HSE
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# Rough weather rescue

Prepared by
**WS Atkins Consultants Ltd**
for the Health and Safety Executive

# OFFSHORE TECHNOLOGY REPORT

# 2001/089

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# SUMMARY

This report has been prepared by WS Atkins Consultants Limited on behalf of the Offshore Division of the Health and Safety Executive.

The report documents research to review the types of equipment and techniques currently in use for rescue of persons from the water around offshore platforms in rough weather, and to determine the limitations of that equipment due to extreme environmental conditions. The report also encompasses the results of an extensive questionnaire designed to reflect the views of the various industry sectors. In the context of this study, rough weather is taken to mean the conditions in which training and practice for an emergency situation are not normally carried out for safety reasons.

A literature review of the regulations in place in various oil producing countries found a wide variety of formats. Many countries are moving more towards the type of goal-setting approach used by the UK.

The main findings of the research are that:

In the UK, increasing numbers of companies are employing daughter craft arrangements and looking at the use of equipment such as personal locator beacons (PLBs).

There is a wide variety of types of equipment being used in the UK standby industry. This ranges from equipment that is specifically designed for operation in a severe marine environment to equipment that is unsuitable for use offshore in rough weather. The effectiveness of the service provided is undoubtedly being affected by this equipment.

Fast rescue craft (FRC) offer the best method of rescuing people from the water to an emergency response and rescue vessel (ERRV). The recovery of a FRC to a ERRV is seen as the most difficult factor in rough weather rescue. No particular type of recovery davit is specifically unsuitable, although each model will have its own drawbacks. Powerful hydraulic knuckle davits incorporating constant tension devices offer the best method of recovering FRC.

The provision of a good lee is essential for a successful launch or recovery of FRC in rough weather. In the most severe conditions it may be necessary to steam in circles to flatten the sea.

The device most commonly employed to recover casualties to the FRC is Jason’s Cradle, which has been found to be relatively fast and efficient.

Recovery of casualties directly to the ERRV is almost always carried out using a mechanical recovery device or system, often a rescue scoop such as those produced by Dacon and by Sealift. Other items of equipment, whilst useful in reaching the casualty and getting them to the side of the vessel, have not proved as versatile in practice. There are, however, concerns with the positioning of the mechanical recovery device onboard the ERRV, the risk of injuring the casualties and its use as a scramble net.

Helicopters have been found to offer a good prospect of rescue provided that they can carry sufficient fuel to reach the scene and remain in a hover. The double-strop technique is a suitable method to recover casualties who may be in danger of post-rescue collapse. Stretchers are difficult to use in rough weather and require a helicopter designed with racking to store them efficiently. Rescue baskets are difficult for the casualty to get into and take up a lot of space in the aircraft.

Rescue equipment in use on helicopters and emergency response and rescue vessels has been reviewed in detail by its users with regard to performance in rough weather. However, the predominant factor in determining whether or not a rescue can be conducted in rough weather is

the experience of the crew. This will be a result of the training they have received and the regular practice that is carried out.

Rescue operating limits have traditionally been described using only the significant wave height. It is suggested that the wave period should be used in conjunction with this to give some idea of wave steepness.

It is assumed that a fast rescue craft can typically be launched in waves up to a 5.5 m significant wave height in an emergency, and the mechanical recovery device can be used up to a 7 m significant wave height ($H_S$). With suitable training and experience it is expected that it will be possible to launch the FRC in much worse conditions than this on some occasions. Conversely, it may not be possible to launch and recover if the wave period is short, even in 2-3 m waves. Use of a mechanical recovery device should be avoided if it is possible to launch the FRC.

A method has been proposed for estimating whether or not recovery of a FRC to the ERRV is possible with the equipment available in certain weather conditions, and the average length of time it would be necessary to wait for a suitable lull. It is proposed that work on the interactions between equipment limitations, environmental conditions and human factors is undertaken to enable performance criteria to be established based on this method.

Finally, it was found that ERRV and FRC training courses in the UK are considered by some training establishments and crew to be of a relatively low standard when compared with the situation pre-OPITO and the standards of other countries. This situation may have arisen since the involvement of duty holders and ERRV operators within OPITO, reflecting their desire to minimise training costs. An inconsistent approach and the inability to practise in rough weather are considered to be major shortcomings. The realism of practice simulations is reasonable but could also be improved. Formal rescue scoop training should be considered as an industry standard for all ERRVs.

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# NOMENCLATURE

| | |
|---|---|
| AWWP | Adverse Weather Working Policy |
| DC | Daughter Craft |
| EER | Escape, Evacuation and Rescue |
| ERRV | Emergency Response and Rescue Vessel |
| FRC | Fast Rescue Craft |
| $H_S$ | Significant wave height |
| HSE | Health and Safety Executive |
| IMO | International Maritime Organisation |
| MOB | Man Overboard |
| OIM | Offshore Installation Manager |
| OPITO | Offshore Petroleum Industry Training Organisation |
| PFEER | Prevention of Fire and Explosion, and Emergency Response |
| PLB | Personal Locator Beacon |
| PMRC | Platform Mounted Response Craft |
| RIB | Rigid Inflatable Boat |
| SAR | Search and Rescue |
| SBV | Standby Vessel, alternative term for EERV used in Appendix A |
| SOLAS | Safety Of Life At Sea |
| TEMPSC | Totally Enclosed Motor Propelled Survival Craft |
| UKCS | United Kingdom Continental Shelf |
| VCG | Vertical Centre of Gravity |

# 1. INTRODUCTION

## 1.1 PREAMBLE

This report has been prepared by WS Atkins Consultants Limited on behalf of the Offshore Division of the Health and Safety Executive.

The report concerns a study into the types of equipment used in offshore rescue, their limitations and the effects of adverse weather conditions on their use. The research includes equipment used by emergency response and rescue vessels (ERRVs), fast rescue craft (FRC) and helicopters.

Under the current PFEER regulations, operators of offshore installations are responsible for compiling escape, evacuation and rescue (EER) plans which constitute *"a good prospect of being recovered, rescued and taken to a place of safety"* for all personnel. The regulations are goal setting in nature and not prescriptive. In the development of these procedures, the duty holder must be able to show that properly trained crew are using suitable equipment and that satisfactory response times can be obtained in practice.

The main aim of this research is to review the types of equipment and techniques currently in use for rescue of persons from the water around offshore platforms in rough weather, and to determine the limitations of that equipment due to extreme environmental conditions. The report also encompasses the results of an extensive questionnaire designed to reflect the views of the various industry sectors. In the context of this study, rough weather is taken to mean the conditions in which training and practice for an emergency situation are not normally carried out for safety reasons.

## 1.2 OBJECTIVES

The following objectives were defined in order to achieve the main aim of the project as stated above:

- To review the approaches to rescue provision as overseen by the various marine and offshore safety authorities in the UK, Nordic countries, Europe, USA, Canada and other offshore oil producing countries.
- To review the preferred rescue methods and procedures, and the equipment available, for incident types including:
    - man overboard;
    - helicopter ditching;
    - evacuation from TEMPSC and liferafts.
- To review the limiting capacities of the equipment available, including an examination of certain complete rescue systems in operation.
- To review manufacturers' claimed performance, in terms of operability for these items of rescue equipment, and to compare this with the achieved performance of the equipment.
- To review the different ways the equipment is put to use, and the manner in which each type of incident is planned for.
- To review the definitions of, and attitudes towards, environmental limits of operability of the various forms of rescue equipment.

- To examine a selection of incidents to further clarify the differences in approach that can be taken to a single type of incident according to the strategies and types of equipment used.

## 1.3 STRUCTURE OF THIS REPORT

In Chapter 2, a review of the regulations in some of the main oil producing nations concerning EER is presented. A sample of the EER planning by various operators in these areas is also given.

Chapter 3 reviews the concept of environmental limits and the meaning of the term “rough weather” is discussed.

In Chapter 4, the review of a literature search on the current methods and procedures used to rescue casualties is presented. This is combined with results from a questionnaire issued to duty holders and rescue services, including members of the ERRVA.

In Chapter 5, the types, capacities and limitations of rescue equipment available have been derived from an extensive literature review. This review includes examination of complete rescue systems, such as ERRV and FRC operations.

Chapter 6 lays out the actual limitations of these pieces of equipment in use, as determined from questionnaires and interviews. These limitations are then compared with the manufacturers’ stated performance standards, and conclusions drawn.

In Chapter 7, the types of training courses available to rescue crew members and the suitability of the course contents are examined. Following this is a review of the time spent on practising rescue activities and its effectiveness.

Chapter 8 examines rescue crews’ attitudes towards carrying out activities in difficult conditions and outlines a method for determining the probability of successfully recovering a FRC to the ERRV and for predicting the occurrence of lulls.

In Chapter 9, a review of incidents concerning rescue of people from the water surrounding offshore installations is presented. These are looked at in turn to consider whether different actions would have improved the likelihood of success, and conclusions drawn.

Chapter 10 presents the results of a report by Seacroft Marine Consultants Ltd commissioned to identify problem areas with standby equipment and operations.

In Chapter 11, conclusions are drawn concerning the types of equipment in use, the methods and procedures in which they are used and the suitability of training and practice activities.

Chapter 12 presents the recommendations that have arisen from this study.

# 2. REVIEW OF APPROACH TO RESCUE PLANNING BY VARIOUS COUNTRIES

## 2.1 REGULATIONS

This section provides an overview of the regulations governing EER in a number of oil producing nations.

***United Kingdom:***

The provision for emergency planning and equipment is regulated in the UK by *"The Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations, 1995 (PFEER)"*. These regulations are not prescriptive, instead stating that the person responsible for EER must take necessary and suitable precautions to safeguard lives of crew and visitors.

The requirements for the provision of effective emergency arrangements for an installation are overseen by the HSE. More prescriptive guidelines for emergency response and rescue vessels are provided by the UK Offshore Operators Association (UKOOA) in the form of *"Survey of vessels standing by offshore installations"* and *"The safe management and operation of vessels standing by offshore installations"*. It is important to note that these have no statutory force. Guidelines on emergency response are given in "*Guidelines for the Management of Emergency Response on Offshore Installations*".

***Australia:***

Australian offshore safety is controlled in a similar manner to the UK, with regulations under the Petroleum (Submerged Lands) Act putting the onus on operators to ensure adequate emergency plans and equipment are in place. Many fields off the western coast of Australia do not employ emergency response and rescue vessels. Work boats and FRC are launched from the platform during over-side operations.

Where an emergency response and rescue vessel is used, the "*Australian Offshore Support Vessel Code of Safe Working Practice"* applies. These guidelines state that emergency response and rescue vessels should have a FRC and trained crew ready for immediate use at all times. The FRC should be of a type approved for purpose. Rescue nets and rescue baskets are also advised.

The formation of emergency plans, training procedures and response times are the responsibility of the operator. Supplementary training is suggested in the areas of rescue boat operations, helicopter ditching, recovering people from the water, first aid, man overboard and fire fighting (if applicable).

It should be noted that the weather conditions encountered off the West Coast of Australia are likely to be much more benign than those in the North Sea.

***Canada:***

*"Nova Scotia Offshore Area Petroleum Production and Conservation Regulations"* state that an emergency response and rescue vessel must be stationed within 20 minutes of the installation, and is to attend close by during several prescribed operations. The emergency response and rescue vessel must meet the requirements of the Canadian Coast Guard TP 7920E, *Standards Respecting Standby Vessels*. One fast rescue craft should be carried, which must be capable of carrying its rated capacity of passengers and equipment at 8 knots for 2 hours.

The safety plan guidelines suggest that a dedicated SAR helicopter be maintained on standby, and fitted with equipment for retrieving single and multiple casualties from the water. There is not a statutory requirement for such a helicopter in the regulations.

***Europe:***

The *"COUNCIL DIRECTIVE 92/91/EEC of 3 November 1992 concerning the minimum requirements for improving the safety and health protection of workers in the mineral-extracting industries through drilling"* states that "An emergency plan for sea rescue and workplace evacuation situations must be drawn up ...[and]...must provide for the use of emergency response and rescue vessels and helicopters and include criteria concerning the capacity and response time of emergency response and rescue vessels and helicopters. The required response time must be given in the safety and health document for each installation. Emergency response and rescue vessels must be designed and equipped to meet evacuation and rescue requirements."

***Norway:***

The standards governing health and safety for Norwegian offshore installations take a prescriptive approach. In particular, the *"NORSOK Technical Safety S-001"* standard states that the installation shall be equipped with one platform mounted rescue craft (PMRC), having a fixed lifting frame with one point suspension for handling by cranes. It should be possible to reach the PMRC from two cranes. The PMRC shall be visible from the crane cabins during handling. It should be possible to launch and recover the PMC in 5 meters significant wave height, which shall have a minimum speed of 25 knots in calm sea with 3 men onboard. This is in addition to the mandatory emergency response and rescue vessel which is required to have at least one FRC. The platform shall also be equipped with one basket for the transport of able personnel and one basket for injured personnel.

For not-normally-manned installations the standards are less prescriptive. There is no regulatory requirement for an emergency response and rescue vessel but adequate emergency plans must be in place for when personnel are required to occupy the platform.

***United States:***

Regulations are similar in principle to PFEER, calling for safety targets to be met and a demonstration that these can be met, using emergency response and rescue vessels if appropriate.

## 2.2 CURRENT EER PRACTICES

There are many different duty holders currently working the UK Continental Shelf (UKCS). With the UK regulations now using a goal-setting approach there is scope for a number of different approaches to EER planning, some of which are examined here.

Texaco North Sea operate their own emergency response and rescue vessels in the North Sea. This is based on one vessel to a platform, with either two FRC or one DC and one FRC on each. The only exception to this is in the Captain field where they have a group of platforms within 2.4 miles of each other. One emergency response and rescue vessel is used with one DC and one FRC. Extra personnel are employed such that the DC can operate independently for 24-hour periods.

Amerada Hess subcontracts BUE to operate its standby cover for installations in the North Sea. Conventional standby cover is used, except in one location where they have two platforms

6.2 miles apart, sharing one purpose-built ERRV. They do not operate a DC as they have found, following trials, that they can meet the target criteria without. Over-side working is carried out on one platform at a time with the ERRV in attendance. Rescue exercises are stopped at a wave height of around 2.5 m and routine over-side work at 3 m. Emergency over-side work may be carried out up to 3.5 m. Helicopter operations at wave heights greater than 5.5 m rely on a mechanical recovery device as the means of rescue. They do not currently use PLBs but do equip all helicopter crew and passengers with fully insulated thermal suits instead of the normal immersion suits.

BHP has two ERRV sharing systems in operation in Liverpool Bay. All personnel either wear or have access to survival suits. Over-side work can only be continued at wind speeds above 25 knots after a risk assessment has been carried out and if appropriate safeguards are in place. PLBs are to be introduced shortly for all helicopter transfers and over side work.

Shell Expro have several locations where DC are deployed from an ERRV to guard multiple platforms. They actively require certain equipment on the ERRVs and occasionally carry out checks. There is a requirement for at least one training exercise per trip for the ERRV. Shell recognise that there is a significant difference in standards between different emergency response and rescue vessel operators. They intend to introduce the new wristwatch-style PLBs in the near future.

The above approaches to EER planning cover the majority of methods in use on the UKCS by the other various duty holders.

Similar approaches world wide include Mobil’s safety plan for their platforms in the Gulf of Mexico, which makes use of SAR helicopters, platform launched FRC and shared ERRVs.

# 3. ENVIRONMENTAL LIMITS

Weather conditions comprise elements such as swell, wind driven waves, wind strength, wind direction, temperature, precipitation and visibility. Each of these individual elements may be significantly different in the areas West of Shetland, the northern North Sea, the central North Sea and the southern North Sea.

The sea state will be a combination of two factors: the swell and the wind-driven waves. The swell is produced by the surface winds of an oceanic weather system and may travel large distances before losing definition. Because of the exposure to the Atlantic, swell will generally be larger in the northern North Sea and West of Shetland than the southern North Sea. Shallow water at the installation will have the effect of increasing the amplitude and decreasing the wavelength of the swell. The wind-driven waves at a particular location will depend on the fetch, the wind speed, the duration of wind at that speed and any local tides and currents. When the wind is in opposition to the tide the waves will become significantly steeper and have a larger amplitude, and therefore more likely to have a potentially dangerous breaking crest. The swell will have a wavelength of maybe a few hundred metres, whereas the wind-driven waves will have a wavelength of maybe a few tens of metres.

For the areas West of Shetland and central North Sea the mean wave height falls broadly in line with that predicted by the Beaufort scale for fully developed seas [1]. Wave heights with a 10% probability of exceedence are significantly higher West of Shetland. In contrast, the limited fetch of the southern North Sea leads to the actual wave heights being lower than those suggested by the Beaufort scale for a particular wind speed.

Currently, a significant wave height of 5.5 m is usually taken as the maximum wave height in which a FRC can be safely launched and recovered for emergency operations. A wave height of 3.5 m is considered the maximum for FRC crew training and normal operations in the water. However, in an emergency it is expected that an FRC may well be able to launch in significantly worse conditions, depending on the experience and skill of the crew.

In the context of this study, rough weather is taken to mean the conditions in which training in and practice of an emergency procedure are not normally carried out for safety reasons. From the above FRC limits this may be associated with a significant wave height in the region of 3.5 m. This will also depend on the area of operation, as a 3.5 m mean wave may occur at Beaufort 6 West of Shetland but only at Beaufort 7 in the southern North Sea. This criterion takes no account of the wave steepness.

It should be noted that it is extremely difficult to judge accurately the significant wave height. Usually, the wave height is inaccurately estimated even by experienced seamen. In many accounts of the same incident, the range of wave heights given is so large that conditions would have been entirely different depending on which extreme of the range was true. Data from nearby wave-buoys or several independent accounts will corroborate any reports to some extent and add credibility.

One general theme of the questionnaires and interviews carried out as a part of this project was that the sea conditions should be expressed as the significant wave height combined with the wave period. This then gives a much better idea of the severity of the sea state for defining FRC limits. Many of the AWWPs in use rely on this system, for example stopping overside working when the sea state exceeds 5.5 m with a period of 7 s or less.

The existence of lulls in the wave pattern is a well recognised phenomenon which is already well used in rescue boat operations. If a predetermined limiting wave height is set for launch and recovery operations by the previous method it may well be possible to wait for a lull which provides suitable conditions. Analysis of wave data for the North Sea would allow a statistical estimation of the frequency and duration of such a lull and it would therefore be possible to calculate, for a given sea state, the likely time that one would have to wait for a suitable lull to conduct launch and recovery operations. Although not precisely predictable, these lulls do exhibit some form of periodicity in that a set of large waves will often be followed by a set of small waves. It would also be possible to combine data for many different sea states and draw some conclusions as to the patterns of these lulls and, ultimately, to have sufficient data to determine the likely probability that a rescue craft can be launched. A statistical method for the prediction of lulls is detailed in Section 8.2.

# 4. OVERVIEW OF RESCUE AND RECOVERY METHODS

## 4.1 RECOVERY FROM THE WATER

The rescue of individual personnel from the sea can be performed in many ways, depending on the weather conditions and location of the man overboard (MOB) and ERRV.

Opinions of rescuers on the best method of recovering casualties are varied, probably because of lack of exposure to different methods. The effectiveness of the rescue is also extremely dependent on the skills, experience and teamwork of the crew.

### 4.1.1 Rescue by ERRV

The majority of installations on the UKCS are supported by an emergency response and rescue vessel with fast rescue craft to provide a means of rescue following a man-overboard, a helicopter ditching or a mass escape, such as a rig evacuation. Some installations may share an ERRV with other platforms nearby, using one or more daughter craft with the ERRV acting as the parent vessel.

It should be noted that a single ERRV may support two installations without the provision of daughter craft, subject to the demonstration of suitability of such provision by EER analysis. Over-the-side working will, however, then be restricted to one of the installations where the ERRV will be supporting these operations.

The preferred method of rescue in calm conditions is to launch the FRC and recover the casualties to this either manually or by using a lifting device. The FRC is then fully recovered to the ERRV before the casualties are transferred to the medical facilities on board. For multiple casualties, as in the case of a helicopter ditching, the FRC is then re-launched and the process repeated. The capacity of the FRC in calm weather may be anything up to 15 persons. This technique is assumed to be viable up to a significant wave height of about 5.5 m, equivalent to a force 8 on the Beaufort scale. Daughter craft operate in a similar manner, but it may only be possible to launch and recover them in waves up to about 3.5 m, depending on the equipment fitted to the ERRV.

When it is not possible to launch the FRC it is necessary to recover the casualty directly to the ERRV. This will usually be done using a mechanical recovery device such as an overside rescue scoop. In theory, this will allow recovery of casualties in significant wave heights up to 7 m. Two manufacturers of commonly used rescue scoop systems are Dacon and Sealift.

Above these conditions it is recognised that the probability of a successful rescue is low, although a few incidents demonstrate that it is still possible.

### 4.1.2 Rescue by Helicopter

There are a number of bases for search and rescue (SAR) helicopters throughout the UK. As yet there are no platform-based helicopters designated specifically for search and rescue. There are some existing offshore-based dual role helicopters (e.g. rig transfer) that have the ability to affect limited SAR operations but these cannot be considered as properly equipped for the SAR role.

Rescue of casualties from the water by helicopter can be carried out in two main ways. For single casualties the most common method is to perform an accompanied lift using a double strop technique. One strop is passed around the shoulders and the other behind the knees. This enables the survivor to be lifted in a near-horizontal attitude rather than upright with the single strop method.

Although usually used to recover casualties from vessels or liferafts, the Hi-line technique may also be used in open water if the helicopter is able to deploy an inflatable dinghy. The winch man is lowered on the main hook, carrying a light line which is secured to the winch hook at one end, whilst the winch man holds the other. Near the hook, a weak link of about 80 kg breaking tension is built into the Hi-line. The winch man, in the dinghy, will be able to attach two casualties at a time to the winch hook whilst remaining in contact with the helicopter via the Hi-line. The main advantage of this method is that the helicopter can hover slightly to one side of the casualties to maintain a visual reference whilst the Hi-line allows the winch man to recover the winch hook more easily.

One of key environmental factor for helicopter deployment is the wind speed during rotor engagement on start-up. The non-emergency limit will be around 40-65 knots steady wind speed, depending on the aircraft, and will be lower in gusty conditions. This may be exceeded at the pilot’s discretion. The in-flight wind speed will determine the speed over the ground and hence the amount of fuel required to reach the scene of the incident. The sea state has little effect on the helicopter operation, but will have a debilitating effect on the winch man. Visibility, and in particular fog, may also hinder the operations. The other main limits for helicopter operations include the level of turbulence and the density of the air, both of which may be influenced by fire or gas clouds.

### 4.1.3 Rescue From the Installation

Rescue directly from the platform may be possible in calm weather by means of line throwers but will obviously be difficult in rough weather. Some installations make use of platform mounted response craft (PMRC). These are usually launched from davits mounted on one of the platform decks and as such there will often be a large drop to the sea surface. Problems are encountered during the launch and recovery phase because the platform doesn’t move with the waves in the way that a ship would, resulting in severe relative motions. Because of this PMRC cannot be relied on for rescue and recovery in rough weather.

## 4.2 RECOVERY FROM TEMPSC

### 4.2.1 Recovery of Survivors by Helicopter

The use of a helicopter to recover survivors from TEMPSC is currently the preferred method for many operators. A Hi-line technique is usually used, with the winch-man on the TEMPSC linked to the lift hook by means of a light line with a weak link whilst the helicopter hovers to one side.

This method is dependent on the design of the TEMPSC, as helicopter crews consider it dangerous to recover survivors if the TEMPSC is fitted only with side hatches [2]. A large top hatch makes recovery easier, although stretcher lifts are still hazardous in all but the calmest conditions. The winch man may have difficulties landing and moving about on the TEMPSC canopy.

### 4.2.2 Recovery of Survivors to ERRV via FRC

Fast rescue craft will generally be of the rigid inflatable type and will therefore be relatively resistant to damage and light collisions. The dimensions of a TEMPSC are much closer to those of a FRC than an ERRV and as such the motions will be broadly similar, although the TEMPSC will probably be more buoyant, have slightly larger motions and have less stability than a FRC. A TEMPSC designed with side hatches should allow access for survivors to the FRC. The FRC could either be bowsed to the TEMPSC or the FRC could attempt a transfer whilst under way. This technique becomes progressively more difficult as sea conditions worsen.

There is a serious potential for capsize if all the occupants move towards the hatch in expectation of rescue. Many of the larger TEMPSC may be carrying in excess of 60 passengers, requiring several FRC, or multiple journeys by the same FRC to complete the evacuation. In rough conditions this will mean a full recovery to the ERRV and re-launch, and will take some time. If the conditions are poor it may not be possible to launch the FRC.

# 5. REVIEW OF EQUIPMENT

## 5.1 LAUNCH AND RECOVERY SYSTEMS

It is well recognised that recovery of FRC and DC to the emergency response and rescue vessel is one of the key areas that limits rescue capability in rough weather. Many different types of cranes and davits are in service with varying degrees of success. This section looks at the suitability of the various types of launch and recovery systems. A method for the estimation of the total davit loading in rough weather is presented in Section 8.2.

The emergency response and rescue vessel survey guidelines [6] suggest that a launch and recovery system capable of raising and lowering a fully laden FRC (15 persons) at a speed of not less than 0.3 m/s be fitted. The height from the point of suspension to the water should not exceed 7.5 m and precautions should be taken to prevent swinging. With two FRCs there should be a certain amount of independence between the two davit systems, such that the withdrawal of one from service does not affect the availability of the other.

The prescriptive SOLAS regulations (MSC 81(70)) for merchant shipping state that davit systems should encompass:

i. A system to dampen forces caused by interaction with waves on launch and recovery;
ii. A device to soften forces, reducing pendulation;
iii. A winch fitted with a high-speed tensioning device to prevent slack;
iv. Controllable lowering speed;
v. Capable of recovering the FRC fully laden in sea state 4.

Many davit systems currently in use feature some kind of high-speed tensioning device. The aim is to reduce the high snatching loads that can occur if the main winch cable comes tight because of the wave motion. When the rescue craft is in the water with the davit cable attached the device has the capability of letting out or taking in a certain amount of winch wire at a fixed, low tension which keeps the rescue craft in contact with the water surface. This has the effect of reducing any loads that would otherwise occur from waves slamming underneath the hull. The winch operator may then wait for the ideal moment before recovering the craft without risking damage to the occupants.

Some of the more advanced davits also incorporate motion compensation devices. The FRC is winched up tight to the docking head, creating an almost rigid link. Passive damping is then achieved through the use of hydraulic damping cylinders between the docking head and the davit tip, reducing motions in the pitch and roll directions.

The acceleration of the lift from the water and the lifting speed are seen as critical by crews. Many feel that the suggested minimum lifting speed of 0.3 m/s is too low, especially if a constant tension device is not used. The lifting speed is directly dependent on the power output of the winch motor.

A towing boom is an integral part of many davit systems and has two main functions. When the rescue craft is suspended over the water the bow line attached to the towing boom prevents yawing, which the docking head is usually incapable of doing. When in the water, the towing boom allows the rescue craft to hang back on its bow line clear of the ship’s side whilst awaiting recovery. The main problem with this system is when the length of the bow rope is fixed, so that it is taut when the rescue craft is in the cradle. When the craft is swung over the side the rope goes slack and so cannot work to prevent yawing as it should. The solution to this is to install a winch on the towing boom to take in the slack rope when the craft leaves the cradle. The towing boom is stored inboard when not in use, and is rigged by means of wire stays attached to the gunwale.

Ideally the ERRV, the FRC and the recovery system should all be integrated at the design stage. Davit systems consist of one or two lifting arms either fully fixed or able to rotate only about the ship's longitudinal axis. Cranes are defined as lifting arms able to rotate about the vertical axis (slewing).

### Single fall davits:

These are the most common form of davit found on UK emergency response and rescue vessels. Recovery using this system is conducted close to the ship's side, which will require an effective lee and good FRC handling to prevent damage. Unless the FRC is lifted in contact with the side of the ship, bow and stern lines will be needed to prevent spinning. Use of single fall davits is thought to allow recovery in up to 6 m $H_S$ [7]. A few instances have shown that they may be used in extreme sea states [8]. One of the most popular makes is the Vest davit incorporating a constant tension device.

### Double fall davits:

The main advantage of double fall davits is that they reduce swinging motion commonly found with single attachment point devices. For this reason they may be well suited to high sided ships, such as passenger ferries, where it may not be possible to control the swinging. Constant tension devices have recently been introduced on some double fall davits. The disadvantage is that both falls must be operated together. They will make it difficult to perform a rapid release or connection as is required during launch and recovery, and are therefore unsuitable for use on an emergency response and rescue vessel.

### Cranes and knuckle davits:

The main advantage of using cranes or knuckle davits is flexibility. Some now incorporate a docking head with active hydraulic damping to compensate for ERRV motion. The knuckle boom allows the docking head to be brought much closer to the FRC lifting point than with other systems, resulting in a shorter length of wire to the swinging hook during the hook-up process. The long outreach of the crane arm means that the FRC can be launched in clear water away from the ship's side, clear of fittings and obstacles. A constant tension keeps the wire under low tension whilst the craft is on the water surface to prevent snatching. Lift starts on the upward motion of the FRC on a wave, indicated by the coxswain to the launch and recovery operator. The FRC or DC is usually recovered fully to its cradle before transferring survivors.

Typical small davits for the launching and recovery of FRC are those produced by Caley Ocean Systems. These have a safe working load (SWL) of up to 4 tonnes and are suitable for FRC from 4.5 m to 8 m. A typical larger design by this manufacturer caters for FRC and DC up to 12 m long and has a SWL of up to 12 tonnes. A 5 m outreach and 12 m freeboard allowance increase the envelope for recovery. The manufacturer claims that the davits can easily be operated by one trained person.

For both of these typical davit types, a high tension is applied when lifting, whilst a lower tension is used to prevent slack wire when the FRC is in the water, which may cause high loading through snatching. Lift speeds are up to 0.6 m/s. Pitch and roll damping are introduced through a docking head. A towing boom is used to prevent yawing and to keep the craft well clear of the ship's side.

Using this system the manufacturers claim that it is possible to recover the FRC, transfer the casualty and re-launch in under 1 minute and that the davits can be used for launch and recovery up to sea state 7, which is defined as 6 m $< H_S <$ 9 m [9].

It is interesting to note that ESVAGT, the Danish offshore rescue service, who are widely recognised for their launch and recovery capabilities, use a standard powerful deck crane with an articulated jib arm and a high lifting speed. The single crane is mounted amidships which can launch either one or both of the FRC, depending on the number carried (Note: this arrangement would not satisfy the UK ERRV survey guidelines).

**Cradle:**

The most common cradle system is known as the “Miranda system”. A crescent shaped cradle on a single fall is mounted from the davit. The system claims to allow launch of the FRC with up to 30° list and 15° trim on the ERRV [7]. In the southern North Sea launch and recovery of the Delta 95 daughter craft are normally achieved using Miranda davits, which have one hook forward and one aft. Generally these daughter craft are fitted with TEMPSC-style on-load release mechanisms. The lowering is controlled by the FRC crew. ERRV crews reportedly like the system, though during the recovery phase of the daughter craft both hooks must be attached manually, with a potential of injury to the crew, particularly at the upper sea states. Other problems are usually caused by poor location of the davits on the ERRV deck and from inefficient bowsing in poor conditions. See also section 6.2.2 of the present report.

**Stern ramps:**

This method requires a totally integrated design of ERRV and FRC. One method requires a well to be cut into the stern of the emergency response and rescue vessel and an inclined ramp fitted. The FRC then enters the well and is pulled up the ramp by a hook system. Factors influencing the effectiveness of this system will include ERRV motions, hull shape and handling characteristics. Stern ramps are used by some specialist rescue operations (e.g. German lifeboat) but may not be suitable if other activities are to be carried out. Launching can be conducted in very poor conditions but recovery is recognised to be limited to better conditions. This method has significant cost implications as it requires commitment at the ERRV design stage and retrofitting will not be possible.

## 5.2 FAST RESCUE CRAFT AND DAUGHTER CRAFT

### 5.2.1 FRC and DC Design

The ERRV survey guidelines [6] split ERRVs into three distinct categories: Group A to serve offshore installations with significantly over 300 personnel, Group C for installations with fewer than 20 personnel and Group B to cover all installations between these two. The guidelines state that Group A vessels should carry three FRC with capacities of 15 persons, Group B vessels should carry two FRC with capacities of 15 persons and Group C vessels should carry two FRC, one with a capacity of 15 and the other with a capacity of 9 persons.

Fast rescue craft specifications must be closely linked with the facilities of the ERRV and the capabilities of the davits. It is assumed that the minimum length for a FRC operating offshore will be about 5.5 m as below this the load carrying capacity and operational envelope make such a craft unsuitable. The suggested passenger load carrying capacity of FRC can vary widely between manufacturers. This capacity will only apply before any modifications are made to the FRC (e.g. the fitting of a lifting frame). It may often not be possible to carry the rated maximum number of passengers in rough weather conditions using a small FRC. It is therefore the responsibility of the duty holder to ensure that the FRC can meet the requirements of the EER plans in all weather conditions.

It would seem logical that the larger the FRC the more space there will be for movement and casualty recovery. However, on daughter craft with enclosed areas the clear deck space may be reduced and may make rescue difficult if poorly designed, for example by giving the crew limited access to the foredeck because of superstructure.

When can a rescue craft be considered a DC? Originally, the Green Code defined a DC as any fast rescue craft that provided enclosed weather protection for the crew. In practice, a rescue vessel can be considered a DC when it is designed to operate away from the ERRV instead of solely being launched in an emergency. As such it will have a load line exemption certificate and be equipped with a totally enclosed area containing sleeping quarters for the crew and emergency medical facilities. There may also be PLB direction finding equipment on board. The minimum size for a DC will depend on the time and distance that it is to stay away from the parent vessel. It must at least have a sufficiently large enclosed area for the crew to rest, be watertight and self-righting. Typically, the load line exemption certificate will set the limit of operations to 4 hours away from the mother ship.

The benefits of having a particularly large FRC include improved motions at speed in rough weather and more space to carry survivors. However, above some size the disadvantages will outweigh the advantages, namely:

- Too cumbersome and large to launch and recover in rough conditions;
- Not enough space on ERRV deck for FRC stowage and handling;
- Higher freeboard makes casualty recovery difficult;
- Higher initial and maintenance costs;
- Higher fuel consumption;
- Insufficient recovery crane capacity.

In some conditions it may not be as important to recover a DC to the ERRV as it would be a FRC, as the casualty can be considered as being in a safer environment than aboard a FRC. If the casualty requires substantial medical treatment the DC may either proceed to port (if within range), attempt to recover to the ERRV or attempt a transfer to helicopter. It is believed that only exceptional weather conditions would affect the survivability of the DC and these conditions would preclude launch in the first instance.

One of the most difficult parts of FRC operation is during launching and recovery when the FRC has to hold station alongside the ERRV. This will require the FRC coxswain to maintain a constant course and speed in a confused seaway whilst keeping a safe distance from the side of the ERRV. Waves will be reflected from the ERRV and propeller ventilation may be an issue. A skilled coxswain will be required to operate both throttles and occasionally trim tabs in order to keep on course. The FRC design should therefore take into account handling at low speeds in a confused seaway.

The hull shape is an important factor because of the debilitating effects that severe FRC motions can have on the crew. Forces from repeated wave impact can easily cause permanent back injury. The hull shape of a FRC is usually a deep-V type with hard chines, to allow good course keeping and lower wave impact resistance in a seaway. However, some organisations have opted for a shallower than normal section at the bow to reduce the risk of broaching in following seas, whilst accepting the higher slamming loads [8]. The greatest risk to a FRC in rough weather whilst under way is from breaking waves on the tops of swells which, because of their steep angle, will tend to flip the FRC. The prevention of this is one of the main reasons that the coxswain needs to impose a speed reduction.

The motions of the smallest FRC will follow the sea surface at relatively high frequency, whilst the motions of bigger daughter craft will approach the response of the ERRV. Some rigid inflatable boats (RIBs), such as the Avon 6 m, have a double-bottom construction allowing the use of a water ballast tank to aid low speed recovery. The tank is open to the water via a hole in the transom so that it floods at low speed and empties when the vessel is operating at planing speeds. This sinks the craft into the water to the level of the inflatable sponsons, increasing stability. This enables easier recovery of casualties from the water. However, any marine growth in the double bottom will be difficult to remove, will add extra weight to the craft and may eventually cause the double-bottom to be ineffective due to congestion. The tanks also takes some time to drain on acceleration to enable planing, especially when the FRC is heavily laden.

To enable self-righting on capsize, FRC will generally have some type of gas bag or float deployment device, which is automatically inflated on inversion on top of a rear cage. With the cage being above the vertical centre of gravity (VCG) the craft can be easily righted in calm water by the crew and will usually self-right in waves. As DC have watertight accommodation they are often designed to be self-righting without any other intervention, although this does depend on the cabin door being closed. This may be a real problem in warm weather when the tendency is to leave the door open to avoid unpleasant engine exhaust build-up.

The crane attachment point for launch and recovery usually takes the form of either a hoop on the end of a single pole, a rigid cage or a system of flexible strops. The disadvantage of using a flexible strop system in rough weather is that, on recovery, it is difficult for the crew to hold up the strops and connect the lift hook at the same time. There may also be problems retrieving the strops from below a stretcher or unconscious casualty. A single pole with a lifting ring on the top saves space in the FRC and allows the crew to connect one-handed. Larger FRC and DC generally use a four-legged steel lifting cage, with the attachment point on the top. Care must be taken that the lift point is positioned above and in line with the centre of gravity and that any major changes in equipment location on the FRC are compensated for. An off-load release hook is best positioned on the lifting cage or pedestal to reduce risk of injury from a swinging weight. On launching, the crewman pulls a safety lanyard as the boat hits the water, which enables the hook to release automatically when all the load comes off. This is considered one of the safest hook systems in use. The design of the FRC should be integrated with the selection of the davit system to be installed.

### 5.2.2 Propulsion and Control

The propulsion system has to combine the elements of high speed, good reliability in a marine environment, safety to casualties and ease of maintenance. Propulsion systems can be either petrol or diesel engines, operating outboard or inboard and driving either a conventional propeller or a water-jet. Breakdown problems appear to be more numerous with petrol engines than with diesel or water-jet.

It is generally accepted that there should be two engines for redundancy. It is important to note that failure of fast rescue craft in the past has often been due to engine failure. The advantages of outboard drives include easy replacement and maintenance and more space available inboard. Modern outboard diesel engines are now of comparable size and power to petrol engines and offer the advantage of robustness, lack of electronics and less risk of fire through fuel stowage. They can also be immediately restarted following a full immersion. Inboard engines can be difficult to maintain and replace, as they are effectively fixed units.

There will always be some risk to a casualty in the water from an exposed propeller. This can be mitigated to some extent by installing a wire propeller guard around the blades. Water-jet systems offer the advantages of excellent manoeuvrability with no exposed propellers, but can suffer from adverse effects in rough and following seas. If the impeller becomes fouled it will be more difficult to clear than a conventional propeller.

A RIB fitted with a water jet needs a suitably designed hull form. Characteristics such as a hard chine, longitudinal strakes and a deadrise of 21-28° would provide for good flow of water beneath the hull and course keeping characteristics [10]. Too much lateral plane forward and little aft can result in loss of steerage and uncontrollable yawing. The advantages of water jets can be summed up as:

- Good acceleration;
- Good fuel consumption at high speed;
- Less maintenance requirement through reduction of vibration and wear;
- Better manoeuvrability, turning and stopping characteristics;
- A smoother ride.

Using a single jet unit there is less risk of air entrainment as the unit is lower in the water. However, the effective length of the keel is shorter than for a twin jet unit, resulting in poorer course keeping.

A twin jet unit provides greater manoeuvrability as one bucket can be reversed to allow fast turning. Redundancy is introduced which will be particularly important for rescue craft. The possibility of ventilation is higher than for a single unit as the intakes are positioned closer to the free surface.

Handlebar steering provides good support in rough seas and clearly indicates the ahead position. However, it may promote fatigue in the throttle hand, it is easy to let go and hence crash stop and there is a risk of snagging.

### 5.2.3 Recovery of Casualty to FRC

By far the most common method of rescuing a casualty from the water is by using fast rescue craft. If the FRC can be recovered to the ERRV safely then the actual rescue of the casualty should not be problematic, largely due to the low freeboard and inflatable sponsons. The FRC motions may actually assist in manual lifts if carried out at a suitable time. However, if there are multiple survivors, maybe as a result of a helicopter ditch, the physical exertion required to lift the casualties onto the FRC may be extreme [11]. For this reason it is suggested by the survey guidelines that some form of casualty recovery device is carried on board the FRC.

The most common method of recovering a casualty to a FRC is using a straight physical lift by two crewmen. This is either performed over the bow shoulder or over the stern quarter. Whilst this may be the fastest recovery method it is well acknowledged that it is one of the most physically demanding tasks required of FRC crew. The recovery may be made easier in waves by using the roll of the boat to assist in the lift, but it will also be correspondingly harder for the crew to maintain balance. Casualties recovered in this way have stated that handholds on the sponsons would have made it easier to get into the craft [12] One of the main difficulties for the rescuers is the smoothness and lack of handholds on survival suits, although some manufacturers have started incorporating grab handles on survival suits.

Loose nets can be used as parbuckling devices but are difficult to use, as the net does not assume a shape in the water. It may be difficult to manoeuvre the casualty into the net because of snagging and the lack of rigidity may compromise casualty handling.

One suitable alternative to a loose net is a device such as a rescue frame. This comprises a longitudinally stiff net constructed from polyester and stainless steel. The casualty is recovered in a horizontal position, minimising the chance of post-rescue collapse. The frame rolls up neatly and takes up little space. It maintains a good shape in the water but has been found to squeeze the casualty against the side on parbuckling.

One of the most popular devices is Jason's Cradle. More rigid than a rescue frame, it consists of modular units of fibre-reinforced plastic and stainless steel that form a rigid articulated net when deployed. This has the advantage that the casualty is not squashed on parbuckling. The Royal Navy carried out extensive tests using manual lifts, conventional nets, a rescue frame and Jason's Cradle [13]. They subsequently chose a version of Jason's Cradle on the basis that:

- The frame was easy to deploy;
- It was easy to manoeuvre the casualty into the frame;
- There was reduced casualty handling;
- The lift was quick and safe;
- The posture of the rescuers was improved;
- the lifting force was reduced.

Recovery using a Jason's Cradle with 10 lateral rungs was slow and the device was too bulky to stow. Recoveries using 3 and 6 rungs were both substantially faster than rescue without the frame. It was found that 3 rungs did not provide enough support for the casualty and the casualty occasionally slipped out, even in calm water. Following further tests, a 4 rung frame was finally recommended. The main disadvantage of Jason's Cradle is that it takes up more storage space than other recovery equipment because of its rigidity.

### 5.2.4 Throw Lines

The ERRV survey guidelines [6] state that two devices capable of deploying a line up to 30 m from the vessel should be carried. Throw lines may be used to reach casualties either from the ERRV or FRC. The majority of overside work will be carried out underneath the platform so throw lines are of particular use if the casualty is under the installation and the conditions are unsuitable for the FRC to retrieve him directly.

A floating rescue sling on the end of a throw line will enable the casualty to reach the FRC and will also provide an easy way to lift the casualty on board. Some FRC are equipped with an A-frame that is used to winch the casualty on board. Similarly, a conscious casualty may be recovered directly to the ERRV, taking the throw line to a block and tackle attached to the end of a lifting boom. If a sling is not used, an alternative object should be attached to the end of the rope or knots tied in the rope to make it easier for survivors to grip.

Many devices rely on a charge of compressed air, which can be refilled from a standard diving bottle. They are small and portable and may be used repeatedly. A device such as the "Rescue Rocket" is claimed by the manufacturers to be able to fire a 4 mm line up to 150 m or a line with a self-inflating rescue sling up to 75 m. The makers of the Pneumatic Line Thrower (PLT), commonly used on board emergency response and rescue vessels, claim that it may be accurately be fired a distance of 230 m with a line of 2000 N breaking strain and holds enough compressed air to be used 4-6 times without re-charging. The suitability of these devices will be limited by their accuracy and the time to re-charge and re-load. There may be problems with re-packing a rope that has already been deployed.

Also available are devices using a pyrotechnic charge. A device such as the "Speedline 250" from Pains Wessex is claimed to fire a 4 mm line up to 250 m. These devices must be stored upright in a weatherproof container, and will be more complicated to operate than a compressed air device. They may also be less reliable, and will periodically need replacing.

A strong wind will compromise the accuracy of throw lines, as will the motions of the vessel from which it is fired. However, if the line does not reach the casualty little time has been wasted and another rescue method may be attempted.

## 5.3 EMERGENCY RESPONSE AND RESCUE VESSELS

### 5.3.1 Emergency Response and Rescue Vessel Design

Emergency response and rescue vessels are divided into three Groups as explained in Section 4.2.1. Propulsion, manoeuvrability and stability guidelines are provided for each category within the ERRV guidelines [6]. The current breakdown of types of emergency response and rescue vessels [14] is: 63% converted supply vessels, 20% converted trawlers, 14% purpose built and 3% are other converted vessels. Trawlers may be more suitable for conversion to dedicated emergency response and rescue vessels because of their favourable motions in rough seas, whereas supply vessels offer larger deck space and other facilities for converting to mixed-role emergency response and rescue vessels. There will often be a compromise to safety in converting a supply vessel because of high freeboard and the inaccessibility of the aft deck in rough weather, as discussed below. Design criteria relating to recovery and rescue operations are dealt with in the relevant sections below.

### 5.3.2 Casualty Recovery Directly to ERRV

If the FRC cannot be launched because of the weather conditions it will be necessary to recover the casualty directly to the emergency response and rescue vessel using one of several methods described below. There will obviously be a high risk of injury to the casualty because of the lack of manoeuvrability and the size of the ship. These methods will therefore generally be used as a last resort.

The survey guidelines [6] state that vessels should be provided with both climbing nets (with rigidity) and a power-assisted method of recovering survivors. More than 90 vessels currently use the rescue scoop system. The Dacon Scoop is typical and comprises a net made semi-rigid with stiff longitudinal poles. This scoop is operated using a standard deck crane with an outreach of 3 m to 6 m. When not in use it rolls up tightly and is stowed just inboard, leaving the deck space clear. Ideally, the net is attached away from the edge of the vessel so that it can be climbed. A weighted front edge allows the net to sink into the water so that casualties can be picked up at speeds of up to 3 knots, maintaining ERRV manoeuvrability. Survivors are recovered in a horizontal position, reducing the likelihood of post-rescue collapse. The crane can be raised and the casualty rolled back up into the ERRV. This method requires the master and the crane operator to be in constant contact with each other. A one-day training course is recommended by Dacon for anyone likely to use its rescue scoop.

<u>Dimensions of this typical rescue scoop are:</u>

Length: 5-7 m	Width: 8-10 m
Weight: 350-450 kg	Effective reach: 4-6 m

<u>Typical crane requirements are:</u>

Outreach: 3-6 m	Lift height: 8-12 m
Capacity: 1500 kg	Winch speed: 50 m/min

Scoops have been shown to work well in the poorest weather conditions for the recovery of dummies. Different vessel masters adopt different approaches to recovering casualties, some preferring to steam upwind and some downwind. One method is to approach with the casualty on the lee side, partly to provide shelter and partly so that the ERRV will drift down onto the casualty. Scoops provide a suitable way of rescuing unconscious casualties and multiple casualties bunched together. However, they take up to five minutes to deploy and require a highly skilled master and crew to manoeuvre to the correct position for pick-up. They also have the potential to cause serious injury to the casualty when the rescue is completed as the casualty rolls down the net to the ERRV. There are also concerns that they are susceptible to serious damage in rough weather. It is evident that the rescue scoop can only be of real use if the crew are well skilled in its use, requiring initial training and regular practice. Formal rescue scoop training should be considered as an industry standard for all ERRVs.

The use of Jason's Cradle on the ERRV is mainly as a scrambling ladder for able casualties. A rigid platform can be created at water level to enable a rescuer to reach unconscious casualties, who can then be parbuckled up the side of the ship. This will only be possible in relatively calm weather because of the risk of injury if the survivor hits the hull when the vessel rolls.

A concern with both the rescue scoop and Jason's Cradle is that there is insufficient space provided between the rungs to place a foot safely. This will particularly be a problem if the casualty is wearing a survival suit with "elephant's feet" covering normal work boots.

A maximum freeboard at the rescue zone of 1.75 m is suggested for ERRVs in the survey guidelines. Whilst there is obviously a requirement for an area of low freeboard it can be very difficult to recover survivors in rough seas here, as any shipped green water will often run off deck through these areas. It is therefore necessary to ensure that sufficient deck drainage is provided and that it is kept clear of obstructions. On some converted vessels with low aft decks, such as converted anchor handlers and supply vessels, it may be that the deck is often awash in the higher sea states. At least one purpose-built UK emergency response and rescue vessel has tanks which can be deliberately free-flooded, sinking the ship to give a freeboard of approximately 1 m, which will aid recovery in calm weather.

In relation to passenger vessels, the IMO has said that "the recovery of elderly or frail survivors by scrambling up nets is unrealistic". Whilst it is appreciated that the crew or visitors to offshore platforms are unlikely to be elderly or frail, the question must be asked of the ability of those to climb a net who are in shock, may be injured, are physically exhausted and are in heavy clothing in a rough sea. Clearly, even climbing rigid nets with assistance will not be possible for many survivors. Recovery using lifting strops or rescue seat devices may be quicker, but it is possible to fall out of these and there is a danger of striking the ship's side. The recovery is also in a vertical position, which ideally should be avoided after immersion in cold water. If a mechanical recovery device is not used there are few alternatives to rescue an unconscious casualty directly to the ERRV. Surface swimming by ERRV crews is not advocated; the crews are neither trained nor equipped to offer surface swimming recovery services.

The survey guidelines also suggest that a rescue basket be carried to provide temporary refuge in the sea. Rescue baskets would be deployed only when deployment of rescue craft was impossible owing to the adverse weather. A rescue basket takes the form of a lightweight metal cage to be lowered into the sea from a deck crane that floats at a low enough level that survivors can scramble inside. The baskets are buoyant and are designed to be released and left to float freely. In particularly rough weather there may be difficulty locating the basket again. Baskets generally hold up to 20 people. This equipment is carried by all UK and Norwegian emergency response and rescue vessels.

The use of an A-frame and tackle, as used by some inshore rescue operators, requires a rescue swimmer and a very low ERRV freeboard, so is not particularly suitable for North Sea operations offshore.

### 5.3.3 Launch and Recovery of Rescue Craft to ERRV

The launch and recovery phase is generally accepted to be the primary limiting factor on whether or not a FRC can be deployed. In particular, the lifting of the FRC during the recovery phase can be problematic. At present there is no requirement for formal training and certification of launch and recovery equipment operators.

For a successful recovery operation it is necessary that:

- The master must be familiar with the system, and be able to provide a lee in rough weather;
- Launch and recovery personnel must be experienced and should have undergone training;
- The ERRV must be stabilised as much as possible;
- The crane or davits must be capable of fast, controlled lowering and lifting of heavy loads;
- The hook system must be simple;
- Efficient techniques for the use of guiding lines and bowsing are used.

The traditional method of reducing ship motions for the launch and recovery of a DC or FRC is for the ERRV to be running before the waves at approximately the speed of the waves, about 10° off the sea direction. A speed through the water of 4-10 knots is usually suitable. This allows good steerage of the ERRV and good handling speed for the FRC. In very rough conditions it has been suggested that the most efficient method of flattening the sea by an ERRV is to steam in circles [15]. One or two full circles will have a very significant effect of flattening the sea locally. One suitable subsequent position for launch or recovery is then shown below in Figure 1.

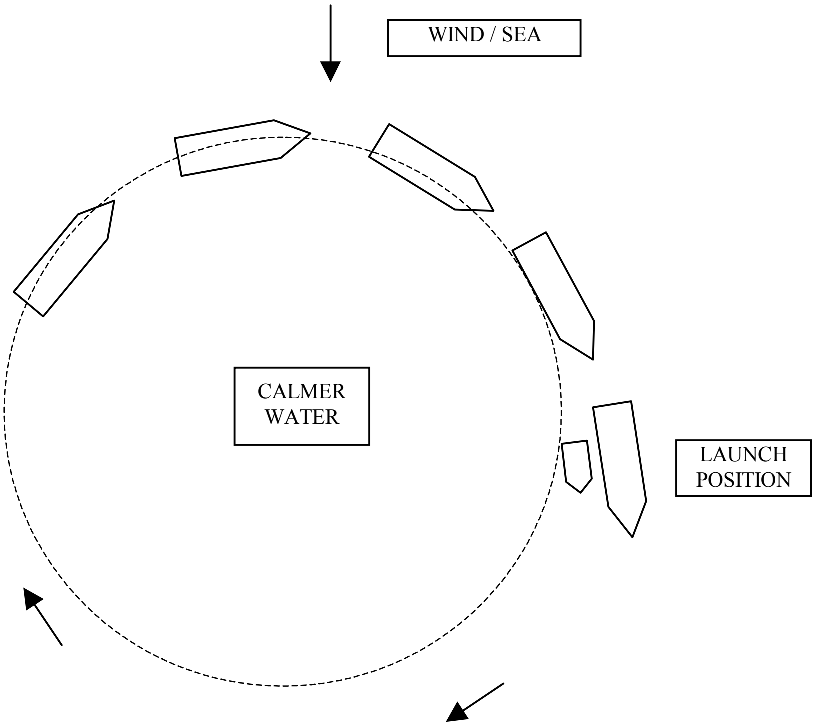

**Figure 1**
**Method of flattening sea by ERRV**

Ideally, the engines should be running before the boat hits the water on launching to enable a fast escape. This may cause damage to conventional outboards through over-revving and this is one area where a water jet with a gearbox fitted may be an advantage. The gearbox is only engaged when the FRC is ready to move off. By starting the engine in advance, any engine problems will be discovered before deployment.

On launching, the main hook is released first followed by the aft check line and then the forward check line. In particular, the coxswain needs to be experienced in holding the FRC on course alongside the parent vessel. This can only really be perfected through practising on the actual vessels used, as each ERRV will have its own unique complex wave pattern alongside the launch and recovery zone. It is important for the coxswain to read the wave pattern in advance and anticipate the responses required. This may involve throttle and trim tab adjustment.

There will be some extra problems with launching and recovering a DC instead of a FRC. The weight on any guiding lines will be correspondingly greater when lowering and lifting the craft, although the use of a docking head will reduce the motions. If the davit is sufficiently powerful there should be no problems lowering or raising the DC. The DC will usually be equipped with an internal quick-release handle to let go of the lifting cable, but there may be a problem attaching the lift cable again for recovery. Normal practice is for one of the crew to stand on a specially designed platform, usually padded, mounted aft of the cabin. He then has the task of reaching the lifting cable and attaching it to the hook mounted on the roof of the cabin. As he is standing relatively high up compared to a crewman performing the same task in a FRC the motions of the DC will be exacerbated. However, other than these problems, many crews using suitable equipment say that the DC is often launched in preference to the FRC because of the extra security it offers.

In calm or moderate conditions, a FRC may be bowsed securely against the side of the ERRV at deck height to allow the casualties easy access to the deck of the ERRV. In rough weather this will not be possible as the wave-induced motion may result in the gunwales of the ERRV becoming submerged and so a complete recovery back to the cradle is required. There is, therefore, a need for easy access to the FRC in its cradle to transfer the casualties to safety, which may include the transfer of stretcher cases. The full recovery of the FRC to its cradle will further slow down the rescue if several casualties are involved and the FRC needs to be re-launched.

The use of a towing boom deployed from the ship's side will make the attachment of a bow line easier and the rescue craft can then hang back on this until a suitable time for recovery.

Davits should be positioned slightly aft of amidships. For a slewing crane, the crane pedestal may have to be some distance away from this so that the hook-up point is located at this desired position. The hook should ideally be permanently attached to the FRC lifting point to avoid a heavy weight swinging around when the crew is trying to connect. A simple eye in the lift wire can then be attached without too much difficulty.

A process of assessing different launch and recovery techniques and equipment should be carried out, within the bounds of the flexibility allowed by the installed system. The current technique may well not be the safest or most efficient.

The vertical position of the crane boom for recovery should be high enough that it does not hit the FRC on rolling and there should be enough slack cable out (even if a constant tension device is used) such that the line never comes taut on the bottom of a wave, causing high dynamic loads.

The theoretical worst case will occur if the ERRV is beam-on to the waves. Assuming an ERRV with a beam of 8 m and a crane with an outreach of 2 m, the following table gives the relative vertical change in height between the end of the crane jib and the FRC for pure rolling:

**Table 1**
**Crane jib height with ERRV roll**

| Roll angle (degrees) | Change of jib height (m above water) |
|---|---|
| 0 | 0 |
| 10 | 1.7 |
| 20 | 3.4 |
| 30 | 5 |

This is the height above still water for roll in one direction. In the other direction (i.e. towards the FRC) the distances would reduce by a similar amount. This shows the importance of running the ERRV down the waves during launch and recovery operations.

## 5.4 HELICOPTERS

### 5.4.1 Helicopter Performance

Helicopters can provide a fast (if platform based) and relatively safe method of rescuing casualties from the water and provide a rapid transfer to advanced medical facilities either on an installation or on land. They can operate in a wide range of weather conditions. However, they may be limited by endurance and cannot usually operate around fires or gas clouds due to changes in turbulence levels and air density.

The main limitation for deploying a helicopter is the ground-level wind strength. The rotors can only be engaged up to a certain wind strength, above which there is danger of blade sailing. This may result in instability of the helicopter and the blades striking the ground or the fuselage. If the aircraft is not pointing directly into the wind this limiting wind strength may be significantly reduced. One way around these problems is to start the helicopter in the lee of a hangar or other bluff body. Often, this may not be possible if the helicopter is being deployed from an offshore installation because of the lack of obstacles. The wind speed in flight will affect the endurance by altering the speed over the ground. Hovering operations will have to be carried out directly into the wind. These is no definitive cut-off wind speed for helicopter operations as the pilot's decision to fly will depend also on factors such as the visibility (night time, fog, rain, etc.), icing conditions, and range to the incident. When unable to fly on visual signals the pilot has to use instruments. This is particularly difficult in helicopters as they are inherently unstable, but this task is continually being made easier by improvements to stabilisation systems and auto-pilots, such as auto-hover and auto-approach. In good conditions a pilot may often be able to fly in higher wind speeds than in poor visibility.

One of the key factors affecting helicopter winch operations is the power required to remain in a hover. The power, and therefore fuel consumption, needed for the helicopter to hover whilst lifting survivors is substantially greater at lower wind speeds, below about 15 knots, because of the reduced lift provided by the wind. This may compromise the number of survivors the helicopter can rescue, especially if the aircraft has had to fly a long way from its base. It may be possible to re-fuel en route by landing at other installations.

Icing conditions are particularly relevant to North Sea SAR operations because of the frequency of extreme and cold weather conditions. Many aircraft are fitted with anti- or de-icing equipment that extends the range of conditions in which they can operate. The danger is encountering more severe icing conditions than were expected, although it may be possible to fly at a lower altitude to avoid this.

### 5.4.2 Helicopter Rescue Equipment

The simplest method of rescue to a helicopter is by using a flexible strop or harness. This provides a fast method of rescuing conscious single survivors. The soft strop minimises injury to the casualty when manoeuvring. The drawbacks are that strops are difficult to use with unconscious casualties and the method may be time consuming to rescue multiple casualties in the water. A two-strop approach is usually used by the RAF so that casualties can be recovered horizontally, reducing the chances of post-rescue collapse.

Helicopter recovery of a MOB in the US often employs the use of a rescue swimmer, allowing two casualties to be hoisted at one time but with considerable risk to the swimmer. In the North Sea this technique is not generally used because of the rough weather and cold sea temperatures.

Unconscious casualties will generally require the use of stretchers or litters. Several of these may be stored inside the aircraft and racking is sometimes provided to accommodate stretchers when aboard. The winch-man will generally accompany the stretcher down to the water and will be responsible for securing the casualty. This may take some time in poor conditions.

To recover multiple casualties, such as in the case of a helicopter ditching, some US Coast Guard SAR helicopters are equipped with a basket for winching. These are designed to float on the surface and may be suitable for injured casualties with assistance. The capacity is limited to 3 people by the winch lift capacity, which is usually around 250-300 kg. The survivors can be recovered to the helicopter and multiple lifts made. This technique has not been widely adopted in the UK.

Winches are generally very reliable but on many helicopters there is no contingency in the case of a malfunction. UK HM Coastguard helicopters are fitted with two winches. It takes a trained crew approximately 20 minutes to install a winch to a suitable aircraft.

Typically the time taken to lower, attach the casualty and recover will be in the region of 2 minutes. For multiple lifts one can assume it takes in the region of 1 minute to make ready to lower for the next time.

Alternatively, it may be possible to use a basket fixed to an under-slung wire. This must be attached on launch and remain deployed throughout the flight, therefore only being suitable for platform-launched aircraft. The lifting capacity is then only limited by the power of the helicopter and may therefore be as much as 3 tonnes, depending on the amount of fuel carried. Baskets such as this would in theory be able to recover in the region of 15 survivors at a time. The survivors are not recovered to the helicopter but are flown directly to the installation beneath the helicopter. In cold conditions the survivors may suffer considerable exposure if the installation is any distance away. The use of a fixed basket also prevents any winch operations from taking place by that helicopter, whilst the heavy weight of the basket may pose a serious threat to the survivors in the water. This method is not currently in use in the UK.

## 5.5 CASUALTY PERSONAL PROTECTIVE EQUIPMENT

Although not directly related to the rescue procedure, it is important to review some aspects of the personal protective equipment (PPE) likely to be worn by casualties as additional features and other equipment carried may have a significant effect on the speed of a rescue.

Although the main factor that influences rescue in rough weather may be the launch and recovery of FRC, it is first necessary to locate the survivors. In rough weather, ERRV masters may choose not to launch the FRC until the casualties have been located, both to prevent the FRC crew from becoming fatigued and to avoid an unnecessary launch. The use of efficient search aids will ensure that little time is wasted on the search.

Personal locator beacons (PLBs) are recognised as the primary aid to reduce search times [16]. The results of tests using dummies fitted with PLBs in waves up to 4 m suggest that the introduction of PLBs would convert a search and rescue operation into one of rescue alone [17]. The unit is activated on contact with water and transmits a signal to the installation. This signal is then re-transmitted to the ERRV up to 50 miles away indicating a course to steer, taking into account tidal effects. When the ERRV is within approximately 1 mile the signal can be received directly from the PLB. The FRC, fitted with standard direction finding (DF) equipment, can then be launched with confidence and will home in on the signal from the survivor. In a situation with multiple casualties the strongest signal should override any others, until the unit is switched off [18]. Incidents involving PLBs suggest that casualties can be located at night in heavy seas within a few minutes by a properly trained crew. Without a PLB this search time may run into hours, with luck becoming the predominant factor as time progresses. A crew member falling over the side, wearing a water-activated PLB, will automatically be detected even if unconscious.

It must be noted that installation of a PLB system may involve considerable cost and training, involving test procedures, installation of alarm repeater modules to all platforms and fitting of transponders to all rescue craft. In many systems, although the PLB unit is waterproof, the signal transmission strength is significantly reduced if the unit is immersed. SBV Operators have voiced concerns about PLBs, particularly ones located in FRCs, regarding effectiveness, compatibility with existing VHF radios, and earthing. Technology in this area is improving rapidly and PLBs already offer one of the best methods of casualty location.

PLBs may also play a role in the protection of the rescuers. ESVAGT have a set of three PLBs onboard each vessel for the FRC crew to wear when on operations.

It is generally recognised that a standard lifejacket light is insufficient for locating casualties at night. Military pilots, whilst relying on PLBs to some extent, also carry xenon strobe lights on their lifejackets which have been found to be extremely effective. A relatively slow flash rate is recommended and will help rescuers pick out the survivor from any background fixed lights. Reflective strips included on lifejackets are very visible at night provided a light is being shone in the general direction, although in rough weather there may be foam streaks in the water which will also show up.

A detailed review of the properties of immersion and thermal suits can be found in reference [19].

# 6. COMPARISON OF CLAIMED EQUIPMENT PERFORMANCE WITH ACHIEVED PERFORMANCE

## 6.1 INTERVIEWS AND QUESTIONNAIRES

A series of questionnaires were distributed (Appendix A) and interviews conducted with emergency response and rescue vessel operators and crews, helicopter crews, oil health and safety representatives, training providers duty holders and consultants. On these questionnaires, emergency response and rescue vessels are referred to by the commonly used alternative standby vessels (SBVs). Most of the answers were obtained through interview, with the person concerned discussing the topics presented on the questionnaires. Interviews were carried out in a relaxed atmosphere in which the subjects were encouraged to talk frankly about equipment and performance in rough weather. All of the interviews were conducted at the interviewees' places of work, which meant visiting several emergency response and rescue vessels in port. This allowed a first-hand appreciation of some of the problems with equipment. During the course of the interviews, the conversation often covered other important points, all of which are included in the results recorded below.

The companies that took part in the questionnaire and interview procedure are listed in the acknowledgements.

## 6.2 RESULTS FROM QUESTIONNAIRE ON EQUIPMENT

### 6.2.1 Performance of Launch and Recovery Equipment

The whole operation of rescue from the water depends very heavily on a combination of teamwork and experience. It was the opinion of most of the ERRV crews that the use of FRC and DC offers by far the best method of recovering casualties from the water safely. The more experienced crews felt that, in a real situation, they would attempt to launch the FRC in any conditions as they see this as the most viable method of rescue. One coxswain stated that they had recently launched in 6-7 m waves for a crew transfer. Crews that appear to get on less well as a team and have less experience tended to indicate that they would only be prepared to attempt to deploy the FRC up to a predetermined weather limit for safety reasons.

Some felt that davits that keep the FRC in contact with the side of the hull are more versatile than those that suspend the FRC away from the side of the ship. The main problem in rough weather is the swinging of the FRC and controlling this with bow and stern lines. ESVAGT use a davit system whereby recovery is alongside the hull and no guiding lines are used at all, making the whole process substantially faster. The cradle-type davits where the FRC hangs in space were criticised.

It is worth noting that, particularly with davits equipped with a constant tension device, the launching of both DC and FRC is considered possible in almost all sea states, and only the recovery is limited. Some of those interviewed thought that the best method of rescue would therefore be to launch the DC or FRC regardless of the conditions and then, if recovery were not possible, to sit out the weather or head for shore. Respondents thought that most of the time the shore would be within range of the rescue craft. It should be noted, however, that the majority of offshore installations are located in the East Shetland Basin and Central North Sea and that, in sea conditions precluding recovery of the rescue craft, its speed would be restricted.

The more experienced crews using Caley davits with constant tension thought that the davits were so good that their performance had little limiting effect on launch and recovery, with the main factor being overall safety of crew in rough conditions over 7 m. The towing boom allows the FRC to drop back once the bow line is attached and the docking head is quite successful at reducing motions.

Many FRC are fitted with flexible four point lifting strops. The advantage of these over single point lifting eyes is that the attitude of the craft in the air is controlled to some extent if the longitudinal centre of gravity changes because of casualties aboard and shipped water. Even so, the crew must be very careful with the load distribution. One disadvantage is that any stretchers must be placed underneath the strops to enable them to be deployed for recovery. If the anchoring points to the FRC are located a long way from the central hook point a large amount of space will be taken up when the strops become taut. Also, the strops will inevitably be harder to connect the hook to than a single point.

The time taken to muster in the FRC or DC following a call was generally thought by the crews to be very quick. Several crews suggested that there should be designated wet lockers or muster areas provided at the exit to the aft deck. Without these, wet gear must be left either in the shower areas or in TV or mess rooms if provided. A time of less than 1 minute was considered sufficient to be present in the rescue craft. Integral life-jackets were considered very important as they are quick to put on and less prone to snagging on things than conventional life-jackets.

The provision of an effective lee by the emergency response and rescue vessel was thought to be the most important factor when recovering rescue craft in rough weather. In moderate conditions usual practice is for the master to drive the ERRV at an angle of 10-15 degrees off downwind at a speed slightly faster than the sea. The rescue craft is then launched or recovered on the lee side. This reduces the amount of roll to a minimum. In rough and very rough conditions many of the masters and coxswains expressed a preference for steaming in a circle several times before launching or recovering, stating that this has a substantial effect on flattening the sea. The use of about 5 litres of vegetable oil also has a significant effect. Of the few incidents mentioned in which the FRC crew felt in danger, most were caused by an insufficient or ineffective lee being formed. Vessels with azimuths amidships can also be driven sideways to sweep a lee.

To transfer survivors the FRC is usually fully recovered to its cradle. Where recovery would be by certain types of davit, in fair weather conditions it may be preferable to bowse the FRC alongside the ERRV gunwale. There are some operators who bowse the FRC in all weather conditions at deck level. This is done using two metal half-hoops into which the side of the FRC is pulled. The master questioned did not have any experience of this system in wave heights over 3.5 m. The coxswain remarked that he thought launch and recovery would be much easier using the Caley davit system than the system currently installed.

### 6.2.2 Performance of FRC & DC Equipment

Most FRC have a length of between 6 and 7.5 m and have a rated passenger capacity of 12-15 persons. With very few exceptions the crews questioned said that the FRC would not safely be able to carry the rated number of passengers in rough weather.

Most rescue craft are launched on a daily basis if the weather allows. The engines generally do not get run if the boats are not launched because of the difficulty of water-cooling them. Pre-heaters connected to an external power supply can be used to improve the reliability of starting diesel engines in the cold, particularly inboard engines on daughter craft.

Most of the FRC in service in the UK use either petrol outboard engines or water jets powered by an inboard diesel. The majority of crews using petrol engines thought them suitable for the task, although there are sometimes problems starting them in cold weather. Many FRC have either electronic engine tilt facilities or trim tabs fitted. Crews using FRC without either of these felt that they would be very useful, particularly in controlling trim when planing as the amount and distribution of load within the FRC could vary significantly. Crews using water jet propulsion were very happy with the system, particularly the low speed handling characteristics and the absence of external propellers. The reverse bucket allows much faster stopping and turning than with outboard engines. The maintenance of the internal diesel engine was not seen to be a problem and the reliability is good.

The coxswain is often the only member of the crew to wear a helmet, because of the integral VHF radio. It was suggested that the other boatmen should also wear helmets with radios to aid communication, as in heavy seas with the engine running it may be very difficult to communicate. The crew would also then know what is required should there be a fault with the coxswain’s headset. One coxswain commented that the radios have a poor range and are not resilient enough.

Travelling to the incident is conducted at high speed as long as the crew are comfortable. There were no reported problems with travelling fast in large waves other than having to impose a speed reduction. On return to the ERRV it is usual to travel in planing mode as fast as is comfortable for the casualty unless they have a suspected spinal injury.

There are normally no serious problems releasing or attaching guide lines and the main hook, if well designed, on a FRC. On a daughter craft the hook release system usually consists of a wire handle through the cabin roof. Releasing the hook is simple, and it is attached on recovery by a crewman standing on a platform behind the wheelhouse which can be more difficult in rough weather. The bow line is attached to a floating fender and is picked up using a boathook by a crewman forward of the wheelhouse. Some DC are fitted with a remote method of releasing the bow line which can be operated from within the wheelhouse. One crew pointed out that the DC is usually used in preference to the FRC when conditions allow as it offers more comfort and protection.

### 6.2.3 Performance of ERRV Equipment

If the FRC cannot be launched because of the weather it will be necessary to attempt to recover the casualties directly to the ERRV. A range of equipment is carried for this purpose and was discussed in the interviews.

All of the operators interviewed and questioned had one or more mechanical recovery devices fitted to the ERRV. It is generally agreed that such a device can be deployed up to about Beaufort 9, or a 7 m significant wave height, but this does not necessarily mean that it provides a good prospect of rescue in these conditions. The device should ideally be deployed at a height of 3 m to 4 m above the water. On many ships it is attached on the aft deck where the freeboard is about 2 m.

There are two main problem areas associated with the mechanical recovery device. Firstly, there may be problems working on the aft deck in rough weather, where the device is installed, because of deck wetness. This may be the case particularly for emergency response and rescue vessels converted from supply vessels with large, open after decks. One master commented that his aft deck is awash in even a moderate sea state and said that the crew have to be clipped on to deploy the mechanical recovery device. This particular vessel had two scoops fitted, one right aft and the other at the forward end of the aft deck. Only the forward scoop is used because of the deck wetness.

The other main problem with a mechanical recovery device is that it may be difficult to approach the casualties at a slow speed in large waves without losing manoeuvrability, and therefore there is a danger of the casualty being sucked under the vessel into the stern gear. This problem will obviously be specific to the ERRV as some are fitted with central azimuth pods which are used instead of the stern gear when operating the device. Whilst a rescue scoop provides an efficient method of “hoovering up” dummies in practice, many masters feel that it would be much more difficult and more hazardous to use it in reality on a live casualty. For the Dacon scoop, the roll motion of the ERRV can result in the mouth of the net, which is narrow even in calm water, dipping in and out of the water in rough weather. If the net is submerged too deeply it will be difficult to handle. There were also concerns that the poles were not far enough apart to get boots into for footholds and concern about the injury that may be caused to the casualty on rescue. Most masters recognised that the rescue scoop is an efficient method of casualty recovery to the ERRV, although several said that they would make every effort to launch the FRC in preference to using the scoop.

The Matesaver was carried on many of the ERRVs in question and, indeed, following guidance given by UKOOA. This consists of a metal pole with a sling on the end. The sling is guided over the casualty in the water and tightened. A pivot system is then used to lift the casualty back on board. The general consensus from the crews was that this item of equipment is not suitable for use on an ERRV and is more for use on small pleasure craft. It is not easy to use and is easily damaged.

Rescue baskets, again an item carried by all emergency response and rescue vessels following UKOOA guidance, are designed to be craned overboard and released to provide a group of casualties with a place of refuge. Most of those interviewed had not used the rescue basket before but some thought it might be a useful piece of equipment in the right circumstances. Some thought that the time taken to deploy the basket could be better spent attempting to launch the FRC or DC, as this would eventually be required anyway, and launching is seen as significantly easier than recovery. The time to launch the DC would be significantly faster than the time to launch the basket and would allow the casualties to be recovered quickly to a place of relative safety.

Most of the emergency response and rescue vessels that are either purpose-built or converted from supply vessels have some kind of stabilisation mechanism. This sometimes takes the form of a seawater tank positioned some distance above the keel, such that filling it with water alters the roll period of the ship. All of the masters using these tanks commented that they make a substantial difference to the motions of the vessel and are easy and quick to use. The other main types of stabilisation device are anti-roll, or flume, tanks. These work on the principle of having two water tanks at the extremes of the beam of the ship, connected by pipes or flumes. By carefully tuning the cross-flow area, these can be set up to such that the flow of water is 90 degrees out of phase with the roll motion. They are usually tuned to the roll natural frequency but will provide some roll damping at all frequencies. Also, at least one purpose-built UK ERRV is able to free flood its ballast tanks in order to lower its freeboard, which will also affect its roll response. Many masters pointed out the importance of vessel stability combined with the provision of a good lee when recovering FRC.

Even though PLBs are starting to come into common usage offshore, most of the UK crews have not used PLB systems before. A few of the ERRVs are fitted with the necessary equipment but this will depend on which platform the ship is assigned to. The notable exception is ESVAGT, who regularly train with PLBs and provide the FRC crew with PLB units for safety.

### 6.2.4 Performance of Rescue Helicopter Equipment

There are a number of organisations around the UK that operate SAR helicopters. Unlike emergency response and rescue vessel cover these are not currently dedicated to offshore rescue. In general, helicopters will be able to operate in similar conditions to emergency response and rescue vessels.

The RAF currently operates Mk3 Sea King helicopters for SAR around the UK. This aircraft is coming to the end of its working life and is no longer being produced. The main problem with it from a performance viewpoint is that it is under-powered. It is in theory capable of carrying 18 passengers but this will only be possible with the lightest of fuel loads. Only one stretcher may be carried because of the absence of appropriate racking. They aim to be airborne within

15 minutes of an alarm during the day and 45 minutes at night, although other aircraft, like the Puma, are faster to start up than the Sea King.

As with all Doppler-based auto-hover systems there can be problems maintaining a stable hover in large waves of over approximately 8 m. However, the pilots questioned stated that it is quite possible to hover without it if sufficiently experienced. The aircraft is fitted with a joystick to give the winch operator limited lateral displacement control whilst in auto-hover.

The only condition in which the aircraft cannot fly is freezing rain, which is rare. In icing conditions it may be necessary to fly at low levels. The rotor engagement wind speed limit is 45 knots for normal operations but in emergencies this has been significantly exceeded, sometimes by finding temporary shelter behind a building. Many aircraft have stiffer blades than the Sea King, which should increase this limit up to about 60 knots. A 45 knot wind speed is approximately the equivalent of a 5 m significant wave height, and 60 knots is the equivalent of a 7.5 m significant wave height. There is no specific weather limit for flying or hovering. The only practical limit may be the fuel load required to reach the scene against a strong headwind. The sea state does not affect rescue in any way other than the difficulty of actually lifting the casualty from the water.

A double sling lift is the preferred method of rescuing the casualty, and is not much more difficult than using a single sling as the legs tend to float up when wearing a survival suit. A stretcher becomes very difficult to handle in rough weather and some current designs have insufficient drainage. Rescue baskets as used by the US Coast Guard are also difficult to manoeuvre casualties into. For multiple conscious casualties a common method is to launch an inflatable dinghy and use this as a base for Hi-line transfers.

The pilot and rear crew interviewed practise for a minimum of 4 hours every day in all weather conditions, with 50% of the training conducted at night. All of the practice (except hovering practice) involves rescuing live “casualties” instead of dummies. In their opinion they need a minimum of 2 hours practice per day to maintain a satisfactory standard. The training course to become a SAR crew takes approximately one and a half years following active service elsewhere in the RAF. The crew stated that the military are the only organisation to provide full SAR training to rear crew in the UK, although some elements of training can be provided by civilian establishments.

The crew are well used to rescues involving the use of PLBs as all military pilots are fitted with them. They suggested that, for incidents involving several casualties such as a helicopter ditching, there might be considerable confusion if all of the PLBs are operating simultaneously. They have experienced situations where even two PLBs operating at once have caused confusion and they stress the importance of switching off the first device immediately on being rescued. They suggested a xenon strobe light worn on the survival suit as a suitable, effective alternative or supplement.

# 7. REVIEW OF TRAINING AND PRACTICE PROCEDURES

## 7.1 TRAINING

Training and continued practice are very important elements for offshore rescue. The frequency of actual incidents is so rare that exercises and practice are the main way of gaining experience of rescue. Initial training courses must take into account that many attendees will never have been to sea before whilst at the same time striving to achieve a high standard of competency. Higher level courses, such as the coxswains' training, must allow for the fact that the attendees, whilst carrying out their own roles on the ERRV, will be involved in onboard training of boatmen and potential coxswains.

Current training courses for working offshore in rescue and recovery are classified by OPITO. The initial basic sea survival and ship inboard operations courses are shore-based. After a period of 3 months sea time as part of an ERRV crew the FRC boatman course can be attended. After another 3 months sea time it is possible to become a FRC coxswain and after a further 3 months a DC coxswain. There is no prerequisite sea time for attending the "Command and control for ERRV masters and first mates" after having completed the initial shipboard operations course. A program of ongoing on board training is provide by the training establishment and a check, in the form of a practice exercise, is carried out annually.

Many of the current OPITO-accredited training providers are of the opinion that the courses are of a lower standard than used to be the case before OPITO classification. It is generally felt that OPITO is heading in the right direction but has insufficient experience to write course specifications. Several areas have been omitted from the courses that the trainers feel should be included. The better establishments get round this by extending the course content over and above that suggested by OPITO, but other establishments can get people through the courses at a much lower standard.

One common theme amongst the crews and trainers is that a practice capsize should be integrated into the courses. This would give the crew experience of an event that may well happen in reality. This could either be carried out in a sheltered sea harbour or in a heated pool. Also, it was thought that part of the course should involve the rescue of live casualties, using the delegates themselves, to give an appreciation of casualty handling and the care required. At present, it is not permissible to use live casualties in water temperatures below 15°C even if they are wearing immersion suits or other suitable clothing. The North Sea rarely reaches this temperature. It would be a useful exercise recovering people in a pool with and without devices such as Jason's Cradle, possibly combined with a capsize practice. It is understood that the inclusion of capsize in the course is currently under consideration by OPITO and the HSE. A further advantage of this is that the course would then also qualify delegates for the Standards of Training, Certification and Watch keeping (STCW 95) rescue craft qualification, which is internationally recognised.

The courses would be more suitable if the delegates on the courses had sufficient practical experience from the sea time required between courses. The biggest problem is that, although crew may spend 3 months as part of an active ERRV crew, they may spend very little or no time in the FRC. In theory, it is possible to become a FRC coxswain with only a few hours total experience of driving the rescue craft. All of the training providers interviewed thought that a better method would be to require a logged minimum amount of time spent practising in the FRC. In this way the course would involve predominantly theory and sheltered water practice, followed up by a structured practice program in "real" conditions on the emergency response and rescue vessels. More of the training used to be carried out on board the boats, and the emphasis has now shifted to shore-based training. The advantage of this is that the contact time will be specifically designated to training, with few interruptions.

The equipment used for the shore-based courses is meant to be the same type as that used in the industry. The problem that the training centres have is the diversity of equipment used on ERRVs. The FRC courses are carried out using both outboard and water-jet boats to give experience of both types. However, most centres do not also operate boats with inboard diesels driving conventional propellers. Launch and recovery are usually conducted on a harbour wall using a standard crane. Training providers appreciate that these shore-based activities do not accurately simulate the real events but are useful to teach the procedures involved. Experience should then be gained through structured ongoing training aboard the ERRV.

The weather limits for practical boat handling on the courses amongst those questioned vary from about Beaufort 4 to 6 with varying degrees of shelter. One establishment practises in the reflected waves of the sea wall, which often results in confused, choppy sea conditions. The training providers appreciate that the courses do not simulate rough weather rescue, but maintain that that is the reason for onboard practice. One trainer pointed out that the Canadian Coast Guard offer the best course with respect to rough weather, as they deliberately train in the worst weather conditions possible. Their fast rescue boat coxswain course lasts for 40 days.

None of the crews responsible for operating the davits during launch and recovery had received any special training. One mate had his crane ticket, but said that it was not really relevant to the role. Most of the training is carried out on the job. At least one davit manufacturer is keen to provide an on board training course on the safe and effective use of the installed types of davit. It is thought that this would be a useful addition to the current training courses on offer.

From the crews' point of view the training courses are seen as fairly suitable, with few complaints. One area that could be improved is the training course progression on board the emergency response and rescue vessels. There is a lack of motivation to carry out training as the crew in charge (e.g. FRC coxswains) are not usually trained as teachers and have other duties to carry out. It is suggested that some initial training in teaching methods should be given to these crew if they are to provide effective training to others. Their competency needs to be higher for teaching others than for just carrying out their EER role.

It is worth briefly mentioning the training methods used by the Danish organisation ESVAGT. The company trains its own instructors in teaching methods. All the training is then provided by the instructors on board through an ongoing training scheme. Refresher courses are provided every 15 months. ESVAGT emergency response and rescue vessel crews are very happy with this system.

There is considerable expense involved with sending crew members on training courses. The crew often have to give up holiday time, and the company will have to pay reasonable expenses. However, many of the crews, particularly the advanced medical aiders (AMA), said they would be interested in attending some kind of refresher course to get rid of bad habits picked up on the job.

The AMA shore-based course was thought to be particularly useful. However, one training provider said that the crews are rarely provided with a copy of the "reference manual" [20] with which they are meant to be familiar.

It is felt by some training providers that some individuals attend so that the ERRV will have the correct number of qualified crew, even though they may not end up carrying out that role. There are no regulations to ensure that the person who regularly drives the FRC is a qualified coxswain.

## 7.2 PRACTICE AND EXERCISES

Practice, including launching and recovering FRC and the simulated rescue of dummies, is a crucial activity to gain experience of rescue and recovery. This is also a means for the installation to establish response times and determine the suitability of their EER plans.

Specific training exercises are usually controlled by the platform OIM and are therefore carried out inside the normal limits for overside working. This will generally mean a significant wave height of less than 3.5 m. All exercises are conducted using dummies to simulate real casualties. On the whole, the crews questioned thought that the dummies were suitable for the task, although not requiring any specific casualty care when handling. In particular, dummies that flood to simulate the weight of a heavy, waterlogged person are more realistic. These ensure that the crew get practice using casualty recovery devices such as Jason’s Cradle. There is a problem in simulating a full rescue boat using dummies as, even by the most conscientious crews, they will be stacked in the FRC and give an incorrect approximation of the amount of space there would be on board with real casualties. One boatman pointed out that they could get 8 “injured” dummies into the FRC without too much problem but would find it difficult to carry more than a couple of real casualties who needed to lie down. This will undoubtedly affect the time taken to rescue multiple casualties in an emergency.

The frequency of exercises varies between installations from several per week to one or two per month. Crews say that too much practice, particularly of similar tasks from different distances, results in less enthusiasm and motivation. One crew had practices such that they picked up 100 dummies in a month. Another crew stated that they were usually warned 15 minutes before the start of an exercise from a particular installation, resulting in an unrealistic state of preparedness and little urgency. The majority of crews said that there should be more opportunity for exercises using more realistic scenarios and dummies. Also, more practice using the mechanical recovery device is required to make this an efficient method of recovery. RAF Search and Rescue crews, in comparison, train for a minimum of two hours each day.

There is also a tendency for the installation to push the close standby limits, particularly if they are involved in drilling. In marginal conditions there is pressure for the ERRV master to continue to provide close standby with no gain but the threat of losing the contract if he refuses.

Other practice is controlled by the ERRV master, and also incorporates regular boat operation for maintenance purposes. Crew transfers and mail runs can be considered part of practice activities. These activities will usually be carried out in much worse conditions than training exercises, depending on the ERRV master, company policy and the experience of the crew. In particular, ESVAGT carry out crew transfers day and night with the only restriction being that night-time transfers take place below Beaufort 7. Some of the UK standby crews claim to be carrying out regular transfers and mail runs in seas up to 6 m significant wave height. Not surprisingly, these are the same crews that say they would attempt to launch the rescue craft in any weather in a real situation. At the other end of the spectrum there are the crews who will only launch in less than 2.5 m waves for normal operations and say they will not launch in more than 3.5 m in an emergency.

These different responses may be an effect of different levels of crew training and competence but may also arise from different environmental conditions in different sectors of the North Sea. If they are sector-specific, this may point to a very important anomaly inherent in sector-specific recovery and rescue performance standards.

As well as consistent practice in rough weather, the more proficient crews seem to have more background experience and work well as a team. One of the key factors that many crew pointed out is whether you know and trust the team members around you, which can only come from having worked together for some time. Crews that practise less say that, if they are prevented from launching for 7 to 8 days by bad weather, there is a noticeable difference in their performance when they get back into the boats. One oil company representative questioned recognised that some UK emergency response and rescue vessel operators are significantly better than others. It is very important for the emergency response and rescue vessel operators to provide the best possible working conditions for the crew to maintain their motivation and ultimately to retain the experienced crews in their company.

# 8. ATTITUDES TO ENVIRONMENTAL LIMITS

## 8.1 GENERAL

One theme that was very clear throughout the interview procedure was that the experience of the crew was a major factor in the decision whether or not to launch a rescue craft. One master stated that he had prevented the launch of a FRC before because the coxswain was not the regular one and had insufficient experience for the weather. The sort of experience required to be able to launch in all conditions can only come from practising in all conditions. The ESVAGT crews and, to a lesser extent, some of the better UK operators are carrying out transfers and normal duties in quite rough conditions and therefore have significantly more experience than some of the other crews.

Whilst there may be theoretical limits for the launch and recovery of FRC, in practice these may not be achievable. One ERRV ex-master, for instance, stated that he would not hold exercises or drills in wind speeds of more than 25 knots and 2-2.5 m wave height. He had previously launched FRC in wave heights between 3.5 m and 4 m in a long swell in the northern North Sea, and suggested that a rescue may have to involve several casualties for him to consider launching in 5.5 m waves and risking his crew. The Cormorant Alpha incident in 1992 involved a helicopter ditching in 55 knots of wind, with the sea being sufficiently rough that neither of the ERRV masters on the scene were prepared to hazard their crew by launching their FRC.

During severe storms in March 1993, Canadian Coast Guard helicopters operated in winds in excess of 80 knots and seas up to 18 m. Although numerous rescues were conducted effectively, in several instances rescue swimmers declined deployment. Although rescue swimmers have authority to decline deployment if conditions are beyond their capabilities, some swimmers were distressed later that they had not deployed. It was discovered that there was a great disparity in perception as to what was deemed too severe. Some rescue swimmers admitted considerable peer pressure to deploy under circumstances they believed might be beyond their abilities. It was proposed that a training program be developed to expose rescue swimmers to high sea conditions. With such training, rescue swimmers would be better able to judge their abilities in extreme situations. Aspects of this may be applicable to the deployment of FRC in the UK.

Most ERRV operators record details of practices and exercises. A formal process for review of performance can expose weak areas and allow improvements to be made. Some operators hold regular review and safety meetings where all crew are invited to attend.

## 8.2 INTEGRATION OF KEY FACTORS OF ROUGH WEATHER RESCUE

### 8.2.1 Background Discussion of Mechanics and Statistics

It has been established in previous sections that the recovery of rescue craft to the ERRV is generally the critical activity in marginal weather conditions. Using analytical and statistical techniques it is possible to gain a better understanding of the processes involved.

All davits and cranes are limited by a certain SWL and available power. The load on the davit will comprise the static weight of the FRC or DC and the added dynamic weight due to the motions of the ERRV. The static rescue craft weight should take account of the number of people on board and any water that has been shipped throughout the rescue. The significant components of the dynamic weight come from the ERRV roll and heave, and can be resolved if the ERRV motion is known. The maximum roll and heave motions can be determined by using the corresponding response amplitude operator (RAO) combined with the significant wave height and period.

The ERRV survey guidelines state that a minimum lifting speed of 0.3 m/s should be possible. Many crews have said that they feel the lifting speed is extremely important and therefore a higher value than this is desired. The lifting speed available will depend directly on the power of the davit. To be able to lift the maximum load calculated above at a certain minimum speed a required power can be calculated. The installed power of the winch motor required to achieve this delivered power will depend on the efficiency of the motor.

As mentioned previously, the occurrence of natural lulls in the wave pattern can be used to extend the envelope of recovery operations. If the lull is of sufficient duration, recovery will be possible in sea states that would otherwise be too severe, especially if a good lee is provided as well. The occurrence of a suitable length lull of a certain threshold wave height is therefore an important factor. Analysis of wave time history data can allow a good prediction of such quantities. However, this requires a large amount of data spanning many combinations of sea states. Similar results can be obtained much more easily by using statistical representations of sea state profiles that approximate real data.

Using statistical methods, it is possible to determine the length of the average lull of a certain threshold for a given sea state. Further, the probability of a lull lasting long enough to recover a rescue craft can be determined. Another important factor is how long on average one would have to wait for a lull to arrive. All of these parameters are dependent on the significant wave height and the wave period.

### 8.2.2 Use in Practice

The elements of the recovery process outlined above can be linked together to form a method for determining an indication of recovery potential. The method may be used in two main ways, as detailed in Figures 2 and 3:

1. Operational use – for the range of installed equipment it is possible to estimate the minimum speed at which the FRC can be lifted, a limiting range of significant wave heights and wave periods and the corresponding probable time required to wait for a lull suitable for recovery operations.
2. Design use – for a prescribed time to wait for a lull of a certain duration and wave height it is possible to calculate limiting combinations of significant wave height and wave period. Using a typical ERRV RAO and a maximum laden FRC weight the required davit SWL can be estimated. For a set minimum lifting speed the required davit installed power can also be calculated.

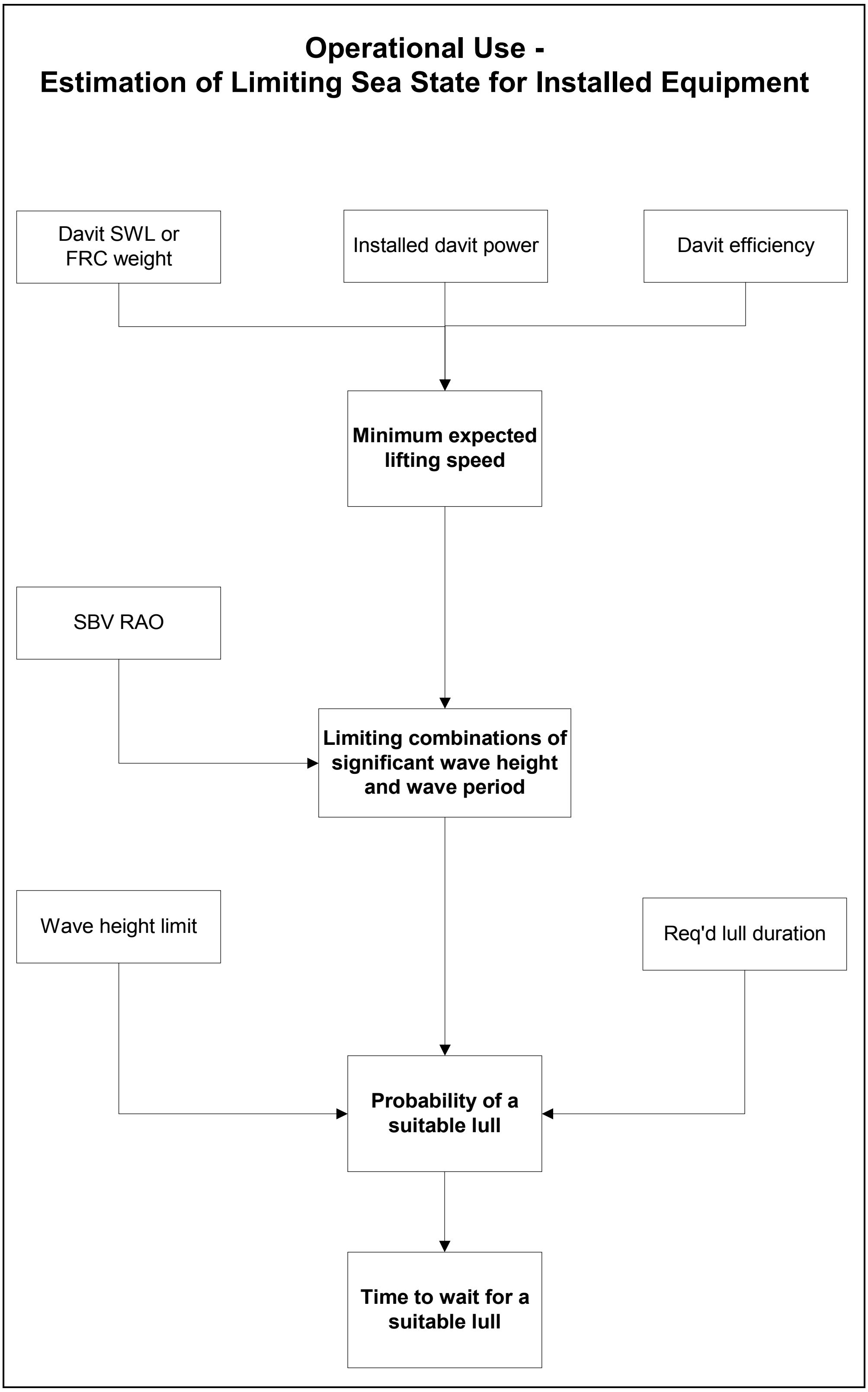

**Figure 2**
**Flowchart of Methodology for Operational Use**

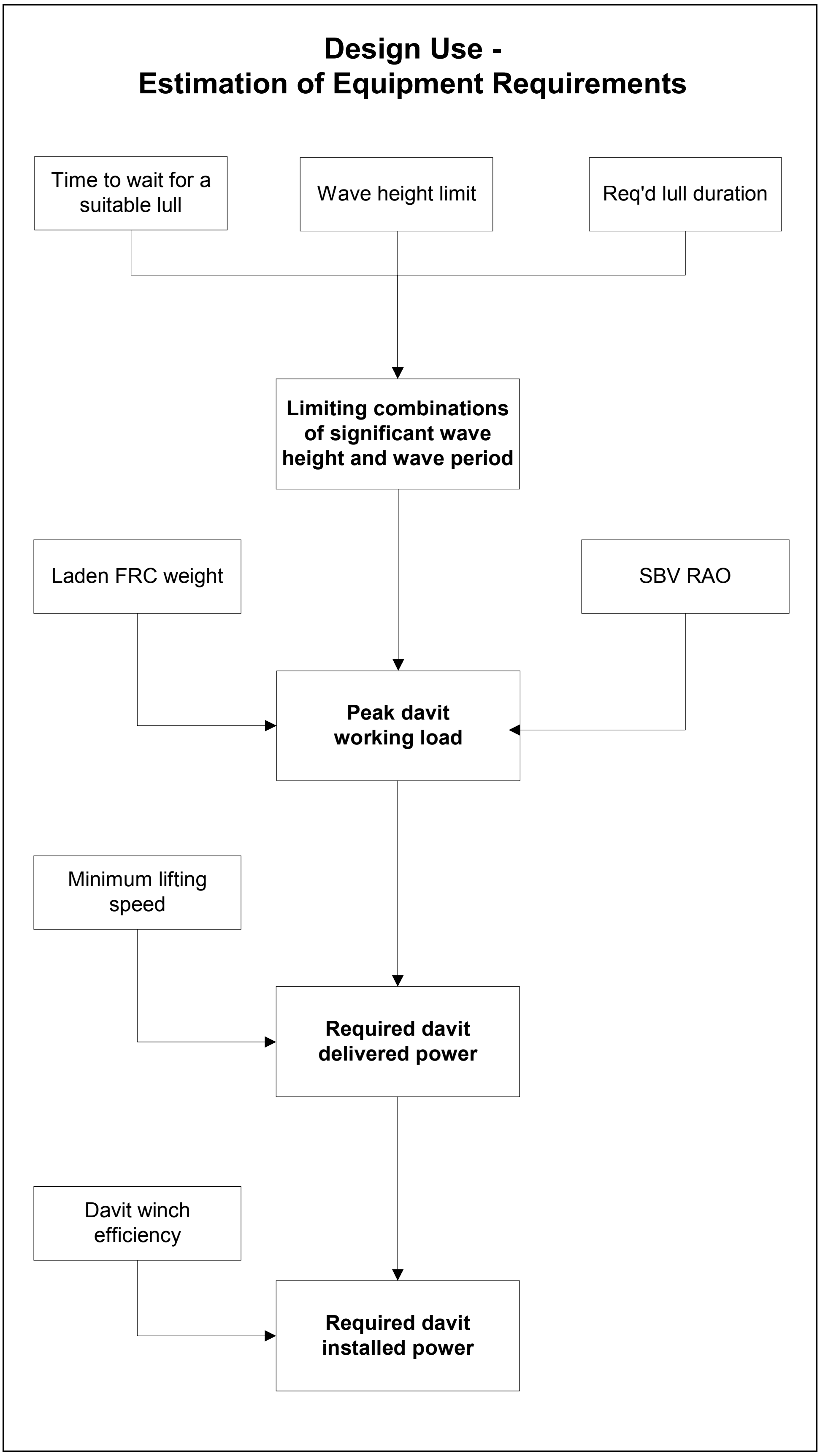

**Figure 3**
**Flowchart of Methodology for Design Use**

### 8.2.3 Example Calculation

An example calculation using the "operational" method to determine the minimum achievable lifting speed and time to wait for a suitable lull is shown below. It should be noted that this is a simple scoping calculation to illustrate the main principles. A detailed description of the method and the equations used is given in Appendix B.

A fully laden FRC of mass 3400kg might comprise the mass of the empty FRC (1200 kg), 15 passengers (1200 kg) and an allowance for shipped water (1000 kg). This is typical of a FRC of around 6.5m in length. Two main dynamic forces will also be present, due to the roll and the heave of the ERRV. In moderate conditions with a significant wave height of 3 m and a significant wave period of 6 s the average wave slope is calculated as [21]:

$$S_{av} = \frac{2\pi^2}{g} \cdot \frac{H_S}{T_Z^2} \qquad (1)$$

where $H_s$ is the significant wave height,
$T_z$ is the wave zero crossing period.

The ERRV will attain a roll angle equal to its response amplitude operator (RAO) for that condition multiplied by the wave slope. The RAO may be much less than unity if the ERRV is running downwind, or may be greater than unity if the roll frequency of the ERRV is near its natural frequency. The use of roll damping tanks may significantly alter the RAO.

Assuming the FRC to be situated at a transverse distance of 10 m from the longitudinal centre of the ship, the peak dynamic component of the load due to rolling can be calculated using:

$$W_R = M \cdot r \cdot \frac{4\pi^2}{T_\phi^2} \cdot S_{av} \cdot Y_S \qquad (2)$$

where $M$ is the FRC mass,
$r$ is the distance from the centreline,
$T_\phi$ is the roll period (assumed equal to the wave period),
$Y_\phi$ is the ERRV roll RAO.

For an ERRV roll RAO of 1.0 (the vessel roll follows the wave slope) the additional load due to roll is 9.76 kN. The component of load due to heave can also be approximated by multiplying the peak heave acceleration by the FRC mass, using:

$$W_H = \frac{M.H_S}{2} \cdot \left( \frac{2\pi}{T_Z} \right)^2 \qquad (3)$$

This gives a weight component due to heave of 5.59 kN. The total load applied to the davit is therefore:

$$W_{total} = W_R + W_H + M \cdot g \qquad (4)$$

which comes to 48.8 kN. This is well above many of the safe working load limits of the davits in service. The overall dynamic loads make up around 1/3 of the total load in this case so cannot be ignored.

The ERRV survey guidelines suggest that the lifting speed is set at a minimum of 0.3 m/s. As the lifting speed is seen as a crucial element of a successful recovery by many crews, it is suggested that a preferred lifting speed is higher than this value. For the purposes of this example, a minimum acceptable lift speed of at 0.6 m/s has been used. The delivered power required to lift at this speed is then:

$$P_D = W_{total} \cdot v \qquad (5)$$

which gives a required delivered power of 29.2 kW in this case.

The installed power required to achieve this delivered power will depend on the efficiency ($\eta$) of the crane or davit such that:

$$P_I = \frac{P_D}{\eta} \qquad (6)$$

An estimate of an efficiency of 65-70% is reasonable. This would lead to an installed power requirement of around 45kW.

Should more detailed data on the response amplitude operators be available, this simple type of calculation can be generalised, and typical sea spectra for the area of operation used in the calculations. Indeed the facility to calculate acceleration spectra at a point on a vessel is a common feature of ship motions analysis software. In this way, power requirements based on a combination of static and dynamic loads can be defined in a straightforward manner.

This more detailed approach would allow an estimate of the frequency of the conditions in which, for a given FRC and installed equipment, recovery would be hindered by either a lack of capacity (SWL) or installed power. Such information would be of considerable use in establishing limits of operability for launch and recovery, when used in conjunction with human and other operational factors.

For the recovery phase, input to the estimation of the total time to recover the FRC can be provided by consideration of the duration and frequency of suitable lulls. For example, having defined limiting values of SWL and power installed in terms of wave-heights and periods, a suitable lull can be defined as a period of time within any given sea-state for which these limits are not exceeded. Both the duration of such lulls and their frequency can be estimated using known statistical methods.

For the example calculation, an estimate the probability of a suitable lull occurring can be made using the methods described in [23] and illustrated in Appendix B. The distribution of the sea surface displacement $\zeta$ has a probability density function as defined in Equation (7) of Appendix B. Assuming that the required lull threshold is 1.8 m (i.e. recovery can be carried out up to this wave height), the average lull duration can be defined as:

$$\bar{\tau} = T_z e^{\frac{1}{2}\left(\frac{4z}{H_s}\right)^2}\left[1 - \Phi\left(\frac{4z}{H_s}\right)\right] \qquad (8)$$

where $\Phi(x)$ is the evaluation of the normal probability integral for ($x$)
$z$ is the threshold value of the lull.

$\Phi(x)$ is solved using the approximation given in Equation (9) of Appendix B. This gives an average lull duration of 1.8 minutes. If we now assume that, for a successful recovery, a lull lasting 2 minutes is required, it is also possible to determine the average time that one would have to wait between suitable lulls. For this example, this turns out to be an average waiting time of 4.4 minutes.

This approach provides a logical basis from which to define the operability of the launch and recovery process during the design stage of an ERRV, and during EER analysis in which overall recovery times in varying sea-states are key performance indicators.

### 8.2.4 General Discussion

There are two indications of operability currently in use. These are the suggested maximum significant wave heights for DC and FRC operations in an emergency, currently 3.5 m and 5.5 m respectively, and the required response times set out in the EER plans by the installation operators. The former is purely a limiting sea state, whilst the latter is based only on a time limit, regardless of sea state. Whilst these are both valuable in their own right, they provide no measure of the increasing difficulty of tasks in increasing sea states. The vast majority of ERRV crew do not carry out training or practice in wave heights over about 3 m. Obviously, it may not be considered safe to practise up to the emergency limit. For estimating response time compliance, the exercises are carried out in the lower sea states and the results extrapolated to the upper sea states. For this reason, the crews are never required to practise in rough conditions and as such may not have sufficient experience to do so safely in an emergency. It is therefore suggested that further work be carried out to determine performance criteria over a range of sea states. This would require crews to practise more in the upper sea states to meet the criteria, hence increasing their experience of rough weather operations. In this way, a better understanding of the capabilities of different operators, vessels and crews can be assessed. The way in which this could be done is outlined below.

The processes involved in offshore rescue are subject to three main factors: equipment capability, environmental conditions and human factors. By considering these and their relationships to each other (Figure 4) it will be possible to estimate the conditions that a task can safely be carried out in.

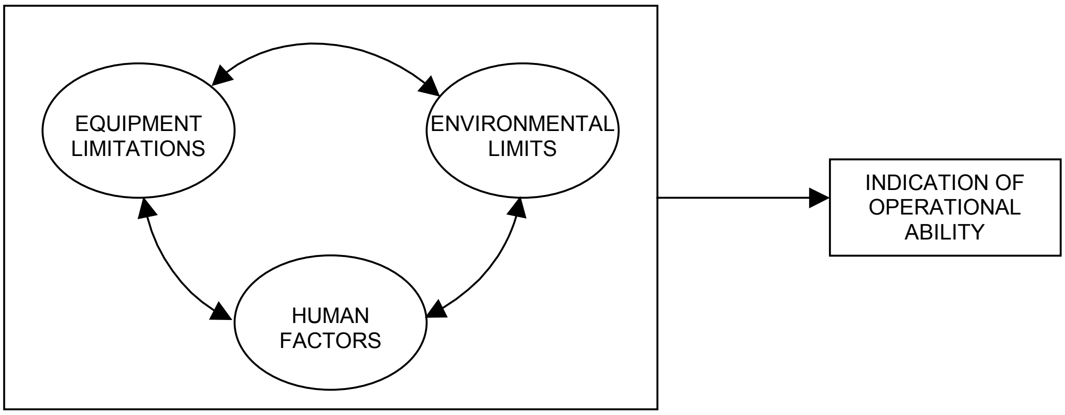

**Figure 4**
**Factors affecting operations**

A method for determining the limitations of equipment has been suggested in the previous section. The example given is for recovery of a FRC, but other methods such as use of a mechanical recovery device could be examined in a similar manner. An overview of a technique for determining weather dependence has also been presented. Human factors will take into account things such as the physical limitations of crew and how the difficulty of tasks changes with the environmental conditions.

By examining these three areas it will be possible to compile, for a range of sea states, a set of probable times that it will take to carry out each particular operation in the rescue process. These times can then be introduced in the form of performance criteria.

# 9. REVIEW OF INCIDENTS AND LESSONS LEARNED

## 9.1 ACCOUNTS OF RELEVANT INCIDENTS

This section provides several accounts of offshore rescue incidents relevant to this study. There are also other well documented accounts which have already been analysed in detail by a number of authors [24].

### 9.1.1 US Coast Guard Account (1):

A roustabout assisting a crane operator in relocating a drill-water-loading hose was struck by the hose on the neck and shoulder after a line lifting the hose parted. The blow knocked him over a handrail 17 m into the water. Other personnel on the rig saw him surface and threw him a life ring. He grabbed it and pulled himself into the buoy. Seas were 3 metres, the air temperature was 3°C and the water temperature was 7°C. When the man overboard alarm was sounded, the emergency response and rescue boat moved in to make the rescue and within a minute was alongside the man in the water. Once close to the man, those on the vessel saw that he was weak and could not help himself. A cargo net was put over the side and a boat hook used to pull the man to the net, but he was unable to climb it. Four crewmen from the vessel took turns going over the side into the net, but they were unable to lift the man up out of the water. An attempt to put a line around him failed, and an effort to launch the emergency response and rescue vessel's rubber rescue boat was also unsuccessful. A line running to the block used to raise and lower the boat was twisted and fouled the blocks. After about 15 minutes another supply boat began an approach in an attempt to assist. The propeller wash from this vessel pushed the man in the water away from the emergency response and rescue boat, and he slipped through the life ring and disappeared.

**Lessons learned:**

- The vessel and equipment must be prepared at all times.
- If the FRC could not be launched the use of a mechanical recovery device would have saved the casualty from having to climb the net.
- Sea temperature will have a debilitating effect on casualty’s strength.

### 9.1.2 US Coast Guard Account (2):

On 10 December 1987, an HH-3F helicopter was deployed to respond to a distress call from a 26 foot fishing vessel taking on water. Visibility was poor in a severe snowstorm, the seas were running at about 7.5 to 9 m and the wind was blowing at 35 knots with gusts up to 70 knots. Aboard the vessel were a 33 year-old man and his 6 year-old son, both of whom were wearing survival suits. In the heavy seas, the tall rigging of the sinking boat swayed violently from side to side, with the stern already awash. Despite numerous attempts, the pilot and hoist operator were unable to get the rescue basket to the two people on the boat. The pilot, after considerable persuasion, convinced the father and boy that their only chance at rescue was to enter the water where they could then get into the rescue basket. With the son strapped to his chest, the father jumped over the side into the turbulent water. However, the man's survival suit leaked, and immediately filled with water. After several attempts to get into the basket, it became apparent that they could not. The pilot turned to the rescue swimmer and directed him to prepare for deployment. In a few short moments, the swimmer was in the water and with the two individuals. Fighting heavy seas and winds, the swimmer struggled to get the two survivors into the rescue basket. Once secured, they were hoisted to the hovering aircraft. With the aircraft being buffeted by extremely gusty winds during the subsequent effort to recover the rescue swimmer, the rescue swimmer was dragged through an enormous sea swell, causing him to lose his mask and snorkel and sustain a minor back injury. He was ultimately recovered, and with the two survivors safely aboard, the H-3 returned to base.

**Lessons learned:**

- Helicopters can provide an efficient means of rescue in the worst sea states.
- Rescue baskets can be difficult for casualties to enter, as suggested by UK helicopter pilots.
- The rescue swimmer was put at considerable personal risk.

### 9.1.3 US Coast Guard Account (3):

On the 11th February 1983, the M/V MARINE ELECTRIC, with a 25,000 ton cargo of pulverized coal, started sinking. Seas were between 7.5 and 12 m with winds blowing at 60 knots. By the time the helicopter arrived, the ship had sunk and 34 people were in water. As the H-3 hovered overhead, a rescue basket was prepared and lowered to the people in the water. Numbed by severe hypothermia, the men were unable to grab the basket and floundered helplessly. A helicopter with rescue swimmer was requested, and a Navy H-3 helicopter arrived on scene following a scramble. Only three persons were recovered alive in one hour of rescue attempts.

**Lessons learned:**

- Again, rescue baskets may not be easy for casualties to use.
- Rescue of multiple casualties by helicopter may not be suitable because of the time taken and the limited capacity.

### 9.1.4 “Ocean Odyssey” Incident:

The semi-submersible drilling rig “Ocean Odyssey” [12] suffered explosions and caught fire following a blowout in September 1998. Most of those onboard were evacuated using two of the installation’s TEMPSC and the others jumped into the sea. All the survivors ended up on either the emergency response and rescue vessel or on a 64m supply ship that happened to be close by. The emergency response and rescue vessel was the 47 m converted trawler “Notts Forest”.

- Only one FRC was available for use, and this had only one working outboard engine.
- The FRC suffered a punctured aft sponson after making contact with the rig, leaving the stern well down in the water.
- One of the FRC crewmen spoke little English, adding to confusion.
- The survivors were alarmed by the speed of the approaching FRC, and two of them were hit on the head and forced under.
- The FRC crew had severe difficulties with manually recovering survivors whose survival suits were flooded. Some form of recovery equipment was required. One of the survivors assisted the FRC crew on the second sortie.
- Even though the sea conditions were only moderate ($H_S$ = 0.5 m) the relative motions between the TEMPSC and the ERRV provided cause for concern. Most of the survivors had removed survival suits and lifejackets for the transfer to help movement.

**Lessons learned:**

- Training, practice and experience are required for the FRC crew to work as a team and carry out an effective rescue.

- Regular maintenance is essential.
- Transfer from TEMPSC to FRC is extremely hazardous, even in relatively calm conditions.

### 9.1.5 MAIB Report:

A pilot was attempting to board a vessel at night in rough sea conditions from a pilot boat manned by a coxswain and two seamen. The wind was Force 6 to 7. Although the pilot boat was in the lee of the vessel, the range of the swell was between 4.5 and 6 metres. As the pilot took hold of the pilot ladder with one hand, the pilot boat descended into a trough, forcing the pilot to lose his grip with the result that he fell into the sea between the vessel and the pilot boat.

The pilot was wearing a personal locator beacon but, because it was on top of his inflated life-jacket and not immersed in the water, it failed to activate automatically. Although the pilot managed to activate it manually, the coxswain switched off the beacon's direction finder to prevent him being distracted during the rescue manoeuvre. He was however able to maintain visual contact with the man overboard.

The pilot was wearing an immersion suit but without the hood over his head. It was trapped under the life-jacket with the result that water was able to enter the suit. No thermal or watertight gloves were provided and, although he was wearing cotton gloves, his hands became numb with cold.

A lifebuoy was thrown from the pilot boat towards the pilot and an attempt was made to recover him in a "Matesaver", (an adjustable loop, which, once passed over the body, enables a casualty to be supported and safely manoeuvred to a suitable recovery area). The prevailing conditions prevented the loop from remaining in the fully extended position, which made it impossible to place it over both pilot and inflated life-jacket. The pilot did, however, manage to hold onto it with one arm and the lifebuoy with the other.

A scramble net was then rigged but a combination of cold and numbness thwarted the pilot's efforts to use it. Furthermore he was unable to get a foothold on the net which, although weighted, lay against the hull and frustrated his efforts to get a toehold.

A leading seaman attempted to get hold of the pilot using the fall rope from the starboard davit but the rope had not been made fast and it ran through the davit pulley. The seaman then managed to loop a mooring rope around the pilot, who was eventually assisted on board using a ladder rigged in way of the aft well deck.

In order to be able to rig the scramble net and to loop the mooring rope around the pilot without being restricted in his movement, the leading seaman was forced to unhook his own safety harness.

The life-jacket light with an additional strobe light enabled the coxswain to maintain visual contact with the pilot throughout the rescue manoeuvre. The pilot was subsequently transferred to a rescue helicopter and transported to hospital, suffering from hypothermia.

**Lessons learned:**

- The Matesaver is difficult to use in an emergency.
- Scramble nets should be suspended away from the hull, or have rigid rods like a mechanical recovery device or Jason's Cradle.
- Strobe lights offer an effective means of casualty location.

# 10. RESULTS OF CONSULTATION WITH INDUSTRY

This section presents some of the views of the offshore industry regarding rescue and recovery. The information has been taken from a report compiled for WS Atkins by Seacroft Marine Consultants Ltd.

## 10.1 MECHANICAL RECOVERY DEVICES

There are several issues concerning the location and deployment of the mechanical recovery device and the associated handling equipment on ERRVs. Some of the points listed below are specific to one or the other of the commonly found systems produced by Dacon and by Sealift.

- The Dacon Scoop is handled by a crane but the Sealift is deployed by a hydraulic arm which is an integral part of the system; the whole system can be transferred as a single package from one vessel to another.
- On many ERRVs using the Dacon Scoop, the rescue scoop is positioned in an unsuitable place. Often the aft deck may be inaccessible in rough weather and the low freeboard may expose the crew to the weather unnecessarily. It will often be possible to relocate the scoop on a higher deck, but then a larger scoop will need to be installed to compensate for the additional height. On some vessels an inappropriate size scoop is fitted even at the designed location.
- Without the provision of suitable controls, possibly remote joysticks, it will often be very difficult for the master to see the casualty in the water or to communicate with the operator of the handling equipment and the deck crew. Some vessels with this problem have devised solutions using combinations of CCTV cameras, hand-held radio communications between the master and deck hands and vocal instructions to the helmsman. It is recognised that wherever the direct visibility is impaired the likelihood of a successful rescue will be reduced. A rescue at night in rough weather would be made particularly difficult without line-of-sight visibility.
- The Sealift system incorporates a rescue scoop often known as a ‘chip pan’ deployed by a hydraulic arm on the ERRV. The system is not particularly common in the UK, but those masters using it said that they thought it far superior to the Dacon Scoop, especially in the higher sea states, because of its ease of use (it can be operated by one person) and probable success rate. The system can be deployed from a hydraulic arm on an upper deck and the casualties recovered directly to the ERRV deck, removing the need for crew to access the aft deck.
- There may be an advantage in deploying one mechanical recovery device over each side, if two are carried, in order to reduce the time that the vessel takes to manoeuvre at the scene of the incident.
- In order to maintain control during a rescue using a mechanical recovery device the ERRV must maintain a speed of about 3 knots. It is common experience that the ERRV may actually arrive at the casualty at a speed of about 6 knots because of the wind and sea conditions on the approach. This frequently causes damage to the training dummies. The bow wave of the approaching ERRV will tends to push dummies wide of the net. Limbs often become tangled in the net and occasionally the heads of the dummies are trapped below the water. Any casualties that pass between the mechanical recovery device and the ship’s side are prone to being hit by the hull on rolling or being struck by the propellers. Once in the net there is a very real danger of exacerbating the casualties’ injuries when being recovered to the ERRV.

- A general trend amongst the ERRV masters and crew is that they have little confidence in the effectiveness of the mechanical recovery device, particularly in the upper sea states. It is seen as a last resort and many would prefer to launch FRC or DC, even if the weather was too rough to conduct an immediate recovery. It is thought that platform staff have misconceptions as to the effectiveness of the mechanical recovery device in the higher sea states, in respect to upper limits for flying operations.
- It has been found that mechanical recovery devices are liable to damage in the upper sea states. This often requires temporary repairs to be carried out.
- Comments noted on possible improvements to rescue scoops include further loading of the leading edge of the net in the middle with weights, a lightweight vertical net at the back of the scoop to prevent 'through-flow' of survivors, a smaller mesh size to reduce drag problems and the adoption of a lightweight metal net.
- The location and performance of the handling equipment is a real problem on many vessels. Handling equipment located in the centre of the deck will impair the operator's visibility of the casualty. A slow hoisting speed will mean that, particularly in rough weather, it may not be possible to hoist the scoop before the casualty is washed out by the next wave. A short boom will not allow the mouth of the net to be opened widely enough. It is also important that the equipment is able to lift and slew at the same time, to control fully the shape of the scoop.

## 10.2 RESCUE CRAFT

This section presents issues raised by both ERRV crews and the offshore workforce concerning the use of FRC and Daughter Craft.

- It is perceived by the crews that the OIMs put an undue emphasis on speed during trials, presumably to achieve performance standards. The need for a quick initial response was agreed but the time required to transfer casualties to a place of safety would depend entirely on their condition. This may even mean that the FRC would wait for the ERRV to arrive at the scene of the incident.
- Many crews feel that they would always deploy FRC or DC before resorting to mechanical recovery devices. If recovery were not possible immediately the rescue craft would hold station until adequate arrangements for the provision of a good lee had been finalised.
- On some vessels the location of the davits and rescue craft is considered poor. Rescue craft located near the aft end will be subject to larger forces and accelerations in severe weather than those located amidships. Craft located on higher decks may be less prone to damage from waves when stowed but it may be more difficult to deploy them because of the greater pendulum effect of a longer lifting cable.
- There is concern that, at sea states of around 5.5 m and above, there would be considerable difficulty in using a casualty recovery device such as Jason's Cradle in the FRC because of the restricted movement of personnel and control of the rescue equipment. In this situation it is expected that the rescuers would have to perform manual lifts to recover the casualties.
- If a davit system is installed such that the FRC cannot be launched in 5.5 m significant waves (e.g. no constant tension) and also a mechanical recovery device is installed on an aft deck that is awash at this sea state it is probable that the ERRV will not be able to meet the duty holder's performance standards.
- Rescue craft crews realised the unsuitability of a fixed limit of 5.5 m significant wave height for FRC deployment. In reality, the ability to deploy will also depend on wave

period, visibility and other environmental factors. Some argued that in a real life situation they would be able to launch in a much higher sea state than the limit indicates.

- It has been suggested that a DC operating at some distance from the ERRV carries a dedicated advanced medical aider and a certificated officer.
- It is recognised that there may be a difficulty recovering casualties from the water to some of the larger DC because of the relatively high freeboard. Use of Jason's Cradle or a rescue net would also be difficult in high sea states.

## 10.3 TRIALS AND TRAINING

It was suggested that the following improvements could be made to trials exercises and training courses.

- It was thought that training courses should focus more on training operators of handling equipment and ERRV masters and mates on the use of mechanical recovery devices and their limitations.
- It was pointed out by the crews that the trials are often unrealistic and, when conducted in calm weather conditions, are relatively useless. In many cases, exercises are initiated much more frequently by the ERRV than by the installation. Emergency response and rescue vessels will rarely carry enough dummies to simulate a helicopter ditching (15-20) so these trials must be initiated by the installation.
- Dummies used for trials should be 'life weight'. Lighter dummies do not allow an adequate simulation of the effort involved in recovery. Light dummies will also tend to be blown unrealistically by the wind which, during bi-annual recovery and rescue validation trials, will otherwise give unrealistic results at the upper sea states.
- There is a real advantage in allowing the chief officer or mate the opportunity to practise manoeuvring the vessel during trials. This would be of benefit particularly if the master was assigned the role of on-scene co-ordinator in an emergency.
- At present, night time exercises are not approved [25]. With the limited hours of daylight, particularly around Shetland in the winter, many of the flying operations have to be conducted in darkness. There is a need for the chance to practise in these potentially difficult conditions, particularly if PLBs are not being used by the installation.
- Trials for determination of response times using a mechanical recovery device are relatively pointless if carried out in weather conditions that normally the FRC would be launched in. The FRC will nearly always be used in preference to mechanical recovery devices.
- The OPITO training course for DC coxswains was thought to be inadequate. If the DC is operating away from the ERRV the DC crew may be responsible for the initial action in the event of an emergency. Further training in the area of command and communication is thought to be necessary. Also, with the bigger daughter craft becoming more difficult to handle, advanced training in launch and recovery methods should be available.

## 10.4 OTHER ISSUES

- A perceived lack of knowledge of seamanship issues often results in installation personnel not appreciating why the ERRV cannot provide cover in marginal conditions. There is concern that masters can be pressured into providing cover in these situations to retain contracts.

- There is concern that those responsible for tasks such as compiling training courses, conducting recovery and rescue assessments and devising limits have little or no practical experience of the environmental conditions experienced offshore.
- It is noted that sometimes relief ERRVs, which may be on duty for several days, may not be able to provide a similar level of cover as the original vessel.
- Communications using VHF between rescue craft and the ERRV can be a problem because of the distance that the rescue craft can be operating up to. In poor atmospheric conditions the VHF may have a range of only a couple of miles. This problem can generally be solved by investing in better communications equipment.
- PLBs are considered essential for the ERRV to have a reasonable chance of locating the casualty at night and in severe weather conditions.

# 11. CONCLUSIONS

## 11.1 DESIGN OF ERRV, DC AND FRC

The following conclusions can be drawn about the design and suitability of emergency response and rescue vessels, fast rescue craft and daughter craft:

- The recovery of FRC and DC to the ERRV is recognised as being the main factor that limits rescue capability in rough weather.
- In rough weather it may not be possible to meet the passenger capacity of the FRC, as rated by the Rescue Craft Manning Certificate issued by the Maritime and Coastguard Agency. Equipment fitted to the rescue craft subsequent to rating, such as a lifting frame, may further reduce the number of passengers it is possible to carry.
- The main advantages of water-jet propulsion over outboard propellers are manoeuvrability (though with problems at the upper sea states) and safety. However, outboards are easier to replace and may handle better in rough weather. Diesel outboards are less vulnerable to harsh weather conditions than petrol outboards.
- There may be engine exhaust build-up and ventilation problems in the enclosed cabin of a daughter craft. This may lead to the door being left open, particularly in warm weather, which will invalidate the self-righting capability.
- Stabilisation systems such as anti-roll tanks can be very effective at altering the natural roll period of the ERRV and thereby assisting in the recovery process.

## 11.2 EQUIPMENT USAGE IN ROUGH WEATHER

All of the items of equipment used for rescue and recovery in the UK have certain practical weather limitations and as a result some are more effective than others. The main conclusions to be drawn from this report on the usage of equipment are:

- There is a wide variety of types of equipment being used in the UK standby industry. This ranges from equipment that is specifically designed for operation in a severe marine environment to equipment that is unsuitable for use offshore. The effectiveness of the service provided is undoubtedly being affected by this equipment.
- The weather conditions in which recovery of FRC can be achieved may be extended by use of a suitable type of davit, which will depend on features of the ERRV and the FRC or DC. The advantages of constant tension devices are recognised, as well as a system that either keeps the FRC close in contact with the side of the ERRV or well away from it. In particular, Caley type davits with a constant tension device are recommended.
- The lifting capacity of many davits and the amount of power they produce may not be sufficient for the recovery of fully laden FRC in the higher sea states.
- On vessels fitted with a high standard of launch and recovery equipment and an experienced crew the limiting factor for rescue craft operations may not be the recovery of the craft itself but instead maintaining an acceptable level of safety during the rescue operation as a whole.
- The provision of a lee by the ERRV is a critical element in the launch and recovery process. In very severe weather it may be necessary to steam in circles to flatten the sea.

- A device for recovering casualties to the FRC is essential, even though this device may not be used when practising. Jason's Cradle offers probably the easiest means of recovery.
- Scrambling nets are unsuitable for rescue in rough weather. The mechanical recovery device is accepted as the best method of recovering casualties in higher sea states, although there is doubt as to its effectiveness for use close to an installation or in very rough conditions. The preferred method of rescue is by FRC or DC if at all possible.
- All rescue equipment must be carefully positioned on the ERRV for it to be used effectively. This will be particularly important on converted vessels.
- Personal locator beacons will certainly speed up the search for casualties, but should be backed up by other devices such as strobe lights.
- Throw lines offer a quick method of attempting to reach a casualty, especially under or near the installation, although their accuracy will be affected by the wind speed. Pneumatic types may allow several attempts with one charge.
- Casualties wearing survival suits may be difficult to recover to the rescue craft if grab handles are not fitted to the suits. The suits are also prone to leaking.

## 11.3 HELICOPTER RESCUE

Helicopters can provide a fast (if platform based) and relatively safe method of rescuing casualties from the water and provide rapid transfer to advanced medical facilities. The main conclusions are:

- The main weather limitation for helicopter deployment is the wind speed when engaging rotors. This will depend on the type of helicopter and the amount of shelter that is available.
- Helicopters offer an efficient method of rescuing conscious casualties from rough water. The number of casualties that can be carried will depend on the amount of fuel needed to reach the scene and remain in a hover. For a ditching incident, a helicopter may need to make several trips to rescue an entire crew of 20 people.
- The double-strop technique is a relatively easy method of lifting conscious casualties in rough weather. A Hi-line technique may be used in calmer weather.
- Stretchers or litters are the preferred method of recovering unconscious casualties from the water. In rough weather this equipment may be difficult to handle.
- In view of the training provided and the quality of the practice simulations, it is recognised that military air crew are highly experienced and professional in the SAR role.

## 11.4 TRAINING AND PRACTICE

- Shore-based training courses do not replicate conditions found offshore. This is accepted by the training providers and crews. Different types of equipment may be limited and it may not be possible to provide training with the equipment the delegate will be using.
- Training on board might be improved if the crews responsible are given some instruction in teaching methods and have a high level of experience in their role.
- There should be a requirement for a minimum amount of time logged as a FRC crew before attending the next course instead of the requirement to spend 3 months at sea.

- Overall, the OPITO training course requirements are of a lower standard than in many other countries.
- A suitable number of practice scenarios should be provided by the installation for crew training.
- Masters and crews should be encouraged to carry out transfers and other activities in the roughest conditions they feel are safe, to expose crew members to conditions they will one day encounter in an emergency. Experience of rescue craft crew is seen as equally important as the type of equipment used.
- ERRV and FRC training courses in the UK are significantly shorter and have less content than those in other countries such as Canada, even when taking into consideration the extra items taught by some training providers. Formal rescue scoop training should be considered as an industry standard for all ERRVs.
- The amount and the quality of practice and exercises carried out by standby operators is relatively low, especially when compared with that carried out by helicopter crews.
- Whilst dummies may be of a suitable size and weight they do not accurately simulate a conscious casualty. There may be pressure to forego elements of casualty care in order to meet faster response times. An unrealistic amount of space may be available in the FRC if the dummies are stacked up.

# 12. RECOMMENDATIONS

The following recommendations are made:

- Methods for determining equipment suitability and weather limitations have been presented. Further work involving examination of the interaction of human factors with equipment and weather would allow a set of performance standards to be compiled over a range of sea states.
- The shore-based training courses should not attempt to replicate conditions offshore, but should aim to teach the required background knowledge and procedures required. The on board training programme should provide the practical experience necessary. Facilitators responsible for on board training should be skilled in teaching methods.
- The content and teaching methods of the OPITO training courses should be reviewed in an effort to train crews to the high standard required. In particular, there should be advanced training in the use of mechanical recovery devices for ERRV masters and mates, some type of formal training for operators of davits and mechanical recovery systems and the opportunity for FRC crew to practise rescuing live casualties.
- Practice and exercises should be made more realistic, possibly by using ‘life weight’ dummies and by practising at night. UKOOA guidelines for ERRVs preclude night-time exercises but it is understood that the guidelines may be revised in 2001. Provision should be made for night-time trials, subject to approval from all industry bodies.
- If suitable equipment is available, crews should be encouraged to practise in rough weather, subject to duty holders’ AWWP and standard operating procedures. There is an implication here that ERRVs without suitable equipment would not achieve the required good prospect of recovery and rescue; this would have far-reaching implications.
- FRC davits should be fast, powerful and incorporate a constant tension device. The contribution to the total load from dynamic effects is significant and should be incorporated at the design stage.
- An off-load lifting hook should be permanently mounted on either a single lifting pole or a lifting frame aboard the FRC or DC, to reduce the danger of a heavy mass swinging on the end of the lifting wire.
- Helmets with a suitably designed, robust VHF radio system should be worn by all FRC crewmen. The radios should be operable at distances up to 10 nautical miles. ESVAGT is understood to possess a robust, reliable and effective system.
- The shape of the fast rescue craft hull should be designed to minimise the wave slamming impact whilst maintaining good course keeping characteristics and good handling in following seas.
- Adverse weather working policies should state that routine over-side working be suspended if a rescue craft cannot be launched.
- A measure of wave steepness or period should always be included with the significant wave height when defining limits and operability ranges.
- A method for the calculation of a limiting sea state for launch and recovery, based on FRC, ERRV and davit parameters should be used. Analysis of the occurrence of lulls would then allow a measure of the probability of successful launch and recovery of rescue craft.
- On modifying equipment on an ERRV or FRC, a check should be made to ensure that the change does not adversely affect the operation or effectiveness of that equipment, in

particular the balance of the FRC, the passenger capacity and the additional load on the davit.

- An assessment should be made to identify the best type of rescue equipment for each particular vessel, not entailing prohibitive cost. Most ERRVs would be capable of meeting recovery and rescue performance standards up to a significant wave height of about 5 m; above 5 m, the capability of mechanical recovery devices is suspect, given that the PFEER requires a good prospect of recovery and rescue.
- The experience and motivation of crew members are seen as the most important factors in the emergency response and rescue vessel industry. All efforts should be made to retain experienced crew members.
- Courses on integrated command and control specific to duty holders should be encouraged. Previous pilot schemes have been well received by those participating. They should involve emergency response teams from installations and ERRVs, where all aspects of command and control (C&C), evacuation and escape (E&E) and recovery and rescue (R&R) are practised. The courses should familiarise all participants involved in handling offshore emergencies and particularly give an in-depth knowledge of each party's mutual responsibilities.
- A robust system should be developed whereby all R&R equipment breakdowns which could affect the achievement by duty holders of their recovery and rescue performance standards are reported immediately to all installation OIMs.
- The training of DC crew should be improved so that they are better prepared to deal with emergencies on installations when distant from the mother vessel and to navigate back to the mother vessel.
- In view of the numerous problems affecting use of mechanical recovery devices, a seminar should be convened, involving relevant industry bodies, ERRV masters and crews to establish the main concerns, and leading to the cost-effective resolution of some of the problems.

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North Star Shipping
NUTEC Centre for Safety
Rescue Co-ordination Centre, Halifax, Canada
Shell Expro UK
Texaco North Sea
202 Squadron, RAF Lossiemouth
Viking Standby

# APPENDIX A – LAYOUT OF QUESTIONNAIRES

## FRC/DC Coxswains

Position held:
Time in current position:

**Launch and Recovery:**

1. Describe briefly your role during launch and recovery operations.
2. On a scale of 1 (easy) to 10 (very difficult), how would you rate the following in the various weather conditions:

| Activity | Significant wave height (m) | | | | |
|---|---|---|---|---|---|
| | < 2m | < 3.5m | < 5.5m | < 7.5m | 10m |
| Lowering: | | | | | |
| Releasing lines and escaping: | | | | | |
| Getting to casualty at speed: | | | | | |
| Recovery of MOB: | | | | | |
| Returning to SBV in displacement mode: | | | | | |
| Holding station alongside awaiting recovery: | | | | | |
| Attaching hooks and guiding lines: | | | | | |
| Bowsing FRC against SBV: | | | | | |
| Transfer of casualties: | | | | | |

3. What are the worst conditions in which you have launched and recovered a FRC / DC?
4. In your opinion, what are the worst weather conditions in which launch and recovery could be carried out safely?
5. What are the key items of equipment which, in your experience, slow down or prevent launch and recovery in rough weather?

**FRC / DC:**

6. What are the dimensions, weight and endurance of the FRC / DC used, and do you consider this ideal?
7. What propulsion system is used by the FRC / DC?
8. What type of lift hook arrangement is used, and what does it attach to on the FRC?
9. What is the rated passenger capacity of the FRC / DC, and do you feel that you could safely carry this many in rough conditions?

**Casualty recovery:**

10. What methods are employed to lift casualties from the water and how suitable are they?
11. Are there any limiting conditions, such as sea state, for these methods?

**Training and Practice:**

12. What are the worst conditions in which training and practice are conducted?
13. Do training and practice activities involve use of Personal Locator Beacons?
14. Are there activities that should be practised more?
15. How suitable and realistic are the training courses that are offered?

## SBV Master

Time in current position:

**SBV:**

1. What is the name of the SBV?
2. Is the SBV purpose built or converted?
3. What speed can be made good (a) in calm weather, (b) upwind in Beaufort 8, significant wave height 5.5m?
4. What is the make, type and capacity of the crane/davit system?
5. How many FRC / DC are carried?
6. If a DC is used, what are the details of the Load Line Exemption (i.e. range, endurance, etc.)?
7. Does the SBV have any passive or active stabilisation systems (i.e. bilge keels, anti-roll tanks, fin stabilisers, etc.)?

**Launch and recovery of FRC / DC:**

8. Is there a designated, trained launch and recovery crewman to operate the davit?
9. Describe your usual method of launching and recovery in rough weather, and any specific equipment used?
10. What are the limitations of the equipment used?
11. In an emergency, what are the worst conditions (a) in which you are expected to launch a FRC (b) that you feel it is possible to launch a FRC.?
12. What are the worst conditions that training is carried out in?
13. In what ways could launch and recovery can be made easier?
14. How is the SBV handled during launch/recovery?

Please provide details of any incidents in which the launch and recovery of a FRC or DC has been adversely affected by equipment performance in rough weather – for example, jamming falls or failure of components.

**Casualty rescue to SBV:**

15. What methods are used to recover casualties directly to the SBV and how suitable are they?
16. What are the limiting conditions in which these methods can be used?
17. How is a lee formed and the casualty approached in the water?

Please provide details of any incidents in which the recovery of casualties has been adversely affected by equipment performance in rough weather.

**Training and practice:**

18. How often are rescue drills practised?
19. In what weather conditions are they practised?
20. How often are FRC / DC launched?
21. Are there activities that, in your view, should be practised more?
22. How suitable and realistic are the OPITO training courses in your opinion, and are there any clear areas where improvements could be made?

**Records of performance:**

23. Are records of training and practice activities kept, such as rescue times, weather conditions, problems encountered, etc.?
24. Is there a log kept of day-to-day events, such as FRC launches, equipment failures, etc.?

## Offshore Installation Managers

**EER:**

1. Which installations do you operate in which UKCS / North Sea fields?
2. If there are any installations that are not tended by a dedicated SBV what DC / helicopter alternative arrangements are in place?
3. In what weather conditions do you require your EER target response times to be met by SBV operators?
4. What are the limiting weather conditions for overside working?
5. If you operate platform launched FRC, what conditions can they be launched and recovered in?
6. Are Personal Locator Beacons used, and in what circumstances are they worn?
7. What other features are included on the personal protective equipment to improve visibility and reduce search times (i.e. lights, reflective strips, etc)?

## Helicopter crew

Position held:
Time in current position:

**Procedures:**

1. What is the preferred method of lifting (a) single, (b) multiple and (c) unconscious casualties from rough seas?
2. What type of aircraft is used?
3. What are the limiting weather conditions for the type of helicopter used, particularly with regards to (a) rotor engagement, (b) icing and (c) hover capabilities?
4. What additional equipment is fitted to the aircraft for its SAR role?

**Practice:**

5. How do the target response times compare with the measured response times in practice?
6. How often are rescue drills practised?
7. In what weather conditions are they practised?
8. In your opinion, are there activities that should be practised more?

**Training:**

9. Do training courses involve use of Personal Locator Beacons?
10. How suitable and realistic are the training courses that are offered?

Please provide details of any incidents in which the recovery of casualties has been adversely affected by equipment performance in rough weather.

## Training Providers

Position held:
Time in current position:

**Training**

1. How suitable are the OPITO certified training courses in practice?
2. Are there areas that should be focussed on in more depth?
3. Is the period of sea time between courses sufficient?
4. Is the training becoming easier / staying consistent / becoming harder?
5. Where is the practical training carried out?
6. How do the courses treat rescue in rough weather?
7. Is there any guidance provided on the effect of rough weather on launching and recovery of FRC?
8. To what limiting sea-state is training carried out in?
9. What, in your view, is the extent to which crews should be trained to cope with rough weather?
10. What equipment do you use for training, and how does it compare with equipment currently used in the industry?
11. Do you have any data or information on the performance of this equipment in rough weather?

# APPENDIX B – METHOD FOR CALCULATING RESCUE CRAFT RECOVERY POTENTIAL

## DAVIT LOAD CALCULATIONS

The peak dynamic component of load on the davit wire due to rolling can be calculated using [21]:

$$W_R = M \cdot r \cdot \frac{4\pi^2}{T_\phi^2} \cdot \phi_A \tag{1}$$

where $M$ is the FRC mass,
$r$ is the distance of the load from the ERRV centreline,
$T_\phi$ is the roll period (assumed equal to the wave period),
$\phi_A$ is the roll angle in radians.

The peak component of load on the davit wire due to heave can also be approximated by multiplying the peak heave acceleration by the FRC mass, using:

$$W_H = \frac{M.H_S}{2} \cdot \left(\frac{2\pi}{T_Z}\right)^2 \tag{2}$$

where $H_S$ is the wave height,
$T_Z$ is the wave period.

Assuming that the davit arm is horizontal at the same height as the ERRV VCG, the total davit load is then:

$$W_{total} = W_R + W_H + M \cdot g \tag{3}$$

The delivered power required to lift at a minimum speed, $v$, is then:

$$P_D = W_{total} \cdot v \tag{4}$$

The installed power required to achieve this delivered power will depend on the efficiency ($\eta$) of the crane or davit such that:

$$P_I = \frac{P_D}{\eta} \tag{5}$$

An estimate of an efficiency of 65-70% is reasonable.

This method can be further simplified. In reality, the wave period will depend on the wind direction, the fetch and the superposition of various wave patterns so for operational considerations the true wave period can be used, as above. However, for design purposes, a statistical estimation of the expected wave period, $T_{av}$ , for a specific significant wave height can be made by [22]:

$$T_{av} = 4.2 H_S^{1/2} \tag{6}$$

Furthermore, the average wave slope can be approximated as:

$$S_{av} = \frac{2\pi^2}{g} \cdot \frac{H_S}{T_{av}^2} \tag{7}$$

The ERRV will attain a roll angle equal to its response amplitude operator (RAO) for that condition multiplied by the wave slope. The RAO may be much less than unity if the ERRV is running downwind, or may be greater than unity if the roll frequency of the ERRV is near its natural frequency. The use of roll damping tanks may significantly alter the RAO.

## SEA STATE DESCRIPTION

A detailed description of the following method may be found in Reference [23].

The value of the sea surface displacement ζ at any random time is normally distributed with a probability density function (PDF):

$$f(\zeta) = \frac{1}{\sqrt{2\pi\sigma_\zeta}} e^{-\frac{1}{2}\left(\frac{\zeta}{\sigma_\zeta}\right)^2} \tag{7}$$

where $\sigma_\zeta$ is the standard deviation of the surface displacement

The fraction of the time that the sea therefore lies below a certain threshold $z$ is thus:

$$\begin{aligned} P &= \int_{-z}^{z} f(\zeta).d\zeta \\ &= \int_{-\infty}^{z} f(\zeta).d\zeta - \int_{-\infty}^{-z} f(\zeta).d\zeta \\ &= \Phi\left(\frac{z}{\sigma_\zeta}\right) - \left[1 - \Phi\left(\frac{z}{\sigma_\zeta}\right)\right] \end{aligned} \tag{8}$$

An approximation can be made to the function Φ($x$) by:

$$\Phi(x) = 1 - q(b_1 + q(b_2 + q(b_3 + q(b_4 + qb_5))))e^{\frac{1}{2}x^2} \tag{9}$$

where $q = \dfrac{1}{1 + a|x|}$

and

$a = 0.2316419$
$b_1 = 0.127414796$
$b_2 = -0.142248368$
$b_3 = 0.7107068705$
$b_4 = -0.7265760135$
$b_5 = 0.5307027145$

In a similar way to the surface displacement, the distribution of the wave velocity $w$ can be described by:

$$f(w) = \frac{1}{\sqrt{2\pi\sigma_w}} e^{-\frac{1}{2}\left(\frac{w}{\sigma_w}\right)^2} \tag{10}$$

where $\sigma_w$ is the standard deviation of the wave velocity

The joint PDF is simply the product of the two individual PDFs. The frequency of each threshold-crossing where the surface velocity is between $w$ and *$(w + dw)$* is then:

$$f_w = \frac{dP_w}{dt} = \frac{1}{2\pi\sigma_\zeta\sigma_w} we^{-\frac{1}{2}\left(\frac{w}{\sigma_w}\right)^2} e^{-\frac{1}{2}\left(\frac{z}{\sigma_\zeta}\right)^2} \cdot dw \tag{11}$$

The average crossing frequency for all waves, irrespective of surface velocity, is then:

$$f = \int_0^{w=\infty} \frac{dP_w}{dt} = \frac{1}{2\pi} \frac{\sigma_w}{\sigma_\zeta} e^{-\frac{1}{2}\left(\frac{z}{\sigma_\zeta}\right)^2} \tag{12}$$

However, $T_z = \dfrac{\pi H_S}{2\sigma_w}$ and $H_S = 4\sigma_\zeta$

Therefore the average frequency

$$f = \frac{1}{T_z} e^{-\frac{1}{2}\left(\frac{4z}{H_s}\right)^2} \tag{13}$$

In the time interval $t$, only $n$ waves from the $N$ that pass will not cross the threshold $z$ such that $n = t\,f$

The probability of the sea being below the threshold value has been calculated in Equation (8). In the time interval *t*, the sea will therefore remain below the threshold for a time $t_1$:

$$\begin{aligned} t_1 &= t\left[2 \cdot \Phi\left(\frac{z}{\sigma_\zeta}\right) - 1\right] \\ &= t\left[2 \cdot \Phi\left(\frac{z}{\sigma_\zeta}\right) - 1\right] \end{aligned} \qquad (14)$$

Therefore, the average duration $\bar{\tau}$ of each of these lulls is:

$$\bar{\tau} = \frac{t_1}{n} = \frac{t_1}{t \cdot f} = T_z e^{\frac{1}{2}\left(\frac{4z}{H_s}\right)^2}\left[2 \cdot \Phi\left(\frac{4z}{H_s}\right) - 1\right] \qquad (15)$$

We can now define the probability density function of the lull duration as:

$$Y(\tau) = \frac{1}{\bar{\tau}} e^{-\frac{\tau}{\bar{\tau}}} \qquad (16)$$

where $\tau$ is a lull duration.

The probability of there being a lull of at least time $\tau_L$ can then be found as:

$$P(\tau_L) = \int_{\tau_L}^{\infty} \frac{1}{\bar{\tau}} e^{-\frac{\tau}{\bar{\tau}}} . d\tau = e^{-\frac{\tau_L}{\bar{\tau}}} \qquad (17)$$

If we then multiply this probability by the probability of actually being in a lull (Equation 8) we get the probability of being in a lull that is suitable for operations:

$$P(suitable) = e^{-\frac{\tau_L}{\bar{\tau}}}\left[2 \cdot \Phi\left(\frac{4z}{H_s}\right) - 1\right] \qquad (18)$$

Conversely, the percentage of time spent waiting for a suitable lull is:

$$P(waiting) = 1 - P(suitable) \qquad (19)$$

Finally, we can calculate the likely time interval that will be spent waiting as:

$$\tau_w = \frac{\tau_L}{P(suitable)} - \tau_L \qquad (20)$$

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