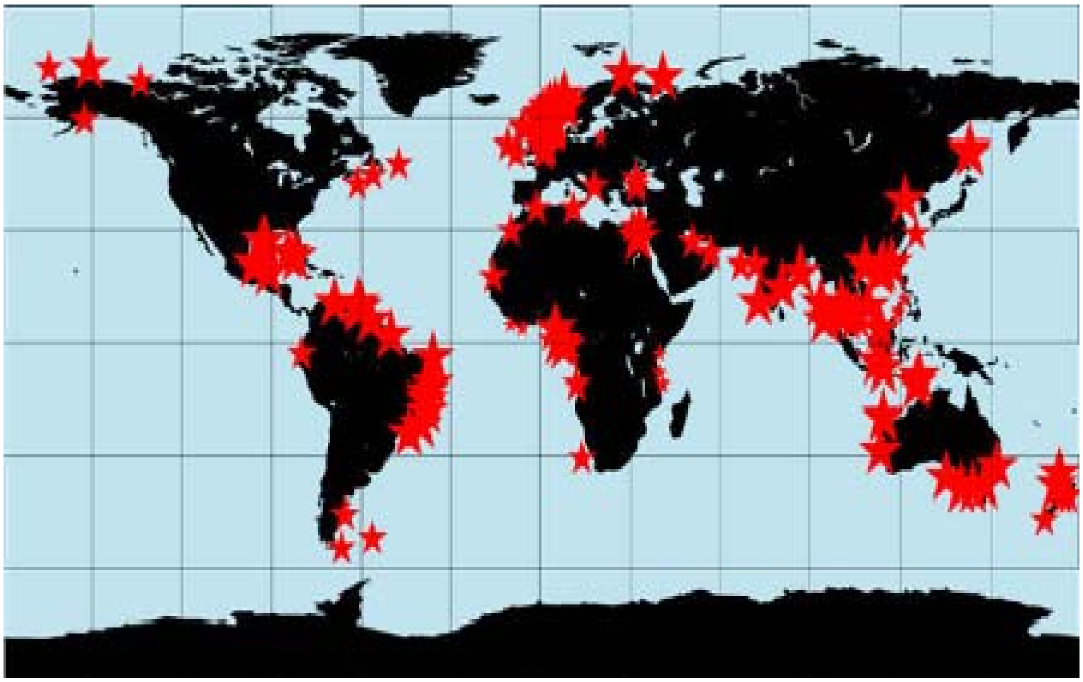
Deepwater fossil fuel extraction and production technologies – a developing source of ocean noise pollution.



Report by Michael Stocker

OCEAN CONSERVATION RESEARCH

Science and technology serving the sea

Deepwater fossil fuel extraction and production technologies – a developing source of ocean noise pollution. Lay language version

Michael Stocker, Ocean Conservation Research. P.O. Box 559 Lagunitas, CA 94938
mstocker@OCR.org

The era of "easy oil" is rapidly closing and more challenging reservoirs are being developed "offshore" on outer continental shelves using a suite of developing technologies. Deepwater (>1000 ft.– 10,000 ft.) development occurs under ambient pressures of 30 to 300 atmospheres (400 to 4000 psi.) and wellhead differential pressures of up to 20,000 psi. Active processing equipment is mounted on the sea floor to diminish the risks and costs of the multiple pipe runs that would be required for above sea level processing. The equipment includes separators, multi-phase and multi stage pumps, injectors, and metering equipment. Given the potential for extreme pressure differentials and the multi-phase nature of the product (liquids, gas, and solids) it is likely that some of these processes generate substantial noise. This paper is a review of the deepwater extraction and production technologies and an overview of the physical conditions found in deepwater fossil fuel exploration and production.

Overview

Incidental noise pollution from human enterprise has been increasing in the ocean since the mechanization of maritime transportation. As a consequence of the globalization of trade, shipping noise source has increased exponentially so that ambient noise in the ocean in certain places is ten times louder than it was just 50 years ago from shipping noise alone. Additionally, global scale noise is also increasing by the expansion of offshore fossil fuel development. From exploration through production, offshore and deepwater fossil fuel operations are raising the ambient noise levels in the ocean at an alarming rate.

While there is some uncertainty about the impacts of the increased ambient noise levels on marine life, it is clear that the marine acoustic habitat of animals that depend of acoustic communication is being adversely compromised. The impacts may include masking of biologically significant signals such as breeding and community coherence calls of kin, navigation cues provided by geological or hydrodynamic features in the natural marine soundscape, and the sounds of predators and prey.

This concern is not isolated to whales, porpoises, and dolphins, which we know have complex acoustical perception and communication systems, but also for fish and perhaps even invertebrates that also rely on acoustical cues for their survival.

Fossil fuel exploration to production sequence

Fossil fuel is the product of once living matter decomposing in geological formations that due to pressure, heat, and physical structure of the earth store the hydrocarbons of the decomposed matter in geological deposits. These deposits are initially identified by way of likely geological features.

Once a likely deposit area is identified the first stage of exploration begins by exciting the substrate with seismic scale stimulus. Seismic airgun surveys are the most common technique used in ocean settings.

When deposits are found and characterized, exploratory wells are sunk to determine the production potential of the deposit and the quality of the product. In deepwater settings exploratory wells are drilled from large stabilized floating platforms.

At the beginning of the exploration, caissons are built to mount a blowout preventer (BOP) – a safety feature used in exploratory settings. Once a deposit is determined to be suitably productive the BOP will be replaced by a flow control system to prepare the well for production.

Fossil fuel deposits are not just oil; rather they contain many other substances in various concentrations depending on the nature of the deposit. It is not uncommon for liquids (oil and brine), solids (sand, coal, shale), and gas (methane, ethane, butane, CO2, nitrogen, etc) to all be part of the product extracted out of the deposit. So the product coming out of the well is called "multiphase" containing gas, liquids and solids.

This multiphase product emerges from the wellhead typically under pressure. The flow is mediated by a "choke" valve and distributed to a manifold.

Each of these materials needs to be separated and handled appropriately. Waste water is often injected back into the well, sand and solids are separated and dumped, and gasses are either burned off, injected back into the well, or extracted and utilized – depending on the proximity to gas processing facilities and the environmental laws of the governing jurisdiction.

In historic shallow water operations separation was done on platforms above water, but increasingly these processes are occurring on the seafloor with seafloor mounted separation and processing equipment.

Control and monitoring of this equipment is accomplished through instrument packages mounted on the various pieces of equipment, and by way both tethered (remotely operated) and autonomous underwater vehicles (ROV's an AUV's respectively). Communication to these instruments and vehicles takes place by way of wired tethers as well as acoustic modems.

Noise sources

Airguns:

Heretofore the main noise concern in the fossil fuel industry was focused on seismic airgun surveys, whereby arrays of airguns are towed across transects, exploding every ten to twenty seconds, sending a seismic level impulse down into the water column and into the seafloor below.

While the signals from these arrays are focused down, noise from the operations can be heard thousands of kilometers from the source – echoing through entire ocean basins. As the surveys take place in ever deeper water the reach of this noise will also increase.

At any given time there are 40 to 50 surveys happening globally.

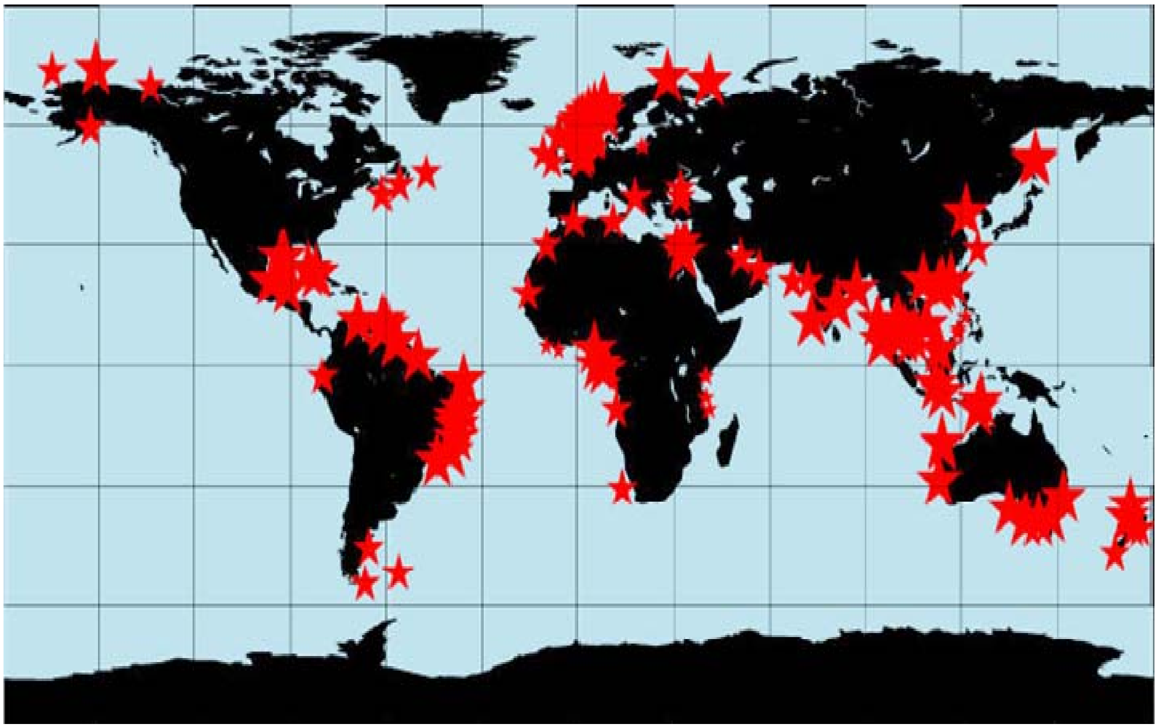


Illustration courtesy of John Hildebrand

Exploratory wells:

Once likely deposits are located, a drilling site is prepared by installing a wellhead "tree" and blow out preventer (BOP). This is then used to seal the wellhead and guide the drilling bits and pipe into the earth. The drill bits and pipe are the fed from the ocean surface from a stabilized drilling platform such as the recent Deepwater Horizon.

These platforms can have deck areas the size of a soccer field with displacements in excess of 30,000 tons. In order to push miles of pipe into a well with accuracy they are dynamically stabilized using six to eight "thrusters" that can keep the drilling operation stable within 1 meter on the x, y, and z axes.

Thrusters are large propellers powered by diesel-electric drives and depending on the sea conditions during operation can generate significant noise from turbulence and blade cavitation.

Photos: Thrustmaster Asia Pacific

The actual drilling noise is not substantial because any noise generated by drill bit will be attenuated by the surrounding earth formation. Even when the pipes “bang the hole” due to eccentricities in drilling actions, these noises when monitored by geophones or seismometers will generate at most a Richter scale value of 1 or less. (By way of comparison, a 40,000 lb. cargo truck passing by might generate a Richter scale 4 “quake” – in a logrhithmic scale 1,000 greater energy than a Richter value of 1.)

Increasingly though equipment used in seafloor operations are fitted with telemetric equipment communicating through multi-nodal networks for dynamic positioning references, equipment identification, equipment condition monitoring, and AUV/ROV communication.

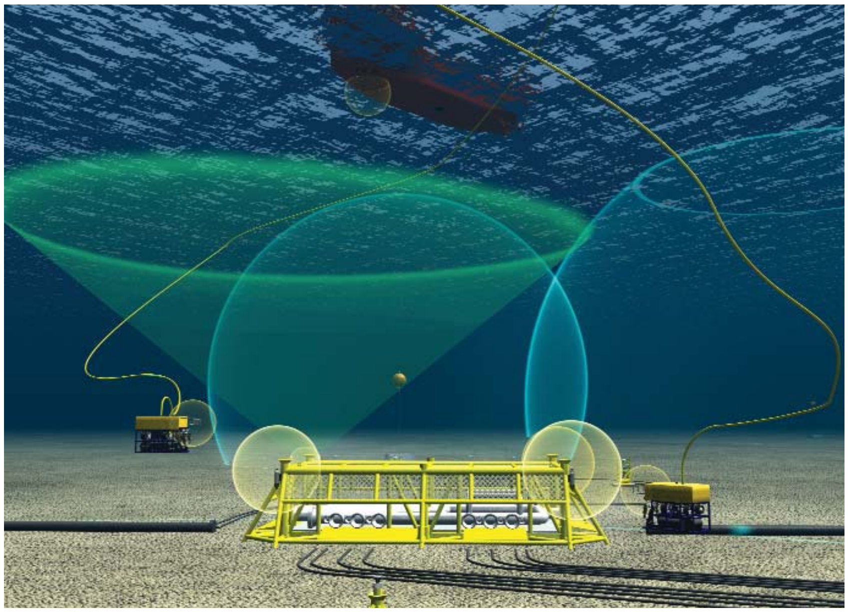


Illustration: Nautronix

These acoustical modems operate in mid frequency (1- 10 kHz) and high frequency (10-50 kHz) ranges, at typical source levels of 180dB re: 1 μPa with an operating range of 5-10 km. Noises in these frequency ranges and amplitudes have been correlated with signals that aggravate beaked whales, porpoises, and dolphins, and may also have negative impacts on some forage fish such as herring or shad.

Production:

Once a well becomes productive the exploratory drilling apparatus' are removed and production piping and processing equipment are deployed. While this processing has historically occurred on "Floating Production and Storage Operations" (FPSO's), increasingly as fields get out in deeper water, production processing is being located on the sea floor – called "subsea processing."

Wellhead pressures can be quite high – ½ psi per foot depth in water and an additional 1 psi per foot depth in rock. (The recent BP Macondo well was kicking out oil, gas, brine, and solids at an excess of 13,000 psi.)

From the borehole the first control contact point for the product is the "choke" – a valve that mediates the flow of product into the distribution tree. Given the excessive pressures and hostile conditions these chokes are made of tungsten carbide "tool steel." Even so they wear out and need periodic replacement. It is likely that the multiphase product flowing through the choke and distribution tree will produce loud broad-band noise.

From the distribution tree the product is piped to separators to separate the valuable product from brine, sand, and solids. Depending on the composition of the mix these separators are gravity, centrifugal, or product density driven. In most cases separators form an expansion point in the product flow, decreasing the net pressure of the product relative to flow, although if possible pressures are kept high enough to push the product up to the surface.

In the cases where the pressure is not adequate to overcome the column weight, multistage pumps are deployed (driven by electrical motors). Additional pumps are used to inject the brine and other waste products back into the deposit. Each one of these pumps may not generate significant noise in and of itself, but as operations expand across the seafloor cumulative noises from all of these pumps will increase the noise floor of the marine habitat.

Illustration: FMC

Once the valued product is separated it is piped to centralized storage and distribution operations. These “tiebacks” can be 20 km from the wellhead and processing field and can be floating platforms (FPSO’s) or in some cases located on shore. Floating platforms will be tended by lighters, tankers, maintenance craft, and crew transport vessels and helicopters, making these operations an area of high noise concentrations.

Heretofore no impact studies have been conducted to determine the effects that these new noise fields have on the short or long term viability of marine life, but there is a high probability that the impacts are not negligible.

End.