The International Journal of Diving History

Volume 16
March 2025

The International Journal of Diving History
published by the Historical Diving Society
Dedicated to promoting and preserving our diving heritage

We invite articles, book reviews, correspondence, and queries on any aspect of the history of diving. Manuscripts, other contributions, and all correspondence should be sent to:

Peter Dick
Ardmore House, Isleworth, Middlesex, TW7 4PH, UK.
UK email: editor@thehds.com
Telephone: +44 (0)20 8560 1907

Information for Contributors

It is preferred that contributors submit papers electronically. Text should be in plain text, Microsoft rtf, or as a Microsoft Word document and should not be formatted. Footnotes and references should be numbered and listed at the end and their position in the text indicated by the same number in brackets or in superscript.

Illustrations are not limited in number but will be reproduced in black and white only. Ideally the images should be submitted electronically as jpegs or tiffs and at 300dpi resolution. Otherwise they may be submitted as drawings, photographs (up to A4 size) or transparencies. The position of all images should be indicated in the text (eg. "picture 4 here") and captions should be provided in a separate document. Original illustrations will be returned but their safety cannot be guaranteed, so contributors are urged to supply duplicates where possible and to retain the originals. Articles may be submitted to suitable referees for scrutiny.

Points of style

Articles should be fully referenced. Footnotes should be in the main body of the text and preceded by the word "Footnote". Notes and references will be printed at the end of the article. Books should be referred to by the author's surname, followed by the author's forename or initials, book title, place and date of publication, and relevant page numbers (in that order). The publisher's name is not required unless relevant for a particular reason, or unless the book is still in print.

References to journal articles should contain the author's surname, forename/initials, the title of the article in single inverted commas, the title of the journal in italics, the volume number, the issue number, the inclusive page numbers and the place and exact date of publication. Please italicise (or underline) the titles of books and journals and the names of vessels. Please also spell out numbers up to and including twenty, unless preceding units of measurement.

The editors reserve the right to make stylistic changes to conform with the format of this Journal.

At present the Journal is issued once a year. Single issues may be purchased from our website: www.thehds.com.

Front cover image: Divers wearing C. E. Heinke Square Pattern diving dress of the 1870s.
Layout: Ann Bevan.

The Historical Development of Scientific Diving in the UK from 1955 to 2000: Part 2 – 1975 to 2000

N.C.Flemming, HDS

ABSTRACT
Scientific Diving is the conduct of research under water by diving scientists and archaeologists using breathing equipment or submersibles. Part 1 of this paper describing the development of scientific diving from 1955 to1975 was published in the HDS International Journal of Diving History, Vol 15 in December 2023. This paper, Part 2, covers the period 1975 – 2000. Part 1 ended with a description of the CMAS international scientific diving conferences from 1973 to the 1980s. By 1975 the membership of the Underwater Association (UA) was growing rapidly, and its members published Codes of Practice in anticipation of legislation to control diving safety. The Government published and enacted Statutory Instruments on diving safety applicable to diving scientists in 1974 and 75, and the first draft of a detailed set of all-encompassing regulations was published by the Health and Safety Executive in 1978. The UK Natural Environment Research Council (NERC) in 1978 had 11 aquatic laboratories which conducted research by diving as part of their work, and they established a Diving Officers' Committee to manage diving resources, training and safety procedures. This evolved into the Scientific Diving Supervisory Committee which incorporated other government laboratories and many university diving teams. In 1972 the UA published its first Code of Practice for Scientific Diving, which was adopted by NERC, and then evolved through several editions, ultimately forming the basis for an international Code published by UNESCO in 1987. Scientific divers negotiated from 1978 to 1997 with the UK Health and Safety Executive and other regulatory agencies to develop sound diving laws. The finally agreed collaboration for the production of the Diving at Work Regulations in 1997 included the concept of Approved Codes of Practice (ACOPS) for different sections of the working diving profession. These Regulations remained in force up to 2023 with ACOPS regularly updated to take account of technical progress.

UK CODES OF PRACTICE FOR SCIENTIFIC DIVING

In 1971, with colleagues from the Underwater Association (UA) and the Institute of Oceanographic Sciences (IOS), I organized a one-day seminar on scientific diving and its applications. Researchers presenting their work included Helen Ross, Bill Hemmings, John Woods, Nigel Kelland, and the chief physiologist from the RN Physiological Laboratory, Dr Val Hempleman (Hempleman 1963, 1969, 1971; Hennessy and Hempleman 1977). Representatives from the military, research, and commercial diving organisations were in the audience.

The seminar revealed that divers in different institutes and universities had developed specialized and ingenious techniques for their own research interests, but were using a range of standards and procedures which, in some cases, were clearly pushing their luck in order to get the work done. There was a hidden potential for accidents. We needed a code of practice for scientific diving that would advise caution against diving procedures that were too risky, while maintaining sufficient flexibility to cope

Fig. 1.
British Antarctic Survey divers photographing and filming biological species living under floating icebergs. The diver has moved some distance under the ice, and away from the point of safe surfacing. Photo: Martin White, courtesy BAS.

with the unusual circumstances that research requires. Some typical research projects require diving at night or diving in caves, or under ice (Fig. 1), in very strong currents, or exposed to unusual chemicals (Fig. 2) or in very remote locations (Fig. 3 and 4), or in low visibility (Fig. 5) and so on. Lists of extreme diving conditions and appropriate safety procedures were included in codes of practice.

By 1972 the membership of the Underwater Association was over 100 divers, involving dozens of UK marine laboratories and universities. The Association, as well as providing support and a forum for research, was soon implicated in the risks taken by the divers who were its members. The Association arranged an insurance cover for diving scientists, provided that the project leader gave a competent report in advance of what they proposed to do to maintain safety. But scientific divers as a community still had no status or published explanation as to how we managed safe diving. Either our employers, or an outside agency or critic, might question our standards of training and operations, especially if there were an accident. We needed a code of practice to encourage scientists who were planning projects to adopt safe methods, and to justify the reduced insurance costs arranged by the UA.

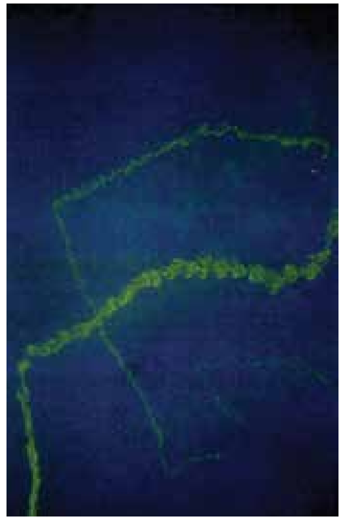
We held a meeting at the diving centre at Fort Bovisand, near Plymouth, attended by 20 or more of the senior members of the Association, at which I chaired the discussion and the revision of successive drafts until we had thrashed out a provisional '*Code of Practice for Scientific Diving*.' The Underwater Association published this (Flemming 1972), and most research groups in the UK rapidly adopted it. Insurance companies specializing in the risks of diving provided favourable rates for divers who abided by the Code.

We produced a revised second edition in 1974, with Doug Miles as my co-editor. The Natural Environment Research Council (NERC) published this version of the Code (Flemming and Miles 1974), after which the group of institutional diving officers within NERC gradually expanded to include other agencies, becoming the Scientific Diving Supervisory Committee (SDSC). I chaired this for its first few years and was vice-chair into the 1990s. It still exists and does excellent work. A fourth edition of the UK Code of Practice was published in 1990 (Gamble *et al.* 1990).

British oceanographic and aquatic laboratories conducted diving research in a variety of extreme environments, including under polar ice (Fig. 1), in high altitude lakes, on remote tropical atolls, in submerged caves, attached to towed trawl nets, with radioactive chemicals, with fluorescein dye (Fig

2) working with potentially venomous or aggressive marine species, in fast river currents, in the open ocean in deep water (Fig 3 and 4), in low and zero visibility (Fig 5), under thick kelp beds, in nuclear reactor shielding tanks, in warm water or hot springs, etc. Each environment needed advice and recommendations based on working experience, not theory. The British Antarctic Survey collaborated with other diving teams, and later the American and British divers published a major workshop report on polar research diving (Lang and Sayer 2007).

Fig. 2a (*left*): Current structure in the Ekman layer revealed by the dyed wake of a sinking fluorescein pellet, viewed from above. The sense of rotation with depth is in the opposite direction to that of the classical Ekman spiral. The structure in the dye was created by Kantian vortices shed in the wake of the pellet as it sank through water that had no ambient turbulence.
Fig. 2b (*right*): Looking vertically down on a dye streak left in the wake of a sinking pellet of fluorescein reveals that the azimuthal vector of the current rotates in the opposite sense to that of the Ekman spiral.
(Photos: John Woods)



In the 1960s and '70s, industrial and commercial diving had progressed rapidly, driven by the urgent requirements of the offshore oil and gas industries. The growth of deep diving, supported by submersible diving chambers, saturation diving, and deck storage and decompression chambers, was spectacular. Heavy industrial work, welding, cutting steel, rig repairs, inspection for damage and corrosion, pipeline inspection, and installing machinery were performed at depths of hundreds of metres. Divers had to live in pressurized surface chambers for weeks at a stretch, descending in submersible bells each day to the engineering work on the seafloor. I had, and have, enormous respect for the men who conducted these amazing dives and those who designed and operated the heavy engineering equipment that made it possible. For obvious reasons, lightweight scuba equipment and divers moving freely in three dimensions are not compatible with heavy machinery and the networks of girders, cables, and pipes that are the fabric of oil and gas rigs. The companies working on the rigs could and should have banned scuba for those conditions, but this was not done. Nor did the Health and Safety Executive (HSE) ban its use on the rigs. The fatal accident rate of divers on the rigs was high, and some of the accidents occurred to scuba divers, but there were many others as well, and scuba accidents were not the majority. (Warner and Park 1990; Limbrick 2002)

In these circumstances the HSE took the decision to try and ban scuba diving equipment for all divers at work. Also, the tough professionals who worked in saturation adopted a dislike and contempt for lightweight scuba diving. They called it "Mickey Mouse diving". I can understand their feeling that scuba diving to depths of 15-30 m (50-100 ft) is almost trivial compared with diving to 200 m (660 ft)

Fig. 3.
Divers working on the Cootamundra Shoals, North Australia 200 miles offshore in 1982 studying sponges at a depth of 23m.
The base port for this project was Darwin, Northern Territory, and the underlying coral crust was dated at 8000 years ago.

in saturation for ten days, but the dislike went further than that and was linked to an unshakeable belief that scuba diving was always dangerous. There are plenty of written statements of this unfortunate opinion. Scuba equipment is not suitable for work on oil rigs, but that does not justify the conclusion that it was always inherently dangerous and should be banned for all people at work everywhere. The correct response should have been to ban scuba on the offshore rigs or around heavy machinery and other heavy industrial operations in open water. Scuba on the rigs could have been banned by the diving companies themselves, by the rig operators, or the HSE. But that was not done.

This condemnatory and restrictive attitude to scuba diving at work produced a confrontation between scientists (and others) with the HSE that over-shadowed our community for 20 years

THE SCIENTIFIC DIVING SUPERVISORY COMMITTEE (SDSC)

NERC was the first government agency to recognise that it had to take responsibility at the Director/Chairman level for the potential risks of injury or death caused to divers who were at work under its employment. I worked with Richard Pope, the NERC Safety Adviser, from 1978 for several years, corresponding with the Diving Officers of all NERC aquatic laboratories. Within a few years it was apparent that other government agencies, as well as universities and some small consulting companies, had similar responsibilities when employing scuba divers, and had similar problems complying with the HSE rules and directives. The NERC Diving Officers' Committee thus expanded to include Diving Officers from other laboratories and agencies across the UK, forming the Scientific Diving Supervisory Committee (SDSC). I still chaired the enlarged group, and Richard Pope and NERC provided secretarial support and paid expenses.

The SDSC encouraged collaboration between laboratories, sharing of expensive equipment (especially the NERC 2-compartment 4-person mobile recompression chamber), joint projects and the sharing of ideas and techniques in underwater research. We analysed the proposed directives from the HSE, and either accepted them, or recommended alternative and better procedures. We regarded

Fig. 4.
Helicopter landing personnel on to the top of Rockall, 370 km out in the North Atlantic from the Hebrides in 1972.
Divers obtained rock samples from submerged volcanic peaks and lava flows around the central rock, for analysis and dating by the Institute of Geological Sciences.
The volcanism occurred in two phases, 81 million years ago and then 52 million years ago.

the higher grades of sports diving training as sufficient for scientific work, provided that the diver had additional training on their obligations as an employee under the Health and Safety at Work Act 1974, obtained an Employment Medical Advisory Service (EMAS) approved medical certificate, and demonstrated competence in basic working methods underwater.

The UA and the SDSC communicated with the American Academy of Underwater Sciences (AAUS) regularly in the early 1980s as the AAUS was negotiating with the American safety agency, the Occupational Safety and Health Administration (OSHA) with the same problems that we had (Occupational Safety and Health Standards Board 1979). Within a very few years OSHA granted a concession to the American universities and government research agencies employing divers which allowed them to draft their own codes of practice, consistent with ethical and legal standards and controls within institutions. Given the American tendency of complaints to lead rapidly to litigation, the standards set by institutions were very high. We explained the American OSHA policy on scientific diving to the HSE, but it was ignored.

Within the European Commission, Dr Marco Weydert, at the Directorate General for Research DG XII, organised a multi-national committee to try and agree equivalent standards of scientific diving between countries. SDSC sent delegates to the meetings, but the minor differences between countries, stipulated by domestic laws, made compromise very difficult. In the UK, the EMAS did not recognise the validity of a diver's medical examination if it had been carried out abroad. That meant that a foreign diver had to travel to the UK and take a medical examination before he or she knew that they could participate with UK divers. This effectively prevented foreign scientists diving in the UK.

Through my membership of various committees in the Intergovernmental Oceanographic Commission (IOC) of UNESCO I was able to discuss the benefits and problems of scientific diving with Dr Selim Morcos. He suggested that IOC could fund a series of workshop meetings to prepare a fully international Code of Practice for Scientific Diving. The members of the CMAS Scientific Committee created a correspondence group with Diving Officers in about 30 countries, and we held meetings in Paris and the USA, before publishing the International Code (Flemming and Max 1987). The final editorial meeting was held at a hotel near Wakulla Springs, in Florida, where we also had some fabulous dives in the water of unique clarity. Two further editions of the International Code were published jointly with Best Publishing (Flemming and Max 1990, 1996)

Scientific diving in the 1980s achieved full recognition by the marine and aquatic sciences agencies at national level, and further recognition by the international agencies, governmental and non-governmental, responsible for marine science. National science bodies equivalent to The Royal Society in the UK collaborated internationally through an association known at that time as the International Council of Scientific Unions (ICSU). The marine sciences were managed within ICSU by the Scientific Committee for Oceanic Research (SCOR). ICSU and SCOR recognised that research by divers was an integral part of exploration and discovery in the sea, and they supported several multi-national projects. I apologise for this emphasis on acronyms of bureaucratic agencies but the acceptance of scientific diving at this level, combined with the very low accident rate, was a major factor in eventually defeating the attempts to ban scuba at work.

The European Commission Directorate for Health and Safety provided secretarial support for a committee entitled the European Diving Technology Committee (EDTC) (Directorate General 1978). This committee adopted a similar policy to the UK HSE and held several multi-national meetings in Luxemburg to develop universally applicable rules for dive planning, medical standards, monitoring decompression incidents, team composition, maximum depth using different gases, etc. Most of the work was laudable. But a combination of commercial diving companies, trade unions and government agencies tried again to ban scuba for diving at work. SDSC paid for UK representatives to attend these meetings, and to present the UK and UNESCO Codes of Practice for scientific diving. We objected strongly to the proposed banning of scuba at work (Flemming 1980, 1985; Flemming and Lonsdale 1990), and showed that scuba was used routinely and safely by millions of sports divers (Schenk and McAniff 1973), and even more safely by several thousand scientists globally (Bellamy 1996). In 1994 EDTC made its final attempt to abolish scuba at work, but abandoned the attempt, and did not raise the idea again.

SCIENTIFIC DIVING AND NEGOTIATIONS WITH THE HSE 1978 – 1997

During the early 1970s there were increasing numbers of accidents to divers operating commercially in the North Sea oil fields (Warner and Park 1990; Limbrick 2002). In 1978 the UK Health and Safety Executive (HSE) published a consultative document on proposed new regulations for divers at work, and, and after heavy amendment, new statutory regulations came into force in 1981 (Statutory Instrument 399, 1981). The 1981 Regulations were accompanied by an Exemption for the various users of scuba at work (HSE 1981). The 1981 Regulations were amended, improved, and updated in 1997 (Statutory Instrument 2776, 1997) with input from the SDSC. During the intervening 20 years the UA and the SDSC were in almost continuous dispute with the HSE, the Manpower Services Commission (MSC) and the Employment Medical Advisory Service (EMAS) about the safest way to conduct scuba diving at work. This dispute continued year after year, notwithstanding the publication of the Codes of Practice described above, and the fatality-free record of the UK scientific diving community over successive decades, carefully managed by the SDSC (Scientific Diving Supervisory Committee 1998).

Ten commercial divers were killed in accidents on oil rigs in the North Sea in 1974, showing that new safety regulations were certainly needed on the rigs. The fatality rate was equivalent to 1% of those at risk per annum (Warner and Park, 1990, p.13, p.45), compared with 0.01% in sports diving. Many lives were lost in other sectors of the diving industry during this 20-year conflict, but there were no serious accidents in British scientific diving and no fatalities. To tackle the accident rate on the rigs the

Fig. 5.
Diver from the Maritime Archaeology Trust at a depth of 11 m at Bouldnor Cliff, off the Isle of Wight, examining a freshly discovered flint tranchet axe or adze, which is 12 cm long, and dates from about 7000 years ago. This tool was found in 2020 amongst hundreds of flint tools and fragments of flint washing out from the top of an old sand bar, beneath a deposit of peat. Just 400 m away there are cut timbers. The occupants of the settlement could have been making dugout boats, though the adze was used more for trimming and scraping wood, and not for gouging out. The water conditions are strong tidal currents with suspended mud and silt.
(Photo: Brandon Mason)

government issued a series of different new Statutory Instrument and Regulations then decided to wrap all the requirements into one Regulation under the Health and Safety at Work Act 1974. This Regulation would apply to all divers at work in all professions and many different environments from inland lakes and canals to the open ocean. The near impossibility of treating all divers as at similar risk using widely different techniques on different tasks resulted in a bureaucratic and technical battle of attrition.

At stake were the lives and safety of hundreds of diving scientists and students in Britain, as well as the careers of many dozens of senior university and institutional staff, diving officers, and diving supervisors.

The core of the conflict was the HSE attitude to scuba diving, and HSE proposals that the conduct and training for scuba at work should be carried out in a way that we knew to be both out-dated and dangerous. HSE Guidance Notes and Regulatory updates after 1981 combined good practical information to improve heavy commercial diving on the rigs with advice and mandatory instructions that made scuba diving more dangerous.

The chronological narrative of this controversy is related in Chapter 8 of my book (Flemming 2021,p. 307 – 308; p. 322- 339). In a nutshell the HSE, as advised by Commander "Jackie" Warner during the 1980s, required scuba diving at work to comply with the following criteria:

1. The cylinders used should be fitted with J-valve cut-off that obstructed the flow of air when there was still 30 – 50 atmospheres in the cylinder; the diver then had to pull a release lever on the cylinder on the diver's back that allowed the remaining air to be breathed, and then to surface slowly.
2. The scuba diver should not be equipped with a contents pressure gauge, and should not rely on a diver's watch or depth gauge.
3. The scuba diver should not be equipped with variable buoyancy such as Adjustable Buoyancy Life Jacket (ABLJ) or inflatable "wings".
4. The scuba diver should be on a lifeline to a tender on the surface, and should be controlled by rope signals to monitor duration and depth.
5. The scuba diver should wear a full face mask and use modulated ultrasonic through-water speech to a companion diver and to the surface tender. (Planned rule by HSE but not implemented).
6. The scuba diver at work should not have surface oxygen therapy available unless there was a doctor present.
7. The scuba diver should not dive below (a very limited depth) without having an on-site decompression chamber, or being within a short travel time of a chamber.
8. Decompression diving should only be conducted if there was a diving expert doctor present.
9. Scuba divers should not be trained in buddy breathing, octopus rig, or free ascents.
10. Working divers using scuba had to be trained and certified by a diving school recognised by HSE and teaching the approved HSE syllabus.

Stated baldly in this fashion the conditions proposed by the HSE for scuba divers at work seem almost unbelievable. But every statement above can be confirmed by the file of correspondence that I kept in the 1980s – 90s, and which I have donated to the HDS archive. In practice the written criteria listed above were distributed between and among many other rules, notices, and procedures so that their cumulative adverse impact was less obvious to the non-expert.

The instructions listed above were justified by the HSE as follows:

1. The diver could not be trusted to read a contents gauge accurately, and in any case could not read one when diving in zero visibility. Thus the J-valve cut-off was deemed a more reliable alternative for monitoring dive duration and surfacing rate. In practice, sports divers abandoned the J-valve cut off system in the early 1960s as inconvenient, difficult to use, potentially dangerous, and a very inaccurate safety factor taking no consideration of the diver's depth. This concern was enhanced in 1992 when 2 trainee divers from a university died during training at an HSE approved course using J-valves.
2. Although most scuba regulators were equipped with contents gauges by the early to mid-1960s, the HSE insisted that a diver reading the gauge could make a mistake. There was an across-the-board objection by HSE to the diver being trusted to read instruments and make decisions.
3. The HSE objected that trusting the diver to adjust buoyancy during the dive could lead to an uncontrolled ascent, or ascent under an overlying obstacle. This is possibly true in rare circumstances, but simple training and hundreds of thousands of safe dives, showed that the risk was minimal or non-existent. Two decades of experience with adjustable buoyancy had already saved many lives, and the device improved safety and comfort, while reducing effort expended during a dive.

4. The requirement that the scuba diver should always be on a tended rope or 'life-line' arose from the fear in the minds of desk-drivers and divers used to secure chambers, that the untethered free diver would get lost, or separated from surface support. There are indeed circumstances where a scuba diver is safest on a tended line, but there is also then a further risk of the line becoming entangled, or the diver being dragged by the moving surface vessel. By the mid-60s it was common for free-swimming scuba divers to tow a small surface float, so that their position was observed and tracked by surface boat cover. In water where divers can easily see each other, it was also common practice to have a surface snorkel swimmer who could track the divers' bubbles, and this was effective even in murky conditions. Thus a surface tended line is sometimes right, but should not be a mandatory procedure since it does not enhance safety in all conditions.
5. The requirement for a full face mask with voice communication arose as a 'high-tech' idea by desk-drivers. Commercial oil field divers always had voice communications by a conducting cable whether in surface-demand mode, or in a chamber, and they criticised scuba for lacking communications. This criticism was picked up by the HSE civil servants, who then tried to stipulate that through-water ultrasonic communications must be used. Graseby Electronics, the maker of an excellent divers' voice system which scientists sometimes used to record observations, was not happy with the proposal that their equipment should be regarded as a mandatory safety device. Voice messages could fail to be received accurately for many reasons, and the system should not be relied upon as a necessary safety link. Full face masks also produced problems in relation to sharing breathing gas between divers, and surface snorkel swimming after a dive.
6. By 1980 it had been established by French doctors in the south of France that breathing pure oxygen at atmospheric pressure on the surface immediately after a dive reduced the risk of damage after missing decompression stops, or an ascent that was too fast. The recommendation of surface oxygen therapy was quickly adopted by sports diving organisations in the UK and USA. The HSE banned this procedure for working divers, unless a doctor was present, on the grounds that oxygen was a medicine. Compliance with this instruction would have made working scuba divers less safe than sports divers.
7. The recommendations and instructions on the availability and proximity of a recompression chamber and a diving qualified doctor varied from time to time, and the SDSC requested moderation and relaxation of overly strict requirements. The HSE tried to make prescriptive mandatory rules that gave the diving officer no freedom of choice or decision. Diving on an offshore rig for a commercial company is very different from collecting algae from a cliff at a depth of 10m in a sheltered bay. Scientific divers would logically insist that a chamber was on site for dives conducted on a remote tropical atoll, or in the extreme Arctic, even if most of the diving was shallow. Conversely, they judged that it was safe to conduct dives requiring in-water decompression when close to the British coast without an on-site chamber.
8. The requirement for an on-site diving doctor also varied during the 20 years of confrontation, but was biased to the assumption that the diving was deep, and was on an offshore rig that could become isolated from the shore by a storm. Scientific divers adapted their decisions to the depth of dive and remoteness and available transport.
9. At the dates under discussion sports divers were trained in buddy breathing from a single regulator, sharing an octopus rig, and in the conduct of free ascent from 10 – 20m. Free ascents dropped out of training at the later dates. Nevertheless, for most of the period under discussion, these three procedures were taught to sports divers, and undoubtedly contributed to safety. They were not taught in the HSE- approved syllabus for scuba divers at work.

10. The scuba training certification for a working diver was known as HSE Part IV, and the syllabus prior to 1993 included the assumptions, techniques, procedures, and recommendations itemised above. Scientific divers who attended some of the early courses concluded that they were unsafe, and taught so badly that the trainee did not obtain accurate information. The SDSC encouraged divers to gain sports diving qualifications to the highest possible standard, and the CMAS Scientific Committee provided plastic identity cards stating that the holder was a 'Scientific Diver'. Scientific employers and divers did abide by the 1974 Health and Safety at Work Act, but we made our own well-informed decisions as to maximising safety. Laboratories sometimes combined together to run special courses that included working techniques often used by scientific divers such as seabed surveys, underwater measurements, and taking samples of rocks, sediments, or biota. For the modern Part IV training standards see (Health and Safety Executive 2014).

The various Regulations promulgated through government Statutory Instruments improved safety for commercial divers on the offshore rigs, but caused danger, inconvenience, loss of efficiency, and increased costs for scientific divers. Our response to successive regulatory cycles was to object in writing, and to explain how we proposed to maximise safety by other means. Our policy was supported by the heads and directors of various Government agencies employing divers, and by the safety officer of the Committee of Vice Chancellors and Principals (CVCP) on behalf of universities.

In 1992 there were four fatal accidents to divers in training in approved HSE courses, and two of these occurred to students from Plymouth University undergoing HSE Part IV training. This university was the only one sending trainees to an HSE Part IV course. The accidents were not reported in public, and there was no public analysis of the accidents with subsequent reports. This secrecy is surprising: any other commercial training school or sports diving training centre would probably have been closed down if 4 deaths occurred within 1 or 2 years during training. I heard about the accidents in late 1993, and enquired about details from the HSE and the University. The occurrence of the accidents was admitted, and I was told that all details were commercially confidential. I was appalled by this situation, which compared badly with the BSAC Diving Officers' Conference annual reports on all accidents and incidents (e.g. BSAC 2021). The public approach enables divers to learn from the examples, and provides evidence to improve training.

The SDSC in mid-1993 was already so concerned by the reduction in safety caused by the HSE Pt IV recommendations, if obeyed, that we considered taking legal action to require Judicial Review of the HSE under the 1974 Health and Safety at Work Act, alleging that the HSE was causing a reduction in safety for a large community of divers at work. I wrote in early November to a barrister, a Queen's Counsel, who gave me contacts with legal firms specialising in Judicial Review. Within a week the Department of Work and Pensions, the ministry that controls the HSE, called for a secret meeting at the highest civil service level to discuss diving safety, to be held at the head office of NERC.

The truth of the unsafe nature of the HSE Part IV training syllabus had finally been recognised at high level, and the Department had realised that they would face very damaging legal confrontations if the fatalities in diving schools became public knowledge or were picked up by the press. There were no minutes of the "secret" meeting, but it is described in my book (Flemming 2021, p 307 – 8; 333 – 4). The representatives of the Department and the HSE conceded that their standards and procedures had been inadequate, and that the Scientific Divers had developed methods that they, the HSE, could learn from. The outcome was that new Regulations were planned to become law in 1997, and the years from 1994 onwards were devoted to creating a set of Approved Codes of Practice (ACOPs) that would apply to different professional categories of diver. The system worked well, and is still in force today (2023) (Statutory Instrument 2776, 1997; Health and Safety Executive 2014a).

After the concessions from the HSE and when the negotiations had been started to revise the Regulations, I tried to obtain a full examination of the accidents in the HSE diving schools in 1992-93. This was rejected by the HSE, but they commissioned a general analysis of the sufficiency and safety of the HSE Part IV training syllabus, the course content and its practice. The result was a convincing document (Hicks 1994, OTH 94 447) that showed in exhaustive detail why the Part IV course was inadequate in exactly the ways that the SDSC had repeatedly claimed. It also showed that the use of the J-valve was dangerous, and that the divers should be taught more skills and techniques regarding use of instruments and self-rescue.

CONCLUSIONS

Scientific diving grew rapidly after 1955, and, as it expanded, with numerous projects of original underwater research, it needed an institutional framework and standards of practice and training to support it. In the UK these were achieved through the co-ordination and activities of the Underwater Association, the Scientific Diving Supervisory Committee, the CMAS Scientific Committee, and the European Scientific Diving Panel. (See Part 1 of this paper).

This paper (Parts 1 & 2) has described events as they developed within the UK, and this results in a lack of discussion of underwater habitats, which were used extensively during the late 20th century in many other countries (e.g. Earle 1976). Also, while some work was done by UK scientists using closed-circuit breathing kit, more emphasis on this technology was shown by scientific divers in the USA (e.g. Hamilton et al 1989; Nuckols et al. 1999; Lang 2001).

In the UK and Europe, the attempts of the HSE and the EDTC to dictate uniform prescribed legally enforced practices onto divers working in many different professions and industries was flawed from the start. OSHA in the USA recognised that different communities needed to use different types of equipment, worked in different conditions, and needed different guidance and rules. In the UK and Europe, unfortunately, it took from 1978 to 1997, 19 years, for the HSE and EDTC to recognise this fact. Equipment, medical knowledge, and professional objectives change and improve continuously and in different ways in each professional community. Legislators must work closely with experienced divers and their employers to maintain rules and constraints that are regularly reviewed and updated.

The Underwater Association performed a vital role in the early stages of scientific diving, but ceased to function in 1992. John Bevan organised a merger with the Society for Underwater Technology (SUT). The situation had changed since the 1960s, when it was very difficult for diving scientists to share expertise, and papers published in academic narrow-discipline journals seldom mentioned if diving had been used. In the absence of electronic search engines, it was impossible to assess the scope or scale of application of underwater observation, nor could one learn from other groups' experimental techniques. The organisation of national and international meetings, followed by publication of proceedings, was the best way to develop the subject. The UA lost membership in the 1980s at least in part due to the continuous mandatory and faulty directives from the HSE. As digital media and citation indices increased, experts preferred to publish in their subject-specialised journals, and did not need to attend meetings devoted to diving science. The ratification of the 1997 Diving at Work Regulations put diving for employed personnel on a sound basis, including the scientific and archaeological divers. Scientific diving has prospered quietly and efficiently in the 21st century, with no drama, no fatal accidents in the UK, and no bureaucratic confrontations. We established the secure foundations in the 20th century. New generations of divers have built on that success and managed the new technologies.

ACKNOWLEDGMENTS

The achievements described in this paper were attained by many hundreds of diving scientists, mostly in the UK, but with frequent international collaboration. I have adopted the formal academic style of bibliographic references so that the original work of these people can be tracked quickly if readers wish to do so. The creation of a multi-national community of diving scientists depended on frequent personal meetings, joint diving projects, and occasional committee sessions and practical workshops. I owe a profound debt of gratitude to many of the people mentioned in this article.

ANNEX: An annual list of the publications of the Underwater Association conferences under the running title 'Progress in Underwater Science' is attached to Part 1 of this paper (in *The International Journal of Diving History,* vol. 15, The Historical Diving Society, 2024)

BIBLIOGRAPHY

Bellamy, N., 1996. *A Quantitative Risk Assessment SCUBA DIVING,* Health and Safety Executive Report 0090. Paras Limited, http://www.hse.gov.uk/research/crr_pdf/1997/ crr97140.pdf

British Sub Aqua Club, 2021. *Annual Diving Incident Report. 2020.* Watson, J. and Peddie, B, 53 pp.

Directorate-General 1978. 'Social Affairs' and Directorate 'Health and Safety' Luxembourg, 1978. *Guidance Notes for Safe Diving compiled by the European Diving Technology Committee, Mines Safety and Health Commission, Industrial Health and Safety, Volume 1*, Commission of the European Communities.

Earle, S.A. 1976. 'Living and working in undersea laboratories'. In: *Proceedings, Fourth World Congress of Underwater Activities 1975*, Adolfson (Ed. q.v.) Vol. II, Section 1. Manned Underwater Systems, pp. 601-613.

Flemming, N.C. 1972 (Ed.). *Code of Practice for Scientific Diving.* Underwater Association. 50 pp.

Flemming, N.C., 1980. 'Safety Procedures and Training for the Scientific Diver' pp.137-176 in: *Technical and Human Aspects of Diving and Diving Safety. Document No. 3000/80E. 9 -10 October 1980.* Directorate of Health and Safety, Commission of the European Communities, Luxembourg.

Flemming, N. C. 1985. 'Law, scientific diving, and Codes of Practice in different countries'. p. 1-30 in: Mitchell C., (Ed.) Diving for Science 1985. *Proceedings of the joint international scientific diving symposium, AAUS-CMAS*, La Jolla, California, 330 pp.

Flemming, N.C., and Miles, D. (Eds), 1974. *Code of Practice for Scientific Diving, 2nd edition*. Swindon: Natural Environment Research Council. 86 pp.

Flemming, N.C., and Miles, D. (Eds), 1979. *Code of Practice for Scientific Diving, 3rd edition*. Swindon: Natural Environment Research Council. 82 pp.

Flemming 2021. *Apollonia on my Mind: Memoir of a paraplegic ocean scientist.* Sidestone Press. 494 pages. 179 illustrations, mostly colour. Paperback ISBN: 9789464260328 . Hardback ISBN: 9789464260335

Flemming, N.C. and Max, M.D. (Eds) 1987. *International Code of Practice for Scientific Diving.* UNESCO Marine Sciences Division, Technical Series, No. 53. Paris: UNESCO.

Flemming, N.C. and Max, M.D. (Eds), 1990. *Scientific Diving: A General Code of Practice.* UNESCO/CMAS/ Florida Sea Grant. ISBN 92-3-102641-0.

Flemming, N.C. and Max, M.D. (Eds), 1996. *Scientific Diving: a General Code of Practice, 2nd edn* Flagstaff, Arizona: Best Publishing/UNESCO Publishing.

Flemming, N.C. and. Lonsdale P.J., 1994. 'Scientific Diving in Europe: Report from the UK Scientific Diving Supervisory Committee'. In *European Diving Technology Committee conference, Harmonisation of Diving Standards in Europe*: 13-15 April 1994.

Gamble, J.C., Clark, P.F. and Pagett, R.M. (Eds). 1990. *Underwater Association Code of Practice for Scientific Diving. Fourth Edition.* For the Underwater Association for Scientific Research Ltd. Published by the Natural Environmental Research Council [1989]. Not paginated.

Hamilton, R.W., Crosson, D.J., and Hulbert, A.W. (Eds), 1989. *Workshop on Enriched Air Nitrox Diving. National Undersea Research Program*, Research Report 89-1, US Government Printing Office.

Health and Safety Executive, 1981. Certificates of Exemption Nos DOW/1/81. Archaeology, DOW/2/81. Journalism, DOW/3/81. Scientific Research replaced by DOW 1/86, DOW/4/81.

Health and Safety Executive, 2014. *Diving at Work Regulations (Part 1- Chamber sat and platforms and dynamic position; Part II – surface supply maximum depth 50m. Kirby Morgan mask and fins or boots; Parts III and IV are inshore engineering diving not deeper than 50m).* http://www.hse.gov.uk/diving/qualifications/approved-list.pdf

Health and Safety Executive 2014a. Scientific and Archaeological diving projects. *Diving at Work Regulations 1997. Approved Code of Practice and Guidance.* ISBN 078 0 7176 6596 9. HSE Books. 36 pages.

Hempleman, V., 1971. *Experimental Observations on Men at Pressures between 4 bars (100ft) and 47 bars (1500ft).* Report No. 1-71 Copy No. 10.

Hempleman, H.V. 1963. 'Tissue inert gas exchange and decompression sickness'. In: Lambertsen, C.J.; Greenbaum, L.J. (eds.). *Proceedings of the Second Symposium on Underwater Physiology* (Report). Washington, DC: Natl. Acad. Sci./Natl. Res. Council.

Hempleman, H.V. 1969. 'British decompression theory and practice'. In Bennett, P.B.; Elliot, D.H. (eds.). *The Physiology and Medicine of Diving and Compressed Air Work.* Baltimore: Williams and Wilkins. pp. 291-318.

Hennessy, T.R.; Hempleman, H.V. 1977. 'An examination of the critical released gas volume concept in decompression sickness'. *Proceedings of the Royal Society of London. Series B.* 197 (1128): 299– 313.

Hicks, M., 1994. Findings of a Human Factors study of HSE Part-IV diver training. Health and Safety Executive, *Offshore Technology Report* OTH 94 447.

Lang, M.A. (Ed). 2001. *Nitrox Workshop, Proceedings of the Divers Alert Network Workshop, November 3-4, 2000.* Divers Alert Network, Durham, NC. 197 pp.

Lang, M.A. & Sayer, M.D.J. (eds.) 2007. *Proceedings of the International Polar Diving Workshop.* Smithsonian Institution: Washington DC, 213pp.

Limbrick, J., 2002. *North Sea Divers: A Requiem.* New Generation Publishing.204 p. ISBN-10: 0755200365.

Nuckols, M.L., Clarke, J.R. and Marr, W.J. 1999. 'Assessment of oxygen levels in alternative designs of semiclosed underwater breathing apparatus'. *Life Support & Biosphere Science: International Journal of Earth Space.* 6 (3): 239–249. PMID 11542685.

Occupational Safety and Health Standards Board, 1979. *Draft Report of the Advisory Committee on Scientific and Technical Diving Operations.* Department of Industrial Relations, State of California.

Schenck, H.V., McAniff, J.J., 1973. *United States Underwater Fatality Statistics 1973,* NOAA Grant No. 4-3-158-31. Report No. URI-SSR-75-9.

Scientific Diving Supervisory Committee1998. *Advice Notes for the Scientific and Archaeological Approved Code of Practice. The Scientific Diving Supervisory Committee (SDSC).*Published by The Scientific Diving Supervisory Committee The Secretary SDSC c/o the Natural Environment Research Council Polaris House, North Star Avenue, Swindon SN2 1EU. ISBN 0 9533997 0 2

Statutory Instrument 399. 1981. *Health and Safety: Diving Operations at Work Regulations.* http://www.legislation.gov.uk/uksi/1981/399/pdfs/ uksi_19810399_en.pdf.

Statutory Instrument 1997 2776. *The Diving at Work Regulations 1997.* https://www.legislation.gov.uk/uksi/1997/2776/contents/made?view=plain

Warner, J. and Park, F. 1990. *Requiem for a Diver*. Brown Son and Ferguson, Glasgow. ISBN 0 85174 578 4.

Woods, J.D. 1969. 'Wave-induced shear instability in the summer thermocline'. *Journal of Fluid Mechanics* 32: 791-800.

WEBSITES

Cambridge University Underwater Exploration Group: http://cuueg.org.uk/
Nic Flemming: www.nicflemming.net
Scientific Diving Supervisory Committee: http://www.uk-sdsc.com/
European Diving Technology Committee, commercial diving standards: http://www.edtc.org/PRAG.htm
Society for Underwater Technology https://sut.org/
CMAS: https://www.cmas.org/en
European Marine Board Diving Panel: https://www.marineboard.eu/scientific-diving-panel
American Academy of Underwater Sciences: https://www.aaus.org/
British Sub Aqua Club: https://www.bsac.com/home/
Nautical Archaeology Society: https://www.nauticalarchaeologysociety.org
International Journal of Nautical Archaeology: https://www.nauticalarchaeologysociety.org/ijna
Cost-free access to e-book *Apollonia on my Mind* - https://www.sidestone.com/books/apollonia-on-my-mind

Dr. Nic Flemming is a diver, author and marine geo-archaeologist. He was Director of the British national oceanographic data centre from 1980 – 1987. He was chair of the Intergovernmental Oceanographic Commission, Committee on Data Exchange, and then Director of the European Office of the Global Ocean Observing System until 2001.

Since learning to dive on oxygen rebreathers in the Royal Marines Special Boat Service in 1956, he has spent over 60 years studying the long-term changes in the oceans, especially those that can be measured by observation of submerged and uplifted coastal cities and from measurements taken in submerged caves dating from the Ice Ages. He has recently published his memoir *Apollonia on My Mind* – an account of his life as a paraplegic ocean scientist and diver.

The Historical Diving Society
www.thehds.com

The Historical Diving Society was founded in England in 1990 with the aims of promoting and co-ordinating research into the history and development of underwater exploration and the preservation of associated archives and artifacts.
It is now widely represented internationally enabling a worldwide exchange of news, views and research which has uncovered much previously hidden material and in many instances, has dramatically changed the perception of diving history.
In addition to the Journal, the Historical Diving Society publishes a magazine, *Historical Diving Times*, monographs of rare works on diving history, videos on the history of diving, and the proceedings of its annual conference which is attended by speakers and guests from around the world.

To purchase copies of its publications and for more information about the Society visit the website, www.thehds.com, or email: info@thehds.com.

Registered charity No. 1159032
Company No. 9204944

978-0-9935076-8-7