Corso di Dottorato di Ricerca in Scienze della Vita e dell'Ambiente, Ciclo XXXVIII

Valorization of marine biodiversity to engage local communities in the design of tailored conservation measures

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Marine habitats are rapidly degrading under multiple stressors [1]. Climate change is strongly impacting the Mediterranean Sea [2] and further degradation of marine biodiversity and ecosystem functions is expected to increase [3]. This project aims to design *ad hoc* strategies i) to raise awareness about climate change's effects on marine biodiversity, ii) to drive politicians and society in smoother acceptance of conservation measures and iii) to engage communities in their implementation. Citizen Science (CS) and Ocean Literacy (OL) programs are developed and addressed to different stakeholders to reach the project's goals.

Chap. 1: Ocean Literacy

The goal of this work is to assess Ocean Literacy and the local sea environment's perception of the local population. An *in-and-outdoor* marine activities project was held involving 434 students from 5 Marche Region's provinces and evaluating the impact through quali-quantitative pre/post surveys. Activities and evaluation methods were defined considering the grade/age of the students. Furthermore, 44 *vis-a-vis* interviews were addressed to Conero Coast society and then used to create a more specific online questionnaire that reached 262 people.

Schools Ocean Literacy

School	Locality	Grade	Participants' ages	Period	Activity	Method	N. of participants
G. Falcone	Ancona	Elementary	10 y.o.	From 03/10/2022 to 07/10/2022	CS (biodiversity and litter), Beach profile observation	OL Questionnaire	66
G. Verne	Ancona	Infant	3-4-5 y.o.	From 18/04/2023 to 21/04/2023	CS (biodiversity and litter), Beach profile observation	Pre/Post drawings	70
A. Caro	Civitanova Marche	Middle	11 y.o.	From 04/11/2023 to 04/12/2023	CS (biodiversity and litter), Tartle workshop and Webinar biodiversity importance and threats	Pre/Post drawings and thoughts	115
B. Rosetti	San Benedetto	High	18 y.o.	From 25/01/2023 to 30/01/2023	Biodiversity, Ecosystem services seminar, Marine Protected Areas seminar and Stakeholder workshop, CS (biodiversity and litter), Macrofauna lab	Pre/Post OL Questionnaire	40
L. da Vinci	Jesi		18 y.o.	02/'24	Biodiversity, Ecosystem services seminar, CS (biodiversity and litter)	OL Questionnaire	11
G. Marconi	Pesaro		16 y.o.	11/'22-10/'23	Biodiversity, Ecosystem services seminar, CS (biodiversity and litter), Macrofauna lab	Pre/Post OLS and OL Questionnaire	123
G. Galilei	Ancona		18 y.o.	11/'22	Biodiversity, Ecosystem services and Marine Protected Areas seminar	IOLS	9
							Tot. n. 434

Tab. 1: Resume of the activities with schools, method used and number of students involved

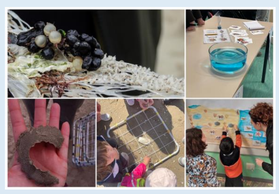

Fig.1: Examples of the diverse activities with which we involved the students

Fig.2: Example of pre/post drawings made by an 11 y.o. student

QrCode to IOLS: International Ocean Literacy Survey

Local population's perception

Face to face interviews			Online questionnaire		
Period	Method	N. of participants	Period	Method	N. of participants
1 Year (from April 2022 to April 2023)	Snawball via whatsapp	16	1 Week (from 02/05/2024 to 09/05/2024)	Snawball via whatsapp/email	/
	Snawball reaching randomly in 6 Ancona's district	28		Snawball randomly reaching during San Ciriaco fair	/
		Tot. n. 44			**Tot. n. 262**

QrCode to the interview form

QrCode to the questionnaire form

Tab. 2: Resume of the Local population's perception assessment survey, number of participants, method used and period

Chap. 2: Local Historical Ecology Knowledge

Local Ecological Knowledge (LEK) standardized protocol procedure was adopted to reconstruct historical changes in marine biodiversity, interviewing 48 fishermen from 3 Mediterranean Seas (Sicily, North Adriatic and North Tyrrhenian Seas) and collecting their perceptions about the abundance trends of 122 species mentioned. Pilot study 3, Pantelleria Island, allowed us to involve the local community in designing and implementing the conservation project PANTHER (**Pan**telleria Ben**th**ic Habitat Recov**er**y).

Fig.3: Map showing the three study cases areas where LEK interviews were conducted in 2022 and 2023

Study cases:

- Pantelleria Island: 12 interviews in 2022
- Alassio-Laigueglia: 12 interviews in 2022
- Ancona: 24 interviews in 2023

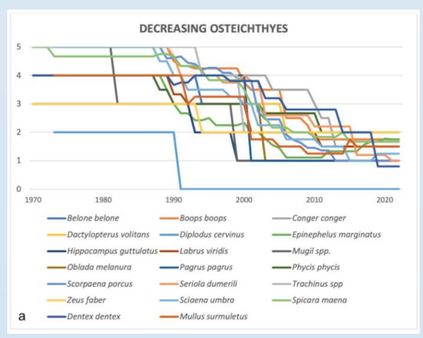

Fig.4: Species of Osteichthyes (a) and other phyla (b) with decreasing trends; Pantelleria Island case study

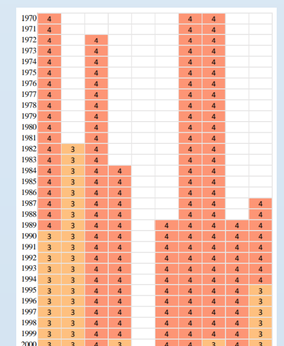

Fig.5: Heatmap of the species *Sepia officinalis*. Each column represents the historical reconstruction of abundances over time concerning an individual fisherman's perception; numbers represent indices of abundance (0=absent to 5=dominant)

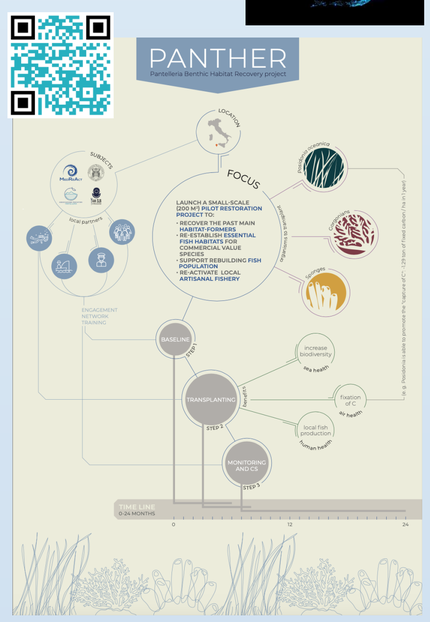

Fig.6: PANTHER project infographic

Chap. 3: Heterobranchia

Sea slugs are organisms with rather specific diets and prey are mostly sessile organisms (including porifera and cnidarians), which are particularly sensitive to climate change. Heterobranchs are also considered flagship species, i.e. species whose characteristics make them attractive to divers (and not only divers!) all over the world. In this context, we investigate whether Heterobranchia could be used as indicator organisms for the effects of climate change on the benthic communities collecting data from different sources and analyzing spatial distribution, seasonality, substrata and food preferences. A pilot experiment on *Spurilla neapolitana* is currently running.

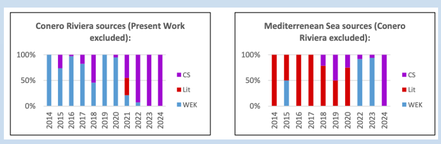

Fig.7: Contribution's baseline of diverse sources used for this work, considering Citizen Science data, Literature data and WEK

Present Work	Sessions	N. of Records	Conero Sites	Period
Scuba Visual Census	41	747	Cava Davanzali, Due Sorelle, Spiaggia del Frate, Relitto M/N Nicole, Passetto, Sassi Neri, Secca dell'Ospedale, La Spiaggiola e Scoglio della Vela	From 9/09/2021 to 06/02/2024
Out of water Visual Census	8	72	Passetto rocky tide pools	

Tab. 3: Contribution's baseline of diverse sources used, considering the data emerged by the present work

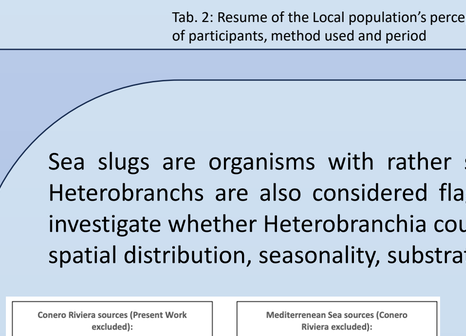

Fig.8: Comparison between the 10 most abundant species record in Conero Riviera and the Mediterranean Sia excluding the Conero site.

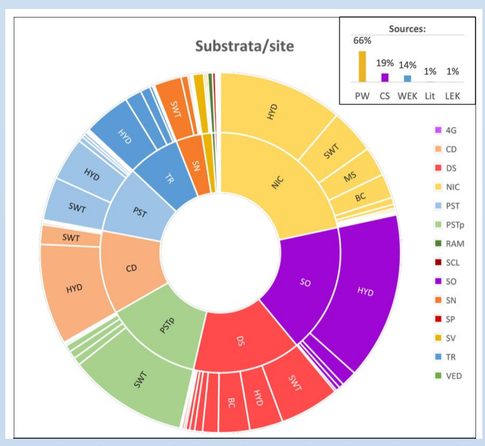

Fig.9: Relative frequency of substrata (outer pie) in each sampling site of the Conero Riviera (inner pie). The small histogram above represents the contribution of each source. The charts below underline the relative frequency of the superfamilies for each substrate in the respective site

Codes:
Sites: 4G = 4 Grotte; CD = Cava Davanzali; DS = Due Sorelle; NIC = Relitto M/N Nicole; PST = Passetto (no tide pools); PSTp = Passetto (tide pools); RAM = Ramona; SCL = Scalaccia; SO = Secca dell'Ospedale; SN = Sassi Neri; SP = La Spiaggiola; SV = Scoglio della Vela; TR = Scoglio del Trave; VED = Spiaggia della Vedova.
Substrata: ANT = Anthozoans; AS = Ascydians; AS+SP = Ascydians+sponges; BC = Rock covered by encrusting organisms/anellids; BIV = Bivalves; Br = Bryozoans; CobPeb = Cobbles or pebbles; CRB = Crab; FL = Floating; HYD = Hydroids; MS = Mussel shells; R = Rock; RCS = Rock covered by seaweeds; S = Sediment; SP = Sponges; SWT = Seaweeds/turf; URC = Sea urchin
Sources: CS = Citizen Science; LEK = Local Ecological Knowledge; Lit = Literature; PW = Present work; WEK = Web Ecological Knowledge

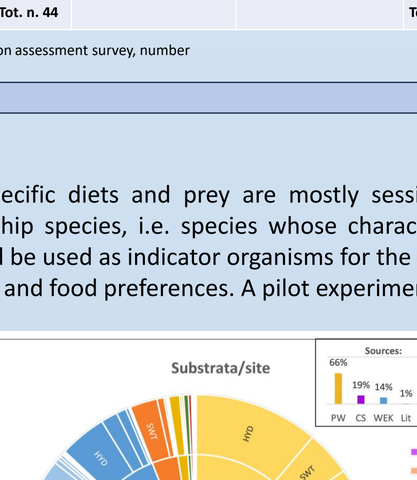

Fig.10: Comparison of the 10 most abundant species of the Riviera del Conero in the Mediterranean Sea (Conero Riviera excluded). The small histogram above shows the contribution of each source.

Fig.11: Comparison between the relative frequency of the substrate for different species in the Conero Riviera and in the Mediterranean Sea (Conero Riviera excluded). The small histograms represent the contribution of each source.

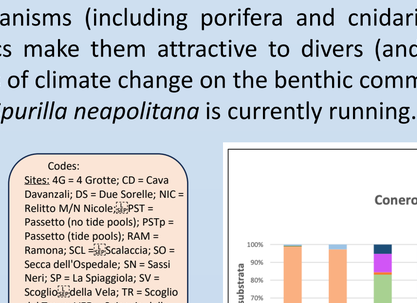

Fig.12: Comparison between the relative frequency of the superfamilies for different substrata in the Conero Riviera and in the Mediterranean Sea (Conero Riviera excluded). The small histograms represent the contribution of each source.

How predatory-Prey interactions influence the *Spurilla neapolitana* life cycle?

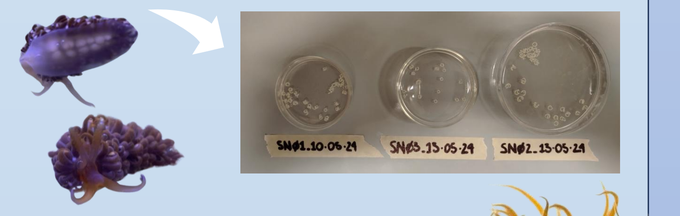

Fig.13: (upper picture to the left) Two specimens of *Spurilla neapolitana*, one of which shows eggs in transparency;
Fig. 14: (upper picture to the right) Egg masses of three S. *neapolitana* specimens;
Fig. 15: (lower picture to the right) *Exaiptasia diaphana* specimens by Joel Sartore

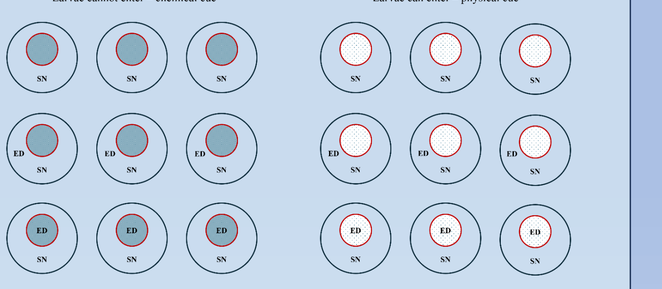

Fig.16: (upper picture) Complete experiment setup with treatments and controls. SN: *Spurilla neapolitana*; ED: *Exaiptasia diaphana*.
Fig. 17: (lower picture) *Spurilla neapolitana* larvae caught during the larve development monitoring

[1] Corrales, X., et al. 2018. Future scenarios of marine resources and ecosystem conditions in the Eastern Mediterranean under the impacts of fishing, alien species and sea warming. *Sci. Rep*. 8, 14284.
[2] Lange, M. A. 2020. Climate change in the Mediterranean: environmental impacts and extreme events. *IEMed: Mediterranean Yearbook*, 30-45.
[3] Pereira, H. M., et al. 2010. Scenarios for global biodiversity in the 21st century. *Science*, 330(6010), 1496-1501.