A Compilation of Recent Research into the Marine Environment

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Australia's oil and gas industry has had a long history of supporting research into the Australian marine environment. The release of the Swan Independent Scientific Review in 1994 (the Blue Book) and the substantial follow up publication of three supplementary studies in 2003 (Blue Book 2) provide the most significant body of work in understanding Australia's marine environment and the effects of oil and gas exploration and development.

In recent years Australia's oil and gas industry has undertaken over 40 additional research projects relating to the marine environment. There is currently no resource that brings this research together and provides a simple summary of the outcomes and findings of these research projects.

Providing simple and concise information that is easy to understand demonstrates the industry's ongoing commitment to environmental research and will address the concerns of those who remain concerned about the industry's impacts. Recent research by the industry has included
20 projects on whales and dolphins; as well as research into:

- other wildlife and flora;
- fish, molluscs and crustaceans;
- the operational effects of oil and gas activities; and
- community projects and education.

This APPEA Compilation brings all this research together into a 1 to 2 page extended abstract summary of the key findings for each research project. These summaries explain

- What was done;
- Why was it done;
- A summary of the research findings; and
- What the implications are for the industry.

The oil and gas industry is committed to sharing of information, with many companies now providing their own public environment reports as well as an industry wide report released by APPEA annually. In the spirit of our commitment to sharing information each company is more than willing to provide further information on any of these projects on request.

Eve Howell

Chair of APPEA's Environment Affairs Committee

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Whales and Dolphins

Project

SEARCH Australian Whales and Dolphins - Interactive CD Rom Identification Guide.

APPEA project with industry contribution, undertaken by Applied Ecology Solutions.

What was done

APPEA and its member companies have produced a CD Rom-based aid for field identification of cetaceans (whales and dolphins) and for the reporting of sightings in Australian waters.

This package compiles information on the distribution and distinctive physical and behavioural characteristics of whales. This information is combined with an extensive reference library of still and movie images of cetaceans behaving as they would be observed at sea or from the air. Together, the package forms a comprehensive literature and visual guide to the identification of all 45 species occurring in Australian waters.
The CD explains key points of differentiation between similar species, and the likelihood of correct identification is enhanced with the provision of information on seasonal distribution patterns. The package also includes a short booklet that summarises information about the 15 species of whales and dolphins that are most likely to be encountered in Australian waters.

Why was it done

The main reason for producing this package was to improve the reliability of field identification of whales and dolphins. Correct identification, whenever possible, is an important component of meeting Australian Government guidelines in managing and mitigating potential disturbance to whales.

The industry is committed to improving the knowledge and understanding of marine wildlife, particularly whales. Offshore exploration and production represent both a source of risk and a source of knowledge about the distribution and behaviour of whales that frequent the areas of activity. This knowledge is the basis for management and mitigation, for which correct identification is important.

The definite identification of a whale or dolphin depends on observing key features that are not always easy to see and only with experience will observers become competent at rapidly identifying whales and dolphins.

The package provides observers throughout Australia with the basis to develop consistent identification and reporting skills. It is available for interested parties generally, and in use for all aerial and on-board observations for the offshore oil and gas industry activities.

Implications for the Industry / Environment

The understanding of whale behaviour in the vicinity of offshore exploration and production activities is rapidly evolving. Over the past two years, much knowledge has been gained through opportunistic learning experience from observation programs on seismic and offshore drilling activities. Observations have revised understanding of whales' apparent responses, tolerance distances and times of different sensitivities to these activities.

Increased knowledge inevitably raises new levels of scientific uncertainty (for example, the meaning of tolerance) and the industry and its regulators face continuous challenges to act in a precautionary manner. However, an overly precautious approach tends to be self limiting in the advancement of knowledge, and is often incompatible to the extent that there are fewer and fewer opportunities to avoid risks of interactions with some species of whales. As the options for more intrusive (eg. physiological) research on whales behaviour are limited, so heavy reliance is placed on real-time observations to improve the knowledge. The identification guide is an essential tool in this process.

Project

Northern Fields Seismic survey

ExxonMobil

What was done

From September 2001 to April 2002, an extensive 3D seismic survey was completed in the northern part of the producing Gippsland Basin fields, currently operated by the Esso/BHPBilliton Joint Venture. A total area of 1500 sq miles was surveyed during this period.

Esso worked with independent consultants and government to develop a comprehensive environmental-management program, this program documentation may be used as a blueprint for future industry exploration activities in Australian waters. A team of three observers conducted cetacean surveys on board the MV Geco Beta from the date that the seismic survey commenced (21st October) until the 20th December—after the conclusion of humpback whale peak migration. For the remainder of the survey, responsibility for observing whales resided with the crew or to additional dedicated observers on board for specific periods. The on-board observations were supplemented by aerial observations from fixed wing aircraft, conducted up to twice weekly from October. Casual aerial observations were also undertaken by pilots of several helicopters serving the offshore installations on a daily basis.
An observation station was established on the roof of the vessel's bridge, from where close to 360° observation was possible. By means of range finding binoculars and angle of observation, the distance to any whale sighted could be rapidly determined from a computerised program. All sightings were recorded, with identifications where possible, along with the management actions taken such as shut-downs when necessary.

During 2002, the use of passive acoustic monitoring (PAM) equipment was trialed. PAM has the potential to detect vocalising whales in the vicinity of the vessels. This emerging technology was used in addition to visual observation, which is limited during rough sea conditions and at night time.

A key component of the survey was the implementation of an extensive consultative process with stakeholders comprising fisheries groups, port, shire and other government agencies and community groups. This involved a series of meetings at the ports of Lakes Entrance, Eden and Port Albert and once the seismic vessel was chosen two-way briefings between captain and fisheries representatives on their respective operations.

Fishing operators were informed on a regular basis of the seismic surveys plans and locations which were to be surveyed. A local liaison officer was engaged to communicate with local fisherman to ensure that concerns were responded to in a timely manner, and that the vessel operator also had an effective mechanism through which to communicate with fishermen.

Why was it done

The survey was undertaken to acquire seismic data on potential hydrocarbon reserves not yet accessed by the Esso/BHPBilliton Joint Venture. As per the EPBC Act - "The Guidelines for Interactions between Offshore Seismic Operations and Larger Cetaceans", Esso was to provide whale observations throughout the survey to ensure that when a cetacean was sighted within the 3 km radius zone around the vessel, the survey was suspended. PAM equipment was trialed to compliment the cetacean observers, to determine the circumstances under which the presence of whales could be detected, and to assess the benefits of improving detection under otherwise adverse conditions.

The mitigation measures and additional aerial and acoustic trialling studies were undertaken to detect the presence of whales, to minimise risks of disturbance to any whales in the vicinity of the vessels, and to gain knowledge of presence, distribution and potential interactions with seismic vessels.

Findings

Humpback whales were by far the most numerous species, comprising 77% of all whales encountered. A total of 79 definite and seven probable humpback whales were observed from the seismic vessel. Group size varied from 1-5 and twelve encounters were with groups that included calves. The data suggest that whales pass through the region in pulses of up to several days in length. Three major periods of migration occurred between the 21st October and the 18th November 2001. A single blue whale was observed from aerial survey and southern right whales were recorded by Longford helicopter pilots. Common dolphins were numerically the most abundant species identified during the survey.

Implications for the Industry

Of 53 whale encounters, shutdowns were required 17 times (32%) of which two were shutdowns of a soft start and one was a shutdown of a test fire. Thirteen of these shutdowns occurred when whales surfaced within the 3 km radius area and were therefore 'immediate shutdowns'. The remainder were 'delayed shutdowns' i.e. the animals were tracked towards the risk area and a shutdown was implemented before they entered the 3 km radius area. The shutdowns resulted in a total standby time of 73.5 hours during the 71 days of survey.

The main objective of project mitigation was to minimise the potential for disturbing a cetacean. As far as the project can reasonably conclude it was successful in meeting this objective by taking all reasonable avoidance measures. The guidelines against which the project was approved were adopted in full and exceeded in many cases in order to minimise any risk of injuring a cetacean.

The Australian Government is now using the marine mammal information to help develop a comprehensive Australia-wide database on whale movements and migration and to make improvements to the management guidelines.

Liaison with the local fishermen continued throughout the survey program, with provision of maps and weekly updates of progress and plans for the upcoming week. This resulted in planned changes in the seismic program to accommodate specific interactions but no time was lost through unplanned interaction with fishing vessels.

Passive acoustic monitoring (PAM) was trailed during this survey. PAM detects cetaceans that are vocalising and was used to compliment traditional visual observations. PAM worked well in detecting cetaceans, which were vocalising in the vicinity of the survey, however the technique has limitations as not all cetaceans vocalise and has limitations in determining exact location of whales.

In the long term PAM technology may become more efficient, effective and sufficiently developed to be able to locate vocalising marine mammals in the water column with adequate levels of confidence to warrant the use of PAM as a mitigation tool on seismic surveys. Therefore, further research into the use of this technology for marine mammal mitigation measures during seismic surveys is warranted. The objective of such research activities would be to determine the range detection capabilities of currently available PAM systems, investigate the practicalities of deployment/recovery of PAM systems from main seismic vessels and generally assess the effectiveness of PAM technology with seismic operations. Information derived from such activities may be used to improve currently available technology in order to provide a more efficient and effective PAM system for marine seismic operations in the future. Needed research is being supported by industry.

Project

Humpback whales of the Perth Basin – Studies conducted during Roc Oil's 2002 Seismic Program.

Roc Oil Company Ltd

What was done

During October and November 2002, Roc Oil conducted 2D marine seismic exploration in the Perth Basin off the central Western Australian coast between Dongara and Abrolhos Islands. Three surveys were conducted in permit areas WA-286P, WA-325P and WA 327-P (known as Jean, Rita and Cheryl) in water depths of 20, 40-50 and 40- 200 m respectively. Following the EPBC referral process, approval for the surveys was conditional upon Roc Oil conducting both on-board and aerial-based whale observation by independent personnel dedicated to this task.

On board the seismic vessel, the observer recorded sightings, species (where identifiable and whether adults or calves), bearing and distances from the vessel and behavioural aspects of whales that could indicate response to seismic signals. The observer had the authority instigate shut-down procedures when whales were seen within a 5 km mitigation zone. Aerial surveys were conducted on a daily basis (weather permitting) to monitor whales' positions within the survey area and near to the seismic vessel. The observers recorded species, position and direction of movement, and any cow-calf pairs. The data from the whale observers have been passed on to the Department of Environment and Heritage, according to requirements.

In addition to the whale observation programs, Roc Oil commissioned a research program. This was to measure underwater sound signals from the air-guns, using sound receivers placed on the seabed near to the seismic activities and one placed 490 km to the south in 450 m depth to record ambient sea noise. Analysis of results has included calculations of the broadband source level for each gun array, and plotting of the received levels and frequencies recorded at different distances from the source. The recordings have also been analysed to determine whether whale vocalisations are detectable. In the longer term, more detailed analyses are in progress, which are intended to contribute to the development of a model to predict noise propagation characteristics throughout the region.

Why was it done

The WA coast is a major migration route for humpback whales. The proposed timing of the three seismic surveys potentially coincided with the southerly migration of humpbacks, including cow-calf pairs en-route from their winter calving and nursery grounds in the Kimberley region to their Antarctic summer feeding grounds. The on-board and aerial observations were required mainly to give effect to the guidelines for minimising interactions between operating seismic vessels and cetaceans but also gathered information on humpback population numbers, migrations, and indications (if evident) of any reactions by whales to operating seismic vessels.

The 2002 seismic exploration program also provided Roc Oil with the opportunity to supplement the observational data with more investigative research into the responses of whales to operating seismic vessels. A subject about which little was known was the underwater propagation and attenuation of seismic airgun noise and levels and frequencies received by whales at different distances from the source. Therefore Roc Oil commissioned the underwater noise recording study to assess these characteristics of the region and at the same time, determine whether whale vocalisations could be detected.

The whale observation and underwater recording studies were undertaken by independent experts in their respective fields, with the intention that in due course, results are published in the scientific arena.

Implications for the environment

Whale observations from air and sea confirmed that a large number (several hundred) whales were present in the survey areas and in the vicinity of the seismic vessel. The majority were humpback whales, including cow-calf pairs, whose movements were generally consistent with the southerly migratory pattern expected during the October-November period. The majority of sightings were in the Rita survey area, possibly indicating an important migratory route along the channel between the mainland and the Abrolhos Islands.

Preliminary analysis of the underwater sound recordings has given some insight into the transmission characteristics of seismic sound in the region. Measurements of sound at different distances from the source indicated the dominant energy received was at low (5-10 Hz) frequency, transmitted predominantly through seabed structures. Significant transmission loss at energies above 60 Hz provided some confirmation of reduced transmission of higher frequency waterborne sound in shallow water, compared with similar sources in deep water. The study is expected to provide greater understanding of regional sound propagation when the analyses are complete

Implications for the Industry

The major implication for the industry is that the surveys were completed with no evidence of adverse effects to whales. The surveys have also provided significant regional information on the migrating populations of humpback whales in particular.

Humpback whales were observed between 0.2 and 9 km from the operating vessel, and shut-downs were required on eight occasions. A 3 km mitigation zone was considered more accurate to monitor and more appropriate in future, as the average distance of whales from the vessel was around 3 km. Other species observed included bottle-nosed dolphins and common dolphins, some of which approached within 100 m of the operating seismic vessel. The 'song' of the whales was recorded both during and after the seismic was acquired and the results indicated that the whales continued to 'sing' during times when seismic data were being acquired.

No avoidance or evasive behaviour was evident during the surveys. However, this finding can be interpreted in different ways. On the one hand, the humpbacks' presence and lack of evident reaction when in the vicinity of the operating seismic survey vessel suggests that the southerly migration continued without undue disturbance. On the other hand, the extent to which the observed locations and movements of whales were normal (i.e. would have occurred in the absence of the survey) is not known. For the most part, whales behaviour is only observable for the brief time they are at the surface, so defining evasive action is imprecise and it is difficult to determine whether the whales are truly undisturbed by seismic noise, or whether they are choosing to endure it rather than avoid it.

These "new" uncertainties can be addressed either by weight of evidence—from similar findings from multiple examples of the above surveys—or by targeted research on the responses shown (for example) by tagged whales, or underwater acoustic tracking of whales entering seismic survey areas. For Roc Oil's 2003 seismic program, both approaches were taken.

Further information is available from Roc Oil Company Ltd, or from the authors of the specific studies:

Curt and Michelle Jenner, Centre for Whale Research (WA) Inc. (Aerial surveys)

C. Burton, Western Whale Research. (On board marine fauna monitoring)

R. McCauley, Centre for Marine Science and Technology, Curtin University. (Measurements of air gun signals)

Project

Humpback whales of the Perth Basin – Studies conducted during Roc Oil's 2003 Seismic Program.

Roc Oil Company Ltd

What was done

Roc Oil's 2003 offshore seismic data acquisition program in the Perth Basin was undertaken from two seismic survey vessels. The first operated both 3D and 2D survey in the Cliff Head (WA-325-E) and Lilian and Mary-Anne (WA-286-E, and WA-286-D) lease areas respectively. A separate vessel undertook 3D seismic survey in the Vicki-Angela (WA-327-P and WA-325-P) lease areas. The surveys were completed between 21 October 2003 and 1 January 2004.

Approval for the surveys was conditional upon Roc Oil conducting whale observation, in accordance with Guidelines on the Application of the EPBC Act to Interactions between Offshore Seismic Operations and Larger Cetaceans. Two independent observers dedicated to this task were on board each of the two seismic vessels. The observations recorded included sightings, species (where identifiable and whether adults or calves), bearing and distances from the vessel and behavioural aspects of whales that could indicate response to seismic signals. The observer instigated shut-down procedures when whales were seen within a 3 km mitigation zone. The data from the whale observers have been passed on to DEH, according to requirements.

Roc Oil commissioned two further research programs during the 2003 seismic program that followed on from the information and experience gained from the studies that supported its 2002 seismic survey program. One study in Exmouth Gulf and Shark Bay, involved remote sensing of whales, using satellite tags to monitor the tracks of southbound migrating whales as they approached a seismic survey underway in the area. This study was introduced mainly as an alternative to aerial survey, for which weather conditions and the hours of darkness impose observational constraints. The second study tracked singing humpback whales using sound receivers placed on the seabed (in a pattern so as to triangulate distance and direction) near to the Cliff head, Lilian and Mary Anne survey areas. Sound recording during 2002 had shown that singing humpbacks were detectable. Only preliminary results are available from the acoustic tracking and sound recording study.

Why was it done

The surveys were timed mainly to avoid the rock lobster fishing season and the consequent risks of gear entanglement but in so doing, coincided with the southerly migration of the humpback whales. The study essentially continued Roc Oil's previous 2002 programme, i.e.;

- to implement guidelines on managing interactions between seismic vessels and whales
- to obtain regional information on whale populations and migration pathways to add to existing databases
- to obtain greater insight on individual whale movements and potential responses to noise from seismic airguns
- to track singing humpback whales and assess evidence of responses as they passed near to the seismic vessel.

As in 2002, the whale observing and underwater sound recording studies were undertaken by independent experts in their respective fields, with the intention that in due course, results will be published in the scientific arena.

Implications for the environment

The observations made on-board the seismic vessels showed that the majority of whale sightings were of humpback whales, including cow-calf pairs. Movements through the coastal waters off Geraldton were generally consistent with the southerly migratory pattern expected during the spring to early summer period. During the Cliff Head, Lilian and Mary Anne surveys (21st October to 17th November 2003), 99 individuals including 26 calves were seen, with similar numbers in each survey area. Most of the sightings were inshore of the survey area, indicating that the migratory route primarily passes between the Abrolhos islands and the mainland. During the Vicki-Angela survey (18th November 2003 – 1st January 2004), 33 sightings comprising 46 humpbacks were seen. No evasive or avoidance behaviour of humpbacks was evident during the survey at Vicki-Angela. Some changes in behaviour observed during the Cliff Head, Lilian and Mary Anne surveys could have been in response to noise from seismic airguns, though no firm conclusions could be drawn from such observational data.

Preliminary analyses of sea noise recordings have successfully detected singing humpback whales at all three (Cliff Head, Lilian and Mary Anne) survey areas. More detailed tracking of the singing whales is still in progress, and this is expected to shed further light on possible responses by whales entering areas of seismic exploration. The recordings also detected regular fish choruses that occur between late evening and early morning each day regardless of the seismic survey. Unfortunately, the attempts to tag humpback whales were not successful for long enough to appraise the level of disturbance from an operating seismic vessel.

Implications for the Industry

Roc Oil's 2003 seismic survey program was completed with no detectable adverse effects to the whales' migration. The information gained in 2003 on the migration routes and populations of humpback whales was consistent with that obtained during the 2002 seismic program.

During the course of the seismic surveys, a total of 16 shut-downs were initiated to minimise potential disturbance to whales that encroached within the 3 km mitigation zone. Some observed behaviour of humpback whales could have been in response to seismic noise but it is difficult to draw conclusions from the observations on seismic vessels alone. The on-board whale observations are primarily for management purposes rather than controlled research, and to a great extent, Roc Oil's additional research on satellite and acoustic tracking was undertaken to shed more light on responses of whales in the vicinity of seismic airgun noise. Acoustic recording successfully detected singing humpback whales in three survey areas although detailed tracking of the whales is still being analysed.

Further information is available from Roc Oil Company Ltd, or from the authors of the specific studies:

Curt and Micheline Jenner, Centre for Whale Research (WA) Inc. (Satellite tagging programme)

Fiona MacKnight and Bronwen Rutherford (On board marine fauna monitoring)

Stefan Walker, Dept marine Biology, James Cook University (On board marine fauna monitoring)

R. McCauley, Centre for Marine Science and Technology, Curtin University. (Airgun signals and acoustic tracking)

Project

Passive Acoustic Monitoring trial

Santos Limited.

What was done

Santos conducted 2D and 3D seismic exploration programs in the Otway, Sorrell and Gippsland Basins using two seismic vessels during the period 15 November 2002 to 10 January 2003. Passive Acoustic Monitoring (PAM) equipment was installed on one of the guard vessels (MV Total Voyager) for the 3D seismic survey conducted by the Western Monarch during 11-20th December 2002.

The PAM equipment is able to detect the underwater sounds covering a wide frequency band, and in this case was used specifically to identify sounds made by vocalising whales. The acoustic signals are fed to monitors that allow operators to see real-time visualisation of the clicks of sound. The received signals are also processed to determine a bearing, and from a series of bearings taken during movements of the vessel, an estimation can then be made of the distance to the vocalising whale. Correlation of acoustic events with observed events was made periodically with the whale observers on board the Western Monarch.

Why was it done

The PAM equipment was deployed primarily as a trial to determine its effectiveness at detecting the presence of whales near to the seismic vessels during recording. The PAM system could potentially improve the ability of the industry to meet Guidelines on the Application of the EPBC Act to Interactions between Offshore Seismic Operations and Larger Cetaceans. The main methods currently used to detect the presence of whales near seismic vessels rely on visual observations, either from the vessel itself or from aircraft. Both have limitations during periods of rough sea conditions and at night.

Implications for the environment

During the nine days when the equipment was deployed, whales were detected on 14 occasions. Nine were during daylight hours, of which 6 were also visually observed and identified as sperm whales. Of the 5 night time detections, 4 were thought to be dolphins and one from a killer whale. Only toothed whales were detected. No baleen whales were detected acoustically or visually during the PAM operating period.

Implications for the Industry

PAM is potentially useful for refining oil industry procedures to mitigate against potential disturbances to large whales during seismic exploration surveys. It is not limited by sea state conditions or darkness, and in that way, can augment visual observations made from vessel or aircraft.

However, PAM does have limitations. It is only capable of detecting whales that vocalise. There are also constraints on the method of deployment of the equipment. In the present case, it was a trial on board the guard vessel, and therefore could not be used when the guard vessel was required to perform other duties. If deployed from the acoustic survey vessel, this would be a much noisier environment and manoeuvring the vessel to get an accurate bearing fix would not be possible. However, these problems are not insurmountable and rather than using dedicated PAM vessels, it may be preferable for PAM systems to be fitted to seismic vessels for use when needed.

Further details are provided in Santos (2003). Cetacean Monitoring on the 2002 Southern Margins Seismic Surveys. Final Report.

Project

Cetacean Observations – blue whale compliance aerial surveys

P. Gill and M. Morrice for Santos Vic P50 and Vic/P51 seismic program 2002/03.

What was done

Santos conducted 2D and 3D seismic exploration programs in the Otway Basin using two seismic vessels during the period 28 November 2002 to 19 December 2003. As the surveys potentially extended beyond December, when blue whales were anticipated to arrive in the feeding grounds of the Bonney Upwelling area, an aerial survey was undertaken to determine the presence of cetaceans in the area and swarms of krill.

Observations were made from aircraft specially fitted with bubble windows to improve downward vision, and followed standard box-pattern survey runs perpendicular to the bathymetry, and covering the survey and remote control areas. The surveys were not initiated when Beaufort Sea States exceeded 4, and were terminated if they exceeded 5. Aerial surveys were made on 17 of the 24 days of the Otway 2D and 3D seismic survey.

Why was it done

The main objective of the aerial survey was to determine the presence or absence of blue whales around seismic activity and if seen, to enable appropriate mitigation actions to be taken against interference with blue or other whales in the vicinity of the seismic vessels. The main mitigation options include soft-starts, shut-down of air-guns or moving to alternative survey areas. A secondary objective was to observe any behavioural reactions (if any) of the whales that approached the seismic vessel.
The aerial surveys also provided the opportunity and to add to general knowledge of patterns of arrival and dispersal of the whales and comparisons with prey (krill) distribution and oceanographic features.

Implications for the environment

A total of 12 whale sightings were made during the period of the seismic survey, including 6 blue whales, 2 sperm whales and 4 unidentified (possibly 2 sperm, minke and blue whales). Krill swarms were extensive, extending into waters <200 m deep.

The two sightings of sperm whales also correlated with sightings by observers on the Western Monarch, suggesting relative tolerance of this species to seismic air-gun sounds. The blue whales were at least 65 km from any active seismic recording, raising the question whether or not this was a displacement response to the seismic sounds.

Implications for the Industry

Krill swarms were clearly evident from the air but were not easily detectable by observers on-board the seismic vessel. Reliance on information supplied by aerial survey for mitigation of potential impacts to whales is reduced when weather conditions do not permit.

If the response distance of the blue whales is truly as much as 65 km, it would be difficult to detect or quantify. However, during Santos's subsequent seismic programme conducted during the spring and early summer of 2003, blue whales were observed to approach seismic vessel to within a few kilometres.

Further details are provided in:

Gill. P. and Morrice, M. 2003. Cetacean Observations. Blue Whale Compliance Aerial Surveys. Santos Ltd Seismic Survey Program Vic/P51 and P52. November – December 2002. Report to Santos Ltd.

Santos (2003). Cetacean Monitoring on the 2002 Southern Margins Seismic Surveys. Final Report.

Project

Southern Margins Seismic Survey Programme.

Santos Limited.

What was done

The Southern Margins Survey is a programme of seismic data acquisition conducted by Santos in the offshore Otway, Sorrell and Gippsland Basins. The programme has involved seismic vessel surveys over the summer periods of 2002/03 and late 2003, with further work planned for late 2004. Each survey has been conducted not only to meet regulatory conditions to prevent or minimise disturbance to whales, but also to maximise the research and adaptive management opportunities for acquiring additional scientific information in the Bonney Upwelling ecosystem and on the behavioural responses of whales to seismic vessels.
Under the Guidelines on the Application of the EPBC Act to Interactions between Offshore Seismic Operations and Larger Cetaceans, Santos has been required to provide whale observations throughout the surveys so that actions (such as shut-downs of the seismic source) can be implemented to prevent any potential harm to whales that venture too close to the vessel. Aerial surveys have also been undertaken to detect presence of cetaceans

Santos supplemented the on-board whale observations with aerial observations and research into the use of Passive Acoustic Monitoring (PAM) to detect presence of vocalising whales not visually observable.

The aerial research has been carried out in conjunction with Deakin University/Australocetus research Blue Whale Study and the acoustic monitoring by Curtin University Centre for Marine Science and Technology.

Why was it done

The Southern Margins survey area encompasses the Bonney Upwelling region that extends along the continental shelf from Robe in South Australia to Portland in Victoria. It is one of a very few areas in the world that are regularly visited by blue whales for feeding.
Santos's Southern Margins seismic surveys are timed to occur during the spring and early summer periods. This has been established partly to coincide with favourable weather conditions and partly to avoid potential disturbance to southern right whales over-wintering in near shore areas. However, any extensions of the surveys into the summer can potentially coincide with the arrival of the blue whales to their summer feeding grounds in the Bonney Upwelling region.
The mitigation measures and additional studies were undertaken to detect the presence of whales, to minimise risks of disturbance to any whales in the vicinity of the vessels, and to gain knowledge of presence, distribution and potential interactions with seismic vessels.

Implications for the environment

The observations indicated that during seismic recording, some species such as dolphins, sperm whales and pilot whales appeared to be relatively tolerant, often approaching within 3 km and in the case of dolphins, altering course to ride bow waves of the vessel while actively operating. Sperm whales in particular appeared to be attracted to the vessel and were seen more often during the 3D survey, in which the survey lines are closer together.

Many more whale sightings were made in deep water on the continental slope than in shallower shelf waters. Active avoidance behaviour was only observed on one occasion, thought most likely to be due to the proximity of the vessel than the air-guns, which had been shut down.

Blue whales are considered potentially more acoustically sensitive than other species, and by extrapolation of behavioural response distances shown by other species, a likely avoidance distance for blue whales was thought to be in the order of 60 km or more. The results of the summer 2002/03 survey gave some support to this theory, as no blue whales were positively identified within 65 km of operating seismic vessels. It was not possible to determine if this distance was a response of the blue whales to their detection of seismic

vessels or a result of chance. However, in the subsequent spring seismic surveys conducted near Portland during November 2003, blue whales were seen, often in association with krill swarms between 17 and 23 km from the survey vessel, with a number around 20 km moving slowly, and in various directions including towards the seismic source. Santos's seismic survey then moved to waters west of Kangaroo Island where blue whales were observed to remain to within about 3 km of the seismic boat. These observations suggest that the range of tolerance by the species is much less than 60 km and potentially less than 20 km.

Implications for the Industry

The surveys were completed without evidence of adverse impacts to whales. The extent to which the mitigation measures contributed to this conclusion is uncertain. The aerial and on-board visual observations can be impaired by sea state and time of day. The PAM system is potentially useful for detecting vocalising whales but is only effective if whales vocalise. Together, the three provide the greatest potential for detecting the presence of whales. In this way, the survey has added to the body of knowledge on whale distribution.

The unexpected presence of blue whales during the November surveys (timed to avoid blue whales) challenges the 'official start' of the blue whale feeding season on 1 December. There is effectively no period when risks of encountering either southern right or blue whales along the Otway coast can be avoided. The presence of significant numbers of blue whales to the west of Kangaroo Island in an area not previously considered to be critical habitat demonstrates the possibility of encountering blue whales and other listed cetacean species along the continental shelf and shelf break at unexpected times. However, there was no evidence of any adverse impacts to blue whales and the radius of avoidance appears to be much less than originally surmised. It is uncertain whether the whales are demonstrating tolerance or habituation to the successive seismic surveys each year but the information base has improved enabling management of potential interactions when necessary.
Further details are provided in:

Santos (2003). Cetacean Monitoring on the 2002 Southern Margins Seismic Surveys. Final Report.

2003 Survey report (draft)

Gill and Morrice 2003

Reliance on information supplied by aerial survey is reduced when weather conditions do not permit.

Project

Deakin University Blue Whale Study (DUBWS)

Santos (financial contribution)

What was Done

Funding has been provided to assist with DUBWS's ongoing monitoring and research work. Specifically this assists in:

- Vessel hire for krill and whale study during April 2003.
- Satellite tagging for the 2003/2004 season.
- Acoustic Recording Packages (ARP) for the 2003/2004 season ($40,000). DUBWS have plans for two ARPs with funds for 0.5 of an ARP already promised from Environment Australia. Santos will fund the further 1.5 ARPs but ideally, at least 3 are needed in the area to assist with more accurate triangulation of whale distance and bearing.

Why was it done

The discovery in the late 1990s of the blue whale summer feeding grounds in the Bonney Upwelling area off Victoria and South Australia, also a region of highly prospective oil and gas reserves, has brought the potential interactions with the industry exploration activities into sharp focus. With such a short time period since the importance of the area was realised, predicting the numbers, timing and distributions of the whales and their potential responses to seismic exploration is a new and evolving process.

Where research and monitoring is heavily focussed around specific seismic or drilling exploration programs, gaps and uncertainties remain about the significance of the areas and times not covered by the survey. Hence this general contribution will progressively improve the ability to provide broad scale information from the region as a whole.

Contribution to the monitoring and research studies is designed to increase the understanding of the timing and distribution of blue whales in the Bonney Upwelling (in particular) and the ecological relationships between krill and blue whales.

Implications for the environment

The study is expected to contribute to the longer term understanding of whale occurrence and behaviour. The information from these programs will improve general scientific knowledge and through better understanding, improve the ability to manage exploration activities in important whale habitats.

Implications for the Industry

Each summer season, a greater level of understanding of blue whale distribution and the responses of blue whales to industry activity is gained. The predictions and assumptions of dates of first whale arrivals and response distances have formed a necessary part of management and mitigation, but have also been subject to much revision in the last two years. Longer term data are required and the industry's contribution recognises the need to maintain the monitoring and research independent of any specific exploration program.

Project

Underwater Sea Noise in the Otway Basin—Drilling, Seismic and blue whales, Oct-Dec 2003.

(by R.D.McCauley Curtin University, for Santos in progress)

What was done

Santos measured underwater noise in the vicinity of offshore seismic operations and an exploration drilling programme in the Otway Basin, Western Bass Strait during the period from October to December 2003. Five loggers, comprising hydrophone, preamplifier and recorders were deployed on the seabed and measured noise frequency and level over the 1-200 Hz bandwidth. The recordings were made over three phases of the offshore exploration activities. In the first phase, the loggers were spaced at doubling increments from the Casino exploration drilling wellhead to determine transmission and attenuation distances. In the second phase, the loggers were placed in shallow water near to a grid of seismic lines run just south of Portland in Vic/P51; and in the third phase, they were placed in a grid to track distance and movements of any nearby blue whales.

At present, only preliminary results from the first phase of noise monitoring during 21 days of drilling at Casino-3 have been analysed. Analysis of the seismic air gun sound propagation characteristics, naturally occurring sources of noise (including shipping), and of blue whale vocalisations is in progress.

From the continuous recordings, the proportion of time drilling-associated broadband noise exceeded defined threshold levels (100 – 120 dB re 1µPa) have been calculated at each logger. The upper threshold (120 dB re 1µPa) is currently considered in the scientific literature as a level of continuous industrial sound above which avoidance or behavioural changes occur in marine mammals.

The noise monitoring was accompanied by deployment of a wave-rider buoy for the collection of oceanographic data in the vicinity of Santos' Otway permit areas.

Why was it done

Many of the prospective areas of the offshore Otway Basin occur near to important whale habitat, such as the southern right whales nursery areas near to Warrnambool and in the Bonney Coast upwelling region, where feeding blue whales congregate in summer and early autumn around the shelf break off western Victoria and South Australia.

While most concerns relate to seismic exploration, relatively little was known about the underwater noise characteristics and risks associated with exploration drilling activities. Furthermore, the preferred management of oil and gas seismic exploration has been through selective timing to avoid whale activity, but there are few periods when this can be reliable, even without the practical constraints of drilling rig/seismic vessel availability. Only through improved knowledge of the characteristics of underwater drilling and seismic noise and the responses shown by whales can management by "hopeful caution" be progressively replaced by understanding of responses and tolerances.

The study was undertaken in the Otway Basin prior to the expected arrival of blue whales to determine the noise characteristics of drilling activities as well as natural ocean noises (eg. waves), and whale vocalisations. The measurements were made in order to estimate the distances over which these noises may be audible to whales and the distances over which they exceed levels sufficient to cause avoidance response. Similar measurements were made by Woodside Energy during their nearby Thylacine drilling program in 2001.

Implications for the environment

Normal ocean noise levels lie between 90-110 dB re 1µPa in the Otway Shelf area. The major man-made sources of sea noise detected during the monitoring of the Casino –1 exploration drilling were from drilling activities, rig support vessel movements and commercial shipping (the outer loggers straddled the east-west shipping lane that runs across southern Australia).

The dominant component of exploration drilling noise is associated with the rig support vessel working with its main engines and bow thrusters under load, for example when moving slowly around the site or holding station at the rig. Support vessel noise levels up to 140 dB re 1µPa were measured at the 2-km logger but were mostly below this level. Drilling itself produces tones with a frequency below 100 Hz associated with the drill string rotation.

Noise associated with drilling activities (drilling and supply vessel movements) was evident at loggers placed 2, 4 and 8-km from the rig but not at the 28-km logger. The background noise at the logger 2-km from the rig exceeded the 100, 105, 110, 115 and 120 dB re 1µPa levels for 80, 60, 36, 8 and 2% of the total time that the rig was on site. These proportions decreased at the loggers located further from the rig, such that significant effects of drilling in the Otway Basin were provisionally estimated to be confined to within 3-km radius of the rig.

Not all of the vessel noise measured was from petroleum activities as the passage of commercial shipping (4-5 vessels per day) was also detected.

Implications for the Industry

As has been observed during other drilling exploration programs, the main source of noise is from the rig tenders, rather than drilling rig or drilling operation.

The noise characteristics measured at 4 km from the rig were consistent with a previous set of measures made 5 km from an exploration drilling rig in a nearby area of western Bass Strait in 2001. The values can be considered typical of an exploration rig operating in shelf waters of the Otway Basin, although sound propagation may be different in deeper water.

The study provides an empirical basis for determining a radius of potential disruption to marine mammals. Within a radius of 3 km, the preliminary results indicate that sound levels exceeding 120 dB re 1µPa response threshold level occur for 1.4% of the time. For a typical 30-day exploration drilling rig on station in shelf waters of the Otway Basin, this equates to a total of around 10 hours disruption over the duration of drilling, and for an average period of 5 minutes for each event.

The actual responses of whales to drilling can only be observed opportunistically from the annual drilling projects in the Otway Basin and other areas. This could determine the validity of the threshold radii or whether more subtle effects will persist for longer periods or whether, as the rig is stationary, habituation occurs.

Results on the transmission and attenuation characteristics of seismic air-gun signals and on the detection of blue whales are yet to be analysed. Once completed, this will provide an estimate of the distances from drilling or seismic source at which sound levels will decrease below threshold response levels.

Project

Summary of aerial surveys conducted for the Santos EPP32 Seismic Survey, December 2003

M. Morrice, P. Gill, J. Hughes and A. Levings (2004).

What was done

Santos conducted 2D seismic exploration survey in offshore permit area EPP32 during December 2003. Although the area was considered outside the critical feeding habitat of the blue whale, Santos undertook an aerial survey across the seismic exploration area prior to the commencement of operations. As a result of sightings of blue whales in the area, a further six aerial surveys were conducted during the seismic program.

Experienced cetacean observers recorded whale position and activity (e.g. direction of movement and feeding) and presence of krill swarms from the aircraft, which followed a standard box-pattern survey, generally perpendicular to the bathymetry, and covering the shelf-break area. Seven aerial surveys were conducted between 2nd and 13th December 2003 and covered a total of 5,700 nautical miles.

Why was it done

The objective of the aerial survey was to determine the presence or absence of blue whales around seismic activity in shelf and shelf-break areas off Port Lincoln and Kangaroo Island, which are to the west of the known Bonney Upwelling critical feeding area. If blue or other whales were seen in the vicinity of the seismic vessel, the whales' positional information was passed on to the vessel crew so that appropriate mitigation actions, such as soft-starts, shut-down of air-guns or moving to alternative survey areas could be taken as necessary.
The aerial surveys also provided the opportunity and to extend the general knowledge of patterns of arrival and dispersal of the whales and comparisons with prey (krill) distribution and oceanographic features, and to observe any behavioural reactions (if any) of the whales that approached the seismic vessel.

Implications for the environment

A total of 152 sightings of blue whales were recorded during the survey with 199 individual whales (including two calves) seen, all within approximately 15 km of the 200m depth contour and generally inshore of steep slope canyon features. The maximum number sighted per day was 48 adults in 39 groups, more than in any previous survey in the Bonney Upwelling.

Many blue whales were observed feeding upon krill swarms, which were abundant along and either side of the shelf break. These observations extend the known areas of significant blue whale feeding to the west of the Bonney Upwelling.

The survey occurred at a time when coincident surveys in the Bonney Upwelling did not detect blue whales until later in December, suggesting an extended foraging range along the shelf break. Correlation of blue whale sightings with remote sensing of sea surface temperature and surface chlorophyll shows some correspondence with surface fronts although data are too limited to draw firm conclusions.

The sightings also included ten individual sperm whales and nineteen dolphin groups.

Implications for the Industry

The aerial survey observations made for the EPP32 seismic survey extend the known presence of blue whales both spatially (to the west of previously known areas) and temporally (early December) compared with previous findings. Apart from the increased knowledge on distribution, the most significant finding is of blue whales at close range (2.4 km) of operating seismic vessel, closer than previously reported. The most vulnerable whales in any population are considered to be the cow-calf pairs, the nearest of which was sighted 7.1 km from the seismic vessel, which was 26% into its 60-minute soft start.

Krill swarms were patchily distributed, most with attendant feeding blue whales. When the whales were

closest to the operating seismic vessel, there were few other patches of krill observed without whales, raising questions of how whales locate and exploit swarms, and the choices they make when swarms, or access to swarms, passes close to an operational vessel.

Experience over the past four years has seen a progressive reduction in the separation distance of blue whales and active seismic vessels from 60 km in 2000 to 2.4 km in 2003. However, the extent to which this demonstrates gradual habituation to seismic activity versus obligatory tolerance when searching for food remains open to speculation.

Further details are provided in:

Margie G. Morrice, Peter C. Gill, John Hughes and Andrew Levings (October 2004). Summary of aerial surveys conducted for the Santos ltd EPP32 seismic survey, 2-13 December 2003.

Gill. P. and Morrice, M. 2003. Cetacean Observations. Blue Whale Compliance Aerial Surveys. Santos Ltd Seismic Survey Program Vic/P51 and P52. November – December 2002. Report to Santos Ltd.

Santos (2003). Cetacean Monitoring on the 2002 Southern Margins Seismic Surveys. Final Report.

These observations extend the known areas of significant blue whale feeding to the west of the Bonney Upwelling.

Project

Humpback Whales Aerial Survey in the Offshore Perth Basin

Woodside Offshore Petroleum Ltd

What was Done

The planned conduct of seismic exploration in the offshore Perth Basin (in Northern Permit area WA-228-P and Southern Permit Area WA-227-P) in 1992 coincided with a period of heightened questioning of the adequacy of Woodside's (and other companies) understanding of the potential impacts of seismic exploration on whales.

Prior to the 1992 seismic survey in the Perth Basin, Woodside commissioned Jenner Marine Biology Consultants to design an aerial survey of whale activity in the permit areas prior to and during the seismic survey. A GPS-referenced line transect survey plan was followed.

The aims of the surveys were:

- To gather scientific information on the route of humpback whales and population numbers passing through seismic acquisition areas during the northern and southern migration periods.
- To provide Woodside with relevant local knowledge to support consultation with and/or respond to concerns of members of the public.
- To demonstrate Woodside's commitment to research into the potential environmental impacts of its offshore activities.

Ten aerial surveys took place (five in each permit area) between 9 September and 25 October 1992. The surveys were flown at a height of around 500 m and speed of 120 kn. Three observers were on board and recorded transect number, location of observation, number of whales, age classes, direction and movement.

A procedure for managing encounters with whales to minimise potential impacts was also implemented during the survey. This involved continuous observation and shut-downs if whales approached within 1 km of the vessel.

Why was it done

Woodside's research on the potential effects of its seismic surveys on humpback whales dates back to 1992 and reflected the need to understand more about humpback whale population and movements in order to meet its concerns about the potential disruption to whale migration.

Findings

The surveys were timed during the expected start of the southern humpback migration, when adults are sometimes accompanied by new-born calves. Whales were observed on 7 of the 10 surveys inside the permit areas; and all whales sighted were within 10-15 km of the coast. A total of 8 humpback whale pods (17 individuals) were reported from the within the Northern (WA-228-P) flights and 9 pods (21 individuals) within the Southern (WA-227-P) survey area. A further 7 were sighted outside the permit area, including cow/calf pairs. Two blue whales (one in WA-228-P; one outside) were also observed. The majority of humpback whales were moving in a southerly direction, consistent with the southern migration period. Because of delays to the seismic surveys, direct correlations between aerial and on-board observations were not possible but procedures to record relevant sighting data were implemented during the survey.

Implications for the Industry

The industry's whale management procedures were the fore-runners of APPEA's guidelines, later to become the Commonwealth Department of Environment and Heritage's Cetacean Guidelines, and included:

- A continuous watch for whales
- An all-clear signal prior to the commencement of each seismic line
- Postponement of commencement of seismic data acquisition if a whale is within 1 km of the vessel and closing
- Start of data acquisition if a whale is at or beyond I km and not bearing towards the vessel, but maintain observation on its behaviour.
- Shut-down of data acquisition if a whale moves closer than I km and is bearing towards the vessel.
- Maintain written records of all whale sightings.
- Availability of video camera to record all sightings of whales at close proximity to the vessel.
- Make information available to relevant government departments and museums

To a very large extent, the adoption of this industry procedure (by Woodside and others) has contributed significantly to the present understanding of whale populations and migratory behaviour around the coast of Australia.

For further information, contact the Principal Environmental Adviser, Woodside Energy Ltd

the adoption of this industry procedure has contributed significantly to the present understanding of whales.

Project

Humpback Whales Aerial Survey in the Offshore Perth Basin (1992/1993)

Woodside Offshore Petroleum Ltd / Jenner Marine Biology Consultants

What was Done

In 1993, Woodside commissioned further research into the population sizes and migratory movements of humpback whales, which essentially continued the aerial survey studies that were conducted during September/October 1992. The aerial surveys were timed to coincide with the peak migratory activity in Woodside's Jurien Bay (WA-228-P) and Bunbury (WA-227-P) lease areas in the Perth Basin. A two-week survey period was selected on the basis of best-available (historical) scientific evidence to maximise the likelihood of observing true densities in the two lease areas and during both the southern and northern migrations. Observations took place during the periods of September/October 1992 and June/July 1993 respectively.

Aerial transect lines and flight paths were designed to cover each lease area adequately.

Why was it done

The primary objective of Woodside's study was to assess the migratory pattern and densities of humpback whales in the Perth Basin. More specifically however, the aim was to determine the locations of the main migratory routes and the extent to which the whales utilised Woodside's lease areas WA-227-P & WA-228-P.

The information was required to understand the potential importance of the lease areas for humpback whale migrations and with that information, to plan exploration activities to minimise impacts.

Findings

All 23 humpback whale pods (46 individuals) seen during the southern migration were within 20 nm of the coast. During the northern migration, 15 pods (28 individuals) were observed at distances that ranged from <10 to >30 nm from the coast. Several killer whales and dolphins were observed near the continental shelf edge during the northern migration survey.

The observations broadly confirmed the mid-October and late-June peaks of the southern and northern migrations past the two lease areas respectively, which were within the predicted observation windows. The actual timing (for predictive purposes) is likely to be determined by many factors and key stimuli, such as daylight hours, temperature and food availability but much remains speculative.

Some differences in the northern and southern migration routes were observed: the northern route being generally further offshore in the Bunbury permit area and crossing the continental shelf further north than the southern migration route. The southern migratory paths in both permit areas are within 20 nm of the coast. Avoidance of predators may be a cause – a number of killer whales were seen during the survey along the continental shelf area adjacent to Jurien Bay. Only one cow-calf pair was seen during the southern migration and it was thought that pairs travel closer to the coast and later than the main group.

Implications for the Industry

Aerial surveys remain the most effective means of observing whales although quantitative accuracy in counts is subject to a number of assumptions that are difficult to verify. The survey has broadly outlined the timing and routes that migrating humpback whales use in the permit areas. This information has significant bearing on the planning of activities such as seismic exploration in order to minimise interactions with the whales whenever practical.

For further information, and details of the analysis of Aerial surveys on the northern and southern routes of humpback whale migration off the Perth Basin, Western Australia (analyses provided by Curt and Michelle Jenner, 1993) contact Principal Environmental Adviser, Woodside Energy Ltd.

Project

Humpback Whales calving ground and Population Monitoring Programme 1995-1997

Multiple funding agencies.

What was Done

Oil companies Woodside, Western Australian Petroleum, Western Mining Corporation along with other industries, government departments and private organizations contributed to a survey of humpback whales in the Kimberley region north of Broome, Western Australia.

The aim of the 1995 survey was to identify the humpback whales' calving grounds, which were not known beyond broad geographical generalizations, based on opportunistic data collected by Coastwatch. Within this general area, the survey was conducted by observers on board a research catamaran sailing on pre-determined transects or track lines. Coastwatch also contributed to the survey with aerial observations made from its routine operations.

During 1996 and 1997, monitoring was continued to document the calving grounds of the humpback whales. In 1997, monitoring concentrated on three areas of particularly high whale concentrations. This helped to increase the opportunities for photo-identification of individual whales, which was done to meet a longer-term aim of determining residence time of individual whales

Recordings of singing male humpback whales were also made in order to compare with eastern Australian whale songs.

Why was it done

Northern Hemisphere Humpback whale populations are divided into groups according to their respective calving areas, which are generally well researched. However, relatively little is known about the calving areas used by Southern Hemisphere populations, and stocks are grouped according to the feeding areas that they use. The humpback whales that over-winter off the western and eastern coasts of Australia are the Antarctic Group IV stocks, and the purpose of the survey was to define the calving grounds off north western Australia.

The offshore oil and gas industry generally has an interest in furthering research that provides improved information that assists management of its exploration and production activities in minimising disturbance to whales.

Implications for the environment

Findings of the surveys suggest that a large proportion of the Group IV stock of humpback whales use the Kimberley region as a migratory end-point and calving ground. The northern-most Camden Sound is an area of particularly high density. Over the survey periods, the peak season as determined sighting and whale density estimates in the Kimberley calving grounds appears to be between mid-August and mid-September.

Implications for the Industry

Confirmation that the Kimberley region is the main calving area for the Group IV humpback whales means that companies proposing exploration and/or production activities in the region will need to consider management measures to minimise disturbance to calving whales. Activities could be timed outside the 12-week period from July to late September when pregnant cows and cows with new-born calves are prevalent.

For further details, contact the principal Environmental Adviser, Woodside Energy Ltd.

Study details are provided to Woodside Energy Ltd in:

K.C.S Jenner and M-N.M Jenner, Centre for Whale research (WA) Inc. 1995

K.C.S Jenner and M-N.M Jenner, Centre for Whale research (WA) Inc. 1998

Project

Aerial Survey of Blue Whales in Otway Basin

Deakin University Blue Whale Study, Final Report to Woodside Energy Pty Ltd. May 2000

What was Done

Woodside Energy contracted the Deakin University Blue Whale Study to conduct aerial surveys for blue whales in block VIC/P43 during the 1999-2000 summer seismic data acquisition period. A total of 14 aerial surveys were conducted throughout a large study area, 10 of which were funded by Woodside Energy to include VIC/P43 prior to its proposed seismic survey. This allowed more extensive and more frequent aerial surveys than during the previous season, which did not include the Vic/P43 area. Aerial surveys are typically flown at 500 m and 140 knots over a pre-set track line. Two or three observers were present and the blue whales are relatively easily identified by their size and pale blue colour when submerged.

Why was it done

The preferred summer period for the acquisition of seismic data from the offshore Otway Basin was based partly on weather conditions and partly to avoid potential interference with the winter-spring presence of southern right whales in the area. However, this was before the Deakin University Blue Whale study discovered the importance of the continental shelf area along the coast of western Victoria and south eastern South Australia as a feeding ground of blue whales. Their food is the krill, which forms dense but patchy swarms, which are often visible and form in response to seasonal upwelling of nutrient–rich cold water (known as the Bonney Upwelling). The upwelling is driven by prevailing south easterly winds during summer/autumn period. While there are as yet, insufficient time series data to correlate whale abundance with strength of upwelling (detectable from remote sensing data), this recently discovered feeding ground is the principal aggregation area in Australian waters for blue whales, which are the subject of an Endangered Species Recovery Plan. Seismic surveys are a potential threat to blue whales and the aerial surveys were undertaken to assess the relative importance of the seismic area to the blue whales and their possible response to seismic operations in the area.

Aerial surveys are the principal method of determining blue whale distribution and relating their distribution to other factors such as upwelling and krill surface swarms.

Findings

The first blue whales were sighted on 15 December 1999, just prior to commencement of seismic operations, and the last on 26 April 2000, about twenty days after seismic operations ceased. The sightings were dispersed over a wide area between Port Campbell, Vic, and Robe, SA. A total of over 120 blue whale sightings were made from air and boat surveys during the summer season, most during March and April. There appears to have been general movement of blue whales and krill swarms from east to west during January, February and March in response to south-east winds (which drive the Bonney upwelling on which blue whale feeding depends), and then a reverse movement eastwards from late March as westerly winds replaced the south-easterlies.

Most blue whale sightings were to the west of the Vic/P43 area. However, five blue whales sightings were made within the permit area and several others close by. Feeding blue whales were observed on two occasions in late January and late April 2000, suggesting that this block is towards the east of the feeding range but a significant aggregation area for krill. Blue whales were seen in or near the seismic survey area between mid-December and late February and again in April 2000. Other species such as sperm, beaked and pilot whales were also observed along the outer shelf break, and sei and fin whales in other parts or the blue whale feeding areas.

Implications for the Industry

The VIC/P43 survey area was clearly a significant aggregation area for krill throughout the 1999/2000 summer season but did not support an equivalent proportion of blue whales. However, at the time of the completion of these surveys, there was insufficient information to draw any conclusions about the potential for seismic activities to affect the feeding behaviour of blue whales in this area. This led to the suggestion that mitigation of potential interactions by seismic survey would be best achieved by timing of surveys during the 'window of opportunity' in October/November each year between the departure of the southern right whales and the arrival of the blue whales, in keeping with the overall philosophy of management by avoidance.

Applying such timing constraints is seldom practical. Experience from the whale observational data gained during the subsequent seismic seasons (to 2003/04) has shown that there is effectively no period that completely avoids potential presence in the area of either southern right or blue whales. The observations of blue whales (and apparent tolerance) within a few km of actively operating seismic vessels suggests coexistence is practical, provided that adherence to mitigation plans is followed.

For further information, contact the Principal Environmental, Adviser, Woodside Energy Ltd.

Deakin University Blue Whale Study. Final report to Woodside Energy Ltd Aerial survey Program 1999 – 2000 (P. Gill, P. May 2000).

The study discovered the importance of the continental shelf area along the coast as a feeding ground of blue whales.

Project

Underwater acoustic environment, Otway Basin, Victoria

By R.D McCauley, Curtin University CMST; for Woodside Energy

What was Done

In April 2001, Woodside Energy conducted a study of the underwater acoustic environment in the vicinity of two proposed wells at Thylacine and Geographe in the offshore Otway Basin. The study measured ambient noise produced by physical sources (eg background waves), man-made sources such as shipping, drilling and seismic operations and biological sources, such as from whales and fish. One underwater sea noise logger was located 5.1 km from the Thylacine-A drilling location, where recordings were made before, during and after drilling. A second logger was deployed in the shipping lane approximately 60 km south of Port Fairy from November 2001 to March 2002. Air-gun trials were also conducted near to the site of the shipping lane logger. A small air gun source was towed at 8 m depth towards and away from the shipping lane logger to measure horizontal sound transmission loss, which was then used to predict the estimated level, with range, for a number of sources associated with petroleum exploration and production.

Why was it done

The proposed drilling area and timing coincided with the known Bonney Upwelling summer feeding grounds for the blue whale, an area that extends along the continental shelf margin along the western Victorian and South Australian coastlines. Concern that the noise from drilling and its associated activities could cause disruption to the feeding blue whales was the major reason for conducting the noise monitoring studies.

The purpose of the air-gun trials was to measure transmission loss, which can then be used to predict the estimated noise levels at different distances from a number of sources associated with petroleum exploration and production. These level estimates have been used to predict the scale of any potential biological effects, in this case, specific for activities in western Bass Strait.

Implications for the environment

The Thylacine drilling rig produced strong tones at frequencies below 100 Hz associated with drill string rotation rates but very little energy at frequencies above 100 Hz. The tones produced were continual although levels fluctuated considerably, associated with drill string loading. Normally the broadband level of tones produced by the exploration drilling rig at 5 km from the well was below 110 dB re 1 μPa.

The noise of the rig tender manoeuvring produced higher noise levels, with a maximum broadband noise level up to 145 dB re 1 μPa. When averaged over the time the drill rig was on site (approximately four weeks), the noise associated with exploration drilling exceeded thresholds of 110, 115 and 120 dB re 1 μPa for 7.6, 2.6 and 0.7 % of the time respectively.

An average of 5.4 ships per day was recorded by the logger. These were sufficiently close for the noise to be discernible as regular, short duration spikes up to 125 dB re 1 μPa, mostly in the 10-100 Hz band; some with higher frequency energy (>100 Hz) thought to be from cavitation from the propellers. In the shipping lane, ships raised the average level above 100 dB re 1μPa (close to rough sea background) 13% of the deployment time, above 110 dB re 1μPa 2.5% of the time, and above 120 dB re 1μPa 0.23% of the time.

Blue whale vocalisations, at frequencies between 15-28Hz were detected at both sites. In the shipping lane they were first detected at long range in late November, then again in late December, after which they were commonly heard at close range. Received levels were mostly in the range 90-110 dB re 1 μPa, occasionally 120 dB re 1 μPa . At the Thylacine site, they were heard throughout the duration of monitoring (i.e. before during and after drilling) but on few occasions and at long range.

A regular pattern of evening and morning fish choruses, with characteristic peak frequency of 1 KHz were recorded at the shipping lane, at broadband levels of 86 dB re 1 μPa. They were detected, but more distant at the Thylacine site, where underwater video showed a mainly barren environment with relatively little fish habitat.

Implications for the Industry

The results provide industry with understanding of the noise frequencies and levels associated with exploration drilling and the means to assess its attenuation from source. Normally, the broadband level of tones produced by drilling was below 110 dB re 1 μPa, marginally above ambient rough sea conditions in an exposed area of ocean such as the Otway Basin. By estimated transmission loss, the drilling noise would fall to background within a few hundreds of metres of source. However, it is the noise of the rig tender that gives the most intense recordings, arising mostly from cavitation during the use of its bow thrusters when holding station at the rig. By estimated transmission loss, this level is reduced below 120 dB re 1 μPa at 5 km distant. In reality, such noise from the tender is not continuous but intermittent and during the 25 days of drilling recording at Thylacene, this threshold level was exceeded for only 0.7% of the time measured at 5 km distant (approximately 4 hours).

The underwater loggers used were also able to detect blue whale calls and thus provide the potential to gain greater understanding of blue whale movements in relation to exploration drilling activities.

Further details can be found in:

Woodside 2003. Otway Gas Project, Environment Effects Statement and Environmental Impact Statement, Main Report Volume 1

McCauley, R.D. and Duncan, A.J. 2003. Underwater acoustic environment, Otway Basin, Victoria. Curtin University Centre for Marine Science and technology. Report for Woodside Energy.

The results provide industry with understanding of the noise frequencies and levels associated with exploration drilling.

Project

Humpback Whale and Mega Fauna Survey North West Cape (2000 / 2001)

Woodside Offshore Petroleum Ltd / Centre for Whale research (WA) Inc.

What was Done

During 2000 and 2001, Woodside commissioned the Centre for Whale Research (CWR) to carry out boat and aerial surveys of whales and other fauna in an area within 10 nautical miles of the North West Cape that included the eastern part of the WA-271-P offshore petroleum lease, offshore from Ningaloo Reef. Aerial surveys were the primary means for observing whales in the large study area, following a progressive grid pattern of parallel transects, each 10 km apart and at a height of 1000 m and speed of 120 knots. Two observers recorded observations, with data entered on computer that logged GPS coordinates of each sighting.

The survey focused mainly on the humpback whales and was carried out to determine the timing, distribution and abundance of their annual migration through the lease area. The study was expanded from one to two years in order to acquire a more robust baseline for future impact assessment. Two sets of surveys, one between December and May, the other between June and November were carried out in 2000 and 2001. During this time, 38 flights were conducted and whale sightings were reported as the number of pods observed, where a pod included one or more animals together. Incidental observations of other species of whales, dolphins, whale sharks, dugongs and turtles were also recorded. The data were also supplemented from historical records of whale migratory data collected during the whaling period.

Why was it done

The migratory patterns of Western Australian populations of humpback whales were generally known from historical whaling records and from other surveys (some commissioned by Woodside). Their migration takes them from summer feeding grounds in Antarctica to winter calving grounds off the WA coast. The North West Cape forms a significant combination of offshore migratory zone and inshore embayment type resting area habitat for southbound migrating animals, particularly cow/calf pairs. Pre-existing information placed the peak of the northern migration generally in July, with the peak of the return southerly migration in September of each year. However, the level of knowledge was not sufficiently detailed to predict likelihood of encounters with humpback whales in terms of timing, distances from shore and depths, and consequently insufficient to manage encounters with least disruption.

The purpose of the surveys was therefore to understand how and when humpback whales use the offshore and inshore regions around North West Cape in order to operate with minimal disturbance to the whales' migrations.

Findings

Humpback whales were the dominant whale species encountered and a total of 1,752 animals in 1,217 pods was observed in water depths up to 700 m over the two years of the survey. The results showed three phases to the humpback migration.

The northern migration occurs from June to August, with most sightings in water depths less than 500 m and highest densities around 200 m. The return southern migration occurs from September to December, when most whales showed a preference for water depths less than 200 m. The maximum number of whales was observed inside Exmouth Gulf during this period and the area may be an important resting area for cow/calf pairs during the southern migration. Between the northern and southern migration, there is an overlap, or transition period, which lasts from late August to early September. During this time there is a peak in the number of pods with some moving north and others south. Pods are dispersed over a wider range of water depths, but mostly between 200 and 300 m.

Implications for the Industry

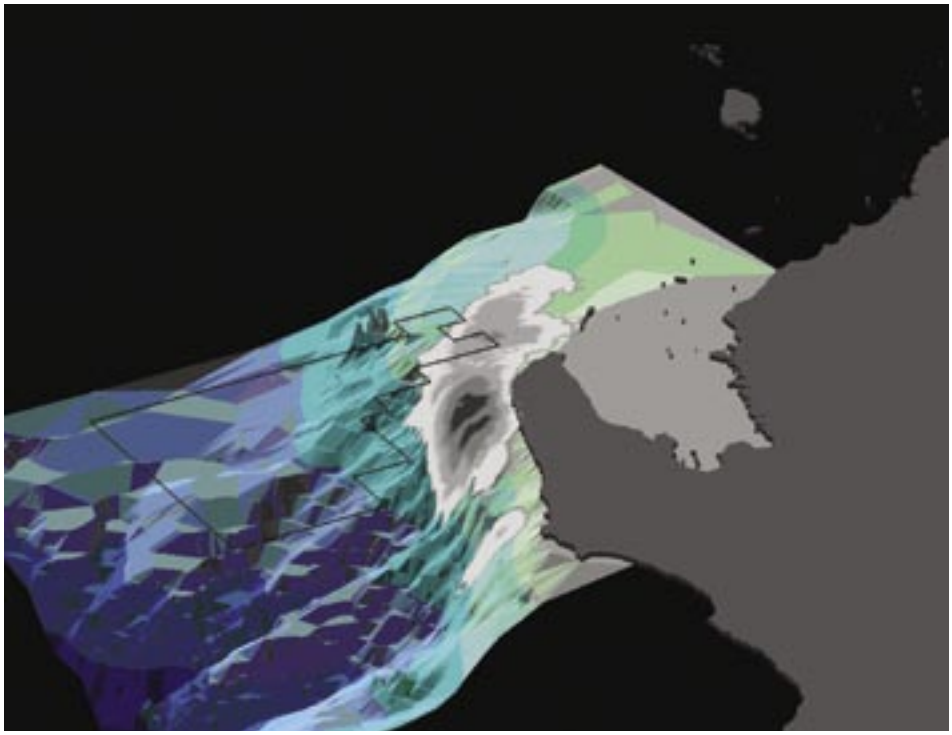
Aerial surveys remain the most effective means of observing whales although quantitative accuracy in counts is subject to a number of assumptions that are difficult to verify. The survey has outlined the timing and routes that migrating humpback whales use in the permit area. This information enables Woodside Energy to plan its exploration and development activities in the light of detailed, site-specific information on the humpback's use of the area for migration and breeding. Knowing when and where to expect the most likely interactions with the migration humpback whales greatly facilitates the application of guidelines to minimise interactions with the whales.

Further information is available from the Principal Environmental Adviser, Woodside Energy Ltd., and from reports prepared for Woodside:

Jenner, C., Jenner, M., Salgado-Kent, C.P. and Bligman, K. (2002). Humpback Whale and Mega Fauna Survey 2000 / 2001, Final Report. North West Cape, Western Australia

Centre for Whale research (WA) Inc Report to Woodside Energy.

The purpose of the surveys was therefore to understand how and when humpback whales use the offshore and inshore regions around North West Cape



Project

The Underwater Acoustic Environment in the Vincent and Enfield Petroleum Leases, North West Cape, Exmouth WA.

Woodside Offshore Petroleum Ltd / Centre for Marine Science and Technology, Curtin University.

What was Done

Between August and late November 2000, Woodside commissioned the Centre for Marine Science and Technology, Curtin University to deploy underwater hydrophone loggers in order to characterise the underwater acoustic environment of the Vincent and Enfield petroleum lease areas offshore from North West Cape, Exmouth, WA. The underwater recordings were made mainly to census humpback whales inshore and offshore of North West Cape and also to identify other natural (physical and biological) and industrial noise associated with petroleum activities in the area. The latter included both drilling operations (a semi-submersible drilling rig with two tender vessels) and a 3D seismic survey conducted by Woodside (the Indian 2000 survey). The seismic survey was conducted by the seismic vessel Geco Eagle, with 3397 cubic inch airgun array of source levels given as 250 dB re 1 μPa^2 rms (mean squared pressure). These airgun details were necessary to predict and identify the airgun source waveform and hence validate a sound propagation model for the region. The drilling and seismic survey areas were approximately 17 km (northwest) and 10-73 km distant from the offshore logger respectively. Understanding of sound propagation was also used to determine each logger's effective sampling area for whales.

The acoustic recordings were made with two sets of hydrophone recording gear. The first, set a few miles west of the Ningaloo Reef edge, was suspended from surface floats at a depth of about 40 m. The second comprised a deepwater logger, set on the bottom, offshore in the vicinity of Woodside's proposed Enfield well sites.

Why was it done

For companies such as Woodside knowledge of the underwater acoustic environment and the relative contribution of its exploration and production activities to natural background noise is essential when operating in areas of significant whale migratory activity. The data are required to develop and validate the sound propagation characteristics for the region and to determine distances over which sound attenuates to background levels, or levels below expected response thresholds for whales. These characteristics vary from location to location, depending on bathymetry and therefore the inshore and offshore hydrophone receivers were deployed.

In order to determine the number of humpback whales within a defined range of each receiver, it was necessary to analyse singing rates and the song structure, which turned out to be a complex structure of different sound types, themes and repeat patterns. The recordings were made coincident with aerial surveys flown for observations of the southern migration of humpback whales across the region (Woodside#6). This enabled the abundances of humpback whales estimated acoustically to be directly correlated with the numbers observed from aerial survey.

Findings

The recordings have enabled the identification of a range of noise sources of natural, biological and man-made origin, including seismic air gun signals, drilling rig and support vessel noise, humpback whales, blue whales, unidentified whales, evening fish choruses, surface wave noise and a variety of low-frequency clicks thought to be associated with great whales.
The airgun noise levels ranged from 105-124 dB re1 µPa (mean squared pressure) at distances of 13–72 km from the offshore logger. The signal was close to background at 70 km range and not audible at ranges of 80-90 km from the inshore logger.

Humpback whale calling was found to decrease over the time of recorder deployment, which is consistent with their southerly migration away from the site in October/November each year. It was also found that the

rates of singing per whale were 3-8.5 times higher at the inshore site than at the offshore site. In comparison, the aerial survey data showed that the density of humpback pods was only 1.4 times higher inshore than offshore over the same period. As humpback singing is generally related to reproduction, this observation was attributed to a higher proportion of reproductively active females (and attendant males) in the inshore area compared with offshore. If so, it implies a sex-age difference between the two regions and implications for assessing whale populations acoustically.

In contrast, blue whales were heard persistently over the recording period, regularly swimming within 5-30 km of the offshore logger. Lack of reception at the inshore site suggested that the blue whales were located well offshore and at depths >250 m.

Evening fish choruses were consistently heard from both inshore and offshore sites, as has been observed from other recording studies around Australia. These choruses are believed to be produced from schools of plankton feeding fish

Implications for the Industry

The study has significantly increased the understanding of natural and man-made sound propagation in the area and contributed to the knowledge of whale movements and behaviour. The higher concentration of humpback whales in the inshore areas as determined from singing frequency and aerial observation has management implications and enables mitigation measures to be taken. Whereas whales in resting areas (eg cow/calf pairs in the inshore areas) may be susceptible to disturbance, higher tolerance of human activities may be expected by animals (mainly immature or male) migrating offshore.

Further details are provided in McCauley and Jenner (2001). The Underwater Acoustic Environment in the Vincent and Enfield Petroleum Leases, North West Cape, Exmouth WA.

Prepared for Woodside Energy

The study has significantly increased the understanding of natural and man-made sound propagation in the area and contributed to the knowledge of whale movements and behaviour.

Project

Southern Right Whale Project – habitat preference and use by southern right whales in waters of the Great Australian Bight, west of Adelaide.

Woodside Offshore Petroleum Ltd / Deakin University School of Ecology and Environment

What was Done

Woodside Energy Ltd is sponsoring a three-year Ph.D research project entitled "Southern Right Whale Project – habitat preference and use by southern right whales in waters of the Great Australian Bight, west of Adelaide", led by Prof B Mitchell and undertaken by R Pirzl of the School of Ecology and Environment, Deakin University.

The project is identifying current and historical areas of important southern right whale habitat on the Australian coastline. Studies are conducted at Warrnambool (Vic), Head of Bight (SA) and Doubtful Island (WA) and examines habitat usage patterns and is attempting to quantify the environmental attributes of the preferred coastal habitats. The study is taking an ecological approach to determine the inshore wintering habitat requirements of southern right whales at broad (whole of coast) and fine (within aggregation areas) scales. The study involves field observation of fine scale whale distribution combined with remote sensing, GIS techniques and statistical correlations with environmental variables.

Why was it done

Southern right whales were severely depleted by commercial whaling during the 19th and 20th centuries and although populations have recovered during the past 25 years, they remain vulnerable to threats from competing human uses of coastal areas. The species is classified as vulnerable to extinction by the world conservation union (IUCN).

The southern right whales move from summer feeding grounds in the Southern Ocean to inshore waters along the southern Australian coast to breed during winter and spring. While the broad scale distribution and period of activity of southern right whale is known, the factors influencing selection of particular locations is not. The study will therefore determine the relative importance of the preferred aggregation areas and define the critical physical features that influence coastal aggregation site selection.

Findings and Implications for the Industry

The study is currently in its final year. From the industry perspective, planning and managing exploration and production in areas potentially critical for whale feeding or breeding is dependent on reliable information about the whales' habitat requirements. This study is an example of a forward planning approach taken by industry to contribute to long term research and understanding that is not necessarily specific to any exploration program but will benefit the planning of such activities if and when they are proposed for the region.

This study is an example of a forward planning approach taken by industry to contribute to long term research and understanding.

Project

Genetic substructure of Western Australian Humpback Whales

Strike Oil Limited, Apache Energy Ltd, Chevron Texaco Australia Pty Ltd, RPS Energy, Shell Company of Australia, Centre for Ecosystem Management, and Australian Geographic sponsored

What was done

Apache Energy Ltd (Apache) and ChevronTexaco are jointly sponsoring a Ph.D study of the genetic diversity and population structure of the humpback whales that annually migrate up and down the Western Australian coast. The Centre for Whale Research is also collaborating in the field work for this study. Three oceanic populations of humpback whales are recognised; these being the North Pacific, the North Atlantic and the Southern Ocean, the latter itself comprising several genetically distinct stocks. The population that annually migrates up the Western Australian coast is collectively known as Antarctica Area Group IV. In 1968, it was estimated that Group IV comprised 268 animals but since hunting ceased, has now recovered to a population size between 6000 and 7000 animals. The humpback whales belonging to Group IV do not appear to carry out their northern and southern migrations in a uniform manner but as several discrete sub populations or pulses, and at various distances from shore. The genetic diversity of these pulses is the subject of the study, which involves taking small biopsy skin samples from around 100 animals during their northern and southern migration.

The skin samples are taken from a biopsy dart used under supervision and with permits from the Western Australian and Commonwealth Governments. This method of sampling has been used extensively in cetacean population study. The biopsy skin samples are then subject to a number of established procedures for genetic analysis and interpretation. The sex chromosomes are analysed to determine the male to female ratios in the migrating groups, as it is not always possible to identify males and females during field observation. Analysis of mitochondrial DNA is then performed and as this is only maternally inherited, this technique determines all the individuals that share the same maternal DNA sequences. This will determine the relatedness within and between the migrating pulses of whales. However, in order to determine both the paternal and maternal gene flow, segments of the nuclear DNA with short, repeated sequences (known as microsatellites) are analysed and these show the genetic distances between different migrating groups (pulses) of migrating whales.

The population genetic diversity data will provide an important understanding of whether sub-groups are genetically detectable.

Why was it done

Making improvements to the management of exploration and production activities in the areas used by the migrating humpback whales depends in turn on increasing knowledge and understanding of whale populations and in this particular case, recognition of the structure of the Group IV whales. The main aim of the study is to determine whether genetically distinct sub-groups exist within the Antarctic Area Group IV humpback whales and whether they reflect separate migratory groups, partitioning of breeding grounds, calving grounds and also feeding grounds in Antarctic waters. If so, the humpbacks in Western Australia may comprise discrete conservation units, where some may be more likely to interact with offshore oil and gas activities and require existing management measures to be adapted accordingly.

Implications for the Industry

The study is in progress and currently, biopsies of 100 humpback whales are being analysed. The Group IV population genetic diversity data will provide important understanding of whether sub-groups are genetically detectable and if they correlate with the observed "pulses" or choice of coastal or non-coastal migratory corridors. Early and late migrating groups will also be compared for differences in genetic

structure. Finally, the study will also examine possible differences in genetic structure between groups with different colouration.

Overall, the study will provide further knowledge about humpback whale ecology, demographics and genetic structure in western Australia. Commitment to long term research and management has provided a substantial body of knowledge on whale migration along the Western Australian coast. The linking of research and monitoring with management requirements and guidance from other government and research agencies aids the process of continuous improvement of long-term protection and conservation management.

Further Information can be obtained from Apache Energy Ltd. and Muriel Brasseur, Centre for Ecosystem management, Edith Cowan University, Joondalup, WA.

Project

Impact of seismic air-gun discharges on humpback whales

APPEA Limited

What was done

An experimental program was funded by APPEA and run by the Centre for Marine Science and Technology of Curtin University to study the effects of offshore seismic noise on marine animals such as whales, fish squid and turtles. The study firstly characterised air-gun signal measurements to model underwater sound propagation and exposure in order to predict the scale of biological effects for a given seismic survey.

The study monitored the movement and behaviour of humpback whales on their southerly migration through an area northeast of Exmouth Cape in which a 3D seismic survey was running. Observers on board the seismic survey vessel (Geco Resolution) and on board aircraft recorded the locations and directions of movements of humpback whales.

Additional experimental trials were carried out under rigorous permit conditions, where humpback whales were approached with a single operating air-gun to observe their responses. The results of these two studies of the humpback whales are described here. In this case, many of the trials were carried out in the semi-enclosed Exmouth Gulf, where most whales were engaged in resting, socialising or courtship behaviour.

Why was it done

The study was conducted to improve understanding of the behavioural responses and potential impacts impacts to a range of marine animals from underwater noise from air-guns used in seismic surveys. Much concern about impacts of noise has focused on whales because of the endangered status of many whale species and the practical difficulties in undertaking surveys in places or times that effectively avoid risks of interactions. Through greater understanding of the responses of whale, the importance of studies such as these is in the progressive development of means to manage interactions with whales (e.g. by application of DEH Guidelines and other appropriate mitigation measures) where interaction cannot be avoided altogether.

Findings

The aerial surveys and on-board observations showed that the 3D survey caused no gross behvioural change and no disruption to the whales' southerly migration pattern. The generalised response of migrating humpback whales to the 3D seismic vessel was to take some avoidance manoeuvre at distances of around 4 km and to alter course to allow the seismic vessel to pass no closer than 3 km.

The trials where pods of humpback whales were approached with a single operating air-gun showed differences in responses between males and females. Pods that contained cows consistently responded to the air-gun approach with avoidance manoeuvres (at sound levels above 126 dB re 1μPa^2.s) and maintenance of standoff distances of 1.22 to 4 km. However, other non-target pods (i.e. those that were not being approached by the air-gun) deliberately and systematically approached the operating air-gun, sometimes at speeds up to 8 knots and circled at 100-400m before departing (at maximum received level of 165 dB re 1μPa^2.s). The underwater sound produced by the air-gun was audibly very similar to sounds of whale breaching events that also happened to be recorded during the survey. The sounds of a 30-40 tonne whale breaching matched the air-gun well in terms of waveform, energy level and frequency. All the pods approaching the air-gun were adult males, so it was considered likely that they had either mistaken the air-gun for a breaching whale or were simply investigating.

Implications for the Industry

Humpback whales actively engaged in their southerly migration were not disrupted by the 3D seismic survey beyond minor alterations of course to avoid the seismic vessel. The other significant finding was the apparent similarity between the single air-gun sound and that of a breaching whale and the attraction of male humpbacks to investigate the source.

Further details can be found in:

Robert D.McCauley, Jane Fewtrell, Alec J. Duncan, Curt Jenner, Micheline-Nicole Jenner, John D. Penrose, Robert I.T. Prince, Anita Adhitya, Julie Murdoch, Kathryn McCabe. 2003. Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals in Environmental implications of offshore oil and gas development in Australia: further research, APPEA Ltd 2003.

Other Wildlife and Flora

Project

Monitoring effects of water quality on coral lipids.

Apache Energy Ltd

What was done

Apache Energy Ltd (Apache) operates the oil and gas facilities on Varanus Island, which process oil from a number of reservoirs including the Simpson Field in the North West Shelf. The development of the Simpson Field has involved the drilling and installation of two oil and gas extraction mini-platforms that are situated approximately 1 km from Varanus Island.

Apache conducted a study of the potential impact of its drilling and pipe laying activities on the surrounding coral reefs, particularly from the increased sedimentation and turbidity associated with the discharge of drill cuttings and adhered drilling fluids. Hard corals from adjacent and control areas were used in the monitoring, for which a condition index, based on lipid ratios in coral tissues, was used to detect potential effects.

Why was it done

The study aimed to assess the sub-lethal impacts that increased levels of drilling-related turbidity and sedimentation may be having on corals. While sedimentation is a known cause of reef degradation, corals are variously susceptible to smothering and associated sub-lethal stresses from light reduction and the energy demands of silt removal. Corals' tolerance to sedimentation can vary widely according to species and site-specific conditions. Measuring lipid ratios is a relatively new technique for detecting changes in condition of corals. Because lipids are the primary energy storage component (compared with proteins and carbohydrates), they are a proxy measure of physiological energetics and stress levels in coral populations. Changes in ratios of neutral to polar lipids have shown correlations with increased sedimentation and reduced light in corals, a finding with potential application to coral monitoring.

Samples of coral tissue for lipid extraction were collected from two species (Acropora nobilis and A. hyacinthus) in conjunction with water quality samples and light (photosynthetically active radiation) measurements at the impact and control areas. Correlations between lipid ratios, light levels and sedimentation could then be made.

Findings

The comparisons of lipid fractions for the two coral species found no significant change between impact and control sites that could be attributed to drilling-related sedimentation. Measurements of light and suspended sediment at the impact and control sites taken during 20 days of drilling showed no reduced light levels or increased sedimentation compared with background conditions.

Effectively therefore, the study measured the lipid ratios under ambient (natural) conditions at each site regardless of its proximity to drilling, but it did show that for both species of corals, storage lipids were higher in corals at sites with relatively higher light levels and lower sedimentation. This effect was more noticeable in A. nobilis, which used more stored (non-polar) lipids during periods of increased sedimentation and reduced light when compared with A. hyacinthus.

Implications for the Industry

Measurement of lipid ratios as an index of coral health is a new technique and this study by Apache is the first attempt to use it to monitor sub-lethal impacts from increased sedimentation on reef areas.

While the results did not show any changes to the lipid ratio index in corals from drilling "impact" sites compared with control sites, this may have been because any drilling-related increase in sedimentation and reduction in light did not reach as far as the "impact" site which was 1 km distant. This is an important finding for the industry and suggests that the physical disturbance from drilling in this part of the Simpson Field is limited to within this distance from the source.

Notwithstanding, the technique of using coral condition index may have potential for monitoring effects of sedimentation as significant correlations were found between lipid ratios in tissues and natural levels of light and sedimentation.

Further information is available from Apache Energy Ltd

The physical disturbance from drilling in this part of the Simpson Field is limited.

Project

Integrated Shearwater Monitoring Program

Apache Energy Ltd

What was done

The oil and gas storage and processing facilities that have been constructed on Varanus and Airlie Islands in the North West Shelf are located in close proximity to colonies of wedge-tailed shearwaters (Puffinus pacificus). These birds usually return to the islands to breed in August of each year. Egg laying is normally complete by November/December and fledging of chicks by mid to late March. In 1994/95, Apache Energy Ltd, BHP Petroleum and Western Mining (Petroleum) combined their individual shearwater monitoring programs into a regional Integrated Shearwater Monitoring Program. This overcame some problems of standardisation of methods and interpretation. Since 1999 the program has been managed by Apache Energy Ltd as the sole contributor..

Breeding performance and overall success is monitored over the two periods each year corresponding to egg laying and fledging. Bridled and Serrurier Islands do not have oil and gas infrastructure and are monitored as control locations. A number of parameters are used to monitor the overall breeding success and these include:

- Density or occupancy of burrows at the start and end of the season
- Seasonal net gain/loss of burrows,
- Proportion of burrows respectively with eggs, incubating adult, hatchlings and fledglings.

These factors are compared each year with regional oceanographic and climatic conditions, where food availability to the birds is often governed by seasonal factors such as the El Niño Southern Oscillation (ENSO) and tropical cyclones.

It must also be noted that the absolute reproductive success, as determined by the numbers of fledged birds is not always in proportion to the other factors (such as burrow density) but can, for example, be maintained when other parameters decline.

Why was it done

Many of the islands in the North West Shelf region are both Nature Reserves and of considerable utility to the offshore oil and gas industry. The monitoring was initially set up in 1994 to determine the impacts (if any) of the development activities on breeding populations, measured at that time as the number of active burrows. The Integrated Shearwater Monitoring Program has since expanded the biological and climatic factors measured because any changes observed in the numbers of active burrows could not easily enable discrimination between project development related factors and environmental variables such as sea temperature, cyclones, food supplies or predators.

Findings

Over the duration of monitoring, it has emerged that the reproductive success is governed primarily by regional influences on food availability which is in turn, related to ENSO effects on ocean productivity. During the La Niña conditions from 1999 to 2001, the (presumed) high availability of shearwater food gave rise to above average reproductive success on all islands for the following two seasons, but with a decline of most (but not all) of the breeding parameters measured in 2002/03, following the shift to El Niño conditions in 2002. No cyclones have affected breeding in recent seasons but within the generally overriding El Niño pattern, other localised factors such as burrow stability, fitness of breeding birds and predation by monitor lizards can also affect local breeding success.

On the islands (Airlie and Varanus) where oil and gas facilities are located, the breeding parameters have generally followed the regional trends, indicating a lack of any effects from industry. This is true for all

parameters on Airlie Island. On Varanus Island, the nesting participation (density of active burrows at the start of breeding) declined in 2002/03 against the regional trend and it is hypothesized that increased flaring near to one colony may have been the cause. However, the absolute breeding success, as measured by the numbers of fledglings produced was not negatively impacted on Varanus during the 2002/03 season and the long-term breeding success on Varanus has remained similar to that on control islands, which does not suggest any industry-related impacts on Varanus island.

Implications for the Industry

The main implication for industry when monitoring bird populations is the required commitment to long term study, without which knowledge of the natural oscillations in abundances might not easily emerge. Within these natural ENSO-related cycles, the industrial facilities on Airlie and Varanus Islands have not had any negative effect on overall breeding success.

The other parameters used to monitor reproductive performance have shown no effects related to industry, particularly on Airlie Island. On Varanus, the possible correlation between increased flaring and lower burrow occupancy (but without effect on fledgling production) in 2002/03 remains to be investigated with further seasonal monitoring.

Further Information can be obtained from Apache Energy Ltd.

The breeding parameters indicate a lack of any effects from industry.

Project

Turtle Lighting Monitoring Program

Apache Energy Ltd

What was done

Apache Energy Ltd (Apache) operates the Varanus Island oil and gas processing facilities located on the North West Shelf. These facilities process oil from a number of reservoirs including the Simpson Field, located to the east of Abutilon Island.

Varanus Island is part of the Lowendal group of islands and is a declared "C" class nature reserve. Three species of turtle (hawksbill, flatback and green), all of which are classified as vulnerable under the Commonwealth EPBC Act 1999, are known to nest on Varanus Island's beaches. Apache has actively worked towards reducing the potential for lights from the processing facilities and nearby drilling activities to impact on turtle nesting and turtle hatchling behaviour. This has been achieved through:

- A Lighting Management Plan (LMP), which is an active, best practice document that identifies sources of light that might impact upon turtles and describes methods used to minimise and monitor impacts on turtles.
- Commitment to long term turtle research and monitoring on the effects of artificial light on turtles and hatchlings.

Apache has been collecting information on sea turtles on Varanus Island since 1986 through research and monitoring programs in order to understand more about turtle behaviour in its area of activity and to assess the effectiveness of lighting controls.

These programs have included:

- Annual turtle monitoring, which is conducted in collaboration with the WA Department of Conservation and Land Management, involves researchers tagging and recording nesting and hatchling emergence on most beaches at Varanus Island.
- Hatchling Orientation Monitoring, which is undertaken as part of the overall research effort in order to assess the effectiveness of lighting management measures and to quantify any hatchling disturbance. The direction of tracks left on the beach, or presence of hatchlings in the vicinity of illuminated drilling rigs may indicate disorientation.
- Ad hoc monitoring, for example, during recent drilling operations in November 2003 at the Simpson Bravo Field to determine if lights from the drilling rig might attract turtle hatchlings from nearby beaches on Varanus and Abutilon Islands.
- Research support to PhD study of turtle biology through Murdoch University, which includes investigations of turtle population biology and impacts of light on hatchlings both onshore and at sea.

Why was it done

Lighting for Apache's infrastructure is necessary for safety and operational reasons. However, stray artificial light can cause disorientation and increased predation on turtle hatchlings, which naturally orientate towards light when first emerging from the nest. Within these constraints, Apache is committed to employing lighting management and continuous improvement processes to ensure that the local turtle population is not adversely affected.

The LMC and associated research and monitoring activities are aimed at achieving no evidence of disorientation from artificial light, and follow a continuous process of review, audit and implementation of mitigation recommendations as required.

Findings

The research and monitoring has greatly enhanced the knowledge about turtle populations, periods of peak activity, nesting behaviour and the relative importance of nesting beaches on Varanus Island. Hawksbill turtles are most common species found nesting on the island, followed by flatback and green turtles. Between 1986 and 2002, 397 hawksbill and 140 flatback turtles have been tagged within the Lowendal Islands. Annual visitation (nesting) rates range from 98-264 for hawksbills and 30 - 603 for flatbacks. Hatchlings typically orientate towards the brightest light source. On some occasions, moonlight may be brighter than artificial light, but artificial lighting is directional and potentially disruptive to hatchlings around times of new moon. As there is a very high natural rate of predation on hatchlings, particularly from silver gulls, it is particularly important that effects of artificial light do not enhance this mortality rate.

Options for the management of light considered under the LMC have included removal or relocation / reorientation of lights, turning lighting off when not required, shielding, reductions in height of light source, reductions in power, or altered type and wavelength. The LMC includes plans for routine and non-routine conditions to minimise impacts while ensuring safety of operations.

Implications for the Industry

Commitment to long term research and management has provided a substantial body of knowledge on turtle occurrence and behaviour around the Lowendal Islands. The linking of research and monitoring with management requirements and guidance from other government and research agencies has enabled appropriate lighting management practices to be applied at the Varanus island oil and gas facilities.

Further Information can be obtained from Apache Energy Ltd.

The research and monitoring has greatly enhanced the knowledge about turtle populations.

Project

Big Bank Shoals of the Timor Sea – An Environmental Resource Atlas

Edited by Andrew Heyward, Edward Pinceratto and Luke Smith. BHP Petroleum (now BHP Billiton) and Australian Institute for Marine Science.

What was done

During 1995 and 1996, BHP Petroleum, in cooperation with the Australian Institute for Marine Science, conducted a study of the ecosystems of the Big Bank Shoals, which are a group of submerged banks located in the Timor Sea off the northwestern Australian continental shelf and overlie prospective hydrocarbon reserves. The area is of particular geomorphic and environmental interest and lies in the Timor Sea Joint Petroleum Development Area.

The study resulted in the production of a resource atlas of the diverse biological communities and habitats of the area. The atlas is a compilation of the various baseline studies that were undertaken and included:

- Bathymetric survey of seabed geomorphology, including side-scan sonar interpretation of seabed classification and habitat mapping
- Visual confirmation of the seabed habitat classification and distribution using Remote Operated Vehicle (video), and diver-held video to survey the animals inhabiting the ocean floor.
- Grab and core sampling of the seabed to validate the video habitat assessment and provide material for physical and chemical analysis.
- Oceanographical analyses necessary to predict the fate and impacts of discharges or spills potentially associated with petroleum development.

The atlas also includes descriptions of the geopolitical setting of the study area, including traditional Indonesian fishing activities and other commercial fishing.

Why was it done

The study was conceived by BHP Petroleum, primarily to understand the environment in which it operates and also to provide the scientific basis upon which strategies to minimise the environmental impact of petroleum exploration and production can be developed. In this example, the extent and detail of the study exceeds that normally required for impact assessment purposes. This reflects the coincident environmental, geomorphological and geopolitical features of the project location as well as BHP Petroleum's commitment to environmental protection.

Findings

The completed atlas comprises over 100 pages of illustrated scientific text that describes the physical and biological environment of the Big Bank Shoals. The shoals comprise some 13 major submerged carbonate banks, ranging in size from 0.05 km^2 to 40 km^2 that rise from a water depth of 200-300 m to within 16-30 m of the surface. The Shoals are described in terms of their origin, morphology and oceanographical conditions in which they occur.

Various theories of the origins of the banks are put forward, mostly relating to their relative subsidence (or uplift by carbonate deposits from coralline algae {Halimeda} and coral growth where there is sufficient light) relative to the rate of sea level rise over the past 1800 years.

Biologically, the shoals were classified according the nature of the dominant biota and three types were recognised. These included shoals whose communities were dominated by:

- Halimeda (a calcareous coralline alga), with lesser amounts of encrusting sponges and soft corals. Halimeda banks formed the major category of the Big Bank Shoals.

- Hard coral ecosystems, dominant on the plateaux of four of the submerged banks.
- Filter feeders, such as sea fans and sea whips that dominate on three banks that are too deep for sufficient light to support the extensive growth of Halimeda or hard corals seen on the other banks.

Between the banks, where depths exceed 200 m, continental shelf epi-benthic ecosystems dominate, which appear mainly as expanses of soft sediment with little topographic relief and sparse emergent fauna. Three such sites were surveyed and described in the Atlas.

Implications for the Industry

The study has contributed significantly to the understanding of the Big Bank Shoals area and in particular, the classification of the banks in terms of dominant fauna, in turn related mainly to depth and light availability. This will be important in the assessment of potential pathways of impact from any proposed exploration or production activity.

Project

Green turtle tracking project (Pendoley in prep, 2003).

This project is managed by Murdoch University PhD Candidate, Kellie Pendoley. It is a component of a larger satellite tracking program funded by ChevronTexaco, Apache Energy, Woodside, Santos and BHP Billiton.

What was done

On October 12 2002 platform terminal transmitters (PTTS) were attached to two Green sea turtles nesting on Sandy Island at Scott Reef, located 300kms off the north west coast of Western Australia. The transmitters were applied to the two turtles by fibre-glassing them to the animals shells, when they came ashore to nest. The turtles returned to the ocean after nesting and were tracked using the ARGOS polar orbiting satellite system. These transmitters operate by sending signals to overhead satellites whenever the turtle surfaces to breathe. The data are downloaded from the satellites to a base station in France as the satellites circle the earth and are retrieved by the project scientist via the internet.

The two turtles, (christened Kelly B and Trouble), were the focus of Murdoch University PhD candidate, Kellie Pendoley's, research to discover the feeding grounds for green turtles. They were tracked as they migrated from their nesting site on Sandy Island to their remote feeding grounds for green turtles. They were monitored for up to 12 months or as long as the transmitters continued to transmit data.

Why was it done

Green turtles are classified vulnerable under Commonwealth EPBC Act 1999. The existing oil and gas infrastructure off Australia's north west and northern coastlines, and the continuing offshore exploration and production of hydrocarbons occurs in areas known to be frequented by turtles.

Findings

Green sea turtles have a life cycle that includes a migratory reproduction phase. Most of their adult lives are spent on feeding grounds where seagrass and algae are abundant. Every five years the adults migrate to their nesting grounds, often thousands of kilometres away, where they lay 4-5 clutches of 100 eggs every two weeks. During this time the females do not feed at all. Within hours of laying the last clutch they leave the nesting ground and swim back to their feeding ground, where they spend the next five years building up body fat to make the next reproductive migration. In order to discover the feeding grounds for green turtles scientists have adapted recent advances in satellite technology to track their movements at sea.

The two tagged turtles (KellyB and Trouble) left Sandy Island in late November 2002 after they had completed nesting for the summer. Both swam eastward towards the WA coastline and appear to have feeding grounds near Melville Island in the Northern Territory.

The movements of these turtles were monitored for up to 12 months or as long as the transmitters continued to transmit data.

Implications for the Industry

While there is no indication of adverse impacts to turtles from these developments, the offshore industry collectively has taken the opportunity to improve understanding of movements of breeding adults by contributing to institutional research projects.

The decision to sponsor turtle research for three years was a natural progression of learning more about the environment in which offshore exploration takes place.

Exploration is being undertaken in some areas that have great environmentally sensitivity (including Scott Reef), and in need of more research to assist in making exploration decisions that minimise impact or disruption of the marine environment.

For further information, please contact Kellie Pendoley at Murdoch University.

Project

Westernport Seagrass Partnership

ExxonMobil Ltd

What was done

ExxonMobil provides support and funds to the Western Port Seagrass Partnership Ltd, which is conducting research on methods to regrow declining seagrass in Western Port. Esso operates the Long Island Point facility near Hastings, which is an important contributor to the local community.

The concept of a 'Seagrass Partnership' originated as an initiative of the Victorian EPA, with extensive interest and support from local community groups, business and governments who agreed to form a Company limited by guarantee, with the name Western Port Seagrass Partnership. The Company is fully independent of government, with a strong community base. The Company's aim is to establish a partnership to coordinate people and organisations to conduct research, to protect and restore the ecosystems of Western Port, its catchment and seagrass communities, as well as raise awareness of the important environmental diversity of Western Port.

ExxonMobil has been a crucial supporter of this Partnership from its inception. The Partnership is also supported by EPA Victoria, community volunteers, BHP Billiton, P&O Ports, Cardinia and Mornington Peninsula Shires.

Specific project funding has been provided by ExxonMobil and the Commonwealth Government's Natural Heritage Trust

Why was it done

Seagrass meadows in Western Port declined by as much as 70% in area between 1971 and 1985, caused mainly by increased sediment and nutrients in runoff from the catchment. Seagrass is a critical component of the ecology of Western Port and is significant for stabilising sediments, nutrient cycling and providing nursery areas for fish breeding. The decline in seagrass may have contributed to impacts on economic, recreational and human use values such as fishing and swimming.

The vision of the Western Port Seagrass Partnership is to restore the environment of the Western Port catchment and bay to provide the foundation of a sustainable, healthy natural productive ecosystem.

The vision is being achieved through:

- Identification of rehabilitation sites.
- Development of seagrass transplantation techniques.
- Development of procedures to cultivate seagrass in vitro.
- Conduct of workshops and seminars.
- Community monitoring and care programs.
- Contributing to improved catchment management.

Findings

Although Heterozostera tasmanica is the species that has experienced the major decline in Western Port, Zostera muelleri has been selected as the species with highest restoration potential because of its greater transplanting success in colonising denuded mudflats. The process of identification of suitable transplant sites considered factors of tidal velocity, surface water quality pore-water quality and sediment quality, from which three sites, Long Island Point, Coronet Bay and Newhaven were selected.

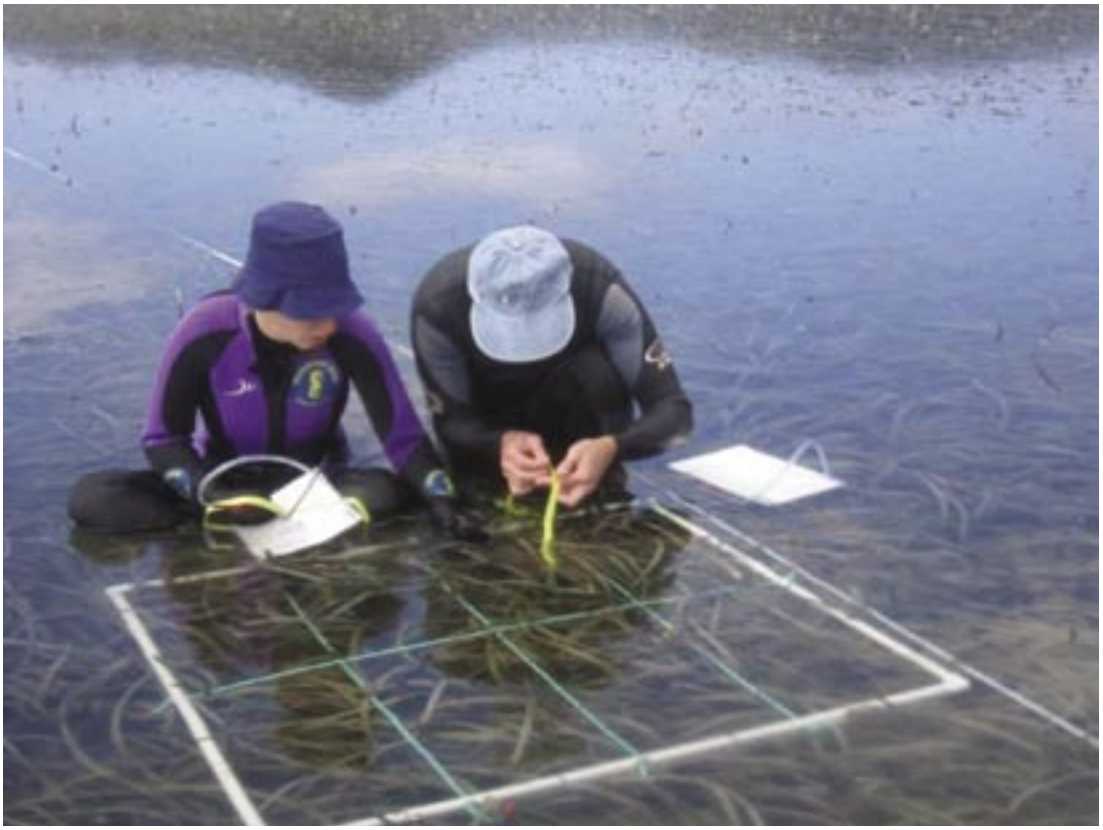
Based on transplantation trials, 15-cm plugs planted in high density had greatest success and this method was selected as the most appropriate for transplanting. While seagrass restoration relies heavily on natural seagrass beds as the source of planting stock, in-vitro cultivation techniques provide opportunities to reduce reliance on donor beds. A technical tissue culture investigation was completed by Professor John Hamill at Monash University, studying the eelgrass Heterozostera tasmanica. Under these controlled conditions, research on nutrient, chemical and hormone levels have been conducted on seagrass growth.

Implications for the Industry

In pursuing its vision, the Western Port Seagrass Partnership is seeking to achieve the following overall objectives:

- To empower the community to be involved in natural resource planning, management and research in Western Port by providing high quality information and clear opportunities for participation.
- To provide leadership in developing innovative solutions and projects to tackle natural resource management problems in Western Port.
- To encourage, guide and sponsor research into seagrass and the broader Western Port ecology to ensure decision making is based on sound scientific knowledge.
- To develop community and business relationships via common goals of habitat restoration.

Seagrass is a critical component of the ecology of Western Port.



Project

Australian Fur seal research and tracking

ExxonMobil / Phillip Island Nature Reserve

What was done

ExxonMobil is sponsoring a program to track Australian Fur Seals in order to learn more about the feeding and breeding habits of this species in the Bass Strait region.

Why was it done

Since the offshore platforms were installed in Bass Strait in the 1960s, they are frequently used as resting places for seals, although relatively little is known about their significance for the seal populations.

The research has increased understanding of the feeding and breeding habits and the project has provided the opportunity for cooperative research with the Phillip Island Nature Reserve, at Seal Rocks, on Phillip Island. This area is home to a large colony of Australian fur seals. Seal research addresses management and conservation issues related to these seals. This research aims to find out which areas of the ocean are important to them (where they catch most of their fish) and where they may encounter human activities such as fisheries.

Findings

Seals are tracked using satellite technology. A transmitter, called a Platform Transmitter Terminal (PTT), is attached to the seal and the transmitter sends a message which is detected by satellites, and soft-ware programs to determine and track the location and movement of the seals. Esso sponsor the Phillip Island Nature Reserve web pages which allow the public to track the seal movements on line.

To conduct the field work, a team of scientists travel to the seal colony at Seal Rocks, select the age and sex of the seal to be tracked. A transmitter is glued centrally on the seals' back (this will fall off when the seal moults). When out of the water, the transmitters (PTTs) send messages every 45 sec. To save battery power, the units go into sleep mode after 2 h dry periods (the seal might haul out to rest for several days).

PTT transmissions are recorded by instruments on polar orbiting satellites then relayed to ground stations where locations are calculated. All location predictions are assigned an accuracy level, based on satellite to transmitter geometry, transmitter frequency stability, the number of detections during a single satellite pass (it can take 11 minutes for the satellite pass) and the distances between the predicted locations.

The seal tracking program is ongoing, and is providing scientists with regular information regarding the distances and areas seals of differing ages travel to find food. The program has tracked seals from Seal Rocks during 1999 to 2001 and females from Seal Rocks, Lady Julia Percy Island, Kanowna Island and The Skerries during 2001 to 2003. The 2004 Seal tracking program was aimed at identifying the locations seal pups forage, and the distances from shore that they travel.

Implications for the Industry

Relatively little is known about Australian Fur Seals feeding, breading habitats, the numbers of seals and their genetic diversity. The working being undertaken by the Phillip Island Nature Reserve is important to long term protection and management of the Australian Fur Seals.

Since the offshore platforms were installed in Bass Strait in the 1960s, they are frequently used as resting places for seals, although relatively little is known about their significance for the seal populations. This research will assist in determining the importance of these offshore installations to the Australian Fur Seals at Seal Rocks, as well as providing essential information required to assist in the effective and long term management and protection of the seal colonies.

The on-line tracking program allows members of the public to become involved and increase awareness of the important research programs being undertaken by the Phillip Island Nature Reserve.

Offshore platforms are frequently used as resting places for seals.

Fish, Molluscs and Crustaceans

Project

Assessment of environmental effects of seismic testing on scallop fisheries in Bass Strait.

By Parry, G.D., Heislers, S., Werner, G.F., Asplin, M.D. and Gason, A., (2002). Marine and Freshwater Research Institute, for Esso Australia Pty Ltd.

What was done

Field experiments were conducted in Bass Strait to assess impacts of seismic exploration on selected marine life, including adult scallops, fish eggs and plankton.

Adult scallops used in the experiments were placed in cages and suspended in the water column 22 m from the surface directly below the seismic vessel air-gun discharge from the seismic vessel, Geco Beta, which used a 3542 cubic inch, 24-gun array (8 guns in three arrays) towed at 6 m depth. Scallops were also held in cages at control plots located 20 km distant. Mesh bags of fish eggs (black bream eggs obtained from MAFRI's hatchery) were also attached with the scallop cages. The effects of seismic testing on plankton (including larval scallops) were measured by comparing plankton communities immediately behind the seismic vessel with those sampled before and after exposure and at control areas.

After the survey, scallops were assessed for survival and strength of the adductor muscle (the edible muscle that holds the two shell valves together). Bad weather immediately after the deployment of the fish eggs delayed the seismic surveying and recovery of the fish eggs/larvae before all died through lack of food. Plankton were analysed in such a way as to discriminate between those live or dead at the time of sampling—i.e., to identify any planktonic organisms lethally impacted by the seismic discharge.

A detailed review of the scientific literature on the effects of seismic exploration on shellfish and larval fish and plankton was also included in the study.

Why was it done

The experiments were carried out to determine whether seismic exploration has an adverse effect scallop fisheries in Bass Strait. Much of the literature on the impacts of seismic exploration on larval planktonic stages of fish and shellfish relates to North American and European studies. Although the results from these analogues may be scientifically relevant, validation with local species in local conditions and during a commercial survey is often more convincing to local stakeholders.

Implications for the environment

The study found no evidence that direct exposure to seismic exploration affected scallop mortality or adductor muscle strength. As the experiments were conducted at the shallowest parts of the survey area, where exposure distance between air-gun and scallops was closest, risks of impacts to scallops on the seabed in the remainder of the survey area would be smaller.

The studies also found no evidence of changes to plankton communities or abundances in the 20 m water column exposed to the seismic air-gun discharges.

No results were obtained for the fish eggs/larvae. Due to weather restrictions, these could not be retrieved within the experimental timeframe.

Implications for the Industry

The results are consistent with the general conclusions drawn from the scientific literature that shellfish, which do not contain gas spaces (cf swim bladders of fish) are resilient not only to the air-gun discharges currently used in seismic survey, but also to more powerful explosions.

The results of the investigation showed that there was no evidence that seismic testing affected the mortality or adductor muscle strength.

The effects of seismic testing on plankton were also investigated. Plankton were sampled from a minimum of 4.9km behind the seismic array on 6 transects. Statistical analysis of the samples indicated no statistically significant changes for any planktonic taxa exposed to seismic testing relative to the control sites. These finding support previously published findings that any effects of seismic surveys are localised and of very small magnitude. The non-detectable impact to plankton in the 20 m water column impacted is also consistent with theoretical assessments (eg. Swan et al. 1994), which conservatively estimate a lethal range of 10 m. The study showed that at greater distances (20 m), impacts would be so small that only very intensive sampling effort would be needed to determine whether effects are detectable at this range.

Further details can be found in:

Parry, G.D., Heislers, S., Werner, G.F., Asplin, M.D. and Gason, A., 2002. Assessment of environmental effects of seismic testing on scallop fisheries in Bass Strait. Marine and Freshwater Research Institute, Report No. 50. Marine and Freshwater Institute, Queenscliff.

The study found no evidence that direct exposure to seismic exploration affected scallop mortality or adductor muscle strength.

Project

Review of Western Australian Rock Lobster fishery in the offshore central WA coast, between Cliff Head and Dongara.

Roc Oil Company Ltd

What was done

Prior to conducting seismic surveys in permit areas WA 286-P, 325-P and 327-P in 2002, Roc Oil sought information about the biological and commercial aspects of the Western Australian Rock Lobster Fishery, in order to plan its activities with least disruption to both industries. Dr Bruce Phillips of Curtin University of Technology was commissioned to complete a desk-top study to describe the relevant aspects of the fishery and in particular, the fishing operations in the area of Roc Oil's areas of exploration and potential production interests. The report described the biology and life cycle of the rock lobster, the management of the fishery, and the potential impacts to lobsters and fishing operations from all offshore oil and gas activities, not just seismic exploration.

Why was it done

The review was undertaken for management purposes—to understand the fishery and the potential issues that Roc Oil might encounter in order to implement management measures to avoid potential conflict. The Western Australian Rock Lobster fishery is recognised as Australia's most valuable and sustainably-managed single species fishery.

Implications for the environment

The review considered that impacts to adult and larval lobsters from seismic noise would most likely be minimal because only a small proportion of the population would be within the potential impact distance from the airguns (considered for this review as 20 m). The main concern for the fishery is the risk of entanglement with pots and fishing gear from the seismic streamers. To manage this risk, alternative arrangements with guard vessels, line clearance or temporary exclusions and compensation need to be negotiated. However, a consequence of timing surveys to avoid the rock lobster fishery increases potential interaction with humpback whales during their southbound migration.

Adverse impacts to rock lobster fishery from other exploration activities such as drilling, (including support vessels and helicopters), and from the release of water-based muds and cuttings were considered unlikely because of their transient nature. Exclusion zones and loss of fishing ground around permanent offshore structures are matters of greater concern to the fishing industry. The impacts from discharge of any produced formation water and accidental oil spills are matters for which no generalised conclusions apply, and need to be considered on a case by case basis.

Implications for the Industry

Roc Oil's proposed seismic exploration area between Cliff Head and Dongara contains reef areas that are important as nursery habitat and as grounds of intensive commercial and recreational fishing. Fishing boat movements also occur through the area and into Port Denison.

Guidelines from the Western Australian Department of Minerals and Energy state that whenever possible, seismic surveys are to be conducted outside the rock lobster fishing season. Applications to conduct surveys during the fishing season can be granted but need negotiated agreements with relevant professional fishermen's associations about arrangements for clearance of gear or for compensation. However, by targeting the closed season for rock lobster fishing, surveys are more likely to coincide with the period of significant whale migration.

The main implication arising from the rock lobster fishery review is therefore timing. On the one hand, risks to seismic surveys (and fishing) from entanglement with fishing gear maybe substantial if arrangements fail. On the other hand, surveys require greater diligence in managing whale encounters and risk greater loss of time due to shut-downs when whales enter within 3 km of the operating vessel. When other constraints are considered, such as winter weather, or delaying surveys until late in spring when most of the whale migration has occurred, only a narrow window of opportunity exists when all risks can be minimised. The timing of Roc Oil's surveys demands a level of monitoring and research into potential interactions with whales. This approach has advantages in providing the opportunity to improve the information base from which more informed decisions can be made in future.

The Western Australian Rock Lobster fishery is recognised as Australia's most valuable and sustainably-managed single species fishery.

Project

Potential effects of seismic noise on Southern Rock Lobster Larvae

by Seafood Industry Victoria / Andrew Levings for Santos Ltd

What was Done

This desktop study estimated the cumulative numbers and percentage of larval stages of southern rock lobsters that would potentially have been close enough to seismic airgun shots to receive lethal injury. The study was undertaken prior to the Santos/Strike 2002 3D seismic survey in Vic/P44 (Casino prospect, Otway Basin, offshore western Victoria). The abundance of J. edwardsii larvae being transported through the Casino prospect area at the time of the survey was not known (and not sampled) and so was estimated based on known levels of egg production by the parent population, behaviour of larvae, and dispersal mechanisms in the water column.

Knowledge of regional oceanography and larval rock lobster biology was then used to model the likelihood of exposure of larvae within lethal impact range of the airguns. For the purposes of the study, this distance was taken as 10 m, based on findings of the Independent Scientific Review Committee review completed in 1994 (Swan et al. 1994), which was considered to be conservative (an over-estimate). This enabled a calculation of the volume of water affected per shot and total volume of water affected, from which maximum percentages of larvae affected could be calculated.

It is intended that the results of the study will be submitted for publication in the scientific literature.

Why was it done

The increase in offshore seismic exploration activity in recent years, particularly in the offshore Otway Basin has raised concerns among many Victorian and South Australian rock lobster fishers about the potential impacts of seismic exploration to the free-swimming larval stages and to the future recruitment of stocks. This concern has also been heightened as a result of the timing of some seismic surveys. The need to avoid periods of whale activity has resulted in more surveys occurring simultaneously with the period when lobsters release their larvae. The potential seismic impacts on lobster breeding have also been brought into greater focus for fishers facing other threats, not related to the seismic exploration industry, such as restriction of grounds within newly created marine parks and reduced market price.

The study was therefore undertaken to assess the level of potential risk of harm to free swimming rock lobster larvae and the consequent impairment of recruitment.

Implications for the environment

The study indicates that even under the worst assumed circumstances, seismic impacts on free swimming planktonic eggs and larvae are unlikely to be significant. Under assumed worst-case conditions, the study estimated that approximately 0.005% of the combined South Australian, Victorian and Tasmanian hatching may have been affected by the 2002 Casino 3D seismic program.

The results of this study suggest that the potential impact to rock lobster larvae from seismic surveys is minor, particularly when compared with very high natural mortalities associated with their long larval lifecycle (>1 yr), and the fishery management regulations to protect breeding adult stocks.

Implications for the Industry

Many rock lobster fishers would also agree with this finding—others might be less convinced by theoretical, rather than real studies. The study does not "prove" no effect (it cannot) and some fishers still raise concerns about sub-lethal impairment, or identify potential circumstances (eg., specific locations) where even conservative assumptions may not hold. Although further proposals for studies of potential sub-lethal effects have been considered, validation by laboratory or field sampling would be hard to do in a scientifically controlled way. No further study has yet been designed.

Further details are provided in: Levings, A. (2004). The potential of seismic noise to damage lobster larvae and reduce further harvests. (Report to Santos).

Project

Impact of seismic air-gun discharges on fish behaviour

APPEA Ltd

What was done

An experimental study of the behavioural and physiological responses of fish exposed to air gun signals was funded by APPEA and run by the Centre for Marine Science and Technology of Curtin University. An experimental air-gun that could be deployed hanging vertically or towed to simulate seismic survey discharges was used in the exposure trials.

Trials were carried out in which fish (pink snapper), held in cages were exposed to signals from the air-gun towed towards and away from the cages, mimicking the stimulus from a passing seismic vessel. Control fish were kept in similar cages but not exposed to seismic signal.

Sound levels received by the fish were monitored by underwater hydrophone. The behavioural responses of fish were recorded by two underwater video cameras placed in the cage. Physiological stress measurements were taken from cortisol levels in blood. Impacts to fish ears were determined by scanning electron microscopy of the fine ear structures of the exposed and control fish sacrificed at 18 hours and 58 days after exposure to air-gun sounds.

Why was it done

The study was done to improve understanding of the behavioural responses and potential impacts to fish from underwater noise from air-guns used in seismic surveys. Much concern about impacts of noise has focused on whales with relatively little on fish. Reviews of scientific literature on impacts to fish (e.g. APEA 1994) do not necessarily provide a consistent picture. Startle responses, avoidance and reduced catchabilty are generally reported in some (but not all) experimental studies, or by monitoring after seismic surveys. It is not known whether exposure to air-guns has the potential to cause damage to fish ears. With this background, the present study was initiated to determine the potential behavioural and physiological impacts of high energy sound on fish.

Findings

Video recording of the caged fish showed a startle response when start-up of the experimental gun occurred close to the cage and also at high level air-gun signals. These turned to alarm responses at noise levels above 156-161 dB re 1µPa mean squared pressure, but the alarm and startle responses were lessened through time and habituation. The fish generally formed tighter schools and swam lower in the cage during periods of high air-gun exposure, suggesting avoidance had fish not been captive.

There was no evidence of physiological stress attributable to air-gun exposure as determined by blood cortisol levels. There was evidence of damage to the hearing system in the form of ablated or damaged hair cells in fish up to 58 days after exposure.

Implications for the Industry

The main implication to industry is that the results are subject to a number of caveats. Being caged, the fish could not swim away and therefore the extent to which observations mimic actual responses of wild fish is not known. The video monitoring suggests that the fish would have fled the sound source if possible. Had the fish been able to do so, they may also have avoided the physical damage observed to the hair cells. Although the exposure level necessary to produce the damage could not be determined in the experiment, it is likely that this would require exposure to high level air-gun signals at very close range. It is known that fish such as the pink snapper used in the experiments are able to produce the sensory cells throughout their lives, the timing of the experiments could not determine the extent to which regeneration had occurred other than the net loss that remained after 58 days.

Further details can be found in:

Robert D.McCauley, Jane Fewtrell, Alec J. Duncan, Curt Jenner, Micheline-Nicole Jenner, John D. Penrose, Robert I.T. Prince, Anita Adhitya, Julie Murdoch, Kathryn McCabe. 2003. Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals. Environmental Implications of offshore oil and gas development in Australia: further research, APPEA Ltd, 2003.

Robert D.McCauley, Jane Fewtrell and Arthur D. Popper 2003. High intensity anthropogenic sound damages fish ears. J. Acoustic Soc Am. 113 (1), 638-642.

There was no evidence of physiological stress attributable to air-gun exposure.

Project

Impact of seismic air-gun discharges on squid behaviour

APPEA Ltd

What was done

An experimental study of the behaviour of caged squid exposed to air gun signals was funded by APPEA and run by the Centre for Marine Science and Technology of Curtin University. It was part of a larger project studying the responses of other marine animals such as whales, fish and turtles to seismic survey. An experimental air-gun that could be deployed hanging vertically or towed to simulate seismic survey discharges was used as the seismic signal source in the exposure trials.

The trials were carried out on squid (Sepioteuthis australis), held in cages and exposed to signals from the air-gun, which was towed towards and away from the cages, mimicking the stimulus from a passing seismic vessel. Control squid were kept in similar cages but not exposed to seismic signal.

Sound levels received by the squid were monitored by underwater hydrophone and the behavioural responses of the squid were recorded by two underwater video cameras placed in the cage. While pelagic invertebrates such as squid and cuttlefish are capable of detecting vibrations, there is little information in the scientific literature about hearing capability in squid. The statocyst organs of exposed and control squid were preserved for subsequent analysis by scanning electron microscopy.

Why was it done

The study was conducted to improve understanding of the behavioural responses and potential impacts to a range of marine animals from underwater noise from air-guns used in seismic surveys. Much concern about impacts of noise has focused on whales with relatively little on fish or squid. Reviews of scientific literature on impacts of underwater sound to invertebrates (e.g. APEA 1994) cover studies on other species such as prawns, lobsters and oysters. While the reaction to seismic surveys by squid in open water is unknown, the cage-held squid were used in similar trials of the responses to approaching air-guns, as was conducted for pink snapper. As a number of commercially valuable squid jig fisheries are developing around many parts of Australia, the aim of the study was also to provide information about the likely response thresholds of squid exposed to seismic survey.

Findings

At received sound levels of 174 dB re1µPa mean squared pressure (as a sudden exposure), squid showed a startle response by firing their ink sacs and jetting away from the air-gun source. At ramping-up exposure, using air-gun approach and departure, increases in alarm responses and increased swimming speed were observed once the received level exceeded 156-161 dB re1µPa mean squared pressure. In contrast to fish, the squid tended to rise in the water column, rather than descend and in so doing, made use of the sound shadow (12 dB difference) at the surface. A further observation was that their conditioned association of small boat approaching with food was maintained throughout the trials, suggesting little hearing threshold changes.

The analyses of the statocyst organs has not yet been completed.

Implications for the Industry

The main implication to industry is that the results are subject to the same caveats as for the studies on pink snapper. Being caged, the squid could not swim away and therefore the extent to which observations mimic actual responses of squid in the wild is not known. The squid are able to detect the seismic signal and overall, some behavioural response of squid may be expected where thresholds greater than 161-166dB re1µPa occur, for any particular survey.

Further details can be found in:

Robert D.McCauley, Jane Fewtrell, Alec J. Duncan, Curt Jenner, Micheline-Nicole Jenner, John D. Penrose, Robert I.T. Prince, Anita Adhitya, Julie Murdoch, Kathryn McCabe. 2003. Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals. Environmental Implications of offshore oil and gas development in Australia: further research, APPEA Ltd, 2003.

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Operational Effects

Project

Impacts of synthetic-based drilling muds.

Apache Energy Ltd

What was done

Apache Energy Ltd (Apache) operates the Varanus Island oil and gas processing facilities located on the North West Shelf. These facilities process oil from a number of reservoirs including the Simpson Field, located to the east of Abutilon Island. Apache has conducted investigations into the environmental impacts of synthetic-based drilling muds (SBM) that are used in some drilling operations from its shallow water platforms around Abutilon Island. Most SBM is recycled during use and returned to the manufacturer for reconditioning on completion of drilling. However, some (<10%) adheres to the surface of the cuttings that are discharged overboard, with potential impacts to the seabed that are in addition to impacts from cuttings alone, or cuttings coated with water-based muds (WBM).

The investigations involved

- Measuring the chemical composition and progressive degradation of drilling muds in the seabed around the wells drilled with SBM and water-based muds.
- Assessing the biological impacts of the drill cuttings and muds on the surrounding benthic fauna.

Three drilling locations were sampled in 2002 (Agincourt, Gibson/South Plato and Victoria) and again in 2004, adding the Twickenham/Double Island site to complete the studies. At each location, sampling locations followed a design pattern of increasing distances of 20, 50, 100, 200 and 500 m from drilling site arranged along transects perpendicular, and parallel to prevailing tidal current. Underwater video and sediment samples were taken after recovery periods ranging from 1 to 33 months after drilling. The samples were analysed for particle size, barium and polycyclic aromatic hydrocarbons, in order to detect and differentiate between the different types of drilling mud used. Triplicate seabed samples were also taken for the identification and counting of benthic fauna.

Why was it done

For certain sections of drilling, depending on geology and the angle of deviation, the synthetic-based muds perform better and are preferred over water-based muds (WBM), which are used in most applications. The synthetic-based muds have replaced oil-based muds because of their lower toxicity and persistence and greater environmental acceptance by the regulators. However, the degradation characteristics and effects of SBM may vary with in any particular location, depending on temperature, depth of water and prevailing currents, hence Apache commissioned the study to determine the marine chemical and biological impacts in the region in which it operates.

Findings

The study found that the use of WBM alone did not have any significant impacts on the benthic fauna living in the sediment although the traces of WBM were detectable in the form of increased barium content of the sediment and altered particle size. In contrast, clear impacts to benthic fauna resulted from drilling operations using SBM, where concentrations of hydrocarbons from the SBM in the sediment were up to 100,000 mg/kg, mainly within 50m from the platform, but detectable at or above 1,000 mg/kg at 100 m distance. Being immiscible with water, the SBM coated cuttings tend to stick together, creating visible clumps that although smaller in area than when WBM is used, are sufficient to cause high localised levels of hydrocarbons and anaerobic conditions in the sediments. Reduction of sediment hydrocarbons below 1,000 mg/kg is expected to allow sediments to return from anaerobic to aerobic conditions, and this occurred within 1-2 years after drilling. Impacts to fauna are detected at hydrocarbon levels above 1,000 mg/kg, probably caused by the organic enrichment and anaerobic conditions, as the abundance of deposit feeding worms was enhanced while most other groups declined in abundance. The most recent monitoring has shown that recovery of benthic fauna is also occurring, following the degradation of the sediment hydrocarbons.

Implications for the Industry

The study has confirmed what is generally known from the literature and other studies around Australia that the use of WBM alone does not result in any adverse impact to seabed benthic fauna. However, when SBM is used, the more cohesive clumps of SBM-coated cuttings locally change the seabed through physical smothering, altered particle size, organic enrichment and the creation of anaerobic conditions caused by gradual SBM degradation. These conditions in turn caused changes to the benthic fauna, where abundances of certain species such as polychaete worms thrived while most others declined.

The biological results have also borne out the generally considered view from the literature that recovery occurs when sediment hydrocarbon concentration decline below 1,000 mg/kg. The observed impacts occurred mainly within 100 m of Apache's platforms with substantial recovery between 1 and 2 years after drilling. Such statistics may vary with location of drilling but in principle are in agreement with similar studies conducted in 70 m depth in Bass Strait (see APPEA Journal 1998).

Further Information can be obtained from Apache Energy Ltd.

Most SBM is recycled during use and returned to the manufacturer for reconditioning on completion of drilling.

Project

Dispersion, Fates and Effects of Produced Formation Water (PFW) discharged from A) the Harriet A production platform in the Northwest Shelf and B) from the Kingfish B platform in Bass Strait.

This summary describes the study in Bass Strait at the Kingfish B platform.

What was done

Esso Australia Ltd (Esso) on behalf of the Esso/BHP Billiton joint venture produces oil and gas from the Gippsland Basin in Bass Strait. Formation water is produced in association with offshore oil and gas production. A study of the fate of discharged produced formation water (PFW) was applied to a temperate water offshore system, for which the Kingfish B platform in Bass Strait was selected.

In Bass Strait, the majority of formation water is separated, treated (to the regulatory limit of 30 mg/L hydrocarbon) and disposed offshore continuously from the platforms for the life of the field. In 1994, a field survey of the dispersion of PFW was conducted around several platforms in Bass Strait, during which the concentrations of various hydrocarbons in seawater in the vicinity of discharging platforms were measured A combination of water sampling and continuous geochemical tracer methods were used to detect hydrocarbons at trace levels (to ng/L). The study first mapped then modelled the dispersion of discharged PFW to determine and validate the vertical and horizontal distribution of the PFW plumes. The study involved sampling of hydrocarbon and nutrient tracers in the water column, combined with taking measurements of oceanographical conditions taken from the platform. These measurements were then used to calibrate and verify computer models (MUDMAP and OOC models) set up to predict the dispersion of PFWs under operating conditions from platforms in Bass Strait.

Esso's Kingfish B oil production platform was chosen for this fieldwork because its discharge is located within 7 km of two other PFW discharging platforms (Kingfish A and West Kingfish), and the platform continuously monitors oceanographic conditions. Kingfish B platform discharges 11 ML/d of PFW from a vertically oriented pipe 25 m below the sea surface in 78 m of water and is 80 km from the Victorian coast. Dispersion modelling and visual observation has previously shown PFW plumes in Bass Strait to be buoyant and Kingfish B PFW is typically a higher temperature discharge (95°C temperature, 36 ppt salinity).

Why was it done

The overall project objectives were to improve the understanding of the environmental fate of PFW by identifying and measuring appropriate indicators of ecologically significant PFW constituents. The two dispersion models, OOC and MUDMAP are computerised modelling systems used for predicting the near and far-field fate and dispersion of drilling muds, cuttings and PFW. The models are used to assist industry to predict, verify and improve environmental management practices of PFW discharge.

Prior to this study, computer simulation modelling of dispersion indicated rapid dilutions of PFW and contained hydrocarbons to extremely low concentrations and non-toxic levels within tens of metres from the discharge, particularly in the high energy marine environments such as eastern Bass Strait. However, confirming that this was the case and that PFW hydrocarbons were not accumulating over time, required field validation of the distribution and dispersion of discharged treated PFW.

Implications for the environment

The PFW is discharged vertically downward from a sub-surface pipe (12 m depth) and descends until its initial momentum is overcome by buoyancy (due to its higher temperature), and rises to the surface. High dilution is achieved during the initial dynamic mixing phase, followed by horizontal dispersion and dilution. Once discharged, the PFW moved northeast direction on the flood tide and to the south and southwest during the ebb tide.

The results showed that benzene and toluene were preferentially dispersed from the water column (based on comparison of ratios in PFW and seawater), and from the vertical profiles of PFW discharge (0.5 km northeast of the platform), the PFW was mostly confined to the upper 20 m of the water column. The survey also detected some PFW anomalies around Kingfish B platform, which originated from the Tuna platform and could be distinguished on the basis of ratios of the light hydrocarbon tracers.

Implications for the Industry

These results were used to calibrate, verify and compare the application of OOC and MUDMAP models of dispersion of PFW at Kingfish B. By comparing model-predicted plume predictions and dilution with the field measurements, it was possible to define both the horizontal and vertical diffusion parameters of the models and for the region. Both models predicted high vertical and horizontal mixing at the Kingfish B platform with rapid dilution of the plume. Both models predicted similar vertical dispersion between 0.3–1.0 m^2/s. The validation of each model has also provided confidence limits to plume predictions (using a measured current field that changed with time), estimated to be within a factor of five for estimates of concentrations near the platform and within 500 m in terms of plume position for both models. It must be noted that mechanisms such as biodegradation and evaporation that affect the fate of PFW are not addressed in the models, which are therefore conservative with respect to these factors.

Further details can be found in:

Burns, K.A., Codi, S., Furnas, M., King, B., Mcallister, F., Mitchell, A., Heggie, D. and Holdway, D. (2003). Dispersion and Fates of Produced Formation Water constituents in a North West Shelf Shallow water Ecosystem and Bass Strait. Environmental Implications of offshore oil and gas development in Australia: further research, APPEA Ltd, 2003.

High dilution is achieved during the initial dynamic mixing phase, followed by horizontal dispersion and dilution.

Project

Dispersion, Fates and Effects of Produced Formation Water (PFW) discharged from A) the Harriet A production platform in the Northwest Shelf and B) from the Kingfish B platform in Bass Strait.

This summary describes the study at the Harriet A platform in the North West Shelf.

What was done

Formation water is produced in association with offshore oil and gas production. Most is separated, treated and disposed offshore continuously from the platforms for the life of the field. A study of the fate of discharged produced formation water (PFW) was applied to an example in shallow water tropical environments of the North West Shelf, for which the Harriet A platform was selected.

A multi-disciplinary survey was conducted of the dispersion and fates of PFW discharged from the Harriet-A platform into the receiving waters and sediments and biota. The study first mapped then modelled the dispersion of discharged PFW to determine the vertical and horizontal distribution of the PFW plumes. The survey measured critical oceanographical conditions in conjunction with fine resolution measurements of both the horizontal and vertical concentrations of PFW components such as specific light hydrocarbons to map the shape and extent of the plume. Sampling by continuous geochemical tracer methods enabled detection of hydrocarbons at trace levels (to ng/L), many orders of magnitude more dilute than concentrations causing toxicity. Bioaccumulation was also measured in transplanted oysters and dispersion into sediment was measured in sediment samples taken by benthic grab. The dispersion results were then used to calibrate and verify computer models (MUDMAP models) set up to predict the dispersion of PFWs under operating conditions from platforms in the Northwest Shelf.

Since the model can predict plumes over a range of current speeds (and hence will vary over the tidal cycle), the model was used to determine whether previously dispersed PFW might return in later tidal cycles.

Why was it done

The overall project objectives were to improve the understanding of the environmental fate of PFW by identifying and measuring appropriate indicators of ecologically significant PFW constituents and determining their fate. The measurements were then used to validate and calibrate the dispersion model MUDMAP, which is a computerised modelling system used for predicting the near and far-field fate and dispersion of drilling muds, cuttings and PFW. MUDMAP can then be used to assist industry to verify and /or improve environmental management practices of PFW discharge.

Increased awareness of the risks to the environment from the production and transport of hydrocarbons requires an increased level of understanding of the fates and impacts of discharges, particularly off the North West Shelf where operations occur in areas perceived to be of high sensitivity.

Implications for the environment

The PFW mapping indicated a plume extending in the NNW and SSE direction on each tide to a maximum distance of approximately 10 km, with typical distances for 50% dilution around 3.5 km. Horizontal and vertical dispersion profiles suggest that within 1 km from the platform, the plume is mainly a surface feature with high dilutions of the hydrocarbons. Beyond this distance the hydrocarbons were more mixed in the water column. Residence time for traces of low molecular weight oil in aerobic sediments within 1 km of the platform as was estimated to be less than one year. Uptake rates in oysters and bioaccumulation factors indicted potential toxicity would extend to a distance of 1 km from the platform.
The MUDMAP validation has provided confidence limits to plume predictions, within a factor of two for estimates of concentrations near to the platform and within 400 m in terms of plume position overall. This level of accuracy is provided by the high spatial resolution of the analyses of benzene concentrations.

The model has also predicted that near field concentrations may vary significantly as a result of current speed and that PFW concentrations will be measurably higher and localised around the platform during neap tides and light wind conditions.

Implications for the Industry

The study has shown that by validating the key variables, i.e., plume concentration and position in the horizontal and vertical dimension makes MUDMAP an effective management tool for determining the range of potential PFW dispersion patterns possible around Harriet a as measures of best and worst case scenarios for defining potential impacts. MUDMAP can also be used to estimate the influence of altering discharge practices such as the pipe diameter and depth of discharge and PFW concentration. It must be noted that mechanisms such as biodegradation and evaporation that affect the fate of PFW are not addressed in the model, which therefore tends to be conservative with respect to these factors.

Further details can be found in:

Burns, K.A., Codi, S., Furnas, M., King, B., Mcallister, F., Mitchell, A., Heggie, D. and Holdway, D. (2003). Dispersion and Fates of Produced Formation Water constituents in a North West Shelf Shallow water Ecosystem and Bass Strait. Environmental Implications of offshore oil and gas development in Australia: further research, APPEA Ltd, 2003.

Increased awareness of the risks requires an increased level of understanding.

Project

Buffalo Predictions Audit (Environmental Survey) 2001

Nexen Petroleum Australia Inc/Bowman Bishaw Gorham

What was done

In 2001, Nexen Petroleum Australia Ltd (Nexen) became the operator of the Buffalo Field, previously developed and operated by BHP Petroleum. The field lies approximately 550 km northwest of Darwin in the Timor Sea. The project comprises two production wells at the wellhead platform (WHP) located on Big Bank, oil and gas flowlines to a floating production, storage and offloading facility (FPSO), which is moored (in deeper water off Big Bank) to a riser turret that is anchored to the seabed and through which the flowlines attach to the FPSO.

An Environmental Management Plan was prepared by BHP Petroleum in 1998, which required a predictive audit (Environmental Survey) to be conducted every two years to assess the potential impacts predicted at the time of the approval of the project by Environment Australia. In September 2001, Bowman, Bishaw and Gorham completed the first biennial, post-development marine environmental survey on behalf of Nexen to fulfil this requirement.

The environmental survey included the biological, chemical and physical characteristics of the seabed. The surveys assessed impacts attributable to production drilling, construction and the early operation of the facilities, and included comparisons with control areas and pre-development conditions of the marine environment.

Nexen commissioned Bowman, Bishaw and Gorham to undertake the studies, which included;

- Visual survey of the seabed and its benthic communities, using remotely operated vehicle (ROV) 'flown' along GPS-referenced transect lines.
- Water quality sampling (for nutrients, contaminants and naturally occurring radioactive materials).
- Water column profiling on Big Bank and at four distances / orientations from the FPSO.
- Analysis of seabed contaminants (hydrocarbon content, metals) and particle sizes.
- Comparison of water and seabed contaminant concentrations with international (ANZECC/ARMCANZ) guidelines or baseline conditions as appropriate.
- Sampling of abundance and species composition of seabed fauna and statistical correlation of biological assemblages and sediment physical and chemical variables.

Why was it done

The oil and gas reserves lie beneath the Big Bank Shoals, which is a large seamount that rises to within 25 m of the surface from a surrounding water depth of over 200 m. At the time of the development, little was known about the status of the marine environment of the project area. Environmental baseline surveys of Big Bank were first conducted by BHPP between 1996 and 1998 to describe the status of the marine environment. The findings provided the environmental baseline against which predicted constructional and operational impacts could be assessed. The 2001 survey was the first 'Predictions Audit' required, and its aim was to assess impacts against those predicted at the time of project approval.

Implications for the environment

The seabed at the top of Big Bank is described as consisting of gravels (derived from coralline algae, Halimeda) and sands with sparse biota (e.g., sponges, seapens, hydroids, soft corals and small hard corals). Apart from a mound of drilling cuttings (40 m long by 15 m wide and 0.5 m thick), observed close to the platform, no obvious changes have occurred to the benthic habitats and biological communities on the top of Big Bank since 1998. Animal burrows scattered over the surface of the mound indicated a moderate level of colonisation by infauna, but the density of organisms was reduced for a distance up to 30 m from

the edges of the mound. Some depressions in the seabed made during the constructional phase were still apparent but generally colonised as for the surrounding areas.

Elevated barium concentrations were detected in sediments up to 120m from the platform in a pattern aligned with tidal currents and therefore an indicator of spatial dispersion of drilling fluids, but not at concentrations likely to cause toxic effects. Concentrations of metals in sediments were otherwise low and below levels of expected biological effects. Analyses of benthic in-fauna communities and sediment characteristics could not separate sites according to proximity to platform or FPSO location suggesting little effect on the benthic variables analysed.

Similarly, the water sampling and profiling did not detect any measurable effects from PFW or other discharges within 200 m of the facilities and are thus unlikely to have any biological effects.

Implications for the Industry

Overall, the original nature and extent of impact of the development were accurately predicted and with a high degree of agreement between the predicted and observed effects. While the drilling cutting mound and construction imprints on the seabed have persisted slightly longer than anticipated, colonisation is observed and only a very small area of otherwise extensive habitat is affected.

The impacts of the Buffalo Field development have been minor and restricted to the immediate vicinity of the facilities, and detectable mainly a mounds of cuttings that remain in a small area beneath the platform, from drilling during construction. During the initial operational phase, there have been no measurable impacts to water or sediment quality, or to marine biological communities.

Further details are provided in Nexen/Bowman Bisham Gorham (2001). Environment Prediction Audit Survey.

Project

Buffalo Field Prediction Audit 2003.

Nexen Petroleum Australia Ltd/Sinclair Knight Merz

What was done

In 2001, Nexen Petroleum Australia Ltd (Nexen) became the operator of the Buffalo Field, previously developed and operated by BHP Petroleum. The Buffalo Field development lies approximately 550 km northwest of Darwin in the Timor Sea. It comprises production wells at the wellhead platform on Big Bank, oil and gas flowlines to a floating production, storage and offloading facility (FPSO), which is moored (in deeper water off the Bank) to a riser turret that is anchored to the seabed and through which the flowlines attach to the FPSO.

In 2001, Nexen produced an Environment Plan (EP) that superseded the previous EMP (prepared by BHP Petroleum) to bring it in line with regulatory changes. It required a predictive audit (Environmental Survey) to be conducted every two years to assess the potential impacts predicted at the time of the approval of the project by Environment Australia.

In September 2001, the first biennial Environmental Survey was completed by Bowman, Bishaw and Gorham on behalf of Nexen. In September 2003, Nexen commissioned Sinclair Knight Merz to conduct the second biennial Environmental Survey (audit).

Based on the findings of the first survey, the design of the second survey was modified to facilitate assessment of predicted potential impacts, where the following five predictions (hypotheses) were the focus of the survey:

1. Hydrocarbon enrichment of the water column and sediments in the vicinity of the WHP and FPSO.
2. Heavy metal enrichment of the sediments in the vicinity of the WHP and FPSO
3. Nutrient enrichment of the water column in the vicinity of the WHP and FPSO
4. Naturally occurring radioactive material enrichment in the PFW plume in the vicinity of the FPSO
5. Impacts to benthic communities (those living within and on the seabed surface) in the vicinity of the FPSO, the WHP and on Big Bank.

Water, sediment and biological sampling was conducted as for the first survey. However, the design of the second survey was modified to improve the spatial resolution needed to detect the specific discharges from the WHP and FPSO facilities respectively. As the WHP was considered to be a greater source of sediment contamination (from development activities) than the FPSO, and the latter a greater operational source of contaminants to water quality (in PFW), the numbers and locations of sampling reflected these considerations.

Why was it done

The survey was undertaken to meet the commitments of the EP and was the second biennial audit of the potential environmental impacts that were predicted at the time of project approval. The first (BBG 2001) found no evidence of any development or operational impacts beyond a short distance from the WHP facility.

Implications for the environment

According to the five testable predictions,

1. No detectable levels of hydrocarbons were found in waters or sediments within the vicinity of the FPSO or WHP with the exception of trace amounts of total petroleum hydrocarbons at two sites on Big Bank adjacent to the FPSO
2. No heavy metal enrichment of the sediment has occurred in the vicinity of the FPSO or WHP

3. Only ammonium was elevated at the FPSO but limited to the plume 100 m from the PFW discharge point
4. No NORMs were detected in any samples
5. No impacts were detected on the benthic communities in the vicinity of the FPSO, WHP or on Big Bank.

Implications for the Industry

The results of the second biennial predictions audit are consistent with the first in that impacts of the Buffalo Field development have been minor and restricted to the immediate vicinity of the facilities. As the sampling design was changed to give greater focus on the specific impacts/discharges from the FPSO and WHP, the findings also provide greater confidence in the observation that during the operational phase of the Buffalo Field to date, there have been no measurable impacts to water or sediment quality, or to marine biological communities.

Further details are provided in Nexen/SKM (2004). Buffalo Field Prediction Audit – Environmental Survey September 2003.

The design of the second survey was modified to facilitate assessment of predicted potential impacts.

Project

Impact Assessment of Discharge of Produced formation Water

Nexen Petroleum Australia Ltd

What was done

Nexen Petroleum Australia Ltd is the operator of the Buffalo field, comprising an offshore production platform linked to a floating production storage and offloading facility (FPSO), approximately 550 km northwest of Darwin in the Timor Sea. Produced formation water (PFW) is produced in association with oil and gas is separated from the oil and routinely discharged from the FPSO into the Timor Sea.

The discharged PFW contains traces of hydrocarbons and other contaminants. During 2002, Nexen commissioned Sinclair Knight Merz to conduct a suite of studies to determine the potential environmental impacts to the Big Bank Shoal of PFW discharged from the facility. These studies included:

- Identification of the toxicants present in the PFW and their concentrations.
- Ecotoxicological tests.
- Dispersion modelling.

The ecotoxicological tests were conducted under laboratory conditions to determine changes to certain physiological functions such as growth inhibition, fertilisation success and larval development of certain test organisms exposed to PFW at various dilutions. These tests and test organisms, which included marine algae, sea urchins and rock oysters, are standard and routinely used in toxicological studies. They provide information on toxicity and (if toxic), the numbers of dilutions needed for no observable effect, or no observable effect concentration (NOEC) after a specified exposure time.

Numerical models were used to describe the mixing and dispersion of the PFW plume under local environmental conditions experienced at the Buffalo field location. The hydrodynamics of the receiving waters were simulated using HYDROMAP, which is an ocean/circulation model. The mixing and dispersion phases were simulated using MUDMAP, which is a validated 3D-plume model for predicting the near and far-field fate of PFW taking into account turbulent mixing, buoyancy and dispersion stages. The distances from the platform needed for PFW to be diluted to concentrations equivalent to the NOEC was then estimated under 'worst-case' or least dispersive conditions of prevailing wind, tide and current.

Why was it done

The oil reserves lie beneath the Big Bank Shoal, which is a large seamount off the continental shelf of northwest Australia. It rises to within 25 m of the surface of the ocean from a surrounding water depth of over 200 m. The aim of the study was to determine the potential extent of any ecological impact that the discharged PFW may be causing to the Big Bank Shoal area, based on the observed physiological effects on surrogate test organisms.

Implications for the environment

The PFW discharged from the facility contains significant quantities of hydrocarbons, elevated levels of some metals and low levels of naturally occurring radioactive materials. It is moderately toxic to all of the test organisms until it reaches a dilution of 3.3%. The modelling showed that the highest concentrations were found within 2.5 m of the surface and that dilution to 3.3% occurs within 15 m of the discharge site. Ecological impacts are therefore restricted to within 15 m of the discharge point and risks of adverse impact to the Big Bank Shoal are negligible.

Implications for the Industry

Although PFW contains residual quantities of hydrocarbons and other contaminants, the results are consistent with findings of other studies, that in offshore areas, PFW is rapidly diluted to non toxic levels within short distances from the discharge point.

Further details are provided in Nexen/SKM (2002). Impact assessment of produced formation water.

Community and Education

Project

Victorian Marine National Parks

ExxonMobil

What was done

ExxonMobil has entered into a program with Parks Victoria to supply the necessary scientific equipment needed for communities to undertake / participate in the Community Based Monitoring Programme to be established in each of the marine parks. Once the details of the community-based monitoring program are finalised, a brochure will be produced.

The Victorian Government has created a system of 13 Marine National Parks and 11 smaller Marine Sanctuaries. These parks and sanctuaries encompass 5.3% of Victoria's coastal waters, and are intended to safeguard important marine habitats and species, significant natural features, cultural heritage and aesthetic values.

There are a number of different components in Parks Victoria's environmental research and monitoring program for the new Marine National Parks and Sanctuaries. These range from baseline biological monitoring to detailed habitat mapping to community monitoring projects to research partnerships with universities and all in between. Parks Victoria is approaching environmental research and monitoring in the marine environment from a number of different directions.

Parks Victoria is finalising a Research Strategy over the next year. It sets out the directions, context and principles for Parks Victoria's environmental research and monitoring, and lists the major research themes and areas of interest.

Why was it done

The system of marine parks and sanctuaries established to protect representative marine habitats was established with a broad understanding of marine habitats and communities. The first step following the establishment has been to obtain detailed inventory of the marine communities and habitats to further assist with management. The proposed cooperative program of baseline monitoring that is Sea Search aims to involve the community in scientific monitoring in the parks while increasing the knowledge needed to manage and maintain these areas. Different assemblages of animals and plants naturally come and go over time so it is important to establish long term databases from which to manage these parks.

Benefits to Industry

ExxonMobil continues to be a significant operator in offshore waters of Victoria since initial exploration and production in the 1960s. Having an improved understanding of the marine environment is of both technical value to ExxonMobil e.g. in improving its own environmental management plans, and of corporate citizenship value, in supporting others to in meet their obligations and promote scientific understanding of the marine environment. For any activities in and around marine parks and sanctuaries, appropriate management depends fundamentally understanding the communities and ecosystem values to be maintained including sensitivities and variation over time.

Sea Search aims to involve the community in scientific monitoring in the parks while increasing the knowledge needed.

Project

Marine Education and Research

ExxonMobil

What was done

ExxonMobil has been a long time significant supporter of the Queenscliff Marine Discovery Centre, which is an educational facility located at the Department of Primary Industries (DPI) Queenscliff Centre. The Centre facilitates people of all ages to learn about southern Australia's marine environment and includes aquarium, student laboratory, library and classroom facilities. In particular the Centre runs programs from early childhood, primary and secondary school ages to tertiary students studying marine science and ecology. ExxonMobil has sponsored educational posters developed by the Centre to increase awareness and education of marine life.

ExxonMobil has also entered into a partnership with the Victorian Marine Science Consortium (VMSC), which is also located at the DPI Queenscliff, by significantly funding new equipment in the laboratories. The VMSC is a consortium of five tertiary institutions in Victoria and the State Government. The consortium aims to foster marine science research and teaching in Victoria and provide synergies between partner institutions. The areas of research at the facility include:

- Marine ecology
- Fisheries ecology
- Physiology
- Ornithology
- Ecotoxicology
- Introduced species

In addition, undergraduate classes are conducted at all levels throughout the year.

Why was it done

ExxonMobil supports the Queenscliff Marine Discovery Centre and VMSC's Tertiary Marine Education Program to promote teaching and quality marine research in Australia. The DPI Queenscliff Centre and co-located VMSC and Discovery Centre facilities at Queenscliff relocated to new premises adjacent to Swan Bay in November 2004, offering continuing research and educational programs into the future.

Implications for the Industry

Over the years ExxonMobil's partnership with MAFRI (now DPI Queenscliff Centre) has had business and community benefits through:

- Provision of independent research on specific industry issues eg ecotoxicity studies
- Community recognition for ExxonMobil's support of marine environmental education, particularly among primary schools

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For your notes

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