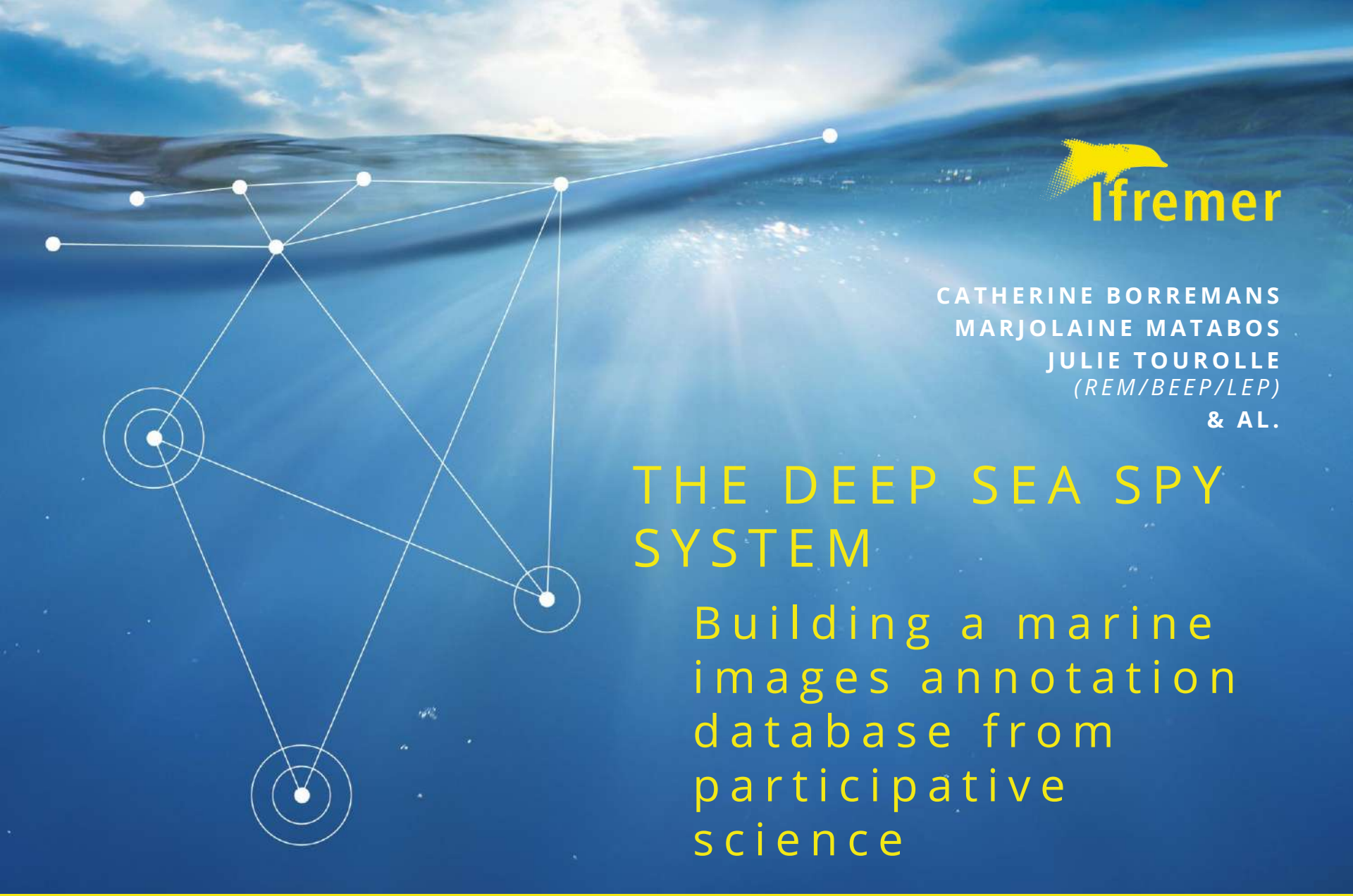


CATHERINE BORREMANS
MARJOLAINE MATABOS
JULIE TOUROLLE
(REM/BEEP/LEP)
& AL.

THE DEEP SEA SPY SYSTEM

Building a marine images annotation database from participative science

ATELIER TECHNIQUE #13 – 9 JUIN 2022

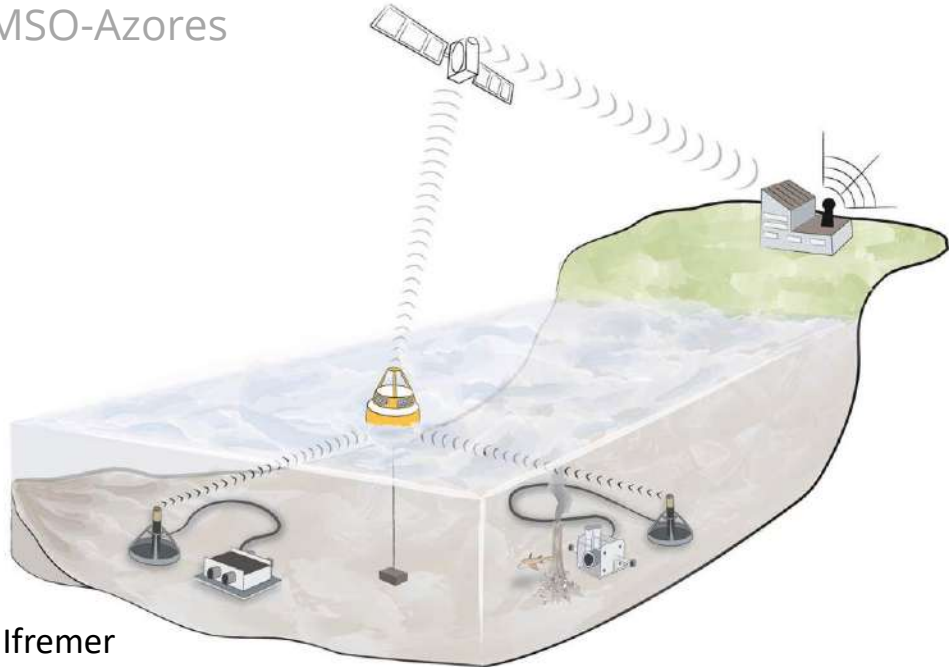
Deep-sea observatories

© Venus/Ocean Networks Canada

Long-term continuous monitoring

- Cabled or autonomous
- Presence 24h / 365 j / 20+ years
- Integrated, multidisciplinary approach
- High resolution sampling
- Real-time or near real-time : event detection capacity, remote sampling
- *In situ* monitoring

EMSO-Azores



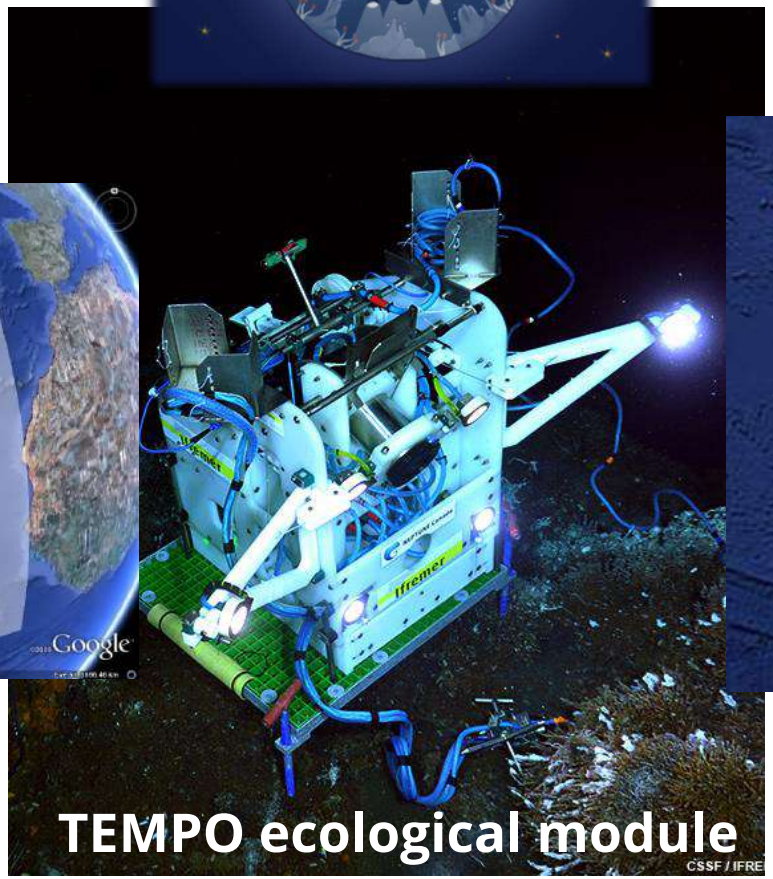
© Ifremer

Deep-sea observatories

EMSO-Azores
2010-…

Mid-Atlantic Ridge
Tour Eiffel, Lucky Strike (1700 m)

Imagery
2 min/6 hrs/365 days



TEMPO ecological module

Ocean Networks Canada 2011-…

Juan de Fuca Ridge
Grotto, Main Endeavour (2200 m)

Imagery
20 min/4 hrs/365 days

Hydrothermal vents

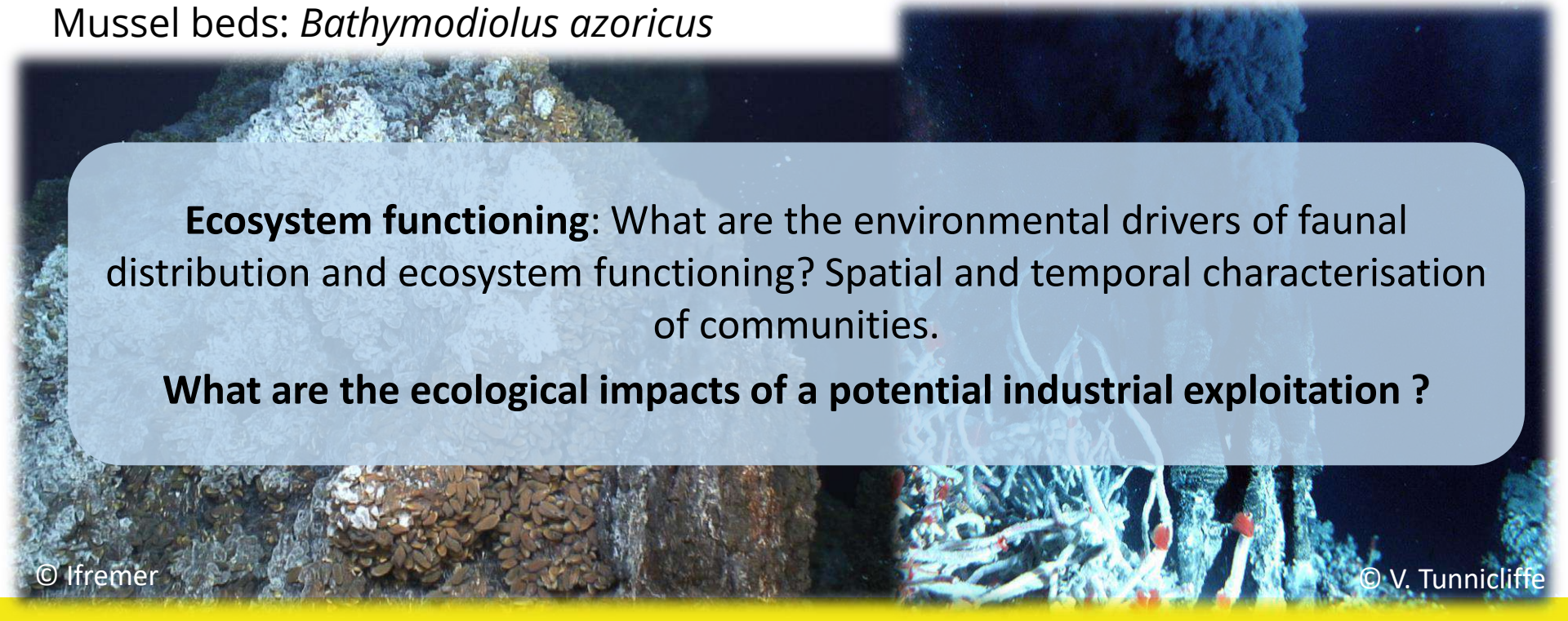
Marine protected areas

Specialized fauna: hot toxic fluid/narrow physico-chemical gradients

Massive sulphide mineral deposits

Mid-Atlantic ridge
Tour Eiffel, Lucky Strike
1700 m
Mussel beds: *Bathymodiolus azoricus*

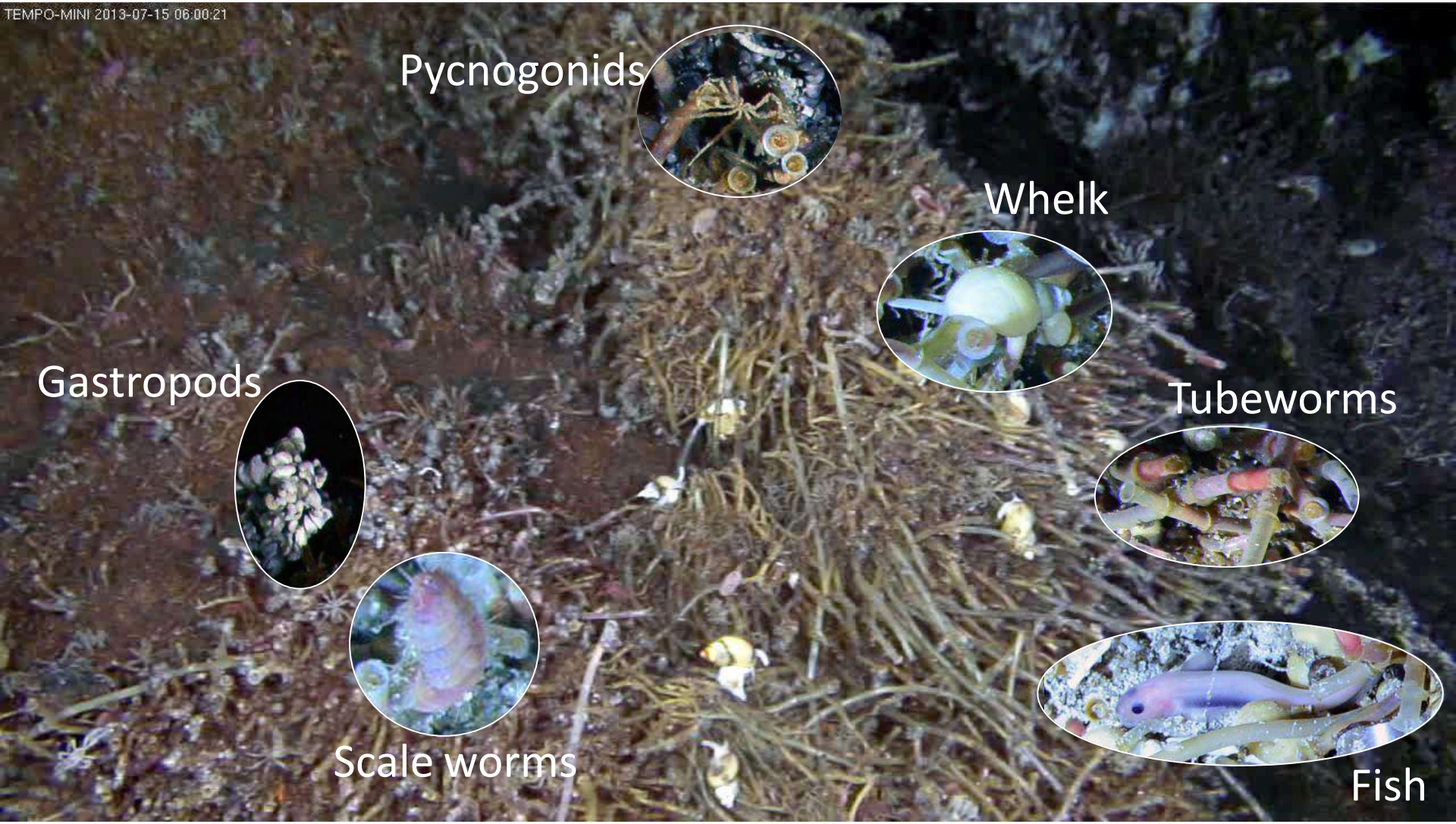
Juan de Fuca ridge
Grotto, Main Endeavour Field
2200 m
Tubeworms: *Ridgeia piscesae*



Ecosystem functioning: What are the environmental drivers of faunal distribution and ecosystem functioning? Spatial and temporal characterisation of communities.

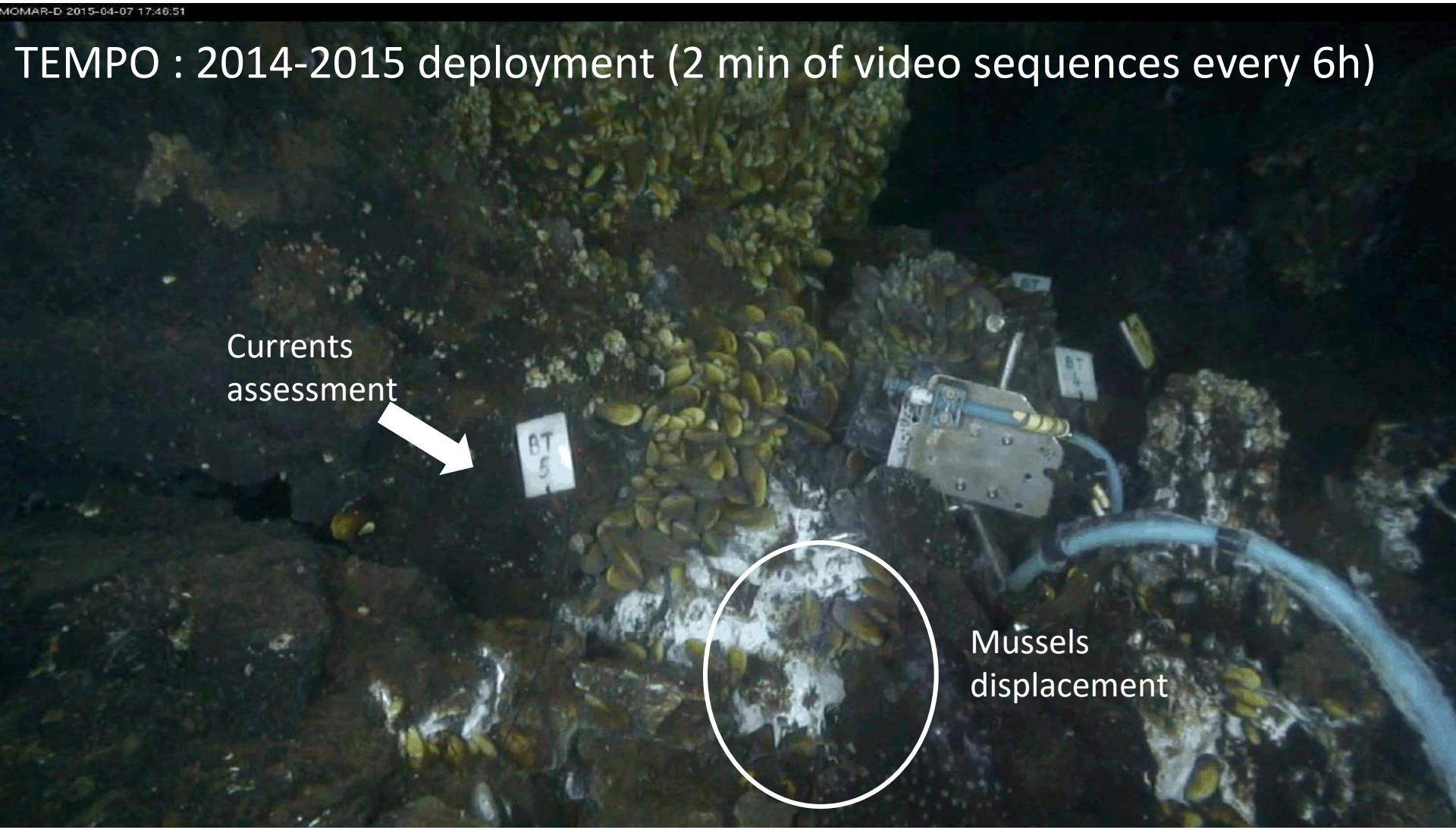
What are the ecological impacts of a potential industrial exploitation ?

Annotate visible inhabitants



Annotate visible inhabitants

Some examples of data analysis



Imagery archive

780 video hours/year…

> 5000 video hours (> 10 Tb)

20 work hours to annotate **1 video hour**

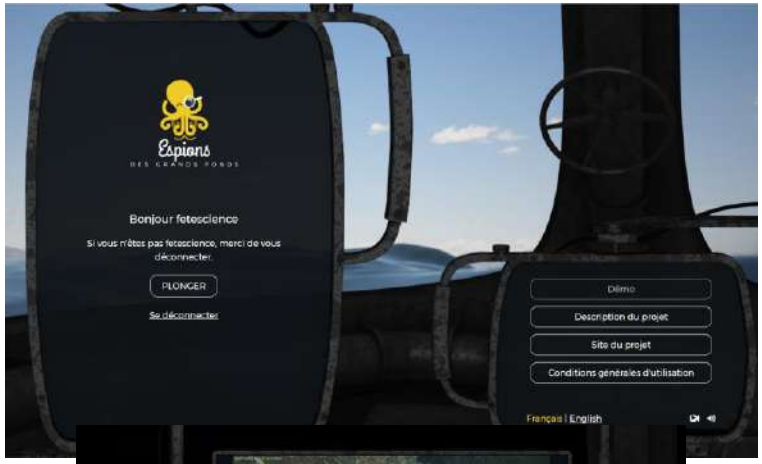
…more than 11 years to annotate the present whole dataset
(which increases every year) !

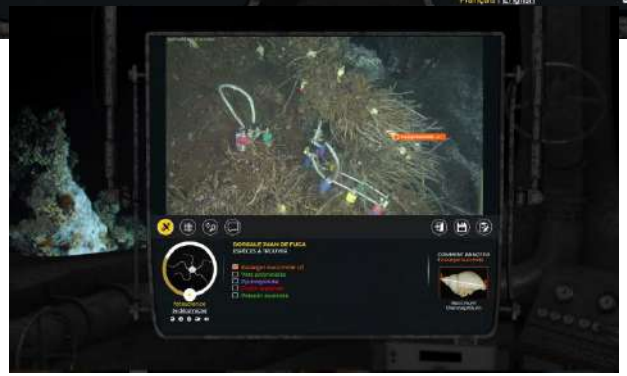
To proceed such a video archive scientists need the help of citizen

Development of a citizen science project

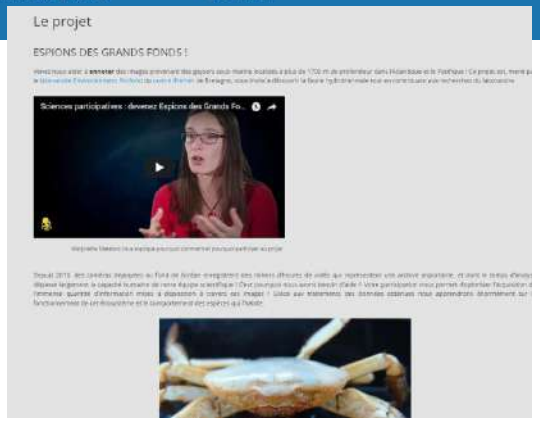
Deep Sea Spy

An online annotation tool



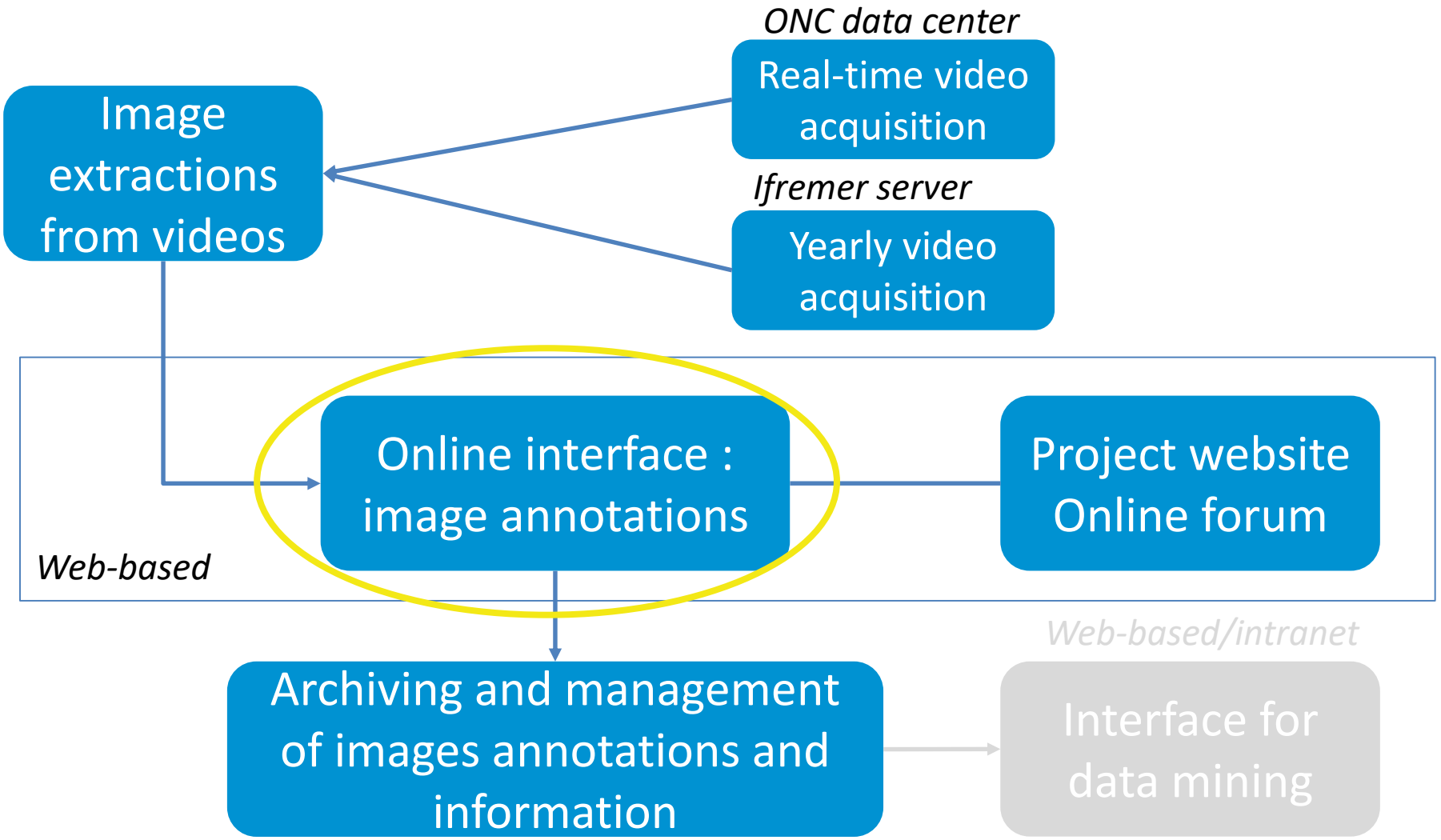


A project website



plus ENVRI

Development of a citizen science project

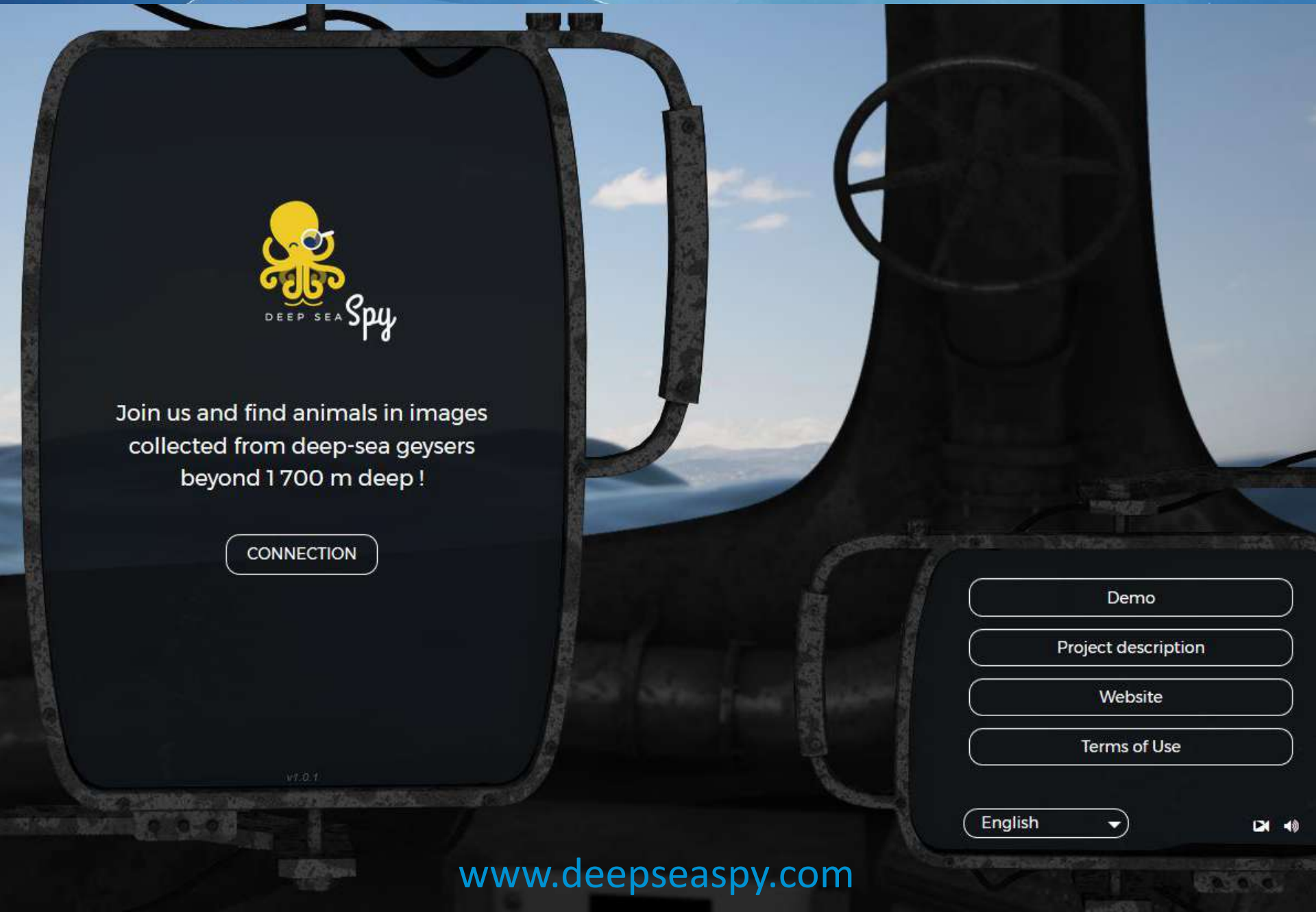


A web-based application to annotate species

- A web-based software for manual image processing that will help gather useful information for scientists
- A fun and engaging interface to raise awareness among the general public to deep-sea ecosystems

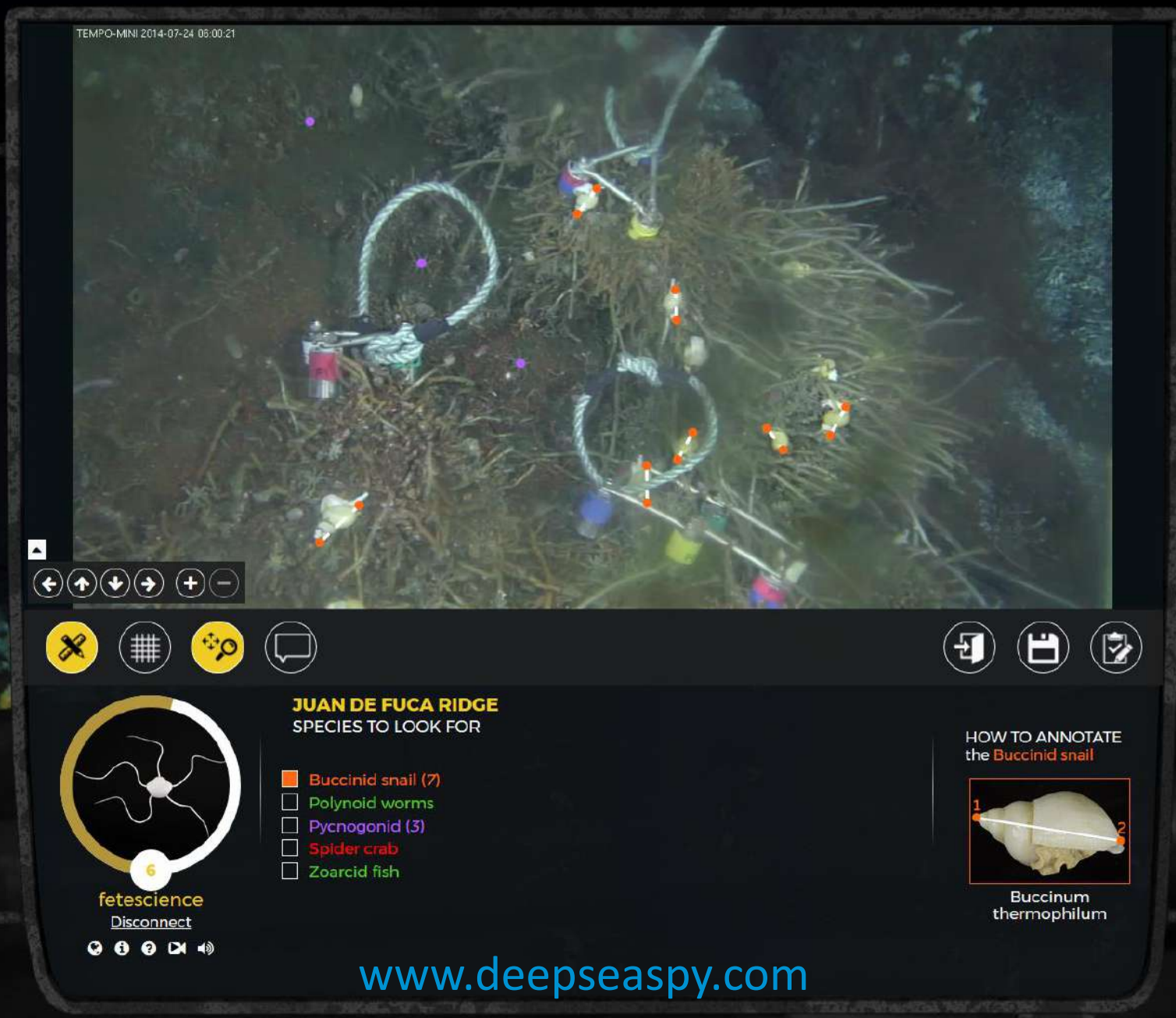
→ **Available online (internet)**
→ **Built as a game**
→ **Tutorial**
→ **Levels (and virtual rewards)**
→ **Data stored in pixels**

The annotation system



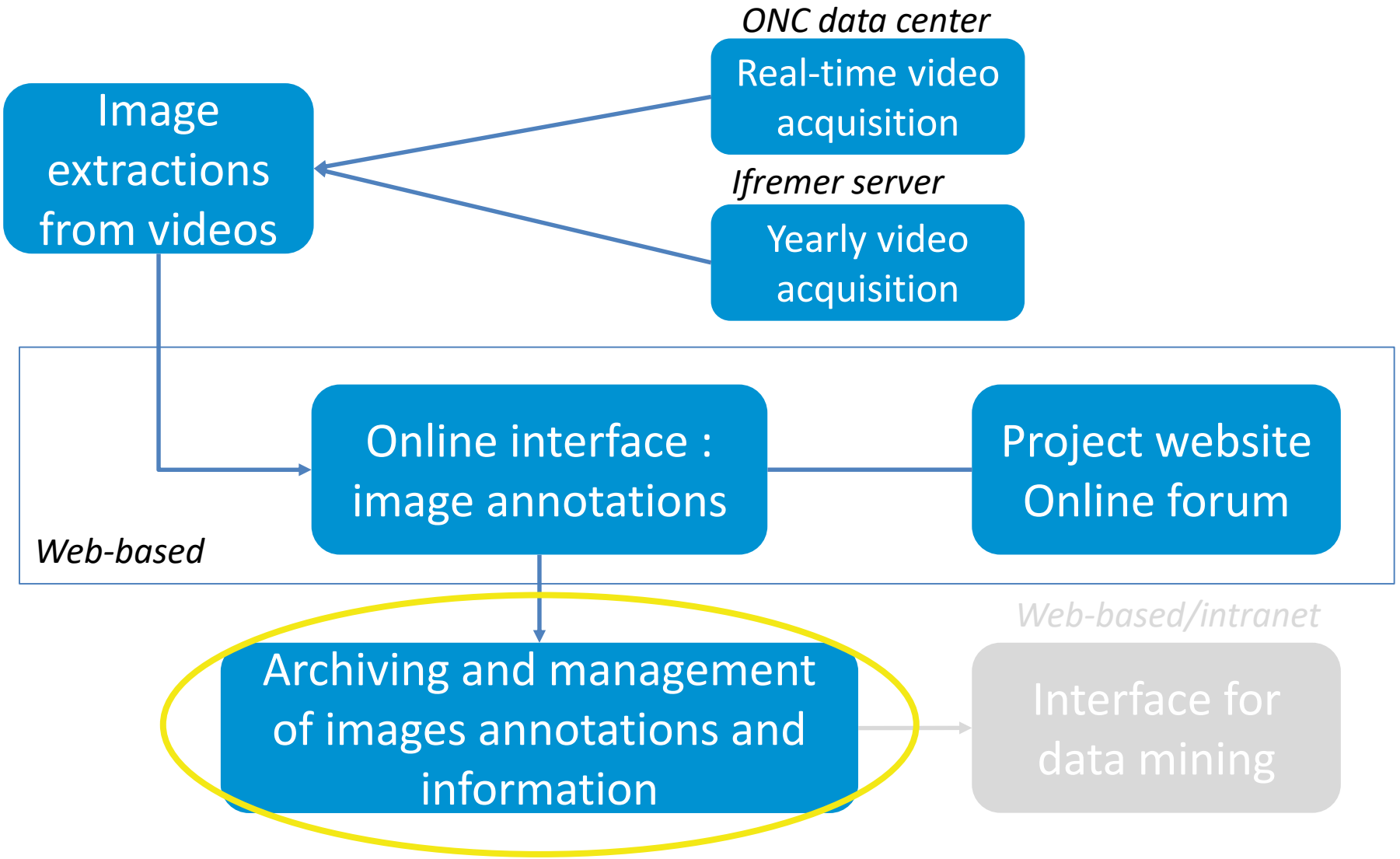
www.deepseaspy.com

The annotation system



www.deepseaspy.com

Development of a citizen science project



The data management

Deep Sea Spy database

Mission

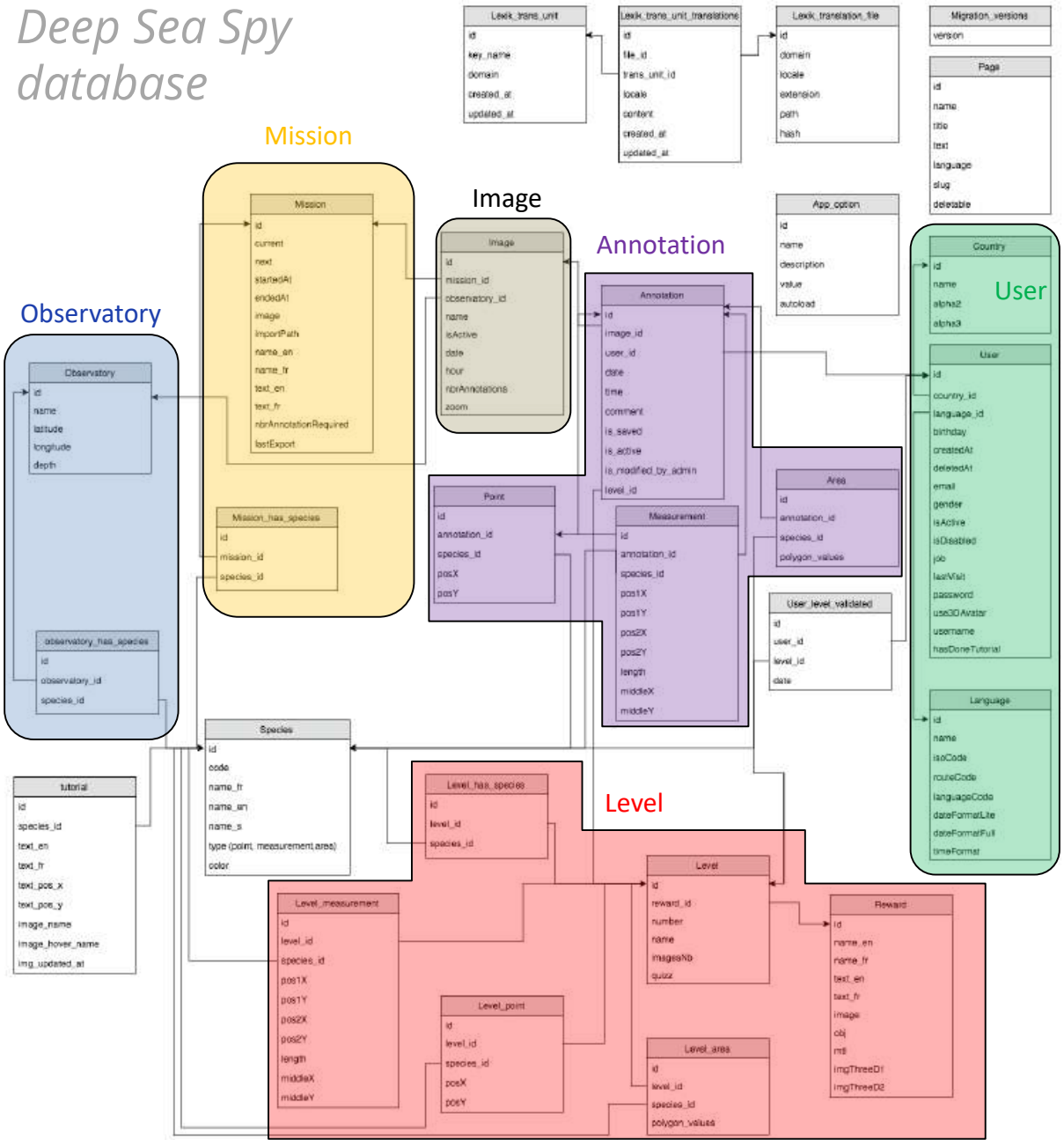
Image

Annotation

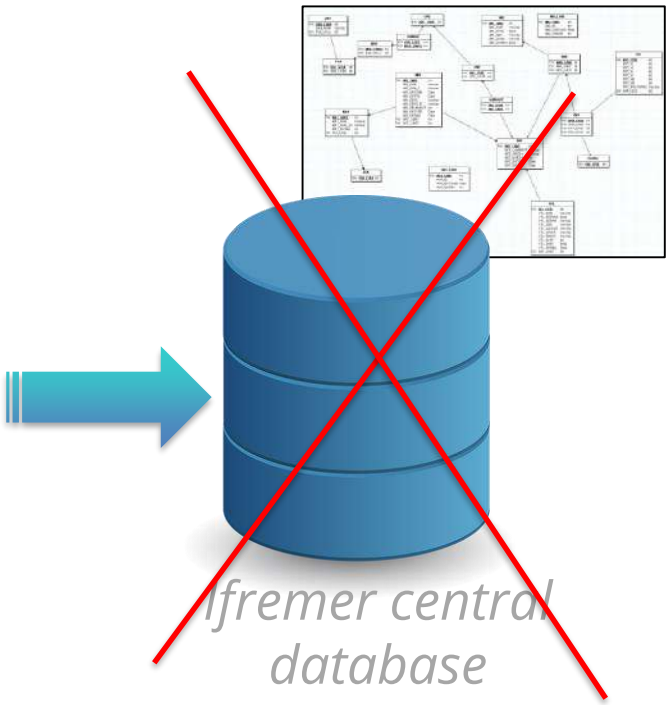
Observatory

User

Level



Citizen Science & Imagery Data



Ifremer central database

Standardisation…

- Taxonomy
- Parameters

Mission 1: Buccinum thermophilum

Total number of buccinid annotated : 140 316

Total ‘real’ number of individuals annotated:

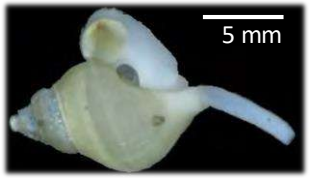
- No threshold: 35 765
- Agreement threshold:

25% : 18 582

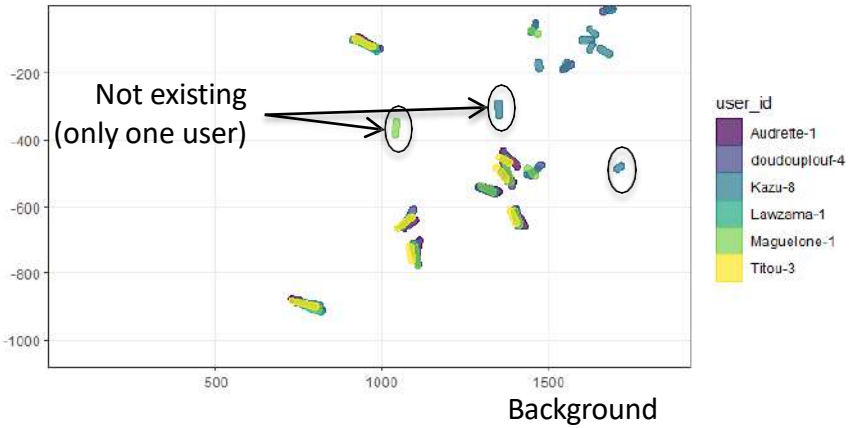
50% : 15 325

75% : 12 609

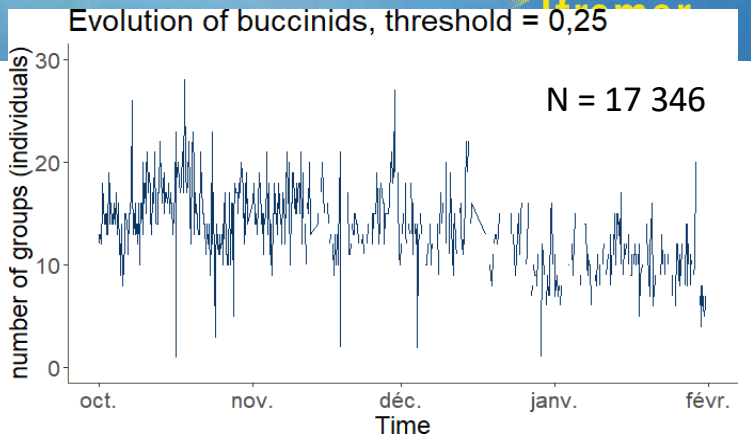
90% : 5 587

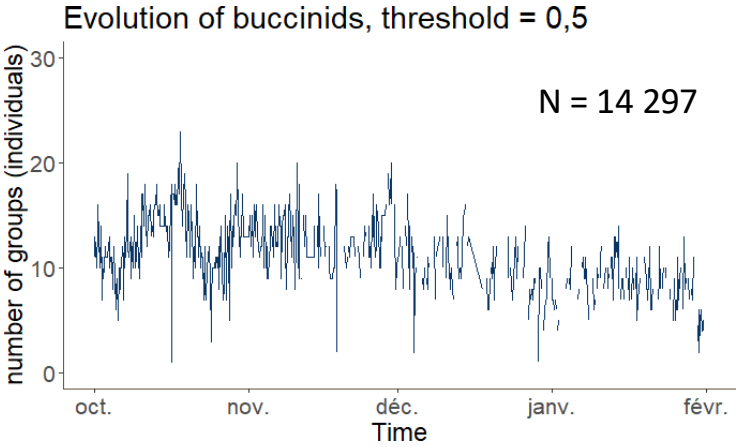


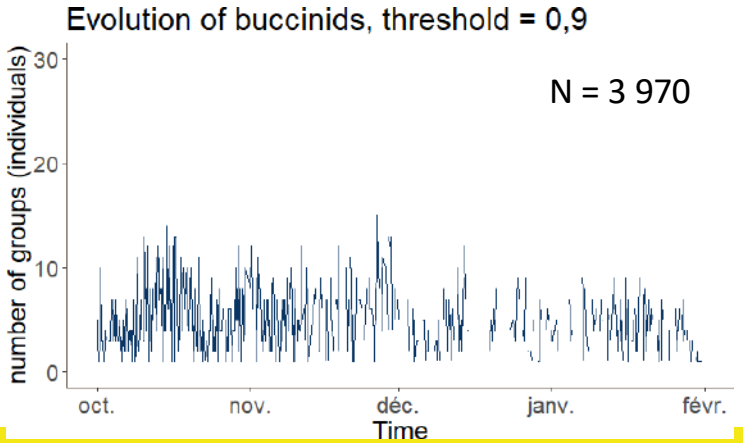
Buccinum thermophilum



Background







Development of AI algorithms Mask-RCNN; Faster-RCNN; YOLOv4

mean Average Precision (mAP): proportion of correct findings -> high score = few false positives

Recall : proportion found of real objects -> if maximised, high proportion of false positive

Intersection over Union (IoU) -> match between the predicted rectangle and the reference annotation one :

0.5 (standard value) - 0.01 (high tolerance).

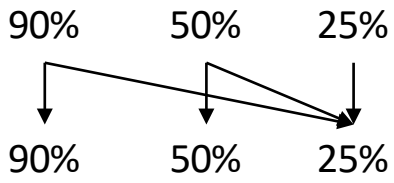
	Training set	
	Expert	Citizen
Zoom	mAP: **91% - 94%** Recall: **92% - 95%**	mAP: 44% - 80% Recall: 52% - 85%
Large view	mAP: 81% - 87% Recall: 83% - 88%	mAP: 69% - 82% Recall: 77% - 86%

Citizen data

Training set (500-700 images)

Validation set

Agreement threshold



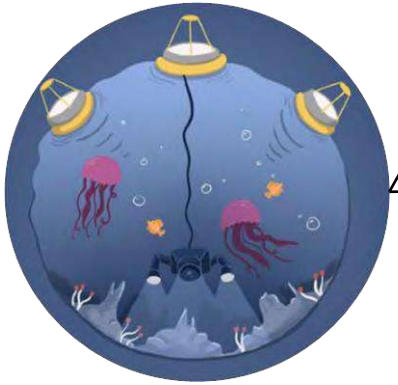
Best values for training set with 50% agreement evaluated on the same corpus

Imagery big data

From acquisition to artificial intelligence application

Ifremer

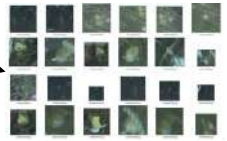
Imagery acquisition



Observatories
ROV/AUVs

Scientist
(few annotations/
limited manpower)

Data Base, catalogues



SISMER

Citizen contribution
(thousands of annotation)

Deep-Sea Spy

Data validation

Output validation by citizens

Feed-back loop: Improving algorithms

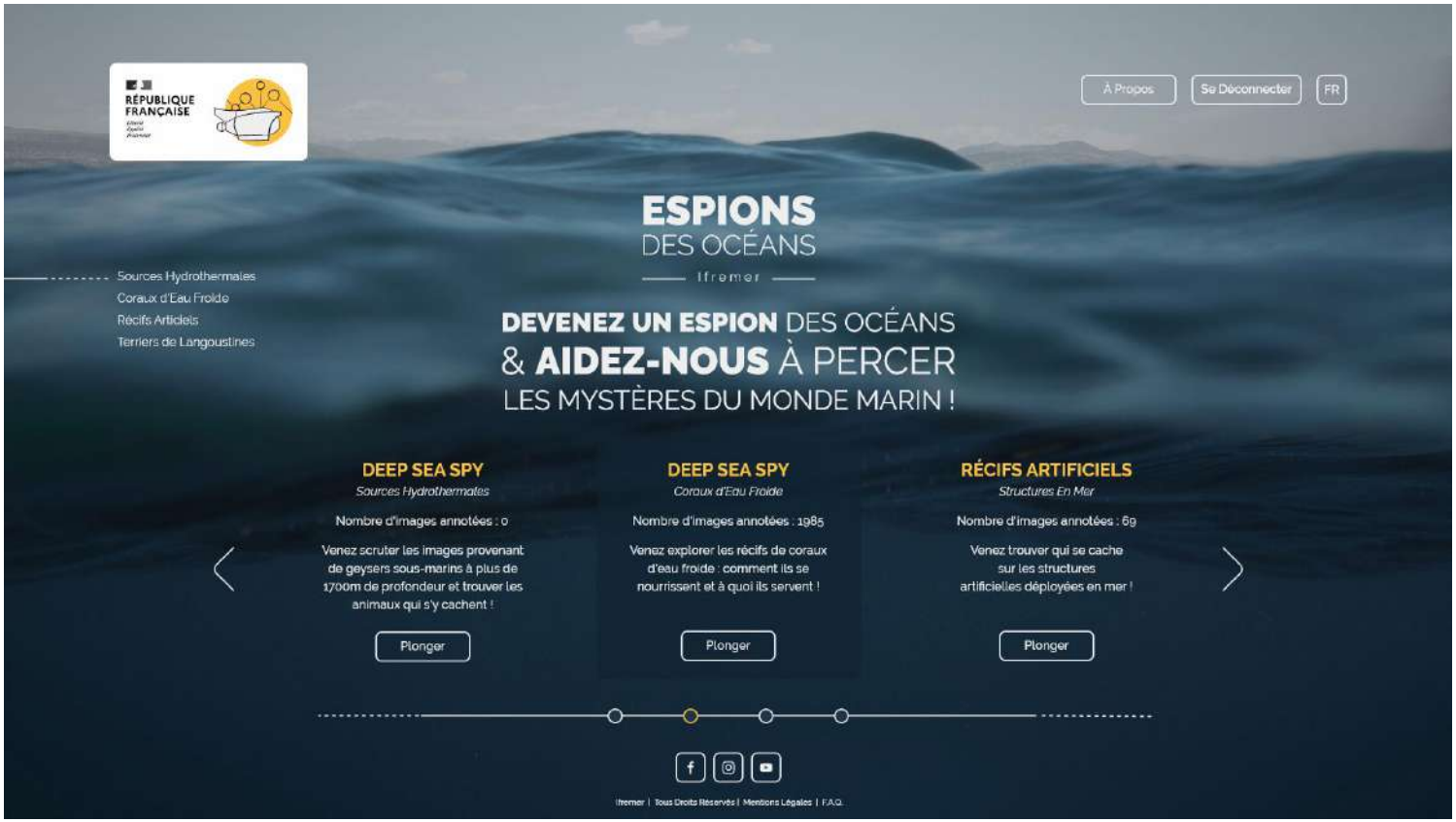
Datarmor server
(Ifremer)

Machine learning

New version of Deep Sea Spy to come!

Ocean Spy – Espions des Océans

A platform dedicated to image annotation by citizen for the study of marine ecosystems

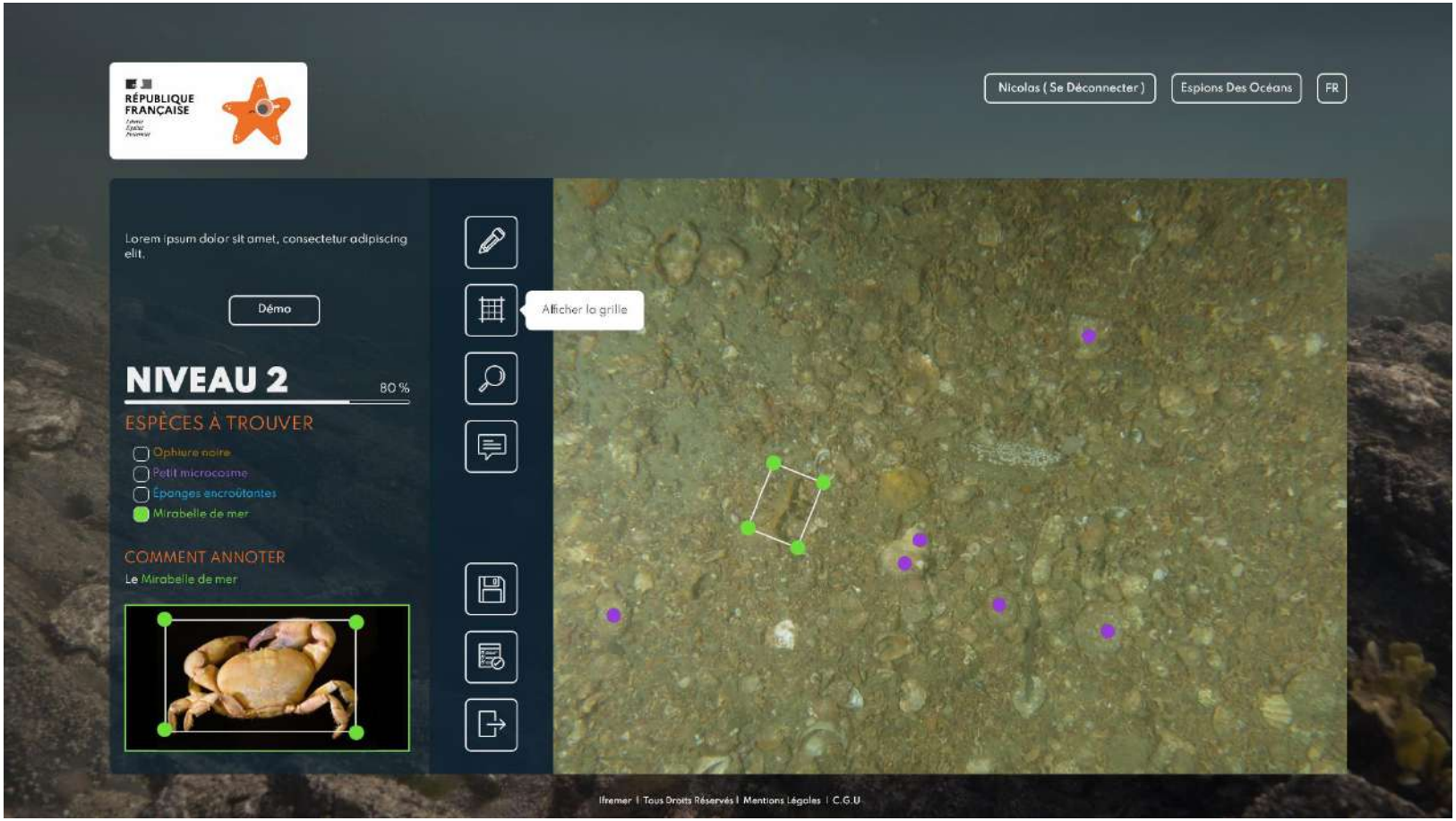


Shore Spy/Espions des côtes

P.O Liabot, A. Carlier, M. Marzloff – DYNECO/LEBCO

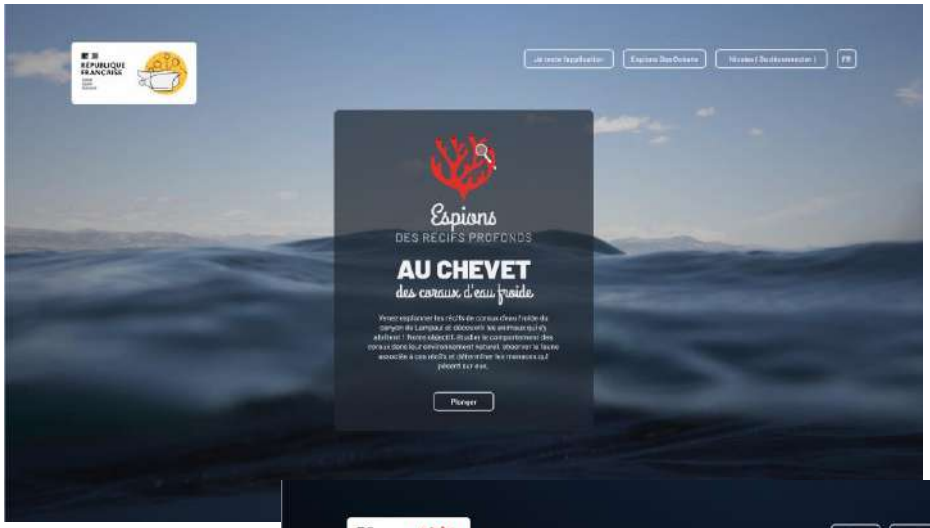
Shore Spy/Espions des côtes

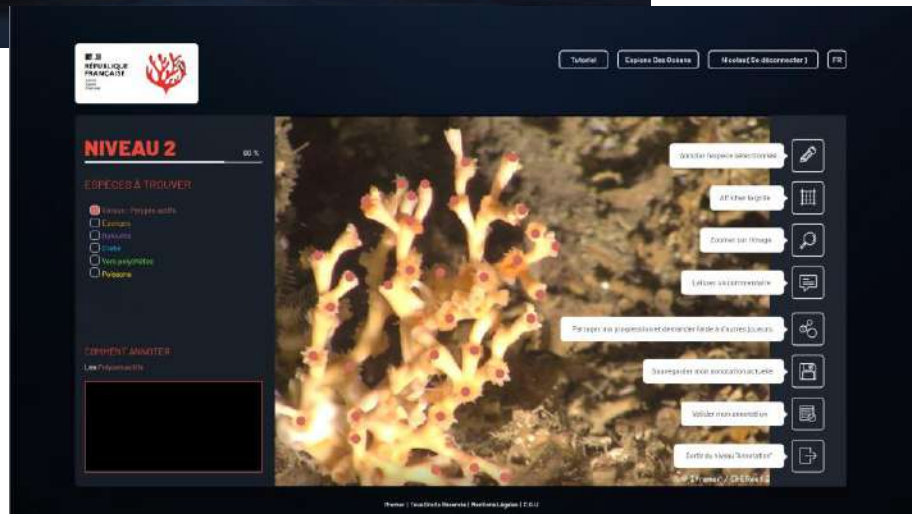
P.O Liabot, A. Carlier, M. Marzloff – DYNECO/LEBCO



Deep Reef Spy/Espions des récifs profonds

J. Tourolle – BEEP/LEP



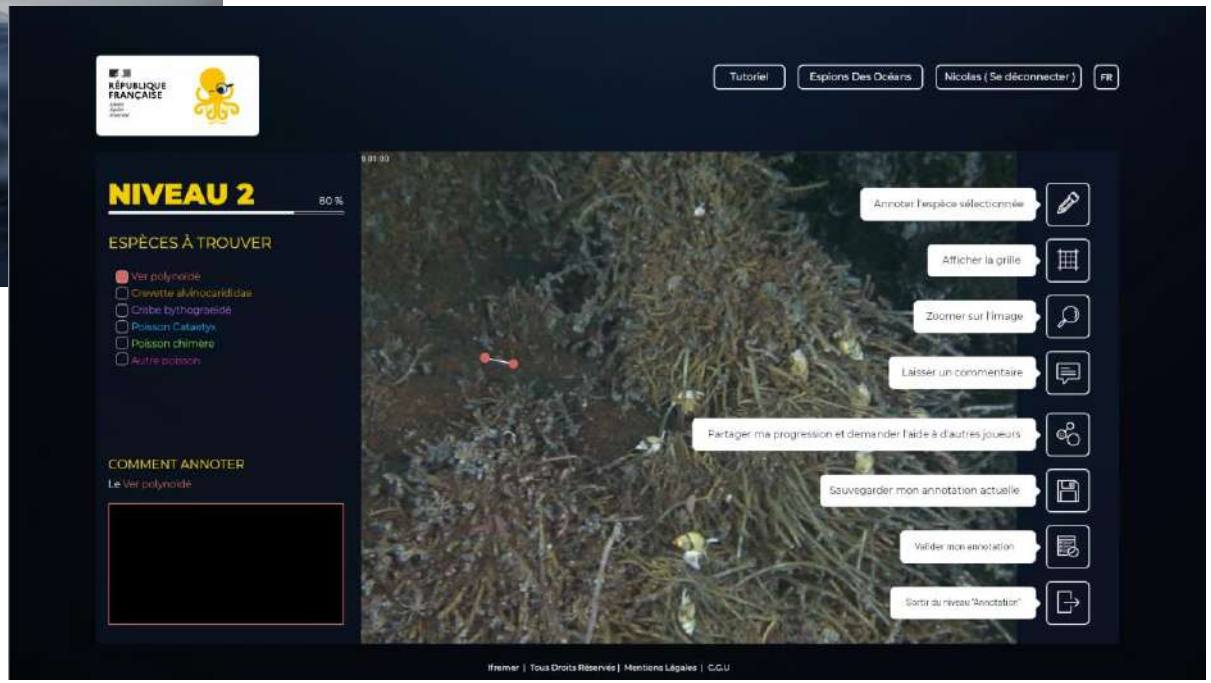


Monitoring of deep coral communities from the Lampaul canyon (Bay of Biscay)

Future images from Marley observatory

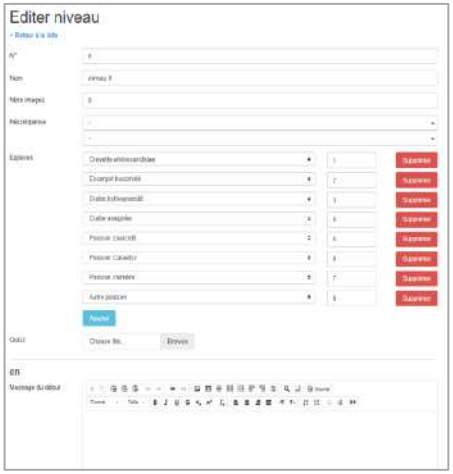
Deep Sea Spy/Espions des grands fonds redesign

M. Matabos – BEEP/LEP



Work in progress & perspectives

- Integration on the Ifremer IT infrastructure
- Development/Finalization of sub-projects
- Administration integration



- New sub-projects (e.g. STAVIRO images)
- New features (e.g. citizen validation)

- Animation and communication around the project
- "Ocean Decade" label

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Thank you to…

Yannick Cenatiempo
Nicolas Roullet
Jozée Sarrazin
Pierre-Marie Sarradin
Jean-François Rolin
Olivier Soubigou
Guillaume Clodic
Yann Lelièvre
Johanna Martin
Patrick Bossard
Thomas Gandarias
Claude Seveno
Réjane Quémeneur
Alicia Cuculière
Antoine Carlier
Pierre-Olivier Liabot
Martin Marzloff
Delphine Binos
Sébastien Rochette
Roland Duffau
Anne-Charlotte Philippe
Clara Ulrich
…

Engineers from ONC and Ifremer

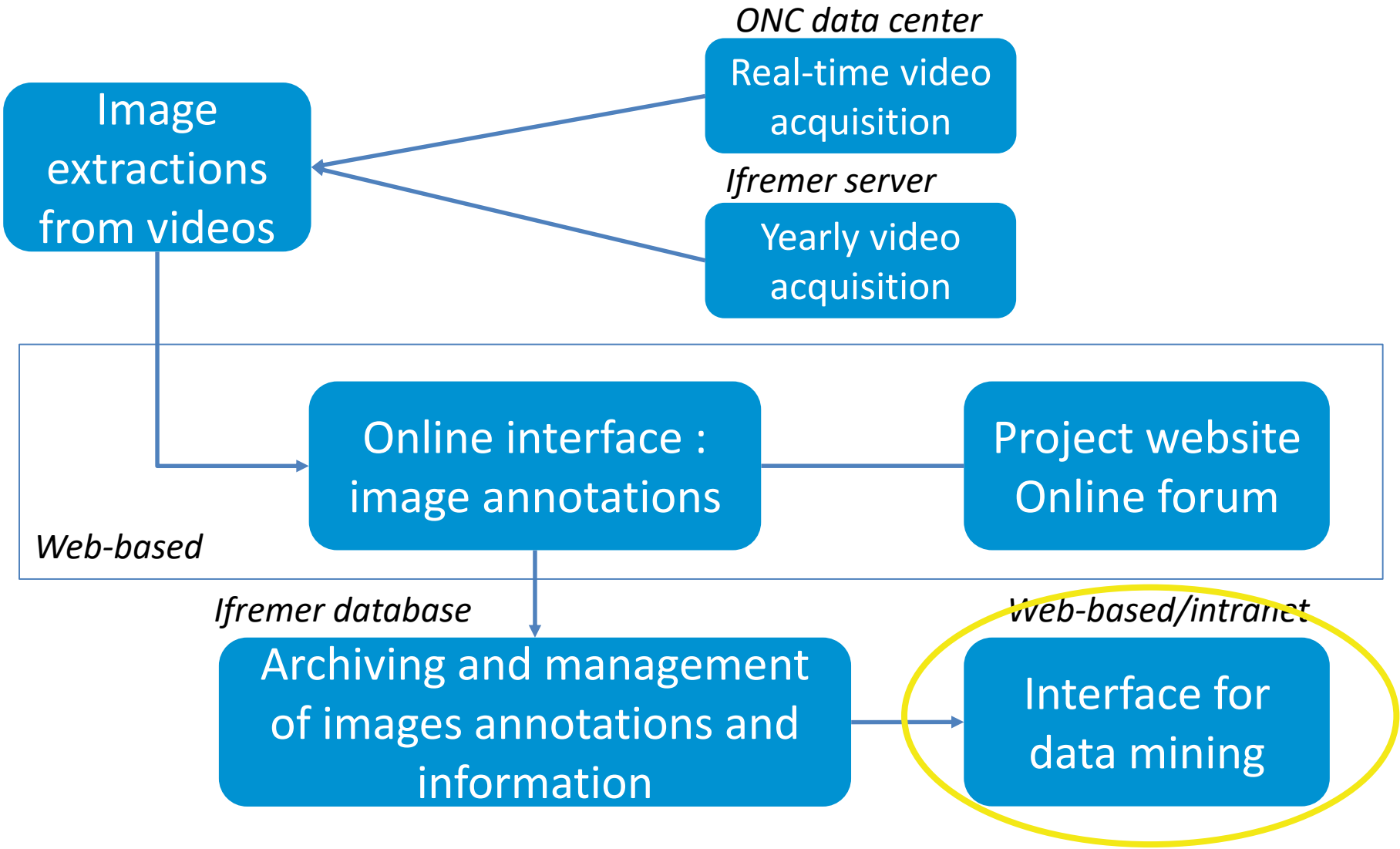
Crews of the RVs Pourquoi Pas?, Thalassa, T.G. Thompson & J.P. Tully and pilots of the ROVs Victor 6000 & ROPOS

& all the deep sea spys!

Thank you for your attention


Ifremer

Development of a citizen science project

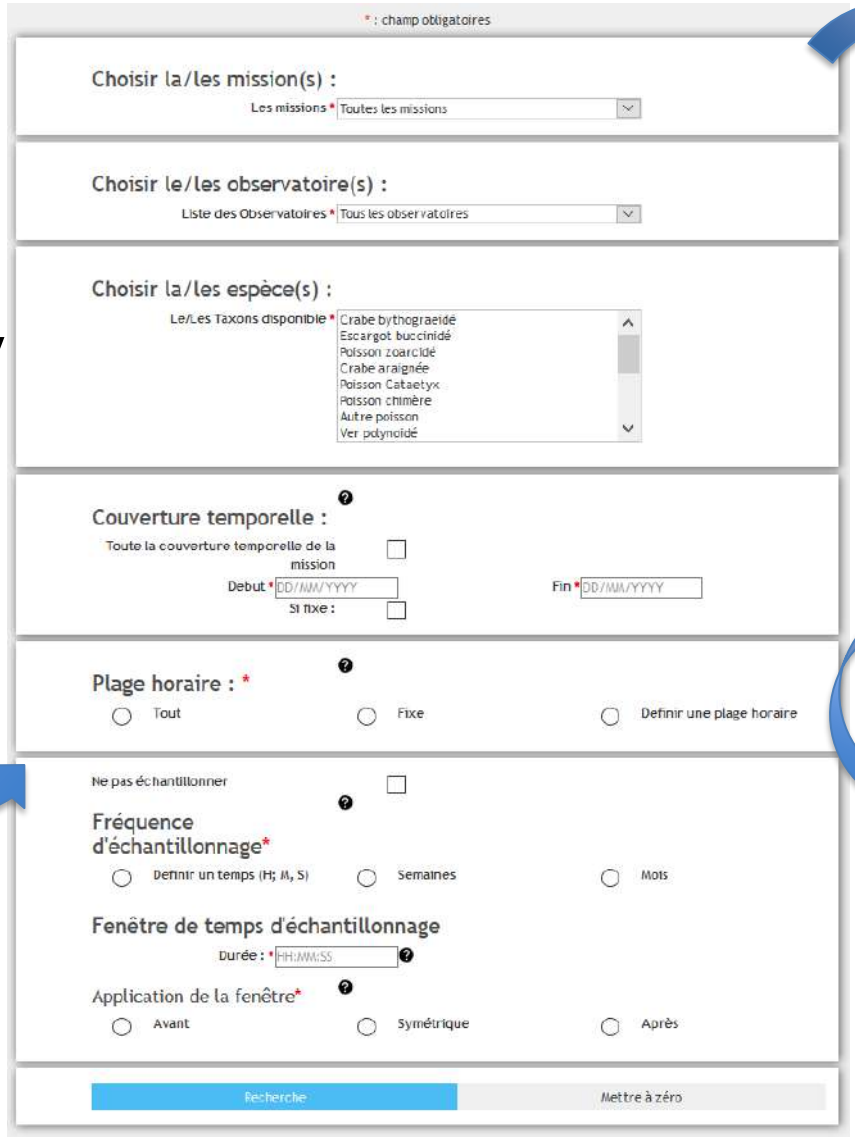


The query system – *DSS Request*

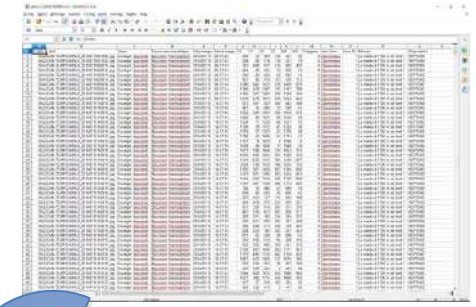
A web-based application to search DSS data

Selection :

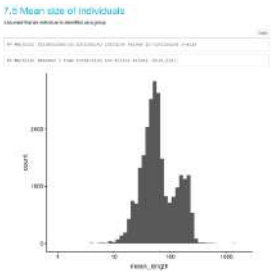
- Mission
- Observatory
- Time
- Species



CSV file export

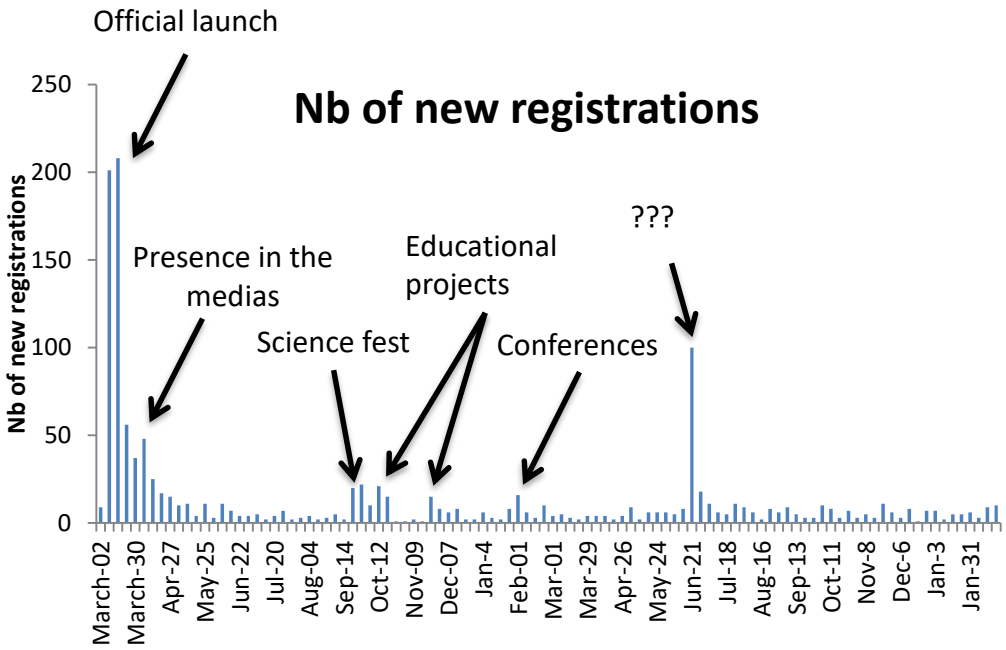


R import & further statistical analyses



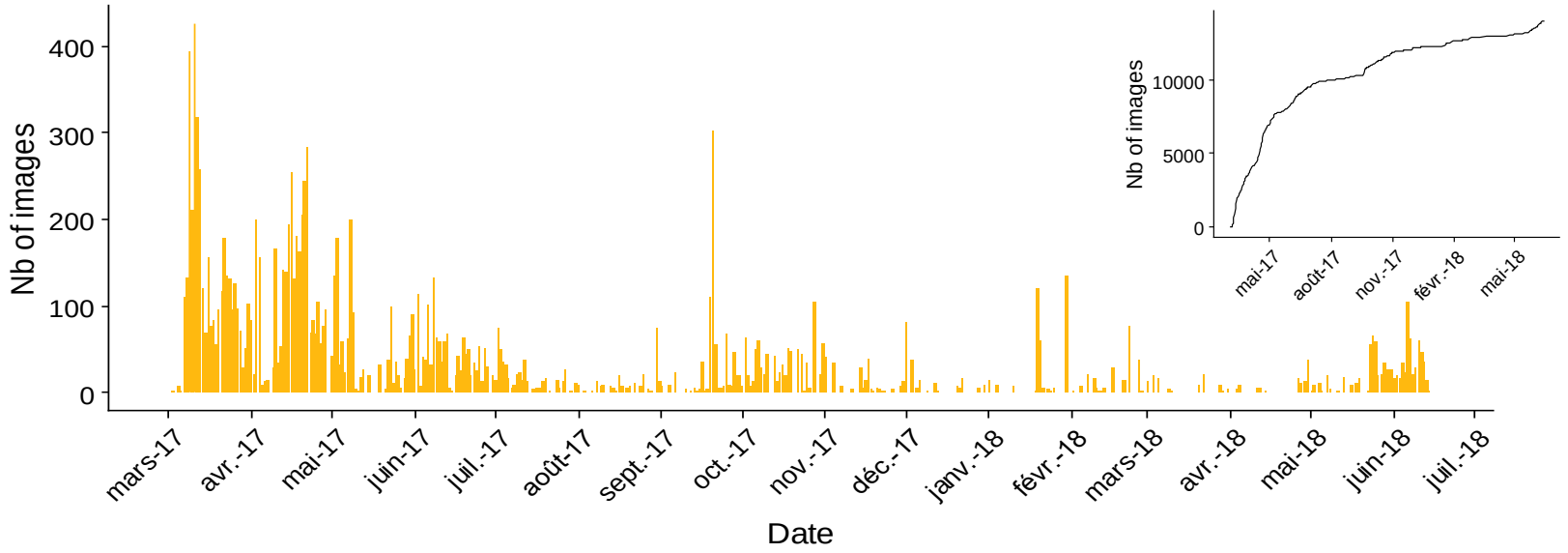
(habitats mapping, ecological studies…)

Preliminary results



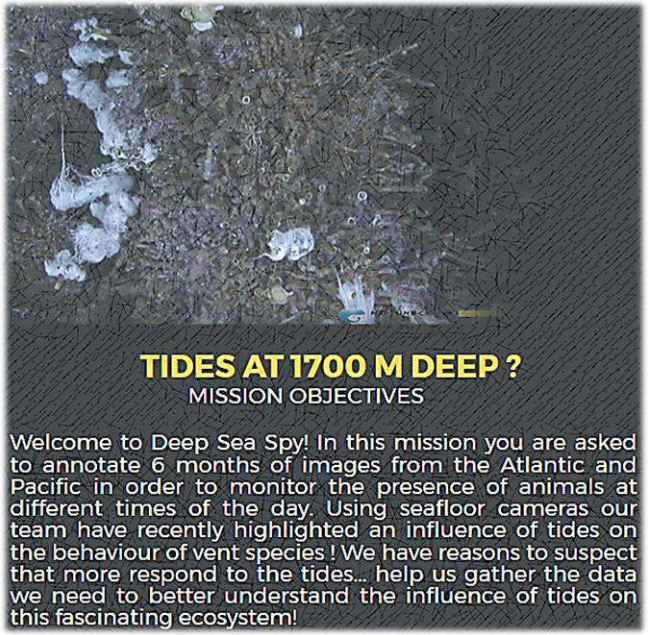
Nb of registered users	1315
Nb of active users (at least one image annotated)	669
> 5 images	384
> 10 images	224
> 100 images	45
> 500 images	8
> 1000 images	5
> 2000 images	1

From 22 countries



Mission: « Tides at 1700 m »

Six months of data: every 6h in the Atlantic and 4h in the Pacific



Nb of **unique image annotated**: 3952

- 3398 from Pacific
- 554 from Atlantic

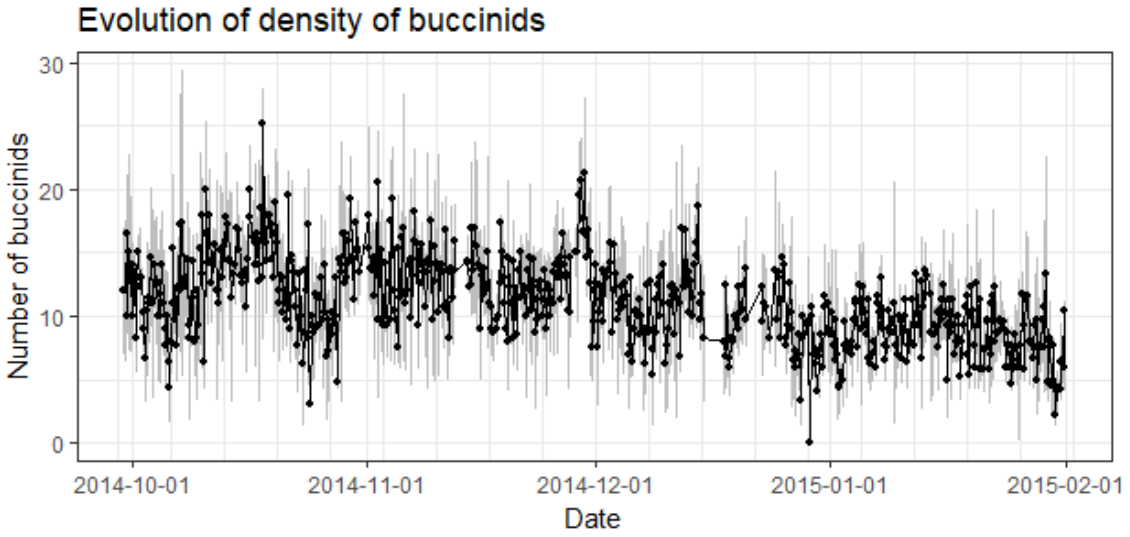
Total nb of **images annotated**: 23177

→ An image is annotated between 5 and 6 times on average

Nb of **participants**: 611

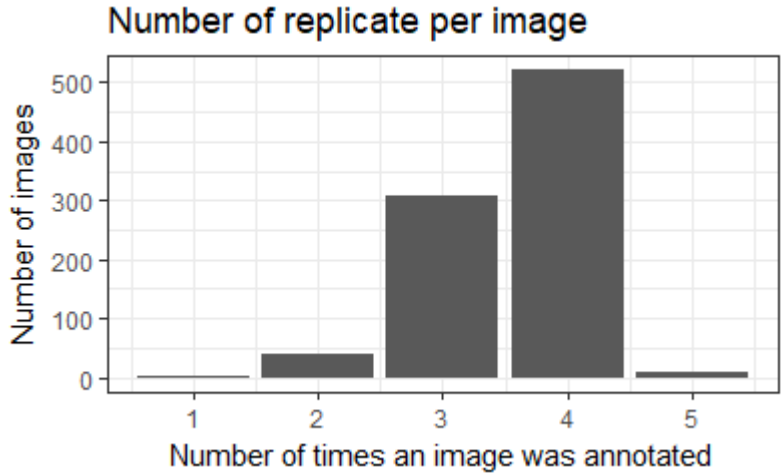
Nb of **annotations**: 188508

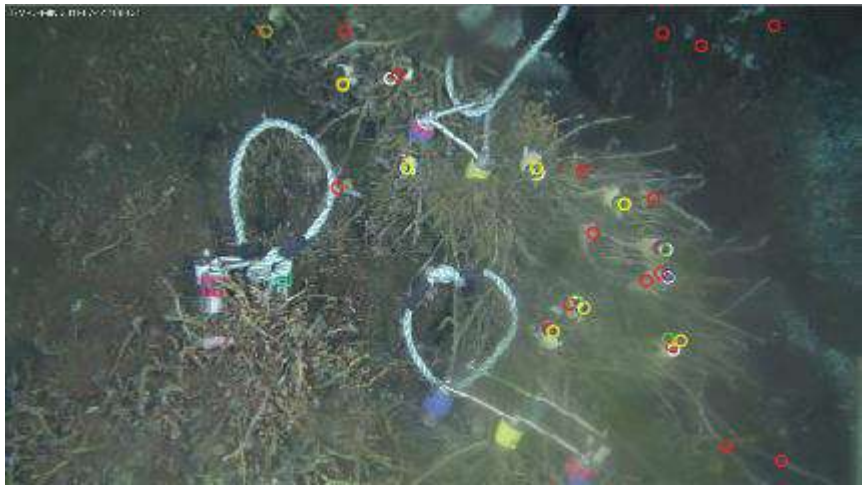
Buccinids



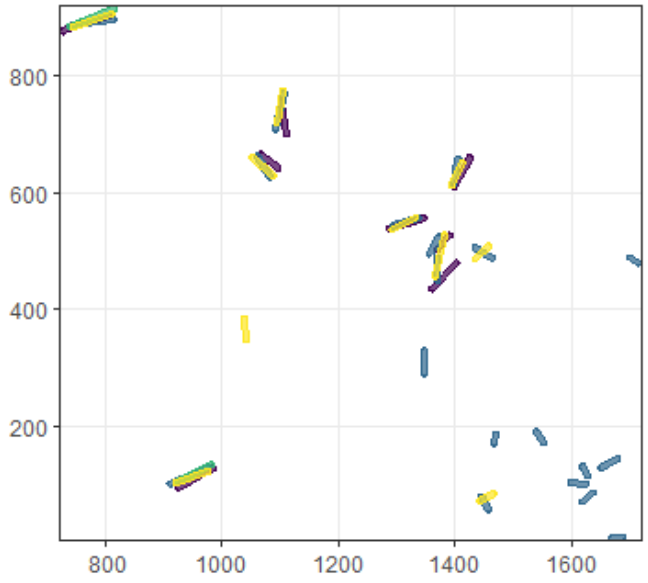
Nb d'annotations: 11,030
Nb d' images uniques: 3,237

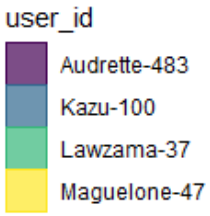
Nb total de buccinidés
- Annotés: 55,041 ind
- 'vrai': ~ 9,790 ind

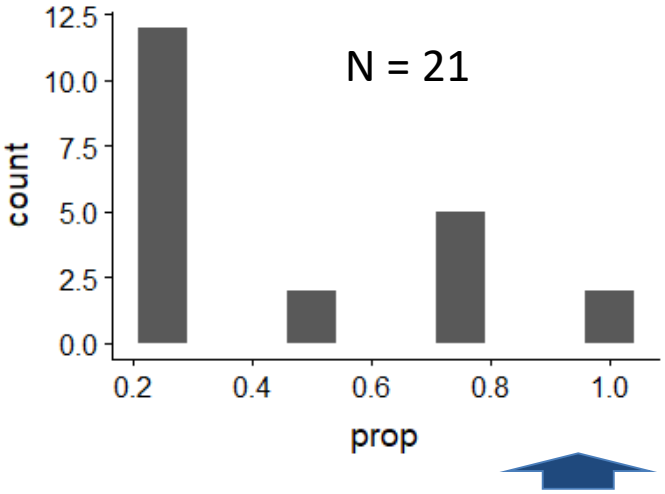


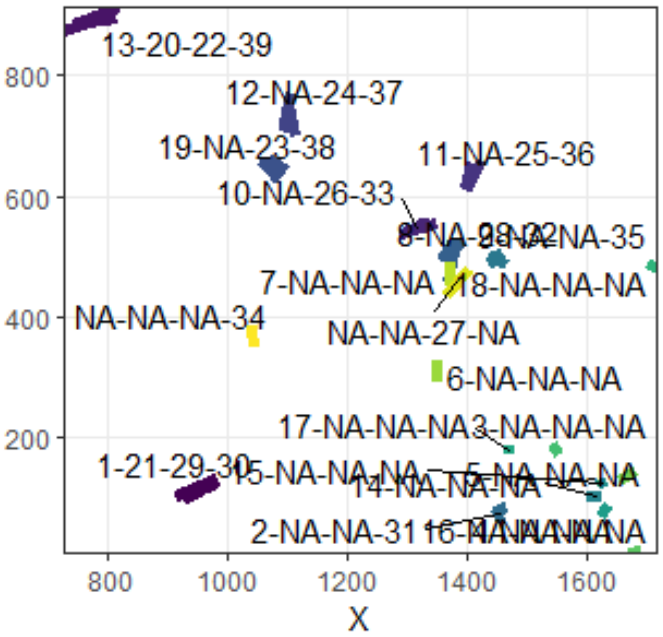


Buccinids: multi-participant validation









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10681	11-NA-25-36	3	4	0.75	list(c(1395, 1398.46153846154, 613, 620.3076923...
10681	12-NA-24-37	3	4	0.75	list(c(1112, 1103.37091757387, 700, 753.6920684...
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10681	6-NA-NA-NA	1	4	0.25	c(1349, 1348, 328, 290)
10681	7-NA-NA-NA	1	4	0.25	c(1370, 1371, 488, 449)
10681	8-NA-28-32	3	4	0.75	list(c(1383, 1380.09090909091, 526, 513.4545454...
10681	9-NA-NA-35	2	4	0.50	list(c(1464, 1447.04657794677, 487, 497.5228136...
10681	NA-NA-27-NA	1	4	0.25	c(1362, 1403, 435, 479)

Outreach: *General Public*

Oceanopolis,
Computer terminal


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Science fest
Brest, Quartz, 2016

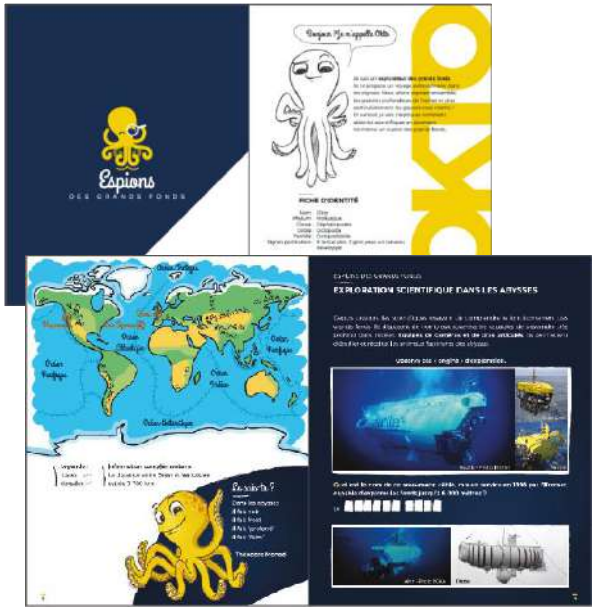
Science fest
Paris, Cité de la science et de l'Industrie, 2017

Ocean fest, Paris, aquarium de la porte Dorée
Ocean Hackaton, Brest
General public conferences…

Outreach: *Schools/education*

Immersion sciences (Loctudy)

Educational booklets
Cycles 1-2-3 (3-11 years)



Educational projects

Training for school teachers (Oceanopolis)

Training for middle and high school teachers (Regional school academy- CSTI)

Young reporters of art and science (Oceanopolis)

Educational days

Preliminary conclusions & perspectives

- Results allow detection of trends in accordance with previous studies
- High variability among participants
- Spatial analyses will bring additional information and highlight the need for multi-participant data
- Validation processes still to be defined
- Generate a reference dataset for the development of machine learning algorithms
- Share the system with other Ifremer imagery data types (coastal environment, fisheries…)