Horizon Oil Spill: Recent Activities and Ongoing Developments by Jonathan L. Ramseur Specialist in Environmental Policy and Curry L. Hagerty, Specialist in Energy and Natural Resources Policy, January 31, 2013 Congressional Research Service, 7-5700, www.crs.gov. R42942)

SLIDE 45 - How much oil remained after all response methods?
The purpose of using dispersants is to prevent oil from drifting ashore and damaging oil-sensitive coastal habitats and resources.

We do not know how much oil actually came ashore.

According to National Oceanic and Atmospheric Administration (NOAA) shoreline survey data, the maximum extent of shoreline oiling involved almost 1,100 miles of shoreline. As of December 21, 2012, approximately 339 miles of oiled shoreline remain subject to evaluation and/or cleanup operations.

If no dispersant had been used, and all other response methods were the same, approximately 39% of the total amount of oil released would have remained at sea and some would have come ashore. 39% of 4.9 million barrels is 1.9 million barrels of oil.

Depending on which estimate case is used, dispersant use reduced this amount to 0.4 million barrels ("Best" Case), 1.1 million barrels ("Expected" Case) or 1.5 million barrels ("Worst" Case).

SLIDE 46 - Did the dispersed oil harm fisheries?
Fishing was banned while the oil was being released and for some time after the oil flow was stopped. This would have happened whether or not dispersant was used.

Fish catches were higher after the fishing ban was lifted than before. The area was over-fished and stocks recovered while the ban was in place. This has happened at other major oil spills.

SLIDE 47 - Did the dispersed oil harm marine life?
There was (and is still) some concern over tainting of shrimp. Studies have found no problems, but some of the public and some shrimp fishermen remain unconvinced.

NRDA (Natural Resource Damage Assessment) studies will continue for years. Many studies have been started and the *Deepwater Horizon* / Macondo is going to be the most studied oil spill in history.

SLIDE 48 - Conclusions 1
A lot is still unknown about the effectiveness and consequences of dispersant use at the *Deepwater Horizon* / Macondo incident. Some things will never be known with any accuracy.

Dispersant use, particularly sub-sea dispersant addition, appears to have been very effective, but could not be accurately quantified.

It has been estimated by the US Government that at least 0.5 million barrels, and perhaps 1.4 million barrels of oil, were dispersed by the use of dispersant. This is in addition to the 0.6 million barrels of oil that was estimated to have been naturally dispersed.

SLIDE 49 - Conclusions 2
It seems that the amount of oil that could have come ashore was substantially reduced by dispersant use, but this cannot be accurately quantified.

Studies that are still being conducted might help us to understand exactly what happened.

Dispersant use was hindered by a lack of understanding of some of the basic issues about dispersant use. A lot of misinformation and wild speculation about dispersants became available on the internet and this caused concern and fear in some people.

Studies currently being undertaken will clarify these concerns.

SLIDE 50 - Thank you for your attention