COURSE OUTLINE FOR A SCUBA DIVING SPECIALITY "UNDERWATER SURVEY DIVER"

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ABSTRACT:

The purpose of this paper is to outline a course for the training of divers with a special interest in underwater surveying (e.g. surveyors, archaeologists, biologists, geologists, photographers/videographers). This outline presents: i) the Courses' Standards ii) the Learning Objectives for the related Knowledge Development, iii) the Skills that have to be conducted, iv) the Performance Requirements for the students and v) the Open Water Considerations for the Training Dives. It is expected that the resulting course outline will be used as a reference for the training of certified divers who want to become underwater surveyors, providing them basic knowledge and skills to survey adequate data for the detailed documentation of submerged features. Moreover the combination of knowledge (what) and the skills (how) that are presented during the proposed course attempt to define a protocol for the recording of underwater features in favor of mapping and 3D modeling.

1. INTRODUCTION

As the scuba diving community is growing, more people are getting in contact with natural or cultural features of the marine environment. Wrecks, conservation areas, underwater museums, thematic designated diving sites and scout diving are offering an extensive field for the explorers of the underwater environment and history. What about all those divers who want to share the details of their explorations? Many of them, during their scuba activities are using their cameras for taking photos or videos, while others have developed the ability to observe and keep track of underwater features either for their navigation or for search and recovery purposes. All of them have the readiness to spot and provide some kind of information for a place that they have dived. Furthermore, the participation in underwater surveys (e.g. for debris monitoring or identification of marine species) and the mapping of new diving sites have introduced in the diving community the habit of taking notes or sketching in favor of a more detailed documentation. Divers with such kind of experience have probably already developed additional skills, beyond their diving ones, for the representation of underwater features. Occasionally there is another type of diver, such as the surveying expert, the researcher or the scientist, who is bringing a "know how" in the procedures of surveying and mapping and who could apply this knowledge for an objective representation of underwater features with the accuracy of map or the fidelity of a three-dimensional (3D) model. The integration of the above groups of divers gives a challenging opportunity for a systematic recording, the modelling and the monitoring of submerged features.

Appropriate training for in-water activities is crucial in order to assure safety. Moreover scuba diving for recreational purposes has to be an enjoyable experience. Diving is an activity that can be performed in a variety of environmental conditions (e.g. open sea, freshwater, covered surface etc) and may involve the use of special equipment beyond the standard one of a diver (see cameras, reels, marking buoys etc). Thus, several training organizations provide the adequate education for each type of diving, mostly known as diving specialities. Standards for the training of divers apply in order to maintain an overall quality of a scuba course and lead to a worthwhile certification occasionally acknowledged by international educational and vocational training authorities (PADI, 2015a). Educational research and practical application has proven that objectives are a useful, fundamental tool in the instructional development, delivery and learning process, so a major concern during the formation of a course content is to clarify i) what a learner should be able to do, ii) under what conditions the learner will be able to do it and iii) how well it must be done (Wohlers, 2015). By answering to the above questions it is attempted to conform with the educational standards that have established for the training of divers and apply for an official recognition of the proposed course. Professional Association of Diving Instructors (PADI) is the world's leading scuba diving training organization. All PADI programs, from entry-level through scuba instructor training, fall under strict educational standards monitored for worldwide consistency and quality. PADI courses are certified as compliant with ISO standards for Recreational Diving Services by an independent auditor, the European Underwater Federation and the Austrian Standards Institute. The ISO standards relate to five levels of diver, two levels of instructor and a service provider or dive center. Each of those standards equate to a PADI certification or member level, which means that, in effect, divers or members holding one of these qualifications can also be said to have met the requirements of the relevant ISO standard (PADI, 2015b).

The perspective of applying to PADI for the recognition of a new course entitled **"Underwater Survey Diver"** has structured the presented outline in six sections, according to Rockwoods' guidelines (2010) and following the PADIs' Distinctive Specialty Course Template (PADI, 2015c). The first one gives a general description of the course mentioning the goals. The second lists the Standards for the instructor, the students, the conditions and the educational material. Third section describes the Learning Objectives for the related Knowledge Development. Fourth section presents the Skills that

have to be conducted during the Confined Water Dives. Performance Requirements for the students during the Confined and the Open Water Training Dives are explained in the fifth section and follows another one for the Open Water Considerations for the Training Dives. At an additional seventh section are discussed the conclusions of this effort.

The content of the proposed course has resulted from the experience of the author gained during the underwater archeological researches of Hellenic Institute of Marine Archaeology (HIMA, 2015), working as a scuba diving instructor certified by PADI and as a surveying engineer involved in projects for the documentation and promotion of natural and cultural features of the Aegean archipelagos.

2. COURSE DESCRIPTION

2.1. Course Philosophy

Several diving skills are combined during an underwater survey and new tasks are introduced in the dive plan (Green et al, 2007; HIMA, 2015; Holt, 2007; Leatherdalea et al, 1991). Adequate planning, simplification and delegation of tasks as well as teams' preparation and proper use of special equipment are essential for a dive towards the mapping or the 3D modeling of underwater features (Demesticha et al, 2014; Pizarro et al, 2009; Shortis et al, 2009, Telem et al, 2010).

The development of knowledge and skills for the planning, the teams' preparation and the proper use of special equipment for an underwater survey is the scope of this course. Post-diving procedures for processing of survey data towards the mapping or the creation of 3D models are beyond the purpose of this introductory course but they are also described as an optional chapter of the knowledge development for those who have a special interest in mapping and 3D modeling. That is, even non - divers with such an interest may be involved in this optional part of the course.

According to PADIs' philosophy this course should be mainly an introduction to Underwater Surveying that intends to familiarize divers with the skills, knowledge, planning, organization, procedures, techniques, problems, hazards and enjoyment of diving. That is, such a course is intended to serve as a safe and supervised introduction to Underwater Survey diving while the training emphasizes safety and fun (PADI, 2015c).

2.2. Goals

The goals of the proposed training course include:

1. The development of knowledge that relates to the use of maps.
2. The introduction of students in planning and organization of an underwater survey.
3. The familiarization of participants with the special skills, procedures and techniques for an underwater survey.
4. The determination of problems and hazards of an underwater survey.
5. The development of teams' spirit among the participants.
6. The enjoyment during a collaborative diving activity.

2.3. Principals

The proposed course contains a knowledge development session, a confined water skill development session and three open water training dives. The knowledge development is divided into two sections. The first one should be conducted before the confined water one training. The second one may follow the open water dives one and two, it is optional and could be attended by non-divers as well. The confined water skill development session must precede the open water training dives. There are three open water dives to complete. Skill sequences should not be altered within each dive and the sequence of dives must stay intact as well. More dives may be added as necessary to meet student divers' needs. The course is organized in such a way to incorporate environment friendly techniques throughout each dive, to accommodate student diver learning style and logistical needs.

3. STANDARDS

The following standards have applied in order to outline the course and conform with PADI guidelines for the preparation and the application of a new Distinctive Specialty.

3.1. Minimum Instructor Rating

It is considered essential that the instructor of this course should have the background to conduct the knowledge development session and the dive training. Apart the instructors' qualification, an academic title on a discipline that relates to surveying and mapping (e.g. Surveying Engineer or Cartographer) or documented experience in underwater surveys is highly recommended. The **PADI Underwater Survey Diver Distinctive Specialty Instructor** rating is expected to cover this standard.

3.2. Prerequisites and Minimum Age

For the divers that participate in the course the proposed prerequisite is to be at least a PADI **Advanced Open Water Diver** with at least one **Peak Performance Buoyancy Adventure Dive** and one **Search and Recovery Adventure Dive**. The minimum age of a participant should be **15 years**.

3.3. Ratios Open Water

The Students per Instructor ratio is set to **6:1** in order to maintain direct control of all activities and ensure that all performance requirements are met during the course. Two more students may be added for one certified assistant.

3.4. Site, Depth, Maximum Depth

Choosing of sites with conditions and environments that are suitable for completing requirements is an essential consideration for this course. Environmental conditions and logistical challenges are crucial for the accomplishment of any underwater survey. Shallow dives will provide divers with more time to complete tasks. Sites with currents or surge should be avoided and good visibility conditions (more than 15 m) should be preferably met. The recommended depth for the open water dives is **6-12 m** with a maximum depth of **18 m**.

3.5. Hours, Minimum Confined and Open Water Dives

The proposed duration of the course is **20 hours** in which are included one knowledge development session, minimum **1**

Confined Water Dive and **2 Open Water Dives**. As many optional mini dives can be included in the confined water session of the course, after the participants have completed the development of all the confined water skills. Allow 2 hours for each optional mini dive. Another 10 hours may be added for the optional part of the course which includes knowledge development two, confined water dive two and open water dive three.

3.6. Materials and Equipment

An instructor should use the presented outline (Underwater Survey Diver Course Instructor Outline) as a guide for this course. The use of all s**tandard diver equipment** (mask, snorkel, fins, gas tank, BCD with low pressure inflator, primary regulator and alternative air source, SPG, depth monitoring device, quick release weight system, exposure protection suit, audio signaling device for the surface, RDP and time device or dive computer) plus a compass and a diving knife are mandatory for each student. Supplementary a visible signaling device and a marker buoy with dive flag for the instructor and the certified assistant are required (PADI, 2015d).

A supplementary list for the **special equipment** of this course includes:

1. Nautical map of the area (large scale).
2. Metallic poles (bronze is recommended) 50 cm each (at least 4 per pair).
3. Hammers (one per pair).
4. Retractable reels at least 30 m (1 per pair).
5. Surface Marking Buoys with retractable reels (1 per pair).
6. Several thin plastic cards (size postcard - 9 X 13cm) in bright yellow color (at least 10 per pair).
7. Permanent markers.
8. Thin cord or coated wire for tying (several metres).
9. Blank slates (size A4 - 21 X 30 cm) with underwater pens or pencils (1 per pair).
10. Digital underwater photo/video cameras (1 per pair).
11. Plastic measuring tapes at least 10 m long (1 per pair).
12. Metallic ruler 50 cm long (1 per pair).
13. Plummet tied with 1-1,5 m line and a small floater (1per pair).
14. Underwater carrying net/bag (1 per pair).

4. KNOWLEDGE DEVELOPMENT

According to Wohlers (2015), well-written objectives have three basic characteristics that answer three questions: i) what should the learner be able to do?, ii) under what conditions the learner should be able to do it?, and iii) how well must it be done?

An objective always says **what a learner is expected to be able to do**. Expected student behavior in an objective is always stated as a verb - describe, list, recall, state, recite, demonstrate, perform, dive, clear (as in a snorkel), hover, etc. Words such as know, understand, appreciate and enjoy are not used to develop objectives because they are open to many interpretations. An objective is useful only to the extent that it specifies what learners must be able to do or perform when they demonstrate mastery of the objective. The most important and indispensable characteristic of a useful objective is that it describes the kind of performance that will be accepted as evidence that the learner has mastered the objective.

An objective should describe only the important and necessary **conditions** (if any) **under which the performance is to occur**. Conditions typically include, but are not limited to environmental factors, other people factors, equipment factors, problem definition and time factor. Not every objective needs a condition. Some objectives are clear enough without them. The rule is to add enough description to an objective to clearly explain what is expected of a diving student.

Wherever possible, an objective describes the degree or criterion of acceptable performance by describing **how well the learner must perform** in order to be considered acceptable. Speed, accuracy and quality are three common ways of describing the criterion of acceptable performance. This is how well the learner must perform in order to be considered acceptable.

4.1. Learning Objectives

Considering the above three characteristics and the structure of the course, the learning objectives are developed during two sessions. The first one includes basic knowledge for the mapping and the second, which is optional, more specific ones for the 3D modeling of submerged objects/features.

4.1.1. Knowledge Development One

By the end of knowledge development one, student divers should be able to:

1. List three natural and two cultural underwater features.
2. Describe what the geographic, the projection and the relative coordinates are.
3. Describe what a nautical map is.
4. State the difference between a sketch and a diagram.
5. State what bathymetry and elevation are.
6. Find the coordinates of a point on the nautical map.
7. Demonstrate proper orientation of a nautical map using a compass.
8. State what a backsight is.
9. Demonstrate proper orientation of a nautical map without a compass.
10. Perform three backsights from a given position and list its coordinates and depth/elevation using a compass and a nautical map.
11. Describe how coordinates are calculated with a GPS device.
12. Demonstrate setting up an approximately 2 X 2 meters grid.
13. Demonstrate sketching the content of the grid.
14. Demonstrate the calculation of the depth/elevation difference between two points.
15. State what the slope distance is.
16. Recall the relation between slope and horizontal distance.
17. Demonstrate the calculation of the relative coordinates of the grids' corners.
18. Demonstrate drawing a diagram representing the grid.
19. Perform at least two horizontal measurements from the grids' corners to one point within the grid, using a measuring tape and a plummet.
20. Calculate the relative coordinates of a point, using the horizontal measurements, a ruler and a diagram.
21. Demonstrate drawing a diagram representing the content of the grid.

22. List the minimum special equipment that may used for an underwater survey towards the drawing of a diagram.
23. List the considerations during the planning and the organization of an underwater survey towards the drawing of a diagram.
24. Demonstrate writing a report for an underwater survey dive.

4.1.2. Knowledge Development Two (optional)

By the end of knowledge development two, student divers should be able to:

1. Describe what a photo-mosaic is.
2. State what ground-truth points are.
3. Demonstrate taking vertical measurements towards depth/elevation calculations, using two reference points with known depth/elevation, a measuring tape, a ruler and a plummet.
4. State what a surface profile/intersection is.
5. Demonstrate drawing a surface profile between two reference points with known depth/elevation, using a measuring tape, a ruler and a plummet.
6. Describe what a Digital Surface Model is.
7. Describe what an orthophoto is.
8. State the difference between an orthophoto and a 3D model.
9. List the minimum special equipment that may used for an underwater survey towards the 3D modeling of a submerged object/feature.
10. Describe the main procedures during an underwater survey towards the mapping or the 3D modeling of a submerged object/feature.
11. Describe the main procedures after an underwater survey towards the mapping or the 3D modeling of a submerged object/feature.

5. CONFINED WATER DIVES

All underwater skills should be done without touching the bottom or breaking the surface, performing proper breath control and demonstrating proper use of special equipment. Buddies are enforced to collaborate for the accomplishment of tasks.

5.1. Confined Water Dive One

By the end of the basic confined water training session, student divers should be able to:

1. Decent while holding the underwater carrying bag/net with all necessary special equipment.
2. Swim around for at least for 1 min holding the underwater carrying bag/net with all necessary special equipment.
3. Hover for at least 30 sec holding the underwater carrying bag/net with all necessary special equipment.
4. Swim around and leave one metallic pole every approximately 2 metres, with minor use of BCD.
5. Sketch the relative position and direction of each metallic pole, demonstrating proper use of the blank slate and the compass.
6. Measure and write down the depth readings at two distant points, demonstrating proper use of the depth monitoring device or the dive computer.
7. Calculate the difference of the depth between two distant points.
8. Measure and write down the slope and horizontal distance readings between two points, demonstrating proper use of the plastic measuring tape and the plummet.
9. Place the metallic ruler at the bottom in such direction to point the north, demonstrating proper use of the compass.
10. Take an almost vertical shot of the metallic ruler, demonstrating proper use of the photo/video camera.
11. Swim around and pick up each metallic pole with minor use of BCD.
12. Exchange the underwater carrying bag/net with all necessary special equipment between buddies with minor use of BCD.

5.2. Confined Water Dive Two (optional)

Two additional skills should be conducted for those divers who have participated in the optional Knowledge development session. By the end of the optional confined water training session, student divers should be able to:

1. Take a sequence of at least 4 almost vertical shots with approximately more than 60% overlapping on the sequential frames, demonstrating proper use of the photo/video camera.
2. Take two stripes of at least 4 almost vertical overlapping frames each, following a U-pattern with approximately more than 30% overlapping between the stripes and 60% between the sequential frames, demonstrating proper use of the photo/video camera.

5.3. Mini Dives

After having complete the development of the above skills, one ore more mini dives may be included in the confined water session. Students should have the time to plan and organize the mini dive by scheduling and delegating the tasks among the group. It is enforced to use a realistic scenario, share rules among participants and perform as a team during each mini dive.

6. PERFORMANCE REQUIREMENTS

In this section are described the training dives of the course. Each open water dive is listed separately, with details concerning the planning, preparation and the exercises that are introduced. Each dive have course specific objectives for the students to accomplish which are pertinent to the specialty being conducted. Typically, each list should begin with the suiting up, the predive safety check and the buoyancy check at the surface, followed by the new skills and ending with the dive for fun and practice and the ascent. Those common objectives have been omitted from the following lists. The requirements are described in such a way so the instructor may evaluate the performance of each student.

6.1. Open Water Dive One

By the end of the first open water dive, student divers are expected to be able to:

1. Plan a dive for the recognition, the marking and the sketch up of the area with the submerged object/

feature to be surveyed, including the preparation and use of special equipment, delegation of underwater tasks, underwater communication, gas/depth/time limitations, entries and exits.
2. Search an area approximately 30 x 30 meter, either form the surface or underwater to find the submerged object/feature to be surveyed, using any search pattern.
3. Deploy a delayed surface marker buoy (DSMB) from underwater to mark the location of the submerged object/feature.
4. Take photos or video for an overview and details of the submerged object/feature
5. Put the metallic poles approximately every 2 metres to describe the area of the submerged object/feature in a rectangle.
6. Deploy the retractable reel to set up a grid over the submerged object/feature with grid cells of approximately 2 X 2 metres.
7. Use the blank slate to sketch up the submerged object/feature in accordance to the grid cells and to take notes.
8. Remove the DSMB.
9. Write a report for the dive.

6.2. Open Water Dive Two

By the end of the second open water dive, student divers are expected to be able to:

1. Plan a dive for the measuring of depths and horizontal distances within the area of the submerged object/feature to be surveyed (including the preparation and use of special equipment, delegation of underwater tasks, underwater communication, gas/depth/time limitations, entries and exits).
2. Attach the plastic cards on the metallic poles or characteristic points of the submerged object/feature.
3. Use the depth monitoring device of dive computer to measure the depth of each control point (metallic poles or characteristic points of the submerged object/feature).
4. Use the plastic measurement tape and the plummet to measure horizontal distances between the metallic poles and the characteristic points of the submerged object/feature.
5. Use the blank slate with the sketch of the submerged object/feature to write down the depth readings and the measured horizontal distances.
6. Use a compass to orient the metallic ruler pointing the north, next by a characteristic detail of the submerged object/feature.
7. Use an underwater photo/video camera to take an almost vertical shot with the characteristic detail of the submerged object/feature including the metallic ruler pointing the north.
8. Retract the reel, remove the metallic poles and all special equipment from the area of the submerged object/feature.
9. Write a report for the dive.

6.3. Open Water Dive Three (optional)

By the end of the third open water dive, student divers are expected to be able to:

1. Plan a dive for the photographic/videographic coverage of the area with the submerged object/ feature to be surveyed (including the preparation and use of a photo/video camera, delegation of underwater tasks, underwater communication, gas/depth/time limitations, entries and exits).
2. Use an underwater photo/video camera to take two stripes of at least 4 almost vertical overlapping frames each, following a U-pattern. The sequential frames should overlap approximately more than 60% and the stripes more than 30%.
3. Retract the reel, remove the metallic poles and all special equipment from the area of the submerged object/feature.
4. Write a report for the dive.

7. TRAINING CONSIDERATIONS

Although specialty diver courses should not rehash entry-level skills (Wohlers, 2015) and the prerequisite for the participants of this course is to be a PADI Advanced Open Water Divers with proof of experience in Peak Performance Buoyancy and in Search and Recovery dives, it is highly recommended to insist in remind the relevant skills before any open water dive. Certified assistants may conduct a mini dive as an optional confined water session before the open water training in order to emphasize in the planning and organization of underwater survey dives.

Realistic conditions should be met during this course. A mixed coverage of the bottom (e.g. sand, gravel, formations of small rocks and low vegetation) with a smooth inclination (no more than 15%) of the survey area will provide an efficient field for the training. The existence of a submerged cultural feature (e.g. wreck or underwater constructions) would stimulate participants' interest. All underwater skills should be done without touching the bottom or breaking the surface, performing proper breath control while demonstrating adequate use of the special equipment. During the dives buddies are enforced to work together towards the accomplishment of tasks. Moreover delegation of sequential processes among groups of divers will develop a teams' spirit which is essential during any surveying project.

8. CONCLUSIONS

Several skills from other diving specialties could be incorporated with those of the proposed course for the accomplishment of an underwater survey. Such specialties are those of Multilevel, Underwater Navigation and Surface Marker Buoy for the planning and the preparation of a survey dive, Digital Underwater Photography, Videography and Against Debris for the optimization of the recording processes, Altitude, Cavern, Deep, Ice and Wreck for the adaptation to various environmental conditions and Boat, Enriched Air, Dry Suit, Propulsion Vehicle or Side Mount for the facilitation of the diver (PADI, 2015d). The Precision Dive Distinctive Specialty Outline presents advanced techniques related to the equipment configuration, fine tuning, dive planning and communication that might be helpful to the participants of this course and moreover those of an underwater surveying project.

Considering the proposed outline as a general protocol for the documentation of submerged features, it is expected to facilitate the planning and the implementation of underwater surveys.

Researchers and experts from related disciplines (e.g. geology, biology, archaeology, informatics, engineering) are expected to contribute by proposing and introducing additional or alternative procedures according to their needs and in order to cope with more specific issues.

For the academic community, potential application of such a course in the curriculum of educational institutions or as vocational training aside with the expansion of the diving industry could lever the transfer of knowledge, the exchange of personnel and students between institutions, as well as the development of new specializations or multidisciplinary studies.

Simultaneously, by providing this diving specialty to the underwater enthusiasts (e.g. scout divers, photographers, wreck divers), it is expected to motivate them in the documentation of the unexplored part of shallow water as well as at the continuous monitoring of already mapped natural or cultural features.

Finally, non-divers who may attend the optional part of this course are getting in the diving community and are becoming potential contributors in underwater survey projects (e.g. on board personnel, post processing experts).

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