TWACHTMAN SNYDER & BYRD, INC.

Comparative Risk In The Complete Removal Of Large Offshore Platforms

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1. INTRODUCTION

This paper summarizes the results of a study carried out for the Minerals Management Service (MMS) in response to their Request for Proposals of September 20, 2001, and the solicitation 1435-01-01-RP-31174, with requested revisions (“the study”). A complete copy of the study report is available through the MMS.

The study provided a comparative risk assessment of the decommissioning options for removing three specific platforms, as directed by the MMS. The selected platforms are Eureka, Hidalgo, and Irene. The characteristics of these platforms are shown in Table 1.

Table 1 - Selected Platform Characteristics

	Eureka	Hidalgo	Irene
Year Installed	1984	1986	1985
Water Depth (ft)	700	430	242
Conductors (#)	60	10	24
Estimated Component Weights (st):			
Jacket	18,500	10,950	3,100
Piles	2,000	2,000	1,500
Conductors	3,442	371	552
Deck Structure	5,200	8,100	2,500
Deck Modules	8,000	8,028	2,500
Total	37,142	29,449	10,152

The focus is on removal of the platforms in the Pacific Outer Continental Shelf Region (POCSR). However, the information provided is relevant to all similar platform removals. The risk assessment focuses on Health and Human Safety (HHS). The risk assessment considers the principal options available for complete removal of the subject platforms. The assessment considers the impact of specific removal methods such as diver versus non-diver operations, and alternative lifting methods, which may be common to all disposal approaches.

This study did not consider explosive methods of severing piles and skirt piles because, with the exception of the Eureka platform skirt piles, all of the piles and skirt piles are too large to be severed by conventionally configured charges of less that 50 lb., the current weight limit.

The overall objective of the study was to examine the relevant issues and to quantify them in the context of comparative HHS risk as well as in the context of industry practice and available technology. The following were the specific objectives:

1. Define / identify the principal options available for the complete removal of the POCS platforms.

2. Develop plausible complete removal scenarios for three representative platforms using the most likely options. Development of these scenarios included work plans which identified the time and resource requirements.

3. Quantify the specific issues related to the decommissioning of the subject platforms which carry significant risks in terms of HHS. As part of this process, an industry forum on decommissioning safety will be held. Participants in this forum will be carefully selected to provide a cross section of industry experience and interests.

4. Evaluate these risk issues for the various decommissioning options. The HHS risk is quantified to the maximum extent allowed by the data available.

5. Evaluate these risk issues for the alternative technologies, e.g., diver versus non-diver methods, and alternative lifting systems.

6. The study did not encompass plugging the wells, cutting and removing the well conductors and casing and onshore dismantlement of the structures. Considerations in the study end when structures are safely tied down on a cargo barge.

7. The study considers:

    - In-Situ cutting and removing the jackets in place, both in large pieces using a twin crane semi-submersible crane vessel (SSCV) with 5000 ton capacity, or greater, and in smaller pieces using a 2000 ton capacity derrick barge or crane vessel (DB). Typical lifting vessels are shown in Table 2.

    - Hopping the jackets into successively shallower water locations and cutting the jackets into pieces with most of the cuts being above the water surface to minimize diver cuts using the SSCV only.

8. Defining options available for mitigation of the most risky aspects of offshore platform decommissioning.

Table 2 - Sample of Industry Lifting Vessels

Vessel Type	Vessel Name	Vessel Owner	Lifting Capacity (st.)
DB	Hercules	Global Industries	2,000
DB	Castoro Otto	Saipem	2,000
DB	HLS 2000	NPCC	2,000
DB	Stanislav Udin	Stolt	2,000
DB	Pearl Marine	Saipem	2,400
DB	DB 30	McDermott	2,300
DB	DB 101	McDermott	2,100
DB	Odin	McDermott	2,700
DB	DB 50	McDermott	4,400
SSCV	Hermod	Heerema	3,960, 4,950, 8,928[1]
SSCV	Balder	Heerema	4,000, 6,930[1]
SSCV	Saipem 7000	Saipem	7,000, 14,000[1]
SSCV	Thialf	Heerema	7,810, 15,620[1]

Notes: [1] Using Tandem Lift

2. RESULTS OF THE ASSESSMENT OF WORK-EFFORT REQUIRED

For the methods considered, the maximum risk man-hours estimated in the study for each platform are shown in Table 3. Figures 1 through 3 show graphs of the comparative maximum risk man-hours for the three platforms. Figure 4 shows the total spread hours for the different methods

The major conclusions from the assessment of required work-effort are as follows:

- All complete removal scenarios involve large amounts of high risk work, ranging from approximately 16,000 man-hours for platform Irene to approximately 50,000 man-hours for Eureka.
- Total spread times for the complete removal scenarios ranged from approximately 14 days at Irene to approximately 50 days at Eureka.
- The “hopping” method eliminates saturation diving and significantly reduces surface diving and total spread time.
- Total high risk man-hours are greater for the “hopping” method.

Table 3 - Maximum Risk Man-Hours for Platform Complete Removal

Work Category:	**Riggers**	**Welders**	**Sat. Divers**	**Surface Divers**	**Total**	**Total Spread Time**
	(man-hrs)	(man-hrs)	(man-hrs)	(man-hrs)	(man-hrs)	(Hours)
Eureka						
	Removal *in-situ* small piece					1268
	21,640	19,476	1214	114	42,444	
	Jacket hopping					1055
	24,936	24,936	0	295	50,167	
Hidalgo						
	Removal *in-situ* small piece					904
	12,760	11,484	938	147	25,329	
	Jacket hopping					604
	14,496	14,496	0	196	29,188	
Irene						
	Removal *in-situ* large piece					343
	8,232	8,232	144	72	16,680	
	Removal *in-situ* small piece					459
	9,180	8,262	186	70	17,698	

Figure 1 - Eureka Complete Removal High Risk Work Effort

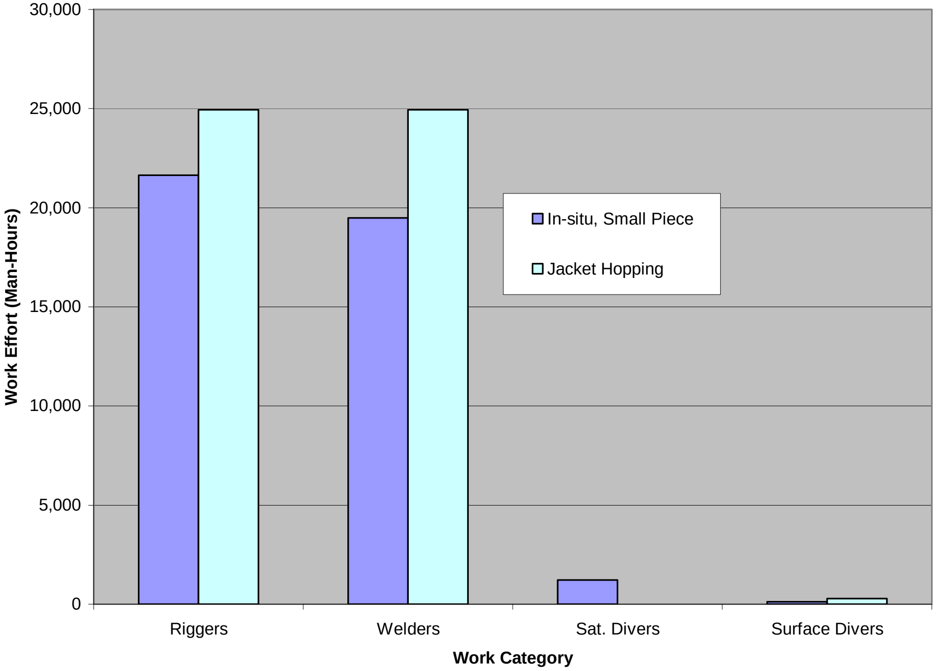


Figure 2 - Hidalgo Complete Removal High Risk Work Effort

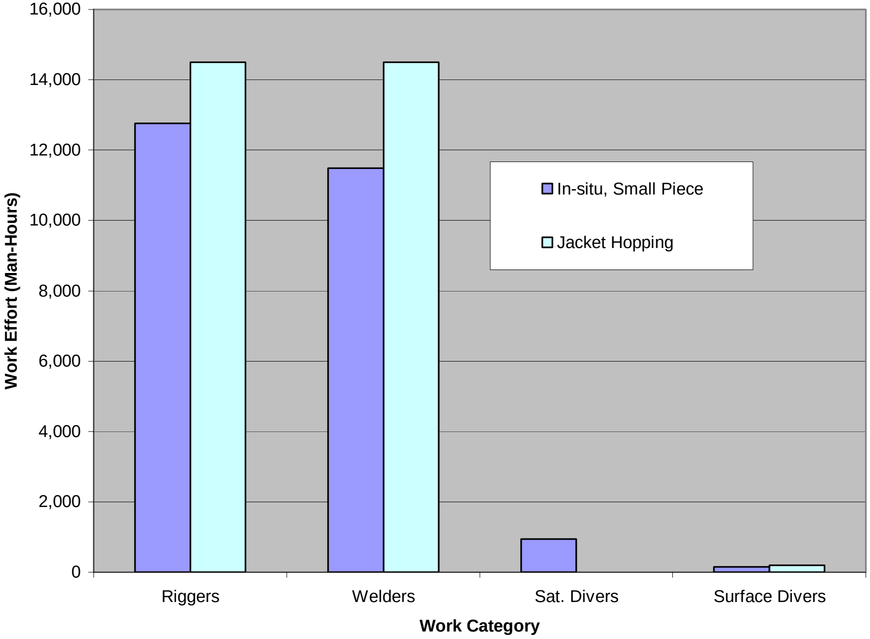


Figure 3 - Irene Complete Removal
High Risk Work Effort

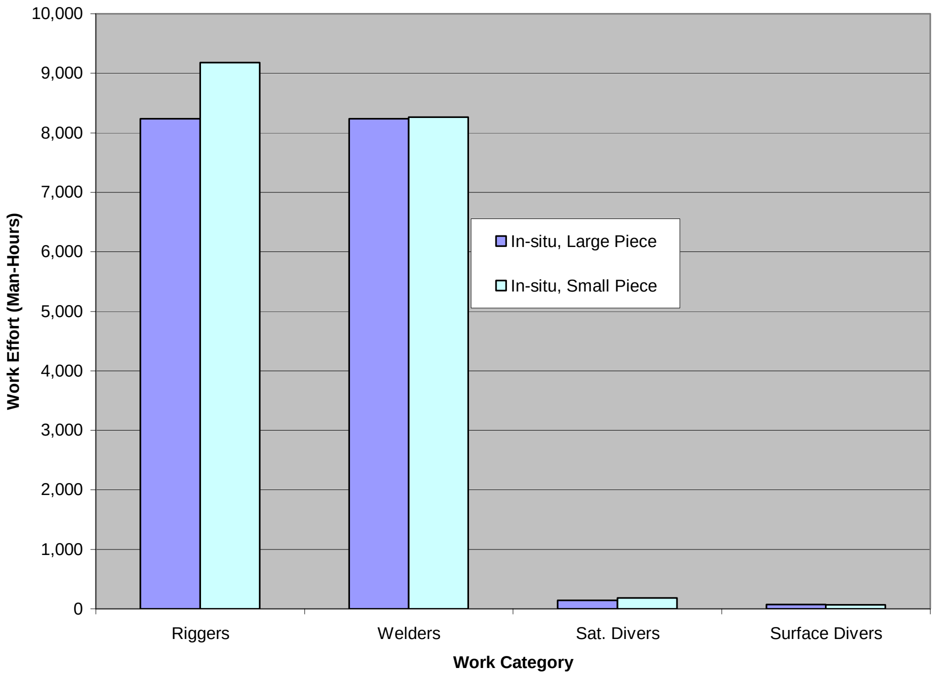
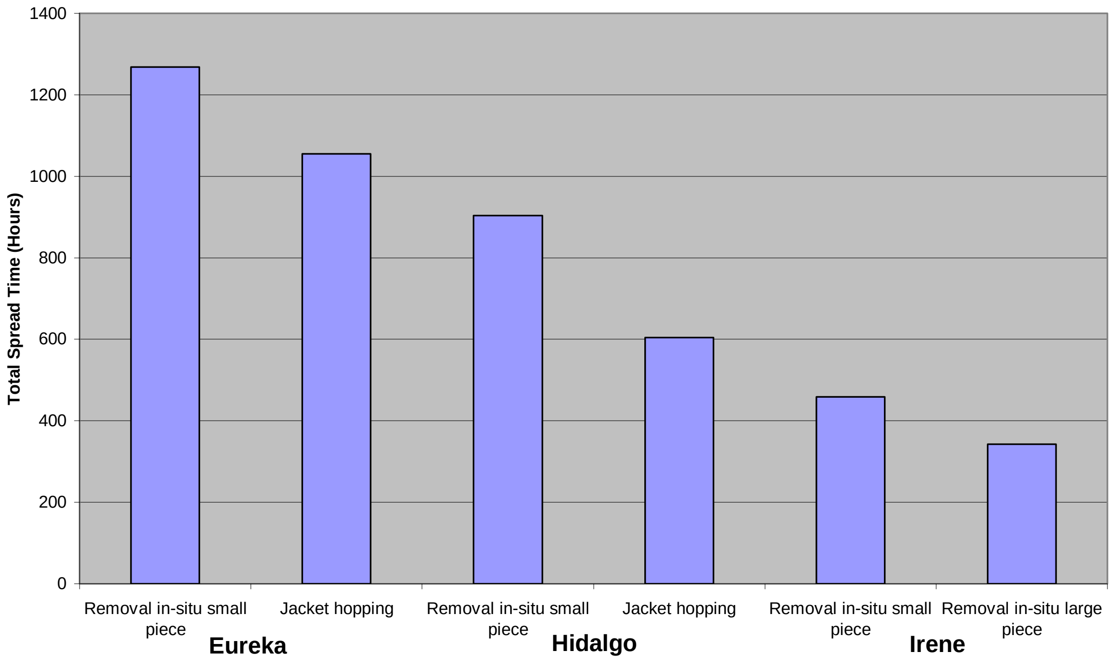


Figure 4 - Complete Removal
Total Spread Time



3. DEVELOPMENT OF SERIOUS ACCIDENT AND FATALITY RATES

This study gathered all of the accident and fatality data that is publicly available and relevant to offshore platform decommissioning. Appendix B of the study provides a report by Professor Robert Bea of the University of California, Berkeley, titled "Summary of Industry Accident Statistics," which identifies the data sources that are available. It was originally intended that individual accident rates would be provided for each of the individual labor categories. However, in the end this was not possible because of the limited availability of data. Another issue was the general lack of accident data from sources in the US offshore industry. To be useable in the context of the study, the "rate" of accidents for a given number of hours worked must be available. All of the sources accessible by the study reported only actual accident information for the US based offshore industry, without the reporting the hours worked associated with the accidents. This information was not useable in the probabilistic models used in the study. Therefore, the accident rates used were based primarily on data generated in Europe. It may be argued that the rates for the US offshore industry are different. However, this can not be verified at this time.

Tables 4 and 5 (from the study report Appendix B), provide the rates for serious injuries (SIR) and for fatal accidents (FAR), respectively, that were used.

Table 4 – Proposed lower bound, most probable, and upper bound SIR (injuries per 10E6 hours of exposure) for decommissioning operations

Decommissioning activity	Lower bound SIR	Most probable SIR	Upper bound SIR
Onshore	2.0	5.0	10.0
Offshore above water	2.0	3.0	5.0
Air diving	1700	2000	2300
Saturation diving	1700	2000	2300

Table 5 – Proposed low bound, most probable, and high bound FAR (injuries per 10E8 hours of exposure) for decommissioning operations

Decommissioning activity	Lower bound FAR	Most probable FAR	Upper bound FAR
Onshore	5.0	6.0	9.0
Offshore above water	2.0	4.0	6.0
Air diving	500	600	700
Saturation diving	500	600	700

4. PROBABILISTIC MODELING OF OFFSHORE DECOMMISSIONING ACCIDENTS

We do not have the ability to specifically predict accidents under any circumstances. However, by careful review of the history of accidents and with a good understanding of the work processes involved, we can draw broad conclusions about the relative safety of one particular approach versus another. That is what the study attempts to do.

The study evaluates the relative risk in terms of projected serious injury or fatalities from decommissioning of large offshore platforms by using two different approaches to complete removal of all material. To accomplish this, probabilistic models were developed for scenarios believed to be applicable for the particular structures considered.

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The process for developing the probabilistic models is as follows:

1. Detailed task lists are developed for each removal scenario.
2. For each task, the minimum, most probable, and maximum duration are determined based on a specified work crew sizes.
3. The above is input as triangular probability distribution functions (PDFs) for task duration in the model.
4. Total work requirements (man-hours) are calculated for each task, including a breakout for each labor category.
5. Overall statistics are calculated for all labor categories for the entire project.
6. The above are applied with accident rate PDFs to develop projected accident statistics.
7. For comparison, the results for each case are normalized against a base case.

The base case in the study is the **Irene** platform in-situ removal using a smaller derrick barge. This was believed to be the project scenario that is closest to what would be considered a "typical" decommissioning project as of the date of the study.

The probabilistic modeling is performed with commercially available software: Palisade's @Risk for Excel Professional, version 4.5.2. Representative output for each case is contained in Appendix A of the study report.

All PDFs in the study were input as triangular distribution functions, as represented in Figure 5. The **minimum** (lower bound) value is taken as the value of the variable with a 5% chance of <u>not</u> being exceeded in multiple trials of the same project. The **maximum** (upper bound) is the value that has a 95% chance of <u>not</u> being exceeded. The **most probable** is the value with the highest probability of occurrence (the mode).

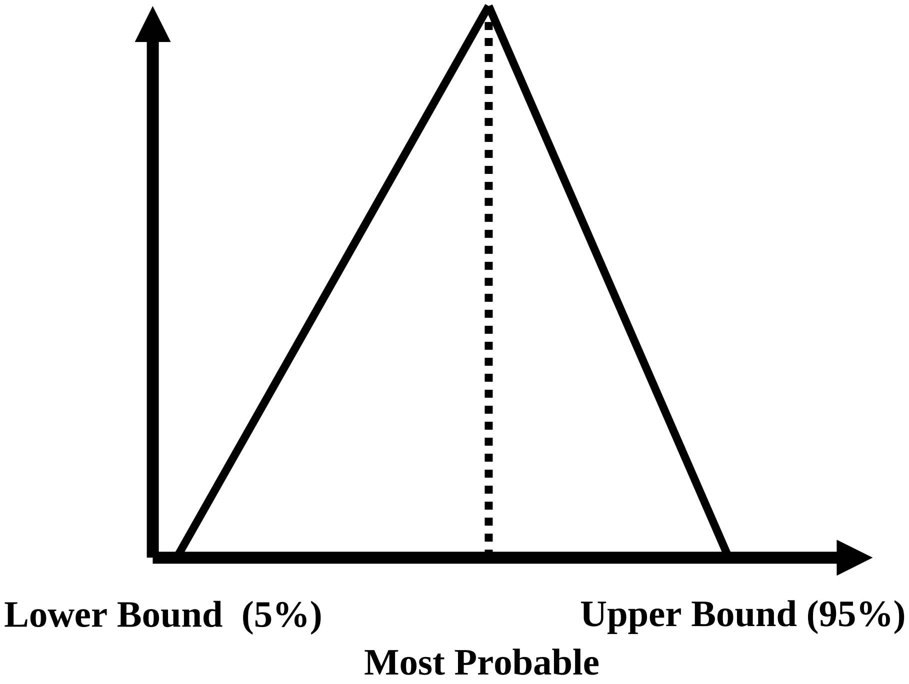

Figure 5 - Triangular Distribution of Work, FAR or SIR

5. RESULTS OF COMBINING WORK-EFFORT & ACCIDENT STATISTICS

Table 6 shows how the different labor categories are placed into work categories for the purposes of defining the risk.

Table 7 shows the Relative Risk of serious injuries during each decommissioning scenario, broken down by work category. The results are normalized against the **Irene In-Situ Small DB** case, which is considered the most representative of the industries current experience in decommissioning. For the purpose of normalization, the base case is set to an Average Value (AV) of one (1) serious accident during the decommissioning process. The actual AV may be found in Appendix A.

Figure 6 shows the Relative Risk of serious injury as a function of water depth for each decommissioning method. Figure 7 shows the Relative Risk of fatal injury as a function of water depth for each decommissioning method.

Table 6 - Work Category Grouping

Work Category	Personnel
On Deck High Risk	Riggers, Welders, Clean Tech. Riggers, X-Ray Hand
On Deck Support	Dive Support, Project Mgmt., Foremen, Crane Operator
Marine & Other Support	Marine and Other Support
Air Diving	Air Divers
Saturation Diving	Saturation Divers

Table 7 - Relative Risk of Serious Injury During Decommissioning

Work Category	Irene In-Situ Small DB (Base Case)	Irene In-Situ Large DB	Hidalgo In-Situ Small DB	Eureka In-Situ Small DB	Hidalgo Hopping Large DB	Eureka Hopping Large DB
On Deck, High Risk	0.075	0.073	0.128	0.174	0.109	0.167
On Deck, Support	0.016	0.010	0.032	0.040	0.012	0.014
Marine & Other Support	0.042	0.038	0.082	0.117	0.065	0.115
Diving, Air	0.394	0.145	0.599	0.364	0.351	0.487
Diving, Saturation	0.473	0.274	2.207	3.706	0.000	0.000
Totals	1.000	0.540	3.048	4.401	0.537	0.782

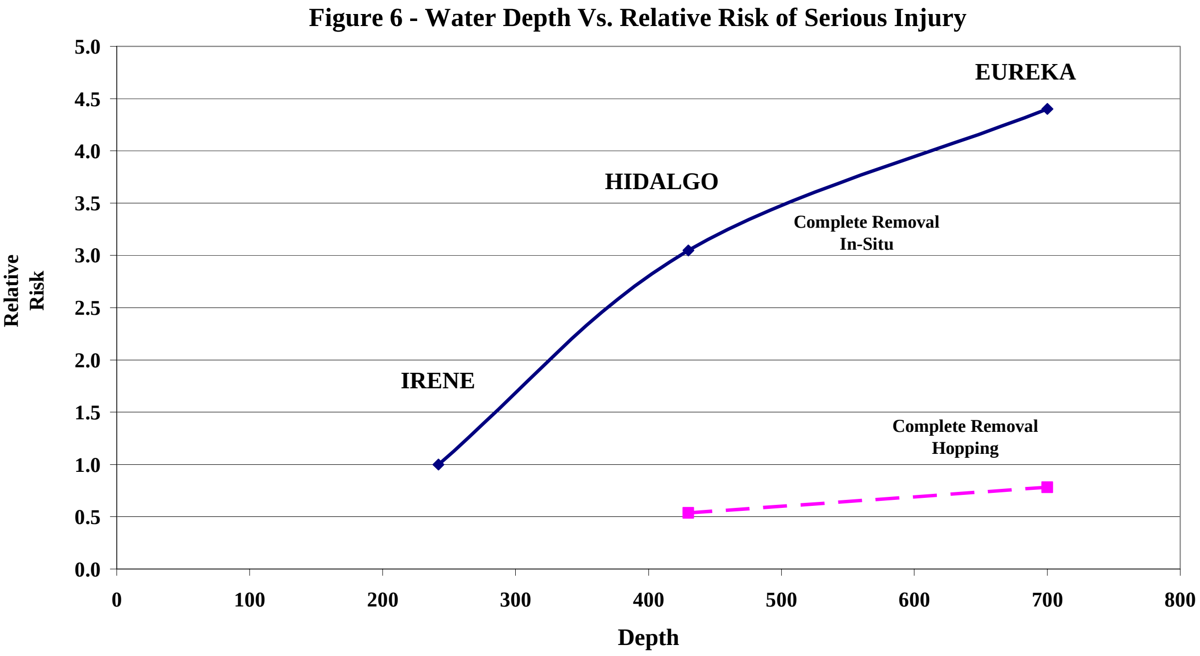
Figure 6 - Water Depth Vs. Relative Risk of Serious Injury
Relative Risk
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
600
700
800
Depth
EUREKA
HIDALGO
IRENE
Complete Removal In-Situ
Complete Removal Hopping

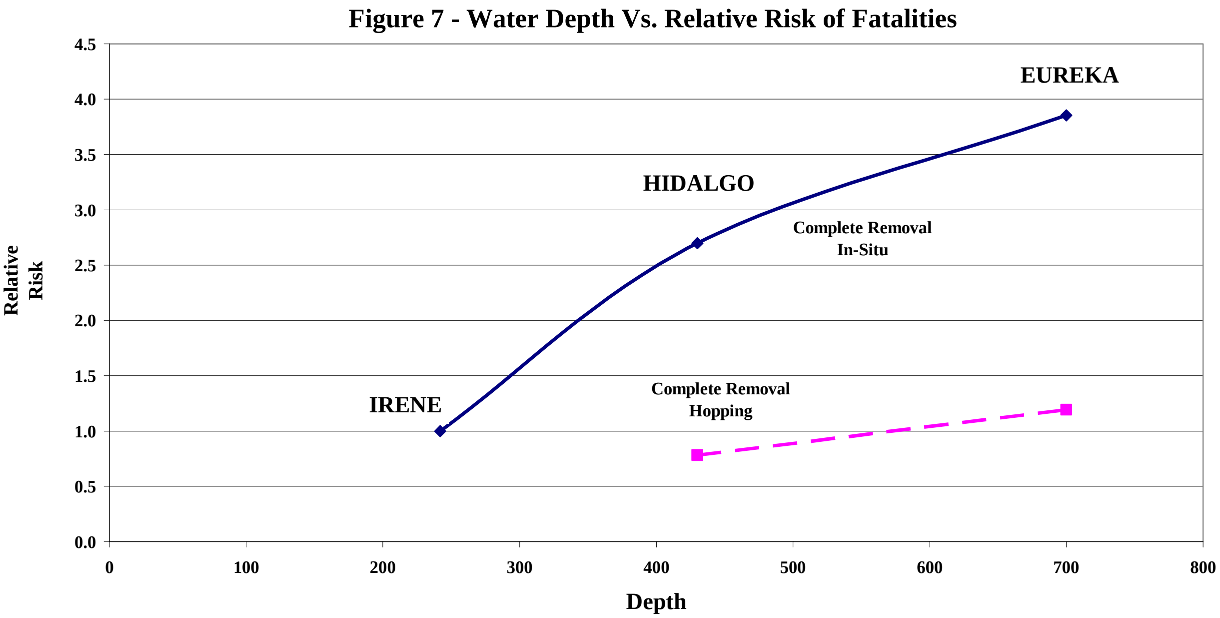
Figure 7 - Water Depth Vs. Relative Risk of Fatalities
Relative Risk
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
100
200
300
400
500
600
700
800
Depth
EUREKA
HIDALGO
IRENE
Complete Removal In-Situ
Complete Removal Hopping

6. CONCLUSIONS

The results of the study lead to the following conclusions:

- Complete Removal In-Situ will be more time consuming and demand more human resources than the Hopping method. This assumes the use of the technology and methods that are readily available today.
- The Hopping method appears to be much safer in a relative sense, when compared to In-Situ jacket removal.
- Risk of accidents increase with water depth for both methods, but it increases much faster with the In-Situ method.
- Review of the accident rate data presented in the study and the analysis results point to underwater work with divers as the major risk area.
- In general, every effort should be made to eliminate or reduce diver usage and to shorten the time required for decommissioning.