Rilevamento geomorfologico a nuoto delle coste rocciose: il progetto GEOSWIM

Stefano FURLANI, Dipartimento di Matematica e Geoscienze
Università di Trieste, Italia

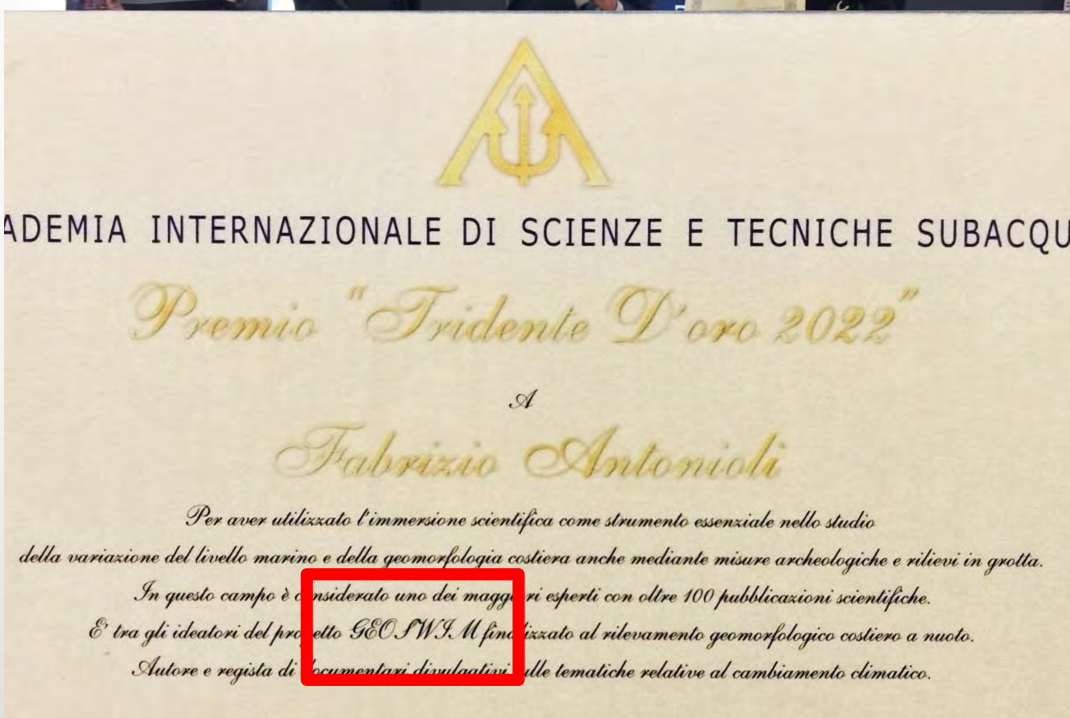
Geoswim: perché?

- Perche rilevare a nuoto?
- Perché rilevare le coste rocciose?
- Perché nel Mediterraneo?
- Per chi?
- Entro quando?
- …ma davvero finiremo?


ARRIVO geo SWIM
DOPO AVER LE ONDE SOLCATO...
...BENTORNATO
ARRIVO geo SWIM
Luglio 2012
COMUNE DI TRIESTE


Stefano Furlani
ISTRIA
SOTTO
SOPRA
260 CHILOMETRI A NUOTO LUNGO LE COSTE DELL'ISTRIA OCCIDENTALE E DEL GOLFO DI TRIESTE
EUT

…anche il tridente d'oro!

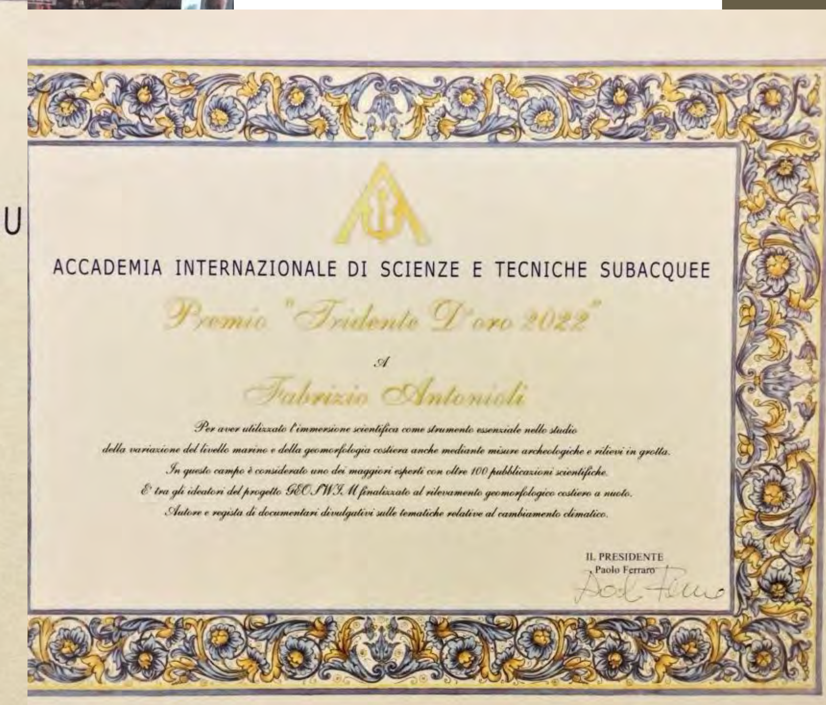

ADEMIA INTERNAZIONALE DI SCIENZE E TECNICHE SUBACQU

Premio "Tridente D'oro 2022"

A

Fabrizio Antonioli

Per aver utilizzato l'immersione scientifica come strumento essenziale nello studio
della variazione del livello marino e della geomorfologia costiera anche mediante misure archeologiche e rilievi in grotta.
In questo campo è considerato uno dei maggiori esperti con oltre 100 pubblicazioni scientifiche.
E' tra gli ideatori del progetto GEOSWIM finalizzato al rilevamento geomorfologico costiero a nuoto.
Autore e regista di documentari divulgativi sulle tematiche relative al cambiamento climatico.


ACCADEMIA INTERNAZIONALE DI SCIENZE E TECNICHE SUBACQUEE

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IL PRESIDENTE
Paolo Ferraro

Il team Geoswim2.0

Il team Geoswim3.0

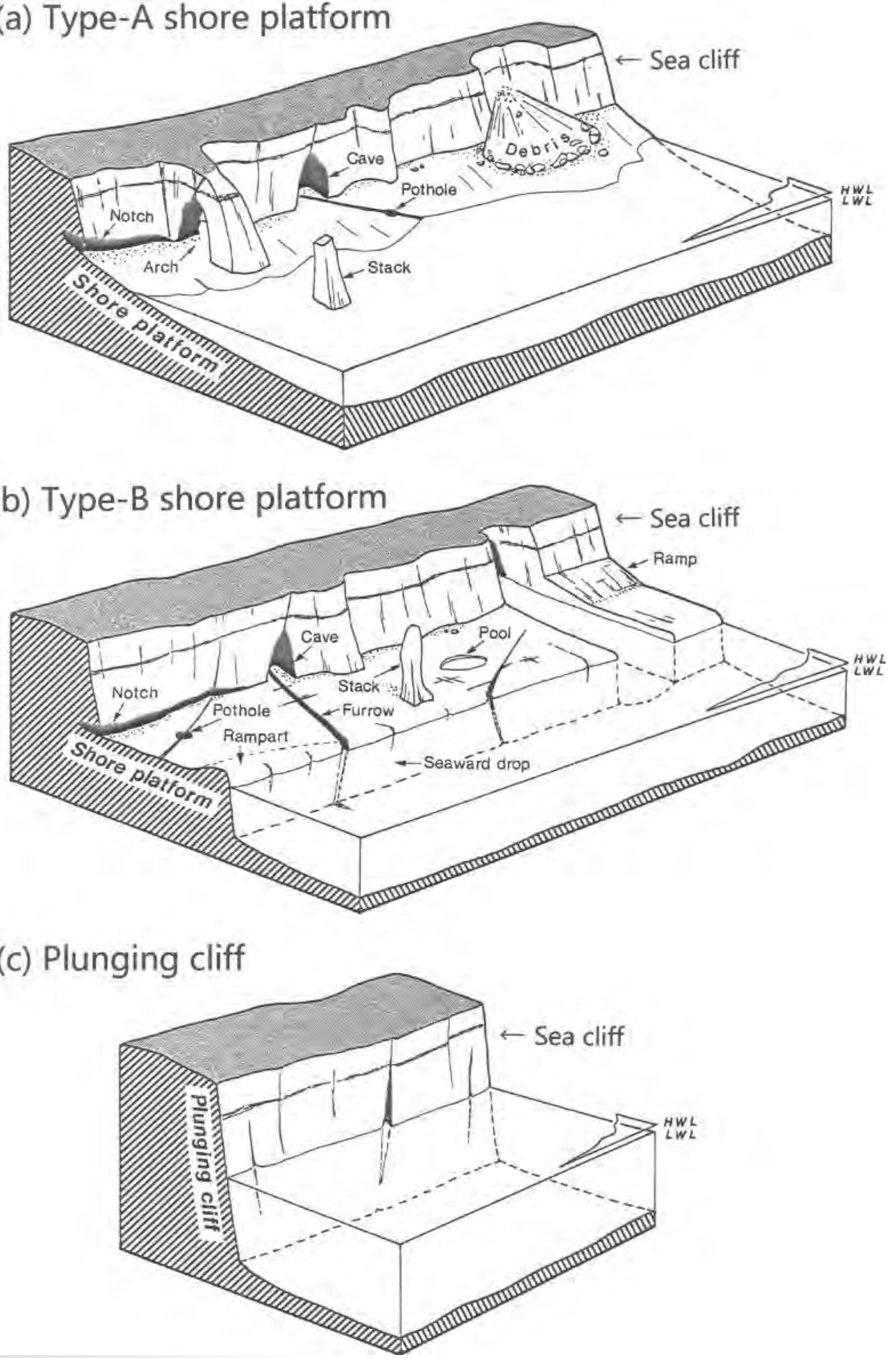
Ansedonia

Le coste rocciose

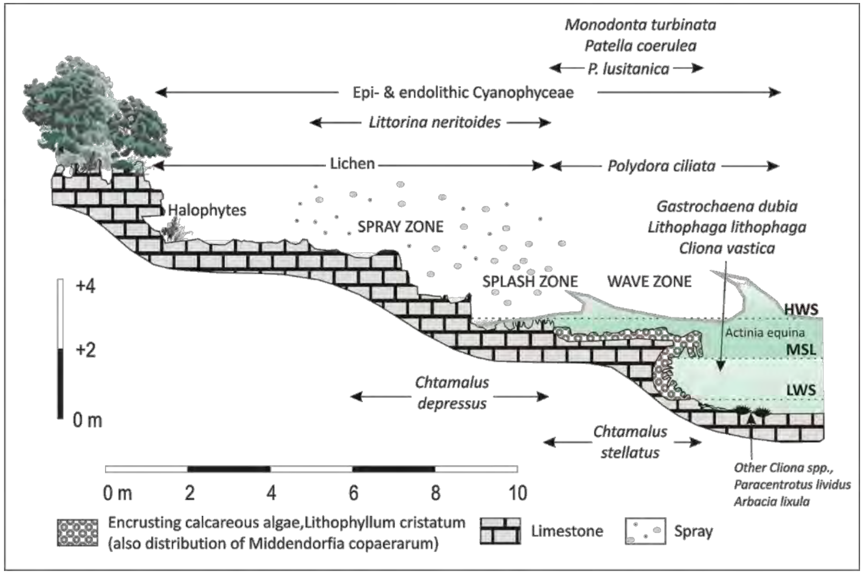
- Le coste rocciose coprono oltre la metà delle coste del mondo e si presentano in situazioni climatiche, geologiche e forme molto diverse







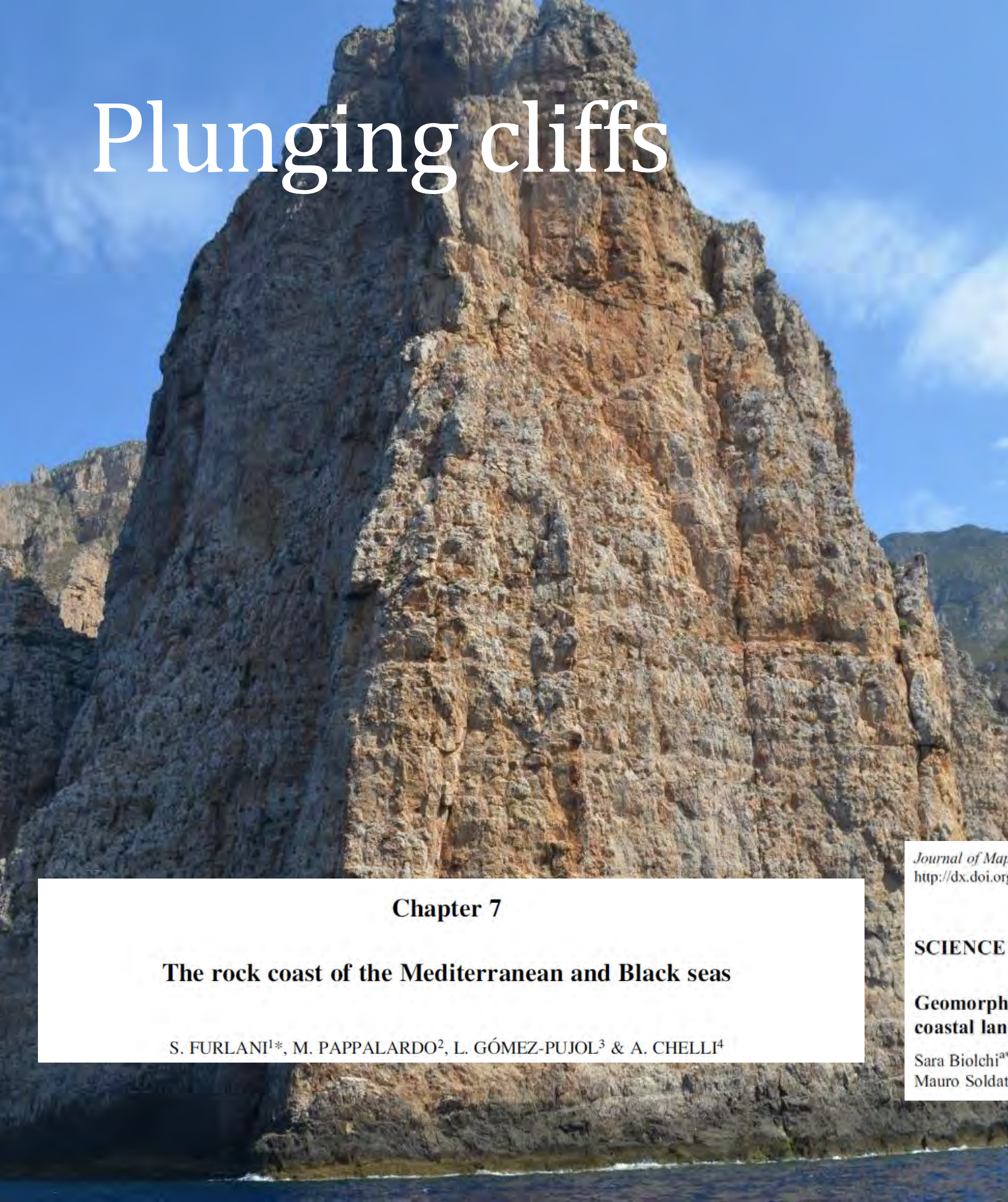
Sunamura (1992)

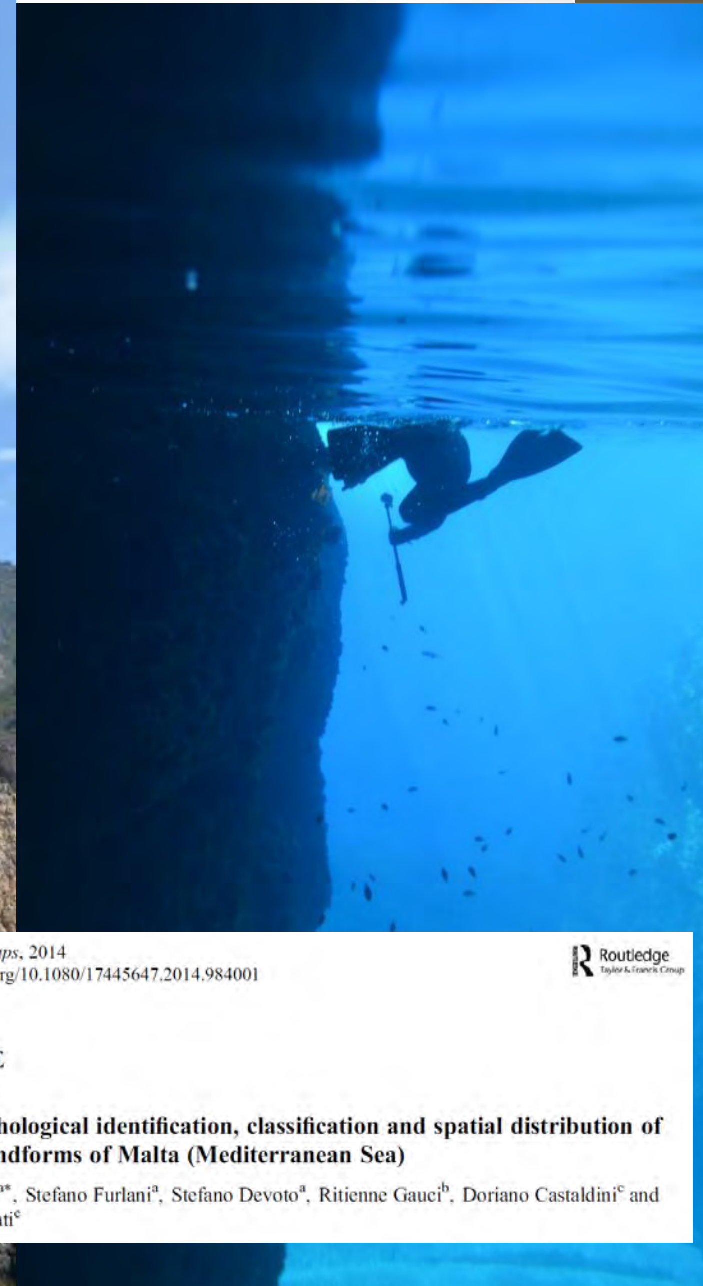


From **Furlani et al., GSL, 2014** (modified from **Schneider, 1976**

COSA SONO LE COSTE ROCCIOSE?

Plunging cliffs





Chapter 7

The rock coast of the Mediterranean and Black seas

S. FURLANI[1]*, M. PAPPALARDO[2], L. GÓMEZ-PUJOL[3] & A. CHELLI[4]

Journal of Maps, 2014
http://dx.doi.org/10.1080/17445647.2014.984001
Routledge Taylor & Francis Group

SCIENCE

Geomorphological identification, classification and spatial distribution of coastal landforms of Malta (Mediterranean Sea)

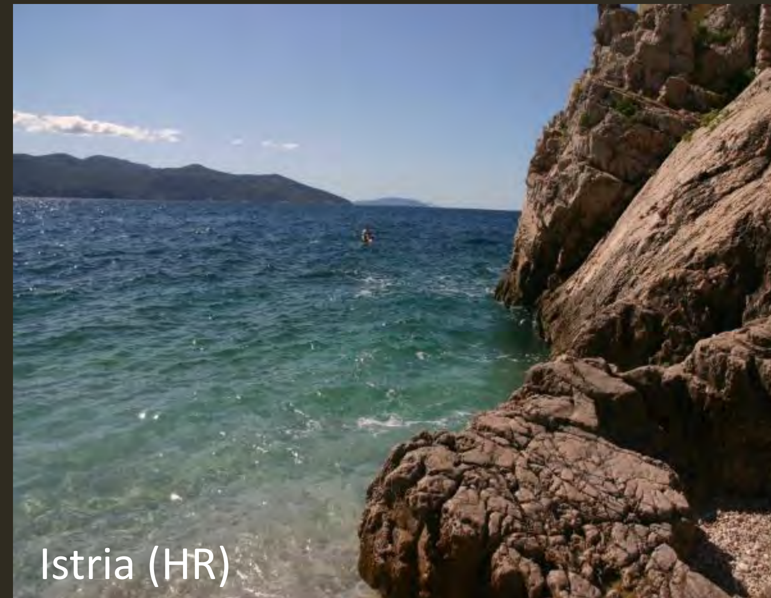
Sara Biolchi[a*], Stefano Furlani[a], Stefano Devoto[a], Ritienne Gauci[b], Doriano Castaldini[c] and Mauro Soldati[c]

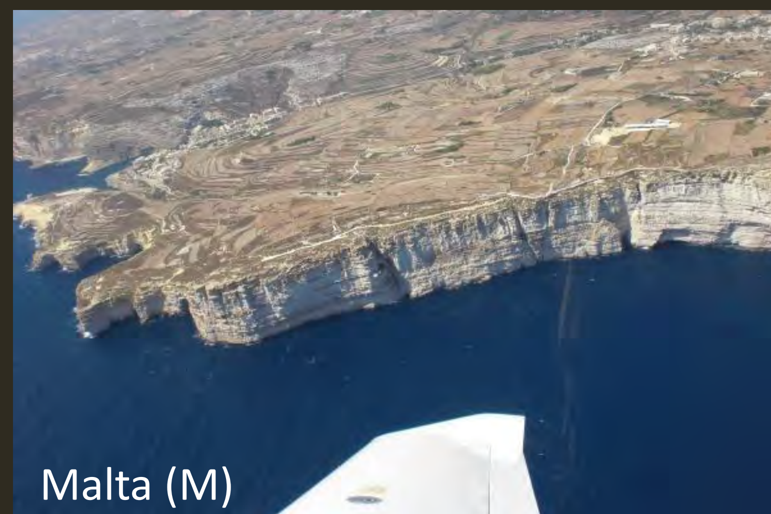

Sloping coast

Scree


Cliff/platforms


Pocket beach





Rocky coasts in the Mediterranean

Limestone coasts

Come sono studiate?

- Studies on rocky coasts focussed on specific sites or problems, and studied with punctiform observations, are mostly carried out walking (e.g. Kennedy, 2013; Kennedy et al., 2014 and references therein) or through remote sensing-based data.
- The common feature of the works examined here is the fact they are very localized, because of the complex logistics of swim and underwater surveys (Furlani et al., 2014a). The greater efforts related to the physical commitment of swimming has certainly discouraged many researchers from swimming along rocky coasts, especially along plunging cliffs.

Special Section - Through the barricades: history of boundaries in Geology

Sea surface: a physical and metaphorical border

Stefano Furlani[1] & Daniele Musumeci[2]

[1] Department of Mathematics and Geosciences, University of Trieste, via Weiss 2, 34128 Trieste, Italy.
[2] Department of Humanities, University of Catania, Piazza Dante 32, 95124 Catania, Italy.

Tanti punti, poca continuità…

- Da un punto di vista geomorfologico, le coste rocciose sono solitamente studiate in maniera puntuale (grotte, forme particolari tipo solchi marini, archi e faraglioni, ecc)

Quaternary Science Reviews 119 (2015) 1–19

ELSEVIER

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Tidal notches in Mediterranean Sea: a comprehensive analysis

CrossMark

Fabrizio Antonioli [a], Valeria Lo Presti [b, a, *], Alessio Rovere [c, d], Luigi Ferranti [e], Marco Anzidei [f], Stefano Furlani [g], Giuseppe Mastronuzzi [h], Paolo E. Orru [i], Giovanni Scicchitano [j], Gianmaria Sannino [a], Cecilia R. Spampinato [k], Rossella Pagliarulo [l], Giacomo Deiana [i], Eleonora de Sabata [m], Paolo Sansò [n], Matteo Vacchi [o], Antonio Vecchio [f]

[a] ENEA, UTMEA, Casaccia, Roma, Italy
[b] Department of Earth Sciences, "Sapienza" University, Rome, Italy
[c] MARUM, University of Bremen & ZMT, Tropical Marine Ecology Center, Bremen, Germany
[d] Lamont-Doherty Earth Observatory, Columbia University, NY, USA
[e] Department of Earth Sciences, Environment and Resources, "Federico II" University, Napoli, Italy
[f] Istituto Nazionale di Geofisisica e Vulcanologia, Roma, Italy
[g] Department of Mathematics and Geosciences, University of Trieste, Italy
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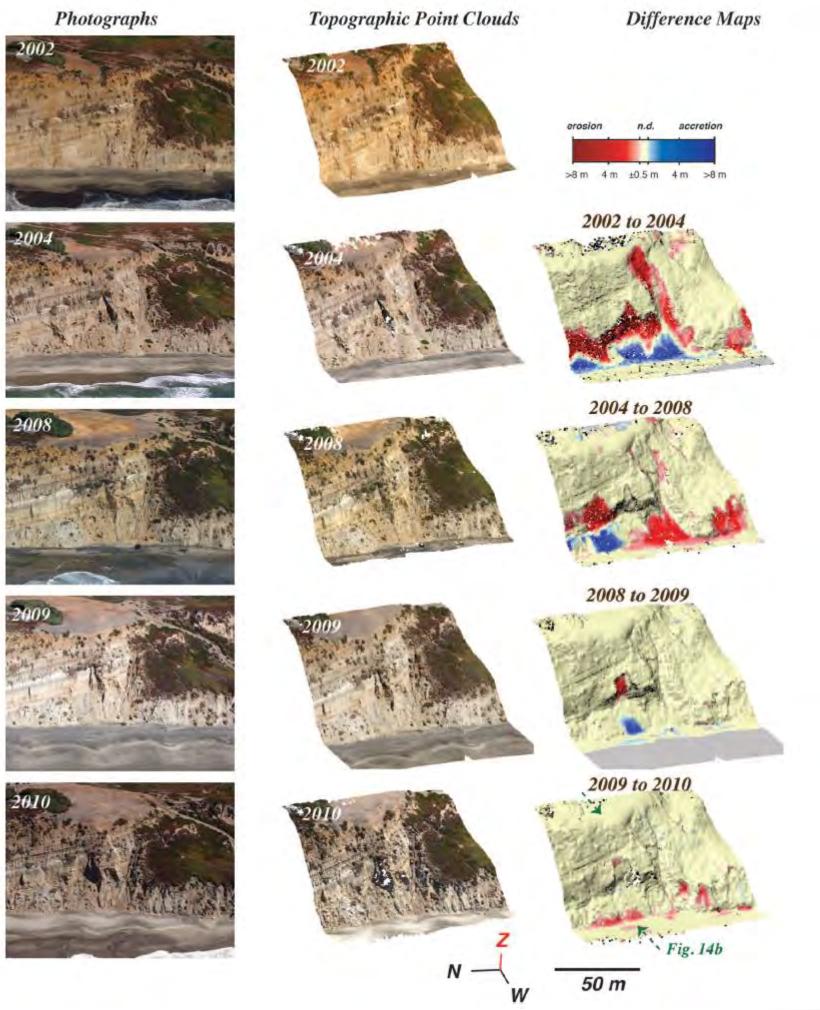
[i] Department of Chemical and Geological Sciences, University of Cagliari, Italy
[j] Department of Phisics and Earth Sciences, University of Messina, Italy
[k] Department of Biological, Geological and Environmental Sciences, University of Catania, Italy
[l] CNR, IRPI, Bari, Italy
[m] MedSharks, Roma, Italy
[n] Department of Biological and Environmental Sciences and Technologies, University of Salento, Lecce, Italy
[o] Aix-Marseille Université, CEREGE CNRS-IRD UMR 34, Europole de l'Arbois Aix-en-Provence, France

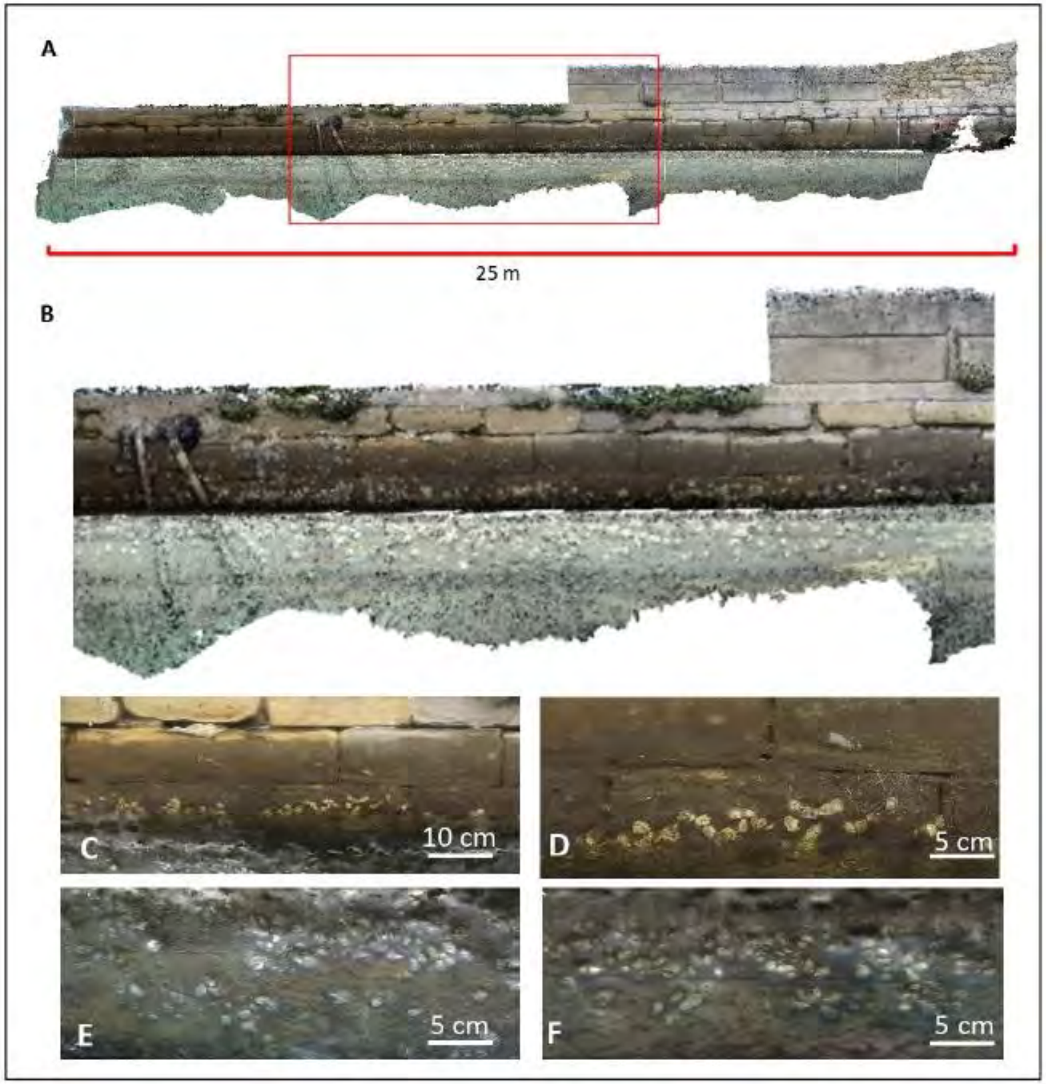
A chance

- The availability of very detailed remote data, both in the subaerial and underwater environment, such as, respectively, **LiDAR** and **Multibeam** data, **cannot satisfactorily contribute** to describing the **tidal and neartidal zone**, its peculiar landforms, such as tidal notches, or the horizontal variations in these parameters.



From: Warrick et al. (2020) JCR

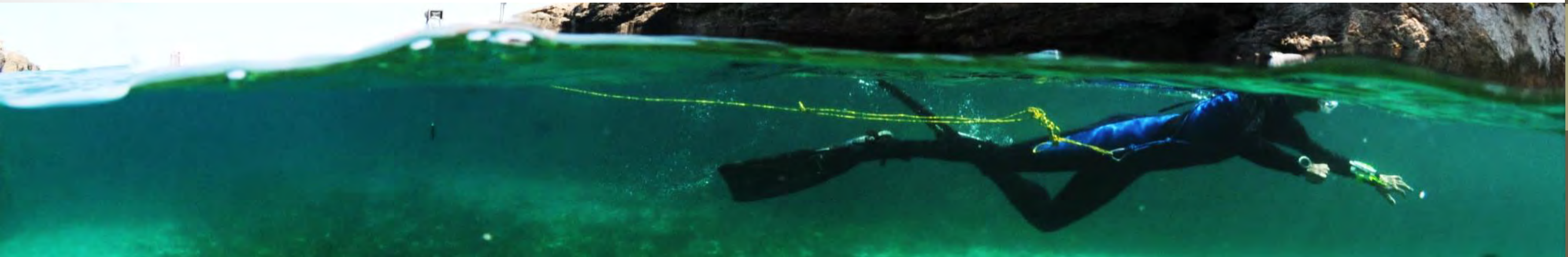
Modelling the intertidal and neartidal



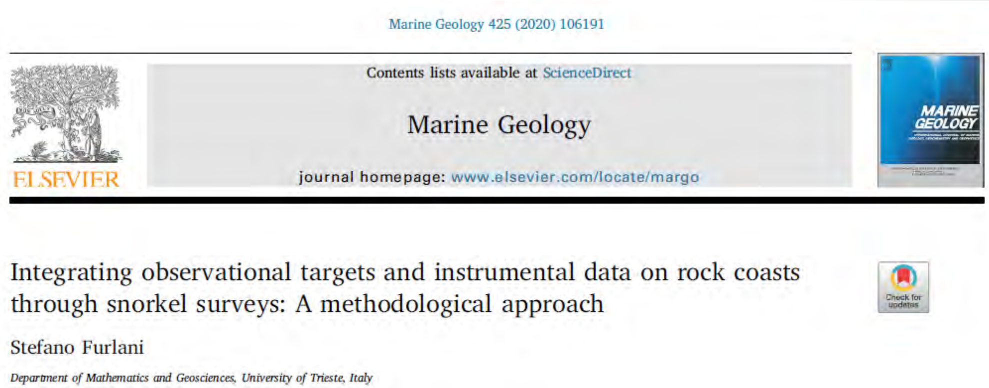
What is Geoswim?

GEOSWIM IS AN APPROACH OF SWIM-SURVEY OF ROCKY COASTS

- By **swimming with mask and fins**
- Collecting **time-lapse images** of the intertidal and nearshore zone
- …surveying of **coastal landforms, physical/chemical parameters**, etc



Conceptual model



Marine Geology 425 (2020) 106191

Contents lists available at ScienceDirect

Marine Geology

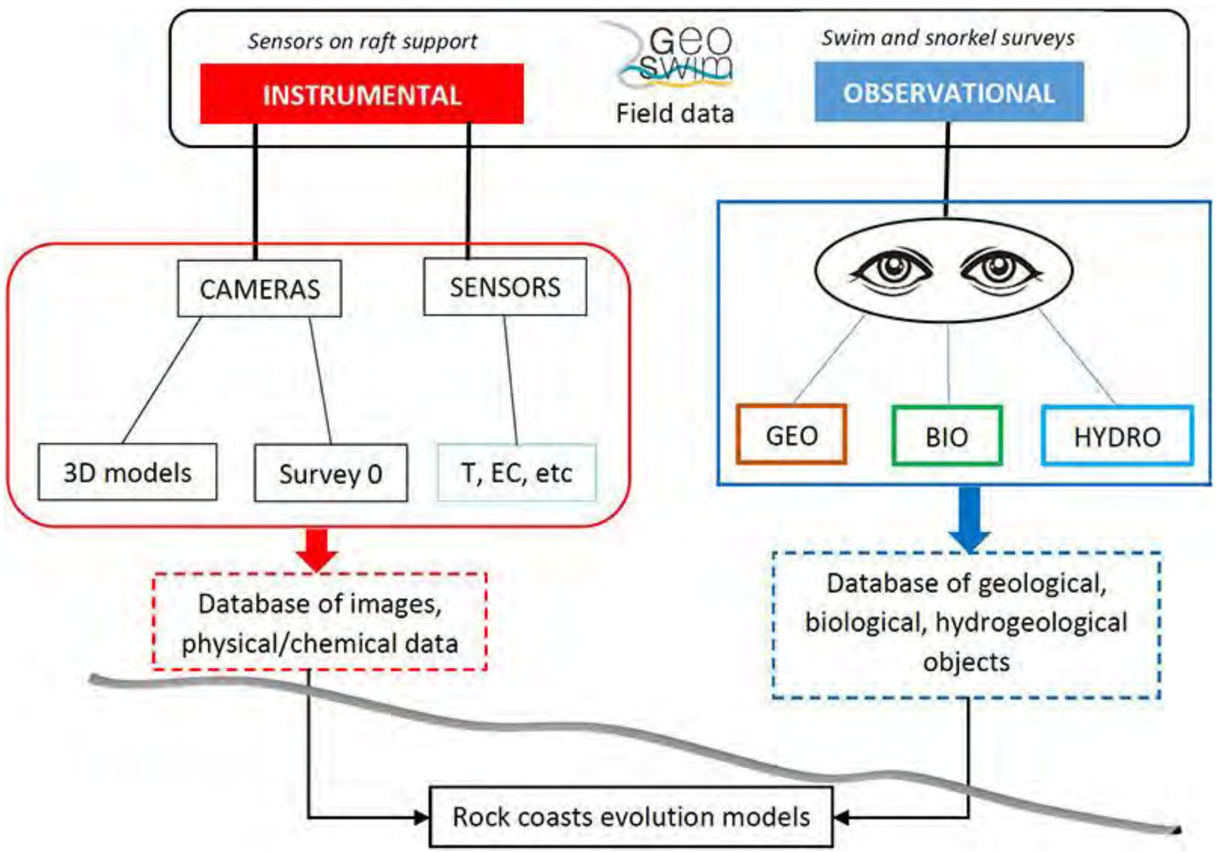
journal homepage: www.elsevier.com/locate/margo

ELSEVIER

Integrating observational targets and instrumental data on rock coasts through snorkel surveys: A methodological approach

Stefano Furlani

Department of Mathematics and Geosciences, University of Trieste, Italy



From: Furlani (2020) Marine Geology

Swim-surveys

- Swim-surveys represent an intriguing challenge for geologists and geomorphologists that are commonly involved in field surveys of rocky coasts.

- A swim-survey can be classified as an expedition, or a long journey undertaken with specific aims, in this case for scientific, exploratory and geographical purposes.

- The **expedition** involves a single rough survey implying a loss in resolution, while **fieldwork** involves returning to the same place, to examine the same and related scientific issues, possibly with other scientists, and recovering the richness forfeited in the successive losses in resolution of the expedition (Richards, 2011).

First experiences

Quaternary International 332 (2014) 37–47

Contents lists available at ScienceDirect

Quaternary International

ELSEVIER

journal homepage: www.elsevier.com/locate/quaint

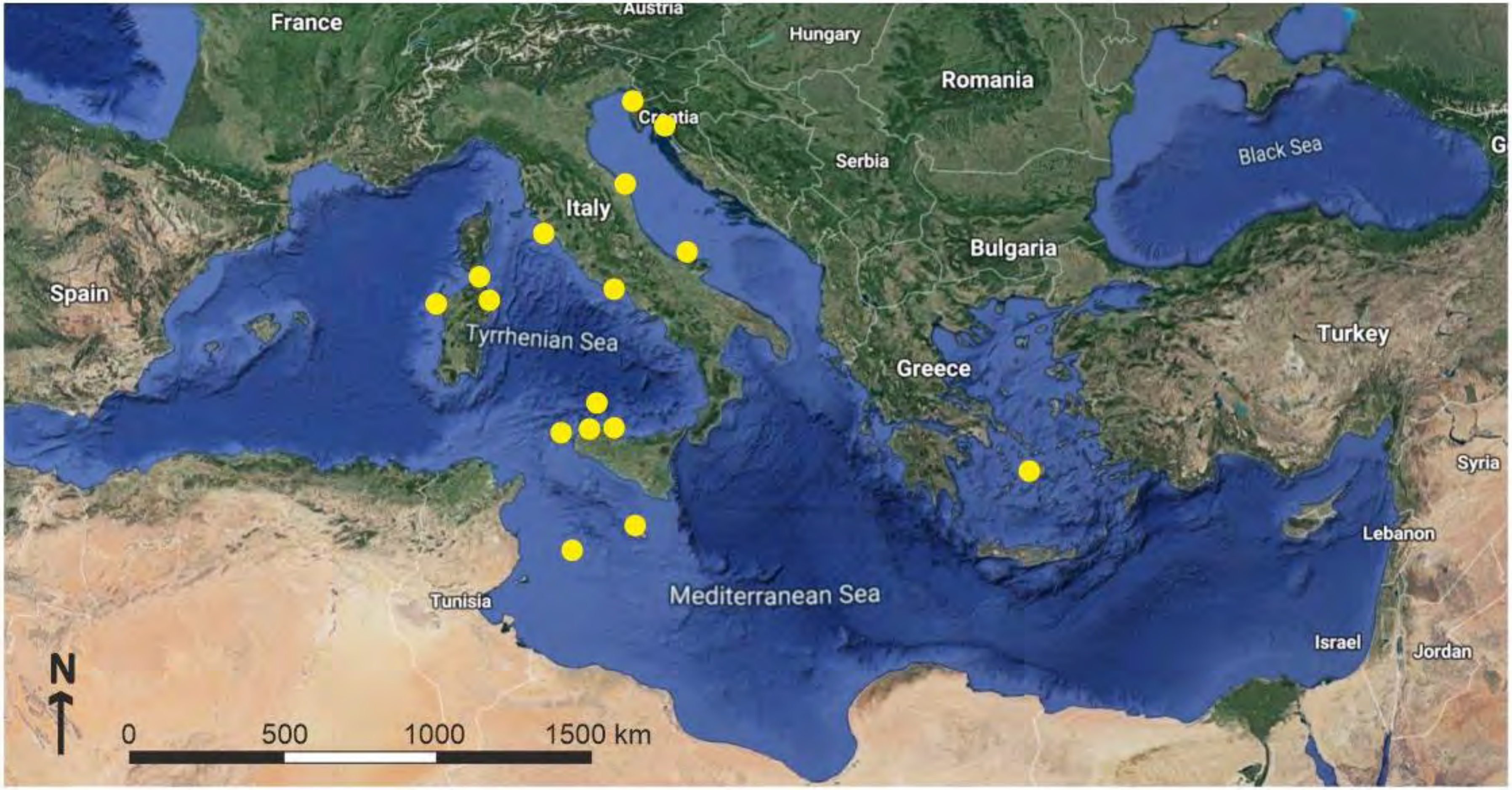
Submerged notches in Istria and the Gulf of Trieste: Results from the Geoswim project

CrossMark

Stefano Furlani [a,*], Andrea Ninfo [b], Enrico Zavagno [a], Paolo Paganini [c], Luca Zini [a], Sara Biolchi [a], Fabrizio Antonioli [d], Franco Coren [c], Franco Cucchi [a]

[a] Department of Mathematics and Geosciences, University of Trieste, via Weiss 2, Trieste, Italy
[b] Department of Geosciences, University of Padova, Italy
[c] INOGS, Trieste, Italy
[d] ENEA, UTMEA TER, Roma, Italy

- Until 2012, swim and snorkel surveys for long routes were never used for scientific purposes along the coasts (Furlani, 2012).
- In 2012, an extensive programme, called ‘Geoswim’, began collecting geomorphological, hydrogeological and biological data together with field visual observations along wide sectors of rocky coasts in the Mediterranean basin (Furlani, 2020 and references therein)
- We have use wide-ranging swims around the Mediterranean rocky coasts, that cover about half the basin (Furlani et al., 2014b).
- Despite their importance, extensive swimming or underwater surveys had never been carried out before the Geoswim experience.



About 23.000 km of rocky coasts in the Mediterranean and Black Sea

Furlani et al., Geological Society of London, 2014

THE GEOSWIM APPROACH

Snorkeling and swimming along rocky coasts

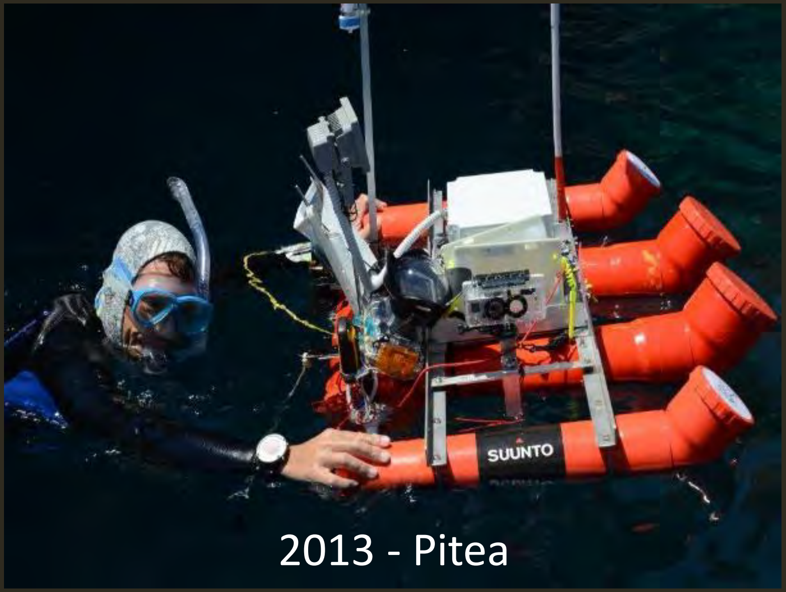
How to swim and survey?

- The raft (ISR, *Instrumental-supported raft*), the fleet
- Instruments
- Navigation issues
- Data
  - Instrumental data
    - Time-lapse images and videos
    - CTD data
    - Depth data
  - Observational data
- Data storing, time register and coordination between instruments and data saving and storage
- Users training and expertise
- Expedition design and limitations

The raft

- The snorkel surveys are carried out using a specially-built raft to support the swimming activities and to house all the surveying equipment. A base constituted by the spearfishing Sporasub platform EVA was adopted.
- Its total length is 1.15 m, the width is 0.57 m and the total height 0.13 m without the plastic glove for fish storage, while the weight of 3 kg. The raft is constructed with Ethylene-vinyl acetate (EVA), a light polymer, about 0.98 g/cm3 with very good resistance to permanent deformation after compression and quite good resistance to abrasion, excellent resistance to UV and very resistant to seawater.
- It is considered virtually unsinkable by producers.


2012 - Wilson



2013 - Pitea

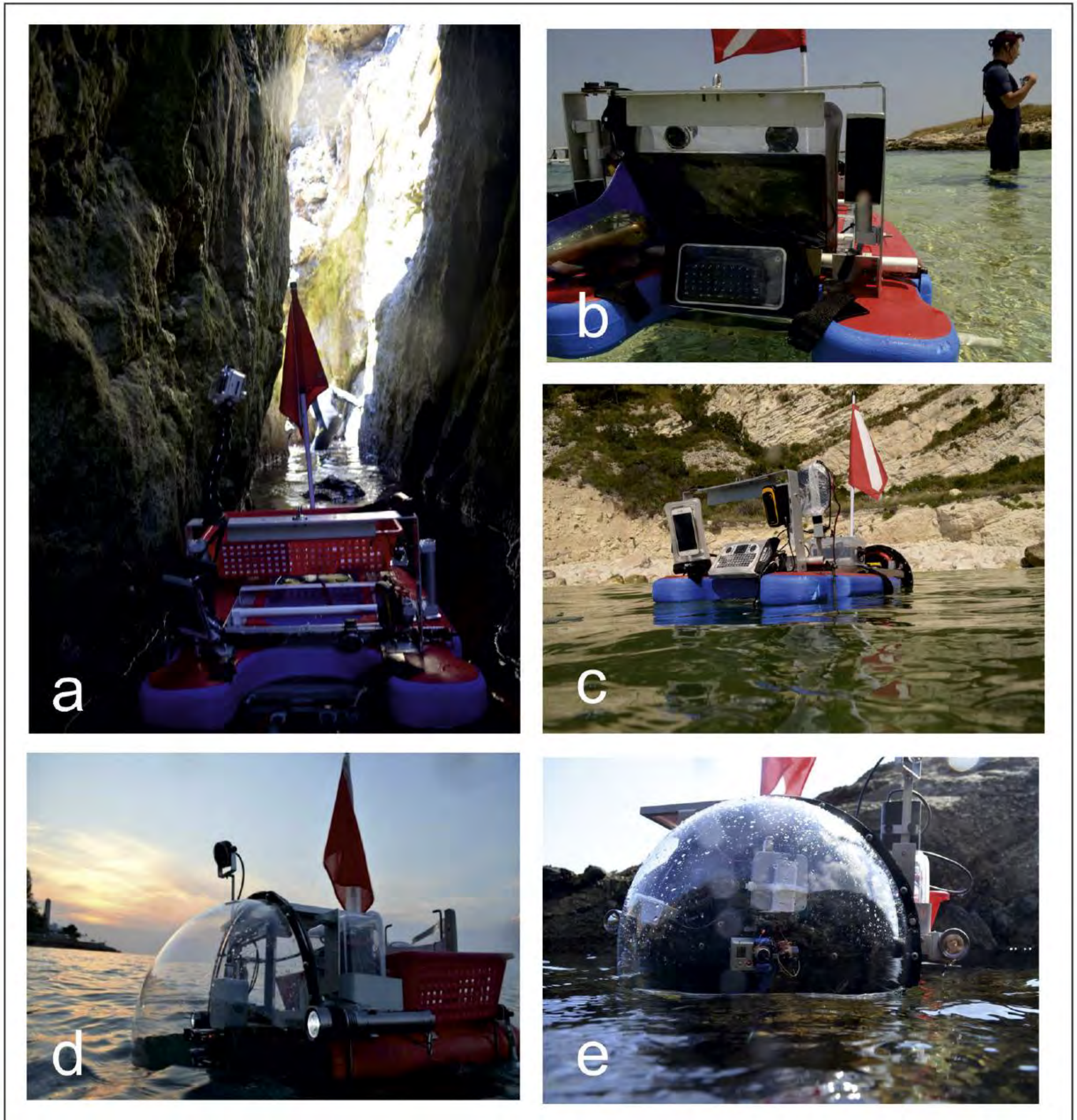

2014 - Ciclope I


2015 – Ciclope II (test)

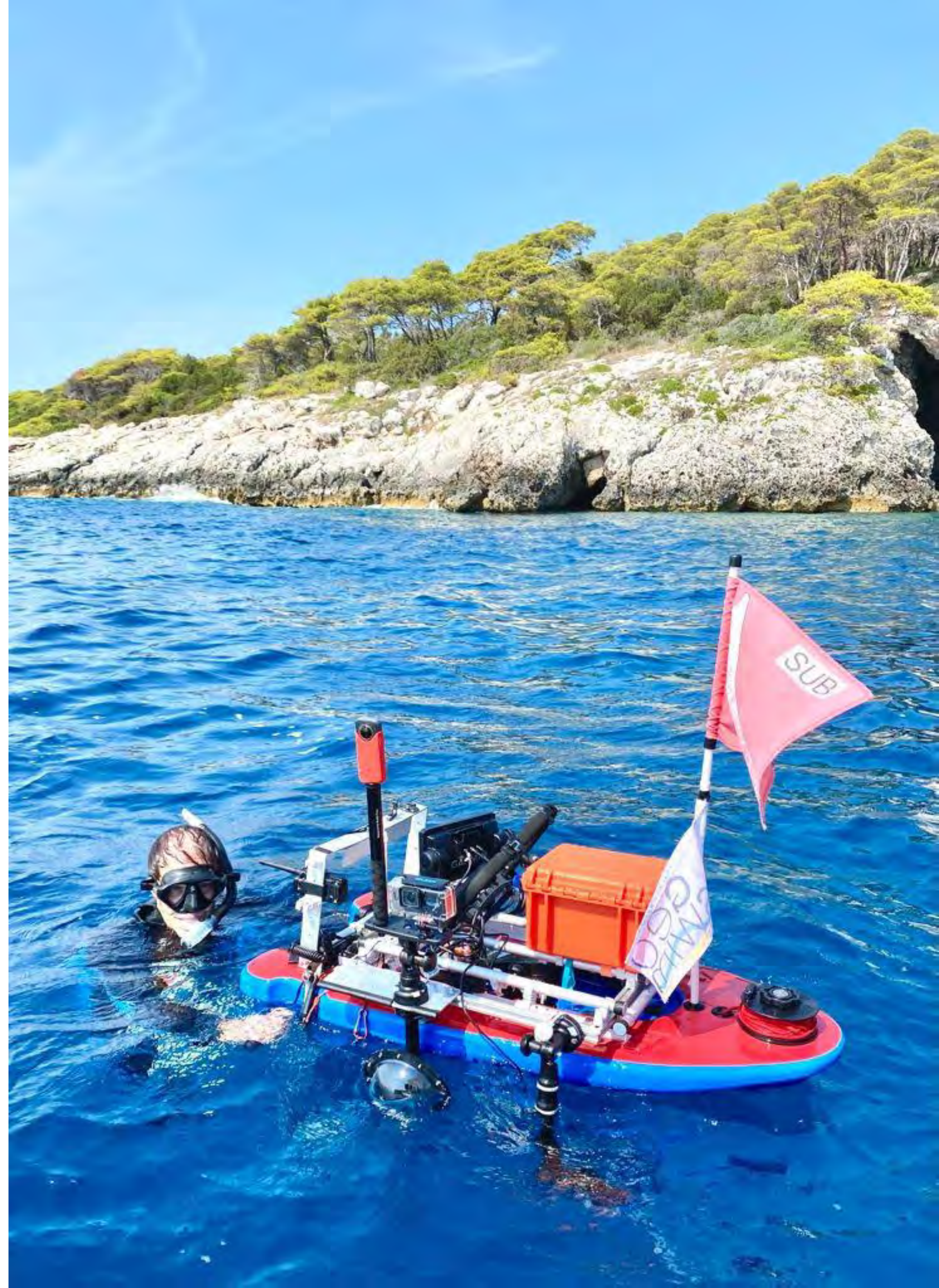
Evoluzione del barchino

2016 – Last evolution of the Ciclope III (test)

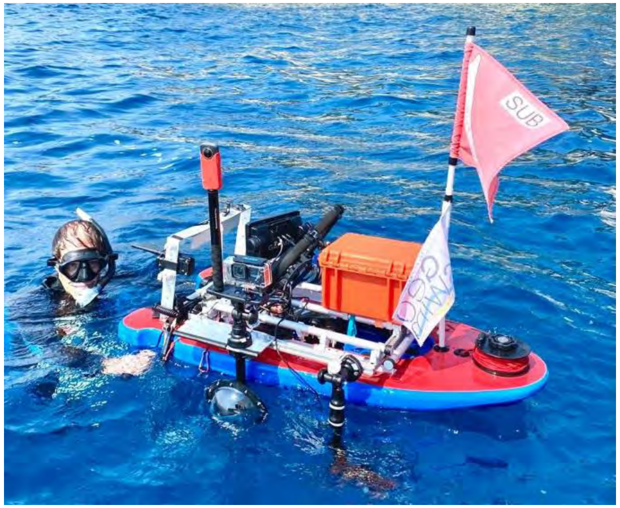
Ciclope III


a
b
c
d
e

2021 Tremiti



The fleet

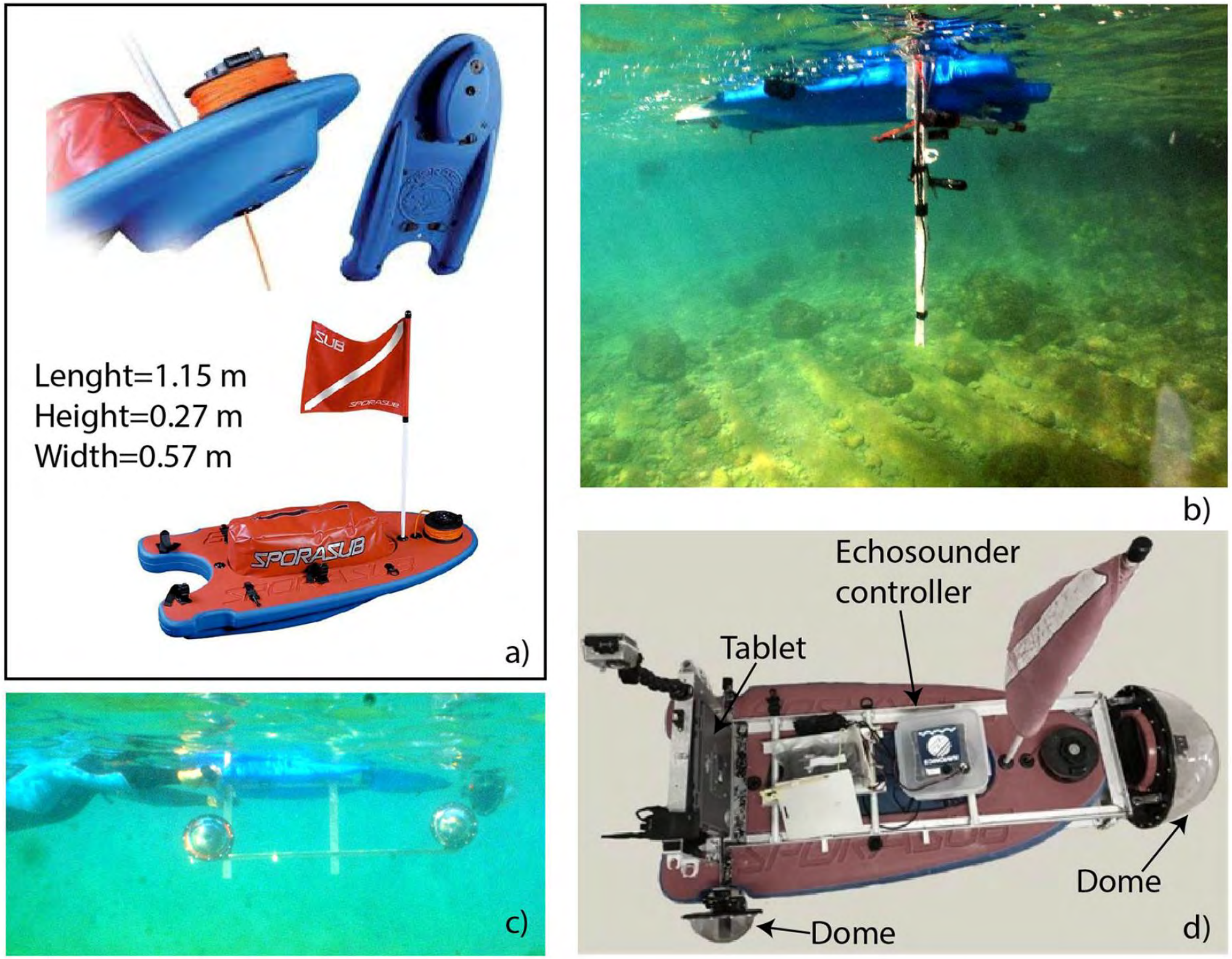


INSTRUMENTS

How to collect data

- Cameras
- CTD sensors
- Echosounder
- GPS

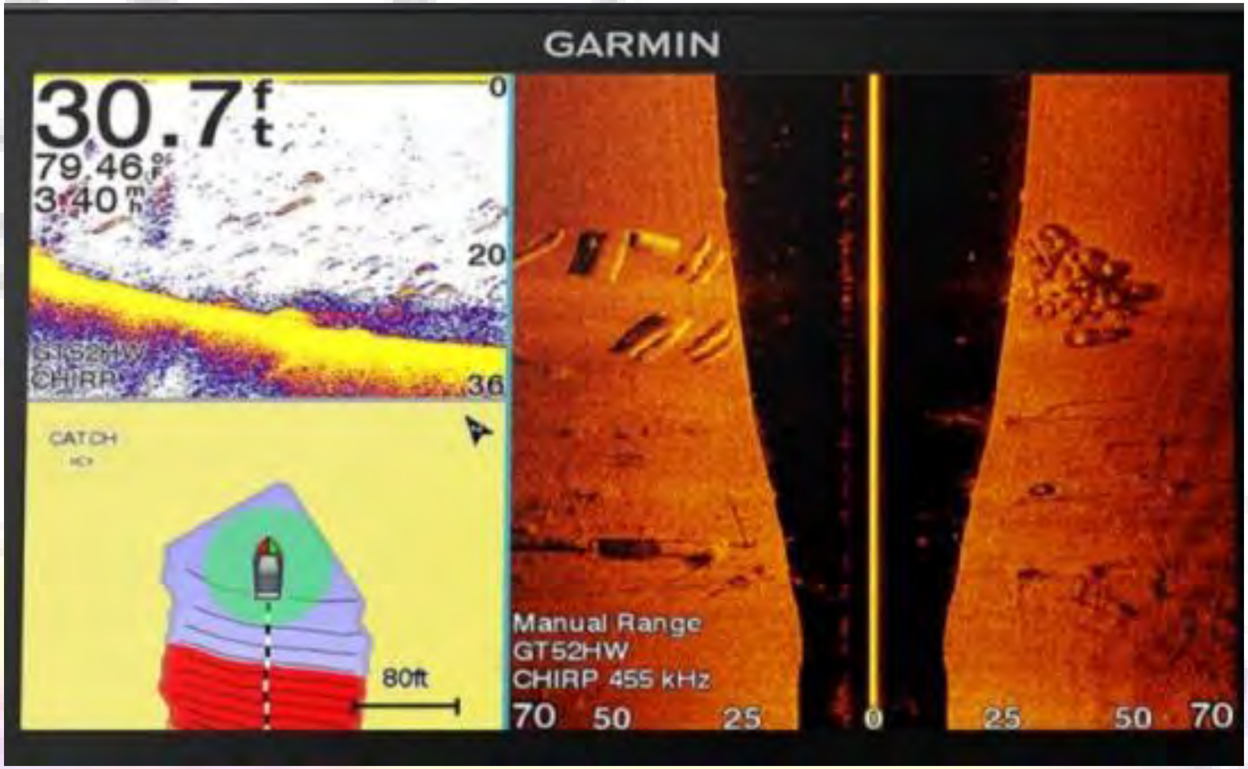
Instruments



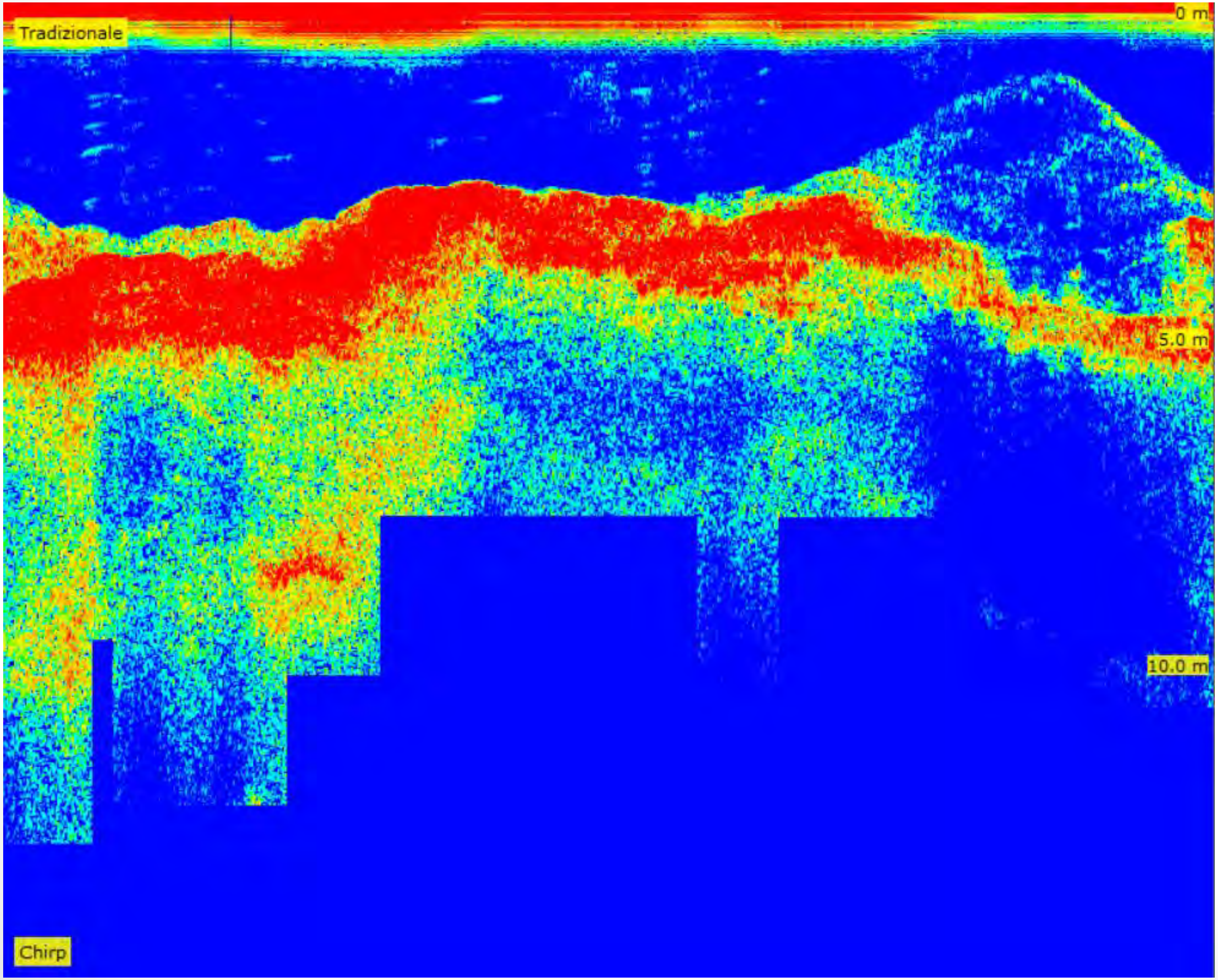
From: Furlani (2020) Marine Geology


SUB

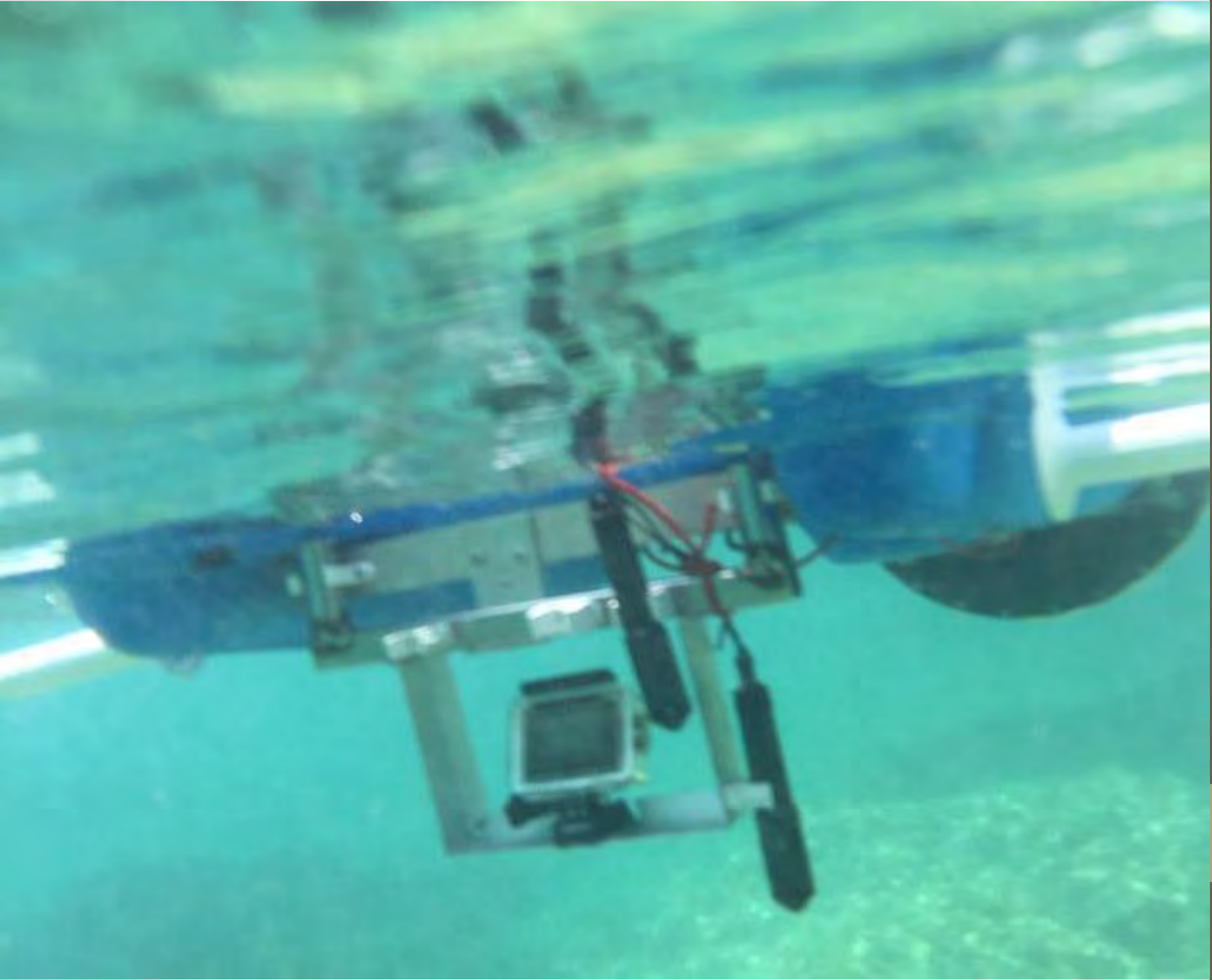
Echosounder



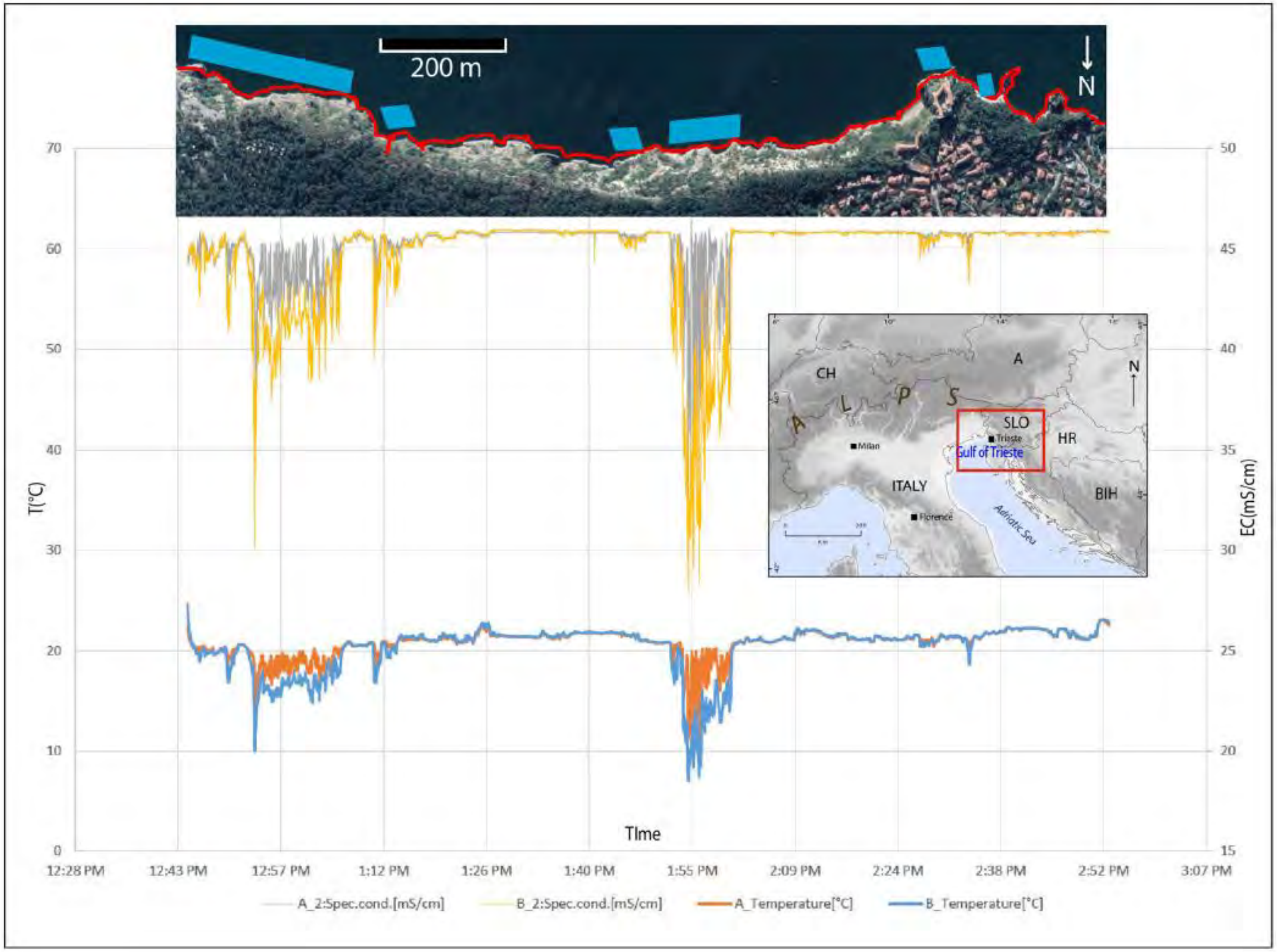
Depth data



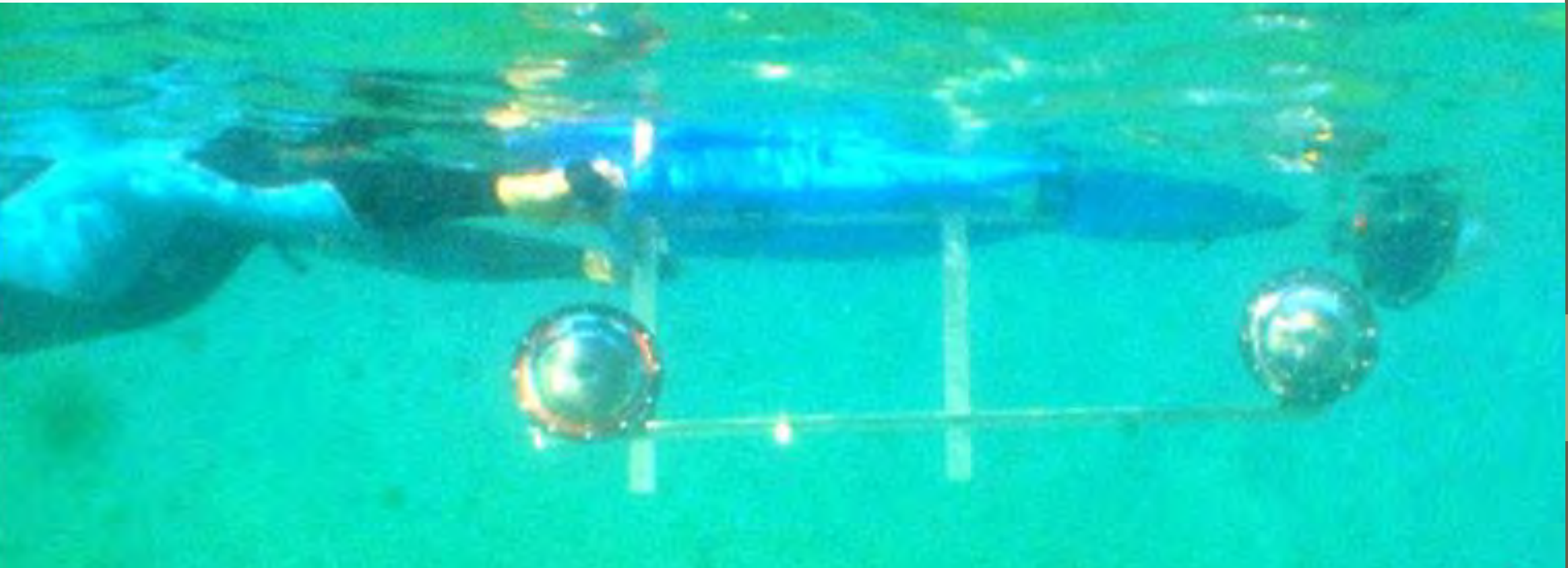
CTD divers and sensors



Chemical/physical data

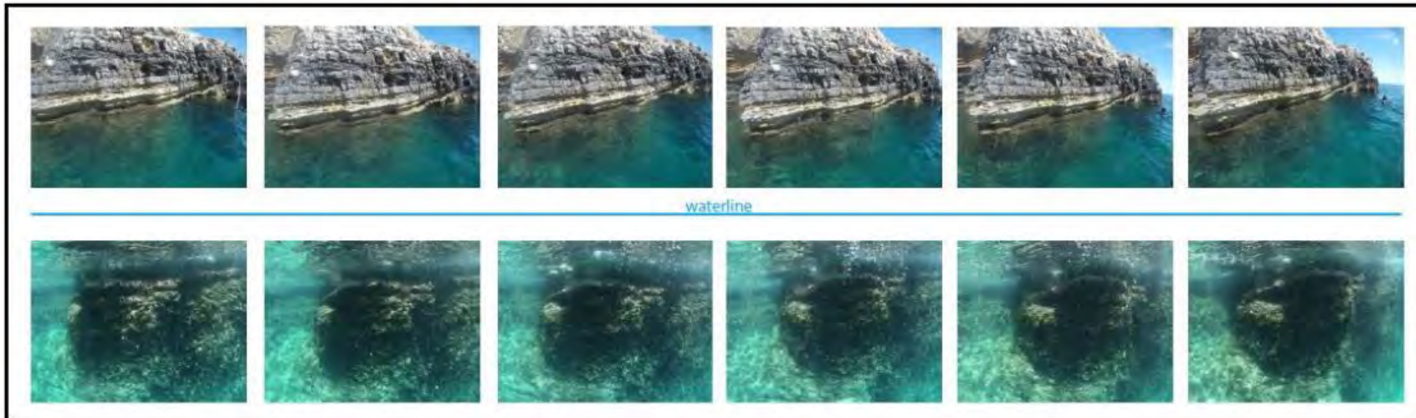


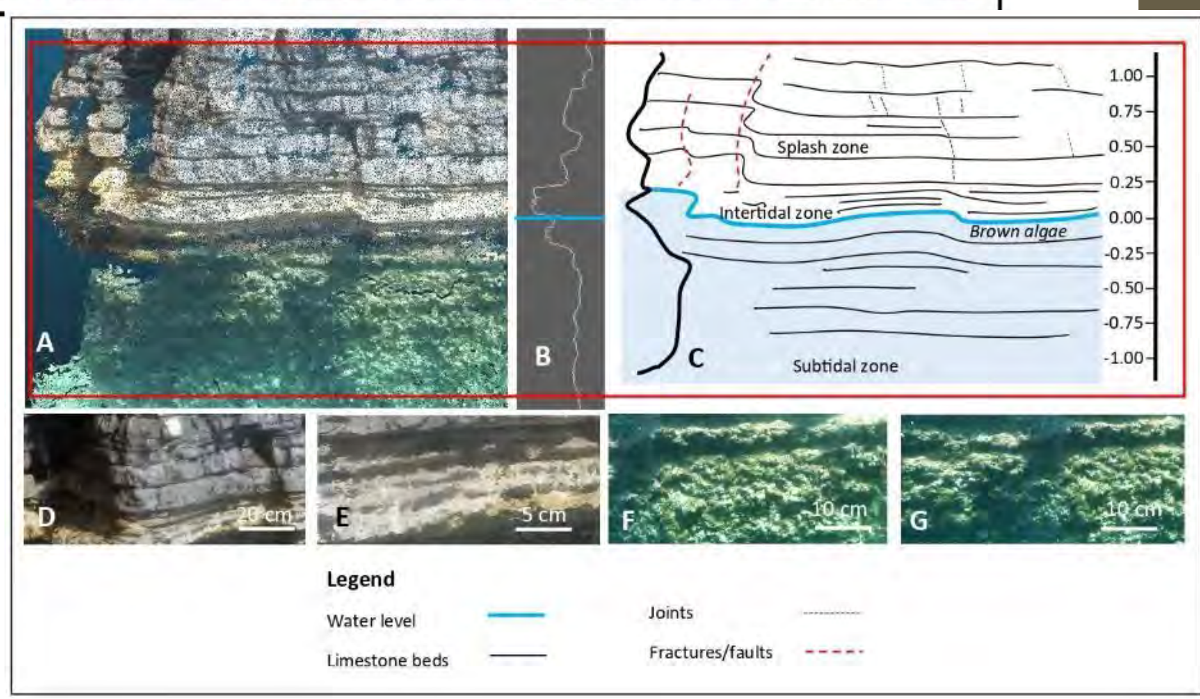
Cameras



360 images

Time-lapse images





From: Furlani et al. (2020) Remote Sensing

Furlani et al. (2020) Remote Sensing

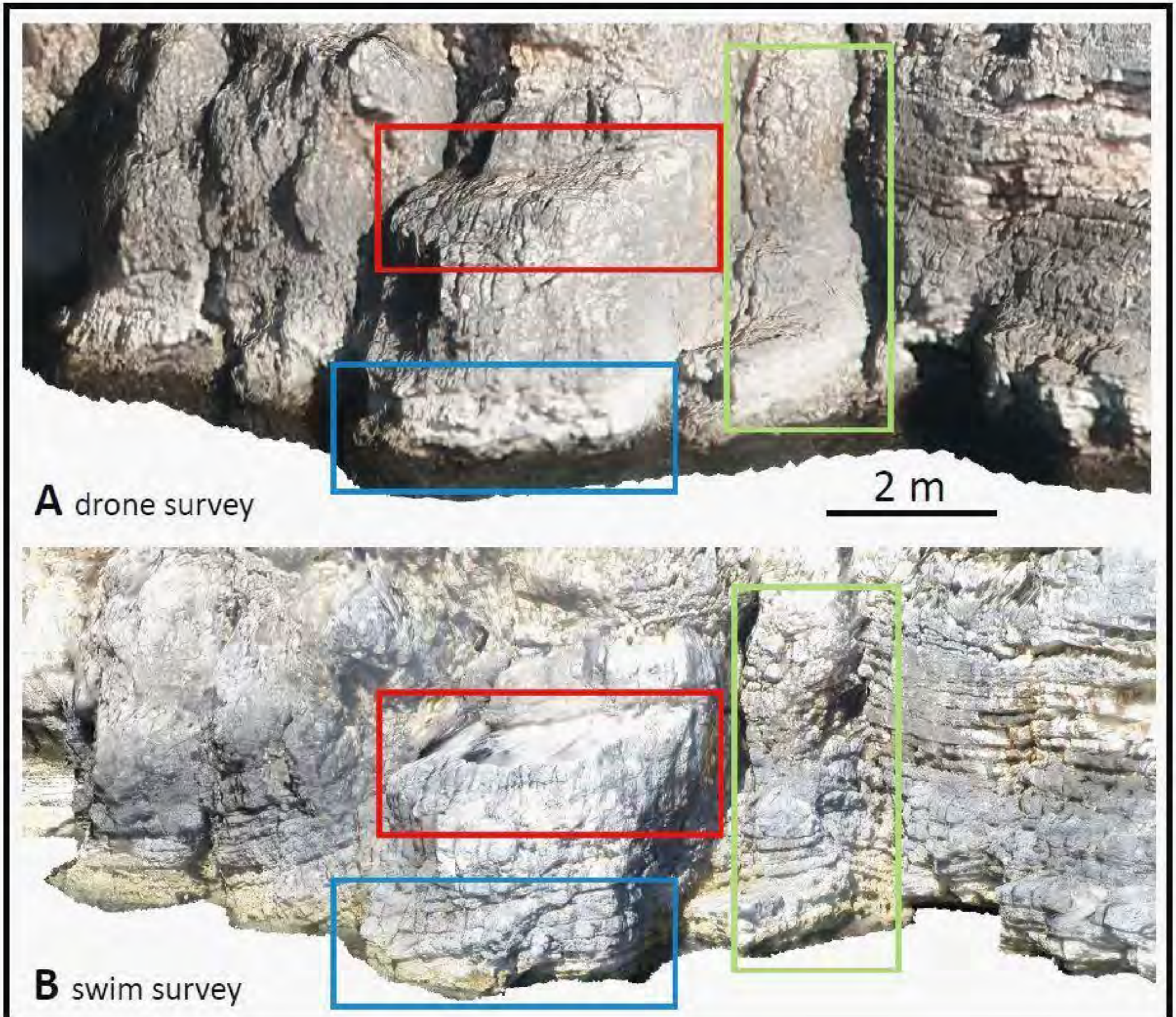
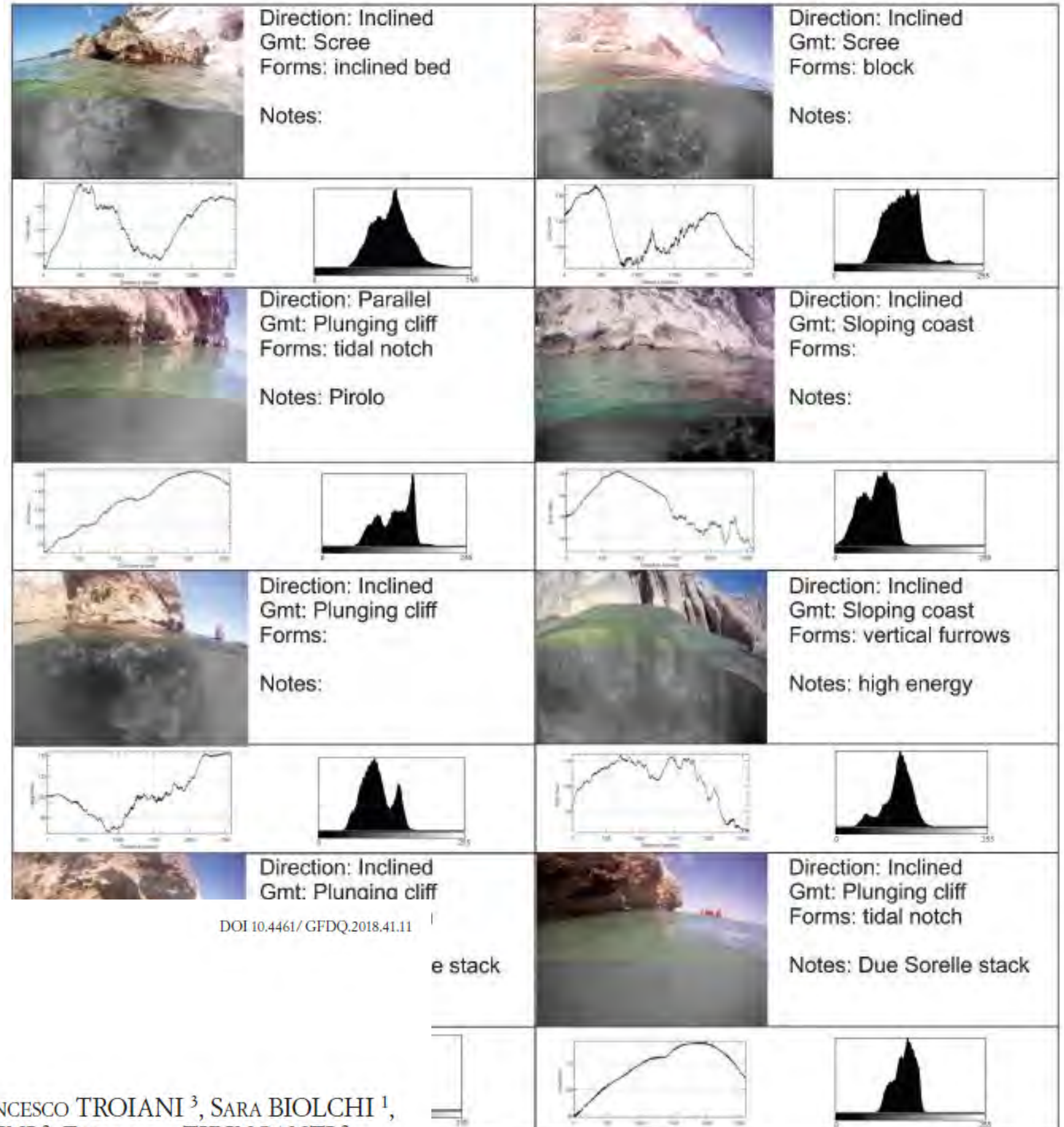


Image analysis



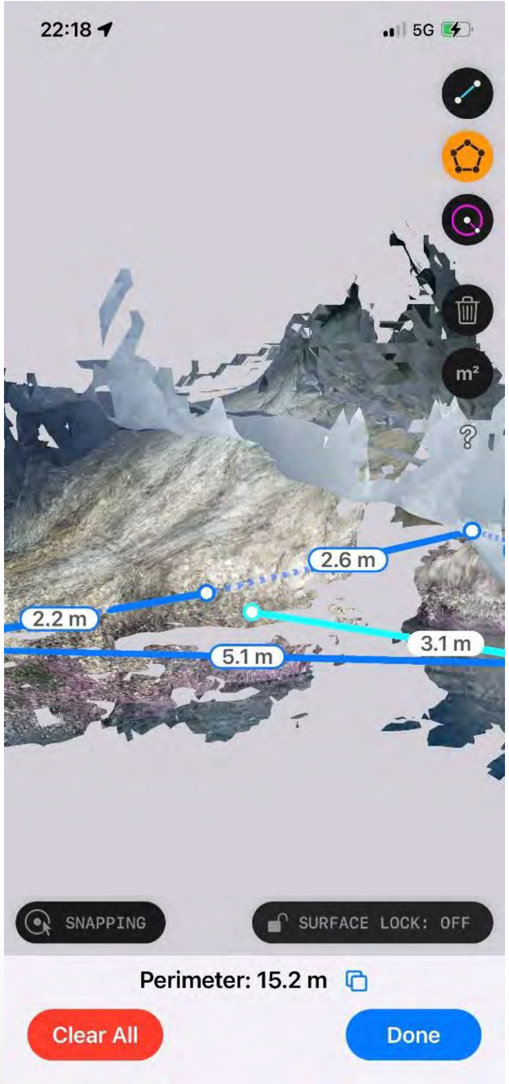
Geogr. Fis. Dinam. Quat.
41 (2018). 33-46, 11 figg., 1 tab.

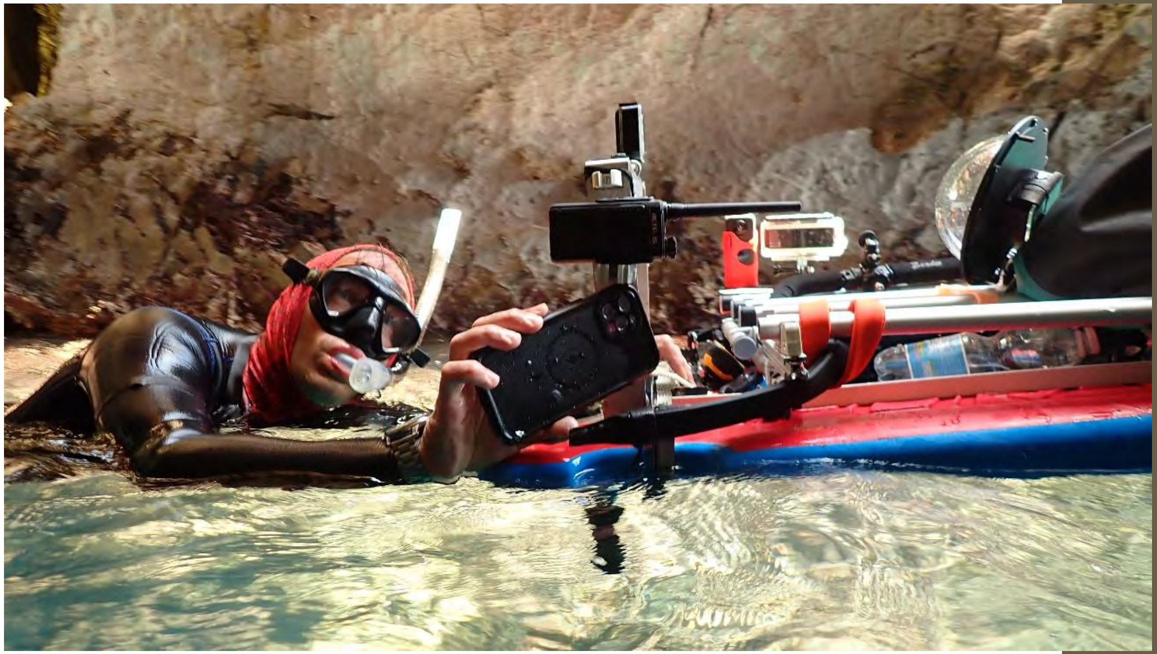
DOI 10.4461/ GFDQ.2018.41.11

STEFANO FURLANI [1*], DANIELA PIACENTINI [2], FRANCESCO TROIANI [3], SARA BIOLCHI [1], MATTEO ROCCHEGGIANI [2], ANDREA TAMBURINI [2], EMANUELA TIRINCANTI [2], VALERIA VACCHER [1], FABRIZIO ANTONIOLI [4], STEFANO DEVOTO [1], OLIVIA NESCI [2] & MARCO MENICHETTI [2]

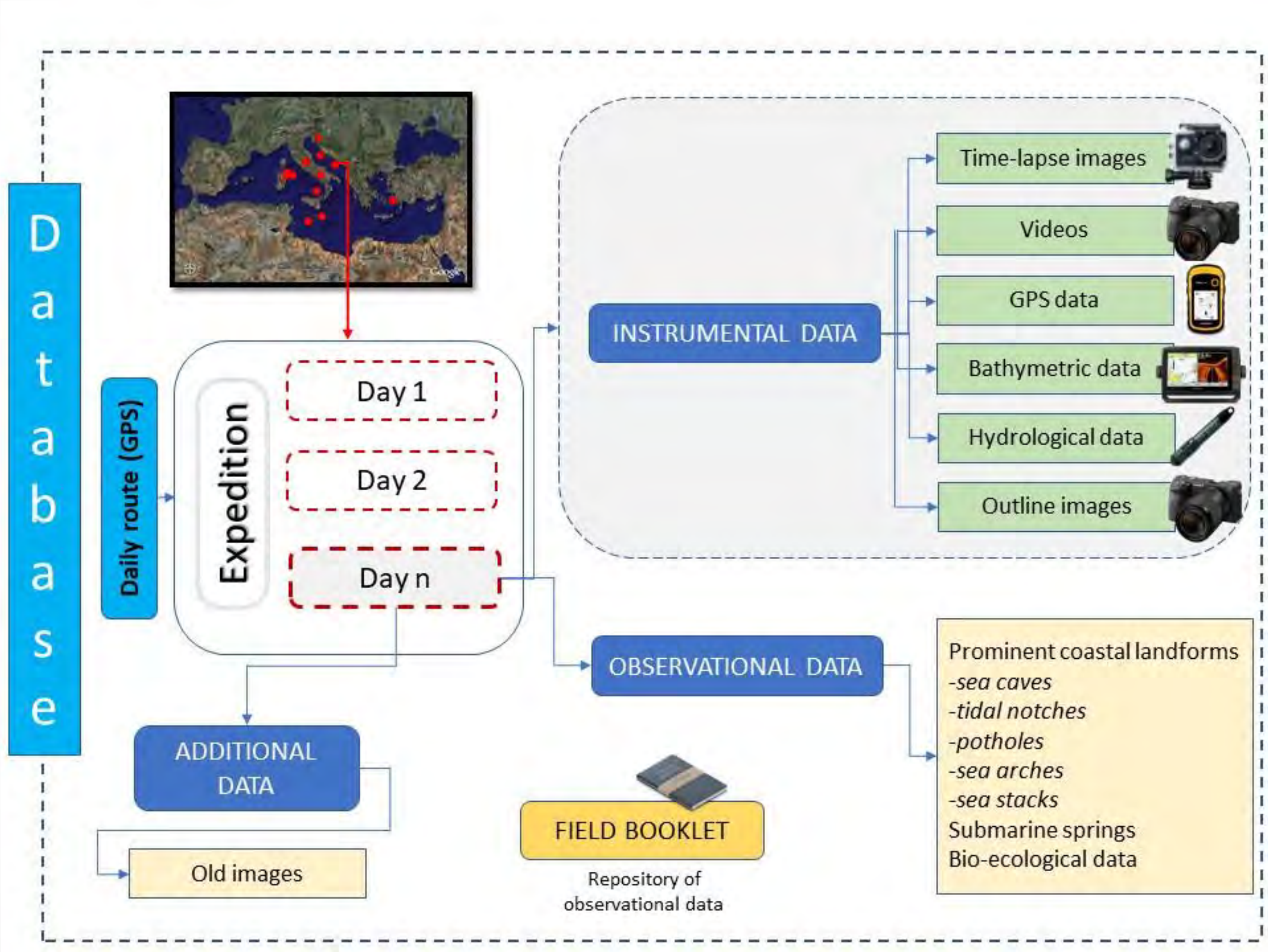
TIDAL NOTCHES (TN) ALONG THE WESTERN ADRIATIC COAST AS MARKERS OF COASTAL STABILITY DURING LATE HOLOCENE

Acquisizione Lidar





Il database



Database
Daily route (GPS)
Expedition
Day 1
Day 2
Day n
INSTRUMENTAL DATA
Time-lapse images
Videos
GPS data
Bathymetric data
Hydrological data
Outline images
OBSERVATIONAL DATA
Prominent coastal landforms
-sea caves
-tidal notches
-potholes
-sea arches
-sea stacks
Submarine springs
Bio-ecological data
ADDITIONAL DATA
Old images
FIELD BOOKLET
Repository of observational data

NAVIGATION ISSUES

How to navigate

- The Geoswim approach is based on field surveys of long sectors of rocky coasts carried out following a planned route and using snorkeling.
- Usually the campaigns are carried out during the spring or summer seasons, because of the generally favourable sea conditions that allow easy navigation.
- The survey follows a route at roughly 1 m to 5 m from the coastline in order to identify the lateral variations in coastal geotargets, and at the same time collect time-lapse images above, below and at water level.
- Small changes in the route can occur with respect to the planned one due to the local topography or due to worsening in weather and sea conditions. The latter forces the swimmer to move out from the coast for safety reasons.
- The navigation usually proceeds at a constant speed, ranging between 1 and 2 km/h, unless they encounter significant changes in the coastline, prominent geomorphological features, or topographic obstacles.

I sopralluoghi

Instrumental and observational data

DATA

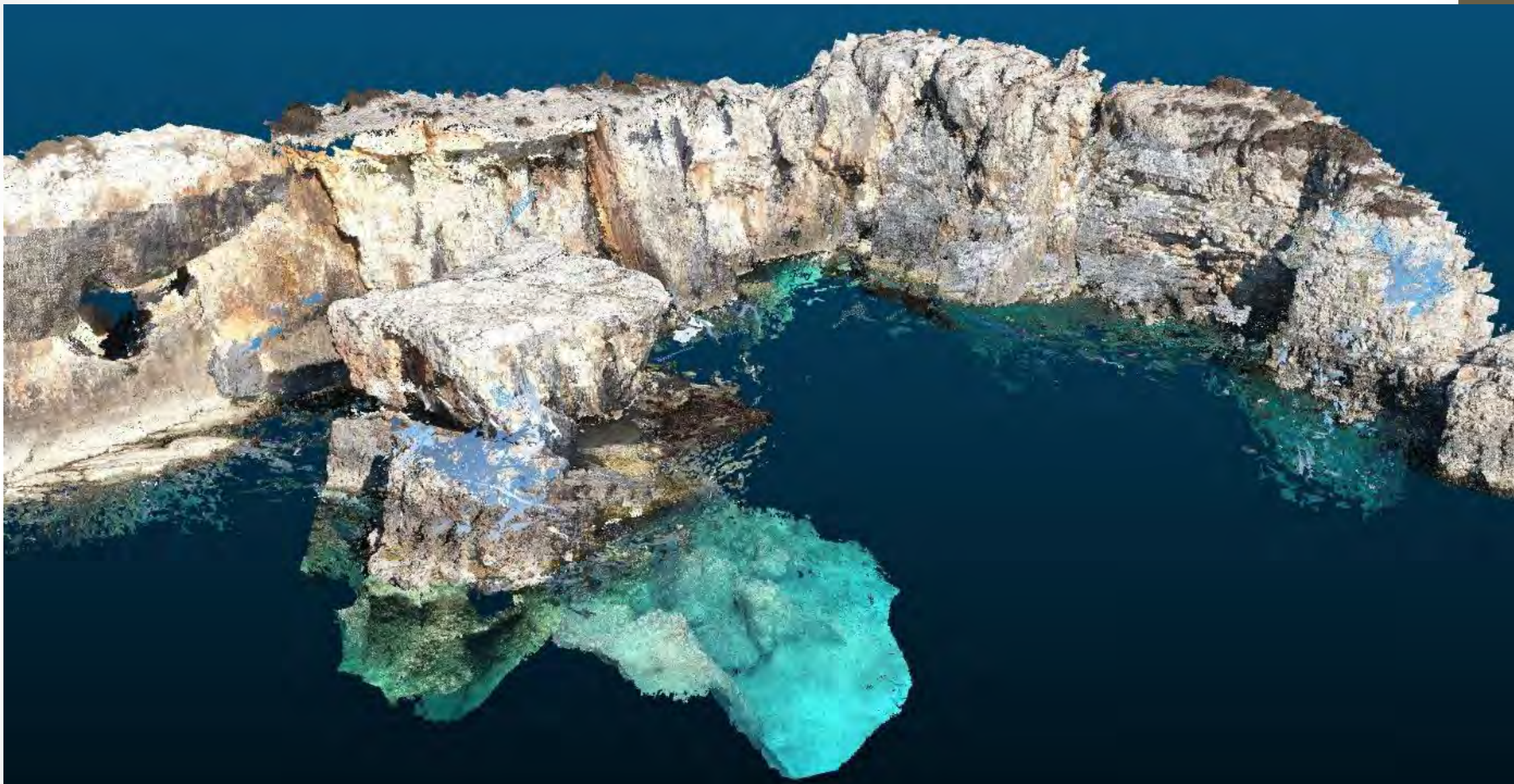
What are we searchin for?

Table 2
Description of type of data collected during Geoswim expeditions. The table includes A) the category of data collected; B) type of data collected; C) unit of measure; D) the natur
the type of coverage; G) the type of instrument; and H) notes.

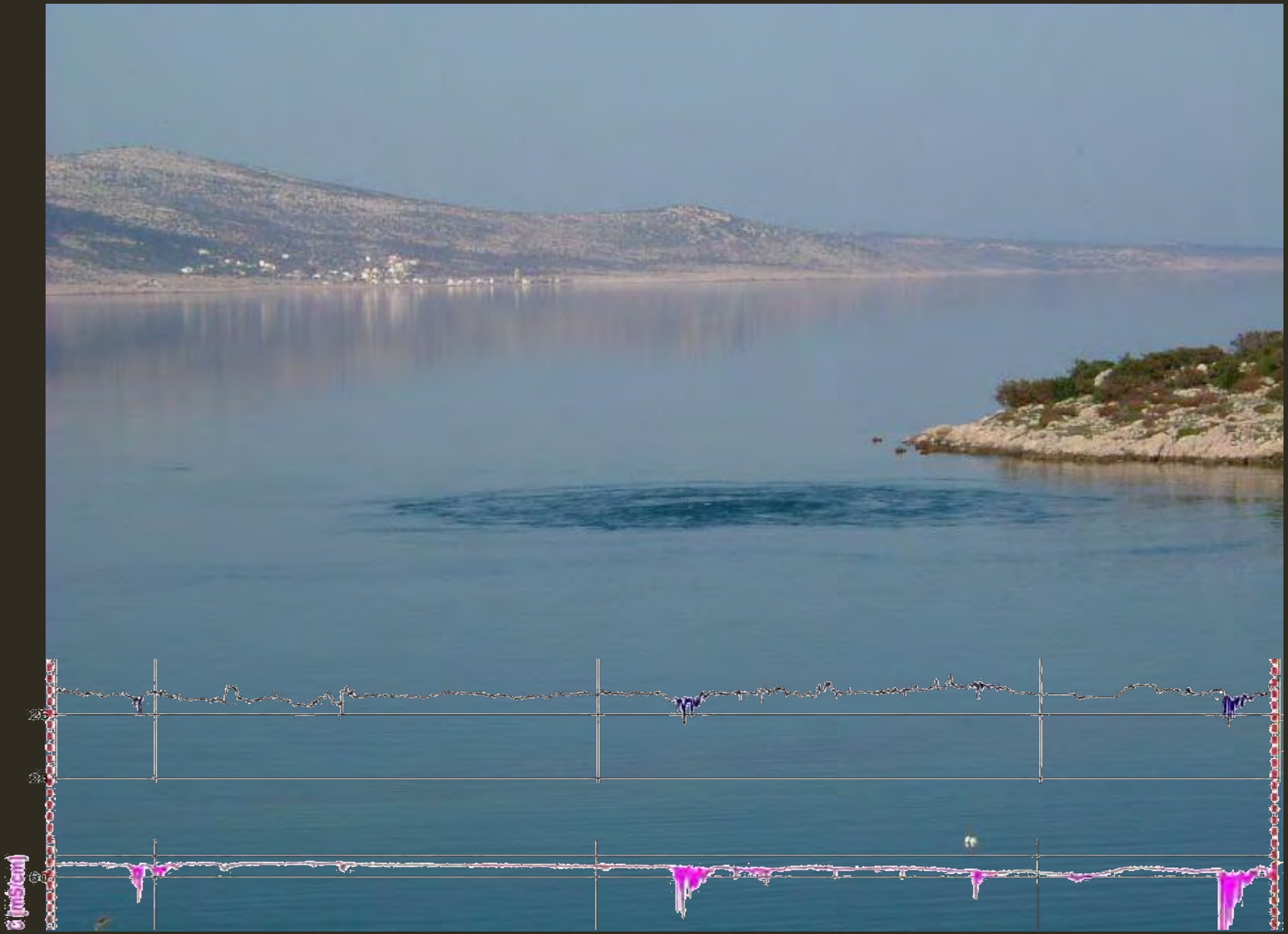
A Category of data	B Data	C Unit of measurement	D Nature of data	E Type of survey	F Coverage	G Type of instrument	H Notes
Instrumental data	Temperature	°C	Physical data	Instrumental	Continuous survey of lateral variability	CTD sensor	/
	Electrical conductivity	mS/cm	Physical data	Instrumental	Continuous survey of lateral variability	CTD sensor	/
	Depth	m	Physical data	Instrumental	Continuous survey of lateral variability	Echosounder	/
	Depth	M	Physical data	Instrumental	Puntiform survey	Portable echosounder	Punctu
	Time-lapse images	Number/s	Visual	Instrumental	Continuous acquisition of images	GoPRO action camera set in time-lapse mode	These c creating
	Images	Number	Visual data	Instrumental	Puntiform survey	Reflex or other action cameras	/
Visual data	Sea-caves	Number/total length	Geomorphological data	Visual census of presence/absence	Puntiform observation	/	/
	Submarine springs, freshwater	Number/total length	Hydrogeological data	Presence/absence	Puntiform observation	/	Survey temper water t
	Stacks	Number/total length	Geomorphological data	Visual census of presence/absence	Puntiform observation	/	/
	Sea arches	Number/total length	Geomorphological data	Visual census of presence/absence	Puntiform observation	/	/
	Marine notches	/	Geomorphological data	Morphometric survey and coupled with visual description	Puntiform observation	Invar rod, ruler	/
	Potholes	Number/total length	Geomorphological data	Morphometric survey and coupled with visual description	Puntiform observation	Invar rod, ruler	Large n
	Lithology	Descriptive	Geological data	Visual description of specific ecological transects	Puntiform observation	Hammer	Visual c obtaine
	Structural description	Descriptive	Geological data	Visual description of specific landforms associated with the local structural setting	Punctiform observation	/	Joints,
	Biological objects	Descriptive	Biological data	Visual observation of presence/ absence of specific organisms	Punctiform observation	Ruler	Possibly below t
	Ecological description	Descriptive	Biological data	Visual description of specific ecological transects	Punctiform observation	Ruler	Visual c collecte
	Prominent objects	Descriptive	All the types	Visual description and possibly measures	Punctiform observation	All the type of available tools	Visual c collecte

A Category of data	B Data
Instrumental data	Temperature
	Electrical conductivity
	Depth
	Depth
	Time-lapse images
	Images
Visual data	Sea-caves
	Submarine springs, freshwater
	Stacks
	Sea arches
	Marine notches
	Potholes
	Lithology
	Structural description
	Biological objects
	Ecological description
	Prominent objects

From: Furlani (2020) Marine Geology



Furlani et al. (2020), Remote Sensing

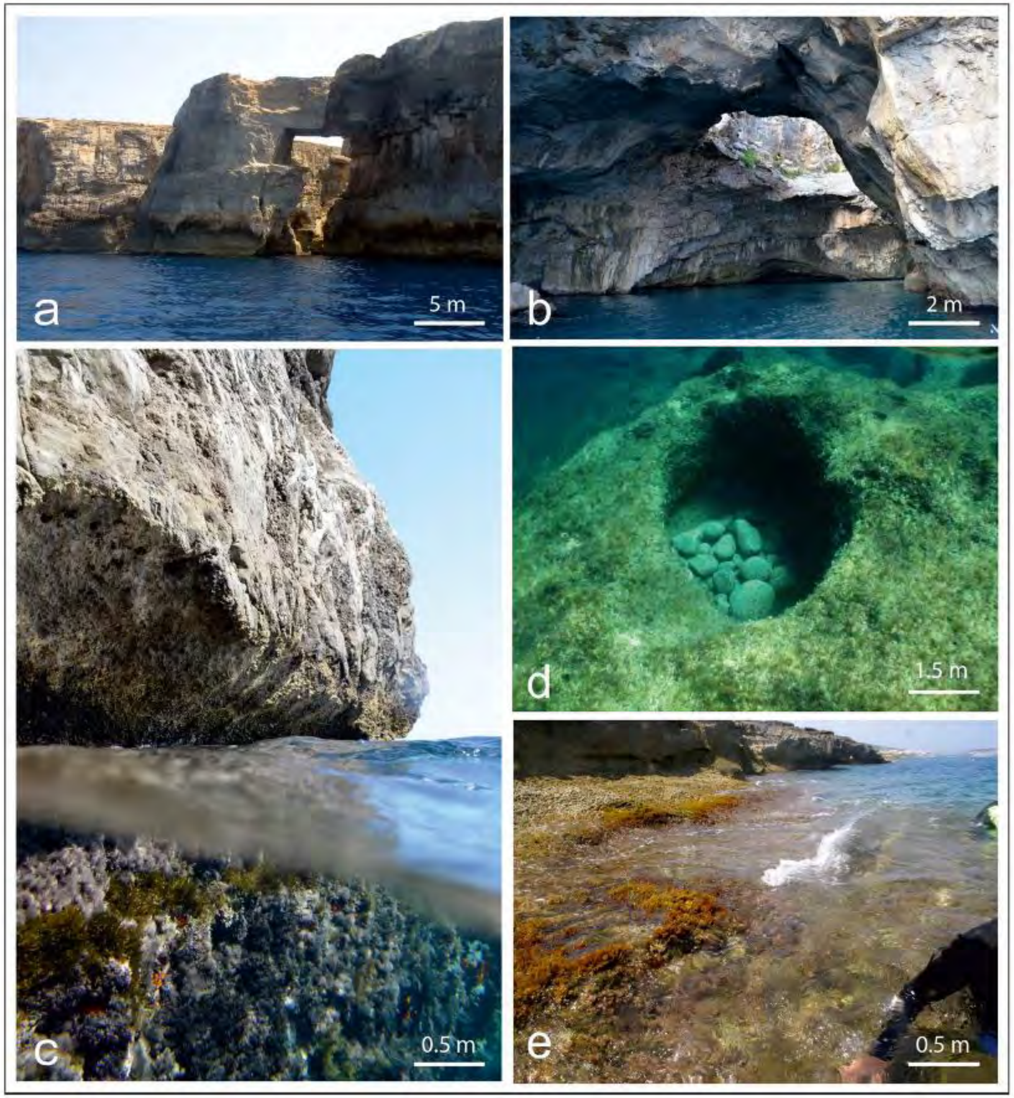


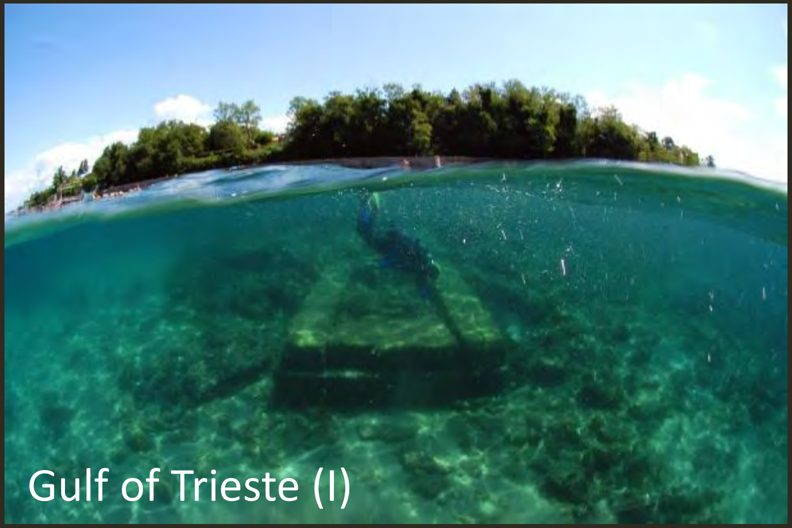
Submarine springs (Dalmatia, Croatia)

Are they importnat in tidal notch genesis?

Present-day notch at Gozo (Malta)

Geomorphological targets





Millenial sea level changes

Historical slc in the Mediterranean Sea

SWOT analysis: pro and contra

Table 3
The SWOT matrix. This analysis allows the identification of the strengths allows to define the characteristics of the method that give an advantage to other approaches of coastal survey; the weaknesses allow to define the characteristics of the approach that need improvements; the opportunities define the goals, or the elements that the project could exploit to its advantage, while the threats analyze the obstacles for using at maximum the method.

SWOT analysis	Helpful	Harmful
Internal	Strengths • Potential detailed surveys of many kilometres of rock coasts; • Only one surveyor can collect a large amount of data, in particular instrumental ones; • The method represents a useful approach to model the topography of the tidal and nearshore zone of rocky coasts in microtidal environments; • It is a relatively cheap approach; • Gathering more than one field of research on rock coasts, such as geology, geomorphology, hydrogeology, biology, etc. • It is the only approach tested to study large sectors of rock coasts.	Weaknesses • Many kilometres of rock coasts to be surveyed with a time-consuming method; • Low-lying rocky coasts are difficult to survey using this approach; • The distance of navigation is often different from plans because of local topography; • Observations are strongly observer-influenced; • The accuracy of observations of the final sectors of long routes can be affected by fatigue that reduce the capability to observe and collect data.
External	Opportunities • Emerging need of data on rock coasts for applied sciences, such as researches about sea level changes, ecological changes along rock coasts, etc. • The resulting database represent a survey zero for future comparisons; • Opportunity to test the capability of snorkel surveys to provide useful field data; • Opportunity to improve technologies for coastal surveys; • Training for safety field activities.	Threats • Weather and sea conditions can limit or prevent the acquisition of field data; • the patterns of landforms or structures may be evident only at a certain distance from the coast, that may change slightly during the survey because of topographical or environmental factors, preventing a detailed survey • Weather and sea conditions can cause safety issues to snorkel surveyors; • The battery life of the cameras can affect the possibility to collect images in the final sectors of long routes. Local laws limitations, such as environmental or archaeological ones, can limit or prevent the surveys.

EXPEDITIONS 2012-2020

Table 1

The expeditions within the Geoswim programme from 2012. The total number of kilometres geo-swum over these years is much greater considering the long sectors of rocky coasts, mainly in the Gulf of Trieste, used to test the instrumentation. The table reports A) the year in which the expedition took place; B) the location; C) the number of snorkel surveyors involved; D) the type of support provided to the surveys and surveyors, either on a boat or on land; E) the type of rocks outcropping along the studied sector; F) the total length of the route snorkeled during the expedition in kilometres; G) the duration of the expedition (survey days).

A Year	B Location	C Number of surveyor	D Support (land/ boat)	E Type of rocks	F Total length of the route (km)	G Days of survey	H Type of data collected	H Literature
2012	W Istrian Peninsula (Croatia, Slovenia, Italy)	One-man survey	Land	Limestone, sandstone and marlstones	253,2	27	Geomorphology, hydrogeology	Furlani, 2012; Furlani et al., 2014a
2013	Gozo and Comino (Malta)	10	Boat	Limestones, clays	57	7	Geomorphology, hydrogeology	Furlani et al., 2017b
2013	Stara Baska (Krk, Croatia)	One-man survey	No support	Limestones	2,2	1		/
2014	Egadi Islands (Italy)	7	Boat	Limestones, dolostones, siltite, breccias	67	7	Geomorphology, hydrogeology, biology	Busetti et al., 2015 Antonioli et al., 2015
2015	Gaeta Promontory (Latium, Italy)	4	Boat	Limestones	2,5	1	Geomorphology, hydrogeology	Work in progress
2015	Ustica (Sicily, Italy)	5	Boat	Volcanic rocks	14	2	Geomorphology, lithology, hydrogeology, biology	Furlani et al., 2017a
2015	Razzoli, Budelli, Santa Maria (Sardinia, Italy)	7	Boat	Granites	22,5	3	Geomorphology, lithology, hydrogeology, biology	Work in progress
2015	Capo Caccia (Sardinia, Italy)	6	Boat	Limestones	26	2	Geomorphology, hydrogeology, biology	Work in progress
2015	Tavolara (Sardinia, Italy)	7	Boat	Limestones, granites	14,9	2	Geomorphology, hydrogeology, biology	Work in progress
2015	Malta (Malta)	7	Boat	Limestones	19,2	3	Geomorphology, hydrogeology, biology	Work in progress
2015	SE Istria (Croatia)	5	Boat	Limestones	7	1	Geomorphology, hydrogeology	/
2016	Monte Conero (W Adriatic Sea, Italy)	3	Boat	Limestones, marlstones, calcarenites	2,9	1	Geomorphology, hydrogeology, biology	Furlani et al., 2018
2016	Addaura (Palermo, Sicily, Italy)	5	Boat	Limestones, breccias	7	1	Geomorphology, lithology hydrogeology, biology	Caldareri et al., 2019
2017	Paros (Greece)	10	Land, boat	Marbles, volcanic rocks	24	8	Geomorphology, hydrogeology, biology	Work in progress
2017	Sistiana-Duino (Gulf of Trieste, Italy)	One-man survey	Land	Limestone	2	1	Geomorphology, hydrogeology,	Furlani and Biolchi, 2017
2018	Ansedonia and Argentario (Tuscany, Italy)	7	Boat	Limestones, breccias, dolostones	10	2	Geomorphology, hydrogeology, biology	Work in progress
Total					**531,4**	**69**		

From: Furlani (2020) Marine Geology

Papers

Marine Geology 425 (2020) 106191

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Integrating observational targets and instrumental data on rock coasts through snorkel surveys: A methodological approach

Stefano Furlani

Quaternary International 332 (2014) 37–47

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Submerged notches in Istria and the Gulf of Trieste: Results from the Geoswim project

Stefano Furlani[a,*], Andrea Ninfo[b], Enrico Zavagno[a], Paolo Paganini[c], Luca Zini[a], Sara Biolchi[a], Fabrizio Antonioli[d], Franco Coren[c], Franco Cucchi[a]

Geomorphology 299 (2017) 94–106

Contents lists available at ScienceDirect

Geomorphology

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Tidal notches, coastal landforms and relative sea-level changes during the Late Quaternary at Ustica Island (Tyrrhenian Sea, Italy)

Stefano Furlani[a,*], Fabrizio Antonioli[b], Danilo Cavallaro[c,d], Pietro Chirco[e], Francesco Caldareri[e], Franco Foresta Martin[f], Maurizio Gasparo Morticelli[e], Carmelo Monaco[c], Attilio Sulli[e,g], Gianluca Quarta[h], Sara Biolchi[a], Gianmaria Sannino[b], Sandro de Vita[i], Lucio Calcagnile[h], Mauro Agate[e]

Quaternary International 439 (2017) 158–168

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Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Marine notches in the Maltese islands (central Mediterranean Sea)

Stefano Furlani[a,*], Fabrizio Antonioli[b], Timmy Gambin[c], Ritienne Gauci[d], Andrea Ninfo[e], Enrico Zavagno[a], Anton Micallef[f], Franco Cucchi[a]

STEFANO FURLANI[1*], DANIELA PIACENTINI[2], FRANCESCO TROIANI[3], SARA BIOLCHI[1], MATTEO ROCCHEGGIANI[2], ANDREA TAMBURINI[2], EMANUELA TIRINCANTI[2], VALERIA VACCHER[1], FABRIZIO ANTONIOLI[4], STEFANO DEVOTO[1], OLIVIA NESCI[2] & MARCO MENICHETTI[2]

TIDAL NOTCHES (TN) ALONG THE WESTERN ADRIATIC COAST AS MARKERS OF COASTAL STABILITY DURING LATE HOLOCENE

water

MDPI

Article

Preservation of Modern and MIS 5.5 Erosional Landforms and Biological Structures as Sea Level Markers: A Matter of Luck?

Stefano Furlani[1], Valeria Vaccher[1], Fabrizio Antonioli[2], Mauro Agate[3], Sara Biolchi[1,*], Chiara Boccali[1], Alice Busetti[1], Francesco Caldareri[3], Fabio Canziani[4], Renato Chemello[3], Joanna Causon Deguara[5], Elisa Dal Bo[6], Silas Dean[7], Giacomo Deiana[8], Eleonora De Sabata[9], Yuri Donno[10], Ritienne Gauci[5], Thalassia Giaccone[11], Valeria Lo Presti[12], Paolo Montagna[13], Augusto Navone[14], Paolo Emanuele Orrù[5], Alessandro Porqueddu[15], John A. Schembri[5], Marco Taviani[16,17], Fiorenza Torricella[8], Egidio Trainito[14], Matteo Vacchi[8] and Elisa Venturini[1,18]

remote sensing

MDPI

Article

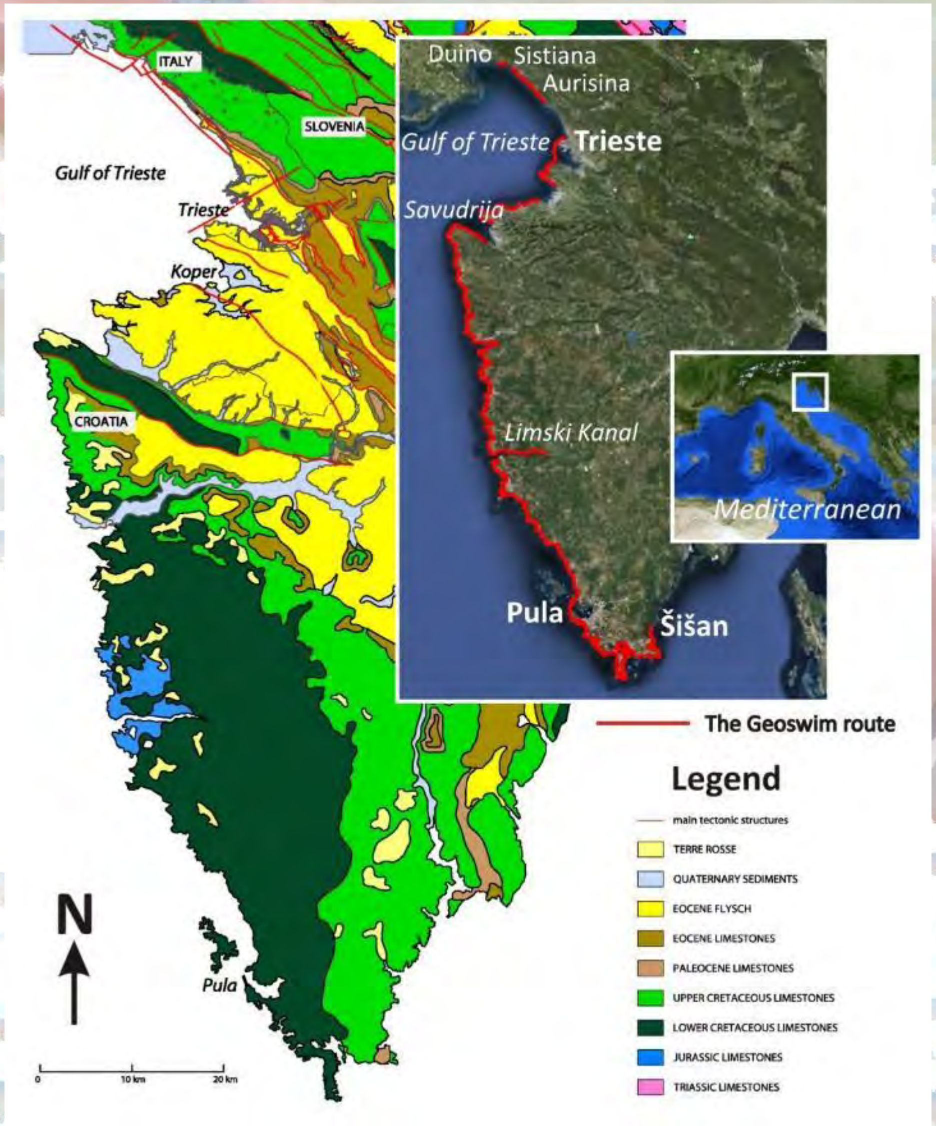
A Cost-Effective Method to Reproduce the Morphology of the Nearshore and Intertidal Zone in Microtidal Environments

Stefano Furlani[1], Valeria Vaccher[1,*], Vanja Macovaz[2] and Stefano Devoto[1]

Istria (Croatia) and Gulf of Trieste (Italy)

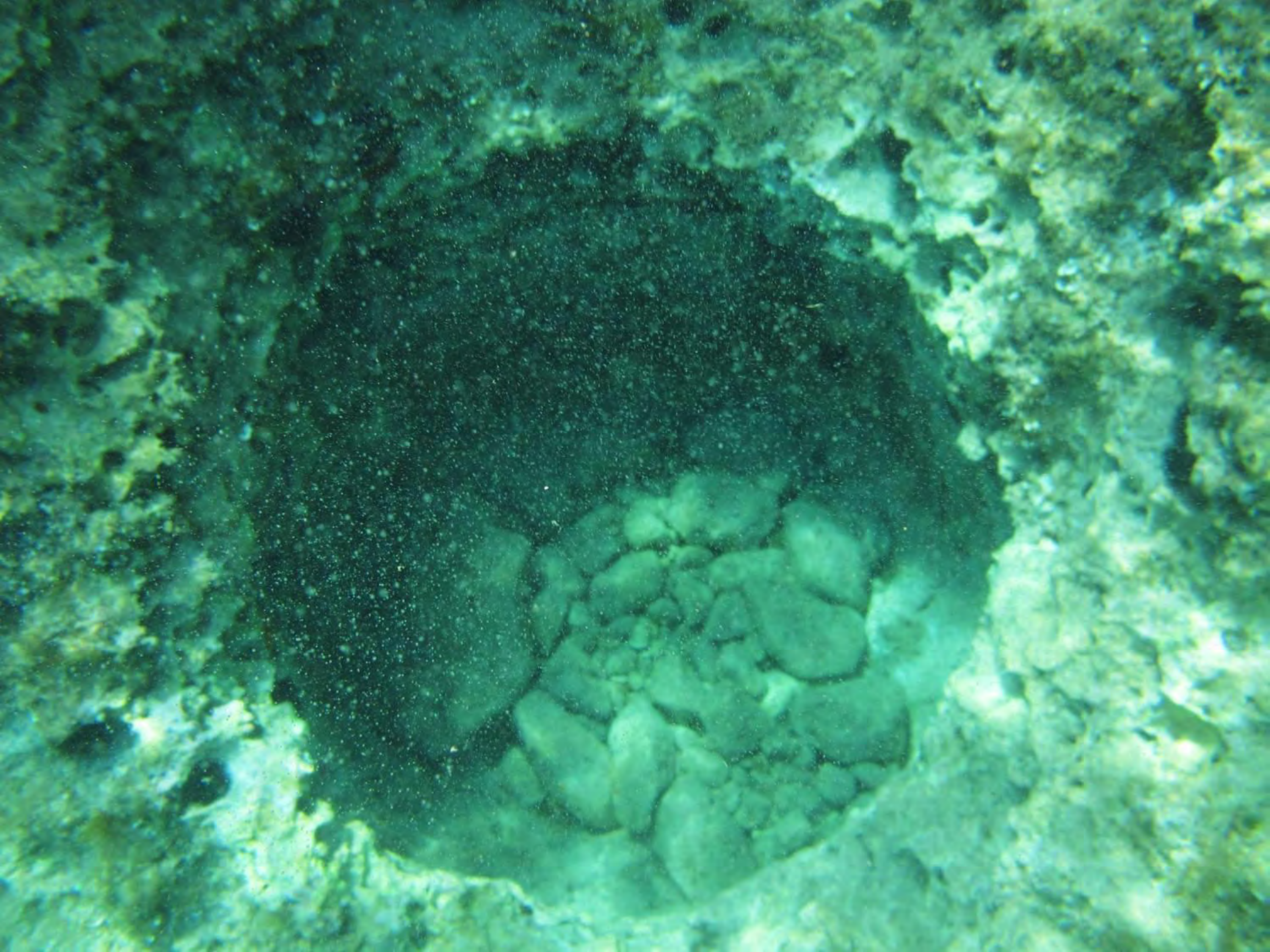
2012

Geoswim in Istria



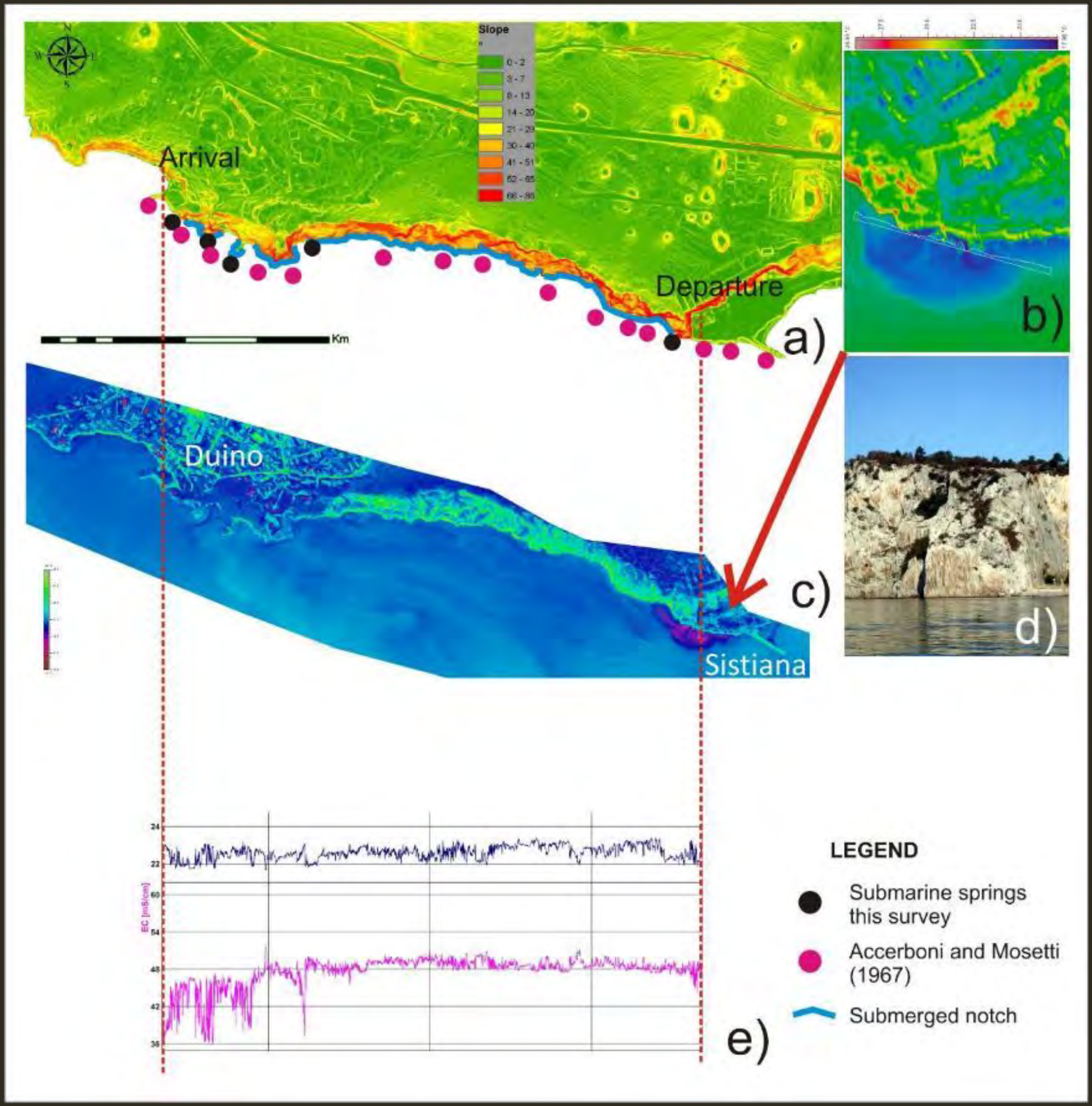

SAMSUNG
eTrex 10
GARMIN

Assistenza a terra



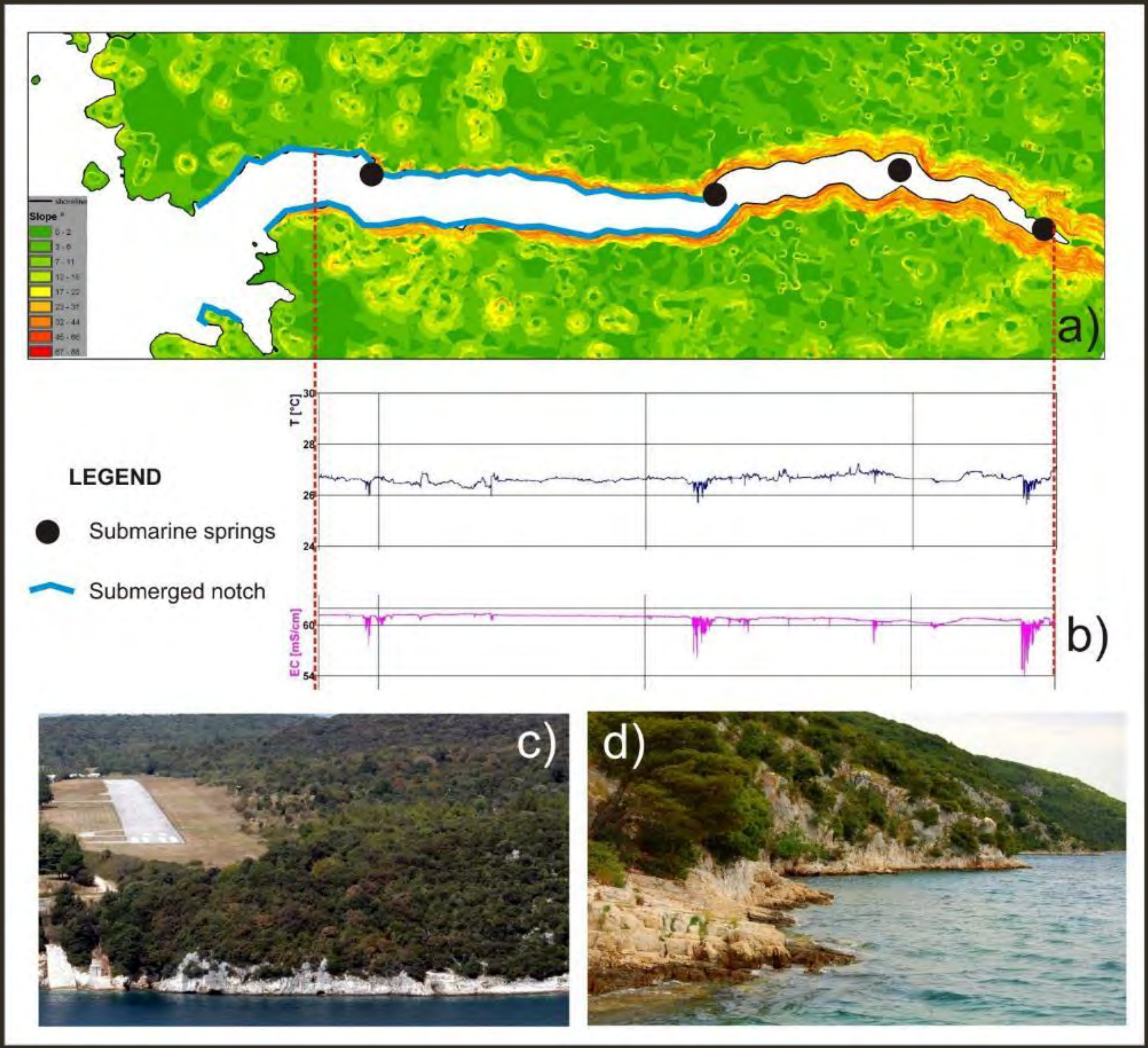
A Number of stage	B Place of departure	C Place of arrival	D Length (km)	E EC min (mS/cm)	F EC mean (mS/cm)	G EC max (mS/cm)	H T min (°C)	I T mean (°C)	L T max (°C)
Test site	Sistiana	Duino	2.2	35.960	47.614	51.520	21.7	22.6	23.8
1	Šišan	Liznijan	6	56.892	61.140	62.000	25.2	26.7	29.3
2	Liznijan	Kamp Medulin	11	60.248	61.671	62.528	25.0	26.3	29.2
3	Kamp Medulin	Pomer	8	60.604	61.730	62.844	25.3	27.4	30.1
4	Pomer	Kamp Stupice	8	53.400	59.509	60.456	26.7	27.8	30.7
5	Kamp Stupice	Premantura	14	57.652	59.201	60.256	23.4	26.2	27.5
6	Premantura	Banjole	11	57.696	59.630	61.732	24.5	26.6	29.2
7	Banjole	Stoja	12	54.532	57.049	58.220	24.7	26.5	29.7
8	Stoja	Pula	9	56.508	60.608	61.544	26.1	27.3	29.5
9	Pula	Peroj	8	58.960	59.640	60.832	27.2	28.4	30.6
10	Peroj	Bale	13	58.180	58.180	60.088	27.4	28.0	29.2
11	Bale	Rovinj South	8	58.368	60.093	60.848	27.2	28.3	30.4
12	Rovinj North	Valalta	10	/	/	/	/	/	/
13	Limski Kanal	Koversada	10	53.928	60.820	61.468	25.6	26.6	29.4
14	Koversada	Zelena Laguna	11	58.956	61.951	62.560	25.5	26.0	28.8
15	Zelena Laguna	Porec	7	60.728	62.556	63.338	24.8	25.3	26.2
16	Porec	Cervar	13	60.136	62.833	63.828	25.2	25.9	28.6
17	Cervar	Mirna	9	60.772	62.704	63.260	25.2	25.9	27.3
18	Mirna	Novigrad	6	59.536	60.875	61.940	25.5	26.6	29.1
19	Novigrad	Daila	8	52.916	60.415	61.044	25.9	26.3	27.4
20	Daila	Sv. Pelegrin	7	60.064	62.430	63.276	23.6	24.8	26.1
21	Sv. Pelegrin	Umag	8	60.648	63.593	64.012	20.8	21.7	24.2
22	Umag	Savudrija	9	60.924	63.240	63.644	/	/	/
23	Savudrija	Kanegra	7	61.408	62.602	63.052	24.1	24.3	24.9
24	Kanegra	Strunijan	8	59.724	60.552	61.352	23.9	24.8	26.5
25	Strunijan	Koper	12	60.036	60.807	61.408	23.9	25.6	27.5
26	Koper	San Bartolomeo	6	59.140	60.823	62.048	25.0	26.7	30.2
27	San Bartolomeo	Trieste	12	57.592	59.502	60.448	24.4	25.8	26.7

EC/T – Istria (Geoswim 2012)



Dissolution: submarine springs and notches

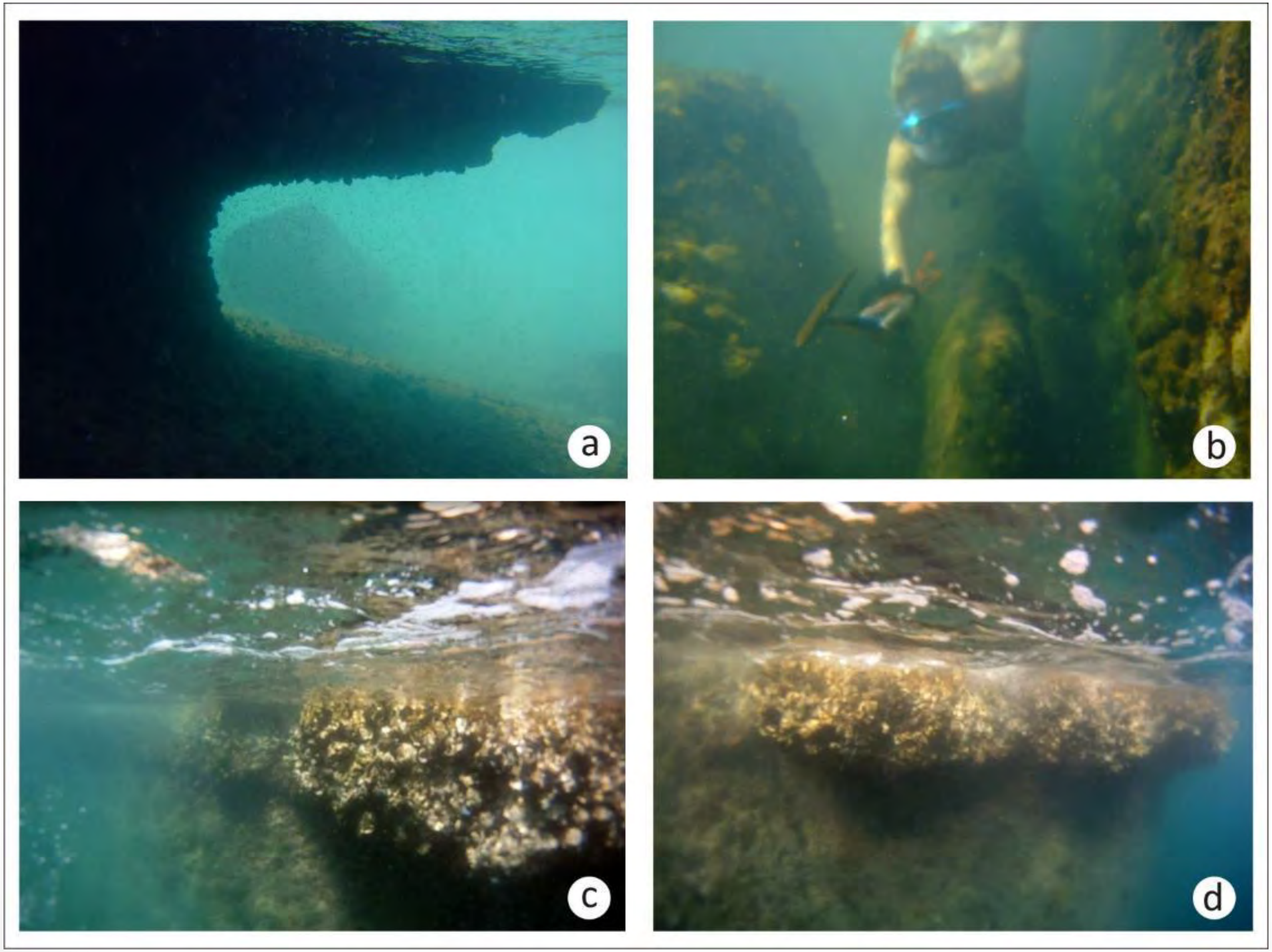
Gulf of Trieste (I). Furlani et al., submitted (QI)



Dissolution: submarine springs and notches

Limski Kanal (HR). Furlani et al., submitted (QI)

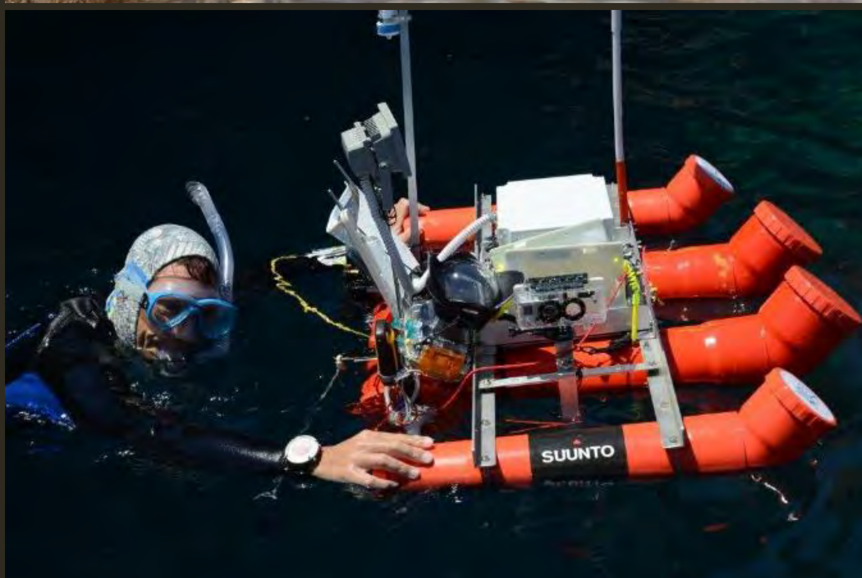
The submerged notches: ancient sea level markers



Gozo and Comino (Malta)

2013

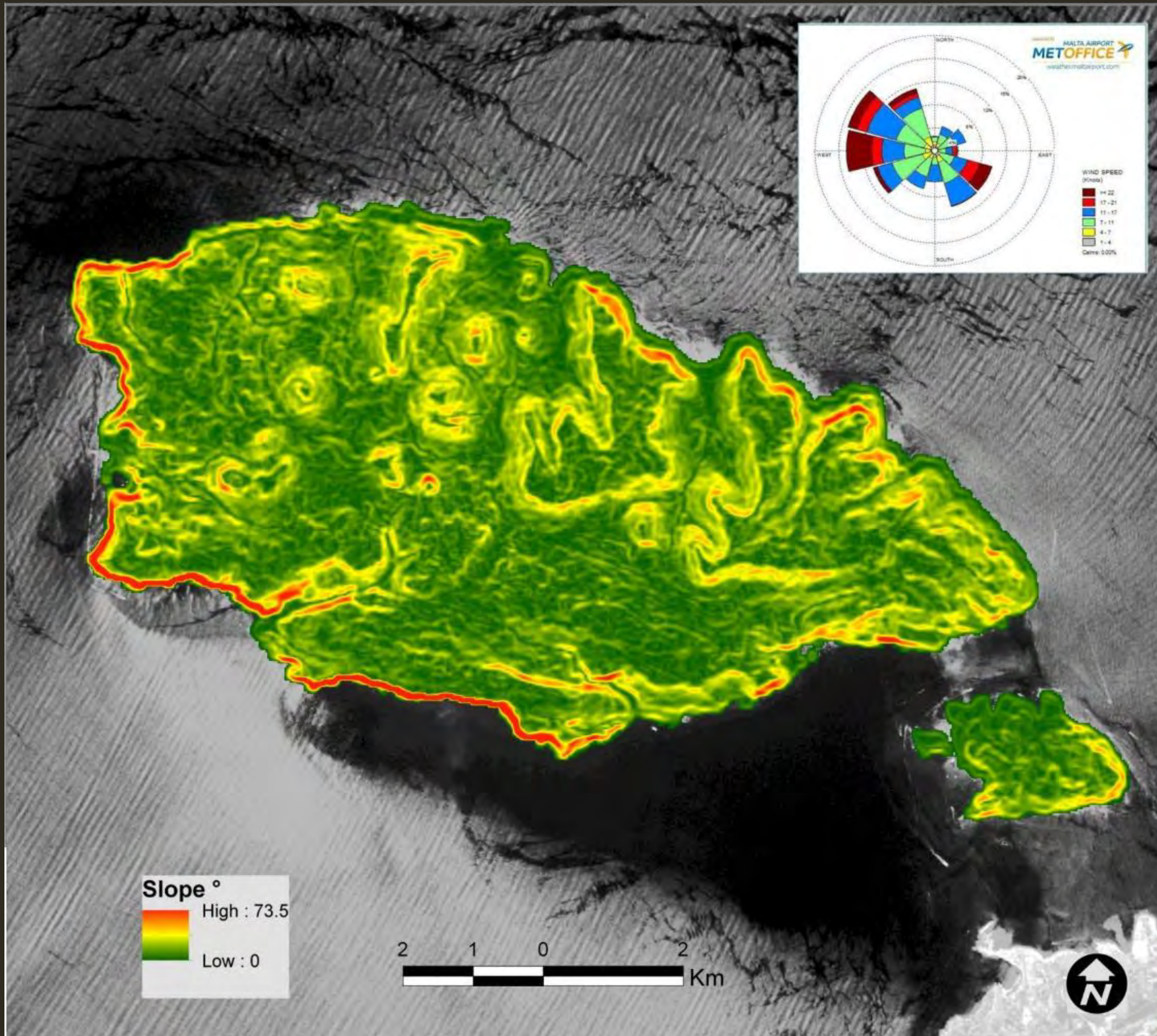
Geoswim2.0 – il percorso



The Geoswim Project

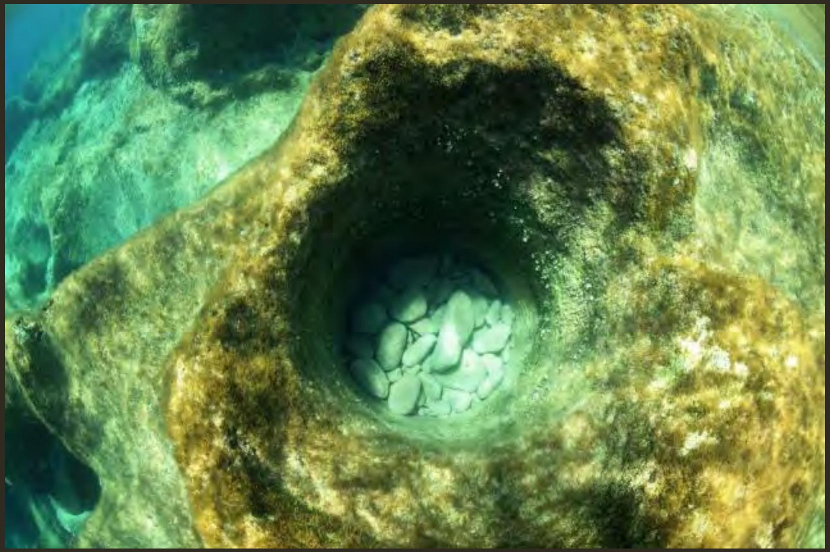
…non sempre ottime condizioni del mare…

Geo swim



MALTA AIRPORT
METOFFICE
NORTH
WEST
EAST
SOUTH
WIND SPEED
Slope °
High : 73.5
Low : 0
2 1 0 2
Km
N

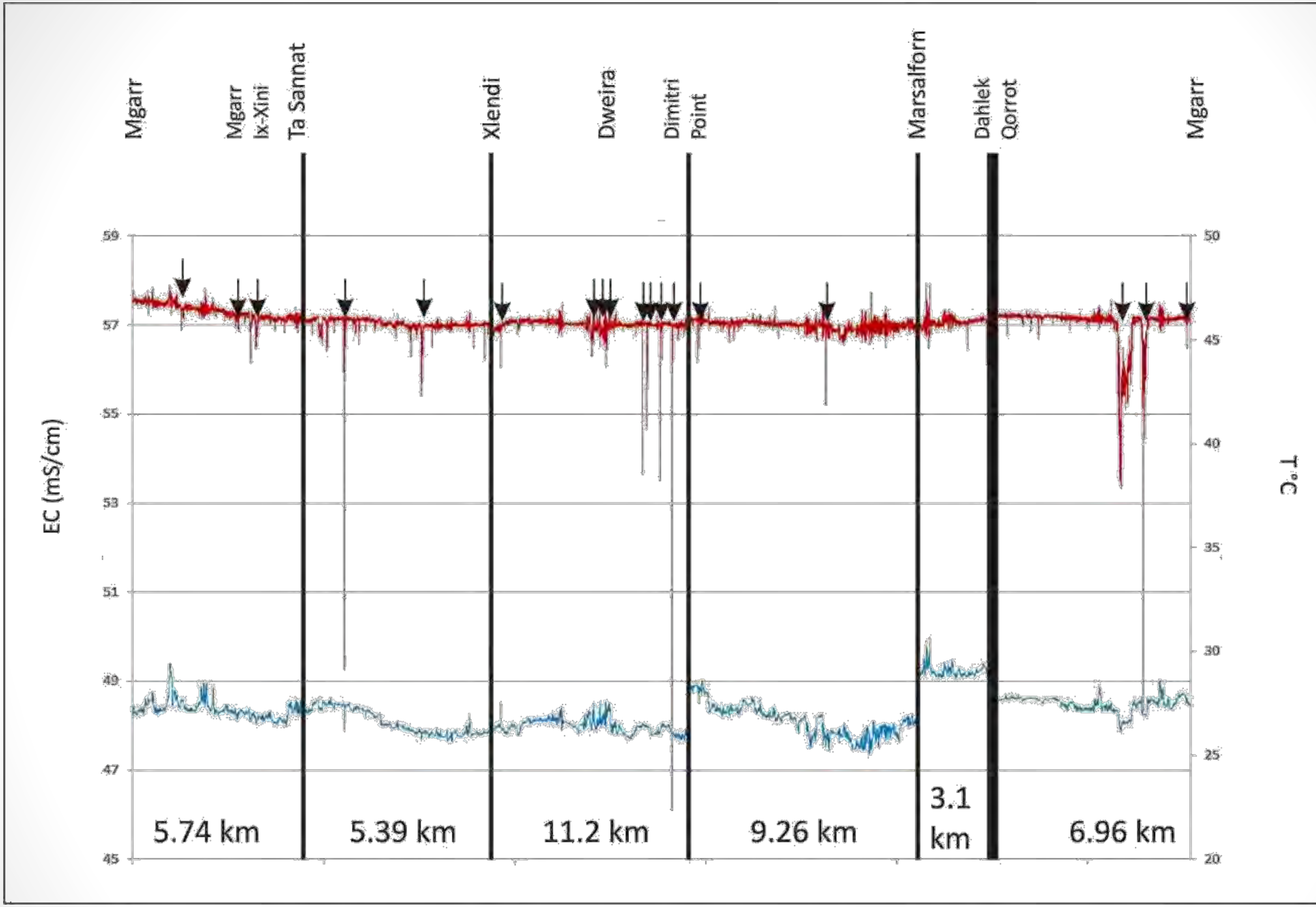
3 types of notches



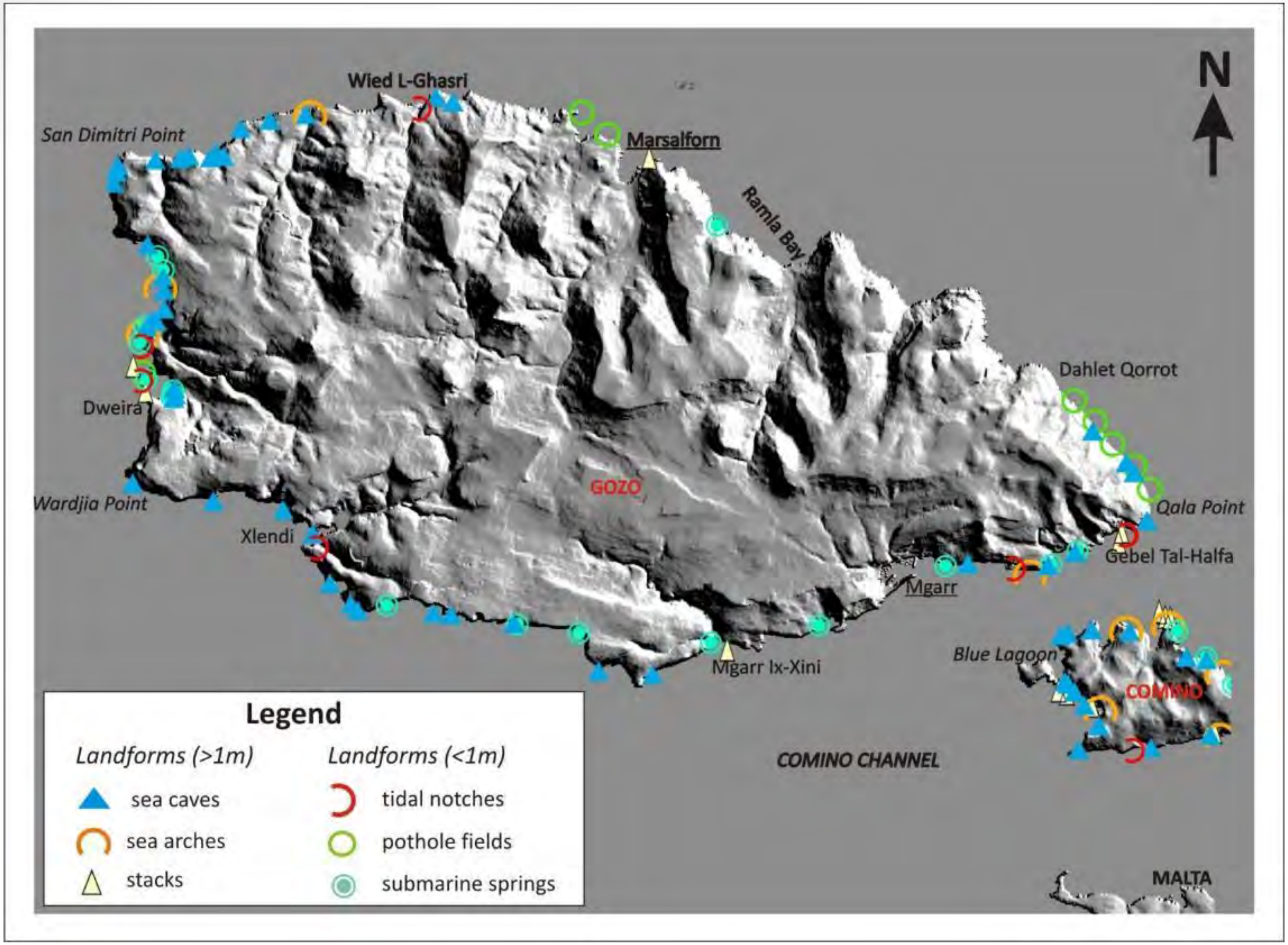
Results – Rocky coasts coastal forms – potholes, etc

Submarine springs (Gozo, Malta)

Submarine freshwater can play a significant role in coastal solution/erosion



EC/T – Gozo and Comino (Geoswim 2013)



Elementi geomorfologici ed idrologici rilevati

Furlani et al. 2017

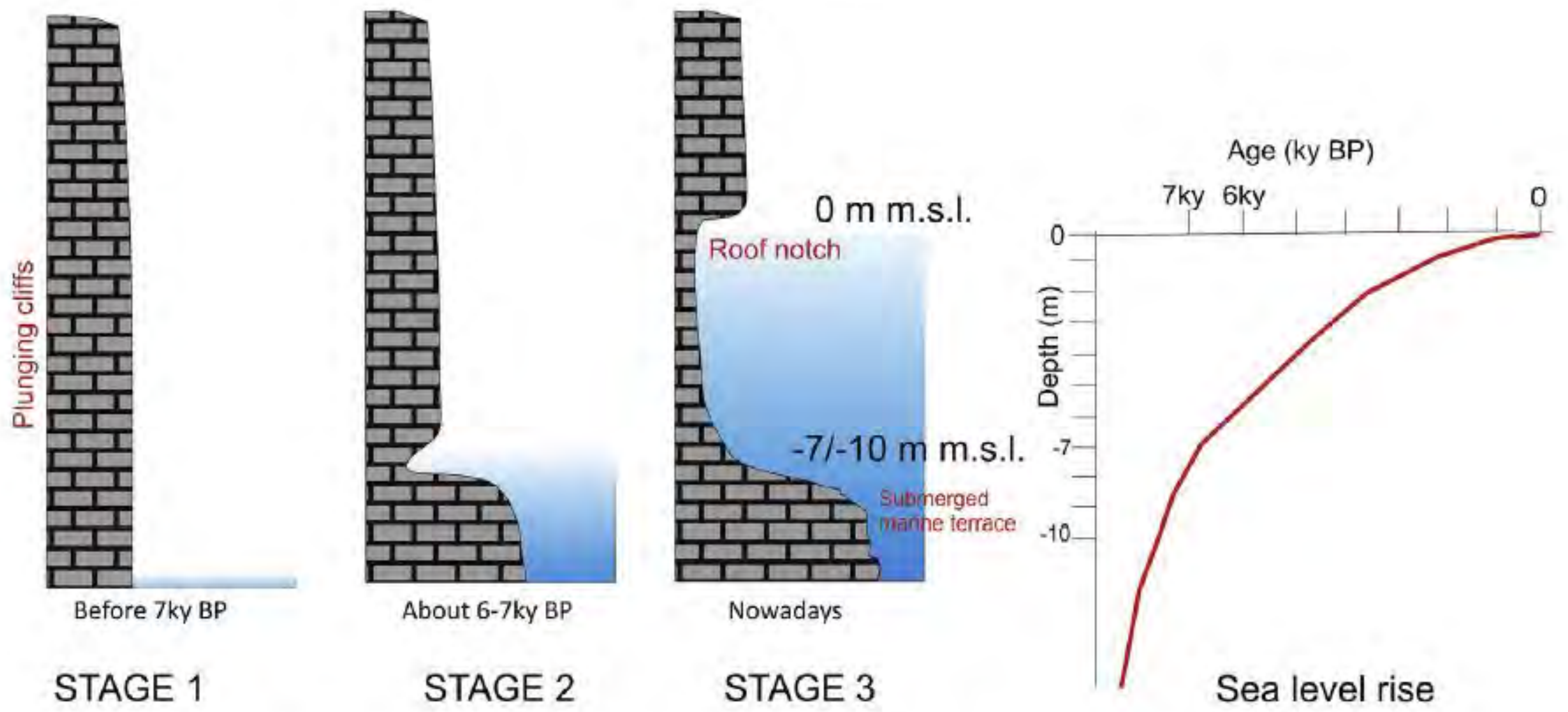


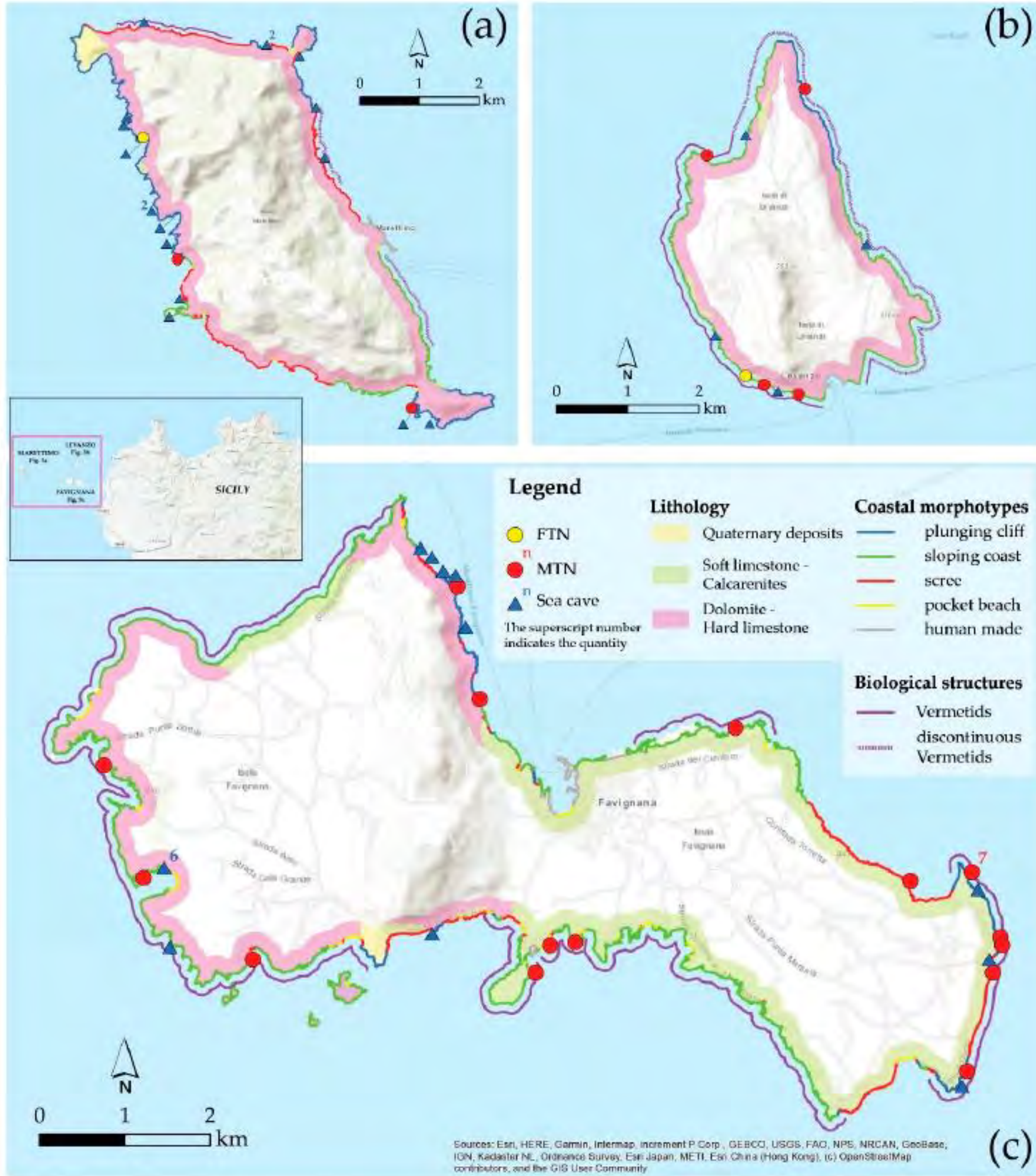
Fig. 9. Sketch of the formation of the roof notch and the submarine platform in the study area.

Formazione del roof notch a Malta


Egadi Islands (Sicily, Italy)
2014

The route

Cod	Location		Area	Country	Days of survey	Lenght
	Departure	End				
2014-EG-01	Cala Manione	Punta Bassana	Marettimo	Italy	14/09/2014	7,1
2014-EG-02	Punta Bassana	Punta Pegna	Marettimo	Italy	15/09/2014	8,0
2014-EG-03	Punta Pegna	Punta Troia	Marettimo	Italy	16/09/2014	7,4
2014-EG-04	Punta San Leonardo	Punta S. Vituzzo	Favignana	Italy	18/09/2014	4,9
2014-EG-05	Punta Faraglione	Cala Fumere	Favignana	Italy	19/09/2014	3,2
2014-EG-06	Punta Faraglione	Punta Sottile	Favignana	Italy	20/09/2014	5,3
2014-EG-07	Cala Dogana	Cala Dogana	Levanzo	Italy	21/09/2014	12,0
2014-EG-08	Punta Sottile	Puntazza	Favignana	Italy	22/09/2014	11,0
2014-EG-09	Punta San Vituzzo	Puntazza	Favignana	Italy	23/09/2014	7,8



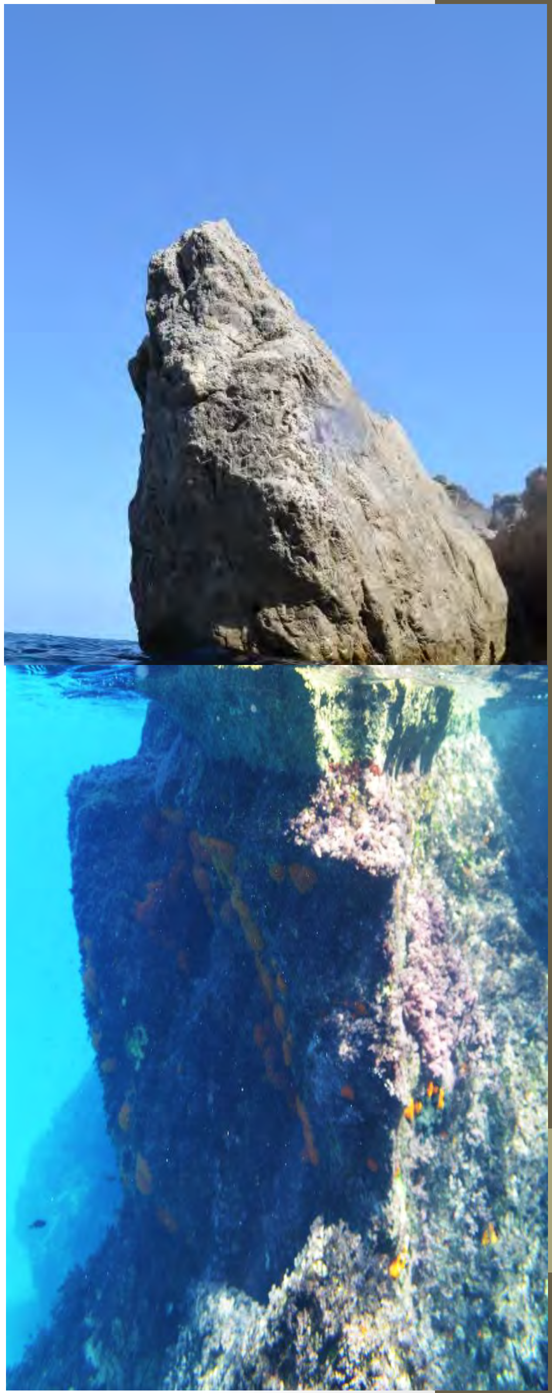
Furlani et al. (2021)

MORFOELEMENTI A MARETTIMO

RISULTATI LEVANZO-Solchi

Sito	Lat	Long	Litologia	Ampiezza solco (cm)	Profondità solco (cm)	Profondità piattaforma(m)	Note
Levanzo (223)	37.985.319	12.337.012	Calcari dolomitici	145	150	0,70 (ampiezza 45cm)	
Levanzo (226)	37.986.344	12.332.737	Calcari dolomitici	90	90	0,20	Profondità fondale -1.30m
Levanzo (240)	38.008.357	12.325.216	Calcari dolomitici	40	70	Vermetidi	
Levanzo (245)	38.015.881	12.336.670	Calcari dolomitici	75	50	Fori litofagi	Solco Tirreniano

Solchi Tirreniani


Sea caves at Egadi islands

RISULTATI LEVANZO-Grotte

Isola	Long	Lat	Rilevamento Geoswim	Rilievo 1994	Schema	Note
Levanzo	12.333081	37.98603	x			
Levanzo	12.326398	37.99079	x	x		2° grotta del Buco (14) cunicolo di ingresso sfocia in ambiente più ampio
Levanzo	12.329472	38.01112	x	x		7° Gr. Di Cala Tramontana (39) Genesi carsica
Levanzo	12.343796	38.00025	x			

Sviluppo carsico superficiale.

Grotta sopra al livello medio mare con ingresso sommerso.

RISULTATI FAVIGNANA-Grotte

Nome Grotta	Isola	Long	Lat	Rilevamento Geoswim	Rilievo 1994	Note
Grotta delle Meduse	Favignana			x	x	Gr.1° di Punta (10) punto 339 o 340
Grotta delle stalattiti	Favignana	12,314316	37,944875	x		punto 338
Grotta dei crolli	Favignana	12,309933	37,950955	x	x	Gr. 2° s.l.m(6) punto 343
Grotta GEOSWIM	Favignana	12,311251	37,949766	x		punto 342
Grotta dei cordini	Favignana	12,309693	37,951607	x	x	Gr. 1°s.l.m (4) punto 344
	Favignana			x		
Cala Rotonda1	Favignana	12,280688	37,924574	x		punto 261
Cala Rotonda2	Favignana	12,281248	37,924546	x		punto 263
Cala Rotonda3	Favignana	12,281538	37,924514	x		punto 264
Cala Rotonda4	Favignana	12,282933	37,924905	x		punto 266
Cala Rotonda5	Favignana	12,283621	37,924433	x		punto 268
	Favignana	12,283993	37,918521	x		punto 274
Grotta della Foca Monaca	Favignana	12,311193	37,919560	x		punto 287
	Favignana	12,368188	37,923082	x		punto 315
Grotta del Bue Marino	Favignana	12,369740	37,917133	x		punto 326
	Favignana	12,366284	37,906603	x		punto 331

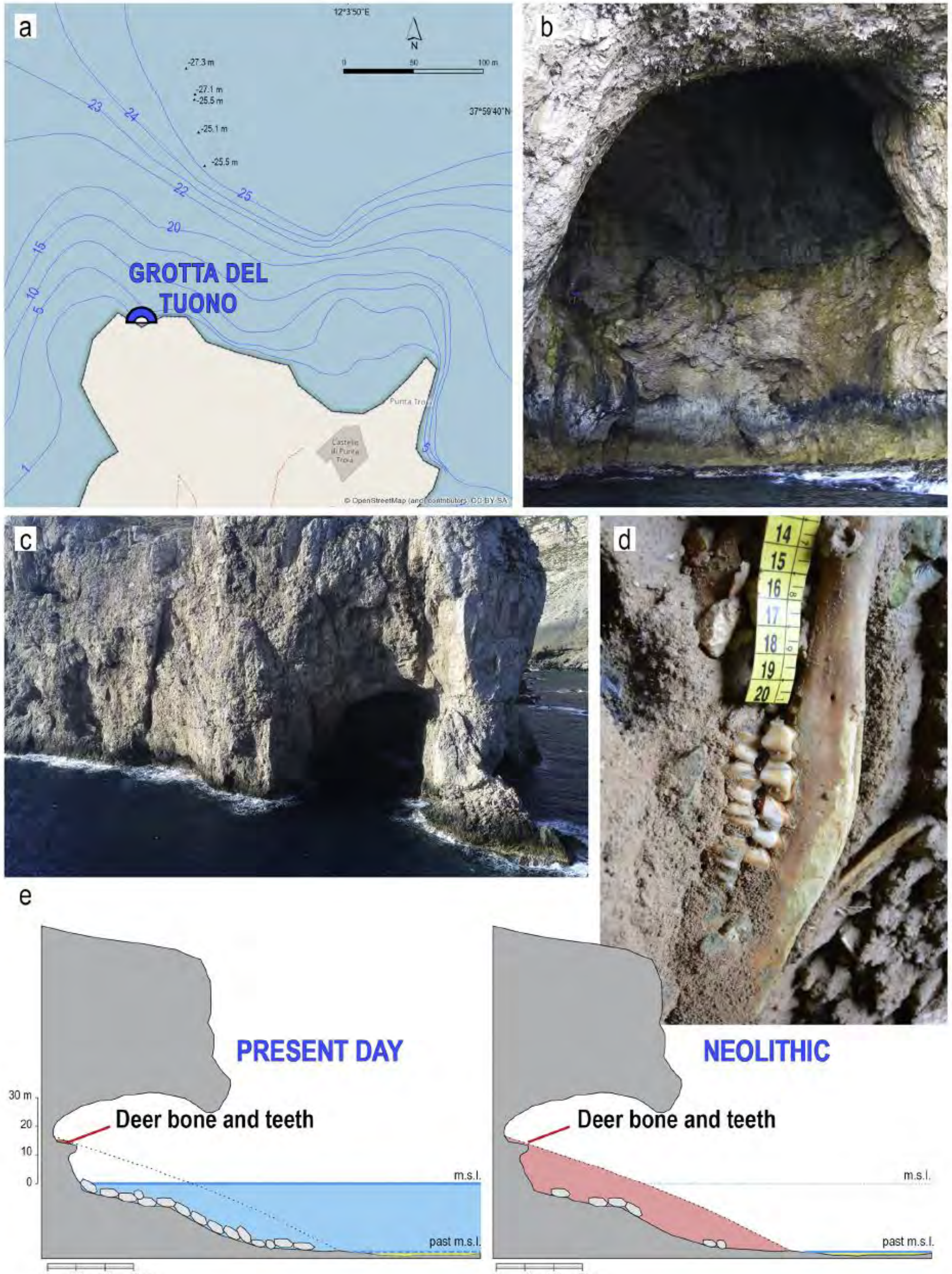
RISULTATI MARETTIMO-Grotte

Nome Grotta	Isola	Long	Lat	Rilevamento Geoswim	Rilievo 1994	Schema	Note
Grotta del Tuono	M	12.063415	37.98964	x	x		
	M	12.064894	37.97728	x	x		Vicino Grotta Cammello (9)
Grotta del Cammello	M	12.064421	37.98331	x	x		
	M	12.082936	37.94527	x	x		Cisternola(24)
	M	12.080147	37.94774	x			
	M	12.042608	37.95850	x			
	M	12.045547	37.96029	x	x	si	Libeccio o Gr. Della strada (32-33)- grotta di crollo
Grotta Bombarda	M	12.043594	37.96742	x	x	Si	Bombarda (36-37)
	M	12.044011	37.97084	x	x		Grotta Bombarda 2
	M	12.041310	37.97074	x	x		Grottiglia (39)
Grotta del Presepe	M	12.040917	37.97081	x	x	si	Grotta del Presepe(43)
	M	12.036267	37.98094	x			
Grotta Ficara	M	12.039491	37.97911	x	x	si	Grotta della figarella (47)
Grotta Perciata	M	12.036713	37.98215	x	x		Gr. Perciata (48)
	M	12.039037	37.99302	x	x		Mugnone (51)
	M	12.057308	37.99083	x			
Grotta della Pipa	M	12.057449	37.99082	x			Solo citata(frattura con forma a L)

Grotta del Tuono

Palaeogeographical evolution of the Egadi Islands (western Sicily, Italy). Implications for late Pleistocene and early Holocene sea crossings by humans and other mammals in the western Mediterranean

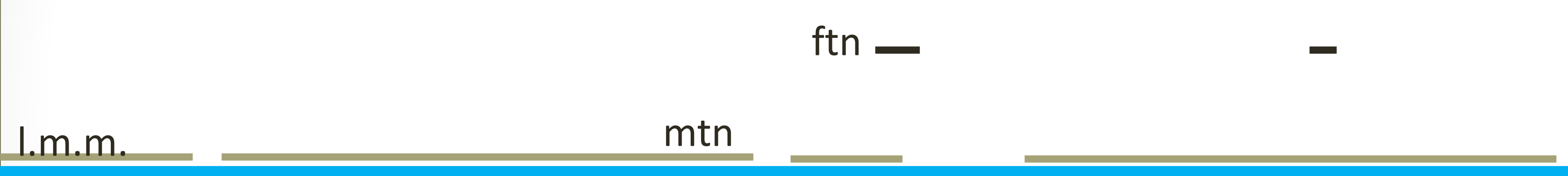
Lo Presti V.[1], Antonioli F.[1], Palombo M.R.[2], Agnesi V.[3,4], Biolchi S.[5], Calcagnile L.[6], Di Patti C.[3,4], Donati S.[7], Furlani S.[5], Merizzi J.[8], Pepe F.[3], Quarta G.[6], Renda P.[3], Sulli A.[3], Tusa S.[9]

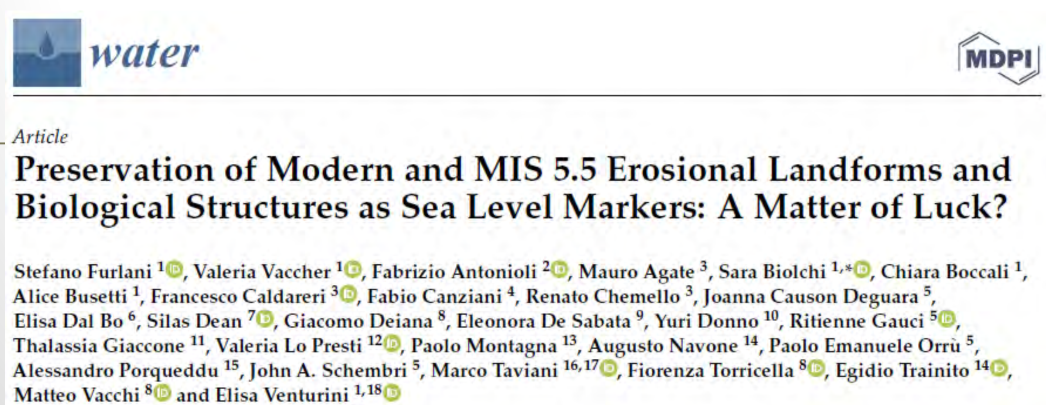


a
GROTTA DEL TUONO
N
b
c
d
e
PRESENT DAY
NEOLITHIC
Deer bone and teeth
Deer bone and teeth
m.s.l.
past m.s.l.
30 m
20
10
0
0 10 20 30 m

Rapporto tra mtn attuale e ftn (MIS 5.5) in aree stabili

mtn=90%, ftn=1%





water

MDPI

Article

Preservation of Modern and MIS 5.5 Erosional Landforms and Biological Structures as Sea Level Markers: A Matter of Luck?

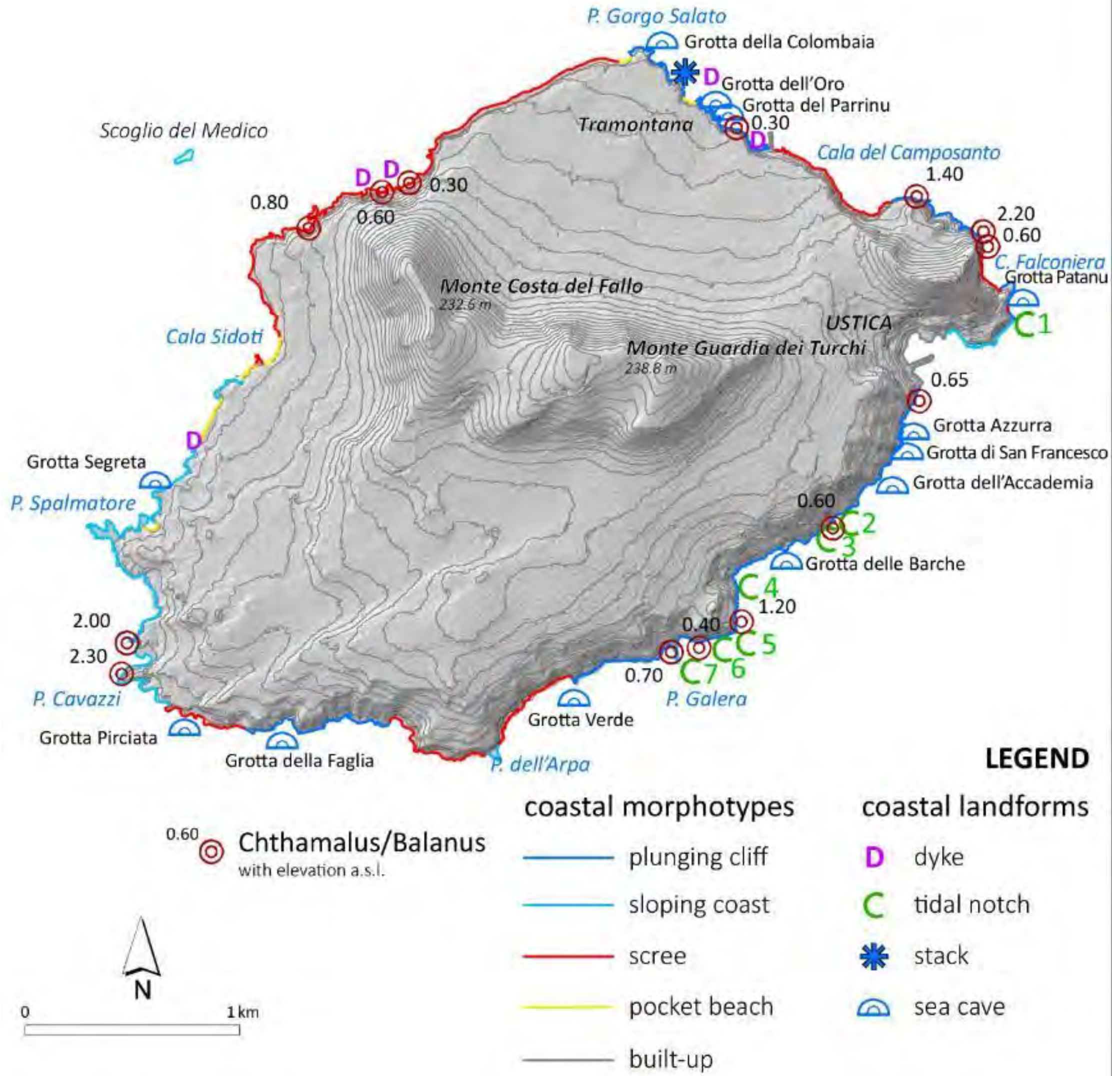
Stefano Furlani [1], Valeria Vaccher [1], Fabrizio Antonioli [2], Mauro Agate [3], Sara Biolchi [1,*], Chiara Boccali [1], Alice Busetti [1], Francesco Caldareri [3], Fabio Canziani [4], Renato Chemello [3], Joanna Causon Deguara [5], Elisa Dal Bo [6], Silas Dean [7], Giacomo Deiana [8], Eleonora De Sabata [9], Yuri Donno [10], Ritienne Gauci [5], Thalassia Giaccone [11], Valeria Lo Presti [12], Paolo Montagna [13], Augusto Navone [14], Paolo Emanuele Orrù [5], Alessandro Porqueddu [15], John A. Schembri [5], Marco Taviani [16,17], Fiorenza Torricella [8], Egidio Trainito [14], Matteo Vacchi [8] and Elisa Venturini [1,18]

Ustica, Sardinia, Malta NE

2015

Stacks, sea arches and coastal landforms

- The coastline in the study area is indented, with small bays alternated to headlands and high plunging cliffs.
- The height of the cliffs and plunging cliffs along the Ustica coastline range between few meters to about 100 meters at Capo Falconiera.

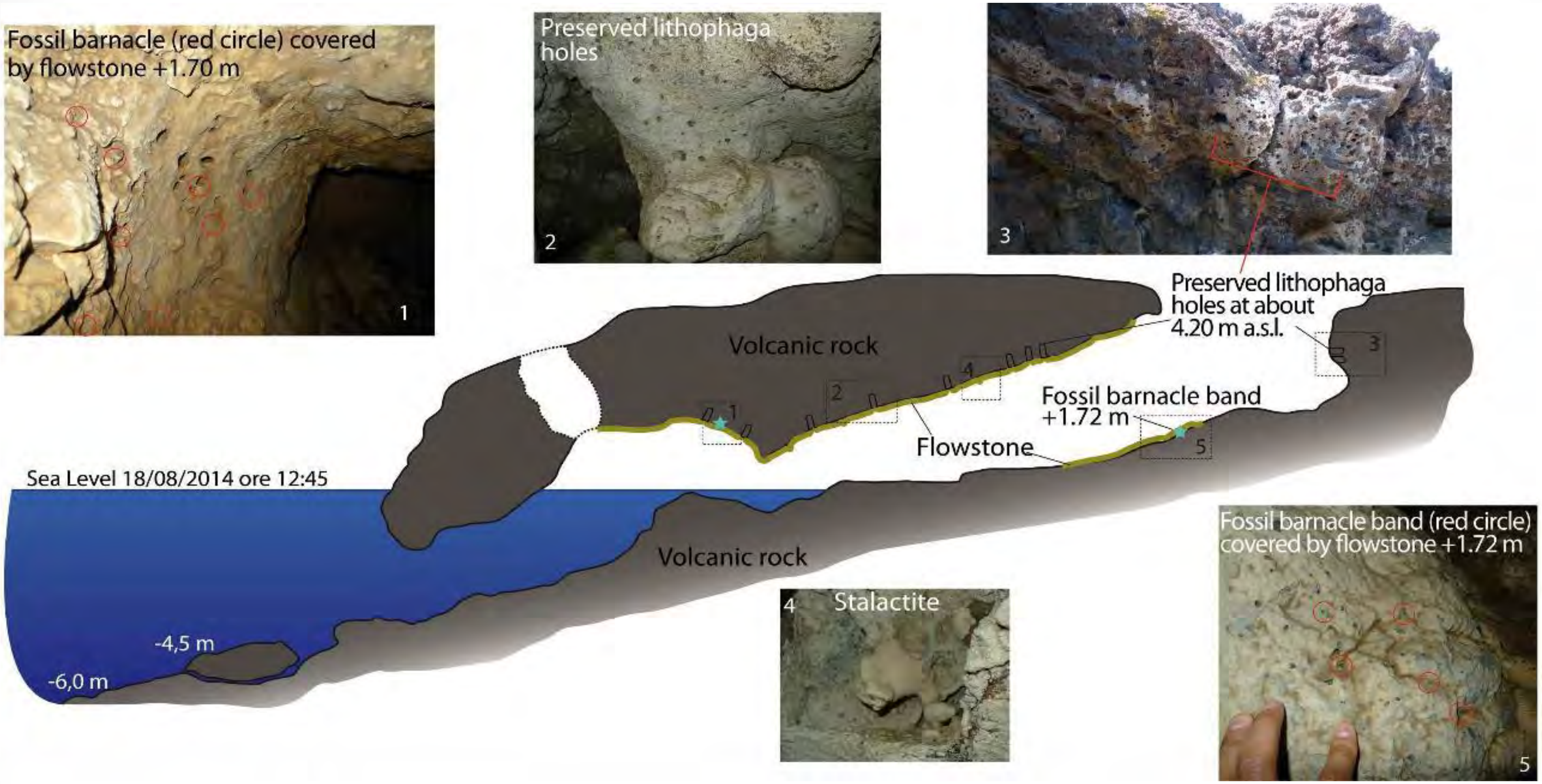


Stacks

Sea caves

The coastal scenery is characterized by 12 caves opening at the sea level, stacks, arches and rocks.

Grotta Segreta cave: geomorphological and paleontological features



Lithophaga holes have been recognized on the cave wall (3). Often the lithophaga holes are covered by about two-three centimetres thick of flowstone (1,2). Small stalactite have been recognized in the upper portion of the cave (4). Fossil barnacle bands covered by flowstone are recognized over 1,70 meters above sea level (1, 5).

Volcanic landforms

Notch in volcanics

- Geoswim allowed to discover, for the first time in the Mediterranean area, the tidal notch carved in small carbonate inclusions in volcanics, at the present-day sea level.

Tidal notches at Ustica

ID	Site	Survey point	WGS84 coordinates (lat°; long°)	Lithology	Average notch width (m)	Reef depth (m)	Notch depth (m)	Direction of Exposure	Notes
1	Punta Falconiera	109	38.709615; 13.200622	Calcarenites and lava pebbly conglomerates	0.60	1.20	0.45	E	Slightly carved notch with wide Vermetid reef
2	Costa SE	47	38.701262; 13.191363	Sub-alkali basaltic to hawaiite lava	0.80	1.00	0.60	SE	/
3	Costa SE	49	38.700755; 13.190747	Sub-alkali basaltic to hawaiite lava	0.65	1.30	0.65	SE	/
4	Costa SE	55	38.698233; 13.186252	Sub-alkali basaltic to hawaiite lava	0.60	/	/	SE	Slightly carved
5	Punta dell'Arpa	58	38.696195; 13.185851	Sub-alkali basaltic to hawaiite lava	0.70	2.00	/	SE	Vermetid reef
6	Punta dell'Arpa	59	38.696028; 13.185328	Sub-alkali basaltic to hawaiite lava	0.65/0.75	/	0.60	SE	/
7	Punta Galera	62	38.695857; 13.183127	Sub-alkali basaltic to hawaiite lava	0.75	1.50	0.60	SE	Vermetid reef

MIS5.5 notches

- Moreover, MIS5.5 tidal notches were found at 25 m a.s.l., in Spalmatore sector, as result of the uplift of the island.

Marche coastline (Italy)

2016

The «Ciclope II»

Local conditions during the survey

Landslides

I rilievi hanno messo in evidenza un litorale caratterizzato da un’elevata suscettibilità ai movimenti franosi, legata alle condizioni geologiche (stratificazione dei calcari e calcareniti con angoli quasi verticali) e alle rocce particolarmente poco conservative.


Per la stessa ragione, le forme marine sono poco rappresentate lungo il litorale

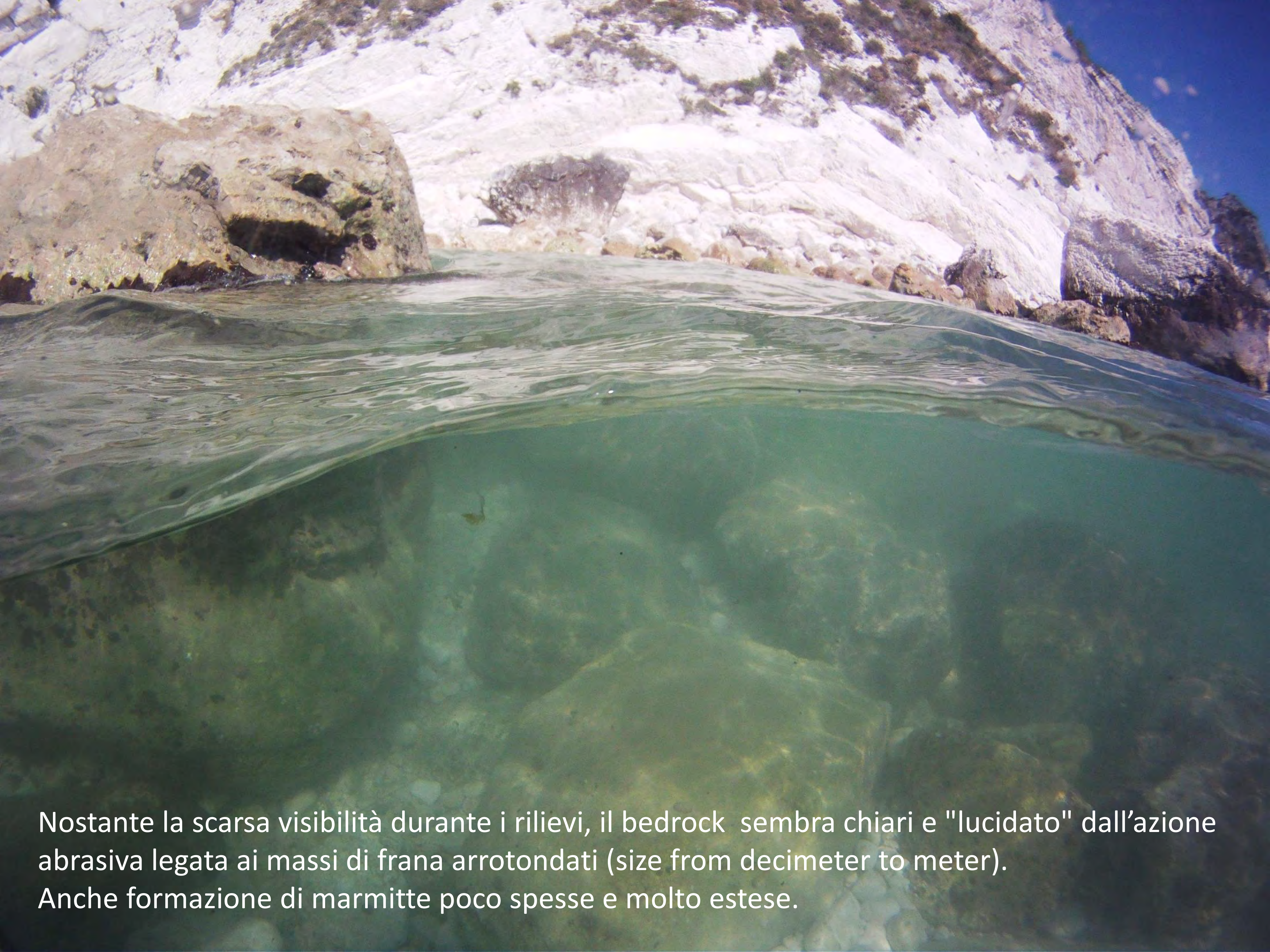
Tidal notches

Tidal notches on the Due Sorelle rocks and other 3 sites

Tidal notches are rare in this sector, only in correspondence of vertical limestone layers, off-shore inclined

A tidal notch forms in 300-500 years

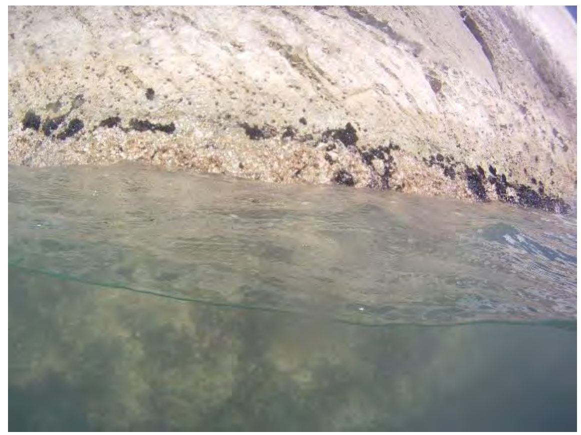

Le grosse frane che investono il promontorio
del Conero potrebbero avere questa cadenza?



Nostante la scarsa visibilità durante i rilievi, il bedrock sembra chiari e "lucidato" dall’azione abrasiva legata ai massi di frana arrotondati (size from decimeter to meter).
Anche formazione di marmitte poco spesse e molto estese.

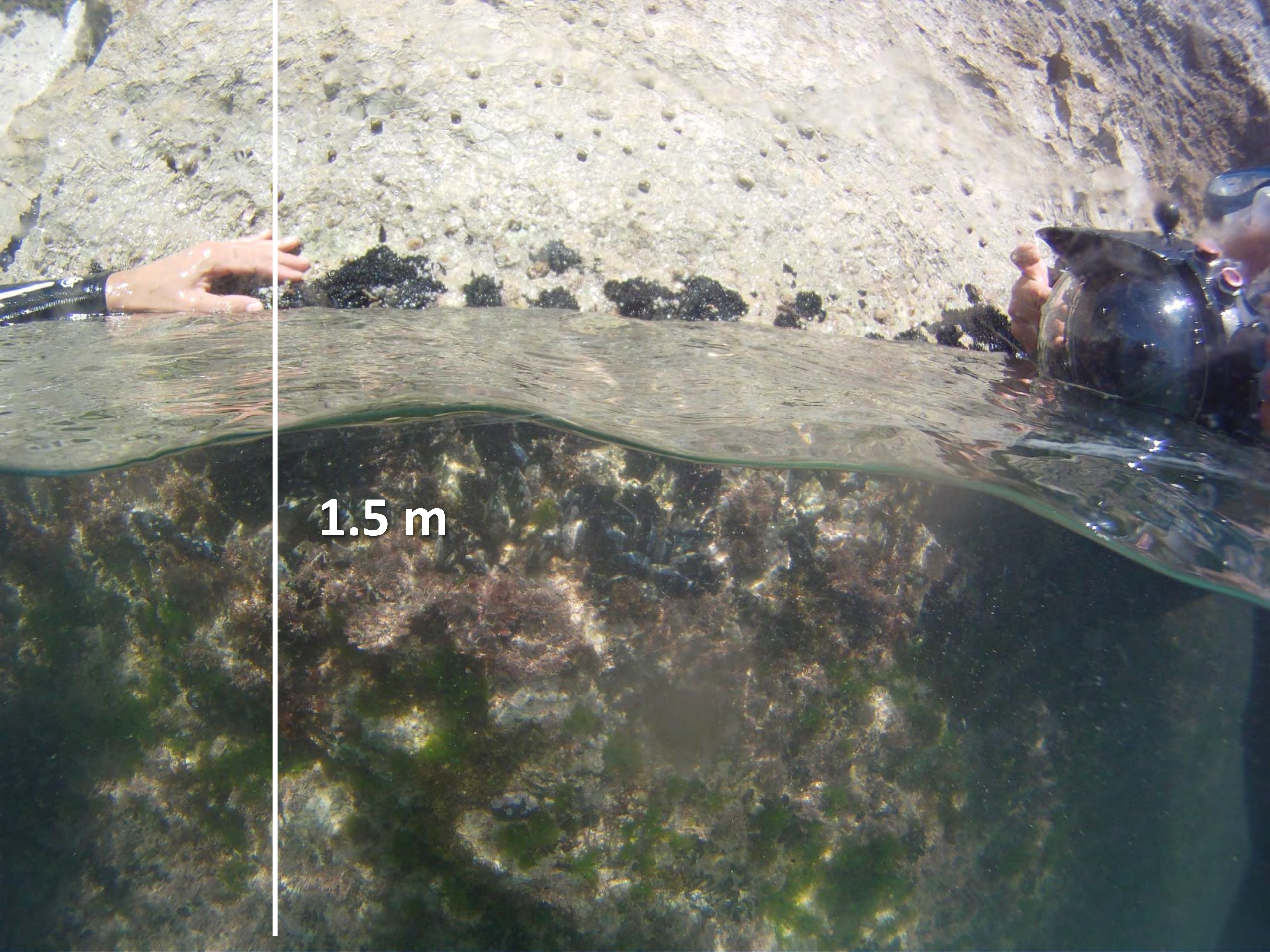




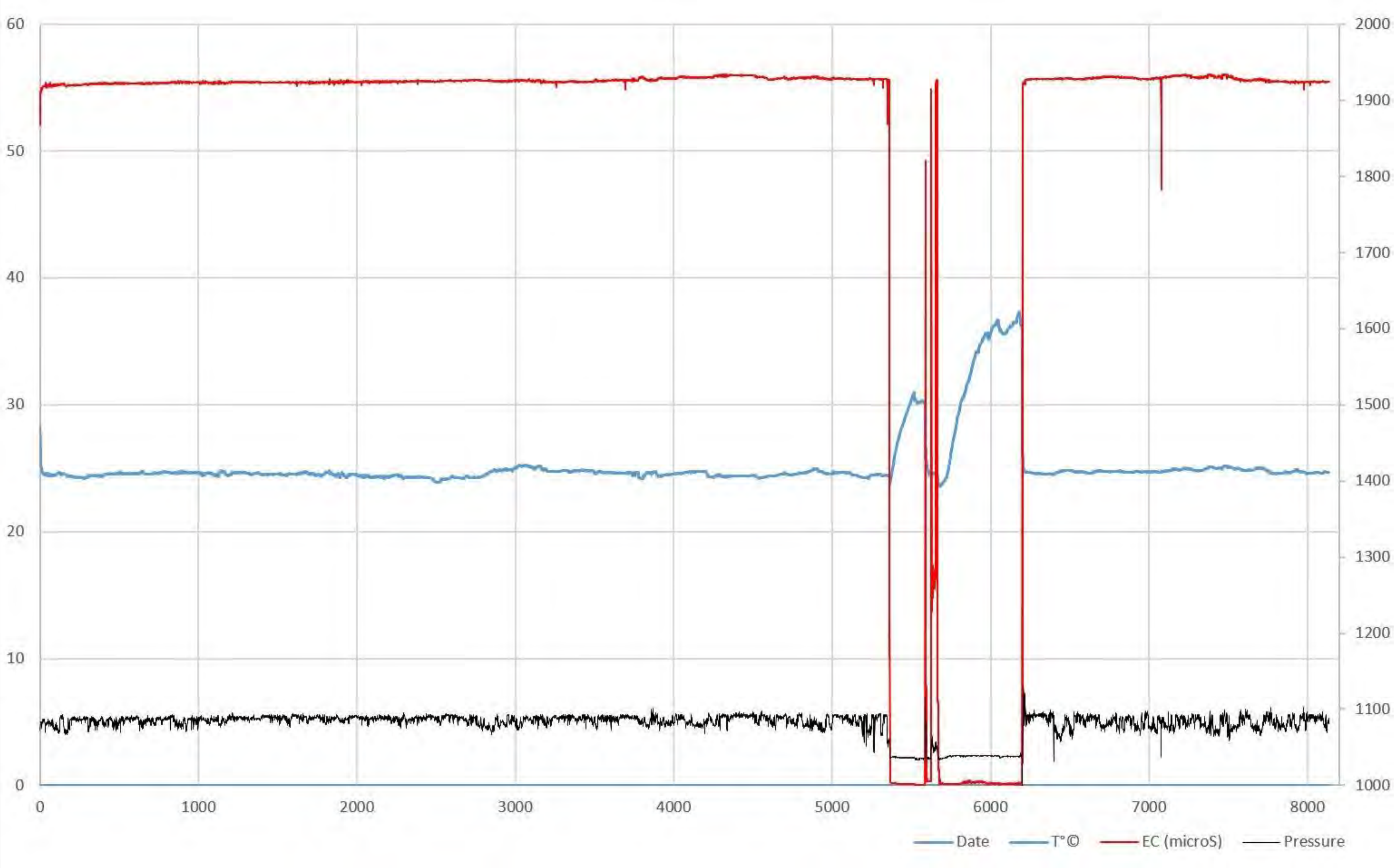




La linea di riva, nella zona infralitorale, presenta spessori di circa 0.80 m colonizzati da *Mytilus Galloprovincialis*, anche di notevoli dimensioni, che fino al livello medio del mare, con gusci di piccole dimensioni.


1.5 m

CTD data



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Date
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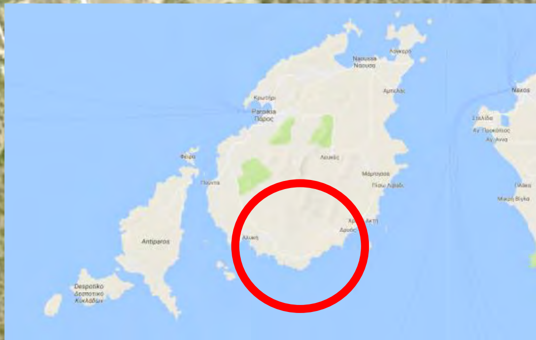
EC (microS)
Pressure

Paros Island (Greece)

2017



- The island of Paros is located in the Central Cycladic islands (Aegean Sea, Greece)
- From a geological point of view, the area consists mainly in metamorphic rocks (micaschists, marbles, gneiss, etc). Marbles outcrop in the study area
- The area is exposed to southern winds and


RESCUE BOAT
RESCUE BOAT

Morphometric parameters

The sinkhole is:
10 m high,
41 m long (NNE-SSW direction);
20 m large (WNW-ESE direction).

Its bottom is half covered by blocks collapsed from the lateral cliffs.

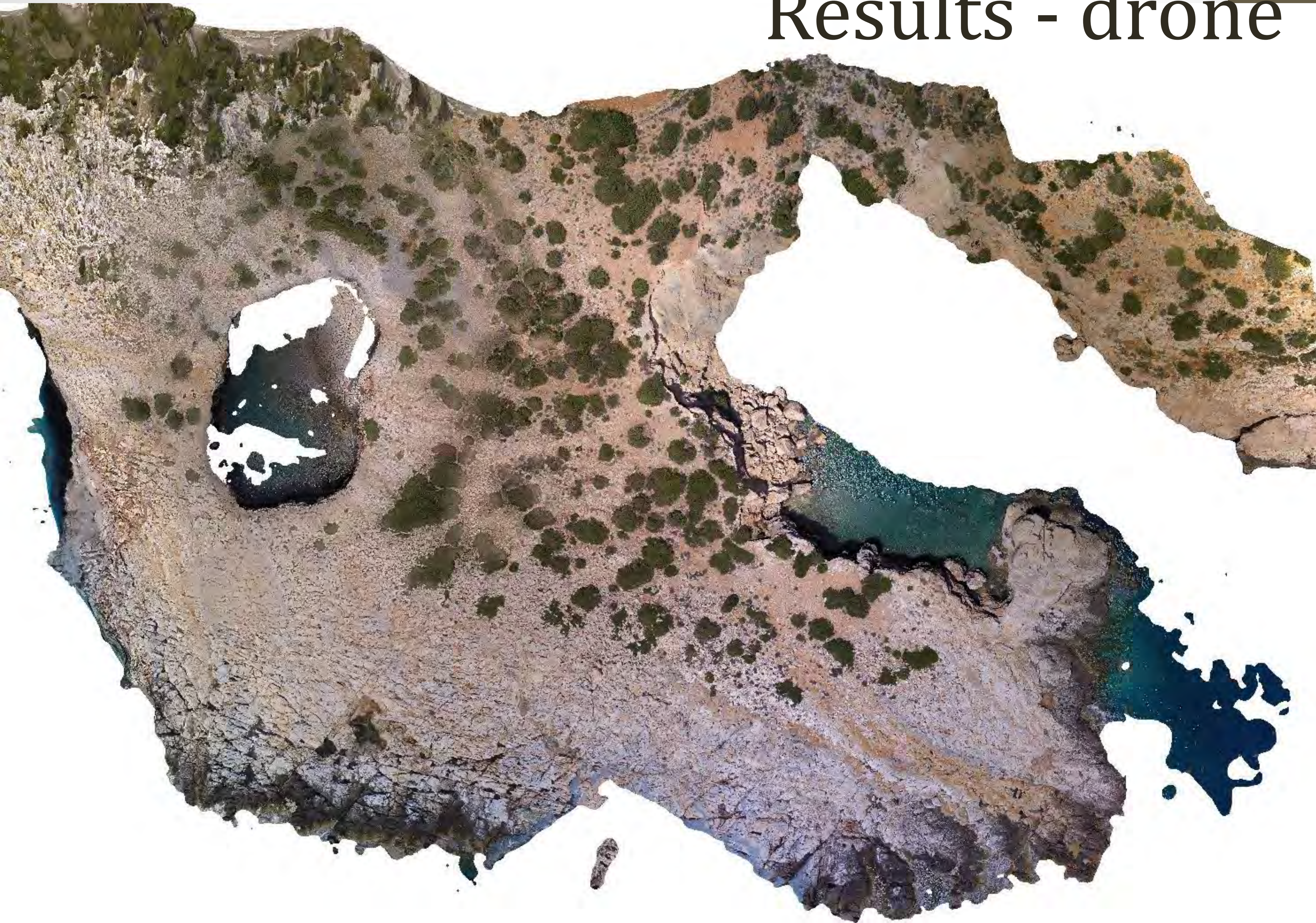
In the remaining half, the maximum depth is maximum 3 m and it increases at the entrance up to 8 m.

Results – Geological survey

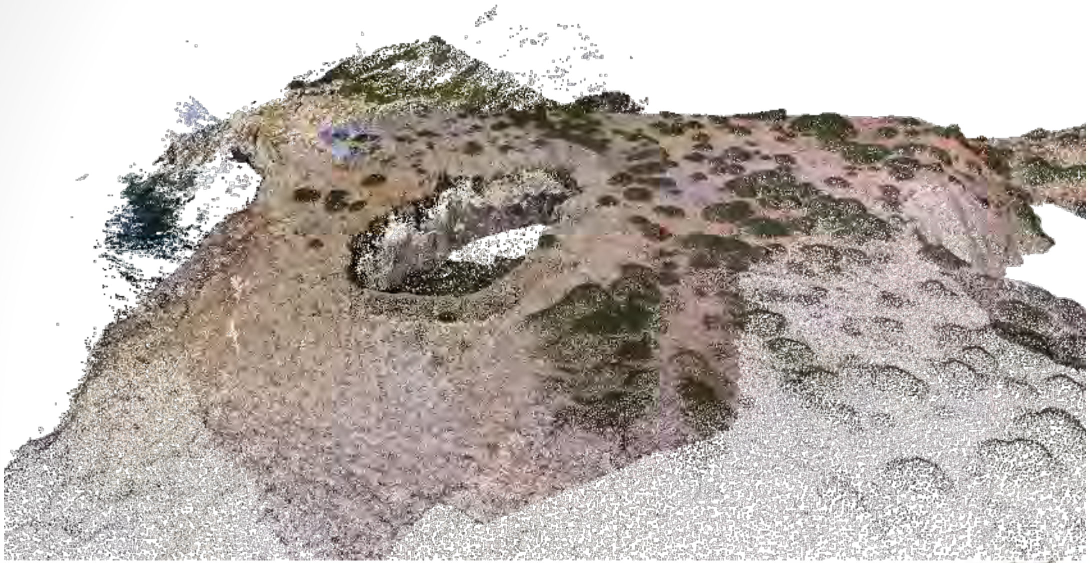
From a geological point of view: layered Mesozoic marble of the blue-schist facies of the lower unit of the Attic-Cycladic complex and minor non-carbonate lithotypes.

The site is affected by folding and faulting, responsible of intense deformation and fracturing of the affected lithologies.

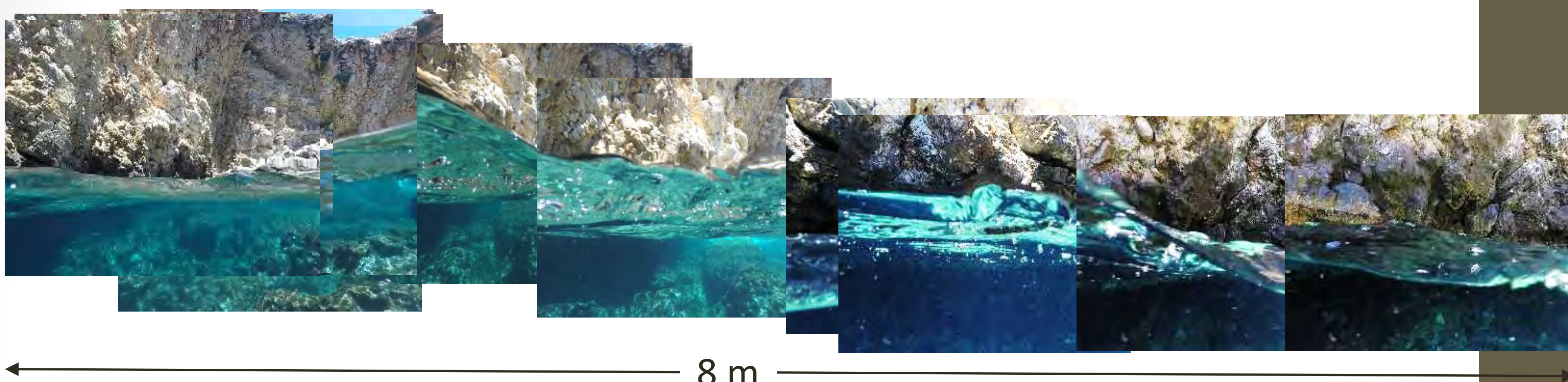
Results - drone

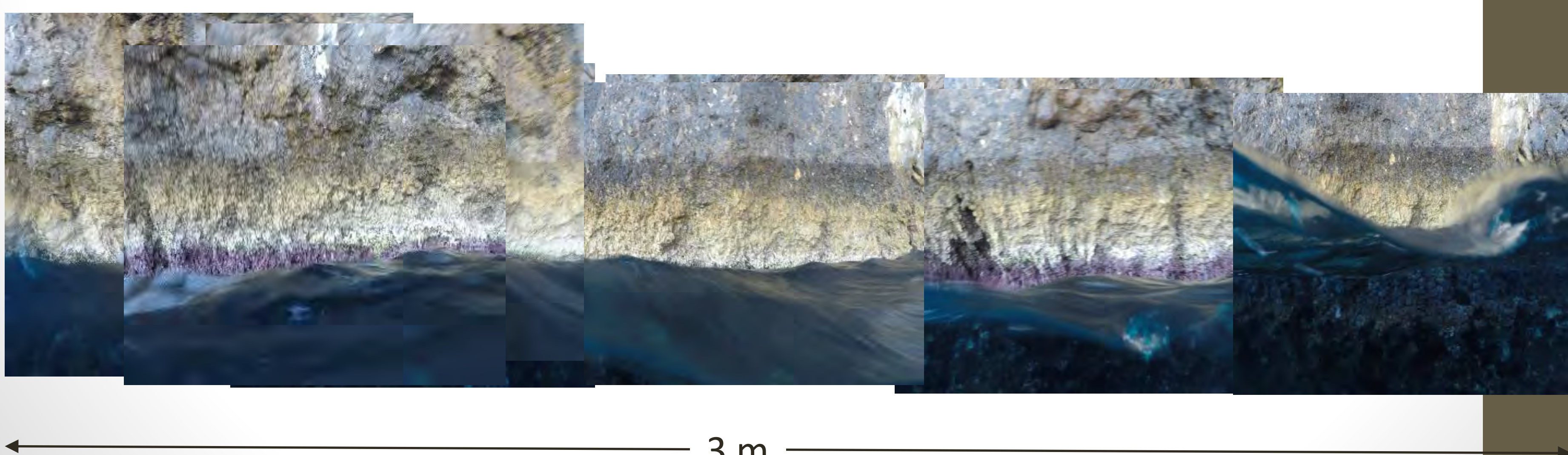


Results - drone

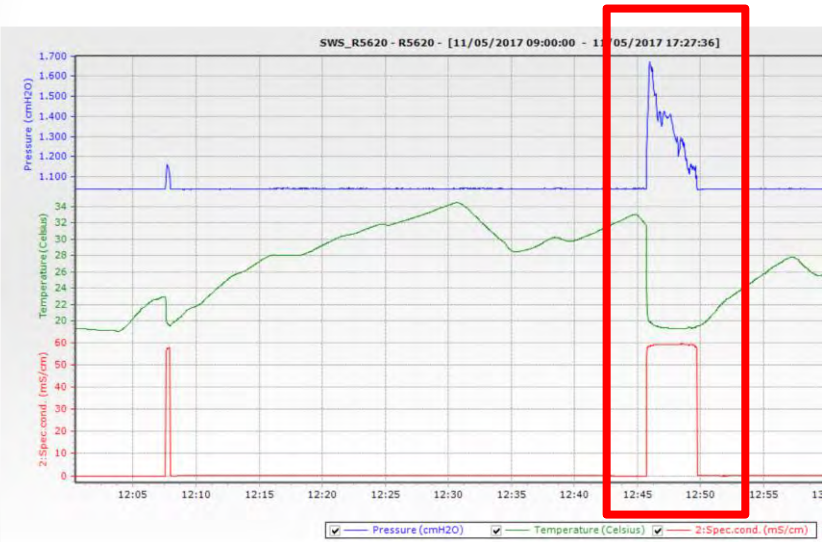


Results – time-lapse images

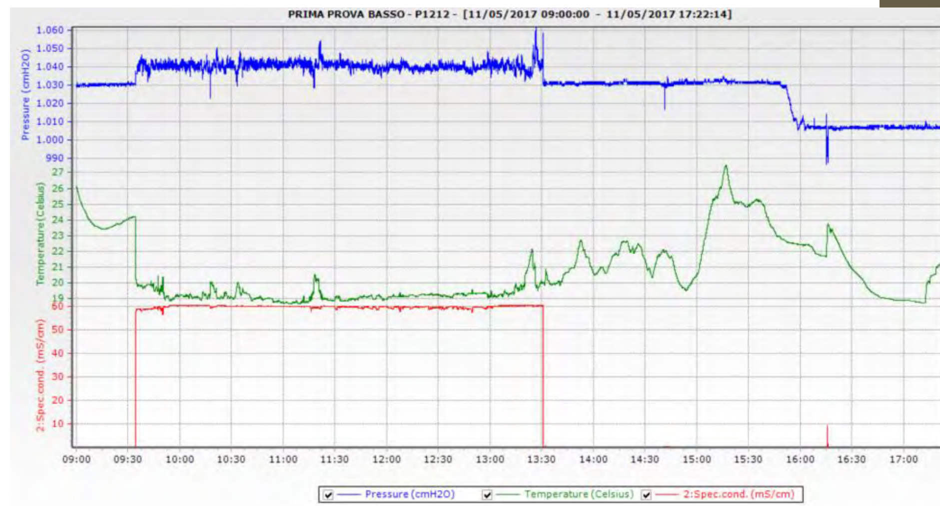




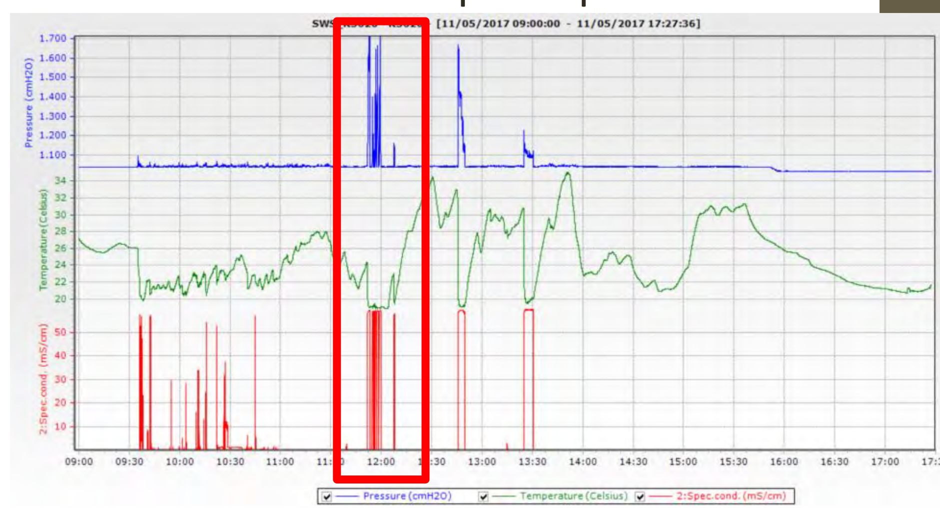
Results – CTD data



-0.05 m b.s.l.



multiple depths



Some consideations…

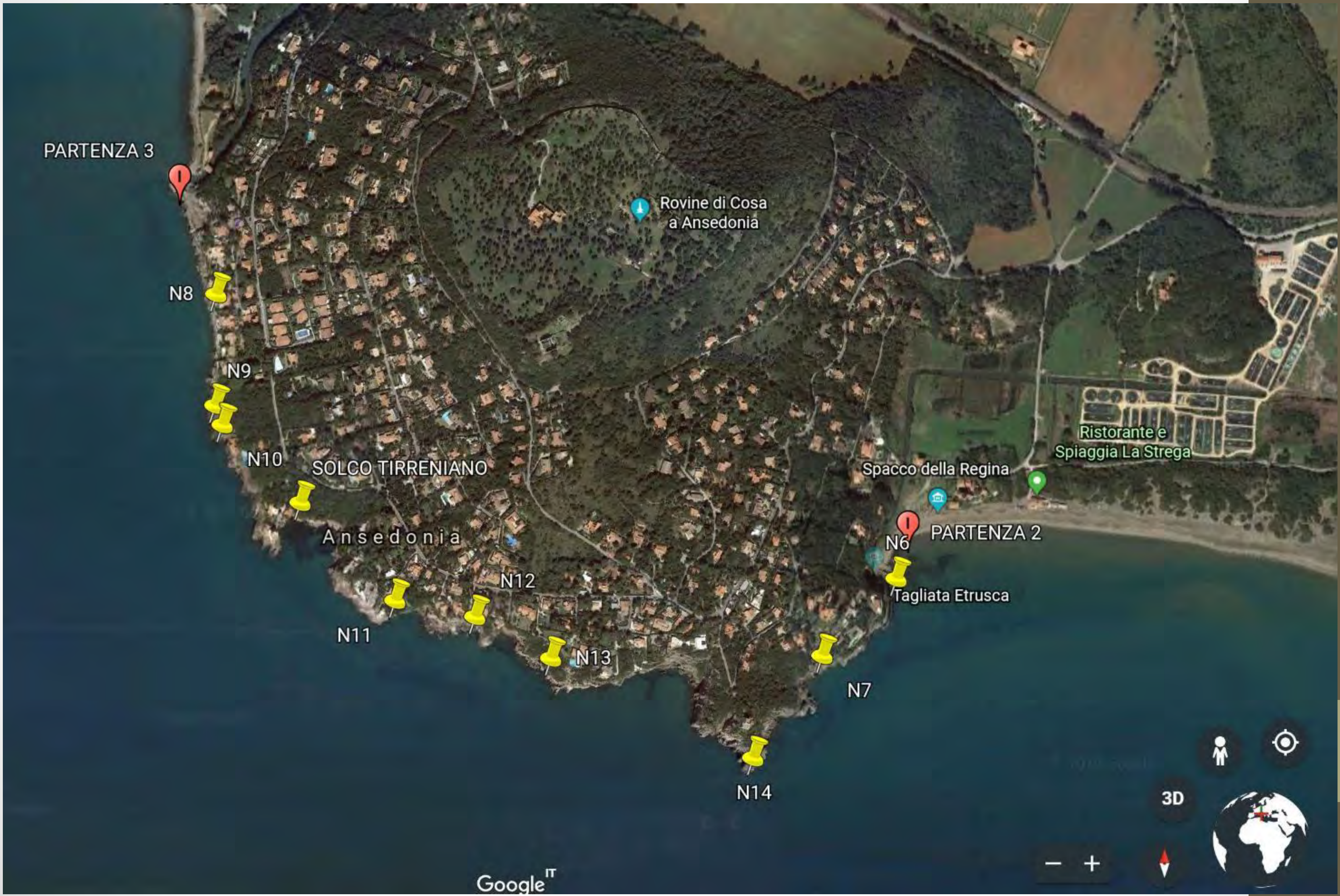
- We hypothesized that tectonics in conjunction with erosive processes determined the formation of a former sea cave and subsequently, after the collapse of the roof, sinkhole, or roof-less cave.

- Fracturation weakened the bedrock down to the production of small blocks, and the wave action promoted with time not only the partial collapse of the roof and the cliff, but also the seawards removal of resulting blocks and, above all, of the highly-erodible non-carbonate rocks.
- This process (tectonic fracturing and selective erosion) sub-excavated the bedrock until the roof collapsed, resulting in the formation of the sinkhole which is, in fact, the sole example of such along the entire coastline.
- Just aside the sinkhole, a few tens of meters along the coast and in comparable tecto-lithological scenario, there is another possible example of a former sinkhole/roofless cave now evolved into a small cove.

Argentario and Ansedonia (Tuscany, Italy)

2018

Study area



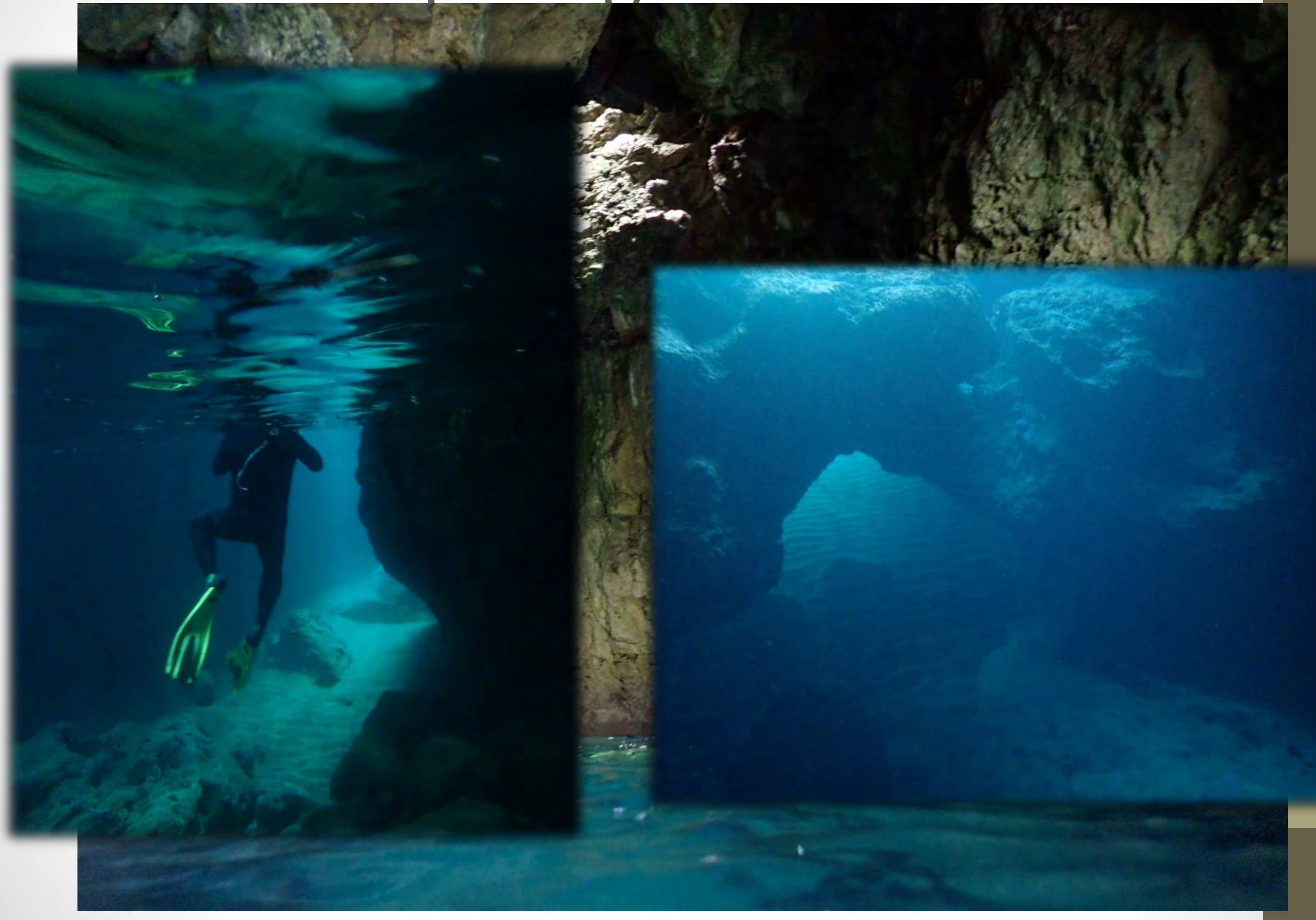
PARTENZA 3
Rovine di Cosa a Ansedonia
N8
N9
N10
SOLCO TIRRENIANO
Ansedonia
N11
N12
N13
N14
N7
N6
PARTENZA 2
Tagliata Etrusca
Spacco della Regina
Ristorante e Spiaggia La Strega
3D
Google

Geomorphological results: notches

mushroom-like landforms


MIS5.5 tidal notch

Geomorphological results: caves



17 sea caves were mapped and measured, specially on the eastern sector of the study area

Lampedusa, Linosa, Lampione

2020 ISOLE PELAGIE

…Geoswim 2022…

Geoswim at Tremiti Islands (Puglia, Italy)

Thank you for attention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LA SCOPERTA
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LIBRERIA DETKEN E ROCHOLL
B. JOHANNOWSKY