I. INTRODUCTION

The Unidad de Tecnología Marina (UTM), belonging to the Spanish Research Council (CSIC), is the main service provider to the Spanish marine research community. It manages different sea-going facilities as well as the Spanish Antarctic Station. Since late 2010 it has been operating two small Autonomous Underwater Vehicles (AUVs).

The main missions for such vehicles are the use as test beds for sensor R&D and instrument platforms for marine research in littoral and shallow waters. Part of the initial operations policy was to try to minimize risks during training operations as part of a confidence build-up period, during this time broad safety directives were issued as well as a general insurance policy. During these past two years some of the procedures have been optimized and during the present paper we will present the current risk mitigation policy using three different scenarios where we have been working.

II. OPERATIONAL RISKS ON COAST WATER OPS.

During the last years several approaches have been made to try to quantify the ongoing risks on AUV operations on different scenarios. Different scenarios have been studied [1] and coastal surveys have been recognized as one of the most challenging scenarios for AUV [2]. Potential risks are numerous, and can include both environmental hazards and risks derived from human activity. With the purpose to achieve a high survival probability, a risk mitigation strategy is necessary.

III. PRACTICAL CASES

In order to illustrate the problem and the solutions taken we will use three different cases that we have been working:

**Port Forum (Barcelona):**
Located 2 n.m. North of Barcelona Port. This area is outside the commercial ship lines but has two nearby marinas with moderate to high motor boat activity, mainly in summer time. The area is shallow (20 – 50 m) and has two sewage pipes (one inactive) that can be used for target location tests. This area is used for sensor and vehicle testing as it is only 40 minutes away from our premises.

Main hazards in this area are (in order of importance):
- Motor board traffic (only in summer)
- Artisanal fishing (early hours of the day)
- Besos river discharge (episodic)

**Sada (La Coruña):**
The study area was located on a small bay on the Rías Altas. One of the most important economic resources of this area is the mussel culture. Environmental studies of these sites is essential to determine the conditions for optimal growing rates and they also could help to predict toxic algae blooms that could lead to farm and economical closure[3].

The study was conducted under a worst-case scenario setup. Main hazards in this area are (in order of importance):
- Strong industrial activity. It’s a mussel farm area with high activity along the year.
- This zone is located on a small bay, with a beach surrounded by rocky cliffs.
- The seafloor below the mussel farm is full of debris, including anchors, ropes and mussel lines.
- This region suffers adverse weather during autumn and winter seasons.

**Port Soller (Mallorca):**
This natural Port is located in the NW coast of Mallorca Island, it is a very touristic place along the year, but especially during the summer season. The study area has two sections. On one hand, the military harbour output and the entrance of the recreational boats (max. depth 15 m). On the other hand, the second section is situated close to a cliff, in a deeper area.

In this case, the objectives of this mission were to check the entrance of seabed with a side scan sonar and to film the seagrass areas. The main hazards in this area were (in order of importance):
- Motor board traffic and anchored boats.
- Natural risk (depth, rocky coast, etc).

IV. RISK MITIGATION PROTOCOL

In order to reduce the risk of the AUV operations a small protocol has been developed. The procedure is divided in three phases and the basic outline is as follows:

1. **Information phase.**
   Information on potential hazards in the study area is collected, directly by us and requested to the IP’s who has interest to are work in the area. This should include:
   - Recreational activities (divers, motorboats, etc.)
   - Fisheries / industrial activities
   - Local authorities contacts (Police, Coast Guard, Port Authority, etc.) in case some of the AUV activities could be in their area of influence / surveillance.
   With this information the most probable hazards are identified and appropriate mitigation measures are investigated.

2. **Execution phase.**
   Mitigation measures are studied and carried out just before the execution of the survey, this can include pre-survey meetings with authorities, dive checks in the area to geo-locate for potential risks, etc.
   Also, if possible AUV surface missions are run to check navigation and currents.

3. **Analysis phase.**
   Analysis and record of the results of the risk mitigation protocol to enhance security of future surveys in the area.

V. CONCLUSIONS

AUV’s are still a highly unknown tool on the Spanish Scientific community, the UTM has started to use them and a risk mitigation policy has been established. Risk mitigation protocols can be embarrassing and time consuming, but can be advantageous when the vehicle is working on repetitive surveys on relative small areas, increasing the security and productivity of such surveys.

So far most of the missions have been short ranged (less than 2 hours) and a tight monitoring has been provided for the longer lines. Due to technical problems last year and a low rate of use we do not have yet enough data to make a consistent analysis of the results of this policy, to address this problem, a new reporting protocol is being implemented to fill the data gaps and establish a database which can help to improve our operations in the near future.

REFERENCES: