3.4.4 CC monitoring Protocols in Zakynthos MPA

MPA ENGAGE

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Version 3
08/02/2022

Project co-financed by the European Regional Development Fund

IDENTIFICATION

Project Number	5MED18_3.2_M23_007	**Acronym**	MPA-ENGAGE
Full title	MPA Engage: Engaging Mediterranean key actors in Ecosystem Approach to manage Marine Protected Areas to face Climate change		
Axis	3.2: To maintain biodiversity and natural ecosystems through strengthening the management and networking of protected areas		
Partner Responsible	<National Marine Park of Zakynthos>		
Contact Person	<Charalampos Dimitriadis>		

Deliverable	3.4.4	**Title**	CC monitoring Protocols in Zakynthos MPA
Work package	3	**Title**	Testing
Delivery date	17/11/2021	**Submission**	<22/12/2021>
Status	☐ Draft ■ Final		
Level	☐ Task ☐ Coordination Team ☐ Steering Committee ■ Main deliverable		
Dissemination Level	Internal ■ Public		

Description of the deliverable	This is the second (of two) monitoring reports describing the integration of the standardized protocols for monitoring the effect of the CC in the MPA monitoring plan (set of protocols identified and proposed in WP4). Specifically, this report will describe the implementation status of the selected protocols
Key words	Ionian Sea, Invasive species

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DOCUMENT HISTORY			
Name	**Date**	**Version**	**Description**

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1. Context – The project

MPA-Engage ("Engaging Mediterranean key actors in Ecosystem Approach to manage Marine Protected Areas to face Climate change") is an Interreg Med funded project with a budget of € 3M euros aiming to support marine protected areas (MPAs) managers to enhance management plans to face climate change (CC) effects in the Mediterranean Sea.

MPA-Engage establishes a network of marine scientists, conservation and management practitioners to work together on the future of Mediterranean MPAs under the impacts of CC. The overall objective of the MPA-Engage project is to support and promote the role of Mediterranean MPAs as nature-based solutions for the implementation of adaptation and mitigation actions to confront CC effects. The project will produce local climate change mitigation and adaptation plans for the MPAs and will put the Mediterranean Sea at the forefront of marine conservation in the face of CC.

Through a participatory approach, MPA-ENGAGE will monitor in a harmonized way the CC impacts, will elaborate vulnerability assessments and will develop climate change mitigation and adaptation action plans in 7 MPAs (located in 6 Mediterranean countries): Brijuni in Croatia, Cap de Creus in Spain, Calanques in France, Zakynthos in Greece, Karaburuni in Albania, Portofino and Tavolara Punta Coda Cavallo in Italy. Furthermore, some associated MPAs and Networks of MPA, gathered in the MPA4Change Chaptalization Board, have expressed their interest to test part or the whole process on a voluntary basis. In this way we enhance the transferability of the monitoring tool-kits developed in MPA-ENGAGE to the Mediterranean MPAs.

MPA-ENGAGE will be carried out over a period of 32 months (November 2019-June 2022) and its main lines of action will focus on:

- Engaging local communities, small-scale fishermen and citizen scientists in monitoring CC impacts;
- Promoting MPAs as nature-based solutions for CC adaptation;
- Facilitating a Mediterranean policy dialogue with scientists, MPA managers, decision-makers, environmental NGOs and socio-economic stakeholders.

MPA-Engage is articulated around three work packages (WPs): Testing (WP3), Transferring (WP4) and Capitalizing (WP5).

For more information on the project please visit the website https://mpa-engage.interreg-med.eu/.

2. WP3 – Testing

The main goal of WP3 is to enhance the resilience to CC effects by testing the implementation of harmonized and novel set of tools, organized in 5 testing activities. Under the coordination of SZN, each testing activity

is be led by a specific project partner. The project partner, (which is also in charge of the corresponding capacity building and transferring activity in WP4), support the pilot MPAs through the testing phase:

1. Assessing CC vulnerability (ecological and socio-economic) of MPAs – Led by UVIGO. Assessing the ecological and socio-economic vulnerability to CC in the MPAs is a key step in the development of an MPA adaptation plan and it will allow to take into account the local environmental and social conditions via the use of a common framework.

2. Monitoring CC effects on MPAs - Led by SZN. CC is affecting marine ecosystems at Mediterranean and global level. The adoption of harmonized monitoring protocols will provide a common framework to analyze the CC impacts both at local and global scale.

3. Involving citizen scientists, (in particular recreational divers and small-scale/recreational fishers) in monitoring actions- Led by UNIVPM. Marine Citizen Science activities offer a unique opportunity to expand the spatial and temporal resolution in tracking the CC effects. The acquired data will complement the information gathered by MPA management bodies providing a more comprehensive view of the CC effects. In addition, these activities are an excellent showcase of the quintuple helix engagement framework that is deployed within the project towards the elaboration of adaptation plans.

4. Engaging all key actors of the quintuple helix framework (MPA managers, Scientists, Public Authorities, Socio-Economic Stakeholders, General Public) - Led by MIO-ECSDE. Participatory approaches are crucial for a successful identification and eventual implementation of climate change mitigation and adaptation measures. Therefore, elaborating and implementing a comprehensive methodology to design and setup effective participatory mechanisms is essential.

5. Mainstreaming climate change within the MPAs management and mitigation & adaptation plans - Led by MIO-ECSDE. The local climate change mitigation and adaptation plans will integrate the results and capitalize upon the outputs of related initiatives, identifying targeted actions and measures towards mitigating and adapting to climate change effects at MPA level (Fig. 1).

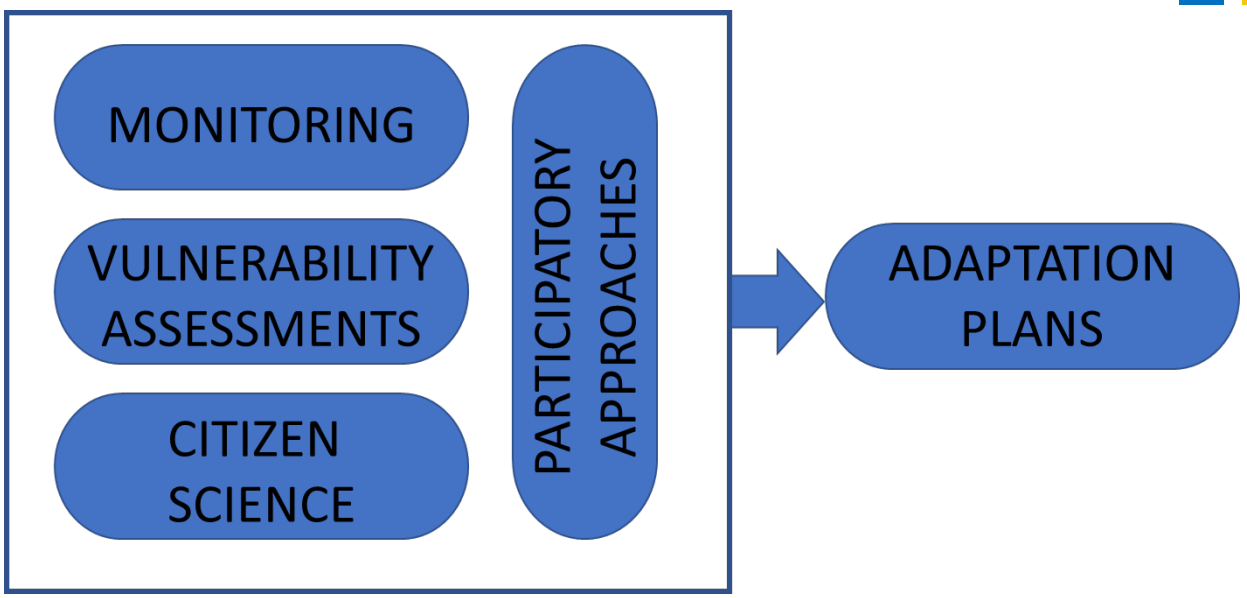

Fig. 1. Proposed integrative approach of Pilot Actions linking the 5 lines of action within WP3.

This integrative approach will be implemented in each of the 7 Pilot MPAs, and will allow for a comprehensive implementation of all project activities towards the successful elaboration of Joint Plans, building upon the results, outputs, findings and lessons learned from the Pilot MPAs.

3. The monitoring rationale and approach

Adaptive planning requires specific arrangements for monitoring and evaluation of climate change impacts, but the complexity of ecological transformation along with inadequate human and financial resources usually hampers our observation capabilities, especially at the large geographical scale.

Previous Interreg MED experience, carried out within the framework of the MPA-ADAPT project, recently led to the successful implementation of five standard protocols (Garrabou et al., 2018) https://digital.csic.es/handle/10261/176395, which provided a first practical guidance to track climate-related impacts in Mediterranean MPAs and beyond. The guiding principles and architecture of these tools respond to the requirements of the Ecosystem Approach undertaken under the auspices of UNEP/MAP Barcelona Convention, with the ultimate objective of achieving the Good Environmental Status (GES) of the Mediterranean Sea and coasts. Technically these tools are inspired to the concept of Essential Climate Variables and focus on a restricted set of simple measurements to capture greater dimensions of environmental change. The characteristics of these protocols and their practical feasibility allowed to collect periodical information from a network of MPAs and to involve them in a collaborative monitoring process. Participating MPAs worked together for the same goals, adding value to existing monitoring practices and building a common and consolidated strategy to track climate change effects at regional scale. The engagement of local stakeholders is another key ingredient in some of these methodologies, which for the first time have brought together the voices and knowledge of people from different Mediterranean

countries, ultimately preparing for a world of global ecological change. This beneficial partnership, which was here demonstrated to provide tangible results at the regional scale (Azzurro et al., 2019). Within the framework of the MPA-ENGAGE project, a Monitoring Coordination Team, represented by researchers and experienced MPA technicians, transfer the knowledge to the participating MPAs and provide them with technical assistance for the protocol implementation.

A. THE PROTOCOLS

The participating MPAs in the MPA-ENGAGE project implemented a total of 11 standardized monitoring protocols. These tools are conceived to provide key information on main categories of indicators related to climate change: i) temperature conditions; ii) shifts on species distribution; iii) episodic events; iv) changes in phenology. Indicators are chosen on the basis of their scientific relevance, feasibility, and cost effectiveness covering key habitats of Mediterranean MPAs. The first five protocols have been developed by the Interreg Programme MPA-ADAPT project and are available here https://digital.csic.es/handle/10261/176395. Additional 6 monitoring protocols were developed within the implementation of the MPA-ENGAGE project. Overall the adoption of these standard tools will allow to track climate change impacts at both the local and the Mediterranean scale.

PR 1. MONITORING TEMPERATURE CONDITIONS

Originally developed by the T-MEDNet initiative and adapted for the purpose of the project MPA-Adapt. Videotutorial: http://t-mednet.org/observation-system/videotutorials

PR 2. MASS MORTALITY MONITORING

Originally developed for the project Seawatchers (also known as Observadores del Mar) and adapted for the purposes of the project MPA-Adapt. Videotutorial: http://t-mednet.org/observation-system/videotutorials

PR 3. LEK-1: EXPLORING LOCAL ECOLOGICAL KNOWLEDGE TO RECONSTRUCT HISTORICAL CHANGES

Originally developed by the CIESM project 'Tropical Signals' and adapted for the purposes of the Interreg project MPA-Adapt, with the contribution of FAO projects AdriaMed and MedSudMed. Videotutorial: https://www.youtube.com/watch?v=AX-_RSJXkm0

PR 4. LEK-2: EXPLORING LOCAL ECOLOGICAL KNOWLEDGE FOR PERIODICAL MONITORING

Conceived for the purposes of the MPA-ADAPT project and capitalizes the experience and scientific discussions made through the FAO projects AdriaMed and MedSudMed projects.

PR 5. FISH VISUAL CENSUS OF CLIMATE CHANGE INDICATORS

Adapted from a previous version developed by the CIESM project "Tropical Signals" for the MPA-ADAPT purposes. Videotutorial: https://www.youtube.com/watch?v=b7gYYg4n7SE

PR 6. LEK 3: MASS MORTALITIES - NEW

This protocol will provide information on past mass mortality events affecting different species including fishes and invertebrates, based on the interviews with key stakeholders

PR 7. POFA: *POSIDONIA OCEANICA* FAST ASSESSMENT ON MEADOWS CONSERVATION STATUS FACE TO CLIMATE CHANGE - NEW

This protocol will capitalize ongoing monitoring activities in the MPA on *Posidonia oceanica*. It will require field work in the MPA *P. oceanica meadows*: shoot density and flowering events will be the main indicators to be reported.

PR 8. FAP: FAST ASSESSMENT PINNA NOBILIS CONSERVATION STATUS - NEW

This protocol will capitalize ongoing monitoring activities on *Pinna nobilis* population status in different areas of the Mediterranean. Field work will be required in order to quantify the presence and survival of *P. nobilis* individuals.

PR 9. URCH: SEA URCHINS POPULATIONS - NEW

This protocol will capitalize ongoing monitoring activities in the MPAs on the abundance of sea urchins populations. It will require field work using visual census techniques.

PR 10. BRD: BENTHIC SPECIES RAPID DETECTION -NEW

This protocol is based on the photographic sampling at selected depths in order to detect the arrival and/or the abundance of alien benthic species (e.g. macroalgae, corals, mollusks etc.) on rocky substrata communities. Besides the photographs will be analyzed to characterize the community composition according to broad taxonomic groups.

PR 11. SFM: PHOTOGRAMMETRY AS MONITORING TOOL FOR BENTHIC HABITATS STRUCTURE AND DYNAMICS - NEW

This protocol capitalizes ongoing initiatives on underwater photogrammetry to track climate related changes in the seascapes (>100 m^2). Due to the methodological and technical complexity of this methodology, its adoption is not compulsory for the MPAs but the Monitoring Team provide assistance to those MPAs willing to implement it.

In the framework of MPA- ENGAGE project, a Monitoring Protocols Tool has been developed and implemented in PowerBI to allow Pilot MPAs to easily generate results for each monitoring protocols. The Monitoring Report Tool generates results starting from standardized data reporting excel sheets that have been provided by Coordination Team to Pilot MPAs. For each protocol, the Monitoring Protocols Tool generates results at different “levels of assessment”, disentangling results for sites, species, depths, and reporting synthetic values combining information from the different levels. The tool generates a pdf including an exhaustive compilation of all the results for each protocol. The pdf is attached as annex to this deliverable, while in the present document only the main results are reported for each monitoring protocol.

4. Reports' structure

Two reporting periods on the monitoring activities were planned within MPA-ENGAGE: October 2020 (1st unit) and November 2021 (2nd unit). The present report represents therefore the 2nd Unit of reporting on implementations of CC monitoring protocols. The report contains information on: the implementation status of each protocol in the MPA (e.g. if the protocols was implemented or not, by whom it was implemented, in how many sites etc.) (section 5), the results produced by the implementation of each protocol (section 6), an assessment of the costs associated to the implementation of each monitoring protocol based on the experience gathered by the MPA on the field (section 7), an assessment of strengths, weakness, opportunities and threats of each protocol (section 8) and conclusions on the status/effect of CC in the MPA and information on potential strategies to implement these protocols in MPA management plan (section 9).

5. Implementation status of standardized protocols for monitoring the effect of the CC

5.1. STANDARDIZED PROTOCOLS FOR MONITORING THE EFFECT OF THE CC IMPLEMENTATION PLAN AND IMPLEMENTATION STATUS

I. PROTOCOL 1 - MONITORING TEMPERATURE CONDITIONS:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

☐ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify its type, e.g. University, Research Center, SME, etc):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Number of temperature data loggers*	*Depths setup*	*Starting date of temperature series*	*Upload temperature data files to T-MEDNet data repository. Yes/no*
Total number of sampling sites:				

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes, please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you did not implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

It was not possible to implement the protocol due to technical difficulties, but it will be implemented in the near future.

II. PROTOCOL 2 - MASS MORTALITY MONITORING:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

☐ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Surveyed depths*	*Surveyed species*	*Total number of populations surveyed*	*Total number of colonies/specimens surveyed by species*	*Mortality surveys uploaded to T-MEDNet? Yes/No*
TOTAL					

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes, please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

III. PROTOCOL 3 –LEK-1: EXPLORING LOCAL ECOLOGICAL KNOWLEDGE TO RECONSTRUCT HISTORICAL CHANGES:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

☐ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) Please fill the following table:

Number of interviews carried out	*Upload data files to Google Drive (please include the link/s to the data files)*
20	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

The MPA gathers data related to fisheries and to species catches for over a decade, including invasive species, so implementation of this protocol fitted within the recurrent monitoring activities in the MPA for the compilation of long time series information.

IV. PROTOCOL 4- LEK-2: EXPLORING LOCAL ECOLOGICAL KNOWLEDGE FOR PERIODICAL MONITORING:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

☐ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) Please fill the following table:

Number of interviews carried out	*Upload data files to Google Drive (please include the link/s to the data files)*

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

Covid 19 pandemic restrictions and technical issues led us to abort the implementation of this protocol

V. PROTOCOL 5 - FISH VISUAL CENSUS OF CLIMATE CHANGE INDICATORS:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

☐ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify its type, e.g. University, Research Center, SME, etc):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Species were added to the standard protocol*	*Depths range*	*Number of replicates*	*Upload data files to Google Drive (please include the link/s to the data files)*
Site 1	*Siganus luridus, Siganus rivulatus, Pterois miles, Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 2	*Siganus luridus, Siganus rivulatus, Pterois miles, Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 3	*Siganus luridus, Siganus rivulatus, Pterois miles, Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 4	*Siganus luridus, Siganus rivulatus, Pterois miles, Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 5	*Siganus luridus, Siganus rivulatus, Pterois miles, Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 6	*Siganus luridus, Siganus rivulatus, Pterois miles,*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*

	Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster			
Site 7	*Siganus luridus, Siganus rivulatus, Pterois miles, Enchelycore anatina, Stephanolepis diaspros, Sphoeroides pachygaster*	*Shallow*	*4*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Total number of sampling sites: 7				

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☒ *No*

e) Which was the rationale behind the selection (or the exclusion if you did not implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

The MPA is recurrently monitoring fish fauna and invasive species with underwater visual census so the implementation of this protocol fitted well in such activities for long term data gathering.

VI. PROTOCOL 6 – LEK-3: MASS MORTALITIES:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

☒ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) Please fill the following table:

Number of interviews carried out	*Upload data files to Google Drive (please include the link/s to the data files)*

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

VII. PROTOCOL 7 - POFA: POSIDONIA OCEANICA FAST ASSESSMENT ON MEADOWS CONSERVATION STATUS FACE TO CLIMATE CHANGE:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

■ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Depths range*	*Surveyed depths*	*Number of replicates (quadrats)*	*Upload data files to Google Drive (please include the link/s to the data files)*
Total number of sampling sites:				

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

VIII. PROTOCOL 8 - FAP: FAST ASSESSMENT PINNA NOBILIS CONSERVATION STATUS:

a) What is the implementation status of this monitoring protocol?

■ *The protocol was implemented in the MPA*

☐ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

■ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Depths range*	*Surveyed depths*	*Number of transects (replicates)*	*Upload data files to Google Drive (please include the link/s to the data files)*
Site 1	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 2	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 3	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 4	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 5	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 6	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 7	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 8	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 9	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 10	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 11	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*

Site 12	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 13	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 14	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 15	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 16	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 17	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 18	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 19	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 20	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 21	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 22	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 23	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 24	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 25	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 26	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*

Site 27	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 28	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 29	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 30	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 31	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 32	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 33	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 34	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Site 35	*Shallow (0 to 17.5 m)*	*Shallow (0 to 17.5 m)*	*1*	*https://drive.google.com/drive/folders/1_E1WD2tHdPQ4eAqfLkqr04y_kip7N4xV*
Total number of sampling sites: 35				

d) Did you face any difficulty while implementing the protocol?

☐ Yes (if yes please describe the difficulties):

☒ No

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

Previous assessments on *P. nobilis* suggested the existence of healthy populations in the MPA from 2010 to 2019 (e.g. Zotou et al., 2020 doi:https://doi.org/10.12681/mms.23777).

IX. PROTOCOL 9 -URCH: SEA URCHINS POPULATIONS:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

■ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Species surveyed (Paracentrotus lividus, Arbacia lixula, Sphaerechinus granularis, (C) No sea urchins)*	*Depths range*

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

X. PROTOCOL 10 -BARD: BENTHIC SPECIES RAPID DETECTION:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

■ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Sampling site	*Depths range*	*Nº of photos taken*	*Nº of photos analysed*
TOTAL			

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

XI. PROTOCOL 11 -SFM: PHOTOGRAMMETRY AS MONITORING TOOL FOR BENTHIC HABITATS STRUCTURE AND DYNAMICS:

a) What is the implementation status of this monitoring protocol?

☐ *The protocol was implemented in the MPA*

■ *The protocol was not implemented in the MPA*

b) Who did implement the protocol?

☐ *MPA staff*

☐ *External contractor (in case of external contractor please specify the status of selection procedures, e.g. contract already done, contractor under selection, still defining administrative procedures):*

☐ *Other (If other, please indicate who):*

c) For each sampling site please fill the following table:

Number of sites	***Number of replicates***	***Surveyed depths***	***Photogrammetry surveys uploaded to Engrep (Engage Repository; www.engrep.ubicasrl.com/login) or other repositories Yes/No (please include the link)***
TOTAL			
XX			

d) Did you face any difficulty while implementing the protocol?

☐ *Yes (if yes please describe the difficulties):*

☐ *No*

e) Which was the rationale behind the selection (or the exclusion if you do not plan to implement the protocol) of the implemented protocol (e.g. related to its feasibility in your MPA, availability of previous data for which you want to continue data collection to obtain a time series, absence of particular species/habitat etc.)?

5.2. OTHER PROTOCOLS FOR MONITORING RELATED TO THE CC IMPLEMENTED IN THE MPA

The MPA of Zakynthos implements several protocols for the evaluation of the impacts of climate change on the protected elements under concern. In this respect the MPA has design, adopted and implemented protocols and methodologies for sea level rise projections on sandy beaches including the ones that are used for nesting by loggerhead sea turtle *Caretta caretta* through recurrent monitoring and research projects (e.g. MEDPAN NORTH, BLUECOAST). This methodology includes data gathering and analysis through seasonal beach profiles, 2D morphodynamic modelling of beach retreat under different RCPs, wave forcing and nesting activity of loggerheads (Dimitriadis et al., 2021 submitted in Regional Environmental Change journal). Yet the MPA assess erosion rates on sandy beaches through satellite images from 1945 onwards to elucidate the effect of increased erosion in the protected area and to predict future changes which have impacts on critical ecological (sea turtle nesting capacity) and socioeconomic features (recreational use of the beaches) (BLUECOAST project results, Deliverable 3.3.). Still, we recurrently monitor sand temperature at nesting sites via data loggers in an effort to identify the possible effects of increasing climate warming due to climate change on the sex ratio of sea turtle hatchlings at each nesting year (sex in sea turtles is thermally determined during egg incubation period thus female biased hatchling sex ratios are expected on increased sand temperature) through the protocols that were developed from MAVA project (https://mava-foundation.org/oaps/protecting-sea-turtle-nesting-sites/). Invasive, range expanding and thermophilic species are regularly monitored in the MPA through several protocols and methods since 2009 (e.g. Dimitriadis et al., 2021 - https://doi.org/10.3390/d13020071; Dimitriadis et al., 2020 - https://doi.org/10.12681/mms.21845; Dimitriadis et al., 2018 - https://doi.org/10.1016/j.ecss.2018.04.012).

6. Results of standardized protocols for monitoring the effect of the CC

6.1. STANDARDIZED PROTOCOLS FOR MONITORING THE EFFECT OF THE CC IMPLEMENTATION PLAN AND IMPLEMENTATION STATUS

XII. PROTOCOL 1 - MONITORING TEMPERATURE CONDITIONS:

Was not implemented in the MPA

XIII. PROTOCOL 2 - MASS MORTALITY MONITORING:

Was not implemented in the MPA

XIV. PROTOCOL 3 –LEK-1: EXPLORING LOCAL ECOLOGICAL KNOWLEDGE TO RECONSTRUCT HISTORICAL CHANGES:

A total of 20 local fishers were interviewed in the National Marine Park of Zakynthos. They were all (100%) professional artisanal fishers. More than one fishing method was often adopted by the respondents, with ‘‘nets’’ being the most commonly employed fishing gear (66,84%) followed by longlines (28,95%) and hooks (4,21%) (Fig. 6).

According to our compilation of local knowledge, at least 3 fish resulted to have passed through drastic changes in their abundance. Amongst the most cited species was *Pterois miles* perceived as increasing by the 80% of the respondents followed by *Siganus rivulatus* as indicated by the 75% of the respondents. Only one species, *Sarpa salpa*, was cited by the respondents to have declined up to its disappearance (100% of the interviewed fishermen).

Fig 6. Upper boxes show the percent distribution of professional fishers interviewed in Zakynthos MPA and the fishing methods adopted by the respondents. Lower box illustrates the species cited by the respondents and the number of times in which they were assigned to the groups 'decreasing', 'fluctuant', 'increasing' or 'stable'.

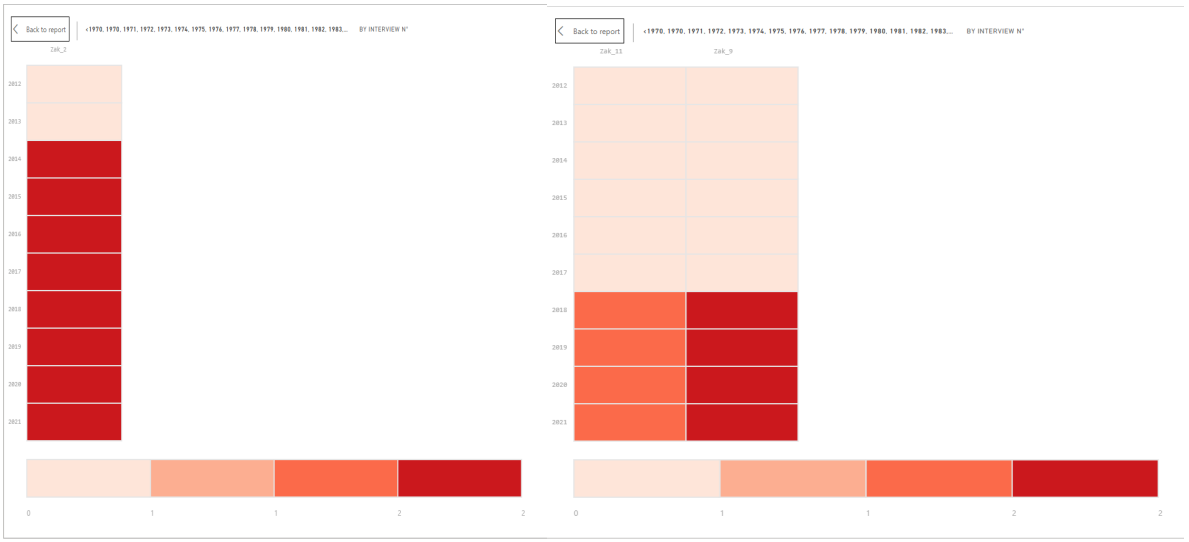

Fig 7. Perceived trends of relative abundance on a scale from 0 to 5 of *Alepes djedaba* (on the left) and *Callinectes sapidus* (on the right) in the National Marine Park of Zakynthos.

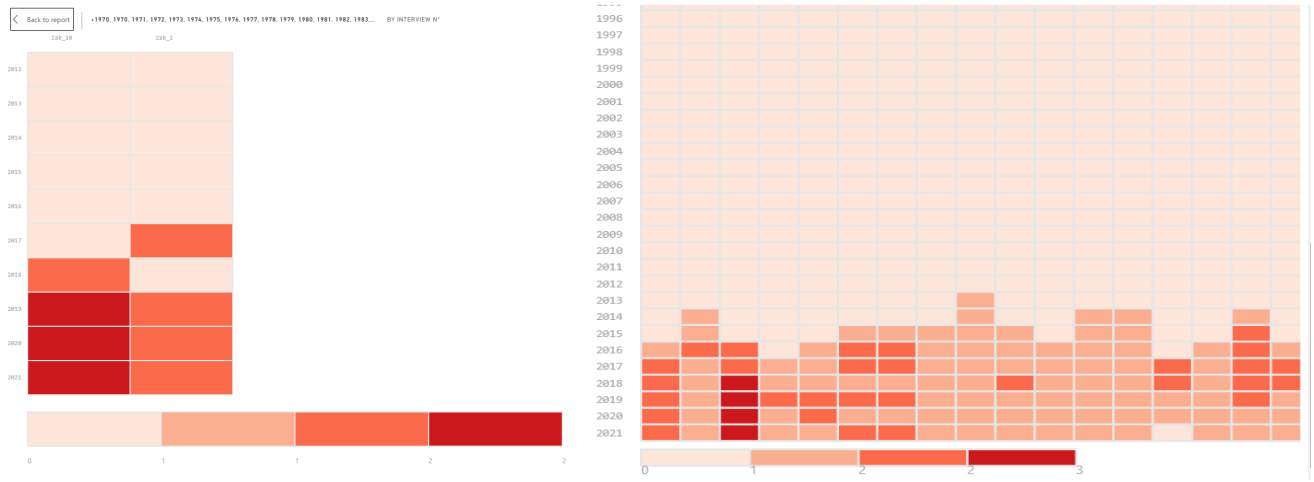

Fig 8. Perceived trends of relative abundance on a scale from 0 to 5 of *Erugosquilla massavensis* (on the left) and *Fistularia commersonii* (on the right) in the National Marine Park of Zakynthos.

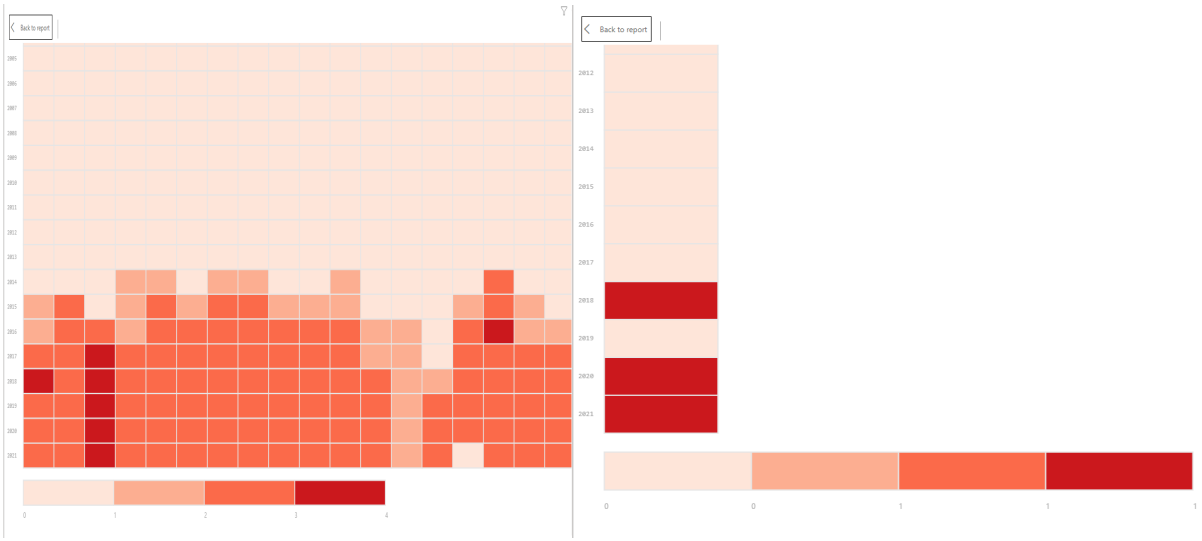

Fig 9. Perceived trends of relative abundance on a scale from 0 to 5 of *Lagocephalus sceleratus* (on the left) and *P. incisus* (on the right) in the National Marine Park of Zakynthos.

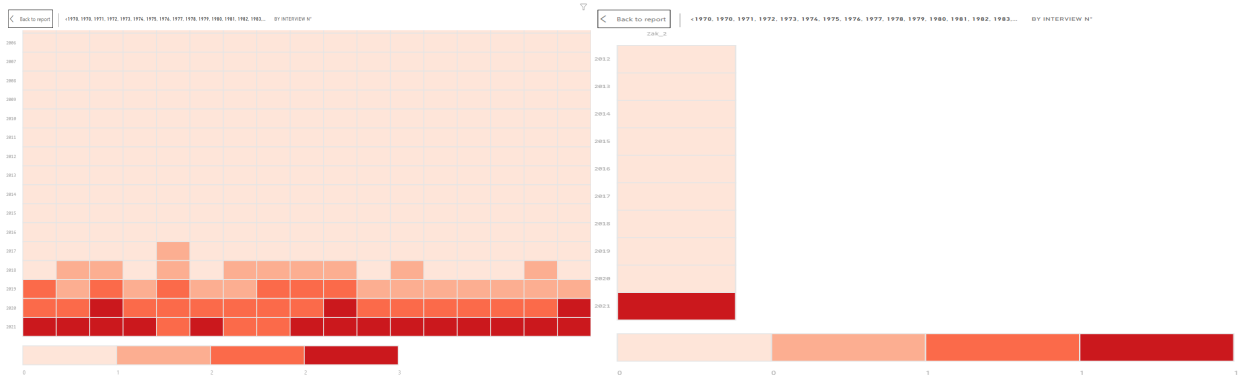

Fig 10. Perceived trends of relative abundance on a scale from 0 to 5 of *P. miles* (on the left) and *S. chrysotaenia* (on the right) in the National Marine Park of Zakynthos.

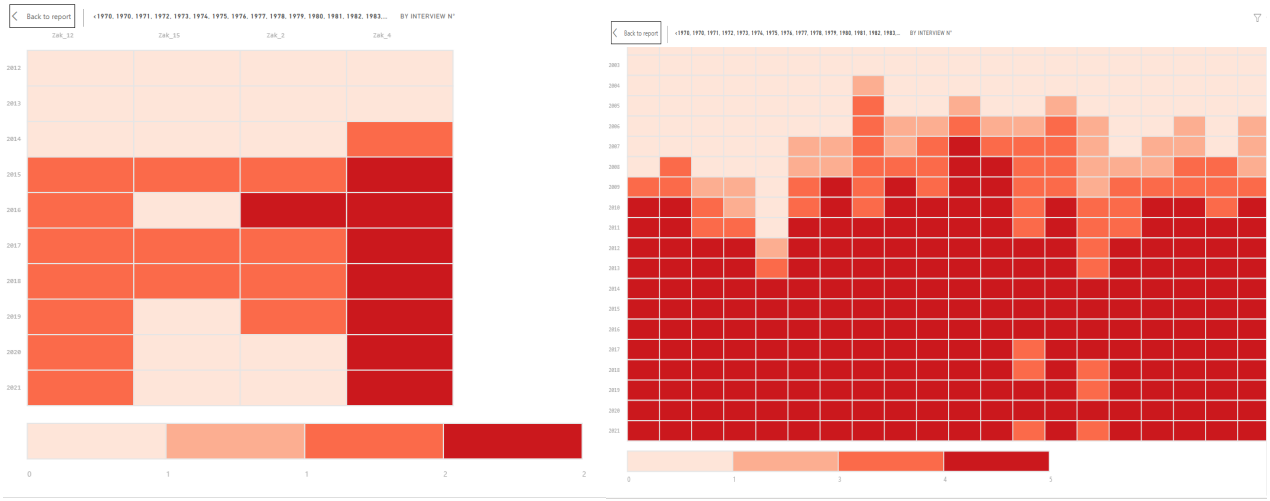

Fig 11. Perceived trends of relative abundance on a scale from 0 to 5 of *S. diaspros* (on the left) and *S. luridus* (on the right) in the National Marine Park of Zakynthos.

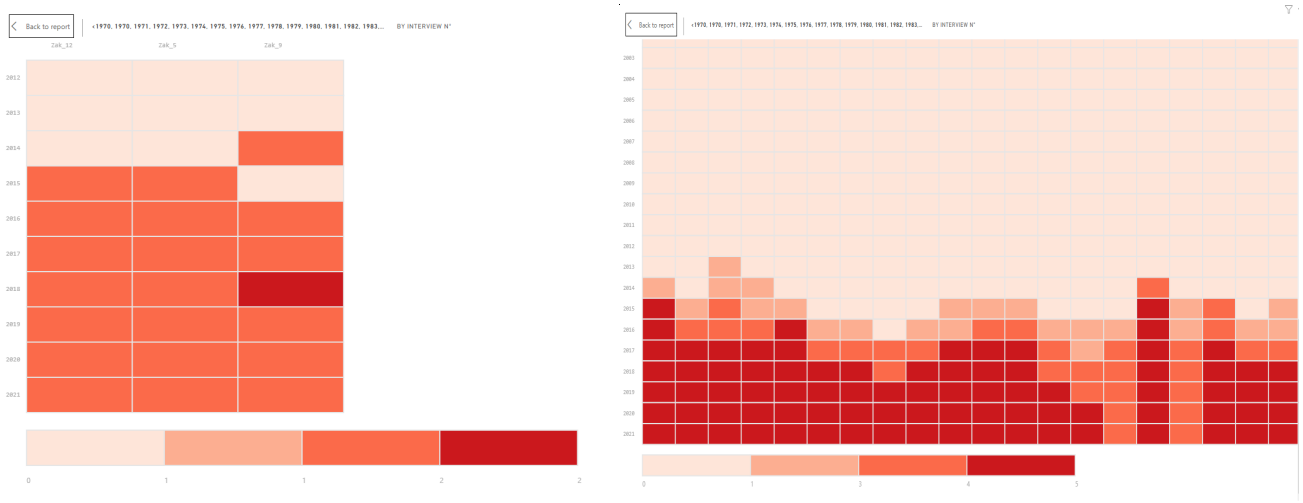

Fig 12. Perceived trends of relative abundance on a scale from 0 to 5 of *S. pachygaster* (on the left) and *S. rivulatus* (on the right) in the National Marine Park of Zakynthos.

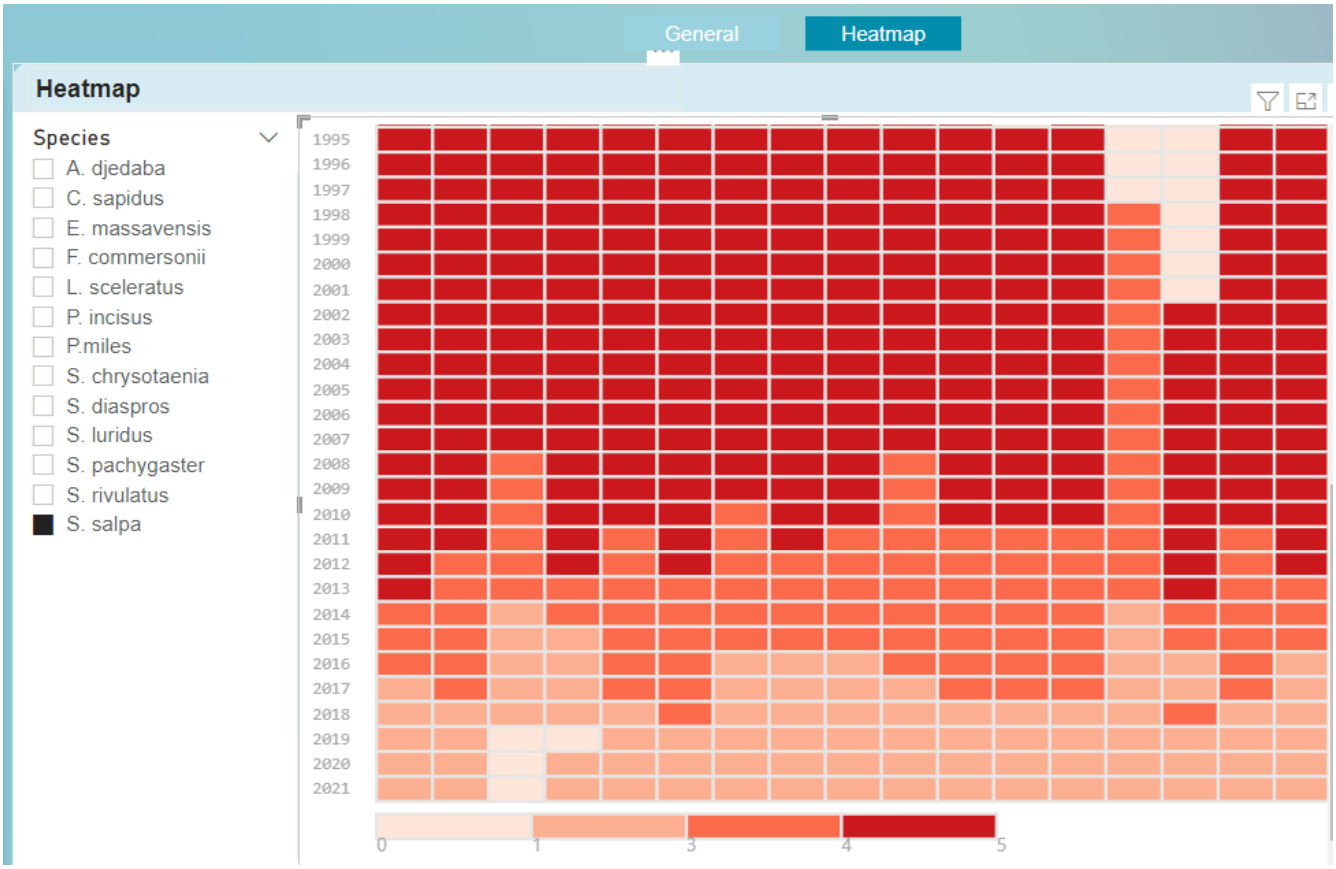

Fig 13. Perceived trends of relative abundance on a scale from 0 to 5 of *S. salpa* in the National Marine Park of Zakynthos.

For additional details about results please go to the Supplementary Material.

XV. PROTOCOL 4- LEK-2: EXPLORING LOCAL ECOLOGICAL KNOWLEDGE FOR PERIODICAL MONITORING:

Was not implemented in the MPA

XVI. PROTOCOL 5 - FISH VISUAL CENSUS OF CLIMATE CHANGE INDICATORS:

The protocol was implemented in 7 sites, as reported in the map in Figure 14. Among the 15 target species surveyed in the National Marine Park of Zakynthos MPA, the most abundant one in 2020 was *Siganus sp.* followed by *S. cretense* (Fig. 14). Average abundance of exotic species registered at MPA level were: *S. luridus* (47,14/250m²), *S. rivulatus* (28/250m²), *Pterois miles* (2,04/250m²), *Enchelycore anatina* (0,07/250m²), *Stephanolepis diaspros* (0,07/250m²) and *Sphoeroides pachygaster* (0,04/250m²).

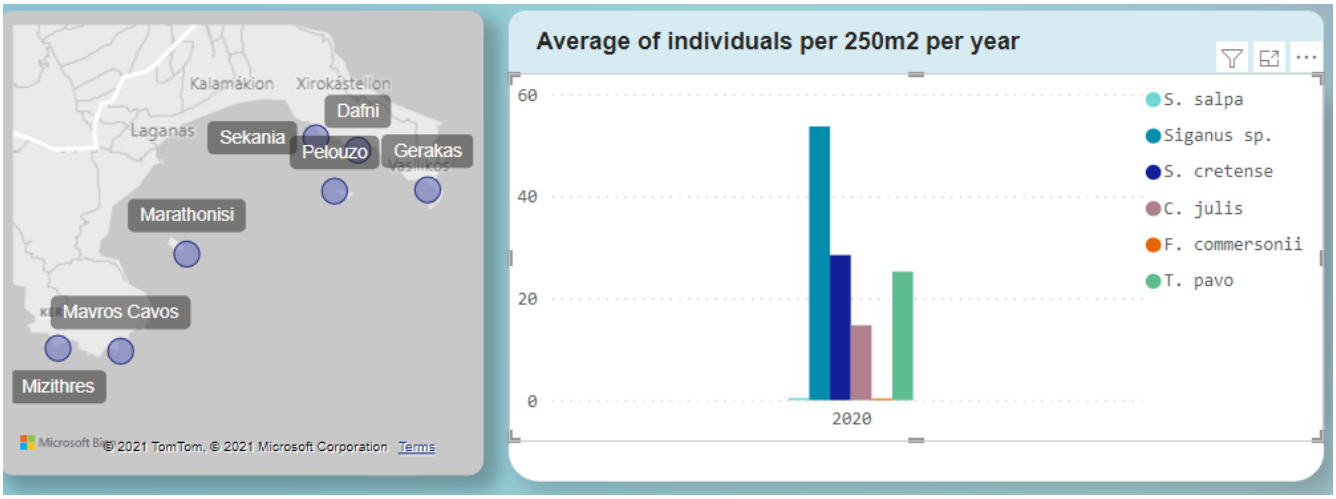

Fig. 14. Mean number of individuals/250m² of the monitored species (excluding new exotic species, including *Siganus sp.*) during 2020 was 17,02 when all depth strata (5-10m) and surveyed sites were merged.

The Tropical Index ranged from 5 in five sites to 6 in two sampling sites during 2020 (Fig. 15). The assessment was deemed tropicalized in 71% and highly tropicalized in 29% of the sites.

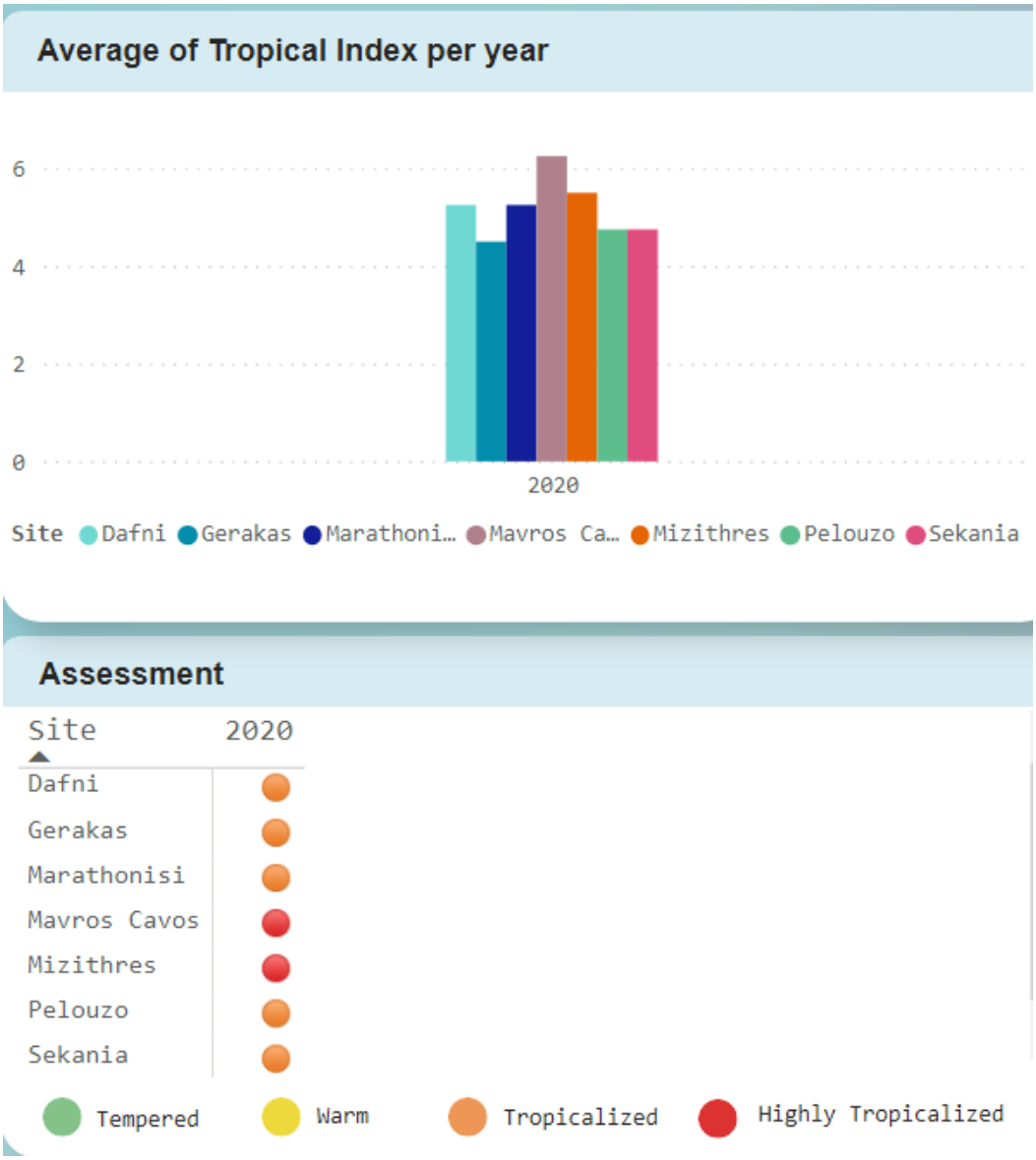

Fig. 15. *Value of tropicalization index per year at each sampling site (top panel). Color-coded summary of tropicalization assessment is provided (bottom panel).*

For additional details about results please check the Annex.

XVII. PROTOCOL 6 – LEK-3: MASS MORTALITIES:

It was not implemented in the MPA

XVIII. PROTOCOL 7 - POFA: POSIDONIA OCEANICA FAST ASSESSMENT ON MEADOWS CONSERVATION STATUS FACE TO CLIMATE CHANGE:

It was not implemented in the MPA

XIX. PROTOCOL 8 - FAP: FAST ASSESSMENT PINNA NOBILIS CONSERVATION STATUS:

The protocol was implemented in 35 sites and one depth range (shallow) of Zakynthos MPA during 2019 and 2021 (see map in Figure 16). In the shallow depth the mean shallow % of dead individuals ranged from 0 to 100 % in year 2019 and to 100% during 2021, respectively (Figure 16).

Overall, *Pinna nobilis* populations showed severe impact as in 2021 no alive specimens were recorded in the MPA, contrary to the 24 alive individuals during 2019.

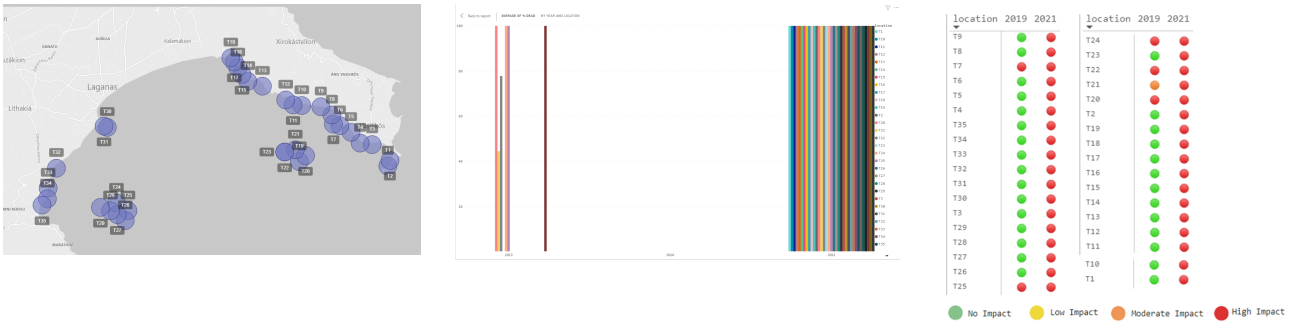

Fig. 16. *Mean % of dead individuals per depth and year*

In year 2019 all alive specimens were observed in the shallow depth range; specifically, the alive specimens were observed in sites (transects) 5, 6, 8, 10, 11, 21, 22, 30, 31, 32, 33, 34 and 35. In general, assessment of *P. nobilis* status indicated a low impact on their population during 2019, while a highly impacted status was detected during 2021.

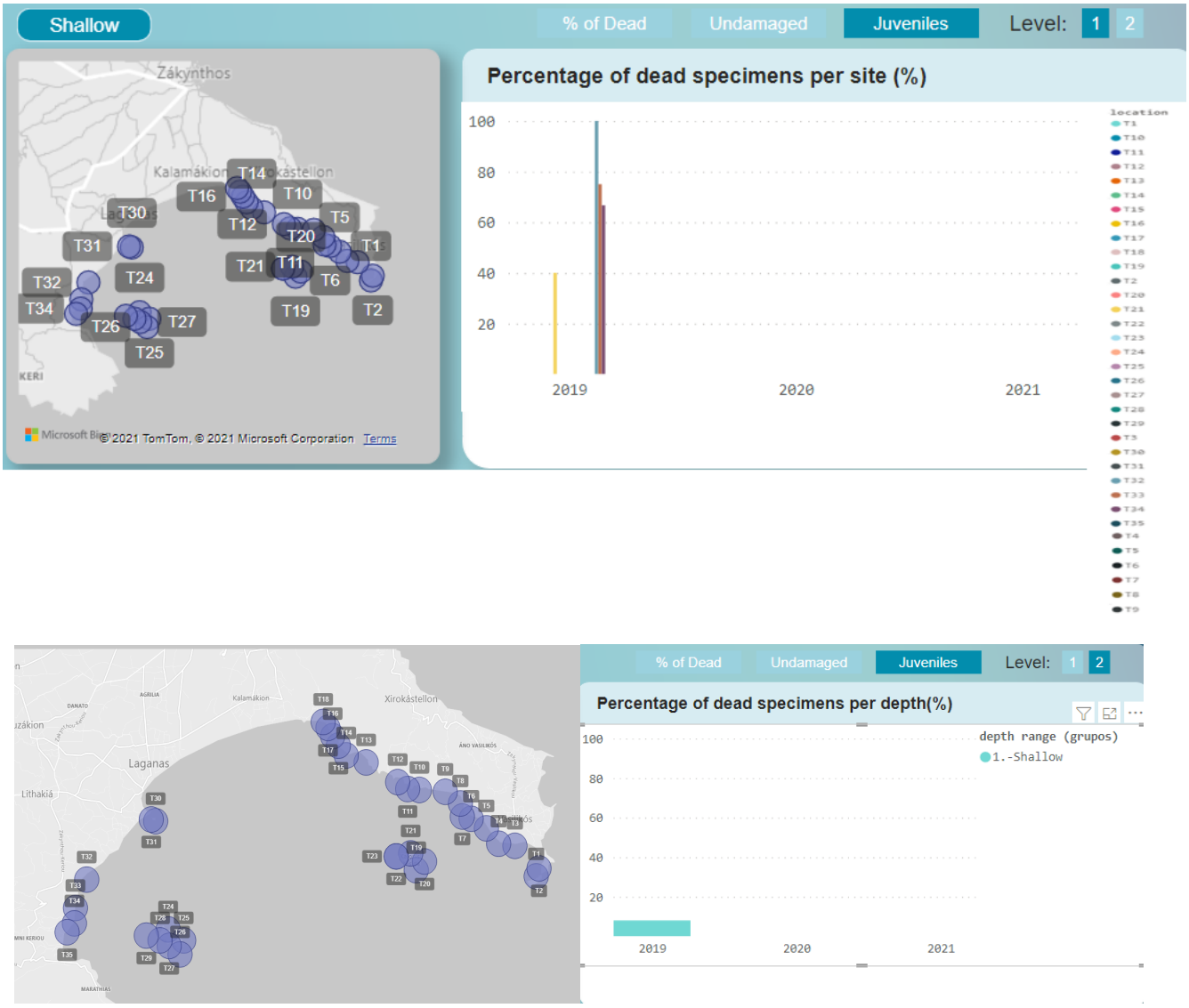

Fig. 17. Mean % of alive juveniles per depth and years

XX. PROTOCOL 9 -URCH: SEA URCHINS POPULATIONS:

It was not implemented in the MPA

XXI. PROTOCOL 10 -BARD: BENTHIC SPECIES RAPID DETECTION:

It was not implemented in the MPA

XXII. PROTOCOL 11 -SFM: PHOTOGRAMMETRY AS MONITORING TOOL FOR BENTHIC HABITATS STRUCTURE AND DYNAMICS:

It was not implemented in the MPA.

7. Cost estimation of the implementation of standardized protocols for monitoring the effect of the CC in the MPA

The costs estimation is given for one year of implementation of protocols selected in the Zakynthos MPA (Table 1). Cost of a full time equivalent (FTE), meaning one person working full time, is estimated to 80 €/day for MPA staff.

Protocols	MPA staff time (FTE)				Costs (euro)				Additional notes
	preparation	field work	data reporting	Total	MPA staff	External contractor	Equipment and boat	Total	
P1 - temperature	-	-	-	-	-	-	-	-	
P2 - mass mortality	-	-	-	-	-	-	-	-	
P3 - LEK 1	2	4	3	9	720		-	720	
P4 - LEK 2	-	-	-	-	-	-	-	-	

P5 - fish visual census		12	5	17	1360		900	2260	Field work cost : (fuel, boat, diving equipment - 150€ per day + staff cost per employee– 80€ per day, 2 employees) [(310€ x 6 days = 1860euros); Reporting cost: 1 employee x 5 days x 80€ = 400 €
P6- LEK 3 mass mortalities	-	-	-	-	-	-	-	-	
P7 - POFA	-	-	-	-	-	-	-	-	
P8 - FAP	0	12	5	17	1360	0	900	2260	Field work cost : (fuel, boat, diving equipment - 150€ per day + staff cost per employee– 80€ per day, 2 employees) [(310€ x 6 days = 1860euros); Reporting cost: 1 employee x 5 days x 80€ = 400 €
P9 -URCH	-	-	-	-	-	-	-	-	
P10 - BARD	-	-	-	-	-	-	-	-	
P11 - SFM	-	-	-	-	-	-	-	-	
Total	**2**	**28**	**13**	**43**	**3440**	**0**	**1800**	**5240**	

Table 1. Standardized protocols for monitoring the effect of the CC implemented in the MPA. For each implemented protocol details on implementation costs and the number of staff involved are reported.

8. Integration of protocols for monitoring the effect of the CC in the MPA management plan

LEK-1 protocol will be integrated in the MPA management plan since it is a cost-effective and easy to be implemented method. It also falls within the framework of the regular monitoring of small-scale fisheries that the MPA implements in the protected area and therefore it will be embedded an integral part of fisheries management. Fish visual census of climate change indicators and FAP protocols implementation will be also embedded in the recurrent monitoring and management that the MPA already implements in the protected area since they are simple, straightforward and effective methods. The high capacity building of the personnel of the MPA in UVC methods (having also proper equipment, e.g. diving equipment, boat, software for data analysis) renders these method as very cost-effective ones.

Albeit Monitoring Temperature conditions, Mass mortality monitoring, LEK2, LEK3, URCH, BRD and SFM protocols were not implemented in Zakynthos MPA , it is planned to be implemented in the future as part of the regular monitoring and management in the MPA supported by the collaborating to the MPA research groups (University of Aegean, Ionian University and HCMR).

Table 2. SWOT analysis of the monitoring protocols implemented in the MPA.

Protocols for monitoring the effect of the CC	Strengths	Weakness	Opportunities	Threats
Monitoring Temperature conditions	NA	NA	NA	NA
Mass mortality monitoring	NA	NA	NA	NA
LEK-1: exploring local ecological knowledge to reconstruct	Cost-effective, already existing management plan for fisheries	Time consuming, personnel demanding	Long term data series, planning of targeted mitigation actions,	Long term funding

historical changes			participatory approach	
LEK-2: exploring local ecological knowledge for periodical monitoring	NA	NA	NA	NA
Fish visual census of climate change indicators	Cost-effective, already existing management plan for fish fauna	Trained personnel and equipment demanding	Long term data series, planning of targeted mitigation actions	Long term funding
LEK-3: mass mortalities	NA	NA	NA	NA
POFA: *Posidonia oceanica* fast assessment on meadows conservation status face to climate change	NA	NA	NA	NA
FAP: fast assessment *Pinna nobilis* conservation status	Cost-effective, combined with other protocols	Trained personnel and equipment demanding	Long term data series, planning of targeted mitigation actions	Long term funding
URCH: Sea urchins populations	NA	NA	NA	NA
BRD: Benthic species rapid detection	NA	NA	NA	NA
SFM: Photogrammetry as monitoring tool for benthic habitats structure and dynamics	NA	NA	NA	NA

9. Conclusions

MPAs are conservation tools aiming to safeguard biodiversity from threats, promote healthy and resilient marine ecosystems, and provide societal benefits. Therefore, as climate change prevails, the effectiveness

of the MPAs will be affected or ultimately MPAs will fail to meet the initial purpose of their existence even if they are well managed and enforced. Zakynthos MPA is well known for its prime ecological value while at the same time multiple human pressures acting in concert are rendering management and conservation a challenging task. The data collected through the MPA Engage monitoring protocols demonstrate that climate change has already considerable impacts on critical ecological aspects of Zakynthos MPA, with the most striking ones being the tropicalization of the ecosystem (presence of) and the loss of endemic species with narrow thermal niche (e.g. *S. salpa*) or high vulnerability to infectious diseases (*P. nobilis*). Hence the exogenic effects of climate change on protected species and habitats and on the ability of the MPA to produce societal benefits further undermines long-term management and conservation success. The protocols that were implemented in this study are providing long-term and cost-effective tools to monitor the tropicalization status of the MPA, while the produced results are pointing on where to redirect efforts for mitigation and adaptation to climate change. Thus, managing invasive and thermophilic species in the MPA (e.g. population control, selective removal, enhancement of top – down predation control, Giakoumi et al. 2019; Dimitriadis et al. 2021; Kleitou et al. 2021) should facilitate in alleviating climate change impacts.

Table 3. Assessment values for each indicator within a CC monitoring protocol. Values are specified per depth range. [1]**(Otero et al. 2013/UNEP-MAP Identification and streamlining of Climate Change indicators SPAMI WG.431/Inf.11))**

Categories of Climate Change indicators[1]	Protocol	Indicator		2019			2020			2021			Notes
				Shallow	Interm.	Deep	Shallow	Interm.	Deep	Shallow	Interm.	Deep	
Mortality and bleaching events	PR2	Percentage of all affected colonies by habitat (%)		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	Use level 3 of the indicator
	PR2	Percentage of recent affected colonies by habitat (%)		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	Use level 3 of the indicator
	PR6	Fish % of perceived mortality	*species 1:*	*NA*			*NA*			*NA*			Report data for 2019,
			species 2	*NA*			*NA*			*NA*			

			species 3:	*NA*			*NA*			*NA*			2020, 2021
	PR6	Intertebrates % of perceived mortality	*species 1:*	*NA*			*NA*			*NA*			
			species 2	*NA*			*NA*			*NA*			
			species 3:	*NA*			*NA*			*NA*			
	PR8	Percentage of dead specimens (%)	*14,92 %*	*NA*	*NA*	*NA*	*NA*	*NA*	100 %	*NA*	*NA*	Use level 2 of the indicator	
Range shift of alien / temperature sensitive species	PR5	Tropical index	*site 1: Gerakas*	*NA*					*NA*			Use level 3 indicator	
			site 2: Dafni	*NA*					*NA*				
			site 3:Sekania	*NA*					*NA*				
			site 4: Pelouzo	*NA*					*NA*				
			site 5: Marathonisi	*NA*					*NA*				
			site 6: Mavros Cavos	*NA*					*NA*				
			site 7: Mizithres	*NA*					*NA*				
	PR10	Percentage of invasions (%)		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	Use level 2 of the indicator
Reproduction and breeding date	PR7	Average shoot density (shoots/m2)		*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	Use level 2 of the indicator

Notes: PR2: Protocol 2 - Mass mortality monitoring; PR3: Protocol 3 – LEK 1: Exploring ecological knowledge; PR5: Protocol 5 – Fish visual census; PR6: Protocol 6 – LEK 3: Mass mortalities; PR7: Protocol 7 - POFA: Posidonia oceanica fast assessment on meadows conservation status face to climate change; PR8: Protocol 8 – FAP: Fast assessment Pinna nobilis conservation status; PR10: Protocol 10 -BRD: Benthic species rapid detection.

10. Cited literature

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