SHAFAG ASIMAN OFFSHORE BLOCK 3D SEISMIC EXPLORATION SURVEY ENVIRONMENTAL IMPACT ASSESSMENT

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1. EXECUTIVE SUMMARY

Introduction and Project Description

BP and SOCAR (the State Oil Company of the Azerbaijan Republic) have signed a Production Sharing Agreement (PSA) on October 7th, 2010 to joint exploration and development of the Shafag-Asiman structure, which lies 125 km to the south-east of Baku in the Azerbaijan sector of the Caspian Sea, see Figure 2.1.

BP intends to carry out a conventional 3D seismic survey over the Shafag and Asiman structures, in 3Q / 4Q 2011 (possibly extending into 1Q 2012). The objective of the surveys is to obtain detailed information on the geological structure and any geohazards in the area, as well as to assess the structures for commercially viable hydrocarbon reserves.

In order to comply with the requirements of the Ministry of Ecology and Natural Resources (MENR) an environmental impact assessment (EIA) has to be carried out and submitted for this work and this is the subject of this report.

The purpose of the EIA is to present the current understanding of the Caspian environment sensitivities to the proposed seismic activities, and to assess the potential impacts and identify appropriate mitigation measures to be adopted to ensure that these activities are conducted in such a manner as to avoid or minimise adverse impacts.

The seismic survey is scheduled to commence in September 2011 for an approximate period of 110 days. There is the possibility that delays to the schedule could mean that the programme may not be fully completed until early 2012. BP has selected the seismic vessel, M/V Gilavar, and two support vessels.

The objective of the survey is to acquire approximately 1500 km² of full-fold 3D seismic data in the Shafag Asiman block. The block itself is located in a deepwater section of about 650-950 metres water depth, with an estimated reservoir depth of about 7000 metres. An approximate total of approximately 100 lines will be surveyed, with each surveyed line being in the range 30-55 km. It is anticipated that this will result in a total amount of line data of around 5000 km.

The survey will be conducted according to international, industry best practice (as per the requirements of the PSA). Typically appropriate standards are the International Association of Geophysical Contractors (IAGC) standards.

The seismic source will be multiple arrays of airguns (24 in total), and multiple streamers of hydrophones to receive the seismic return signal. There will be a total of 6 streamers deployed, and these will extend approximately 6000 m behind the seismic vessel and be towed at a depth of 10m +/-1m. The airguns will be towed ahead of the streamers (approximately 560m behind the seismic vessel) at a depth of 6m +/-1m.

Potential Impacts and Mitigation

The seismic survey is considered a non-intrusive operation and the potential environmental impacts and area of influence will be small in aerial extent and duration, and relatively remote from many potential sensitive receptors. Within the southern Caspian no significant environmental effects were predicted or subsequently observed as a result of seismic surveys undertaken in the Azerbaijan sector in recent years.

As a consequence of the limited duration of the seismic survey, the remote location of the seismic survey area and the various mitigative measures that will be employed to reduce or avoid potential impacts or disturbance, no significant environmental impacts are anticipated.
Overall it is generally accepted, from previous published studies, that normal seismic survey activities result in both:

- negligible long term adverse effects that would inhibit recovery of the environment to its normal state; and

- negligible adverse acute biological effects.

However, it is understood that seismic activities can lead to minor changes to normal behaviour of higher organisms such as fish, sea mammals and birds and that within close range (< 5 m) of a firing airgun, mortality of plankton and juvenile fish unable to swim away from the airgun could occur. Mortality and injury effects are predicted to be most frequent and serious within only 1.5 m of the airgun source (Dalen et al., 1996) and are not considered to represent statistically significant impacts to plankton populations or specifically to fish recruitment at the population level.

Risk of injury and disturbance to the Caspian seal will be mitigated by the implementation of soft-start procedures in accordance with the JNCC guidelines.

Due to the location of the seismic survey area:

- very few bird species, and low numbers of birds are likely to be present within the vicinity of the seismic survey operations. Those within 100 m of the vessel will probably be disturbed (McCauley, 1994) and move from the area;

- impacts on commercial fishery activity are not anticipated as the nearest recognised fishing grounds are located some 55 km to the west and north-west of the seismic survey area;

- impacts on seabed fauna are not anticipated due to the deep water characteristic of the seismic survey area (i.e. water depths ranging from 600 to 900 m);

- seals and adult fish present within the vicinity of the seismic survey operations will exhibit avoidance behaviour. Avoidance responses have been observed up to 1 km from seismic vessels (McCauley, 1994); and

- induced increases in background seismicity levels are not anticipated from the seismic operations.

Total emissions to air from the vessel operations are not considered to significantly contribute to global warming or result in localised smog or acid rain effects. Routine discharges to sea have been minimised and contingency measures for the potential accidental events will be defined and environmental procedures will be implemented by BP.

With the exception of sewage and grey water, Solid and liquid waste streams will be appropriately managed by transfer to shore for disposal, following BP waste transfer procedures.

Whilst considered outside the scope of this assessment, it is understood that the transit of the seismic survey vessel from outside Caspian waters via the Volga Don waterway, will follow internationally accepted best practice to avoid / minimise the transfer of alien invasive marine species, through hull fouling and ballast / bilge water.

Navigational equipment onboard the seismic vessel, streamer cable tailbuoys and the support vessel will provide warning to other sea users of the location of the cables. In addition, the streamers will be fitted with a ‘Syntrieve’ recovery system. Thus damage to the equipment and possible resultant spillages or loss of equipment to the marine environment can be avoided.

Offshore, no direct economic impact on commercial shipping or commercial fisheries is anticipated as the seismic survey area does not lie within a recognised shipping lane or recognised fishing ground and is generally remote from the main fish spawning and nursery grounds for the commercially exploited species. Associated onshore activities should have little or no detrimental socio-economic impact, and should on balance provide a limited short
term direct benefit to the local economy. In the medium term, if the findings of the survey indicate the potential presence of hydrocarbon reserves, further exploration activities and any further development activities associated with potential subsequently proven reserves, will provide an important direct source of revenue to the Azerbaijan Republic.

Overall, as a consequence of, the timing and location of the seismic survey, and the mitigation measures that will be employed to reduce or avoid potential impacts or disturbance, no significant environmental impacts are anticipated.
2. INTRODUCTION

2.1 Background

2.1.1 Production Sharing Agreement
BP and SOCAR (the State Oil Company of the Azerbaijan Republic) have signed a Production Sharing Agreement (PSA) on October 7th, 2010 to joint exploration and development of the Shafag-Asiman structure, which lies 125 km to the south-east of Baku in the Azerbaijan sector of the Caspian Sea, see Figure 2.1.

The PSA itself was signed on the 7th October 2010 and forms a legally binding agreement for the joint development and production of the Shafag Asiman Contract Area. As well as specifying commercial and technical requirements, it also states environmental standards and practices that BP projects and operations have to abide by.

2.1.2 Previous Shafag Asiman Exploration Activities
Caspian Geophysical conducted non-exclusive 2D seismic survey activities over the Shafag and Asiman structures (previously called D8-D10) between 1995 and 1999. This resulted in approximately 800 km of 2D seismic data.

2.1.3 Proposed BP Shafag Asiman Exploration Activities
BP intends to carry out a conventional 3D seismic survey over the Shafag and Asiman structures, in 3Q / 4Q 2011, with the possibility of extending into 1Q 2012.

The objective of the surveys is to obtain detailed information on the geological structure and any geohazards in the area, as well as to assess the structures for commercially viable hydrocarbon reserves.
Figure 2.1: Location of the Shafag Asiman Contract Area
2.2 **Seismic Survey Environmental Assessment (EIA)**

Seismic survey is the first stage in the exploration and production process and is a non-intrusive operation, thus the potential environmental impacts and area of influence are less significant and less extensive than those associated with drilling and production.

The purpose of this EIA is twofold:

- Firstly, to present the current understanding of the sensitivities of the Caspian environment to the proposed seismic activities.

- Secondly, to assess the potential impacts and identify necessary measures to ensure that the activities are conducted in such a manner as to avoid or minimise adverse impacts.

This report comprises the following main elements:

- A review of the legislative framework and controls for seismic survey operations.

- A project description providing the technical details of the surveys.

- Identification of discharges and emissions, with emphasis on the operation and presence of airguns and hydrophones.

- An environment description focusing on key issues.

- An assessment of the possible impacts of the surveys, including accidental events.

- A discussion of mitigation measures to prevent or reduce the identified impacts.

2.3 **Scoping & Consultation**

2.3.1 **BP Internal Scoping**

In accordance with BP Group requirements, an Environmental and Social (E&S) Screening Workshop was held on the 31 August – 1 September 2010, and attended by BP Environmental, Social and Exploration Group representatives from both the UK and Azerbaijan.

The objective of the workshop was to allow early identification and understanding of key environmental and social sensitivities associated with the Shafag Asiman seismic survey activities, and prioritise potential impacts in order to improve management throughout the life of the project and through to operations.

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1 BP Group Defined Practice - Environmental and Social Requirements for New Access Projects, Major Projects, International Protected Area Projects and Acquisition Negotiations (GDP 3.6-0001).
2.3.2 Scoping & Consultation with Authorities

A meeting to discuss the Scope for Shafag-Asiman Offshore Block 3D Seismic Survey and schedule was held with the Ministry of Ecology and Natural Resources (MENR) on the 11th May 2011. The scope of the EIA was discussed, and questions from MENR representatives were addressed.

2.3.3 Public Consultation

As the proposed seismic survey activities require BP to initiate work in a new Caspian Contract Area, a public consultation meeting will be held in Baku in first decade of September 2011. BP will provide the minutes of meeting to MENR after the Public Consultation has been conducted.

The purpose of this meeting will be to present information on environmental sensitivities in this new access area, inform the public of the proposed seismic survey operations, and obtain feedback on issues of concern.
3. SUMMARY OF LEGISLATIVE FRAMEWORK AND CONTROLS FOR SEISMIC OPERATIONS AND EIA

3.1 Introduction

The Shafag-Asiman field seismic survey project will be undertaken in accordance with the Shafag-Asiman Production Sharing Agreement (PSA), applicable requirements of international conventions ratified by the Azerbaijan government, International Petroleum Industry Standards and Practices, applicable national legislation and BP’s Health Safety Security and Environment (HSSE) Policy. The legislative framework governing the Shafag-Asiman field seismic survey project is illustrated in Figure 3.1 below.

Figure 3.1: Azerbaijan Legal Hierarchy
3.2 Regulatory Agencies

The Ministry of Ecology and Natural Resources (MENR) has primary responsibility for environmental regulation. The MENR’s statutes were adopted by presidential decree in 2001, making this body responsible for:

- Development of draft environmental legislation for submission to the Azerbaijan Parliament (Milli Mejlis);
- Implementation of environmental policy;
- Enforcement of standards and requirements for environmental protection;
- Suspension or termination of activities not meeting set standards;
- Advising on environmental issues;
- Expert review and approval of environmental documentation, including ESIA and EIA; and
- Implementation of the requirements set out in international conventions ratified by the Azerbaijan Republic (within its competence).

Other ministries and committees have functions that relate to environmental regulation including:

- Ministry of Emergency Situations (MES) - responsible for the management of natural disasters and industrial accidents and the implementation of safety rules in construction, mining and industry. MES (along with the State Oil Company of the Azerbaijan Republic (SOCAR), MENR and other appropriate Ministries) require prompt notification in the event of an emergency, or accident;
- Ministry of Health - state institution controlling the sanitary-epidemiological situation in the country and regulation of health protection in the work place;
- Ministry of Fuel and Energy - responsible for oil and gas activities, the sale of oil and gas products, and the efficient utilisation of Azerbaijan's energy resources;
- Melioration Water and Utilities Open Joint Stock Company - monitors water use, issues water abstraction permits for surface waters and imposes payments for water use; and
- State Committee for Construction and Architecture - regulates engineering surveys, and the implementation of design and construction rules and standards.

3.3 The Constitution

The Constitution is the highest law in the country. The following Articles help determine the applicability of national and international requirements to the Shafag-Asiman field seismic survey project:

- Article 148.II - International agreements acceded to by the Azerbaijan Republic become an integral part of the legislative system of Azerbaijan; and
- Article 151 - If any conflicts arise between the normative-legal acts which constitute the legislative system of Azerbaijan (except for the Constitution and the acts adopted
via referendum) and the international agreements acceded to by the Azerbaijan Republic, the provisions of the international agreements shall apply.

The Constitution (Article 39) also provides the right to all to live in a healthy environment; to have access to information on the state of the environment, and to obtain compensation for damage to person or property arising from a violation of environmental legislation.

3.4 Production Sharing Agreement

The Shafag-Asiman PSA is the legally binding agreement for the joint development and production sharing of the Shafag-Asiman field in the Azerbaijan sector of the Caspian Sea. This agreement, signed between SOCAR and the Contractor applies to all phases of the Shafag-Asiman Project and (not yet) has been enacted into Azerbaijan law. Under the terms of the PSA, Contractor has the right, for the entire term of the PSA, to explore, develop and produce hydrocarbons from the Shafag-Asiman offshore field. The PSA states that the conduct of operations should be undertaken with respect to the general environment, other natural resources and property, with the order of priority being the protection of life, environment and property.

Article 26.1 of the PSA states:

“Contractor shall develop jointly with SOCAR and the Ministry of Ecology and Natural Resources of the Republic of Azerbaijan ("MENR") safety and environmental protection standards and practices appropriate for the regulation of Petroleum Operations. The safety and environmental protection standards shall take account of the specific environmental characteristics of the Caspian Sea and draw, as appropriate, on (i) international Petroleum industry standards and experience with their implementation in exploration and production operations in other parts of the world and (ii) existing Azerbaijan safety and environmental legislation. In compilation of such standards and practices account shall be taken of such matters as environmental quality objectives, technical feasibility and economic and commercial viability”.

Article 26.2 of the PSA requires that:

“Contractor shall conduct the Petroleum Operations in a diligent, safe and efficient manner in accordance with the Environmental Standards and shall take all reasonable actions in accordance with the Environmental Standards to minimise any potential disturbance to the general environment, including without limitation the surface, subsurface, sea, air, lakes, rivers, animal life, plant life, crops and other natural resources and property. The order of priority for actions shall be the protection of life, environment and property. Contractor shall implement an integrated management system covering all health, safety and environmental aspects of the activities carried out in relation to the Petroleum Operations as outlined in part I of Appendix 9")(.)

Article 26.4 of the PSA requires the Contractor to:

“comply with present and future Azerbaijani laws or regulations of general applicability with respect to public health, safety and protection and restoration of the environment, to the extent that such laws and regulations are no more stringent than the Environmental Standards”.

Appendix IX, Environmental Standards and Practices of the PSA, require for seismic surveys to be conducted through:

- Environmental impact assessment;
• Health, safety and environmental management plan for seismic operations, including emergency procedures, oil spill contingency plan, waste management plan and an audit programme.

3.5 International and Regional Environmental Conventions

The requirement to prepare environmental documentation, including an Environmental Impact Assessment of any new facilities is also a condition of Appendix IX Section I B (1) of the PSA. The specific environmental standards that must be met throughout the life of the PSA are stipulated in Appendix IX of the PSA (Appendix 2A).

Since its independence, Azerbaijan has sought to reform the policy, legal and institutional framework that it inherited from the former Soviet Union in order to move towards a modern market oriented economy. Accordingly, in recent years, the Azerbaijan Government has engaged in international and regional processes to support this objective. International and regional conventions currently in force in Azerbaijan relevant to the scope of the Shafag-Asiman field seismic survey project are described below in Table 3.1 and Table 3.2.
### Table 3.1: Summary of International Conventions

<table>
<thead>
<tr>
<th>Convention</th>
<th>Purpose</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN Framework Convention on Climate Change</td>
<td>To collate information on greenhouse gas emissions and cooperate in planning.</td>
<td>Azerbaijan not formally required to meet specific reduction targets</td>
</tr>
<tr>
<td>Bern Convention</td>
<td>Conservation of wild flora and fauna and their natural habitats</td>
<td>In force in Azerbaijan since 2002</td>
</tr>
<tr>
<td>Basel Convention</td>
<td>Primarily deals with transboundary hazardous waste movement</td>
<td>Azerbaijan acceded in 2001</td>
</tr>
<tr>
<td>Stockholm Convention on Persistent Organic Pollutants</td>
<td>Reduction in releases of dioxins, furans, hexachlorobenzene and PCBs with the aim of minimization or elimination</td>
<td>Azerbaijan acceded in 2004</td>
</tr>
<tr>
<td>Vienna Convention on the Protection of the Ozone Layer</td>
<td>Framework for directing international effort to protect the ozone layer, including legally binding requirements limiting the production and use of ozone depleting substances as defined in the Montreal Protocol to the Convention</td>
<td>Azerbaijan acceded in 1996</td>
</tr>
<tr>
<td>Convention on Biological Diversity</td>
<td>Conservation of biological diversity including the sustainable use of its components and the fair and equitable sharing of benefits</td>
<td>Azerbaijan became party to the Convention in 2000</td>
</tr>
<tr>
<td>International Maritime Organisation</td>
<td>The principal IMO conventions relevant to this EIA are: MARPOL – Annexes I-VI covering the control of discharges and emissions from vessels London Convention – the prevention of marine pollution by dumping of wastes and other matter Antifouling Systems Convention Ballast Water and Sediments Convention</td>
<td>Entered into force in Azerbaijan in 2004 At the time of writing. Azerbaijan is not a signatory to the protocol to the Convention Not ratified by Azerbaijan at the time of writing (entered into force in 2008 for the countries that had ratified it) Not ratified by Azerbaijan at the time of writing (and not yet entered into force for the countries that have ratified it)</td>
</tr>
</tbody>
</table>
Table 3.2: Summary of Regional Conventions

<table>
<thead>
<tr>
<th>Convention</th>
<th>Purpose</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aarhus Convention*</td>
<td>To guarantee the rights of access to information, public participation in decision-making and access to justice in environmental matters</td>
<td>Azerbaijan acceded in 2000</td>
</tr>
<tr>
<td>Espoo Convention*</td>
<td>To promote environmentally sound and sustainable development through the application of ESIA, especially as a preventive measure against transboundary environmental degradation.</td>
<td>Azerbaijan acceded in 1999. At the time of writing, Azerbaijan had not signed a related protocol on Strategic Environmental Assessment</td>
</tr>
<tr>
<td>Convention on the Protection and Use of Transboundary Watercourses and International Lakes*</td>
<td>To prevent, control or reduce and transboundary impact resulting from the pollution of transboundary waters by human activity</td>
<td>Azerbaijan acceded in 2002</td>
</tr>
<tr>
<td>Protocol on Water and Health*</td>
<td>To protect human health and well-being by better water management and by preventing, controlling and reducing water-related diseases</td>
<td>Azerbaijan acceded in 2003</td>
</tr>
<tr>
<td>Geneva Convention on Long-range Transboundary Air Pollution*</td>
<td>Provides a framework for controlling and reducing transboundary air pollution</td>
<td>Entered into force in Azerbaijan in 2002. Has been extended by 8 protocols, none of which at the time of writing have been ratified by Azerbaijan</td>
</tr>
<tr>
<td>Convention on the Transboundary Effects of Industrial Accidents*</td>
<td>To prevent industrial accidents that may have transboundary effects and to prepare for and respond to such events</td>
<td>Azerbaijan acceded in 2004</td>
</tr>
<tr>
<td>International Carriage of Dangerous Goods by Road*</td>
<td>Provides requirements for the packaging and labelling of dangerous goods and the construction, equipment and operations of transportation vehicles. Annexes provide detailed technical requirements</td>
<td>Entered into force in Azerbaijan in 2000</td>
</tr>
<tr>
<td>Tehran-Caspian Framework Convention</td>
<td>Ratified by all 5 littoral states and entered into force in 2006. Requires member states to take a number of generic measures to control pollution of the Caspian Sea. Four protocols have been drafted which will, when adopted, form the basis for national legislation and regulations</td>
<td>Convention is ratified, but protocols are at the time of writing still in draft form and do not therefore at present provide a binding basis for the development of legislation</td>
</tr>
</tbody>
</table>

* A UNECE agreement; Azerbaijan became a member of the UNECE in 1993. The major aim of the UNECE is to promote pan-European integration through the establishment of norms, standards and conventions.
3.6 National Environmental Legislation

The Law on Normative-Legal Acts stipulates that acts in force prior to independence, that were not subsequently cancelled and that do not contradict the Constitution, remain in force. This results in a transitional legislative structure that combines soviet era and post soviet era regulations. The on-going transition process is being supported through a Partnership and Cooperation Agreement (PCA) between Azerbaijan and the European Union, which has been in force since 1999.

The Government has committed to a process to align national environmental legislation with the principles of internationally recognised legislation, based on EU environmental legislation. As this process is on-going, the Shafag-Asiman field seismic survey Project will comply with the intent of current national legal requirements where those requirements are consistent with the provisions of the PSA and do not contradict or are otherwise incompatible with international petroleum industry standards and practice.

The framework for national environmental legislation in Azerbaijan is provided by the Law on the Protection of the Environment (1999), which addresses the following issues:

- The rights and responsibilities of the State, the citizens, public associations and local authorities;
- The use of natural resources;
- Monitoring, standardisation and certification;
- Economic regulation of environmental protection;
- State Ecological Expertise (SEE);
- Ecological requirements for economic activities;
- Education, scientific research, statistics and information;
- Ecological emergencies and ecological disaster zones;
- Control of environmental protection;
- Ecological auditing;
- Responsibility for the violation of environmental legislation; and
- International cooperation.

According to Article 54.2 of the Law on Protection of the Environment, ESIAEs are subject to SEE, which means that the environmental authority (MENR) is responsible for the review and approval of ESIA reports submitted by developers. The Law establishes the basis for the SEE procedure, which can be seen as a “stand-alone” check of compliance of the proposed project with the relevant environmental standards (e.g. for pollution levels, discharges and noise). In addition the law determines that projects cannot be implemented without a positive SEE resolution.

The SEE approach is based on Soviet approval and planning processes requiring state authorities to formally verify all submitted developments for their potential environmental impacts. Current internationally recognised practice emphasises a proportionate, consultative and publicly accountable approach to assessing impacts.
3.7 National Permitting Requirements

This Shafag-Asiman seismic survey EIA report must be submitted to the MENR in order to gain the official approval. At the Scoping meeting held on May 11th, MENR recommended that the following state organisations be informed about the proposed seismic survey:

- The Hygiene and Epidemiology Centre for Water Transport
- The Hydrographic Services of the National Navy - to give notification of the seismic survey to all sea users and ensure that no existing facilities will be damaged by the work.
- Institute of Geology of Azerbaijan National Academy of Sciences

Once approval has been given by the above organisations, the permits will be submitted to the MENR.
### Table 3.3: Key National Environmental and Social Law

<table>
<thead>
<tr>
<th>Subject</th>
<th>Title</th>
<th>Date</th>
<th>Description / Relevance to the Shafag-Asiman Field Seismic Survey Project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Law of Azerbaijan Republic on Ecological Safety No. 677-IQ</td>
<td>08/06/1999</td>
<td>One of two keystone laws of the country’s environmental legislation (along with the Law on the Protection of the Environment). Its purpose is to establish a legal basis for the protection of life and health, society, the environment, including atmospheric air, space, water bodies, mineral resources, natural landscapes, plants and animals from natural and anthropogenic dangers. The Law assigns the rights and responsibilities of the State, citizens and public associations in ecological safety, including information and liability. The Law also deals with the regulation of economic activity, territorial zoning and the alleviation of the consequences of environmental disasters.</td>
</tr>
<tr>
<td>Ecosystems</td>
<td>Law of the Azerbaijan Republic on Specially Protected Natural Territories and Objects No. 840-IQ</td>
<td>24/03/2000</td>
<td>Determines the legal basis for protected natural areas and objects in Azerbaijan.</td>
</tr>
<tr>
<td></td>
<td>Law of Azerbaijan Republic on Fauna No. 675-IQ</td>
<td>04/06/1999</td>
<td>Defines the animal world, property rights over fauna and legal relationships between parties. It also describes issues of State inventory and monitoring, and economic and punitive regulations.</td>
</tr>
<tr>
<td>Water</td>
<td>Water Code of Azerbaijan Republic (approved by Law No. 418-IQ)</td>
<td>26/12/1997</td>
<td>Regulates the use of water bodies, sets property rights and covers issues of inventory and monitoring. The Code regulates the use of water bodies for drinking and service water and for medical treatment, spas, recreation and sports, agricultural needs, industrial needs and hydro energy, transport, fishing and hunting, discharge of waste water, fire protection and specially protected water bodies. It provides for zoning, maximum allowable concentrations of harmful substances and basic rules of conduct for industry.</td>
</tr>
<tr>
<td></td>
<td>Law of the Azerbaijan Republic on Water Supply and Wastewater No. 723-1Q</td>
<td>28/10/1999</td>
<td>Applicability limited to onshore operations. Restricts industrial waste releases into the sewage system; requires segregation of stormwater and industrial wastes from sewage, and requires legal entities to acquire permissions to operate sewage plant.</td>
</tr>
<tr>
<td></td>
<td>Rules of Referral of Specially Protected Water Objects to Individual Categories, Cabinet of Ministers Decree No. 77</td>
<td>01/05/2000</td>
<td>The Caspian Sea is a specially protected water body. This resolution requires special permits for disposal if there are no other options for wastewater discharge. The resolution allows for restrictions to be placed on the use of specially protected water bodies, and for further development of regulations related to these water bodies. It requires consent from MENR for activities that modify the natural conditions of specially protected water bodies, and includes provisions for permitting of any discharges to water that cannot be avoided. There are also special requirements for the protection of water bodies designated for recreational or sports use (which includes the Caspian).</td>
</tr>
<tr>
<td>Subject</td>
<td>Title</td>
<td>Date</td>
<td>Description / Relevance to the Shafag-Asiman Field Seismic Survey Project</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Rules for Protection of Surface Waters from Waste Water Pollution, State Committee of Ecology Decree No. 1</td>
<td>04/01/1994</td>
<td>Under this legislation the <em>Permitted Norms of Harmful Impact Upon Water Bodies of Importance to Fisheries</em> require discharges to meet several specified standards for designated water bodies in terms of suspended solids; floating matter; colour, smell and taste; temperature; dissolved oxygen; pH; BOD and poisonous substances. Limits are based on Soviet era standards and are to be achieved at the boundary of the facility (specific “sanitary protection zone limits”) rather than “end-of-pipe” limits. End of pipe limits are defined in facility-specific “eco-passports” and are established with the intent to ensure compliance with applicable ambient standards.</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>Law of Azerbaijan Republic on Air Protection No. 109-IIQ</td>
<td>27/03/2001</td>
<td>Establishes the legal basis for the protection of air, thus implementing the constitutional right of the population to live in a healthy environment. It stipulates the rights and obligations of the authorities, legal and physical persons and NGOs in this respect, sets general requirements for air protection during economic activities, establishes norms for mitigating physical and chemical impacts to the atmosphere, establishes rules for the State inventory of harmful emissions and their sources and introduces general categories of breaches of the Law that will trigger punitive measures.</td>
</tr>
<tr>
<td>Methodology to Define Facilities’ Hazards Categories Subject to Hazardous Substance Emissions Levels and Need to Develop Projects’ Maximum Permissible Emissions (MPEs).</td>
<td>04/09/1990</td>
<td>Under this methodology the maximum permissible concentrations of harmful substances and their hazard classes are provided. Limits are based on Soviet era standards.</td>
<td></td>
</tr>
<tr>
<td>Waste</td>
<td>Law of Azerbaijan Republic on Industrial and Domestic Waste No. 514-IQ</td>
<td>30/06/1998</td>
<td>Describes State policy in environmental protection from industrial and household waste including harmful gases, wastewater and radioactive waste. It defines the rights and responsibilities of the State and other entities, sets requirements for the design and construction of waste-treatment installations, licensing of waste generating activities, and for the storage and transport of waste (including transboundary transportation). The Law also encourages the introduction of technologies for the minimisation of waste generation by industrial enterprises. There is a general description of responses to infringements. This law is specified by Resolutions of the Cabinet of Ministers on the rules of certification of hazardous wastes, state strategy on management of hazardous wastes in Azerbaijan and by Instructions on the Inventorisation Rules and Classification System of the Wastes generated by Industrial Processes and in the Field of Services approved by the MENR.</td>
</tr>
<tr>
<td>Subsurface</td>
<td>Law of the Azerbaijan Republic on Subsurface Resources No. 439-IQ</td>
<td>13/02/1998</td>
<td>Regulates the exploitation, rational use, safety and protection of subsurface resources and the Azerbaijani sector of the Caspian Sea. The Law lays down the principal property rights and responsibilities of users. It puts certain restrictions on the use of mineral resources, based on environmental protection considerations, public health and economic interests.</td>
</tr>
<tr>
<td>Information</td>
<td>Law of the Azerbaijan Republic on Access to Environmental Information No. 270-IIQ</td>
<td>12/03/2002</td>
<td>Establishes the classification of environmental information. If information is not explicitly classified “for restricted use” then it is available to the public. Procedures for the application of restrictions are described. Law aims to incorporate the provisions of the Aarhus Convention (ratified by Azerbaijan in 1999) into Azeri Law.</td>
</tr>
</tbody>
</table>
### Description / Relevance to the Shafag-Asiman Field Seismic Survey Project

<table>
<thead>
<tr>
<th>Subject</th>
<th>Title</th>
<th>Date</th>
<th>Description / Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community health &amp; safety</td>
<td>Law on Sanitary-Epidemiological Services (authorized by Presidential Decree No. 371)</td>
<td>10/11/1992</td>
<td>Establishes sanitary and epidemiological requirements for industrial entities to be met at design, construction and operational stages, and for other economic activities. Aims to protect the health of the population. It addresses the rights of citizens to live in a safe environment and to receive full and free information on sanitary-epidemic conditions, the environment and public health.</td>
</tr>
<tr>
<td>Health</td>
<td>Law of the Azerbaijan Republic on Protection of Public Health No. 360IQ</td>
<td>26/06/1997</td>
<td>Sets out the basic principles of public health protection and the health care system. The Law assigns liability for harmful impact on public health, stipulating that damage to health that results from a polluted environment shall be compensated by the entity or person that caused the damage.</td>
</tr>
<tr>
<td>Radiation</td>
<td>Law of the Azerbaijan Republic on Public Radiation Safety No. 423-IQ</td>
<td>30/12/1997</td>
<td>Includes requirements for ensuring radiation safety in industrial entities. The Law establishes the main principles of government policy on radiation safety, as well as environmental norms protecting the safety of employees and populations in areas potentially affected by the use of radioactive sources. The Law provides for compensation for damage to health, property and life during accidents.</td>
</tr>
<tr>
<td>Liability</td>
<td>Law on Azerbaijan Republic on Mandatory Environmental Insurance No. 271</td>
<td>12/03/2002</td>
<td>Identifies requirements for the mandatory insurance of civil liability for damage caused to life, health, property and the environment resulting from accidental environmental pollution.</td>
</tr>
<tr>
<td>Permitting</td>
<td>A System of Standards for the Environment Protection and Improvement of Natural Resources Utilisation. Industrial Enterprise Ecological Certificate Fundamental Regulations, GOST 17.0.0.04-90</td>
<td>01/07/1990</td>
<td>The MENR issues ecological documents on the impact on the environment of potentially polluting enterprises. The documents include maximum allowable emissions, maximum allowable discharges, and an &quot;ecological passport.&quot; The last item is specific to countries of the Former Soviet Union and contains a broad profile of an enterprise's environmental impacts, including resource consumption, waste management, recycling, and the effectiveness of pollution treatment. Enterprises develop the draft passport themselves and send it to MENR for approval.</td>
</tr>
</tbody>
</table>
3.8 National EIA Guidance

Guidance on the EIA process in Azerbaijan is provided in the Handbook for the Environmental Impact Assessment Process in Azerbaijan. The handbook introduces the main principles of the ‘western’-type EIA process and details:

- The EIA process, i.e. the sequence of events and the roles and responsibilities of applicants and Government institutions;
- The purpose and scope of the EIA document;
- Public participation in the process;
- Environmental review decision (following its submission to the MENR, the EIA document is reviewed for up to three months by an expert panel); and
- The appeal process.

A summary of the guidance provided in the handbook is given in Table 3.4 below.

The approval of an EIA by the MENR establishes the compliance framework, including the environmental and social standards that an organisation should adhere to.

Table 3.4. Summary of Guidance on the EIA Process in Azerbaijan

<table>
<thead>
<tr>
<th>Screening</th>
<th>The developer is required to submit an Application (containing basic information on the proposal) to MENR to determine whether an EIA is required.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scoping</td>
<td>Requirement for a Scoping Meeting to be attended by the developer, experts and concerned members of the public, and aimed at reaching a consensus on the scope of the EIA.</td>
</tr>
<tr>
<td>Project Description</td>
<td>Full description of technological process and analysis of what is being proposed in terms of planning, pre-feasibility, construction and operation.</td>
</tr>
<tr>
<td>Environmental Studies</td>
<td>Requirement to describe fully the baseline environment at the site and elsewhere, if likely to be affected by the proposal. The environment must be described in terms of its various components—physical, ecological and social.</td>
</tr>
<tr>
<td>Consideration of Alternatives</td>
<td>No requirement to discuss project alternatives and their potential impacts (including the so-called “do-nothing” alternative), except for the description of alternative technologies.</td>
</tr>
<tr>
<td>Impact Assessment and Mitigation</td>
<td>Requirement to identify all impacts (direct and indirect, onsite and offsite, acute and chronic, one-off and cumulative, transient and irreversible). Each impact must be evaluated according to its significance and severity and mitigation measures provided to avoid, reduce, or compensate for these impacts.</td>
</tr>
<tr>
<td>Public Participation</td>
<td>Requirement to inform the affected public about the planned activities twice: when the application is submitted to the MENR for the preliminary assessment and during the EIA process. The developer is expected to involve the affected public in discussions on the proposal.</td>
</tr>
<tr>
<td>Monitoring</td>
<td>The developer is responsible for continuous compliance with the conditions of the EIA approval through a monitoring programme. The MENR undertakes inspections of the implementation of activities in order to verify the accuracy and reliability of the developer’s monitoring data. The developer is responsible for notifying the MENR and taking necessary measures in case the monitoring reveals inconsistencies with the conditions of the EIA approval.</td>
</tr>
</tbody>
</table>

3.9  Regional Processes

3.9.1  European Union

EU relations with Azerbaijan are governed primarily by the EU-Azerbaijan Partnership and Cooperation Agreement (PCA) and the European Neighbourhood Policy (ENP). The PCA entered into force in 1999, under Article 43:

“The Republic of Azerbaijan should endeavour to ensure that its legislation will be gradually made compatible with that of the Community”.

As part of the PCA an EU assessment of Azerbaijan’s environmental legislation against EU Directives identified a number of recommendations for the approximation of national legislation with EU Directives. Based on this, a draft national programme was developed that emphasises a flexible approach to amending national legislation to take account of institutional capacity and cost.

Following the enlargement of the European Union, the EU launched the ENP and Azerbaijan became part of this policy in 2004. The current National Indicative Programme for implementing the ENP includes a commitment to support legislative reform in the environmental sector, including:

- Approximation of Azerbaijan’s environmental legislation and standards with the EU’s;
- Strengthening of management capacity through integrated environmental authorisation;
- Improved procedures and structures for environmental impact assessment; and
- Development of sectoral environmental plans (waste and water management, air pollution, etc.)

3.9.2  Environment for Europe

Environment for Europe is a partnership of member states, including Azerbaijan, and other organisations within the UNECE region. Under the auspices of the Environment for Europe a series of ministerial conferences on the environment have been held that have resulted in the establishment of the UNECE conventions described in Section 3.5.

3.10  International Petroleum Industry Standards and Practices

The Shafag-Asiman seismic survey related activities are required to comply with national legislation “to the extent that such laws and regulations are no more stringent than the [developed] Environmental Standards” (Shafag-Asiman PSA, Art. 26.4). The safety and environmental protection standards shall be developed by the Contractor jointly with MENR.

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4 SOFRECO (undated) Support for the Implementation of the PCA between EU-Azerbaijan, Draft Programme of legal Approximation.
and “shall take account of the specific environmental characteristics of the Caspian Sea and draw, as appropriate, on (i) international Petroleum industry standards and experience with their implementation in exploration and production operations in other parts of the world and (ii) existing Azerbaijan safety and environmental legislation”.

Consideration of relevant international industry standards is therefore an important element in determining the applicability of national legislation or otherwise. Industry standards including those of the International Association of Oil and Gas Producers (OGP), the International Association of Geophysical Contractors (IAGC) and the International Association of Drilling Contractors (IADC) were specifically mentioned in the Shafag-Asiman PSA.

3.11 BP Requirements

The BP Environmental Group Defined Practice (GDP) on E&S Requirements for new projects (GDP 3.6-0001) includes minimum requirements applicable to the Shafag-Asiman seismic survey Project. These requirements include two main components of environmental and social assessment practice applicable to the Project; namely the Impact Management Process (IMP) and the Performance Requirements (PR). The latter represent a comprehensive set of environmental standards and the minimum requirements therein are in accordance with international petroleum industry standards as required by the Shafag-Asiman PSA.

3.11.1 IMP

IMP seeks to identify and assess the project’s environmental impacts. The project uses this information to avoid, minimise, mitigate and remediate the impacts. EIMP is a full lifecycle process and comprises:

1. Screening
2. Compliance
3. Stakeholder Consultation and Community Engagement
4. Impact Assessment
5. Residual Impacts
6. Delivery of Commitments
7. Managing Transitions

3.11.2 PR

The PR define the criteria BP shall meet to achieve a consistent delivery of environmental performance and are to be considered at all stages in the Environmental Impact Management Process:

PR-1 Air Quality
PR-2 Community Disturbance
PR-3 Community Investment
PR-4 Cultural Heritage
PR-5 Drilling, Completions and Workover Wastes and Discharges
PR-6 Greenhouse Gas and Energy Management
PR-7 Indigenous People
PR-8 Involuntary Resettlement (includes economic and physical displacement)
PR-9 Marine Mammals
PR-10 Ozone Depleting Substances
PR-11 Physical and Ecological Impacts (including International Protected Areas)
PR-12 Prevention of Soil and Groundwater Pollution
PR-13 Security and Human Rights
PR-14 Waste Management
PR-15 Water management
PR-16 Workforce Welfare and Local Employment (includes child labour and forced labour)

3.11.3 Shafag-Asiman Seismic Survey Project Standards

The environmental standards and regulatory requirements of seismic survey projects have previously been agreed between the Contractor and the MENR on a project specific basis throughout the previous phases of regional seismic survey activities conducted in the ACG contract area and SD contract area of the Caspian Sea, that were carried under the ACG PSA and SD PSA respectively. These standards were reflected in:

- ACG EIA Regional Seismic Survey Addendum Chirag Azeri Reservoir Seismic Project (CARSP) (2006)
- SD ETN Proposed Ocean Bottom Cable Seismic Survey (2007 – 2008)
- ACG EIA Regional Seismic Survey Environmental Addendum Concerning Proposed Chirag Azeri Reservoir Seismic Project Phase 2 (CARSP) (2008)
- COP Project ESIA (2010)

The developed standards took into account Azerbaijan’s environmental legislation and regulation, which is currently in a transitional stage, as well as international standards, such as those mandated by the EU. This process has enabled MENR to assess, approve or modify the mitigation, controls and standards proposed by the projects in liaison with BP.

A similar approach has been adopted for the Shafag-Asiman seismic survey EIA. Existing controls associated with Shafag-Asiman seismic survey events are summarised within the impact assessment chapters of this EIA (Chapters 6, 7 and 8) and comprise mitigation and monitoring (Chapter 9) inherent in the project design including the relevant environmental performance standards.
4. PROJECT DESCRIPTION

4.1 General Description of Seismic Surveys

4.1.1 Introduction

The two main types of seismic exploration are seismic refraction and seismic reflection. Refraction measures the travel time of seismic energy, which travels to the top of a distinct subsurface density contrast, is refracted along the top of the density contrast and returns to the surface as a head wave. Reflection measures the travel time of seismic energy that is reflected from a subsurface density contrast and is the method to be used here.

Seismic reflection exploration is routinely used worldwide both onshore and offshore to identify and assess subsurface geological structures, and the potential presence and extent of any associated oil and gas deposits. Data acquired during initial 2D seismic exploration typically assists in defining more prospective areas, which can be comprehensively examined through 3D seismic surveys. These can provide detailed images of geological structures and identify the best locations for exploration drilling. All of this is aimed at reducing any oil and gas exploration operational risks, which can pose subsequent risks to the environment, if not managed properly.

In the offshore environment seismic surveys are conducted by discharging directionally focused energy pulses in the form of low frequency sound into the water column. These pulses travel though, and are reflected back from, boundaries exhibiting a difference in acoustic impedance, defined as the product of seismic wave velocity and density. These reflections are recorded by receivers (hydrophones), which are deployed in streamers towed behind the seismic survey vessel (Figure 4.1). Depths and spatial extent of the strata are then calculated and mapped, based upon the difference between the time of the energy being generated and subsequently recorded by the receivers.

![Figure 4.1: Schematic of Marine Seismic Survey](image-url)
4.1.2 Seismic Sound Source

In the early years of offshore oil and gas exploration and up until the 1960’s explosives were used as a seismic source. However now offshore seismic surveys are acquired using arrays of various sized airguns.

The typical modern day configuration of a seismic survey vessel and equipment is shown in Figure 4.1. The airgun (Figure 4.2) is now the most common energy source used in seismic surveys. It works as follows:

- An array of airguns is trailed behind the survey vessel, under the surface of the water (usually at a depth of anywhere between 5 and 30m, depending on the environmental characteristics of the marine environment, and also on the target geological structures being imaged).
- Air at high pressure (c. 2000 psi) is supplied continuously to the airguns from air compressors on the survey vessel. This forces the piston downwards, and the chambers fill with high-pressure air while the piston remains in the closed position.
- When triggered to do so (at prescribed time or distance intervals) the solenoid valve opens and the piston is forced upwards; and
- Compressed air in the lower chamber flows rapidly out. An air-filled cavity is produced in the water that expands and then collapses, then expands and collapses again and continues cyclically. This oscillation creates seismic pressure waves releasing the energy (sound) into the water column.
- One of the objectives of using an array of airguns is to increase the power of the source. Another objective is to maximise the peak to bubble ratio – i.e. guns with different volumes will have different bubble periods, leading to a constructive summation of the first (primary) peak and destructive summation of the bubble amplitudes.
- For each airgun the amplitude of the signal is a function of the volume and pressure of the air inside the cylinder and the cylinder’s depth under the water surface. The larger the volume and higher the pressure, the greater the amplitude.
Seismic arrays are often measured over 0 – 250 Hz although the largest amplitudes are usually generated in the 20 – 100 Hz frequency band. However some energy will be present up to 500 – 1000 Hz. Although the high frequency components are weak compared to the low-frequency components they are strong compared to the ambient noise level.

Airguns produce a short sound (< 30 ms), with a relatively rapid rise time (time to reach maximum amplitude typically < 8 ms). Sound levels emitted are typically around 250 dB @ 1 m distance for an airgun array (Turnpenny and Nedwell, 1994). To place seismic signal levels in perspective, low level background noise in coastal regions is about 60 dB, this corresponds to gentle wave action and little wind. In adverse weather conditions, the background noise increases to 90 dB (Evans & Nice, 1996). Sound levels produced by other natural and anthropogenic activities in the marine environment are summarised in Table 4.1.
Table 4.1: Sound levels produced by other natural and anthropogenic activities

<table>
<thead>
<tr>
<th>Noise Source</th>
<th>Maximum Source Level</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undersea earthquake</td>
<td>272 dB</td>
<td>Wenz, 1962</td>
</tr>
<tr>
<td>Seafloor volcano eruption</td>
<td>255 dB</td>
<td>Northrop, 1974</td>
</tr>
<tr>
<td>Typical Airgun array</td>
<td>250 dB</td>
<td>Johnston &amp; Cain, 1981</td>
</tr>
<tr>
<td>Fin whale vocalisations</td>
<td>200 dB</td>
<td>Watkins, 1981</td>
</tr>
<tr>
<td>Container ship</td>
<td>198 dB</td>
<td>Thiele &amp; Odegaard, 1983</td>
</tr>
<tr>
<td>Offshore dredge</td>
<td>185 dB</td>
<td>Greene &amp; Richardson, 1988</td>
</tr>
</tbody>
</table>

4.1.3 Characteristics of Pressure waves

The operation of an airgun creates propagating pressure (sound) waves through the water and to a much lesser extent through the air. The sound waves generated extend radially from the source. Those which travel upward reach the surface of the sea and to a large extent are reflected (resulting in a surface ghost) or dissipated at this interface. Some do escape into the air to create the ‘muffled’ pop that characterises airgun operations at the surface. The sound waves that travel downwards reach the seabed and further reflection and attenuation occurs, although enough penetrate and return from the subsurface rock layers to provide the data for seismic analysis. The sound waves that travel sideways continue until they meet an object or are dissipated by normal decay of the signal (Macduff-Duncan & Davies, 1995).

The amplitude of sound waves generally declines with distance from the source. This weakening of the signal with distance, termed attenuation, is frequency dependent, with stronger attenuation at higher frequencies. The main factors determining the amount of attenuation of a seismic signal with distance are:

- geometrical spreading - in deep water, such as that found in the seismic survey area, pressure waves propagate as a spherical wave, the energy of which will decay at a rate proportional to the inverse of the distance squared;
- transmission / reflection - pressure waves transmitted into the sea bottom are reflected from the density boundaries. The transmitted/reflected signals will in some cases be stronger than the primary signal transmitted in the water but, due to different propagation paths, the transmitted/reflected signal will not have the same characteristics as the original pulse close to the signal source;
- absorption - transmission loss due to frictional dissipation and heat which is an exponential function of distance, weak in sea water but more significant in the seabed; and
- scattering - reflection, refraction and diffraction from inhomogeneity in the propagating medium causing transmission loss and an important part of the weakening of the seismic signal, especially in the sea floor.

In practice the decay of a sound wave will be dependent on the local conditions such as water temperature, water depth, bottom conditions and depth at which the signal is generated.

The propagation of sound in the sea is dependent on the frequency used. A practical formula for estimating the sound level from low frequency sources (such as seismic airguns) is:

\[ SL = A \log (r) - B \cdot r - C \]

(Gausland, 1998)

Where:

- \( SL \) is the received pressure level at a distance \( r \) from the source.
- \( A \) is the wave mode coefficient. For spherical waves \( A = 20 \).
B is an attenuation factor that is dependent on water depth and sea bottom conditions.

C is a fixed attenuation due to acoustic screening. In open water this will be 0.

This formula assumes a spherical decay law. However, variations in water depth will influence the propagation of seismic signals. As a consequence many authors have proposed a cylindrical decay law for seismic signals in shallow water, which can be expressed as:

$$SL = 10 \log (r)$$

This law may be correct for high frequency signals, but the low frequency nature of the seismic signals will cause these to travel through the rocks beneath the sea, and therefore attain a decay rate that is much closer to the deep-water conditions (i.e. a spherical decay law (Gausland, 1998).

4.1.4 Types of Reflection Seismic Survey

2D surveys

In 2D surveys one hydrophone streamer is towed behind the survey vessel, together with a single source. The reflections from the subsurface are assumed to lie directly below the streamer/source. This produces a vertical slice or 2D image of the geology below the source. Typical 2D surveys are designed to cover wide areas and provide a broad understanding of the subsurface geology. Survey duration varies from several days to months.

The processing of the data is less sophisticated than that employed for 3D surveys. 2D data can often be distorted with diffractions and events produced from offline geologic structures, making accurate interpretations difficult.

3D Surveys

The vast majority of resources expended on seismic surveys today are for 3D surveys. In 3D surveys several hydrophone streamers are towed behind the survey vessel, together with multiple (generally dual) sources. It is this technique that is proposed for the exploration of the Shafag Asiman structure.

Because seismic waves travel along expanding spherical wavefronts they have surface area. A truly representative image of the subsurface is only obtained when the entire wave field is sampled. A 3D seismic survey is more capable of accurately imaging reflected waves because it utilises multiple points of observation. Multi streamer, multi source surveys allow a range of different angles (azimuth) and distances (offset) to be sampled resulting in a volume, or cube, of seismic data.

This allows a more detailed and accurate delineation of the boundaries and extent of subsurface geological structures. Potential oil and gas reservoirs can be imaged in three dimensions allowing interpreters to view the data in cross-sections along 360° of azimuth, in depth slices parallel to the ground surface, and along planes that cut arbitrarily through the data volume. Information such as faulting and fracturing, bedding plane direction, the presence of pore fluids, complex geologic structure, and detailed stratigraphy are now commonly interpreted from 3D seismic data sets.

3D survey data is normally acquired as shown in Figure 4.3, with a ‘racetrack’ pattern being employed reducing the time necessary to turn the vessel while allowing adjacent lines to be recorded with the data in the same direction. This minimises processing artifacts, which could adversely affect the interpretation of the data. In general the survey area is broken into areas in which swaths of lines are completed in phases.
This approach is responsible for acquiring primary coverage. A secondary or a series of infill passes are made, generally once the primary coverage has been completed. Ocean currents have an obvious impact on how faithful the streamers are in adhering to the pre-programmed sailing coordinates. The amount of infill is greatly influenced by overall sea conditions.

Other types of seismic surveys include 4D surveys – i.e. surveying the same area over time; multi vessel undershoots to allow imaging under fixed obstructions and wide azimuth multi vessel surveys to further increase the sampling of the seismic wave field.

4.2 Outline of the proposed 3D Seismic Survey

4.2.1 Objective

The objective of the survey is to acquire approximately 1500 km$^2$ of full-fold 3D seismic data over the Shafag and Asiman structures (previously called D8 and D10 respectively) in the southwest Caspian Sea.

4.2.2 Overview

It is expected that BP and SOCAR (Azerbaijan’s state owned oil and gas company) will explore and develop the structures. Caspian Geophysical (a joint venture between SOCAR and WesternGeco) will collect the seismic data on behalf of BP.

The two-structure block lies approximately 125 km (78 miles) to the southeast of Baku. It is located in a deepwater section of about 650-950 metres with reservoir depth of about 7 000 metres.

4.2.3 Survey Programme

The survey programme will comprise a dual source, multiple streamer 3D survey. It is anticipated that the total data acquisition period will be approximately 110 days in duration (dependent on weather conditions), with survey start-up planned for September 2011. A contingency for potential delays has been allowed for in the programme, which may see the total duration extend until 1Q 2012.
The field programme will consist of the following main components:

- Mobilisation of vessels (including seismic vessel and support vessel(s));
- Deployment of towed equipment (airgun array and streamers);
- Data acquisition, comprising the bulk of the programme (NB. Vessels may be kept on standby due to adverse weather conditions, equipment repair etc); and
- Retrieval of equipment and demobilisation from the area.

During data acquisition, the seismic vessel will follow the pre-determined sail lines that may be subject to change depending on prevailing current and wind conditions. The actual distance covered by the seismic vessel during shooting and recording, during which the airguns will be fired at regular intervals, will be approximately 5000 km.

The 3D seismic survey will have approximately 100 vessel sail lines orientated in a northeast / southwest direction and will be shot in a “racetrack” pattern (Figure 4.3). The vessel will travel up to 12 km beyond the boundaries of the seismic acquisition area in order to turn at the end of each line.

When on standby the survey vessel may leave any or all of the towed equipment deployed in the water. In severe weather the streamer and source array may be retrieved (Section 4.2.8). When the vessel is planning to return to port all in-water equipment will need to be retrieved.

For this survey programme the recommended towed streamer acquisition parameters are as follows:

- Streamer length: 6 km
- Streamer depth: 10 m (+/- 1 m)
- Shot interval: 50 m flip flop
- Source depth: 6 m (+/- 1 m)
- Migration aperture: 2 km
- Fold of data: 60

### 4.2.4 Survey Area

The details and co-ordinates of the 3D survey area are presented in Table 1.2 and an outline of the survey area, detailing the 3D operating area and the full fold area, is provided in Figure 4.4.

#### Table 4.2: Summary details of 3D survey area

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. water depth (m)</td>
<td>650 - 950</td>
</tr>
<tr>
<td>Approx. distance offshore (km)</td>
<td>70 - 115</td>
</tr>
<tr>
<td>Co-ordinates of vessel operating area</td>
<td>Described in Figure 4.4 (overleaf)</td>
</tr>
<tr>
<td>Area of survey (km²) (Full-Fold Data Acquisition)</td>
<td>1500 (approximately)</td>
</tr>
<tr>
<td>Approx. number of acquisition lines</td>
<td>100</td>
</tr>
<tr>
<td>Length of lines (km)</td>
<td>30 - 55</td>
</tr>
<tr>
<td>Total line km of data (km)</td>
<td>ca. 5000</td>
</tr>
</tbody>
</table>
4.2.5 The Survey Schedule

The survey is planned to start in September 2011 and last for approximately 110 days in total, with all work completed in 1Q 2012.

4.2.6 Vessels

The M/V Gilavar, a dedicated seismic research vessel, (Figure 4.5) will be used to conduct the seismic survey. The seismic vessel and support vessels will operate on a 24-hour basis during the seismic survey period. Specifications for the seismic vessel M/V Gilavar are shown in Table 4.3.

The support vessels M/V Barra and M/V Baki, operated by Topaz Marine and SOCAR Fleet KMNF respectively will be used during the operations to ensure safety and protection for the seismic streamers. The support vessels will monitor the streamer location with regard to other vessels in the area and ensure that no interference with other activities occurs. Specifications for the support vessels are shown in Table 4.3.
Table 4.3: *M/V Gilavar and Support vessels* specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>M/V Gilavar</th>
<th>M/V Barra</th>
<th>M/V Baki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Caspian Geophysical</td>
<td>Topaz- Marine</td>
<td>SOCAR Fleet KMNF</td>
</tr>
<tr>
<td>Type</td>
<td>Seismic research vessel</td>
<td>Standby Vessel (chase/supply vessel)</td>
<td>Seismic/accommodation Vessel (Chase / crew vessel)</td>
</tr>
<tr>
<td>Vessel Length</td>
<td>84.90 metres</td>
<td>53.88 metres</td>
<td>81.85 metres</td>
</tr>
<tr>
<td>Draught (Mean)</td>
<td>5.9 metres</td>
<td>4.22 metres</td>
<td>5.9 metres</td>
</tr>
<tr>
<td>Tonnage (Gross)</td>
<td>3898 metric tonnes (Suez)</td>
<td>977 metric tonnes</td>
<td>3256 metric tonnes</td>
</tr>
<tr>
<td>Engine Size</td>
<td>3136 kW</td>
<td>1491 kW</td>
<td>3356 kW</td>
</tr>
<tr>
<td>Maximum Number of Berths</td>
<td>50</td>
<td>22</td>
<td>60</td>
</tr>
<tr>
<td>Endurance</td>
<td>42 days</td>
<td>25 days</td>
<td>35 days</td>
</tr>
<tr>
<td>Diesel Fuel Storage Capacity</td>
<td>800 t</td>
<td>210 t</td>
<td>474 t</td>
</tr>
<tr>
<td>Fuel Consumption per day</td>
<td>20 t</td>
<td>5 t</td>
<td>9 t</td>
</tr>
<tr>
<td>(normal working)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel consumption per day</td>
<td>15.4 t</td>
<td>8 t</td>
<td>11 t</td>
</tr>
<tr>
<td>(steaming full speed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubricating Oil Capacity</td>
<td>22 cubic metres</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is anticipated that the seismic vessel and support vessels will be mobilised from Baku, some 125 km to the north of the survey area. It is estimated that the time to reach the survey area will be approximately 6 hours assuming a steady engine speed of 11 knots (20.3 km / hr).
The normal working speed for the seismic vessel and support vessels during the survey will be 4 - 5 knots (7.4 - 9.3 km/hr).

Based on endurances for the seismic vessel and the support vessels of six weeks (42 days) it is estimated that the vessels will need to return to Baku at least once during the survey period for refuelling, back loading and re-supplying.

Positioning of the survey vessel is vital for accurate data production. Vessel positioning and navigation will be undertaken using a Trinav differential global positioning system (DGPS). Source array and tailbuoy positioning will be carried out using Seatrack 220 and Seatrack 330 for acoustic positioning and Digicourse 5010 for streamer depth control. Streamer positioning will be carried out using Sonardyne Range GPS, Digicourse compasses and Trinav DGPS tailbuoys

4.2.7 Seismic Source

The energy source will consist of two Bolt 1500/1900 airgun arrays, each with a combined chamber volume of 5085 cubic inches (83.4 litres), towed at a depth of 6 +/- 1m beneath floats. Energy source specifications are outlined in Table 4.4; a plan of the array is presented in Figure 4.6.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total array volume</td>
<td>2 x 5085 cu inc</td>
</tr>
<tr>
<td>Gun types</td>
<td>BOLT 1500 / BOLT 1900</td>
</tr>
<tr>
<td>Number of arrays</td>
<td>2</td>
</tr>
<tr>
<td>Number of sub arrays</td>
<td>6</td>
</tr>
<tr>
<td>Number of airguns per array</td>
<td>24 guns</td>
</tr>
<tr>
<td>Volume of each sub array</td>
<td>1695 inc max</td>
</tr>
<tr>
<td>Nominal operating pressure</td>
<td>2000 psi</td>
</tr>
<tr>
<td>Array length</td>
<td>15 m</td>
</tr>
<tr>
<td>Array width</td>
<td>16 m</td>
</tr>
<tr>
<td>Tow depth</td>
<td>6 m (+/- 1 m)</td>
</tr>
<tr>
<td>Distance of array from stern</td>
<td>560 m</td>
</tr>
</tbody>
</table>
Within each array there will be three sub-arrays each of one string. Each of the sub-arrays will have a total volume of 1,695 cubic inches (27.8 litres). In total there will be 48 guns in the two arrays (i.e. 5 single guns and 2 clusters in each of the six sub-arrays) (see Figure 4.6). The seismic source will generate power of up to 109.9 bar-m peak-to-peak amplitude corresponding to 260.8 dB re 1 µPa @1 m.

When firing at full capacity for data acquisition, each airgun array will be fired at the rate of once every 50 m in a flip-flop pattern, resulting in a shot interval of 25 m. Based on the length of the longest line and the working speed of the vessel, the maximum duration of firing on any one 3D line is anticipated to be no more than 8 hours.

As part of environmental best practice on seismic survey vessels, the output of the seismic source usually undergoes a “soft start”. This is the process whereby a single small-volume airgun is initially fired, gradually introducing both more airguns and those of a larger volume, until the full working capacity is reached. In general, the soft start period is a minimum of 20 minutes duration; a maximum of 40 minutes should elapse between the end of a soft start and the start of a seismic line (UK JNCC Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys, 2010).

### 4.2.8 Streamers and hydrophones

Six streamers of 6 km will be towed behind the seismic survey vessel at a depth of 10m (±1m) (Figure 4.7). The streamers will be Sercel Sentinel fluid filled streamers. Summary detail of the streamers is given in Table 4.5.

Figure 4.6: Proposed layout of airgun array
Table 4.5: Summary details of streamer

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of streamers</td>
<td>6</td>
</tr>
<tr>
<td>Streamer length</td>
<td>6 km</td>
</tr>
<tr>
<td>Streamer manufacturer/model</td>
<td>Sercel Sentinel</td>
</tr>
<tr>
<td>Towing depth</td>
<td>10 m (+/- 1m)</td>
</tr>
<tr>
<td>Streamer type</td>
<td>Fluid-filled</td>
</tr>
</tbody>
</table>

The end of each streamer will be marked with a tail buoy, to give a warning to other sea users about the presence of the cable in the water and to act as a platform for the positioning systems.

The streamer is equipped with multiple units of SRD-500 – a streamer recovery device that automatically activates inflating buoys, when the streamer sinks to a depth of 48 m or pressure of 70 psi. These are attached every 300 m along the streamer. The safety and protection of the cables will also be ensured by the presence of support boat(s).

Each of the six streamers will be split into sections 100 m long. The hydrophones (Sercel Flexible Hydrophones) are located at precise intervals along the streamer, with one group centre every 12.5 m.

As the cable is towed along, each receiver group will collect data from the same spot as the receiver that preceded it, allowing for a ‘stack’ of traces to be overlaid on top of each other. Random noise will be cancelled out and true events will be reinforced, improving the quality of data. The data from the cables will be recorded onto magnetic tape by the recording system onboard the vessel.

4.2.9 Deployment and retrieval of equipment

For a 6 km, 6-streamer dual source configuration, as presented here, it usually takes about 2-3 days to deploy all the equipment. The initial deployment often takes several days longer as the streamer needs to be balanced and time is often spent troubleshooting. If there are no
major problems then the equipment can be recovered in a day or two. All equipment is usually recovered in the reverse order in which it was deployed.

Deployment of a single 6 km streamer usually takes up to 24 hours, though initial deployment may take several days due to the issues described above. The equipment can be recovered in under a day.

Under certain wind and current conditions it may be necessary for the vessel to stand by in the survey area until suitable conditions prevail. In such situations the airgun array will be retrieved. Depending on the severity of the conditions the decision will be made, in accordance to operating procedures, to either retrieve the streamers or leave them deployed.

Caspian Geophysical has detailed written procedures covering the deployment and recovery of the deflectors, tailbuoys, streamers (including the birds and acoustic modules), stretch sections, lead-ins, GPS floats, airgun arrays and floats. In general, the deflectors (monowings or paravanes) are deployed first followed by the outer streamer sections, then the inner streamer sections. Signal continuity to the hydrophone groups, acoustic modules, compasses, birds and GPS receivers on the tailbuoys and gun floats are checked as the equipment is deployed. Once the streamers are deployed, and spacing is checked and verified, the airgun subarrays are deployed one at a time.
5. ENVIRONMENTAL DESCRIPTION

5.1 Physical and Chemical Environment

5.1.1 Meteorology and Oceanography

The Contract Area is located within the Azerbaijan sector of the southern Caspian Sea. The Caspian Sea is the largest interior sea in the world, extending for 1174 km from north to south with an average width of 326 km. It has a total area of 375 000 km² and a water volume of 78 700 km³. It is bounded to the south by Iran, to the west by Azerbaijan and Russia, and to the north and east by Kazakhstan and Turkmenistan. Figure 5.1 shows the Shafag Asiman seismic survey area in the context of the Southern Caspian region.

The main distinguishing features of the Caspian Sea are its isolation from the world ocean and intracontinental situation. The hydrological structures are formed primarily by the atmospheric processes in action over the whole basin and sea. These atmospheric processes are under the influence of the European / Asian land mass as well as local factors such as coastal relief. Climate and hydrologic structure of the Caspian Sea is presented as Figure 5.2. The following meteorological information is based on material from previous literature reviews and on longer term data collected from Neftchala meteorological station, located 92 km west of the Contract Area at its nearest point, on the adjacent coast.

Caspian Basin

The Caspian Sea occupies a deep continental depression. It is fed by the largest catchment basin in Europe, occupying the area between approximately 35°- 60°N latitude and 30°- 60°E longitude. Since the Caspian has no present connections with the world ocean or present outflow, total river inflow is the main income part of its water balance. Several large and numerous small rivers flow into the Caspian; altogether there are over 130. The catchment basin occupies 3.66 million km², and the ratio between the areas of catchment and the sea itself is 1:10. The major inflowing system is the Volga River, with a catchment area of 1.38 million km² - 40% of the total catchment area (Ferronsky, V.1. et al., 1995).
Figure 5.1. The Shafag Asiman offshore block 3D seismic survey area
Sea Level

The level of the sea has fluctuated considerably during geological, historical and recent times due to a poorly constrained combination of climatic, tectonic and human factors (Rodinov, 1994; Kroonenberg et al., 2000, Mamaev, 2002). The water level of the Caspian presently stands at 26m lower than that of the ocean (Arpe, 2007). From 1929 to 1977 the sea level fluctuated from around -26m to –29m (Kosarev and Yablonskaya, 1994). This was the lowest level reached during the past 400-500 years. In 1978 a rapid rise began, the level reaching – around -27.0 m by 1994. From 1995 to 2001 there was a slight regression observed in the sea level, before it began rising again to its present level.

Wind Regime

Wind characteristics over the Caspian are determined by the large-scale influence of the circulation of the atmosphere and local thermal conditions. The wind conditions are influenced by the north-south orientation of the Caspian as well as the physical and geographical conditions of the coastline.

In the south-west Caspian prevailing winds (i.e. those present for more than 50% of the time) are from the north and north-east. Strong winds and storms can arise at any time of the year but are more common during the winter months with the largest number of days with storm winds of > 15 m s\(^{-1}\) occurring on the Absheron Peninsula. South-western coasts are less influenced by winds and here the winds are strongest in winter and in the middle of summer.

Air Temperature Regime

Air temperatures show considerable seasonal variation in the Caspian region. According to Kosarev & Yablonskaya (1994), average air temperatures for the Caspian typically peak at 25.5°C during the summer and drop to near to 0°C in the winter. Air temperature data recorded at Neftchala meteorological station over the 10 year period 1988 to 1997, shows that the mean annual temperature along the south-west coast of the Caspian is 14.9°C, with a mean maximum of 35.3°C and a mean minimum of -3.9°C over this 10 year period.

Rainfall and Evaporation

Annual precipitation levels in the vicinity of the Absheron Peninsula are typically low, approximately 200 - 300 mm, with most rainfall occurring during the winter months. Rainfall totals, recorded at Neftchala meteorological station over the 10 year period 1988 to 1997, show that the mean annual rainfall along the south-west coast of the Caspian is approximately 229 mm/annum. Peak rainfall totals are recorded during the period October-April when over 80% of the annual precipitation falls.

Evaporation is a much more important process in the Caspian basin in terms of water balance, with around 1 m of water on average evaporating per year (Kosarev & Yablonskaya, 1994). The deficit between rainfall and evaporation is filled by river flow into the Caspian.

Visibility

Moisture saturated air converges in the south-west Caspian giving rise to foggy conditions during the winter months. Such conditions are likely to occur for around 10% of the year, mainly between October and May (Kosarev & Yablonskaya, 1994).

Water Temperature Regime

Differential climatic conditions between the north and south Caspian cause large latitudinal variations in sea surface temperature. The north-south inhomogeneity is most clearly expressed during winter, when the top 10m of the water column temperature varies from 0°C in the north to 10°C in the south. This difference decreases to about 3°C in the summer; 25°C
in the north to 28°C in the south. The coldest parts of the sea are on the east coast, 1-2°C lower than the west.

Water temperatures of the abyssal layer of the water column, at depths below 100 m, are between 5.7 °C to 6.3 °C with little seasonal variation (Kosarev, 1974). The small vertical thermal differences in deep water of the sea are due to intensive convective mixing (Kosarev and Yablonskaya, 1994). The temperature differences between surface and deeper water layers lead to the formation of a seasonal thermocline (an area of a rapid rate of temperature change). The presence of a thermocline restricts mixing of the upper and lower water layers.

Within the Southern Caspian, a thermocline begins to develop in the upper layers of the water column at water depths of between 20 - 50 m in spring (March – April). During summer and autumn, however, the thermocline moves deeper reflecting the increase in vertical mixing in the upper layers promoted by the increased frequency of storm events. As the thermocline becomes deeper, the range of temperature change gets smaller, until the thermocline eventually breaks down during the winter months.

The Caspian partially freezes over each winter; the northern part freezes over in winter every year while in the southern part ice only appears during very severe winters (Kosarev and Yablonskaya, 1994). The formation of large masses of ice in the North Caspian is due not only to low winter air temperature but also to the low salinity of the waters and the shallow depths.
Figure 5.2: Climate and hydrologic structure of the Caspian Sea

Adapted from www.caspinfo.net with additional data from Kosarev and Yablonskaya (1994)
Wave and Current Regime

Wind induced waves are a predominant feature over this part of the Caspian and wave heights in storm conditions can reach over 10 m. Maximum wave heights and wind velocities over a 20-year period for the central southern Caspian have been recorded as 14 m and 26 ms\(^{-1}\) respectively. Northerly waves prevail during the whole year and the largest waves occur during the autumn / winter months with April having the least wave activity (Marine Annual Reference Books, cited in Woodward-Clyde International, 1996).

The Caspian can be described as effectively non-tidal. Residual currents in the upper layers appear to be primarily influenced by wind action, with a secondary but important part played by density variations. Other causes of motion in the water body are subsurface relief - leading to some isolation between the north, middle and south Caspian areas - configuration of the coastline, differential water temperatures from north to south and the delta zones of inflowing rivers, especially the Volga (Kosarev and Yablonskaya, 1994).

Early models of general current circulation in the Caspian Sea were developed by Knipovich (1921) and Mikhaylevsky (1931). These have since been amended and supplemented by numerous authors. According to Furman and Shukarova (1995, cited in Woodward Clyde International 1996), large-scale circulation patterns influenced by wind, seabed relief and water temperature differences, occur in the Caspian. In the northern and middle Caspian, two internal anti-clockwise circulation patterns are present, whereas in the southern Caspian there exists two gyres - the western anticyclonic and the eastern cyclonic (Figure 5.2d).

Salinity

Within the enclosed Caspian the salinity is almost three times lower than that of the world ocean, and on average it is 12.8 - 12.9 ‰. The salinity changes from 0.1 - 0.2 ‰ near the deltas of the Volga and Ural, through 10 - 11 ‰ on the shelf edge bordering the middle Caspian to a maximum of 13.5 ‰ in the south-east (Figure 5.2b) (Kosarev and Yablonskaya, 1994). The freshening influence of rivers draining into the western coast of the middle Caspian explains the shape of the 12.5 ‰ isohaline along this shelf edge around the peninsula. The almost complete lack of riverine input into the south-east of the Caspian Sea explains the highest salinities being found in this area, as salinity is increased due to the concentrating effect of evaporation.

The salinity of the surface water in the vicinity of the Contract Area remains relatively constant all year round at approximately 12.5 – 13 ‰. This is due to the lack of freshwater influxes in this offshore location.

Hydrochemical Regime

The deepwater areas of the Southern Caspian are characterised by poor penetration of sunlight, stable temperature conditions and low dissolved oxygen levels. Typical dissolved oxygen levels close to the Contract Area (within 20 km) are shown in Table 5.1.
Table 5.1: Dissolved oxygen levels in the vicinity of the Shafag Asiman Contract Area

<table>
<thead>
<tr>
<th>Season</th>
<th>Surface levels of dissolved O₂ (mg/l)</th>
<th>Levels of dissolved O₂ at 500 m (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>12.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Summer</td>
<td>10.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>


5.1.2 Geology and Geomorphology

The Shafag Asiman block is located approximately between 50°30 and 51°5 longitude and 39°16 and 39°40 latitude in the South Caspian Basin. The area of full-fold seismic data acquisition and vessel operation will extend beyond this however. The prospects are located in a deepwater section to approximately 1000 metres with a reservoir depth of about 7000 metres. Previous 2D seismic surveys indicate potential deep-lying structures that may contain large reserves of gas.

The seabed of the Shafag Asiman study area slopes from the north-east to south-west, with depths ranging from shallowest at approximately 650 m in the centre to deepest at around 950 m in the south-west corner (Figure 5.3).
The South Caspian Basin (SCB) and the North/Central Caspian Basin are morphologically and geologically different. The feature separating the two basins is the Absheron Sill which is a bathymetric high in the form of a linear ridge, rising from the Caspian Sea bed, and aligned approximately WNW-ESE running from the Absheron Peninsula on the west coast of the Caspian Sea to Cheleken on the east coast. The Sill is considered to be the sea floor expression of the Absheron-Prebalkhan Uplift Zone, which lies along and defines the northern margin of the South Caspian Basin.

The SCB occupies the southernmost Caspian Sea and continues onshore within Azerbaijan as the Kura Basin in the west and as the West Turkmenistan Basin in the east (Figure 5.4). The basin is defined to the north by the Absheron-Prebalkhan Uplift Zone and to the west, south and east by the Talesh, Alborz and Kopet Dagh mountain ranges and fold belts. These active fold belts are the result of intense late Cenozoic shortening, and their accurate shape follows the form of the rigid aseismic crust of the basin.
5.1.3 Stratigraphy

To date no drilling activity, or 3D seismic exploration, has taken place over the Shafag Asiman structures. The discussion presented here is based available literature and on coring data from the wells drilled in the western shelf zone. Given that the thickness of the Lower Pliocene deposits increases towards the central (deep water) parts of the South Caspian, it can be assumed that the structures comprises Upper Pliocene - Quaternary deposits which may have a total thickness of 8,000 – 10,000 m. Figure 5.5 is a stratigraphic column of East Azerbaijan and corresponding Para-Tethys stages compiled from Alizadeh et al. (1998), Reynolds et al. (1998), Blackbourn Geoconsulting (1999) & Harland et al. (1982).

The sediment fill of the SCB is young and exceptionally thick, some 25 km of Tertiary to Recent sediments having accumulated with as much as 10 km of this deposited in the Pliocene-Quaternary (Figure 5.6). Thus about half of the sediment in the basin accumulated in less than the last tenth of its history. The most important deposits in the SCB basin, in terms of oil and gas production, are the ‘Productive Series’, which is the main hydrocarbon reservoir, and the underlying argillaceous Maykop (or Maikop) suite being the principal hydrocarbon source.
During the Oligocene and Early Miocene the Caspian Sea was a deep basin open to fully marine conditions, and the lower part of the Maykop Suite was deposited (Meulenkamp and Sissingh, 2003). This suite is widely developed throughout the South Caspian and interpreted as a deep marine deposit (Blackbourn Geoconsulting, 1999). These are dark grey, sandy, subcarbonaceous clays containing interlayers of consolidated sands and sandstones and thin layers of marl and are considered to be a main source of the oil and gas resources of the region (Schoellkopf et al. 1997).

At the end of the Miocene these muds were covered by sands that entered the basin through the major delta systems of the forerunners of the modern Kura, Amu D’arya and Volga rivers. This latest Miocene-Early Pliocene sequence of sandstones and mudstones of broadly fluvio-deltaic origin is the Productive Series (Jackson et al., 2002). They are up to 5 km thick, were deposited in about 1-2 Myr and form the principal hydrocarbon reservoir rocks in the basin (Reynolds et al., 1998). A consequence of the rapid sand deposition is the overpressuring of the underlying muds that resulted in abundant mud volcanoes and diapirs both offshore and onshore. Post depositional folding of the Productive Series has produced many of the hydrocarbon traps, with the folds assumed to detach in the underlying overpressured muds (Jackson et al., 2002).

Intraformational shales form seals within the middle Pliocene reservoirs. Transgressive shale sequences within the Productive Series and Akchagylian and Absheronian strata provide effective seals for the middle Pliocene reservoirs.
Figure 5.5: Stratigraphy of East Azerbaijan and corresponding Para-Tethys stages
5.1.4 Seabed Sediments

Seabed sediment sampling has been undertaken to the north and west of the Shafag Asiman seismic survey area, at the ACG and Zafar Mashal contract areas. It is understood that no sediment sampling has taken place within the Shafag Asiman area. Kosarev and Yablonskaya (1994) describe the deep-water sediments of the Southern Caspian basin as calcareous argillaceous silts.

Sediments in the ACG contract area are described similarly as clay-silts and very fine sands, with increasing organic content and consequently more elevated levels of hydrocarbons in the vicinity of mud volcanoes. Elsewhere throughout the contract area, hydrocarbon levels are consistently low, and similarly trace and heavy metal concentrations are typically below background levels, with the exception of certain sites close to where drilling activities, which could explain higher levels of barium in sediments (AIOC, 2009).

At Zafar Mashal sediment grades vary between clay and silt, with a predominance of clay. Finest sediments occurred in the deepest water depths on the south-western side of the Zafar Mashal structure (80% silt/clay) while on the north eastern side (closest to the Shafag Asiman seismic survey area) the proportion of fines in the sediments was 70% (AETC, 1999).
5.1.5 Tectonics

The fastest and deepest subsidence to accommodate the sediments in the SCB occurred within a regional compressional tectonic setting related to the closure of Neo-Tethys, the ocean that formed in the Triassic and separated northern Gondwanian structural blocks from Africa. Its closure occurred during the Arabia-Eurasia collision uplifting the adjacent mountains of the Great Caucasus, Talesh-Alborz and Kopeh Dagh. Due to the ongoing Arabian-Eurasian plate convergence a relatively high level of seismic and mud volcano activity is observed in the Caspian region.

The Absheron Sill, the northern margin of the South Caspian Basin, coincides with an anticline affecting late Miocene-early Pliocene deposits of the Productive Series. Only at the top of the Productive Series are sediment thicknesses affected by the folding suggesting that the anticline development is late Pliocene in age (Jackson et al., 2002).

In addition to the folding of the deposits over the Absheron Sill the sediments within the South Caspian Basin are also folded, the latter folds tending to follow the strike of the onshore folds of the surrounding mountain ranges that wrap around the basin. However, the remarkable aseismicity of the crust of the basin itself leads to the conclusion that the folds within the basin do not continue into the underlying basement but are completely decoupled from it. Devlin et al. (1999) puts the age of this folding as younger than 3.4 Ma. The development of thick mud horizons within the South Caspian sedimentary fill would provide the planes along which the decoupling, aided by mud diapirism, could occur. The impetus for the offshore folding is suggested by Jackson et al. (2002) to be a subsidiary effect of the forces causing the deeper basement shortening that produced the folding in the mountain ranges surrounding the basin.

Alizadeh et al. (1999) conducted studies on the Zafar Mashal structure, which lies directly to the west of Shafag Asiman structure, and identified locations of faults, earthquakes and mud volcanoes in the vicinity of the contract area. Figure 5.7 is a schematic map of the geomorphology, tectonics, seismicity and mud volcanoes in the area reproduced after Alizadeh et al. (1999), in relation to the Shafag Asiman seismic survey area.

From Figure 5.6 it can be seen that the Shafag Asiman structures represent the limb of a large anticlinal structure extending in a north-east south-west direction. This fold pattern can also been seen in the summary structural map of the South Caspian Basin, Figure 5.4.

In the Pliocene and probably in the Miocene deposits there are a number of anticlinal structures similar to the Shafag Asiman Structure. Approximately 15 km to the north lies the Shah Deniz anticline, and adjacent to the contract area the north-south oriented Zafar Mashal structure.
5.1.6 Seismicity

Three classes of earthquakes are generally recognised, namely tectonic, volcanic and artificially induced. The tectonic variety is by far the most damaging and are caused by stresses induced by movements of plates which make up the earth’s crust. The southern Caspian stands out as an aseismic block surrounded by areas of intense tectonic earthquake activity (Figure 5.8).
Earthquake data of the former Soviet Union is usually given in energy classes (K) while in the West the unit is the magnitude (M). **Table 5.2** compares these two units, which both describe the energy at the source of the earthquake. Intensity figures (I) are based on the Richter scale but cannot be directly compared as they are related to the surface effects of an earthquake.

<table>
<thead>
<tr>
<th>Energy Class (K)</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude (M)</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>5</td>
<td>5.5</td>
<td>6.1</td>
</tr>
</tbody>
</table>

According to seismic statistics a number of seismic epicentres have been registered within the South Caspian Basin, although these are relatively few compared to the number observed around the margins of the basin. The majority of these are located north and west of the structure.

According to instrumental data earthquake epicentres have been registered within the proposed seismic survey area of the Shafag Asiman Structure (**Figure 5.7**). Statistical data from 1960-1997 indicate the occurrence of events with energy classes (K) of 13 (magnitude 5) in the coastal part of East Azerbaijan, including the Baku archipelago. However most of the strongest earthquakes occur onshore, associated with tectonic movement in the Caucasus.
mountain region. In addition earthquakes originating in the surrounding mountain chains (Talysh, Alborz, Kopet Dag) have affected the area of concern. In terms of background seismicity, levels in the southern part of the South Caspian basin are low to moderate. Further west the Azerbaijan shelf area as well as the adjacent continental slope and deeper water areas, adjacent the Shafag Asiman Structure, has low background seismicity levels.

5.1.7 Mud volcanoes

One of the most important aspects of the geology of the South Caspian Basin is the presence of many marine mud volcanoes, which contribute to the complicated seabed topography. In the entire Caspian, it is estimated that there are more than 170 mud volcanoes.

These phenomena are formed as a result of overpressuring of muds and are found most commonly in areas where there are thick, rapidly deposited young sediments. The development of mud volcanoes in the region has been stimulated by the intensification of deformation of the South Caspian Basin in the Neogene and Quaternary Periods.

Eruptions from mud volcanoes can initiate sediment movements on slopes of very low gradient, and underwater turbidity currents can transport these muds over large distances into deeper water. In addition to the basic mud medium, rock fragments, water, gas and oil often erupt from the volcanoes, depositing sediments highly distinguishable from the well sorted clays, silts and sand deposits of the surrounding seabed.

Alizadeh et al. (1999) identified at least 3 prominent mud volcanoes in the Shafag Asiman contract area and mud volcanoes are also developed within adjacent anticlinal structures (Figure 5.7). Based upon historical and geological factors, there is a potential for the formation of new mud volcanoes in addition to the existing ones.

5.1.8 Commercial and recreational use

The coastal waters of Azerbaijan are the focus for both recreational and commercial fishing activity. The Shafag Asiman contract area is located in an open offshore area of the Caspian, between approximately 80-160 km to the east of the closest coastline of Azerbaijan. Kouliev & Gasymov (1999) report that fishing activity within the adjacent Zafar Mashal block is not considered commercially viable, due to its remoteness from the fish landing ports and the relatively low concentrations of commercial fish species. It can be assumed that the Shafag Asiman offshore block is similarly quiet with respect to fishing activity, as it is slightly further offshore.

Overall Caspian fish stocks are considered to be extremely depleted, in part due to extensive overfishing, and a lack of recruitment from the larval and juvenile populations as a result of the invasive ctenophore Mnemiopsis leidyi introductions. The officially licensed Azerbaijan offshore fishery has catch quotas for kilka set by the MENR that it is assumed are within sustainable limits based on knowledge of the fishery status.

In addition to the overall depletion of the kilka fishery, the proportional share of species in catches has changed in recent years, from being dominated by anchovy kilka (Clupeonella engrauliformis) to ordinary Caspian kilka (Clupeonella cultriventris). This change in dominance has resulted in commercial vessels fishing in shallow water depths during the summer months corresponding to the distribution of ordinary kilka rather than in deeper waters at the traditionally targeted offshore fishing banks (Figure 5.9), further highlighting the lack of significance of the Shafag Asiman contract area for the offshore commercial fishery (AIOC, 2010). It is possible however that fishing vessels from other Caspian littoral states may exploit the area.
Figure 5.9: Azerbaijan traditional offshore fishing grounds
The primary commercial ports of Azerbaijan are situated on the Absheron Peninsula and south of, and around Baku. Shipping activities in the waters of the middle and southern Caspian include commercial trade, passenger, scientific, and supply vessel operations for the offshore oil and gas industry. The Baku - Nousheikh (Iran) recommended shipping lane passes approximately close to the west of the Contract Area boundary, and the Baku - Okarem (Turkmenistan) recommended shipping lane passes close to, or possibly through the north-eastern end of the Contract Area. It should be noted that other vessels must give way to survey vessels due to the restricted manoeuvrability of the surveying vessel.

The Shafag Asiman Contract Area is located in close proximity to other existing oil and gas exploitation or exploration sites. The nearest contract area is Zafar Mashal previously operated by ExxonMobil. This is another deep water prospect located adjacent to the Shafag Asiman area to the west. One exploration well showing non-commercially viable reserves has been drilled on this structure, although it is reported that further exploration is expected to be carried out. Approximately 15 km to the north of Shafag Asiman structure is Shah Deniz, the largest gas production field in Azerbaijan, which is operated by BP and began production in late 2006.
5.2 Biological Environment

The Caspian Sea exhibits a relatively low level of biodiversity when compared to water bodies of similar a size and degree of isolation. This level of diversity is effectively depressed by the distinctive physical and chemical properties of the sea’s aquatic environment, as discussed in the previous section. Conversely, it is these same properties that dictate the unique biological environment, and range of endemic and unique organisms, that that subsist in the largest enclosed sea in the world.

5.2.1 Planktonic Communities

Phytoplankton

Phytoplankton of the southern Caspian are typically marine, euryhaline, and brackish water forms, and are considerably less influenced by the freshwater inputs observed in the northern Caspian. Between 1962 and 1974, the total number of phytoplankton species recorded over the whole Caspian Sea was 449 (Kosarev & Yablonskaya, 1994). These species were comprised of 163 diatoms, 139 chlorophytes, 102 cyanophytes, 39 dinoflagellates, 5 euglenophytes and 1 chrysophyte. In addition, it was observed that moving north to south, the species numbers of the phytoplankton decreased, with 414 in north, to 225 in the mid Caspian, and 71 in the south. This reduction in number so of species can be attributed to the reduction of fresh water forms towards the south.

The most numerous phytoplankton of the southern Caspian, in terms of both numbers and species are diatoms, followed by dinoflagellates and cyanophytes (blue-green algae). Of the diatoms, *Rhizosolenia* are generally the most abundant, primarily represented by *Rhizosolenia calcaravis* (also known as *Pseudosolenia calcaravis*). *R. calcaravis* is an invasive diatom from the Black Sea, and is now found to be generally present throughout the year. The species has an exceptionally large cell size, and combined with its abundance, can result in it constituting for up to 90% of the total phytoplankton biomass. In a recent study of the nearby ACG contract area, *Rhizosolenia* along with *Coscinodiscus* and *Chaetoceros*, were found to be the dominant diatom taxa (AOIC, 2009).

Phytoplankton growth follows a seasonal cycle that exhibits two periods of peak biomass, autumn and spring (with the autumnal peak being the larger). During the winter phytoplankton production is low due the decrease in water temperatures and lower levels of sunlight. In spring there is a dramatic increase in growth dominated by species such as *R. calcaravis*. Phytoplankton production remains high throughout the summer but as the sea temperature increases, diatom growth is depressed while dinoflagellate growth such as *Propocentrum* spp, increases. Species such as *Prorocentrum compressum*, *Prorocentrum cordatum* and *Prorocentrum scutellum* dominate, and can constitute almost 50% total phytoplankton abundance (Kideys et al., 2005). Through the autumn the warm waters continue to be highly productive before phytoplankton biomass decreases again in winter (BP, 2000).

Aside from seasonal changes in limiting parameters such as temperature and sunlight, other ecological and environmental conditions play an important role in phytoplankton distribution and abundance in the Caspian Sea. Unfortunately, there are few studies available which discuss the factors influencing these planktonic populations and indeed phytoplankton of the Caspian Sea (Kosarev & Yablonskaya, 1994; CEP, 2000). However, in recent years the introduction of an invasive species of ctenophore, *Mnemiopsis leidyi* is thought to have led to significant shifts in Caspian Sea food webs. The ctenophore is recognised to depress zooplankton populations (mainly copepods, cladocerans and meroplankton) through heavy predation rates. As the zooplankton numbers have decreased, their prey item, phytoplankton, has conversely been subject to abnormal increases (Kideys & Moghim, 2003).

Anomalous Algal Bloom
An anomalous algal bloom occurred in the southern Caspian region during August and September 2005. The area affected covered approximately 20,000 km². It is thought that the bloom originated in the central offshore areas of the southern Caspian (Figure 5.10) shows the algal bloom in relation to the Shafag Asiman contract area), and was caused by the cyanobacteria/cyanophyte *Nodulaira*. The biomass of the bloom was significant, and as the bloom subsequently drifted south toward the Iranian coastline, where it was estimated as having a thickness of over 10 cm at some locations (IFRO, 2006).

The formation of algal blooms is a wholly natural annual occurrence, but when compared to satellite imagery of the region since 2000, this bloom was the largest event in the region since monitoring began. Fortunately, changes in weather conditions caused the bloom to stay off the Iranian coastline and break down, with the only disruption caused to local fishing activities. The bloom, however, is thought to be a sign of changes within the Caspian Sea ecosystem, which are poorly understood.

**Figure 5.10: Anomalous Blue/Green Algal Bloom recorded by MODIS satellite during August and September 2005. Source CEP, Internet 2010. A: shows the AAB on August 17th, B: shows the AAB at its maximal extent on September 1st.**
The southern Caspian is inhabited by approximately 180 species and sub-species of zooplankton, of which 66% are Protista, Rotifera and Cnidaria, 23% are Copepoda and Cladocera, 7% are pelagic crustaceans, and 4% are larvae of invertebrate organisms (Kasimov, 1994). In general Copepoda and Cladocera are the dominant zooplankton groups by biomass and abundance respectively.

Seasonal abundances of the zooplankton are closely related to that of the phytoplankton, with two similar peaks in biomass lagging after those of the phytoplankton, by approximately one month. Zooplankton distribution is also governed by the phytoplankton, although it is not limited by reliance on sunlight and depth in the same way. Consequently, zooplankton often exhibit significant vertical migrations during the daily cycle.

As with the case of the phytoplankton, zooplankton food web structure appears to have been perturbed by events such as the introduction of invasive species. In past years, analysis of southern Caspian zooplankton communities tended to show relatively healthy communities, comprising endemic or acclimated species. Copepod species, such as Halicyclops, Eurytemora, Limnocalanus, and cladoceran species such as Evadne, Pleopsis, Polyphemus were prevalent. Since 2000 however, the diversity of the holoplankton (permanent members of the plankton species, excluding temporary larval forms of fish and benthos) has been severely diminished (AIOC, 2009).

According to a series of recent studies undertaken between 1994 and 2006 (AOIC, 2009), apparent shifts in zooplankton community structure have led to the zooplankton now being chiefly dominated by two species, Acartia tonsa (copepod) and the aforementioned Mnemiopsis leidyi. Although Acartia was found to be one of the more dominant taxa, abundances recorded were relatively low. This would tend to indicate a low level of productivity. However, due to it being so widespread throughout sampling stations, it is envisaged that at present the species represents the main food source available to planktivorous and commercially important fish species, such as kilka, sprat and shad. The ability of Acartia to withstand the indiscriminate predation rates of M. leidyi is attributed to their reproductive cycle, which differs from native zooplankton species.

In terms of the meroplankton (temporary residents of the plankton) in the vicinity of the Shafag Asiman seismic survey area, eggs and larvae of anchovy kilka (Clupeonella engrauliformis), big-eye kilka (C. grimmi) and grey mullet (Liza saliens) may be present. Both kilka species are known to over winter in the southern Caspian at depths of around 500 to 750 m. During the spring adults will migrate toward the middle/southern Caspian for spawning. Additionally, the eggs and larvae of C. engrauliformis may be present in surface waters between April and May, and lower concentrations of C. grimmi may be present from May onwards in deeper water layers, as peak spawning takes place later in the year (Kouliev & Gasymov, 1999).

Eggs and larvae of grey mullet (Liza saliens) may also be present in the vicinity of the contract area at certain times of year. Spawning takes place during June-July in the southern and middle Caspian, at a range of depths between 5-700 m. The pre-larval and larval stages congregate at depths of 10 - 40 m, until they are able to migrate from the central Caspian towards the shallower coastal areas (AETC, 1999).

Non-commercial species such as gobies (Gobiidae) are recognised as being relatively abundant in the offshore area. Mass spawning takes place during June-July in central areas of the southern and middle Caspian where eggs concentrate at water depths of 5-100 m.
5.2.2 Benthic Communities

According to Kasimov (1994) there are 420 macrobenthic faunal species in the Caspian, a large number of which are endemic to the Caspian and Black Sea basins. The faunal composition of the Caspian benthos can be divided into four distinct (genetic) complexes. The most numerous is the autochthonous complex (~80% of total species), followed by the freshwater (~30 species), the Mediterranean (~30 species), while the least represented in the benthos is the Arctic complex (~10 species) (Kosarev & Yablonskaya, 1994). The majority of the alien species found in the Caspian have been introduced over the last 60 – 70 years either deliberately, (to improve the food supply for sturgeon) or unintentionally, through the Volga-Don shipping canal.

Communities of benthos in the Caspian exhibit a relatively low species richness and diversity compared to the open sea. The densest benthic communities are found in the coastal regions at depths of 50-75m. Diversity and abundance generally decrease with a corresponding increase in water depth (BP, 2000).

The distribution of Caspian benthos will normally be dictated by a basic relationship between depth and sediment type. Finer sediments accumulate to a greater extent in deeper water, where the near-seabed water velocities are lower than in shallow water.

Depth and sediment type, although important, are not the only determining factors for benthic community distribution throughout the year. For instance, in summer a combination of poor mixing below the thermocline and high organic deposition rates can lead to an oxygen deficit, which would effectively exclude all but a few tolerant taxa (BP, 2000).

The dominance of the shallow-water communities by species such as bivalve molluscs, are likely to be a consequence of a number of factors. These factors may include the availability of suitable settlement conditions for larvae, organic content of the sediment, sediment particle size, and the availability of suitable attachment substrates for recruited juveniles and adults. The deeper, finer sediments would be less suitable for benthic colonisation. These deeper water zones, which are characterised by reduced oxygen, light and temperature levels, are often dominated by small polychaetes and oligochaetes and amphipods.

Typically communities comprise 10-12 frequently occurring taxa, with a highly variable number of less frequently-occurring taxa. Samples have been taken at a number of stations within the Azeri Chirag and Deepwater Gunashli (ACG) contract area to the north of the Shafag Asiman seismic survey area as part of the ongoing AzSPU Integrated Environmental Monitoring Programme (IEMP). The studies have demonstrated that the variability observed in the benthic communities is a natural characteristic, due in part, to the dynamic nature of the communities (large numbers of species with a rapid growth potential are present) and in part to the scattered nature of the habitat, resulting in a very variable distribution of organisms. Grab sampling as part of the IEMP at the ACG contract area has therefore resulted in organisms being present in reasonably large numbers per sample, or often not present at all.

The predominant deposit and suspension feeding benthic invertebrates are well-adapted to maintaining their position in environments with high sediment deposition rates. In addition their relatively short generation times mean that populations of these animals have the potential to replace losses within months rather than years. Persistent impact is only likely in instances where there is sustained or persistent chemical contamination. Amphipods, for instance, are sensitive to hydrocarbons in sediment and populations may be reduced for as long as significant contamination is present.

Bivalve and gastropod molluscs are also seen to be important constituent benthic groups in the ACG contract area become increasingly important closer to shore (in shallower water) although there are areas offshore where Dreissena and Didacna are present. Bivalves are either deposit feeders (Abra) or filter feeders (Dreissena, Didacna, Cardium, Mytilaster). Bivalves reproduce and grow relatively slowly. Consequently, any damage to these populations can take longer to repair.
Caspian gastropods are a diverse group, all of which are very small and are surface deposit feeders. Under optimal conditions, gastropods are generally capable of achieving high population densities quite rapidly, although there is no evidence of this in surveys of the ACG contract area. In addition larger crustacea, such as cumaceans and isopods, occur throughout the ACG contract area, although only cumacea achieve significant abundance. It is likely that there will be a similarly representative crustacean assemblage within the Shafag Asiman seismic survey area.

5.2.3 Fish

There are approximately 123 species and subspecies of fish in the Caspian and associated river deltas. When compared to that of the Mediterranean (540) and Black sea (180), the number of species found in the region does not appear particularly diverse.

Like the benthic assemblage, Caspian ichthyofauna can be divided into four distinct genetic complexes; endemic or autochthonous, freshwater, Mediterranean and arctic. Endemic fish populations are generally represented by species such as gobies, shad and carp. Of the freshwater complex, five species of sturgeon exist in the Caspian. The Mediterranean species are fewer in numbers, but represent integral links in Caspian Sea food webs. These species include sandsmelt, pipefish and two species of mullet (see Table 5.3).

Many of these fish species have wide geographical ranges within the Caspian, with some migrating long distances to spawn in rivers and shallow water areas. Based on the habitats they occupy, Caspian basin ichthyofauna also fall into four distinct ecological groups (Kouliev & Gasymov, 1999):

- Typical fresh water fish - those that spend their entire lives in the freshwater parts of the Caspian or the lower reaches of rivers. These include tench (\textit{Tinca tinca}) and northern pike (\textit{Esox lucius});
- Anadromous fish – those which feed in the sea before becoming mature and spawning in rivers. These include the sturgeon species, black-backed shad (\textit{Alosa kessleri kessleri}), Caspian salmon (\textit{Salmo trutta caspica}) and inconnu (\textit{Stenodus leucichthys});
- Semi-migratory fish - those which feed in the sea, but breed during the flood water season in the freshwater parts of the Caspian and river deltas. These include the vobla (\textit{Rutilus rutilus caspicus}), kutum (\textit{R. frisii kutum}), Caspian asp (\textit{Aspius aspius taeniatus}), bream (\textit{Abramis brama orientalis}) and common carp (\textit{Cyprinus carpio}); and
- Marine fish - those that spend their entire life cycles in the sea. These include kilka, and the majority of shad and mullet species.

In general, the main distributions of fish in the southern Caspian are to be found in shallow water, usually at a depth of less than 50m. However, within deeper-water areas such as the Shafag Asiman contract area, overwintering fish would be expected to be found. The distribution and spawning times of fish associated with the southern Caspian are illustrated in Table 5.3.

In recent years, declines in Caspian fish populations have been observed over a number of commercial fish species, particularly in sturgeon and kilka (discussed briefly in Section 5.2.7). The decline in surgeon numbers can mainly be attributed to a combination of overfishing and poaching. Sturgeon demand high prices at market, and its roe is highly regarded as a delicacy. Attempts at subsidising sturgeon populations have been undertaken by fish hatcheries, but it is thought that this approach is unlikely to greatly increase natural populations.
The primary commercially caught species in offshore areas are kilka. Anthropogenic pressure in the form of pollution, oil and gas development, unregulated fishing and the introduction of the invasive ctenophore *Mnemiopsis leidyi*, have exerted significant pressures on this fishery, and as a result in recent years the offshore fishery has drastically declined (Section 5.2.7).
<table>
<thead>
<tr>
<th>Family/Species</th>
<th>Recorded in nearby ACG area (2008)</th>
<th>Importance / IUCN Classification</th>
<th>Distribution in southern Caspian</th>
<th>Spawning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sturgeon (Acipenseridae)</td>
<td></td>
<td>All valuable commercial fish</td>
<td>Winters in southern Caspian at depths of 130 - 200 m. Largest concentrations of overwintering fish will be present in coastal areas of the south-west Caspian from November - February, however, individuals may be present within Contract Area.</td>
<td>Migrates to Kura, Sefid Rud, Terek, Ural and Volga all year long to spawn. Migration peaks to Kura are in March / April and October / November, to Volga in March / April and August / October, to Ural in April and August / September.</td>
</tr>
<tr>
<td>Beluga sturgeon (Huso huso)</td>
<td>✓</td>
<td>Very valuable for its caviar as well as a food fish. - IUCN Endangered</td>
<td>Winters in southern Caspian at depths of 130 - 200 m. Largest concentrations of overwintering fish will be present in coastal areas of the south-west Caspian from November - February, however, individuals may be present within Contract Area.</td>
<td>Migrates to Volga, Ural and Terek to spawn between March and November. Migration peaks in July.</td>
</tr>
<tr>
<td>Russian sturgeon (Acipenser gulendstadit)</td>
<td>✓</td>
<td>Very valuable. - IUCN Endangered</td>
<td>Winters in southwest Caspian at depths of 100 - 130 m. Largest concentrations of overwintering fish will be present in coastal areas of south-west Caspian from November - February, however, individuals may be present within Contract Area.</td>
<td>The majority of migratory fish enter the Kura River between April and August with a spawning peak in June. Some older individuals spawn in the Volga and Ural Rivers between June and July.</td>
</tr>
<tr>
<td>Persian sturgeon (Acipenser gulendstadit persicus)</td>
<td>✓</td>
<td>Very valuable. - IUCN Endangered</td>
<td>Found in the South Caspian predominantly at depths of less than 50 m.</td>
<td>Spawns in the Ural and Kura, and occasionally the Terek between April and May.</td>
</tr>
<tr>
<td>Kura barbel (Spine) sturgeon (Acipenser nudiventris)</td>
<td>✓</td>
<td>Fishing for spine sturgeon is prohibited because of diminished stocks. - IUCN Endangered</td>
<td>Winters in southern Caspian at depths of approximately 50 m. Largest concentrations of overwintering fish will be present in coastal areas of south-west Caspian from November – February.</td>
<td>Spawns in Kura, Araks and Sefid Rud between May and August and the Volga, Ural, Terek and Sulak between June and August.</td>
</tr>
<tr>
<td>Kura (South-Caspian) stellate sturgeon (Asipenser stellatus)</td>
<td>✓</td>
<td>- IUCN Endangered</td>
<td>Widespread throughout the Caspian.</td>
<td></td>
</tr>
<tr>
<td>Family/Species</td>
<td>Recorded in nearby ACG area (2008)</td>
<td>Importance / IUCN Classification</td>
<td>Distribution in southern Caspian</td>
<td>Spawning</td>
</tr>
<tr>
<td>----------------</td>
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</tr>
<tr>
<td><strong>Herring (Clupidae)</strong> - <strong>Kilka (Clupeonella spp.)</strong></td>
<td></td>
<td><strong>Commercial fish and an important food source for other fish and seals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anchovy kilka (Clupeonella engrauliformis)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Low Vulnerability</td>
<td>Distribution in the South Caspian is highest in winter when populations may be found at depths of between 35-100 m.</td>
<td>Spawns at shallow depths near the shores of the middle and south Caspian as well as the north Caspian. In the southwest Caspian spawns from February-May in shallow waters.</td>
</tr>
<tr>
<td>Big-eyed kilka (Clupeonella grimmi)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Low Vulnerability</td>
<td>Coastal and offshore waters of southern Caspian.</td>
<td>Spawns at 20-200 m water depth in the middle and southern Caspian between January and September. Larvae distributed into deep water and transported by circular current system.</td>
</tr>
<tr>
<td>Caspian common (ordinary) kilka (Clupeonella delicatula caspia)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Low Vulnerability</td>
<td>Throughout Middle and South Caspian.</td>
<td>Spawning from May - November (with peak spawning in September - October) in middle / southern Caspian at depths of 50 - 200 m. Spawning occurs in circular current system. Eggs and larvae pelagic.</td>
</tr>
<tr>
<td><strong>Herring (Clupidae)</strong> - <strong>Shad (Alosa spp.)</strong></td>
<td></td>
<td><strong>Commercial fish and an important food source for other fish and seals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caspian shad (Alosa caspia caspia)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Least Concern</td>
<td>Winters in the southern Caspian at depths of 30 - 40 m, or deeper. Largest concentrations of overwintering fish will be present in coastal areas of south-west Caspian from November -February</td>
<td>Spawns in shallow waters off mouth of Volga during April to May.</td>
</tr>
<tr>
<td>Family/Species</td>
<td>Recorded in nearby ACG area (2008)</td>
<td>Importance / IUCN Classification</td>
<td>Distribution in southern Caspian</td>
<td>Spawning</td>
</tr>
<tr>
<td>----------------</td>
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<td>----------</td>
</tr>
<tr>
<td>Big-eyed shad (<em>Alosa saposhnikovi</em>)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Least Concern</td>
<td>Overwinters in middle and southern Caspian. Largest concentrations of overwintering fish will be present in coastal areas of south-west Caspian from November - February</td>
<td>Spawns in shallow waters of northern Caspian during April to May.</td>
</tr>
<tr>
<td>Volga shad (<em>Alosa kessleri volgensis</em>)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Endangered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black-backed shad (<em>Alosa kessleri kessleri</em>)</td>
<td>✓</td>
<td>Most valuable commercial shad species. - IUCN Least Concern</td>
<td>Overwinters in southern Caspian along the eastern and western coasts at depths of 50 - 100 m. Largest concentrations of overwintering fish will be present in coastal areas of south-west Caspian from November - February</td>
<td>Spawns in shallow waters of northern Caspian during April to May.</td>
</tr>
<tr>
<td>Dolginka shad (<em>A. brashnikovi brashnikovi</em>)</td>
<td>✓</td>
<td>Valuable food fish - IUCN Least Concern</td>
<td>overwinters in middle and southern Caspian. Migrates to the brackish waters of the northern Caspian for breeding. Largest concentrations of overwintering fish will be present in coastal areas of south-west Caspian from November - February</td>
<td>Spawns in shallow waters of northeast Caspian during April - May.</td>
</tr>
</tbody>
</table>

**Carp (Cyprinidae)**  
All an important food source for other fish and

**Salmon (Salmonidae)**  
Commercial fish and important food source for other fish and seals

<table>
<thead>
<tr>
<th>Family/Species</th>
<th>Recorded in nearby ACG area (2008)</th>
<th>Importance / IUCN Classification</th>
<th>Distribution in southern Caspian</th>
<th>Spawning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caspian salmon (<em>Salmo trutta caspius</em>)</td>
<td>✓</td>
<td>- IUCN Critically Endangered</td>
<td>Western coastal areas of middle and southern Caspian at depths up to 40-50 m.</td>
<td>Spawns in Kura river from October to January.</td>
</tr>
<tr>
<td><strong>Carp (Cyprinidae)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family/Species</td>
<td>Recorded in nearby ACG area (2008)</td>
<td>Importance / IUCN Classification</td>
<td>Distribution in southern Caspian</td>
<td>Spawning</td>
</tr>
<tr>
<td>----------------</td>
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<td>----------------------------------</td>
<td>--------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Vobla</strong> (<em>Rutilus rutilus caspicus</em>)</td>
<td></td>
<td>- IUCN Least Concern</td>
<td>Widespread along the west coast of the South Caspian. Abundant in big and small Kyzyl Agach Bays.</td>
<td>Spawns mainly in the shallow waters of small Kyzyl Agach Bay and Kura River in late March</td>
</tr>
<tr>
<td><strong>Kutum</strong> (<em>Rutilus frisii kutum</em>)</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td>Abundant along western shore of Caspian.</td>
<td>Anadromous fish, spawns in Kura, Terek, Samur, and Lenkoran rivers during late March / early April.</td>
</tr>
<tr>
<td><strong>Caspian asp</strong> (<em>Aspius aspius taeniatus</em>)</td>
<td></td>
<td>- IUCN Least Concern</td>
<td>Mainly in the South Caspian.</td>
<td>Spawns in Kura and Araks rivers during late April</td>
</tr>
<tr>
<td><strong>Caspian bream</strong> (<em>Abramis brama orientalis</em>)</td>
<td></td>
<td>- IUCN Least Concern</td>
<td>Widespread in big Kyzyl Agach Bay and near delta region of the Kura river. Mainly present at the depths up to 10-16 m.</td>
<td>Spawns in the Kura River and small Kyzyl Agach Bay in late April / May.</td>
</tr>
<tr>
<td><strong>Common carp</strong> (<em>Cyprinus carpio</em>)</td>
<td></td>
<td>- IUCN Vulnerable</td>
<td>Widespread in both big and small Kyzyl Agach Bays and Kura tributaries.</td>
<td>Spawning begins in late April. Fish hatcheries also release juveniles.</td>
</tr>
</tbody>
</table>

**Mullet** (*Liza spp.*)

<p>| Commercial fish and an important food source for other fish and seals | Marine fish. Migrates to northern Caspian in spring to feed and migrates south in autumn to overwinter. Migratory path follows the western and eastern coasts of the Caspian, possible passage of fish through the Contract Area. Eggs and larvae may be present in the period August - September. | Spawning takes place during July - November in central areas of the southern and middle Caspian at depths of 300 - 600 m. Eggs small and pelagic. Larvae migrate towards shallower coastal areas. |
| Golden mullet – <em>Liza auratus</em> | ✓ | Food fish - IUCN Least Concern | | |
| Grey mullet - <em>Liza saliens</em> | ✓ | Food fish - IUCN Least Concern | Migrates to northern Caspian in spring to feed and migrates south in autumn to overwinter. Migratory path follows the western and eastern coasts of the Caspian, possible passage of fish through the Contract Area Eggs and larvae may be present in the period | Mass spawning during June-July in central areas of the southern and middle Caspian. Eggs concentrate at water depths of 5-100 m. Larvae migrate from central Caspian towards shallower coastal areas. |</p>
<table>
<thead>
<tr>
<th>Family/Species</th>
<th>Recorded in nearby ACG area (2008)</th>
<th>Importance / IUCN Classification</th>
<th>Distribution in southern Caspian</th>
<th>Spawning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gobies (Gobiidae)</td>
<td></td>
<td>Non-commercial fish but an important food source for other fish and seals</td>
<td>Over 30 species present in Caspian, majority are coastal species, however, several are associated with the deep-water areas of the western shelf. Occur at depths of 40 - 500 m. These species may be present within the Contract Area throughout the year.</td>
<td>Spawn in shallow coastal waters, down to 70 m, during April / May. Eggs benthic. Not very prolific fish, number of eggs ranges from 3,000 - 6,000 (Kouliev &amp; Gasymov, 1999).</td>
</tr>
<tr>
<td>Caspian goby - Neogobius caspius</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Round goby - Neogobius melanostomus affinis</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caspian syrman goby - Neogobius syrman eurystomus</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monkey goby (Neogobius fluviatilis pullusi)</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caspian big-headed goby (Neogobius kessleri gorlap)</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knipovich long-tailed goby (Knipowitschia longicaudata)</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grimm big-headed goby (Benthophilus grimmi)</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family/Species</td>
<td>Recorded in nearby ACG area (2008)</td>
<td>Importance / IUCN Classification</td>
<td>Distribution in southern Caspian</td>
<td>Spawning</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Other Species</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandsmelt (Atherina mochon pontica)</td>
<td>✓</td>
<td>- Not Evaluated</td>
<td>Present in southern Caspian throughout the year. Major concentrations in shallower coastal waters, only individuals found in offshore areas, usually at water column depths of 5 - 10 m.</td>
<td>Spawning has been recorded in south-west part of northern Caspian, near the Peninsula of Buzachi and in Kyzyl-Agach Bay during April / May.</td>
</tr>
<tr>
<td>Pipefish (Syngnathus nigrolineatus)</td>
<td>✓</td>
<td>- IUCN Least Concern</td>
<td>Plankton feeding marine fish. Numerous but do not concentrate in shoals. Majority in shallower coastal areas, only individuals found in deep water areas.</td>
<td>Spawning all over Caspian during spring/summer period but mainly in coastal areas. Eggs and larvae held in pouch in adult male, therefore eggs and larvae not in the meroplankton.</td>
</tr>
<tr>
<td>Caspian lamprey (Caspiomyzon wagneri)</td>
<td></td>
<td>- IUCN Near Threatened</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.2.4 Marine Mammals (Caspian Seal)

The Caspian seal is the Caspian Seas sole marine mammal representative. The Caspian seal is the world’s smallest seal, and is endemic to the Caspian basin. This species is now listed in the IUCN Red List as ‘endangered’ as of 2008, having recently being upgraded from ‘vulnerable’. This change in conservation status is a direct result of the species undergoing a 50% reduction in overall numbers over the past three generations. It has also been estimated that seal numbers have declined from 400,000 to 111,000 over the past decade (AIoC, 2009). The decline in seal numbers can be attributed to a wide range of factors such as; hunting, wide scale reductions of prey items (esp. *kilka* sp.) due to *Mnemiopsis*, fishing activities, outbreaks of a phocine strain of canine distemper virus (CDV), and pollution originating from oil and gas activities, heavy metals and organic pesticides. 2005 and 2006 estimates of the total seal populations are around 111,000 individuals (CISS, 2006). Most recent estimates of the Caspian seal populations have been estimated in AIoC (2010b) to be further reduced from the 2005/2006 population numbers (CISS, 2008).

Mass mortalities of seals have occurred in spring of 1997, autumn 1999, and throughout the spring of 2000. These events have since been determined to be the result of CDV, exacerbated by coincidental poor ice formation in the northern Caspian (resulting in crowding together of the breeding populations, increasing social contact and aiding the spread of the distemper virus) (Reeves *et al.*, 2002).

The majority of the Caspian Seal population (85 - 90%) spend the winter breeding season in the Northern Caspian, where water conditions are brackish and shallow, with depths of 2–10 m. The freezing of this northern habitat provides for a critical breeding habitat for the seals. Pups are born on the ice surface from the end of January to the beginning of February, and weaned after 4–5 weeks. Shortly after, mating takes place between mid-February and mid-March.

Once the ice has begun to melt, the seals begin a southerly migration along the shelf zones where they will spend the summer months feeding. This migration has two routes, the majority along the eastern Caspian coast with a minority along the west. Seals are known to reach the coastal areas of the mid/south Caspian at around April/May, with peak accumulations at the end of May. Dependent upon the severity of the winter period, the seals initially confine their feeding range to the coastal waters where they replenish their fat reserves, which can be depleted by up to 50%. Figure 5.11 shows the approximate extent of seasonal feeding areas for seals throughout the Caspian, with regards to the Shafag Asiman seismic survey area.

At this time they are particularly vulnerable, as the ability of the seals to swim will have decreased, and they cannot sustain long period in the open water. Subsequent to these initial feeding stages, which are closely associated with the coast, their fat reserves have been replenished and therefore buoyancy restored. At this point the seals will start moving into the deeper water areas of the middle and southern Caspian (during May to June), where the *kilka* populations are concentrated, returning periodically to their haul-out sites. The proposed study area is likely to be utilised by seals from a number of regional populations during this feeding period. The remaining 10-15%, of non-migratory individuals (mainly juveniles and non-breeding individuals), remain in the middle and southern Caspian year round.

From June onwards seal densities may increase in the vicinity of the Shafag Asiman seismic survey area as both the migratory and non-migratory seals move from the coastal shallows to deeper waters to feed. The majority of seals, however will tend to congregate further inshore and further south where the greatest proportions of their primary prey species (namely *kilka*) are concentrated. They will remain in these feeding areas for the majority of the summer months returning periodically to coastal haul-out sites to rest.
Previous studies indicated both seasonal and year-round haul out sites on the remote coastlines and offshore islands of the Absheron Peninsula Gadjiyev & Aybatov (1998, and 1999). These areas included Shahdili Spit, Chilov Island, Kichik Tava (Malaya Plita), Boyuk Tava (Bolshaya Plita), and Tavaalti (Podplitechniy) Island. It is worth noting however, that more recent surveys of the Absheron haul outs recorded no animals present (CISS, 2006), and as such it is thought that these areas are no longer of particular importance to the remaining seal populations. It is thought that the traditional haul outs of the Absheron archipelago are now used on a short-term basis during migration to and from southern Caspian waters in spring and autumn, rather than on a permanent or seasonal basis (AIOC, 2010b). Seal numbers in Azerbaijan’s waters peak during spring around the Absheron offshore islands. This same period will also correspond with greatest numbers of seals in the vicinity of the Shafag Asiman seismic survey area. During autumn seals will also be expected to be present in this area as they migrate northward. Summer and particularly winter represent periods of lowest sensitivity for seals in the vicinity of the Shafag Asiman area.

The likelihood of significant numbers of seals remaining for extended periods in the vicinity of the Shafag Asiman seismic survey area is considered low, and those that do remain will not be in significant population numbers.
Figure 5.11: Approximate seasonal Feeding Areas for Seals in the Caspian. (After AIOC, 1996). A: Spring; B: Summer; C: Autumn; and D: Non-Migratory seals in Winter.

A: Feeding areas of seals in Spring

B: Feeding areas of seals in Summer
C: Feeding areas of seals in Autumn

D: Feeding areas of non-migratory seals in Winter
### 5.2.5 Birds

The coastal areas of the southern Caspian, particularly those sensitive areas on the coast of Azerbaijan, including the Kyzyl Agach Reserve, the Absheron Peninsula and the Kura Delta, lie on important migratory routes for a number of migrating bird species. 119 bird species of European conservation concern regularly breed in Azerbaijan and its coastal areas. In addition, 54 species of conservation concern (on the International Union for Conservation of Nature (IUCN) Red List) regularly over-winter or occur during passage (Heath and Evans, 2000). Large numbers of birds (divers, grebes, swans, geese, ducks, waders and coot) migrating to and from Asia, the Middle East and Europe, utilise these coastal areas of the southern and Mid Caspian between August and December, during their southward migration, and between February and June on their way north (AETC, 1999). Birds originating from the central and north-western districts of Russia may migrate to the coast along the Volga River. In the delta areas of the Volga, this stream of migrant birds merges with those from Asia. The Ural and Emba rivers are also recognised important migratory paths. Accordingly, the area is considered to be of national and international ornithological importance. Internationally designated areas for bird conservation on the Caspian coasts in the Middle Caspian are shown in Figure 5.12.

In offshore areas, such as the vicinity of the Shafag Asiman seismic survey area, there is little baseline information pertaining to the distribution and abundance of birds. It can only be inferred from studies at other contract areas of what resident bird populations are to found within the study area.

During the winter red-throated and black-throated divers from Russian breeding populations have been found in Azeri waters. Birds such as these range further offshore than wildfowl and coot species, and as a result, may be expected to be found in the seismic survey area. In addition, gulls (Larus sp.), particularly the herring gull (Larus argentatus) may be found all year round in the vicinity of the Shafag Asiman seismic survey area, as they are generally widespread though the Caspian offshore area. Other bird species regularly recorded offshore include Great cormorant (Phalacrocorax carbo), Common tern (Sterna hirundo), and the Sandwich tern (Sterna sandvicensis) (AIOC, 2009).

It should also be noted that aside from the more resident offshore species, offshore areas may well accommodate a transient population of migratory birds at any given time.
Figure 5.12: Internationally designated areas for coastal and wetland bird conservation
5.3 Summary of Sensitivities and Identification of Focal Issues

The environmental description is focused specifically on the components of the environment within the southern Caspian Sea basin, and in particular in the vicinity of the Shafag Asiman seismic survey area, that may be potentially impacted by the proposed operations.

The seasonal activities of the higher organisms within the Southern Caspian are summarised briefly below and described in more detail in the Biological Environment section (Section 5.3). It can be concluded that as a result of the fact that the Shafag Asiman seismic survey area is a significant distance offshore (Figure 5.1) that:

- the seismic survey area is not of particular importance for feeding, roosting, breeding or moulting for the bird populations of the southern Caspian (pers. comm. Gara Mustafayev, 1999). The closest sensitive bird areas are located on the coast of Azerbaijan and are described in Section 5.3.5;

- the commercial fish species big-eyed kilka, anchovy kilka, grey mullet and golden mullet could be expected to be present in the seismic survey area at certain periods throughout the year (typically spawning periods are between late Spring and Autumn for the main commercial species). However, fishing activity within the seismic survey area is not considered commercially viable due to the remoteness from the fish landing ports and relatively low concentration of commercial fish species (Kouliev & Gasymov, 1999). Further to this in recent years the offshore fishery has become severely depleted and a resulting change in catch dominance has meant that the offshore fishery tends to target shallower waters during summer months for ordinary kilka, rather than at the deeper water fishing banks which have traditionally been fished for anchovy kilka (AIOC, 2010); and

- it is likely that seals would feed within the seismic survey area during the summer months, however, the area is not recognised as being particularly important as a feeding area for seals as the majority tend to congregate in shallower shelf areas where kilka species are concentrated. These shelf areas are a significant distance to the north and west of the seismic survey area. In addition recent surveys of the traditional haul outs in Azerbaijan’s shelf waters did not indicate recent usage (CISS, 2006). Moreover the overall population of Caspian seal has suffered a drastic decline in recent years (as described in section 5.3.4) and as a result it is not thought that the shelf waters of Azerbaijan are of the same importance for non-migratory and summer feeding/resting seals as in previous years. The area is anticipated to be of highest sensitivity for seals to seismic survey in spring during the southward migration, and to a lesser extent during autumn, when seals migrate north to breed (AIOC, 2010b).

For lower organisms, the main findings are summarised as follows:

- the seismic survey area is characterised as a deep water area (depth range approximately 650 m - 900 m. As a consequence, the benthic fauna of the area is impoverished in terms of both species composition and biomass. The benthic community is not considered to consist of specialist species adapted to and restricted in their distribution to deep water areas;

- the zooplankton of the seismic survey area is typified by a diversified species composition, dominated, in terms of biomass, by copepods down to depths of 200 m. Below 200 m the zooplankton consists of an homogenous species composition consisting of mysids, amphipods and copepods. The main zooplankton concentrations are found at depths down to 50 m. Seasonal peaks in zooplankton biomass have been recorded in the southern Caspian in summer. Pelagic eggs and larvae of anchovy kilka and golden mullet may be found in the meroplankton, whilst the eggs and larvae of big eye kilka and grey mullet may be present in the deeper water layers. Eggs and juveniles of commercial species will be present in the zooplankton for periods that correspond approximately with the spawning periods of these species; and
• the phytoplankton of the southern Caspian is dominated, in terms of biomass, by diatoms at all depths. Phytoplankton concentrations have been recorded in water depths ranging from 0 - 56 m, with peak biomass observed in the photic zone (depth range 0 – 25 m). Seasonal peaks in phytoplankton biomass in the southern Caspian have been recorded in spring and autumn.
6. IMPACTS OF AIRGUNS ON MARINE LIFE AND RESOURCES

6.1 Introduction

Previously, and as late as the 1960s in some places, the most commonly used energy source for offshore seismic surveys was chemical explosives. However, due to safety issues and the negative environmental impact on marine life, their use has been largely superseded by other sources such as water guns, gas detonators, spark generators and predominantly airguns.

During the proposed seismic survey, airguns will be used as the seismic source. The following chapter, therefore, firstly presents a summary review of environmental impacts from airgun operation in the marine environment as reported in the literature. This information, together with current knowledge of the environmental sensitivities of the seismic survey area is then drawn on to describe the potential environmental impacts in the vicinity of the seismic survey area.

Many studies have been undertaken at various locations worldwide to assess both potential physical damage and interference with normal daily activities associated with acoustic disturbances generated by airguns during seismic survey work. These studies have encompassed the assessment of effects on macrobenthic and planktonic organisms, fish and fisheries, birds and marine mammals. Caspian specific studies include those addressing the effects on adults and juveniles of sturgeon and other fish species (Kasimov et al. unpublished). These were presented as a seismic workshop held in Baku in October 1997 (ERT, 1997).

6.2 Literature Review

6.2.1 Macrobenthos

A limited number of studies assessing the impact of seismic operations on macrobenthic communities have been reported in the literature. These studies have tended to focus on potential impacts to macrobenthic species of commercial importance. According to Kosheleva (1992), who conducted trials within the Barents Sea (water depth 63 m), airgun arrays with volumes of 60 - 180 cubic inches (deployed at water depths of 6 m and 3.5 m) and source levels of 220 - 240 dB re1µPa @ 1 m, had no effect on caged macrobenthos at distances of more than 1 m from the seismic source. This finding was supported by Otto et al. (1995) following a survey carried out in a German lake. This study indicated no damage to macrobenthos following the use of airguns.

The findings of several more key studies on the assessment of the potential impact of seismic operations on specific macrobenthic organisms are summarised in Table 6.1.
<table>
<thead>
<tr>
<th>Author</th>
<th>Species</th>
<th>Experimental work</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Webb &amp; Kempf, 1998.</td>
<td>Brown shrimp</td>
<td>Wadden Sea. Array of 15 airguns, total volume 480 cubic inches at 2,000 psi. Source level 190 dB re 1 µPa @ 1m. Water depth 2 m.</td>
<td>Observations during the survey showed no mortality of shrimp and no evidence of reduced catch rates. Impact limited due to lack of gas voids and rigid exoskeleton.</td>
</tr>
<tr>
<td>La Bella et al. 1996.</td>
<td>Venerid clam</td>
<td>Central Adriatic Sea. Array of 16 airguns, total volume 2,500 cubic inches at 2,000 psi. Intensity 210 dB/Hz re 1 µPa @ 1m. Water depth 15 m.</td>
<td>Sampled using a commercial clam dredge. Same density estimates were obtained from the dredge samples before and after the seismic acquisition with no evidence of clam mortalities.</td>
</tr>
<tr>
<td>Steffé &amp; Murphy, 1992.</td>
<td>Prawns</td>
<td>New South Wales coast - Australia. Monitored co-operative catch data before and after a seismic survey.</td>
<td>Unable to show any significant effects on prawn catch rates before, during or after seismic survey.</td>
</tr>
</tbody>
</table>

### 6.2.2 Plankton and Fish Recruitment

Planktonic organisms can be divided into two broad divisions, the phytoplankton (photosynthetic plankton largely capable of independent growth, mostly unicellular algae) and zooplankton (heterotrophic organisms which are dependent on other organisms as a food source). The zooplankton can be further divided into:

- holoplankton (organisms which spend all of their life in the plankton);
- meroplankton (planktonic organisms which only spend part of their life in the plankton, such as the eggs and larvae of fish and invertebrates); and
- pleuston (organisms whose bodies lie simultaneously in the air and water).

The phytoplankton forms the major basis for the marine food chain. Phytoplankton species are characterised by relatively resistant unicellular structures and short generation times, ranging from a few doublings per day for the faster growing species, to one doubling every week to ten days for the slower growing species (Harris, 1986). Their natural population dynamics are further characterised by high mortality rates and marked patterns of seasonal and annual fluctuations in abundance.

Zooplanktonic organisms are multicellular, and have organs and tissues, which are more sensitive, at close proximity to the airgun, to pressure waves created by the airgun. The degree of exposure of zooplankton to the seismic airgun array is dependent upon abundance, spatial distribution, seasonal timing and the duration of the seismic survey.

The normal seasonal fluctuations in zooplankton abundance typically closely follow the phytoplankton blooms in the spring and autumn. Daily variations in vertical distribution of zooplankton are typically observed, with many species undergoing migrations to the surface layers at night. As for phytoplankton, natural population dynamics for zooplankton are characterised by short generation times and high natural mortality rates, with some species having natural mortality rates as high as 99.999% per generation (McCauley, 1994).

The holoplankton is generally the dominant component of the zooplankton, with copepods making up the bulk of the biomass. The copepods are an important food source for many organisms (Raymont, 1983). However, it is the meroplankton, especially fish eggs and larvae, that have been the focus of studies reported in the literature, as the fitness of these stages of the fish life cycle is considered to be an important factor in determining adult fish population structure (Doherty & Williams, 1988).
The findings of several key studies undertaken to assess the extent and type of injuries to eggs and larvae exposed to airguns are summarised in **Table 6.2**

<table>
<thead>
<tr>
<th>Author</th>
<th>Experimental work</th>
<th>Results and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kosheleva, 1992</td>
<td>Source level 220 dB re1µPa @ 1m.</td>
<td>Eggs and larvae of plaice died at 1 m distance, but uninjured at 2 m.</td>
</tr>
<tr>
<td>Matishov, 1992</td>
<td>Source level 250 dB re1µPa @ 1m.</td>
<td>Damage to 5 day old cod at distances of 1 m. Delamination of the retina.</td>
</tr>
<tr>
<td>Dalen &amp; Knutsen, 1987</td>
<td>Source level 222 dB re1µPa @ 1m.</td>
<td>No mortality of cod eggs and larvae (small airgun Bolt 600B).</td>
</tr>
<tr>
<td>Holliday <em>et al.</em> 1987</td>
<td>Source level 223 dB re1µPa @ 1m.</td>
<td>Damage to eggs and larvae of anchovy at distances up to 2 m. Possible mortality of larvae at 2 m.</td>
</tr>
<tr>
<td>Kostyvchenko, 1973</td>
<td>Source level 230 dB re1µPa @ 1m.</td>
<td>Injuries to eggs of red mullet, anchovy and various other species, within a radius of 5 m. Damage included deformation of the outer egg membrane, spiral curling of the embryo, displacement if the embryo and damage to the vitelline membrane.</td>
</tr>
</tbody>
</table>

**Source:** Adapted from DNV, 1993

The findings of these studies indicate that injuries and mortality to eggs and larvae are highest at close range, within 2 m of the source, and decrease rapidly with distance from the gun. Outside a range of 5 m no effects are demonstrated (Kostyvchenko, 1973).

In an attempt to update this data and determine the internal injuries that eggs, larvae and fry might exhibit, studies on the impacts of airguns on the early life stages of fish were continued at Havforskningsinstituttet (the Norwegian Institute of Marine Research) during 1992 and 1995.

The findings of these investigations confirmed those of previous experimental work. Mortality effects for fish eggs were demonstrated up to a distance of 5 m from the airgun source. For yolk-sac larvae the mortality rate was especially high, ranging from 40 - 50% at distances of 2 - 3 m. Lower mortality rates were demonstrated for anchovy at the same distances (Dalen *et al.*, 1996).

Experiments investigating later life stages such as larvae, post-larvae and fry revealed that relatively high mortality rates were found in plaice with 10 - 20% mortality at a distance of 2 m, and pronounced mortality was also shown in cod at 5 m. Increased mortality rates at the post larval stage were also demonstrated at 1 - 2 m from the seismic source (Dalen *et al.*, 1996).

Other observed effects included changes in the organisms buoyancy, which influences the ability to avoid predators, and the condition of the larvae which in turn affects their ability to survive (Dalen *et al.*, 1996).

This experimental data indicates that seismic surveys only cause direct damage to eggs and larvae within a very limited area around the seismic source that varies depending on species (up to 5 m from the source). As a result of the findings of this work, the Norwegian Authorities made the decision not to impose restrictions on survey work on the basis of damage to fish eggs, larvae and fry (Webb & Kempf, 1998). The findings indicated that the effect of seismic surveys at the population level, in terms of species recruitment, is not statistically significant (Dalen *et al.*, 1996) as ichthyoplankton species are generally widely distributed, and recovery, in terms of both abundance and diversity, is usually rapid in response to localised impacts. McCauley (1994) demonstrated that the fraction of the meroplankton affected during an airgun survey is much less than 1% of the natural mortality.
In addition, stochastic (chance) events may also grossly override any deterministic processes involved in larval replenishment. Hence events such as storms, and plankton drift may completely mask any effects from seismic surveys (McCauley, 1994).

6.2.3 Adult Fish

Several studies have been performed to determine whether seismic airguns cause damage to adult fish. Field experiments have been conducted using penned fish held at different distances from a seismic source. The findings of some of the key studies are shown in Table 6.3.

<table>
<thead>
<tr>
<th>Author</th>
<th>Experimental work</th>
<th>Results and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Bella et al.</td>
<td>Captive fish in cages at 12 m depth. Airgun array 210 dB/Hz re1µPa @ 1m. Seismic vessel passed at a minimum of 150 m.</td>
<td>200 Sea Bass. Behavioural response to the approach of the sound source, but no lethal event was recorded on captive sea-bass immediately after the seismic shooting. The cage was recovered after 6 hours, no evidence of traumatic effects on fish skeleton structure.</td>
</tr>
<tr>
<td>Matishov (1992)</td>
<td>Single airgun. 226 dB re1µPa @ 1m.</td>
<td>Transient stunning; cod died within 48 hours owing to internal injuries.</td>
</tr>
<tr>
<td>Kosheleva (1992)</td>
<td>Single airguns and arrays. 1,000 - 3,000 cubic inches Source level 220 - 240 dB re1µPa @ 1m.</td>
<td>50% of Barents Sea cod, subject to airgun emissions, with peak sound pressure levels estimated in the range 220 - 240 dB, suffered damage to blood cells, internal bleeding and eye injuries when in the immediate vicinity (i.e. within 0.5 m) of the firing airgun or array.</td>
</tr>
<tr>
<td>Falk &amp; Lawrence</td>
<td>Single airgun 4916 cm³ Source level 230 dB re 1µPa @ 1m.</td>
<td>Caged whitefish exposed to a single large airgun resulted in several fish with swimbladder damage.</td>
</tr>
<tr>
<td>Kasimov et al.</td>
<td>Sound waves of pressure 150 kg / cm²</td>
<td>Results indicated fatalities (of up to 32%) only for fish immediately under the sound source. No fatalities were recorded for distances 1 m to 3 m from the source.</td>
</tr>
</tbody>
</table>

The findings of the experimental work reviewed indicate general threshold levels for potential pathological and lethal effects in fish. The findings further indicate that beyond a range of 0.5 - 1 m from the airguns, no fish are killed. Internal injuries appear to occur in fish at received sound pressure levels of 220 dB, which only occur very close to the source, and general auditory damage from 180 dB (Turnpenny & Nedwell, 1994). The pressure pulse generated by airguns is considered to be the most important factor leading to tissue damage in fish. In particular, Gausland (1992), reports that fish killed within a distance of 0.5 m of airguns had ruptured swimbladders.

Under natural conditions, fish detect the sound of airguns at long distances, and healthy adult fish will exhibit avoidance behaviour, moving away from the sound source. The fish sense both the strength and direction of the sound produced by airguns as the frequency spectrum, 10 - 200 Hz, coincides with the most sensitive region of fish hearing, 20 - 700 Hz (see Figure 6.1). The hearing capabilities of fish indicate that the sound of a full-scale airgun array may be heard at a distance of more than 100 km (Dalen et al., 1996). The type of behavioural response that may be elicited in response to a range of source levels is summarised in Table 6.4.
Figure 6.1: Fish Responses to Different Sound Levels

Table 6.4: General key threshold values for behavioural effects in fish

<table>
<thead>
<tr>
<th>Source level</th>
<th>Behavioural effect</th>
<th>Range from airgun for these effects to be exhibited</th>
</tr>
</thead>
<tbody>
<tr>
<td>160 dB re 1µPa</td>
<td>Subtle changes</td>
<td>2.1 - 12 km</td>
</tr>
<tr>
<td>180 dB re 1µPa</td>
<td>Alarm response, e.g. tight milling</td>
<td>630 - 2,000 m</td>
</tr>
<tr>
<td>200 - 205 dB re 1µPa</td>
<td>Startle response, e.g. attempts to flee</td>
<td>100 - 316 m</td>
</tr>
</tbody>
</table>

Source: Based on McCauley, 1994

Fish avoidance capacity is largely determined by their size, and it is expected on the basis of established knowledge of swimming ability, that most fish bigger than 30 - 50 mm will swim away and keep a safe distance from the passing seismic source. Hence injuries caused by seismic survey activity would be expected to be restricted to the juvenile stages (i.e. fish less than 50 mm in length).

6.2.4 Fishing Catch and Effort

Geophysical surveys have been conducted continuously in the North Sea for about 40 years. During recent years, seismic survey vessels have been operating on fishing grounds in the Norwegian and Barents Seas. The relevant studies have been focused on the assessment of the potential impacts of seismic activities on catch rates for the fishing industry.

Observations during seismic surveys indicate that fish swim away from seismic sources. Løkkeborg (1991) investigated longline catches off northern Norway in the presence of a two week seismic survey with peak source levels of 238 dB re 1µPa @ 1m. Catch was reduced by 55 - 80% within the survey area and there was a reduction in catch up to a distance of 5 km.
However, catches were observed to return to normal within 24 hours after shooting had stopped.

In the same area, Løkkeborg & Soldal (1993) investigated effects of seismic shooting with source levels of about 239 - 250 dB re 1µPa @ 1m. Trawls were made before, during and after shooting. Cod catches during shooting were reduced by 79 - 83% compared to pre-shooting levels within the acquisition area and up to 9 km from the area. When the shots ended the catches were observed to return to pre-shooting levels within 12 hours.

Probably the most detailed study of changes to fish distribution caused by seismic activities is that of Engas et al. (1993) from the Norwegian Institute of Marine Research, in 1992. Seismic shooting was shown to significantly affect the distribution of two demersal fish species, cod and haddock, even at distances as great as 18 nautical miles from the source. Catch rates were recorded and these showed a reduction of around 50% in the average trawl catch rate for the entire area following the start of seismic shooting. In the centre of the shooting area, reductions as great as 70% were recorded. In this case there was no sign of an increase in cod or haddock from either acoustic mapping data or trawl catches five days after seismic firing had ceased. It has been concluded that it presumably takes a period of time for fish to re-invade an area following its depletion, this may be due to the movement back into the area being less directed than the movement out, or it may be dependent upon the species and how sedentary it is (Evans & Nice, 1996).

Observations have also been made of airguns affecting the shoaling behaviour of fish. Demersal fish species tend to dive away from the suspended sound source into deeper water (Evans & Nice, 1996). This has been demonstrated in experiments conducted by Løkkeborg & Soldal (1993) where they observed the effects of a 20 - 40 airgun array on saithe off the coast of northern Norway. Trawling experiments indicated that the saithe had remained in the area but had gone deeper. Chapman & Hawkins (1969) found from sonar observations that whiting descended to deeper than 54 m when a single airgun was operated.

Dalen & Knutsen (1987) observed the shoaling effects of pelagic fish, particularly blue whiting. Using a 40-gun array with a peak output pressure of 250 dB in the North Sea, they found that the echo-abundance of blue whiting in the survey area was reduced by 54%. Subsequent bottom trawl samples of the seabed to determine whether the fish had descended deeper did not contain any blue whiting; this suggests that they had migrated out of the area.

It should be noted that any effect on fisheries is likely to be a transient one which, whilst it may result in increased fishing effort in the vicinity of the seismic survey area, is unlikely to be of lasting harm to the fish populations. It would also be logical to expect the possibility of higher catches in the areas to which the fish have been displaced. There is some evidence that short exposures to seismic sound may drive some demersal species to the seabed, rendering them more catchable by bottom trawling methods (Turnpenny & Nedwell, 1994).

In summary, the findings of studies undertaken in both the North Sea and the Adriatic Sea indicate that the adult fish were observed to exhibit avoidance behaviour resulting in temporary displacement from the seismic survey area. The extent of this displacement was however considered to fall within the normal geographic range of the species, with recovery of pre-seismic catch levels demonstrated.

### 6.2.5 Marine Mammals

Generally, physical damage to seals is unlikely, due to their specialised adaptations to diving. These adaptations include strengthened lung and air passages, and mechanisms to equalise head space air pressure with surrounding water pressure. Gordon et al., (1998) suggested several impacts that could possibly affect marine mammals as a result of seismic surveys, these are outlined in Table 6.5.
Table 6.5: Possible impacts upon marine mammals from seismic surveys

<table>
<thead>
<tr>
<th>Physical Effects</th>
<th>Behavioural Effects</th>
<th>Indirect Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage to body tissues or ears</td>
<td>Masking of biologically significant noises by man-</td>
<td>Reduced prey availability resulting in reduced feeding</td>
</tr>
<tr>
<td>Permanent threshold shift</td>
<td>made noise</td>
<td>rates</td>
</tr>
<tr>
<td>Temporary threshold shift</td>
<td>Disruption of normal behaviour</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Gordon et al., 1998

In deeper waters, sound may be concentrated within particular layers and thus transmitted over greater distances than in shallower waters. Therefore, for deep diving animals (see Table 6.6) it is possible for them to enter regions in which the received sound levels are even higher than those measured or predicted close to the surface, including those zones in the immediate vicinity of the sound source (Gordon et al., 1998). As a diving animal is normally on a strict energy budget to allow for a dive of a certain duration and depth, energetically costly activities, such as rapid swimming, may not be possible towards the end of a dive when oxygen stores will be at a minimum.

Table 6.6: Recorded typical diving depths for marine mammals

<table>
<thead>
<tr>
<th>Source</th>
<th>Species</th>
<th>Diving Depths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thompson et al. (1998)</td>
<td>Grey seal</td>
<td>Commonly dives to 200 m. Capable of diving to 400 m</td>
</tr>
<tr>
<td>Thompson et al. (1998)</td>
<td>Harbour seal</td>
<td>Commonly dives to 100 m</td>
</tr>
<tr>
<td>Delong &amp; Stewart (1991)</td>
<td>Elephant seal</td>
<td>Recorded depths of 1,000 m</td>
</tr>
<tr>
<td>Watkins et al. (1993)</td>
<td>Sperm whale</td>
<td>Regularly makes dives in excess of 1,000 m</td>
</tr>
<tr>
<td>Gadjiev &amp; Aybatov (1999)</td>
<td>Caspian seal</td>
<td>Normally 10 m, but capable of diving to 100 - 120 m</td>
</tr>
</tbody>
</table>

Physical Effects

The critical factor in the ability of a pressure wave to cause physical damage depends on the wave’s rise time. There is no direct evidence that seismic pulses cause acute physical damage to marine mammals, however, there have been limited studies conducted on this topic. Having been adapted through evolution to be sensitive to sound, ears are the organs most likely to be vulnerable to damage from it. Hearing is the most important sensory modality for marine mammals underwater and the ability to hear well seems to be vital in many important aspects of their lives such as finding food, navigating, finding mates and avoiding predators. Exposure to sufficiently intense noise can cause a reduction in hearing sensitivity (an upward shift in the threshold). These can be temporary threshold shifts (TTS) with recovery after minutes or hours, or permanent threshold shifts (PTS) with no recovery. Temporary threshold shifts have recently been discovered in a bottlenose dolphin exposed to pulses of narrow-band sound underwater and in a harbour seal exposed to industrial noise from sand blasting (Gordon et al., 1998). There have been no direct observations of noise induced PTS in marine mammals.

Behavioural Effects

The extent of physical damage to seals from seismic survey is likely to be very limited as they generally exhibit avoidance behaviour, in the same way as fish, to seismic noise. Available data (McCualey, 1994) suggests that marine mammals avoid seismic vessels within a 1 - 3 km range (i.e. when received impulse levels reach 160 - 170 dB re 1 μPa). Seals are therefore unlikely to be in the immediate vicinity once seismic operations have begun.
There have been few studies on the reactions of seals to seismic survey noise. However, detailed observations of behavioural and physiological responses of harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) have been reported by Thompson *et al*. (1998). These researchers conducted one hour playbacks with small airguns to individual seals that had been fitted with telemetry packs. The telemetry packs allowed the seals’ movements, dive behaviour and swim speeds to be monitored and provided detailed data on the animals’ responses to seismic pulses.

Harbour seals showed short term startle reactions, evidenced by a sudden profound drop in heart rate (bradycardia) and in six out of eight trials showed avoidance reactions to simulated seismic surveys using a three times 30 cubic inch airgun array and a single 20 cubic inch (0.33 litre) gun at ranges of 2 km. In four cases the seals reverted to the undisturbed foraging pattern within minutes of the end of firing. In two cases the animal swam to a haul out site apparently in response to the guns. Grey seals also showed avoidance reactions, moving away from the source and increasing their swim speed. All test animals continued to, or returned to, forage in the areas where they were exposed to airgun sounds (Thompson *et al*., 1998). These results are summarised in Table 6.7 along with data from experiments with ringed and bearded seals.

### Indirect Effects

The indirect behavioural responses of seals are perhaps of more concern than direct physical damage, as they could potentially result in lowered survival or reproductive success (Evans & Nice, 1996). Behavioural changes such as disruption of normal feeding, breeding and migration patterns are all potential effects brought about by seismic survey. These effects are a consequence of the avoidance behaviour of seals to seismic surveys and the displacement of seal populations due to reduced prey availability and the need to search for a new food source (Evans & Nice, 1996).

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Observation</th>
<th>Source</th>
<th>Water depth</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey seal</td>
<td>Scotland and Sweden</td>
<td>Experimental playback. 1 hour exposure.</td>
<td>Single Gun or small array (215 - 224 dB re 1 µPa - 1 m)</td>
<td>20 - 100 m</td>
<td>Avoidance. Change from feeding to transiting behaviour. Haul out. Apparent recovery c 20 minutes after trial.</td>
</tr>
<tr>
<td>Common seal</td>
<td>Scotland and Norway</td>
<td>Experimental playback. 1 hour exposure.</td>
<td>Single Gun or small array (215 - 224 dB re 1 µPa - 1 m)</td>
<td>20 - 100 m</td>
<td>Initial fright reaction. Babycardia. Strong avoidance behaviour.</td>
</tr>
<tr>
<td>Ringed seal</td>
<td>Alaska</td>
<td>Operating seismic</td>
<td>Array of 11 x 120 cubic inch (21.6 litres) guns 222 - 213 dB re 1 µPa - 1 m</td>
<td>&gt; 15 m</td>
<td>Avoidance, possible reduction in diving.</td>
</tr>
</tbody>
</table>


### 6.2.6 Birds

Limited experimental data has been collected on the reaction of birds to seismic operations. Webb & Kempf (1998), conducted a study to determine the impact of a seismic operation in the Wadden Sea. They concluded that bird counts showed no significant deviation in the numbers and seasonal distribution of shorebirds and waterfowl as a result of the seismic survey. Temporary avoidance of individual areas, up to a distance of 1 km, was noted due to the activities of the boats and crew.
6.2.7  Seismicity

It is generally accepted that earth surface loading by large dams and reservoirs or resource extraction such as mining, and geothermal and hydrocarbon production can change the near surface rock stress or fluid pressure regime and may lead to shallow focus earthquakes. However, these induced changes are considered to be small and cannot be held fully accountable for the overall seismicity (e.g. Trifu & Fehler, 1998) in a region.

Although some published studies (e.g. Rutledge et al., 1998 and Phillips et al., 1998) have associated induced seismicity with resource extraction and hydraulic well stimulation (i.e. hydrofracturing), no similar studies are known to us that have established direct links between the acquisition of seismic data and induced seismicity.

Further, according to the findings of the Caltech Seismological Laboratory in Pasadena in the USA, where extensive research on induced seismicity is being undertaken, there is no evidence that the acquisition of seismic surveys has an influence on background seismicity levels. These findings are in line with results from the 1995 Los Angeles Regional Seismic Experiment (LARSE), which detected no increased levels in seismicity in a seismically highly sensitive area, as a consequence of seismic acquisition (pers. comm. Emily Brodsky, Caltech Seismological Laboratory, Pasadena, 1999).

6.3  Experience in the Caspian

An international consortium recently completed the largest single seismic survey ever carried out in the world in the northeast Caspian. An EIA was prepared to assess this activity prior to it taking place. It predicted that no significant environmental effects would result from the airguns used, even though the water was very shallow (< 5 m) and the area was used by sturgeon, other fish and seals. During the survey, monitoring was undertaken to assess the validity of the predictions made. The monitoring confirmed that no significant impacts were detected upon the environment or the fish and seals within it.

Since the mid 1990’s a number of deep-water seismic surveys have been carried out in the Azerbaijan sector of the Caspian Sea by AIOC, CIPCO, BP Amoco (formerly BP Statoil alliance) NAOC and Exxon. The EIA’s for these projects predicted no significant environmental impacts and subsequently none were observed.

6.4  Potential Impacts from the Shafag Asiman Seismic Survey

6.4.1  Introduction

Specific key concerns regarding seismic survey activities in the Azerbaijan sector of the Caspian raised in a seismic workshop held in Baku in October 1997 included potential airgun effects on fish and seals and effects on the background seismicity levels in the region (ERT, 1997).

These potential impacts along with potential impacts on the lower organisms that could result from the proposed Shafag Asiman 3D seismic survey activities are discussed below.

6.4.2  Benthic Communities

The proposed seismic survey area is within water depths ranging from 600-900 m. No bubble pulse train effects, resulting in re-suspension of superficial sediments into the water column, are anticipated due to the deep water of the seismic survey area. It is generally accepted (see Section 6.2.1) that no significant disturbance to the seabed or impacts to the associated benthic community from normal seismic operations would be observed in water depths greater than 50 m.
6.4.3 Planktonic Communities
Within the water column, at close range (generally less than 2 m, but could be up to 5 m) of a firing airgun, mortality may be observed for plankton (including juvenile fish) unable to move away from the firing airgun (see Chapter 6.2). Most frequent and serious injuries would be observed within only 1.5 m of the airgun source (Dalen et al., 1996).

According to the Institute of Fisheries of the ‘Azerbalig’ State Concern it is likely that eggs and larvae of commercial fish species with widespread and extended duration spawning habits, such as the grey and golden mullet and big-eye and anchovy kilka will be found within the zooplankton community during the proposed seismic survey period (see Table 5.6).

As natural mortality rates for planktonic organisms are high, and natural annual fluctuations in population densities can be large, as a consequence of oceanographic and climatic variations (see Section 5.3.1), it is considered that the direct mortality effects of the seismic survey would lead to neither statistically significant nor measurable impacts on plankton populations or specifically to fish recruitment at the population level.

6.4.4 Adult Fish
The adult fish likely to be present, and their seasonal distribution within the vicinity of the seismic survey area are described in Section 5.3.2. Specimens overwintering at depth are unlikely to be found within the vicinity of the seismic source. Those specimens active in the upper water layers are potentially at risk from damage from the seismic source. Adult fish will normally exhibit avoidance behaviour in response to the seismic survey activities thus effectively evading potential damage (see Section 6.2.3). However, within the water column, at close range (less than 5 m) of a firing airgun, mortality could be observed for juvenile fish (< 50 mm in length) unable to swim away from the firing airgun.

Juveniles for all fish species tend to be concentrated in the shallow shelf areas. Natural mortality rates for juvenile fish are high, therefore it is considered that the direct mortality effects of the seismic survey would lead to neither statistically significant nor measurable impacts to fish recruitment at the population level.

The seismic survey area does not encompass or form part of a recognised fishery ground exploited by the Azerbaijan fishing industry. The nearest fishing grounds, supporting all year round fisheries, are located over 55 km to the west and north-west. Therefore potential catch reductions associated with displacement of fish or disruption of commercial fish activity are not anticipated.

6.4.5 Mammals (Caspian Seal)
During the proposed seismic survey period (September-January) peak seal densities are likely to be recorded during the foremost part of the survey period, when the Caspian seal population is migrating from Southern Caspian feeding grounds to the Northern Caspian for overwinter breeding. It should be noted however, that the survey area it is not recognised as an important area for feeding or on a particular migration route for seals. From September onwards seal densities in the vicinity of the survey area will decline as the feeding period draws to a close, and migratory individuals commence their return to the northern Caspian for breeding. The non-migratory individuals that remain in the southern Caspian will be concentrated on the year round haul-out sites on the Absheron Peninsula and the limited foraging expeditions of these seals are unlikely to extend into the seismic survey area.

For feeding purposes, the Caspian seal commonly dives to a depth of 10 m for a limited period of approximately 4 - 5 minutes, although it is capable of diving to depths of 100 - 120 m and remaining underwater for up to 15 - 20 minutes (Gadjiev & Aybatov, 1999). The Caspian seal is therefore a relatively shallow diver, typically diving well within the limits of its diving capability, and is unlikely to enter the deep water layers where sound may be concentrated (see Section 6.2.5).
6.4.6 Birds
Due to the distance of the seismic survey area from the coast it is considered that the only bird species likely to be found in the vicinity are gulls, red and black-throated divers and maybe a small number of waterfowl seeking temporary refuge on the vessel or the water surface prior to continuing their autumn migration.

Acoustic damage to birds could only be experienced if a bird was diving in close proximity to the airgun array (i.e. within 5 m of the array). However, as the array is towed directly behind the survey vessel there will effectively be a bird free corridor where the vessel has disturbed any birds present on the Caspian. Although some alarm may be caused to birds as the array passes, they will already be beyond any harmful range (Macduff-Duncan & Davies, 1995). It is not considered likely that birds will be in the water close to the airgun array once it is operating.

6.4.7 Seismicity
The acoustic source used in the seismic survey will produce sound waves, which travel to the seabed, penetrate the rocks beneath, and reflect from boundaries between the different rock layers.

Background seismicity levels within the Caspian Region have been recorded for approximately 100 years. According to Kerimov (pers. comm., 1995) the background levels have increased from 7.5 degrees to 9 degrees as a consequence of anthropogenic influences, including those associated with oil industry operations. However, the alleged link between such anthropogenic influences and increased levels in background seismicity has neither been documented by Kerimov, or substantiated by other members of the scientific community. Monitoring and research is still ongoing in the Caspian Region, and to date unpublished field survey results indicate that offshore seismic surveys have no effect on the background seismicity levels of the Caspian.
7. IMPACTS OF ROUTINE OPERATIONS

7.1 Socio-economic Factors
Offshore, no direct economic impact on commercial shipping or commercial fisheries is anticipated as the seismic survey area does not lie within a recognised shipping lane or recognised fishing ground and is generally remote from the main fish spawning and nursery grounds for the commercially exploited species. Associated onshore activities should have little or no detrimental socio-economic impact, and should on balance provide a limited short-term direct benefit to the local economy. In the medium term, if the findings of the survey indicate the potential presence of hydrocarbon reserves, further exploration activities, and any future development activities associated with potential proven reserves will provide an important direct source of revenue to the Azerbaijan Republic.

7.2 Physical Presence of the Seismic Survey Spread
Fishing and other sea user activities would need to be precluded from the vicinity of the seismic survey area for the duration of the operations. However, the survey area does not lie in a recognised fishing ground, and the principal fishing grounds exploited by the Azerbaijan fishing fleet are located around the offshore banks on the coastal shelf areas, approximately 55 km to the west and north-west of the seismic survey area. Therefore no disruption of commercial fishing activity is anticipated.

No shipping lanes pass through the seismic survey area or overall seismic survey vessel operational area. The nearest shipping lane (Baku Port to Okarem, Turkmenistan) is located approximately 5-10 km to the north-east of the survey vessel operational area, and as such it is not thought that there will be direct interaction with commercial shipping traffic anticipated.

Birds, mammals and fish are likely to be sensitive to noise disturbance associated with the operation of the vessels and equipment. It is likely that they will exhibit avoidance behaviour moving away from the noise source; therefore, no injury or harm to wildlife is anticipated. It should be noted that the level of disturbance would be no greater than that created by other vessels at sea, therefore no unacceptable impacts associated with normal vessel activity are anticipated.

7.3 Waste Production and Disposal
The volume of waste generated during the seismic survey will be dependent upon the duration of the survey period and the number of crew onboard each vessel. Various types of waste will be produced, each of which needs to be handled appropriately. The international minimum standards for disposal of waste from vessels are set out in Annex V of MARPOL (IMO, 1992).

Typically, the following existing disposal routes will be used for the wastes generated by the vessels, all wastes (with the exception of sewage and grey water discharges, which will be discharged at sea) will be disposed of at appropriate onshore facilities, and any waste transfers will be documented with BP waste Transfer Notes:

- Non-combustible material such as plastics, and certain maintenance and operational wastes will be compacted and stored onboard for transfer to shore for disposal at an appropriate disposal facility. Waste will be transferred for disposal through BP’s central waste accumulation area;

- Combustible galley waste and general waste will also be compacted and stored onboard for transfer to shore for disposal at an appropriate disposal facility. Waste will be transferred for disposal through BP’s Central Waste Accumulation Area;
• Biodegradable food wastes will be stored onboard for transfer to shore for disposal at an appropriate disposal facility. Waste will be transferred for disposal through BP’s Central Waste Accumulation Area;

• Oily bilge waters will be collected in tanks onboard and transferred to barge for disposal onshore during port calls in Baku;

• Spent cable fluid will be collected in dedicated tanks onboard and pumped ashore during port calls in Baku;

• Contaminated oil spill clean-up equipment will be stored in containers onboard the vessel and transferred to shore for disposal through BP’s Central Waste Accumulation.

7.4 Air Pollution

The principal sources of emissions to air are exhaust gases from the vessel engines, and the air compressor generators. An estimate of the emissions from the engine and generator operations, for all vessels, during the mobilisation and demobilisation, the periodic refuelling trips and for survey operations within the seismic survey area is presented in Table 7.2.

For the purpose of this estimate, the average operating speed of the seismic acquisition vessel is 4.5 knots, with an estimated daily fuel consumption of 20-tonnes and the average speed steaming to and from the survey site is 11 knots with an estimated daily fuel consumption of 15.4 tonnes. The average operating speed of the support vessels is 4.5 knots, with an estimated daily fuel consumption for both vessels of 14 tonnes and the average speed steaming to and from the survey site is 10 knots with an estimated daily fuel consumption of 19 tonnes.

For both the survey and support vessels it is estimated that the time taken to reach the seismic survey area from Baku Port is approximately 6 hours. From the seismic program it is estimated that the vessels will be utilised for seismic acquisition for a total of 56 days, with the contingency for this to be extended. Based on the vessels’ fuel capacities, it is estimated that all vessels will need to make at least one return trip for refuelling during the seismic survey period. Based on these assumptions an estimate of the total fuel use has been made (see Table 7.1) (n.b estimates assume a 110 day survey programme duration, using two support vessels, as detailed in Table 4.3).

Table 7.1: Estimated fuel consumption for the seismic survey vessels

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Activity</th>
<th>Fuel consumption (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seismic vessel</td>
<td>Journey to and from the seismic survey area</td>
<td>15</td>
</tr>
<tr>
<td>Seismic vessel</td>
<td>Seismic acquisition</td>
<td>1120</td>
</tr>
<tr>
<td>Support boat (x2)</td>
<td>Journey to and from the seismic survey area</td>
<td>19</td>
</tr>
<tr>
<td>Support boat (x2)</td>
<td>Seismic acquisition</td>
<td>784</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>1938</strong></td>
</tr>
</tbody>
</table>

Industry-standard emission factors were used for calculating the associated emissions. These factors, and the total emission estimates for each air pollutant over the whole period of the vessel operations are presented in Table 7.2.

Table 7.2: Air emission factors for marine vessels

<table>
<thead>
<tr>
<th>Emission Parameter</th>
<th>Emission factor (kg emitted/tonne fuel consumed)</th>
<th>Total emission over period of operations (tonnes) (to the nearest tonne)</th>
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<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>59</td>
<td>114</td>
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<td>CO</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>HC</td>
<td>2.7</td>
<td>5</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>3170</td>
<td>6143</td>
</tr>
<tr>
<td>SO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>8&lt;sup&gt;11&lt;/sup&gt;</td>
<td>16</td>
</tr>
<tr>
<td>Particulates</td>
<td>1.2</td>
<td>2</td>
</tr>
</tbody>
</table>
Report No. 2.59/197, E&P Forum, September 1994

(1) Assumes a sulphur content for marine diesel of 0.4% by weight

From these emissions estimates it is considered that the impact of the emissions to air from the seismic vessel operations would be negligible. In particular, it is considered that the total emissions will not significantly contribute to global warming or other regional / transboundary effects in comparison to other industrial sources or especially in the context of the total annual emissions for shipping and commercial fishing industry sources for the Caspian. As it is anticipated that the atmospheric emissions will rapidly disperse upon release and receptors are very scarce, no impacts are anticipated in terms of localised health effects.
8. IMPACTS OF ACCIDENTAL EVENTS

8.1 Introduction
The key potential accidental events that have been identified for the seismic survey are the loss of part, or all, of the vessel fuel inventory to sea as a consequence of spillage / loss of containment onboard or release following holing of the seismic vessel and/or support vessels in a collision, accidental release of fuel during bunkering operations from one of the support vessels while offshore, and loss of part, or all, of the bunkering vessels (support vessels) fuel inventory to sea as a consequence of spillage / loss of containment onboard or release following holing of the vessel in a collision.

Damage to the fluid filled hydrophone cable(s) resulting in the release of streamer fluid from part or the whole of a hydrophone cable is an issue that needs to be addressed. A discussion of the impacts of the loss of streamer fluid is included in Section 8.2.

8.2 Loss of Streamers and Streamer Fluid
The fluid filled hydrophone streamer cables will contain a light colourless aliphatic hydrocarbon (similar to kerosene) called Isopar-M, which provides electrical insulation and neutral buoyancy.

Loss of all or a significant number of the sections of a streamer would only occur if it became snagged on a large obstacle or severed by the propeller of another vessel. This is a very unlikely event. It is possible, however, that small amounts of streamer oil could be lost to the environment as a result of a hole in the jacket caused by snagging, or during filling or pumping of the cable sections.

The streamers will be divided into isolated sections of 100 m, each of which will contain approximately 125 litres of fluid. Each streamer will therefore have a fluid content of approximately 7,500 litres.

As stated previously, the total loss of all streamers (6) or even one streamer is highly improbable. However, limited discharges of streamer fluid are a possibility. In such instances, a visible film would form on the surface of the sea, as Isopar M is insoluble in water. However, due to the light nature of the fluid, rapid dispersion and evaporation is likely to occur with only a small proportion potentially still remaining on the sea surface after 24 hours. Due to the physical properties of the cable fluid, the impacts of spills of this nature would be limited in extent and time and would have no long-term environmental impact.

The probability of discharged streamer fluid stranding on the coast is negligible since the closest coastline to the seismic survey area is approximately 70 km north and any discharge will be likely to disperse and evaporate before it reaches land.

8.3 Release of Fuel or Chemicals
Spills of fuels and oils are most likely to occur whilst refuelling or bunkering, or result from inadequate storage facilities. As stated in section 8.1 the key potential accidental events within the seismic survey area would be the loss of part or all of the vessels fuel inventory to sea as a consequence of a spillage onboard or as a consequence of release following holing of any of the vessels in a collision. The potential for the same accidental events are also present aboard the supply ship that is bunkering the seismic vessel and chase/support vessels. However, spills from these sources are rare due to the navigational systems onboard and the environmental procedures in place on the vessels (see Chapter 9).

It is anticipated that the seismic vessel will have maximum storage capacities for diesel fuel, of 800 tonnes and lubricating oils of 22 m³, and that the support vessels will have maximum
storage capacities for diesel fuel of 210 and 474 tonnes each respectively. However, valves connecting the fuel tanks would minimise the amount of oil lost if one of the tanks was ruptured. Further, leakages into the storage tank bunds are directed to the oily bilge water tanks, and all decks on which cable fluid is handled are drained into a closed separation system.

In addition to fuels and oils, other chemicals are occasionally used by the geophysical crew. These are generally small quantities of cleaning and maintenance chemicals. Chemical spills will be rare due to environmental procedures in place on the seismic vessels and the small amounts under consideration will have negligible impact on the environment.
9. MITIGATION

9.1 Introduction
The procedures that will be adopted to ensure that the potential environmental impacts associated with the seismic operations are either prevented, or effectively managed and controlled to reduce them to negligible levels are summarised in the following chapter.

9.2 Acoustic Disturbance and Mitigation
It is generally accepted that airguns are the energy source for seismic surveys that cause least environmental impact in the marine environment. The use of chemical explosives as the energy source for marine geophysical surveys has been phased out, and now 97% of marine operations worldwide utilise airguns. In addition, at the start of each airgun activity, power will increase slowly to encourage avoidance behaviour reactions by seals and fish (See Section 9.2.2).

9.2.1 Fisheries
The seismic survey area is located in an open sea offshore area of the Caspian, approximately 70 km south of the Absheron Peninsula. Fishing activity within this area is not considered commercially viable for Azerbaijan, due to its remoteness from the fish landing ports and relatively low concentration of commercial fish species (Kouliev & Gasymov, 1999). However, the likelihood of fishing activity occurring in the vicinity of the seismic survey area cannot be precluded. Fishing vessels from other littoral states may operate in the area but the fact that the Navy will be notified, and the presence of the support vessel, will ensure that all vessels are kept clear of seismic operations.

9.2.2 Mammals (Caspian Seal)
During the proposed seismic survey period peak seal densities are likely to be recorded during at the foremost end of the survey period, when the Caspian seal population is concentrated in the southern Caspian for feeding purposes. It should be noted however, that the survey area it is not recognised as an important feeding area for seals. From September onwards seal densities in the vicinity of the survey area decline as the feeding period draws to a close, and migratory individuals commence their return to the northern Caspian for breeding. The non-migratory individuals that remain in the southern Caspian will be concentrated on the year round haul-out sites on the Absheron Peninsula and are unlikely to be in the vicinity of the seismic survey area. It should be noted however that recent surveys of these haul out sites have not recorded seals at these haul outs in significant numbers (CISS, 2006). During the seismic survey period it is anticipated that Caspian Seals will primarily be concentrated in Northern Caspian waters where they spend the winter months breeding. It is thought that northward migrating Caspian Seals tend to follow the shelf waters on the eastern and western Caspian coasts where the majority of their prey species are concentrated.

As a key mitigation measure BP will implement the soft-start procedures as a precaution in accordance with Joint Nature Conservation Committee (JNCC) guidelines for minimizing the risk of injury and disturbance to marine mammals from seismic surveys (August 2010). The JNCC guidelines are considered international industry best practice for seismic exploration surveys. Prior to acquiring each seismic line and after each break in operations, power will be built up slowly from a slow energy start-up (e.g. starting with the smallest air gun in the array and gradually adding others) over at least 20 minutes to give adequate time for seals to leave the vicinity. The resulting seal avoidance behaviour will minimise the risk of physical damage.
9.3 Routine Discharges and Mitigation

9.3.1 Waste Production and Disposal

A set of operating procedures for the handling of waste will be available to the seismic crew. All waste streams will be recorded onboard the vessels in a master log, which will detail the date, nature of material, disposal method and responsible person. In addition, manifests will be kept of all waste streams transferred to shore.

Wastes brought to shore will be handled by the appointed waste carrier who will be responsible for transfer of the wastes to the appropriate waste handling facilities. Waste will be transferred for disposal through BP’s central waste accumulation area, using appropriate BP Waste Transfer Notes to ensure custody.

The manifesting of wastes generated from the seismic survey operations using BP Waste Transfer Notes will help ensure that wastes are handled and treated or disposed of appropriately.

9.3.2 Air Pollution

Air emissions will be minimised through regular maintenance of all engines onboard, in line with Maritime Registry of Shipping (MRS) requirements. Vessels used for the survey will comply with, and be operated in accordance with Annex VI of MARPOL 73/78.

9.3.3 Transference of Invasive Alien Species

The isolated nature of the Caspian’s marine environment, and resulting high levels of species endemism, make it particularly vulnerable from impacts resulting from the transference of alien invasive marine species. One of the most well documented cases is that of the introduction of the ctenophore *Mnemiopsis leidyi*, and the dramatic consequences this has had on Caspian ecology.

It is understood that the M/V *Gilavar* is currently not in Caspian waters as it is undergoing a refit. As such there is the potential for the transference of alien invasive species to the Caspian either through ballast and bilge water, and / or fouling organisms on the vessels hull.

Whilst it is recognised that the seismic survey vessel will be engaged by BP in Baku, and that therefore the vessels transit to the Caspian via the Volga-Don waterway is outside the scope of this EIA, the transit of the vessel to the Caspian will be undertaken in accordance with international best practice with regards to limiting and mitigating transference of alien invasives, of which there are a number of good examples. BP has specific procedures for mitigating the transfer of invasives into the Caspian, and these procedures refer to international best practice, and will be followed.

The two support vessels will be mobilised from Baku port.

9.4 Accidental Events and Mitigation

9.4.1 Damage or Loss of Towed Equipment

The likelihood of damage to the streamers is mitigated by the fact that the vessels are equipped with sophisticated navigational equipment that provides a warning of the approach of other ships. In addition to this, depth controllers along the length of the streamers can be used to dive the equipment to a safe depth in a short time. The Azerbaijan Navy will be notified of the survey prior to commencement of operations.

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The survey vessel is aware of the exact position of the cables, and other sea users are warned of their presence by a tailbuoy fitted with radar reflectors, night-lights and geographical positioning system (GPS) receivers. Depth controllers and retriever units have also been fitted along the length of the streamers to enable diving of the equipment to a safe depth in a short time and the bringing of the cable to the surface. Additional protection of the cables is ensured by the presence of a support vessel, which will monitor the location of the streamers with regard to other vessels in the area. During adverse weather conditions operations will be suspended and the cables may be taken onboard the vessel.

The loss of streamers is mitigated against through the use of ‘Synretrieve’ recovery units that are fitted to the hydrophone cables every 500 m. These are designed to inflate at 40 m depth bringing the streamer back to the surface.

9.4.2 Accidental Discharges from Seismic and Support Vessels

Streamer fluids

In order to minimise the loss of fluid from damaged streamers, each cable is divided into isolated sections of 100 m length, each of which contain approximately 125 litres of streamer oil. A leak in any section of the streamer will be detected quickly by the instrumentation onboard the vessel and the streamer taken up for repair, therefore only a very small amount of fluid would be lost to the aquatic environment.

Damaged streamers are wound onto a reel system onboard the vessel. The enclosed material is removed and replaced with new stock after the repair is made. A bunded area under the reel collects any onboard streamer fluid spills, which are either drained into a dedicated disposal tank or directed to the cable fluid purification system where the fluid is treated and stored for further use.

Fuel or chemicals

In order to avoid leaks and spills during storage, all petroleum products will be stored in approved labelled tanks, which will be bunded to retain any accidental spillage. The valves between connected fuel tanks will be kept closed, thus minimising the amount of oil that could be lost if one of the tanks were to be ruptured.

Refuelling of the seismic survey vessel and support vessels will be undertaken while at sea, and measures will be taken to ensure that there is no accidental release of fuel during this process. An example would be to ensure that refuelling is carried out during good weather and sea conditions, and during the hours of daylight.

Procedures to ensure the safe implementation of ship-to-ship refuelling at sea will be adhered to at all times to ensure that this task is undertaken appropriately.

In order to prevent spills resulting from collision, the vessels are equipped with navigational, radar, echo sounder and communications equipment to ensure that the likelihood of such an incident is kept to a minimum.

In the event of a leak of fuel or oil, an oil spill response plan will be in place and there will be an adequate supply of absorbent material available onboard to prevent oil entering the sea. Two absorbent kits and 200 litres of oil spill dispersant are kept onboard the MV Gilavar. Waste resulting from the clean-up of spills onboard the vessels will be placed into containers for later disposal onshore.

Both support vessels will also be equipped with 2x standard oil spill kits that comply with MARPOL requirements.

Other chemicals used onboard the vessels, such as cleaning and maintenance chemicals will be stored according to regulations and manufacturers directions. Material Safety Data Sheets (MSDS’s) for all chemicals stored onboard will be readily available. Procedures will be in place for dealing with spills and leaks.
9.5 Health and Safety Plan

Guidelines and procedures for seismic surveys are already highly developed due to the routine nature of seismic surveys. In addition, over recent years considerable improvements have been made in corporate management systems, particularly relating to safety and the environment. Consequently BP will implement the following procedures and policies:

- Survey specific HSE policies for the particular project plan;
- BP’s QHSE policy;
- Safety training – all crew will take part in survival at sea courses;
- Materials safety data sheets will be available for all substances present on the vessel.
10. CONCLUSION

It is generally accepted, from previous published studies, that normal seismic survey activities result in both:

- negligible long term adverse effects that would inhibit recovery of the environment to its normal state; and
- negligible adverse acute biological effects.

However, it is understood that seismic activities can lead to minor changes to normal behaviour of higher organisms such as fish, sea mammals and birds and that within close range (< 5 m) of a firing airgun, mortality of plankton and juvenile fish unable to swim away from the airgun could occur. Mortality and injury effects are predicted to be most frequent and serious within only 1.5 m of the airgun source (Dalen et al., 1996) and are not considered to represent statistically significant impacts to plankton populations or specifically to fish recruitment at the population level.

Risk of injury and disturbance to the Caspian seal will be mitigated by the implementation of the JNCC guidelines as well as coinciding with a period when the bulk of the seal population has migrated to the Northern Caspian waters to breed overwinter.

Due to the location of the seismic survey area:

- very few bird species, and low numbers of birds are likely to be present within the vicinity of the seismic survey operations. Those within 100 m of the vessel will probably be disturbed (McCauley, 1994) and move from the area;
- impacts on commercial fishery activity are not anticipated as the nearest recognised fishing grounds are located some 55 km to the west and north-west of the seismic survey area;
- impacts on seabed fauna are not anticipated due to the deep water characteristics of the seismic survey area (i.e. water depths ranging from 600 to 900 m);
- seals and adult fish present within the vicinity of the seismic survey operations will exhibit avoidance behaviour. Avoidance responses have been observed up to 1 km from seismic vessels (McCauley, 1994); and
- induced increases in background seismicity levels are not anticipated from the seismic operations.

Total emissions to air from the vessel operations are not considered to significantly contribute to global warming or result in localised smog or acid rain effects. Routine discharges to sea have been minimised and contingency measures for the potential accidental events will be defined and environmental procedures will be implemented by BP.

Navigational equipment onboard the seismic vessel, streamer cable tailbuoys and the support vessels will provide warning to other sea users of the location of the cables. In addition, the streamers will be fitted with a ‘Synretrieve’ recovery system. Thus damage to the equipment and possible resultant spillages or loss of equipment to the marine environment can be avoided.

Offshore, no direct economic impact on commercial shipping or commercial fisheries is anticipated as the seismic survey area does not lie within a recognised shipping lane or recognised fishing ground and is generally remote from the main fish spawning and nursery grounds for the commercially exploited species. Associated onshore activities should have little or no detrimental socio-economic impact, and should on balance provide a limited short term direct benefit to the local economy. In the medium term, if the findings of the survey indicate the potential presence of hydrocarbon reserves, further exploration activities and any further development activities associated with potential subsequently proven reserves, will provide an important direct source of revenue to the Azerbaijan Republic.
Overall, as a consequence of, the timing and location of the seismic survey, and the mitigation measures that will be employed to reduce or avoid potential impacts or disturbance, no significant environmental impacts are anticipated.
11. REFERENCES AND BIBLIOGRAPHY


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www.caspianenvironment.org

www.caspinfo.net

12. APPENDICES

12.1 APPENDIX A - Abbreviations

AETC  Azerbaijan Environment and Technology Centre
AIOC  Azerbaijan International Operating Company
bHp  Brake Horse Power
CO  Carbon Monoxide
CO₂  Carbon Dioxide
CO₃²⁻  Carbonate
dB  decibels
DGPS  Differential global positioning system
DNV  Det Norske Veritas
EAOC  Exxon Azerbaijan Operating Company LLC
EC  European Community
EIA  Environmental Impact Assessment
EMS  Environmental Management System
E & P  Exploration and Production
EPS  Environmental Protection Strategy
ERT  Environment and Resource Technology Limited
ESIA  Environmental & Social Impact Assessment
EWP  Environmental Work Program
GESAMP  Joint group of experts on the scientific aspects of marine pollution
GPS  Global Positioning System
HC  Hydrocarbon
Hz  hertz
IAGC  International Association of Geophysical Contractors
IMO  International Maritime Organisation
ISO  International Standards Organisation
IUCN  World Conservation Union
JNCC  Joint Nature Conservation Committee
kW  Kilowatt
LARSE  Los Angeles Regional Seismic Experiment
LL  Long Life
MARPOL  International Convention for the Prevention of Pollution from Ships
MENR  Ministry of Ecology and Natural Resources
MRS  Maritime Registry of Shipping
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tr>
<td>ms</td>
<td>millisecond</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>NO₅</td>
<td>Nitrogen Oxides</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>ppt</td>
<td>parts per thousand</td>
</tr>
<tr>
<td>PSA</td>
<td>Production Sharing Agreement</td>
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<tr>
<td>psi</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>PTS</td>
<td>Permanent Threshold Shifts</td>
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<tr>
<td>SEIA</td>
<td>Seismic Environmental Impact Assessment</td>
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<tr>
<td>SO₂</td>
<td>Sulphur Dioxide</td>
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<td>Safety of Life at Sea</td>
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