Date of Submission	April 2026

IPL Project (IPL-277) Annual Report Form

Period of activity under report
from 1 January 2025 to 31 December 2025

1. **Project Number and Title: Project IPL-277. Rock failures in coastal carbonate cliffs: susceptibility, hazard assessment and monitoring**

2. **Main Project Fields**

   Select the suitable topics. If no suitable one, you may add new field.

   (1) Technology Development

   B. Hazard Mapping, Vulnerability and Risk Assessment

   (2) Targeted Landslides: Mechanisms and Impacts

   A. Catastrophic Landslides

   (3) Capacity Building

   B. Collating and Disseminating Information/ Knowledge

   (4) Mitigation, Preparedness and Recovery

   A. Preparedness

3. **Name of Project Leader: Isabella Serena Liso**

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   Core members of the Project: **Mario Parise, Piernicola Lollino, Giuseppe Mastronuzzi (all of them belonging to Earth and Environmental Sciences Department, University Aldo Moro, Bari, Italy)**

4. **Objectives** (5 lines maximum)

   The project focused on identifying coastal cliff instability sites in soft carbonate rock masses and analyzing preparatory and triggering factors, with particular attention to sea storm impacts and karst processes. It investigated key hydrogeological and geotechnical variables controlling the landslide susceptibility and supported the modelling of coastal failures. Activities also included susceptibility and hazard mapping.

5. Study Area

The study area is located in southern Apulia (Salento Peninsula), along a stretch of about 4 km of the Adriatic coastline, within the municipality of Melendugno, and extends from the Grotta della Poesia sinkhole system to Sant'Andrea. It belongs to the Apulian foreland and is characterized by Mesozoic carbonates overlain by Miocene–Pleistocene calcarenites, calci-siltites, and sandstones. Coastal cliffs mainly develop in weakly cemented deposits, structurally controlled by dense fault and joint systems that strongly condition the stability of the rock mass. Morphologically, the area consists of a gently seaward-sloping carbonate plateau with marine terraces, karst depressions, and an irregular coastline including cliffs, pocket beaches, and bays. Typical landforms include abrasion platforms, notches, caves, and sinkholes, reflecting the strong interaction between atmospheric, marine and land processes. The hydrogeological system is dominated by a basal karst aquifer with local perched water tables in the overlying units. The area is affected by intense coastal erosion and cliff retreat, with widespread instability phenomena such as rockfalls, topples, and block failures, often triggered by wave undercutting and intensified by weathering processes. Failures are frequently associated with extreme meteo-marine events and heavy rainfall, with limited precursory signs. Karstification further increases the susceptibility to failure by weakening the mechanical properties of the rock mass through development of subsurface voids, up to sinkhole formation, as exemplified by the Grotta della Poesia system. Due to its high touristic and cultural value, including nearby archaeological sites (Roca Vecchia), the area comprises important elements at risk that are highly exposed to geomorphological hazards, requiring continuous monitoring and mitigation measures.

6. Project Duration: 3 years

7. Report

1) Progress in the project (30 lines maximum)

During 2025, activities of the project focused on the collection of ancillary and field data, detailed geological surveys, and meteo-marine data analysis and modelling.

Ancillary and field data collection: A monitoring system installed along the coastal cliff, consisting of fixed cameras and crack-meter (extensometer) sensors to continuously measure fracture aperture and detect changes in the rock mass in near real time, has been integrated with UAV-based surveys and photogrammetric techniques (Structure-from-Motion), enabling the quantification of volumetric variations of the cliff and the identification of ongoing instability processes. In addition, a comprehensive database of past failure events along the coastline was compiled from multiple sources.

Field geological survey: Field investigations were conducted to characterize the geological, geomorphological, and hydrogeological features controlling cliff instability. Particular attention was paid to stratigraphy, discontinuity sets, and presence and distribution of karst features. These elements strongly influence rock mass anisotropy, permeability, and mechanical behaviour. The surveys also enabled the identification of predisposing, preparatory, and triggering factors responsible for cliff failures.

Meteo-marine data analysis and modelling**:** Meteorological data, including rainfall and wind velocity records, has been used to assess thresholds related with intense seastorms. The results highlight a clear seasonal pattern, with higher wave energy during autumn and winter, as well as an increasing long-term trend, likely related to climate change, which may enhance the intensity of wave impact on the coastal cliffs.

Acquisition of aereal photos: we are currently selecting the most suitable aerial photographs covering different time spans since 1942, carefully filtering out factors such as cloud cover that may reduce coastline visibility and compromise interpretation accuracy. In addition, we are discussing and standardizing the most appropriate criteria for coastline delineation, including the methodological decision on whether the abrasion platform should be attributed to the land or sea domain, as this choice significantly influences shoreline positioning and the subsequent geomorphological analyses.

2) Planned future activities or statement of completion of the Project (15 lines maximum)

We are currently working on the integration of geological, geomorphological, and hydrogeological factors driving failure susceptibility along the coastal sector, aiming to develop a more comprehensive conceptual model of slope instability. Emphasis will be placed on the mechanical contrast between homogeneous and heterogeneous lithological settings, and on the protective role of abrasion platforms, as well as the development of notches where they are not present. A key planned activity is the implementation of UAV-based thermal infrared surveys and advanced thermal image analysis to detect moisture patterns, structural discontinuities, and potential weak zones in the coastal cliffs. Moreover, multi-temporal analysis of aerial photos using the USGS DSAS software will be performed aiming at detecting the coastal zones most affected by coastal retreat. All these datasets will be integrated to improve and validate susceptibility mapping and to enhance hazard assessment. Future efforts will also focus on validating the wind velocity threshold through continuous monitoring, and on improving the coupling between observational data and predictive models, supporting the development of early warning tools for coastal hazard management. All proposed activities represent the next step toward operational implementation and long-term risk mitigation.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

The main beneficiaries of this project include both scientific communities and coastal management authorities, as well as broader society. From a scientific perspective, the project contributes to the advancement of knowledge on coastal instability processes, providing improved conceptual and predictive models that can support future research and educational activities in geomorphology, geology, and coastal hazard assessment. From a societal and management perspective, the results are of direct relevance to the local communities and to the regional authorities responsible for coastal risk management and land-use planning. The investigated coastal sectors are often highly urbanized and host important touristic infrastructures, which represent a key component of the local and regional economy throughout the entire year, not only during the summer season. Consequently, the improved understanding of landslide and erosion dynamics supports more effective risk mitigation strategies and sustainable coastal development policies. The project also benefits the education sector by providing case studies, datasets, and methodological approaches that can be used in academic training and capacity building. Overall, the outcomes contribute to increase the societal awareness on coastal hazard issues while supporting the protection of economically and socially valuable coastal areas.

4) Results (15 line maximum, e.g. publications)

Predisposing factors inducing coastal failure. From a geological standpoint, two distinct stratigraphic configurations have been identified: homogeneous and heterogeneous settings. The first is characterized by a resistant calcarenite layer at the base of the cliff; the second shows a pelitic layer, more erodible, therefore increasing the susceptibility of such cliff zones to wave action. As regards the geomorphological elements, the presence of an abrasion platform at the foot of the cliff may play a protective role by dissipating wave energy; conversely, where this platform is absent, the formation of an abrasion notch at the cliff base indicates increased vulnerability to erosion processes. Moreover, the presence of diffuse karst features like caves and sinkholes contributes to the overall weakening of the rock mass.

Preparatory and triggering factors. The analysis of past events combined with meteo-marine data allowed the identification of thresholds for failure occurrance along the Melendugno coastline. A critical wave height, associated with wind speeds of approximately 35–40 km/h, has been identified as the main combination likely leading to induce failure, followed by intense or prolonged rain condition.

Furthermore, meteo-marine modeling suggests a progressive increase in significant wave height over time, indicating a potential intensification of coastal hazard conditions in the future.

PAPERS: Liso IS, Lollino P, Parise M (2025) Rock failures in coastal carbonate cliffs: susceptibility, hazard assessment and monitoring. In: Abolmasov B, Alcantara Ayala I, Konagai K, Sassa K, Sassa S, Tiwari B (eds), Progress in Landslide Research and Technology, vol. 4, issue 2. Springer (in press).

Note:

1) If you will change items 2-7 from the proposal, please write the revised content in Red.
2) Please fill and submit this form to ICL Network <icl-network@landslides.org>
3) Reporting year must be one or two years (Maximum).