## **Table of Contents**

| Introduction   | XIII |  |
|--|------|--|
| Chapter 1 - Why Investigate Diving Accidents?        | 17   |  |
| Accident Investigations Satisfy Needs                | 18   |  |
| Other Types of Investigations                        | 19   |  |
| Putting Dive Accidents in Perspective                | 19   |  |
| Risk Recognition for Divers and Diving Professionals | 20   |  |
| Financial Costs of Diving Accidents                  | 20   |  |
| Human Costs of Diving Accidents                      | 22   |  |
| Your Dive Accident Investigation                     | 22   |  |
| Case History – Recreational Diving Accident          | 23   |  |
| Chapter 2 - Modes of Diving                          | 25   |  |
| Snorkeling   | 26   |  |
| Skin Diving or Free Diving                           | 26   |  |
| Scuba Diving   | 26   |  |
| Risk Recognition for Divers and Diving Professionals | 27   |  |
| Scuba Certifications                                 | 27   |  |
| Surface-Supplied Diving                              | 29   |  |
| Hookah Diving  | 29   |  |
| Umbilical Diving - Air                               | 31   |  |
| Surface-Supplied Mixed Gas Diving                    | 32   |  |
| Bell Bounce Diving                                   | 32   |  |
| Saturation Diving                                    | 32   |  |
| Case History – Professional Seafood Diver            | 35   |  |
| Chapter 3 - Types of Diving Equipment                | 37   |  |
| Diver Worn Equipment vs. Support Equipment           | 37   |  |
| Diver Worn Equipment                                 | 38   |  |
| Face Masks   | 38   |  |
| Snorkels   | 38   |  |
| Fins   | 39   |  |
| Thermal Protection                                   | 40   |  |
| Dive Skins   | 40   |  |
| Wetsuits   | 40   |  |
| Dry Suits  | 41   |  |
| Hot Water Suits                                      | 43   |  |
| Weight Belts and Weight Systems                      | 44   |  |
| Buoyancy Compensators                                | 45   |  |
| Scuba Cylinders and Valves                           | 46   |  |
| Regulators   | 49   |  |
|  |      |  |

## **Table of Contents** 51 Instruments Submersible Pressure Gauge 51 Depth Gauges 52 **Dive Computers** 52 Rebreathers 55 Risk Recognition for Divers and Diving Professionals 55 Alternate Air Sources 56 Full-Face Masks 57 Wireless Communications 59 Diving Helmets 59 Bail-Out Systems 61 Support Equipment 61 High-pressure Air Compressors 61 Low-pressure Air Compressors 62 Communications Boxes 63 Breathing Gas Manifolds 64 Umbilicals Diving Stage 65 Open Bottom Bell 66 Decompression Chambers 66 Diving Bells 68 Saturation Systems 71 Life Support Modules (Environmental Control Unit) 72 Divers' Flags and Day Shapes 73 Case History -Recreational Diving Accident 74 Chapter 4 - Physiological Factors in Diving Accidents 77 Non-Fatal Diving Injuries 77 77 Squeezes Mask Squeeze 77 Middle Ear Squeeze 77 Sinus Squeeze 78 79 Contributing Factors in Diving Accidents Nitrogen Narcosis 79 Hypothermia 79 High Breathing Resistance 80 Exhaustion 81 Carotid Sinus Reflex 83 83 Hyperthermia Hypoxia 83 Hyperoxia 83 Carbon Dioxide "Poisoning" (CO2) 84 Drowning 85 Lung Over-Pressure Accidents 86 Risk Recognition for Divers and Diving Professionals 87 Carbon Monoxide Poisoning 87 Accidents Involving Boats 87 Decompression Sickness 88 Helmet Squeeze 90 Case History - Recreational Divers 91

Chapter 5 - Talents and Characteristics of the Dive Accident Investigator

93

93 93

Diving Experience and Knowledge

Technical Knowledge of Dive Gear

| Investigating Recreational & Commercial Diving                      | Accidents  |
|---|------------|
| Investigators Must Be Organized                                     | 94         |
| Risk Recognition for Divers and Diving Professionals                | 95         |
| Your Report is the Product of Your Investigation                    | 95         |
| Risk Recognition for Divers and Diving Professionals                | 95         |
| Photographs and Illustrations Make Reports More Interesting         | 96         |
| Investigators Must be Critical Thinkers                             | 96         |
| Investigators Must be Tenacious                                     | 97         |
| Investigators Must Be Personable                                    | 97         |
| Good Investigators Have No Opinion                                  | 97         |
| Investigators Must Be Discreet                                      | 97         |
| Case History – Introductory Diving Course                           | 98         |
| Chapter 6 - The Tools of the Dive Accident Investigator             | 101        |
| Digital Camera and/or Video   | 101        |
| Risk Recognition for Divers and Diving Professionals                | 103        |
| Laptop Computer   | 103        |
| Flatbed Scanner   | 104        |
| Handheld Organizer  | 104        |
| Color Inkjet or Laser Printer                                       | 105        |
| Voice Recorder  | 105        |
| Dive Gear   | 106        |
| Fiberglass Measuring Tape   | 106        |
| Slate   | 106        |
| Magnifying Glass  | 106        |
| Chalk   | 106        |
| Handheld GPS  | 107        |
| Oxygen Analyzer   | 107        |
| Air Sample Kit  | 108        |
| Other Specialized Equipment   | 108        |
| Charts and Maps   | 109        |
| Case History – Recreational Rebreather Diving                       | 109        |
| Charter 7. Provide for an Investigation                             | 111        |
| Chapter 7 - Preparing for an Investigation                          | 111        |
| Selecting People to Interview                                       | 112        |
| Selecting People to Interview in Recreational Diving Accidents      |            |
| Selecting People to Interview in Professional Diving Accidents      | 112        |
| Selecting People to Interview in Commercial Diving Accidents        | 112        |
| Developing Interview Questions                                      | 113        |
| Develop a Plan for Gear Inspection                                  | 113        |
| Locating Resources  | 113        |
| The Internet, Newspapers, and Libraries                             | 114        |
| Request Long Lead Documents Immediately                             | 114        |
| Check with Every Local Agency                                       | 115        |
| Risk Recognition for Divers and Diving Professionals                | 115        |
| Scheduling Interviews   | 115        |
| Check Out Your Equipment  | 116        |
| Know Where Everything is Located Case History – Recreational Divers | 116<br>117 |
|   |            |
| Chapter 8 - Conducting an Investigation                             | 119        |
| Your Personal Appearance is Important                               | 119        |
| Avoid Criticism or Suggestions                                      | 120        |
| Don't Cue Your Witness  | 120        |
| Interview One Person at a Time                                      | 120        |

## **Table of Contents**

| Be Prepared to Change Your Questions                                      | 120        |
|---|------------|
| Audio Recording of Interviews   | 121        |
| Videotaping Interviews  | 121        |
| Photographing People  | 122        |
| Conducting Interviews by Telephone  | 122        |
| Visiting a Dive Store Involved in a Sport Diving Accident                 | 122        |
| Visiting a Resort or Dive Boat Involved in a Sport Diving Accident        | 124        |
| Visiting Local Agencies   | 125        |
| Risk Recognition for Divers and Diving Professionals                      | 125        |
| Be Prepared to Show I.D.  | 125        |
| Have Documentation  | 125        |
| Be Prepared to Pay for Reports and Documents                              | 126        |
| Visiting the Fire Department  | 126        |
| Visiting the Police Department  | 127        |
| Visiting the Harbor Master  | 127        |
| Visiting the Lifeguards   | 127<br>130 |
| Visiting Back Bangara   | 130        |
| Visiting Park Rangers   |            |
| Foreign Investigations  | 130<br>130 |
| Employing an Interpreter Take Aputhing You Think You Might Need           | 131        |
| Take Anything You Think You Might Need<br>Local Customs Must be Respected | 131        |
| Bureaucracy Is the Same the World Over                                    | 132        |
| People May Tell You What They Think You Want to Hear                      | 132        |
| Medical Records are Confidential in Most Countries                        | 132        |
| Case History – Commercial Oilfield Diving                                 | 133        |
| Case History - Commercial Official Diving                                 | 100        |
| Chapter 9 - Inspecting the Dive Accident Site                             | 135        |
| General Environmental Factors That Affect All Diving                      | 136        |
| Kelp  | 136        |
| Currents  | 136        |
| Tides   | 138        |
| Thermoclines  | 138        |
| Underwater Visibility   | 138        |
| Low Temperatures  | 139        |
| Altitude  | 139        |
| Surf  | 139        |
| Overhead Environments   | 140        |
| Ice   | 140        |
| Wrecks  | 141        |
| Caverns and Caves   | 142        |
| Deep Sites that Require Staged Decompression Following the Dive           | 142        |
| Marine Life   | 143        |
| Risk Recognition for Divers and Diving Professionals                      | 143        |
| Beaches   | 143        |
| Day to Night Changes  | 143        |
| Diving the Site   | 143        |
| Photographing the Site Underwater   | 144        |
| Video   | 144        |
| Inspections of Recreational Sites   | 144        |
| Stairs to Entry Point   | 145        |
| Sites Where Sport Diving Accidents Occur Frequently                       | 145        |
| Catalina Island, California   | 145        |
| Monterey, California  | 146        |
| VIII  |            |

| Investigating Recreational & Commercial D                       | iving Accidents |
|---|-----------------|
| Florida   | 146             |
| Hawaii  | 146             |
| Lake Travis, Austin, Texas                                      | 147             |
| Cozumel, Mexico   | 147             |
| Inspecting Dive Boats and Other Vessels                         | 147             |
| Layout of deck  | 147             |
| Obtain a Copy of the Ship's log                                 | 148             |
| Location of Emergency Equipment                                 | 148             |
| Obtain a Copy of the Manifest                                   | 148             |
| Inspecting the Hull and Propeller of a Vessel                   | 148             |
| Case History – Recreational Diving                              | 150             |
| Chapter 10 - Non-Diving Accidents                               | 153             |
| Oxygen Fires  | 153             |
| Compressor-Fill Station Accidents                               | 154             |
| Eye Injuries  | 155             |
| Risk Recognition for Divers and Diving Professionals            | 155             |
| Sexual Harassment   | 156             |
| Slips and Falls   | 156             |
| Case History – Recreational Diving                              | 157             |
| Chapter 11 - What to Look for in a Recreational Diving Accident | 159             |
| Inspecting Equipment  | 159             |
| You are an Investigator, Not a Tester                           | 159             |
| Testing Equipment   | 160             |
| Confirm Serial Numbers  | 161             |
| Check Rental Numbers on Sport Scuba Gear                        | 162             |
| Check Inspection Tags   | 162             |
| Look for Gross Damage   | 163             |
| Check BC Pockets and Gear Bags                                  | 163             |
| Specific Inspection Points for Scuba Equipment                  | 164             |
| Mask  | 164             |
| Snorkel   | 164             |
| Fins<br>Description   | 164             |
| Dry Suit  | 164             |
| Buoyancy Compensator  | 164             |
| Cylinder Inspection   | 164             |
| Cylinder Valve Inspection                                       | 165<br>165      |
| Regulator Inspection<br>Regulator Testing                       | 165             |
| Weight Belt   | 166             |
| Dive Computer   | 166             |
| Seizing Evidence  | 166             |
| Spoliation of Evidence  | 168             |
| Risk Recognition for Divers and Diving Professionals            | 168             |
| Photographing Equipment   | 168             |
| Recreational Dive Store Records                                 | 169             |
| Air Samples   | 170             |
| Receipts for Purchases  | 170             |
| Training Records  | 170             |
| Case History – Recreational Diving                              | 171             |
|   |                 |
| Chapter 12 - Professional Diving Accidents                      | 173             |
| What is a Scientific Diver?                                     | 173             |
|   | IX              |

## Table of Contents Who Employs Scientific Divers? 173 Scientific Diving and the OSHA Exemption 174 American Academy of Underwater Sciences (AAUS) 174 The Role of the Diving Safety Officer 174 Scientists Do Many Types of Work 175 Scientists Use Many Types of Gear 175 Scientific Diving Sites 175 What is a Public Safety Diver? 176 Diving is Just a Part of the Job 176 Public Safety Divers Have an OSHA exemption 177 Public Safety Diving Equipment 178 Risk Recognition for Divers and Diving Professionals 178 Public Safety Diving Standards 178 Public Safety Diving Accidents 180 Recreational Scuba Instructors 180 Case History - Commercial Diving 181 Chapter 13 - Commercial Diving Accidents 183 The Organizational Environment in Commercial Diving Companies 183 Commercial Diving Regulations 184 OSHA Diving Regulations 184 State Regulations 185 U.S. Coast Guard Diving Regulations 185 The U.S. Coast Guard Takes Diving Accidents Seriously 185 Common Sites of Commercial Diving Accidents. 186 Diving Operations Management 186 Operations Manager (Ops Manager) 186 187 Diving Superintendent Shift Supervisor 187 Rack Operator 188 Life-Support Technician 189 Lead Diver 189 Divers 190 Diver-Tenders 191 Tenders 191 Risk Recognition for Divers and Diving Professionals 192 Dive Team Size 193 The Job-Site Environment 194 Job Hazard Analysis (JHA) 195 Company Safety Manual 195 Record Keeping 195 Use of Rental Equipment by Commercial Companies 196 Types of Commercial Diving Accidents 196 Construction Accidents 196 Polluted Water 196 Explosions' 197 Waterblaster Accidents 197 Pressure Differential 198 Lost Bell 198 199 Contaminated Breathing Air Saturation System Failures 200 Commercial Diving Accidents Involving Boats 200 What Happens When a Boat Snags a Diver's Hose 201 Accidents Involving Dynamically Positioned Vessels 201

| Investigating Recreational & Commercial D                 |     |
|---|-----|
| Jones Act Seaman Status                                   | 201 |
| Case History – Commercial Oilfield Diving                 | 203 |
| Chapter 14 - Preparing Your Report and Testimony          | 205 |
| Interpreting Documents                                    | 205 |
| Understanding the Autopsy                                 | 205 |
| Risk Recognition for Divers and Diving Professionals      | 208 |
| Creating a List of Persons Involved                       | 209 |
| Creating a Chronology                                     | 209 |
| Writing a Summary   | 210 |
| Writing the Gear Inspection                               | 210 |
| Include Photos and Drawings                               | 210 |
| The Appendix  | 212 |
| Table of Contents and Index                               | 212 |
| Confidentiality of Findings                               | 212 |
| Maintaining Files   | 212 |
| Testimony   | 212 |
| Case History – Recreational Diving                        | 214 |
| Recommendations to Help Avoid Commercial Diving Accidents | 216 |
| About the Authors   | 217 |
| Steven M. Barsky  | 217 |
| Tom S. Neuman, M.D., FACP, FACPM                          | 219 |
| Bibliography  | 221 |
| Index   | 223 |