Survey of Active Acoustic Monitoring (AAM) Technologies

Volume III: Active Acoustic Methods and Procedures Undertaken During E&P Contracts

Canadian Seabed Research Ltd.

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Defence R&D Canada – Atlantic

External Client Report
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Abstract

Under the Exploration and Production (E&P) Sound and Marine Life Programme, a research study was carried out on the feasibility of the Active Acoustic Monitoring (AAM) of marine mammals. The purpose of such monitoring would be to detect marine mammals in those ocean areas where E&P activities are being conducted, in order to allow due diligence in mitigating any potential impact of these E&P operations. The study did not include any direct experimentation.

The AAM study encompassed multiple work components. First, the problem domain was delineated in an overview of offshore E&P activities and of the ocean environments in which they are conducted. To make the analysis more concrete, six specific ocean areas of relevance to E&P were selected and their properties described. Next, the potential performance of AAM was investigated via a parametric study of the sonar equation, incorporating available knowledge of sonar technology and environmental effects (e.g., high-frequency backscattering from the ocean boundaries). This part of the study was intended to identify any fundamental limitations to AAM as imposed by technology or by the basic physics of the problem, and also to pinpoint those sonar features that are of key importance for AAM. Special effort was dedicated to investigating the target strength of marine mammals, as this is an area in which scientific knowledge is sparse at present. The parametric analysis included several generic examples, and was also applied to the six specific ocean areas; however, computer modeling of the six environments was beyond the scope of the study.

This report (Volume II) contains a sub-contract report summarizing typical E&P operations which would introduce sound into the marine environment.

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Executive summary

Survey of Active Acoustic Monitoring (AAM) Technologies: Volume III: Active Acoustic Methods and Procedures Undertaken During E&P Contracts

Canadian Seabed Research Ltd.; DRDC Atlantic ECR 2010-042; Defence R&D Canada – Atlantic; March 2010.

Background: Under the Exploration and Production (E&P) Sound and Marine Life Programme, a research study was carried out on the feasibility of the Active Acoustic Monitoring (AAM) of marine mammals. The purpose of such monitoring would be to detect marine mammals in those ocean areas where E&P activities are being conducted, in order to allow due diligence in mitigating any potential impact of these E&P operations. The study did not include any direct experimentation.

Results: The AAM study encompassed multiple work components. First, the problem domain was delineated in an overview of offshore E&P activities and of the ocean environments in which they are conducted. To make the analysis more concrete, six specific ocean areas of relevance to E&P were selected and their properties described. Next, the potential performance of AAM was investigated via a parametric study of the sonar equation, incorporating available knowledge of sonar technology and environmental effects (e.g., high-frequency backscattering from the ocean boundaries). This part of the study was intended to identify any fundamental limitations to AAM as imposed by technology or by the basic physics of the problem, and also to pinpoint those sonar features that are of key importance for AAM. Special effort was dedicated to investigating the target strength of marine mammals, as this is an area in which scientific knowledge is sparse at present. The parametric analysis included several generic examples, and was also applied to the six specific ocean areas; however, computer modeling of the six environments was beyond the scope of the study.

This Volume provides a review of E&P Operations and equipment that may introduce significant acoustic energy into the marine environment. The content of this volume is a deliverable from subcontractor. This Canadian Seabed Research report is intended to provide additional information on O&G activities, specifically related to exploration.

Significance: The study documents the feasibility of using AAM technologies for mitigating potential impacts of E&P acoustic emissions on marine mammals. There exist technologies that could provide a basis for actively detecting marine mammals between 500 and 1000 m. This volume sets the operational circumstances where an AAM sonar systems would operate.

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Table of contents

Abstract ... i
Executive summary iii
Table of contents v
List of figures vi
1 Canadian Seabed Research Ltd. O&G Operations Background 1
2 Acoustic Program Design 2
3 Site/Hazard Survey Activities 2
4 Pipeline Route Survey 3
Working Environment 3
5 Geophysical, Geotechnical Equipment Specifications 4
6 Acoustic Sources 6
6.1 Air Guns 6
6.2 Boomer (Electromechanical) 7
6.3 Sparker (electrical discharge) 9
6.4 Sub-Bottom Profilers (2-12KHz) 10
6.5 Echosounders (33-500KHz) includes Multibeam 12
6.6 Sidescan Sonar (50-900KHz) 13
6.7 Sector Scanning Sonars (100-500KHz) 14
7 Coring and Sampling 15
Distribution list 17

List of figures

Figure 1: Spectrum Sound Levels of engine noise from the CCGS Nahidik at a range of 430m. 5
Figure 2: General Air Gun Configuration 6
Figure 3: Data collected from 2D Site Survey 6
Figure 4: Air Gun Array 7
Figure 5: Towing Boomer 7
Figure 6: Typical Source Signature of Boomer System 8
Figure 7: Data Sample from 100 Joule Boomer 8
Figure 8: Sparker System 9
Figure 9: Sparker Source Signature 9
Figure 10: Data Sample 1500 Joule Sparker 10
Figure 11: CFAV Quest with In Hull Sub-Bottom Transducers 10
Figure 12: Sub-Bottom Profiler Data 11
Figure 13: Sub-Bottom Source Signature 11
Figure 14: Dual Frequency Single Beam Transducer 12
Figure 15: Deep Water Multibeam System Hull Mount 12
Figure 16: Klein 100KHz Sidescan and Integrated SBP 13
Figure 17: Source Signature Klein Sidescan 13
Figure 18:Sector Scanning Sonar Image (platform legs) 14
Figure 19: General Equipment Deployment 15

1 Canadian Seabed Research Ltd. O&G Operations Background

For over 25 years our company has provided geophysical and geotechnical services to several of the large oil and gas corporations around the globe as part of our much broader range of marine and terrestrial services. Most of the projects we undertake for OG&P are in the form of site, hazard and pipeline surveys. These surveys are conducted in terms of feasibility and/or engineering planning for the placement of subsea and subsea anchored assets for the various oil and gas interests. We have also been under an operational contract to the GSCA (Geological Survey of Canada, Atlantic) for several years in the capacity of collecting long term repetitive data, in part which is utilized by The National Energy Board to decide on the usage of offshore O&G resources.

The data acquired and the methodology used to acquire the data has evolved over the many years since we began our offshore involvement. Early industry methods were crude and sometimes left little attention to the environment or the inhabitants thereof. Over the years our own research and that of many other similar private and public organizations have studied methods to mitigate the impact of our active acoustic technologies, thereby reducing the impacts to marine mammals and on the marine environment in general.

Most geophysical surveys are now conducted with an environment first approach, by conducting background scientific research on marine species, known migration and spawning areas as well as fisheries activities the stakeholders (i.e. O&G Companies) are able to instruct their engineering contractors to perform tasks in an environmentally responsible fashion.

Consultation is held before, during and after any operational activities with local fishing and indigenous interests, where concerns are voiced and the ecological science is discussed. The environmental studies on marine mammal population will have been conducted by several government and non-government agencies for perspective lease blocks long before any seismic/acoustic activities have taken place, in some cases decades before. This is not to say that marine science is not ongoing, as fisheries officers, environmental scientists and members of the indigenous community are included on most surveys to advise first hand on specific operational concerns. Measures to mitigate industry impact are agreed upon and the stakeholders expect all participating parties to show due diligence in their efforts to be environmentally aware and provide proof of methodology before any engineering activities commence. This due diligence is specifically spelled out in the form of an operational HSE (Health, Safety & Environmental) Plan as part of the procurement of services for geotechnical/geophysical data acquisition. Methods such as an exclusion zone around sited marine mammals during acquisition periods, soft start of all onboard acoustic sources, and planning the survey operations for seasons or time periods to minimize interference with marine life are all included as standard operating procedures.

The expanse of a geophysical/geotechnical program can vary as to the stakeholder and regulating bodies engineering needs or requirements. In general survey lease blocks can vary in size, from small 2 kilometre by 2 kilometre drill sites to large exploration blocks, (sizes vary too widely to give a sensible average).

2 Acoustic Program Design

Each marine geophysical/geotechnical survey has its own inherent requirements for the specific equipment to be utilized. As our overall purpose is to achieve the best results for our clients while providing minimal environmental impact, careful consideration must be given to each system being deployed to achieve the specific results required. The first consideration is for the unique environment the survey is to be conducted in, the population and distribution of marine mammals as well as the species and habits (relative to interaction with surface or sub-towed acoustic sources), and the known effects sound sources have on the marine life in the survey area. Typically a list of equipment would be provide to the regulatory body and concerns would be addressed, this would either eliminate certain procedures and equipment or modify their usage in terms of duration of activity, sound level maximums and clear instruction on shutdown requirements when whales or other marine life was detected within range of the acoustic source.

3 Site/Hazard Survey Activities

Site Surveys are conducted on behalf of our clients in order to determine the potential constraints that may be encountered when placing a drilling platform over a perspective exploration location. The data acquired will delineate any surface and/or shallow (within the first 50-100m of the seafloor) features that may require engineering mitigation or reconsideration of platform location.

The array of equipment mobilized for this type of survey is fairly standard in industry, sidescan and single beam sonar is used to map the potential site for surficial geology, some company's will require the area to be mapped for bathymetry utilizing Multibeam echo-sounding to ensure complete coverage of a large area around the drill site. The sub-surface geology is mapped using a combination of seismic sources, primarily air-gun, but could also include spark-arrays, boomer and sub-bottom profilers. The collection of magnetometer data to detect anthropogenic debris such as wrecks or debris in known wreck or UXO sites is also useful, but leaves no acoustic signature other than minimal tow noise.

The vessels for this type of work vary greatly and depend on the area the project is being conducted and what vessels may be available – vessel cost is also a driving force when making considerations for any project. These vessels tend to be privately owned and are leased for the duration of the survey, several multinational survey companies have their own fleet of survey vessels but in general these are not purpose built, they have been acquired on the resale market and have had previous work lives as trawlers, supply vessels, tugs and ice-breakers.

4 Pipeline Route Survey

The equipment considerations for a pipeline route survey are similar in scope to that of a site survey. Differences occur when the route reaches shallow water or near land fall. Higher power systems such as air-guns and sparkers are typically not used in shallow water for routing purposes although they may be applied if conditions prove difficult for boomer or sub-bottom profiling to adequately delineate bedrock horizons. This occurs when the pipeline approach is to be buried in the near shore to or below bedrock, or to help the engineers separate bedrock from tills and other overburden that lower power sources cannot penetrate. This is also the case where near shore structures are being emplaced, such as mooring/offloading structures or actual docking facilities.

Working Environment

Water depths for both site surveys and pipeline surveys vary widely around the world, in the 1970's and 80's Beaufort Sea Drilling took place from manmade islands in water depths as shallow as 5m to the deepest at ~25m. In areas of the Norwegian North Sea water depths for gravity based structures can reach over 300m. Deep water drilling and exploration programs have been conducted in water depths over 3000m utilizing dynamically positioned drill rigs and/or anchored floating platforms.

As previously mentioned water depths dictate to a large degree the equipment proposed for the site and/or pipeline surveys. At greater water depths more acoustic energy is required to provide adequate results for the purpose of engineering placement of a pipeline or drill rig. This in-turn requires consideration for the effects this equipment will have on the living environment into which it is deployed.

Geophysical/Geotechnical Survey operations are conducted on a 24 hour basis, with an average survey length of 2 weeks on-site. If the site or pipeline route is approved, follow on surveys are conducted during construction, rig placement or pipe-lay operations. These follow on operations are generally for quality control (QC) purposes, to ensure the structures are placed on the seafloor as to the engineer's designs. Much of this is done with multibeam echo sounders, sidescan and remotely operated vehicles (ROV) equipped with video and sonar acquisition systems.

5 Geophysical, Geotechnical Equipment Specifications

General vessel configuration:

Year Built 1966

Class / Type Oceanographic Research Vessel

Length 133 ft. LOA, Breadth 31 ft., Depth 14.5 ft., Draft Loaded 13.8 ft.

Main engines EMD-8-567CR, Total Horsepower 820 @ 800 rpm

Gears Liaaen ACG50150

Generators (3) Detroit 8V71

Bow Thruster Elliot White Gull

Propulsion Variable Pitch Props

Range 6500 miles @ 9.5 knots

Fuel Oil 29,250 gallons, Lube Oil 410 gallons, Potable water 5,000 gallons

A frame 3.300 pounds, Deck crane S.W.L. 2,880 min 5,310 Max

Crew 8, Scientists 15 including marine technician

Tonnage 289 GRT 73 NRT

Labs Wet: 81 ft2 Dry: 457 ft2, Aft deck 1280 ft2

Cruising speed 10 knots, Max speed 11 knots

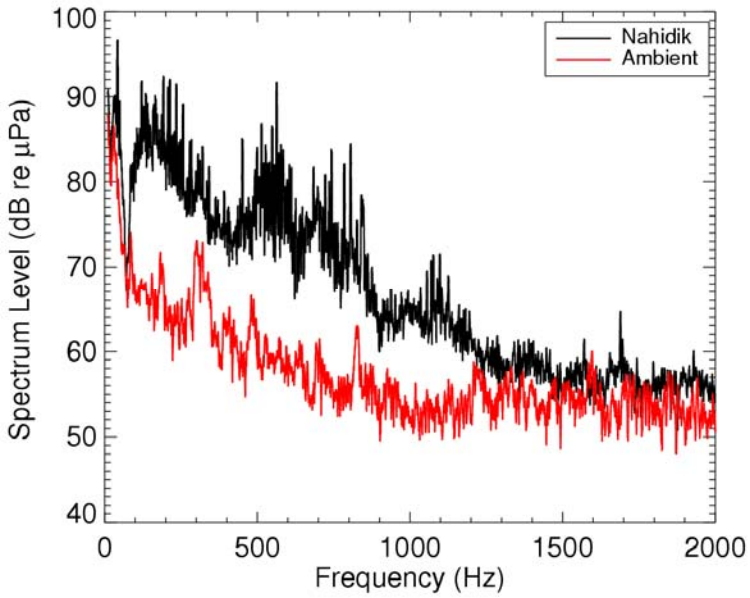

Figure 1: Spectrum Sound Levels of engine noise from the CCGS Nahidik at a range of 430m.

(Acoustic Measurement and Marine Mammal Monitoring Report 2003, LGL/Jasco).

Above is an example of the relative sound levels produced by vessel noise only during a typical survey. This data was collected during the 2003 survey season onboard the CCGS Nahidik in the Beaufort Sea. This vessel is utilized by GSCA and CSR to perform a repetitive ice scour mapping program as well as 2D seismic along the Beaufort Shelf.

6 Acoustic Sources

6.1 Air Guns

Configuration for site surveys varies with dependencies on water depth, bottom geology and target depths as these will dictate the system configuration.

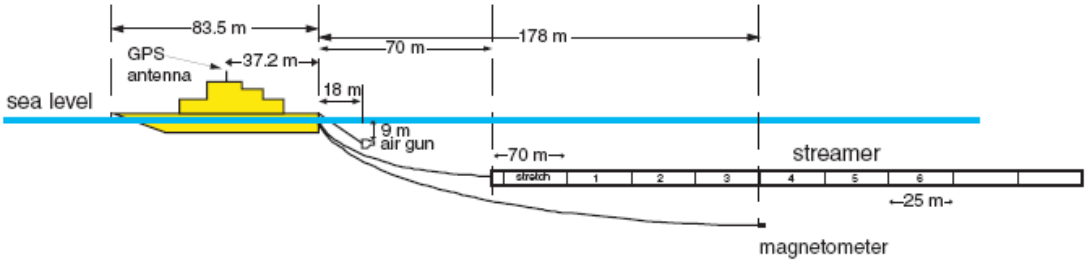

Figure 2: General Air Gun Configuration

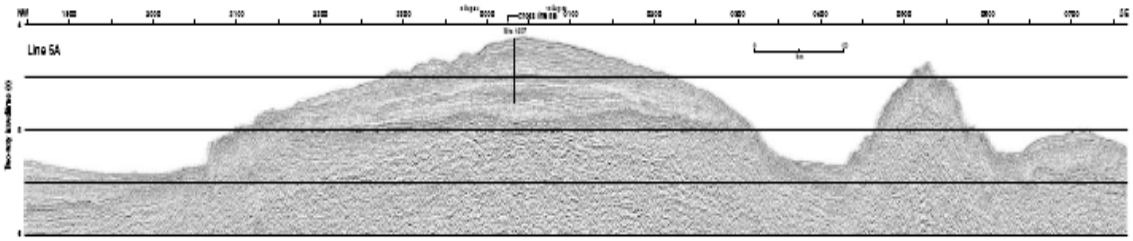

Figure 3: Data collected from 2D Site Survey

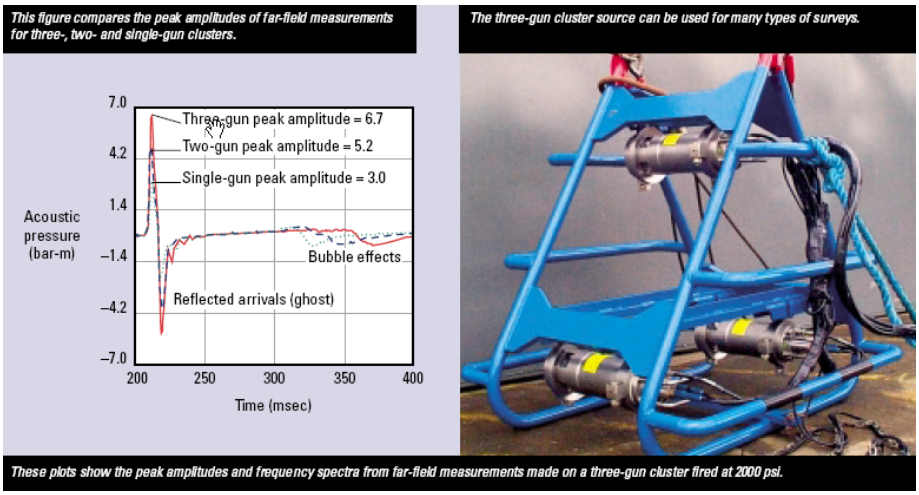

Figure 4: Air Gun Array

6.2 Boomer (Electromechanical)

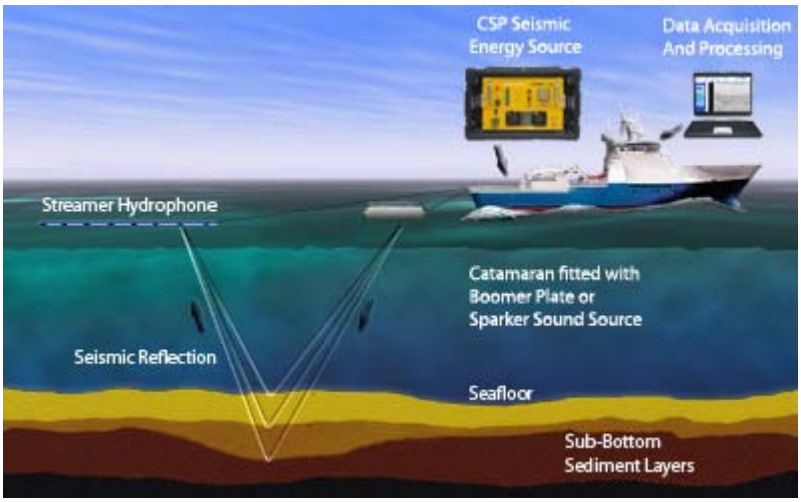

Figure 5: Towing Boomer

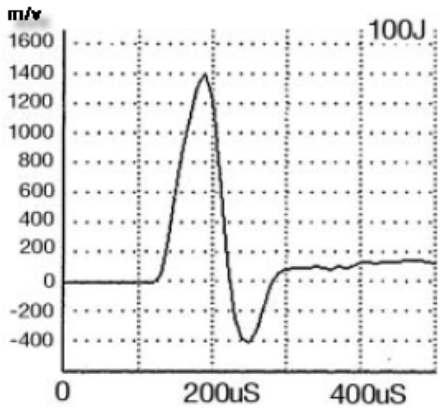

Figure 6: Typical Source Signature of Boomer System

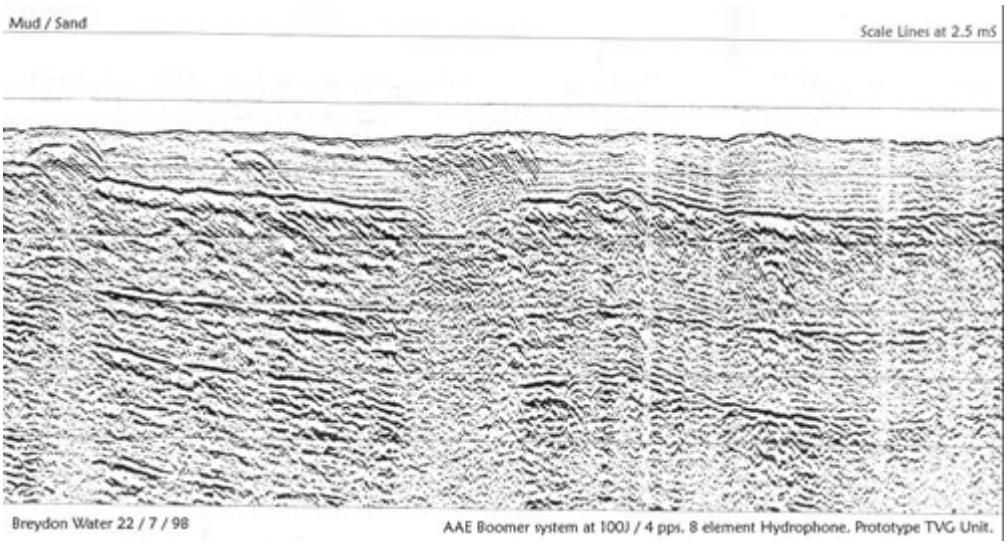

Figure 7: Data Sample from 100 Joule Boomer

6.3 Sparker (electrical discharge)

Figure 8: Sparker System

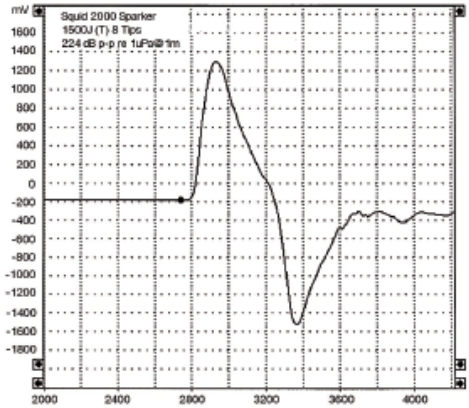

Figure 9: Sparker Source Signature

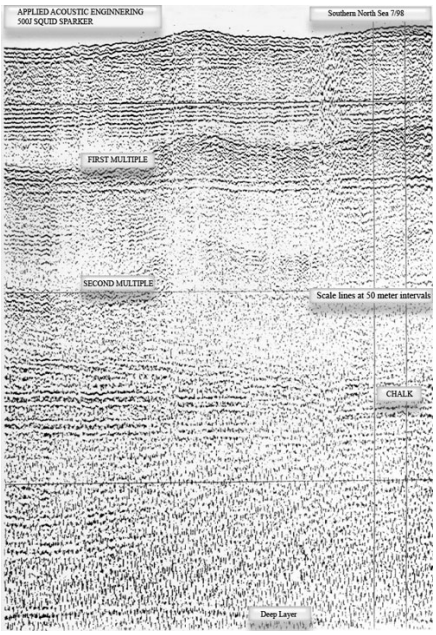

Figure 10: Data Sample 1500 Joule Sparker

6.4 Sub-Bottom Profilers (2-12KHz)

EdgeTech 3300-HM Hull Mount System Installed on *RV Quest*

Figure 11: CFAV Quest with In Hull Sub-Bottom Transducers

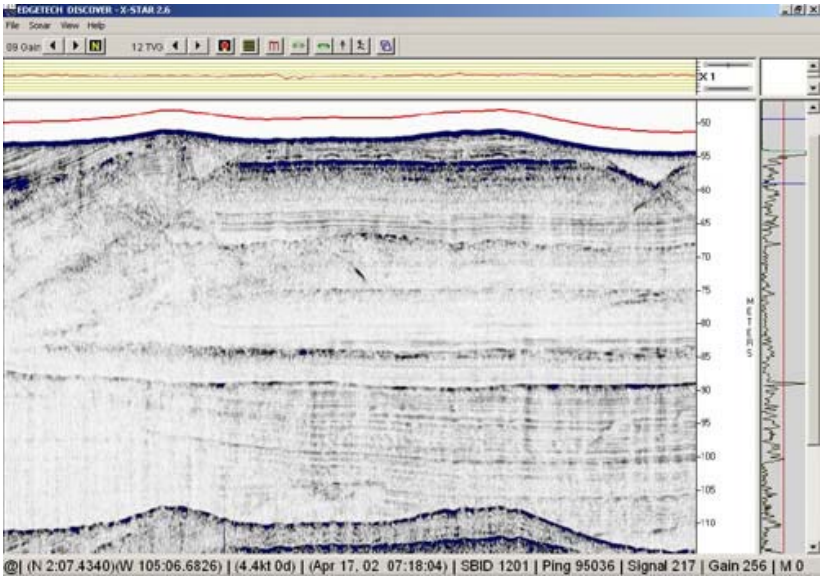

Figure 12: Sub-Bottom Profiler Data

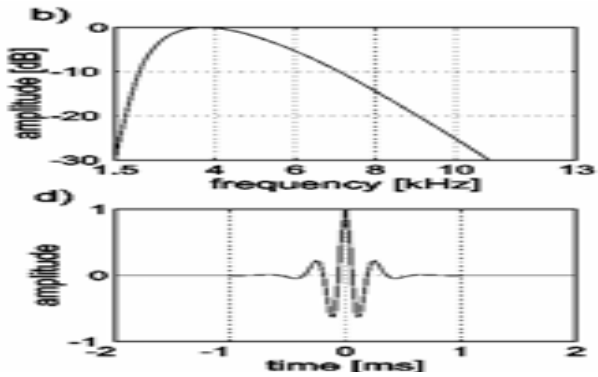

Figure 13: Sub-Bottom Source Signature

6.5 Echosounders (33-500KHz) includes Multibeam

THP200/24-4/20

Weight = 14.5Kg.

Performance Data

Frequency	200kHz	24kHz
Beam Width	4°	20°
Q (transmit)	2	7.6
Rated RMS Power	2KW	1.5KW
Balanced Impedance	ohms	
Peak Figure of Merit	-6db	-9db
Bandwidth	100kHz	3.2kHz
Acoustic Window Material	Urethane	Urethane
Cable Type	C43 (2-14 AWG)	C43 (2-14 AWG)
Cable Size	10mm	10mm

Figure 14: Dual Frequency Single Beam Transducer

Figure 15: Deep Water Multibeam System Hull Mount

Acoustic Info on EM302 as an example:

EM 300/302 1° Beamwidth SPL-237dB, PL-214dB @ 1m, PL-192dB @ 180m

6.6 Sidescan Sonar (50-900KHz)

Figure 16: Klein 100KHz Sidescan and Integrated SBP

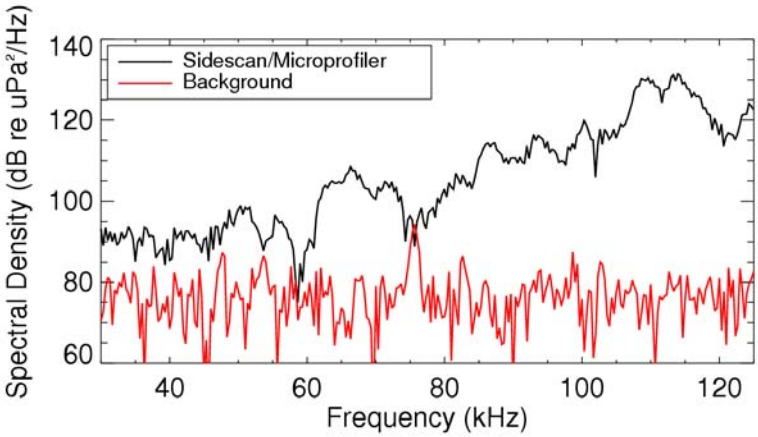

Figure 17: Source Signature Klein Sidescan

The maximum estimated in-beam source levels for the sidescan sonar are:

- SL_{Peak} = 224.7 dB re 1 μPa @ 1 m
- SL_{RMS} = 216.8 dB re 1 μPa @ 1 m
- SL_{SEL} = 180.9 dB re $\mu Pa^2 \cdot s$ @ 1 m

6.7 Sector Scanning Sonars (100-500KHz)

Typically sector scanning sonars are utilized from ROV platforms for the purpose of identifying targets on the bottom from very close range. These sonar system are also utilized for obstacle avoidance onboard AUV (autonomous underwater vehicles).

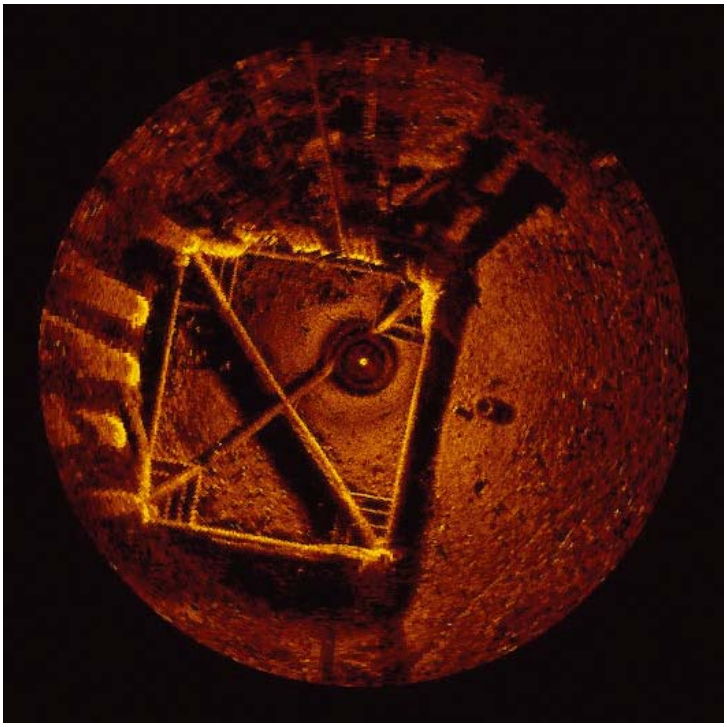

Figure 18:Sector Scanning Sonar Image (platform legs)

Sector Scanning Sonar varies in frequency, the above image is at 675 KHz giving high detail of the rig support legs and the surrounding seafloor; note the large tire to right of platform.

7 Coring and Sampling

Bottom sampling is an intrinsic part of acoustic data acquisition as this provides ground truthing to assist in the interpretation of sidescan and shallow seismic records. These procedures can include gravity coring, vibra coring, grab sampling, box coring in loose sediments or mud. CPT (Cone Penetrometer Testing), gives an analysis of the sheer strengths of the bottom sediments, this is important information for planning pipelines, as the plows that will trench the pipeline are designed for specific material strengths.

Of the above sampling methods only vibra coring is associated with noise over any perceivable duration. The vibra core system is lowered to the bottom where either an electric motor or a pneumatic system with concentric wheels provides the vibrational motion that allows the core barrel to penetrate the substrate. To date no known studies have been performed on the noise levels generated by vibra-coring offshore.

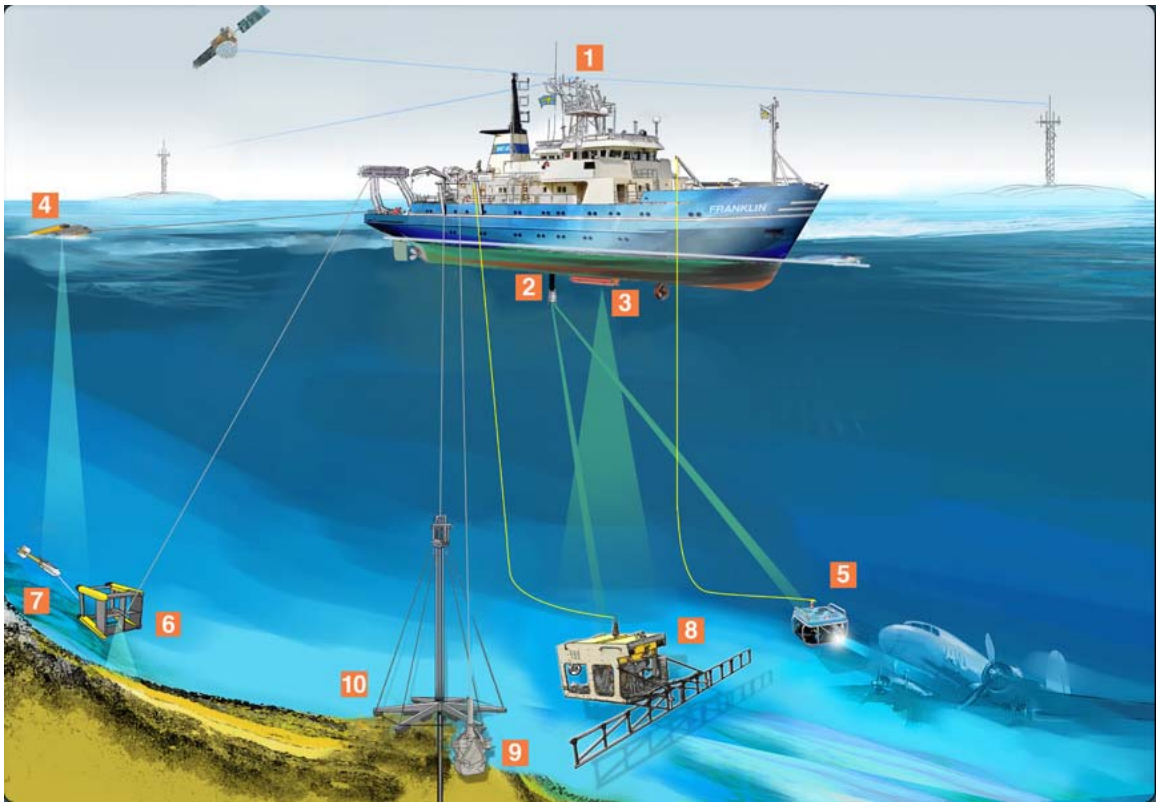

Figure 19: General Equipment Deployment

1) DGPS POS Positioning System w/ Satellite or Beacon Corrections
2) Acoustic Positioning System (ROV, Sidescan etc.)
3) Multibeam Echosounder
4) Boomer, Sparker or Air Gun Array
5) Inspection ROV
6) Sidescan Sub-Bottom Profiler
7) Magnetometer
8) Work Class ROV w/ Pipetracker & Sector Scanning Sonar
9) Grab Sampler or Box Corer
10) Vibra/Gravity Core or CPT

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Active Acoustic Methods; Oil & Gas Industry; Underwater Sound Sources