EXPERT WITNESS REPORT

REPORT DATE: 8th December 2024

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SPECIALITY: Human & Applied Physiology (Extreme Environmental Physiology).

REPORT ON: The survivability of those involved in the events of 23-24 November 2021.

INSTRUCTIONS RECEIVED FROM: The Cranston Inquiry

REFERENCE: Letter dated 22nd August 2024 “The Cranston Inquiry: Request for the provision of an expert report”.

1.0 INTRODUCTION

1.1 I am currently employed as Professor of Human & Applied Physiology, University of Portsmouth. I received my Bachelor's degree from Keele University, UK and Master of Science and Doctorate from the University of London (King's College). I have specialised in research into thermal physiology for over 40 years. I have published over 830 books, papers, abstracts and reports in these and associated areas (publication list available on request). The vast majority of my experimental work has been with adult (18-40 year old) male and female volunteers. My previous roles have included: Trustee/Director of Surf Lifesaving GB (2012-2022); Consultant Head of Division of the Institute of Naval Medicine, MoD (1996-2004); Member of the Medical & Survival Committee of the Royal National Lifeboat Institution (RNLI, 2006-2016); Member of the Maritime Coastguard Agency, Immersion Casualty Review Panel (2007-2023). My current roles include: Council member for the RNLI; Consultant Advisor to the Medical Director of the RNLI; Chair of the National Water Safety Forum. I have assisted many organisations in the UK and abroad with queries related to immersion in cold water, including: The Royal Life Saving Society; Maritime Accident Investigation Branch; National Crime Agency; and various Police Forces, Coroners and legal firms.

1.2 I have been asked (Letter dated 22nd August 2024 "The Cranston Inquiry: Request for the provision of an expert report") to examine the events of 23-24 November 2021, when at least 27 people lost their lives crossing the Channel, and consider survivability in relation to the victims and survivors of this incident. These questions are addressed in Section 4 below.

1.3 I feel qualified to comment on the possible impact of immersion in cold water in relation to survival time.

1.4 In compiling my report I have considered the documents and files listed at paragraph 2.1 and those listed in the references to my background comments (page 14, paragraph 3.4xi)

1.5 I have no connection with any of the parties, witnesses or advisors involved in this case, save as set out in paragraph 1.1. above. I do not consider my assistance to these organisations in the past creates any conflict of interest in providing my report to the current inquiry.

2.0 BACKGROUND

2.1 I have seen the following documents:

   i. Marine Accident Investigation Branch (MAIB) Accident Report on the investigation into the flooding and partial sinking of an inflatable migrant boat resulting in the loss of at least 27 lives in the Dover Strait on 24th November 2021.

ii. Information about victims and survivors (name, sex, date of birth if known, outcome [deceased, missing, or survivor], some of these data are at Annex A).

iii. Audio files and the transcriptions of telephone conversations between HM Coastguard and individuals in small boats (Audio files: INQ001852, 54, 55, 57, 58; Transcriptions: INQ008929, INQ007654, 55,57,58,).

iv. Witness statements: INQ000068, 69, 72, 79, 80, INQ009020, INQ009472, INQ009641,68, INQ009750, 52, 53, 54, 58, INQ001029, INQ010091, 92, INQ010210 and the witness statement of Bayan Hemedemin Saleh Ahmed (no INQ number at time of writing).

v. In Annex B (Version 3, 14th November) notes on: INQ009018, INQ009643, INQ009755.

vi. INQ009006 Multiple Casualty In-Water Triage Tool.

vii. INQ009013 Abstract from the International Maritime Rescue Federation meeting (held in Rotterdam on the 20th June 2023). Title of presentation: "Multiple Casualty In-water Triage Tool" Authors: Morgan, Sheppard & Tipton.

viii. INQ009669 RNLI Multiple person in the water. Check Card.

ix. INQ009670 RNLI Multiple person in the water incident. Flow Chart.

2.2 Information noted from the above, relevant to the topics covered in this report include:

2.2.1 <u>MAIB Report</u>

i. The incident occurred over the evening and night of the 23rd/24th November 2021.

<u>Weather Conditions</u>

ii. Wind: north-easterly force 2 to 3, occasionally 4.

iii. Sea state: smooth near the coasts and slight offshore.

iv. Minimum air temperature 2 °C (from midnight, air temperatures were due to drop from 5 °C to 2 °C at 0600, before rising again to 5 °C).

v. Sea temperature 13 °C (sea surface temperatures were forecast to be between 12 °C and 14 °C throughout the period).

vi. Sunrise on the 24.11.21 was 07:26.

vii. At about 21:00 on the evening of 23 November 2021, about 33 people (13 women and 8 children) boarded an inflatable boat and departed from a beach near to Dunkirk, France to attempt the crossing to the UK.

viii. The boat ("Charlie") reached the UK SRR around 4.5 hours later at about 01:30.

ix. About 4 hours into the journey the boat began to take on water. Shortly after 01:00, the water ingress became uncontrollable.

x. At the same time, the boat's inflated collar (Sponson) began to lose pressure. Some of the occupants attempted to re-inflate it using the hand-operated air pumps provided, but they were unsuccessful.

xi. At some point in the early hours of 24 November 2021, the boat became swamped and the occupants of the boat entered the water: likely between 03:12 and 03:33.

xii. Some of the victims managed to cling to the submerged remnants of the boat; others drifted away. Over a period of hours occupants of the boat perished, with around eight reported to be still alive at sunrise (07:26).

xiii. At about 13:00 on 24 November 2021, a French registered fishing vessel reported sighting bodies in the water approximately 9 nautical miles from Calais within French waters. This triggered a French search and rescue operation, with UK support.

xiv. There was no position data from the victims between the last reported WhatsApp position and the found position around 10.5 hours later.

xv. A total of 27 bodies and two survivors were reported recovered from the sea and taken to France. 4 people reportedly remained missing.

xvi. The victims lost their lives because they entered the sea without the ability to survive prolonged immersion, and they were not found by search and rescue assets before they succumbed to the cold water.

Equipment (MAIB report page 24, para 1.5.3)

xvii. It was variously reported that 14 of the occupants were wearing lifejackets and, conversely, that all on board were.

xviii. The construction of the flotation devices and the consequent level of support they would have afforded to a person in the water was not available to the MAIB investigation.

xix. No information was available on whether any of the flotation devices were fitted with lights.

Immersion in seawater (MAIB report page 52, section 1.15)

xx. The physiological responses of the human body to immersion in cold water (under 15 °C) are described in this section. The descriptions are largely based on work I have done with colleagues (e.g. Golden & Tipton, 2002) – see Section 3 below. Of note, is the final paragraph in this section of the MAIB report: *Survival time of people in the water was dependent on a number of factors, including clothing, body type, weather conditions and body temperature. The IAMSAR manual provided guidance on realistic upper survival times for people in the water wearing normal clothing. For a water temperature of 13 °C the IAMSAR manual indicated a realistic upper survival limit of about 20 hours.*

<u>Survival in the water (MAIB report page 65, section 2.3.5)</u>

xxi. Unexpected immersion in cold seawater has profound and immediate effects on the human body. Once the occupants of migrant boat *Charlie* had entered the water the most pressing danger was the cold water. Without immersion suits or a liferaft to protect them from the elements, the victims' prospects of survival following their unexpected entry into the sea in winter depended on the rapidity of rescue and the effectiveness of any PFD worn.

xxii. This investigation did not have access to definitive information on how many of the occupants of migrant boat *Charlie* were wearing PFDs. However, any occupants not wearing PFDs would have been vulnerable to the effects of cold water shock in the 13 °C water, and those that experienced cold water shock may have succumbed almost immediately on entering the water. Those surviving the initial cold water shock response but not wearing a PFD would then have been vulnerable to the increasingly debilitating effects of cold water incapacitation. The survival time of those occupants of migrant boat *Charlie* that were wearing PFDs was dependent on a number of factors, including the efficacy of the flotation device and their body type. To be effective for survival, a PFD needs to maintain an individual's airway out of the water and keep them floating on their back. A low-quality uncertified flotation device, or one that is improperly fitted, can allow drowning to occur if the material becomes saturated with water and loses its buoyant properties or it fails to keep the person's face and airway clear of the water. Individuals in this category may have survived the initial cold water shock and cold incapacitation before later drowning because they were wearing improperly fitted or poorly manufactured flotation devices. For someone surviving the cold water shock and cold water immersion the realistic upper survival time in 13 °C water was about 20 hours, which might explain why there were two survivors.

xxiii. This investigation did not have access to sufficient evidence to analyse the survival of individuals in depth and there are many uncertainties. That said, the victims likely perished over a period of time, starting from when they entered the water up until they were located, with deaths occurring over time from a mixture of cold water shock, cold water incapacitation and hypothermia. The survival time for each individual is undeterminable with any level of certainty and it further follows that it is not possible to determine where each victim succumbed and whether that was in UK or French waters.

Conclusions (MAIB report page 83, section 3.1, para 5)

xxiv. Information on the number of people on the inflatable boat who were wearing personal flotation devices, the nature of any flotation devices worn and the level of support these provided to people in the water was not available to this investigation. It is likely that many of the victims of this accident wearing flotation devices succumbed to the effects of hypothermia; however, any without flotation support would have succumbed over time to a mixture of cold water shock, cold incapacitation or hypothermia. Given the uncertainty over individuals' survival time in cold water, and the range of time over which their deaths likely occurred, it cannot be determined whether individual victims died in UK or French waters.

2.2.2 Audio files and transcripts

i. Generally little information of value to the subject of this report with exception of the improbability of clearly conveying survival-related information.

ii. INQ007657 Male speaker: part of our body is in the sea and it is very cold.

2.2.3 Witness Statements from family members

General:

i. The periods spent in the camp at Dunkirk ("The Jungle") before departure varied between days and weeks. In most cases this time was associated with living under makeshift tents, having insufficient/poor food and becoming cold, wet and tired (e.g. "tired" INQ009755, INQ009753).

ii. 13 of the statements from relatives reported the swimming ability of those involved in the incident. Three were reported to be "non-swimmers"; 5 were reported to be "able to swim a little", but not in rough water; 5 were thought to be "good swimmers". All of those individuals listed as "missing" were among those thought to be "good swimmers". One of these individuals believed he could swim the distance if necessary (INQ009472, para. 25).

iii. All of those reporting the "build" of those involved in the incident say they were "average/medium" or "slim" build, with the majority being of "slim" build.

iv. Several of the statements report that people were wearing “warm clothes”. Others were reported to be wrapped up in coats and blankets.

v. Several statements include comments that all were wearing lifejackets, but the quality of these lifejackets was poor (INQ009641, INQ001029, INQ009472).

vi. All those involved in the incident were reported to be physically healthy.

vii. There was no mention in any of the statements of motion sickness being experienced (this can accelerate body cooling).

<u>Specific comments:</u>

INQ000068.pdf

i. 21:12 already boarded the boat and on way.

INQ000069.pdf

ii. 34 people on the boat, including a 7 year old child.

iii. 01:30-02:00 boat had some problems; one side was continuously losing air.

iv. 02:37 (GMT) engine of the boat had stopped a few minutes ago.

v. 02:40 message received “we are well, do not worry, we are doing ok”. No contact after this.

INQ010091(para 24)

vi. “He heard her (Halima Mohammed Shikh) shouting ‘help me, I don’t want to die’ after the boat capsized and she was in the water. Halima was not able to swim.

INQ001029

vii. Para 67. Mr Mohammed confirmed that everyone was wearing life jackets on the boat. He said his lifejacket seemed to help him for a while when they were in the water, but that after a short time it seemed not to have much of an effect because it was of poor quality. He also said that some people, because they could not resist the cold, removed their jackets in order to give up.

INQ000079.pdf Comments of Mohammed Shekha Ahmad one of the survivors reported in an online article (Rudaw.net).

viii. Pump for bailing stopped working

ix. “Then we were slowly drowning, the people lost hope and let go”.

x. “Water started seeping into the boat and migrants frantically worked to bail it out”.

xi. “As water slowly started to overwhelm the boat, passengers began panicking”.

xii. “As the boat drifted and lost more air, the passengers, including children, fell into the water. They clung to the deflated dinghy and each other. Throughout the dark night, as the half-submerged dinghy floated in the English Channel, back towards France, everyone held on tight, but their energy gave out when dawn broke”.

xiii. “Everyone could take it until sunrise, then when the light shone, no one could take it anymore and they gave up on life”. “One by one they let go of each other and the boat. Most of the group was dead by the time they were found by a French ferry”, “Two of the migrants died in hospital”.

xiv. The cries of his fellow migrants are still vivid in Mohammad’s mind, screaming and crying.

INQ000080.pdf Comments of Mohammed Isa Omar one of the survivors reported in an online article (Rudaw.net).

xv. “The boat was sinking, the people were dead and I was swimming. We were in the sea for ten hours”.

xvi. <u>Timeline derived from the above</u>

23rd/24th November 2021

21:00	33/34 people (13 women and 8 children) boarded an inflatable boat. *(4 hours in <u>air</u> at 2 – 5 °C)*
01:00	Boat began to take on water, became uncontrollable. *(4 hours 30 min in <u>air</u> at 2 – 5 °C)*
01:30	Boat (“Charlie”) reached the UK SRR *(6 hours 12-33 min in <u>air</u> at 2 – 5 °C)*
03:12 - 03:33	Boat swamped, occupants entered the water *(3 hours 53 min - 4 hours 14 min in <u>water</u> at 12 – 14 °C)*
07:26	Sunrise. Conflicting evidence of the number of occupants still alive (8 occupants alive, rest perished having drifted away [MAIB Report] cp. Everyone could take it until sunrise [INQ000079]). *(9 hours 27 – 48 min in <u>water</u> at 12 – 14 °C)*
13:00	Bodies sighted in water by a French fishing vessel. 2 survivors. 3/4 remained missing.

3.0. HAZARDOUS RESPONSES TO IMMERSION

This section contains a description of the physiological and pathophysiological responses to immersion in cold water, where “cold water” is, somewhat arbitrarily, defined by some as water at a temperature below 15 °C. It is somewhat repetitious of the relevant section of the MAIB report (page 52, Section 1.15), this is because, as noted, the MAIB content is based on the work of myself and colleagues.

3.1 There are four stages of immersion associated with particular risks (Golden & Tipton, 2002), these are:

1. Initial immersion (first 2-3 minutes)
2. Short-term immersion (<30 minutes)
3. Long-term immersion (>30 minutes)
4. Post-immersion.

Of these risks, the first three are, to differing extents, relevant to the present inquiry.

3.2 Initial immersion. The initial responses to immersion in cold water have been given the generic title of "cold shock" (Tipton, 1989). The responses are initialled by rapid cooling of cold receptors located just beneath the surface of the skin and include: a "gasp response", uncontrollable hyperventilation (rapid breathing), peripheral vasoconstriction (shut down of blood vessels) and an increase in cardiac output (volume of blood pumped by the heart). Together these responses significantly reduce maximum breath hold time (to less than a second in some people, Tipton & Vincent, 1989) and increase the work required of the heart (Tipton, 1989), thereby increasing the risk of drowning and cardiac problems on initial immersion in cold water (Shattock & Tipton, 2012). For example, the "gasp" response can be 2–3 L in volume (Tipton et al, 1991), that is, a larger volume than the reported lethal volume of water aspiration for drowning, which is around 1.5 L of sea water for a 75 kg individual (Modell & Moya, 1966). Drowning takes approximately two minutes by which time cardiorespiratory arrest has occurred (Fainer et al, 1951).

3.2i The cold shock response peaks in the first minute of immersion and attenuates within the first 2-3 minutes and, in lightly clothed individuals, attains maximum magnitude in a water temperature between 10-15 °C.

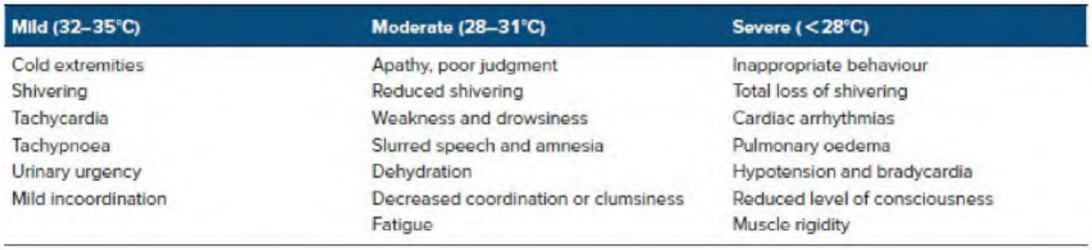
3.2ii The magnitude of the cold shock response varies with factors like water temperature, rate of entry into the water, clothing worn, habituation, aerobic fitness, degree of pre-cooling. There is also substantial inter-individual variation in the size of the cold shock response.

3.2iii After entry to the water, the time casualties are able to keep their airway clear of the water will depend on circumstances. In situations where people are forcibly submerged this phase may be non-existent, e.g. immediately going sub-surface if negatively buoyant. It will also be non-existent if individuals are unconscious or semiconscious (due to pre-existing hypothermia or cardiac arrhythmias on immersion). It may also be relatively short in individuals who cannot swim, and have no, or ineffective, lifejackets. The hyperventilation associated with the cold shock response can significantly impair swimming ability in even competent swimmers (Tipton & Montgomery, 2021).

3.3 Short-term immersion. After skin cooling, the next body tissues to be affected by cooling are the superficial nerves and muscle. The arms and hands are particularly susceptible to cooling due to their anatomy (thin cylinders, superficial nerves and muscles) and physiology (reliance on blood flow for warming – blood flow is shut down [vasoconstriction] to the extremities when cold) (Castellani & Tipton, 2015). Within 10-20 minutes of immersion in water at about 12 °C peripheral neuromuscular cooling can significantly impair manual dexterity and grip strength and result in physical incapacitation (Vincent & Tipton, 1988), making the performance of essential survival actions, including swimming, difficult. If such actions are required to keep the airway above water (e.g. holding onto a partially inflated sponson), drowning can occur at this time.

3.4 Long-term immersion (>30 minutes). For the first time hypothermia may occur. Hypothermia is defined as a deep body temperature below 35°C. It is generally classified as shown in Table 1. The signs and symptoms of hypothermia are shown in Figure 1. Even in a powerful cooling environment, an adult human has a large mass and heat content, and it therefore takes time to remove the amount of heat necessary to lower deep body temperature to hypothermic levels (from 37 to 35 °C). Even naked individuals immersed in very cold water are unlikely to become hypothermic in less than 30 minutes.

Table 1. The stages of hypothermia and associated clinical features (Tipton, 2019).



Mild (32–35°C)	Moderate (28–31°C)	Severe (<28°C)
Cold extremities	Apathy, poor judgment	Inappropriate behaviour
Shivering	Reduced shivering	Total loss of shivering
Tachycardia	Weakness and drowsiness	Cardiac arrhythmias
Tachypnoea	Slurred speech and amnesia	Pulmonary oedema
Urinary urgency	Dehydration	Hypotension and bradycardia
Mild incoordination	Decreased coordination or clumsiness	Reduced level of consciousness
	Fatigue	Muscle rigidity

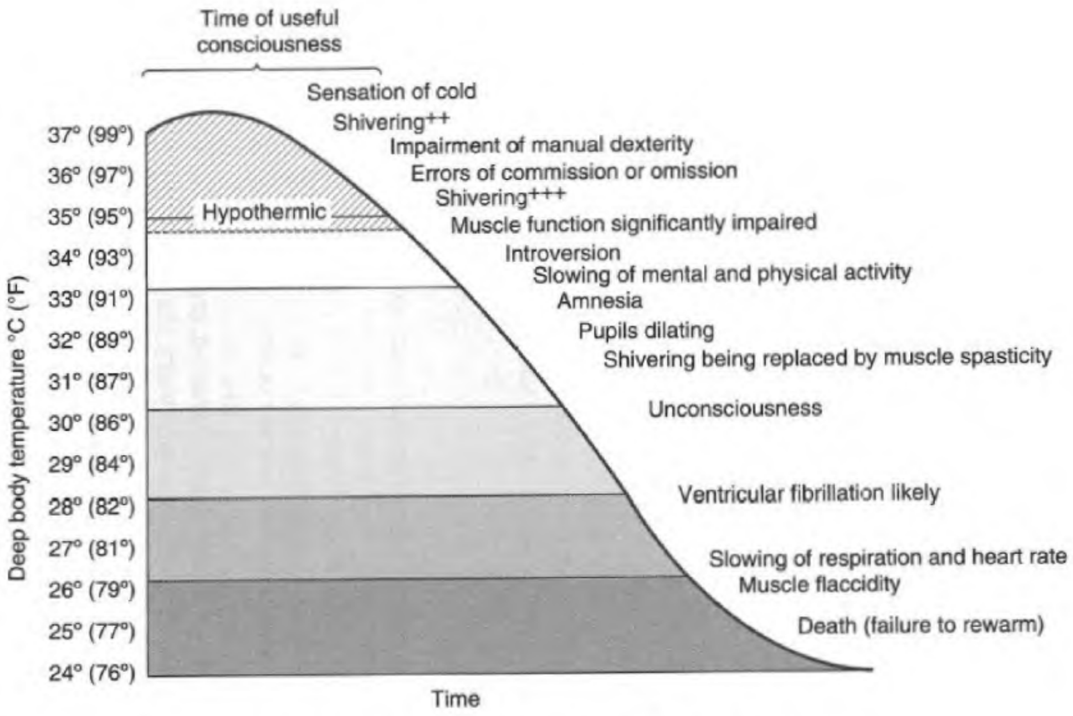


Figure 1. The signs and symptoms of hypothermia (Golden & Tipton, 2002).

3.4i People often confuse "being cold" with being hypothermic. Long before deep body temperature falls, the skin cools (especially of the extremities) and produces the sensation of being very cold.

3.4ii At the point at which an immersed casualty becomes unconscious (deep body temperature of around 30 °C), drowning can occur if activity is required (e.g. swimming, holding onto buoyant material) to keep the airway above the water. At this point, the airway can be supported clear of the water by a properly designed and fitted lifejacket (Lunt et al, 2014). It is worth noting that swimming in cold water accelerates deep body cooling compared with staying still (Keatinge, 1961), and thereby reduces survival time.

3.4iii The prediction of the survival time in cold water informs search and rescue activity. The predictions used by search and rescue organisations do not account for deaths due to cold shock. Historically, it has been the longer-term responses that have been the focus of survival time estimations and consequent search and rescue policies. This approach requires an assumption about the deep body temperature at which death occurs, and some way of modelling the time to reach this temperature (Tipton et al, 2022). The terminal temperature for estimating survival times has tended to be represented by a deep body temperature (Tdb). Although in some cases, the Tdb chosen has been used as an estimation of time to incapacitation ("Cold functional time") due to peripheral neuromuscular cooling (see 3.3 "Short-term immersion" above), rather than a direct effect of the cooling of deep tissues (Figure 2). As a consequence, Tdb values ranging from 25 to 34 °C have been used as the "lethal" deep body temperature (Tipton et al, 2022).

3.4iv A variety of methods have been employed to estimate cooling rate including: the interrogation of data from actual incidents; extrapolations from laboratory or field experimental data; and the use of mathematical models of the human thermoregulatory system (Tipton et al, 2022). As a result of this work, different predictions of survival time for those accidently immersed have been derived.

3.4v Widely used predictive models include the "Cold Exposure Survival Model" (CESM, Keefe & Tikuisis, 2008) and the U.S. Army Research Institute of Environmental Medicine/U.S. Coast Guard (USCG) "Probability of Survival Decision Aid" (PSDA, Xu et al, 2014).

3.4vi The prediction of survival time remains an inexact science due to the large number of environmental and personal variables that can influence this time, and the lack of information about many of these variables at the time of an incident. The variables include: water temperature and state (calm or choppy, flowing or still); the age, body weight, body composition, health, fitness and sex of the casualty; time since the last meal; clothing and protective equipment worn (and its effectiveness); and whether the casualty is able to rest (slower cooling) or must exercise (faster cooling) to stay afloat. It is the variation between individuals and incidents that complicates the prediction of survival time in water and the resulting recommended search time. The five most significant variables for predicting median survival time (i.e. the time that 50% of people would be expected to survive) have been reported to be: water temperature; area of water (e.g. coastal, offshore etc); age of person in the water; and use of an effective lifejacket (Tipton et al, 2022). It follows that these are the most important variables to collect to determine survival time.

3.4vii Because of the variability inherent in the survival time of individuals in cold water, the authorities responsible for SAR activity extend search times to beyond that which they can "reasonably expect" anyone to survive. Historically, as a general, somewhat arbitrary, rule it was considered prudent for the recommended search times to be at least 3–6 times the predicted 50% survival times (Golden and Tipton, 2002). In favourable circumstances (calm water, functioning protective clothing and lifejacket, well insulated individual) the SAR co-ordinator may consider extending search times up to 10 times the 50% survival time. The survival times and resulting search times in water at different temperatures for lightly clothed males are presented in Table 2.

Table 2. Range of estimated survival times (hours) for lightly clad males and recommended search times (hours) for a range of water temperatures (Golden & Tipton, 2002).

Water Temp	50% Survival times	Immersion time resulting in a "likely death"	Recommended search time
5 °C	1.0–2.2	0.9–2.3	6
10 °C	2.0–3.6	2.5–4.0	12
15 °C	4.8–7.7	3.0–9.0	18

3.4viii The International Aeronautical and Maritime Search and Rescue (IAMSAR, 2016) Manual is a manual for the organization and operation of maritime and aviation search and rescue. The IAMSAR Manual is jointly published by two United Nations agencies: International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), it guides all search and rescue activity internationally of the 193 member States on the provision of search and rescue services, thereby providing an effective world-wide system. The IAMSAR "*Realist upper limit of survival time for people in the water wearing normal clothing, from the time of entry into the water*" is shown in Figure 2. It is noted in the manual that the curve in Figure 2 "does NOT show a "*recommended search time. There are many factors to take into account in determining search time*".

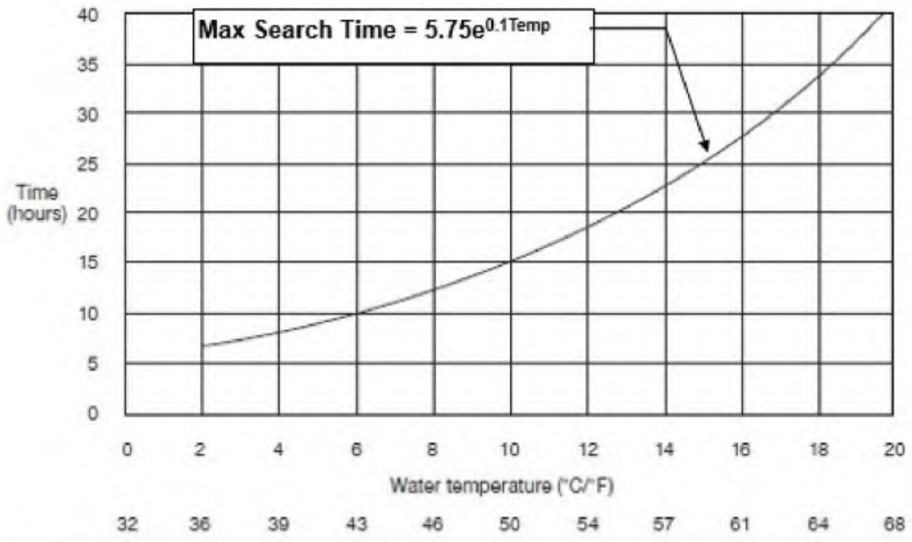


Figure 2. IAMSAR Curve: Realist upper limit of survival time for people in the water wearing* normal clothing, from the time of entry into the water.
*NB. In fact, the curve is based on people wearing all kinds of clothing including specialist immersion suits, this helps to explain why it gives longer times than those shown in Table 2 (Tipton et al, 2022).

3.4ix The curve in Figure 2 (known as the Maximum Observed Immersed [victim] Search Time [MOIST]) is derived from an analysis of the combined data from the UK National Immersion Incident Survey and data from the USCG Marine Information for the Safety and Law Enforcement (MISLE) database. Data points of less than one hour of immersion were removed to focus on individuals that would not have succumbed to cold shock or short-term immersion problems.

3.4x The curve was produced by the US Coast Guard Research and Development Centre (R&DC), its derivation is described in the paper by Tipton et al (2022). It is important to note that the curve is based on twelve survivors who represented the extremes of observed human survival across the temperature range 2 °C – 27.8 °C. To accommodate the fact that these individuals were found alive and could, therefore, have survived for an unknown longer period of time, the R&DC added a safety margin to the upper survival times predicted by the curve. The net effect is that the resulting MOIST curve predicts times that are greater than all but one known immersed survival time. The one "outlier" that exceeds the time predicted by the MOIST was a New Zealand diver who survived a 75 hour immersion in 16 °C water. This case represents the best possible combination of factors for survival: a trained diver with full wet suit, hood and gloves. This case highlights another important point, contrary to that stated in the IAMSAR Manual, the curve is not based on people in the water wearing "normal clothing", it is based on the longest survival time recorded at a given water temperature, irrespective of the clothing worn, casualty size, weight etc. This means the curve recommends relatively long search times ("errs on the side of caution") compared to actual likely survival times for those wearing normal clothing, or who have any other characteristics (e.g. thin, small, poorly nourished, pre-cooled, tired/exhausted [see 2.2.3 Witness Statements from family members. General points I, iii, iv]) that would result in them cooling faster than average (paragraph 3.4vi).

3.4xi References

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xvii. Xu X, Allen A, Rioux T, Patel T, Sinha P, Yokota M, Santee WR (2014). Refinement of Probability of Survival Decision Aid (PSDA). US Army Research Institute of Environmental Medicine, Natick, MA.

4.0 OPINION IN RESPONSE TO QUESTIONS RAISED BY THE CRANSTON INQUIRY TEAM (ANNEX A OF LETTER DATED 22ND AUGUST 2024)

4.1 I agree with the contents of the MAIB Report, Section 1.15 "Immersion in seawater". As noted, the content is largely based on the work I have done with colleagues (e.g. Golden & Tipton, 2002). I also agree with the statement "*Survival time of people in the water was dependent on a number of factors, including clothing, body type, weather conditions and body temperature*". The statement: "*The IAMSAR manual provided guidance on **realistic** upper survival times for people in the water wearing normal clothing. For a water temperature of 13 °C the IAMSAR manual indicated a **realistic** upper survival limit of about 20 hours*" is debatable. As discussed above (paragraphs 3.4viii – 3.4x), the MOIST curve in the IAMSAR manual actually represents a survival time longer than all but one known immersed survival time (that of an experienced diver with specialist skills, specialist immersion-protective clothing and equipment). Thus, the IAMSAR manual MOIST curve is not really a "*realistic*" upper survival time for the casualties in the incident under investigation.

4.2 I agree with the content of the MAIB Report, Section 2.3.5 "Survival in the water", with the following qualifications/exceptions:

i. There is no mention of the inability to swim in order to keep the airway clear of the water on immersion. The 13 family members commenting on swimming ability (section 2.2.3 ii) report that 3 of those involved in the incident were non-swimmers and 5 could swim a little but not in rough water. Therefore, for some, drowning may have occurred soon after immersion, particularly in the absence of a functioning lifejacket and with even a moderate cold shock response. There is some evidence to support the drowning of an otherwise conscious individual shortly after immersion (INQ010091[para 24] vi).

ii. Whilst it is reasonable to mention cold shock on immersion in cold water, I think it may have had a relatively small role in the deaths of the casualties. This is because most of the occupants of the boat will have been pre-cooled by exposure for several hours to 2 - 5 °C air, this pre-cooling of the skin will reduce the cold shock response. In addition, it appears that the boat was swamped and submerged over a two hour period (see Timeline page 7). This could have resulted in a relatively slow entry into the water and a consequent slow rate of change of skin temperature resulting in an attenuated cold shock response. This is supported by the statement in a transcript of an audio file of a male speaker reporting that "part of our body is in the sea" (INQ007657, section 2.2.2 ii). Having said this, there was mention of passengers, including children, "falling" into the water, and passengers "panicking" as water slowly started to overwhelm the boat – this "panic" may have been indicative of a cold shock response.

iii. Several of the statements and news reports of the survivors suggest a more protracted period of cooling leading to fatalities. It is reported that some of the casualties managed to cling to the submerged remnants of the boat, others drifted away. Over a period of hours occupants of the boat perished, with around eight reported to be alive at sunrise (07:26). This is contradicted by the statement that "everyone could take it until sunrise, then when the light shone, no one could take it anymore and they gave up on life". "One by one they let go of each other and the boat. Most of the group was dead by the time they were found by a French ferry" (MAIB Report).

iv. In either case, it seems that most of those that died did so due to either peripheral cooling and physical incapacitation preventing them holding onto the buoyancy provided by the remnants of the boat (section 3.3), or they lost their grip due to unconsciousness caused by hypothermia (section 3.4).

v. For the reasons given above (section 4.1), I do not believe that the *realistic* upper survival time in water at 13 °C for the casualties in this incident was 20 hours. In addition, the occupants of the boat were probably: pre-cooled by exposure to cold air (the exception being those working to keep the sponson (tubular inflatable section surrounding the hull of the boat) pumped up – they may have been warmer; poorly protected (in terms of non-specialist water-protective clothing [e.g. immersion suits] and functional lifejacket); a significant proportion of the passengers were adjudged to be of slim build by their relatives; some were small (e.g. children – high surface to mass ratio); possibly malnourished and fatigued due to their time in "The Jungle" before boarding the boat (section 2.2.3i) and time spent on the beach and at sea before immersion (high stress, cold air). All of these factors would accelerate cooling and thereby reduce estimated survival time.

4.3 For the reasons given (section 4.2ii), I think that whilst some individuals may have succumbed to cold shock on immersion and drowned, this was not the cause of death for the majority. Some may have drowned due to a lack of swimming ability and the absence of a functioning source of buoyancy. I think that most of those who died will have done so when peripheral local cooling got to the point where they could no long hold onto the buoyant remnants of the boat, or they could no longer exercise to keep their airways above the water ("Functional time"). At this point they will have been reliant on a functioning lifejacket to keep their airway clear of the water. Others will have been unable to swim or hold onto the boat as they lost consciousness due to hypothermia. Finally, any individuals with functioning lifejackets or other means of keeping their airway clear of the water may have cooled to the point of cardiac arrest due to hypothermia. I think a more considered estimation of possible survival times in this incident can be attempted (see following sections).

4.4 I asked Dr Peter Tikuisis, the developer of the Cold Exposure Survivor Model (CESM) to predict the survival time of those involved in the current incident. Dr Tikuisis's report is based on the characteristics of the casualties (Annex A) and his report is presented at Annex B. The results are presented in Table 3 below. To interpret the table, and taking the first line in the table as an example (Male, Light sea state, No fatigue), 95% of the male population is expected to survive at least 6.1 h, 75% up to 8.6 h, etc. until only 5% of the population is expected to survive 19.4 h.

4.5 The estimated survival times provided by the CESM are for a general Western population. It is very likely that the individuals in the incident under consideration would not achieve the survival times of this population; for the reasons given (see section 4.1, 4.2v) they would be expected to cool more quickly and therefore have shorter survival times. Therefore, in order to get some idea of likely survival times in the current incident, it is reasonable to concentrate on the predicted survival times for exhausted (see sections 2.2.3i, 4.2v) individuals in a light or turbulent sea state in the 95-50% categories (highlighted in Table 3).

Table 3. CESM predicted survival times for general Western population. Scenarios analysed: age range male 16-46 years, female 7-46 years; Sea temperature 13 °C; Sea states "light" (minimal disturbance [flat water or swell no breaking waves]), "turbulent"; 3 levels of fatigue: none, tired, and exhausted (pertains to availability of the internal energy reserve, which is compromised by poor nourishment and sleep deprivation*); assumed clothing: t-shirt + long-sleeved shirt + heavy sweater + jacket (Courtesy of Dr Tikuisis).

Gender	Sea State	Fatigue	Survival Time (hr) by Population Percentage				
			95%	75%	50%	25%	5%
Male	Light	None	6.1	8.6	10.9	13.9	19.4
		Tired	5.5	7.7	9.7	12.3	17.2
		Exhausted	4.8	6.5	8.0	9.8	13.3
	Turbulent	None	5.2	7.4	9.4	12.0	17.1
		Tired	4.6	6.5	8.3	10.6	14.9
		Exhausted	4.0	5.5	6.9	8.6	11.8
Female	Light	None	4.4	6.6	8.8	11.6	17.2
		Tired	4.0	5.9	7.8	10.2	15.0
		Exhausted	3.6	5.1	6.5	8.2	11.7
	Turbulent	None	3.8	5.6	7.3	9.6	14.2
		Tired	3.5	5.2	6.7	8.8	12.9
		Exhausted	3.1	4.4	5.5	6.9	9.7

*"Sleep deprivation" is an example given in the CESM. There is no evidence that the passengers in the incident under invitation were sleep deprived. However, there were reports of them being tired and having had a poor diet prior to departure (section 2.2.3i).

4.6 Dr Art Allen (USCG, retired) agreed to run the PSDA v1.2 for the scenario of Tw 13 °C, turbulent flow, Ta 2 °C, relative humidity 60%, wind speed 10 knots, immersed to the neck wearing long-sleeved shirt and medium weight trousers. The outputs from these analyses are presented in Table 4. As with the CESM, the data produced are based largely on a Western population (mostly US and UK data) with, as can be seen in Table 4, relatively high body fat percentages even when "lean" is selected. Body fat act as an insulator and slows cooling rates thereby extending survival times. As with the CESM data, it is very likely that the individuals in the incident under consideration would not achieve the longer survival times represented by this population; for the reasons given (see section 4.1, 4.2v); they would be expected to cool more quickly and have shorter survival times. The PSDA predicts a "cold functional time": in the present incident this would be an estimation of the time it would take individuals to become physically incapacitated to the point where they could no longer grip onto the boat for buoyancy. As noted (section 3.3), this occurs before general hypothermia.

Table 4. Output from the PSDA v1.2 Tw 13 °C, turbulent flow, Ta 2 °C, Relative humidity 60%, Wind speed 10 knots, immersed to the neck wearing long-sleeved shirt and medium weight trousers (Courtesy of Dr Allen).

Sex	Age	Height (m)	Weight (kg)	%Fat	50% Cold functional time (hr)[1]	50% Cold survival time (hr)[2]	Cold survival time range (hr)
Male	20	1.78 (medium)	64.2 (light)	14 (lean)	2.2	3.9	2.9-5.7
Male	46	1.78 (medium)	73.8 (light)	19.5 (lean)	5.6	7.8	5.3-10.7
Female	20	1.63 (medium)	57.3 (light)	29.7 (lean)	4.9	6.9	4.6-9.6
Female	46	1.63 (medium)	63.8 (light)	34.4 (lean)	7.2	9.5	6.6-12.7

[1] Functional Time (core temperature above 34 °C) is the length of time (hours) during which an individual may participate in self-rescue or take actions that will enhance survival.

[2] Cold Survival Time (hours) is the time it takes for the core temperature to drop to 28 °C. Below that threshold, the probability of death due to hypothermia significantly increases.

4.7 Given the data presented in Tables 3 and 4 come from different predictive models they agree reasonably well. As noted, the survival times of the individuals in the incident under investigation are likely to be towards the lower end of the range of survival times produced by the models. These times are also in general agreement with those show in Table 2 (using 15 °C as the closest water temperature).

4.8 The major limitation to addressing any questions related to the survival time of the individuals involved in the incident under investigation is the lack of information about them. This includes details such as what clothing they were wearing, whether they had a functioning lifejacket, what they were doing just before immersion, could they swim, what was their body fat percentage, how fit were they, when did they last eat, when did they last sleep, did they have any co-morbidities/injuries, etc. This lack of information means one can only make general probabilistic conclusions about survival time using the data presented in Tables 2-4 from the models predicting survival time.

4.9 Given the ages of the missing individuals (18-20 years), and looking at the predicted functional and survival times in Tables 3 and 4, I think it unlikely that these individuals survived more than 4-5 hours after entering the water. As noted, it is not possible to give precise survival times; the closest approximation would be the times at the lower end of the ranges presented in Tables 3 and 4. Given that two of the missing individuals were considered "good swimmers" (no relevant information on the other two), and one had said that he thought he could "swim the distance" (section 2.2.3ii), it is possible that these individuals attempted to swim to the nearest shore. This would have increased their rate of cooling, reducing predicted survival time, and move them away for the scene (section 3.4ii).

4.10 In terms of overall timing, I think the majority of the occupants of the boat were alive at 03:24. At 07:03 Border Force vessel Valiant informed MRCC Dover that it would have to return to Dover because it would be full, after locating and rescuing occupants of other small boats. 07:03 is a minimum of 3.5 hours after the occupants were thought to have entered the water. There are conflicting reports that 8 occupants were still alive at sunrise (07:26) (MAIB), and that, "Everyone could take it until sunrise, then when the light shone, no one could take it anymore and they gave up on life" (INQ000079). Based on the predicted functional and survival times (Tables 3 and 4), I think some of the occupants will have died by 07:03 in addition to any who died shortly after entering the water at 03:12-03:33.

4.11 With regard to the audio recordings of calls made at the time of this incident between HM Coastguard and individuals in small boats, I could not discern any information that shed any light on aspects of survivability other than, given the number of calls over time, it was apparent that the sinking of the vessel took time. This is supported by the statement in a transcript of an audio file of a male speaker reporting that "part of our body is in the sea" (INQ007657, section 2.2.2 ii). The apparent slow rate of immersion was one of the reasons for my opinion that cold shock was not as major a hazard as it would have been with a sudden capsize.

4.12 As far as I could discern, no information was conveyed during the phone calls I have heard that related to behaviours to improve survivability. Most of the conversations were trying to establish quiet and the location of the vessel, whilst the occupants asked for help. Furthermore, I am not sure, given the language differences, sound clarity against a lot of background noise and general chaos, how effective and practical the provision of such information would have been at this time. Having said this, useful advice might include:

a. Count how many people are on the boat before entering the water.

b. Enter the water slowly (to minimise cold shock) – it is likely this occurred anyway in this incident as the boat slowly deflated.

c. If possible, take a means of communication with you in a waterproof container.

d. Put as many clothes on as possible prior to entering the water (to maximise insulation and buoyancy).

e. Eat and drink any food/fluids you have available before entering the water.

f. Properly secure your lifejacket.

g. If you have no lifejacket, find something buoyant (e.g. empty containers, plastic bottles etc.) to hold onto (including the sponson of the sinking inflatable boat). Consider securing yourself to the buoyant object to ensure you stay with it when unable to hold on anymore.

h. If the boat engine is of no use, consider removing it to maximise the buoyancy provided by the boat.

i. If the boat remains afloat, partially inflated, put the children in the boat and bail it with any container that can be found (e.g. half a plastic bottle).

j. Consider linking/tying yourself to other individuals to assist with location and the maintenance of morale.

k. Do not try to swim to keep warm (humans cool more quickly when they exercise rather than stay still in water colder than 15 °C).

l. Lean back in the water and "float to live": this is the advice given by the Royal National Lifeboat Institution (https://rnli.org/safety/float) and by the emergency control room of HM Coastguard when contacted via emergency phone calls.

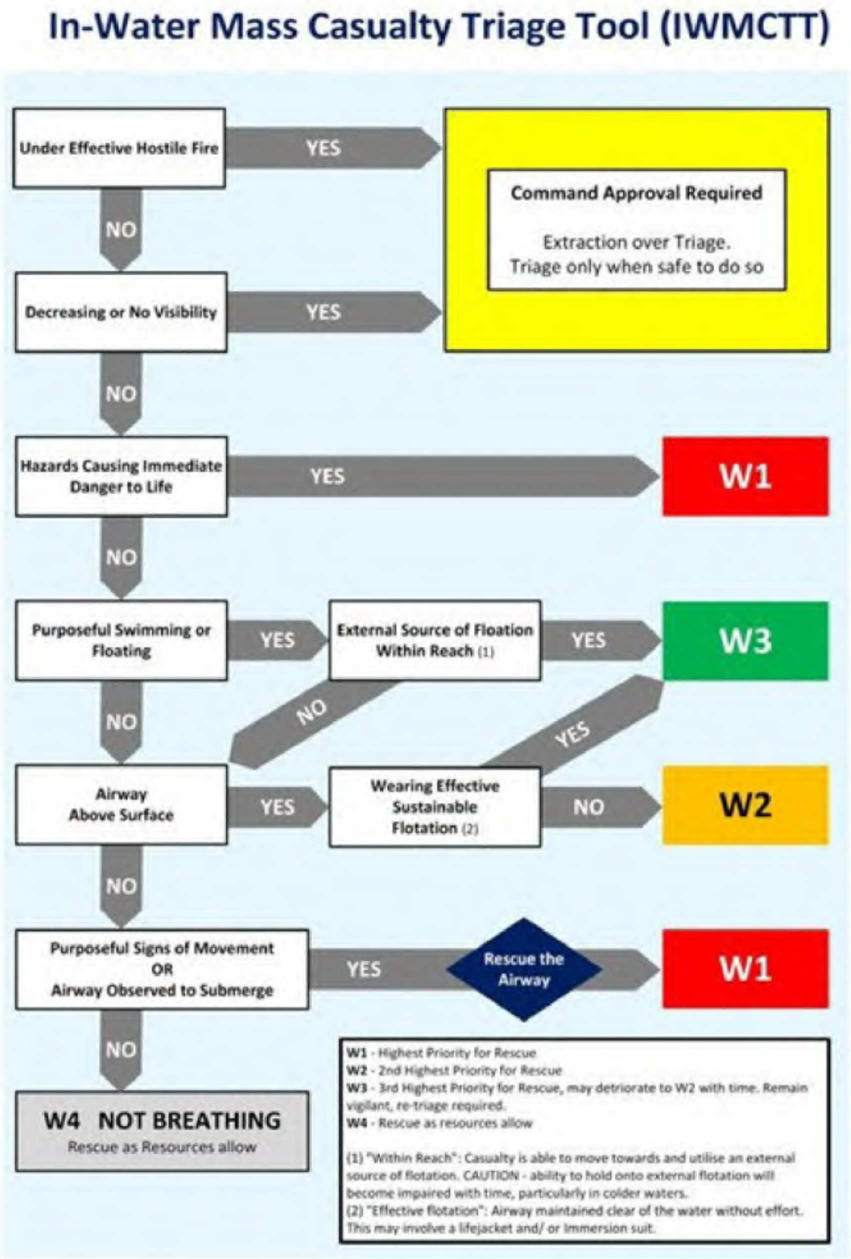
4.13 Given the amount of mobile phone communication, a list of advice, translated into a variety of languages, that could be texted to a mobile phone might be a better way of communicating than verbally. The use of one phone per boat would save unnecessary battery use (the occupants were rationing mobile phone use), and the possession of a waterproof container and bailer would seem to be helpful prior to departure, as would, of course, a functioning lifejacket.

4.14 On a related issue, and in response to the challenges of mass rescue from water being faced by helicopter operators and the Maritime and Coastguard Agency, myself and colleagues* have developed a triage tool for those attending in-water mass casualty incident. The In-Water Mass Casualty Triage Tool (IWMCTT) is novel in that it enables triage (prioritisation for rescue) to be undertaken ***before*** rescue, based upon the likelihood of survival ***after*** immersion. This enables rescue to be prioritised and should improve the efficiency and efficacy of such rescues and, consequently, the survival rate associated with the management of such incidents. The IWMCTT requires further development and evaluation. The Figure associated with this approach is presented below (Figure 3) and the peer-reviewed published paper can be read in full at Annex 3.

*(Barton CA, Morgan P & Tipton MJ (2024) Development of a novel "In-Water Mass Casualty Triage Tool" BMJ Military Health. BMJ Mil Health 2024;**0**:1–4. doi:10.1136/military-2024-002855. First published as 10.1136/military-2024-002855 on 20 November 2024).

4.15 An earlier version of the IWMCTT was first presented at the 5th World Maritime Rescue Conference in Rotterdam in June 2023 by one of my co-authors, Dr Patrick Morgan. It is my belief that the RNLI used this version, possibly seen at the conference or online, as the basis of their Multiple Casualty In-Water Rescue Tool (INQ009006), I was not involved in the development of the RNLI tool, but it appears to be identical to the earlier version of the IWMCTT, presented in Rotterdam. I should state that I have no problem with others using the work that I do with my colleagues in this way. The highest priority is to save the lives of those in water; and we deliberately share the results of the work we do in an ongoing attempt to achieve this objective. To this end the other documents produced by the RNLI (INQ009669, INQ009669) seem reasonable.

4.16 During my and my colleague's subsequent development of the IWMCTT, and as a result of peer review for publication, we added the "Airway Observed to Submerge" to the box containing "Purposeful Signs of Movement" as an indication that if the airway (mouth and nose) of an immersed individual is *observed* to go beneath the surface of the water, they should become a high priority for rescue ("W1" Figure 3). I recommend that, if they agree, the RNLI update the multiple casualty in-water triage tool they are using to the most recent published version (Barton et al, 2024).



W1 - Highest Priority for Rescue
W2 - 2nd Highest Priority for Rescue
W3 - 3rd Highest Priority for Rescue, may detriorate to W2 with time. Remain vigilant, re-triage required.
W4 - Rescue as resources allow

(1) "Within Reach": Casualty is able to move towards and utilise an external source of flotation. CAUTION - ability to hold onto external flotation will become impaired with time, particularly in colder waters.
(2) "Effective flotation": Airway maintained clear of the water without effort. This may involve a lifejacket and/ or Immersion suit.

Figure 3. The "In-Water Mass Casualty Triage Tool (IWMCTT)" has been created to enable rescue agencies to rapidly assess in-water casualties *before* removal from the water. Determining the priorities for evacuation in mass casualty situations. The triage categories (W1 to W4) are defined by the IWMCTT presented at Figure 1. W4 or NOT BREATHING is for individuals who are not breathing, unsalvageable, and show no signs of life. This is used for those whose injuries are so extensive that they will not be able to survive given the care or resources immediately available. As resources allow, they can be extracted from the water.

(Barton CA, Morgan P & Tipton MJ (2024) Development of a novel "In-Water Mass Casualty Triage Tool" BMJ Military Health. BMJ Mil Health 2024; **0**:1–4. doi:10.1136/military-2024-002855. First published as 10.1136/military-2024-002855 on 20 November 2024).

4.17 The IWMCTT is the only triage tool I have been involved in developing. With the exception of the RNLI version of the earlier iteration of the IWMCTT, I am not aware of any other in-water mass casualty triage tools in the peer-reviewed published literature.

4.18 Finally, it would be worth making the function and limitation of the IAMSAR curve (Figure 2) more widely understood (Tipton et al 2022). The work that is underway to refine the estimation of survival time and consequent search and rescue time in water should be encouraged.

5.0 STATEMENT OF TRUTH

5.1 I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

Annex A: Sex, Date of Birth, Outcome, Age of boat occupants

1. FEMALE (F) 01/01/75 DEAD (D)	Age 46 y
2. F 06/04/99 D	Age 22 y
3. MALE (M) 27/05/05 D	Age 16 y
4. F 27/02/14 D	Age 7 y
5. M 23/06/02 D	Age 19 y
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6. M 2000 D	Age 21 y
7. M 29/08/91 D	Age 30 y
8. M 18/03/93 D	Age 28 y
9. M11/11/98 D	Age 23 y
10. M 14/01/02 D	Age 19 y
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11. M 11/04/94 D	Age 27 y
12. M 15/09/84 D	Age 37 y
13. M 01/01/01 D	Age 20 y
14. F Age 24 D	Age 24 y
15. F 21/11/89 D	Age 32 y
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16. M 01/01/02 D	Age 19 y
17. M 22/10/98 D	Age 23 y
18. M 05/06/75 D	Age 46 y
19. F 14/06/99 D	Age 22 y
20. F 31/05/96 D	Age 25 y
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21. M Age 24 D	Age 24 y
22. M Age 40 D	Age 40 y
23. M Age 25 D	Age 25 y
24. M Age 27 D	Age 27 y
25. F 01/01/88 (French DC* 01/01/98) D	Age 33 y
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26. M Age 20 D	Age 20 y
27. M Age 29 D	Age 29 y
28. M Age 18 MISSING (M)	Age 18 y
29. M 30/03/03 M	Age 18 y
30. M 12/01/01 M	Age 20 y
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31. M 27/06/93 SAVED (S)	Age 28 y
32. M Age not known S	Age ??

*Death Certificate
Youngest male: 16 years
Oldest male: 46 years
Youngest female: 7 years
Oldest female: 46 years

ANNEX B: Sea Survival Predictions Based on Body Cooling

Peter Tikuisis[1], PhD

15 Sep 2024

This report provides estimates of survival times of casualties involving the partial sinking of an inflatable vessel in the Dover Strait on 24 Nov 2021 that was occupied by migrants attempting to cross the English Channel.

Predicted survival times are based on the Cold Exposure Survival Model (CESM), which predicts the time of deep body cooling to lethal hypothermia (28°C[2]) assuming that the individuals are healthy, neck-immersed in water, stationary (i.e., not generating heat beyond what shivering provides), and have a normal physiological cooling response to cold (Keefe and Tikuisis 2008[3]). An important caveat underlining the predictions is that the model does not account for early death due to accidents, predation, or drowning (e.g., due to cold shock).

Scenarios analyzed:

i. age ranges: male 16 - 46 years old; female 7 - 46 years old
ii. sea temperature of 13°C
iii. two sea states relative to the immersed individual: light (minimal disturbance; e.g., flat water or swell without breaking waves) and turbulent (determines whether the extent of convective heat loss from the individual is low or high, respectively)
iv. three levels of fatigue: none, tired, and exhausted (pertains to availability of the internal energy reserve, which is compromised by poor nourishment and sleep deprivation)
v. assumed clothing: t-shirt + long-sleeved shirt + heavy sweater + jacket

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[1] Contact: PD @gmail.com

[2] While individuals might survival a core temperature below 28°C, such individuals are beyond self-help and death can be expected if no intervention occurs.

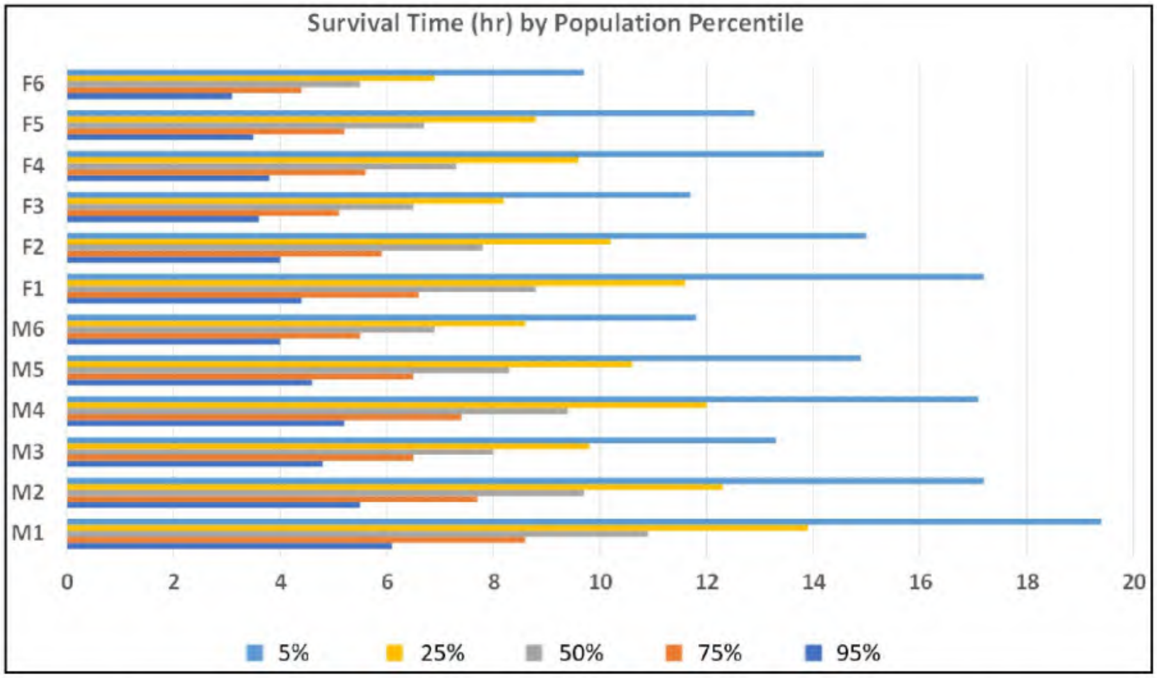
[3] Keefe, A.A., and P. Tikuisis. A guide to making stochastic and single point predictions using the Cold Exposure Survival Model (CESM). DRDC Toronto TM 2008-061, Jan 2008.

Predicted survival times for various percentages of the incident population expected to survive:

Gender	**Sea State**	**Fatigue**	**Survival Time (hr) by Population Percentage**				
			95%	**75%**	**50%**	**25%**	**5%**
Male	Light	None	6.1	8.6	10.9	13.9	19.4
		Tired	5.5	7.7	9.7	12.3	17.2
		Exhausted	4.8	6.5	8.0	9.8	13.3
	Turbulent	None	5.2	7.4	9.4	12.0	17.1
		Tired	4.6	6.5	8.3	10.6	14.9
		Exhausted	4.0	5.5	6.9	8.6	11.8
Female	Light	None	4.4	6.6	8.8	11.6	17.2
		Tired	4.0	5.9	7.8	10.2	15.0
		Exhausted	3.6	5.1	6.5	8.2	11.7
	Turbulent	None	3.8	5.6	7.3	9.6	14.2
		Tired	3.5	5.2	6.7	8.8	12.9
		Exhausted	3.1	4.4	5.5	6.9	9.7

For example, 50% or one-half of the male population would be expected to survive 10.9, 9.7, and 8.0 hr under a light sea state and fatigue conditions of none, tired, and exhausted, respectively.

Below is a visualization of the above predicted survival times where the prefix M and F refer to males and females, 1 through 3 refer to fatigue states of none, tired, and exhausted under a light sea state, and 4 through 6 refer to fatigue states of none, tired, and exhausted under a turbulent sea state, respectively. Best- and worst-case predictions differ by about 60% [e.g., survival times increase by about 60% from the worse scenario (turbulent sea state and exhausted individuals) to the most favourable scenario (light sea state and no fatigue)].



The above scenarios are predicated on the clothing that was likely worn in late fall, as surmised by images of migrant crossings of the English Channel[4]. The predicted survival times, however, are not overly sensitive to the amount of clothing worn assuming a thoroughly soaked condition. For example, the predicted survival times assuming no clothing (i.e., nude) are only about 25% lower than the estimates shown above. The addition of a life-jacket would extend survival times if worn snugly with ample coverage, yet wetness would still limit the additional benefit[5]. Finally, the cold air temperature of 2°C would have contributed to severe body cooling with soaked clothing even if the individual managed to extract part of their body out of the water.

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[4] https://www.gettyimages.co.uk/photos/english-channel-migrants (accessed 06 Sep 2024).

[5] The variability of PFD design and fit precludes assigning a reliable estimate of thermal insulation for predictive purposes.

<u>ANNEX C: Peer reviewed published paper</u>

Barton CA, Morgan P & Tipton MJ (2024) Development of a novel "In-Water Mass Casualty Triage Tool" BMJ Military Health. BMJ Mil Health 2024; **0**:1–4. doi:10.1136/military-2024-002855. First published as 10.1136/military-2024-002855 on 20 November 2024.

Analysis

Development of a novel 'In-Water Mass Casualty Triage Tool'

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ABSTRACT

The number of in-water mass casualty incidents has increased in recent years and provides significant challenges to rescuers. Existing triage systems require the rescue of immersed (in water) casualties before triage is undertaken. A tool that enables triage to be undertaken *before* rescue, and therefore the prioritisation of that rescue, should improve the efficiency, efficacy and survival rate associated with the management of such incidents.

In this paper, we describe the rationale and development of a proposed novel 'in-water mass casualty triage tool (IWMCTT)' to assist in the swift and effective triage of those in the water in mass casualty situations *before* they are rescued, based upon the likelihood of survival *after* immersion. The tool is based on a review of the literature related to the hazards associated with immersion, most notably drowning.

The IWMCTT employs a sequential approach to streamline the identification and prioritisation for rescue of immersed individuals; it considers factors such as hazards, visibility constraints, purposeful swimming, moving or floating, airway position, availability of flotation assistance and flotation device effectiveness. It categorises casualties from W1 (high) to W4 (low) priority for rescue.

The proposed IWMCTT offers a potential solution to some of the challenges faced during water-based mass casualty incidents; providing rescue assets (rigid-hulled, inflatable boats, ships and helicopters) with a rapid and effective approach to assess and prioritise individuals for rescue and medical attention, hopefully thereby reducing mortality and morbidity. The IWMCTT requires further evaluation and validation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There is an increasing requirement for mass rescues in a maritime environment in military and civilian scenarios; this necessitates a re-examination of the approach of rescuers to this challenge.

WHAT THIS STUDY ADDS

⇒ This paper describes the development and rationale for such a triage tool. The 'in-water mass casualty triage tool' (IWMCTT) enables casualties in the water to be triaged before removal based on the likelihood of survival after immersion, assisting with prioritising and therefore optimising rescue efforts.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

⇒ It is hoped that this paper will enable further research, evaluation and validation of the topic. The IWMCTT should improve survival rates of those in maritime mass rescue situations, and is already being considered for implementation into service policy.

INTRODUCTION

In contrast to many land-based emergencies, where casualties are typically in a static location, water-based incidents occur in a dynamic environment where the locations of casualties are determined by external forces such as currents, tides and windage; these forces can scatter casualties over large areas. In addition, water temperature and sea state can represent evolving threats.

Water-based mass casualty incidents have become more frequent in recent years, affecting nations of all socioeconomic backgrounds. Factors like extreme weather events and conflict have led to a significant increase in population displacement over the past decade,[1] most recently associated with the migrant crossing crises.[2] There were a recorded 274 800 migrants arriving in Europe by small boats in 2023, nearly a 35% increase from 2022. It is not unusual for over 30 casualties to enter the water in a single incident.[3] In addition to this civilian issue, the Royal Navy, including its Submarine Service, operate in isolated oceanic conditions around the world. A requirement for ship abandonment could result in large numbers of casualties in the water, that is, another in-water mass casualty scenario.

Military and civilian rescue agencies face great difficulty in finding and prioritising the rescue of large numbers of casualties in the water. 'Triage' is the preliminary assessment of casualties to determine the urgency of their need for treatment and the nature of treatment required.[4] Defined prehospital triage systems, aimed at providing the maximum number of casualties with the most benefit, are essential for reducing morbidity and mortality and optimising resource allocation when incidents occur. In contrast to conventional prehospital military and civilian protocols, in *mass* casualty situations, minimal treatment is administered during the initial triage phase. In this context, a 'mass casualty' incident is one in which casualty numbers exceed rescue capability. In this situation, the objective is to prioritise the transfer of casualties that could most benefit from the life-saving assistance available away from the scene of an incident to more comprehensive care resources. In military settings, operational considerations, such as ongoing enemy activity, may dictate the nature of the triage tool followed.[5]

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All current UK triage tools cannot be conducted effectively *before* casualties are removed from the water (eg, the 10 s triage tool).[6] A more efficient and effective approach with mass casualties in water would be to triage treatment needs *before* rescue; this ensures that rescue activity can be prioritised to those most in need of immediate care; this approach should maximise the number of lives saved. There are currently no fully documented, peer reviewed, triage systems for use with individuals in the water before rescue. The nearest is a tool proposed by Tipton *et al*[7] based on an understanding of the physiological precursors to immersion-related deaths; this tool has been incorporated into a new 'in-water mass casualty triage tool' (IWMCTT) proposed in figure 1.

The IWMCTT is based on the published physiological and pathophysiological responses to immersion, and an assessment of the status of casualties in the water, particularly their imminent risk of drowning and likelihood of survival following submersion or immersion. It also covers the dynamic impact of military settings. It employs a sequential approach, incorporating quick, simple observations that can be conducted from the elevated position of a rescue asset, without the requirement for physical contact with the casualty. It is recommended that the water temperature associated with an incident be established as soon as practicable.

Under effective hostile fire

Higher command approval to proceed should be requested. This enables command to decide on the approach to be undertaken, such as providing support to make the environment as safe as possible, withdrawing the rescue teams until the area is secure, or approving rapid extraction over triage (rescue teams make the best effort in recovering casualties, as seen, as fast as possible without using the IWMCTT). In such circumstances, alternative triage can only be conducted when casualties are handed over to medical teams.

Decreasing or no visibility

Locating casualties can be difficult. Should conditions worsen (eg, daylight diminishing and the weather deteriorating), command approval can be sought for prioritisation of extraction over triage (see 'Under effective hostile fire' section above), accepting the risk of inefficient rescue attempts. It should be noted that in some military circumstances, command may impose certain light disciplines for rescue teams (eg, unable to use white/bright light at night due to tactical disadvantages). In such scenarios, tracking, finding and triaging casualties in the water will become difficult, and the command may opt for extraction over triage.

Hazards causing immediate danger to life

In the event of combat or natural disaster, the water and surrounding area may be littered with hazards to rescue teams, casualties, inflatables (lifejacket/raft) and rescue assets. These hazards might include large objects (trees and cars), razor wire, etc. Casualties may also be drifting towards rocks or an unrescuable position. In such cases, if rescue teams do not act immediately, the casualty or casualties will become unsalvageable. Rescuers need to quickly establish whether they can access casualties without endangering themselves, damaging their rescue vessel or placing the casualty in further danger. Where practicable, such casualties are designated 'Category W1' with an immediate requirement for rescue.

Purposeful swimming or floating

Casualties are assessed and rapidly prioritised while approaching the scene and upon arrival. This does not require specialist skills given the cues being sought. Where the casualties are able to keep their head (particularly their mouth and nose) above the surface of the water without strenuous effort while remaining calm and responsive, which may include actively swimming, they are categorised as 'purposeful swimming or floating'. They are at risk of deteriorating with time (eg, fatigue or local/general hypothermia) but not at immediate risk of drowning. This assessment should be reviewed if environmental conditions (eg, sea state) worsen as time passes.

External source of flotation within reach

This is any external structure that is immediately available to immersed casualties and provides buoyancy (eg, floating debris, partially inflated sponsons, life rafts, rescue sleds from the rescuing assets or stricken vessel). Rescuers should instruct casualties to move towards these sources of buoyancy and use them for support. Advice should also be given to casualties in the water without flotation support to float on their backs and rest (https://rnli.org/safety/float).[8]

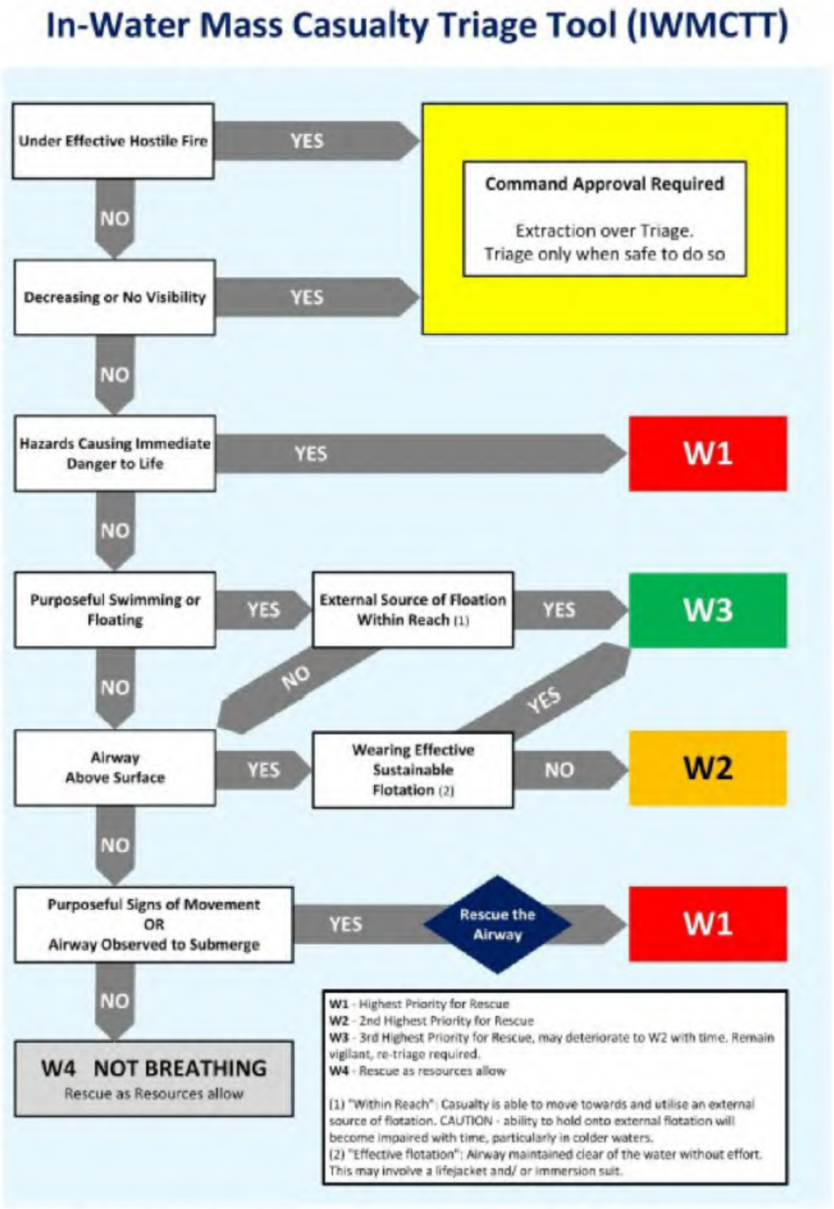
Following a relatively short period (<20 min) of immersion in cold water (<15°C),[9] casualties may experience reduced manual function and require assistance. Furthermore, the dynamic nature of the water environment should be considered; this includes changes in tides, visibility, windage, sea state and distance to platforms. Any casualties left with a buoyancy aid should have their last known location recorded so they can be extracted when resources allow. Actions should also be taken to avoid casualties swimming to and overwhelming the capacity of any rescue asset or platform available.

Initial communications with casualties can follow existing mass casualty legislation or guidance,[10–12] which allows the quick identification of 'walking wounded' or swimming/floating casualties in this case. This approach filters out less severe cases and allows higher-priority casualties to be dealt with.

Airway above surface

A casualty's ability to maintain their own airway (nose and mouth) clear of the water should be assessed. Once the airway is below the surface of the water, a casualty will rapidly progress to a hypoxic state and cardiac arrest. Submersion times of less than 5–6 min before commencement of effective resuscitation are associated with more favourable outcomes; submersion times beyond 25 min are invariably fatal.[13–15] For practical purposes in the mass casualty scenario, it is not possible to establish these time cut-offs. Consequently, it is recommended that if submersion of the airways is observed by the rescuers, these casualties are regarded as W1. If it is not observed and there are no purposeful signs of movement (see 'No purposeful signs of movement' section below), they are graded as W4.

The rapidly increasing probability of death with increasing submersion time is reflected in the National and International Resuscitation Guidelines, which suggest a cut-off of 30 min confirmed submersion in non-icy water (>6°C), beyond which resuscitation attempts are futile (Category W4).[16] Rescue, ongoing resuscitation and transfer to specialist centres for a casualty who has been submerged for a prolonged period of time consume an enormous amount of rescue and clinical resources, and will delay further search and rescue efforts. Where there are adequate resources to continue resuscitation, and the water temperature is below 6°C, the search time can be extended up to 90 min of submersion.[17] However, these prolonged search times assume the casualty has experienced rapid brain cooling prior to becoming hypoxic. This is unlikely if: the water temperature is



W1 - Highest Priority for Rescue
W2 - 2nd Highest Priority for Rescue
W3 - 3rd Highest Priority for Rescue, may deteriorate to W2 with time. Remain vigilant, re-triage required.
W4 - Rescue as resources allow

(1) "Within Reach": Casualty is able to move towards and utilise an external source of flotation. CAUTION - ability to hold onto external flotation will become impaired with time, particularly in colder waters.
(2) "Effective flotation": Airway maintained clear of the water without effort. This may involve a lifejacket and/ or immersion suit.

Figure 1 The IWMCTT. Created to enable rescue agencies to rapidly assess in-water casualties before removal from the water and thereby determine the priorities for rescue in mass casualty situations. The triage categories (W1–W4) are defined by the IWMCTT. W4 or NOT BREATHING, are for individuals who are not breathing, unsalvageable and show no signs of life. This is used for those whose injuries are so extensive that they will not be able to survive given the care or resources immediately available. As resources allow, they can be extracted from the water. The IWMCTT can be integrated with existing maritime legislation and guidance.

above 6°C; the casualties are not children or small adults with a high surface area to mass ratio; and the casualties are wearing survival suits.

Wearing effective sustainable flotation

This may include a lifejacket, immersion 'dry' suit or other form of wearable buoyancy. If worn, an assessment is made concerning whether the casualty's airway is being maintained above the water. Life rings or other supportive flotation rescue devices will increase casualty survival prospects and should be provided where possible. Before arriving at the scene, establish the water temperature and the estimated survival times associated with different levels of clothing protection. If casualties are wearing protective clothing and lifejackets, they are functioning properly, and it is well within the estimated survival time, it is likely that these casualties will be a lower priority (W3) for rescue.

No purposeful signs of movement

The decision to rescue or not is determined by whether the casualty is undertaking purposeful movements. Purposeful movement being suggestive of recent submersion and high probability of survival if rescued and resuscitated quickly. In contrast, a casualty who is face down with body movement determined solely by wave action is a low priority (W4) for rescue.

Triage categories

All 'W' triage categories reflect the priority with which casualties are rescued. Triage is a dynamic process, and in-water casualties can move between 'W' categories as their condition or environmental conditions change. 'W' is used to emphasise that this is a triage based on an assessment of the casualty while *in the water before* rescue. Once a casualty is rescued from the water, their triage categories and onwards treatment should align with current mass casualty triage guidance.

Military rescue vessels

Current military legislation[18] for SOLAS operations or 'man overboard' stipulates only a single 'sea boat' is to be launched from the host vessel[19] with an additional swimmer of the watch (if available). In order to facilitate triage and avoid overwhelming the vessel conducting IWMCTT, we recommend that both seaboats be launched to a mass casualty immersion incident. One is to provide additional lifejackets or other flotation aids and subsequently be a safe haven for those able to move towards it. The second is to undertake triage and rescues as directed by IWMCTT (figure 1).

CONCLUSION

We have described the rationale and development of a proposed novel IWMCTT to assist in the swift and effective triage of those in the water in mass casualty situations *before* they are rescued, and based on the likelihood of survival *after* immersion. The IWMCTT addresses the unique challenges presented by water-based mass casualty incidents and should help with the efficient and effective rescue of immersed casualties and, in doing so, increase survival rates. The IWMCTT requires further evaluation and validation.

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