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Oil in Troubled Waters

Facts and Fallacies about Marine Petroleum Exploration and Development

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Summary

After air and water, petroleum is one of the most essential products for human life as we know it. On a personal level, its by-products—from petrol and perspex to pantihose—are important items for our everyday lives. On a global scale, oil and gas provide 62 per cent of the world's power and have secured the wealth and health of billions of people this century. Over the next century, oil and gas hold the key to the wealth and health of billions more.

Yet petroleum is viewed by many people as more pariah than prize. Thirty years ago an oil well symbolised the prospect of national wealth and higher living standards. The Australian petroleum exploration and development industry stood then on solid ground. Today, for many people, an oil-well suggests blackened beaches and dead birds, and the industry is in very troubled waters.

The causes of that change in perspective are complex, but much of the current concern about petroleum can be traced to inadequate public knowledge about petroleum, making it difficult to evaluate environmentalists' misleading and erroneous claims. This *Backgrounder* offers some facts to counter these widespread and well-publicised fallacies. It looks at the variety and range of products derived from petroleum, and their importance to our national economy and daily routines. It discusses the nature of petroleum and the processes of exploration and production, and their relatively harmless impact on the environment. It shows that, despite severe local short-term damage in some instances, oil spills have minimal, if any, long-term impact.

Unless we put fact before fallacy, and ground the laws we enact and the procedures we adopt on evidence rather than emotion, we will not care for the environment as well as we intend, or provide for the future as well as we might.

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Introduction

> Offshore oil exploration and production activities generally account for a very small portion of marine pollution.[1]
>
> The environmental effects of offshore oil drilling, even without accidents, are very damaging to the marine environment.[2]

These statements represent opposing views in the debate about the environmental effects of offshore petroleum exploration and production. The majority of Australians believes, or fears, that the second statement is correct; they probably see the first statement as self-serving industry propaganda, and likely to be false.

It is, in fact, the second statement—by the multinational corporation Greenpeace—that is self-serving and false. The first statement comes from *Agenda 21*, the action plan for worldwide sustainable development drafted at the 1992 United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro! This conference was widely touted by world leaders and their environmental advisers as humanity's last chance to save the planet. One presumes, then, that they considered the facts long and hard before declaring that petroleum exploration and production cause very little pollution.

For its part, the Australian Government would have taken full notice of the excellent environmental record of the industry in Australia: in 26 years (to 1991) of petroleum exploration and production in Commonwealth waters, 480,000,000 kilolitres of oil were produced and only 70 kilolitres spilt—an amount roughly equivalent to a large backyard swimming pool.[3]

So why do most Australians hold the contrary view? The petroleum exploration and production industry has served the nation well, both economically and environmentally, but is not seen to have done either. Its image in the popular imagination is that of an oil-stained bird; the companies are seen by many to be earning huge profits from an Australian resource, and laying waste the environment in the process.

These images are carefully preserved and embellished by many environmentalists, and given regular and widespread display by the generally sympathetic media. This activism is both symptom and cause of changing public attitudes towards technology and industry generally, and the petroleum industry specifically. The public's receptiveness to anti-petroleum propaganda stands in striking contrast to the enthusiasm that greeted Australia's first oil discovery at Rough Range forty years ago. The reasons for that change are complex but draw substantial impetus from the relative affluence of society today, and the different perspectives and paradigms such affluence sponsors. It is ironic that the discovery and development of Australia's own petroleum supplies have been an important contributor to that affluence.

To the extent that these concerns and fears are emotional and psychological, they are not easily allayed by rational argument and statistics; equally, however, a better public understanding of the facts and figures can only help. There seems to be little public appreciation of the variety and range of products derived from petroleum, and its importance to our national economy and individual daily routines. There is very limited understanding of the nature of petroleum and little knowledge of the processes of exploration, discovery and production, and their relatively harmless impact on the environment. There is certainly no significant community understanding that oil spills have minimal, if any, long-term impact.

The net effect is a public perception that bears little resemblance to the facts, and must be a cause for concern to those who care for the environment. If individual and community opinions are being determined more by emotion than evidence, then the legislature may be similarly misled. Policy based on misinformation and, particularly, disinformation, can only be bad policy.

This confusion at a policy level is already evident. The Federal Government may have signed *Agenda 21*, but it is also the author of ever-increasing legislation and regulation to restrict access for petroleum exploration in Australian waters, with the implicit (and often explicit) assumption that it will damage the environment. One senses that, in many of the corridors of the environmental agencies, there is a longing for a moratorium on all offshore exploration.

This *Backgrounder* has been written to encourage a more balanced and complete view of petroleum, and its role and value in our society. It covers a broad range of topics, from the origin of petroleum to its changing reputation in the popular imagination. There is particular emphasis on the economic significance of petroleum, the ubiquity of its by-products, and the exploration and production processes and their environmental consequences. It

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1 *Agenda 21*, United Nations Conference on Environment and Development, Rio de Janeiro, 1992.

2 Greenpeace, 'Section 45d an environmental threat', *The Australian Nurses Journal*, 21, 3, September 1991, page 16.

3 Department of Primary Industries and Energy, *Accidents and oil spills in the Commonwealth of Australia offshore areas connected with petroleum exploration and development activities*, AGPS, 21 May 1992.

also reviews the facts and fallacies concerning the environmental impact of oil spills on the marine ecosystem.

The interconnectedness of all things is a fundamental tenet of the so-called 'holistic' view of the biosphere. Ironically, many who champion this view seem to practise it poorly, and see petroleum as an evil. They forget that it is an ancient part of the biosphere, the recycled biomass of past aeons. It may pollute the ocean locally and briefly, but it is also a source of food there. It may contribute to smog in the cities, but it has also contributed greatly to the prosperous and free society we enjoy. Unless we accept and accommodate that duality for good and ill within all things, petroleum no more or less than ourselves, we are unlikely to serve future generations and the planet itself as well as we intend.

Prize and Perspex

Daniel Yergin called his 1991 Pulitzer Prize-winning history of the oil industry, *The Prize*[4], not for the petroleum itself but for the wealth and power it accorded the nations and men who found and controlled it. It has caused wars, as critics charge—the promise and pursuit of wealth and power always have—but to blame petroleum for these conflicts is to miss the point of the prize: 'mastery itself', to quote Winston Churchill—the control of one's destiny.

This has been the century of petroleum. Ours is the hydrocarbon society and we are hydrocarbon man. Petroleum and its myriad products determine how and where we live and work, how we communicate and travel, and how we relax. By way of the motor car, it even provides settings for many of our courtship and mating rituals!

Yet, if this is truly the Age of Petroleum, we know it not. Yergin suggested that 'we are so dependent on oil, and oil is so imbedded in our daily doings, that we hardly stop to comprehend its pervasive significance'. A 1990–91 American Institute of Petroleum opinion poll showed that the American public did recognise their dependence on petroleum, and that they resented it. However, the poll also showed that they were focused on petroleum only as a source of petrol for their cars. There was no real appreciation of the numerous petroleum-derived products in their everyday lives.[5] Australians seems to have the same narrow view.

4 D. Yergin, *The Prize*, Simon & Schuster, New York, 1991.
5 This poll of American consumers and opinion leaders was conducted between May 1990 and March 1991.

We all know that motor cars use petrol; what we don't know, or don't notice, is how much of the car itself is also made from petroleum: foam padding, hoses, panels, and so on. We drive the kids to basketball, resenting the cost of petrol, but never noticing that the surface of the court, the teams' clothes and shoes, and the basketball itself, are all petroleum-derived. So too the family refrigerator and washing machine, the house paint, cosmetics, drugs, perspex, pantihose and polyester pyjamas.

Products derived from petroleum[6]

Petroleum fractions	Products	Derived products
Gases	Automotive LPG	Welding gases, refrigerants
Solvents	Paint solvents, lacquer diluents	Adhesive tapes, cleaning fluids
Kerosenes	Aviation fuel, lamp oil	
Lubricants	Transmission, hydraulic, etc.	Printing ink oils, waterproofing
Paraffin	Medical oil, cosmetic cream	Hydraulic oils, insecticides
Waxes	Ointments, UV creams	Rubber, candles, food preservatives,
Petrolatums	Ointment, lipstick	Waterproofing, corrosion inhibs
Residual oils	Industrial fuel	Blast furnace fuel
Bitumens	Hotmix	Floor coatings
Coke	Abrasives	
Carbon black	Carbon paper	

A better appreciation of petroleum's role on the global stage is also needed. World trade in petroleum is larger than the trade in all the other commodities combined. This is indeed the century of oil. The wealth and health of billions of people depend on it. So does the prospect of improving the wealth and health of billions more: energy is essential to raising living standards in the developing countries. Petroleum and natural gas supply over 60 per cent of the world's energy needs, and will continue to do so for some time. We may be in a transition period to other energy sources, but it is a long-term transition.

Calls for greater public transport, alternative energy supplies and other initiatives to reduce petroleum consumption have value, but are too often simplistic in their limited understanding of

6 Australian Institute of Petroleum Ltd, *Australia's oil industry*, Melbourne, August 1992.

the pervasive presence of petroleum in the home and workplace, and its basic role in national and international economies. The transition to new power sources such as solar energy must be managed properly. Evolutionary change seems the most likely to maximise use of resources; the revolutionary approach more likely to waste them, and violate the principles of sustainable development.

Denouncing Western countries for disproportionate use of petroleum ignores the fact that Western ideas and enterprise underwrote the technology to find it, and develop so much from it—which is not to suggest that people and organisations from Western countries, being as human as the rest, didn't seek their own advantage in doing so.

A better appreciation of petroleum's ubiquity and importance, whether in personal or global terms, might be a first step towards correcting petroleum's current image as a pariah in modern society. It would help people to put in better perspective the anti-petroleum propaganda that is increasingly thrust before them by environmental groups and the media. There need be no lessening of their concern for the environment, but there would be a more balanced awareness of the risks and rewards inherent in our search for and use of petroleum.

Economic Importance to Australia

Australia uses about 650,000 barrels of petroleum each day; about 88 per cent for fuel and energy generation (30 per cent for distillate and petrol, 9 per cent for kerosene fuel, 11 per cent for electricity generation, 23 per cent for heating, and 15 per cent to provide power for factories) and 12 per cent for petrochemicals, lubricants and plastics. In 1992, approximately 79 per cent of the national requirement was produced locally.[7]

The economic impact of this domestic production is two-fold: industry pays royalties and tax on income earned from sales of oil and gas, and the nation is saved the expense of having to buy it abroad. Had we been obliged to import our oil and gas requirements over the past 30 years, the cost would have been about $120 billion for oil and $60 billion for gas. Instead, the nation benefited from revenues approaching $100 billion. The Australian oil and gas industry now contributes nearly $3 billion per annum in revenue to the Federal government, a significant contribution towards the social and environmental programmes the nation enjoys.[8]

Over 90 per cent of oil production comes from offshore fields. For the past two decades the giant oilfields of the Gippsland Basin, deep below Bass Strait, have provided Australia with near self-sufficiency in petroleum. These fields are now in decline and the energy province of the future is the vast North West Shelf, stretching from Exmouth Gulf in the south to Darwin in the north. Production from oilfields there is now 35 per cent of Australia's total, and will increase significantly through the 1990s. Offshore fields also provide most of Australia's gas supplies.

The current decline in self-sufficiency in oil supplies has serious consequences. In 1986, Australia's petroleum self-sufficiency peaked at 97 per cent, with a net cost for imports of only $44 million. Our Liquified Natural Gas (LNG) export earnings that year were $1.1 billion. Self-sufficiency is projected to be 75 per cent in 1993 and 68 per cent in 2000. The cost of imports in the year 2000 is estimated at about $4 billion at today's prices; import costs this decade will be about $30 billion. For a nation already so far in debt, the potential economic consequences of that extra expenditure will be significant.[9]

To maintain the current level of self-sufficiency into the next century, Australia needs to discover about 2 billion barrels of oil over the next decade—more than double the discovery rate achieved in the 1980s. That is, in sporting terms, a big ask. The Australian Petroleum Exploration Association (APEA) estimates that an investment by Australian and international companies of $25 billion will be needed. The best hope for the discoveries is in the offshore area, particularly on the North West Shelf.

The good news is that exports of LNG to Japan from the giant gas fields of the North West Shelf will help offset that import bill: earnings to the year 2000 are estimated at $18 billion. It is likely that these gas fields will also supply the Australian market, as onshore gas supplies diminish and the shift from oil and coal to gas for power generation increases. The indications are that the North West Shelf has enormous gas supplies, and their development for use and export should be a major source of income to Australia over coming decades—if that development proceeds.

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7 Peter McGregor, *The Australian Petroleum Resource Book*, Joint publication of the Australian Institute of Petroleum and the Australian Petroleum Exploration Association, Australian Resource Books, Victoria, 1993.

8 R. Wells, 'The recent performance of the oil and gas sector, and multiple land use in the future', *PESA Journal*, June 1992, pages 44–6.

9 Shane Bush *et al.*, *Energy demand and supply projections Australia, 1992–93 to 2004–05*, ABARE Research Report 93/2, Canberra, 1993.

Maintaining the quality of life for Australians requires an acceleration of the offshore petroleum exploration effort, not an abandonment of it, as advocated by Greenpeace and other environmentalists, including some Government agencies. The alternative is a slow but significant decline in living standards. Some environmentalists might be quite happy with that; indeed, it might be their aim. It is unlikely, however, that the rest of the public understands the cost to them of such a policy.

Petroleum as Natural Product

Petroleum—or crude oil (oil, for short)—is a naturally occurring liquid which varies in consistency and composition from thick and black, like motor oil, to light and transparent, like petrol. ('Petroleum' is often used to include natural or petroleum gas, but here refers only to the liquid.) It is composed mainly of various compounds of carbon and hydrogen, collectively referred to as hydrocarbons—a term explorers use loosely for both petroleum and natural gas. Petroleum also contains trace amounts of other components, including sulphur compounds, nitrogen and oxygen, and very low concentrations of metals such as vanadium, lead and nickel. These differences in composition reflect the origin and history of each deposit: the make-up of the original organic matter and the temperature and pressure conditions to which it has been subjected.

The current fixation on the perceived 'evils' of petroleum has obscured the fact that hydrocarbons are a fundamental part of the carbon cycle in the geosphere, and the elemental building blocks of life on earth and perhaps elsewhere. Some scientists speculate that hydrocarbons came to earth in a meteorite billions of years ago, developed into plants, and set in process the evolutionary chain to human life when the hydrocarbon 'soup' in primordial swamps was struck by lightning.

The rain forests may be the earth's lungs, as we are constantly told these days, but there could be no heartbeat without hydrocarbons. Carbon dioxide from the atmosphere and oceans is converted to living tissue by plants and organisms; these die or are eaten by other animals, who likewise live and die, consuming and being consumed. The animals and plants return carbon dioxide to the atmosphere while alive and, by way of bacterial decay, when dead. It is, in one moment, the photosynthesis of carbon dioxide into living tissue and, in another, the oxidation of dead tissue, that completes the cycle and sustains life.

Throughout the earth's history, a small amount of organic matter (less than 1 per cent) has escaped the cycle because it has fallen into oxygen-deficient lakes and oceans, been buried there, and converted to hydrocarbons of one sort or another. A minuscule amount (less than 0.05 per cent of the 1 per cent) is preserved in concentrated deposits within the earth and ultimately converted to coal or oil or gas. Later uplift may expose these deposits, and the hydrocarbons are then oxidised back into the cycle. Those that have remained buried are the fossil fuel resources we depend on today.

In this global ecosystem, then, man's exploration for, and exploitation of, the fossil fuels such as petroleum are part of a very recent loop in the carbon cycle. The burning of fossil fuels returns to the atmosphere the carbon dioxide that was removed millions of years ago. The consequences may be unclear, and the process controversial, but it remains part of nature's cycle—and none the less for man's involvement in it.

Formation of Petroleum

Contrary to popular belief, petroleum does not occur as vast submarine lakes and rivers. It exists as microscopic globules in the pore spaces between the grains within porous rocks such as sandstone and limestone. Nor does it occur at random localities anywhere in the subsurface: petroleum is found only in so-called sedimentary basins—depressions in the earth's surface where, over millions of years, great thicknesses of sedimentary rocks have accumulated. Nor do all basins have oil; its presence, particularly in commercial quantities, requires a complex chain of events and conditions: organic material in sufficient quantity must be buried, then converted to petroleum, expelled from the source rock and then 'trapped' in porous layers.

The conversion of organic material to petroleum is a long and complex process. As organic material degrades, complex molecules such as proteins break down into smaller simpler compounds, mainly by bacteria and other micro-organisms feeding on it. These new compounds interact, dissolving and combining into each other, and reforming into larger complex molecules known as kerogens which, as they are buried deeper and subjected to increasing temperature and pressure, are converted into liquid and gaseous hydrocarbons. Gas forms first; then oil, and finally gas again.

The presence of oil or gas in an area is also determined by the type of organic material preserved within the sediments. Algae, for instance,

break down to form a kerogen that converts to oil. By contrast, the organic chemistry of most land plants tends to favour the formation of gas.

The oil is squeezed out of the source rock by the pressure of overlying rocks, and migrates into and up through adjacent porous layers until it is trapped against an impermeable layer (for example, shale) either in a dome-like structure or against a fault. The oil can reach the surface if the reservoir layer is exposed, or by leaking up faults and microfractures.

These specific and complex conditions make a commercial oil deposit, in scientific terms, a rare event. Exploration, if it is to be successful, must be conducted in areas where the geological conditions have been favourable. Inevitably that occurs in areas, both on land and offshore, that have other valuable resources, be they ecological, economic, cultural or whatever, and accommodation between the various uses and users is necessary.

The solution is not to prohibit exploration and development in an area because of the other resources; just as the solution is not to prohibit, for example, tourism or wildlife preservation in potentially oil-bearing areas. The solution requires the simultaneous or sequential use of an area for the different purposes—the so-called 'multiple land use' concept.

Excluding exploration in areas with petroleum potential denies the nation the use and value of that resource, and incurs the economic cost of purchase elsewhere. This violates the principle of 'sustainable development', as originally conceived by the Brundtland Commission, and incorporated into the National Conservation Strategy for Australia. It is this balance between conservation and development that has been abandoned, albeit quite deliberately, in the subsequent redefinition of 'sustainable development' as *'ecologically* sustainable development'. The trend now seems to be to remove the dreaded word 'development' altogether and refer to 'sustainable use'—thereby precluding the need to consider development at all.[10]

Exploration for Petroleum

Natural seepages of petroleum have been exploited by mankind for millennia, for purposes as varied as lighting and medicine, by cultures as diverse as those of New Guinea and Egypt. Petroleum greased the wheels of Roman chariots, sealed the hulls of early rafts and ships, and bound together the stones in the Tower of Babel and the Great Wall of China. The English word naphthalene is derived from the Greek *naphtha*, itself derived from one of the languages of the ancient Middle East. The word petroleum comes from the Greek *petra*, stone or rock, and the Latin, *oleum*, oil.

Systematic exploration for petroleum began in the late nineteenth century when whale oil supplies in the USA were diminishing and entrepreneurs saw 'rock oil' as a possible alternative. The early drilling was on surface seepages but soon progressed to the dome-like geological structures visible on the surface in many areas. Many of the world's first oilfields were found this way.

The surface features were not always indicative of the structure at depth, however, and geophysical exploration techniques developed. These techniques, of which the seismic reflection method soon became pre-eminent, were essential for the move to offshore exploration in the 1950s. They are based on the measurement of various physical parameters of the earth, such as its gravity field or acoustical response, and the interpretation of the results in terms of subsurface geological structure.

The procedures and instrumentation of the modern seismic reflection method are complex and sophisticated, but the underlying concept is ingeniously simple, essentially an echo-sounding of the subsurface structure. An energy wave, artificially generated near the surface, penetrates down through the earth, and is progressively reflected back upwards by the different layers it encounters. Sensitive instruments called geophones record the vibration of this returning energy. In marine surveys, these are contained in a plastic cable, often several kilometres long, towed behind the survey vessel. By taking seismic soundings along intersecting profiles and displaying the reflected energy patterns side by side, the geophysicist is able to construct cross-sections of the earth, and identify and map structures that might contain oil.

None of these geophysical techniques confirms the presence of oil or gas; the only sure test is to drill. Offshore, depending mainly on the water depths, this is conducted using a drill ship, a semi-submersible platform, or a 'jack-up' rig. A drillship is a specially-built ship, capable of drilling through a hole in the hull. A semi-submersible uses giant buoyancy tanks well below the surface to stabilise the partly submerged platform. Drill ships and semi-submersibles use anchors for posi-

10 Brian J. O'Brien, *Nationalising the Australian Environment: The Agreements of '92* (IFA Policy Paper No. 23, April 1993) presents a detailed analysis of the 'ecologising' of the sustainable development principle. On the 'unfortunate' term, development, see G. Carleton Ray *et al.*, *Marine and Estuarine Protected Areas: A Strategy for a National Representative System Within Australian Coastal and Marine Environments*, Consultancy report for the Australian National Parks and Wildlife Service, Canberra, 1993, page 4.

tioning, and maintain their position over the drill-hole using computer-driven motors. The jack-up rig is used in shallower waters, and as the name suggests, has legs which rest on the sea floor and a drilling platform that is then jacked up above the water.

The rotary drilling technique used on oil wells employs a drill-bit mounted on a string of steel pipes which are screwed together using the tongs and chains seen so commonly in film coverage of drilling operations. The bit is cooled by drilling fluid, colloquially called 'mud', which is pumped down the drill pipe and returns up to the surface outside the pipe, carrying with it the rock chips (cuttings) cut by the bit. The weight of this fluid also prevents any oil, gas or water encountered during drilling from flowing unchecked into the hole, and causing a blow-out.

Drilling technology and engineering are now extremely proficient and safe, with computer-linked down-hole equipment able to direct the drill-bit precisely, and transmit data about the rocks back to the surface. Down-hole monitoring can provide instantaneous warning of pressure changes, and trigger in the appropriate blow-out prevention procedures.

Contrary to Hollywood tradition, a discovery of oil is not signalled by a blow-out at the surface. A small amount of gas or oil may flow into the hole and be seen at the surface in the drilling fluid; the cuttings from that layer may also show signs of oil. These 'shows' are very exciting to the explorers, but pretty dull on the big screen--hence Hollywood's preference for blow-outs! The significance of these 'shows', and often the first real indication of hydrocarbons, comes from the 'logs'—electrical, sonic, and radioactivity parameters measured down the hole—which reveal the nature of the rocks and the fluids they contain.

If a discovery is made, there will be extensive follow-up drilling and geophysical surveying before the size of the accumulation and its commercial significance can be established. Production facilities will then be designed to fit the geological and surface conditions, with a view to maximised recovery of oil from the reservoir and minimised environmental impact.

Environmental Effects of Exploration

Aeromagnetic and gravity surveys are conducted using airborne and shipborne instruments, and have no real impact on the marine environment. Modern seismic surveys are also relatively harmless but this is not the public perception, and environmental propaganda certainly argues otherwise.[11]

Some of the public concern may be a remembering of surveying techniques of decades ago when high-velocity explosives were used to create the energy waves: the lethal impact varied with different conditions and species but there was no escaping the trail of dead fish behind the survey vessels. This was a source of increasing concern to industry in the early 1960s, long before it became a public issue, and research led to the invention of other energy sources, notably a compressed air discharge. Explosives were quickly phased out: by 1969 they were used in only one per cent of surveys worldwide; in Australia their use in routine survey work ceased altogether in 1970.

The so-called 'air-gun' is the energy source for almost all marine surveys in Australia. Air is compressed in a steel chamber in the 'gun' and then released instantaneously at about 6–10 metres depth, sending energy waves out into the water and down through the underlying earth layers. Experiments have shown that its effects are very local; fish show no effects at distances of 1–5 metres. Fish eggs and larvae of some species are injured if closer than 5 metres to the discharge; others show no effect as close as 1 metre.[12]

During the 1970s concern developed about the air-gun's effects on Cetaceae, the mammal family, because of their use of echo-sounding for navigation and food detection, and perhaps communication. The large whales were, and are, of particular concern: some are endangered species and their annual migratory routes often pass through areas of petroleum exploration. This concern was exploited by Greenpeace in their opposition to BHP Petroleum's exploration programme offshore Victoria in 1991.

The evidence available, though mainly anecdotal (controlled experiments being difficult and undesirable), suggests that air-gun surveying causes no significant disturbance to whales, except perhaps at very close quarters. Changes in heading, behaviour and respiration rates have been observed within two kilometres of recordings of air-gun noise but whales observed during actual surveys in USA waters, including a cow nursing a calf, seemed unaffected.[13] Observations during

11 Peter Gill and Vera Hughes, 'Oiling along', *Greenpeace Australia News*, 2, 2, Autumn 1991.

12 R.P. Warren, 'Offshore oil and gas exploration: what are the environmental effects and do they justify limitations on access in coastal waters?', *The APEA Journal*, 29, 1, 1989.

13 These 1983 recording experiments by C.I. Lalme *et al.* are cited in D.F. Boesch and N.N. Rabalais (eds), *Long term environmental effects of offshore oil and gas development*, Elsevier Applied Science, New York, 1987. The observations by R.S. Gails (1981) during surveys were cited in C. Pierce, *The*

surveys off the coast of Western Australia and elsewhere reveal a range of reactions: some animals turn in towards the vessel and follow it for a distance; others turn away; still others show no change in heading or behaviour at all.

Dolphins and porpoises seem to enjoy the company of vessels the world over and seismic survey vessels are no exception. They often swim alongside for considerable distances and, to the human eye at least, appear to be at play. There does not appear to be any information regarding dugong in northern Australian waters.

Several whale species have suffered near-extinction in order to supply oil and other items for human use, and the current concern for these animals is a welcome development. At the same time, however, some of the fears seem poorly founded. It is, for instance, part of many people's fascination with whales and other Cetaceae, that these mammals seem relatively intelligent. It might show a more genuine respect for cetacean intelligence to accept that, in the presence of disturbing underwater sounds, they would simply swim away!

Much of the current concern for nature has little to do with the reality of nature, and more to do with the urban romantic image of it: whales are no exception. They are not delicate beings in a noise-free ocean; they live in an often noisy world, and their auditory system routinely handles very large pressure changes during underwater earthquakes and ice-pack movements, as well as from diving. They are also obviously able to handle the enormous instantaneous pressure changes associated with jumping: when a large whale breaks the surface and falls back into the water, it generates a peak sound pressure of about 1.5 pounds/square inch. This is the peak noise level at a distance of about 5 metres from an air-gun. Whale songs, moans, and tail slaps are of similar intensity to the noise 50 metres from an airgun.[14]

It is not surprising, then, that whales are seemingly unconcerned by air-gun surveying. The air-gun 'pop' banging against the side of their vessel reportedly concerned Greenpeace activists during surveys offshore Victoria in 1991. The facts suggest that the 'pop' had no more effect on any nearby whale than if it had, for its own amusement or theirs, jumped skyward and fallen back into the ocean.

biological effects of marine seismic activities—a literature survey, California State University Press, Hayward, 1984.

14 W.J. Richardson *et al.*, *Effects of Offshore Petroleum Operations on Cold Water Marine Mammals: A Literature Review*, American Petroleum Institute Report, 1989; G.M. Wenz, 'Acoustic ambient noise in the ocean: spectra and sources', *Journal of the Acoustic Society of America*, 34, 1962, pages 1936–1956.

Environmental Effects of Drilling and Production

A main public concern about petroleum exploration and production seems to be that a blow-out will cause a major oil spill. Indeed, the image of a rig with oil soaring skyward and raining down upon jubilant oilmen has become archetypal of the industry. As an image, however, it owes more to Hollywood than to oil-field practice of the past 50 years or more.

Oil often exists in the subsurface at great pressure and, in the early days, when wells were drilled with only air or water in the hole, the oil could rush into and up the hole and 'blow out' at the surface. For reasons of economy and safety, the early oilmen soon put a stop to that practice. The rotary drilling technology developed rapidly, including special drilling fluids with additives to control their density and consistency, and counterbalance the pressure of inflowing oil or gas. Modern drilling rigs are also fitted with blow-out prevention controls—complex systems of metal clamps and shutters which can be used to seal the hole if unexpected high pressures are encountered.

Drilling is an exploratory exercise in more ways than one. Not everything can be predicted, but most things can be prepared for. Companies and government regulatory agencies are well aware of the risks, and have developed policies and procedures to minimise them. Companies are not given permission to drill an offshore well until their blow-out prevention and oil spill contingency plans are approved. If a pocket of higher pressure oil or gas is encountered, the well 'kicks', as the drillers say: the inflowing fluid or gas pushes drilling fluid back out the top of the hole. The appropriate procedures are followed (for example, increasing the density of the drilling fluid), the well is stabilised, and drilling proceeds.

There can be no denying that major blow-outs still occur, and cause loss of life, as well as severe ecological trauma and economic loss. Fortunately, the available technology and proper precautions make them very rare events. Since offshore drilling commenced in Australia in 1965, there has not been a single oil blow-out. Six gas blow-outs occurred during that time—five in Bass Strait and one in the Timor Sea. The Bass Strait blow-outs were all controlled relatively quickly; the Petrel well in the Timor Sea flowed gas for 15 months. Only one well involved any spillage of oil, and the amount was negligible. It is a comment on improv-

ing technology and safety procedures that four of the incidents occurred in the 1960s, one in 1971 and the last in 1984.

The statistics on oil spills from offshore exploration and production in Australian Commonwealth waters are shown in the table below. About 70 kilolitres of oil (440 barrels) have been spilt during the drilling of over 1,100 wells and production of over 480 million kilolitres. In total, over 26 years, this spillage is roughly equivalent in size to a large backyard swimming pool. The main spills have actually occurred in the loading of fuel onto production platforms; they had nothing to do with the oilwell itself. There has also been some minor spillage in territorial waters in Western Australia during that period.

Australian Drilling Record

Total number of incidents on offshore facilities from 1965 to 1991, involving spills >320 litres, or causing injury or damage	51	
Platform oil spills	27	
Explosions and fires	13	
Blow-out	6	
Pipeline breaks and leaks	2	
Other	3	
Total number of wells drilled	1,100	
Total number of kilolitres (barrels) of oil produced	480,000,000	(3,100,000,000)
Total number of kilolitres (barrels) spilt	70	(440)
Largest single spill in kilolitres (barrels)	10	(63)

Source: Oil Spills in the Commonwealth of Australia offshore areas connected with Petroleum Exploration and Development Activities. Department of Primary Industries and Energy.

In addition to the oil spill issue, there are concerns about other discharges from the drilling and production facilities: sanitary and kitchen wastes, drilling fluid, cuttings and produced water.

Putrescible sanitary and kitchen wastes are discharged into the ocean but must be processed in accordance with regulations set by the Federal government. This material is diluted rapidly and contributes to the local food chain, without any risk of nutrient oversupply. All solid waste material must be brought ashore.

The cuttings are sieved out of the drilling fluid and usually discharged into the ocean. In shallower waters they form a low mound near the rig; in deeper water a wider-spread veneer forms, generally within one kilometre of the drillsite, although this depends on a number of factors. Some benthic (bottom-dwelling) organisms may be smothered, but this effect is local and variable, generally limited to within about 100 metres of the discharge point. Better-adapted organisms soon replace them and storm-driven wave activity frequently sweeps away the material.

Drilling fluid is also discharged directly into the ocean. Most of the common constituents of water-based fluids used in Australia have low-to-nil toxicity to marine organisms. Some additives are toxic but are used only in small concentrations and infrequently. The small amounts of heavy metals present have limited bioavailability, and biomagnification in the food chain is unlikely. Field studies have shown that dilution is normally very rapid, ranging to 1,000-fold within 3 metres of the discharge point. At the Rivoli-1 well in Exmouth Gulf, the input was chemically undetectable 560 metres away.[15]

Oil-based drilling fluids have a more toxic component, and discharge to the marine environment is more significant. However, they are used only rarely in Australia, and the impact remains relatively local. At Woodside's North Rankin 'A' Platform offshore Western Australia, the only facility currently using oil-based fluids, the discharge is diluted 2,000-fold within 1 kilometre downcurrent, and undetectable beyond 200 metres either side.[16]

In the event of a discovery, the presence of a permanent production facility and the discharge of 'produced water' are additional concerns. 'Produced water' is the water associated with the oil or gas deposit, and typically contains some petroleum, dissolved organic matter and trace elements. Most produced water is effectively non-toxic but, even when relatively toxic, is quickly diluted to background levels. The impact occurs mainly within about 20 metres of the the discharge point, but is observable in some instances for about 1 kilometre down-current.[17] Government regula-

15 J.M. Neff, 'Biological effects of drilling fluids, drill cuttings and produced water', in D.F. Boesch and N.N. Rabalais (eds), *op. cit.*, pages 460–538; information on Rivoli-1 from L. LeProvost *et al.*, 'Environmental Management Program', Petroleum Exploration Permit EP 325, Report for Minora Resources NL, Perth 1990.

16 A. Chegwidgen *et al.*, 'The fate of hydrocarbons associated with drilling from the North Rankin "A" gas and condensate platform, Western Australia', *The APEA Journal*, 33, 1, 1993, pages 386–394.

17 B.S. Middleditch, 'Ecological effects of produced water effluents from offshore oil and gas production platforms', *Ocean Management*, 9, 3–4, 1984, pages 191–316; J.M. Neff *et al.*, *Fate and Effects of Produced Water Discharges in Nearshore Marine Waters*, American Petroleum Institute Publication No. 4472, Washington, 1989.

tions limit the oil content allowed to be discharged, and the produced water is treated on the platforms to meet those specifications. The discharge points are carefully selected to maximise dispersion and dilution, and avoid any particularly sensitive local environments.

In 1992, there were 31 offshore production facilities in Australian waters, including fixed platforms and floating systems. Ultimately the best test of the real environmental effect of drilling and producing operations may be the response of the environment to the fixed production platforms. In many areas the platforms quickly become artificial reefs, with the underwater supports of the platforms providing a range of habitats, from seabottom to surface, and quickly colonised by a wide range of marine plants and animals. In subtropical areas, such as Australia's northern waters, complex reef systems develop in 5–6 years, and support productive and diverse ecosystems. Fish densities around the 4,000 platforms in the Gulf of Mexico are 20–50 per cent higher than in nearby areas.[18] Anecdotal evidence from Australia's North West Shelf suggests that the areas around production platforms near Thevenard Island are favoured fishing spots.

Greenpeace claims that 'oil drilling can cause serious and long term damage to the marine environment.... The technology simply does not exist to prevent or effectively contain blowouts or oil spills that occur as a result of offshore drilling'. Even allowing for their long-admitted policy of 'extravagant postulating'[19] to promote their cause, these statements are difficult to reconcile with the facts.

The technology does exist, and is in use, and successful—as the safety record of the Australian petroleum exploration and production industry demonstrates. To suggest otherwise is to argue a knowably false argument and to invite harsh scrutiny of the motives and the political and economic agenda involved.

Petroleum in the Marine Environment

All of this is not to say, of course, that petroleum does not enter the marine environment and pollute it. The United States National Research Council (NRC) has estimated that 3.2 million tonnes of oil enter the sea worldwide each year, but the figure could be as high as 8.8 million tonnes.[20] Statistics are not available specifically for Australia. The various sources of the global input have been estimated as:

- spillage from marine transport (48 per cent);
- municipal and industrial waste and run-off (33 per cent);
- atmospheric input (9 per cent);
- natural seepages (8 per cent); and
- spillage from oil exploration and production facilities (2 per cent).

These figures show that there is good cause for concern about petroleum polluting the marine environment. They make clear, however, that to blame petroleum exploration and production activities is to miss the point entirely. Pollution from shipping and from land-based activities are by far the dominant sources of pollution.

The figures are also a valuable reminder that a large amount of oil enters the oceans quite naturally every year by seepage from submarine oil deposits. Indeed, seepages are sufficiently common that aerial detection of associated hydrocarbon gases is an exploration technique. Estimates of total global input from seepages vary greatly. The NRC figures mentioned above suggest 0.256 million tonnes, but other estimates range to 6 million tonnes; the US National Academy of Science has suggested 0.6 million tonnes as a compromise figure. An enormous oil-rich water layer discovered offshore Venezuela in 1988 and traced to submarine seepages there, contained an estimated one million tonnes of oil, and can be taken as an argument for the higher figures.[21]

Oil slicks and tar balls pointing to offshore oil seepages have been known in Australia for over a century, with early sightings clearly pre-dating the era of tanker transport. Seepages are known in the Bass Strait. Oil slicks have been found off South Australia after storm activity for many years; geochemical analyses show that these are mostly weathered petroleum which, in the absence of any producing fields, must come from local seepages. Bitumen stainings are common down the Western Australian coast. Recent geochemical analyses suggest that they may be derived from Indonesian-type crudes, possibly indicating submarine oil

18 P.K. Driesson, 'Offshore oil platforms: an invaluable ecological resource', *Proceedings of Ocean 86 Conference*, Marine Technology Society, Washington, September 1986.

19 Robert Hunter, a member of the Don't Make Waves Committee from which Greenpeace grew, described their tactics for manipulating public opinion:

> It's not that we had ever lied ... but we had painted a rather extravagant picture.... We never said that's what would happen, only that it could happen.

20 US National Research Council, *Oil in the sea; inputs, fates and effects*, National Academy Press, Washington, 1985.

21 General statistics on seepages from R.D. Wilson *et al.*, 'Natural marine oil seepage', *Science*, 184, 1975, pages 857–865. Data on Venezuelan seepage from G.R. Harvey *et al.*, 'Observation of a subsurface oil-rich layer in the open ocean', *Science*, 205, 1979, pages 999–1001.

transport akin to the Venezuelan occurrence, perhaps carried south in the Leeuwin Current.[22]

These offshore seepages do not constitute pollution; they are natural phenomena, and the ocean accepts, adjusts and exploits them, as is Nature's way. The seepages function as local food supplies, supporting large colonies of petroleum-consuming organisms. In the deep waters of the Gulf of Mexico, far below the level of photosynthesis, similar seepages support unique chemosynthetic ecosystems by providing the hydrocarbons for tissue growth.

Spillage from oil tankers is a major contribution to petroleum pollution in the ocean, but more focused analysis suggests that the dramatic media coverage of the major accidents distorts public perception of their overall significance. Detailed breakdown of the NRC figures mentioned above shows that 13 per cent of marine oil pollution comes from tanker spills but that 22 per cent is related to routine operations. In some years, and within particular regions, accidents such as the *Exxon Valdez* in Alaska and the *Kirki* in Western Australia are major items in the oil-spill statistics. Overall, however, these catastrophic events contribute less to, and are arguably less damaging than, the routine spillage associated with dry-docking and fuel oil transfer, occurring mainly in ports and along shipping lanes. Based on statistical modelling of oil spills in Australian waters and ports, the Australian Bureau of Transport Economics routinely expects 40–70 spills each year.[23] Short of a drastic reduction in the consumption of oil in Australia, it is difficult to see the logic in environmental activism to limit oil exploration in Australia. This could only require more shipments of crude oil supplies through Australian waters and ports, and increase the risk of spills.

Oil exploration drilling and production operations carry far less risk to the local and global ecosystem, including their human component, than oil-transport operations. It is far safer to drill for oil and pipe it ashore, than to have a tanker deliver it to the port. This point is not made to disparage the tanker industry: over 3,250 ocean-going tankers move over 1,100 million tonnes of crude oil per year, with a historic spill rate of 0.01 per cent, and improving steadily; most operators are concerned about pollution, and critical of the unscrupulous few.[24] The point is made only to remind those so inclined that equating oil spills with drilling, and ignoring the risks involved in shipping, is to misread or misrepresent the facts, and policy so based must carry an increased risk to the environment.

The different restrictions regarding petroleum exploration and transport in Australia's Great Barrier Reef Marine Park may be a case in point. Concerns about oil pollution there were heightened by the *Oceanic Grandeur* tanker accident in Torres Strait in 1970. Yet it is oil drilling that has been prohibited, while tanker traffic has continued through the reef, with about 200 vessels per year bringing supplies to Brisbane and other cities. There is also extensive use of the Park waters by commercial ships, fishing boats and tourist craft. An average of over one spill per week occurs in the Park, mainly as a discharge of waste oil from fishing boats. These are usually small, but larger oil spills from operational discharge by commercial vessels were occurring about every three months in 1991–92.[25]

The relative safety records suggest that the reef would be safer with drilling and pipelines than continued tanker passage, not to mention other commercial and recreational use. Greenpeace recently announced a campaign to stop tanker traffic through the reef area. Given the current indications that waste oil from ships and boats is becoming a more significant source of pollution than tanker operations, consistency might require a campaign against all marine users of the Park.

The public is understandably concerned about oil spills in Australian waters, particularly the coastal zones, and State and Federal governments reflect that concern in their legislative and regulatory initiatives to ensure proper protection of our oceans. It does appear, however, that the concerns have been misdirected by some environmentalists, within both private organisations and government agencies, to overstate the risks to the environment inherent in petroleum exploration and production activities.

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22 D.M. McKirdy and Z. Horvath, 'Geochemistry and significance of coastal bitumen from southern and northern Australia', *The APEA Journal*, 16, 1, 1976, pages 123–135; R.C. Sprigg and J.B. Woolley, 'Coastal bitumen in southern Australia, with special reference to observations at Goltwood Beach, south-east South Australia', *Transcripts of the Royal Society of South Australia*, 86, 1963, pages 67–103; T.J. Currey *et al.*, 'Coastal bitumens from Western Australia—long distance transport by ocean currents', *Organic Geochemistry*, 18, 1992, pages 595–601.

23 David G. Kay, 'Oil spill experience and risk in Australia', *Proceedings of the National Oil Spill Conference*, Melbourne, October 1987.

24 Australian Institute of Petroleum Ltd, 'Oil Industry—Ship Inspection Procedures', 27 July 1992.

25 Wendy Craik, 'Oil spills in the Great Barrier Reef region', *Proceedings International 1991 Oil Spill Conference*, American Petroleum Institute, Washington, 1991, pages 55–60; 'The effect of oil on Australian marine environments with particular reference to the Great Barrier Reef', *Proceedings of Spillcon 1992*, Australian Institute of Petroleum Ltd, Melbourne, 1992.

There is also very common distortion of the facts concerning the environmental impact of petroleum on the oceans. Oil spills are presented as near-universally devastating events, extremely destructive in every circumstance, with recovery slow, if ever, and Nature irrevocably scarred. It is a very emotional issue and, unfortunately, facts often have little to do with it. The truth is that oil spills are very variable in their short-term impact and have little long-term impact at all.

The Fate of Oil at Sea

Almost every reference to the marine environment these days seems to describe it as fragile. The implication seems to be that nature is on the knife-edge of some delicate and precarious balance, and powerless to enforce its own survival. (Environmentalists seem unaware of the arrogance inherent in this perception.) The sea is also cruel, even brutal; relentless in its force and intolerant of intruders. The notion of a harmless, fragile environment upon which the invading petroleum will wreak havoc is nonsense. There is no denying that the initial impact of an oil spill on the coastal zone may be devastating to the local ecology and economy. The black oil scum, the reek of fumes, and the litter of dead birds and animals are all visually and emotionally disturbing. We must be careful, however, not to mistake the initial conflict for the longer war.

As soon as petroleum enters the ocean it is attacked by the environment and will eventually be consumed by it. Ultimately, the physical, chemical and biological forces arrayed against the intruder will recycle the carbon and remove all effective traces of the petroleum. The only question is one of time; the outcome never varies.

The fate of the petroleum depends on the physical, chemical and biological conditions inherent in the oil and the environment in which it has intruded. The initial processes are spreading, evaporation and dispersion into the water column. The lighter, more toxic components are more volatile and evaporate relatively quickly, limiting the volume dissolving into the water. As spreading proceeds, evaporation and emulsification increase, raising the viscosity and inhibiting further spreading. Finally, the non-volatile, heavier fraction begins to form tar-balls, and sinks.

Biodegradation of dissolved and dispersed oil by surface organisms becomes a significant and even dominant process after the first few days. There are nearly 100 species of marine microorganisms which consume petroleum, degrade it by metabolic oxidation, and excrete a by-product. This faecal material sinks to the bottom where it is ingested and further degraded by benthic organisms.

Petroleum-eating organisms include bacteria, fungi and yeasts, and are known from open ocean, coastal and estuarine environments. The average litre of clean sea water has about 10 potential hydrocarbon-consuming organisms; in the presence of a major oil spill, and given the right conditions, that community explodes to 50 million per litre within a few days. These organisms feed on the petroleum, are themselves consumed by other organisms, and so on up the food chain. In this respect then, petroleum is like any other organic material in the marine environment: a source of food.[26]

It may well be the ultimate example of petroleum's duality in Nature that a spill may create a breeding and feeding frenzy, even as it is lethal to other life. That is not an excuse for indifference, but it is a reminder that the world is more complex than the urban imagination sometimes allows.

Oil Spills Ain't Oil Spills

That the sea defends itself by exploiting the invading petroleum does not lessen the need to prevent oil spills. The bloom of bacteria that feed on the floating oil may be a natural marvel, but is no reason for less diligence. At the same time, there is a need for a better-informed position regarding oil spills. Like many other concerns about the global environment, the issue of oil spills is driven by emotion rather than evidence.

No two oil spills are identical. To paraphrase the well-known jingle: oil spills ain't oil spills. Some spills have relatively little effect, even though the volumes involved may be quite large. Other smaller spills can be quite damaging to the local area, at least in the short term. The differences in environmental impact are ultimately determined by a great number of factors.

The amount and type of oil are both very important. The larger the spill, the greater the potential impact. Lighter oils and refined products have greater concentrations of toxic components and can have a greater environmental effect. However, their more rapid evaporation and degradation help minimise ecological and visual impact, and the likelihood of shoreline damage. For example, a spill of North West Shelf oil would

26 J.E. Mielke, *Oil in the ocean: the short and long term impacts of a spill*, Congressional Research Service Report for Congress, Washington, 1990. I have made extensive use of this excellent paper in all sections dealing with spills.

usually evaporate by 70 per cent or more within 24 hours.

The location of the spill is important on both local and global scales. A spill in a cold environment may be more harmful than an equivalent incident in the tropics: the colder temperatures inhibit evaporation, slow down biochemical processes, and lower the regenerative ability of marine biota.

Location also determines the environment and biota that will be affected. Different ecosystems, like different species within a particular ecosystem, are affected differently. Nearshore and coastal environments, with their diverse and abundant communities are most at risk. Coral, seagrass and mangrove ecosystems are of particular concern. Many corals and sea-grasses are relatively tolerant of oil, but prolonged exposure can be lethal. Most corals regenerate quickly; seagrasses take from months to years. Mangrove communities are most susceptible: the limited tidal and wave action does not significantly flush out the oil, which is retained in the sediments for a long time. Some of the most lingering effects of oil spills are observed in the inter-tidal and littoral environments. Saltmarshes contaminated by the *Amoco Cadiz* spill in Brittany in 1978 took over 5 years to recover from the contamination.[27] By contrast, the effect of even a large spill in open waters can be significantly less and shorter-lived.

Fish kills of any significant size are rare, presumably because the fish swim away from the contaminated area. Of greater significance is the fact that plankton (floating organisms) populations do not seem to be significantly affected by oil spills. In some instances there is even an increase in overall population, probably because the oil has greater impact on predator zooplankton—though their ranks are quickly rebuilt by reproduction and migration. This is very important because the plankton includes the eggs and larvae of a great many benthic organisms and fish, and are the basic element of the marine food chain.[28]

Benthic communities, including bivalves, crustaceans and algae, show reduced diversity and numbers when oil reaches the sea-floor by direct leakage or sinking. The impact on these communities in low-energy environments such as mangrove swamps or estuaries can be locally severe and regeneration can take years; it is considerably less in open waters.

The number and diversity of animals and birds in the area are obviously critical to the impact of the spill on marine life. Birds lose buoyancy and suffer from reduced insulation if covered with oil. This is damaging to some species and there is often a high mortality rate. Fur-bearing animals also suffer loss of insulation, and ingestion during grooming efforts can also be lethal. Whales, dolphins and seals suffer no thermal effects from oil coating (their insulation is by blubber layers beneath the skin) and there appears to be little effect from short-term skin contact. The filtering systems on baleen whales do not seem to be impaired. It appears that some marine animals detect the presence of oil and avoid it.

The timing of the spill is also significant *vis-à-vis* the changing oceanographic and meteorological conditions in an area. Local wind and currents help spread the oil and may drive the floating slick offshore, as did the Leeuwin Current with the *Kirki* spill offshore WA in 1991. On the other hand, winds may drive the oil into sensitive environments onshore, as occurred in 1969 at West Falmouth, Massachusetts, where marshlands contaminated with diesel took years to recover. Sediment-laden flood waters from seasonal rains can cause oil to settle offshore, thereby protecting more delicate near-shore environments but obviously affecting local benthic life. The timing also influences the impact on local animals and birds: larvae and oysters are more vulnerable early in their life cycle; seal communities, immediately after calving; birds and turtles, during nesting.[29]

Clean-up methods are now seen as a significant component of the environmental impact of a spill. Sinking agents, for instance, may simply transfer the problem from surface to the ocean floor. Dispersants can be very helpful in preventing nearshore and intertidal damage but do introduce an additional low-toxicity contaminant into the environment. Hot-water scrubbing of rocky coastlines has a visual benefit, of emotional value to residents and workers, but is destructive of surviving organisms. Nature itself is increasingly recognised as the best cleaning agent.

These variables all contribute to the severity and duration of the impact of an oil spill on the marine environment, and nothing argued here seeks to belittle the terrible local and short-term

27 B.J. Baca, 'Recovery of Brittany coastal marshes in the eight years following the Amoco Cadiz incident', *Proceedings American Petroleum Institute 1987 Oil Spill Conference*, 1987, pages 459–464.

28 R.B. Clarke, 'The impact of oil pollution on marine populations, communities and ecosystems: a summing up', *Philosophic Transactions of the Royal Society of London*, B 297, 1982, pages 249–259.

29 R. Wainwright, 'Current was hero in the oil spill saga', *Sunday Times*, Perth, 4 August 1991, page 29; H.L. Sanders *et al.*, 'Anatomy of an oil spill: long term effects from the grounding of the barge Florida off West Falmouth, Massachusetts', *Journal of Marine Research*, 38, 1980, pages 265–280.

effect that an oil spill may have. However, the effect *is* local and short term, and must be viewed in a proper perspective.

Many environmentalists emphasise the need to think globally, and argue for a 'holistic' philosophy. Yet few display anything of this in their reaction to oil spills. There is little acknowledgement that a spill is no different from any other disturbance of the ecosystem. Some of the local organisms are killed, but replacement occurs naturally, through regeneration or through opportunistic species moving in, until diversity and stability are re-attained.

The loss of individual animals does not mean the loss of a species. Oil-stained dead birds and animals are distressing to most people, and obviously regrettable, but the losses need to be viewed in the context of normal annual mortality rates. Even when very large numbers are involved, as can be the case with bird casualties from large near-shore oil spills, the figures need to be seen in perspective. The deaths of 'tens of thousands' of birds from oil spills in the North Sea, for instance, must be balanced against an estimated annual death rate from natural causes of over 1,000,000.[30] Over 5,000 sea otters were killed by the *Exxon Valdez* spill, but the population was thriving two years later. In most instances the mortality figures are not so terribly high, and recovery is relatively quick.

There may well be changes in the relative dominance of different species in an area after a spill. Ultimately each species will regenerate to fill whatever ecological niche it can claim and defend against other species. Nature is warm and cuddly only in the urban imagination. Some burrowing bivalves are quite susceptible to oil, for instance, while other burrowers feed on it and rapidly colonise the oil-contaminated environment. We regret the contamination, and the bivalve, if it could, would agree; the oil feeders are perfectly happy with their new and richer world!

The current focus on individual oil-caused deaths and the visual impact of the spill seems to suit the urban conscience, but it distracts from the broader view of the impact on the ecosystem as a whole. There is a vast amount of research and monitoring needed, but the considerable data already available suggest that the effects of an oil spill on the ocean are relatively short-term, with minimal, if any, long-term impact.

30 C.M. Dunnett, 'Oil pollution and seabird population', in R.B. Clark (ed.), *Effects of Oil Pollution on Marine Populations, Communities and Ecosystems*, The Royal Society, London, 1982, pages 229–243.

Short- and Long-term Effects of an Oil Spill

The Congressional Research Service of the USA's Library of Congress recently reviewed the impact of six major oil spills, all chosen because sufficient time has passed for an evaluation of their long-term impact. Each of these spills received extensive media coverage at the time and is still seen by many people as having caused major and lasting environmental damage.

The spills have all had two life cycles:

> One is the short-term cycle generated by the human environment, including the media and other interests (primarily affected individuals, State and local governments and environmental groups); the other life cycle is the biogeo-chemical cycle of carbon and its compounds in the natural environment. The former is generally given great attention; the latter is rarely considered outside of the technical and scientific literature. Consequently, *the perceived impact of an oil spill may be little related to what ultimately happens* to the oil or to the interaction that the oil has on the affected area, but rather what is said about the event at the time. *This is significant because the public and the policy decision makers can be influenced by perceived impact of events.*[31]

The short-term impact of a spill occurs during the first cycle and receives intensive and extensive coverage. An oil spill is news: from the serious to the sensationalist, the event is easy 'copy'. The photographs and television footage can be very dramatic and touching: few images tug at the urban heartstring like an oil-stained bird or seal. With some spills, these images are too easily found; with others, they are less representative and may even be misleading. Yet they remain in the individual and collective memory as archetypal.

At some point, as the crisis passes or another breaks elsewhere, public and press attention shifts. Investigations and follow-up studies may take a year or more. It isn't news anymore; no one is interested. An announcement that no lasting damage was done, if it gets reported at all, may well be dismissed as a 'cover-up', allowing the reporter to revisit all the emotion of those early days.

A year after the *Exxon Valdez* spill, the city of Valdez in Prince William Sound issued a statement asking the press 'to avoid creating errors and myths' when reporting the anniversary. They pointed out that the wildlife lost during the spill

31 J.E. Mielke, *op. cit.*, pages 2–3. Emphasis added.

had been a relatively small fraction of existing populations and the coastline affected was remote from areas visited by tourists. This was not to suggest that the spill should not to be treated very seriously; only that it should be treated rationally.

The *Exxon Valdez* is constantly cited by the press and environmentalists as an environmental disaster from which Prince William Sound will never recover. The truth is that it has recovered, very quickly and very effectively. About 260,000 barrels of North Slope crude were spilled in the sound in March 1989. Hydrocarbon levels in the water were back to normal within three months. The 1990 harvest of pink salmon was the largest on record. The 1991 sac-roe seine herring harvest was the largest in ten years; 1992 was bigger again. Over 1,300 miles of shoreline were contaminated; traces were detectable along only 7 miles in 1992. Intertidal communities, even in heavily oiled areas, are recovering. The sea otters are reproducing successfully in the area of the spill.[32]

Three Major Spills Reviewed

The most famous oil spill, at least until the Gulf War, was the 1969 blow-out in the Santa Barbara Channel, offshore California. The well was quickly controlled by the blow-out preventors but the enormous pressure ruptured the rock layers below the platform, and oil and gas began flowing out from the sea-floor. An estimated 10,000—77,000 barrels leaked into the ocean at the time, and the site still leaks oil at a rate of about 350 barrels per year.

In visual terms, Santa Barbara was a disaster, and is ingrained as such in the environmentalist psyche. The actual effects on the biota were locally severe, but were not long-lasting. Some barnacle communities were destroyed but quickly regenerated, as did other less-damaged communities, including abalone, lobsters and mussels. Reported lower harvests of spiny lobster in subsequent years could not be separated from natural variation and other causes, such as urban development onshore. Fish did not appear to be affected and spawning occurred normally. Over 3,600 bird mortalities were documented and overall estimates range to 15,000. However, the populations were already recovering strongly within a year.

For the people there, the oil-stained beaches were not only emotionally distressing but the cause of a sharp and economically painful decline in tourism and property values. Not insignificant in those declines and the rate of recovery, was the very sensational reporting by the media, and the public statements of the local environmentalists about the permanence of the damage.

Tar continues to be found along the beaches and is frequently blamed on the oil wells offshore. The oil actually comes from the 2,000 natural oil seepages in the Santa Barbara Channel. It has been estimated that as much as 250,000 barrels of oil enter these waters naturally every year, creating an ecosystem well used to a hydrocarbon component, and well able to recover quickly from, and adjust to, the appearance of one more seepage among thousands.

The *Argo Merchant* tanker accident offshore Massachusetts in 1976 released 183,000 barrels of No. 6 residual fuel oil. The EPA described it as the biggest oil spill disaster in US history. The President was asked to declare a disaster area. The press coverage initially suggested minor or no damage, then shifted to major catastrophe. Scientists who studied the spill concluded that this depiction 'as an ecological catastrophe had no factual basis'. There was no observed significant impact on the marine fauna and little effect on the coastal and marine bird populations. People working in the tourist, water transport and fishing industries in the area generally reported a good year. Yet one year after the spill, a survey found that over half the population still believed that the *Argo Merchant* spill had caused significant economic and ecological damage.

The 1979 blow-out of the Ixtoc-1 well in the Bay of Campeche, Mexico, is the largest accidental marine oil spill ever. Over the 9 months before it was fully controlled, the well dumped about 3.5 million barrels of oil into the Gulf of Mexico. Dispersants were used to keep the oil at sea and away from the shrimping grounds along the 1,000 miles of Mexico's coast. The shrimp catch in subsequent years was unchanged or larger. Oil did reach the Yucatan shoreline, but large fresh water outflow from heavy rains kept it out of coastal lagoons. The impact in Mexico was inadequately studied but there have not been any observable adverse long-term effects. Some relatively-weathered oil reached the USA coastline, causing some bird deaths (82), and short-term detriment to recreational and tourist use of local beaches. By the end of 1980, the only evidence of the spill was scattered tar patches along the Texas beaches—indistinguishable from the tar mats that are caused every year in the area by offshore seepages.

These spills have not been selectively chosen to make the point here; the same is true of the *Burmah Agate* and *Amoco Cadiz* tanker spills or, more recently, the *Kirki* spill offshore Western

32 Exxon Company, *Three years after—conditions in Prince William Sound and the Gulf of Alaska*, Houston, October 1992.

Australia. All are remembered by many people and regularly described in the press as major environmental catastrophes. There is no denying the often brutal ecological impact at the time of the spill. In most instances, however, beyond a few months, any remaining oil is weathered to a tarry residue and reduced to trace levels in sediments and biota. That the petroleum may still be chemically detectable in minute amounts may be of scientific interest, but in terms of further ecological impact is likely to be fairly insignificant.

In some instances, such as the *Amoco Cadiz*, where the oil contaminates low-energy, mangrove environments, the recovery process is slower, and must be measured in years rather than months. The end result is the same, however. Predictions of decades, or even a century, for the recovery of the Brittany coastline after the *Amoco Cadiz* spill proved unfounded. The $2 billion claim for damages against Amoco was reduced to $115 million because the courts found relatively little long-term ecological damage.

This is not the position taken by many environmentalists. The fact that petroleum is still detectable ten years or more later in a small portion of the contaminated area is proclaimed as evidence of the long-term impact of all spills. If no long-term effects on local marine life are detectable, the indices used are criticised as not being sensitive enough. If short-term impacts appear minimal, they switch their doom-laden predictions to the long-term effects, as occurred recently with the *Kirki* and *Braer* spills.

The argument that the oil spill pollution continues until the area has returned to its precise pre-spill condition ignores the realities of Nature. One suspects this is sophistry in some, serving their activism, and a romantic naïvety in others. The marine ecosystem, like Nature itself, is not static and stable, but in an erratic and constant state of adjustment on large and small scales. The apparent stability of an ecosystem at any one time might be better seen as a pause between periods of change—momentary order in the chaos, as it were. It will never return to exactly what it was, any more than it is precisely restored after unusually severe seasons or storms or any other natural disturbance. 'Substantial restoration of something like the former flora and fauna' occurs within a few years in virtually all areas damaged by oil spills.[33]

It is clear that the initial impact of spills on the marine environment is often severe; it is equally clear that the environment recovers relatively quickly in most instances. We should insist that procedures and precautions are improved to minimise future risks to the environment from human activity. We should also insist that those procedures and precautions are based on facts, not fallacies, and are designed to sustain both the ecology and the economy.

The Press as Environmental Propagandist

A large part of the significant difference between the scientific reality of an oil spill and its ecological impact, on the one hand, and the public perception of the event, on the other, appears to be media-driven. A detailed analysis of several major spills in the 1970s concluded: 'once the press portrays a possibility for, or existence of, substantial damage, the subsequent withdrawal of such claims evidently does not alter the perception of extensive damage held by a large part of the population'.[34] It is especially significant that press speculation about *possible* environmental damage can serve to direct public opinion regardless of the facts. Given the pursuit of the sensational and the predilection for editorialising that characterises much modern reporting, particularly on television, this offers good cause for concern.

The Shetland Islands spill early in 1993 was touted as 'Britain's worst environmental disaster'; it turned out to be an 'invisible incident'. The oil dissipated rapidly in the rough seas, and life quickly returned to near normal for the island's communities, both human and other species. The official death toll was 1,000 birds, one seal, a rabbit and a polecat. Four dead otters were found, but autopsies revealed that one died of old age, two died of gastric ulcers, and the fourth was run over by a Norwegian television crew. Faced with these facts, many press items focused on speculation about higher death tolls and the threat of long-term ecological impact. Recent monitoring has shown that some sea-bottom areas remain contaminated, and concerns about fish tainting have prompted fishing restrictions, but otherwise there is little indication that the spill ever occurred.[35]

Local media responded in like fashion when the tanker *Kirki* broke up north of Perth in 1991: this was potentially 'the biggest environmental marine disaster in Australia'. When the light crude evaporated quickly as it was swept out to sea by an eddy

33 R.B. Clarke, *op. cit.*, page 258.

34 A. Rappaport *et al.*, 'The Media and Oil Spills: Does the Press Influence Damage Perceptions?', *Proceedings 1981 Oil Spill Conference*, American Petroleum Institute Publication 4334, page 77, cited in Mielke, *op. cit.*

35 'Hidden menace of Shetland oil spill', *The West Australian*, 20 January 1993, page 26.

in the Leeuwin Current, the sigh from the press gallery seemed one of disappointment rather than relief. In 1992, when oil drilling was announced offshore near Perth, local TV stations illustrated their reports with dramatic footage of the *Kirki* oil spill. Not only does this juxtaposition of images raise public concern improperly, it offers the community a flawed perspective. Given the very different safety records of offshore production and tanker transportation, the safest thing for Perth people and the marine environment so central to the city's charms, would be for an oil discovery to be made nearby and a submarine pipeline to bring the oil ashore, thereby removing any need for oil tankers to enter the region.

The recent announcement of oil drilling near the Ningaloo Reef in northern WA has been the subject of similar disinformation: the editorial cartoon in *The West Australian* on April 27, for instance, showed Premier Court guiding tourists through an oil-splattered sea, with a rig blowing out oil in the background.

Television and newspaper reports highlighting the beauty of the Ningaloo Reef area were a valuable service to a public generally unaware of its ecological diversity and value. It would also have been useful to explain to the public that park boundaries in such a setting are inevitably subjective. The park was extended into Exmouth Gulf to include the Bundegi Reef, but the boundary was drawn about 15 kilometres east of it. Why not 16 kilometres? Or 20? Or 10? The local ecology is virtually indistinguishable at any of these points.

It would have been useful as well to advise the public that there have been four wells within 20 kilometres of the Bundegi Reef, one of them a gas discovery, without any detrimental impact. Further, it would have been useful to mention that the Muiron Islands a few kilometres northeast of the park are themselves an ecological rarity, but have not been damaged by extensive petroleum exploration on and around them: there are 12 wells within 20 kilometres of the islands, including the significant West Muiron-3 discovery.

A more balanced perspective would have noted the complex ecology of the broader region, extending north past Barrow Island, and encompassing many islands, coral reefs, seagrass beds, sandy bays, and mangrove swamps. These provide nursery areas for prawns and fish, support turtle and dugong populations, as well as rookery habitats for many seabirds. Exploration in these areas has led to the discovery and development of large oil and gas deposits, to the greater economic benefit of the State and nation and, by way of the detailed studies conducted, to our better understanding of the ecology.[36]

So why don't the media mention all that? Some of the omissions and errors are, no doubt, due to inexperience and inadequate research. Unfortunately, a good part seems traceable to the anti-industry, pro-environmental views of the individual journalists. Such biased reporting is having a major influence on community opinions, the political and economic decisions those opinions dictate through the political process, and their expression in legislation and regulation.

'Green' Tape

The petroleum exploration and production industry operates within a strict legislative and regulatory system controlled by State and Federal governments, both separately and in co-operation. The States have responsibility within three nautical miles of the State baseline; beyond that, responsibility lies with the Commonwealth. The legal framework is provided by the *Commonwealth Petroleum (Submerged Lands) Act* 1967, together with mirror legislation in each State. Western Australia has complementary legislation to cover certain shallow-water areas that are classified as part of the State. Areas are gazetted for exploration on a regular basis, and companies compete for them by nominating work programmes, mainly seismic surveys and wells.

The claim that exploration offshore Australia occurs without control or concern for the environment is nonsense. When a permit is granted, conditions can be applied to protect specific aspects of the local environment or to accommodate other activities within the area. Work may be prohibited during certain periods, for example, because of commercial crayfishing or whale calving. The environmental impact of each petroleum exploration and development proposal is subject to the *Environmental Protection (Impact of Proposals) Act* 1974, or appropriate State legislation, and the *Australian Heritage Commission Act* 1975. There are also various acts that accord with international agreements, such as the *Environmental Protection (Sea Dumping) Act* 1981 and the *Whale Protection Act* 1980.

The legislative system covers all Australian waters, and seems to have served our economic and ecological interests rather well. So why is it continually claimed by environmentalists that only about 4 per cent of Australian waters 'are classed as having some protection'? From a poorly infor-

36 I. LeProvost, 'Marine Environmental Management of Three Offshore Oilfields in Tropical Waters of North-West Australia', *The APEA Journal*, 31, 1, 1991, pages 423–432.

med or ideologically-blinded individual, such a statement might be excused; from the Federal government, it sits odd indeed. Yet this is the fundamental justification given for *Ocean Rescue 2000*, a Commonwealth initiative to ensure 'the conservation and sustainable use of the marine environment'. Perhaps the politically-correct *language* is the clue here; it is *use*, not *development* that is being considered. Indeed, it seems likely that the whole idea is to prevent as much development as possible.

A key objective of *Ocean Rescue 2000* is the creation of a system of so-called MEPAs, Marine and Estuarine Protected Areas, that are to be given special status and protection. 'Appropriate use' will be permitted in these areas. But who will define 'appropriate use'? In like fashion, the recent WA government report proposes the reclassification of over half of the Western Australian coastline as either Marine Park, Marine Nature Reserve or Environmentally Significant Areas, to give it 'protection ... particularly from oil pollution'.[37]

The principle underlying many of these ideas is admirable enough: namely, that the environment is more than just a few spectacular localities. The problem is the perception that the only way to care better for the greater region is to restrict or exclude petroleum exploration. It appears that the environmental bureaucracy, growing at what seems a near-exponential rate, is driven not only by its commitment to the environment, but by an often intense anti-development ethos. Too few of the facts about petroleum, and too many of the fallacies, permeate the innumerable documents from the ever-expanding network of agencies and organisations.

There are risks involved in petroleum exploration and development, but the Australian industry has shown both the technology and the environmental awareness to manage them successfully. APEA has had its 'Code of Environmental Practice—Onshore and Offshore' since 1978, long before the current public focus. Producing companies have established the Australian Oil Spill Response Centre in Geelong, operated by the Australian Institute of Petroleum. Environmental policy-makers should not see the industry simply as a threat to the environment, but as part of our society with a long-standing practice of environmental concern.

37 Department of the Arts, Sport, the Environment and Territories, *Ocean Rescue 2000*, (information brochure), Canberra, 1993; Environmental Protection Authority (WA), *Protecting the marine environment—A guide for the petroleum industry*, Bulletin 679, Perth, 1993. For an account of the mushrooming of environmental authorities, see O'Brien, *op. cit.*

Independent Scientific Review

In an effort to inject some hard facts into the debate, APEA has recently commissioned an independent scientific review of the environmental effects of offshore petroleum exploration and production activities in Australia. Chaired by Professor John Swan, former Dean of Science at Monash University, the project should provide a detailed and credible assessment of scientific knowledge available world-wide, and its relevance in Australia. Environmental impact studies by companies and ongoing monitoring have provided a vast amount of data on the Australian marine ecology, but much of the reference material is based on northern hemisphere environments. The study will identify areas of main concern and give direction to future investigation and research.

That research should allow even better environmental care during oil exploration and production in Australian waters in the years ahead. An active exploration industry, with access to Australia's prospective basins, but operating under proper environmental codes, seems clearly in the national interest. The deliberate exaggeration by environmentalists of the risks of offshore oil exploration and production seems, by contrast, clearly against the national interest. When the exaggeration is from international corporations such as Greenpeace, it is hard not to agree with former Senator Peter Walsh who called it 'active economic sabotage'.[38]

The Greenpeace Connection

The facts have never got in the way of a Greenpeace campaign: their approach has less to do with scientific research than it does with scaremongering.[39]

Greenpeace: 'oil companies driven by greed and self interest are allowed to plunder our national resources for short-term profit'. *Fact*: the effective after-tax return on funds employed by the petroleum exploration and production industry was 11.3 per cent in 1991-92. Profitability of the petroleum refining and marketing industry in 1989–91 averaged 10.3 per cent. Both are below the risk-free long-term bond rate at that time of over 12 per cent.[40]

38 P. Walsh, 'Environmentalists and the Current Account', *Quadrant*, 35, 278, page 10.

39 The first two quotations are from Greenpeace, *op. cit.*; the third quotation is from Greenpeace's US 'oil industry specialist', Kelly Quirk, speaking at the Labour Centre, Perth, 9 April 1991.

40 APEA, *Petroleum Exploration and Production Industry Financial Survey 1991-92*, APEA Publication, Sydney, 1992.

Greenpeace: 'Oil drilling and extraction can cause serious and long term damage to the marine environment'. *Fact*: there is no evidence to support this.

Greenpeace: 'From exploration to use, oil causes environmental havoc. The combined environmental damage of oil and gas will make the world uninhabitable within our lifetime'. *Fact*: there is no scientific basis for these charges.

This last example is a neat illustration of the 'never really lie' approach that Greenpeace uses so well to influence public opinion and solicit funds. They didn't say that drilling *did* cause damage, only that it *can*—and of course it can, if proper drilling techniques and valid environmental procedures aren't followed.

In 1990, the Federal government announced a long-term plan for gazettal of exploration acreage offshore Australia.[41] This will allow proper planning, both economic and ecological, and would seem to be sound conservation practice. Greenpeace has described it as ill-conceived, and a conspiracy between the oil companies and the Federal government. Their strategy seems to be to denounce the government's actions as confrontational, and thereby justify any campaign by Greenpeace to stop exploration and production in Australia.

That they have been committed to that end has been openly admitted for some time. They have now publicly announced their commitment to stop oil exploration and production worldwide, with Australia as one of the main targets.[42] Quite why isn't clear, given Australia's relatively low level of production, but may relate to Greenpeace's expectations of success levels here rather than elsewhere.

The reason given for this opposition is that 'fossil fuels contribute to global warming and acid rain and because of the environmental damage of oil spills'. It is difficult not to look for some more basic reason than these: the argument regarding spills is unsustainable, as outlined in this paper, and that regarding global warming at least debatable.[43] It seems more likely that a deliberate limiting of the world's power supplies is the underlying issue. For these environmentalists, petroleum has replaced uranium as the main enemy.

Concluding Remarks

Limiting the supply of energy, especially to the Western industrial countries, has been a priority issue with most environmentalists for decades. It was the discovery in the 1960s of this common cause that unified activists with very different economic, social and political agendas, and led ultimately to environmentalism, with all its reformist and religious overtones. Whatever the issue—Western capitalism, industrial growth, third-world exploitation, over-population, pesticides, pollution, etc.—it could be opposed by restricting energy supplies.

Many of these causes were renewed expressions of the age-old urban intellectuals' pessimistic view of civilisation and the future, and their romanticised view of nature and primitive society.[44] 'The great see-saw' of history, between Optimism and Pessimism, was tilting down to Pessimism again: faith in human technology was lost, and fears about expanding population, dwindling food supplies and diminishing resources became endemic.[45] This fear and pessimism is now prevalent in Western societies, having found broad acceptance in the more affluent, better-educated populace. The reasons are many and complex, and beyond the scope of this *Backgrounder*. Suffice to say that, to the extent that pessimists question man's ingenuity and ability, they deny history even as they doubt the future. The renewed affection for nature, as this century ends, is to our benefit; the loss of faith in technology is not.

It is arguably humanity's greatest challenge of the next half-century to raise the standard of living in third-world countries in the face of rapidly expanding populations and increasing pressure on the environment. The pessimistic world-view, without faith in man or technology, and blind trust in nature-mysticism, can see only destructive solutions to this challenge: we must de-develop, they say. Raising the standard of living in the third world to something approaching that in Western countries is seen as disastrous because of the resources needed and the pollution that would result. Yet equality in the global village dictates that people in Western countries cannot remain so much better off; hence, the standard of living in

41 Department of Primary Industries and Energy, *Offshore Strategy: Promoting Petroleum Exploration Offshore Australia*, AGPS, Canberra, 1990.

42 Greenpeace Australia representative, Molly Olson, appearing on *The 7.30 Report* in April 1991, agreed with the suggestion that Greenpeace 'is opposed to exploration for oil off Australia full stop'. The worldwide plan is discussed in P. Reaney, 'The future for Greenpeace is oil free', *Daily Commercial News*, April 1993.

43 Richard S. Lindzen, 'Global Warming: The Origin and Nature of Alleged Scientific Consensus', IPA *Environmental Backgrounder*, No. 10, 18 June 1992.

44 P.G. Purcell, 'Conservation, Development and Environmentalism—Historical Perspective and Future Imperatives', *The APEA Journal*, 30, 1, 1990, pages 399–412

45 G. Blainey, *The Great Seesaw: A New View of the Western World, 1750-2000*, Macmillan, Melbourne, 1989.

the West must be reduced. The public is quite receptive to the conservationist component of environmentalism; they are generally unaware of this underlying economic and political programme.

The World Bank's 1992 *World Development Report* provided a timely reminder that environmental care is linked to peoples' standard of living, and that the standard rises or falls with the availability of cheap energy supplies. Petroleum and gas currently provide 62 per cent of the world's power; coal provides 28 per cent. Petroleum is both more efficient and cleaner, and gas is even better again. Greenpeace has suggested that global use of oil could be halved in 40 years and completely phased out over a century. It is likely that alternative energy sources will be developed over the next century, and the importance of petroleum may diminish. That remains to be seen, and the speculation, however interesting, should not distract from the importance of petroleum for the foreseeable future.

Fears that the world will soon run out of oil and gas are unfounded. World supplies are many times larger than were known in 1950. Indeed, known reserves of natural gas have increased fivefold since 1965. The 1992 *World Development Report* concluded that 'fossil fuel resources are probably sufficient to meet world energy demands for the next century; perhaps longer'. During that time technology will change beyond our imagining. New power sources will emerge as the need demands, and technology responds; the motivation seems likely to be both ecological and economic.

The future may be a computer chip, and the sea and stars may be harnessed for power, but for the foreseeable future petroleum is fundamental to our global economy and our daily lives. The exploration process is relatively benign in the environment and our technology constantly improves, lessening the risks and increasing our ability to handle problems.

Risk is a part of life for all species, humans included, in all cultures and with all technologies. Californians, for instance, are now coming to grips with the massive bird loss associated with windpower. The 17,000 wind turbines that provide that pro-environmental society with barely one per cent of its power kill about 700 birds per year. If the State's entire energy supply was wind-powered, the annual death toll would be of the order of 70,000.[46] Even the worst oil spill pales by comparison.

Petroleum is a natural product of the biosphere, processed within the earth and derived from the remains of life, a recycling of the biomass of the past. After air and water, it is one of the most essential products for human life as we know it at the closing of this second millenium. The future we offer to generations to come depends on our wise use of it, as it does on our use of all the resources around us and within us. There is no solution in a return to the forest, literally or metaphorically.

Viewed on a global scale, the negative environmental impacts of petroleum are limited in both time and space. We can, and must, minimise the risks by acknowledging them and developing our technology to prevent them. When we fail, we can take some comfort from Nature's wonderful regenerative and adaptive capacity. There may be minor changes that occur in the biosphere as a result of our search for and use of petroleum, but they are better seen as part of the constant flux there. Such a view will never lessen our obligation to the environment, but it may offer a more rational and humbler view of our impact on it, and allow us to better plan and protect the future.

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46 M. Goodavage, 'Battling "safe" windmills', *USA Today*, 27 May 1993, page 3A.

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