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Diver Location Aids: HSE Report

1. INTRODUCTION

A diverse range of location aids is available for use by divers in order to promote their relocation and recovery from the water. Location devices may be used routinely in the course of normal diving operations to facilitate a particular diving procedure or they may be used to attract attention when the diver has become separated from their diving support facilities.

Recreational and commercial divers undertake many thousands of dives each year with most of these dives taking place without incident. The majority of incidents that do occur take place on the surface and each year there are numerous reported incidents of missing or lost divers. The causes of these are numerous but may include; poor navigation, offshore winds or tidal currents, location devices not used or used ineffectively or incorrectly, engine failure, failure of skipper or boat crew to monitor divers position, deteriorating weather resulting in increased swell, waves, failing light etc.

Many recreational divers use a wide selection of location aids for dives under particular conditions. The most common devices in use are surface marker buoys (SMB's). These marker buoys are colloquially referred to by divers as 'deco bags', and they are generally conspicuous in shape, size, and colour to provide visible markers of the location of a diver. They may be inflatable bags that are inflated prior to the descent, thus marking the divers position from the onset of the dive, or more typically, these devices are carried by the diver during the course of a dive, deflated and stowed in a convenient position. The device may then be inflated underwater during the ascent. The inflated buoy ascends to the surface thus marking the divers position underwater. This latter form of SMB is generally referred to as a delayed SMB. These location devices are frequently used by divers undertaking decompression stops. The marker buoy enables a diving support vessel to observe the divers position and the positive buoyancy of these buoys facilitates the diver to carry out stops at more precisely controlled depths over longer periods of time.

Commercial diving contractors undertaking inspections, maintenance and fabrication work, most frequently perform these projects while adhering to strictly controlled procedures and would rarely require any need for location devices. Other groups of divers at work may include scientific, archaeological, media and recreational instructors. A number of working divers regularly dive for shellfish. Commercial shellfish divers periodically work in strong tidal areas utilising 'solo' diving techniques. Frequently there may be two or more divers in the water at any one time. A coloured buoy or combination of buoys is used to mark their position. On occasions, significant distances may separate the divers and during periods of reduced visibility, moderate sea states or diving in areas where there are numerous similar buoys marking fishing creels, the diver's buoy can be confused or 'misplaced'. Diving contractors are required to undertake diving operations whilst adhering to relevant legislation and Approved Codes of Practice. Risk assessments must be carried out for these diving projects to identify any site-specific hazards and their risks. Using this information, diving project plans must be prepared. Amongst many other components, these project plans should identify the techniques to be adopted and the means by which a diver would be relocated and retrieved from the water in the event of any foreseeable emergency. The ability to monitor the divers position whilst underwater is of paramount concern for the duration of the dive. Consequently, particular location devices may be beneficial in both instances.

A wide range of other surface marker aids are available for use by divers. These include pyrotechnics, telescopic flags, fluorescent dye, flashing strobes, whistle's, torches and personal EPIRBS (Electronic Position Indicating Radio Beacons). Divers have used a selection of these devices to good effect for many years. Some devices have been trialed by manufactures under a range of environmental conditions and consequently particular claims may be made. Some groups of divers have also conducted their own independent assessments on location devices. Much of this work has only provided qualitative information regarding how effective a particular location device is considered to be. Little work has been undertaken to provide more quantitative evaluations on their performance or limitations against one another under comparable conditions. The requirement of any location device is to promote the recovery of an in-water diver. Any location aid that can consistently and reliably provide this, would be an asset in those instances when divers find themselves for whatever reasons, separated from their diving platform.

1.1 OBJECTIVES OF STUDY

This study assesses a diverse range of diver location devices under an extensive range of environmental conditions to provide an assessment of their particular benefits or limitations. The main objectives were:

To ascertain and define the performance limitations of diver location devices from the most commonly used diving platforms, namely inflatable boats and hard boats.

To provide recommendations on the optimum type or combinations of diver location devices for particular environmental conditions and search facilities.

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2. THEORY

An obvious criterion that can be used to compare the performance of devices against each other is the maximum distance at which a particular device can be relocated. Prevailing environmental conditions may well be expected to have considerable effects on the relocation distances of devices that are deployed at or close to sea level and require a visual sighting. These conditions would primarily include sea state and light intensity.

The components of sea state include wind speed, location, wave height and swell height. Sea state is grossly affected by geographic location. In enclosed waters, or near land with an offshore wind, wave heights will be smaller, and the waves steeper. Additionally, for any given wind force there may be considerable influence upon wave height in tidal areas. As sea state deteriorates it would be expected that the location distances of many devices would decrease.

The components of light intensity include cloud cover, cloud type, precipitation and time of day. The period of time from darkness to daylight varies by day and the intensity of light increases and decreases quickly over a short period of time during the sunset and sunrise hours. Light intensities fluctuate less markedly during normal daylight hours, irrespective of cloud cover and cloud type. The acuity of the human eye decreases with falling light intensities and the location distances of devices at sea level that do not provide an artificial light source will decrease correspondingly.

The aspect of a device above sea level and its colour may reasonably be expected to have some bearing on the relocation potential. Similarly, the elevation of the observers' platform above sea level will have an effect on relocation. The precise effects of this will however require determination as the size and type of boat will determine the observers eye height above sea level. Commonly used diving support vessels include inflatable boats and hard boats. Consequently, vessels of this type were used as the main observation platforms.

3. EXPERIMENTAL PROCEDURES

3.1 ENVIRONMENTAL CONDITIONS

A methodology was utilised to ensure that as far as was reasonably practicable, direct comparisons of all location devices could be made under comparable conditions and from a range of observation platforms. The methodology employed assumed no prior knowledge of the performance and limitations of any particular location device.

The components of prevailing weather were recorded throughout the field trials. These included; wind direction, wind speed, cloud cover, cloud type, precipitation, light intensity and visibility. Wind speeds and sea states were continuously recorded during the course of each trial by anemometer and by estimating the sea wave height. The location devices were tested under a wide range of sea states from calm to marginal. An attempt was made to trial all devices under a broad range of light intensities ranging from light to dark. Light intensity was monitored and recorded in lux (lumens per square meter) using a Gossen Lunasix F light meter.

3.2 LOCATION DEVICES

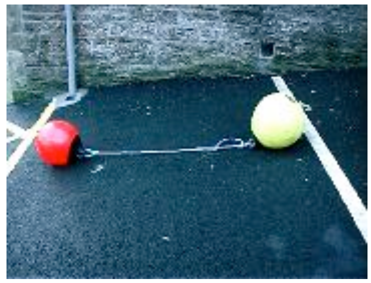
A variety of location devices available for use by divers on the surface were selected for field trials. A brief description of each device is detailed in Table 1. A summary of device specifications is detailed in appendix Table 21.

Table 1
Location devices used in trials

Location device	Description
Pyrotechnic rockets	Pains-Wessex Miniflare 3
Pyrotechnic flare and smoke	Pains-Wessex Day/Night Distress Signal
Marker Dye	High visibility green dye
Surface Marker Buoys	Polyform buoys and Delayed SMB's
Folding Diver's Flag	Day-glow Yellow, Red, Orange, Black and A-Flags
Torches	MiniQ, SL4, UK400, UK1200
Strobes	Seaman Sub Signal Flash and Jotrun

Polyform buoys vary in colour and size. Red, orange and pink are the most common although some divers use bright yellow. These were used in paired combinations and separated by a minimum of 2 m. These buoys had a diameter of approximately 40 cm. These devices are typical of those used by shellfish divers for position marking. Delayed SMB's included a red AP Valves self-inflating decompression marker buoy, red AP Valves decompression sausage (self sealing), and Bowstone red and yellow decompression sausages (open ended). The torches that were selected represented a range of power outputs and are typical of those used by divers as main and backup torches. Two types of marker dye were tested. Sea-Streak from Advanced Diving Products is a small tablet of solid dye that slowly dissolves when a white tear seal is pealed from the plastic pouch and exposed to water. Sea Marker Dye (from Presto Dyechem) retailed by BCD International is also a small plastic pouch which is pealed apart to release a cloth bag on a length of tape containing powdered dye. Both types of dye release a plume of bright green dye on contact with water. The folding diver's flags are assembled from three sections of hollow white plastic pipes that slot into couplings to form a pole 1.8 m in length. When folded, the pole sections are held together by a length of bungee cord running through the centre of each section. A square coloured pennant is attached to one end.

Location aids trialed.

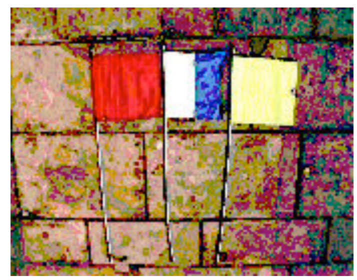


Polyform buoys

Self-deploying SMB

Decompression sausages
AP Valves and Bowstone

AP Valves self-inflating bag



Folding flags

Strobes
SOS and Jotrun

Torches
UK1200 UK400
SL4 MiniQ

Sea Marker Dye

Pyrotechnics
Day/Night Mk4 Miniflare 3

3.3 OBSERVATION PLATFORMS

The observer eye height in the inflatable was just less than 2 m. Observation heights from the hard boat were between 3 m and 4 m and were made from the wheelhouse and bows. The skipper of each vessel and several University staff all undertook observations for location devices. A limited number of trials were also conducted in Shetland using the Sumburgh based Bristows SAR Coastguard helicopter for aerial observations from typical search altitudes. In the latter stages of the trials a relocation exercise for diver location devices was undertaken in Scapa Flow incorporating the search capabilities of two Lifeboats and the SAR helicopter.

3.4 TRIAL AREA

The majority of trials were conducted in Scapa Flow, Orkney and a limited number of relocations by helicopter were undertaken in Shetland. The maximum relocation range of each device, observed from inflatable and hard boat was determined under a wide range of prevailing conditions. The trial area was a relatively sheltered body of inshore water that is not subjected to significant swell waves. Although an inshore area, Scapa Flow is subject to a substantial fetch from the South East through to the West. Consequently, this region can experiences sea waves of heights exceeding 1.5 m. Small swell waves are sometimes generated in this area at very high wind speeds.

3.5 DEVICE DEPLOYMENT

Location devices were deployed in fixed positions by securing to a weighted shot line. As a standard against which all location devices may be compared, a series of location trials to simulate a diver on the surface with no additional location device was undertaken. A buoy was covered with a black neoprene diving hood and weighted below to represent a diver’s head above water. The weight served to damp movement of the buoy. A relocation of a real, fully equipped diver was also undertaken for comparison. The folding flags required the attachment of small buoys to emulate the deployment height as a diver would hold the flag. Strobes were attached in an elevated position by fixing to the top of a diver’s folding flag. Pyrotechnics and torches were activated from inflatable by holding them 0.5 m above sea level.

3.6 DEPLOYMENT AND RELOCATION STRATEGIES

All deployment and relocation positions were recorded as a Global Position System (GPS) fix.

3.6.1 Method A

During the initial trials, a wide range of devices were relocated by placing a selection of devices along a transect secured by weighted shot lines at each end. In the first instance, the initial approaches were made heading directly towards the mid-point of the transect to ascertain maximum relocation distances. When a visual sighting was made the search vessel recorded the GPS position fix. The search vessel then continued its search for the remaining, unsighted devices. The search vessels then made approaches from a variety of aspects to determine any differences in relocation distances.

3.6.2 Method B

On several trialing days, devices were deployed in random positions and attached to shot lines to prevent drifting. To simulate more realistic relocation potentials, observers did not witness the deployment of the devices. The search vessels then made approaches on headings chosen to cause the observers to search for the devices through a 120^{o} sector.

3.6.3 Method C

Devices were deployed in groups of three or four in extensive triangular or rectangular formations. The search vessels made approaches to all devices from a selection of headings to take prevailing wind directions into account. The formation of the devices allowed repetitive runs to be made between all devices, thus maximising the number and variety of relocation approaches. The devices were deployed in relatively open bodies of water, generally devoid of obvious landmarks.

3.6.4 Method D

Two days of trials were also conducted using a single deployment position for a selection of devices in turn. Each device was relocated from similar aspects. Headings were selected in order for the search vessel to run into, against and across the prevailing wind and wave direction. This method of relocation was used to standardise the relocation aspects in respect to the prevailing wind and wave direction.

3.6.5 Aerial location

Devices were deployed for aerial relocation on two occasions. Deployment method A was utilised in the first instance and subsequently, method B.

3.6.6 Search Exercise

A search exercise for diver location devices was undertaken on 20th March in Scapa Flow incorporating the search capabilities of the RNLI Stromness and Longhope lifeboats and Bristows SAR Shetland Coastguard helicopter. This exercise was co-ordinated by MRSC Pentland. A selection of location devices were deployed in predetermined locations within a search area of 8 square nautical miles (nm2) in an open expanse of Scapa Flow to assess the search capabilities of lifeboats and helicopter for these devices. Each lifeboat independently searched a sector of 4 nm2 employing a creeping line ahead with a track spacing of 0.2 nm (370 m) whilst the helicopter independently searched the total area at an altitude of 300 feet (90 m) utilising the same search pattern.

3.6.7 Location Distance Calculations

The relocation distances were calculated between the deployment and relocation GPS position fixes using the following mathematics:

$$\text{Departure} = \text{diference in longitude} \times \cos \text{Mean latitude}$$

$$\text{Course} = \arctan(\text{departure} / \text{diference in latutude})$$

$$\text{Distance} = (\text{diference in latitude} / \cos \text{Course})$$

3.7 LOCATION DEVICE QUESTIONNAIRES

A questionnaire regarding location devices was distributed to over 80 recreational sub-aqua diving clubs in the UK (see appendix). The questionnaire was used to assess the current range of location devices presently used by this group of divers and their preferences for particular devices. Several shellfish divers based in Orkney were interviewed to evaluate their comments regarding the relocation of divers undertaking this type of commercial diving operation and to assess the range of location devices presently used by this group.

4. RESULTS

Fieldwork was undertaken between January 11th and March 20th 1999. The summaries of the daily data records for this period are detailed in the appendices. The relocation of devices was undertaken over a continuos period of time on each field trial excursion. Consequently, wind speed and sea state on many trialing days fluctuated markedly. In order to conduct a comprehensive matrix of relocations under comparable conditions, it is preferable for the prevailing environmental conditions to remain constant. Although the fieldwork was conducted over a two-month period, the trialing conditions did not frequently provide protracted periods of stable conditions. Inevitably, not all devices have been trialed under the full range of conditions. This was particularly the case with light intensity.

4.1 DEPLOYMENT METHODS

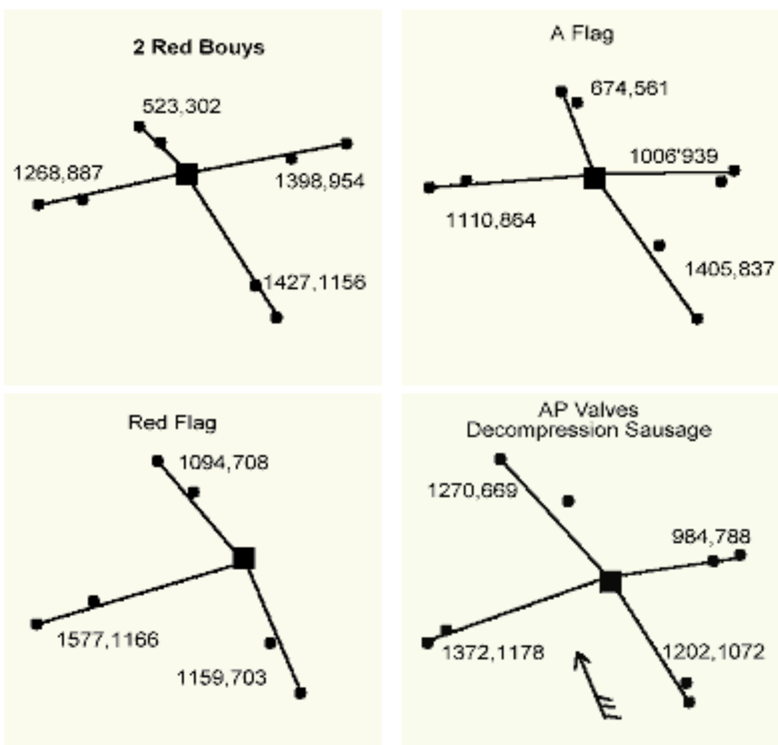
Deployment method A was used on four days and proved useful in providing initial relocation distances. The first device to be sighted on any approach drew the observer's attention immediately towards adjacent devices, thus giving a false impression of the relocation distances of other devices. Additionally they do not simulate the relocation of devices under real search conditions. The random deployments conducted on four days produced a more diverse range of relocations. In some instances, observers would unknowingly mark an approximate deployment position upon relocation of a device if a prominent landmark formed an obvious transit to it. These position fixes proved to be of little assistance however when additional relocations were undertaken on reciprocal headings or other tangents to the same device. Deployment method C was used on twelve occasions and provided the largest number of relocations. Though observers witnessed the deployment of devices whilst using this method, relocations proved difficult in many instances. The search vessels used a variety of headings and observers could not readily estimate deployment positions due to the open expanse of the deployment area. Method D was used on the last two days of trialing. These relocation distances allow more direct comparisons between devices as relocation headings were standardised for each device. The deployment and relocation of devices were plotted for most trial days and correlated with search aspect and wind direction. Figure 1 shows a typical example of these plots. These plots were used to ascertain any differences in relocation distances with change in search aspect.

4.2 ENVIRONMENTAL CONDITIONS

A wide range of environmental conditions was experienced during the course of the research. Sea states ranged from calm to rough, with waves occasionally higher than 1.5 m. Cloud cover ranged from clear to overcast, with overcast predominating. Visibility ranged from less than 2 nm to more than 10 nm, though typically this was between 6 and 10 nm. During the period of the field trials, relocations were conducted between 10:00 hours and 19:00 hours with the typical daylight hours changing with increasing day length. Devices were relocated under a rage of light intensities from 1.4 to 175,000 lux. Daytime light intensities typically ranged from 5,500 to 175,000 lux. Light intensities of less than 175 lux typically represent failing light towards darkness. An intermediate light intensity is covered between 175-4,500 lux, and intensities greater than 4,500 lux were typical of dull, overcast days through to clear and bright days. As a guide to the dynamic range of light intensity, a bright sunny day may be 100,000 lux, office lights, 1000 lux; and a full moon 0.1 lux . The period of time for falling light intensities following normal daylight hours was relatively short during the trial period. Light intensities during the afternoon of 19th January are clearly demonstrated in Table 2.

Table 2 Light intensity with time, 19th January 1999

Time (GMT)	**Light Intensity (lux)**
14:40	88,000
16:10	5,500
16:20	2,800
16:25	1,400
16:55	1.4



The two values reresent the first and the last observer to relocate the device.
Distances in meters

Conditions

Date: 10th March 1999
Windspeed: 12-25mph
Wind direction: SSE
Wave height: 0.5-0.7m
Broken cloud with sunny spells
Light intensity:88,000lux
Visibility:10 miles plus

4.3 DATA COLLATION

The range of sea states experienced during the course of the research ranged from less than 0.5 to 2.0 metres. Sea waves in excess of 1.5 m were experienced only on brief occasions. Whilst wave height increased with wind speed there was often a delay in the period of time required to manifest the corresponding wave height. Similarly, this delay was also experienced with decreasing wind speeds. It is therefore not possible to classify broad divisions of sea sate with any given range of wind speed in the first instance. For the purposes of summarising data, relocation distances were collated and grouped into wave height classes of less than 0.5 m, 0.5 to 0.9 m and greater than or equal to 1.0 m.

Data was also grouped into three broad divisions of light intensity. These were selected at less than 175 lux, 175 to 4,500 lux and greater than 4,500 lux. These divisions approximate to darkness, intermediate and daylight. Relocation distances of each device falling into the appropriate matrix of wave height, light intensity and observation platform, were extracted from all the daily data records, collated and averaged. These summaries are detailed in tables 3 to 17 and represent a total of 481 individual relocations.

Tables 3 to 17 Collated relocation distances (meters) of devices from (a) hard boat and (b) inflatable

Yellow Flag

Table 3a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500

Table 3b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500

<0.5			3148
0.5-0.9	482	652	2016
>=1.0		1185	896

<0.5			1851
0.5-0.9	279	316	1260
>=1.0			

Orange / Red Flag

Table 4a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			1201
0.5-0.9		270	1053
>=1.0			714

Table 4b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			1591
0.5-0.9		206	984
>=1.0			

A Flag

Table 5a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			738
0.5-0.9	210		1002
>=1.0			

Table 5b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			760
0.5-0.9	72		682
>=1.0			

Black Flag

Table 6a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			
0.5-0.9		250	832
>=1.0			686

Table 6b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			
0.5-0.9		244	645
>=1.0			

AP Red Decompression Bag

Table 7a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			976
0.5-0.9		763	822
>=1.0		378	1032

Table 7b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			851
0.5-0.9		508	688
>=1.0			

AP Red Decompression Sausage

Table 8a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			897
0.5-0.9		201	991

Table 8b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5		392	929
0.5-0.9		384	282

>=1.0			

>=1.0			

Bowstone Red Decompression Sausage

Table 9a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			938
0.5-0.9			
>=1.0			656

Table 9b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			365
0.5-0.9			1191
>=1.0			

Bowstone Yellow Decompression Sausage

Table 10a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			938
0.5-0.9		250	745
>=1.0			739

Table 10b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			575
0.5-0.9		405	494
>=1.0			

Pink and Yellow Buoy

Table 11a			
	Light Intensity (lux)		

Table 11b			
	Light Intensity (lux)		

Wave Ht(m)	<175	175-4,500	>4,500
<0.5			1153
0.5-0.9	387	297	710
>=1.0			

Wave Ht(m)	<175	175-4,500	>4,500
<0.5			839
0.5-0.9	132	208	559
>=1.0			

2 Red Buoys

Table12a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5	ND		921
0.5-0.9		501	805
>=1.0			680

Table 12b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5			995
0.5-0.9		210	774
>=1.0			

Torches observed from hard boat only

Table 13								
	MiniQ		SL4		UK400		UK1200	
Wave Ht(m)	<175	>4,500	<175	>4,500	<175	>4,500	<175	>4,500
<0.5			5320	3887	8962	5610	8962	5610
0.5-0.9		975		1669		2453		2598
>=1.0					1780			

Jotrun Strobe on Flag

Table 14a			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5	2199	ND	
0.5-0.9	2023	ND	
>=1.0			

Table 14b			
	Light Intensity (lux)		
Wave Ht(m)	<175	175-4,500	>4,500
<0.5	4639	ND	
0.5-0.9	1666	ND	
>=1.0			

Pyrotechnics observed from Hard Boat only

Table 15			
	35-40 mph 175,000 lux wave ht 1.0m	5-8 mph 44,000 lux wave ht <0.5m	5 mph 1.4 lux wave ht <0.5m
Orange Smoke	4401	8555	
Night flare		8555 white smoke only	Not detected at 8962
Mini flare		8555	9328

Divers Head

Table16a	
	Light Intensity (lux)

Table 16b	
	Light Intensity (lux)

Wave Ht(m)	<175	175-4,500	>4,500
<0.5	ND		
0.5-0.9		197	230
>=1.0			148

Wave Ht(m)	<175	175-4,500	>4,500
<0.5			
0.5-0.9			230
>=1.0			

In-water diver

Table 17b	
	Light Intensity >4,500 lux Wave Ht <0.5m
Arm down	254
Arm up	661

Table 17b	
	Light Intensity >4,500 lux Wave Ht <0.5m
Arm down	291
Arm up	678

4.4 RELOCATION DISTANCES

The relocation of devices from inflatable and hard boat ranged from not detected in some instances to more than 9 km. Flags and buoys typically afforded location distances of up to 3 km whilst pyrotechnics, torches and strobes were observed at distances generally in excess of this. The ranges of relocation distances from both observation platforms have been extracted from the summary tables and are shown in table 18 below.

Table 18 Typical ranges of relocation distances from inflatable and hard boat

Location device	Distance range
Pyrotechnics	4401-9328 m
Torches	975-8962 m

Strobe on flag	1666-4639 m
Yellow flag	279-3148 m
Orange/red flag	206-1591 m
Decompression sausages	201-1191 m
Paired buoys	132-1153 m
Decompression bag	378-1032 m
A flag	72-1002 m
Black flag	244-832 m
In-water diver	254-678 m
Divers head	197-230 m

4.4.1 Flags

The folding flags were visible at significant distances. This was particularly the case for the day-glow yellow pennant that was consistently located at distances in excess of 2 km and at a maximum of 3 km. Under all conditions and for all observers, this colour proved to be the most noticeable passive relocation device. This colour was the most readily observed in all sea states, including periods of breaking wave crests. Equally, it was the colour that was located in deteriorating light intensities when it was not possible to locate pennants of any other colour. This colour was most pronounced and was never confused with numerous buoys in the area. It was noted that this pennant collected dirt and the brightness of the colour became slightly faded during the course of trialing. This did not appear to have an observable effect on the relocation potential.

Most observers found orange or red pennants were the next favourable colour after yellow. Two observers suffered from degrees of red-green colour blindness and had difficulties in relocating these colours. Occasionally these observers only located the flags at a few hundred metres. The movement of the pole or the merest flutter of the pennant often drew their attention to the flags position. Towards the upper extent of the location distances for flags of this colour, they were occasionally confused with red and orange fishing buoys that were present within the trialing area. This problem was not experienced with the bright yellow flag, as buoys of this colour are not frequently encountered in the marine environment. Red and orange flags were also more difficult to locate under intermediate light intensities than the yellow flag. The black pennant was located better than expected and was observed well in dull and overcast conditions. The A-flag was the weakest in all conditions. During periods of breaking waves, the location of this flag was extremely difficult and the white pole was frequently sighted before the pennant. The location of the folding flags was largely facilitated through their elevation above waves and in some instances when there was movement of the flagpole and pennant as a consequence of wave motion and wind speed. Relocation distances of flags were maximised when headings were made at aspects close to or approaching abeam to the wind direction. These aspects presented the greatest visible surface area of the pennant to the observers. Location of flags was more difficult when the search heading was into or against the wind direction.

4.4.2 Decompression Devices

The location distances of these four devices were very similar, providing location distances up to 1 km. The AP valves decompression bag had a slight advantage other devices. This inflatable bag was a day-glow orange/red colour and was noticeably brighter than the AP Valves and Bowstone red decompression sausages. On many occasions observers noted that this device was more prominent than the two red buoys. It was however difficult to make a positive identification on this device until much closer than the initial sighting. At distance, the device resembled a single red buoy, typical of fishing buoys.

The decompression sausages produced similar average location distances. Several observers found that the AP Valves sausage was located more easily than the Bowstone sausage. This was most likely a result of the slightly larger diameter and height. Most observers found the yellow sausage difficult to locate though the relocation distances for this device are not significantly lower than related devices.

4.4.3 Buoys

The paired red buoys were much better to relocate than single buoys. The separation distance between buoys facilitated their relocation in areas where numerous similar coloured and sized fishing buoys were deployed. It was noticed that the separation distance between buoys permitted an independent movement of each under increasing wave heights. The buoys movement produced a yo-yo effect in these conditions, thus there was a more continuous period of time that buoys were visible to the observers. The separation distance of the two buoys varied between one and two metres. It was noted that location of the buoys was facilitated in most circumstances at the greater separation distance. The combination of two bright red buoys was marginally better than the combination of a large pink and yellow buoy overall (tables 11 and 12). The pink and yellow buoys did afford a slightly enhanced location range under calm conditions.

4.4.4 Torches

The diving torches produced very bright beams and were clearly located during daylight at distances in excess of 4 km increasing to 9 km in darkness. It was apparent that location was restricted when the person activating the torch pointed it towards the search vessel. Location was enhanced when the torch beam was directed towards the general position of the search vessel and moved slowly but steadily in a scanning motion (horizontally and vertically) to produce a much wider detection sector.

4.4.5 Strobes

Strobes were only deployed attached to folding flags. Initially the strobes were attached just below the pennant, but this was found to produce intermittent flashes. This was believed to be the result of motion on the flagpole in waves, and the pole itself obscuring the lens of the strobe. Subsequently, strobes were attached to the top of the poles with the lens clear of the pole. Strobes were not observed at light intensities above 175 lux. The Jotrun strobe was observed at distances up to 4 km at light intensities lower than this. Typically, this strobe was located at an average of 2 km. The Jotrun strobe was found to be more effective than the Seeman Sub strobe, generating a much brighter and regular flash. On one occasion the Seeman Sub strobe was observed at 2 km and on two relocations at 1 km and 1.3 km.

4.4.6 Pyrotechnics

A limited number of trials were conducted with the range of pyrotechnics. Prior arrangements with the Coastguard were required before testing these devices and the period of time for their activation was kept to a minimum. The hard boat retreated a considerable distance from the deployment position and observers viewed in the general direction of the deployment position. The observation vessel then retreated to more distant positions for subsequent deployments. The orange smoke from the day/night distress signal had a burn time of 20 seconds. This produced a smoke cloud that appeared dense at 4 km and lingered for approximately 90 seconds. As the distance was increased to 8.5 km, the smoke remained visible but appeared less dense and had a much lower profile. Wind speed on this occasion was less than 10 mph. The night flare on the day/night distress signal produced a dense white smoke in daylight that was also visible at 8.5 km. The location distance of the night flare in darkness was not established. Miniflares had burn times of 10 seconds and were estimated to achieve a height in excess of 100 m. These were observed up to 8.5 km in daylight but they appeared much brighter at distances less than 6 km. In darkness the Miniflares were very easily located at over 9 km.

It was noted that cold hands hampered the activation of the pyrotechnics. Several researches commented that they would be uncertain as to how practicably these devices would be operated by a diver wearing gloves with cold hands.

4.4.7 Diver

The simulated divers head was only observed at relatively short distances (up to 230 m). It was generally agreed that this device, whilst simulating a diver who was heavy in the water, did not realistically mimic the aspect that most divers would be able to maintain at the surface. A diver wearing full scuba equipment was deployed and located by inflatable and hard boat. Approaches were made towards the diver and repeated with the diver raising one arm. The location distances of the diver from both observation vessels were comparable in both instances and were doubled to more than 600 m through the diver raising one arm (see Table 17a and 17b).

4.4.8 Recovery Vessels

The location distance of hard boat and inflatable by an in-water diver was ascertained by deploying a diver on a shotline at a fixed position. The vessels moved away from the diver and the position noted when the vessel was beyond visual sight of the diver. During daylight and with a wave height of 0.5 to 0.75 m, the diver lost sight of the inflatable at 1333 m and the hard boat at 4397 m (see appendix Table 11). These distances are far greater than those for the relocation of a diver from these platforms. This demonstrates that an in-water diver without a supplementary location aid will be able to see a recovery vessel some time before the vessel is close enough to locate them.

4.4.9 Aerial Relocations

The search undertaken on 2nd February failed to locate several devices. Devices that were sighted included the Dyechem sea marker dye and the yellow flag. The marker dye produced a very concentrated plume of dye upon activation. It was noted that the dye release remained consistent for approximately two hours. Four hours after deployment the release of dye was significantly reduced. Location distances of these devices were increased at an increased search altitude. The search undertaken on the 3rd February was under marginal conditions. It is highly likely that diving operations would not normally take place under these conditions. However, weather and sea conditions may deteriorate very quickly during the course of normal diving operations and they therefore provide realistic search conditions. The devices that were located included the marker dye, yellow flag and A flag. The relocation distances of the yellow flag and dye were significantly reduced under these conditions compared with the previous search. The results of these helicopter searches are detailed in the appendices.

4.4.10 Search Exercise

The devices deployed for the search exercise and their relative location distances are shown in table 19 below.

Table 19 Relocation distances of devices deployed for search exercise

Device	Lifeboat	Helicopter
Yellow flag (1)	1226 m	Not detected
Yellow flag (2)	1800 m	892 m
Red flag	827 m	1901 m
A flag	Not in sector	396 m
2 Red buoys	482 m	898 m
Decompression bag	Not in sector	48 m
Decompression sausage	Not in sector	169 m
Diver (simulated)	< 50 m	Not detected
Marker Dye (Sea Streak)	50 m	Not detected

The marker dye was activated 30 minutes prior to the commencement of the search. The simulated diver used for this exercise was a 25 litre barrel attached with a buoy covered with divers black hood and mask, and a buoyancy device. The barrel was ballasted with water to simulate the form and size of an on-surface diver with no additional location aids.

The initial search headings of the lifeboats were from West to East. The Stromness lifeboat located all devices deployed within their designated sector. Additionally, the Stromness lifeboat located three devices that had been deployed in the adjacent search area. The yellow flags provided the greatest location distances and were typical of the average distance derived for these devices under comparable environmental conditions from the hard boat observations. The relocation distance of the red flag was also typical to those relocations made from the hard boat. The diver was only located a few metres directly ahead of the lifeboat and lifeboat crew commented that the device appeared realistic. Each lifeboat required two hours to search their designated sectors. The position fixes of device relocations by the Longhope lifeboat were not reported. The helicopter covered the total search area in approximately one hour and located six of the ten devices. On completion of the exercise the deployment vessel collected devices and it was noted that the Sea-Streak marker dye did not release a significantly noticeable concentration of dye. The plume of marker dye was extremely diffuse and relocation of the buoy to which it was attached required several minutes of searching from downwind of the deployment position.

4.5 QUESTIONNAIRES

4.5.1 Recreational

A total of 55 responses were received from recreational divers in the UK. The results of these responses are detailed in appendices. Delayed SMB's are by far the most common location device used by recreational divers. These are either used routinely for planned decompression or infrequently when unplanned decompression may be required. The most popular colour of these devices is red or orange, but largely as a result of manufactures predominantly fabricating these devices in these colours. Detailed comments on the questionnaires identified a preference for self-inflating or self-sealing decompression marker buoys as they do not expel air if they are allowed to fall over. This frequently occurs when open-ended SMB's are incorrectly deployed. Flags, torches and whistles all appear frequently as location devices. Almost 50% of divers questioned use, or have used folding flags. Similarly, red and orange are the most common pennant colours. More than 50% of divers carry two or more torches, with a small torch frequently used as a backup to a larger lantern style main torch. A similar proportion of divers regularly carries a strobe that in most cases is attached to the divers buoyancy device. Whistles are generally incorporated as a fixture on buoyancy devices. These are typically moulded plastic mouth whistles. A small proportion of divers also commented that they used air-powered sirens attached to their buoyancy devices.

Colour blindness was only reported in 5% of the divers. One diver that reported colour blindness preferred yellow to red or orange. From question 10 relating to particular colours that stand out more than others, orange is largely recorded as the most readily observed. Several divers commented that they found red and orange better colours to observe than yellow and green in bright conditions. Day-glow pink was also noted as a good colour to observe. The questionnaire responses indicate that almost 50% of divers have been missing for an average of more than 30 minutes and the device that aided relocation was most frequently a delayed SMB.

A wide selection of additional comments from question 11 on the questionnaire appears in the appendices. Many relevant issues regarding relocation devices additional to those that have been dealt with in this research appear in the list.

4.5.2 Commercial

Several shellfish divers were interviewed on a wide range of issues regarding shellfish diving operations and diver location in these circumstances. These divers predominantly use pairs of polyform buoys attached to their line to enable the boatman to distinguish between the diver and any fishing buoys in the immediate vicinity. Some divers use a combination of large and small buoys and two buoys of different colours. The separation distance between buoys had not been considered as a factor that may promote location and none of the divers questioned used a supplementary location device.

Commercial shellfish divers periodically work in strong tidal areas utilising ‘solo’ diving techniques. There are commonly one or two divers in the water at any one time. These divers may be deployed in close proximity of each other or at distances up to 1 km. If multiple divers have been deployed and the divers become separated, the support vessel will remain equidistant from each. On occasions the divers can be grossly separated (up to 2 km) as a result of tides or the divers swimming on diverging courses, and during periods of reduced visibility or moderate sea states the diver’s marker buoys can be misplaced. Depending on environmental conditions it may be impossible to readily locate the position of each diver. Several divers commented that they have been missing or lost by a support vessel on numerous occasions over many years of diving. The amount of time varying greatly from a few minutes too more than one hour. Some divers also reported swimming to shore on occasion. The most common explanation for these incidents is the lack of awareness of the boatman to keep the divers marker buoy in sight. The ability of the boatman to remain in visual contact with the divers is not facilitated when multiple divers are deployed in tidal areas or in non-tidal locations over an extensive area. Most divers commented that they take all relevant factors into consideration when undertaking this type of diving operation.

Many divers commented that prevailing weather and tidal conditions are always considered when deploying divers in any particular location. During periods of spring tides, many of the favoured fishing grounds are avoided due to adverse current speeds. This is not related to the risk of a working diver becoming separated from the support vessel, but because the divers cannot search the seabed effectively when they are drifting over the seabed at excessive speed. Similarly, these areas are avoided if a particular wind direction and windspeed are against the general direction of tidal movement, therefore generating moderate sea waves.

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5. DISCUSSION

A range of devices are suitable for use as diver location devices. Some devices have consistently demonstrated greater relocation distances than others. There are many factors that must be taken into account in the process of selecting an appropriate device. The potential relocation distance of any device is only one consideration. The choice of location device in many circumstances is dictated by the particular scope of the diving operation. Delayed SMB's are certainly required when divers plan to undertake scheduled decompression stops. They should also be considered as a device to be available should unplanned decompression stops be required. Particular environmental conditions relevant to the type of diving, such as drift diving, require the use of a permanent surface-marking device such as a self-deploying SMB. This marker buoy should be capable of remaining inflated and should be as large and as conspicuous as possible. The use colours other than red or orange should always be considered.

The folding divers flags have demonstrated excellent relocation capabilities and should be considered an invaluable location device for divers on-surface. They are relatively cheap and are extremely robust and reliable. They provide a suitable elevation to enhance relocation of the diver from diving support vessels. These devices are also located by helicopter but less readily so than from vessels. They are conveniently stowed to the side of the scuba set by attaching to the cylinder with elasticated straps. A variety of diver location devices have been trialed by recreational divers. The Dorset Diving Sub-Aqua Club amongst others, conducted a series of limited trials in collaboration with the Royal Naval Air Station at Portland. A selection of location devices was assessed and their relative merits and limitations highlighted. It was concluded that the folding divers flag was the best location device tested.

Working shellfish divers have commented that the colour and size of buoys affects ease of sighting under particular light conditions and sea states . The results of this research suggest that this is certainly the case in many instances. Plastic buoys commonly used as markers vary in colour. We have found that red and orange does become more difficult to locate than brighter day-glow colours in low light conditions. On the basis of our findings there is good support for the use of buoys as SMB's for shellfish divers that are as large as may practically be used. The use of paired buoy combinations is also considered to provide enhanced location over single buoys. An adequate separation distance between buoys also facilitates their relocation potential under particular search aspects. Guidance notes for commercial shellfish diving projects have been previously issued by the Health and Safety Executive. This guidance recommends that the divers are 'equipped with a means of emergency location such as flares, strobe light, high visibility flag or a combination of these . Divers undertaking this scope of work should consider an emergency location device that is both durable and reliable under the rigours of heavy daily use, additional to the marker buoys on shotlines.

Any electrical device that is intended for use in a marine environment, and those particularly designed to withstand hydrostatic pressures must be reliable. Diver's torches have evolved over many years and there are now many high quality reliable torches on the market. The reliability of these devices in the long term is often aided through regular and thorough inspection and maintenance. Particular attention must always be given to sealing surfaces and o-rings. In our experience of many types of waterproof housings, a seal is often made with only one o-ring against a flat sealing surface. University staff have frequently used strobes during the course of normal diving operations and have found that high quality strobes are as prone to the ingress of water as lesser quality strobes. The operator can only endeavour to use these devices according to the manufactures instructions and pay particular vigilance to seals. The reliability of these cases could be greatly improved by manufacturers incorporating two independent seals.

During the course of the initial relocation exercises it was apparent that the ability to relocate devices varied considerably between observers. Some observers consistently located all devices at significantly greater distances than others. Those observers that that were considered to be weaker at locating the devices did improve during the course of the trials. This is most easily attributed to a steadily improving search ability and familiarity of the device aspect in relation to observation height and the prevailing environmental conditions. This individual ability to relocate particular devices must be considered an important factor in complementing the location properties of any device. Individual observers who consistently recorded lower sighting distances after a protracted period of search exercises may be accounted for by differences in eyesight. For some divers, skippers and boat crews, visual impairments may have a profound effect on the ability to relocate those devices that require visual sighting in respect to colour and distance.

HM Coastguard is the authority responsible for the initiation and co-ordination of Civil Maritime Search and Rescue. This includes responding to calls for assistance from divers and diving craft. On conclusion of any diving related incident, the Coastguard Maritime Rescue Co-ordination Centre (MRCC) responsible for co-ordinating the incident forwards an incident report to the National Diving Liaison Officer (NDLO) to extracts details of each incident. The summary of these incidents between 1996 and 1997 indicates 42 incidents of missing/lost divers, representing 22% of all incidents. During 1998, these incidents numbered 33 (17% of all incidents). Engine failure represented 12% (1997) and 12.5% (1998) of all incidents . The number of 'missing diver' incidents is likely to be much higher than reported. A 'missing diver' should be regarded as all instances that involve an initial inability to relocate the diver. These incidents are likely to be unreported in the first instance until a preliminary search has been made. In many instances divers are temporarily lost and subsequently relocated in a relatively short period. However, it is not uncommon for calls for assistance from the Coastguard. In some cases large scale search and rescue (SAR) facilities are required to relocate divers.

Divers undertaking decompression stops for significant lengths of time can drift considerable distances. Suitable decompression markers allow the boat to mark a divers position as the diver remains submerged. Variations in the direction and rate of tidal movement can separate and carry divers considerable distances. The majority of divers are conscientious regarding adjustments to diving schedules and procedures in accordance with changing weather and sea conditions in order to minimise this risk. There are however many occasions when this is not the case, and divers have been 'lost or misplaced' for significant lengths of time whilst the diving vessel searches in what is judged to be the most likely direction of drift.

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6. CONCLUSIONS

It is not possible to draw statistical significance from the results due to the wide range of variables. The summarised data do however provide an indication of the range of location distances for individual devices and enables direct comparisons between devices. The collated data (section 4.3) clearly demonstrate three main observations:

Relocation distances of devices decrease with increasing wave height.

Relocation distances of devices decrease as light intensity falls whilst those devices which provide a light source are more readily located as light intensity decreases.

Relocation distances of devices are increased at elevated observation heights.

Additional to this, detailed notes and comments were recorded on daily record sheets. In particular, the names of individual observers were attributed to a significant proportion of each device relocations. The deployment and relocation of devices were plotted for most trial days and correlated with search aspect and wind direction. The following observations were clearly apparent:

Relocation distances of some devices are optimised from particular search aspects.

The ability of individuals to relocate visual devices varies greatly.

The folding divers flag with a day-glow yellow pennant is considered to be the best all round location device. Devices including flags and paired buoys are more clearly observed when the search aspect is abeam to the direction of wind due to the larger surface area that is presented to the observer. Flags are not located by helicopter as readily as from vessels.

Jean Elaine
Scapa Flow Charters

Diver Location Aids: HSE Report

APPENDICES

Some of the raw data is not presented here to save on space: all the results have been documented in the preceding text.

Table 1: Abbreviations used when presenting data.

Abbreviation	Device
YF	Yellow flag
RF	Red flag
OF	Orange flag
AF	A flag
BF	Black flag
PYB	Pink and Yellow buoys
1RB	One red buoy
2RB	Two red buoys
AP DB	AP Valves red decompression bag (self-inflating)
AP DS	AP Valves red decompression sausage (self-sealing)
BR DS	Bowstone red decompression sausage
BY DS	Bowstone yellow decompression sausage
YSMB	Yellow self-deploying SMB.
DH	Divers head
JS	Jotrun strobe

SS	Seaman Sub strobe
UK1200	Large lantern torch
UK400	Medium lantern torch
SL4	Medium torch
MiniQ	Small torch
OS	Orange Smoke
NF	Night flare
MF	Miniflare
MD	Marker dye

Table 21: Device specifications

Device	Specifications	Cost
Sea-Streak marker dye	Tablet of dye in peel open dispenser, green/yellow dye	£15
Sea marker dye	Powdered dye in peel open dispenser, green/yellow dye Manufactured by Presto Dyechem	£14
Folding flag	Total height 1.8m Height above sea level when held by diver 1.3m Pennant size: 50cm x 50cm	£15
Jotrun strobe	No specifications available	£70
Seeman Sub Signal Flash	Flash performance: continuous flashing for 15 hours Waterproof to 50m Visibility: over 3km on	£22

	clear night with unobstructed view	
Pains-Wessex Day & Night Signal	Ends of flare are fully waterproofed with ‘o’ ring seals. Ideal for divers. Burning times: Red flare 20 seconds of 10,000 candela Orange smoke: 18 seconds minimum	£32
Pains-Wessex Miniflare 3	8 red aerial flares projected to a height of over 80m with a flare burning for 6 seconds at 3,000 candela	£27
Bowstone decompression sausage	Height: 1.35 m Width: 9 cm £15 AP Valves SMBC decompression sausage Height: 1.40 m Width: 10 cm	£30
AP self-inflating decompression bag	Height: 75 cm Width: 55cm	£120
Polyform buoys	Diameter: 40-50 cm	£5
MiniQ torch	2.1 Watts power output Burn Time: 5-6 hours £15 SL4 torch 5.5 Watts power output Burn Time: 4-5 hours	£25
UK400R torch	18 Watts power output Burn Time: 1 hour	£100
UK1200 torch	No specifications	£150

LOCATION DEVICE QUESTIONNAIRE

Q1. What location devices do you use?

Self deploying SMB (ie a surface buoy that pays out a line as you descend)
Delayed surface marker buoy (open ended bag/sausage, self inflating bag, other; what colour is it?)
Folding flag (What colour is the pennant eg red, orange, A flag, day glow yellow?)
Torches: (small backup / lantern or other)
Strobes: (Jotrun, Seeman Sub or other). Where do you attach your strobe?
Pyrotechnics: (Miniflares, day/night distress signal)
Whistles:
Sea marker dye:
Bright hood/reflective strips:
Light sticks:
Other:

Q2. Do you have any experiences of relocating missing divers?

Q3. How long were they on-surface before recovery?

Q4. Did the diver/s use any location device?

Q5. Have you ever been missing / temporarily lost by your support vessel?

Q6. If so, how long did you wait for recovery?

Q7. Did a location device promote your recovery?

Q8. What was this device?

Q9. Are you colour blind?

Q10. Have you ever found any particular colour/s stand out better than others?

Q11. Do you have any other comments regarding diver location devices?

Table 22 Recreational diver questionnaire responses

No.	sdSMB	deSMB	col	Flag	col	Torch	Type	Strobes	Attach	Pyros	Whistles	Dye	Hood Reflect	Lsticks	Other
1		y	R			y	s	y	L		y			oc	
2	y	y	Y	y	DGG	y	L	y	st				y	deep	
3	oc	y		y	O								y	nd	
4		y	Y	y	Y	y	s								Fins
5		y	O			y	s			y	y		y	nd	
6	y	y				y	s	y			y		y	nd	
7		y	O			y	L				y		y	nd	
8	y	y	Y	y	Y	y	m.L	y	st		y		y		
9	y	y	O			y	L	y	st		y		y	nd	reflectors on stab
10	oc	y	O			y	s,m,L				y				
11	y														
12		y	O	y	DGY	y	bk,L	y	st	y	y			nd	
13	y	y	R			y	L				y				mouth
14	y	y	R			y	s,L	y	st		y				
15	y	y	O			y	s	y	st		y				
16	y	y	O			y	s,m,L	y							
17	y	y	R	y	DGY	y	bk,L				y		y		mirror
18	y	y	O	y	R	y	s,L				y				
19		y	DG	y	R	y	L,L				y			nd	yellow

			O												stab
20	y	y				y	s,L				y		y	nd	
21		y		y	DGO	y	s,m,L	y	h					nd	
22		y	O	y		y	2 s,L	y	p		y				
23		y	O	y	O	y	m,L								
24	y	y	O	y	O	y	2 s,m,L	n			y			nd	
25		y	O			y	bk,L	y	st	y	y				
26	y	y	O								y				
27	y	y	O			y	bk	y	st		y				DGO drysuit
28	y	y				y	s,L	y	st		y			nd	
29	y	y	DGO			y	bk,L	y	st		y		y	nd	
30	Y	Y	0	Y	Y	Y	bk,s,L				y				DGY Fins
31	oc	y	O			y	s,L				y		y		
32	y	y	O			y	s				y		s		
33	oc	y				y	L								air horn
34	y	y	O	y	R	y	L				y		y		
35		n		y	R	y	mbk,L								
36	y	n				y					y				

37	y	y	O	y	R	y	sbk,L	y	st		y			nd	
38	y	y	O			y	s,L	y	st		y		y	nd	
39		y	O			y	s								
40		y	DGO			y	L				y				
41		y	O			y	L				y				
42		y	R	y	Y & R	y	sbk,L				y				
43	oc	y	O			y	mbk,L	y	st	y	y				
44	oc	y	O	y	Y	y	L	y	st		y				
45	y	y		y		y		oc				y		oc	
46		y	O			y	sbk,L	y	st		y			nd	
47	y	y	O	y	DGP	y	sbk,L				y			nd	
48	y	y	O			y	sbk,L	y	st		y			oc	
49	y	y	O	y	O	y	bk,L	y	st		y			y	
50		y	R	y	O			y	st		y				
51	y	y	DGR			y	sbk,L				y		y	y	
52	y	y		y	R	y		y	st				y		
53	y	y	O	y	O	y							y		
54	y	y		y	DGY	y	s								

55	y	y	DGY	y	O	y	sbk,L	y	st	nd	y		y	nd	

a = always oc = occasional nd = night dive deep = deep dive h = head L = lower arm st = stab-jacket col = colour

s = small m = medium bk = backup L = Lantern sdSMB = self deploying surface marker buoy delSMB = delayed surface marker buoy Lsticks = light sticks

DG = day-glow P = Pink Y = Yellow G = Green O = Orange R = Red B = Blue Bl = Black W = White

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Table 22 Questions 2 to 10

No.	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1				n				n	R,O,Y
2	y	60	Flag	y	50	y	Torch	n	DGO, DGY, DGG
3	y	30	deSMB	y		y	Flag	n	None
4	y	10	SMB	y	60	n		n	O
5	y		y	n				n	
6	y	5	deSMB	n				n	Colour depends on conditions
7	y	45	deSMB,Flag	y	15	n		n	
8				n				n	Depends on conditions
9	y	20	deSMB	y	45	y	deSMB	n	O
10				n				n	O, bright green
11	y	5-	arm	y	10	y	speargun	n	O, R, Y

		10							best B, G , Bl & W worst
12	y	10-20	Flag	y	10	y	flag	n	O, Y
13				y	2	y	whistle	y	Prefer DGY to R or O
14	y	30	flare, deSMB	y	5-10	y	deSMB	n	R & DGO is better than DGY
15	y	5	deSMB	n				n	O, R & silver
16				y	15-20	y	deSMB	n	O, Y better on dull day
17	y	20	deSMB	n				n	DGR,DGO
18	y	10	deSMB	n				n	O or Y
19				n				n	DGY or O
20				y	10	y	Flag	n	O
21				n				n	Y or bright O are more visible than A flag
22	y	15-20	Flag	n				y	Black seems to stand out well
23				y	5-10	y	Flag	n	O
24	y	90	n	n				n	O better than others
25				y	10-15	y	SMB	n	O
26	y	120		n				n	DGO
27				N				n	O
28				y	60	y	O sausage & reflective hoods	n	All fluorescent

									colours
29			DeSMB	y	5	y	Flag	n	Y on dull day. O easier on bright day
30				y	10	y	deSMB held as flag	n	DGY best
No.	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
31				n				n	
32				n				Partly	
33				y	10	y	Flag	n	R/O better than Y/G, especially sunny days
34				n				n	
35				n				n	DGO
36	y	3	n	y	5	y	Whistle	n	DGO
37	y	30	Whistle,delSMB	y	45	y	Whistle,delSMB	n	O
38				y	5	n			DGG
39	y	2	deSMB	y	10	y	Whistle, torch	n	DGG & DGP
40	y			n				n	
41				n				n	Bright days - O/R, Dull days - Y
42				n				n	Bright conditions - O better than Y. DGP best
43	y	180	n	y	20	y	Flag	n	
44	y	30	SMB	y	20	y		n	DGR
45				y	15	n	deSMB,whistle	n	Lime Green
46				n				n	DGP/DGO better than

									DGG/DGY in bright conditions
47	y	10	Buoys & Strobes	n				n	Y & O
48				n				n	
49				n				n	R
50				n				n	DGR & DGO
51				n				n	n
52				n				n	Red / Yellow
53				n				n	DGO & DGY
54				n				n	n
55				n				n	R,O & Y

RECREATIONAL DIVER QUESTIONNAIRE COMMENTS

Q11. Do you have any other comments regarding diver location devices?

Flag best (simple, reliable) even catch light glimpse at night. Not convinced that it is possible to work flares with cold wet hands, difficult to blow whistle if full of water, and cold lips. Visual aid better, best if whistle in conjunction with this.

Flags very useful, especially rough seas, but not cheap.

Flag is very effective in daylight. It gives a much greater height than other manual devices and is convenient to carry strapped to the tank. Until you see it you don't realise how effective it is.

Flag best - cost effective, stowed easily by tank, easily deployed, and very visible with sufficient extension.

Flags are one of the best in my opinion.

All should be encouraged to carry a flag on open water dives. They are simple, cheap and require no maintenance or batteries.

I am considering an orange or day-glow flag.

Visual device is better than audible. Plan to get a flag.

Bright coloured SMB or Flag advantage to hold above waves, and not too expensive.

What do fisherman always use - BLACK! Orange is much easier to see than lime green. Would like EPIRB, but expensive.

Would consider EPIRB. Taller SMB stands out more, filters to identify strobes.

Colours must be bright but not too light / pale. Pyrotechnics used in remote location but only survive 25 immersions and are quite pricey.

DGY not very effective in bright sunlight, flares go out of date.

Fluorescent colours when overcast, R/O on sunny days. Used to carry a DGY flag but found it too bulky and offered little benefit over delayed SMB.

Red/Green colour blindness but never had any problems distinguishing colours of SMB's. Whistles next to useless (invariably wind blows sound wrong way). Sausage shaped SMB's tend to fall over.

Would like EPIRB, but expensive. Yellow items disappear in strong sunlight. Shape important. Movement attracts eye. Flares preferred, than sea dye for air search.

Inflated sausage SMB can be waved at boat; the more affordable, most frequently used. Most easily stowed, reliable.

Flares seem good idea, but uneasy about potential hazard of igniting accidentally.

Pyrotechnics only presumed functional until required. SMB’s don't show on boat radar. Only SMB works underwater.

4ft high SMB easily lost by vessel in swell. Small SMB's no use in rough seas. Can only spot sausage-shaped SMB’s. Open-ended tend to fill with water and sit lower in the water.

What about air horns? Tomorrow’s world are always ecstatic about white noise!

Always picked up delayed SMB before diver reaches surface. Non-attentive skipper - few devices help!

Need several types, no one good for every situation.

Divers between sun and boat, no device for this.

Device is specific to situation. Best visual aid in daylight - flag/SMB; night-time - torch/SMB/Light stick. Plus competent skipper / shore cover.

Prevention is better than cure.

Experienced skipper very important.

Must carry a location device on 100% of dives.

More allows redundancy and choice.

Many small boat operators do not know how to search for a diver.

Little diver training for diver location devices.

Dive alert' air powered whistle, very effective at close range (<500 m), plus deco-bag & self-sealing sausage good combination. Smoke more effective than flares. To develop something which is small, unobtrusive, and cannot be set off by accident! Dislike buzzers - impossible to locate and can be confusing and stressful to divers, especially trainees.

ACKNOWLEDGEMENTS

We wish to acknowledge the assistance of, and resources provided by:

Health & Safety Executive. MCA MRSC Pentland. MCA MRSC Shetland.
Oscar Charlie, SAR helicopter, Bristow Helicopters Ltd, Shetland.
RNLI Stromness lifeboat. RNLI Longhope lifeboat.
Jean Elaine and skipper, Mr Andy Cuthbertson. Girl Mina and skipper, Mr Terry Todd. Ramsay Dyce and skipper, Mr Keith Oliver.
Department of Harbours, Orkney Islands Council.
Lerwick Harbour Trust, Shetland.

REPORT PRODUCTION

Alister Wallbank Colin Bullen Carol Daniels Bill Chilton Dr Jon Side

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THANKS THE CHECK IS IN THE POST< MARK AND RICH!!