frontiers

Supplementary Material

An Urgent Call for More Ambitious Ocean Literacy Strategies in Marine Protected Areas: a Collaboration Project with Small-scale Fishers as a Case Study

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1 Supplementary Tables and Figures

Date	Event	Autorship/Hosted by
1974	National Marine Education Conference on The University of Rhode Island campus in Kingston, Rhode Island. The meeting was aimed at all segments of the education community that had some interest in the "World of Water".	University of Rhode Island
1985	National Marine Educators Association (NMEA) forms	NMEA
1990 - …	Various researchers showed the cost-effectiveness and fairness to indigenous peoples territorial rights of integrating LEK into development and conservation projects (also referred as Indigenous technological knowledge, ITK)	Tiltilola (1990), based on Aswani et al., 2018

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2000	First online onboard journal from the Institut de Ciències del Mar (ICM-CSIC, Barcelona, Spain)	ICM-CSIC
2002	Oceans for Life conference: Production of a guide with detailed ocean content for teaching (mainly geography): *Oceans for life: A scope and sequence for geography education K-12*	National Geographic Society (NGS) and College of Exploration (CoE)
2002	First publication about LEK related to marine knowledge, in Equador	Guest (based on Aswani et al., 2018)
2003	Role of LEK in ecosystem management	Gadgil et al., 2003. Exploring the role of local ecological knowledge in ecosystem management: three case studies. *Navigating social-ecological systems: building resilience for complexity and change*, *189*, 209.
2004	The term 'Ocean Literacy' was originally coined in 2004 by a group of ocean scientists and education professionals in the USA, who recognised a lack of ocean-related subjects in formal education and developed a comprehensive framework to encourage the inclusion of ocean sciences into national and state standard education	UNESCO, 2018
2004	"ICM Divulga", an ICM-CSIC's institutional platform for marine knowledge outreach and education purposes is created	ICM-CSIC

2005	Production of an Ocean Literacy (OL) guide for teachers from kindergarten to high school to use ocean content. The guide contained a definition and a set of seven principles and 45 concepts: *Ocean Literacy: The essential principles and fundamental concepts of ocean sciences K-12**	CoE, NGS, National Marine Educators Association (NMEA), National Oceanic and Atmospheric Administration (NOAA) Office of Education, Lawrence Hall of Science in California, Centers for Ocean Science Education Excellence (COSEE)
2006	LEK study in Kenya	Crona (based on Aswani et al., 2018)
2007	International Pacific Marine Educators conference: International Pacific Marine Educators Network (IPMEN) forms	IPMEN
2007	*The Marine education white paper* is published	Taiwan Ministry of Education
2008	Ocean Literacy guide is published in Japanese	NMEA
2008	LEK study in Santha (India)	Santha (based on Aswani et al., 2018)
2008	Role of LEK and the management of MPA (case study in Brazil)	Gerhardinger et al., 2009. Local ecological knowledge and the management of marine protected areas in Brazil. *Ocean & Coastal Management*, *52*(3-4), 154-165
2009	Production of the “Scope and Sequence” for OL	NMEA
2009	US-based Great Lakes Literacy Guide published	American Geophysical Union
2010	NMEA special report #3: The ocean literacy campaign published	NMEA
2010	“El Mar a Fons” project (The Sea in Depth) is created in the	ICM-CSIC

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	ICM-CSIC with the aim to provide educational and outreach resources and assistance for both formal and non-formal education	
2010	The Center for Ocean Sciences Education Excellence of China (COSEE China) forms	COSEE China
2010	Ocean Literacy Guide published in Chinese	NMEA
2011	Ocean Literacy Guide published in Portuguese	NMEA
2011	LEK study in USA	Ainsworth (based on Aswani et al., 2018)
2012	European Marine Science Educators Association (EMSEA) forms; Conference on ocean literacy in Bruges, Belgium; ocean literacy campaign begins in Bangladesh.	EMSEA
2012	The citizen science project “Observadors del Mar” (Sea Watchers) is created in the ICM-CSIC for connecting marine researchers and citizenship	ICM-CSIC
2013	Ocean Literacy Guide version 2 published	NMEA
2013	Sign of the Galway Statement on Atlantic Ocean cooperation	Canda, EU and the United States
2013	Canadian Network for Ocean Education (CaNOE) forms	CaNOE
2014	The vision statement for transatlantic ocean literacy is published	Organizers of the Transatlantic Ocean Literacy Workshop
2014	ICM-CSIC representation in	ECSA

	the European Citizen Science Association (ECSA)	
2014	First International Marine Science Communication conference	CIIMAR, EMBCP and Ciência Viva
2015	Ocean Literacy/Next Generation Science Standards alignment published	NMEA
2015	Sea Change project, a 3-year long european project with 17 european partners is launched to foster Ocean Literacy in citizenship	Funded by the EU
2015	ResponSEAble project	Funded by the EU
2015	All-Atlantic Ocean Research Alliance emerges	All-Atlantic Ocean Research Alliance
2015	Asia Marine Educators Association (AMEA) forms	AMEA
2015	LEK study in Solomon islands	Aswani and Albert (based on Aswani et al., 2018)
2015	LEK study in Nicobar (India)	Patankar et al. (based on Aswani et al., 2018)
2015	EMSEA-Med forms	EMSEA-Med
2016	CommOCEAN 2016	Organizers of CommOCEAN
2016	The project “Petits Oceanògrafs” (Little Oceanographers) is created in the ICM-CSIC as an institutional annual opportunity for schools to connect with marine researchers from different specialties	ICM-CSIC
2016	Natusfera: A platform to integrate citizen science approachs for monitoring marine ecosystems is created by the Ecological and Forestry	ICM-CSIC

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	Applications Research Centre (CREAF) and the ICM-CSIC	
2016	1st Global Ocean Science Workshop	UNESCO
2017	Ocean Literacy for All conference	UNESCO
2017	Mediterranean Sea Literacy published	EMSEA
2017	REEDUCAMAR emerges as a repository to put together spanish OL efforts and resources, with several ICM-CSIC's resources and efforts on OL	Spanish government
2017	Korean Ocean Literacy Guide published	NMEA
2017	*Ocean Literacy for all: A toolkit* published	UNESCO
2018	African Ocean Literacy Network forms	African Ocean Literacy Network
2018	Ocean Literacy Italia forms	Ocean Literacy Italia
2018	CommOCEAN 2018	Organizers of CommOCEAN
2018	Global trends of LEK and future implications	Aswani et al., 2018. Global trends of local ecological knowledge and future implications. *PloS one*, *13*(4), e0195440
2018	"Espai Mediterrani" is created in Barcelona (Spain) with the participation of the ICM-CSIC and local civil associations around 3 objectives (territory and marine culture, sustainability and social justice and Ocean Health)	Espai Mediterrani
2019	*Exemplary practices in marine*	Fauville et al., 2019

	science education: A resource for practitioners and researchers published	
2019	RELATO Océano forms	RELATO
2020	Ocean Literacy Guide version 3 published	NMEA
2020	Virtual Ocean Literacy Summit	UNESCO's Intergovernmental Oceanographic Commission
2020	EU4Ocean Coalition forms with european associations including the ICM-CSIC as a founding member	European Maritime Forum
2020	The ICM-CSIC launches the Network of Marine Schools with first connections to Barcelona's and Catalan's government for embedding ocean knowledge in formal education	Espai Mediterani
2021	Launch of the Decade of Ocean Science for Sustainable Development (2021-2030)	United Nations
2022	The ICM-CSIC signs the Charter on Education commiting to Ocean Literacy during the EMSEA conference	EMSEA
2023	LEK study in Cap de Creus MPA	Biel-Cabanelas et al., 2023
2023	New framework for Ocean Literacy with 10 dimensions: knowledge, awareness, attitude, behavior, activism, communication, emotional connections, access and experience, adaptive capacity & trust and transparency.	McKinley et al., 2023

* Later referred as the "Ocean Literacy guide"

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Supplementary Table 1. Chronology of Ocean Literacy (globals in blue and locals in orange) and LEK efforts (in green) through time.

I. About You:

1] Interview #		
2] Date:	3] Place:	
4] Interviewer:		
5] Recording:	☐ Yes	☐ No
6] File code:		
7] Name and surname		
8] Age	9] Sex:	
10] Start of professional career (year)		
11] in the case of being a fishing skipper, indicate whether you are also the owner (and the number of fishing units)		

BOAT	
12] Name	

13] Length (m)		14] Toonage (TRB or GT)	
15] Power (CV or kW)		16] Material (wood, fiberglass…)	
17] Year of constructi on		18] Hull material (wood, steel, plastic)	
19] Crew number[1]		20] Number of sailors	
21] Fishing gear used		Main gear	
		Gear 2	
		Gear 3	
		Gear 4	

1) How many years have you been fishing in the Cap de Creus area?

More than 30	
20-30	
10-20	
5-10	

[1] Including ship's captain

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Less than 5	

2) To which fishing association do you belong?

Roses	
Cadaqués	
El Port de la Selva	
Llançà	

3) Have you always been a member of the current fishing association? Yes No

(If not, specify in which other fishing association you have worked:_____)

4) Do you fish year-round? Yes No

If not, indicate which months of the year you fish (check them off)

January		July	
February		August	
March		September	
April		October	
May		November	
June		December	

5) Which month or months of the year do you usually set your fishing gear most frequently? (Check them off)

January		July	
February		August	
March		September	
April		October	
May		November	
June		December	

6) How often do you typically lift your fishing gear?

More than once a week	
Weekly	
Every two week	
Monthly	

7) Is fishing your only source of income? Yes No
If not, what do you combine with fishing?

8) What are the top 6 main "target" species you focus on? Please rank them from most to least important:

1.
2.

3.
4.
5.
6.

9) Why do you believe these species are important?

10) Which of the following adjectives do you identify with the most as a fisher?

fair	
respectful	
correct	
exploitative	

activist	
sustainable	
Other (write it/them):	

11) What impact do you think you have on the seabed?

High	
Moderate	
Low	
No impact	

12) Would you participate in projects with biologists again? Yes No

13) Have you talked about the gorgonian projects with people? Yes No

14) If yes, in what areas? (Check the options you consider)

Family	
Friends	
Tourists	
Fishing association	
Fishers from other associations	
Recreational fishers	
Divers	
Natural Park personnel	

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Administration personnel	
Other biologists	
Other (write it/them):	

15) From the previous areas, which are the top 2 areas where you talk the most?

1._____

2._____

16) With which individuals/entities/groups have you specifically talked about the project? (Provide at least 10 names, or more if possible; they can be family members, friends, summer residents, tourists, other fishers from the association, fishers from other associations, divers, local people).

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

II. Regarding the people you mentioned in the previous question:

Put the person's name here and respond about this person: _____

1) What age would you place this person in?:

1 to 10	
11 to 20	
21 to 30	
31 to 40	
41 to 50	
51 to 60	
61 to 70	
71 to 80	
Over 80	

2) Is this person male or female?

Male	

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Female	

3) Where does this person live, regularly?

El Port de la Selva	
Selva de Mar	
La Vall	
Llançà	
Cadaqués	
Roses	
Colera	
Other (write the place name):	
I don't know	

4) How many years, approximately, have you known this person?

More than 30	
20-30	
10-20	
5-10	
Less than 5	

5) How close do you feel to this person?

Not close at all	
Not very close	
Fairly close	
Close	
Very close	

6) Which category best describes the frequency of contact with this person?

Every day	
Twice a week	
Once a week	
Twice a month	
Once a month	
Twice a year	
Once a year	

7) How do you typically contact this person (choose one, the most preferred)?

In person	
By phone, talkint	

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By phone, WhatsApp	
By email	

8) When you talk to this person, are there usually other people in the conversation?

Yes No

9) If you contact them in person, where do you typically talk with him/her (choose one, the most common)?

At my home	
At their home	
On the street	
In a bar	
At the fishing association	
Other (write the name of the place):	

i. Mark the answer (only one) that you think is most appropriate:

*1. Marine forests of gorgonians, *Posidonia*, and corals:

a) are not affected by ship anchors or fishing nets
b) are heavily affected by anchors and fishing nets, one of the reasons why fish stocks are decreasing
c) are significantly affected by anchors and fishing nets, but this does not affect the quantity of fish caught
d) are affected by fishing nets but not by ship anchors

*2. What is *Posidonia*?

a) an animal
b) a marine plant
c) an alga
d) a mineral structure

*3) *Posidonia*:

a) is not important as a habitat for numerous commercial species
b) currently has increasing populations from recent years
c) protects the coastline and is an important habitat
d) damages the coastline with leaves that reach the beaches

*4) What is a gorgonian?

a) an animal
b) a marine plant
c) an alga
d) a mineral structure

*5) Why are gorgonians important in the sea?

a) they create habitat within the sea and offer protection to other organisms
b) they serve as food for most fish
c) they are mainly ornamental, very attractive to divers
d) they help consolidate sediment, like *Posidonia*

*6) If you return gorgonians directly to the sea after catching them in the nets…

a) there is a good chance they will stand up and recover
b) it is very difficult for them to survive and thrive
c) they will not reach the bottom because they will be eaten by fish
d) they only need a small piece of rock attached to survive on the seabed

*7) When we talk about gorgonians forming communities, we mean that, among other things, they are:

a) important breeding habitats for various fish and invertebrates
b) dirty areas of the sea
c) unimportant breeding habitats for various fish and invertebrates
d) unimportant breeding areas when compared to *Posidonia*

*8) Conserving underwater gorgonian forests:

a) usually leads to more catches in the long run and is beneficial for marine life
b) usually results in fewer catches in the long run but is beneficial for marine life

c) usually has no effect on future fishing activity or marine life
d) usually has no effect on future fishing activity and can harm marine life

*9) In recent years, many populations of commercially valuable fish:

a) have significantly decreased
b) have significantly increased
c) have not changed much
d) have decreased but not significantly

*10) In general, in recent years, the size of the fish catches:

a) has significantly decreased
b) has significantly increased
c) has not changed much
d) has decreased slightly, but not significantly

*11) Of the gorgonians that are returned to the sea with scientists:

a) many of them survive
b) not many of them survive
c) most of them are found back in the nets
d) most of them are eaten by fish

*12) Small-scale fishing:

a) does not harm gorgonian forests
b) harms gorgonian forests but the impact can be minimized with good practices
c) harms gorgonian forests and there is nothing that can be done to minimize the impact
d) promotes the expansion of gorgonian forests

*13) Why is it important to return gorgonians attached to a stone to the sea?

a) to make them stand up and thus favor their survival
b) because it is more difficult for them to get caught in the nets
c) because we want to create a more rocky seabed
d) to identify them

*14) What has been the main gain from participating in the projects you have been involved in?

a) working with biologists
b) receiving financial contributions
c) reducing the impact of fishing as requested by the authorities
d) collaboration in the conservation and restoration of the marine environment

*15) What would you propose to reduce the impact of trammel nets on gorgonians?

a) since there is little impact, there is no need to change anything
b) reducing the size of the net and the time it is set
c) changing the net collection system
d) changing the fishing gear

16) Collecting and recovering gorgonians during fishing…

a) has required work but has been worth the effort
b) has involved a lot of extra work
c) has caused many logistical problems during the fishing day
d) has been easier than I thought

17) For fishers, working with biologists…

a) is positive in the short term but negative in the long term
b) is generally positive
c) is a complication
d) is a way to share knowledge

18) What has been the main benefit of viewing, along with scientists, the videos from the trawl nets recorded by the ROV?

a) there has been no benefit
b) it was fun but did not provide me with new information
c) getting to know the seabeds where we work and understanding the impacts of fishing
d) I have discovered a possible new source of income

19) Participating in the project:

a) has improved our relationships as small-scale fishers
b) has generated conflicts among us and with other marine sectors
c) has given greater visibility to our work as small-scale fishers at the Natural Park
d) has empowered us as a group in relation to other sectors (divers, recreational fishers, government…)

20) Which option would you choose?

a) I would recommend other fishers to participate in projects like this, but I would not like to continue participating in similar projects; I have had enough.
b) I would recommend other fishers to participate in projects like this, and I would like to continue participating in similar projects.
c) I would not recommend other fishers to participate in projects like this, and I would not like to continue participating in similar projects.
d) I think the conditions need to be changed to be able to recommend and participate in similar projects.

*21) From now on, if I find gorgonians in the nets…

a) I will return them to the sea if they have sufficient rocky support
b) I will return all of them to the sea
c) I will try to remove as few as possible, and if I do, I will return them to the sea if they have sufficient rocky support
d) I will clean the nets when I return to port

22) Did you know about gorgonians before the project? How did you know about them? Provide an example of what was done with gorgonians (e.g., eating them, drying them, using them for ornamental purposes, or doing nothing with them).

23) Would you like to add anything else?

i. Indicate whether you agree (Yes) or disagree (No) with the following statements. If you want to clarify something, you can write it in the space provided for each statement:

* 24) Posidonia is important as a habitat for numerous commercial species.

Yes No

Comment:

* 25) *Posidonia* protects the coastline.

Yes No
Comment:

* 26) *Posidonia* has been declining for years.

Yes No
Comment:

* 27) Lobster populations have increased in recent years.

Yes No
Comment:

* 28) Scorpionfish populations have increased in recent years.

Yes No
Comment:

* 29) Cuttlefish populations have increased in recent years.

Yes No
Comment:

* 30) The size of caught fish has decreased over the last ten years.

Yes No
Comment:

* 31) The size of captured lobsters has been decreasing in the last 10 years.

Yes No
Comment:

* 32) Groupers are generally smaller than they were ten years ago.

Yes No
Comment:

* 33) There are fewer octopuses than before.

Yes No
Comment:

* 34) Fish species that have no commercial value have increased their populations.

Yes No
Comment:

* 35) There are fewer fish in the trawl nets of the Cap de Creus PN.

Yes No
Comment:

* 36) The protected area helps to fish more around it.

Yes No
Comment:

* 37) There are more large specimens outside the protected area than inside.

Yes No
Comment:

* 38) Spearfishing has damaged the ecosystem.

Yes No
Comment:

* 39) Noise pollution drives away fish.

Yes No
Comment:

* 40) Pollution leads to less *Posidonia*.

Yes No
Comment:

* 41) Gorgonian forests are important to prevent fish populations from declining.

Yes No
Comment:

* 42) Gorgonians that are directly returned to the sea survive.

Yes No
Comment:

* 43) *Posidonia*, gorgonians, and corals have similar habitat-creating functions in the ecosystem.

Yes No

Comment:

44) I fish differently than I did five years ago.

Yes No
Comment:

45) There are little-known fish species that could be sold and consumed more.

Yes No
Comment:

* 46) Protecting seagrass, gorgonians, and corals protects trawl nets.

Yes No
Comment:

* 47) Fishing closures are usually respected.

Yes No
Comment:

* 48) Minimum catch sizes are usually respected.

Yes No
Comment:

* 49) Gillnets destroy habitats and ultimately lead to fewer fish.

Yes No
Comment:

* 50) Small-scale fishers can contribute to ecosystem recovery.

Yes No
Comment:

51) People have a negative image of fishers in general.

Yes No
Comment:

52) People value small-scale fishers positively compared to industrial fishing.

Yes No
Comment:

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53) It is necessary to explain to schools and the public how certain types of fishing can be more environmentally friendly.

Yes No
Comment:

Supplementary Table 2. Full survey used for compelling the data for PNA, OL assessment and CCA. OL questions used for CCA are indicated with an asterisk.

Number of Question		Number of answers by fishers
1	a	0
	b	4
	c	4
	d	1
2	a	0
	b	5
	c	4
	d	0
3	a	0
	b	0
	c	9
	d	0
4	a	4
	b	4
	c	0
	d	1
5	a	8
	b	1
	c	0
	d	0
6	a	1
	b	7
	c	0

	d	1
7	a	9
	b	0
	c	0
	d	0
8	a	9
	b	0
	c	0
	d	0
9	a	6
	b	0
	c	1
	d	2
10	a	5
	b	1
	c	3
	d	0
11	a	9
	b	0
	c	0
	d	0
12	a	0
	b	9
	c	0
	d	0
13	a	9
	b	0
	c	0
	d	0
14	a	2
	b	1
	c	6
	d	0
15	a	5
	b	2

	c	0
	d	1
16	a	3
	b	2
	c	0
	d	4
17	a	1
	b	4
	c	0
	d	4
18	a	0
	b	0
	c	9
	d	0
19	a	1
	b	0
	c	5
	d	3
20	a	0
	b	8
	c	0
	d	1
21	a	2
	b	2
	c	5
	d	0
22	I knew about them but nothing was done with them	1
	I didn’t know much about them and their ecological role	1
	I knew about them from scuba diving	1
	I knew about them, I put them back in the water, sometimes I used some specimens for ornamental purposes	1

23	I am glad to have had the opportunity to learn so much from biologists	1
	The decrease of fish is caused by sportive fishing	1
	I am glad to have had the opportunity to work with biologists but I am aware that they use to restrict fishing activity	1
24	No	0
	Yes	9
25	No	0
	Yes	9
26	No	2
	Yes	7
27	No	5
	Yes	4
28	No	5
	Yes	4
29	No	6
	Yes	3
30	No	4
	Yes	5
31	No	4
	Yes	5
32	No	4
	Yes	5
33	No	8
	Yes	1
34	No	8
	Yes	1
35	No	5
	Yes	4
36	No	1
	Yes	6
37	No	5
	Yes	2

38	No	2
	Yes	7
39	No	1
	Yes	7
40	No	2
	Yes	7
41	No	0
	Yes	9
42	No	2
	Yes	6
43	No	1
	Yes	8
44	No	3
	Yes	6
45	No	1
	Yes	8
46	No	0
	Yes	9
47	No	0
	Yes	9
48	No	0
	Yes	9
49	No	0
	Yes	9
50	No	2
	Yes	7
51	No	0
	Yes	9
52	No	3
	Yes	6
53	No	1
	Yes	8

54	No	0
	Yes	9

Supplementary Table 3. Results of the OL survey conducted with small-scale fishers in Cap de Creus MPA. Results include the answers provided by the son of one of the fishers, who despite not participating formally, also participated in the project since the beginning and agreed to answer the OL test. Some of the questions were not answered by all of the fishers.