THE INTERNATIONAL MAGAZINE OF THE BP GROUP ISSUE 2 2011

BP MAGAZINE

NEW PROSPECTS

BP Magazine talks to the company's Exploration leader about investing for the future.

Welcome. There's been a lot of debate lately about whether the days of 'easy oil' are over. But, I suspect that if you were to ask the late William Knox D'Arcy – BP's founder – he would probably have told you there was nothing 'easy' about looking for oil in the early 20th century. One thing is clear – finding new sources of energy remains the lifeblood of any oil and gas company. We talk to Mike Daly, BP's head of Exploration (page 8), about this ongoing search and find out why flexibility is crucial to success. On page 22, we head for India, a nation with rising energy needs and the hydrocarbon potential to meet some of that demand. In other parts of the magazine, we return to the Gulf of Mexico (page 32), to find out what some of the local fishermen are experiencing as they get back to work a year after the oil spill; we take a look back at 60 years of the *BP Statistical Review of World Energy* (page 46); and on page 60, British Paralympian Shelly Woods talks about preparing for London 2012 and her role as one of BP's athlete ambassadors.

Lisa Davison> Editor

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Cover image: The FPSO Polvo in Brazil. BP will become the operator of the Polvo field, following a transaction between it and Devon Energy. Polvo currently produces 25,000 barrels of oil per day.

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+ Features

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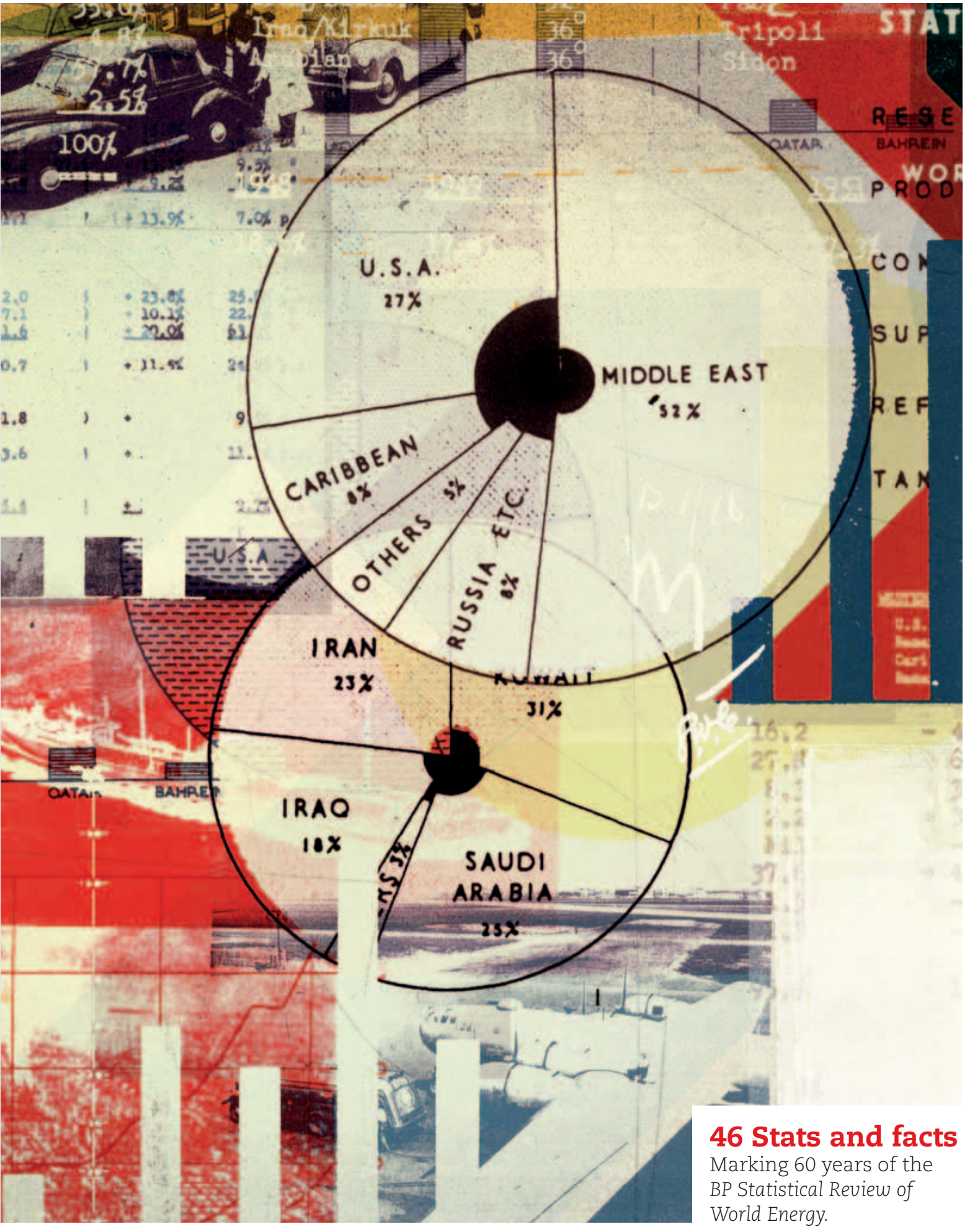


46 Stats and facts

Marking 60 years of the *BP Statistical Review of World Energy*.

For the record

the quarter in numbers

3

The number of contractors that BP and Davy Process Technology are to collaborate with to promote the commercialisation of the BP/Davy Fischer Tropsch process.

5

The number of laboratories that BP has helped open at the Qafqaz University, Azerbaijan.

5.6%

The rate of growth in global energy consumption in 2010. This is the highest rate since 1973.

$680 million

The amount in cash, subject to closing adjustments, that BP will receive from the sale of ARCO Aluminum to a consortium of Japanese companies.

China: energy growth

China became the world's largest energy consumer in 2010, overtaking the US during a year in which the rebound in the global economy drove consumption higher, and at a rate not seen since the aftermath of the 1973 oil price shocks. Demand for all forms of energy grew strongly in 2010 and increases in fossil fuel consumption suggest that global carbon dioxide emissions from energy use rose at their fastest rate since 1969. The figures come from the 60th annual *BP Statistical Review of World Energy*, the longest-running, consistent set of objective, global energy data used by business, academics and governments to inform policy and decision making. For more on the history of the *Statistical Review*, see page 46.

Energy giant: China overtook the US as the world's largest energy consumer for the first time in 2010.

US

GoM agreement

BP has reached an agreement with MOEX Offshore and its affiliates, Mitsui Oil Exploration and MOEX USA Corporation, to settle all claims between the companies related to the Deepwater Horizon accident. MOEX had a 10% interest in the Macondo well and has joined BP in recognising and acknowledging the findings of the Presidential Commission. Under the agreement, MOEX USA Corporation will pay BP $1.065 billion. BP will immediately apply the payment to the $20-billion trust fund it established to meet individual, business and government claims, as well as the cost of Natural Resource Damages.

UK

Wytch Farm sale

BP has agreed to sell its interests in the Wytch Farm (above), Wareham, Beacon and Kimmeridge fields to Perenco, for up to $610 million in cash. The price includes $55 million contingent on Perenco's future development of the Beacon field and on oil prices in 2011-13. The sale of these interests is part of BP's plan, announced in July 2010, to divest up to $30 billion of assets by the end of 2011.

Azerbaijan

Agreement ratified

The Parliament of the Republic of Azerbaijan has ratified the new production sharing agreement between BP and SOCAR on joint exploration and development of the Shafag-Asiman structure in the Azerbaijan sector of the Caspian Sea. Under the 30-year agreement, BP will be the operator, with a 50% interest, while SOCAR will hold the remaining 50% equity.

US

Gulf restoration

BP has signed an agreement with federal and state agencies that will accelerate work starting this year to restore areas of the Gulf of Mexico that were affected by the Deepwater Horizon accident. The agreement commits up to $1 billion to projects that will restore injured natural resources in the Gulf at the earliest opportunity. It allows projects important to the Gulf's recovery to begin now, as early restoration projects, rather than waiting for the trustees to complete all of the Natural Resource Damage Assessment (NRDA) studies that are underway.

Indonesia

New contracts

BP has signed four new coalbed methane (CBM) production sharing contracts in the Barito basin of South Kalimantan, Indonesia. BP and co-owner Pertamina were jointly awarded the Tanjung IV CBM PSC through a direct award from the Government of Indonesia. Meanwhile, BP and co-owner PT Sugico Graha (Sugico) were jointly awarded the Kapuas I, II and III CBM contracts.

UK

Olympic exhibition

BP and London's Royal Opera House are collaborating with The Olympic Museum to create a free exhibition that will tell the Olympic story through the endeavours of ancient and modern Olympians. Called *The Olympic Journey: The Story of the Games*, the exhibition will be staged at the Royal Opera House for the duration of the 2012 Olympic Games. Unique artefacts, graphics, film and audio from The Olympic Museum in Lausanne, Switzerland, will be shown in London for the very first time as part of the exhibition.

Brazil

Deal approval

The Brazilian National Petroleum, Natural Gas and Biofuels Agency has given final approval for BP to complete its purchase of 10 exploration and production blocks from Devon Energy. The blocks will give BP a broad deepwater exploration position offshore Brazil and includes two onshore licences in the Parnaiba basin.

Germany

Refinery partnership

Rosneft has become a new partner in BP's German refining joint venture, Ruhr Oel GmbH. This follows the completion of the deal announced last October, in which BP's existing partner, PDVSA of Venezuela, agreed to sell its 50% interest in the joint venture to Rosneft.

Brazil

Biofuels expansion

BP is to acquire majority control of the Brazilian ethanol and sugar producer Companhia Nacional de Açúcar e Álcool (CNAA). When CNAA's assets are fully developed, this is expected to increase BP's overall Brazilian production capacity to around 1.4 billion litres of ethanol equivalent per year. BP will pay approximately $680 million to acquire 83% of CNAA shares and to refinance 100% of CNAA's existing long-term debt.

Report> Jaclyn Clarabut
Illustration> Brett Ryder

Stop the rot

In an industry where so many assets are made from different types of metal, the threat of corrosion is something that companies such as BP must protect themselves against every day. But what is corrosion and why does it occur?

Look for the orange mark peeping from behind the peeling paint on thousands of cars doors – or the rust on a garden gate or latch – and you'll notice corrosion is commonplace. In fact, wherever there is metal, there is the threat of corrosion. However, that threat increases when the metal meets the harsh environments in which the oil industry operates. And with millions of miles of pipelines carrying corrosive crude oil, and giant structures standing up to 600 metres (2,000 feet) tall in biting seawater, energy companies have a lot of metal to take care of. Protecting that metal is a crucial job, because unless the risk of corrosion is monitored and managed carefully, once-strong metals will crumble away in layers.

But why does corrosion happen and what starts the process? In simple terms, corrosion is the deterioration of a metal or material by the reaction with its environment. That reaction is simply the metal trying to return to its original state – as a compound of a metal and oxygen or oxide – before it was converted to a base metal. A lot of energy is applied in the conversion to remove the oxygen. When a metal is exposed to any environment where oxygen is present, there's a powerful drive for it to return to its original chemical formula. In the case of iron, this becomes iron oxide – which is commonly known as rust. So, all metals in a certain environment will corrode in some way and go back to an oxide – a more stable chemical form. The reality is unless metal is kept in a vacuum, corrosion is inevitable.

But if you can anticipate corrosion, you can keep it under control. In the oil industry, a simple way to ensure integrity of the structures is to determine the corrosion rate of a material and then make sure that the material is thick enough to accommodate, for example, a loss of thickness of 0.1 millimetres per year.

Knowing the corrosion rate is also an important factor in the choice of metal used to build a rig or pipeline. However, selecting the most corrosion-resistant material is not always a viable option, as the economics of a project might prevent a rig, for example, being built in titanium, which does not corrode easily, but is expensive.

Living with the effects of corrosion means having to use a range of possible control measures. A car is made of steel, but its paint acts as a good corrosion control measure. While the paint excludes air and water, it is the owner's monitoring regime that will then keep corrosion in check by maintaining the paintwork.

In a refinery, it's important to keep a close eye on corrosion as the crude oil processed at a refinery can be of different corrosive strengths depending on from where it has come. Knowing which crudes are having the most corrosive effect by careful monitoring is key to keeping the refinery going.

Corrosion can be very expensive, and it's not always straight forward controlling its effects, but choosing the best combination of construction material, corrosion control measure and monitoring regime is vital to maintaining safety and integrity.

For more on how BP monitors and manages corrosion, see page 16. ■

Types of corrosion

The method of managing corrosion will depend on its type, of which there are a few examples:

Uniform corrosion

As it suggests, this type of corrosion happens at a steady and predictable rate on the surface.

Localised corrosion

This can be more severe than uniform, as it can happen without warning. This sometimes occurs if two metals have come into contact with each other, sparking a chemical reaction.

Pitting corrosion

This sometimes occurs when a protective coating is broken, leaving the exposed metal susceptible to tiny pits.

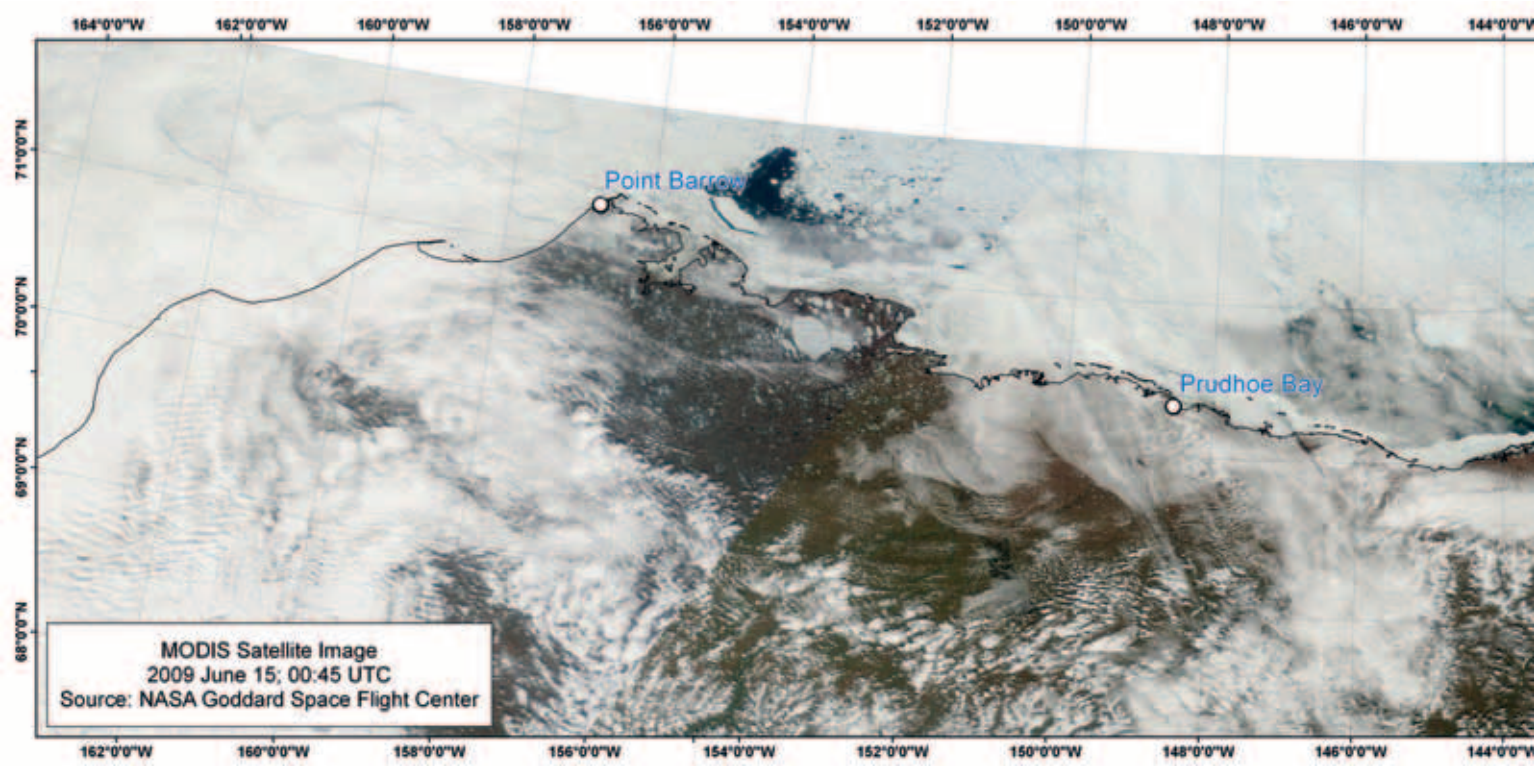
Exploration> Interview with Mike Daly

Report> Lisa Davison
Photography> BP Imageshop/Corbis

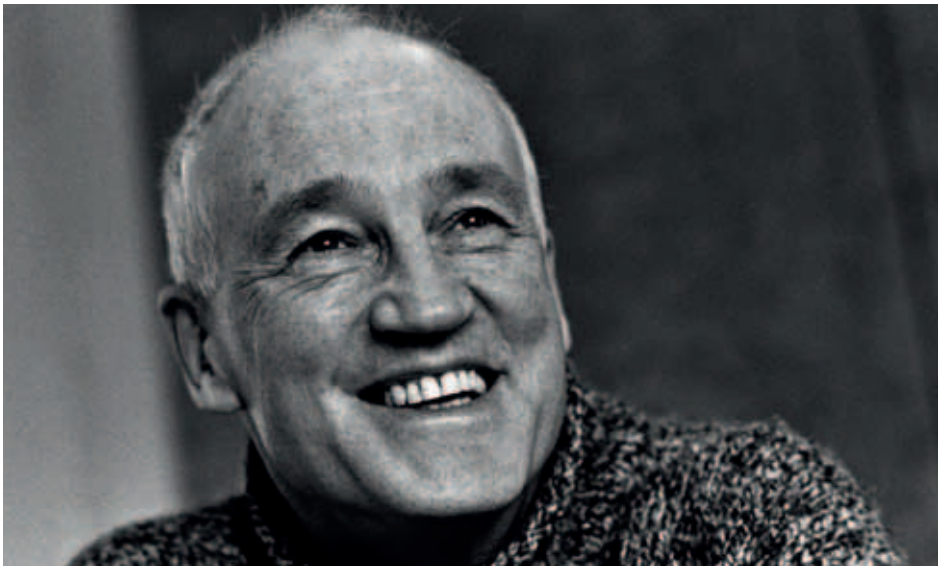
Global outlook: deepwater exploration remains a key part of BP's strategy (opposite, top). Middle, a major seismic study is underway in Jordan, where BP is due to test an idea that could transform the Risha gas field. Bottom, BP has begun exploring in the Canadian Beaufort Sea, where ice management will become a major part of future operations. Below, BP's new deal with Devon Energy gives it access to eight deepwater blocks in Brazil.

THE NEW FRONTIERS

While the tragic accident in the Gulf of Mexico has led to many changes in BP's operations, one thing that remains fundamental to the company is finding oil and gas. Mike Daly, BP's executive vice president for Exploration, believes that with the land and resource base that BP has access to – and the additional investment being made – his division has a promising future.



When BP began work at the Rumaila oilfield in Iraq last year, it didn't have to start from scratch. In fact, the company's geologists were able to dust down research that BP had originally carried out at the giant field some 60 years ago. It demonstrated a heritage of knowledge about oil and gas basins that the company's executive vice president for Exploration, Mike Daly (below), sees as a distinctive strength.

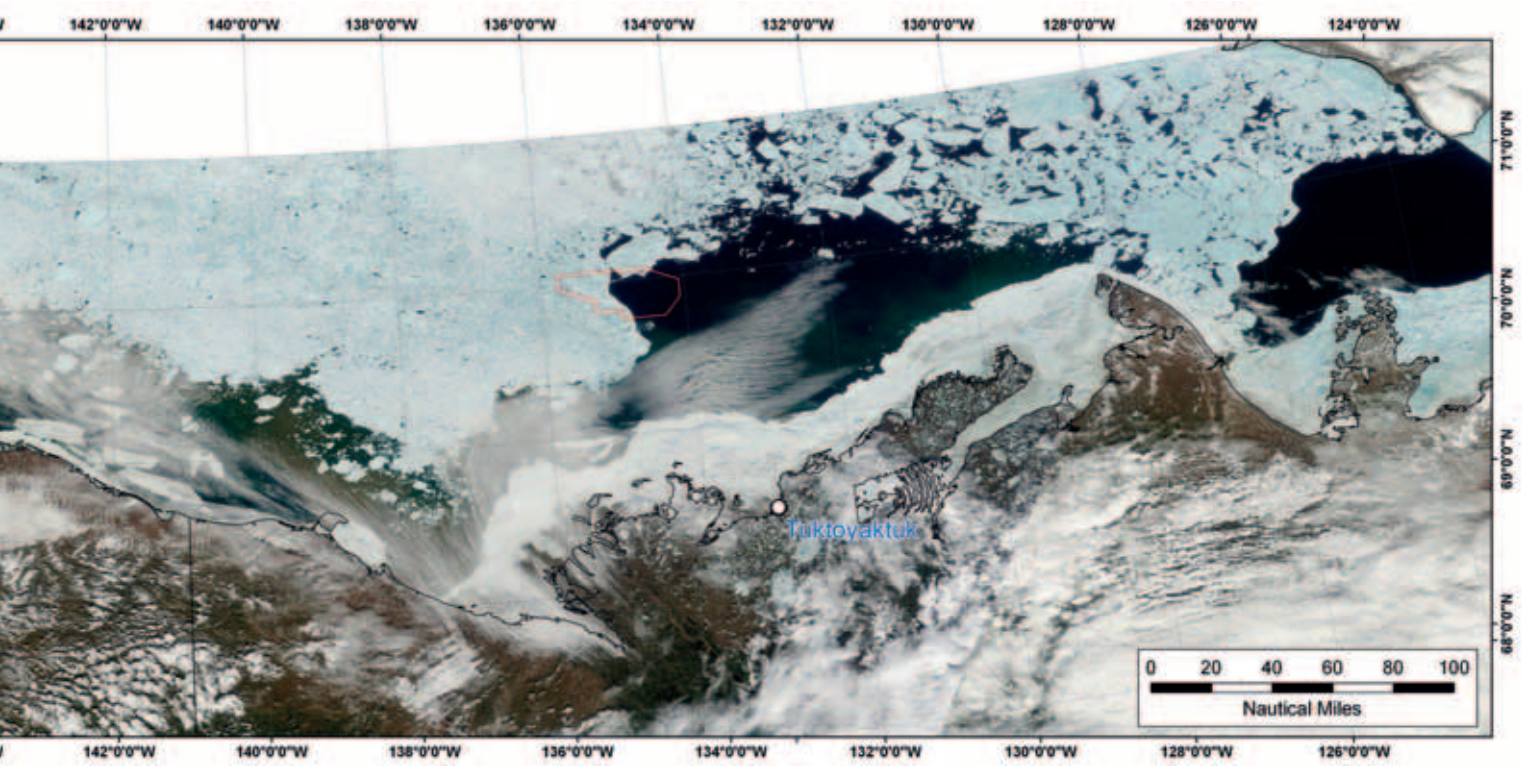


"When we were studying Rumaila, we were able to pull out our own maps and schematics from the 1950s," he says. "We're very lucky to have this immense legacy of knowledge about the world's geology."

BP's ability to find oil and gas is well-known and, for the past 18 consecutive years, has helped it add more to its annual reserves than it has produced, what's known as a 'reserve replacement ratio' of more than 100%. This track record is important, because it demonstrates a company's sustained potential for long-term growth – something BP chief executive Bob Dudley has highlighted as a priority, with plans to double exploration spending in the next few years.

The company has also announced one of the biggest structural changes to its upstream business for 20 years, with the former Exploration & Production segment now divided into three divisions – Exploration, Developments and Production. That move is expected to deepen the company's expertise, while adding greater clarity and accountability without losing its entrepreneurial spirit.

As a consequence, the big decisions about where to explore and how much to invest in each location are made by the top management, as a team. This helps balance the natural tension that historically lies between explorers, whose goal is to renew



Arctic overview: taken on 15 June 2009, the above aerial image shows the scale of the ice challenges facing BP in the Arctic. The red outline shows the area of the Beaufort Sea in which BP acquired 3D seismic in the summer of 2009. Right, BP's seismic survey in Jordan is a 24-hour operation.

an oil and gas company's long-term prospects, and the producers who boost value by drilling wells and optimising existing fields.

Interestingly, a collaborative approach isn't new in exploration. Back in the 1990s, BP created its first Exploration Forum. Its aim was to bring together the leaders in the company who were accountable for and knowledgeable about exploration, and ask them to collectively decide the best global exploration portfolio. That forum has grown and changed over the past two decades, but, says Daly, its essence remains the same, a global team committed to the best exploration outcome for BP.

"The forum provides a completely independent form of challenge and assurance," he says. "For example, if you're based in Australia and you've just spent the past three years working up a prospect, you really want to see it drilled. In the forum, you make your case and then everyone debates its merit and how it fits in the overall portfolio. That way, we can concentrate on the very best quality projects."

There is, of course, a step before all of this, which involves getting access to new basins in the first place. And that means building and maintaining relationships, something Daly believes BP is still good at, in spite of last year's tragic accident in the Gulf of Mexico.

"We have continued to build upon the lessons we have learned from the Deepwater Horizon accident and have shared those lessons with industry and government regulators globally," says Daly. "We know that the way in which we embed those lessons in our business is critical to our continued good relationships with governments around the world."

The spate of recent access announcements – all of which take years to mature – back this up, with new access that includes Brazil, India, Australia, China, Azerbaijan and Egypt (see page 12). Even before the accident, BP had made significant progress in building new access, particularly in the Middle East, in Jordan, Oman, Libya and Iraq.

"The way to think about it," says Daly, "is that we've got this strong proven base of reserves in places such as Angola, Egypt and the Gulf of Mexico, and, through exploration, that base is going to continue to grow in the next 10 years. All the work we've done to explore in Brazil, India and China and other places is where the growth will come from. That's the opportunity." An »

THE DALY VIEWS

BP has announced a series of new access deals in recent years, from shale gas in the US to exploration in deepwater Australia. Each is unique and each has exciting prospects. Here is what Mike Daly has to say about them:

Australia

The South Australian Ceduna basin is a big move into a frontier deepwater basin. It's a choppy environment with important environmental considerations, but it is a large area [24,000 square kilometres] with only one well drilled. So, it's a real frontier basin – the sort of thing BP classically does. We have an idea based on detailed science that suggests all the ingredients are there for a petroleum province. We hope to begin 3D seismic acquisition later this year, which will transform our geological knowledge of the area and begin to test the idea.

Brazil

BP has a long relationship with Brazil, previously working with Petrobras exploring the Amazon Delta. The results of this early exploration were disappointing, but we continued our efforts to find the next 'play'. Because we were in the Amazon, we missed the Santos basin and the pre-salt opening, but our new deal with Devon now puts us in the country with eight exploration and production blocks in the deepwater. Interestingly, we also have two onshore blocks as a result of the deal, both with Petrobras as a partner. This is a good start in such a big, emerging country and complements our biofuels and other businesses there.

India

India is interesting because, as well as a large resource base, our tie up with Reliance Industries (see page 22) is all about relationships and a growing market, something BP is historically good at. Reliance has some great project managers who have done exceptional things. What BP can bring is twofold: subsurface skills of managing a giant gas field in early decline with great upside; and the development of a gas market as India liberalises.

South China Sea

In the past, BP has explored the shallow waters of the South China Sea, looking for oil generated in small rift basins. Our new access is searching for gas in the deepwater. We hope the two blocks we have captured in 2011 are the first steps to establishing a significant position in deepwater gas, focused on the Chinese domestic gas market. Almost certainly, our future here will be closely tied to the relationship with the national oil companies of China.

Shale in the US

Our move into shale gas in the US was a natural build on our big Lower 48 onshore gas position. We took some time to figure out where we wanted to be geologically, as shale remains a young resource, and then moved quickly. So far, things are going well for us, and we continue to deepen our understanding in this area.

Oman

The Khazzan gas field in Oman was discovered by the Petroleum Development of Oman (PDO). However, the field was believed to be difficult to develop. So, what is interesting here is the opportunity for BP to bring in giant fraccing technology from Canada and the US and apply it for the first time in this part of the world. We have had a great impact on well production rates from the field, exceeding anything previously thought possible. Consequently, we can now see a potentially commercial outcome. It's a great example of how BP uses technology, but also our flexible approach to knowledge and technology transfer.

Jordan

In Jordan (pictured), the Risha gas field was discovered many years ago, and has produced limited amounts of gas. On the basis of its regional geological perspective, BP is testing a new idea that could transform this small field. We believe there may be something bigger and different beyond the existing reservoirs. So, that's what we're going to test. A significant gas resource in Jordan would have important implications for the Middle East and Europe. The Jordan team has been acquiring new 3D seismic during the first half of 2011 and the programme has set new land acquisition records.

"The important thing is to remain flexible, learn from events, and never think you know all the answers."

Mike Daly

» added dimension in this story is that BP is now present in the upstream in all four BRIC countries. Daly sees this as a distinctive feature of BP's portfolio that will create further options for the Group as well as the upstream business.

There is another part of the world that is proving equally exciting – the Arctic. BP has spent the past five years conducting a study of the whole Arctic region and has a clear idea about where it would like to be. This includes the Beaufort Sea, off the coast of Canada, where BP conducted the most northerly piece of 3D seismic in 2009. The results of that study are promising, but the company faces some big challenges if is to successfully develop the area. At the very least, it is going to have to deepen its expertise in ice.

"Since we began in the Beaufort Sea, we've learned a huge amount about ice movement, and have started to think about how we manage it and ourselves in it," says Daly. "The ice sheet covers this area every year, moving north for two to three months each summer. Understanding how to extend the working window, and how to manage ourselves in the Arctic will be part of our technology programme for the future."

Daly believes that technical ability helps make BP distinctive in exploration – particularly its seismic imaging skills, which are widely considered to be some of the best in the world.

But technology is nothing without the people who develop and use it. Daly is proud of BP's accumulated expertise in exploration and that it invests a lot of time ensuring knowledge is passed on to the next generation. "We're unusual in that we do a lot of the training ourselves in exploration, much of which is taught by key BP people who have decades of experience and lots of passion."

He is also keenly aware of the role he plays as a leader and ensures some of his time is spent sitting in on these internal courses. This helps him get to know his new recruits and allows him to show support for the continuation of such programmes. He also maintains a number of links with universities and professional advisory groups. "I think it's important that the more senior you are, the more you question what your real job is. One aspect is replacing a company's capability, so getting involved with students, maintaining academic links are crucial."

Just as crucial for the company's ongoing success is an openness to new ideas and a sensitivity to risk. Exploration, says Daly, focuses on four main issues – keeping people safe out in the field, often in challenging conditions; being as good at reading the data as possible to predict the presence of material hydrocarbons; replenishing the inventory through successful access; and remaining at the forefront of technology, so that the company doesn't miss 'the next big thing'.

"This industry is always changing," says Daly. "Obviously, the physical presence of oil, or lack of it, stays the same, but our ability to judge if it is there, to see it, and to find it has changed dramatically. BP has changed, too, as part of our long-term effort to improve safety and risk management, and as a result of difficult circumstances. The important thing is to remain flexible, learn from events, and never think you know all the answers." ■

Global team: members of the Exploration Forum (below) meet on a quarterly basis to discuss the overall exploration portfolio. The emphasis is on quality through choice. Left, Daly believes BP's technical ability in seismic imaging, visualisation and integration make it distinctive in the industry.

New prospects: an outcrop at the Serra da Capivara National Park, Brazil. Left, Rabi Bastia joins BP's Exploration Forum to discuss the new partnership with India's Reliance Industries.

The role of the division:

The Exploration division decides, based on its collective knowledge of the world's geology, which sedimentary basins BP is going to explore in and, within that, based on the geoscience, which part of the basin to drill in. The team works up the prospects, defines where and how deep it thinks the hydrocarbons are, and makes a prediction on what will be found there. At that point, Exploration hands over to Developments and the global wells organisation, who decide how best to construct, execute and then operate the well. In the event of success, a discovery is worked by the resource appraisal team to define its true scale and quality and the possibility it presents for development. At the point the resource is ready for conceptual development studies, it moves into what is called the project appraise stage, which sits inside the global developments organisation.

MAKING SENSE OF **CORROSION**

Controlling corrosion is one of the largest challenges in the oil and gas industry, with thousands of kilometres of steel oil processing facilities and pipelines exposed to harsh environments. But how is it possible, for example, to really know the condition of a 10-inch-diameter carbon steel pipeline that is exposed to internal and external corrosion? BP is developing new technologies that give its engineers more capability to do just that.

Report> Jaclyn Clarabut
Photography> Marc Morrison

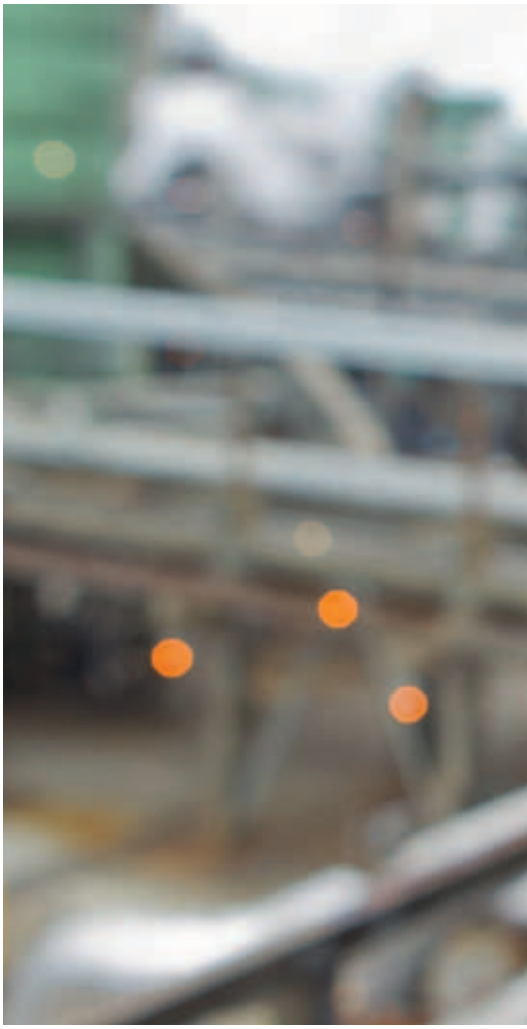
On location: the orange boxes on these permanently-installed sensors wirelessly transmit information to a desktop, helping BP monitor corrosion in refineries, such as Cherry Point, in the US.

The fight against corrosion never stops. In the hydrocarbon industry, oil and gas is constantly flowing through pipelines that are typically made from carbon steel, and wherever there is carbon steel, there is the risk of corrosion (for more on corrosion, see page 6). Unless properly managed, there is a risk of leaks, which may impact the safety of workers and the environment and lead to costly repairs.

The aim is to avoid reaching that point, by managing corrosion at each pipeline or facility in three steps. First, the corrosion mechanisms that pose a threat to the pipeline or facility must be identified. For each of these potential corrosion risks, one or more barriers must be selected to mitigate that threat. Finally, a monitoring and inspection regime should be established to determine whether the barrier method is working properly.

BP is developing a range of technologies that are providing greater facility integrity assurance at its refineries and upstream production facilities. For example, in BP's upstream business, a new approach using established technology is making sure the chemicals used to inhibit internal corrosion are getting to the right spots. In refineries, permanently-installed sensors that continuously monitor wall thickness using the latest wireless technology are revolutionising the work of corrosion and inspection engineers.

Constant fight: a half section of pipe (right) where corrosion has been detected on the right-hand side. Far right, the new wireless sensors can measure the thickness of a pipe or vessel wall to a resolution of 0.1 millimetres. Any unexpected changes in that thickness alert engineers to potential corrosion.



BP Magazine hears how both technologies are being rolled out across BP's operations worldwide, providing the company with greater facility integrity assurance.

Protecting pipelines

The oil and gas industry relies on chemical corrosion inhibitors to protect the majority of its pipelines and facilities. These chemicals, which need constant replenishing, form a thin layer protecting the internal metal from the fluids it carries. Without them, corrosion would eat away at the insides of pipelines, meaning these inhibitors are vitally important to operations.

Chemical inhibitors are injected into pipelines by what are known as 'chemical injection skids', which are collections of pumps, valves, filters and piping. But like all pieces of equipment, these skids are prone to break down. Breakdown in this case means the critical chemical does not get to the right place at the right time. The first sign of a problem is often when someone happens to notice that a pump is not working, or a chemical storage tank is empty.

For a process so critical in protecting its facilities, BP decided a new approach was needed. The result is the 'highly reliable chemical injection system'. The system is inherently reliable in two ways.

First, for all components that are prone to failure, standby parts are included so that, when failure is detected, the spare kicks in to keep the inhibitor flowing. The addition of a twin or spare part means that the skid is available to inject chemical more than 99.5% of the time.

Second, instruments on the skid provide real-time data to a unique piece of BP software that helps production chemists and corrosion engineers to manage corrosion more effectively. Users can see the condition of the skid and the injection rate from their desktop. Furthermore, should inhibitor dosage fall below specified levels, users receive instant alerts by email, allowing them to rectify the underlying issue quickly.

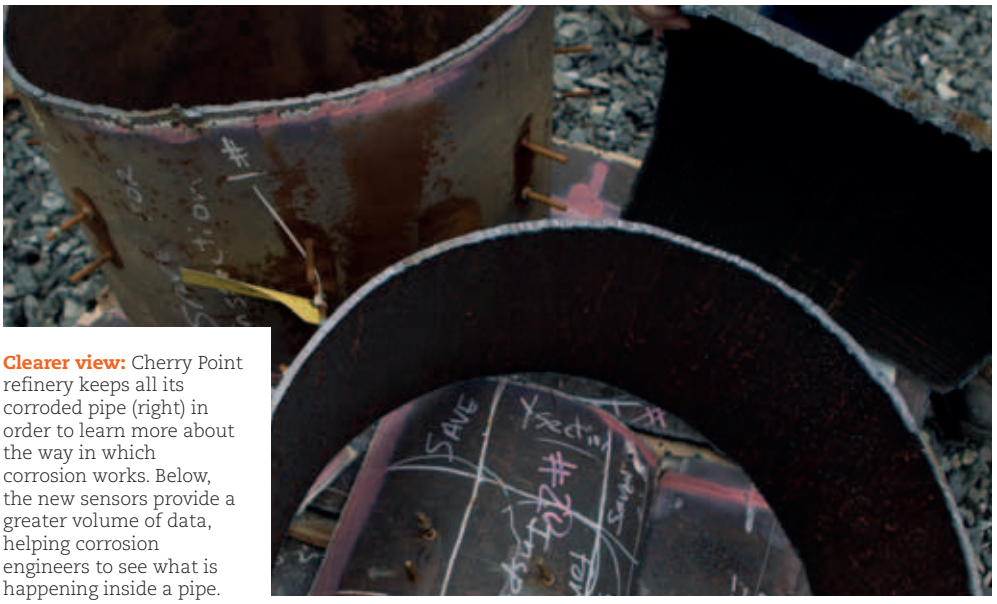
BP's Mike Popham is part of the inherently reliable facilities (IRF) team who developed the system. "Our aim is to stop corrosion from ever happening," he says. "We often rely on an inhibitor to manage corrosion risk, so it's essential we get it right.

"We're really proud of the fact that by combining some established technologies in a new way, we've designed a new skid that performs better than the sum of its parts."

IRF programme manager Steve Groves agrees: "We've shown that we can really get the reliability of the injection up by making some simple hardware improvements.

"In addition, the software shows we are delivering the right amount of inhibitor for the right amount of time, showing that chemical inhibition is used effectively," says Groves.

This level of data, he adds, is allowing BP's assets to state with greater confidence »



Clearer view: Cherry Point refinery keeps all its corroded pipe (right) in order to learn more about the way in which corrosion works. Below, the new sensors provide a greater volume of data, helping corrosion engineers to see what is happening inside a pipe.

that they are meeting their tough chemical injection availability targets – the amount of time that chemical is running through the pipelines.

The software used in the new system was developed by BP's Field of the Future data-2-desktop (D2D) programme, led by Greg Hickey. "In the past, we only had part of the information we needed," he says. "The new software, combined with the simple hardware improvements, now allow us to see the whole picture."

The software shows a production chemist on their desktop the condition of the skid – whether the hardware is working; the dosage of the chemical at its delivery point; and the ratio between the chemical injected and the amount of production fluid in the process.

Never before has there been so much information available on how well chemical injection is working. Hickey says: "We have an example at one asset where the water quality analyser was faulty. The chemist was able to demonstrate there was an issue by looking at the trends, and quickly saw that the analyser condition was making it difficult to ensure the chemical injection was effective. They were rapidly able to get something done so that chemical injection was not affected.

The highly reliable chemical injection system has started to have a major impact, rapidly going from design to wide scale roll-out across BP's Production division and on its new upstream projects. Design began in 2009 and this year, 20 new systems – either the software, skids or both – will be in place in six regions. All of BP's production facilities should benefit from the new approach to chemical inhibitor injection by the end of 2012.

A technology that has proven successful in refineries will also go on trial at upstream operations over the next few years. The new permanently-installed waveguide wireless sensors can measure the thickness of a pipe or a vessel wall to a resolution of 0.1 millimetres. Any unexpected changes in the wall thickness

"This technology is quite something, and changes everything we've done, by giving us the ability to understand and actually see what's happening inside the pipe."

Jeff Waytashek

alerts corrosion engineers to an unduly corrosive process.

Wall thickness has always been routinely measured at refineries as part of a corrosion monitoring regime, but never before has such consistent and regular information been available. Some points in the refinery can be hard to reach, meaning technicians would have to go out with harnesses and take readings from scaffolding. Cherry Point refinery corrosion engineer Jeff Waytashek (see page 51) explains: "It was a tough job – a lot of climbing around and there is the risk to people when you're dealing with hot pipes."

On the new sensors, which have been in place at Cherry Point since August 2010, he says: "I'm confident these sensors will be standard in all refineries one day. The data is so remarkable – I think this is one tool corrosion engineers won't be able to live without.

"We found several of the crudes we were using were causing a higher rate of corrosion than other crudes. We then had to figure out how to run them without corroding through the side of the pipe."

Without the permanent sensors, infrequent information readings would mean that engineers might not be able to identify with confidence the exact process or crude that had the most corrosive effect.

The Permasense 'waveguide' wireless sensors are not only permanently installed in Cherry Point, but also at Gelsenkirchen refinery in Germany, and many BP refineries across the globe. Thousands more are set for deployment in the US, Europe and Australia. The success of the sensors in monitoring corrosion has led to the IRF technology team trialling these and similar sensors with a view to deploying them in upstream operations over the coming years.

The sensors were first developed by Professor Peter Cawley's world-renowned, non-destructive evaluation group team at Imperial College, London. The department is concerned with solving real problems in industrial inspection and monitoring. At the same time, BP was looking for permanently-installed monitors that could cope with temperatures at 600°C (1,100°F) and provide continuous readings.

Professor Cawley explains how the sensor works. "The basic idea is like a metal handle of a saucepan. You have the sensor at one end, and at the other end, it sits bolted to a pipe that reaches 600°C."

> "Our aim is to stop corrosion from ever happening. We often rely on an inhibitor to manage corrosion risk, so it's essential we get it right. We're really proud of the fact that by combining some established technologies in a new way, we've designed a new skid that performs better than the sum of its parts."
>
> **Mike Popham**

Over the 30 centimetre (12-inch) length of the waveguide, the temperature drops 600°C with the cool end of the waveguide housing electronics that won't tolerate high temperatures contained in a bright orange box.

The name waveguide is a clue to its shape, and is the key to its success. Others have tried to develop a similar technology but used the wrong shape for producing the designed signal. In the Imperial design, an ultrasonic pulse is transmitted along the length of the stainless steel waveguide and reaches the joint at the bottom. The pulse transmits into the pipe and then returns to the electronics contained in the orange box on the top, which wirelessly transmits the measurements to the corrosion engineer's desktop.

Highly reliable: the 'highly reliable chemical injection system' is being deployed throughout BP's upstream business, providing real-time data to a unique piece of BP software that helps BP staff manage corrosion more effectively.

Programme manager Steve Orwig has overseen the implementation of the technology. "Having a permanently-installed device allows you to get a better trend," he says. "You can get higher resolution and far better repeatability compared to manual measurements. This technology reduces human error and the wireless transmission capability gives us a greater volume of data to detect changes in operations with higher levels of accuracy."

The sensors do not do away with corrosion inspectors, but they are freed to devote their skills to higher-level tasks. Asset managers are now able to make better decisions on the time to replace process equipment, and whether to accept crudes that have been shown to have an impact on asset integrity.

Back at Cherry Point, Waytashek agrees: "This technology is quite something, and changes everything we've done, by giving us the ability to understand and actually see what's happening inside the pipe."

A new company has been spun out of Imperial College called Permasense Ltd, which has now commercialised the technology, meaning the Permasense 'waveguide' wireless sensors are now available for use by others interested in revolutionising corrosion management in their facilities. ■

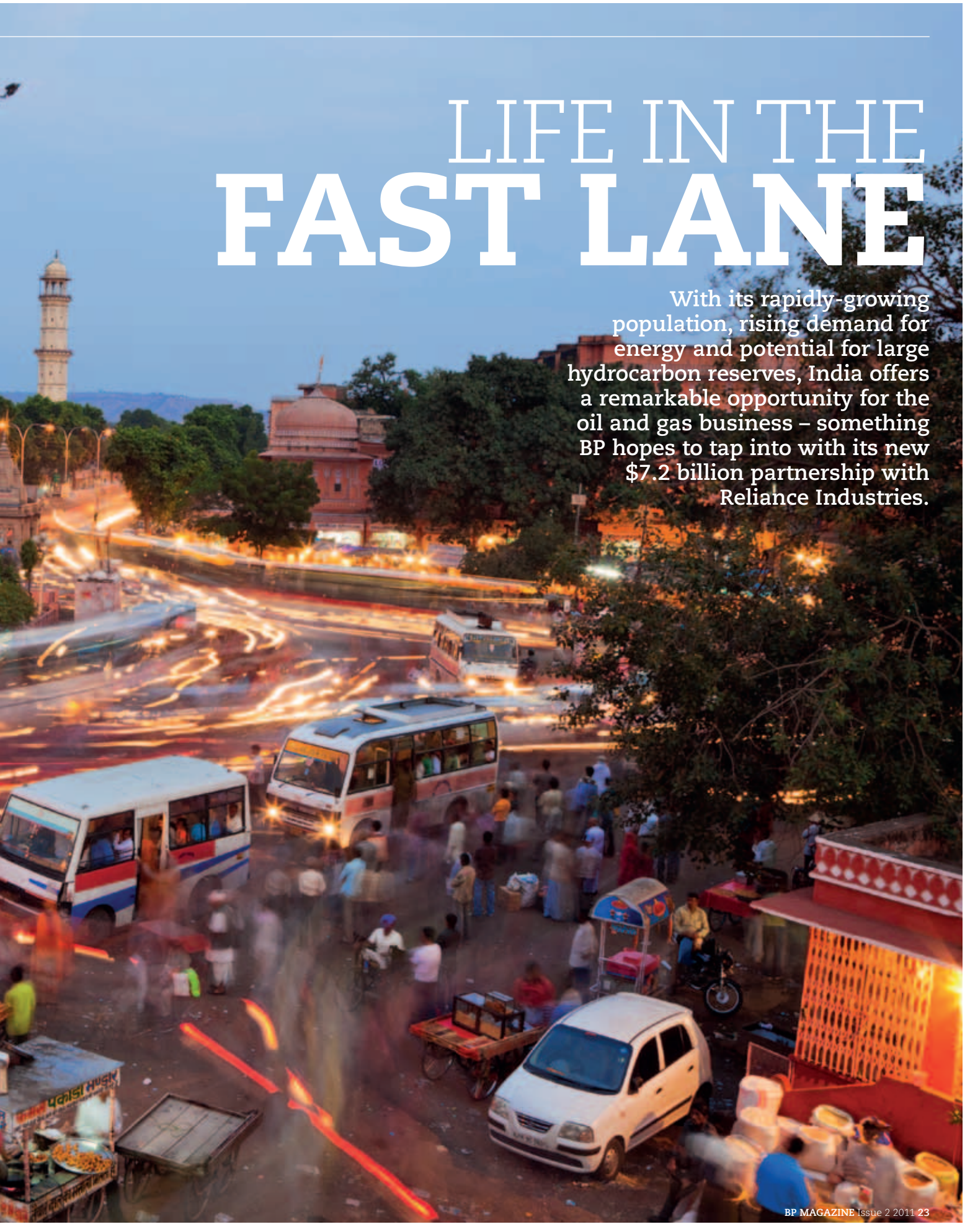
Country report> **India**

Report> Amanda Breen
Photography> Simon Kreitem/Corbis/iStockphoto

Rush hour: this busy traffic scene in Jaipur gives an indication of the fast-growing car market in India. Sales grew by around 30% during 2010.

LIFE IN THE FAST LANE

With its rapidly-growing population, rising demand for energy and potential for large hydrocarbon reserves, India offers a remarkable opportunity for the oil and gas business – something BP hopes to tap into with its new $7.2 billion partnership with Reliance Industries.



Internet generation: life in India is changing rapidly, with technology playing an increasingly important role.

For residents of the world's second most populous nation, the transformation that their country has undergone in two decades has been almost unimaginable. Among those to witness it has been Sashi Mukundan, BP's region president and head of country for India.

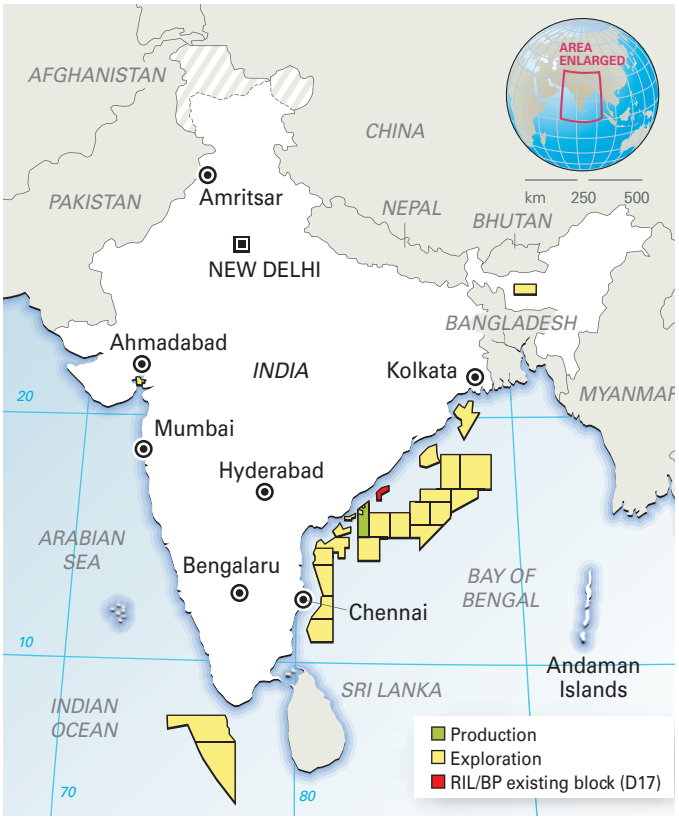
"When I was growing up, everything was pretty much in short supply; simple things like getting a telephone connection could take years," he says. "Likewise, if you ordered a car, it could take five years to get hold of it. India was probably one of the few countries in the world where you bought a vehicle, drove it out of the dealership and its value increased, because there was a huge market for that car."

Superficially, it would seem that things haven't actually changed that much: India still has an enormous market for new cars. In fact, it emerged as the fastest-growing car market last year, with sales increasing by around 30% during 2010. But, of course, lack of supply is no longer the issue. It's all about a nation that has a thriving economy, a booming population and increasing wealth.

"From a scenario where a telephone landline took years to connect, we've arrived at a situation today when it takes five minutes to set up a mobile phone," reflects Mukundan. "You can see this progression touching many walks of life."

Growth is the buzzword for modern India – growth in the population, the economy and the use of energy. The population continues to increase at more than 1% per year. India currently has 1.2 billion people, who are seeing their society transformed from one largely driven by agriculture into an industrialised nation. As household incomes rise, so, too, does the demand for transport and electricity – all leading to more energy consumption.

"Like other emerging economies, India needs adequate supplies of energy at affordable prices to meet the demand of its rapidly-growing economy," the country's Prime Minister, Dr Manmohan Singh, told representatives of the hydrocarbon industry at the international Petrotech conference late last year. »



Vital statistics:

Name: Republic of India
Total area: 3,287,263 square kilometres (1,269,220 square miles)
Population: 1.21 billion
Life expectancy: 66.8 years *(CIA – The World Factbook)*
Capital city: New Delhi
Climate: varies from tropical monsoon in south to temperate in north
Languages: Hindi, English and 14 other official languages including Bengali, Telugu, Marathi, Tamil, Urdu, Gujarati, Malayalam, Kannada, Oriya, Punjabi, Assamese, Kashmiri, Sindhi, and Sanskrit.

"Like other emerging economies, India needs adequate supplies of energy at affordable prices to meet the demand of its rapidly growing economy."

Dr Manmohan Singh

India's economy is expanding at a rate second only to China's among the world's major developing countries. According to BP's *Energy Outlook 2030* (based on an assessment of the most likely development path for the country), India's projected annual economic growth of 6% until 2030 is only just surpassed by China at 6.3% per annum.

The booming economy and population are expected to drive up energy demand by almost 4% per annum, more than doubling energy consumption over the next 20 years. Like many big, growing countries, securing enough sources of energy to meet this growth is the challenge now facing India.

"There is a huge gap between the energy that is being produced here in India and the quantity that we are consuming," says Mukundan, who oversees BP's $3 billion activities in India. "The country now imports three-quarters of its oil needs and, overall, our energy import dependency lies at around 36%.

"That means there are huge opportunities for those who find and produce energy resources here, while at the same time, there is a significant market for imported fuels. That is likely to continue for years to come."

A combination of factors make India an exceptional place for BP to do business, according to Mukundan. "When we drew up our strategy, we identified that this country has three things that make it distinctive: its potential for large oil and gas reserves, its growing economy and population, and its huge resource base in terms of people – there are not many places in the world that can offer all three."

Two priorities emerged for BP: to pursue upstream opportunities in the prolific Krishna Godavari (KG) basin, which lies on and off the east coast between Chennai and Kolkata; and to create a pathway into the downstream sector to provide the country with fuel.

In 2008, as an initial step into the Indian upstream – and in a precursor to further collaboration – a 50:50 consortium of BP and Reliance Industries was awarded the deepwater block, D17, in the KG basin for exploration. There, seismic data acquisition is set to get underway next year.

Taking the relationship between the two companies to a much deeper level, a major partnership was announced in February this year, that is due to see BP and Reliance »

BP in India

Aside from its upstream activities, BP operates a variety of businesses in India, employing around 8,000 people, both directly and indirectly:

- Castrol India is the market leader in retail automotive lubricants and also operates in the industrial and marine lubricants markets;
- BP trades crude oil and petroleum products in the Indian market and in 2009, began supplying liquefied natural gas;
- in petrochemicals, BP supplies around 200,000 tonnes of acetic acid and around 100,000 tonnes of purified terephthalic acid (PTA) annually;
- Tata BP Solar was established in 1989 to manufacture solar cells and modules. Today, the joint venture focuses on providing customised solar solutions to a variety of sectors;
- around $500 million worth of information technology application development and maintenance takes place in India on BP's behalf, as well as some financial and procurement services;
- more than 1,000 of BP Shipping's marine crew – including captains and chief engineers – call India home.

In numbers: India's energy landscape

52.9%
The percentage of India's total energy consumption in 2010 that came from coal. This compares with 29.7% from oil and 10.6% from natural gas.

75%
The percentage of India's oil consumption that is imported.

1,201 million tonnes
India's proven reserves of oil equivalent.

13GW
India's total amount of wind power capacity by the end of 2010.

2.4%
The percentage that wind, solar, and biomass energy contribute to India's electricity generation mix.

Source: BP Statistical Review of World Energy

Strong heritage: Castrol has had a presence in India for the past century and is the country's market leader. Its BikeZone motorcycle maintenance outlets (top) are designed to provide motorcyclists with the highest levels of technical advice and customer service. Below, India has seen its society transformed from one largely driven by agriculture into an industrialised nation.

co-operate across the entire hydrocarbon value chain. In the upstream, BP is taking a 30% stake in 23 mostly deepwater oil and gas blocks that, together, cover an area of some 270,000 square kilometres (105,000 square miles, about the size of New Zealand), while downstream investment will come as part of the formation of an equal joint venture to source and market natural gas.

The $7.2 billion deal reflects BP's strategic objectives to seek significant positions in the world's leading hydrocarbon basins, to increase its presence in the downstream markets in the emerging BRIC (Brazil, Russia, India and China) economies, and to form alliances with strong national partners.

"Reliance has a fantastic set of assets and people," says Mukundan, who was part of the partnership talks with Reliance for some four years prior to inking the agreement. "Clearly, we have a partner with a great track record and capability that we can build on and offer complementary skills."

At a press conference in London to announce the deal, the chairman and managing director of Reliance Industries, Mukesh Ambani, said the alliance would bring "not just more investment, but also technology that can result in more oil and gas discoveries, higher recovery rates and enhanced gas production."

Reliance will continue its role as operator of the offshore blocks, while BP will focus on enhancing subsurface understanding. It also expects to optimise gas recovery from the D6 block, already in production and currently providing around 40% of all gas sold in India. The best practices from both companies will be implemented to align standards of safety, risk management, compliance and ethics.

"We're setting up an overarching technical committee that will ensure the blocks are explored in the right way and developed to the highest standards," adds Mukundan.

One of the earliest priorities for the downstream alliance will be to examine how the venture can provide more gas to the fast-growing Indian market. It also aims to accelerate the establishment of vital infrastructure to receive and transport gas across the country. Gas is expected to be the fastest-growing fossil fuel for India, with its consumption set to increase at almost 5% every year to 2030. Almost half of this increment is likely to be driven by the

Ground control: Reliance control room monitors activity on the D6 block in the Krishna Godavari basin. Under its partnership with Reliance, BP plans to optimise gas recovery in the block, which currently provides around 40% of all gas sold in India.

Mobile phone statistics

826.93 million

the number of mobile phone subscribers at the end of April 2011, according to Telecom Regulatory Authority of India.

15.34 million

the number of new mobile phone connections registered in India in the month of April.

power sector, which is currently reliant on coal to generate electricity.

Overall, coal is the dominant fuel in India's energy mix, accounting for around half of total consumption. "The main reason for our dependence on coal is that we have extensive domestic sources of this fossil fuel," explains Rajeev Kumar, BP India's vice president for policy and regulatory affairs. "India is still a developing country, so the primary concern right now is to use energy in a form that is available here. Hence, coal is likely to continue to be a major source of fuel for the foreseeable future."

But the natural gas market has great potential, especially as it is the cleanest fossil fuel. For a country that proposed a voluntary cut of up to a quarter of its per capita emissions from 2005 levels by 2020, at the United Nations Climate Change Conference in Copenhagen in 2009, clean fuels will take on greater significance.

In 2009, according to the US Energy Information Administration, India was the third largest emitter of greenhouse gases in the world, behind China and the US. That means the country is also seeking low-carbon alternatives, with solar and wind power already playing their parts. The government's National Solar Mission outlines long-term plans to reach an installed solar power generation capacity of 20 gigawatts (GW) by 2020, which would be increased further to 200GW by 2050. The plan also aims to reduce the cost of solar power generation to make it competitive with fossil fuels.

In the meantime, greater availability of a domestic gas supply would allow it to compete with other fuels, particularly in coastal regions, where the reliance on imported sources proves more costly.

"The natural gas market is evolving in India," says Kumar, "but it is still relatively new, and there's a need not only to find more resources, but also to build more infrastructure, such as pipelines and terminals. The regulatory environment is evolving, too, with the government encouraging investment from international companies."

Looking ahead, it is clear that India is a land of opportunity for the energy industry, with its thriving economy and population ready to consume all types of fuel. With the Reliance deal, BP is making one of the largest-ever direct foreign investments into India, signalling a firm confidence in the country and its potential. As Mukundan sums it up, "We're an organisation that believes in India's growth story, its ability to support such a large deal and its hydrocarbon potential." ■

"The natural gas market is evolving in India, but it is still relatively new and there's a need not only to find more resources, but also to build more infrastructure, such as pipelines and terminals."

Rajeev Kumar

Sowing the seeds of innovation

In an industry reliant on technical innovation, it's important that companies such as BP encourage young students to get more involved in what are known as STEM subjects – science, technology, engineering and mathematics. In May, BP did just that, holding a STEM festival at its International Centre for Business and Technology (ICBT) in Sunbury, UK. The festival was a chance for 14-17-year-old students to showcase their work in two BP-supported programmes – G04SET and the Engineering Education Scheme. The programmes are run by the Engineering Development Trust, an organisation set up to help motivate young people to choose a STEM-based career. BP provides sponsorship and mentors for the two programmes, and came up with the idea for this year's G04SET project. "With BP supporting the Olympic and Paralympic Games in London next year, we asked students to create their own sustainable sports hall," says Moira Farley, BP's community affairs lead at the ICBT. "Many of the ideas were fantastic, and there was a real buzz on the day of the festival." As well as giving BP employees the chance to learn more about the company's links with education, each of the projects was assessed by a group of BP experts, who chose a number of winners, including best overall project. That honour went to Tiffin Boys' Grammar School, Kingston, Surrey. ■

REPORT: **LISA DAVISON**

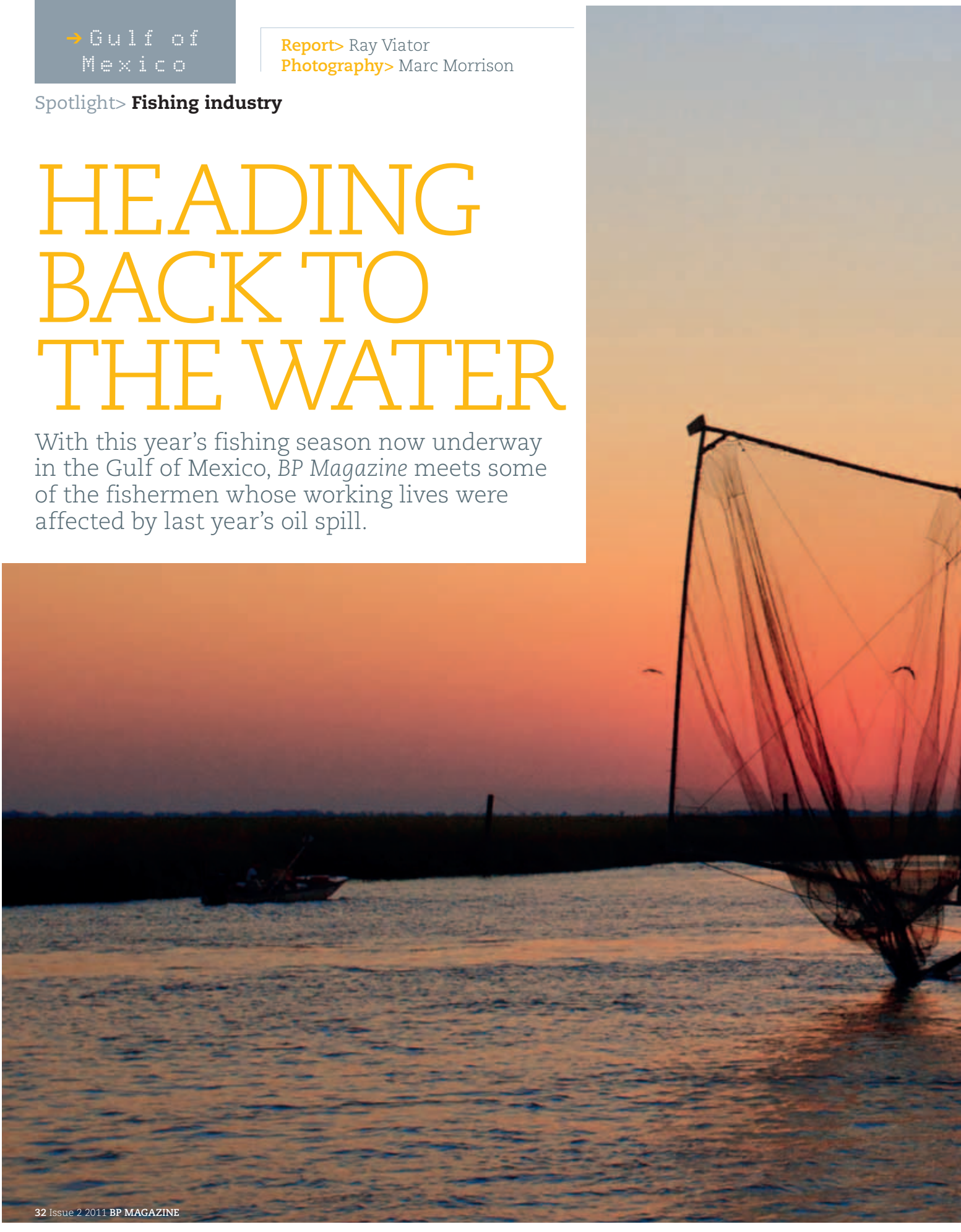
PHOTOGRAPHY: **JON CHALLICOM**

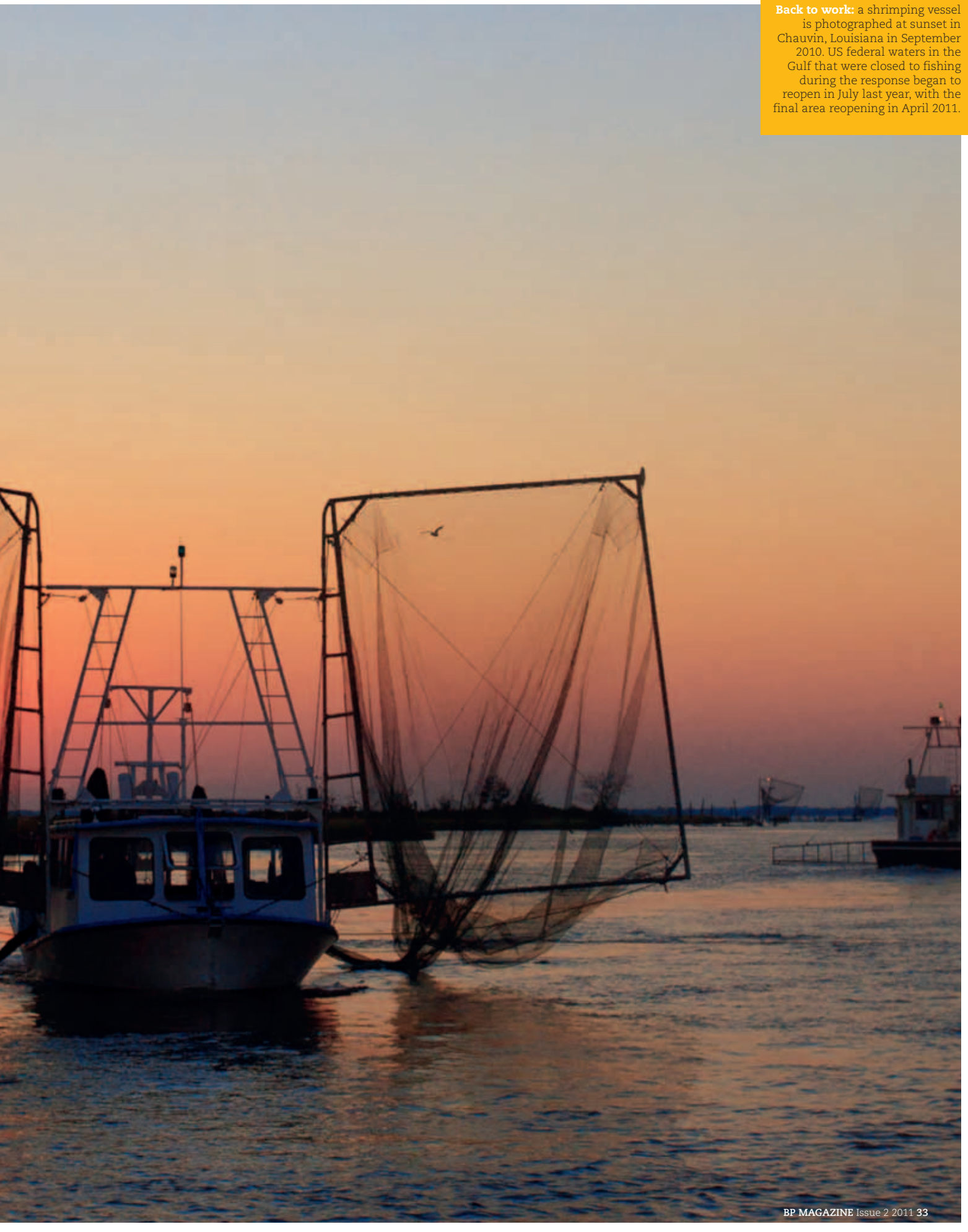
Report> Ray Viator
Photography> Marc Morrison

Spotlight> **Fishing industry**

HEADING BACK TO THE WATER

With this year's fishing season now underway in the Gulf of Mexico, *BP Magazine* meets some of the fishermen whose working lives were affected by last year's oil spill.





Back to work: a shrimping vessel is photographed at sunset in Chauvin, Louisiana in September 2010. US federal waters in the Gulf that were closed to fishing during the response began to reopen in July last year, with the final area reopening in April 2011.

Family affair: Terry Vegas, Sr (left) has shrimped in the Gulf for 46 years, like his father and grandfather before him. Below, the daily work of a shrimp boat is carried out. Right, Donny Waters has been fishing since he finished high school and now holds one of the largest individual fishing quotas in the Pensacola area. Far right, eighth-generation fisherman Pete Floyd has been fishing for 40 years.

While each new fishing season along the Gulf Coast brings a sense of excitement and a hopeful outlook, perhaps none has been more anxiously awaited than that of 2011.

In fishing communities along the coast – from Texas to the panhandle of Florida – thousands of residents whose livelihoods are tied to the bounty of the Gulf have spent the past year worried about whether the Deepwater Horizon accident would have an impact on their favourite fishing waters.

At its peak, approximately 37% of US federal waters in the Gulf were closed to fishing, as part of seafood safety protocols put in place by the National Oceanic and Atmospheric Administration (NOAA) and the US Food & Drug Administration. Similar closures were put in place in state waters along the Gulf. In July 2010, NOAA began reopening closed federal waters as designated areas were determined to be free of oil and samples of seafood successfully passed both a sensory examination and chemical analysis in an approved laboratory. In April 2011, NOAA reopened the final closed area immediately around the Macondo well, declaring all federal waters safe for fishing.

Among the first out this spring was Terry Vegas, Sr who has shrimped the waters of the Gulf near his hometown of Grand Isle, Louisiana, for 46 years.

For Vegas, there's both a long family tradition and a personal passion about shrimping. "My father was a fisherman and his father before him. Our family has always been fishermen," he says in his distinctive Cajun accent. "We've been doing this at least four generations, maybe more."

As he prepared to take out his 15-metre (50-foot) boat, *Miss Andrea*, for his first shrimping trip of the new season, he explained how the rigorous testing programmes made him confident about the safety of the shrimp he will harvest this season. He is also encouraged by reports from other Louisiana shrimpers about good catches.

"We heard that they were catching good sized shrimp on the east end of Grand Isle, so that's where we're headed tonight," he said, as he inspected his nets and the ship's rigging.

As deckhands scurried around the boat, Vegas was on his phone talking with other shrimpers and customers. Even before he

left dock, he had heard from several regular customers who wanted to know when he would be bringing in his catch.

As one of hundreds of local fishermen who worked in BP's Vessels of Opportunity (VoO) programme last year, Vegas and his boat were hired to transport boom during the response to the oil spill. In addition to the large flotilla of vessels they provided as part of the VoO programme, local vessel owners, such as Vegas, greatly benefitted the response with their knowledge of the surrounding waters.

That insight into the local waters is evident as Vegas discusses his plans for the 2011 shrimp season, as well as where and when he plans to work different areas of the coast. An ardent follower of the tides and the phases of the moon, Vegas says he has his own system for knowing where and when to shrimp.

It's a hard life in many respects, working 12-14 hours a day during two shrimping seasons in Louisiana waters that, combined, can stretch from April to December. But it's a life and a lifestyle that Vegas says he wouldn't trade for anything else.

It's a lifestyle shared by Donny Waters, who works the Gulf waters hundreds of miles to the east, in the area around Pensacola, the self-described 'red snapper capital of the world'.

"Fishing has always been a passion for me. It was my first job out of high school, and I bought my first boat in 1980," says Waters, who today mainly focuses on reef fish, such as red snapper, grouper, tilefish and amberjack. "I fish according to the market and what fish houses want."

The key to success, he says, is knowing where to find the various species and then having the right tackle to catch each specific one. While he has fished as far west as Louisiana, Waters prefers to work both the natural and artificial reefs in the Pensacola area.

A typical fishing trip on Waters's boat, the *Hustler*, begins in the early morning hours and can last three to five days.

While on the water, Waters and his crew are in almost constant motion. Line fishing on a commercial boat means that the crew must individually bait 40-50 hooks on each of the four fishing lines on the boat. Working in water depths ranging from 25-90 metres (80-300 feet), the crew lowers »

Fishing by the numbers

The seafood industry is a key component of the Gulf Coast economy.

During 2009, the combined waters of Texas, Louisiana, Mississippi, Alabama and the west coast of Florida accounted for approximately: *

$629 million in seafood landings
- $314 million of shrimp
- $86 million of finfish
- $85 million of oysters
- $61 million of menhaden
- $57 million of crabs
- $13 million of spiny lobsters

In 2009, the Gulf represented approximately 37% of seafood poundage landed in the US (excluding Alaska), including: *

85% of spiny lobsters
80% of shrimp
71% of menhaden
62% of oysters
38% of blue crabs

* Source: National Oceanic and Atmospheric Administration

Way of life: shrimp boats in Chauvin, Louisiana. Shrimpers such as Terry Vegas, Sr have welcomed the rigorous testing programmes in place as they help to reassure customers.

each line and then uses the boat's hydraulic winches to reel them in again.

Once onboard, the fish are removed individually and immediately iced down, before the crew begins the whole process again, baiting and lowering each line.

When the fish aren't biting, Waters and his crew use the time to clean up, eat, and, when possible, get some much-needed sleep.

As a holder of one of the largest individual fishing quotas (IFQ) in the Pensacola area, Waters is both optimistic and concerned about the future of the seafood industry in the Gulf of Mexico.

"I've heard good reports, but the jury is still out, in my opinion, and I'm very concerned about the condition of the fishery over the next two years," he says. "Obviously, the spill was very disruptive and it will take a while for the market to build confidence in the safety of Gulf seafood."

As a result, he is a strong proponent of continued testing of Gulf seafood in order ensure the health of the fishery, as well as to reassure consumers.

Recognising the importance of the seafood industry to the Gulf Coast economy, BP has committed more than $90 million to promote seafood safety testing, monitoring and marketing efforts.

"As part of our commitment to the Gulf Coast, BP is working with each of the states to support ongoing seafood monitoring, testing and marketing programmes designed to reassure consumers throughout the US that Gulf seafood is safe," says Mike Utsler, head of BP's Gulf Coast Restoration Organization.

In Mississippi, eighth-generation fisherman Pete Floyd says his catches have been "as good as any I can remember in 40 years of fishing, both inshore and offshore – snapper, kingfish, mackerel, mullet, trout, skipjack [ladyfish], etc." Floyd notes that the oil does not appear to have hurt the fish populations, even the juvenile fish. "We are seeing juvenile fish that were in the spill area that are unbelievably abundant. These would have been eggs or microscopic fish at the time of the spill."

Floyd says that's important to him and his family, since his two sons also make their livings off the water, while his daughter works for a state marine agency. Like other fishermen along the coast, the Gulf of Mexico is not simply a part of their life, it is their way of life.

Floyd also participated in the VoO programme and helped to search for wildlife, place booms and remove oil from the Gulf during the 2010 response.

"The VoO programme was a lifesaver for the commercial fishermen because it allowed us to work," he says. "If VoO had not been implemented, many commercial fishermen would have probably lost most of what they owned and had to get other jobs, if they could find them. Thanks to VoO, a lot of commercial fishermen have upgraded their gear because they made money and were able to buy better equipment to continue their fishing."

New offers: charter boat captain Bryan Watts, Jr (left) wants to help the industry position itself as a new entertainment option for visitors to the Gulf, particularly during the important vacation season. Above, many fishermen took part in the Vessels of Opportunity programme during last year's oil spill. These ones were photographed heading down Bayou Lafourche past Golden Meadow, Louisiana, in July 2010.

While the sandy beaches and towering hotels and condos are some of the most visible symbols of Gulf Shores and Orange Beach in Alabama, the area is also home to one of the largest concentrations of charter fishing boats.

As one of the youngest charter boat captains in the area, Bryan Watts, Jr began as a teenage deckhand on other charter fishing boats, before starting his own business in 2000.

It's something that he had always dreamed of doing. "I fell in love with being on the water, watching the sun rise each morning, and meeting new people every day."

Despite the US recession of the past few years and then last year's oil spill, he's still optimistic about the future. That's because he believes that there is a pent-up demand from people who are looking for a holiday vacation on the Gulf Coast. His goal is to help the charter boat fishing industry position itself as a new entertainment option for visitors to the Gulf Coast.

"The charter boat industry has changed over the years. In the past, many of our customers were either companies that would book full-day trips to reward clients or employees, or groups who would fish to stock up their freezers."

Now, Watts says, companies don't have those kinds of budgets and fewer groups are buying full-day trips. As a result, Watts is targeting some of his efforts at attracting families who want an experience that they can share together and remember. That means focusing more on half-day trips, and making sure that his deckhands are both knowledgeable and even more customer-friendly, which includes letting kids steer the boat and being prepared to answer lots of questions.

Like others in the fishing and seafood industry along the Gulf Coast, he recognises that the biggest challenge facing the industry this year is overcoming misperceptions about seafood safety.

"We are definitely seeing more fish and larger fish during our trips this year. The biggest impact on our market is perception, and we're trying to address that by providing our customers with lots of information on our website and linking to government websites, where they can see the data themselves and find objective information." ■

A NEW WAVE OF EFFICIENCY

For centuries, the shipping industry has adopted a 'hurry up and wait' approach to delivering cargo, regardless of any known delays at port. But a new initiative devised by BP Shipping looks set to change all that, with the potential to reduce both costs and greenhouse gas emissions across the industry.

Report> Ian Valentine
Photography> Graham Trott

Virtual passage: the *British Security* is one of a number of BP vessels to start using the Virtual Arrival programme on certain voyages. It is shown here docking at Falmouth, UK.

A new initiative established by BP Shipping to regulate the journey times of cargo vessels is being hailed as one of the most innovative programmes ever launched in the industry.

Called Virtual Arrival, it sounds more like a computer game or science fiction movie than an innovation that will re-write two centuries' worth of standard shipping practice, but according to internal and external experts, it represents a vital step forward for an industry that needs to adapt to the evolving global environmental agenda.

Historically, the shipping industry has always taken a 'hurry up and wait' approach, meaning merchant vessels would steam to meet a pre-agreed schedule, regardless of known delays at port. Consequently, excess fuel was burned with 'full ahead' steaming, leaving vessels often sitting idle at port awaiting berthing slots.

Virtual Arrival, on the other hand, uses weather analysis and algorithms to calculate and agree a notional vessel arrival time, so that the ship will arrive 'just in time'. This radically reduces bunker fuel consumption and emissions, while easing congestion and enhancing safety. Importantly, the authority of the vessel's master remains unchanged. Furthermore, waiting time compensation, or what is known as 'demurrage', is calculated as if the vessel had arrived at the originally stipulated time, hence the name 'Virtual Arrival'. Post-voyage, any savings in bunker costs or carbon credits are calculated and

> "Not everyone was convinced it would work when we first announced it. They thought it was far too big a nut to crack. But it is working and changing the way commercial shipping operates."
>
> **Lars Dencker Nielsen**

split between the counterparties. Aside from the financial incentive, Virtual Arrival could also offer a significant prize in the reduction of many millions of tonnes of greenhouse gas emissions if it was adopted widely.

"Not everyone was convinced it would work when we first announced it," says Lars Dencker Nielsen, global chartering manager for BP Shipping. "They thought it was far too big a nut to crack. But it is working and changing the way commercial shipping operates." A fact demonstrated by a growing body of external endorsement for the idea.

Inevitably, such a big change has taken time to prove itself. One potential concern is the perceived threat to the ship master's autonomy at sea. While the charter parties have traditionally stipulated the speed that vessels must attain throughout the voyage, in reality, the speeds achieved on a particular voyage were reliant on issues such as the prevailing weather. The prudent master, therefore, might choose to progress full steam ahead to avoid any unforeseen delays, preferring to be early rather than late. As a result, the charterer typically had no say in the route taken by the vessel, or the actual speed at which the voyage progressed.

However, under Virtual Arrival, it is the ship operator who usually sees that there is a delay at the discharge port, for example, because of congestion at the berth, or lack of tank space at disport. The cargo receiver or operator may then suggest that Virtual Arrival is used on the voyage. If there are no other factors to consider, such as periodical maintenance, a mutually acceptable agreement can be made and the procedure can commence. The master will then be contracted to continue at the prescribed speed. To ensure the accuracy and independence of the calculation of a vessel's performance, and to avoid the risk of post-fixture disputes, it is necessary to employ an industry-approved weather analysis provider that specialises in weather and vessel performance analysis. »

Careful planning: life aboard a BP vessel involves meticulous route planning and regular maintenance checks (left). Above, BP Shipping charterers work with the vessel owner and weather analyst to decide whether to use Virtual Arrival.

David Sale, period charterer, has worked on the project from the start and explains that Virtual Arrival is quietly percolating through the industry. "Previously, masters had little faith in weather forecasts and would forge on regardless, determined to get ahead of schedule in case of delays or complications. With Virtual Arrival, they will now get there in the most efficient manner, avoiding potential storms in their path," he says. "In our 25 test voyages – targeted on journeys where delays were inevitable – we have so far saved the company $1.5 million in bunker fuel costs alone. That makes a compelling case, but does nothing to diminish the master's ultimate accountability for the safety of ship, crew and cargo, if different decisions need to be made."

Best interests

Global voyage operations manager Dan Read is at the sharp end of Virtual Arrival, as he must convince the masters that the contract is in their best interests. On a practical basis, this means holding the conversation during the viable window when savings can be made. "The perception of 'hurry up and wait' is slowly changing," he says. "In my experience, both charterers and ship owners are getting their heads around the financial consequences of shifting to Virtual Arrival when applicable. Everyone benefits from this system."

The scientific element of weather predictions represents the latest shift in culture for masters, who are no longer the sole arbiters they once were. "It should be stressed that the authority of the masters is not questioned, as they remain ultimately accountable for the safe passage of their own ships. But they have all had to adapt to the waves of new technology that have carried shipping forward in the past decade," says Read. "The notion that they are all alone on the seas is outdated now. They are no longer left to their own devices. With that, comes a degree of trust that the technology will improve their business. The future for Virtual Arrival looks rosy."

This trust is at the core of Virtual Arrival's success. "It is important that both sides are comfortable with the contract beforehand," says Read. "The future success of Virtual Arrival will rely on masters and charterers sharing case studies and experiencing the financial benefits of implementing it. It is very important that independent industry bodies keep passing the data across. The more communications we have through them, the better."

Fortunately, the industry is only too happy to broadcast the attraction of Virtual Arrival to its members. Erik Ranheim, manager of research and projects for the International Association of Independent Tanker Owners (INTERTANKO) is one such supporter. "There is great pressure on shipping to reduce greenhouse gas emissions, which, in general, means reducing fuel oil consumption. Owners have a huge incentive to reduce this consumption, as it can represent some 60-80% of the owner's costs," he says. "Virtual Arrival can help deliver considerable financial savings. It is not a short-term speed-reduction measure introduced in response to market and economic demands. On the contrary, it is a sustainable and practical process aimed at improving efficiency within the transportation chain, while achieving real benefits with regard to safety, fuel saving and the reduction in vessel emissions."

Operationally smarter

Garry Hallett, deputy director of the independent Oil Companies International Marine Forum (OCIMF), agrees. "Virtual Arrival fits in so well with the OCIMF's drive to make shipping operationally smarter, which could avoid the need for unpopular levies to reduce greenhouse gases," he says.

He admits that it will take a few years for the industry to gain confidence in Virtual Arrival, but predicts it will be mainstream in less than a decade. "Companies won't be able to afford to operate without it. The bunker price, combined with levies or carbon credits, will ensure that ships have to steam in the most efficient way possible."

The project has been a source of great pride for Dencker Nielsen, who believes it is vital that BP shares innovations of this type with the industry. "We cannot be proprietary with Virtual Arrival," he says. "There is no competitive advantage to us developing it. It will save other companies money as it does for us. But it was important that we take a lead on this. It has been a hugely satisfying journey." ■

Virtual Arrival in action

GEORGIA TO THE UK

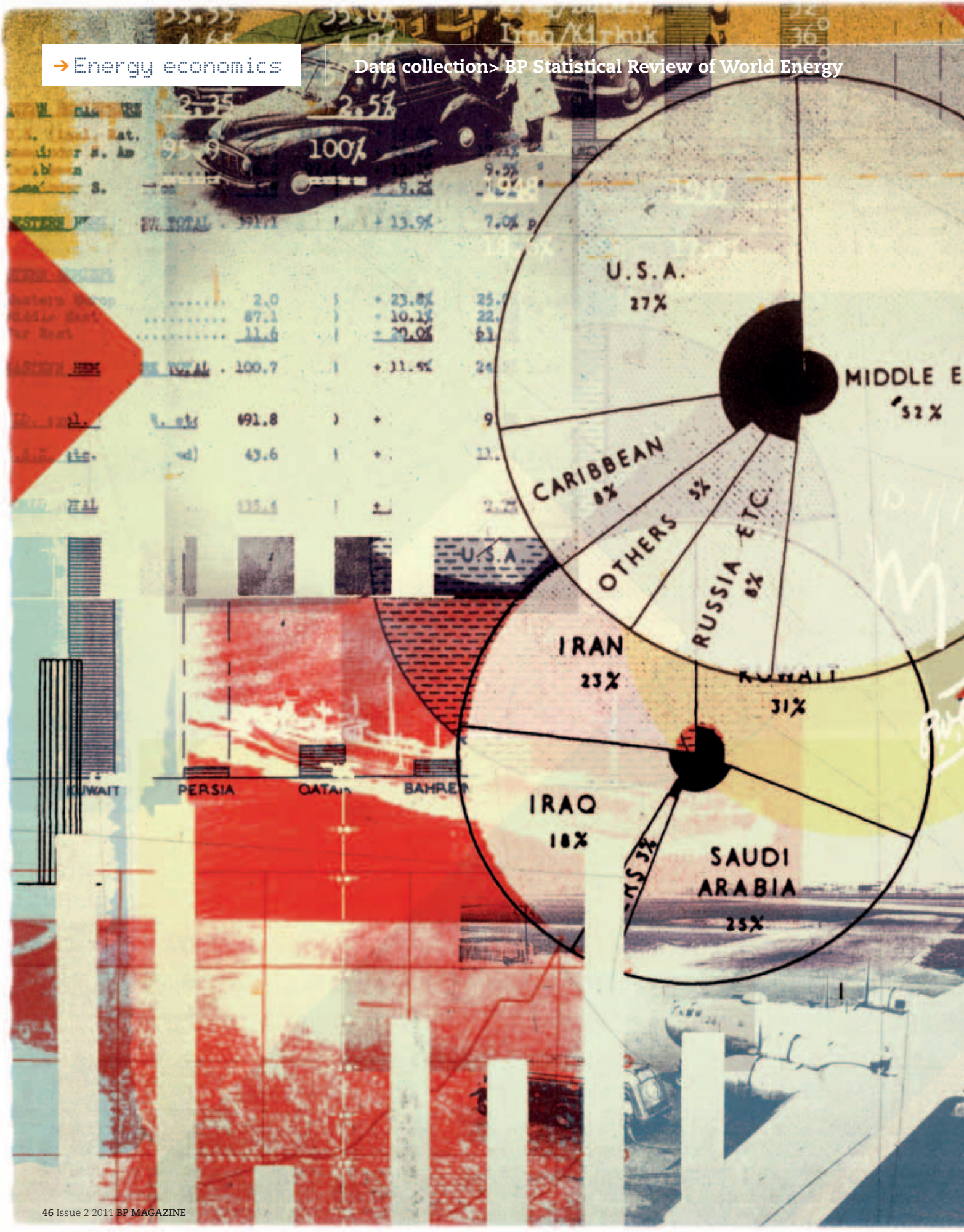
One example of what the clause is capable of saving in financial terms, involved a loading of oil from Batumi in the Black Sea, which was shipped 3,500 nautical miles to the Isle of Grain in southeast England. The charterer knew there would be delays at the destination, so approached the market to find an owner willing to initiate the Virtual Arrival contract.

The charterer engaged a weather analyst provider to predict the impact of the weather and issued daily reports to ensure both parties were kept up-to-date of progress, so guaranteeing absolute transparency. Instead of sailing full steam ahead to the destination port and waiting for 27 hours, the ship kept a steady pace and arrived when the port was ready for it.

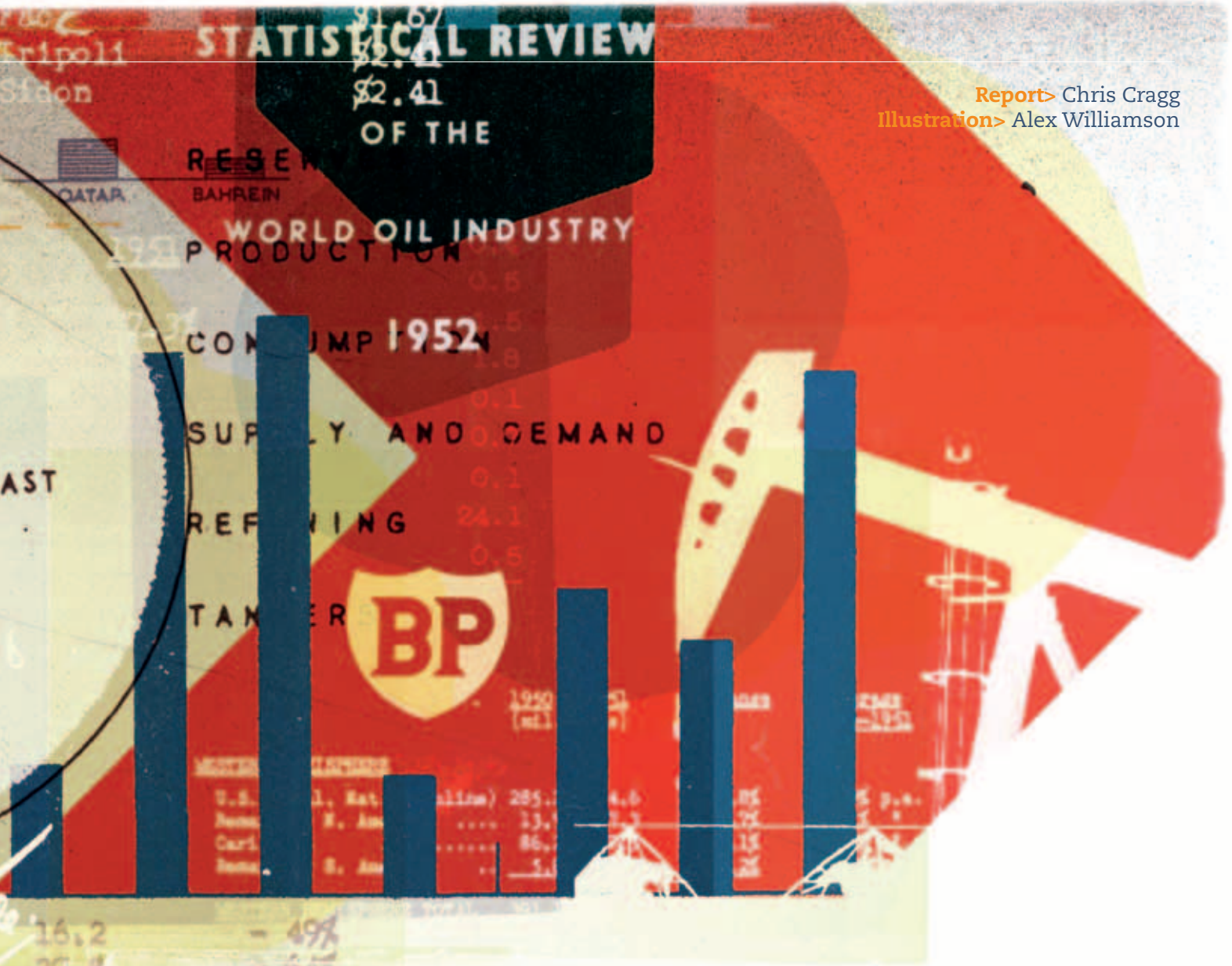
The demurrage of 27 hours was still paid, making the ship's 'virtual arrival' more than a day earlier. The overall reduction in emissions represented 183.2 metric tonnes of carbon dioxide, 4.4 metric tonnes of nitrogen oxides and 3.5 metric tonnes of sulphur oxides, equalling a 27% reduction in fuel consumptions and emissions over the length of the voyage. The total bunker savings of 59 metric tonnes of heavy fuel oil were shared between both parties.

Financial savings: the Virtual Arrival programme relies on close coordination between all parties involved in a journey. So far, BP's first 25 test voyages have saved the company $1.5 million in bunker fuel costs.

Data collection> BP Statistical Review of World Energy

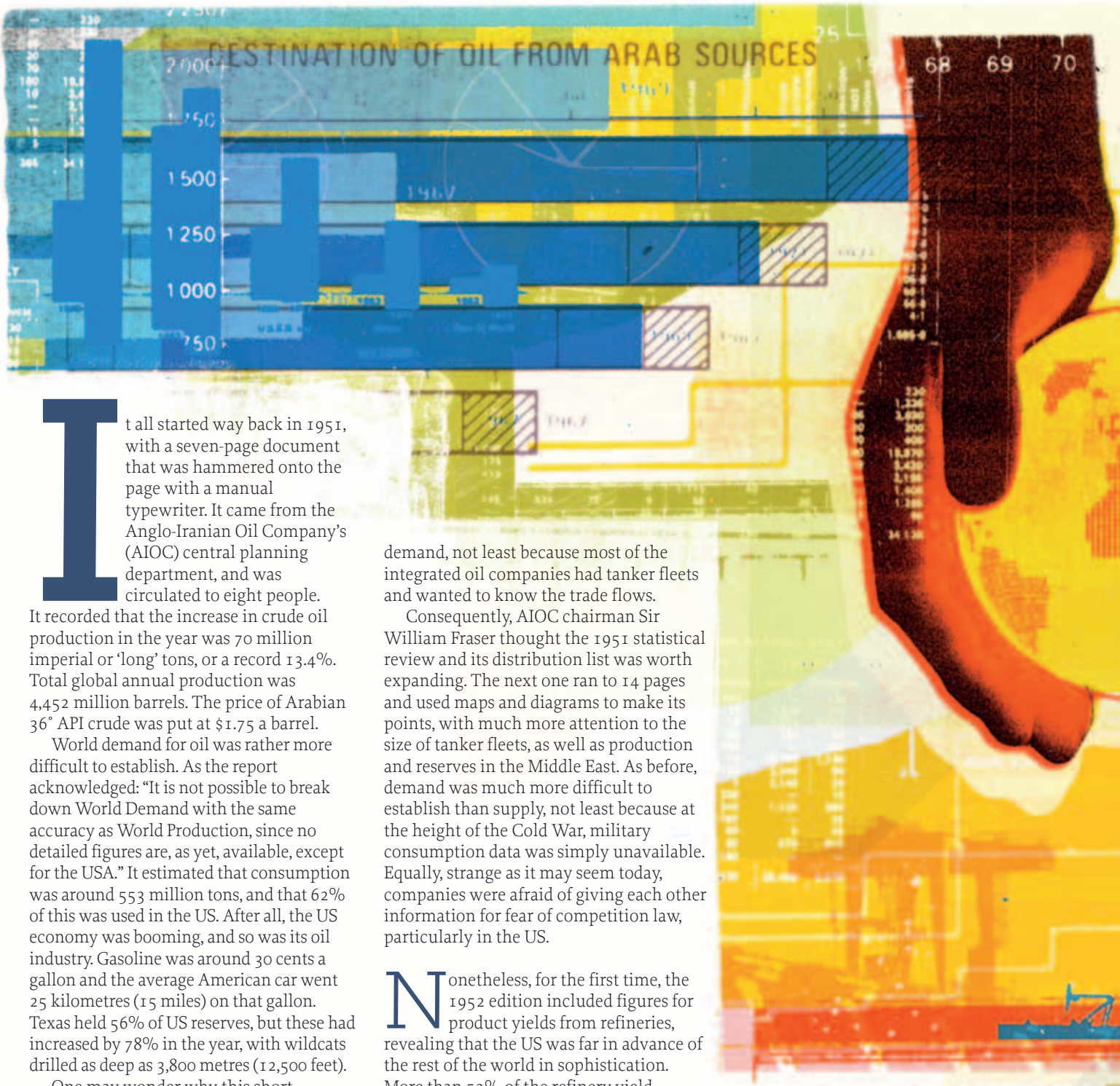


Report> Chris Cragg
Illustration> Alex Williamson



SIXTY YEARS AND COUNTING

In June, BP's chief executive, Bob Dudley, and its chief economist, Christof Rühl, faced a large audience of journalists, economists and analysts to introduce the 2011 edition of the *BP Statistical Review of World Energy*. Most of this distinguished audience concentrated on its immediate analysis and figures. How fast or how slow is oil production growing? How fast is natural gas and coal consumption rising? Far fewer may have realised that the *Statistical Review* is now 60 years old and represents one of the longest continuously running collections of energy data available…



It all started way back in 1951, with a seven-page document that was hammered onto the page with a manual typewriter. It came from the Anglo-Iranian Oil Company's (AIOC) central planning department, and was circulated to eight people. It recorded that the increase in crude oil production in the year was 70 million imperial or 'long' tons, or a record 13.4%. Total global annual production was 4,452 million barrels. The price of Arabian 36° API crude was put at $1.75 a barrel.

World demand for oil was rather more difficult to establish. As the report acknowledged: "It is not possible to break down World Demand with the same accuracy as World Production, since no detailed figures are, as yet, available, except for the USA." It estimated that consumption was around 553 million tons, and that 62% of this was used in the US. After all, the US economy was booming, and so was its oil industry. Gasoline was around 30 cents a gallon and the average American car went 25 kilometres (15 miles) on that gallon. Texas held 56% of US reserves, but these had increased by 78% in the year, with wildcats drilled as deep as 3,800 metres (12,500 feet).

One may wonder why this short document was so important as the forerunner of the current 50-page edition, 60 years later. The answer is that very few people at the time had the slightest idea how much oil was being produced and consumed, let alone what it cost. True enough, the industry had a vague idea of how much had been produced annually since 1920, when it was estimated to be around 733 million barrels. However, this number was largely extrapolated from US government figures. With the spotlight on growing new sources in the Middle East, it was time to get a better fix on supply and demand, not least because most of the integrated oil companies had tanker fleets and wanted to know the trade flows.

Consequently, AIOC chairman Sir William Fraser thought the 1951 statistical review and its distribution list was worth expanding. The next one ran to 14 pages and used maps and diagrams to make its points, with much more attention to the size of tanker fleets, as well as production and reserves in the Middle East. As before, demand was much more difficult to establish than supply, not least because at the height of the Cold War, military consumption data was simply unavailable. Equally, strange as it may seem today, companies were afraid of giving each other information for fear of competition law, particularly in the US.

Nonetheless, for the first time, the 1952 edition included figures for product yields from refineries, revealing that the US was far in advance of the rest of the world in sophistication. More than 52% of the refinery yield outside of the US was residual fuel oil and just 20% gasoline and aviation fuel. It also produced a breakdown of oil tankers, by age, ownership and size, while estimating the proportion of the fleet making deliveries into North America and Europe. Given the sheer lack of this kind of information, circulation of the Review shot up into the tens of thousands. It was still supposed to be internal, but no doubt circulated freely elsewhere.

By 1961, with AIOC now BP, the *Statistical Review of the World Oil Industry* was 24 pages long, and well established. Reserves, production and consumption numbers were still divided into Western and Eastern hemispheres, but individual countries began to appear. The staggering increase in Middle Eastern reserves-to-production ratios, from 73 years to 1951 to 92 years a decade later, was duly noted. The world tanker fleet had doubled in size in that time and the familiar pattern of trade out of the Arabian Gulf was now well established. Nobody mentioned prices.

In fact, oil prices worldwide remained remarkably obscure throughout the 1960s. Jan Nasmyth, a British war hero and oil »

"BP's *Statistical Review*, and the essential databases that support it, is one of the fundamental resources for understanding world energy. Rigorous, clear, consistent, wide-ranging – and the product of a great deal of hard work and commitment over six decades – the *Review* is the global 'go-to' source for decision-makers and analysts around the world. Those tables of numbers, in their myriad units, tell an extraordinary narrative of how the world has changed – and the challenges ahead. I not only use it, but I read it regularly, because it is such a great story."

Daniel Yergin
Chairman, IHS Cambridge Energy Research Associates

industry journalist passed briefly through BP at the time, and was then asked by the United Nations to prepare a survey of world energy resources. He concluded that the task was impossible without more available pricing information, and subsequently founded the *Petroleum Argus* price reporting service to try and make them more transparent. It took the 1973 OPEC price shock, when the US opened its doors much wider to Middle Eastern crude, to make price information more freely available.

If 1973 and the subsequent crisis over the Iranian Revolution in 1979 did anything, it was that the industry began to take notice of energy as a whole. Under Tony Scanlan's editorship, the *Review* began recording country consumption figures for natural gas, coal, 'water power' and nuclear power. Prior to the late 1960s, natural gas had been seen as something of a nuisance to the oil industry and flare stacks covered the Middle East. However, the gas consumption boom in Europe, due largely to the North Sea discoveries and the development of LNG, suddenly made it much more important. By 1981, the *Review* had expanded to 37 pages and included movements of gas by pipeline and sea and coal reserve numbers. It was now called the *BP Statistical Review of World Energy* and there was no longer any pretence that this was an internal document. It was freely available to anyone who wanted it.

By the late 1980s, historical crude prices were now part of the package, initially with 'official prices' mostly from OPEC, and then, by 1991, spot prices. More detail about natural gas appeared in a separate publication, which was eventually re-incorporated into the *World Energy Review* in 1996, the first year in which it also featured an introduction from the chief executive. Equally, the editors had noticed its value as an educational tool. A simplified computer version was distributed to schools and colleges in 1985, while a comprehensive version was produced on diskette two years later. By 2000, it was freely available on the internet.

A decade later, the *Review* is now 50 pages long, and includes five pages of detailed discussion of the year, regarding crucial aspects of energy in the context of the world economy. Although longer than some of its predecessors – largely a result of the increase in information and energy types to report on – the team behind it continue to take great care that the final document is kept as slim – and, therefore, digestible – as possible. A wealth of additional information can now be accessed via bp.com: detailed discussions can be downloaded as video talks; the numbers can be downloaded in numerous different ways; charting tools allow a choice of types of graph or columns and, thus, manipulation of the whole database; gaps in numbers going back years have been filled in right across the energy industries.

This is now going to expand farther. This year's *Review* produces much more detail about the rapidly expanding area of renewable energy. In addition, in January this year, BP's economics department produced its first public *Energy Outlook 2030*. Like the original statistical review, this was first intended for internal consumption, but is now available online. It uses the original database to project the next 20 years of energy demand, looking at population growth, political risks, emission policies, energy intensities and other global trends.

If all this seems a long way from a seven-page memorandum on oil production in 1951, it does undoubtedly derive from it. Short as it was, the 1951 *Statistical Review* was the start of a massive and unique collection of detailed data about energy, one of the largest on the planet, and that has taken 60 years to create. It is often referred to by its users as the 'bible' of data on energy economics. Projecting it forward in time is the obvious next step.

Looking back down the years, the numbers tell a remarkable story of 'the century of oil', which has an obvious connection with the issues of climate change and peak oil that trouble us today.

Back in 1951, the best guess at global oil consumption was 553 million long tons, a unit now rarely used. In 2009, it was 3,882 million tonnes. Allowing for the difference between the slightly bigger long ton and the metric tonne – making world consumption 562 million tonnes in 1951 – global consumption has increased almost sevenfold in the past 60 years.

So happy 60th anniversary *BP Statistical Review of World Energy*. There is nothing quite like it for putting things in perspective. ■

Photography> Marc Morrison

DETECTIVE WORK

Jeff Waytashek
Corrosion engineer

Most of the job of a corrosion engineer is solving mysteries, according to Cherry Point refinery's Jeff Waytashek. "Every time the inspectors come across unexpected corrosion in a pipe, we have to work out what caused it," he says. Jeff's detective work is sparked by something out of the ordinary, such as a pipe deteriorating more quickly than expected. In this case, he'll question the process engineers who have worked on any new fluids that could have caused the hike in corrosion. "Crude oils are getting a little tougher to run these days, so we need to know the effect each one has." Jeff gets a real kick out of investigating each 'mystery' and says, "I play on the best team in the world, in the best refinery in the world!"

Fighting corrosion is a full-time job in the northwest Washington area, where there's high humidity and rain for nine months of the year. "Things rust indoors, here," Jeff says. "It's a standing joke in the refinery that the corrosion engineer has the rustiest truck on the lot." Finding the cause of that corrosion isn't difficult – the one-tonne truck came from the coast of Alaska, where the salt air has caused the corrosion. He's slowly removing it, but says, "You can't get away from corrosion." ■

Home turf: British Paralympian Shelly Woods is looking forward to competing on home soil at the London 2012 Paralympic Games. She's photographed here at the BT Paralympic World Cup in Manchester, UK, in 2009.

Report> Amanda Breen
Photography> Serena Ovens | Action Images

BEST OF BRITISH

BP is supporting six British athletes as they prepare for the London 2012 Olympic & Paralympic Games. Among them is wheelchair racer Shelly Woods, who is training to compete in three Paralympic events. After falling from a tree aged 11, Shelly suffered a spinal cord injury, but that did not stop her pursuing her passion for sport.

SHELLY WOODS

Sport: wheelchair athletics
Events: 1,500 metres, 5,000 metres, marathon
Age in 2012: 26
Main achievements: bronze and silver medals in 2008 Beijing Paralympic Games in 5,000m and 1,500m; broke 5,000m world record by more than three seconds in June 2010; current British record holder in 800m, 1,500m, 5,000m and marathon; marathon wins include London, Paris, Los Angeles and Oensingen.

On the downhill rush...

"For me, wheelchair racing is special because I like the speed. When you're out on the road in a marathon, speeds can reach up to 20 miles per hour – and faster for the men. Because we're so low to the ground, it feels really fast; going downhill can sometimes be quite scary, but it's exciting.

This sport is very physical, but it also requires strategy. In a race like the 1,500 metres on the track, it's all about your positioning among the other competitors. I take part in different events in the middle- to long-distance range, as they all complement each other in training. In the marathon, it usually comes down to a sprint finish, so I need the raw track speed to try to overcome everybody at the end to win."

On coping with a bad day...

"I've had a bit of a black cloud over competing at the London Marathon, due to punctures and other things beyond my control. A few days before this year's race, I changed both tyres on my chair and later I found that they had gone down overnight, which is not normal. I didn't have new ones and needed to find them, but still had to go training, of course. My first thought was, 'This is just my luck with London, things always go wrong,' but after

talking to my sports psychologist, I came to realise that it's not about luck, but when something supposedly 'bad' happens, the brain's awareness is heightened and is looking for other things to happen.

The main thing that keeps me going on a bad day is the thought that if I'm not training, someone else around the world is. I always want to have that edge, the advantage to beat my rivals."

On lessons from her last Paralympic Games...

"Crashes happen sometimes in this sport, because racers are so close to one another. In the Beijing Games 5,000 metres final, everyone was a bit edgy as we hadn't raced in a while. On the penultimate lap, there was a crash that took out half the field.

I managed to dodge the pile-up and took a silver medal. However, the decision was taken to rerun the race, which was unusual – normally, if there's an incident in the first 200 metres, the race is recalled, but the controversy in Beijing was caused by a change to the rules after the event was finished.

I looked at that experience as a wake-up call at my first Paralympic Games – I'd had a race plan where I was supposed to be in the leading pack, but I'd found myself boxed in at the back. When you have a plan, you need to execute it properly, so in the next race, I knew I needed to do things differently and I was lucky to have another opportunity. When the race was rerun, I got a bronze – that's how races go, I was still on the podium and no-one could take this medal away from me."

On competing in London...

"I've raced marathons all around the world, from New York to Los Angeles, Paris to Beijing, but London is my favourite, because people line the entire length of the course in support. The crowds know my name and shout, 'Go on, Shelly!' which is brilliant. Coming into The Mall at the end of the race, the noise is just deafening. In other cities, there is support, but it seems to be on a different level in London.

The Olympic & Paralympic Games here will be really special, not only for the athletes competing on home soil, but for everyone, as we're so passionate about sport. I'm really looking forward to it; racing in Beijing was my first opportunity to experience 90,000 people in a stadium – imagine that at home."

On her role as an athlete ambassador...

"It's an honour to be one of BP's six athlete ambassadors for London 2012; the support that the company is giving me is fantastic, and that allows me to train and race to my full potential. Its fuel support also helps me to get around to different competition venues and through the Target Neutral programme, I'll be leaving a smaller carbon footprint."

BP AND LONDON 2012

As the Official Oil and Gas Partner for the London 2012 Olympic & Paralympic Games, BP will provide fuels and lubricants for more than 4,000 official vehicles, as well as bottled gas for catering facilities at venues. BP is also a Sustainability Partner, with a key role in creating a lasting legacy after the competitions end. Advanced fuel options will help power the Games' fleet and vehicle carbon emissions will be offset by BP's Target Neutral programme.

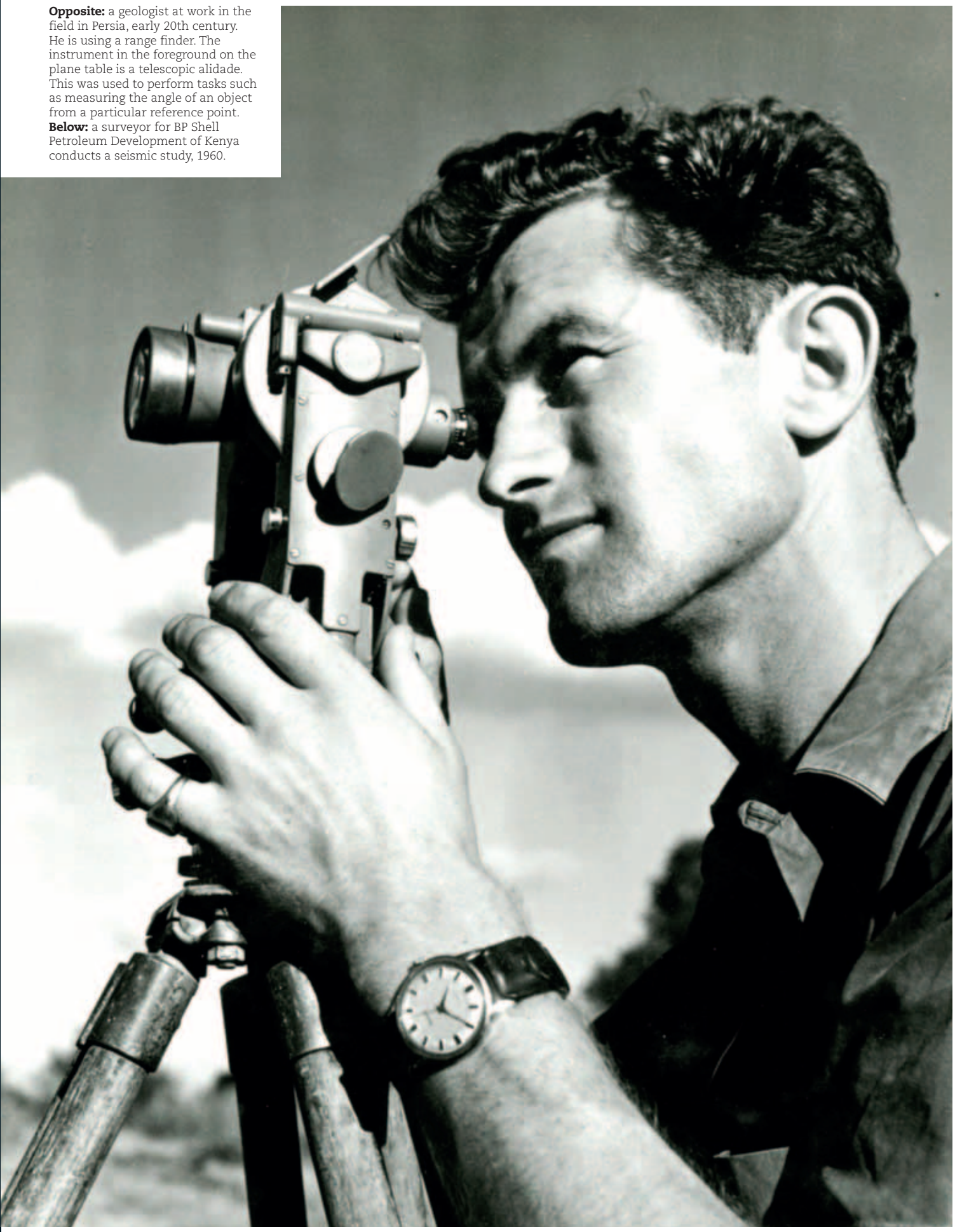
Arts, culture and education have played important parts in the Olympic movement since its foundation in Ancient Greece. In BP's role as a Premier Partner of the Cultural Olympiad and London 2012 Festival, it continues the long-time support of these areas, during events such as the annual London 2012 Open Weekend and the Tate Movie Project.

● *Further details of BP's London 2012 activities can be found at* www.bp.com/london2012

A CENTURY OF EXPLORATION

Throughout its history, BP has relied on the skills of some talented people to find new reserves of oil and gas and, as these images show, they frequently did it using the latest technology of the day.

Opposite: a geologist at work in the field in Persia, early 20th century. He is using a range finder. The instrument in the foreground on the plane table is a telescopic alidade. This was used to perform tasks such as measuring the angle of an object from a particular reference point.
Below: a surveyor for BP Shell Petroleum Development of Kenya conducts a seismic study, 1960.



Above: a seismic survey is conducted in the marshes of Basrah, Iraq, in 1958. **Top right:** a BP geologist examines rock along the shores of an oily lake in the Samovar Hills in Alaska, 1961. **Right:** a geophysicist for the BP Exploration Company in Libya uses a gravimeter in the Libyan desert, 1966. A gravimeter is used to measure the local gravitational field of the Earth.

Left: geophysicists examine seismic data from the Jebel Aswad structure in Oman, 1985. The truck in the background is where the seismic waves are recorded for later analysis. **Below:** a BP geologist and helicopter pilot unpack a folding canoe as part of investigations around Disenchantment Bay, on Osier Island, Alaska, 1961. **Bottom:** one of BP's highly immersive visualisation environments (HIVE) at its offices in Canada, 2001. Geologists, geophysicists, computer scientists and drilling engineers come together in a HIVE to view seismic data in four dimensions, the fourth being time.

Photography> Jon Challicom

Welcome distraction

This year's BP Portrait Award winner is Dutch artist Wim Heldens, for his portrait of a 25-year-old philosophy student, whom he has painted since he was seven. The third time entrant, photographed here (left) at the awards ceremony at London's National Portrait Gallery, was selected from a record 2,372 entries. Heldens's painting, entitled *Distracted*, depicts Jeroen, a philosophy student who has sat for the artist – a father-figure to the student since the age of four – 17 times throughout different stages of his life. As well as the £25,000 prize money, Heldens will receive a commission from the National Portrait Gallery, worth £4,000.

For more information on all of this year's winners visit www.bp.com/artsandculture

The next edition of *BP Magazine* will be out in September 2011.

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Helping to move the Games smoothly.

At BP, we're dedicated to fuelling the success of London 2012. We're using our latest technology to help over 5000 Games vehicles run smoothly with our advanced fuels, lower carbon biofuels and engine oils. We're also supporting British athletes like Lizzie Armitstead as she prepares for the Games.

Find out more at bp.com/2012

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